URBAN TREES: Growing miracles and an untapped resource.

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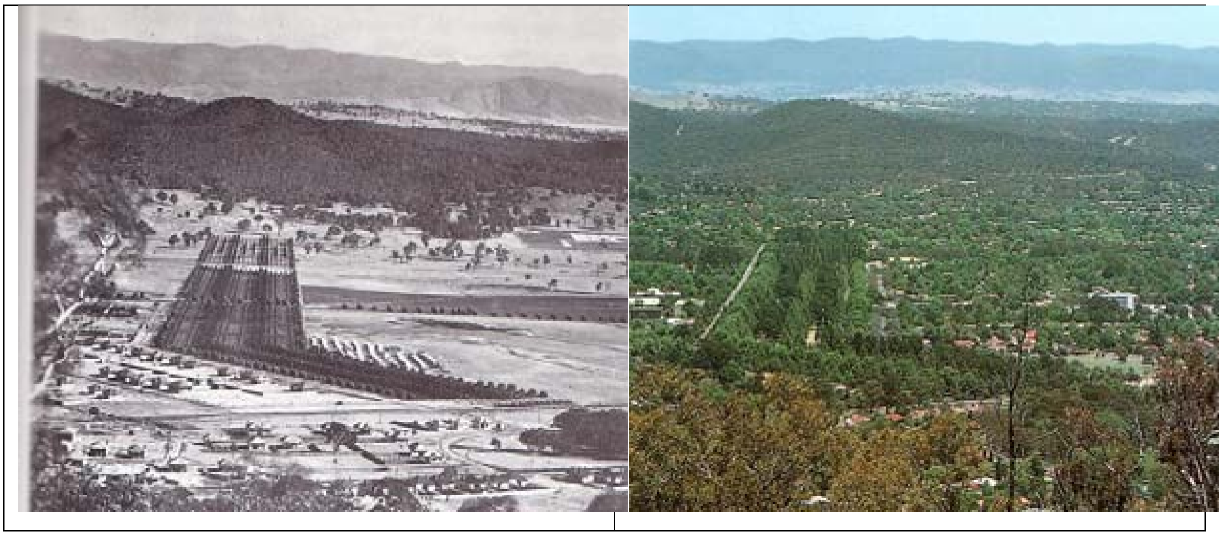
Introduction

There is no doubt that urban trees provide valuable services. Many individuals spend significant time and resources planting and maintaining trees (Figure 1), and as Mansfield et al (2002) note "…everyone has observed that the first thing people do in new, clear-cut subdivisions is plant trees."

Figure 1: View from Mt Ainslie at northern extent of Canberra (as denoted by the row plantings in Haig Park, 1927) and expanded city (1990), showing the substantial number of trees planted.



The services provided vary by the species (or species group chosen) and their location (e.g in parks or open places and along streets). The services can range from mitigation / amelioration of unpleasant and harmful environments to direct provision of positive and valuable environments (Table 1).

Numerous studies have attempted to quantify the benefits of these services. For example, Wee (1999) predicted that a single urban tree in Canberra, planted appropriately, could provide an estimated $16,000 of benefit during its safe lifetime by means of energy savings, air pollution uptake, water quality improvement and property value increases. Brack (2002) estimated that the planted trees on public land in Canberra had a combined energy reduction, pollution mitigation and carbon sequestration value of US$20–67 million during the period 2008–2012 (the Kyoto commitment period relevant to carbon sequestration). Other urban forest studies, particularly in the US have similarly estimated the ecosystem services or pollution mitigation values in the tens to hundreds of millions of dollars. Brack and Merritt (2005) used the DISMUT model (Brack, 2006) to calculate the amenity value of trees in Canberra and concluded they these may be up to $1,100 million or $3,100 / tree (using the Thyer Method).

However, there is also no doubt that urban environments can be very harsh on trees, and consequently trees may display significant stress in their crowns and their life span may be substantially less than the maximum biological ages observed in nature. When the tree crown breaks up or otherwise loose substantial branches and leaf area, many of the services they provide are also lost. Even though some services remain, especially those related to habit, many trees may be classified as having reached the end of its "Useful Life" (UL) at this stage. In the interests of safety and aesthetics, trees may be removed after only a few to several decades rather than after centuries. It is not uncommon for urban forest inventories to include Useful Life Estimates (ULE), with individual trees being classified into classes of remaining life of, say 0-5; 5-10; 10-20; 20-40; 40+ years.

