Extreme trees

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The desire for instant landscaping effect in China's high volume residential development sector has recently generated an extreme form of arboricultural practice. Very mature trees (trunk diameter up to 3000mm dbh) are being extracted from areas of natural vegetation, and having most of their root systems and all of their canopy removed to allow them to be transported to commercial tree nurseries, where they are brought back to life and sold on. The authors visited four commercial nurseries near Guangzhou specializing in this form of extreme transplantation, and three landscaping sites that had used trees from the nurseries, to make detailed observations and to conduct interviews with the operators and site managers to understand the specific operations and techniques employed in handling the trees, and the values associated with this practice. Current scientific literature on the responses of mature trees to transplanting and physical damage gives us some insight into the arboricultural condition of these trees and how they might be able to survive such treatment, and allows us to speculate on how their condition might develop afterwards. This 'extreme transplantation' is contrary to all established arboricultural science and practice guidelines for transplanting mature trees. The apparent commodification of our green heritage, also contradicts the principles of environmental preservation and stewardship that underpin the landscape profession.

Newly arrived Ficus microcarpa without root ball

Introduction

Mature trees have been used in landscape construction projects for more than 300 years, to bring an immediate sense of maturity and enclosure to a space. It is commonly understood that successful transplanting requires as much as possible of the original root system and canopy to be moved intact in order to minimise water stress, and ensure survival and healthy growth. The mechanics of lifting and moving trees gets progressively more difficult as tree size increases. Transplanting very mature trees (>750mm trunk diameter) this way can be problematic.

An alternative, extreme form of transplanting has developed in China over the last twenty years, to address some of the operational issues involved. Very mature trees, some with trunk diameters in excess of 3000mm (DBH), are now being transplanted from areas of natural vegetation, with most of the root systems and all of the canopy removed to allow them to be transported easily to commercial tree nurseries, where they are brought back to life and sold on.

Extreme transplanting practices

Four different nurseries specialising in extreme transplants in Guangzhou were visited in 2014. Sample trees were measured and their health condition was assessed, and two of the constructed root balls were partially excavated to examine the root condition. Some of the on-going operations involved in moving the trees were also observed. During the visits, interviews were conducted with the nursery owners and site managers to determine the operational and horticultural processes involved in the business. Three landscaping projects which had used trees from these nurseries, were also visited and the condition of twelve extreme transplants, which had been re-planted between 2012 and early 2013, were assessed.

The nursery owners reported that this form of transplantation was mostly practiced in Guangdong Province[1] but had also been adopted in Hainan, Hunan, Guangxi, Jiangxi, and Yunnan provinces. Some trees were taken directly from forests in Vietnam or Malaysia which are being cleared for infrastructure and development projects, others come from local forests in China, notably where vegetation is removed for new road projects. Across Guangdong, at least thirteen local species of tree are now being transplanted in this way (Table 1).

Bischofia polycarpa 重陽木
(approx. 30% of the market)
Ficus microcarpa 榕樹 (approx. 25%)
Cinnamomum camphora 樟 (approx. 20%)

Other 25% is made up of:
Artocarpus nitidus subsp. *lingnanensis* 桂木
Dimocarpus longan 龍眼
Hibiscus tiliaceus 黃槿
Ficus altissima 高山榕
Ficus benjamina 垂葉榕
Ficus virens 黃葛樹
Ilex rotunda 鐵冬青
Litchi chinensis 荔枝
Podocarpus macrophyllus 羅漢松
Sapindus saponaria 無患子

