NSW GOVERNMENT

# Tropical Soda Apple Best Practice Manual

www.dpi.nsw.gov.au

**Tropical Soda Apple**
**Best Practice Manual**

www.dpi.nsw.gov.au

Cite as:
Bignell, T. (2024). Tropical Soda Apple Best Practice Manual.
New South Wales Department of Primary Industries, Orange, NSW

ISBN: 978-1-76058-774-1
ISBN: 978-1-76058-769-7 (Digital online)



For updates to this publication, check
www.dpi.nsw.gov.au

Cover photograph:
NSW DPI © State of New South Wales

## Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (Feburary 2024). However, because of advances in knowledge, users are reminded of the need to ensure that the information upon which they rely is up to date and to check the currency of the information with the appropriate officer of NSW Department of Primary Industries or the user's independent adviser.

The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended and that the inclusion of a product name does not imply endorsement by the department over any equivalent product from another manufacturer.

Recognising that some of the information in this document is provided by third parties, the State of New South Wales, the author and the publisher take no responsibility for the accuracy, currency, reliability or correctness of any information included in the document provided by third parties.

## Always read the label

Users of agricultural chemical products must always read the label and any permit before using the product and strictly comply with the directions on the label and the conditions of any permit. Users are not absolved from any compliance with the directions on the label or the conditions of the permit by reason of any statement made or omitted to be made in this publication.

18445.11-02/24

## Acknowledgements

The New South Wales Tropical Soda Apple Taskforce was the driving force behind the development of this best practice manual. The Taskforce consists of weeds professionals from the following organisations:

- Bellingen Shire Council
- Clarence Valley Council
- Coffs Harbour City Council
- Department of Agriculture and Fisheries Queensland
- Forestry Corporation of New South Wales
- Hunter Local Land Services
- Kempsey Shire Council
- MidCoast Council
- Nambucca Shire Council
- New England Weeds Authority
- New South Wales Department of Primary Industries
- New South Wales Farmers Association
- New South Wales National Parks & Wildlife Services
- North Coast Local Land Services
- Northern Tablelands Local Land Services
- Port Macquarie-Hastings Council
- Rous County Council
- Tenterfield Shire Council

Particular thanks to:

- Greg Egan (Kempsey Shire Council) for leading the development of this manual and providing advice, input, and feedback throughout the entire process.
- Wendy Gibney (NSW DPI) who provided many resources and references.
- NRM South and Hunter Regional Weeds for sharing weed hygiene resources and images.

Professional input from the following individuals is also greatly appreciated:

- Andrew Hughes (Coffs Harbour City Council)
- Birgitte Verbeek (NSW DPI)
- Keegan Noble (Nambucca Shire Council)
- Kylie Ostler (MidCoast Council)
- Matthew Ryan (Queensland DAF)
- Nicola Dixon (NSW DPI)
- Rhett Patrick (Rous County Council)
- Rod Ensbey (NSW DPI)
- Shane Landrigan (Clarence Valley Council)
- Terry Inkson (MidCoast Council)

# Preface

The intention of this manual is to provide practical guidance to assist the entire community in the management of tropical soda apple (*Solanum viarum*). Whether you are a landholder, livestock producer, hay maker, transport carrier, or small hobby farmer, this manual will help you to reduce the risk of tropical soda apple having a significant impact on your property or livelihood. This manual also serves as a guide for those in other industries such as forestry, quarrying, abattoirs and saleyards, which may be impacted by tropical soda apple.

In developing this manual, we have considered all situations where tropical soda apple is known to be present and those that are at risk from this invasive weed. The information provided in this manual is based on the current research available and legislative requirements at the time of writing. We have incorporated thirteen years of practical experience and observations by Biosecurity Weeds Officers, DPI professionals, and landholders actively managing tropical soda apple on their properties.

When tropical soda apple was first discovered in Australia, in the Upper Macleay Valley of New South Wales, lots of information came from experiences in the USA where tropical soda apple dominated very quickly following its introduction. We soon learnt that this plant also adapted to the North Coast environment extremely well and had the same ability to monopolise our farming land and natural environments. However, due to our unique climate and conditions, we have had to adapt different approaches to its management.

