Recovery Plan for the Yellow Wood Tree, *Zanthoxylum flavum,* in Bermuda

Government of Bermuda
Ministry of Health, Seniors and Environment
Department of Environment and Natural Resources

Recovery Plan for the Yellow Wood Tree, *Zanthoxylum flavum*, in Bermuda

Prepared in Accordance with the Bermuda Protected Species Act 2003

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OTEP

Primary Author

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Cover photo: Potted yellow wood trees at a plant nursery in Bermuda
Photo credit: Robin Marirea

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"To conserve and restore Bermuda's natural heritage"

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An electronic version of this recovery plan will also be made available at www.environment.bm

Director
Department of Environment and Natural Resources
Government of Bermuda

6TH MAY 2016
Date

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EXECUTIVE SUMMARY

Current Species Status:
This recovery plan addresses the need for conservation actions for the yellow wood tree *Zanthoxylum flavum*, a species that is native to Bermuda. Current legal protection is provided by the Protected Species Act (2003) and the Protected Species Amendment Act (2011). Following regional assessment criteria established by the International Union for Conservation of Nature and Natural Resources (IUCN), the yellow wood tree is listed as locally 'Critically Endangered' (CR) under the Bermuda Protected Species Order (2016).

Habitat Requirements and Threats:
Yellow wood trees grow best in well-drained soils and cannot tolerate over-shading by taller trees. They are also vulnerable to damage by a variety of insects including several citrus pests (Wingate, 2002). This species needs shelter from wind and salt spray, and is considered to be drought resistant. Local threats include predation of immature seed by rats and slow seed germination which does not favour successful self-seeding. Invasive plant species have been known to smother yellow wood trees. On a global scale, the yellow wood is predominantly threatened by habitat loss and/or degradation. Furthermore, clear-cutting and harvesting are contributing to the decline of the species.

Recovery Objective:
The short-term recovery objectives are to undertake genetic analyses of the species in Bermuda and initiate a standardized seed collection programme at the Millennium Seed Bank for preservation purposes. Long-term objectives include the implementation of the propagation programme, the engagement of the Bermuda community in a seedling planting programme and the implementation of a monitoring programme to track growth and survival of planted seedlings to sexual maturity.

Recovery Criteria:
Favorable conservation status for this species in Bermuda will be achieved when there is:

- Ex situ seed preservation,
- A locally implemented propagation programme,
- Community engagement in an island-wide planting initiative,
- A minimum of 10 sites sustaining optimal growth and reproduction of at least 10 mature yellow wood trees per acre per site.

Actions Needed:

1. Collection and preservation of genetic material from selected yellow wood trees
2. Analysis of genetic material
3. Seed collection from selected plants and export following standard protocols
4. Seed preservation at the Millennium Seed Bank
5. Seed collection from selected trees in the wild to maximize genetic diversity of propagated individuals
6. Seedling production through optimized germination techniques
7. Select sites identified as being suitable for planting yellow wood trees

8. Habitat restoration and continued management, including the control of invasive plants
9. Develop collaborative management of Paynter's Hill relict population
10. Develop protocols for determining optimal size at planting
11. Develop methods to sex potted trees to ensure planting in mixed-sex stands to promote production of viable seed
12. Translocation of nursery-grown yellow wood seedlings
13. Monitor growth and survival of planted individuals
14. Encourage the public to plant yellow wood trees in suitable locations on private lands

Recovery Costs:
The total cost of recovery actions cannot be defined at this point. Funding needs to be secured through non-governmental organizations (NGO's), overseas agencies, and other interested parties for implementing the necessary research and monitoring studies. Developing budgets for each action are the responsibility of the leading party as outlined in the work plan.

PART I: INTRODUCTION

A. Brief Overview

The yellow wood tree, or West Indian satinwood, *Zanthoxylum flavum* Vahl, is native to Bermuda, and is listed under the Protected Species Act 2003, as Critically Endangered (CR, D) as per criteria established by the IUCN. The total population in Bermuda does not exceed 50 mature plants, the majority of which are found at one location, and several of which are reproductively isolated. This species was listed on the IUCN Red List version 2.3 as Vulnerable (VU, A1c) in 1998 (Areces-Mallea, 1998).

This recovery plan discusses threats and conservation efforts for the yellow wood tree summarizing current knowledge of the taxonomy, distribution, habitat requirements, biology and threats. The plan first recommends the ex situ preservation of genetic material through the Millennium Seed Bank (U.K.) and the propagation of the species for the establishment of self-sustaining populations throughout the island. If these measures are successfully carried out, it may be possible to down list *Zanthoxylum flavum* to a less threatened status and/or remove it from the Protected Species list.

