Conservation Management Plan

Osage Orange hedge

Peats Crater, Muogamarra Nature Reserve

Northerly view along Osage Orange hedge, Peats Crater. 8 June 2003

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6 October 2006

Conservation Management Plan for Osage Orange hedge in Peats Crater, Muogamarra Nature Reserve

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Purpose of report

This report is provided in response to a request to prepare a Conservation Management Plan of the Osage Orange hedge in Peats Crater, Muogamarra Nature Reserve.

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Conservation Management Plan for Osage Orange hedge in Peats Crater, Muogamarra Nature Reserve

1. Summary

A line of exotic Osage Orange (*Maclura pomifera*) trees running north-south across Peats Crater in Muogamarra Nature Reserve is a hedge planted along the boundary between two portions of alienated freehold land. The portions were taken up in the mid to late 19th century, and although details of management and occupation are obscure, the land was cleared, grazed and farmed up to about World War 2, and grazed to 1969.

Hedges were the dominant form of fence used in Great Britain in the 18th and 19th centuries, and although a few were planted in Australia, they were never common except in northern Tasmania. Osage Orange was the favoured hedge plant in the prairie states of the United States before the invention of barbed wire in 1874. Some colonial Australian nurserymen and others praised the plant for fences, but by the 1860s the *de facto* standard fence in Australia was post-and-wire.

The hedge in Peats Crater is a highly significant historic heritage item , satisfying multiple heritage criteria at such a level as to be considered of ***State significance***. Hedges were a technological dead-end in the Australian colonies. They were never common in rural NSW, and any that survive, either as boundary markers or as fences, are rare today. This example demonstrates one approach to marking boundaries. ***(Criterion a)***. The hedge combines British fencing technology (hedges) of the 18th and 19th centuries with the most widely used hedge plant in the USA in the 19th century before the invention of barbed wire in 1874. ***(Criterion e)***. The Peats Crater hedge is currently one of a very few known Osage Orange hedges to survive in NSW. It is probably in the best condition and longest of the surviving hedges. Thus it is a rare example combining cultural (hedges, property boundaries) and natural (use of Osage orange) history. ***(Criterion f)***.

The Osage Orange in Peats Crater does not pose any threat to the natural environment within Peats Crater. Rather it should be considered an important heritage item, of State significance, demonstrating an early approach to marking property boundaries.

The recommended management approach is to return the hedge to its likely original form as a bushy hedge 3-4 m high along the boundary line. This will be achieved through pruning the trees after determining the best pruning method by experimenting on Osage Orange trees off the line of the hedge. On-going maintenance will be annual pruning.

Interpretation material (signs and leaflets) should explain the significance of the hedge and management, both at the experimental / early pruning stages, and later maintenance stage.

2. Location and environment of Peats Crater

Peats Crater is located in the northern end of Muogamarra Nature Reserve, on the northern outskirts of Sydney (Figure 1). Access is via a four-wheel drive management trail, originally known as St Johns Road (Richmond 2000, pp. 12-17) but called the Peats Bight Road in the Plan of Management (NPWS 1998, p. 6). Because the Crater is entirely within the nature reserve, it is not generally open to the public, and there is no public use of vehicles on the trail. Muogamarra Nature Reserve is open to the public for six weeks in spring. During this time, guided and self-guided tours are provided by staff of the Parks and Wildlife Division, Department of Environment and Conservation, and knowledgeable local residents.

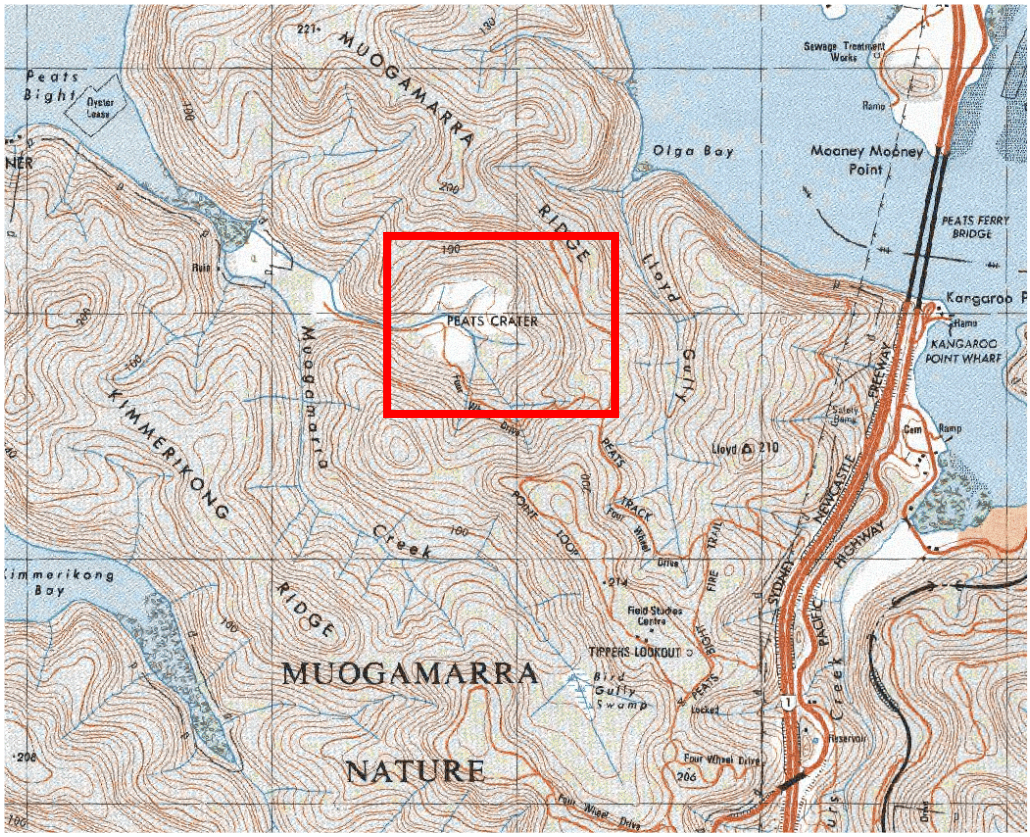


Figure 1. *Location of Peats Crater. Red rectangle shows area of Figure 2. Grid squares are 1 km.*

Source: Detail of Cowan 9130-IV-N topographic map. Copyright © Central Mapping Authority of NSW.

The Crater is the erosional expression of a weathered breccia diatreme (Figure 2). Some breccia is exposed in the creek flowing through the crater, and breaching the western walls. Soils in the crater are complex and range from clays derived from weathering of the breccia to slope-wash deposits from the surrounding sandstone ridges. The nutrient status of the different soils varies markedly, with those derived from breccia having higher levels of various elements. Because of its depth and more-or-less circular shape, the floor of the crater is protected from wind.

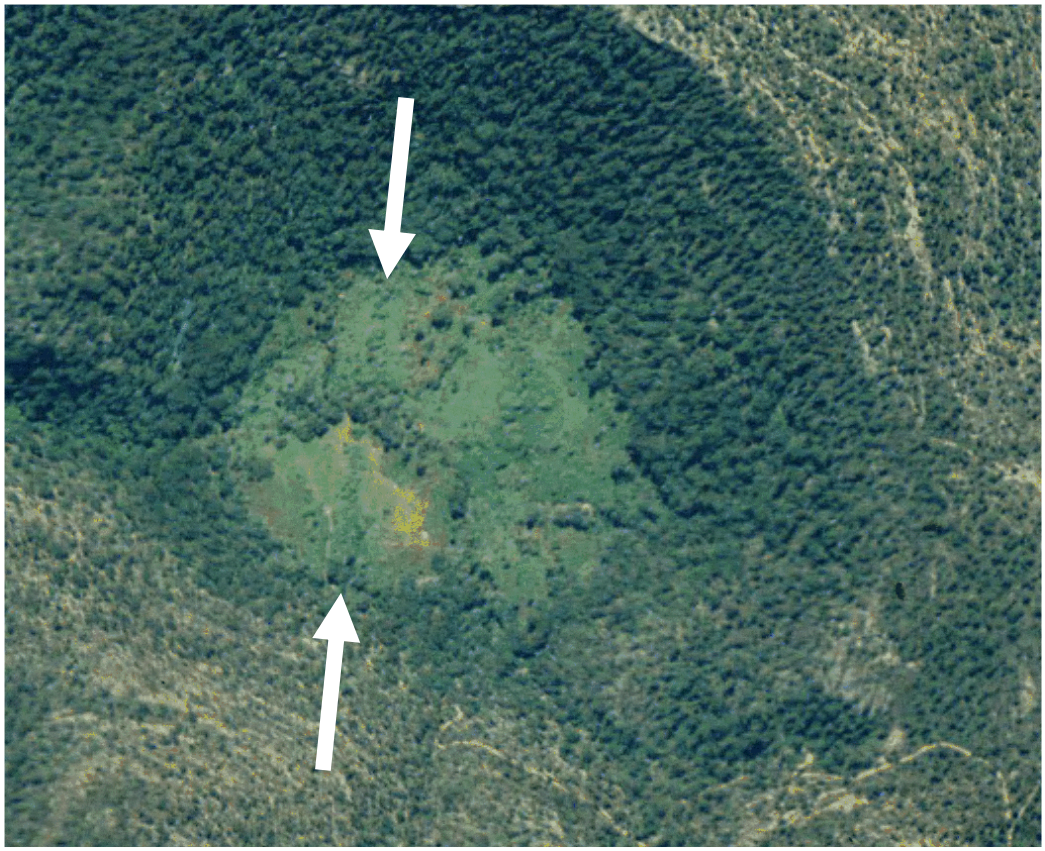


Figure 2. *Detail of vertical aerial photo of Peats Crater showing line of hedge of Osage Orange (arrowed). The access management trail (St Johns Road) is visible along the lower edge of the image which is approximately 1 km wide.*