We have learnt the impact that flooding can have by witnessing the rapid and unpredictable spread of tropical soda apple throughout the North Coast catchments during catastrophic weather events. We now know it can dominate riparian zones, and we understand how important quick action is needed to control it. Those involved in driving the development of this document wish that we had a similar resource when we first encountered tropical soda apple in Australia. Now we are given the opportunity through this best practice manual to assist others and highlight our shared responsibility as an entire community to work together to manage the risk that tropical soda apple poses to Australia.

Greg Egan
Weeds Officer
Kempsey Shire Council

# Contents

# 1. Introduction

This manual presents best practice advice for the management of tropical soda apple in New South Wales (NSW), Australia. The information provided is based on a full review of published literature, current field practices, and NSW biosecurity legislation. Although most references to legislative requirements relate to NSW specifically, the general management principles found in this manual will be relevant across Australia.

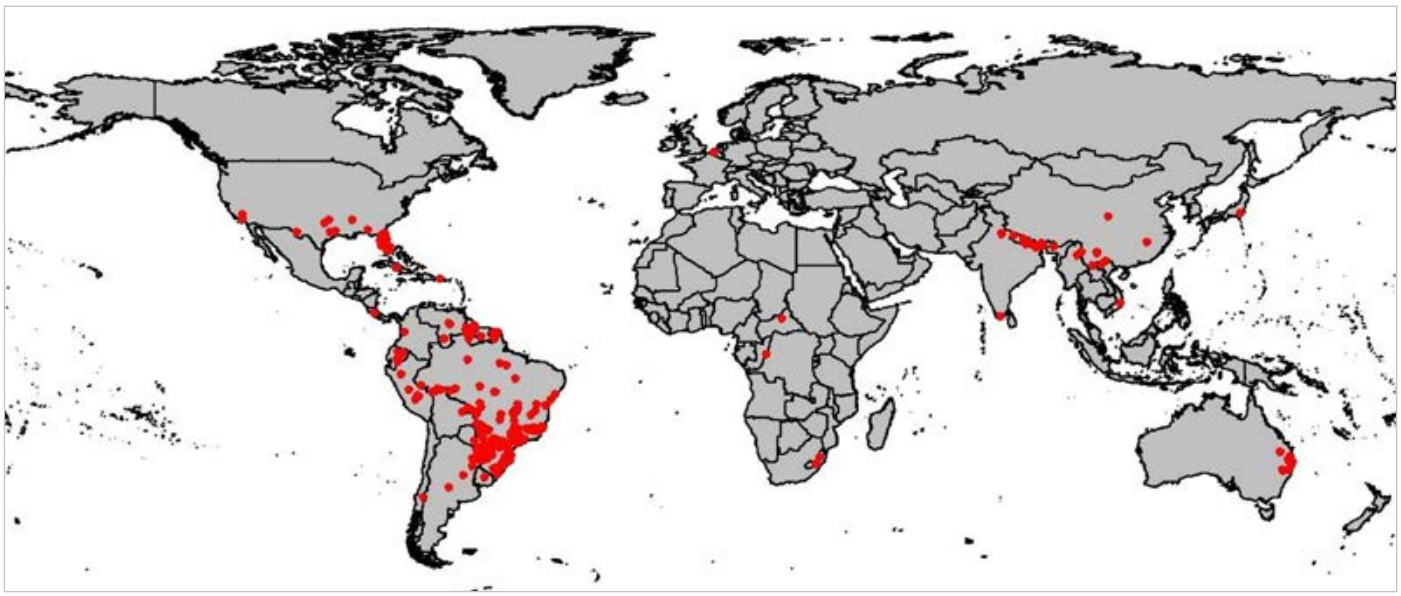
## 1.1 What is tropical soda apple?

Tropical soda apple (*Solanum viarum*) is a fast growing, highly invasive, prickly perennial shrub which grows up to 2 metres high and 1.5 metres wide. The leaves are unpalatable to stock however the fruit is readily consumed by domestic livestock, feral animals, and native fauna. Tropical soda apple reproduces via seeds which are found within its fleshy fruit. Each individual plant can produce up to 45,000 seeds per year.

In favourable conditions the plant can flower just 46 days after germinating and can start fruiting from as early as 75 days after germination. Tropical soda apple can also regenerate from vegetative materials such as the roots or stems. The plant is poisonous to humans, but its effects on livestock are unknown.