Table 1: (Derived from Brack, 2002) Services of an urban forest

Benefits relating to pollution mitigation
Amelioration of urban climate extremes Mitigation of urban heat islands Store and sequester carbon Reduce noise pollution Improve air quality Improve water quality Lower temperatures of parked cars Reduce volatilisation of bitumen Reduce consumption of electricity for heating and cooling Reduce need to invest in new power utilities
Other benefits
Aesthetic contribution, scenic beauty, visual amenity Architectural enhancement of buildings Improve property values Increase privacy, barrier against unpleasant/stressful scenes Control urban glare and reflection Improve general liveability and quality of urban life Increase tourism Provide opportunities for outdoor recreation and enjoyment Contribute to human health and relaxation, reduce stress and anxiety levels Attract birds and other wildlife

Removing trees at the end of their Useful Life is expensive. As well as requiring substantial community involvement to explain the removal and replacement options, the removals also often includes disruption to traffic and power services for larger trees. Disposal of the material is an additional and not insubstantial cost – a few small portions of trees may be sold to local wood turners and hobbyists, but the majority of the tree is often chipped or dumped. Woodchip is a very low value product and, where the tree was diseased, may not be usable for landscaping due to fear of spreading pathogens. In the ACT, the removed material may not be dumped in Territory facilities, nor may it be used as firewood (even if dried and split) due to a policy of discouraging wood stoves and heaters to potentially improve air quality.

Tree removals often occur on an *ad hoc* basis in response to requests from the public, but given the nature of the original tree plantings (whole suburbs and thousands of tree may be planted in one period) and the fact that climate cycles tend to stress or kill a wide range of trees at the one time, such *ad hoc* requests are rarely evenly spread across the years. Management of this waste material can be quite a significant issue for the Government or private companies contracted for removal.

Unexpected forest products

Clark et al (1997) conclude that “A sustainable urban forest is one that recycles its products by composting, reusing chips as mulch and/or fuel and using wood products as firewood and lumber.” However, as noted above, chipping and composting produce relatively low value products and may be associated with disease spread while fuelwood/firewood sales may be banned due to agendas that discourage wood-based heating or cooking. Lumber production, both for general or specialty timbers, are usually restricted to larger, more “conventional” forested areas that exist on the boundaries of urban areas. Street tree plantings or small treed reserves and parks within urban boundaries very rarely provide lumber on a commercial or regular scale.

However, over recent decades, the range of products available from trees has been expanding and the efficiency of small scale production has improved. These trends may allow improved sustainability of urban forests by improving the potential to recycle material and/or support profitable micro and “cottage” industries.

Edible Urban Forests

Fruit and berries are obvious products produced by urban forests. Breeding and other modern developments have expanded the ranges of these products to allow them to be grown in harsher urban environments. However other parts of trees can also be eaten, including a few dozen species of trees whose leaves are regularly eaten by humans (e.g. *Toonia sinesis* - Fragrant Spring Tree - with a garlicy flavour). Of course, the spice cinnamon is simply the dried bark of the *Cinnamomum* sp. Small cottage industries could develop to produce and market these foods, similar to the “local honey” movement which is gaining popularity. Unfortunately, many modern urban dwellers distrust foods harvested in the city, fearing that urban pollution or even human interference may make consumption unhealthy. It is not uncommon to see fruit on public trees left to fall and rot, adding further to the safety issue of pedestrians and cyclists with slip hazards. Recent trends of public food gardens and food forests returning to urban environments however may indicate a change in these fears and urban forests may once again become a source of human consumable food.

However, these traditional forest foods will usually only be produced by healthy trees which are also producing the other beneficial services to the city – that is, the production of these food goods happens at the same time as the production of the other services before the trees have reached the end of their Useful Life. Some wood however, laid down when the tree was healthy and actively growing, may be fit and attractive for human consumption. Yacaratia wood (*Jacaratia spinosa*) for example is soft and fibrous and has been made into a commercially successful lemon soup, a cream cheese, and even a cinnamon ice cream. Some wood pulp can now be made into an edible noodle that’s rich in fibre, low in calories and carbohydrates, and free of gluten and fat. Mixing this pulp with a plant called konjac produces a new type of flour that can be used to make ramen, pasta and dumplings – with only 27 calories per pound as compared to 1,669 calories per pound for wheat[14]. The manager at Omikenshi where the flour has been developed - Takashi Asami – suggested that such a low calorie food option may be promising because the “demand for diet food is strong”. A risk-taking city enterprise might be able to develop a niche health market where clients take a healthy stroll through its urban forest before consuming the low calorie and environmentally sound trees felled to keep the forest balanced and healthy.

