# J.W Gottstein Memorial Trust Fund

The National Educational Trust of the Australian Forest Products Industries


## AN INTERNATIONAL REVIEW OF PESTCIDE USE AND CULTURE: PEST MANAGEMENT STRATEGIES, CHEMICAL REGULATIONS / FOREST MANAGEMENT CERTIFICATION AND IMPACTS FOR TREE SURVIVAL AND YIELD

**KIM THOMAS**

2015 GOTTSTEIN FELLOWSHIP REPORT

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# Joseph William Gottstein Memorial Trust Fund

The Joseph William Gottstein Trust Fund was established in 1971 as a national educational Trust for the benefit of Australia's forest products industries. The purpose of the fund is "*to create opportunities for selected persons to acquire knowledge which will promote the interests of Australian industries which use forest products for the production of sawn timber, plywood, composite wood, pulp and paper and similar derived products.*"

Bill Gottstein was an outstanding forest products research scientist working with the Division of Forest Products of the Commonwealth Scientific Industrial Research Organization (CSIRO) when he tragically was killed in 1971 photographing a tree-felling operation in New Guinea. He was held in such high esteem by the industry that he had assisted for many years that substantial financial support to establish an Educational Trust Fund to perpetuate his name was promptly forthcoming.

The Trust's major forms of activity are:

1. Fellowships and Awards – each year applications are invited from eligible candidates to submit a study programme in an area considered of benefit to the Australian forestry and forestry industries. Study tours undertaken by Fellows have usually been to overseas countries but several have been within Australia. Fellows are obligated to submit report on completion of their programme. These are then distributed to industry in appropriate. Skills Advancement Awards recognize the potential of persons working in the industry to improve their work skills and so advance their career prospects. It takes the form of a monetary grant.
2. Seminars – the information gained by Fellows is often best disseminated by seminars as well as through the written reports.
3. Wood Science Courses – at approximately two yearly intervals the Trust organizes a week-long intensive course in wood science for executives and consultants in the Australian forest industries.

Further information may be obtained by writing to:

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# Contents

# Executive Summary

Chemical use for forestry applications is considered a vital element in effective forest management, however is relatively low overall in comparison to the total agricultural chemical use in Australia. Pesticides in Australian plantation forestry are used to ensure that trees meet both silvicultural and commercial objectives without impediments of competitive vegetation. The demand for timber is increasing resulting in plantation management in Australia becoming more intensive, as mangers try to extract greater volume and value out of each hectare. The same trend exists in other countries, with research implemented to improve productivity and value of a plantation taking into consideration the challenges faced regarding the increasing forest management restrictions.

Within Australia, the Forest Stewardship Council (FSC) is one of two forest management certification systems available to forest growers; the other being the Australian Forestry Standard (AFS). A key part of the FSC ideology for the sustainable management of forests is the elimination of the use of chemicals in the environment. Reduced availability of chemicals in Australia will have a detrimental effect on the Australian forest industry. As an internationally recognised forest management certification system, FSC also extends throughout New Zealand and the United States.

In Queensland, HQPlantations forest management systems are independently certified by the Forest Stewardship Council (FSC) and the Australian Forestry Standard (AFS). Both forest certification systems require HQPlantations to meet internationally-accepted criteria for sustainable forest management covering economic, social, environmental and cultural perspectives. New Zealand is very pragmatic, innovative and clever in their research and solutions in weed management. Most of the main grower operations are FSC certified; but the majority of smaller operations are not. The New Zealand research team commenced a new R&D program to try to double productivity of their plantation estate, resulting in effective and targeted weed management becoming the key research area within the program. Forestry companies in south-eastern America are certified to FSC or Sustainable Forestry Initiative (SFI). Pesticides are used during the establishment and mid rotation phase of their plantation management and deal with numerous environmental, cultural and economic issues regarding the application of chemicals.

A study tour was undertaken to north-eastern Australia, New Zealand, and south-eastern America during September 2015. Included in the tour was the Scion Crown Research Institute, the North Carolina State University, and seven international Forestry companies (HQPlantations, Hancock Forest Management New Zealand, Timberlands, Weyerhaeuser, Resource Management Services (RMS), Campbell Global and Hancock Forest Management USA). The study tour consisted of numerous field trips, including to the Biltmore House, in the vicinity of the Pisgah National Forest, being the first of North Carolina's national forests and the location of the first professional forestry school held in the United States (Schenck’s Biltmore Forest School). Of particular interest was the visit to the Carl Alwin Schenck Memorial Forest; a 245 acre forest located near Raleigh (North Carolina), managed by North

Carolina State University as a teaching and research forest, to demonstrate the multiple benefits generated by an actively-managed forest.

Experiencing international forestry techniques and practices has proven to be of great benefit, demonstrating and highlighting a broader perspective on a whole new set of objectives forest growers need to manage.

## Study Tour Objectives

The aim of this study tour was to review pesticide use and culture in north-eastern Australia, New Zealand, and south-eastern America by talking to key forestry representatives directly involved in pesticide use, managing and monitoring compliance, and to see the impacts reduced pesticide use or reduced availability of chemicals has on plantation forest management. To achieve this aim it was vital to experience first-hand how applied research into plantation pesticide use is conducted internationally, particularly;

- The reduction of pesticide use due to regulations/public views/restrictions in other countries
- The impact pesticide restrictions/forest management certification has on tree survival and plantation growth
- Review pesticide use in highly regulated areas to determine alternative or non-chemical methods to control weeds/pests.
- The longer term implications of regulations and certification (FSC for example) for pest management and tree productivity, and possible longer term implications of regulation in Australia.

# Acknowledgments

I would like to acknowledge and thank the J.W. Gottstein Trust Memorial Trust Fund for providing the financial support which allowed me to undertake this study tour.

Michelle McAndrew (Senior Forester Sustainability) and Bob Lewis (Operational Manager, Imbil) HQPlantations.

Dr Peter Clinton (Science Leader – Forest Systems) and Dr Carol Rolando (Pest Management Scientist) from SCION New Zealand Crown Research Institute.

Colin Maunder (Forest Risk Manager) Timberlands, Rotorua New Zealand.

Dave Lowry (Technical Forestry Manager) Hancock Forest Management, Rotorua New Zealand.

David Wilkinson (Silviculture Manager, Birmingham Alabama) and Jeremy Kessinger (Area Manager, North Carolina) Hancock Forest Management (HFM).

Elizabeth Snider, North Carolina State University.

Nancy Thompson (Public Affairs Manager) Weyerhaeuser.

Pryor Gibson (Executive Vice President) North Carolina Forestry Association.

Tony Doster (North Carolina Region Manager) and Clay Jenkins (Forest Planner) Resource Management Services (RMS) North Carolina.

Brett Goulding (Region Manager, Wilmington) Campbell Global.

Joey Ferguson (South Carolina Region Manager) and Amy McClellan (Forestry Manager) Resource Management Services (RMS) South Carolina.

Jim Peeler (Manager of Silviculture and Research) Resource Management Services (RMS) Birmingham, Alabama.

Robert Milstead (Stewardship Manager Eastern Division) Hancock Forest Management (HFM) Harpersville, Alabama.

Paul Adams (Forestry Tasmania) for all the help and advice planning for this study tour.

ForestrySA and OneFortyOne Plantations for financial support and the time to undertake the study tour.

# Tour Itinerary

| Date | Activity | Contact |
|---|---|---|
| 31st August 2015 | HQPlantations, Gympie Queensland | Michelle McAndrew<br>Bob Lewis |
| 3rd September 2015 | Scion, Christchurch New Zealand | Peter Clinton |
| 7th September 2015 | Scion, Rotorua New Zealand | Carol Rolando |
| 8th September 2015 | Timberland, Rotorua New Zealand | Colin Maunder |
| 9th September 2015 | Hancock Forest Management, Rotorua New Zealand | Dave Lowry |
| 14th September 2015 | Hancock Forest Management, Charlotte North Carolina USA | Wayne McKenzie<br>Jeremy Kessinger |
| 15th September 2015 | North Carolina State University, Raleigh North Carolina USA | Elizabeth Snider |
| 16th September 2015 | Weyerhaeuser, Raleigh, North Carolina USA | Nancy Thompson<br>Pryor Gibson |
| 17th September 2015 | Resource Management Service, Wilmington North Carolina USA | Tony Doster<br>Clay Jenkins |
| 18th September 2015 | Campbell Global, Wilmington North Carolina USA | Brett Goulding |
| 21st September 2015 | Resource Management Service, Georgetown South Carolina USA | Joey Ferguson<br>Amy McClellan |
| 24th September 2015 | Resource Management Service, Birmingham Alabama USA | Jim Peeler |
| 25th September 2015 | Hancock Forest Management, Harpersville Alabama USA | Robert Milstead |

# Australia

Overview

Pesticide use is an efficient and cost-effective forest management tool in Australian Forestry. Competition for light, space, water and soil nutrients from vegetation can have detrimental effects on tree survival and productivity of plantation tree species. In Australia, pesticides are regulated by the Australian Pesticide and Veterinary Medicines Authority (APVMA) and State agencies. The regulation of a pesticide product can take more than three years for field testing and analysis of the new active ingredient (Jenkins and Tomkins, 2006). Before registering a product, the APVMA is required to conduct an assessment of the potential impacts of the pesticide on the environment, human health and trade, and of the likely effectiveness of the pesticide (APVMA, 2015). Therefore all pesticides available on the Australian market have been approved by the APVMA and can be used in Australia according to label requirements. Safe Work Australia (SWA) prepares national standards for the safe use of chemicals in the workplace, and in turn becomes legislation for States and Territory governments.

The Environmental Protection Authority (EPA) provides educational guidance on pesticide use and facilitates communication among different stakeholder groups to help pesticide users improve their management of pesticides (EPA, 2005). The EPA license aerial pesticide applicators, and as of 2015 license pest management technicians and fumigators under the Pesticides Regulation 2009. Most restrictions on chemicals in Australia are contained in state and territory legislation, although they may reflect codes of practice developed at a national level (EPA, 2005) assisting to make controls more uniform throughout Australia.

Forest Certification in Australia

Most forestry organisations in Australia, be they state or privately owned, have undertaken or are undertaking certification (Ferguson, 2012), either through the PEFC-recognised Australian Forestry Standard (AFS) and/or through the Forest Stewardship Council (FSC). The Program for Endorsement of Forestry Certification (PEFC) is an international independent non-profit global umbrella organization (AF&PA, 2016). The PEFC is dedicated to sustainable forest management through independent third-party certification and works by endorsing national forest certification systems (PEFC, 2016). Forest certification endorsed by PEFC undergoes rigorous third-party assessment against PEFC's unique sustainability benchmarks to ensure consistency with international standards (PEFC, 2016). Total forest area of endorsed forest management systems by PEFC within Australia in 2014 was over 10 million hectares; in comparison the United States had over 33 million hectares while New Zealand had zero (Figure 1). The recently established New Zealand Forest Certification Association (NZFCA) become New Zealand first national member of PEFC in 2015, whose standards were derived in conjunction with the AFS. The PEFC is the world's largest forest certification system, having 38 endorsed national certification systems and 275.3 million hectares of certified forests internationally in 2016 (Figure 2).

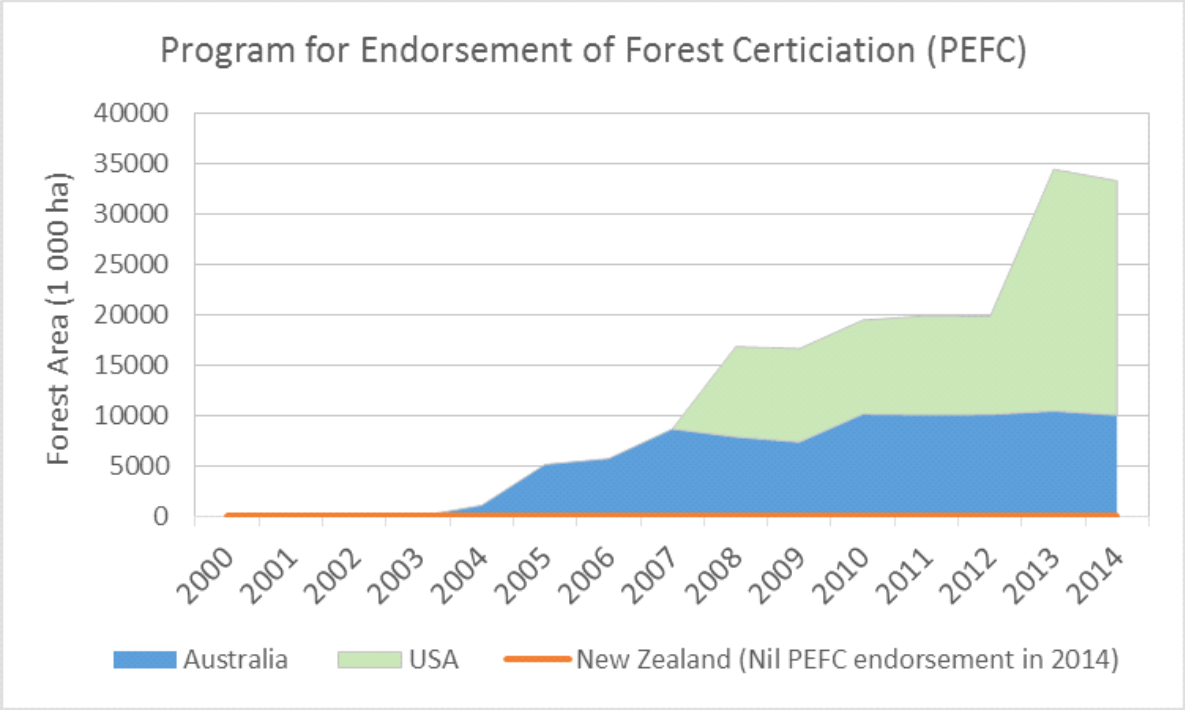


**Figure 1:** Program for Endorsement of Forest Certification (PEFC) forest area for Australia, New Zealand and USA. Source FOA 2015.

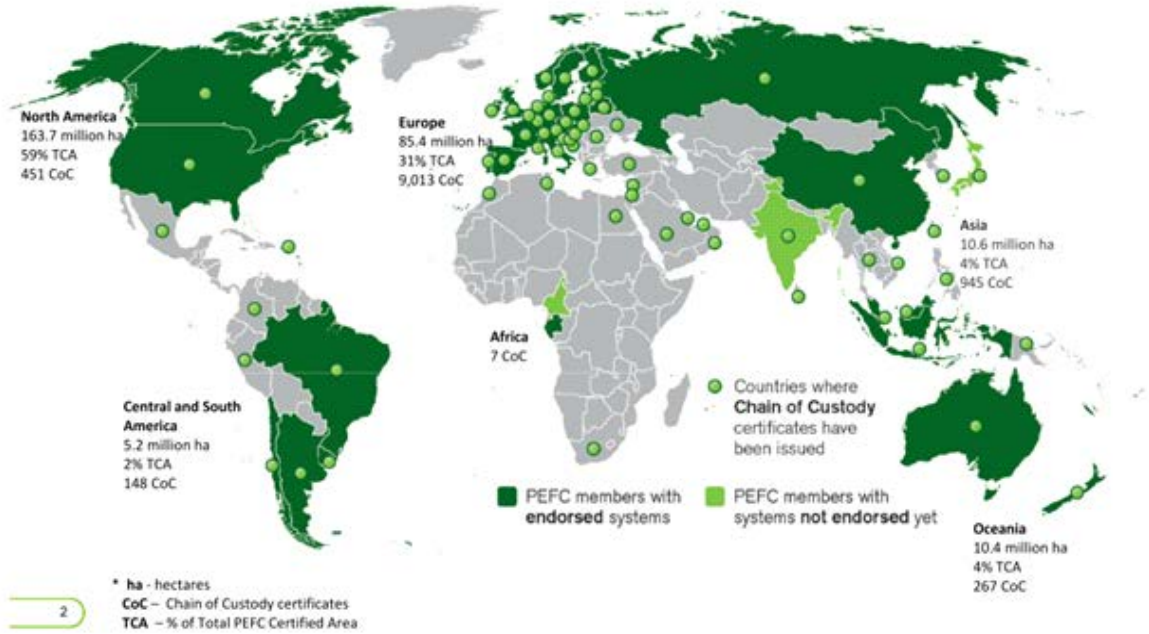


**Figure 2:** PEFC members and endorsed systems: international distribution of certificates. Source: PEFC Global Statistics Sustainable Forest Management & Chain of Custody Certification, 2016.

The Australian Forestry Standard (AFS) was established in 2002 to promote the sustainable management of Australia plantation and native forests. AFS owns and manages the Australian Forest Certification Scheme (AFCS) which is based on two standards; sustainable forest management and chain of custody for forest products (AFS, 2013). In order to retain PEFC endorsement the AFCS must be compliant with a number of PEFC standards. Specific

requirements surrounding chemical use in forest management is one key aspect to both the AFS and PEFC. Within Australia there are rigorous legislative and regulatory framework for the registration, control and use of pesticides (AFS, 2014). The combination of Australian law and the specific requirements in the Australian Standard creates a framework which is consistent with the intent of the PEFC requirements (AFS, 2014).

The vast majority of Australia's major wood production forest managers have chosen to have their management independently certified against the Australian Standard (AS4708). In 2015 AFS certified over 10 million hectares of forest area in Australia (Figure 3).