Source: Detail from NSW Department of Lands Orthoview aerial photography, sheet 9130, scene LH 424. Copyright © NSW Department of Lands.

Vegetation on the surrounding sandstone varies markedly with aspect (Figure 2). Denser more mesic forest occurs on the northern side (i.e. the southerly aspect), and more open xeric woodland on the southern slopes (i.e. the northerly aspect). The original vegetation in the crater and on the slopes above the crater was selectively logged in the 19th and perhaps early 20th centuries. The floor of the crater has been completely cleared of original vegetation. The date of this clearing is unknown, but certainly dates from the late 19th and early 20th centuries. Current vegetation is a mix of colonising *Pteridium* (Bracken) and *Acacia* spp. (Wattles) expanding from the margins, and a large range of exotic herbs and sub-shrubs which are remnants of previous agriculture in the crater.

3. European history of Peats Crater

Peats Crater has a long history of European occupation and use, but key details about management remain sketchy and elusive. Land ownership in the Crater is summarised in Table 1 and illustrated with copies of original plans (Figures 3-5).

Although Richmond (2000, p. 12) states that the first land grant was to George Peat in 1836, the original applicant was John Donovan, and Peat purchased the block in October 1835 (annotations on Plan 214.690, NSW Department of Lands). Peat's motives for the purchase appear to have been speculation rather than settlement or farming. He was

anticipating a road from the crest of the ridge through the Crater and then to Peats Bight. Such a route would service settlers on the lower reaches of the river.

> *The extent to which the land in Peat's Crater was ever worked during Peat's life is a question that largely defies investigation. It may well be that Peat extracted useful timber from the area and he may well have run a few cattle there. Some authors have suggested that Peat had a house in the Crater, but there seems to have been no reason for this to have been true. The existence of Madden's hut* [Michael Madden was a convict assigned to Peat] *away from the Crater would suggest that there was no permanent residence on Peat's Crater holding.* (Richmond 2000, p. 12)

Table 1. Summary of land ownership in Peats Crater

Portion	**Portion 8**	**Portion 10**	**Portion 23a**
Area	50 acres (20.2 ha)	30 acres (12.1 ha)	~ 15 acres (6.1 ha)
Original applicant	John Donovan (NSW Department of Lands Plan 214.690)	George Peat 1840 (NSW Department of Lands Plan 414.690)	? Henry Britten
Original purchaser	George Peat, 14 October 1835 (NSW Department of Lands Plan 214.690)	George Sullivan ?1840	Henry Britten 1882
Subsequent changes in ownership	Heirs of Peat including J. Moss & John Campbell & Co 1921	Samuel Solomons 1842	William Henry Wood 1906
		John Dawson 1844	
		Richard Lloyd 1870s	
		Henry Britten 1883	
		William Henry Wood ~1908 / George Higgins ~1908	
	John Gray Wood 1920s – 1930s		
	NSW NPWS 1968		

Sources: Richmond (2000) and Bailey (1980s) except where noted.
Note: This compilation is incomplete, but further details are currently unknown.

In 1840, Peat applied for a second block of 30 acres at the eastern end of the Crater, adjoining his 50 acre block, but it was purchased by George Sullivan (Plan 414.690, NSW Department of Lands). There is no evidence that Sullivan ever used the land. Rather, like Peat, he seems to have been speculating on the likely route of a permanent road (Richmond 2000, p. 12). In the 1870s, Richard Lloyd bought land in the Crater, and this may have been Sullivan's block (Richmond 2000, p. 13). The third and final block of land in the Crater was acquired by the Reverend Henry Britten in 1883 (Figure 4). Britten was the first preacher at St Johns Church on Bar Island (Richmond 2000, p. 15). At nearby Peats Bight, Joseph Izzard and his family built a boarding house in the 1880s. All of this settlement was serviced by the river or via the track built by George Peat into the Crater. The track became known locally as "St Johns Road" as it was used as a route from the nearby centre of Brooklyn to river communities including Bar

Island, where St Johns Church was built in the early 1880s (Richmond 2000, pp. 12, 15).

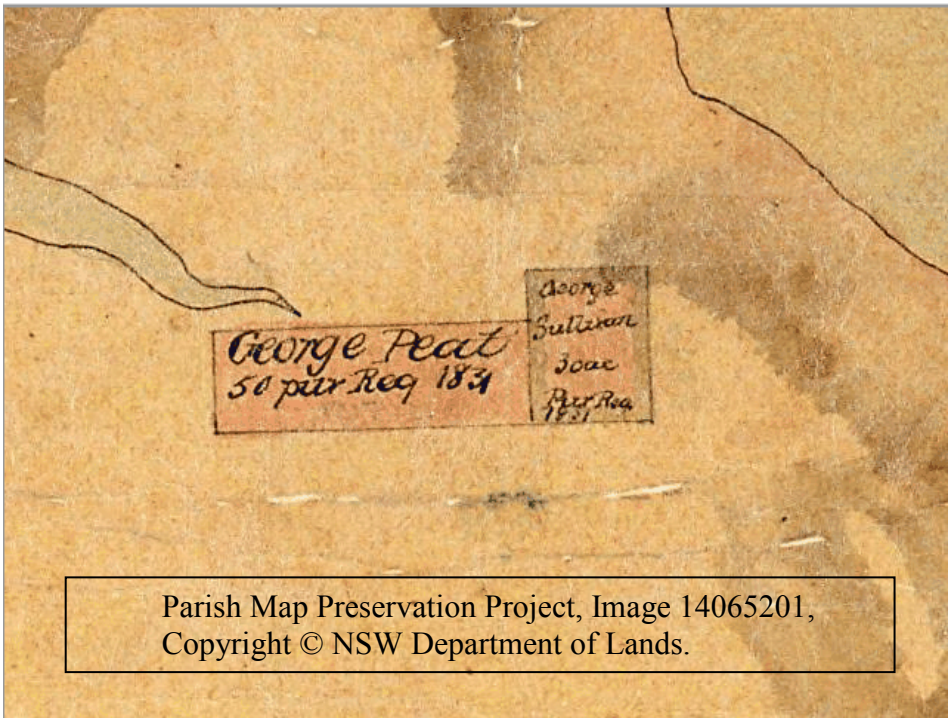


Figure 3. *Detail of plan of Parish of Cowan, unknown date, pre-1883, showing the 50 acre block purchased by Peat in 1835, and the adjoining 30 acre block purchased by Sullivan in 1840.*

