

FOREST MANAGEMENT OF A NEW ARBORETUM

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Abstract

The National Arboretum Canberra (NAC) was opened in February 2013. With planting having started in 2007, there are now 94 forests on a site of 250 ha representing rare, threatened or otherwise significant trees from around the world. To date, about 40,000 trees have been planted. Although the collection has been planted predominantly in small one or two species forests, the management regime has had to include horticulture as well as silviculture to highlight the different features of each species planted and provide for outcomes such as soil amelioration and fire hazard reduction. The NAC has a valuable role in improving knowledge through attempting to manage several species that were previously poorly known in Canberra. The presentation will touch on a range of operational aspects at the individual tree and whole of forest level, including irrigation, formative pruning, thinning, pests and disease and weed control.

Introduction

In 2003 the bushfire that ravaged Canberra was the catalyst for the creation of an arboretum originally envisaged by the designer of the city of Canberra, Walter Burley Griffin. It provided an opportunity to promote and in some cases conserve threatened species, and provides a valuable future resource in Canberra for ongoing education and research and a place for community recreation. The goal is to create a place of outstanding beauty, of international standard and interest.

In December 2003 the ACT Government agreed that the burnt-out pine forest area known as Green Hills is to be preserved as an international arboretum. It is being developed on a 250-hectare site near Lake Burley Griffin about six kilometres from the centre of Canberra. The site incorporates existing stands of Himalayan Cedar (*Cedrus deodara*) and Cork Oak (*Quercus suber*) much of which was planted about 80 years ago. It was seen that the design would make provision for a wide range of commercial and community activities which could bring more activity to the area and support the development of the arboretum.

A national design competition for what was then called the Canberra International Arboretum commenced in September 2004, and on 31 May 2005 the ACT Chief Minister, Jon Stanhope MLA, announced the landscape architects Taylor Cullity and Lethlean, with the architects Tonkin Zulaikha Greer, as the winners with the "100 Forests 100 Gardens" entry. As the name suggests, the design includes a series of forests, such as the existing ones of cedars and oaks, instead of the usual wider arboretum collection of individual trees or small clumps. Further information about the competition and the design can be seen at <http://www.nationalarboretum.act.gov.au/>.

As a part of the early development of the Arboretum, the inclusion of a research forest connected to the Australian National University was discussed, and there is now a forest in which grow stands of *Eucalyptus tricarpa* and *Corymbia maculata*. The forest has been established to look at how these two different species will respond to the drier climate and longer droughts likely to occur in Australia as a result of climate change. Since the development of the Arboretum commenced, another one of the forests has been used for the establishment of the Southern Tablelands Ecosystems Park by a Canberra community group, in which grows stands of all of the ACT's *Eucalyptus* species.

Site Preparation

The Arboretum site had been originally used as a commercial radiata pine forest since the 1920's and contained large amounts of pine regrowth, exotic weeds, woody weeds, surface rocks, old irrigation lines, and compacted forestry tracks. The initial thought to bulldoze the 100 forests free from rocks and pine trees, quickly became a major cost and management issue. It became obvious that it was not possible to just bury the rubbish under the forests growing in neat and tidy fields of lucerne.

To address this, a 5 tone excavator was introduced to the project with rock grabs attached. It would simply pull the trees out and bypass the sites rocky outcrops, leaving them as future hubs for local native vegetation. The pines were put in wind-rows and tub ground to supply mulch for the future plantings.

The basic plan after the trees were removed was as follows:

1. Deep rip the forest planting areas and adjacent allees to 600mm deep at 1m centres.
2. Back blade lots to pick up all rock brought to the surface larger than 100mm in size.
3. Rock pick the forest lot and adjacent allee.
4. Bore tree holes to 800mm in depth using a 600mm diameter toothed auger.
5. Trench and install irrigation sub-mains, feeder lines and dripper lines on a bed of sand.
6. Over sow the entire forest and adjacent allees with a lucerne mix.

Scope of the Living Collection

Since the planning started for the National Arboretum Canberra, there has been a strong emphasis on plant conservation and just over 40% of the 90 forests planted to date represent a rare or threatened species. However, since the commencement of the species selection the number of principal themes has expanded to include:

- conservation
- plant use
- symbolism

In addition, an effort has been made to represent trees from:

- a wide range of countries around the world
- a wide range of habitats, with an emphasis on drier climates
- a wide range of botanical families, including
 - evergreen and deciduous species
 - broadleaved trees and conifers

As a part of the species selection process, there was obviously a strong desire for the species selected to have the potential to perform well on the NAC site. However, several of the species selected are new to Canberra and for some they could be close to their climatic boundaries, with the main issue being frost tolerance. The few species likely to be on a 'climatic cusp' will not only test the species survival over time, but also be possible indicators of climate changes in the Canberra region.