Historical Distribution

The yellow wood tree is a valuable timber tree, native to Bermuda, the Bahamas and other countries in the Caribbean and was closely associated with the early history of Bermuda colony. The timber value of this fine-grained yellow aromatic wood was discovered by European colonizers, who rapidly cut down trees on most of the Caribbean islands (including Bermuda) until it was virtually exterminated. The wood was highly prized in England as cabinet-wood. The high price of wood led to illicit shipping, and despite various attempts made to check its exportation, this intense lumbering caused the population decline of a tree which used to be common and generally distributed over Bermuda in early times. Exportation to England was restricted by gubernatorial proclamation as early as 1632 (Britton, 1918); by then, it was nearly exterminated. Verrill notes “Yellow-wood timber was also shipped, so long as it lasted, but it was probably nearly extinct as early as 1650” (Verrill, 1902).

Apparently early Bermudians used the term ‘yellow wood’ to refer to at least two species of tree, which causes some confusion when searching the early records for mention of it. Most of the early writers agree that this tree was found in the Walsingham district, specifically “on a hill east of Paynter’s Vale” (Lefroy, 1884; Verrill, 1902; Small, 1913; Britton, 1918) and also on Cooper’s Island (Verrill, 1902; Britton, 1918). Verrill (1902) writes extensively about Yellow woods occurring on Ireland Island, and notes a map of Ireland Island dated 1694 in the British Museum clearly shows “a Yellow Tree”. Lefroy speculates that the Ireland Island landmark tree was not *Zanthoxylum flavum*, but in fact *Erythrina velutina* (Lefroy, 1884).

In his 1884 *Botany of Bermuda*, Lefroy only mentions one specimen of yellow wood on a hill east of Paynter's Vale which was 10 inches in diameter and had "a few seedlings" around it (Lefroy, 1884). It is believed that Governor Lefroy, marked the trunk of a yellow wood tree in the vicinity of Paynter's Hill. The initials "R.H.L." and date "1872" are carved in the trunk, and are hardly legible today. Although this marking is not considered good practice among botanists, it has provided some idea of growth of this particular tree (Fig. 1), as the girth measurement was also recorded in Governor Lefroy's journal. It has been debated that it was indeed Governor Lefroy's initials, as his initials should have been J.H.L. and that the gesture was atypical of such a renowned botanist; nonetheless, the date and girth measurements are factual (Wingate, 1970; Jones, 1979).

Figure 2. Yellow wood tree believed to have been marked by Governor Lefroy during the late 19th century (credit: Alison Copeland).

Lefroy (1884) gives the girth as 30.5 inches. Britton (1918) noted that he measured the tree in December of 1912 and it was 33.5 inches in girth, therefore it had increased "less than 3 inches in girth in 40 years". Also Lefroy wrote that the tree never flowered, while Britton observed that it "flowered and fruited abundantly in September 1913."(Britton 1918). Hubert Jones of the Department of Agriculture and Fisheries re-measured the tree in 1972 at which time it had a girth of 36 inches; and again in 1979 when the trunk was 36.5 inches (Jones, 1979). He noted that 50 feet from Lefroy's yellow wood is a second

yellow wood tree (with a girth of 23 inches in 1979) whose trunk has been carved with the name B. Fox. He proposes that this tree and the supposed Lefroy yellow wood were carved at the same time by two boys (Jones, 1979). Both the 'B. Fox' tree, and the tree believed to be Lefroy's yellow wood survive at the time of writing, although they are crowded by invasive plants (Fig. 1).

In 1962, efforts were made by the Department of Agriculture to induce, what is believed to be Governor Lefroy's tree at Paynter's Hill, to seed. Early experiments with germination of seed were promising, and germination occurred in 100 days. Seedlings were planted on Nonsuch Island. Some were girdled by land crabs, but the remainder grew well despite minimal care. Germination trials were continued until 1968, and more than 4,000 seedlings had been germinated at Tulo Valley for planting on Government owned nature reserves (Wingate, 1970). Trees on Nonsuch Island continued to grow, but slowly. The largest reached five feet in height in seven years at which point it began to flower. This showed the possibility for controlled propagation of the yellow wood through seed germination and early seedling growth in a nursery environment. In 1970, to commemorate the 350th anniversary of Bermuda's Parliament the Tulo Valley Nursery made available to the public 1,000 seedlings in one gallon pots free of charge (Wingate, 1970). Unfortunately, there was little monitoring, and causes of mortality seen in the majority of these trees could not be determined.