Tropical soda apple grows in full sun and part shade. It is most often found growing in pastures and riparian areas. However, it can infest a wide variety of situations including land used for cropping and horticulture, as well as forests, recreational areas, urban environments, and roadsides.

A young tropical soda apple plant. Photograph by Terry Inkson.



Map showing the approximate distribution of tropical soda apple throughout the world. Source: www.weedfutures.net


Tropical soda apple awareness sign. Photograph by Shane Landrigan.

## 1.2 Where is tropical soda apple from?

Tropical soda apple is native to north-eastern Argentina, south-eastern Brazil, Paraguay and Uruguay. Due to its invasive nature, the plant has become a problematic weed of other areas of South America and throughout various parts of the world including the USA, Mexico, Africa, India, China, Vietnam, Honduras, Nepal, the West Indies, and Australia.

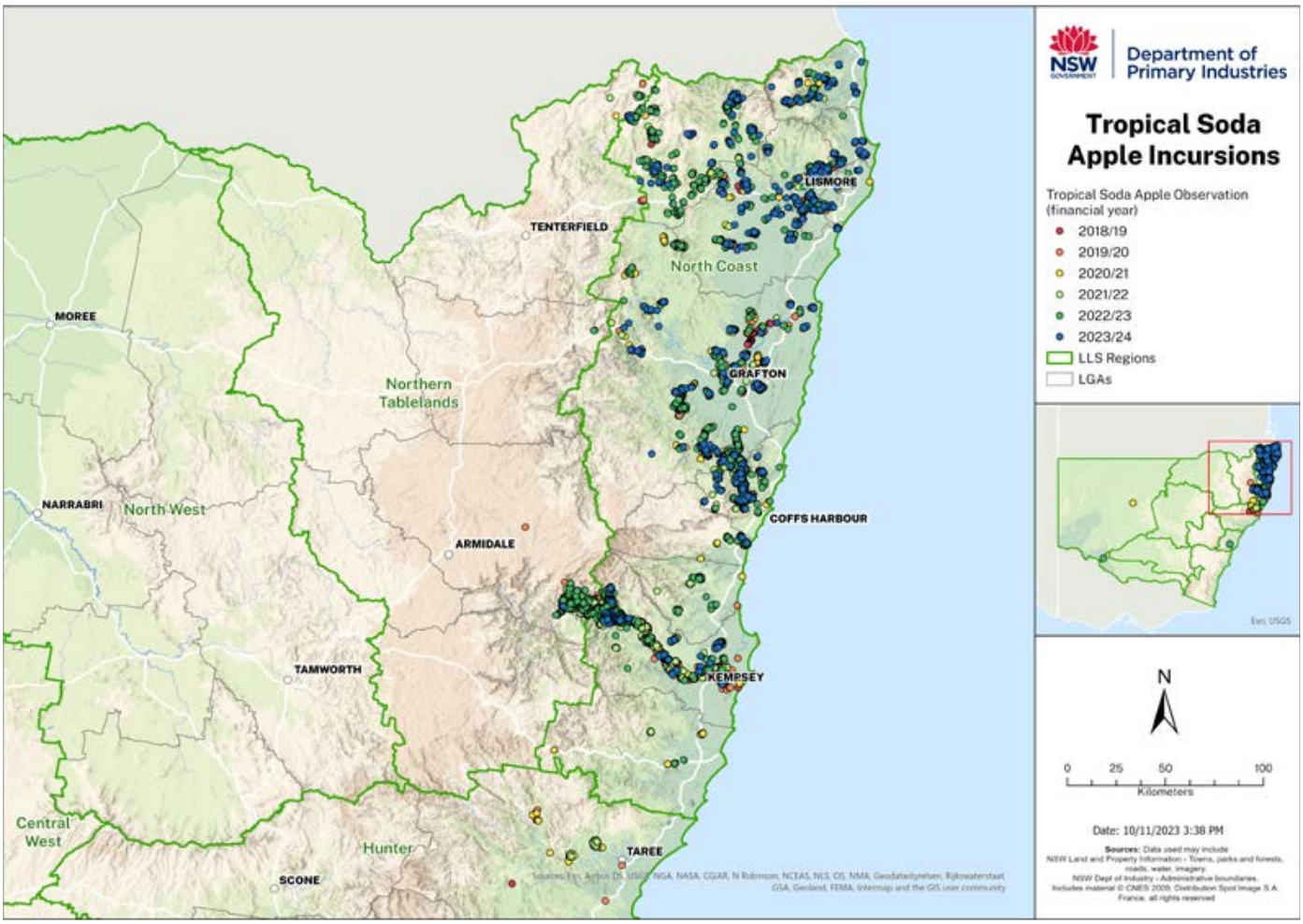
## 1.3 When did tropical soda apple arrive in Australia?