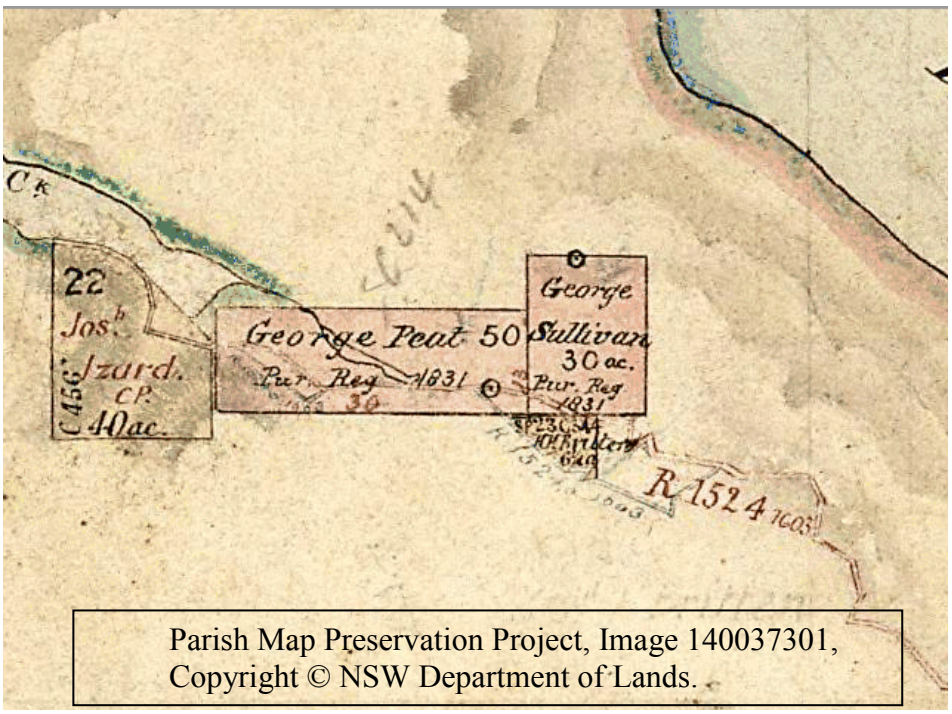


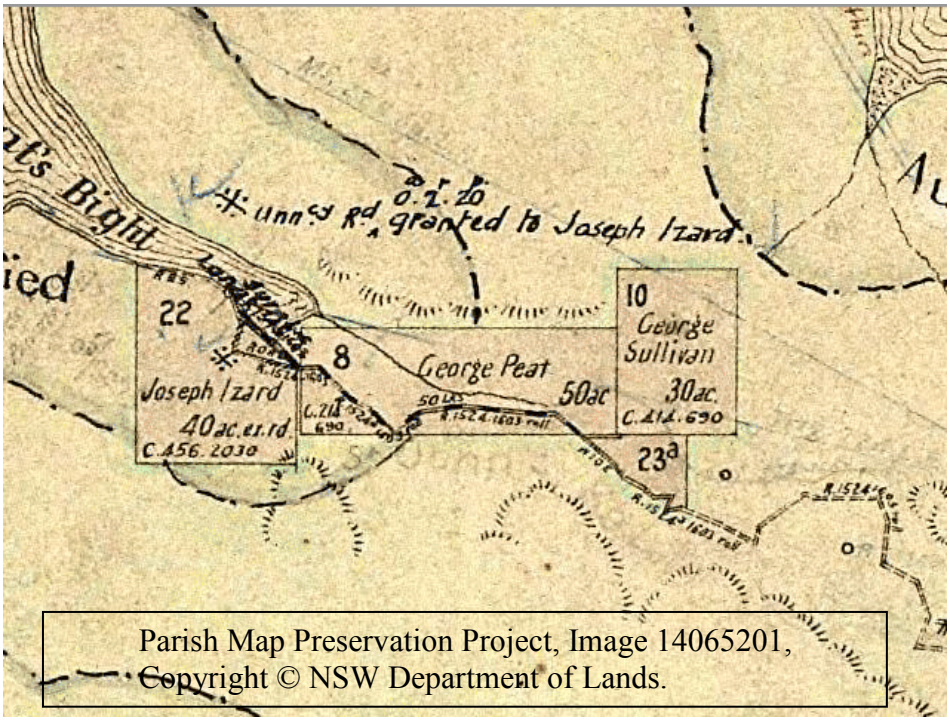
Figure 4. *Detail of plan of Parish of Cowan, unknown date, post-1883, showing small triangular block purchased by Britten in 1883.*

After various changes of ownership of land in the Crater,

> *Jack Wood gained control or ownership of the whole Crater … during the 1920s and 1930s. He operated a dairy* [near Brooklyn and moved cattle] *from the Crater* [to the dairy] *by means of St John's Road, …* (Richmond 2000, p. 27)

During World War 2, the army had a camp in Peats Crater, presumably as part of coastal defences against a possible invasion, but there appears to be no information on what impact this had on the Crater. In 1969, the entire area was proclaimed Muogamarra Nature Reserve, and the last of Jack Woods' cattle were mustered and removed or destroyed (Richmond 2000, p. 31).

The extent and intensity of farming in the Crater is difficult to determine. Various undulations on the northern side of the Crater are probably crop marks from previous orcharding and farming. They suggest that at least the richer breccia soils in the Crater were intensively managed in the past. The most visible signs of former agriculture and grazing are the line of Osage Orange trees and the numerous agricultural weeds infesting the Crater.



Parish Map Preservation Project, Image 14065201,
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Figure 5. *Detail of plan of Parish of Cowan, 1898 showing blocks and portion numbers assigned in 1885.*

4. Historical background to hedges

Hedges have been used for centuries for three primary purposes: to mark boundaries, to provide a barrier to stock or people, and as a shelter-belt / windbreak (Fitzherbert 1534; Nicol 1799; Sinclair 1832; Malden 1899; Beddall 1950; Van Eimern *et al.* 1964; Hooper and Holdgate 1970; Pollard *et al.* 1974; Brandle *et al.* 1988). Indeed, "live fences" or hedges were perhaps the commonest forms of fences in England in the 18th century even though they are labour-intensive to establish and then maintain (Rackham 1986, pp. 181-204).

English colonists in the American colonies initially used a variety of fences to protect crops from stock. Before the invention and successful commercialisation of barbed wire in the USA in 1874 (Krell 2002, pp. 11-27), farmers in the prairie states used a variety of approaches to fencing. In 1870, 64% of American fences were worm (or Virginia or zig-zag) and 12% were board (Primack 1969, p. 288). The chief problem was that worm fences used prodigious amounts of timber, which was scarce on the prairies. One solution was hedges, and Osage Orange (*Maclura pomifera*), a spiny shrub or small tree native to Texas, was a favoured species (See Appendix 2). Numerous nurseries supplied millions of seedlings to farmers eager to fence and subdivide their land (Warder 1858, Winberry 1979, Hewes 1981, pp. 513-514).

Hart (1998, pp. 172-173) summarised the boom and bust of Osage Orange hedges in the US:

> *Settlers from the East were concerned about the lack of wood for fencing when they moved into the treeless prairie grasslands of the Midwest. Some tried ditches and banks of sod, but neither of these worked well, and some experimented with plants they might use for hedgerows. The most popular was the Osage orange, which enjoyed a tremendous boom after 1845. Farmers from Illinois westward to Kansas planted thousands of miles of Osage orange to make thick, thorny hedgerows four feet wide and five feet high that they boasted were "horse-high, pig-tight, and bull-strong." The young plants had to be protected by some other kind of fence until they were three years old, and thereafter they had to be cut back regularly or they would grow into trees fifteen to twenty feet high.*
>
> *The Osage orange boom lasted only a decade; it collapsed abruptly after many plants were killed by the severe winters of 1855 - 56 and 1856 - 57. Some prairie areas still have a few long derelict strips of overgrown Osage orange hedgerow that begin nowhere and end nowhere, but most of the old hedgerows have been grubbed out or bulldozed.*

Nineteenth century fencing in New Zealand included hedges, but Gorse (*Ulex europaeus*) was favoured above all other plants, and Osage Orange rarely used despite being promoted by some agricultural writers (Hargreaves 1965, p. 150).

Fencing in colonial Australia before the 1850s was relatively uncommon because sheep were shepherded, and cattle allowed to roam freely (Pickard in press). In wooded areas, the fences were a mix of simple brush or log fences, and the more advanced post-and-rail fence (Pickard 1999, 2005). But fences were the exception rather than the rule until the late 1850s (Pickard submitted). Before extending onto sparsely-treed plains, Australian farmers and stock-owners did not lack timber, but English observers were distressed at the untidy fences (log, brush, post-and-rail) they saw, and predicted that these would be supplanted by hedges. Thus Howitt (1855, vol. 1, pp. 53-54) described fence development as a simple linear progression leading inevitably to the zenith of fences: hedges in the English style:

> *The fields are enclosed by what they call brush fences, that is, simply the trees as they are felled thrown along in long lines, and their branches piled upon them. That is the first rude fencing of a new country, and we passed plenty of it. After these come posts and rails; and finally as cultivation and wealth advance, will planted hedges succeed.*

Similar views about the role of hedges in a proper farmed landscape are apparent in early America:

> *To common farmers perhaps, the fence was nothing more than a necessary expense to protect their fields from intrusion, but to the gentleman farmer the hedge and other viable forms of enclosure were symbols representing various facets of his conceptions of land, nature and society*. (Bourcier 1984, p. 547).