But if you think that consuming wood is going too far, you might be surprised to read that powdered cellulose derived from wood pulp already can be found in several shredded or grated cheese products[15] to help keep them looking attractive and edible. Xylan, extracted from Birch Trees, is also added to some yoghurts to provide a smooth and creamy taste and reduce flatulence!

Urban Forest Warmth and Energy

Standing, healthy urban trees can warm cities by blocking cold harsh winds. Haig Park in Canberra (Figure 1) was planted at the birth of the city to mark the formal entrance to the city but also to mitigate the strong and bitterly cold winds for which the area was renowned. Trees past their Useful Live can also warm the city as environmentally produced firewood - as recommended for a sustainable urban forest by Clark et al (1997). Firewood is relatively low value and the demand for dry, split logs may decrease as open, restricted or even slow combustion stoves are being discouraged in many urban areas. However, there are an increasing number of options being developed where wood can efficiently produce heat without the coproduction of unhealthy or unsightly smoke.

Pellet fires, using wood chips or even other organic matter that is compressed and dried into uniform pieces, are very efficient sources of home heating with efficiency ratings up to more than 80%[16]. Pelletisers can be as small as bench-mounted units for occasional personal consumption up to commercial engines to supply the mass and export market.

Gasifiers and ethanol digesters are also making a come-back as technological advances improve the efficiency and cost effectiveness of turning wood into fuel.

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[14] Gizmodo 18 Nov, 2014

[15] http://qz.com/704172/theres-wood-pulp-in-our-food-and-apparently-we-like-it/

[16] http://energy.gov/energysaver/wood-and-pellet-heating

The gas or ethanol can be used for heating or as a non-stationary fuel. Transport running on gasification was commonplace in the mid-20th Century, when almost every motorised vehicle in continental Europe was converted to use firewood during World War 2.
Since that period, there has been relatively little change in the underlying theory or processes of production, but improved tools and materials have resulted in lighter and more reliable units. Energy efficiency is better than the best solid fuel fireplaces and when the fuel is sourced from sustainably managed forest it has a much better environmental footprint than petrol or diesel. As wood is more freely available that battery charge stations, wood-fired vehicles are also free of the current limitation of electric vehicles over long distances.

Both gasification and ethanol digestion are scalable, with gasifiers being fitted to power cars and trucks or to supply energy to large apartment buildings.

Growing your physical structures

Lumber, both from general or specialty species, may be produced from urban trees at the end of their Useful Life. Urban trees growing along street or in open parks may have very large diameters due to the lack of competition, while pruning to maintain pedestrian and vehicle clearance may also result in these large pieces remaining free from knots. In the right circumstances, large knot-free wood can command substantial price premiums. Unfortunately, without the right conditions, large dimensional lumber is difficult to handle and often requires separate processing to "break it down" into more manageable sizes. The open growth may also result in rapid rates of taper and a nieloid form which hampers the traditional recovery of useful timber. Urban trees, especially near the end of their Useful Life, may also contain internal rot and other defects as well as foreign (and potentially dangerous) items due to wounds inflicted by cars, children and other agencies.

While the non-standard size and pockets of decay may render much of an urban tree unfit for routine or large-scale timber milling, niche market and hobby makers may enjoy and profit from "interesting" resources that engage their imagination and artistic talent. A major barrier to enabling such a market would be "finding" the appropriately shaped or coloured piece of raw material of the right species from the thousands of pieces of trunk and branches that result from removing trees. Scanning lasers and cheap Radio Frequency Identification tags (RFID) now allow three-dimensional images to be captured and identified for each piece in an inventory which could allow makers to specify then find the shapes of pieces they need to almost literally put together jigsaw-style an artistic or functional wood-based structure.