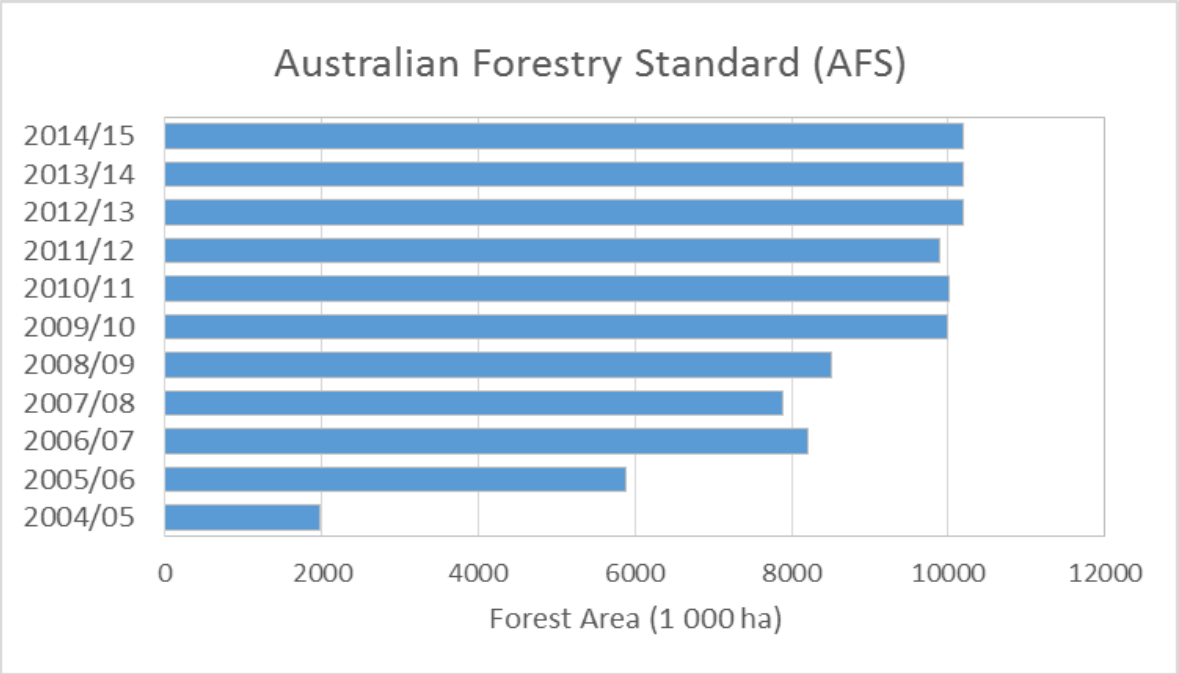


**Figure 3:** Australian Forestry Standard (AFS) approximate forest area 2004 - 2015. Source AFS, 2015.

Being certified to the AFS prohibits forest owners to use pesticides identified on the World Health Organisation (WHO) registered chemicals list, Type 1A (Extremely Hazardous) and Type 1B (Highly Hazardous), and also the Stockholm Convection on Persistent Organic Pollutants.

The Forest Stewardship Council (FSC), founded in 1993, is a non-profit membership based organisation, founded and operated by environmentalists, social interest groups, indigenous peoples' organisations, responsible retailers and lead forest management companies (FSC, 2002). The FSC has developed standards based on the '10 Principles for Forest Stewardship' by which responsible forest practice can be measured (FSC, 2012). These standards ensure that environmental, social and economic needs are balanced, and that long-term forest management plans are implemented (FSC, 2012).

FSC criterion 6.6 and 10.7 (Figure 5) state managers are required to adopt non-chemical methods of pest management, to avoid and move away from chemical pesticides wherever possible (FSC, 2002). In addition to the prohibited use of pesticides located on the World Health Organisation (WHO) registered chemical list (Type 1A (Extremely Hazardous) and

Type 1B (Highly Hazardous)), and also the Stockholm Convection on Persistent Organic Pollutants; the FSC identified a list of specific chemicals that cannot be used unless there is shown to be no viable alternative, in which case a temporary derogation may be granted (FSC, 2002).

The FSC prohibited list is reviewed periodically (most recently in 2014). A recent revision by FSC has seen herbicides formally banned now approved for use in FSC certified forests, including hexazinone and terbuthylazine which were removed from the highly hazardous pesticide list as a result of new thresholds.

Three locations visited during the study tour within Australia and New Zealand included: Gympie, Queensland, and Christchurch and Rotorua in New Zealand (Figure 4). Collectively, five key forestry representatives within three forest growers and one Research Institute including; HQPlantations, Timberlands, Hancock Forest Management NZ, and SCION Research Institute were visited. HQPlantations are certified to both the AFS and the FSC; while all forest growers visited in New Zealand are certified to the FSC.

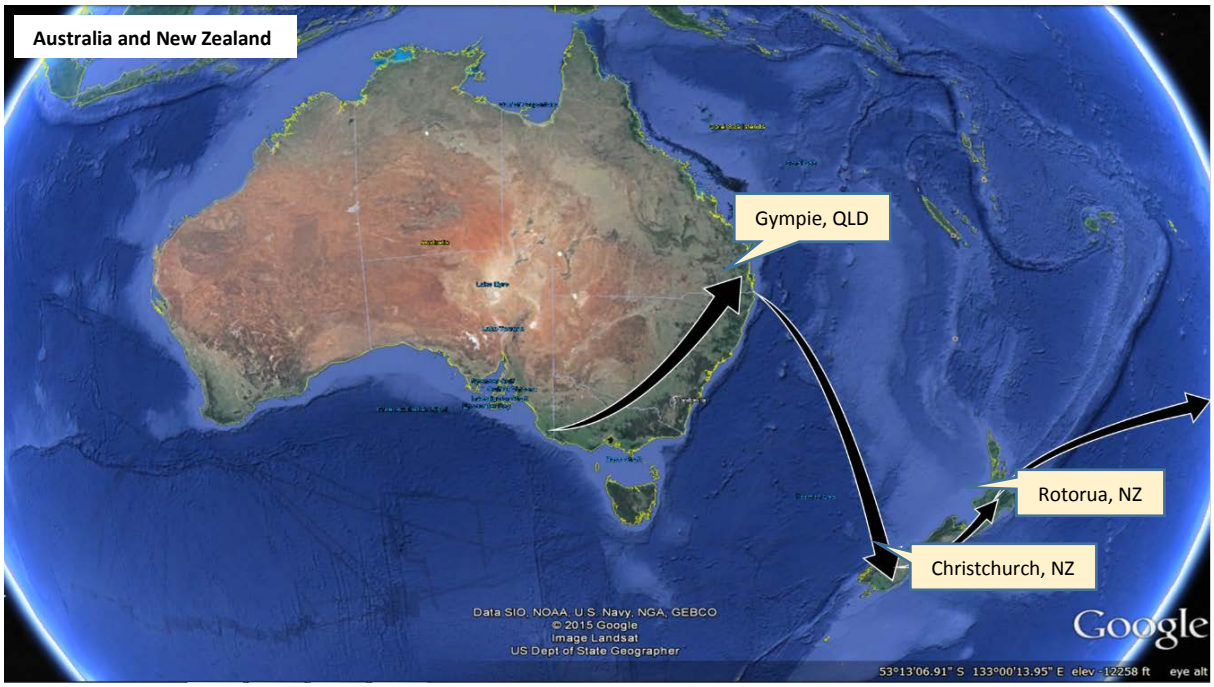


**Figure 4:** Locations visited during study tour within Australia and New Zealand.

A direct comparison of pesticide performance measures in terms of pesticide use for AFS and FSC forest certification systems can be seen in Figure 5.

| AUSTRALIAN FORESTRY STANDARD (AFS) | FOREST STEWARDSHIP COUNCIL (FSC) |
|---|---|
| Criterion 5.6 - Chemical Use<br><br>1. The forest manager must minimise the use of chemical and any adverse impacts arising from their use.<br>2. The forest manager shall not use World Health Organisation (WHO) Type 1A (Extremely Hazardous) and 1B (Highly Hazardous) pesticides shall be prohibited, except where no other viable alternative is available.<br>3. The forest manager shall not use pesticides banned by any international agreements defined in the Stockholm Convection on Persistent Organic Pollutants. | Criterion 6.6 – Management systems shall promote the development and adoption of environmentally friendly non-chemical methods of pest management and strive to avoid the use of chemical pesticides.<br>- World Health Organisation Type 1A (Extremely Hazardous) and 1B (Highly Hazardous) and chlorinated hydrocarbon pesticides; pesticides that are persistent, toxic or whose derivatives remain biologically active and accumulate in the food chain beyond their intended use; as well as any pesticides banned by international agreement, shall be prohibited.<br>- If chemicals are used, proper equipment and training shall be provided to minimise health and environmental risks.<br>Criterion 10.7<br>- Intergrated pest management shall form an essential part of the management plan, with primary relience on prevention and biological control methods rather than chemical pesticides and fertilisers.<br>- Plantation management shall make every effort to move away from chemical pesticides and fertilisers, including their use in nurseries. |

**Figure 5:** Australian forest certification system performance measures in relation to pesticide use; Australian Forestry Standard and Forest Stewardship Council.

## Gympie, Queensland – HQPlantations

Visit 1 of the study tour consisted of a day spent with Michelle McAndrew (Senior Sustainability Forester) from HQPlantations located in Gympie, Queensland. The morning was dedicated to a field trip north of Gympie, to observe non-chemical weed control through chopper rolling, and visiting herbicide and genetic trials within southern pine plantations. The afternoon consisted of a field trip tour with Bob Lewis (Operation Manager, Imbil) through hoop pine plantations and discussions about pesticide use in Queensland forestry.

HQPlantations are certified to both the Australian Forestry Standard (AFS) and the Forest Stewardship Council (FSC).

Overview

Majority of Queensland's timber is sourced from southern pine plantations. Southern pine is a well-established group of commercial plantation species including Slash pine (*Pinus elliottii* var. *elliottii),* Caribbean pine (*Pinus caribaea* var. *hondurensis)* plus hybrids of each, generally on a 30 year rotation length. HQPlantations is the largest plantation company in Queensland, having bought a 99 year plantation license to manage, harvest and grow timber plantations from the Queensland Government (HQP, 2015).

HQPlantations forest management systems are independently certified under the Forest Stewardship Council (FSC) and the Australian Forestry Standard (AFS). Michelle McAndrew currently manages HQPlantations' chemical/weed control research program as well as the chemical management system which includes compliance with regulatory and certification (AFS/FSC) requirements. The main focus for research within HQPlantations is genetics, as southern pine alone is highly valued for its excellent wood quality (Figure 6). Plantation establishment of southern pine is planted at approximately 833 stems per hectare, can be up to 1000 stems per hectare on certain sites. Wider row planting for their southern pine plantations allow machine access for non-chemical weed control options.

**Figure 6:** Southern pine containerised clones, Gympie Queensland.

Weed management is also a high priority as there are woody weed species (melaleuca sp. and lantana (*Lantana camara*)) which encourage the establishment of herbicide trials to find an alternative herbicide control. In addition, HQPlantations has established native hoop pine (*Araucaria cunninghamii*) plantations, a slower growing species. Together with their southern pine estate HQPlantations collectively makes up over 200,000 hectares of plantations. Queensland are also expanding their hardwood estate, which is likely to start producing timber post 2020 (HQP, 2015).

**Pesticide Use**

Site preparation herbaceous weed control

At site preparation, HQPlantations don't commonly have problems with herbaceous weeds, with pre plant chemical applications focusing more on grasses, vines and woody weeds which can quickly take over sites if not managed at pre planting. Typical site preparation consists of one pre plant application applied aerially by helicopter. Sensitive sites and plantation areas in close proximity to neighbours are applied on the ground by a tractor or hand sprayed. There are occasions where two pre plant applications may occur but is site specific. HQPlantations ideally leaves a site to fallow for 6-9 months to allow weeds to germinate prior to a knockdown application before planting.

HQPlantations have very high rainfall sites (>1000mm annually) and warm climates, favourable conditions that encourage vegetation weeds to thrive. Weed control using chemical herbicides is an important tool for HQPlantations to aid in reducing competition to their plantation trees for the first two years after establishment.

In the past, forest managers at HQPlantations applied up to eight treatments of herbicide for weed control. Previously their objective was to have bare earth (zero vegetation) at the time of planting, and in the first few year post planting a three meter band tend (strip application) was maintained until trees reached 1.5 meters in height. However, at that time the focus was on growing big trees and not necessarily about how much money was being spent or aiming to minimise the use of pesticide chemicals. Research by HQPlantations has found that within their plantations one pre plant (aerial) and two post plant applications (band tending) of chemical herbicide is generally sufficient enough to allow plantation trees to establish themselves. Post plant treatments do not usually provide a control of grasses (Figure 7), which can suppress plantation trees at establishment. Monitoring occurs in years two and three for further herbicide treatment, however by year four they are well established and grass in the understorey will not affect them.

**Figure 7:** Two year old Southern pine plantation, Gympie, Queensland.

Non-Chemical Weed Management

Prescribed fire is used by HQPlantations in their southern pine plantations for understorey grass and woody weed control. One grass species in particular, blady grass (*Lagurus sp.*) can create high fuel loads in the understory of southern pine plantations (Figure 8). Fuel reduction burning primarily occurs during winter. This management tool also helps reduce fuel for wildfires that may occur during more hazardous conditions in spring/summer months. Hoop pine plantations are not subject to fire, as this species is fire sensitive. Hardwood plantations prescribed fires are limited, with grazing being the primary means of reducing fuel loads (HQP, 2015).

**Figure 8:** Prescribed burning undertaken by HQPlantations to reduce fuel, and control grass and woody weeds in the understory of southern pine plantations; Gympie, Queensland.

HQPlantations also manage woody weeds in younger southern pine plantations by using a slasher or chopper roller inter row (Figure 9). Wider row spacing for southern pine allows for machine access inter row which is one reason they plant at approximately 833 stems per hectare. Chopper rolling or slashing does not control the woody weeds, however it provides good suppression and reduces competition for southern pine plantation trees (Figure 10).

**Figure 9:** Chopper roller used as mechanical weed control inter row within their southern pine plantations, north of Gympie Queensland.

**Figure 10:** Southern pine plantation after chopper rolling inter row, north of Gympie Queensland.

Another method of non-chemical weed control practiced by HQPlantations is cattle grazing. Steep terrain can limit access for slashing/chopper rolling and in some cases limit the application of herbicides post planting, especially in their hoop pine plantations. Grazing is considered as weed control of the past in many locations visited throughout the study tour, however for HQPlantations grazing provides benefits for maintaining vegetation to a minimum until the trees are well established. Figure 11 displays typical terrain HQPlantations have south of Gympie. One downside to grazing is cattle may cause damage to Hoop pine by biting the growing tip of young trees.

**Figure 11:** Typical rolling terrain south of Gympie, Hoop pine (*Araucaria cunninghamii*) plantations.

Pest Problems

Pest problems forest managers encounter include environmentally invasive plants of national significance, including: Lantana (*Lantana camara*), Cats Claw Creeper (*Dolichandra unguis-cati*) and Madeira vine (*Anredera cordfolia*). Plantation weeds coming from adjacent rainforests also cause problems as they are required to be protected. Biological control agents are used by HQPlantations where applicable. Lantana can be a problem at plantation establishment as it's the first to emerge following pre plant treatment. One negative side effect from broadcast aerial spraying pre planting is having bare earth at establishment which encourages Lantana growth.

Dense regrowth of Melaleuca (*Melaleuca quinquenervia*) is a particular issue for southern pine plantations, more so on lowland coastal sites. It can be overcome on a first rotation site where intensive mechanical site preparation can be implemented, however management through intensive and repeated cultivation is high risk for soil and water properties, and the operation itself is very expensive. HQPlantations have established herbicide screening trials to test alternative herbicide products that have been identified through proactive research and liaison with chemical manufacture companies, and also through the Australian Plantation Industry Herbicide Research Consortium (APIHRC).

Chemical Restrictions / Forest Management Certification

Being certified to both AFS and FSC, HQPlantations are prohibited on using chemicals registered on the World Health Organisation (WHO) type 1A (Extremely Hazardous) and 1B (Highly Hazardous) tables, and the Stockholm Convection on Persistent Organic Pollutants list. HQPlantations are also restricted in using chlorinated hydrocarbon pesticides and any pesticides banned by international agreement.

In line with their forest management certification policies, HQPlantations continue to reduce their use and reliance of chemicals for various management activities. Currently they use a small amount of herbicides that are located on the FSC prohibited list, however are able to seek derogation of approvals for conditional use for these chemicals in certain areas. In saying this, HQPlantations endeavour to seek alternative herbicides in an attempt to reduce or eliminate the use of chemicals prohibited by the FSC. The AFS do not have the same restrictions.

Additional chemical restrictions for pesticide use for HQPlantations include alongside watercourses, close proximity to airports, neighbours, and non-targeted vegetation (rainforest species). These restrictions do not prohibit the use of pesticides, however it does restrict the method of application (ground based instead of aerial). Additional personnel training and application permits are also be required. HQPlantations also recently had their spray equipment and nozzles tested under different flying conditions to identify what wind speed and direction you can apply and still have excellent accuracy and reduced spray drift.

# New Zealand

Overview

Herbicides are used in New Zealand forestry for a range of purposes such as reducing competing vegetation, managing species composition, controlling invasive weeds, managing wildlife habitat, and maintaining facilities and access ways (Baillie et al, 2015). Vegetation management in New Zealand forests is normally provided by the use of herbicides. Weed control in planted forests underpins highly productive trees, uniform forests, and is one of the most important tools when establishing trees in New Zealand (Rolando and Harnett, 2015). Management of vegetation during the establishment phase of plantation trees is considered the single most important silvicultural practice used to maximise timber yield (Rolando and Watt, 2011).

New Zealand vegetation management practices have been relatively the same since 1995. Changes that have occurred have been driven by a number of factors; effective vegetation control strategies, reduced government funded research, and changes to pesticide regulation (registration and the use of pesticides). Regulation for the use of pesticides in New Zealand have become a lot more stringent since the late 1990's, affecting herbicide use in plantation forestry. Forest certification is the other driving factor to changes in vegetation management in New Zealand. The types of active ingredients approved for use in certified plantation forests, methods of application (restrictions), and environmental factors (not economical) dictate acceptable forest management practices, with or without scientific support (Rolando et al, 2015).

In New Zealand, agricultural pesticides must be authorised under the Agricultural Compounds and Veterinary Medicines (ACVM) Act 1997, the Hazardous and New Organism (HSNO) Act 1996, and through the Environmental Protection Authority (EPA) and its regulations. All pesticides under the agricultural compound definition (herbicides, insecticides and fungicides) go through rigorous individual assessment prior to registration, including harm to the environment and human health. The Hazardous Substance and New Organisms (HSNO) Act deals with pesticide toxicity and ecotoxicity of substances, and biosecurity, as well as other factors (EPA, 2012). Due to regulatory constraints from HSNO and increases in cost for registration of agrichemical products, the result from these influences has caused the reduction in new pesticide products, not only introduced into New Zealand but available for plantation forestry use.