In 1847 Mundy (1852, p. 61) observed that "there is hardly a mile of hedge in Australia". Presumably he meant the mainland, because in 1850 he noted numerous Sweet Briar (*Rosa rubiginosa*) and Hawthorn (*Crataegus monogyna*) hedges in Tasmania (pp. 181 – 182). At about the same time, Howitt (1855, vol. 2 pp. 365, 366, 375) also recorded numerous hedges in Tasmania including Furze or Gorse. An anonymous woman writing in 1861 (Anon 1861, pp. 14-17) clearly favoured hedges over fences, giving some instructions on establishing Hawthorn hedges. Today, Hawthorn hedges are a major feature of rural landscapes in northern Tasmania where many kilometres are still managed as property and paddock boundaries (Tassell 1998, pp. 80-82).

Some Australian nurserymen, seeing the huge trade in Osage Orange in the USA, were eager to create a similar market in Australia. One pamphlet (Anon 1867) extolled the virtues of the plant in glowing terms with extended quotations from American experts. However, hedges were not planted on a broad scale by Australian farmers at this time as the use of wire fences was spreading rapidly (Pickard submitted).

The Victorian Inspector of State Forests of Victoria (1873, p. 74) was impressed with Osage Orange as a fence:

> *The Osage orange (Macluria aurantiaca) has been highly recommended, and in America it is not equalled, but I most confess that, unless in deep alluvial soils and in warm districts, I have never yet met with a substantial fence of it.*
>
> *I believe, however, that in the deep warm soils of the Goulburn and Murray districts, hedges of Macluria may be grown to the greatest perfection; a hedge of it, when properly managed, is invincible.*

Osage Orange was planted in Australia as both ornamental tress and as hedges. Today it is essentially impossible to determine how many Osage Orange hedges were planted in Australia. They appear to have been quite rare, and today are even less common. Known examples of both hedges and individual trees are listed in Appendix 1. The example in Peats Crater is one of the very few surviving examples of a form of fencing technology that was tried briefly in colonial Australia but could not compete with iron and steel wire. It is also the longest and probably in best condition of the surviving Osage Orange hedges in New South Wales.

5. Osage Orange hedge in Peats Crater

An interrupted line of small trees of Osage Orange (*Maclura pomifera*) runs in an approximately north-south direction across Peats Crater in Muogamarra Nature Reserve. The trees appear to be a remnant hedge (Figures 6-9), approximately following the line of the boundary between portions 8 and 10, Parish of Cowan (Figures 3-5). The best expression of the hedge is on the southern side of the creek where a straight line of Osage Orange extends for some 120 m from an old wooden fence post to a position above the creek (Figures 8 and 9). Osage Orange trees also occur on the northern side of the creek for

approximately 60 m, but are not in a straight line, instead they are roughly clumped, so that it is difficult to discern if the hedge was continuous over the full width of the Crater.

The southern line contains numerous multi-stemmed trees to about 10 m high, with several isolated individuals nearby. A second very discontinuous line of smaller Osage Orange trees lies parallel to the southern section and about 2 m to the west (Figure 8). This suggests that a double line of trees was planted at some stage, but that only the eastern line has thrived. Several cut stumps on the secondary line indicate that at least some of the western trees have been deliberately removed.

The northern extension of the hedge on the other side of the creek is more difficult to trace, with the plants not being arranged in as neat a line as those on the southern side. Several isolated individuals and clumps occur at varying distances away from the line of the hedge. These isolated plants appear to be similar in age to those in the hedge line and are likely to also be intentional plantings. Some of these isolated plants are very large individuals, with considerably larger diameter trunks than those on the southern section of the hedge. Generally these very large plants are on soils derived directly from weathered breccia.

***Figure 6**. Southerly view across Peats Crater showing the Osage Orange hedge (arrowed) on the southern side of the crater. The section of hedge on the northern side is hidden by trees on the hillside.*

Figure 7. *Northerly view of Peats Crater showing the Osage Orange hedge with yellowing autumn foliage on the southern side of the crater, and extension on northern side of the creek.*

At some stage, but probably well into the 20th century, various lengths of plain and barbed wire have been strung between Osage Orange trees on the southern side (Figures 8 and 10). Presumably this was to form part of a yard.

6. Historical interpretation of Osage Orange in Peats Crater

Interpreting the Osage Orange (Figure 9) in Peats Crater is problematic. As noted above, hedges serve three primary, sometimes simultaneous, functions: to mark boundaries, to provide a barrier to stock or people, and as a shelter-belt / windbreak.

It is highly unlikely that the line of plants was intended as a shelter-belt or windbreak. The floor of the Crater is some 100 m below the surrounding ridges, and is well protected from winds.

If the line was on the boundary between portions 8 and 10, this would be strong evidence that the hedge was intended to at least mark the boundary. Unfortunately, the original plans of these portions (Figures 3-5) lack any reliable position data, thus attempts to accurately overlay the portion boundaries on the rectified air photo were unsuccessful. However, the line of the hedge appears to be along the portion boundary, and can be provisionally interpreted as a boundary marker.

Figure 8. *Northerly view down western side of hedge showing second parallel but discontinuous line of Osage Orange on western side of main hedge. Note plain wire attached to right-hand trunks.*

Figure 9. *Northerly view along the eastern face of the Osage Orange hedge.*

The next question is whether the hedge was intended as a fence. An old post survives at the southern end of the hedge, but despite careful and repeated searching, no trace of a fence

has been found on the margins of the crater. Even though there is little feed etc. to attract stock to the sandstone slopes, stock (and especially cattle) will wander into forest for shade, and to selectively graze any plant that is palatable. While it is conceivable that repeated bush fires have burnt any posts that may have originally been present, it is unlikely that no trace remains. Experience with both log and post-and-wire fences in other highly fire-prone areas (e.g. Pilliga forest, Albert State Forest and Kosciuszko National Park) shows that log fences and wooden posts can survive for well over 100 y (Pickard in preparation).

Some of the Osage Orange trees near the southern end of the hedge have various lengths of plain and barbed wire attached to them and embedded in the trunks (Figures 8 and 10). Despite careful searching, these wires have not been found along the full length of the hedge. This suggests that the southern end of the hedge may have been used at some time as one side of an enclosure or yard, rather than as a full-length fence. The barbed wire used was known in the trade as Waukegan barbed wire, and was commercially available in Australian from at least the late 19th century and has been used throughout the 20th century. This barbed wire is widespread across Australia, but not particularly common (data from field work). As the barbed wire has been used over such a long period, it is not possible to assign even an approximate date to this probable yard.

***Figure 10**. Waukegan barbed wire embedded in the trunk of Osage Orange tree near the southern end of the hedge. Barbed and plain wire in the section of the hedge may have been used to strengthen the hedge as a stock barrier, or to form one side of a yard. The wire poses a severe safety hazard to chainsaw operators during pruning.*

At this stage, with no additional archival information, I conclude that the line is indeed a hedge, but one to *mark* a boundary, rather than to serve as a stock-proof barrier.

7. Heritage significance of Osage Orange hedge

The following assessment uses the criteria of the NSW Heritage Office (2001, p. 9, 12 - 25)

> **Criterion a**: an item is important in the course or pattern, of NSW's (or local) cultural or natural history.

The history of fencing, both to mark boundaries and to retain / exclude stock, is complex. Despite the views of early English observers, fencing in the Australian colonies did not follow the preferred development from brush to post-and-rail to the zenith, hedges in the English style. Instead, hedges were surpassed by the more prosaic, cheaper and easier to manage post-and-wire fences that became dominant in the 1850s. Any surviving boundary or stock-exclusion hedges are thus important in demonstrating the evolution of fencing in NSW and Australia.

Grading: Exceptional
Significance: State level

> **Criterion b**: an item has a strong or special association with the life or works of a person, or group of persons, of importance in NSW's (or local) cultural or natural history.

George Peat was an important figure in the early settlement of the Hawkesbury River, and more particularly in the development of a trafficable route across the River. However there is no evidence that he was directly associated with the hedge.

Grading: Nil
Significance: Nil

> **Criterion c**: an item is important in demonstrating aesthetic characteristics and / or a high degree of creative or technical achievement in NSW (or the local area).

The hedge does not demonstrate aesthetic characteristics nor creative or technical achievement.

Grading: Nil
Significance: Nil

> **Criterion d**: an item has a strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons.

There is no evidence of strong or special association with any particular group.

Grading: Nil
Significance: Nil

> **Criterion e**: an item has potential to yield information that will contribute to an understanding of NSW's (or local) cultural or natural history.

The Osage Orange hedge is one of very few known to currently survive in NSW. It is an important record of a rare combination of technology from Great Britain (hedges as

boundaries) using a hedge plant that was the dominant fence in the United States prior to 1874. Thus it forms part of the rich history of fencing in NSW and Australia.