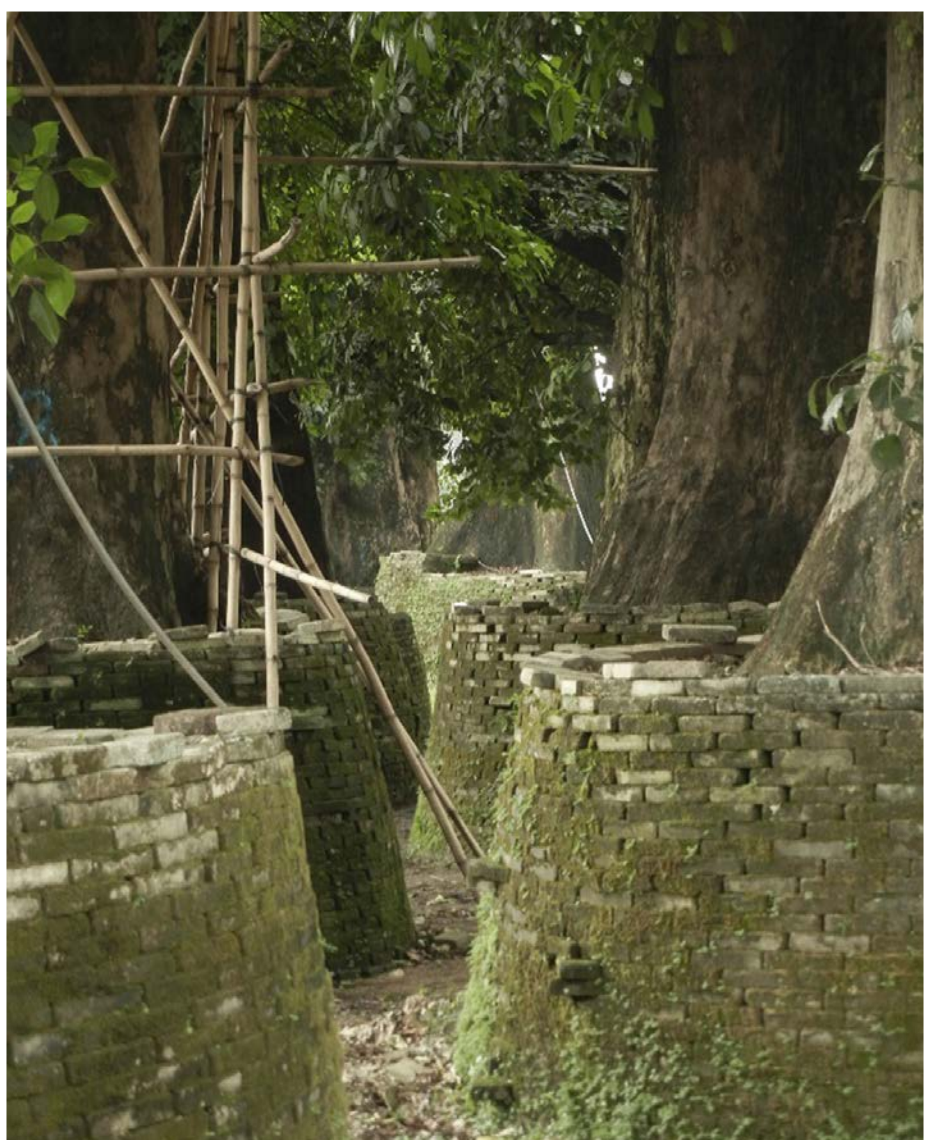
Table 1. Common species of tree subject to extreme transplantation

Each of the nurseries visited sold principally *Bischofia polycarpa, Ficus microcarpa,* and *Cinnamomum camphora* trees. They were bought by government agencies for public landscaping works and by real estate developers for residential and commercial developments.[2] The price of the trees in the nurseries varied from RMB 90,000 to RMB 2,500,000 based on size, form and health condition. *Ficus microcarpa*, in particular, were prized for their unusual trunk formations.

Specimens were usually sold within the second or third year after arriving in the nursery, i.e. when they had produced sufficient new foliage to have a recognisable tree-like appearance and to hide the wounds. Some trees, however, had been in the nurseries for four years. The comparatively low operational cost compared to potential returns, offset the significant failures and inefficiencies in the business.

Demand was, reportedly, high and each nursery had recently expanded its operations.[3] It was believed that there were 15 nurseries in the Guangzhou area selling only this form of extreme transplant, while many traditional horticultural nurseries also had a few extreme transplants in stock. Collectively it was estimated that there were between 1,800 and 2,200 such trees on sale in Guangzhou (in 2014).

Nursery owners claimed the survival rate for these extreme transplants to be about 95%, although a higher proportion of failures were apparent in the nurseries and evidence of dieback suggested that the life expectancy of many specimens would be short.



Brick walls built to create a new root ball

Where possible, trees were harvested (root pruned) in early spring (Feb-Mar), although the nurseries avoided the period around the Ching Ming festival (early April) as the trees did not survive well if cut at this time.[4] Transplanting was also undertaken in late summer and early autumn (up to the end of September) but survival rates tended to be lower. Transplantation was not considered feasible between November and January due to the low humidity.

The original sizes of the *Bischofia polycarpa* specimens before pruning were typically 18-25m tall with 0.8-2.0m trunk diameters: *Ficus microcarpa* specimens were originally 10-20m tall with 0.6-3.5m trunk diameters, and *Cinnamomum camphora* were 18-40m tall with 0.6-2.3m trunk diameters.