Forest Certification in New Zealand

The concept of sustainable forest management across New Zealand has been enshrined in their legislation since 1991. Forestry industries within New Zealand have essentially supported the FSC certification scheme since 1998, by the end of 2008 majority of the larger forest growers in New Zealand were certified to the FSC. In 2014, New Zealand had 1.27 million hectares certified to the FSC (Figure 12); in comparison Australia had 1.08 million hectares and the United States had just under 16 million hectares (FOA, 2015).

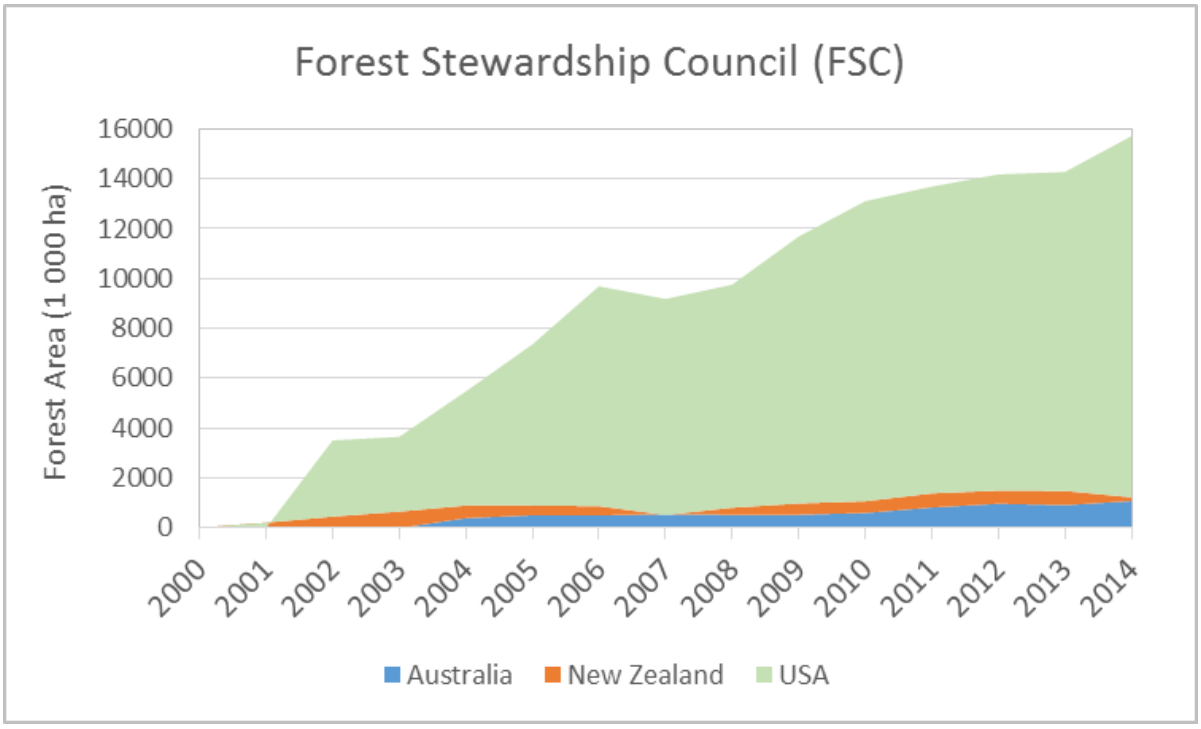


**Figure 12:** Forest Stewardship Council (FSC) forest area for Australia, New Zealand and USA. Source FOA 2015.

In 2016, FSC recorded over 190 million hectares internationally of certified forests in 81 countries (Figure 13), including New Zealand's 1.2 million hectares of FSC certified plantation forests.

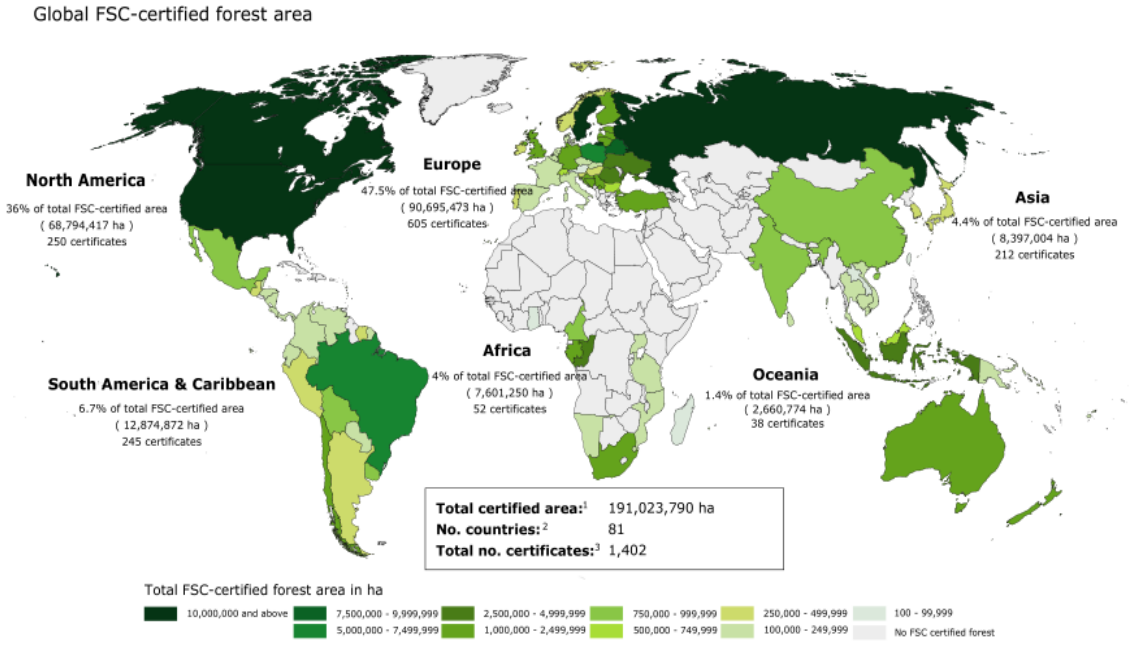


**Figure 13:** Global FSC certified forest area. Source: FSC, 2016.

FSC Criterion 6.6 and 10.7 state managers are required to adopt non-chemical methods of pest management, to avoid and move away from chemical pesticides wherever possible (FSC, 2002), and are prohibited to use pesticides located on the World Health Organisation (WHO) registered chemical list Type 1A (Extremely Hazardous) and Type 1B (Highly Hazardous), and also the Stockholm Convection on Persistent Organic Pollutants. In addition, the FSC identified a list of specific active ingredients that cannot be used unless there is shown to be no viable alternative, in which case a temporary derogation may be granted (FSC, 2002). In 2005, 26 pesticides were on FSC prohibited highly hazardous list; while in 2007, an additional 20 pesticides were included and 12 pesticides were removed (Mendell et al, 2015). During the 2007 review, two common herbicides used in New Zealand forestry, hexazinone and terbuthylazine, were included on the FSC prohibited pesticide list, triggering New Zealand forest growers and research institutions to consider alternative herbicide active ingredients and/or alternative methods of vegetation management. Vegetation management through the use of herbicides is not the preferred method of control for eco-certified forests (Rolando and Watt, 2014). The FSC prefer forest managers to shift away from herbicide use that may negatively affect the environment (Rolando and Watt, 2014), and to incorporate mechanical and other non-chemical controls of vegetation management, with the aim of reducing or eliminating pesticides from FSC certified plantations.

Approximately 60% of New Zealand's total plantation forest area is FSC certified. All forest growers (Timberlands and Hancock Forest Management New Zealand) and Research Institution's (Scion Research at Christchurch and Rotorua) visited were certified with the FSC.

## Christchurch, New Zealand – Scion Crown Research Institute

In New Zealand, the first visit of the study tour was Peter Clinton (Science Leader, Forest Systems) at Scion Crown Research Institute (Scion), Christchurch. Scion specialises in research, science and technology development for the forestry, wood product and wood-derived materials and other biomaterial sectors (Scion, 2015). Peter Clinton is one of New Zealand's leading experts in sustainable forest management and manages the Research & Development (R&D) program which undertakes various aspects of research, including the use of pesticides in the New Zealand Forestry Sector. During the visit, Peter outlined the key objectives of the new R&D program 'Growing Confidence in Forestry's Future' (GCFF).

New Zealand has 1.8 million hectares of planted forests, 89% of which is *Pinus radiata* (radiata pine). Scion has been a key player in pioneering the domestication of radiata pine as a major commercial softwood species in the Southern Hemisphere (Scion, 2015). Forest growers in New Zealand have a vision to significantly improve profitability by doubling their productivity on a per hectare basis while also improving wood quality (Scion, 2014). Raising the profitably of commercial forestry investments is imperative for New Zealand's forestry sector. Through the GCFF program, Scion aims to shift forest management to 'precision' forestry through a system wide approach (Scion, 2014), improving the value from existing forests, and doubling the productivity of future forests (Rolando et al, 2015: Scion, 2014).

The GCFF R&D program began in 2013 and will be implemented over six years. The GCFF's three main Research Aims (RA) are:

**RA1**: A systems approach to maximising benefits from existing forests

- Segregating of the current resource
- Enhancing productivity of older stands

**RA2**: Building more productive, higher quality forests for the future

- Phenotyping the forest
- Doubling radiata pine productivity
- Enhanced activity of the soil microbial community

**RA3**: Sustainability under intensified regimes

- Sustainability of soil, water and biodiversity
- Sustainability over multiples rotations
- Spatial economic modelling for sustainable forestry

Under each research aim, Scion have allocated key hypothesis, activities, and timelines. There is a strong emphasis on doubling forest productivity within this program (RA2), this program focuses on herbicide use applied alone or in conjunction with fertiliser and cultivation practices, microbial research and disease resistance/control. Doubling the productivity of radiata pine is an ambitious goal (Scion, 2014), and one that will require research and an increased understanding of the physiology of *P. radiata* species (Scion, 2014). After gaining an understanding of the new GCFF research program from Peter, the study tour moved to Rotorua, New Zealand to meet Carol Rolando (Pest Management Specialist at Scion) and forestry representatives at Timberlands and Hancock Forest Management (HFMNZ) to gain insight about pesticide use in New Zealand.

## Rotorua, New Zealand – Scion Research Institution, Hancock Forest Management NZ and Timberlands

The visit to Rotorua, New Zealand, involved networking with three key forestry representatives: Colin Maunder (Forest Risk Manager) from Timberlands, Dave Lowry (Technical Forestry Manager) from Hancock Forest Management (HFMNZ), and Carol Rolando (Research Leader and Pest Management Scientist) from Scion Research Institution. Within three separate meetings pesticide use in New Zealand plantation forestry, the impacts of reduced chemical use due to certifications/regulation, research into environmentally friendly herbicide alternatives, and non-chemical weed control options was discussed.

### Overview

Pesticide use within New Zealand forestry is concentrated on herbaceous and woody weed control during the first four-five years of a 28 year rotation. Consequently, the overall use of pesticides in the timber production cycle are minimal. Radiata pine (*Pinus radiata*) is the most widely planted commercial forest tree species in New Zealand; all forest growers visited in New Zealand manage *P. radiata* on their estate.

At Scion Research Institute, Carol Rolando specialises in developing practical methods for managing forest weeds, pest and diseases. Her work in weed research has earned Carol recognition from the forestry industry, as New Zealand constantly strives to reduce herbicide use. Carol's research capabilities include herbicide use in forest vegetation management, alternative (non-chemical) vegetation management practices for radiata pine re-establishment, forest management certification, chemical control on insect pest and diseases, and biological control. Research projects Carol has been working on in previous years include the environmental fate of forestry herbicides used in New Zealand on varying soil types, and research into alternative herbicides, especially as there were two herbicides previously prohibited by FSC.

For effective control of the broad spectrum of weeds typically found in planted forest environments in New Zealand, two or more active ingredients will be required for effective control (Rolando and Watt, 2014). Previous research into active ingredients to replace hexazinone and terbuthylazine in first-year weed control has identified five possible alternatives; clopyralid, triclopyr, haloxyfop, picloram and mesotrione (Rolando and Watt, 2014). However trial results have shown that the addition of terbuthylazine is still a key requirement to cover weed spectrum on sites. It was anticipated that terbuthylazine would be removed from the FSC prohibited list, and not hexazinone (Rolando and Watt, 2014), therefore many of the research trials established included a chemical prescription with terbuthylazine. Combinations of terbuthylazine, triclopyr and picloram were shown to be most effective against key weed species in a series of controlled trials (Rolando and Watt, 2014), and although several herbicide combinations have been highlighted as potential replacements, and were not phytotoxic to *P. radiata*, there were instances of reduced tree growth for several of the alternative combinations tested.

The Scion Research Institute provides forest growers with knowledge, advice and decision support tools that aid forest managers to ensure higher returns through maximum production and improved quality of wood and fiber (Scion, 2014). Both Timberlands and HFM (along with other forest growers in New Zealand) obtain chemical control advice and recommendations from Scion Research Institute. New Zealand forest growers and Scion work extremely well together to solve common problems and are more than happy to work together and share results to benefit all forest growers in New Zealand.

**Pesticide Use**

Site preparation herbaceous weed control

A recent survey conducted in 2013, regarding weed management practices and pesticide use in New Zealand (Rolando et al, 2013) has highlighted glyphosate, hexazinone and terbuthylazine as the most common herbicide active ingredients used during plantation forestry establishment in New Zealand. Glyphosate as a foliar applied knockdown pre plant, and hexazinone and terbuthylazine combination post planting to control a range of competitive vegetation during the first year after establishment; herbaceous broadleaves (including annual weeds), perennial woody weeds and grass species.

Some of New Zealand's major weed species that occur in forest plantations include: broom (*Cytisus scoparius* L.), gorse (*Ulex europaeus* L.), blackberry (*Rubus fruticosus* L.), buddleja (*Buddleja davidii* Franchet) and bracken (*Pteridium esculentum*) (Rolando et al, 2011; Richardson et al, 1996). All forest growers visited in New Zealand apply broadcast pre plant applications of glyphosate plus metsulfuron-methyl (aerially) at respective rates needed for the weed spectrum present.

The bulk of the herbicides used in New Zealand forestry are for release purposes. Forest growers in New Zealand including Timberlands and HFMNZ, and as surveyed by Rolando et al in 2013, carry out one post plant herbicide release application, with 73% of forest growers also applying a second post plant application one to five years after planting (Rolando et al, 2013). The decision to carry out the second post plant application is site specific. The two choices for method of application when applying post plant is either aerially or by spot weed control (1.7m average spot diameter) (Rolando et al, 2013). On ground applications are determined by terrain, vegetation loading, vegetation type and access. If uncontrolled, gorse is one invasive weed species that can block access for ground crews and are only left with the choice of applying herbicides aerially. Soil type is also taken into account when selecting method of control. Hexazinone and terbuthylazine are principally two herbicides of choice for the first post plant application. Haloxyfop and clopyralid combinations with hexazinone or terbuthylazine are also used by selected forest growers.

The hexazinone plus terbuthylazine post plant combination is a standard vegetation management regime, which is not phototoxic to *P. radiata*, which can be applied aerially at low cost (Richardson et al, 1996), and provides continuous control of competing vegetation (especially woody weed species) for up to one year following application (Rolando and Watt, 2014; Richardson et al 1996; Watt and Rolando, 2012). It is a priority that any alternative active ingredients fulfil this set of requirements (Watt and Rolando, 2012). Trials established to test alternative herbicide products have returned some promising results, however some treatments haven't been consistent across various trial sites and tree productivity decline has been observed in several alternative treatments.

Non-Chemical Weed Management

One alternative to chemical use for vegetation management in New Zealand is oversowing prior to planting. Following numerous trial experiments, fog grass (*Holcus lanatus*) or legume species (*Lotus uliginosus)* were recommended for oversowing. The objective of oversowing prior to planting is to occupy the site with an easy-to-manage cover crop soon after harvesting which minimises the regrowth of more competitive woody weeds (broom, gorse, blackberry, etc). Applying oversowing in conjunction with spot weed control post planting will reduce overall herbicide use (Rolando et al, 2013), assist in the prevention of erosion, and if sown with lotus species in particular will be beneficial on nitrogen deficient sites. However, it's a practice not highly used, responses from Rolando et al survey in 2013 also states that non-chemical methods were not being used as there was no benefit over existing weed control practices, and it is more cost effective to apply herbicides for vegetation management.

Mechanical means of vegetation control equates to increased soil disturbance, which does not always favoured when trying to achieve effective weed control (depending on weed species), and will have a negative impact on sites prone to erosion. The combination of herbicides and mechanical methods of weed control have been tested by Scion; however studies have concluded that this combination would not likely be effective, or more importantly is not cost efficient when compared to herbicide use.

Prescribed fire, mechanical and manual control combinations are possibilities of non-chemical vegetation control in New Zealand; however as with the mechanical/herbicide combination they are not cost effective in comparison to aerial, broadcast applications of hexazinone plus terbuthylazine. Additional to cost, the time to complete non-chemical methods is amplified and there are also additional regulations, public perception, and loss of onsite nutrients to consider when prescribe burning. If applicable, mechanical methods of vegetation control can be utilised on sites with flat terrain or where woody weed vegetation (gorse and broom) may become problematic. Earlier methods of site preparation included mechanical control in combination with prescribed fire, however these practices have become somewhat historical. Mechanical operations are prohibited on steep slopes due to the obvious safety issues involved. Forest managers have found it increasingly difficult to obtain good manual labour in areas where they have steep topography.