Grading: High
Significance: State level

> **Criterion f**: an item possesses uncommon, rare or endangered aspects of NSW's (or local) cultural or natural history.

Hedges were never particularly common in NSW on rural properties other than as windbreaks / shelterbelts, or ornamental driveways. Very few good examples of boundary hedges survive, few of these are actually managed today as hedges (e.g. near Bowral). The Peats Crater hedge is one of the very few known using Osage Orange to survive in NSW. Thus it is a rare example combining cultural (hedges, property boundaries) and natural (use of Osage orange) history.

Grading: Exceptional
Significance: State level

> **Criterion g**: an item is important in demonstrating the principal characteristics of a class of NSW's (or local) cultural or natural places; or cultural or natural environments.

The hedge demonstrates none of these features.

Grading: Nil
Significance: Nil

Summary of heritage significance

The Osage Orange hedge in Peats Crater demonstrates multiple heritage criteria, and satisfies criteria a, e and f, at such a level as to be considered of *State significance*.

Hedges were a technological dead-end in the Australian colonies. They were never common in rural NSW, and any that survive, either as boundary markers or as fences, are rare today. This example demonstrates one approach to marking boundaries. **(Criterion a)**.

The hedge combines British fencing technology (hedges) of the 18th and 19th centuries with the most widely used hedge plant in the USA in the 19th century before the invention of barbed wire in 1874. **(Criterion e)**.

The Peats Crater hedge is currently one of very few known using Osage Orange to survive in NSW. Thus it is a rare example combining cultural (hedges, property boundaries) and natural (use of Osage orange) history. **(Criterion f)**.

8. Potential invasiveness of Osage Orange

The Plan of Management for the nature reserve raises concerns that the Osage Orange in Peats Crater is spreading and threatening the surrounding natural environment (NPWS 1998, pp. 24-25). I first saw this hedge in the 1970s and several times since and there is little evidence of this threat.

Experience in the US suggests that the plants can reproduce by suckering (see Appendix 1) . However there is no sign of this in the crater despite several roots being exposed on the surface (Figure 11).

The plant is dioecious, i.e. there are separate male and female plants. This accounts for the lack of fruit under many of the trees. The female trees in Peats Crater produce abundant fruit (Figure 11), but these simply lie on the ground and rot. A few are partially eaten by wildlife, although it is unknown whether this is by birds (e.g. cockatoos) or mammals.

Figure 11. *John Pickard pointing to an exposed root of Osage Orange which is not suckering. Note the abundant fruit lying on the ground, and the lack of ground cover other than fallen leaves in the dense shade from the hedge.*

The isolated trees and clumps on the northern side of the crater range from a small plant about 3 m high to massive multi-stemmed clumps. Despite the sheer size of the clumps, and the large numbers of fruits, there is no evidence of seedlings around them.

There is no evidence that the plant poses a threat to the natural environment through spreading by either seed or vegetative means.

The deep shade under the dense crowns of clumps of Osage Orange, together with surface roots effectively prevents most plants from germinating or growing under the crowns. This is particularly apparent under the massive trees on the northern side of the crater. A range of herbs and sub-shrubs grow up to the margin of the crown, but scarcely penetrate the shaded area. As many of these plants are exotics, including aggressive species such as *Tagetes* (Stinking Roger) and *Rubus fruticosa* (Blackberry), the Osage Orange is inhibiting their spread. If the trees are removed, these exotic species will immediately colonise the newly available bare ground.

9. Management alternatives

As Peats Crater is in Muogamarra Nature Reserve, the Osage Orange hedge is an exotic element in an area dedicated primarily to conservation of the natural environment. Under normal circumstances and approaches to management of nature reserves, such exotic plants would be removed. However as the hedge is a significant item of historic heritage, its retention is more appropriate. Like other NSW government agencies, the Parks and Wildlife Division of the Department of Environment and Conservation has obligations to manage historic heritage, both under the *National Parks and Wildlife Act 1974* and the *Heritage Act 1977* (see e.g. the State Agency Heritage Guide http://www.heritage.nsw.gov.au/docs/StateAgency_HeritageGuide.pdf prepared by the NSW Heritage Office)

The hedge is of state heritage significance, and thus should be managed to conserve this status. The alternatives are:

a) *status quo*: continue present approach of retention but no active management.
While this may be a less resource-intensive alternative, it does not meet the conservation requirements of the hedge as an item of significant cultural heritage.

b) active management: return the trees to their likely original form.
Hedges intended as boundary markers in Great Britain were generally pruned regularly to keep the plants about 3 m high, and bushy. To achieve this, the trees on the line of the hedge would be pruned to remove much of the bulky crowns, and encouraging stem suckers to form a dense hedge close to ground-level, growing up to perhaps 3 or 4 m high.

c) active management: as in b) plus remove isolated trees.
Scattered isolated trees not on the line of the hedge would be removed. While this satisfies the imperative to remove an exotic element from the nature reserve, it has consequences mentioned above: an immediate spread of exotic weeds already in the Crater onto the bare ground under the Osage Orange trees. This is not desirable. Further, while there is currently no information (archival or anecdotal) on the reasons for these isolated plants, such information may become available in the future. Removing these trees now loses any heritage significance that may be determined in the future.

Thus, the isolated trees should be retained unless there are sound reasons for removing them. An exception would be to experiment on selected isolated trees to determine the effectiveness of pruning.

d) remove all Osage Orange trees from Peats Crater
This is not an appropriate option given the significance of the hedge.

RECOMMENDATION: the hedge should be actively managed and returned to its likely original form by progressive pruning after experimental pruning on isolated individuals to confirm that such pruning will achieve the desired outcome.

10. Advice from USA on managing Osage Orange

On 27 April 2005 I posted a query on the US-based discussion group H-RURAL (H-RURAL@H-NET.MSU.EDU) seeking information on US experience in managing Osage Orange hedges, and specifically the likely effect of pruning the 10 m high plants back to about 2-3 m high to achieve the likely original form of the hedge.

The consensus of replies was:

1. pruning the Osage Orange causes it to sprout many more times outward, and that good pruning causes the hedge to become more hedge-like and less tree-like.
2. pruning a plant with a single stem will probably kill the plant
3. in the case of multi-stemmed plants, test prune one of the stems to see if new growth sprouts from the base.
4. if this test pruning is successful, set up a three to four year cycle to cut one stem per year. Prune the stem to the ground and let the new growth achieve the desired height of the hedge.
5. in the case of large plants, it may be appropriate to prune by thirds: remove the top third in year 1, the next third in year 2, etc., until the desired height is achieved.
6. the timing of pruning can be critical
7. pruning is best accomplished when in dormancy or at times other than spring flush or before dormancy
8. for minor pruning, less than 5-10% of plant mass / volume, seasonal considerations are less important

11. Proposed management of Osage Orange hedge

The proposed management follows the principles and procedures specified in Articles 14-25 of the Burra Charter (Walker and Marquis-Kyle 2004, pp. 52-77).

a. Objectives

1. To return the line of Osage Orange on the southern side of Peats Crater to the form of hedge, perhaps 3 – 4 m high by pruning / lopping the trees.
2. To retain all other trees of Osage Orange until their significance can be better determined.

b. Returning the hedge to its likely original form

1. Experiment by lopping / pruning a number of individuals in the isolated clumps to see if the plants survive and respond by stem suckering.
2. If this is successful, commence a program of removing approximately one-third of the height of individual stems in each multi-stemmed tree on an annual basis until the trunks are uniformly reduced to a basic height of about 1 m.
3. Remove any native trees / shrubs that have invaded along the line of the hedge.

c. On-going maintenance

1. Allow the plants to grow to about 3 or 4 m high before commencing maintenance pruning on an annual basis.
2. Remove any native trees / shrubs that have invaded along the line of the rejuvenated hedge. This should be extended out from the hedge for say 15 m on either side to retain the integrity of the hedge and to emphasise its original function as a boundary between portions.

d. Experimental plants

1. Any multi-stemmed plant not wholly within the main and secondary parallel lines of the hedge on the southern side. These can be identified during a site inspection and flagged.
2. Although there are several trees on the northern side which are off the line of the hedge, most are massive and their removal poses serious OH&S and ecological risks. At this stage, these should be retained as is, at least until the experiment is ended.

e. OH&S considerations

1. The plant is spiny, and the long spines pose a danger to any person working close to the plants, especially during trimming or lopping operations.
2. The wood is extremely hard, one of the hardest in North America. It is reputed to quickly dull chainsaws, thus care is required to maintain sharp saws. A misguided axe will bounce off the wood.
3. Barbed and plain wire is deeply embedded in the trunks of some of the trees near the southern end of the hedge. Chainsaw operators will need to be extremely careful when pruning these trunks.