B. Current Protection Status

Legal protection for the yellow wood tree is provided by the Protected Species Act (2003). This species is classified under the Protected Species Amendment Order (2016) as level 3, Critically Endangered (CR, D) following IUCN criteria. Selected mature plants are also protected under the Tree Preservation Order (1998) (TPO No. 28/6 and 28/4 Paynter's Hill, Hamilton Parish).

Legal Protection

The Protected Species Act (2003) states that a person is committing an offence if they willfully damage, destroy, injure, disturb, uproot, fell or kill a level 3 protected species. Under Section 9 of the Protected Species Amendment Act (2011) offenders are liable, on summary conviction, to a fine of $5,000 or six months imprisonment for offences against a level 3 listed species. Despite its Critically Endangered status, the yellow wood was listed as a level 3 protected species because it was recognized that successful recovery of this species must involve the general public.

Furthermore, the Tree Preservation Order (TPO 28/6) protects 16 selected (and marked) trees at Paynter's Hill from being cut down, topped, or willfully destroyed in any manner.

Habitat Protection

For those trees growing in areas designated as Parks or Nature Reserves protection is provided by the Bermuda National Parks Act (1986). Trees growing in the Walsingham Nature Reserve are protected from development by the Walsingham Trust Act (1942). Under the 2008 Bermuda Plan, 6.6 acres of Paynter's Hill has been given a Nature Reserve Zoning. A Tree Protection Order (TPO 28/4) covers an area of 0.28 acres at the top of Paynter's Hill where the greatest concentration of yellow woods are found.

C. Taxonomy and Description of Species

Kingdom: Plantae (Haeckel, 1866)
Subkingdom: Viridaeplantae (Cavalier-Smith, 1981)
Phylum: Tracheophyta 1935 (ex Cavalier-Smith, 1998)
Subphylum: Spermatophytina (auct.) (Cavalier-Smith, 1998)
Infraphylum: Angiospermae auct.
Class: Magnoliopsida (Brongniart, 1843)
Subclass: Rosidae (Takhtajan, 1967)
Family: Rutaceae
Subfamily: Rutoideae
Tribe: Zanthoxyleae
Genus: *Zanthoxylum* (Linnaeus, 1753)
Species: *flavum* (Vahl)

Zanthoxylum (from the Greek meaning "yellow wood") is a genus of about 250 species of deciduous and evergreen trees and shrubs which are native to warm temperate and subtropical areas worldwide. Common names include prickly-ash and Hercules' club.
The yellow wood tree (*Z. flavum*) is also referred to as West Indian satinwood, yellowheart, yellow-head, or yellow sanders (Areces-Mallea, 1998). In the literature, it has been scientifically referred to as *Zanthoxylum aromaticum* by Verrill (1902), and as *Z. Clava-Herculis* by Lefroy (1884) and Small (1913). The tree belongs to the citrus family Rutaceae, and bears some resemblance to an orange tree in general appearance. However, the leaves are distinctive, for instead of being simple and entire in outline as in the orange, they are divided, with several leaflets, as in the walnut. It has smooth grey bark, spreading branches with evergreen, pinnately compound leaves, strongly scented yellow blossoms which attract bees and numerous small, berry-like green fruits on panicles with hard black seeds inside (Wingate, 1970). It is known to grow in height to 30 feet (9 m) in sheltered areas (Wingate, 2002).

Figure 2. Yellow wood sapling (credit: Alison Copeland).

The following taxonomic description is given by Coile and Garland (2003):

> "*A shrub or small tree to 12 m tall; without prickles; leaves compound with 5-7 leaflets alternate, to 30 cm long; flowers in terminal clusters, unisexual; petals 5, 4-5 mm long*."

Britton (1918) describes the yellow wood tree as an unarmed evergreen shrub or smooth-barked tree with spreading branches, its twigs, foliage and inflorescence tomentose, or glabrate in age. Leaf-blades pinnately compound, 4-12 inches long; leaflets 5-11, the blades oblong or ovate, or the terminal one oval, 1 ½ -3 inches long, obtuse, rounded at the apex, slightly crenate or nearly entire, inequilateral, short-petioled, shining above, pubescent with stellate hairs when young, becoming glabrous; panicles 3 -6 inches long; pedicels; flowers in terminal cymes; calyx; sepals triangular-ovate, acutish; petals 5, oblong or oblong-ovate, recurved, relatively thick; stamens longer than the petals; ovary glandular-punctate; carpels obovoid, glandular-punctate; seeds lenticular, faintly reticulated, black.