Weed mats have also been trialed in New Zealand. Paper/cardboard mats are placed around the tree base at establishment to suppress weed growth. Labour to carry and place mats on each tree, and material costs for the mats themselves are very expensive. Results from weed mat trials have provided good weed suppression for up to 12 months, however the high cost of labour and the possibility that a post plant herbicide application will still be needed at age years 2 – 4, does not make this option economical, and even more expensive than general manual control (axes, slashers, brush cutters, etc).

For non-chemical methods to be applied in New Zealand forestry, at the very least weeds need to be reduced to a level that will not impede access for planting gangs nor impair early tree growth. Currently herbicides are the most appropriate method of vegetation control, albeit their preferred active ingredients are now available to use in their FSC certified plantations (without derogations). Scion will continue to research alternative vegetation management options whether chemical or non-chemical, to reduce the reliance upon the same chemicals (certification and/or resistance), and to ensure that forest plantations in New Zealand remain sustainable both economically and environmentally.

Pest Problems

Biological control is one non-chemical method of vegetation control for individual invasive pest species. The use of biological control has not been widely explored in New Zealand (Rolando et al, 2015), however there has been one individual weed species (*Buddleia davidii*) that has responded well to biological control. In 2006, a biological control agent for *B. davidii*, buddleia leaf weevil (*Cleopus japonicas*), was released (Figure 14).

**Figure 14**: *Buddleia davidii* and biological control agent the buddleia leaf weevil (*Cleopus japonicas*). Source Scion 2013.

Initial results were positive, significantly reducing *B. davidii* growth, however the buddleia leaf weevil population numbers and spread was not significant enough to eliminate herbicide use. Additionally, where the buddleia leaf weevil was successful, other competitive weeds were found to occupy the site, requiring herbicides for control. HFMNZ has seen promising results from the release of the buddleia leaf weevil, although a slow start after its release in 2006, by 2009 HFMNZ forest managers have seen the buddleia leaf weevil throughout their estate.

Insect pests are in greater abundance with warmer temperatures, but there are generally no major insect problems in New Zealand. There are concerns climate change may increase insect pest populations, however the influence climate change may have in the future is unclear.

Dothistroma needle blight (*Dothistroma septosporum*) can be a problem, with its severity variable across New Zealand. Forest managers at HFMNZ survey most of their 2 – 15 year old plantations annually as part of their forest health surveying program to gauge its severity, and if required apply fungicides aerially up to 6 times during their 30 year rotation. The fungicide used, cuprous oxide (copper), is listed on the FSC prohibited list due to its toxicity to aquatic organisms, and remains on the list following the most recent review in 2015. Improved genetics have helped with resistance to needle blight, additionally good silvicultural practices have improved susceptibility.

Swiss needle cast (*Phaeocryptopus gaeumannii*) is the most widespread disease for Douglas-fir. Carol Rolando is involved in research for possible chemical treatments. There have been positive results from external research work outlining that cuprous oxide may be beneficial for needle cast. Carol is also researching a chemical for export fumigation purposes, for which chemical registration has been hard to achieve.

The general public have concerns regarding environmental aspects with herbicide use. 1080 is one pesticide in which the public protest against forest manager use (possums are forest manager's main target). A lot of time and money has been spent looking for an alternative control, however 1080 is still highlighted as the most effective (and humane) control.

The Sirex Woodwasp (*Sirex noctilio*) has been present in New Zealand since the early 1900's, however Sirex has not caused any major, or noticeable problems. Dave Lowey has not seen a

live Sirex (adult or larvae) in their plantations since 1975. Entomologists survey HFM plantations in New Zealand but no evidence of their presence has been found.

Chemical Restrictions / Forest Management Certification

All forest growers in New Zealand need to demonstrate to certification schemes that they are using pesticides in an environmentally manner. FSC certification has not affected the type and quantities of herbicides used in pre plant vegetation control (Rolando et al, 2013), however with the ever increasing awareness of reducing the amount of herbicides used has resulted in some degree of change (Rolando et al, 2013). There are management options for forest managers which include minimising the time between harvest and replant, and prescribing herbicide rates relevant for the weed spectrum present onsite. Conversely this can also increase herbicide use (Rolando et al, 2013).

Between 2007 – 2015 both hexazinone and terbuthylazine were two herbicide active ingredients located on FSC prohibited pesticide list, and due to this restriction New Zealand forest growers sought derogations for their use. Due to the recent review in 2015 of the FSC indicators and thresholds for pesticides, both these active ingredients were removed from the prohibited list. Prior to FSC chemical restrictions, Timberland forest growers used nine main chemical active ingredients in the establishment phase of their plantations rotation. With the FSC chemical restrictions in place, six of these active ingredients were included on the prohibited list. Although derogations were needed for the application of hexazinone and terbuthylazine, Timberlands reduced the number of active ingredients used as glyphosate pre plant and hexazinone plus terbuthylazine post plant provides good weed management. Now that their standard post plant herbicide operations comply with FSC certification requirements following the lift of these two from the prohibited list, it is extremely beneficial to all forest growers certified to the FSC. Scion has conducted research into the environmental fate of hexazinone and terbuthylazine over the last 6-7 years and has played a key role in supporting the continued use of hexazinone and terbuthylazine on FSC certified land under derogation (Rolando et al, 2015). This research has conceivably influenced the removal of these active ingredients from the list of prohibited herbicides (Rolando et al, 2015).

The FSC still require forest managers to reduce or eliminate chemical pesticides (and fertiliser), and will continue to be a requirement by FSC criteria. Therefore there is a focus from Scion to find alternative chemicals and/or methods of application to reduce their chemical use. Spot weed control methods are used by forest growers in New Zealand to aid in reducing herbicide volume usage, helping to meet the requirement of FSC certification. Additional to certification compliance, spot weed control has its benefits in sensitive areas, in areas where vegetation competition is minimal, on steep slopes prone to erosion, close to neighbouring properties/crops, and also aids in reducing the risk of herbicide drift. The use of spot weed control is restricted by topography; if applied can reduce 20% of the total herbicide usage onsite.

HFM do not have a legislative requirement to monitor waterways for chemicals they have applied during their pre plant/post plant operations. Legislative restraints surrounding water

monitoring is commonly in regards to debris from harvesting operations or to soil erosion more so than chemical detections. Other land use in New Zealand have higher chemical use than forestry (horticulture).

One chemical restriction from FSC that may cause numerous problems in the future is stated in Criterion 10.7 of the FSC criteria ‘forest managers shall make every effort to move away from chemical pesticides and fertiliser, including their use in nurseries’.

# South-eastern America

Overview

Pesticides are an invaluable tool for forest management in south-eastern America for the control of competing vegetation, for species composition, and to enhance forest health, growth and wildlife habitats. Herbicide use enhances forest productivity and thus is important for the economics of forest management in the Unites States (Weatherford et al, 2015). Herbicides are also used to address objectives unrelated to timber production (Weatherford et al, 2015).

Pesticide use commonly falls into three categories: site preparation, herbaceous/woody weed control, and forest health or nutritional improvement. Herbicide applications during site preparation are typically intended to create microclimate conditions conductive to the establishment and growth (Weatherford et al, 2015) of *Pinus taeda* (Loblolly Pine) plantations, and may be completed alone or in combination with fire or mechanical practices. Herbicide applications are applied pre and post planting to address herbaceous/woody weed issues, and during mid-rotation for control of invasive species, and also for ecological restoration and enhancing wildlife habitat (Weatherford et al, 2015)

A survey of twelve Unites States forest product companies regarding herbicide use, conducted by the National Council for Air and Stream Improvement (NCASI) in 2011, saw twelve different herbicide active ingredients commonly used, within 56 unique prescription combinations (Weatherford et al, 2015). Nationally, imazapyr was the most widely used herbicide followed by sulfometuron-methyl, metsulfuron-methyl, glyphosate, triclopyr and hexazinone (Weatherford et al, 2015). Prescriptions are tailored for local site conditions, with use concentration rates well below the maximum label requirements, and incorporate numerous techniques and best forest management practices to reduce risk, including the potential for herbicides to affect non-target areas (Weatherford et al, 2015). The most widely used method of application during site preparation was identified as broadcast via helicopter, and via banding when applied post planting using ground based application methods for herbaceous weed control. Herbicides continue to be an important tool across south-eastern America for managing forest vegetation, particularly in intensively managed softwood plantations (Weatherford et al, 2015). While this survey confirms pesticides use remains imperative for vegetation management control, herbicide use patterns, chemical prescriptions, forest vegetation and application purposes differ by region (Weatherford et al, 2015).

In the United States, pesticides are classified by the Environmental Protection Agency (EPA) as general use as per label requirements, or restricted where pesticides are seen to be potentially harmful to humans and/or the environment. During the review process, the EPA considers information about pesticide use in forestry and how they are applied (Weatherford et al, 2015) through available scientific data, to ensure the pesticide will not cause unreasonable risks to human health or the environment (including endangered species) when used as directed on the label (Weatherford et al, 2015).

Forest certification south-eastern America

There are four primary certification systems in the United States. The Program for Endorsement of Forest Certification (PEFC), Sustainable Forestry Initiative (SFI), American Tree Farm System (ATFS) and the Forest Stewardship Council (FSC). Both SFI and ATFS standards have been endorsed by the PEFC since 2005 and 2008 respectively; programs for both standards reflect the different forest ownership patterns in the Unites States. The SFI is a fully independent, non-profit, charitable organisation dedicated to promoting sustainable forest management, which addresses large public land, and medium to large private forest landowners (AF&PA, 2016). SFI is the world's largest single forest certification standard (AF&PA, 2016) certifying 61 million acres in the US alone. The ATFS is the oldest forest certification programme in the United States (established in 1941), a programme of the American Forest Foundation (AFF) Centre for Family Forests (ATFS, 2011) and represents small family forest landowners in the United States (AF&PA, 2016).

The SFI forest management standard has long had requirements for minimizing chemical use and protection of water quality. The approved use of chemicals in sustainable forest management plays a vital role in prompt and effective restocking of forest lands after clearcut. SFI and ATFS forest certification does not affect the ability to use forest pesticides across any of the forest companies visited, however, SFI do ban chemicals located on the World Health Organisation (WHO) registered chemical list Type 1A (Extremely Hazardous) and Type 1B (Highly Hazardous), and also the Stockholm Convection on Persistent Organic Pollutants. The ATFS will only allow pesticides approved by the EPA. Both the SFI and ATFS do not have an additional restricted list like FSC.

Pesticide performance measures in terms of pesticide use for the SFI, ATFS and FSC forest certification systems can be seen in Figure 15.

| FOREST STEWARDSHIP COUNCIL (FSC) | SUSTAINABLE FOREST INITIATIVE (SFI) |
|---|---|
| Criterion 6.6 – Management systems shall promote the development and adoption of environmentally friendly non-chemical methods of pest management and strive to avoid the use of chemical pesticides.<br>- World Health Organisation Type 1A (Extremely Hazardous) and 1B (Highly Hazardous) and chlorinated hydrocarbon pesticides; pesticides that are persistent, toxic or whose derivatives remain biologically active and accumulate in the food chain beyond their intended use; as well as any pesticides banned by international agreement, shall be prohibited.<br>- If chemicals are used, proper equipment and training shall be provided to minimised health and environmental risks.<br>Criterion 10.7<br>- Measures shall be taken to prevent and minimize outbreakes of pests, diseases, fire and invasive plant introductions.<br>- Intergrated pest management shall form an essential part of the management plan, with primary relience on prevention and biological control methods rather than chemical pesticides and fertilizers.<br>- Plantation management shall make every effort to move away from chemical pesticides and fertiliser, including their use in nurseries. | Performance Measure 2.2. Program participants shall minimise chemical use required to achieve management objectives while protecting emploees, neighbours, the public and the environment, including wildlife and aquatic habitats.<br><br>Indicators:<br>- Minimised chemical use required to achieve management objectives.<br>- Use of least-toxic and narrowest-spectrum pesticides necessary to achieve management objectives.<br>- Use of pesticides registered for the intended use and applied in accordance with label requirements.<br>- The World Health Organisation (WHO) Type 1A (Extremely Hazardous) and 1B (Highly Hazardous) pesticides shall be prohibited, except where no other viable alternative is available.<br>- Use of pesticides banned under the Stockholm Convection on Persistent Organic Pollutants shall be prohibited.<br>- Use of intergraded management where feasible.<br>- Supervision of forest chemical applications by state- or provincial- trained or certified applicators.<br>- Use of management practices appriopriate to the situation. |
| **AMERICAN TREE FARM SYSTEM (ATFS)** | |
| Indicator 4.1.1 - Forest owner must implement specific to State Forestry Best Management Plans (BMP's) that are applicable to the property.<br>Indicator 4.2 - Forest owner must consider integrated pest management to control pests, pathogens, and unwanted vegetation.<br>Indicator 4.2.1 - Forest owner should evaluate alternatives to manage pest, pathogens, and unwanted vegetation to achieve specific management objectives<br>Indicator 4.2.2 - Pesticide used must be EPA-approved.<br>Indicator 4.2.3 - Pesticides must be applied, stored, and disposed of in accordance with EPA approved labels and by persons appropriately trained, licensed and supervised. | |

**Figure 15:** South-eastern America forest certification performance measures in relation to pesticide use; Sustainable Forestry Initiative, American Tree Farm System and the Forest Stewardship Council.

During the study tour 3,000 km and six locations (Figure 16), across three states (North Carolina, South Carolina and Alabama), and collectively twelve key forestry representatives within various forestry companies including Hancock Forest Management, Weyerhaeuser, Resource Management Services, Campbell Global and North Carolina State University were visited. Pesticide use across all three states were similar, however geographical and vegetation differences saw different approaches or views for best forest management practices.

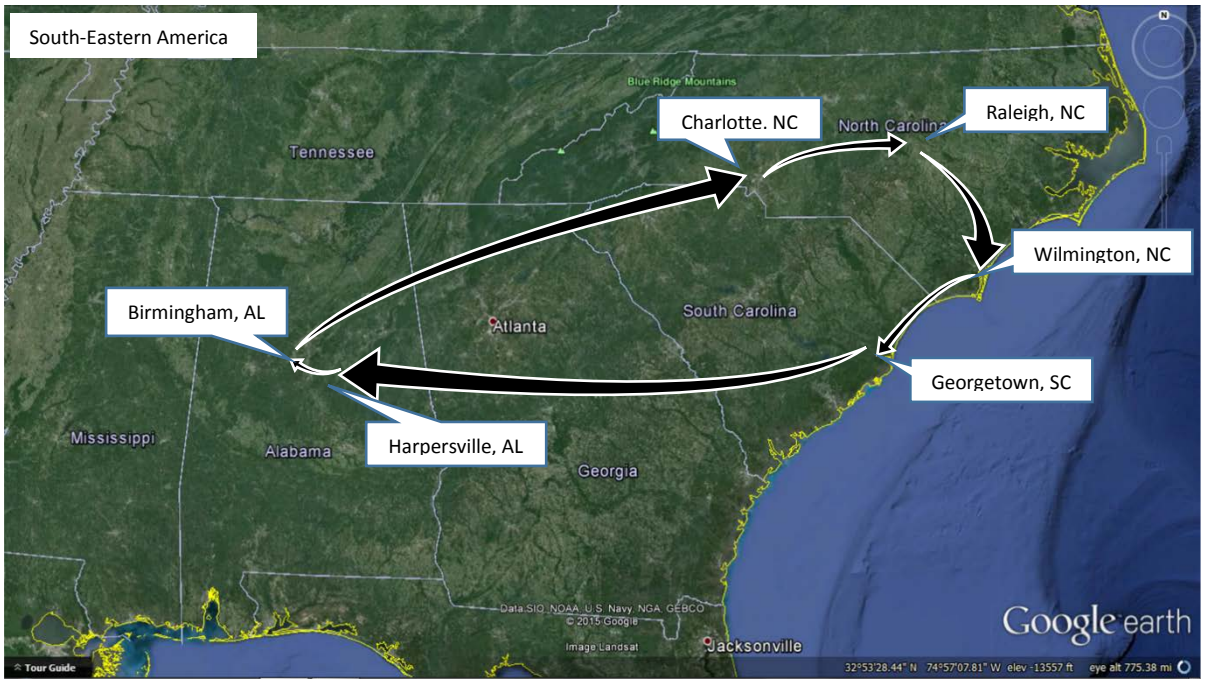


**Figure 16:** Locations of sites visited during study tour in south-eastern America.

The most difficult challenge to understand about forestry in the United States is the scale compared to Australia and New Zealand. Forests dominate the landscape in south-eastern America, comprising about 40% of the land base, you can drive for hours along the interstate highways and see little else but pine trees. Approximately 80% of these forested lands are under private ownership, two thirds of which are owned by families or individuals, and the remainder mostly by Timber Investment Management Organisations (TIMOs) and to a lesser extent the forest products industry (who largely sold their forests to TIMOs about a decade ago). Approximately 22 million hectares (25%) is loblolly pine, and 80% of this is managed for timber production.

## Charlotte, North Carolina – Hancock Forest Management (HFM)

The first visit with Hancock Forest Management (HFM) in Charlotte, North Carolina, consisted of a field tour with David Wilkinson (Silviculture Manager, Birmingham Alabama) and Jeremy Kessinger (Area Manager, North Carolina) of the Chester County area south of Charlotte, and over the border into South Carolina. HFM are certified to the Sustainable Forestry Initiative (SFI).

Overview

The Chester county area is surrounded by almost all Loblolly pine (*Pinus taeda*) plantations, hand planted at 480 to 545 stems per acre (equates to 1185 - 1345 stems per hectare) during winter (December – January). No mechanical site preparation is completed, although there are soils in some areas of North Carolina that require ripping (rocky or hard setting), and some very flat sites which require mounding. Due to no cultivation, planting is line marked, which has had a history of causing very wobbly rows. Hand planting typically occurs due to soils and rolling terrain, however machine planting occurs at selected sites.

Fertiliser is generally applied mid rotation, possibly around the second thinning. The need for fertilising is monitored through Leaf Area Index (LAI) measurements for an indication of when to apply. HFM do not routinely conduct soil samples, even on new plantation acquisitions where they may not have fertiliser history. HFM have a strong focus on mid rotation woody weed control as part of their best management practices, as they have found that adequate woody weed control at mid rotation is just as good as a fertiliser application, and herbicide is much cheaper.