f. Ecological considerations

1. Removing dense crowns will expose the ground to light, and thus provide opportunity for invasion by exotic herbs and sub-shrubs which are already rampant across the crater.
2. Several native trees and shrubs are invading the line of the hedge. This is inevitable, but they should be removed to enhance the integrity of the hedge. There will be minimal environmental impact in such removal.

g. Disposal of cut logs and branches

1. Disposing of cut material poses a problem, as the wood decays extremely slowly. Cutting into relatively short lengths (perhaps 1 – 2 m) and piling to dry before burning about 12 months later is probably the least damaging approach.
2. An alternative for the larger pieces of wood (say > 100 mm diameter) is to sell them to wood-turning enthusiasts and cabinet makers for specialised timber work. This would require some prior investigation to determine if there is a market for the timber, likely price to at least cover some of the costs, any immediate treatment needed (e.g. painting cut ends of logs with polyethylene glycol (PEG) to assist better seasoning), and removal from the Crater. Magazines such as *The Australian Woodworker* (http://www.skillspublish.com.au/Skills%20AWW%20Current.htm) would provide some of the necessary information, or at least contacts from whom to elicit additional information. There are several firms and individuals who specialise in timber salvage who may be interested in tendering for salvage of the Osage Orange timber (see above website, and click on “Timber Salvage”).

12. Interpretation of the Osage Orange hedge

Although public access Peats Crater is heavily restricted, at least some visitors visit the Crater outside authorised and guided visits. All visitors to the Crater would recognise the hedge as a linear exotic element in the nature reserve. However it is unlikely that many visitors would understand the history, significance, and the management plan

actions used to maintain the hedge. Thus, interpretation material is essential. Further, it is required at two distinct stages.

1. *During experimentation and early heavy pruning stage*
   Interpretation should focus on both the significance of the hedge, and the reasons for the apparent heavy destruction caused by the heavy pruning.

2. *During on-going maintenance stage*
   Interpretation should focus on the significance of the hedge, and the reasons for the on-going maintenance pruning.

13. Acknowledgements

Tegan Burton (National Parks and Wildlife Division, Department of Environment and Conservation) commissioned this study of the Osage Orange hedge at Muogamarra Nature Reserve. Tom Richmond (local historian of Brooklyn) provided considerable advice on the early history of Peats Crater and the likely origin of the hedge.

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Unless otherwise acknowledged, all images are by John Pickard.

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Appendix 1: Distribution of Osage Orange hedges in Australia

On 17 August 2006 I posted a query on Osage Orange to the email list of the Australasian Society for History Archaeology. The following summarises the responses.

New South Wales

The Flags Inn site, Main Road 55, Coolah to Mullaley via Tambar Springs, Warrumbungle Shire.
A number of Osage Orange trees on the road reserve are remnants of a hedge that originally defined the yards associated to the inn. The inn operated from c. 1875 to c. 1920. (Ray Christison, heritage consultant).

Bullock Creek, north east of Tullamore.
Dr Peter Mitchell (Groundtruth Consulting) noted a short hedge along the public road near the property *Corella* in the 1980s. Whether this hedge still exists is currently unknown.

Araluen Valley
A number of individual Osage Orange trees in Araluen Valley are remnants of plantings near the old gold-mining settlements that once occupied the valley. None of the plants form hedges. (Kirsty Altenberg, heritage consultant)

Combewood, Penrith
The original Osage Orange hedges at *Combewood* were removed in the mid-20th century by the then-owner because advice from the NSW Department of Agriculture suggested that the fruits are poisonous to stock (Colleen Morris, specialist in garden and landscape history)

Dunheved
A hedge on the eastern bank of South Creek, but its present status is unknown. (Warwick Mayne-Wilson, Mayne-Wilson & Associates, Conservation Landscape Architects)

Jarvisfield (currently Picton Golf Club)
An Osage Orange hedge that has not been maintained, so the plants have grown into trees. The entire complex including the hedge is on the NSW State Heritage Register (http://www.heritage.nsw.gov.au/07_subnav_01_2.cfm?itemid=5045544 accessed 19 September 2006) (Stuart Read, Heritage Officer, Heritage Office, NSW Department of Planning)

Argyle, 25 km ESE of Inverell
Osage Orange hedge on property *Argyle* (Camilla McCrae). The hedges surround yards at the woolshed (Stuart Read, Heritage Officer, Heritage Office, NSW Department of Planning)

Trevallie, 9 km NW of Armidale on Primrose Hill Road
Osage Orange hedge on property originally known as *Trevallie*, now shown on 1:25,000 topo map (Dumaresq - 9237-111-S) as "Old Stone Cottage". (Camilla McCrae).

Springfield, Goulburn
Three individuals of Osage Orange are probably the remnants of a hedge around sheep yards behind the woolshed. (Stuart Read, Heritage Officer, Heritage Office, NSW Department of Planning)

Bungonia and Goulburn
Hedge remnant at the Old parsonage, Bungonia (Brookes 1995, p. 6) as well as various trees in this area reported by Colleen Morris (specialist in garden and landscape history).

Victoria

Strathfieldsaye near Bendigo
A row of Osage Orange is planted along a main road. The trees are widely spaced and not trimmed, thus they form an avenue rather than a hedge (Andrea Murphy, heritage consultant).

Rutherglen
"A single Osage Orange - or it may have been a small clump - planted on the fence line between a vineyard and the main road near Rutherglen in northern Victoria. I don't think it is there any longer, but it was certainly there in the 1940s and 50s. It was approximately three kilometers from Rutherglen on the road to Wahgunyah on the south side, directly under a house, known as Cannobie, on the top of a low hill set back about 800 metres or so from the road." (Campbell McKnight, heritage consultant).

Eddington (approximately midway between Bendigo and Maryborough
An Osage Orange hedge on Mock Orange Lane is listed on the National Trust of Australia – Victoria Register. Item T11198, State level significance: "Location or Context: historic planting style typical of the way this species was used, this row 0.6 km in length, is quite intact and extensive. It is the longest hedge planting of the species known in Victoria. Measurements: Spread (m): 7.2 Girth (m):Height (m): 7.5 Estimated Age (yrs): 90 Condition: Good".
(http://www.nattrust.com.au/trust_register/search_the_register/maclura_pomifera accessed 20 September 2006) (John Hawker, Horticulturalist, Heritage Victoria).

Everton (22 km south east of Wangaratta on Great Alpine Road / Ovens Highway)
Hedges of Osage Orange on both sides of the road. The main section is on the southern side of the road. The hedge on the northern side has been successfully pruned from large trees cut about 1 m above ground level. The southern hedge is on the National Trust of Australia – Victoria Register. Item T11209, State level significance: "Location or Context: historic planting style; Aesthetic Value An outstanding hedge planting (windbreak) first introduced from the USA in the 1860s, few examples survive. Remnants occur around the vineyards at Rutherglen. Measurements: Spread (m): Girth (m):Height (m): Estimated Age (yrs): 100 Condition: Good-Fair"
(http://www.nattrust.com.au/trust_register/search_the_register/maclura_pomifera__1 accessed 20 September 2006) (John Hawker, Horticulturalist, Heritage Victoria)

Other sites in Victoria
Osage Orange occurs at other sites in Victoria, but none of the hedges is as extensive as the examples at Eddington: Bullen (two hedgerows planted in 1930s at the Heide Art Gallery), Beaufort (Mawallok), Hamilton (Murndal), Myers Flat near Bendigo, Castlemaine, Ivanhoe, and Lilydale (John Hawker, Horticulturalist, Heritage Victoria)

South Australia

Glenthorne Estate, southern Adelaide
Four Osage Orange trees not forming a hedge are listed in the National Trust of South Australia's Register of Significant Trees for their horticultural value. Their history is uncertain, but they were probably planted before 1878 as an acclimatisation experiment. The Glenthorne Estate was in several private ownerships as an agricultural farm from 1839 until 1913, then operated by the Army as a remount depot, later a CSIRO experimental laboratory, and now owned by the University of Adelaide. (Dr Peter Bell, Consulting Historian, Historical Research Pty Ltd)

Tasmania

No records. (Anne McConnell, Hobart; and Gwenda Sheridan, landscape historian)

Appendix 2: Extract from US Forest Service *Silvics of North America. Volume 2 Hardwoods*

http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/maclura/pomifera.htm
(URL verified 18 August 2006)

Burns, Russell M., and Barbara H. Honkala, tech. coords. (1990). *Silvics of North America: 1. Conifers; 2. Hardwoods*. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 pp.