Figure 3. Yellow wood buds (credit: Alison Copeland).

D. Ecology

Habitat Requirements

The yellow wood tree was historically recorded to grow in rocky woodlands between Harrington Sound and Castle Harbour (Britton, 1918). It grows best in well-drained soils, but cannot tolerate over-shading by taller trees. This species is vulnerable to a variety of insect pests, including aphids, mealybug and scale insects. It requires shelter from wind and salt spray, and is considered to be drought resistant (Wingate, 1970).

Reproduction and Life Cycle

The yellow wood tree flowers in Bermuda in autumn with heavily scented yellow blossoms, which attract bees, and the ripening fruits attract birds, especially the white-eyed vireo *Vireo griseus* (Wingate, 2002). The flowers are chartreuse in colour, ranging

as pale green, pale yellow, and yellow-green. The seeds are known to ripen from January to May. It is thought that yellow wood trees in Bermuda produce seed when they attain 8-12 feet in height (ca. 20 years old). They are dioecious, and only the females produce seeds, and the males only produce flowers. This species can be propagated from dried seed which will germinate in about 100 days (Wingate, 2002). Seed may be collected anytime from September to December, depending on the year (J. Madeiros, pers. comm.). Germination time has been recorded to be between 12 and 40 weeks, with an average of 100 days. Recommended time to planting in the soil is at 3-5 years old (J. Madeiros, pers. comm.). This tree is described as being slow-growing in Bermuda (Wingate, 1970). Local propagators have obtained 6-12 inch potted seedlings in eight months from germination, and up to four foot growth (height) with one inch diameter trunk in 1.5 years (R. Marirea, pers. comm.). Further information is required on the growth rate of this species in optimal conditions.

E. Current Threats

The apparent slow growth of yellow wood trees limits reproductive output. Known populations in Bermuda do not appear to be self-propagating, although they do produce seed. Possible reasons for failure to self-seed may include seed consumption by rats and birds. Furthermore, this species appears to be unable to regenerate on lands cleared for grazing or agriculture, and the soft tree bark is readily girdled by cattle. Yellow wood trees also compete poorly with introduced and invasive plants.

On a global scale, the yellow wood is threatened by habitat loss and habitat degradation. Clear-cutting and over harvesting are on-going activities in various parts of the world which are contributing to the global decline of the species.

F. Current Status

Global Distribution

Zanthoxylum flavum is listed as Critically Endangered on the Cayman Islands Red List of Threatened Plants (Burton, 2008). Populations are also found in Anguilla, Bahamas, Bermuda, Brazil (Amazonas), Cuba, Dominican Republic, Honduras, Jamaica, Puerto Rico, St. Lucia and the United States (Florida) (Areces-Mallea, 1998).

Local Distribution

There are 22 separate locations across Bermuda where 125 yellow wood trees were confirmed growing in the environment during surveys undertaken between 2013 and 2016 (Department of Environment and Natural Resources, Biodiversity Section, unpublished data). These include a mixture of reproductively mature and immature individuals. It should be noted that relict populations exist in the Walsingham Nature

Reserve and on Paynter's Hill in Hamilton Parish. Trees recorded at the other sites, as well as some of the trees at Walsingham Nature Reserve, are plantings of nursery-raised stock (Table 1; Fig. 4).

The size of the relict population of wild trees on Paynter's Hill has been given at various times as 18 mature individuals (Dill, 1991) to 21. The Tree Protection Order (TPO 28/6) covers 16 trees. In April, 2016 nine large trees were mapped on Paynter's Hill, although more are likely to occur there. Fallen trees, likely damage from recent hurricanes, prevented access to parts of Paynter's Hill. The numbers given below represent yellow woods on public lands and private land where public access is allowed. In addition, there are an unknown number of trees planted in private gardens.

Additionally, there are three known plant nurseries in possession of potted yellow wood trees; Tulo Valley (with approx. 30 trees), Save Open Spaces and Robin Marirea (with 87 trees in 10 and 20 gallon pots in April 2016).