Depending on the market there is a possible pulp thinning around 12 years of age (T1 outrow plus bay selection) which is all operator self-selected, plantations can be thinned two-three times prior to clearcut (clearfell).

All pesticide application is conducted by contractors. Contractors are responsible for sourcing, storing, transport, mixing and applying pesticides. All contractors are given shape files and operational plans in advance detailing chemical prescriptions, and provide maps showing the area of application; however sometimes site maps are indicative rather than actual. Contractor meetings are held with HFM pre job, but doesn't necessarily cover a visit to each site. As the operational plans don’t always cover all hazards (such as powerlines), it is largely left to the helicopter pilot to check pre-flight; all risks are generally on the contractor.

HFM have a strong interest in the outcomes of their pesticide applications. Contractors are to supply usage records and GPS tracks following application (helicopter and skidder). These records are required by law, similar to usage records we are required to keep in Australia, and details exclusion zone buffer widths, minimum droplet size, prescription and target area. Normally there are no HFM staff present during spraying operations, if any areas are found to be missed the contractor will respray at their own cost.

**Pesticide Use**

Site preparation weed control

Site preparation typically consists of pre plant application in the summer or early fall (Figure 17). This application is generally applied by helicopter but can also be applied on ground via tractor or hand sprayed in sensitive areas or in areas of close proximity of neighbours. Herbaceous weeds compete with seedlings at establishment. Vine species including Kudzu ((*Pueraria montana var. lobata*), Greenbriar (*Smilax* spp.) and Japanese honeysuckle

(*Lonicera japonica*) compete for light and nutrients, and have the ability to strangle trees by dragging down branches and crowns. Poison ivy (*Toxicodendron radicans*) is also found in plantation forests, not a concern for plantation crops however it is a human health hazard. Vines are the most difficult to control, they have excellent sprouting habits and need systemic herbicides (glyphosate) to kill the root system.

**Figure 17:** Inspection of pre plant application (approximately 3 months post treatment). This treatment has provided very poor kill on *P. taeda* wildlings.

At establishment the aim is to control herbaceous weeds in spring before growth of tree seedlings begin and then to use residual herbicide to extend weed control throughout the seedlings first growing season. Hardwood species such as Sweet gum (*Liquidambar styraciflua*) and Popular (*Salicaceae* sp.) are major pests at re-establishment and can cause significant losses in forest production. Hardwood species are managed at site preparation by using a drum chopper (chopper roller) to knock down and chop up hardwood species, and then use prescribed fire to help clean-up the site. Fire versus herbicide use management of hardwood species has been trialled by HFM. Intensive management has been worth the investment with mechanical (drum chopper) plus herbicide application combination proved to be the best treatment for hardwood species in North Carolina.

The preference for forest managers in southern America is not to utilise *P. taeda* wildings for establishment due to the amount of wilding that emerge (1044 wildlings/acre), it's much more practical to manage with herbicide at re plant. A new herbicide, Detail (saflufenacil) which greatly improves spectrum of control, is of great interest to HFM who are trialing it in

combination with glyphosate, with results indicating that it provides better control of pine wildlings pre planting. Pre plant herbicide application is usually applied broadcast, helicopter application is preferred as there is more precision, however the cost is higher and HFM tend to use fixed wing. Banding (strip spraying) or spot spraying are the preferred methods of application when applying post planting. During dry-summer climates, short-lived herbicides encourage winter ground crop to develop. This is important to HFM as they like to retain some vegetation to reduce soil damage.

Single post plant chemicals and method of application varies with site and weed spectrums. HFM may have two post plant herbicide applications occurring within the first 12 – 24 months post planting, site dependent. The field trip consisted of visiting two *P. taeda* plantations at planting plus 12 months (Figure 18) and planting plus 24 months (Figure 19).

**Figure 18:** Planting plus 12 months *P. taeda* plantation, has received a single pre-plant and post plant herbicide application, this plantation is now well established, it's hard to see but some trees are up to 2 meters tall.

**Figure 19:** Planting plus 24 months *P. taeda* plantation, has received a single pre-plant and post plant herbicide application.

Herbaceous understorey in older *P. taeda* plantations is not seen as a problem as long as the trees are well established; hardwood species have proven to be an issue which are managed during mid-rotation.

Mid-rotation woody weed control

Mid rotation herbicide application is applied one to two years following thinning (12-14 years of age) to allow weeds to recover, or could be later if there are specific weed issue(s). Herbicides applied alone or in combination by HFM can be applied by helicopter, however is generally applied by skidder traversing accessible inter rows, spraying at a maximum angled height of 15 feet (4.5 meters), and treating woody weeds up to 30 feet high (9.1 meters). Application by skidder is the preferred method as it is accessible to about 70 to 80% of the planted area. Herbicide chemical treatment is preferred to mechanical controls (slashing/mulching), as it is half the price. Mid rotation weed control is only a temporary suppression (Figure 20).

**Figure 20:** Post first thinning *P. taeda* plantation due for mid-rotation weed control via tractor.

Chemical Restrictions / Forest Management Certification

Being certified to SFI, HFM are prohibited on using chemicals located on the World Health Organisation (WHO) type 1A (Extremely Hazardous) and 1B (Highly Hazardous) tables and the Stockholm Convection on Persistent Organic Pollutants. HFM have no major issues being restricted from using their preferred pesticides, as all required products are registered for forestry use, approved by the EPA and are not located on either of the above prohibited list. Counties in North Carolina and South Carolina have no jurisdiction to make forestry laws unlike north-western states in America.

HFM Best Management Practices (BMPs) require all pesticide applications (aerial and ground) to have a minimum 35 foot buffer Streamside Management Zone (SMZ) (Figure 21). SMZs adjacent to perennial or intermittent steams are designed to prevent erosion from reaching waterways for protection of water quality. Vegetation within these buffers heavily completes with *P. taeda* seedlings for light and moisture at establishment, and in turn can dramatically reduce tree health (or survival) and yield. HFM do have the ability to treat the SMZ by knapsack with herbicides at much lower rates, but they have limited manpower for completing the work, and are left with numerous areas where herbicide does not get applied. At clearcut, HFM retain standing trees around streams for easier identification and to exclude for spraying; pine wilding are removed as much as possible.

**Figure 21:** Streamside Management Zone (SMZ) nearby *P. taeda* plantation. 30 foot spray buffer applied outside of retained vegetation which is typically hand treated after aerial spraying; and a newly food plot site and feed station on an old thinning's ramp site.

States have guidelines for buffers on streams; contractors completing the application use their GPS plans to ensure their application area has complied with buffer requirements.

HFM have not had many public complaints, there have been some concerns about the pesticide being applied when a helicopter flies close to a residence. HFM have very good liaison with their neighbours and endeavour to contact them, and also the sheriff department in case they get calls of complains.

There are not many plantation areas where pesticides are completely restricted. There may be areas with buffer restrictions near streams or neighbours where they apply less chemicals, however HFM can still apply something; they are not restricted to nothing.

HFM have no requirement to test water for pesticides. The state and/or federal government conduct general water quality monitoring, but are mostly interested in turbidity. Their federal government are looking to introduce new laws where no herbicide can be applied to any drainage channel (HFM are unsure if this will come into force).

Alternative chemicals

Pesticides applied by HFM are generic chemicals as they are cheaper. They do not put out tenders for alternative products with same active ingredient and they do not test alternative chemicals to their preferred brands.

HFM do not research unregistered chemicals, do not establish trials to test chemicals, and are not approached by chemical companies to try different herbicide products. Recently HFM chemical suppliers have been encouraging them to try alternative spray drift agents. However, research into alternative herbicides are completed by State Universities, not by HFM. Forest companies within North Carolina and across south-eastern America work extremely well together and share information on issues they encounter and help each other pursue methods of resolving them.

Pest Problems

Kudzu vine (*Pueraria montana var. lobata*), whilst not mandatory to control, HFM endeavour to manage (Figure 22). Kudzu chokes young trees, can bring down power lines, infest abandoned homes (NCSU, 2016), and can be difficult to contain let alone control (NCSU, 2016). Herbicides that can control Kudzu will also kill Wisteria vine (*Wisteria sp.)* infestations, another problematic pest. Both vines have a significant negative effect on tree survival and timber quality.

**Figure 22:** Kudzu (*Pueraria montana var. lobata*) infestation along roadsides in North Carolina and Alabama.

Southern pine beetle (SPB), D*endroctonus frontalis* Zimmermann, is the most destructive insect pest for pine species in the southern United States (Meeker, 2000; Fox and Mickler, 1997), of which *P. taeda* is its primary host (Fox and Mickler, 1997). A historical review has estimated that SPB caused $900 million of damage to pine forests from 1960 through 1990 (Meeker, 2000). *P. taeda* trees attacked by SPB often exhibit hundreds of resin masses or pitch tubes (Figure 23) on the outer tree bark (Meeker, 2000). SPB feed on phloem tissue where they construct winding S-shaped galleries, introduce blue-stain fungi (Meeker, 2000), and can effectively ringbark a tree.

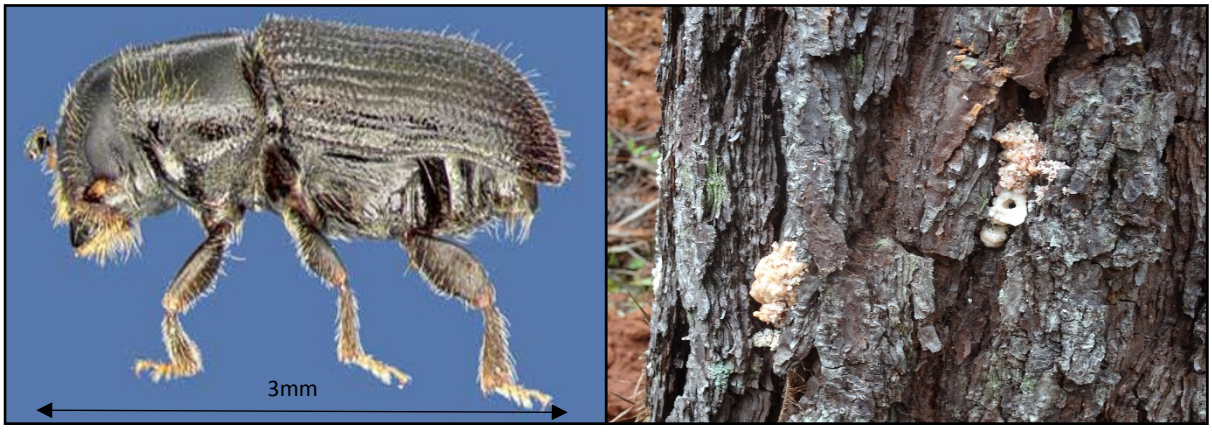


**Figure 23:** Southern pine beetle (SPB) *Dendroctonus frontalis* Zimmermann; and pitch tubes of SPB on the outer bark of a *P. taeda* tree in Alabama. Source: Meeker, 2000.

HFM have found detections of SPB in stressed *P. taeda* stands within North and South Carolina, however HFM have not had any significant outbreaks for a number of years. SPB population levels are generally sporadic and fluctuate rapidly from stable, endemic populations,

to unstable epidemic populations (Fox and Mickler, 1997). HFM manage SPB through clearcutting or by thinning affected areas, the best way to manage SPB is to maintain a healthy forest (Cameron, 1987). Pesticides can be used to control SPB, however they need to be applied at the right time of their lifecycle for effective control (SGSF, 2014); and can be expensive.

A 40 year summary by the Southern Group of State Foresters shows SPB outbreaks have occurred somewhere in the South almost every year (Figure 24) (SGSF, 2014). Currently, a catastrophic infestation of SPB is threatening pines in Virginia, Kentucky, Tennessee, North Carolina and Georgia (SGSF, 2014).

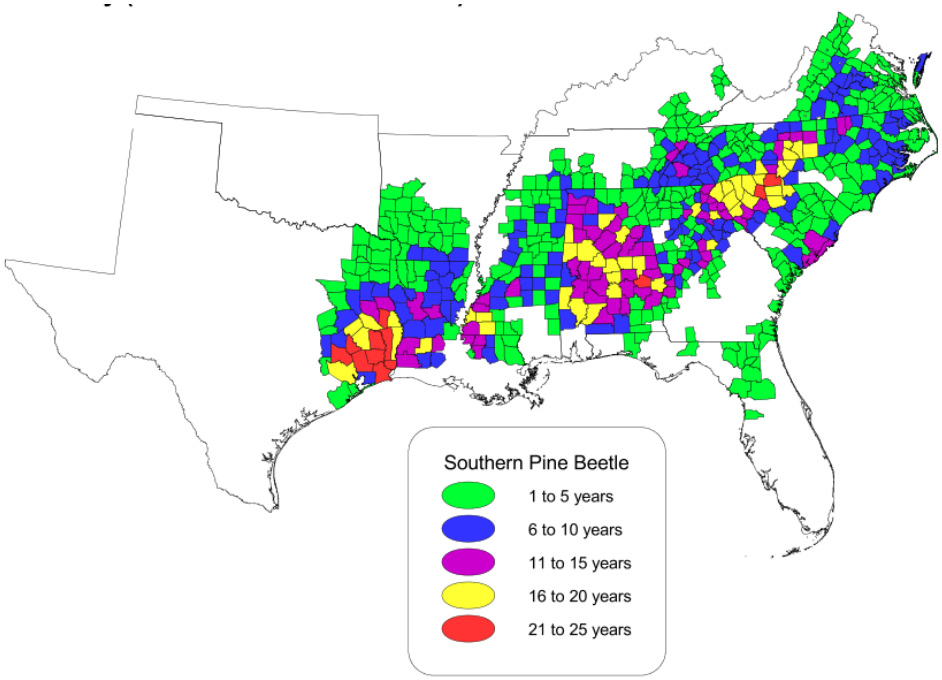


**Figure 24:** American counties outbreak status for the Southern pine beetle (*Dendroctonus frontalis* Zimmermann) a 40 year summary 1960 – 2000 (Source Southern Group of State Foresters, 2014).

HFM have had problems with Nantucket pine tip moth (*Rhyacionia frustrana*) damage, which can be an issue in young stands and nurseries. Nantucket pine tip moth kills the growing tip bud of *P. taeda*, causing deformed stems and having a big impact on tree form and yield. North Carolina State University (NCSU) have established Nantucket pine tip moth trials since 2008, see next section (Raleigh, North Carolina – NCSU).

HFM also have a number of food plot programs throughout their *P. taeda* plantation estate. Game animals can cause damage to trees and eat the growing tip of young *P. taeda* trees. Food plots are ¼ acre – 2 acres (0.1 – 0.8 ha) in size, and are planted and maintained by local hunt clubs. Food plots are sometimes established on old thinning ramp sites (Figure 21) and have sitting stations (hides) for hunters to hide in for shooting.

Additional pest issues include bears scratching trees for sap, porcupines ring barking young trees to promote sap running (then eat the insects as they come for the sap), and beavers blocking waterways and creating floods. HFM monitor waterways and endeavour to keep beaver numbers low.

## Raleigh, North Carolina – North Carolina State University

The second visit within the US was with North Carolina State University (NCSU) and consisted of a number of field tours with Elizabeth Snider (Liaison Silviculturist, North Carolina State University). The morning was spent at Taylor Tract (near Whitakers, NC), where a Nantucket pine tip moth trial was established in 2008; and the afternoon at Carl Alwin Schenck Memorial Forest where demonstrations of fire management versus herbaceous weed control using herbicides where presented, and then a stop by a *Pinus palustris* (longleaf pine) tree farm (near Raleigh, NC).

Taylor Tract – Nantucket Pine Tip Moth (Rhyacionia frustrana) Trial

The Nantucket pine tip moth (*Rhyacionia frustrana),* a major forest insect pest in the United States (Yates et al, 1997), is a native shoot-boring tortricid which severely effects *P. taeda* plantations through loss of growth (SGSF, 2014) and deformation (Figure 25). Adult females deposit eggs singly on needles and shoots with a significantly greater proportion being laid on needles (King et al, 2014). Larval feeding leads to shoot mortality, tree deformity, height and volume reductions, compression wood and occasional tree mortality (King et al, 2014; Asaro et al, 2003).

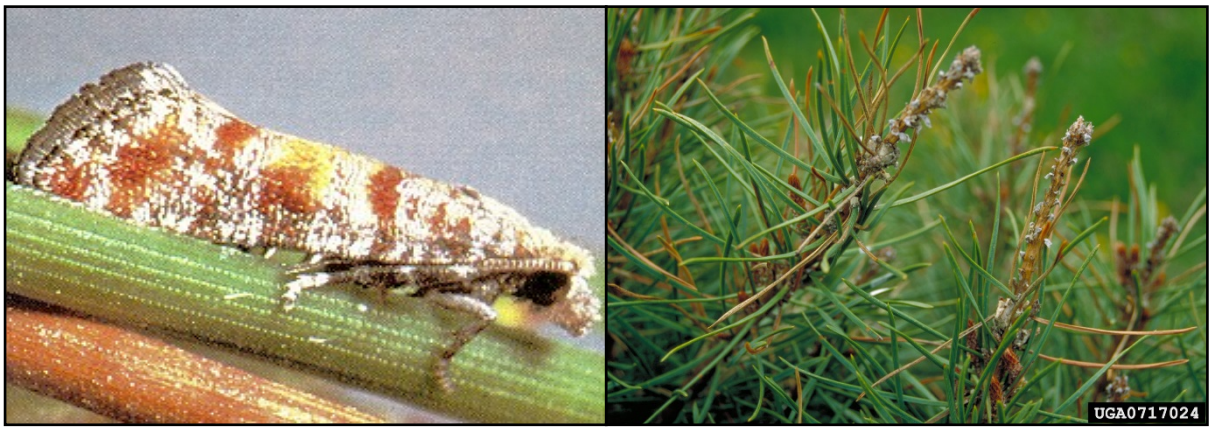


**Figure 25:** Adult Nantucket pine tip moth (*Rhyacionia frustrana)* and damage to pine bud of *P. taeda,* Source U.S. Department of Agriculture Forest Service, 1997.