Tropical soda apple was first identified in Australia in 2010, when it was discovered in the upper Macleay Valley in NSW. However, it is believed that the weed had been present in the area for some years prior to its detection. The initial core infestation covered approximately 50 ha, with smaller infestations subsequently found in surrounding areas following inspections by State and local government officers. Despite robust surveys and extensive tracing of cattle movements, the original source of introduction to Australia is likely to remain unknown.

Tropical soda apple has the potential to spread throughout most of Australia

## 1.4 Where is tropical soda apple found in Australia?

Currently, most tropical soda apple infestations are found in the North Coast region of NSW. This includes the areas in and around the Upper Macleay, Richmond Valley, Nambucca Valley and Clarence Valley, as well as Bellingen, Coffs Harbour, and Port Macquarie. The plant has also spread west into parts of the Northern Tablelands including Armidale, Tabulam, and Tenterfield, and south into the Hunter region around Wingham, Taree and Gloucester. Several infestations have also been found north of the border in South-East Queensland. Although tropical soda apple is known to occur in these areas at present, it has the potential to spread throughout most of Australia and could appear anywhere within its suitable habitat.




Map showing the current distribution of tropical soda apple in New South Wales.
Source: NSW Department of Primary Industries.

# 2. Why do we need to control tropical soda apple?

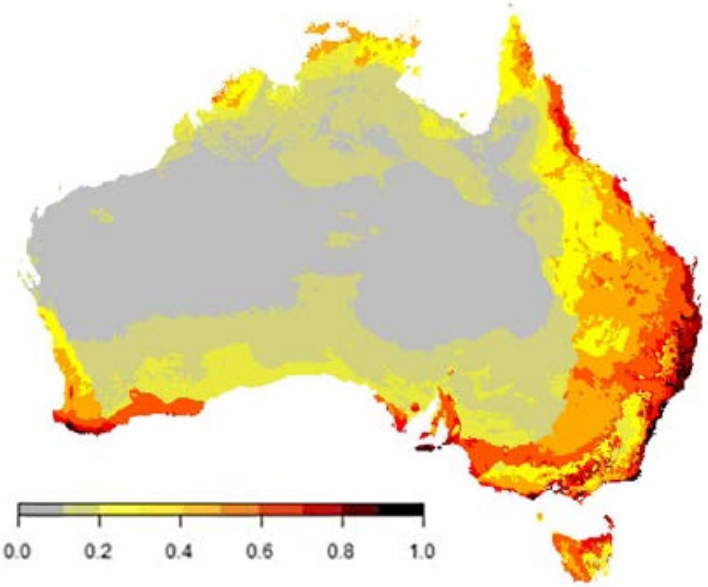
## Tropical soda apple is having a serious impact on Australia's agriculture and environment

Tropical soda apple is a highly invasive plant which is a significant agricultural, economic, and environmental threat to Australia. This plant is extremely adaptive and germinates under a wide range of environmental conditions. A plant can produce thousands of viable seed from a very early stage of its life cycle, and as a result can spread rapidly if left unmanaged. Once established tropical soda apple can be difficult to eradicate if not dealt with promptly. The advice contained in this manual will assist all landholders in managing tropical soda apple effectively to minimise its impacts.

In Australia, tropical soda apple can have serious impacts on pastures, crops, and horticultural areas. The leaves are unpalatable to livestock which reduces the carrying capacity of infested land. In large numbers the plant forms dense thorny barriers, which prevent animals from gaining access to shade and water. Tropical soda apple harbors several pests and diseases which can be introduced to nearby susceptible crops.