Maclura pomifera (Raf.) Schneid. **Osage-Orange (Moraceae)**

J.D. Burton

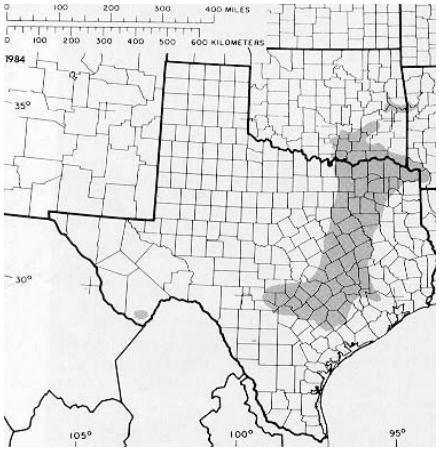
Osage-orange *(Maclura pomifera)* produces no sawtimber, pulpwood, or utility poles, but it has been planted in greater numbers than almost any other tree species in North America. Known also as hedge, hedge-apple, bodark, bois-d'arc, bowwood, and naranjo chino, it made agricultural settlement of the prairies possible (though not profitable), led directly to the invention of barbed wire, and then provided most of the posts for the wire that fenced the West. The heartwood, bark, and roots contain many extractives of actual and potential value in food processing, pesticide manufacturing, and dyemaking. Osage-orange is used in landscape design, being picturesque rather than beautiful, and possessing strong form, texture, and character.

Habitat

Native Range

The natural range of Osage-orange is in the Red River drainage of Oklahoma, Texas, and Arkansas; and in the Blackland Prairies, Post Oak Savannas, and Chisos Mountains of Texas (28). According to some authors the original range included most of eastern Oklahoma (34), portions of Missouri (49, 54), and perhaps northwestern Louisiana (28, 49).

Osage-orange has been planted as a hedge in all the 48 conterminous States and in southeastern Canada. The commercial range includes most of the country east of the Rocky Mountains, south of the Platte River and the Great Lakes, excluding the Appalachian Mountains.



The native range of osage-orange.

Climate

Within the natural range of Osage-orange, average annual temperature ranges from about 18° to 21° C (65° to 70° F), July temperature averages 27° C (80° F) and January temperature ranges from 6° to 7° C (43° to 45° F) with an extreme of -23° C (-10° F). The frost-free period averages 240 days. Average annual precipitation ranges from 1020 to 1140 min (40 to 45 in), and April to September rainfall from 430 to 630 min (17 to 25 in).

Osage-orange is hardy as far north as Massachusetts but succumbs to winter-kill in northeastern Colorado and the northern parts of Nebraska, Iowa, and Illinois (34, 36).

Soils and Topography

Even within the limited native range, growth of Osage-orange before agricultural settlement was restricted to about 26 000 km² (10,000 mi²) , and probably half that area produced no trees of merchantable size (17, 32). Some pure stands covered as much as 40 ha (100 acres), but most were much smaller. Pure stands appeared on rich bottom-land Soils and were called "bodark swamps" (colloquialism for bois-d'arc). Though not true swamps, these areas frequently became inundated. Over much of its natural range, particularly south of the Red River, Osage-orange grew in isolated small stands, either pure or mixed with other hardwoods, interspersed with prairie. The largest trees and those of the best quality grew on bottom lands of the Red River tributaries in Oklahoma. Most bodark swamps have been converted to fields, and within the Red River system today Osage-orange grows most commonly on sandy terraces not yet occupied by other vegetation and on Blackland Prairie soils underlain by chalk or marl. Distribution and abundance of natural regeneration seem to depend more on lack of competition than on kind, quality, or condition of soil.

Osage-orange readily escapes from cultivation and invades exposed, eroding soil, particularly in overgrazed pastures. Thickets are characteristically found along fence rows, ditch banks, ravines, and around abandoned farmsteads.

Most observers report that Osage-orange grows vigorously on all soils (32, 34). Some state, however, that hedges planted on soil from which the Al horizon is removed do not thrive as well as those on less eroded sites (48). On sandy soils where the topsoil has blown away, growth of Osage-orange (and other species) in the Prairie States Forestry

Project is strongly retarded (33). Natural regeneration is abundant and vigorous on many soils (Alfisols, Ultisols, Vertisols, and Mollisols), including those too alkaline for most forest trees. The species is sensitive to soil compaction. It thrives best on moist soils but tolerates extreme drought. It is resistant to heat, road salt (22), and urban air pollution (42).

Associated Forest Cover

Osage-orange is not included in any of the forest types recognized by the Society of American Foresters (13). In moist, well-drained minor bottom lands in northwestern Louisiana and nearby parts of Oklahoma, Arkansas, and Texas, it is found with white oak *Quercus alba),* hickories *(Carya* spp*.),* white ash *(Fraxinus americana),* and red mulberry *(Morus rubra)* (37). In Nebraska and Kansas, it invades overgrazed pastures, accompanied by honeylocust *(Gleditsia triacanthos)* and is succeeded by black walnut *(Juglans nigra),* oaks *Quercus* spp*.),* hackberry *(Celtis spp.),* hickories, and elms *(Ulmus* spp.) (18). Among the most common associates on lime stone- derived soils in middle Tennessee and neighboring portions of Kentucky and Alabama are eastern redcedar *(Juniperus virginiana),* black walnut, hickories, and elms (45).

Life History

Reproduction and Early Growth

Flowering and Fruiting- Osage-orange is dioecious. The simple, green, four-part flowers appear soon after the leaves on the same spurs, opening from April through June, and are wind pollinated. Male flowers are long peduncled axillary racemes 2.5 to 3.8 cm (1 to 1.5 in) long on the terminal leaf spur of the previous season; female flowers are in dense globose heads, axillary to the leaves, about 2.5 cm (1 in) in diameter (2). The female flower in ripening becomes very fleshy, forming a large multiple fruit or syncarp composed of 1-seeded drupelets. The fruit ripens from September through October. The ripe fruit, 7.6 to 15 cm (3 to 6 in) in diameter, yellowish-green, resembles an orange, often weighing more than a kilogram (2.2 lb). Fruits average 23/dkl (80 to the bushell) (53). When bruised, the fruit exudes a bitter milky juice which may cause a skin rash and which will blacken the fruit on drying.

Female trees often produce abundant fruit when no male trees exist nearby, but such fruit contains no seeds.

Seed Production and Dissemination- Female trees bear good seed crops nearly every year, beginning about the 10th year. Commercial seed-bearing age is optimum from 25 to 65 years, and 75 to 100 years may be the maximum (53). Germinative capacity averages 58 percent. Seeds are nearly 1 cm (0.4 in) in length. The number of clean seeds ranges from 15,400 to 35,300, averaging 30,900/kg (7,000 to 16,000, averaging 14,000/lb). Livestock, wild mammals, and birds feed on the fruit and disseminate the seed. The seeds have a slight dormancy that is easily overcome by soaking in water for 48 hours or by stratifying in sand or peat for 30 days. Fruit stored over winter in piles outdoors is easily cleaned in the spring, and the seed germinates promptly. Viability can be maintained for at least 3 years by storing cleaned, air-dried seeds in sealed containers at 5° C (41° F) (56). Recommended sowing depth is about 6 to 13 min (0.25 to 0.5 in); soil should be firmed.

Seedling Development- Germination is epigeal. Natural regeneration apparently requires exposed mineral soil and full light. A study of survival and growth in the Prairie States Forestry Project windbreaks indicated average survival of Osage-orange at age 7 years to be 68 percent, ranking seventh of 16 "shrubs"; total height was 2.4 m (8 ft), ranking fifth of 16; and crown spread was 1.8 m (6 ft). Osage-orange was usually planted in the shrub (outer) rows and sometimes in the tree (inner) rows. It grows too fast, however, to be considered a shrub and often overtops slower growing conifers (33).

Vegetative Reproduction- Osage-orange may be vegetatively propagated using root cuttings or with greenwood cuttings under glass. To propagate thornless male (nonfruiting) clones for ornamental use, scions or cuttings should be taken only from the mature part of the crown of a tree past the juvenile stage. Perhaps the easiest way to grow selected stock is by grafting chip buds onto nursery-run seedlings and plastic-wrapping the graft area (30, 31).

Sapling and Pole Stages to Maturity

Growth and Yield- Osage-orange is a small tree or large shrub averaging 9 m (30 ft) in height at maturity. Isolated trees on good sites may reach heights of as much as 21 m (70 ft); crowded trees usually do not grow so tall. In windbreak plantings on the Great Plains, Osage-orange grew 6 m (20 ft) tall on average sites during a 20-year period; on some sites it grew 12 m (40 ft) tall (39).