The rapid abundance of the Nantucket pine tip moth is strongly affected by the availability of preferred hosts that are in susceptible age classes (Yates et al, 1997; SGSF, 2014), commonly less than five years of age, and are most likely benefiting from the increase and widespread deployment (King et al, 2014) of uniform pine plantations. Several insecticides are registered for tip moth control, but due to high cost, the cost/benefit ratio is small for large-scale treatments (Yates et al, 1997); pine nurseries, seed orchards and christmas tree plantations being the exception.

In 2008, NCSU forestry students and technicians were involved in the establishment of stand-level Nantucket pine tip moth control trial at Taylor Tract, North Carolina. Their aim was to quantify the efficacy of the Nantucket pine tip moth control product SilvaShield™ (Bayer CropScience); a forestry tablet applied next to the tree's root system at planting (King et al, 2014). Each tablet contains 1g herbicide active ingredient imidacloprid, a neonicotinoid

insecticide (systemic agricultural insecticide resembling nicotine), that has been shown to be active against Nantucket pine tip moth and plant defence responses (King et al, 2014), and a NPK fertiliser.

Initial Taylor Tract trial results have shown SilvaShield™ has provided a significant positive impact to the early stand development of *P. taeda* plantations (Kelley and King, 2015). NSCU have also found that the reduction of Nantucket pine tip moth damage increased the productivity of the pine plantation, especially with improved tree genetics (Kelley and King, 2015) and adequate initial weed control. Where SilvaShield™ was not used, *P. taeda* growing tips were damaged and caused tree stems to become wavy and deformed.

There has been active research for decades on the effects of Nantucket pine tip moth infestations on growth and yield of *P. taeda* (King et al, 2014). There are views that infestations of Nantucket pine tip moth are in fact secondary attack pests, and that fusiform rust, caused by the fungus *Cronartium fusiforme*, can commonly be the primary cause for stressed *P. taeda* trees. Research from King et al (2014) and the European and Mediterranean Plant Protection Organisation (EPPO) have both concluded an association between fusiform rust and incidence of Nantucket pine tip moth damage. The EPPO states attacks by the lepidopteran pest *Rhyacionia frustrana* appears to favour infection of *P. taeda* by *C. fusiforme* (EPPO, 1996). Adequate control of *C. fusiforme* in *P. taeda* trees, in particularly at nurseries (with fungicide applications), may be an important prevention for future control of Nantucket pine tip moth infestations. Further study into the association between *C. fusiforme* and Nantucket pine tip moth populations is warranted.

The best proactive control method for infestations is during site preparation practices. It has been reported that intensive site preparation practices can have a negative effect on controlling Nantucket pine tip moth populations (AFC, 2015). Excessive herbaceous weed control can eliminate habitats for its natural predators (AFC, 2015). There is limited evidence that certain insecticides used for Nantucket pine tip moth control can have adverse effects on its parasitoids.

Additional to the Nantucket pine tip moth damage observed at the Taylor Tract, this trial also highlighted problems caused by ice (Figure 26). In North Carolina, *P. taeda* trees are susceptible to ice damage, caused by snow build up on tree branches. Warmer weather during the day begins to melt the snow, but then freezes to form ice overnight. More snowfall allows continuous build-up of ice, and causes deformation of *P. taeda* trees.

**Figure 26:** Nantucket pine tip moth damage; and deformed branches resulting from ice damage, both at Taylor Tract, North Carolina.

Carl Alwin Schenck Memorial Forest

The Carl Alwin Schenck Memorial Forest (aka Schenck), is a 300 acre forest located in western Wake County near Raleigh, North Carolina. It is managed and owned by North Carolina State University as a teaching and research forest for forestry students. Carl Schenck, a highly renowned forester for many decades, taught and influenced countless forestry students throughout his career (Figure 27).

**Figure 27:** Carl Schenck (with moustache back row) and his forestry students in 1912. Source: Jolly, 2006.

Schenck established the Biltmore Forest School in 1898 (on George Washington Vanderbilt's Biltmore Estate near Ashville, NC, part of the study tour), the first formal school of forestry in America (Jolley, 2006). Schenck Forest plays a vital role as an outdoor laboratory for a number of academic programs developed by NCSU, including research studies in the areas of tree growth, genetics, hydrology, and wildlife habitat.

Within the 300 acres at Schenck Forest there are numerous demonstration compartments, showcasing effects of fire, site preparation, herbicide trials, and silvicultural practices on *P. taeda* (loblolly pine) and *P. palustris* (longleaf pine) plantations.

NCSU comply with three certification systems; SFI, FSC and the ATFS. Pesticide use in NCSU managed forests is for invasive plant species control, insect pest control (including southern pine beetle), hardwood stocking control, site preparation and crop tree release. Managing and monitoring compliance is compulsory for regulatory requirements (North Carolina laws and regulations, EPA) and all three certification systems. This includes educational training (pesticide applicator and certification license), pesticide operation plans, application records

and up to date chemical storage inventories. The impacts of reduced pesticide use on plantation forestry is significant (Snider, 2015, pers. comm., 15 September), however North Carolina regulations and forest certification on minimising the use of pesticides has not had an impact on growth/yield for NSCU managed forests. Additionally, NCSU aim to practice alternative methods of weed control, especially the use of prescribed fire. Pressure for reducing pesticide use does come externally via the public, and more currently, the types of chemicals used by NCSU are being carefully selected to reduce harm to bees and other pollinators.

Although new chemical testing is restricted for NCSU, numerous non-chemical methods during site preparation are commonly demonstrated including mowing, disking, drum-chopping, grazing, and prescribed fire. The only highly regulated areas where pesticide use is restricted for NCSU are in riparian zones.

Additional educational demonstrations at Schenck Forest include: grafted seed orchards (Figure 28), where seed of desired traits are collected and planted into progeny tests to evaluate the offspring of the tree, and mixed-stands of *P. taeda* (loblolly pine) and *P. palustris* (longleaf pine), which demonstrates various silvicultural management options and also numerous recreational activities.

**Figure 28:** Schenck Memorial Forest grafted seed orchard.

*Pinus palustris* (longleaf pine)

As part of the visit to Schenck Forest numerous *P. palustris* seedlings at various stages of growth (Figure 29 & 30), and mature *P. palustris* trees at a nearby tree farm (Figure 31) were visited. The one year old *P. palustris* seedlings where found to be quite unique in their grass-like stage (Figure 29), which can last for more than two years (more depending on seedling health). The seedlings are 'stemless' after one growing season, it is during this stage that the *P. palustris* seedling develops an extensive root system, and the root collar increases in diameter (Carey, 1992). Once the root collar diameter is approximately 1 inch (or 2.5 cm) the seedling begins to grow in height, and has the capacity to grow 10 feet (3 m) in 3 years once

height growth is initiated (Carey, 1992). *P. palustris* seedling use its stored reserves to quickly grow a straight stem with no branches. Branch production is delayed until the seedling reaches 10 to 16 feet (3-5 m) in height (Carey, 1992).

**Figure 29:** One year old *P. taeda* (loblolly pine) wilding next to a two year old *P. palustris* (longleaf pine) at Schenck Memorial Forest.

The most efficient forest management tool to reduce herbaceous or hardwood competition to *P. palustris* seedlings is not through the use of herbicides, but through fire.

*P. palustris* has many adaptations to fire. This Pinus species is classified as fire-resistant (Carey, 1992) and ideally suited to a high-frequency, low-severity surface fire regime. Conversely, questions still remain surrounding the vulnerability of young *P. palustris* seedlings toward fire in numerous literature, however it is clear that timing of introducing fire to young *P. palustris* is the key to effective fire management. In the absence of frequent fire, *P. palustris* is replaced by hardwoods and other southern pines, especially *P. taeda* wildings, and will invade and eventually dominate a site of grass-stage longleaf pine (Carey, 1992).

*P. taeda* wildings are particularly troublesome and in many instances *P. taeda* wildings outnumber planted *P. palustris* seedlings. The use of herbicides would be the most efficient form of control, however the herbicide treatment to use are not selective for *P. taeda* and not for *P. palustris*, nor is there likely to be one in the foreseeable future (Carey, 1992).

**Figure 30:** Established young P. palustris (longleaf pine) at Schenck Memorial Forest.

**Figure 31:** Mature *P. palustris* (longleaf pine) Tree Farm near Raleigh, North Carolina.

## Raleigh, North Carolina – Weyerhaeuser

The next stop for the tour was lunch with Nancy Thompson (Weyerhaeuser Public Affairs Manager) and Pryor Gibson (Executive Vice President of North Carolina Forestry Association), to discuss pesticide use, forestry in general, and the many differences between Australia and United States. Following lunch a guided tour of all the current and new harvesting equipment at the logging expo was conducted by Pryor Gibson (Figure 32).


**Figure 32:** Stump blaster promoted at the logging expo and Pryor Gibson with Kim Thomas and Michelle McAndrew.

Weyerhaeuser is one of the world's largest forest product companies, operating in 10 countries and with customers worldwide. The Weyerhaeuser estate in North Carolina consists of 400,000ha of plantations which are based of Loblolly pine (*P. taeda*). Their chemical management works hand in hand with their product stewardship program where they integrate environmental, health and safety considerations.

Companywide, Weyerhaeuser focus on reducing chemical risk through the use of a comprehensive local chemical approval process (EPA), where potential new chemicals are thoroughly reviewed and any controls needed are determined prior to local approval and use. Weyerhaeuser are certified to the SFI, and seek to reduce or eliminate the overall number of chemicals used in operations, including certain high risk chemicals and products containing PCBs, asbestos, lead-based paints, and certain aerosols. Additional to forest certification and EPA regulations, Weyerhaeuser pursue less hazardous substitutes for chemicals and implement their use companywide. Pesticide reduction efforts are highlighted through improved inventory management of all chemical products and better Safety Data Sheets (Weyerhaeuser, 2015).

Herbicide use at Weyerhaeuser is similar to Hancock Forest Management where herbicide application is carried out prior to planting, and also a release spray up to 2-3 years post planting. Through their own research, and through research conducted within State Universities, Weyerhaeuser prefer to ensure adequate weed control, rather than rely on fertiliser as herbicides are a lot cheaper. Herbaceous woody weed release also occurs during mid rotation.

## Wilmington, North Carolina – Resource Management Service (RMS)

The first of two visits in Wilmington, North Carolina, consisted of a field trip with Tony Doster (North Carolina Region Manager) and Clay Jenkins (Forest Planner) from Resource Management Services (RMS). This visit included seeing numerous compartments where herbaceous weed control were due for herbicide application, and sites that had already received their herbaceous weed control and were being prepared for planting. Numerous plantations at various stages of management (including Campbell Global plantations as they are intertwined with RMS forests) were also visited. RMS specialises as a Timberland Investment Management Organization (TIMO), and are certified to the Sustainable Forestry Initiative (SFI).

Overview

RMS in south-eastern US is the largest privately held forest management and consulting firm in the United States. The size of its forest estate is approximately 3.5 million ha, with 240,000 ha located in North Carolina alone. RMS grow mostly *P. taeda* pine because this species has good form and growth, and they are easy to grow in mono stands which respond well to silvicultural and fertilization management practices. *P. taeda* plantations are hand planted to a stocking of 450 – 550 stems per acre (equates to 1111 - 1357 stems per hectare) during winter (January – February) with mechanical site preparation completed at most sites. The majority of operational activities within RMS are undertaken by contractors.

RMS are members of State Universities, ArborGen (largest global supplier of seedling products and leading provider of improved genetics to the forest industry), and the North Carolina State Tree Improvement Cooperative (aim to economically increase forest productivity through the genetic manipulation of loblolly pine). Arbogen supplies all of RMS's planting stock, and have a long term contract with Arbogen to maintain stability. Arbogen have their own breeding programs which enables RMS to plant by genetics in specific areas. RMS are very interested in planting genetic families that are resistant to fusiform rust (*Cronartium fusiforme*), with bare rooted (open rooted) seedlings being their preferred planting stock. They have established

clones in the past, to determine if they outperformed their controlled pollinated trees, however their performance did not justify the cost to plant them. RMS have also considered containerised seedlings, but initial research has seen them moved away from containers due to additional cost, and as with clones saw no significant benefit to continue. Additionally, RMS receive plentiful rainfall and the 'plug' of the container seedling does not provide an advantage as it would lower rainfall areas.

RMS don't tend to use insecticides as they have few issues with Nantucket pine tip moth (*Rhyacionia frustrana)* nor Southern pine beetle (*Dendroctonus frontalis* Zimmermann). The weather is usually a common issue; floods and ice storms cause a lot of damage in their North Carolina plantations.

## Pesticide Use

Site preparation herbaceous weed control

RMS apply herbicides pre and post planting in an aim to control woody and herbaceous weeds. Chemicals used for pre plant weed control are applied as a broadcast application. Once harvesters have clearcut an area, ideally RMS will leave it to fallow for 12 months to allow vegetation to grow (Figure 33). RMS do not disturb vegetation during this period to reduce the amount of herbicide needed during fall (September, October, November), and also allow grasses to emerge during the warmer part of the season. Once pre plant herbicide applications have occurred, the area will be left alone until the end of spring (March, April, May).

**Figure 33:** Compartment in fallow period prior to site preparation. Resource Management Service try not to disturb vegetation during this periods to reduce their herbicide use.

RMS manage herbaceous and woody weeds at site preparation by using a combination of chemical and mechanical methods. Herbicide combination prescriptions allow a complete knockdown of existing weeds and provide a residual control for certain herbaceous weeds

which can provide competition for moisture and light at the establishment phase of a plantation. The v shear is applied prior to bedding (Figure 34) which will shear branches and debris out of the way and breakup woody weeds still persisting following herbicide application. At the end of July, the bedding plough is brought in to form mounds (Figure 35). RMS try to avoid pulling beds later than August (so weeds don't emerge), but aim to bed as late as possible in the season to avoid new growth, therefore reducing their herbicide use.

**Figure 34:** Compartment recently subject to shearing using a v shear blade which removes branches and other debris out of the way prior to bedding.

**Figure 35:** Bedding recently completed.

RMS apply a post plant application of herbicides, however it is applied via banding over each row to ensure the inter row is not sprayed. Inter row vegetation is retained to provide habitat for wildlife; herbicide application via banding provides adequate protection for *P. taeda* seedlings for the first 12 months. During the second year of establishment there is a lot more vegetation, especially inter row, however this does not affect RMS. Once *P. taeda* seedlings have established themselves they don't need exception from the vegetation as it doesn't significantly affect plantation growth (excluding invasive species); RMS encourage understorey vegetation for wildlife habitat and hunting.

As with HFM, all pesticide application is completed by contractors. RMS will use the same contractors every year, as they commit with the people they know will do a good job. Contractors are to communicate when they are spraying, where and time, so RMS are always aware where they are and every time they move, etc. In terms of monitoring, RMS are required to do 20% inspections on all sites, but also have high priority sites (schools, occupied dwellings) in which they will monitor more frequently.

Mid-rotation woody weed control

As with site preparation, during mid rotation RMS utilise chemical and mechanical methods of woody weed control. Undergrowth expected during this stage is mainly hardwood species (sweet gum, red maple) which can be controlled utilising two different approaches. The use of prescribed fire for weed management is not common, but it's a practice that can be considered during mid rotation against chemical use. Fire as non-chemical approach to weed control can be utilised to also reduce fuel loads, enhance wildlife habitat and reduce *P. taeda* wilding numbers.

Chemical Restrictions / Forest Management Certification

Being certified to SFI, RMS are prohibited on using chemicals located on the World Health Organisation (WHO) type 1A (Extremely Hazardous) and 1B (Highly Hazardous) tables and the Stockholm Convection on Persistent Organic Pollutants. RMS have no major issues being restricted with using their preferred pesticides, as all required products are registered for forestry use, approved by the EPA and are not located on either of the above prohibited lists. Additionally, RMS have their own approved chemical list that can only be used by employees and contractors.

RMS have restrictions on using pesticides on land where they have entered into an agreement with the federal government to convert small part of their land into wetlands; in exchange RMS receive wetland mitigation credits that they can sell on the open market. This restriction includes harvesting and plantation re-establishment; the only exception is hunting activities. This restriction is forever; once converted to wetland it cannot be converted back.

RMS restrict pesticide use in close proximity to watercourses and areas of occupied dwellings. They don't have too many neighbours, but do have a lot of hunting clubs. Standard practice is to notify their neighbours and retain a buffer surrounding these features. RMS make a big effort to have excellent communication, not only with neighbours and hunting clubs, but also with environmental companies and the Land Trust to ensure an effective relationship. Within

compartments where RMS incorporates ditches due to excessive wet areas, they apply a buffer (approximately 5 meters width including ditch) where RMS do not spray herbicides and retain vegetation (and stags) for habitat.

As part of sustainable forest management and in line with SFI criteria for chemical use, RMS endeavour to protect water quality and wildlife habitat by limiting the amount of pesticides used. There are occasional public complaints regarding pesticide use, however the public does not necessarily understand how to manage a forest. Public education about pesticide use and sustainable forestry is important; at time these topics gain great resistance from people with preconceived perceptions edification is needed to bring about social reform.

Pesticides used by RMS are reviewed every season. SFI forest management certification does not encumber them in using herbicides, nor eliminate their use, however forest growers do encourage their managers to minimise their pesticide usage, where applicable. Due to the operational cost of alternative non-chemical options, herbicides are always going to be the most efficient and economic option. All areas subject to herbicide application will be part of an herbicide tour to assess the weed spectrum(s) on site. Herbicides are applied at the minimum effective rate as per label, while the importance of avoiding weed resistance.

## Wilmington, North Carolina – Campbell Global

The final visit in Wilmington, North Carolina, was an office meeting with Brett Goulding (Region Manager, Wilmington) from Campbell Group. The visit included a tour through some of the Campbell Group estate. Campbell Global are certified to the Sustainable Forestry Initiative (SFI).

Overview

As with RMS, Campbell Group specializes as a Timberland Investment Management Organization (TIMO). Campbell Global offers clients complete and fully integrated timberland and natural resource investment management services. Worldwide, Campbell Global manage 2.7 million acres (1.1 million hectares) of plantation estate, 95% being *P. taeda* plantations, including 140,000 acres managed in South Carolina.