Trees were pruned three months in advance of moving. The canopy was cut first to stop all transpiration, before root pruning was undertaken. This was to help avoid severe desiccation and immediate death. The canopy was removed completely with a horizontal cut through the trunk and main stems at approx. 9-11m above the ground (to allow them to be moved by road and sea). Smaller side branches were removed. In taller forest specimens where branching started high up, the tree was truncated to a single massive stem.

The roots were cut very close to the trunk. The root ball ratio for trees with a trunk diameter of, say 750mm, might be 3:1, for larger trees it tended to 1:1. The diameter of the root ball did not exceed 2.25m (except where the trunk did so), and the depth was between 0.6 and 1.5m. For *Bischofia polycarpa* most of the root ball soil was removed (essentially the trees were transplanted bare rooted). The remaining roots had to be wetted constantly to avoid desiccation. *Ficus microcarpa* could be transplanted either with no soil, or with small soil root balls. *Cinnamomum camphora*, required soil root balls. The remaining trunk and root system were wrapped entirely in clear plastic to reduce water loss.

Trees were lifted via padded straps around the trunk. Trees from overseas were loaded into standard shipping containers with a crude wetting system to keep the roots moist. Trees from local sources were transported on flat bed trailers. Total weight of the trees was approx. 6-12 tonnes.

Upon arrival in the nursery, trees were lifted by crane into an upright position atop a small pedestal of compacted soil to elevate it above the surrounding ground, to avoid the possibility of flooding. After the roots had been unwrapped, a wall was constructed from loose laid bricks in a ring immediately around the root ball. The wall was inclined inwards slightly for stability. It was backfilled with soil as it was constructed. The ultimate height of the wall was approx. 0.9-2.2m.

Intense efforts to re-hydrate a failing Bischofia polycarpa

The backfill soil was a nutrient poor pond mud that has been cut into rough cubes (20-45mm) and allowed to dry and harden. This material was very dense and broke down very slowly even with repeated wetting. It allowed the development of fine soil root interaction within the root ball while achieving both good drainage and high water-holding capacity. Peanut residue[5] was applied to the soil surface as a rapidly decomposing organic fertilizer, every six months.

Newly constructed root balls were thoroughly watered to ensure the soil was at field capacity (based on the nursery worker's judgement), and then the brick structure was wrapped in plastic film to keep the moisture in. The root ball was only watered again when it is seen to be drying out, with the intention of promoting deeper rooting.

Tree set on bricks before root ball walls constructed around what is left of the roots

Micro-spray irrigation systems were sometimes installed to apply water to the cut upper surface of the trunk, in an attempt to keep the bark from drying out. This was seldom effective, and often counterproductive. Some nursery owners bound the bark at the top of the trunk with steel bands to prevent it from splitting. The trunk was also wetted up to three times per day to reduce moisture loss through the bark and decrease surface temperatures. The plastic film wrapping on the trunk was not removed until new buds had begun to appear.

Pruning wounds could be very extensive, particularly the top of the trunk.[6] Nursery owners often covered the surface of the wound with paint or plastic film to keep the exposed heartwood dry and to discourage fungi and insects. Trees were also sprayed with fungicide on a regular basis to try and prevent decay. If the bark around a wound died, it was cut back to live tissue to encourage the growth of callus tissue.

Nursery owners reported that new roots appeared within one month of transplantation for each species. Brick walls of two *B. polycarpa* specimens which had been in the nursery for approx. nine months were dismantled and the soil carefully removed, to allow the development of roots to be observed. Fine new roots (<2mm dia. x 30-60mm long) could be seen around most of the cut ends of old roots. Roots were encouraged to develop within the brick wall structure, but those that grew through the wall were cut as the trees needed to be moved again to their final planting locations.

Buds appeared within one to two months of transplantation for each species. Buds appearing on the lower part of the trunk were removed to encourage bud formation towards the top and twig elongation in an upward direction (i.e. avoiding the development of lateral branches). Sprouting was dense from the cut bark tissue around the wounds. Trees that had been in the nursery for three years, had regenerated branches up to 75mm diameter and 4.5m in length, forming a dense, narrow canopy. This shape balanced the need for foliage to make the tree saleable, while facilitating transportation after sale, without further substantial pruning.

Despite the surface treatment of the pruning cuts in the nursery, the health condition of many of the wounds was poor, with notable bark cracking and die back and limited evidence of callus tissue being formed. Obvious Areas of decay were noted on approximately half of the *Ficus microcarpa* specimens.

Trees were sold on the basis of their size, shape and condition. Those in poor health were removed from the nursery. Nursery owners estimated that life expectancy of the transplants was likely to be only a few years.