Tropical soda apple is having a significant impact on local and regional environments. It establishes in native forests and can displace Australian flora and disrupt essential ecological processes. The plant readily invades riparian zones where it outcompetes native vegetation. Riparian vegetation is important to maintain for habitat, to improve water quality and to reduce soil erosion. Infestations in riparian zones have a very high risk of spreading further if not managed properly.

Tropical soda apple has the potential to establish in a wide range of environments but has not yet reached its full potential distribution in Australia. Due to the serious risk posed by tropical soda apple, a Biosecurity Control Order under the NSW *Biosecurity Act 2015* (Biosecurity Act) was established for the entire State of NSW. This means that there are certain obligations for owners and occupiers of land where tropical soda apple is present that must be fulfilled – see obligations of owners and occupiers of land. This will help protect local communities, their livelihoods, and the environment.




Map showing the current suitable habitat for tropical soda apple in Australia. The darkest red shading represents the most suitable areas, through to grey (not suitable at all).

Source: www.weedfutures.net

## 2.1 Worst case scenario: “the plant from hell”

In the United States of America (USA), tropical soda apple is known as “the plant from hell” for good reason. It was first discovered in Hendry County, Florida in 1987 and was identified as a potentially problematic weed in 1988. By 1990 it covered 10,000 hectares and by 1994 it had spread to all 67 counties in the state. By 1995 it had infested approximately half a million hectares of land. The plant was declared a federal noxious weed in 1996, however tropical soda apple had spread into Georgia and Alabama and by 2007 it had reached a total of 11 south-eastern U.S states as well as the island of Puerto Rico.

Agriculture in the USA including pastures, fruit and vegetable crops, and sugar cane have all been affected by tropical soda apple. The economic impact from this invasive weed has been severe, which includes an estimated loss of $15 million USD per annum to cattle producers in Florida alone (2006)*.

$15 million loss to cattle producers*

Tropical soda apple infested half a million hectares of land in just 5 years

# 3. How to identify tropical soda apple

Tropical soda apple is an upright, highly branched, woody, and prickly shrub which grows to 2 metres high and 1.5 metres wide. The plant is a member of the Solanaceae family which includes many similar looking Australian natives and introduced species. Knowing how to identify tropical soda apple is important so that it is not mistaken for other plants. There are some key characteristics of the plant that will help with identification on the following pages of this manual.

Tropical soda apple looks like several other plants:

✓ **Learn** how to identify it using this manual

✓ **Ask** your local Biosecurity Weeds Officer if unsure

Tropical soda apple. Photograph by Greg Egan

# 3.1 Leaves

The leaves of tropical soda apple are green and normally the same shade throughout. The underside of the leaf can appear lighter green or yellowish at times. The leaves are generally 10–20 cm long and 6–15 cm wide. They have small, fine hairs on the upper and lower surface. Cream-coloured thorn-like prickles can also appear on both sides of the leaf, most often from the veins. The mid-vein and prominent lateral veins are cream-coloured on both sides. The leaves are deeply to shallowly lobed. Each leaf generally has 5–7 lobes.

Top: Tropical soda apple leaf with lobed edges, cream-coloured veins, and thorn-like prickles. Photograph by Greg Egan.

Bottom left: Leaves of an adult tropical soda apple plant. Photograph by Greg Egan.

Bottom right: Leaves of a juvenile tropical soda apple plant. Photograph by Bec Miller. NSW DPI © State of New South Wales.

# 3.2 Prickles

Sharp thorn-like prickles can be found scattered over tropical soda apple. The prickles on the leaves are generally straight, cream-coloured, wider at the base, and are most commonly found growing from the veins. The prickles can be up to 12 mm long and be found on both surfaces of the leaf. Sometimes the prickles have darker coloured tips. The prickles found on the stems can be straight or curved and are often smaller.

**Note:** If a tropical soda apple plant is growing in shade, the prickles may be fewer and less developed.

Top left: Cream-coloured prickles scattered over tropical soda apple. Photograph by Terry Inkson.

Top right: Smaller prickles can be found on the stem of tropical soda apple. Photograph by Terry Inkson

Centre: Straight prickles with darker tips growing from the veins on the leaves of tropical soda apple. Photograph by Terry Inkson.