Annually, Campbell Group re-establish 2,000 acres (809 hectares) of *P. taeda* plantation with bare rooted planting stock; occasionally containerised seedlings. Ninety percent of the area is establishment using a v shear and bedding plough. Campbell Global and RMS forest growers show very similar silvicultural practices and best management practices (BMP's).

Campbell Global fertilise twice throughout a 28 year rotation (two thinning's during rotation). At establishment (0-1 years), stands receive nitrogen (N) + phosphorous (P) fertiliser application, and then N+P again post first thinning. Post thinning fertiliser is based on soil analysis on certain sites and tree growth inventory to identify how plantation is going.

Campbell Global rarely use insecticides as they minimal problems with Nantucket Pine Tip Moth (*Rhyacionia frustrana)* nor Southern Pine Beetle (*Dendroctonus frontalis* Zimmermann).

The weather is usually a common issue; floods and ice storms cause a lot of damage in their North and South Carolina plantations.

## Pesticide Use

Site preparation herbaceous weed control

Campbell Group have very similar BMP's to RMS in terms of pesticide use and general forestry management. Campbell Group also apply two pesticide applications (pre and post planting) with the aim to control woody and herbaceous weeds within their plantation estate at establishment. Chemicals used are also similar for both forest growers.

All operational work carried out by Campbell Global is contracted. In North Carolina, Campbell Global have access to 4-5 pesticide aerial applicators; these applicator only undertake forestry operations. Majority of the time other contractors can be tied up completing work external to forestry, and see forestry as a smaller scale operation. Because of this, Campbell global use the same contractors that focus on forestry operations. Therefore, the same contractors used for pesticide application are the same contractors that are used for planting.

Mid-rotation woody weed control

Undergrowth expected during mid rotation are mainly hardwood species (sweet gum, red maple, etc) which are controlled utilising two different approaches. The most common method, however, is through herbicides during mid rotation to control or at least supress woody weeds.

Non-chemical practices for weed control includes the use of prescribed fire. However, fire for weed management is deemed historic to the Campbell Group, who don't utilise prescribed fire as it is seen as too risky to use as a forest management tool within their stands.

Chemical Restrictions/Forest Management Certification

Being certified by SFI, the Campbell Group are prohibited of using chemicals located on the World Health Organisation (WHO) type 1A (Extremely Hazardous) and 1B (Highly Hazardous) tables and the Stockholm Convection on Persistent Organic Pollutants. However, as with HFM, NCSU and RMS they have no major issues being restricted from using their preferred pesticides, as all required products are registered for forestry use, approved by the EPA, and are not located on either of the above prohibited lists.

The Campbell Group are restricted from applying pesticides in and near water sources and ditches, however if the chemical label states 'no water, no buffer' then they are not restricted and can apply as normal practice. They do apply buffers to ditches, occupied dwellings, and recreational areas where no pesticide is permitted to be applied. The Campbell Group endeavour to reduce their chemical usage by using the minimal label rate required to achieve required outcome, and only apply the herbicide(s) needed for the weed spectrum present. Pesticide usage is managed state by state with no thresholds within forest certification to calculate annual chemical use and no requirement to undertake water monitoring.

Forest growers across different counties work extremely well together. Campbell Group have excellent communication with RMS, HFM and State Universities as forest growers are commonly researching similar problems and looking for similar outcomes.

## Georgetown, South Carolina – Resource Management Service (RMS)

Next on the itinerary was a visit with Resource Management Services in South Carolina which consisted of an office visit and field tours with Joey Ferguson (South Carolina Region Manager) and Amy McClellan (Forestry Manager) from Georgetown, South Carolina. As part of this visit to the South Carolina estate, one and two year old *P. taeda* plantations where visited, discussing herbicide use, mid rotation woody release sites, and various areas of roadside spraying. As with RMS in North Carolina, RMS in South Carolina are certified to the Sustainable Forestry Initiative (SFI).

Overview

RMS consists of eight main regions and seven different properties (investors). The red mountain region alone consists of 315,000 acres, mostly within South Carolina and a small amount in eastern Georgia. The greater part of the RMS property was acquired from International Paper in 2006. This region contains 26% natural hardwood forests which are left alone for wildlife habitat and water protection. Hunting clubs are very common in this region, having approximately 320 leased hunting clubs; these provide significant income to RMS, and also provides 'eyes in bush'.

One hundred percent of all on ground operational activities (site preparation, pesticide application, silviculture, etc.) are contracted. RMS do not store chemicals onsite, do not order chemicals, and do not apply chemicals as part of their SFI RMS policy. RMS foresters indicate areas where herbaceous weed control or woody release is warranted, determines the appropriate chemical(s) and rates to use, and also signifies buffers required. Contractors put in a price to undertake the work.

Annually, RMS re-plant 2,000 acres (809 hectares) of *P. taeda* plantations during winter but are known to plant outside their normal timing during October/November (fall) with containerised seedlings to assess their survival and growth. Planting stock of choice for RMS are both bare rooted and containerised. As with most forest growers in south eastern America, RMS obtain their planting stock from ArborGen.

Unlike North Carolina, RMS in South Carolina have commenced soil analysis programs to determine which sites require establishment fertiliser (as Campbell Global does in their South Carolina plantations). This is on the basis of previous research results, highlighting that adequate P fertiliser persists in soil longer than a single rotation. RMS use LAI obtained annually from Landsat to determine mid rotation N & P requirements. The soil analysis program so far is finding most sites have adequate levels at establishment. Another difference RMS have found is the preference to hand fertilise at establishment in preference to aerial application; the overall result is an increase in cost to apply, but a significant decrease in fertiliser usage throughout the region.

**Pesticide Use**

Site preparation herbaceous weed control

*P. taeda* seedlings at planting are 8 inches tall (20cm, standard specification when leaving nursery). However, *P. taeda* is a quick growing species that can reach 15ft (4.5m) in 3 years. Pesticide use in South Carolina is similar to North Carolina, however due to the difference in weed spectrum, there are slightly different state requirements and in turn differences in BMP's. For example, aerial pre plant broadcast herbicide application is only undertaken in 500 – 1000 acres of the planted area or less. Pre planting herbicide application is only undertaken on sites determined by their weed spectrum.

The field trip visit was to a one year old *P. taeda* plantation that did not receive any pre plant application at establishment, and only received a post plant application soon after planting (Figure 36). RMS believes the mid rotation release provides excellent residual control, especially of hardwood species, and at re-establishment herbaceous and woody weeds following site preparation may not become a problem until post planting. After one year of growth, foresters complete an inventory of plantations for survival, and also to indicate the type of weeds competing with the *P. taeda* seedlings; this assists them in deciding if an area is required for juvenile release post planting. An assessment of the number of hardwood stems per acre provides RMS a trigger (150 stem/acre) to determine if juvenile release is required.

**Figure 36:** 12 month *P. taeda* plantation (approx. 5 months since application), and planting plus 24 months *P. taeda* plantation; both have received one single band herbicide application post planting.

To understand the effects of vegetation on *P. taeda* plantations at two years of age it was important to visit a two year old *P. taeda* plantation that had received only a post plant application. As seen in Figure 36, the beds are not clear and contain numerous herbaceous and woody weeds. However, due to the fast growing nature of *P. taeda*, these trees have established themselves enough that the competing vegetation does not significantly impact their growth, and further herbicide application is not required. Applying herbicide after the second year of growth does not give them additional economic return.

One hundred percent of RMS plantation establishment sites are v sheared (in North Carolina forest growers v shear in strips). The mechanical disturbance from 100% shearing and bedding, plus a single band tend following planting is generally adequate to get the crop though the first

few years after establishment. In 2015, RMS decreased their stocking and establish wider rows at planting to allow for better machine access. When re-establishing a site that was previously a young stand (taken out by fire, wind, ice storm etc), RMS can v shear and bed a row at the same time.

Mid-rotation woody weed control

Understory vegetation competition in *P. taeda* plantations requires a woody weed release during mid rotation, or sometimes earlier when needed. Mid rotation woody weed release can be applied aerially by helicopter or on the ground by skidder (tractor); the skidder can only be used if the area has been thinned. On occasion, an earlier woody weed application is completed by helicopter with an herbicide prescription suitable to apply over the top of *P. taeda* trees, however it doesn't always provide comparable results to the prescription used for skidder application, especially if the vegetation type has a waxy component to its leaves.

As part of the field trip, visits were conducted to mid-rotation *P. taeda* plantations that were marked for mid rotation woody weed control (Figure 37), and also a site that had received mid rotation weed control five months prior (Figure 38). Their prescription combination for mid rotation provides excellent knockdown of their existing vegetation and provides excellent residual control or at least suppression on their harder to control vegetation species.

**Figure 37:** *P. taeda* plantation that has been marked for mid rotation woody weed control in 2016 via skidder.

**Figure 38:** *P. taeda* plantation that had recently received mid rotation woody weed control via skidder application.

Roadside Spraying

Roadside spraying within RMS plantation estate is typically on a five year cycle for treatment. Foresters travel with the contracted applicator to all sites when applying chemical for roadside weed control to provide direction, and to ensure sensitive areas are protected. RMS have minimal annual roadside spraying which is completed in only a few days.

Wet areas are treated with chemicals listed for aquatic use or are excluded from herbicide spraying altogether. Their typical brew used for roadsides knocks down herbaceous and woody weeds, and provides excellent residual control. Tractors are used for application which are able to treat both sides of the road at same time (Figure 39).

**Figure 39:** Recent roadside spraying, near Georgetown South Carolina.

Roadside spraying is treated exactly the same as if spraying plantations. SFI and RMS policies require operational maps to signify nearby neighbours (plus provide notification), water sources, areas of treatment, chemicals and rates, etc. South Carolina has further requirements that a log is kept of all people commencing and completing chemical application, and when accessing these sites. All contractors are required to keep records of their chemical use which is supplied to RMS; this data is used to calculate their annual pesticide usage.

Non-Chemical Weed Management

Within the first few years after site establishment, *P. taeda* wildlings can cause problems amongst planted areas. Foresters are required to maintain *P. taeda* wildling numbers in areas next to mature stands, due to the amount of seed a mature tree can produce. Pesticide application is not available as the chemical used to control *P. taeda* wildlings will also kill the planted trees. Therefore, mechanical control in the form of a chopper roller is used inter row to control wildling numbers. The trigger for inter row chopper rolling for wildling control is 900 wildlings per acre and is completed after three growing seasons to ensure the wildling are big enough for adequate control.

During roadside spraying, some mechanical work is utilised if vegetation is too big (bush hog, rotary mower), to reduce vegetation height prior to spraying. Some herbicides require vegetation to be a certain height for effective control, also the 100% spray coverage is always

best to provide effective control. There are downsides to 'mowing', including spreading seed and vegetation can often come back more dense.

RMS do not use prescribed fire for vegetation management as a standard management tool. However, they do 100% v shearing for site preparation, not strip v shearing as seen in Figure 34.

Chemical Restrictions / Forest Management Certification

Being certified to SFI, RMS are prohibited on using chemicals located on the World Health Organisation (WHO) type 1A (Extremely Hazardous) and 1B (Highly Hazardous) tables and the Stockholm Convection on Persistent Organic Pollutants. However as with other forest growers, RMS have no major issues being restricted with using their preferred pesticides, as all required products are registered for forestry use, approved by the EPA and are not located on either of the above prohibited lists. RMS do not have customers internationally that require FSC certified wood, and there is currently no plan to go down the FSC direction.

Pesticide restriction for RMS include: spraying ditches (within and outside plantation areas), water courses, cemeteries, historical sites, and conservation easements. RMS apply buffers around them and leave these sites undisturbed. Existing ditches can be maintained and cleared out post harvesting and pre site preparation. Some ditches do not drain directly into natural water systems but are still excluded from pesticide application. Small silvicultural ditches (bucket width and depth and run the length of the compartment) can be created to drain problem areas into existing ditch networks. This work is generally done by eye rather than surveying. Hardwood vegetation within buffers of ditches (5m width including ditch) can be treated by stem injection, or excluded completely from treatment. High cultural sensitive sites, riparian zones, and locations known to have species of interest are excluded from treatment and are to be noted on operation plans and maps.

SFI requires buffers on all sites of significance, and check these buffers post operation against GPS flight tracks. Additionally foresters also check 10% of their spraying operations while they are in progress.

State regulations in South Carolina require large area applicators to hold a discharge permit to develop an annual pesticide discharge management plan, and to provide an annual report post operations for all chemical applications. The report has a particular focus on any breaches in the buffering, and is also used for SFI and contractor performance monitoring. To date the State has never asked to see the plan, but RMS still develop and hold a hard copy on site each year. The discharge management plan contains all completed site plans, policies, and SDS for pesticide application.

Pest Problems

Due to the potential infestation of Nantucket Pine Tip Moth (*Rhyacionia frustrana)*, RMS monitor younger plantations to determine infestations during survival assessments. Results from previous years show Nantucket Pine Tip Moth is present within their *P. taeda* plantation estate, however not in significantly high numbers. In 2014, 12% of the RMS estate was

determined to be infested with Nantucket Pine Tip Moth; in 2013 18%, and in 2012 12% across their total estate. The trigger to apply insecticides is very high. The insecticide is very expensive, and will only control part of the pest's life stages; repeated applications are needed for effective control.

Forest growers in other regions have higher percentages of Nantucket Pine Tip Moth infestations (40-50% infestation), however due to the cost of insecticides they don't spray, focusing more on nursery insecticide application. Nantucket Pine Tip Moth trials have been established in previous years by Jim Peeler (Manager of Silviculture & Research) for RMS in Alabama (see next section).

Additional to pest problems, ice storms are a big issue in South Carolina, causing deformed stems and branches in their *P. taeda* plantations. Ice storms are seasonal and cause a great deal of damage to trees. Ice damage cause RMS greater problems than Nantucket Pine Tip Moth.

## Birmingham, Alabama – Resource Management Service (RMS)

The visit to Birmingham, Alabama were Jim Peeler (Manager of Silviculture & Research) from Resource Management Services (RMS) discussed research within RMS, risks emerging regarding pesticide use, and Nantucket Pine Tip Moth (*Rhyacionia frustrana*) trials established by RMS.

Overview

Decades of research has occurred regarding management of *P. taeda* from site preparation, pesticide application, fertiliser, and silviculture in conjunction with tree improvement co-operatives, State Universities, ArborGen, forest biological weed co-operatives and other forest growers in different states.

The strategic goal for research within RMS focusses on their responsibly to improve the productivity of their forest resources. RMS continue to develop ways to improve efficiencies in growing trees. For example, a new approach to monitoring responses to forest fertilization has allowed RMS to maximize the gain achieved from applying the least amount of fertilizer needed. Secondly, the use of genetically advanced seedlings in replanting their *P. taeda* stands means that the stands planted today will produce higher growth rates and better potential for high quality products than in previous generations. The trees RMS plant today are also expected to exhibit higher resistance to pests and disease.

**Pesticide Use**

The main risk and emerging issues surrounding pesticide use in the forestry industry is the reliant on a handful of herbicides. The majority of these products are currently going through a relabelling process by the EPA, which may increase restrictions on use, for example; increased buffer requirements and application methods. Presently, RMS internal policies are more restrictive than regulatory requirements.

The number of pesticide products available to forest growers in south eastern America have reduced by approximately 60% over the last few years, as products have come off patent. This has resulted in companies downsizing their technical staff and limiting research into testing new products. RMS undertake limited operational testing of generic brands and alternative chemical products, however this is not common. Pesticides used within south eastern America, and across all forest growers are similar, if not hold the same active ingredients. The herbicides they are using work extremely well and there is no focus on testing alternative pesticides. The chemical supply brokers used by RMS also supply training and up to date product information regarding testing results of pesticides as a part of their service. However, if the preferred active ingredients presently used by most forest growers in south eastern America for whatever reason become restricted, they do not have alternative active ingredient or combination of herbicides which cover the same weeds spectrum needed.

Silvicultural Practices versus Productivity Improvements

RMS employ proven forest management practices to improve the productivity of the plantations they manage (RMS, 2015). Key aspects of primary forest management practices for RMS are: the deployment of selectively bred seedlings, application of herbicides to control herbaceous and woody weed competition, amelioration of soil conditions that limit tree root development (RMS, 2015), and the addition of nutrients through forest fertilization. Figure 40 shows the contributions of silvicultural practices to productivity improvements and rotation lengths in managed pine plantations between 1940 through to 2010. RMS analyses silvicultural treatments to ensure that they meet minimum target return requirements (RMS, 2015).