The twelve specimens observed in the three ornamental landscaping sites were in full foliage but still had narrow canopies with a mass of small diameter upright branches. They were all supported with large bamboo tripod stakes. The landscape site managers confirmed that the trees did not receive any special horticultural maintenance, but were simply watered as other trees. As the trees were seen to be growing and in full leaf they were assumed to be healthy.

No treatment was made of the cut wounds or preventive measures taken against pests and disease. Despite outward appearance of vitality, each of the trees had sizeable pruning wounds, although these were mostly obscured by surrounding foliage and water sprouts. None of the wounds observed had closed significantly, and the surface condition was generally very poor with areas of bark dieback, incipient decay, and signs of insect attack wounds.

Understanding tree responses to extreme transplantation

The extreme approach taken with these very mature specimens seems to contradict established science and technical guidance on transplanting trees. Considering arboricultural responses to typical transplanting operations and physical damage helps us to understand how these trees are able to survive this extreme form of transplanting. It also allows us to reflect on the different commercial and environmental values that are associated with transplanting mature trees.

To survive transplantation, a tree has to overcome water stress which results from the reduction in water absorbing capacity due to the root pruning needed to facilitate relocation, while continuing to lose water through transpiration. Trees do not recover from water stress until they have regenerated enough new fine (<2mm dia.) water absorbing roots to restore water balance.[7]

The severity of the water stress suffered depends on the species. Those that have the highest chance of survival have:

(a) high tolerance of root loss and ability to initiate and grow new roots in the soil outside the root ball,
(b) high root : shoot ratio (a measure of the physical and physiological balance between root system and canopy),[8] and
(c) high vigour, as this gives the tree greater capacity to change its growth pattern to re-establish internal balance.

Transplanting is most successful when soils are moist and warm, and transpiration is low.[9] Root pruning operations should not be undertaken during periods of natural shoot elongation.

American National Standards for Tree Care Operations provide guidance on the transplanting of mature tree specimens in the United States.[10, 11] These are based on established arboricultural research coupled with long practical experience. They emphasise approaches which minimise disruption and damage to the tree, and envisage that as much of the mature tree's canopy as practical will be retained intact. In doing so, the volume of the root system moved with the tree should also be maximised.

The Standards suggest a root ball ratio (root ball diameter: trunk diameter) for trees >450mm trunk diameter to be minimum 8:1. Recent research in Hong Kong has indicated that root ball volume (as opposed to diameter) is a more relevant measure in this regard as it aligns closely with leaf area index (the measure of tree canopy), i.e. the water absorption capacity of the root system and transpiration through the canopy are in balance. The research studied examples of mature tree transplanting and concluded that it could be successful at smaller root ball ratios (5:1) if care was taken in mapping root systems and adjusting root ball shapes to match.[12]

Extreme transplantation practices observed in the nurseries, reflect an understanding of the water balance and transplant stress, but adopt an opposite strategy to the Standards. The removal of most of the roots (est. >95%) is off-set by the removal of all foliage. The constant watering of the roots and the trunk is intended both to reduce water loss through transpiration through the trunk and maximise water uptake through regenerating fine roots. This raises the question as to how they can re-grow without a functioning root system or foliage, and at what cost to the tree.

During periods of shoot growth, trees rely on stored carbohydrate energy to initiate and grow new roots.[13] After shoot growth ceases, root growth is supported by newly produced photosynthate. Extreme transplants, which have had all of their foliage removed, have to depend on carbohydrate stored in the trunk to initiate root growth. In mature trees, however, this should be adequate to support root growth, as a much higher proportion of total stored carbohydrate is in the trunk rather than in the root system,[14] when compared to small trees. Further, transplanted trees require much less carbohydrate to produce new roots than established trees do to generate the constant turnover of fine roots. So it is possible for extreme transplants to grow sufficient new fine roots to absorb water to support a limited amount of top growth, based solely on trunk stored carbohydrate.

Brick wall structure containing the backfill soil

Dense pond mud cubes used as an open soil material in the new root ball

In the long term, the trees need to regenerate a significant proportion of their original root system to support a full canopy. The limited growth on the trees observed in the field suggests that they had yet to do this.

Extreme transplantation, requires other significant compromises in the long-term health of trees, which may overwhelm them before they have had a chance to re-establish their root and canopy systems fully.

Accepted transplanting practices embody the principle of retaining enough of the branching structure to allow the tree to regain a balanced form afterwards. In removing all the branches, extreme transplantation results in the complete loss of structural form. The dense new foliage observed at the top of re-planted specimens gave the appearance of healthy growth, but this consisted of a large number of small diameter water sprouts arising from the ends of truncated stems. The unbalanced canopy that is likely to develop from these, and the associated structural weaknesses, are likely to increase health problems for the tree in time. Thinning of water sprouts may help to address this, but may further compromise the appearance.