Bottom: Prickles on the stems and underside of the leaves of tropical soda apple. Photograph by Bec Miller. NSW DPI © State of New South Wales.

# 3.3 Flowers

Tropical soda apple flowers consist of 5 white petals which curl backwards. They are 1.5–2 cm wide and occur on a short stem in small clusters of 3–6 flowers. The stamens found in the centre of the flower are cream-coloured.

Top: Small clusters of tropical soda apple flowers with 5 white petals on each flower. Photograph by Shane Landrigan.

Centre: Flowers of tropical soda apple with cream-coloured stamens in the centre of the flower. Photograph by Terry Inkson.

Bottom: Individual tropical soda apple flowers and buds growing on short stems. Photograph by Terry Inkson.

# 3.4 Fruit

Immature tropical soda apple fruit looks like a small watermelon. It is a rounded berry that is green with white or light green mottling. The fruit changes colour to yellow as it ripens. Individual fruits are generally 2–3 cm in diameter growing from a short stem. They can be found on the plant in small clusters of 3–6 fruit. The fruit does not have prickles.

Top left: Immature fruit of tropical soda apple resembles a small watermelon. Photograph by Greg Egan.

Bottom left: Ripe yellow fruit of tropical soda apple growing from a short stem. Photograph by Terry Inkson.

Bottom right: A cluster of ripe tropical soda apple fruit. Photograph by Greg Egan.

Top right: The different stages of tropical soda apple fruit. Photograph by Matt Bell.

# 3.5 Seeds

The seeds of tropical soda apple are brown, partially flattened, and approximately 3 mm long and 2.5 mm wide. The seeds are embedded inside the fruit in a sticky substance. Each fruit can contain over 400 seeds.

Below: Partially eaten tropical soda apple fruit exposing the sticky seeds inside. Photograph by Greg Egan.

Inset: The small, brown seeds of tropical soda apple. Photograph by Terry Inkson.

# 3.6 Seedlings

Tropical soda apple seedlings are covered in fine hairs. A very young, newly emerged seedling will first appear with just two narrow leaves. It will quickly develop more leaves and the leaf shape will become more rounded or heart shaped. As the seedling develops further, the leaves will continue to change appearing more lobed (or maple leaf-shaped) and the thorn-like prickles will develop on the plant.

Right: A newly emerged tropical soda apple seedling covered in fine hairs. Photograph by Bec Miller, NSW DPI © State of New South Wales.

Below: Tropical soda apple seedlings at various stages following a fire. Photograph by Josh Biddle.

# 4. How to get help with weeds identification

The best way to get assistance with the identification of tropical soda apple or any other weed species is to contact your local control authority (council or county council) and ask for an inspection by a Biosecurity Weeds Officer.

Another great resource with information on over 330 weed species is NSW WeedWise which you can find at weeds.dpi.nsw.gov.au.