The conservation theme has provided the Arboretum with an excellent opportunity to highlight the fact that many of the world's trees, sometimes common in cultivation, are in fact threatened in the wild. For several of the species, it could also help to protect them through *ex situ* conservation.

While the conservation of our flora must be seen as the priority for conservation programs in Australia, the nature of the collections at the NAC takes into account its role to promote the importance of trees in a world-wide sense. By being the diplomatic capital of Australia, Canberra is well placed to fulfil such a role. As a part of this, it is intended to look at telling these stories using interpretation in languages other than English that are particularly relevant to the where the trees occur naturally. This would include an indigenous language where English is the national language – including for the Australian species.

At the individual species level, the Arboretum has already worked with in-country and international conservationists. One such species is *Cedrus libani*. While the species is already in Australia and is reasonably easy to acquire, a closer link with the natural stands in Lebanon was sought. A contact was made in Lebanon with the Lebanese Agricultural Research Institute who collected the seed at the Al Chouf Cedar Nature Reserve. The seed was passed on to the Arboretum via the Millennium Seed Bank in Kew. By doing so it not only has made other conservationists aware of the Arboretum but will also be an opportunity to promote the conservation of the species and the Al Chouf Cedar Nature Reserve through the Arboretum and the Lebanese Embassy in Canberra.

The selection of plant use as a theme was, in many ways, an expansion of the conservation theme. It has meant that in addition to those species that are threatened in the wild and require conservation, species that have been important for human use, have also been highlighted as worthy of conservation. This includes species with a broad range of uses like *Brachychiton rupestris* (Bottle Tree), *Maclura pomifera* (Osage Orange), *Eucommia ulmoides* (Chinese Rubber Tree) and *Cercis canadensis* (Eastern Red Bud).

The highlighting of the symbolism theme was in part driven by the interest that was being shown by embassies in Canberra. With the NAC collection representing just over 100 countries some of the species symbolic of those countries include: the national tree of Chile (Monkey Puzzle or *Araucaria araucana*); the national tree of Pakistan (Himalayan Cedar or *Cedrus deodar*); the State tree of Louisiana and Mississippi (Southern Magnolia or *Magnolia grandiflora*); the national tree of the Czech and Slovak Republics (Small leaved lime or *Tilia cordata*), and; the symbolic flower of Kiev, (Horse Chestnut or *Aesculus hippocastnum*). As a part of this, one section of the Arboretum is devoted to single plantings by national leaders from around the world.

Some of the species chosen are also regarded as being sacred in different countries and these include: the Parana Pine (*Araucaria angustifolia*) revered by several Brazilian tribes; the Yunnan Cypress (*Cupressus dulouxiana*) considered holy by Buddhists in China, and; the Bunya pine (*Araucaria bidwillii*) held sacred by several aboriginal tribes.

Provenance

Although it was initially intended that all proposed seed collections or plants were to be characterised by credible provenance, the speed at which the arboretum was established and the number of trees required for the forests made this very difficult. It resulted in there often being an insufficient number of plants for the threatened species at the time of planting.

While this was partly overcome by introducing the plant use theme, the majority of the non-conservation related forests came with no provenance and it was still desirable to maintain the use of the threatened species that had already been acquired and grown. This was addressed by the use of a host species. For example, the few threatened Spanish Birch (*Betula pendula* ssp. *fontqueri*) the NAC had propagated from provenance seed have been planted with the host species Silver Birch (*Betula pendula* ssp. *pendula*) with the intention of slowly removing the Silver Birch and replacing it with Spanish Birch over time. These new trees would come from both cuttings from the original planting and more seed obtained from Spain. While it was easy to obtain approval to thin eucalypt and pine plantings there was difficulty in getting approval to thin the birches! The eventual achievement of having a forest of just the Spanish birch may now take a little longer.

WEEDINESS

One of the important issues that had to be taken into account when selecting the NAC species was the possible or recorded weediness of the species and the CRC for Australian Weed Management's weed status list (Randall, 2007) played an important role in plant selection. As a result, several species meeting numerous other requirements for the Arboretum have been rejected because of likely weed issues.

This has not been an easy task as the variation in the localities that plants have become weedy is substantial and as a result trees known to have been weedy in areas thought different to Canberra have sometimes been accepted. For example, although the California fan palm, *Washingtonia filifera*, is considered to be a serious weed in central Australia it was still seen as a suitable planting for the NAC. However, the previous records must not be ignored and it is noted in NAC management plans that if a newly introduced species commences to show a weediness that could lead to it becoming naturalised, it should be removed.