Table 1: Yellow wood trees recorded between 2013 and 2016

Site	**Number of Trees**	**Note**
Paynter's Hill	at least 9	9 large trees located April 2016
Walsingham Nature Reserve	13	includes plantings and 'natural' trees
Palm Grove (Devonshire)	23	
Cooper's Island	13	includes a stand of 12 planted Dec 2013
Sear's Cave	11	all saplings
Fairview (Mitchell property)	11	note: private property
Nonsuch Island	9	may include Bahamian trees (see Wingate 1989)
Stokes Point Nature Reserve	7	1 older tree and 6 planted in 2013
Alfred Blackburn Smith Nature Reserve	3	large tree c.1970s, 2 planted Earth Day 2016
Somerset Long Bay East Nature Reserve (Pitman's Pond)	4	
Government House	3	commemorative trees
Botanical Gardens	2	woodland tree damaged in hurricane Gonzalo 2014
Penhurst Park	1	
Arboretum	1	
BAMZ	2	planted by R. Marirea
Carter House	3	
Gladys Morrell Nature Reserve	2	
Greenfield Lane farm (Somerset)	1	large tree, possibly from 1970's planting
Queen Elizabeth Park (Par-la-Ville Park) Hamilton	1	sapling
Marirea property	2	male/female pair. Note: private property
St. Peter's Churchyard	1	
Windreach	3	
Total	125	

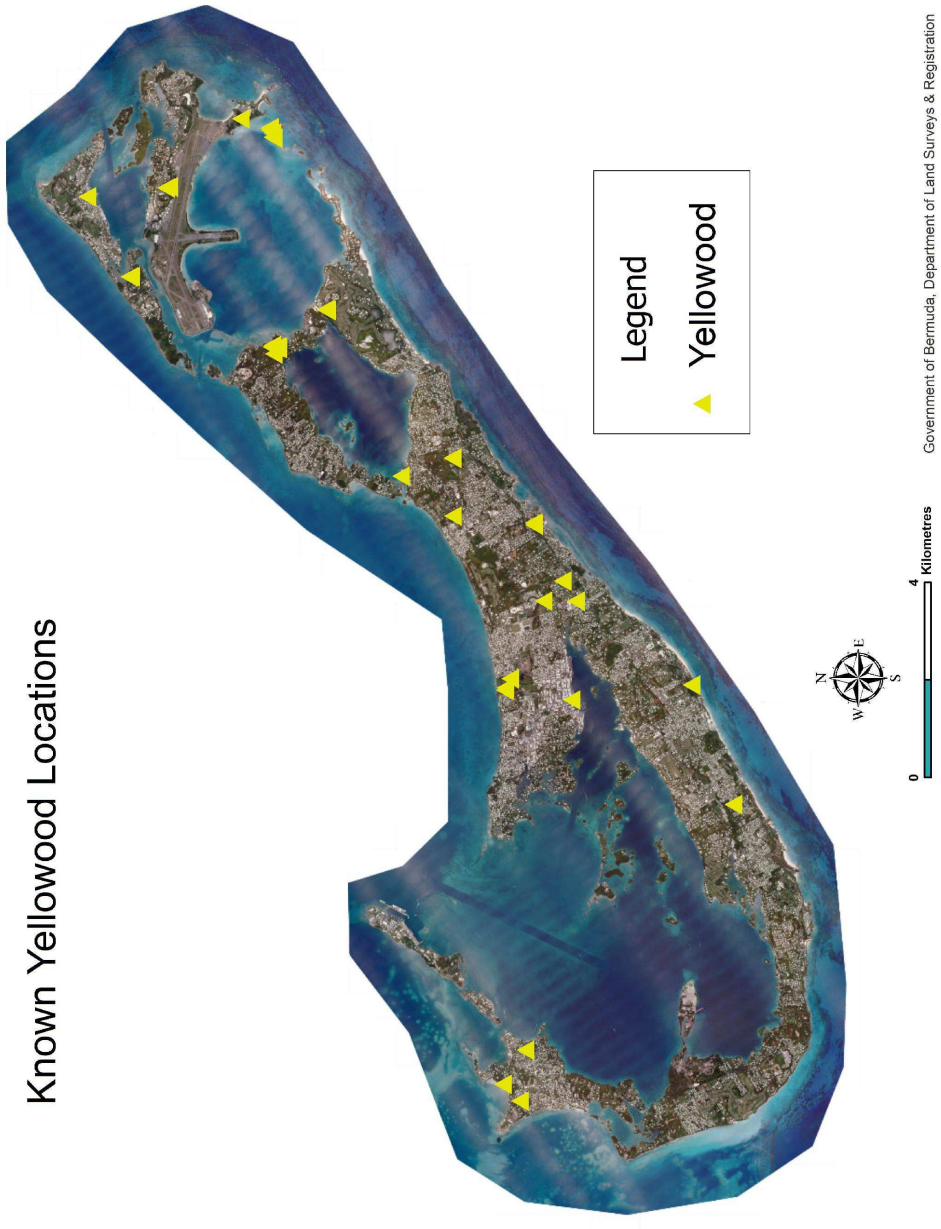

Figure 4. Known locations of yellow wood trees across Bermuda.