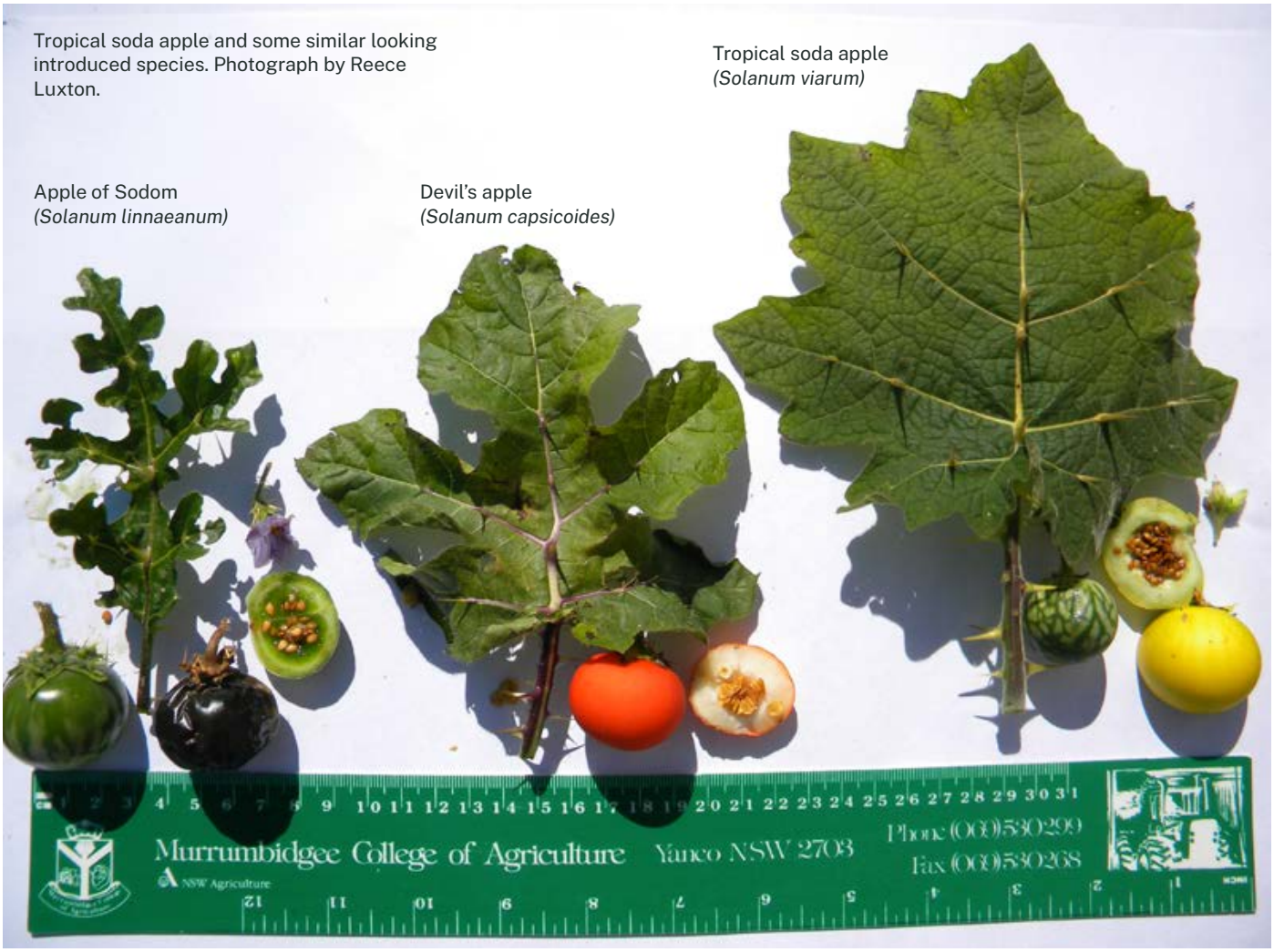
App Store

You can also download NSW WeedWise as a smart phone app via Google Play or the App Store – scan the appropriate QR code.

Google Play

For general enquiries or to report prohibited weeds, contact NSW Department of Primary Industries:

- via phone on **1800 680 244** (The Invasive Plants and Animals enquiry line)
- via email at weeds@dpi.nsw.gov.au



# 5. Similar species and knowing the difference

Several closely related plants can be mistakenly identified as tropical soda apple, so it is important to know the key differences between them. The following pages describe 6 Australian native species and 6 introduced species, and how to distinguish them from tropical soda apple.

## 5.1 Native species

***Solanum cinereum*** also known as Narrawa burr is an Australian native plant which is widespread in eastern NSW. It is also present in Victoria and South Australia. This species grows on hills and slopes in eucalypt woodland and is commonly found following a fire or other disturbance. It has been recorded as far north as Inglewood in southern Queensland.

### How is this species different from tropical soda apple?

- Flowers are mauve-purple with a yellow centre
- Underside of leaves are white-grey to pale yellow
- Leaves are generally shorter and narrower 5.3–12.4 cm long, 3.5–6 cm wide
- Only grows to 1 m high
- Immature fruit is very similar (like a small watermelon) but turns orange at maturity and brown as it dries.

Bottom left: *Solanum cinereum* in flower. Photograph by D. Hardin ©The Royal Botanic Gardens & Domain Trust.

Bottom right: Similar immature fruit of *Solanum cinereum.* Photograph by A.R. Bean.

Top right: Ripening and ripe orange fruit of *Solanum cinereum*. Photograph by Waltraud Pix, Majura, ACT.

***Solanum campanulatum*** is a native Australian shrub which grows mostly in wet and dry sclerophyll forest. It occurs in NSW coastal districts and adjacent ranges between Wollongong and Lismore.