Branchlets growing in full sunlight bear sharp, stout thorns. Slow-growing twigs in the shaded portions of the crown of mature trees are thornless. The thorns, 1.3 to 2.5 cm (0.5 to 1 in) long, are modified twigs. They form in leaf axils on 1-year-old twigs. Shade-killed lower branches remain on the tree many years. Regional estimates, based on the 1964-1966 Forest Surveys, indicated virtually no Osage-orange of commercial size and quality on forest land in Oklahoma, Texas, and Louisiana. There are two reasons for this: the species usually grows on nonforest land, and merchantability standards for forest trees do not apply to Osage-orange. Mature trees have short, curved boles and low, wide, deliquescent crowns. Even in closed stands on good sites, less than half the stems contain a straight log, 3 m (10 ft) long, sound and free of shake.

Rooting Habit- Osage-orange is characteristically deep rooted, but because it has been planted so widely, the species is usually off-site, where its rooting habit is variable. When the tree grows on shallow, fertile soils over limestone, the lateral rootspread is tremendous (32).

Excavation of root systems in 7-year-old or older shelterbelts revealed a lateral radius of 4.3 m (14 ft) and a depth of more than 8.2 m (27 ft) for Osage-orange near Goodwell, OK (9). The soil was Richfield silt loam. Most of the lateral roots were in the uppermost 0.3 m (1 ft) of soil. Excavations in Nebraska revealed a lateral radius of 2.1 m (7 ft) and a depth of 1.5 m (5 ft) for 3-year-old Osage-orange in Wabash silt loam; for 23-year-old Osage-orange in Sogn silty clay loam, lateral radius was 4.9 m (16 ft) and depth was 2.4 m (8 ft) (47). At both ages, there was a well-developed taproot, and most of the long laterals originated within the first 0.3 m (I ft) of soil. At 3 years, most of the long laterals were within the first 0.6 m (2 ft) of soil; at 23 years, laterals were as abundant in the eighth as in the first foot of soil.

Reaction to Competition- Osage-orange is tolerant according to some authors (6, 37) and very intolerant according to others (3). Overall, it is most accurately classed as intolerant of shade. The occurrence and circumstances of natural regeneration suggest intolerance, but the growth of planted Osage-orange in hedges and shelterbelts, under strong competition, indicates tolerance. How vigorously and at how advanced an age the species responds to release has not been deter-mined. Severe competition does not prevent abundant seed production. Osage-orange sprouts vigorously, even following cutting of interior rows in windbreaks.

No literature on the silviculture of naturally regenerated forest stands of Osage-orange is known.

Damaging Agents- Although Osage-orange is one of the healthiest tree species in North America, it is attacked by some parasites. Cotton root rot, caused by *Phymatotrichum omnivorum,* attacks Osage-orange and most other windbreak species in Texas, Oklahoma, and Arizona (59). Losses are greatest in plantings on dry soil where rainfall is scant. Cotton root rot is the only serious disease.

Two species of mistletoe, *Phoradendron serotinum* and *P. tomentosum,* grow in the branches and cause witches' brooms. Osage-orange ornamentals in the Northeast have occasionally succumbed to Verticilliurn wilt, caused by *Verticillium albo-atrum.* Leafspot diseases are caused by *Ovularia maclurae, Phyllosticta maclurae, Sporodesmium maclurae, Septoria angustissima, Cercospora maclurae,* and *Cerotelium fici*. Seedlings in a Nebraska nursery have been killed by damping-off and root rot caused by *Phythium ultimum* and *Rhizoctonia solani* (21). *Phellinus ribis* attacks stemwood exposed in wounds. *Poria ferruginosa* and *P. punctata* are the only two wood-destroying basidiomycetes reported on Osage-orange; they occur only on dead wood, mainly in tropical and subtropical parts of the western hemisphere (21). Maclura mosaic virus and cucumber mosaic virus have been identified in leaf tissue of Osage-orange in Yugoslavia (35).

Osage-orange trees are attacked by at least four stem borers: the mulberry borers *(Doraschema wildii* and *D. alternatum)* (4)*,* the painted hickory borer *(Megacyllene caryae),* and the red-shouldered hickory borer *(Xylobiops basilaris)* (8). The twigs are parasitized by several scale insects including the European fruit lecanium *(Parthenolecanium corni),* the walnut scale *(Quadraspidiotus juglansregiae)* the cottony maple scale *(Pulvinaria innumerabilis)* the terrapin scale *(Mesolecanium nigrofasciatum),* and the San Jose scale *(Quadraspidiotus perniciosus)* (25, 46). The fruit-tree leafroller *(Archips argyrospilus)* feeds on opening buds and unfolding leaves. Osage-orange is attacked by, but is not a principal host of, the fall webworm *(Hyphantria cunea)* (55), an Eriophyid mite, *Tegolophus spongiosus* (51), and the fourspotted spider mite, *Tetranychus canadensis* (4).

Osage-orange trees and several other species in 1 to 5-year-old plantations on old fields in the prairie region of Illinois were partially or completely girdled by mice. Severity of damage was greatest where weeds were most abundant (26).

Windbreaks on the Great Plains, unless given cultivation during their early years, are invaded by herbaceous vegetation, become sod bound, and are permanently damaged

(33, 38, 39). This vegetation may harbor rodents. Grazing is not satisfactory for herbage control; multiple-row windbreaks should be fenced to exclude livestock.

Osage-orange sustained less damage by insects, diseases, drought, hail, and glaze than any other species planted in the Prairie States Forestry Project. Along with bur oak *(Quercus macrocarpa)* it survived better than any other deciduous species on uplands of the Southern Plains (7, 38).

Special Uses

Osage-orange has been planted in great numbers, first as a field hedge, before barbed wire became available, secondly as a windbreak and component of shelterbelts, and thirdly to stabilize soils and control erosion.

The single-row field hedge proved to be a valuable windbreak on the prairie; evidence of this was the raised ground level under 15-year-old hedges, caused by accumulation of windborne soil material. Hedges around every quarter-section were common, especially in areas of deep sand (20, 38). These hedges were a source of durable posts. Prairie farmers customarily clearcut hedges on a 10- to 16-year cycle, obtaining about 2,500 fence posts per kilometer (4,000 per mi) of single-row hedge. The slash was piled over the stumps to protect the new sprouts from browsing livestock. Pole-sized and larger Osage-orange trees are practically immune to browsing, but seedlings and tender sprouts are highly susceptible. Recommended practice is to thin the new sprout stands to 240 vigorous stems per 100 m (73/100 ft), 3 to 5 years after the clearcut, and to protect the sprouts from fire. If inadvertently burned, the sprouts should be cut back immediately to encourage new, vigorous growth (20).

Osage-orange heartwood is the most decay-resistant of all North American timbers and is immune to termites. The outer layer of sapwood is very thin; consequently, even small-diameter stems give long service as stakes and posts (40, 43). About 3 million posts were sold annually in Kansas during the early 1970's. The branch wood was used by the Osage Indians for making bows and is still recommended by some archers today. The chemical properties of the fruit, seed, roots, bark, and wood may be more important than the structural qualities of the wood. A number of extractives have been identified by researchers, but they have not yet been employed by industry (11, 12, 23, 24, 44,58). Numerous organic compounds have also been obtained from various parts of the tree (16, 44, 57). An antifungal agent and a nontoxic antibiotic useful as a food preservative have been extracted from the heartwood (5, 24).

Osage-orange in prairie regions provides valuable cover and nesting sites for quail, pheasant, other birds, and animals (20, 33), but the bitter-tasting fruit is little eaten by wildlife. Reports that fruit causes the death of livestock have been proven wrong by feeding experiments in several States.

Osage-orange has been successfully used in strip mine reclamation. Its ease of planting, tolerance of alkaline soil, and resistance to drought are desirable qualities (1, 14, 29). These qualities plus growth, long life, and resistance to injury by ice, wind, insects, and diseases make Osage-orange a valued landscape plant (15, 30, 31).

Genetics

There is no known literature on the genetics of Osage-orange, and no information on geographic races is available. A thornless cultivar, *Maclura pomifera* var. *inermis* (André) Schneid., can be propagated by cuttings or scions taken from high in the crowns of old trees, where the twigs are thornless (30, 31). The only known hybrid, x *Macludrania hybrida* André, is an intergeneric cross: x *Macludrania = Cudrania x Maclura. Cudrania tricuspidata* (Carr.) Bureau is a spiny shrub or small tree, native to China, Japan, and Korea. The *Maclura* parent is variety *inermis.* The hybrid is a small tree with yellowish furrowed bark and short, woody spines (2, 41). Some authorities believe that the tropical dye-wood, fustic *& ChIorophora tinctoria* (L.) Gaudé belongs in the genus *Maclura;* however, the majority opinion is that there is only one species of Osage-orange (28).

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