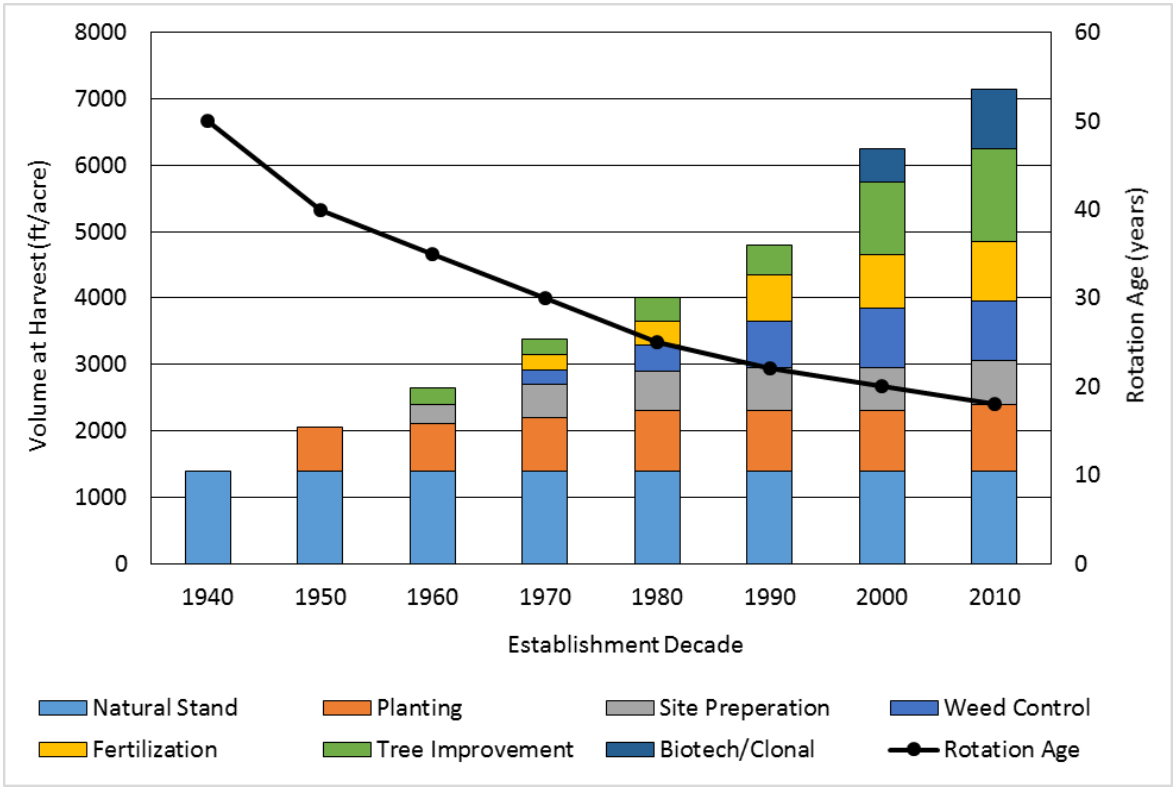


**Figure 40:** Contribution of silvicultural practices to productivity improvements and rotation lengths in managed southern pine stands (Fox et al, 2007, 2010; Jim Peeler 2015).

Pest Problems

Pine pitch canker (a disease of conifers caused by the fungus *Fusarium circinatum*) and Nantucket Pine Tip Moth (*Rhyacionia frustrana*) are highlighted by Jim Peeler as the main forest health problems in southern America and there are no economic pesticide solutions available for either. PTM (active ingredient fibrinol) soil injection with insecticide can control the Nantucket Pine Tip Moth, but currently is still operationally expensive. However, this option is a viable option at selective sites; high value sites, clone banks, christmas tree plantations and nurseries.

Nantucket Pine Tip Moth is a pest that is hard to evaluate from an economic stand point. RMS established four tip moth trials in 2014 (in Texas and Alabama) using containerised seedlings treaded with PTM by an international forest company prior to shipment. Results have shown that there is no doubt PTM cuts down on the infection rate and reduced height loss in the one and two year old *P. taeda* plantations. Further research is needed to investigate the effect of tip moth on stem quality. Operation treatment price is high at $80 per acre (treating 450 trees per acre - restriction on the label). There are other insecticides available for Nantucket Pine Tip Moth control, however these products need to be tested to ensure all stages of tip moth are controlled.

'Pine decline', thought to be caused by a soil fungal disease can impact stands periodically. Again, no viable chemical treatment has been identified and the problem is generally managed through salvage harvest, adequate fallow to prevent reinfection, and maintaining general stand health through good silviculture.

It is SFI policy to prevent invasive species. RMS have issues with Kudzu vine (*Pueraria montana var. lobata*) and also privet species (*Ligustrum* sp.), which are thick forming evergreen shrubs up to 35 feet tall, RMS monitor their plantations to keep infestations are low.

## Harpersville, Alabama – Hancock Forest Management (HFM)

The last visit for the study tour was with Robert Milstead (Stewardship Manager Eastern Division) from Hancock Forest Management (HFM) in Harpersville, Alabama. Robert hosted an office and field tour of HFM plantations in southern Alabama, visiting various site preparation plantations, two year old *P. taeda* plantations, mid rotation chemical application, and prescribed fire management sites.

Overview

Alabama forests generate over $21 billion in timber production and processing revenue. There are 23 million acres of timberland in Alabama, accounting for 69% of the total land area in the state. The single most prevalent forest type is “loblolly pine” which occupies 8.5 million acres (AFC, 2007). Amongst *P. taeda* plantations lies numerous white oak native forest (Figure 41), a common area for hunting clubs.

**Figure 41:** White oak native forest maintained for wildlife and recreation, Alabama.

HFM practice both chemical and non-chemical site preparation when establishing *P. taeda* plantations. With or without the use of fire, chemical site preparation can duplicate or exceed mechanical site preparation results (AFC, 2007), with less impact on water quality. All pesticide applicants must follow the chemical manufacturer label instructions, Alabama State Law and any EPA guidelines. In SMZ, no herbicide is to be applied by broadcast or aerially. Due to no herbicide application in SMZ, the suffocating vine, Kudzu (*Pueraria montana var. lobata*), is HFM biggest invasive weed problem.

**Pesticide Use**

Site Preparation Herbaceous Weed Control

In comparison to other properties visited on the tour, forests in this area are located on more rolling terrain, bringing a new set of silvicultural challenges. Top of the list is *P. taeda* wildling control. HFM typical pre plant chemical application is not always effective at controlling young pine wildlings, and timing can also result in a large seed crop coming up post spraying or post planting. As these sites are typically direct planted with poorly defined rows and generally no machine access, it is extremely difficult to be able to control *P. taeda* wildlings. Problems with *P. taeda* wildling post planting is that the common method of control is hand tending. When hand tending, it is often difficult for contractors to distinguish wildlings from the genetically improved planted stock. The use of chemical pre-planting plus a broadcast burn, if timed well, can often assist in *P. taeda* wildlings control. Plantings with high perimeters adjacent to mature pine are the most difficult for wildling control.

*P. taeda* can produce between 300 - 20,000 wildings per acre, producing a mat of wildling, as no herbicides can be sprayed post planting mechanical chopper rolling may be utilised inter row. Audit assessment audits are conducted 1 year post planting.

Non-Chemical Weed Management

Within Alabama, HFM undertake prescribed burning for vegetation control at site preparation (Figure 42 and 43). The risks of burning (escapes and nutrient losses) are acknowledged by the region, however the benefits in gaining effective weed control, *P. taeda* wildling control, and gaining better access for planting are currently thought to be worthwhile.

**Figure 42:** *P. taeda* establishment site marked for site preparation prescribed burning.

**Figure 43:** Site preparation prescribed burning just completed. Burning is conducted 4-8 weeks following aerial spraying.

Prescribed burning in Alabama is site specific, as the loss of leaf litter covering and vegetation aids with their soil/erosion issues present in steep terrain areas (Figure 44). Additionally, this region is much less populated, and state regulations for fire are less prescriptive than the eastern states where prescribed fire use is much more limited.

**Figure 44:** Typical rolling terrain in south Alabama pine plantations. Wildling issues prevalent where there is a large perimeter of mature pine.

Mid-rotation woody weed control

HFM research has found that if mid rotation fertiliser is conducted on unthinned stands, it can have a detrimental effect on stand health and growth. In this region, stands are flown post thinning to refine treatment maps, due to slope constraints there are often large portions left unthinned. These unthinned areas are excluded from fertiliser programs.

Mid rotation hardwood control has been found to provide similar volume benefits to fertiliser, however it's about a third of the cost, therefore in certain areas weed control replaces fertilising. On highly productive sites mid rotation weed control and fertiliser are both seen as being economical. Price differential between pulp and sawlog has recently decreased, making it no longer viable to spend as much on stands as they have in the past, as the main benefit of mid rotation weed/feed is increasing the proportion of sawlog. This is influencing decisions on whether to focus on weed control or fertiliser, or both (or neither).

Chemical Restrictions / Forest Management Certification

HFM are certified through Sustainable Forestry Initiative (SFI). SFI are not considered to have any major constraints on pesticide use over and above federal and state regulations, and the companies own policy. The Forest Stewardship Council (FSC) is seen as difficult to obtain (and often to no economic advantage) due to issues in interpretation of natural, native forest versus plantation. FSC chemical derogations are also seen as a barrier.

Recent changes in pesticide regulations/policies will impact pesticide use; including new labels developed by the Environmental Protection Agency (EPA) imposing larger buffers and restricting aerial applications (including Oust Extra). HFM have recently revised their own Best Management Practices (BMP's) regarding pesticide applications; guidelines for risk assessments are now much more comprehensive than previously outlined. New legislation being drafted is also causing concerns (this concern was mentioned across all states and companies visited) which includes buffers for chemical application to be mandatory on any drainage line draining into a watercourse. HFM do their own internal audits for their herbicide spraying to ensure they comply with SFI.

State regulations and SFI requires SMZ to be audited 12 months post spraying. During this audit property boundaries are also checked for (visual) chemical damage. Staff are currently being encouraged to undertake increased observations during spraying operations. HFM staff are also required to undertake 4-6 week checks of pre-plant spraying operations in order to plan follow up burning. Contractors are responsible for undertaking neighbour/hunt club notifications. But it's a SFI requirement that HFM ensure contractors do this. Contractors are also responsible for dealing with complaints (e.g. overspray allegations), however HFM monitor (and document) these, and ensure they are resolved.

HFM BMPs relate back to the Clean Water Act. Being SFI certified has allowed HFM to improve their BMPs for environmental and social impacts to minimise or prevent issues from herbicide applications arising. Figure 45 shows an example of buffers that are applied to SMZ's with HFM current BMPs in an area with multiple watercourse types. Recently the Clean Water

Act has been updated to clarify new restrictions when applying pesticide, especially in SMZ, however this 'clarification' has created more confusion.


**Figure 45:** Example of SMZ buffers applied by HFM through their best management practices. All SMZ have buffers minimum 35 feet. Source AFC, 2007.

Pest Problems

Kudzu vine (*Pueraria montana* var. *lobata*) causes HFM a significant amount of problems in their SMZ's where herbicide application is restricted. When left alone Kudzu can form a thick solid mat, blocking off sunlight and suffocating everything underneath. HFM can keep on top of Kudzu in their plantations during their pre plant application, or at least supress it, but it can be difficult to completely control Kudzu in SMZ. Kudzu is HFM's biggest invasive weed problem if they are unable to use herbicides. Additionally neighbours on adjacent land need to control Kudzu on their side of the fence so it doesn't cause HFM issues in their *P. taeda* plantations post planting. In south eastern America, Kudzu covers 7 million acres of land and in favourable conditions can grow one foot per day. As Kudzu is outside of its native origin it has no natural predators, with high rainfall during the summer, and no insect pests and diseases to keep it regulated, Kudzu will flourishes. The only benefit Kudzu has is soil erosion prevention.

# Conclusion

Forest certification is not a perfect tool for describing sustainable forest management. Conversely, forest management certification is an important proxy that can be monitored and verified independently to a known standard. Forest certification with a third-party verification provides a good indication that the forest manager is investing in sustainable continuous improvement to ensure use of best practices will result in stable forest production and conservation values. The objectives of this study tour were to review pesticide use and culture internationally, to understand the impacts from pesticide restrictions and forest certification, review non-chemical methods of vegetation control, and become aware of the longer term implications of regulations and certification for pest management.

Herbicide use in forestry internationally is most often limited after the first few years of plantation establishment. Consequently, the overall use of pesticides in the timber production cycle are minimal. Effective vegetation management of herbaceous grass, broadleaf and woody vegetation during this period is one of the major contributing factors for survival and good early growth for plantation trees. Forest growers across Australia experience their own issues with competitive vegetation within plantation forestry, depending on their climate, terrain, rainfall and silvicultural practices implemented. Experiencing forestry internationally demonstrated a broader perspective, identifying a whole new set of objectives forest growers need to manage.

The use of herbicides across all countries visited are somewhat different, however vegetation management objectives are similar. The most common active ingredient used by forest growers is glyphosate (Table 1) as a pre plant broadcast application, commonly applied aerially. All forest growers, universities and research institutions visited throughout this study tour have a heavy reliance on glyphosate as a foliar knockdown site clean-up herbicide, as it is non-selective, provides very effective vegetation control prior to planting and is not restricted by federal/state regulations or forest management certification.

**Table 1:** Most commonly used herbicide active ingredients for Queensland Australia, New Zealand and south-eastern America.

| Queensland, Australia | New Zealand | South-eastern America |
|---|---|---|
| Glyphosate | Glyphosate | Glyphosate |
| Triclopyr | Metsulfuron-methyl | Imazapyr |
| fluroxypyr | Hexazinone | Picloram |
| 2,4-D salts | Terbuthylazine | Sulfometuron-methyl |

Pine wildlings are highlighted to be a major problem across most locations visited; especially within *P. taeda* plantations across south-eastern America. Without an effective pre plant herbicide control forest growers can end up with a dense crop of pine wildings mixed in with genetically modified planted seedlings and no easy way to tell the difference. The most commonly used chemicals are off patent and thus inexpensive, new herbicide products can be expensive, therefore chemical companies have dramatically reduced their research and development as there is no incentive to research new products forest growers will not pay for.

As in the past, anything new comes out of the agricultural sector. One new product of potential interest to forest growers in south eastern America is Detail® (active ingredient saflufenacil), which is reported to make glyphosate mixtures more effective and is of particular interest for pine wildling control. There is a saflufenacil product available in Australia (Sharpen® WG Herbicide) and is registered for forestry use; however the no aerial application restraint is not ideal for forest managers.

Release herbicides dominate post plant herbicide use, and the type of residual herbicides used is dependent on vegetation type. One of the key differences across the three countries visited was the different vegetation types found within forest plantations. Depending on the physiology of these plant species they all require different management methods for control; hence the variation of post plant active ingredients used across these countries (Table 1).

Objectives following clearfell harvest are similar to how *Pinus radiata* plantations are managed in the Green Triangle region, South Australia. Forest managers aim to allow a growing season to facilitate weed germination and to ensure adequate pre plant control prior to planting. Weed control using chemical herbicides is a vital tool for all forest managers to assist in reducing competition from their plantation trees for the first five years after establishment, regardless of their location. The number of post plant treatments, type of active ingredients and method of application did vary due to the various vegetation types that germinate and become competitive for light, water and nutrients following planting. A negative effect from broadcast spraying of glyphosate to achieve bare earth (zero weeds) is it can encourage additional and possibly more competitive vegetation to germinate. One non-chemical approach in New Zealand is oversowing prior to planting to occupy the site with an easy to manage crop soon after harvesting and minimising the regrowth of more competitive weeds. This practice is used in combination with spot weed control post planting and provides numerous benefits, but as with a lot of non-chemical methods identified during this study tour, there is no benefit over existing weed control practices. Additionally, it is more cost effective to apply herbicides for vegetation management.

The use of prescribed fire and chopper rolling in Queensland, Australia, and the application of herbicide during mid-rotation across south eastern America has been very effective. All forest growers visited establish their plantations at a much lower stocking (wider rows) than the *P. radiata* plantations in southern Australia, encouraging more vegetation growth and extending the time it takes for canopy closure. However, wider rows have allowed the option of mechanical weed control inter row in the form of mulching or chopper rolling. Although grazing is somewhat historic to most forest growers, it is still being used as a management tool in Queensland in their hoop pine plantations as an alternative form of weed control, especially on sites where terrain is a safety concern for standard operations.

Insect pests and diseases as a whole were quite limited. The potential for Nantucket Pine Tip Moth and Southern Pine Beetle in south-eastern America to become bigger problems is a concern. Good silvicultural practices are paramount, not only for the productivity of the forest crop but also to reduce susceptibility against pest and diseases, including pine pitch canker and

'pine decline'. Interestingly, environmental factors (climate, terrain, flooding, cyclones, snow, and ice storms) have been more of an issue than pest and diseases in south-eastern America.

South eastern America mid rotation fertilisation (mostly nitrogen) has been routinely practiced on nearly all sites for many years, however this practise is starting to be questioned at a few of the sites visited during the tour. Research has been showing that effective woody weed control can have just as good a response for lower cost. Therefore, for lower site index sites, the economics of fertilisation can be prohibitive. Research has also found that on un-thinned sites, mid rotation fertilisation can have detrimental effects to the health and growth of the stand.

Recent changes in pesticide regulations/policies in south-eastern America will impact pesticide use in the future, including new labels developed by the Environmental Protection Agency (EPA) imposing larger buffers and restricting aerial applications. HFM have recently revised their own Best Management Practices (BMP's) regarding pesticide applications, guidelines for risk assessments are now much more comprehensive than previously outlined. New legislation being drafted is also causing concerns (this concern mentioned across all states and companies visited) which includes buffers for chemical application to be mandatory on any drainage line draining into a watercourse.

Regardless of the location, all forest growers are prohibited on using chemicals located on the World Health Organisation (WHO) type 1A (Extremely Hazardous) and 1B (Highly Hazardous) tables and the Stockholm Convection on Persistent Organic Pollutants. In line with their forest management certification policies, HQPlantations continue to reduce their use and reliance of chemicals for various management activities. Currently they use a small amount of herbicides that are located on the FSC prohibited list, however are able to seek derogation of approvals for conditional use for these chemicals in certain areas.

FSC certification has not affected the type and quantities of herbicides used in pre plant vegetation control, however the ever increasing awareness of reducing the amount of herbicides used has resulted in some degree of change. The two most common post planting active ingredients used in New Zealand, hexazinone and terbuthylazine, have recently been reviewed and removed from FSC prohibited list, eliminating the need to seek derogations for their use. In southern America, the FSC is seen as difficult to obtain (and often to no economic advantage) due to issues in interpretation of natural, native forest versus plantations. FSC chemical derogations are also seen as a barrier. All forest growers visited in south-eastern America were certified to the SFI and have no major issues being restricted from using their preferred pesticides, as all required products are registered for forestry use, approved by the EPA and are not located on either of the above prohibited lists by WHO or the Stockholm Convection. Additionally, the majority of forest growers do not have customers internationally that require FSC certified wood.

One pesticide restriction from FSC that may cause numerous problems for forest managers that manage their own nurseries is stated in Criterion 10.7 of the FSC criteria 'forest managers shall make every effort to move away from chemical pesticides and fertiliser, including their use in nurseries'. Research into alternative and cost effective methods across all countries visited will

continue to be investigated, and even more so as forest certification schemes encourage forest growers to strive in minimising or reducing their chemical use.

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