G. Current Conservation Action

Active propagation is presently taking place at two plant nurseries; a private nursery operated by Mr. Robin Marirea and the nursery of the NGO Save Open Spaces. Wild collected seeds resulted in the growth of approximately 60 seedlings (6-12 inches height), however the germination success rate was reported to only be 5% (R. Marirea, pers. comm.). The Save Open Spaces nursery focuses on propagating native and endemic species and has reported a promising 50% germination success rate from wild collected seeds, which resulted in the production of 54 seedlings in 2006. It has been reported that seeds planted in January germinated in May. The potting medium was kept moist and seedlings apparently grew rapidly outside. Propagators have mentioned that they are limited in obtaining good quality seeds.

Propagators have observed that potted trees, when still small, grow 2 to 3 times faster than those that have been planted in the ground, provided that they are regularly fed and watered. It is possible that this is because the black pots keep the roots warmer than the ground does (Marirea, pers. comm).

Mapping of endemic and rare native plant species, particularly those listed under the Protected Species Act 2003, has been ongoing within the Department of Environment and Natural Resources (DENR) since 2013. In that time, 123 yellow woods have been recorded, and the invasive plants around them catalogued (Dept. of Environment and Natural Resources, Biodiversity Section, unpublished data.).

There are a number of locations where there is a single yellow wood tree growing (e.g Penhurst Park, Arboretum, Alfred Blackburn Smith Reserve, Par la Ville Park). Planting additional trees around these single specimens has been identified as a future conservation action necessary to ensure pollination and seed production. Additional trees were planted at Stokes Point Nature Reserve by the DENR in collaboration with the Bermuda Audubon Society to hopefully promote pollination of the previously solitary tree there.

Staff from DENR are involved with the periodic cutting back of invasive plant species around yellow wood trees growing in nature reserves.

PART II: RECOVERY

A. Recovery Goal

The principal aim of this Recovery Plan is to promote the propagation, growth and survival of yellow wood trees throughout Bermuda.

B. Recovery Objective and Criteria

Favourable conservation status will be achieved when there is:

- Ex situ seed preservation,
- A locally implemented propagation programme,
- Community engagement in an island-wide planting initiative,
- A minimum of 10 sites sustaining optimal growth and reproduction of at least 10 mature yellow wood trees per acre per site.

These overall objectives translate into specific targets outlined below:

The short-term (two year) recovery objectives are to undertake genetic analysis of the species in Bermuda and initiate a standardized seed collection programme with the Millennium Seed Bank for preservation purposes. Long-term (20 year) objectives include the implementation of a propagation programme, the engagement of the Bermuda community in a seedling planting programme and the implementation of a monitoring programme to track growth and survival of planted seedlings to sexual maturity.

These combined goals will expand the geographical distribution of this locally critically endangered species. It is anticipated that a minimum of 10 mature trees per acre will be necessary for self-propagation at any one site.

C. Recovery Strategy

The population growth of the yellow wood tree addressed in this Recovery Plan is limited by availability of suitable habitat, knowledge of optimal propagation techniques and growth requirements for the species, as well as the apparent slow growth of the species in the natural environment.

The lack of habitat is in part caused by the uncontrollable growth of invasive plant species. The selection of new habitats will include the control of invasive species identified as being problematic to yellow wood trees. The presence of rats is an island-wide problem, although their effect on seed consumption should be assessed.

Seed collection has traditionally occurred from only a few mature trees in the wild which has resulted in the propagation of seedlings with limited genetic variation. Future propagation efforts will have to involve as much genetic diversity as possible which means that seeds will have to be systematically collected from different mature trees. It is advisable that the collection of seeds from the wild be coordinated through a limited number of licensed individuals or DENR who then distribute the material to those parties interested in germination. Preliminary information is available for germination, but techniques need to be further developed and refined to obtain higher success rates.

It has been recommended that trees are planted out when 6 to 8 feet tall, rather than when they are in small 1 gallon pots (Marirea, pers comm). There is evidence that larger saplings survive better in general, but also planting larger trees prevents trampling and damage from landscapers as they are more easily seen.