Uses for the NAC forest species:

Research

As with all significant arboreta the management of the NAC will encourage and support research studies, including all avenues of scientific enquiry concerning the forests and their associated biodiversity. Arboricultural and silvicultural research as well as basic research (e.g. carbon flux and tree physiology) will be encouraged. The potential for social and cultural research associated with the amenity, educational and recreational values of the NAC is also acknowledged.

Given the significant themes underpinning the arboretum design, research priorities may be directed towards a better understanding of:

- Rare and endangered plant species;
- Climate change and adaptation;
- Species suited to the Canberra environment
- Understanding Urban forests interfaces and values

Particular strengths of the NAC as a site for research are: i) the potential longevity of research activities to build valuable long term data sets and studies; ii) the proximity of the site to major research Canberra-based institutions, including CSIRO and the Australian National University; iii) its strong connection with a likely user of the research results, that is, the ACT government, and iv) the significant community profile of and support for the site as a significant cultural asset. A major contributor to the latter is the Friends of the National Arboretum Canberra. This includes their involvement in regular growth measurements in all of the forests over the past 4 years.

Species Trials:

Although the introduction of poorly known tree species can be a risk, the trialling of them will undoubtedly help to identify species suitable for planting in Canberra's urban forest in the future. It is not only an opportunity to learn more about the trees that are already adapted to the Canberra climate but also trees that may be affected by climate change over time.

The trials that have already commenced are for those species expected to survive in Canberra but are still poorly known in the city's urban forest. These include species that have not been known to have been planted in Canberra before, such as Toromiro *Sophoratoromiro*, and species that had only been grown to very limited extent, such as the monkey puzzle tree *Araucaria araucana* and the Wollemi pine *Wollemianobilis*. Both species have been used to form forests with the latter having been reduced in size.

Prior to the planting of the Wollemi Pines at the Arboretum, the number growing in the ACT was still very small, with the species having not long been discovered or being freely available for horticulture. Since the first planting at the Arboretum, much has been learned about growing this species in Canberra. While the genetic diversity in the species is exceptionally small (Peakall et al, 2003), there is considerable landscape variation across the site where the trees are growing and the impact of those differences is already showing strongly. As a result of the experience to date it is likely that another Wollemi pine planting will be done in another area of the NAC that best provides the conditions in which the species has grown most successfully to date.

Although using the planting of whole forests as a part of these trials has a greater risk in terms of the number of trees lost, it has been found that the plantings have not only benefitted from the various growing conditions across the forest site but also, in some species, from the genetic variation in the planting.

If for example only 10 Wollemi pines had have been originally planted it is highly likely that it would have been declared as unsuitable in Canberra, given that nearly 2/3 of the forest planting have died over the past seven years. It is only because it was planted as a forest that the opportunities have been identified.

The second trials will be carried out in two forests that have considerably different growing conditions. Neither of these trial lots has yet been planted. Unlike the main forests, the main aim for these trials will only be to grow the trees long enough to determine whether they are in fact suited to the Canberra conditions and what maintenance issues might exist. There will only be 10-12 trees per species and the length of time each of the species is kept on trial will depend very much on the success of the tree. The more successful or unsuccessful the tree is, the faster will be the removal and replacement.

Tree Management

Although the trees have been planted as monocultures, it does not mean that they are to be managed as timber forests. It is the aim of the Arboretum to provide visitors with a feeling for each of the species that has been planted. Although there will be some formative pruning for most of the species, this will still involve giving the trees some freedom to express themselves. There will also be others within the individual forests that need to be treated differently from one another to fit in with original landscape design.

Of course, there is still going to have to be an appreciation that the areas around the trees will need to be maintained and so consideration will have to be given to people and the likes of mowers and other vehicles being able to pass through under the trees.

For all of the forests, the retaining of information has been important. This information has included details of the species' provenances, their propagation, their growth, flowering and fruiting and will also include information about pests and diseases and any tree losses and replacements. The information is currently still held as basic files and maps but the Arboretum is currently reviewing possible options for a botanic gardens style database.

Maintenance Guidelines

While the Arboretum's general maintenance directions are viewed as the expected standards across the site there are also particular guidelines which apply to every forest and associated tree species. A very important aspect of the Arboretum's guidelines is that it they are still evolving as we learn more about the species planted. Some of the issues that have had to be addressed are as follows:

Irrigation

It has always been the intention of the ACT government that the tree plantings of the Arboretum will not be watered with potable water. Instead, the irrigation water will be obtained from the dams and bores or will be trucked-in recycled water.