An alternative to the above approach where the unique shape and size of each piece of the recovered urban tree is used would be to break everything back down to the smallest common size and shape – pulp. While wood pulp has a reputation for being of low value and only good for low value and transient products, modern technology has again made such a reputation outdated. Giant 3D printers can literally print large scale structures overnight! Other developments, not quite as futuristic-looking as a building-scale 3D printer, allow waste or "scrap" wood to be formed into self-supporting panels of custom dimensions with superior thermal and soundproofing capabilities. These processes can reconstitute wood from an extremely wide range of sizes and qualities, to produce products which are flexible, beautiful and potentially very long lasting.

Growing the future right outside your door

The real future of wood products though might be considerable smaller that the woodchip – nanocrystalline cellulose (NCC). NCC starts as "purified wood" with all the impurities removed. The purified pulp can be formed into a "thin" paste of crystals which moulded to form a laminate or strands of amazing toughness despite being incredibly lightweight. This new material, as well as related off-shoots are being used in an incredible range of new products that range from very strong yet fully biodegradable drink bottles; flexible computer chips to clothing that generates electricity and the wearer moves. And, if the geneticists succeed, there might even be a return to wooden street lights, or more specifically lights from genetically modified trees glowing in the dark - acting as a sustainable source of lighting in your sustainable urban forest[17].

[17] https://www.theguardian.com/science/2016/jul/03/fungi-glow-dark-luminscent-mushrooms-conservation-enviroment-bioscience

A “normal” forest; a certifiably sustainable forest

In addition to concluding that a sustainable urban forest should use or recycle its products, Clark et al (1997) also state that a mix of age classes and a mix of species is critical. They conclude that no more than 10% of trees should be of any one species, and that the age class distribution should be appropriate for a mixed age forest where the net forest canopy remains relatively stable.

Unfortunately very few urban forest estates meet the idea diversity of species and age classes, with an irregular pattern of species and age classes reflecting various periods of establishment and public or government enthusiasm. The urban forests of Canberra, for example, despite Canberra having a reputation as a “planned city” where trees were considered right from the establishment of the city, has a very unbalanced distribution of ages and species. The city is dominated by one Genus with Eucalyptus representing over half the street plantings. The forest is also dominated by trees planted in the 1970’s (40 – 50 years old now) with uneven numbers spreading up to more than 100 years old and a relatively small number still being established in new suburbs.

In traditional forestry terms, forest with a balanced age class and species structure is termed a “normal” forest – not in the sense of an “average” but rather in the Greek sense of a “model” or “ideal”. A normal forest means that silvicultural (arboricultural), establishment and removal operations are evenly balanced across the entire estate, which minimises cost and extreme resource requirements. Further, a sustained yield of goods and services is more easily regulated from a normal forest. Any unbalanced structure in an urban forest can be progressively transformed in to a normal forest by the removal of over represented classes even before they reached their Useful Life. For example, if there were no further expansion in the urban forests of Canberra, and if management desired a 50 to 75-year rotation with a *normal* forest structure, then 1/50 to 1/75 of the total trees would need to be replaced (felled and processed, then replanted) annually. If the desired estate was proposed to be larger, then more trees may initially be planted than are felled, but some of the heavily overrepresented classes should never-the-less be replaced to avoid an ongoing imbalance in the overall structure. This annual program would gradually change the irregular age class distribution to a regular pattern, although in the case of Canberra, such a transformation would take more than three decades to complete.

An urban forest which is “normal” could easily gain certification as a sustainable forest and also have the best structure to withstand unexpected future stresses from climate change, population increase, etc. However, it would be expensive to convert to such a normal forest. Banks et al (2002) concluded that to bring the urban forest of Canberra into a *normal* state would require many years of systematic effort, including the replacement of about 6000 trees / year. Many of those replaced trees after the first few years of removing those with some obvious stress or other obvious signs of stress of incipient mortality, would appear to be healthy and valuable to the community. Thus, effort would also need to be directed towards the education of the community into the health and safety benefits of keeping the life cycle of the trees well below their biological maximum, and possibly even below their Useful Life during the transition to a robust and healthy normal forest.

It is possible that the new products described above and their resulting urban forest-based niche industries that allow local Canberra residents to engage their creativity, independence from big industry and even engage in a healthier and wealthier lifestyle would greatly enhance community engagement and support for active urban forest management.

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