The density of the newly formed canopy with respect to the total loss of anchor roots may also make extreme transplants more susceptible to failure in typhoons.

Tree after one year in the nursery

This would also emphasise the necessity of thinning.

Pruning cuts require trees to devote energy away from growth and towards wound responses, so Standards recommend minimising cuts. Open wounds create a route for fungal infection and pest attack (notably termites) of the heartwood of the tree.[15] Declining availability of resources in mature trees means that they have less capacity to respond to damage than younger specimens,[16] and are likely to take longer to recover.[17] Larger size wounds take proportionately more energy and longer time to close. Wounds on each of the extreme transplants seen in the nursery were so wide (dimensions up to the diameter of the trunk), that they were not able to compartmentalise and close them. Indications of extensive decay were observed in many of the specimens.

Species that are able to survive extreme transplantation can be broadly divided into two groups; those with very active growth that allows them to respond rapidly to changes in growing condition, and those with dense, decay resistant wood.

The *Ficus spp.* trees transplanted this way are all strangler figs.[18] They are fast growing and can initiate and produce new roots rapidly. Aerial root structures allow them to develop their root system from multiple points, bypassing areas of damage or decay and taking advantage of different ground conditions. This is particularly the case for *Ficus microcarpa,* which has resulted in it being one of the most commonly transplanted tree species in Hong Kong, with one of the highest survival rates.[19]

In contrast, *Bischofia polycarpa* and *Cinnamomum camphora* are slower growing trees which are better at compartmentalising wounds, and have dense heartwood which is more resistant to insect attack and decay. This allows them more time to overcome the extensive pruning cuts inflicted during extreme transplanting. Both species appear to initiate shoots and roots from cut stems easily. Nursery owners reported successful cases where *B. polycarpa* trees, with 1500mm diameter trunks, were cut into multiple trunk sections and regenerated effectively as hard wood cuttings.

Survival is a relative term in tree transplanting. No specimens were observed in either the nursery or in the landscape projects that had successfully closed wounds. In the humid climate, decay and insects get into wounds quickly, and the size of the wounds on these trees were clearly too large for the tree to deal with. The effects may be hidden for a time, but there is a strong suggestion that these wounds start an inevitable process which leads to decline and death within a few years. In effect, the tree's adaptation and resistance probably keeps them alive and apparently healthy just long enough for the nursery owners to sell them.

Commodification of Nature

Extreme transplants have considerable commercial value, so why do landscape architects find them abhorrent?

First, the assumption that the value of the trees is disposable, i.e. used just to sell a property or give instant effect to new landscape, suggests that the trees are regarded as a commodity rather than a part of nature. It is sadly ironic that the value of the trees to buyers lies in their mature appearance (which has grown over decades), but due to their treatment that value is very short-lived. It is not clear if buyers were unaware that the trees might have short life expectancies, or did not care. From discussions with nursery owners, it was apparent that these trees were bought solely for immediate, decorative effect. No concern was expressed that the trees may need to be replaced within a few years. Rapid obsolescence has been an accepted facet of property development in China for a long time, but is now beginning to manifest itself in associated landscaping works.

Secondly, this commodification of trees purely for profit, represents a despoliation of nature. Setting aside any sentimentality, trees of this size must have had significant ecological value in their original, natural settings, not to mention any possible cultural, heritage or amenity worth. The validity of the sources from which the trees were obtained, and the ethics of removing them, seem highly questionable.

Landscape architects undoubtedly come under pressure from their clients to use such trees, but as professionals entrusted with a duty of care for the environment, they should view the use of such trees as unacceptable.

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New top growth, after two years in the nursery

Re-planted extreme trees in an ornamental landscaping site in Guangzhou

Cut stems quickly succumb to decay, which is often hidden by water sprouts

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1. Notably in the cities of Guangzhou, Zhongshan, Zhuhai and Zhanjiang.

2. Extreme transplants have been used in landscape schemes in Hong Kong.

3. The total number of trees in stock in 2014 were 120, 260, 110, and 190

4. Period might coincide with the period of natural shoot development, during which root pruning can severely disrupt the internal system of a tree.

5. Peanut residue is a by-product of peanut oil extraction process, and has a small carbon-nitrogen ratio.

6. Trees have great difficulty in effectively compartmentalising the wounds from substantial heading cuts.

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