It is a stressful period in any plant's life after it has been transferred from the nursery environment (where care and resources are in abundance) to the natural environment (where resources are unpredictable and care may be non-existent). A monitoring programme that evaluates the growth, health and survival of transferred seedlings of varying sizes will be critical to the success of the planting programme.

The propagation efforts made by several individuals are promising. It is anticipated that a cohesive programme in which collaboration and the sharing of information will benefit all propagators by developing optimal procedures for seed collection, germination and seedling care. The propagation of yellow wood trees has evidently been successful in Florida and any information available from overseas experts should be investigated and applied locally.

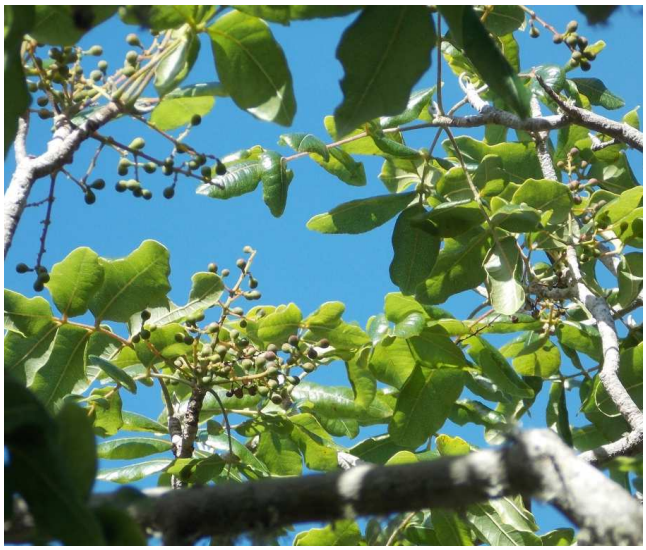

Fig. 5 Ripening Yellowood Fruit (Credit: Alison Copeland)

D. Tools Available for Strategy

A 2007 workshop with experts from the Royal Botanic Gardens Kew has already provided the standard protocol for collecting sample material necessary for herbarium vouchers and genetic analysis. Similarly, seed collection and shipment for preservation at the Millennium Seed Bank was standardized by the same experts (Sarkis, 2007).

Collected seeds preserved at the Millennium Seed Bank are re-assessed for viability every 10 years; this implies that a long-term seed collection programme needs to be established in Bermuda, allowing for seed collection and shipping every 10 years to the Millennium Seed Bank, should stored seeds lose their viability during long-term storage.

In addition a handheld GPS unit is available to accurately record the locations of known trees, and a GIS system (ArcMap 10.2.1) is available within the Department of Environment and Natural Resources to manage and display the collected population data. This map should be updated regularly as plantings occur.

Although a structured propagation programme is not in place, the techniques for propagation of this species have been established. For the most part, they have proven successful. Propagation is done through seed germination and translocation to wild habitats and garden settings have been promising. Bermuda-based NGOs have expressed a willingness to assist in seedling production, as has the Department of Parks (Tulo Valley Nursery). Community clubs have also indicated interest and should be encouraged to help in the growing of this species across the island. Planners, such as landscape architects may be brought on board for larger scale integration of natives and endemics in developments, including golf courses. Long-term sustainability will only be achieved with the help of the afore-mentioned groups, and requires an island-wide programme, such as that conducted for the Bermuda cedar in previous years.

E. Step-down Narrative of Work Plan

Abbreviations used in Section E and Part III:

BAMZ – Bermuda Aquarium Museum and Zoo
DENR – Department of Environment and Natural Resources
Tulo Valley – Government Nursery for the Department of Parks
Kew – Royal Botanic Gardens Kew
Parks – Department of Parks
SOS – Save Open Spaces

The actions needed to achieve recovery are as follows:

1. Genetic analysis of the species to confirm status.

Actions proposed:

- Collection and preservation of genetic materials from selected yellow wood trees,
- Analysis of genetic materials.
- *Z. flavum* occurs in other UK Overseas Territories (Anguilla, BVI, Cayman and TCI) so it is possible that comparative genetic analysis could be done as a cross-territory project.