However, the provision of non-potable water for the rapidly expanding arboretum has been a particularly difficult task with the issues of environmental conditions, site topography, filtration, water security and irrigation maintenance. These have all been consistently monitored and adjusted to suit the current conditions where and when possible. The current water sources available to date are as follows.

1. Bore # 1 = 10ML
2. Front Dam = 30ML
3. Bore #2 = 37 ML
4. Other (Lower Molonglo surface water) = 50 ML

To assist the effective use of the water available, the Arboretum has developed a thresh hold for soil moisture in each forest. The measurements are done at 3 random locations within each forest and during the peak seasons weekly readings are collected indicating where the water is required.

To date the Arboretum has been successful in only using potable water, even during the extreme conditions in January 2014. Although this will be tested with more trees to be planted and the possibility of drier conditions, a significant number of the forests will survive in the future on very limited irrigation.

Weed Control

Weeds that were already well established on the site are another significant issue that the Arboretum has had to manage over its entire 250Ha site, although it was it was quickly learnt that not all weeds are nasty but can in fact aid in soil retention.

To assist ensuring effective weed management, a listing of the most problematic weeds recorded on site has been prepared and each is targeted in individual programs across the whole site. Of all the weeds being controlled, blackberry has required the most time to date. It was throughout the 250ha site when the development of the Arboretum was started and it is still present in many areas of the Arboretum, including the areas of remnant pine forest that surround the Arboretum.

However, as time allows the site to recover from the pine forest, fire and disturbance during re-planting, the weeds will become controllable through consistent mowing and the weed management programs.

Pruning and thinning

As the arboretum is a living collection of forests rather than a park or forest for timber, the formative pruning is being done in a somewhat different way than the typical Australian stands of urban or timber forests.

Of course, the general rules still apply to try and obtain a safe form or structure, but as a forest of 200 or more trees will eventually form a canopy connecting with each other, the form of the forest can be as important as the individual tree's form. This has opened the potential problem of having to produce a specification to prune forests which if not well supervised could possibly have devastating and long-term results. The conclusion was for the Arboretum's senior horticulturist to take on the responsibility for formative pruning across the whole site.

Thinning has also been driven by a number of issues. As mentioned earlier, the thinning of a radiata pine or eucalypt forest has raised little comment, but the proposal to thin a forest of what is viewed to be an 'ornamental' species can produce far more resistance. However, throughout the Arboretum there will be whole forests that will need to be thinned – both for the benefit of trees around them or to enable the expanding of the planting of the threatened for which the forest was originally established.

Pests and diseases

It is generally held that the treatment of pests and disease in the Arboretum should be restricted to those trees that are being seriously affected and that spraying of pests should be avoided. While several trees have been lost across the Arboretum as a result of pest and disease attacks, it has only affected an entire forest on one occasion.

The most serious pest attack to date has been on the Buchan blue forest (*Acacia caerulescens*) which has suffered from splitting of the bark, weeping of sap, weakening and losses of tree limbs and the death of a substantial number of trees. It is likely that this has primarily been caused by the jewel beetle *Agrilus hypoleucus* although it is not recorded as a threat to the species where it grows naturally in Victoria. A possible result of this is that the forest will be replaced with another species, but this is yet to be decided.

When *Phytophthora cinnamomi* was first discovered on the site during what were relatively dry years it was not occurring in areas that were a threat to the forests.

However, during a very wet summer in 2010, it was identified in at least six forests, including the Wollemi pine (*Wollemianobilis*), maidenhair Tree (*Ginkgo biloba*), giant sequoia (*Sequoiadendron giganteum*), Japanese flowering dogwood (*Cornuskousa*), European beech (*Fagus sylvatica*) and eastern redbud (*Cercissiliquastrum*). Although the prolonged periods of rainfall in the summer of 2010 and 2011 provided perfect conditions for *Phytophthora* to survive, all of the forests seen to be at risk have been drenched with phosphate and potassium and the losses across the Arboretum have not been as significant as expected.

A disease which is becoming a considerable concern is the cypress or Seiridium canker with likely outbreaks already recorded on pencil pine, (*Cupressus sempervirens*), Lawson cypress (*Chamaecyparis lawsoniana*), Saharan cypress (*Cupressus dupreziana*) and giant sequoia (*Sequoiadendron giganteum*). Although Seiridium is essentially a weak pathogen requiring some defect by which to enter, it is over time, becoming more evident in the Canberra region and there are perhaps four more tree species in the Arboretum that are vulnerable. Removal of dead and dying limbs and the application of a copper based fungicide is the current action being taken but it may be a significant issue to be addressed in the future.

References

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