Work Team: DENR, SOS, BAMZ, Kew
Team Leader: DENR
Assistance: Members of the community
Outputs: Confirmation of native status of extant populations in Bermuda
List of Equipment: Funding required for shipping and genetic analysis

2. Seed collection and preservation.

Actions proposed:

- Identify seed source trees
- Seed collection from selected trees and export following standard protocols,
- Seed preservation at the Millennium Seed Bank.
- Explore options for on-island seed preservation

Work Team: DENR, SOS, BAMZ, Millennium Seed Bank
Team Leader: DENR
Assistance: Members of the community
Outputs: Ex situ seed preservation of Bermuda's yellow wood tree
List of Equipment: GIS software, record-keeping sheets, collection materials, packaging/shipment materials, funding for shipment.

3. Propagation of the species in local plant nurseries.

Actions proposed:

- Seed collection from selected trees in the wild to maximize genetic diversity of propagated individuals (may need to hand pollinate wild trees).
- Transfer of collected seed to propagators (if not collectors).
- Seedling production through optimized germination techniques.
- Exchange of seed between propagators to maximize diversity
- Determine sex of potted trees and mark tree trunks with tags.

Work Team: DENR, SOS, BAMZ, Tulo Valley, Licensed propagators
Team Leader: DENR
Assistance: Members of the community
Outputs: Availability of seedlings for translocation programme and documentation of propagation techniques.
List of Equipment: collecting materials, propagation materials.

4. Translocation of propagated specimens to sites deemed suitable for optimal growth.

Actions proposed:

- Select sites identified as being suitable for planting yellow wood trees,
- Habitat restoration and continued management, including the control of invasive plants,
- Develop protocols for determining optimal size at planting,
- Translocation of yellow wood seedlings, ideally as male/female pairs or mixed groups.
- Ensure tree guards are used to prevent girdling of trees
- Monitor growth and survival of planted individuals,
- Encourage the public to plant yellow wood trees in suitable locations on private lands, and promote its use for ceremonial plantings

Work Team: DENR, SOS, Tulo Valley, landowners including NGOs such as Bermuda National Trust and Bermuda Audubon Society
Team Leader: DENR
Assistance: Members of the community
Outputs: Increased habitat availability for species, expanded island wide distribution of species, report on growth and survival assessing habitat adequacy.
List of Equipment: Plants for translocation, tree guards

5. Manage relict wild population on Paynter's Hill.

Actions proposed:

- Agree a management and access relationship between the landowners and Department of Environment and Natural Resources (as a formal MOU if necessary).
- Manage Paynter's Hill yellow woods and surrounding habitat for threats
- Mark and map all yellow woods on Paynter's Hill

Work Team: DENR, landowners
Team Leader: DENR
Assistance: Members of the community, NGOs
Outputs: Improved management of habitat around relict trees for threats, continued health of relict trees

F. Estimated Date of Down Listing

It is anticipated that it will take two years to confirm the genetic status of Bermuda's yellow wood tree. Should the species prove to be a subspecies endemic to Bermuda, its classification will be re-assessed immediately. It is anticipated that the first monitoring report on the growth, survival and reproduction of planted seedlings will be produced in three years. Down listing or removal from the Protected Species Order is anticipated to occur within 20 years should this species exist on 10 separate sites containing at least 10 mature yellow wood trees per acre per site.

PART III: IMPLEMENTATION

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
Priority 2: An action that must be taken to prevent a significant decline in the species population/habitat quality, or some other significant negative impact short of extinction.
Priority 3: All other action necessary to provide for full recovery of the species.

Priority #	Task #	Task description	Task Duration	Responsible Party
3		**Genetic analysis**		
	1	Sample collection	12 months	DENR
	2	Genetic analysis	12 months	Kew
1		**Seed collection & preservation**		
	3	Seed collection and export	24 months initially 12 months every 10 years thereafter	DENR
	4	Seed preservation	Indefinite	Millennium Seed Bank
1		**Propagation**		
	5	Seed collection	Annual	DENR or licensed individuals
	6	Seed germination	Annual	Licensed plant nurseries & individuals, Tulo Valley
	7	Seedling production	Annual	Licensed plant nurseries & individuals, Tulo Valley
2		**Translocation**		
	8	Site selection	1 month	DENR, landowners
	9	Habitat restoration	5 years	DENR, Parks, landowners
	10	Habitat management (control of invasive species)	Annual	DENR, Parks, landowners
	11	Translocation of seedlings	Annual	DENR, Tulo Valley/Parks
	12	Engage community in planting	Indefinite	Licensed plant nurseries & individuals, NGOs

	13	Monitoring of growth and survival and seed production	Annual	DENR, NGOs
2		**Relict Population**		
	14	Management agreement	3 months	DENR & landowner
	15	Manage Paynter's Hill	Annual	DENR
	16	Mark and map trees	2 weeks	DENR

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