## How is this species different from tropical soda apple?

- Has lavender-purple flowers with yellow centre
- Only grows to 1 m high
- Leaves are similar but are generally shorter and narrower (4.7–13.4 cm long, 3–10.4 cm wide)
- Fruit is similar in size and colour at all stages, but is half-enclosed in a leaf-like structure (calyx), which has prickles
- Seeds are black.

Top right: Flower of *Solanum campanulatum*. Photograph by Judy Morris ©The Royal Botanic Gardens & Domain Trust.

Top left: Immature fruit of *Solanum campanulatum*. Note: fruit is half enclosed in calyx (leaf-like structure) with prickles. Photograph by Judy Morris ©The Royal Botanic Gardens & Domain Trust.

Bottom left: Leaves of *Solanum campanulatum*. Photograph by Judy Morris ©The Royal Botanic Gardens & Domain Trust.

***Solanum ditrichum*** is an Australian native plant found in Queensland and NSW. It is generally found growing in wet sclerophyll forest and rainforest margins along the coast and tablelands. It has been recorded as far south as Dungog, NSW and as far north as Gympie in Queensland.

## How is this species different from tropical soda apple?

- Only grows to 60 cm high and often sprawls over the ground
- Flowers are purple with yellow centre
- Leaves are generally shorter and narrower (6–12 cm long and 4.5–9.5 cm wide)
- Prickles on upper leaf surface are generally smaller (2–8 mm long)
- Fruit can be yellow-green or pale green with dark green or purple streaks.

Bottom right: Mature fruit of *Solanum ditrichum*. Photograph by Shane Landrigan.

Bottom left: *Solanum ditrichum* flower and prickles on leaf surface. Photograph by Peter Woodard.

Top left: Immature fruit of *Solanum ditrichum*. Photograph by A.R. Bean.

***Solanum prinophyllum*** is an Australian native also known as forest nightshade. It grows in sclerophyll forests and margins throughout NSW in coastal areas and adjacent ranges. It is also found in Victoria and Queensland.

## How is this species different from tropical soda apple?

- Has lilac-blue flowers with a yellow centre
- Only grows to 50 cm high
- Leaves are shorter and narrower (3.8–9.4 cm long, 1.5 – 5 cm wide)
- Mature fruit is generally smaller (16–20 mm diameter)
- Immature fruit is very similar (like a small watermelon) but develops a purple colour as it matures.

Top right: *Solanum prinophyllum* flowers. Photograph by T.M. Tame ©The Royal Botanic Gardens & Domain Trust.

Top left: Leaves, prickles, and young fruit of *Solanum prinophyllum.* Photograph by A.R. Bean

Bottom left: *Solanum prinophyllum* habit. Photograph by Stuart Mackay.

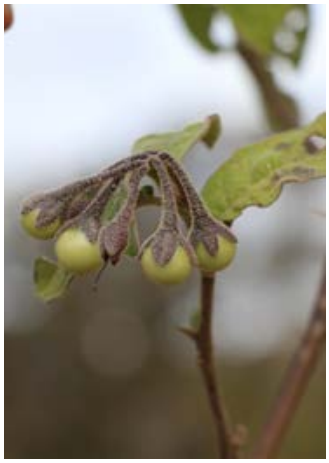
Bottom right: Close up of ripe fruit of *Solanum prinophyllum*. Photograph by John Tann.

***Solanum sulphureum*** also known as Manning yellow solanum is listed as endangered under Commonwealth and NSW legislation. It is a prickly shrub found in sun-lit clearings within rainforest and wet sclerophyll forest, or in rainforest regrowth on pasture land. It is restricted to the North Coast region of NSW.

## How is this species different from tropical soda apple?

- Flowers are purple with bright yellow centre (stamen)
- Fruit is generally smaller (14–19 mm diameter) and yellowish-green or striking sulphur yellow
- Adult leaves are ovate (egg-shaped) and not lobed (juvenile leaves can appear lobed)
- Underside of leaves are greenish-white or white to grey.

**Endangered species**



Top left: *Solanum sulphureum* adult ovate leaves.

Top right: Purple flower of *Solanum sulphureum* and juvenile leaves.

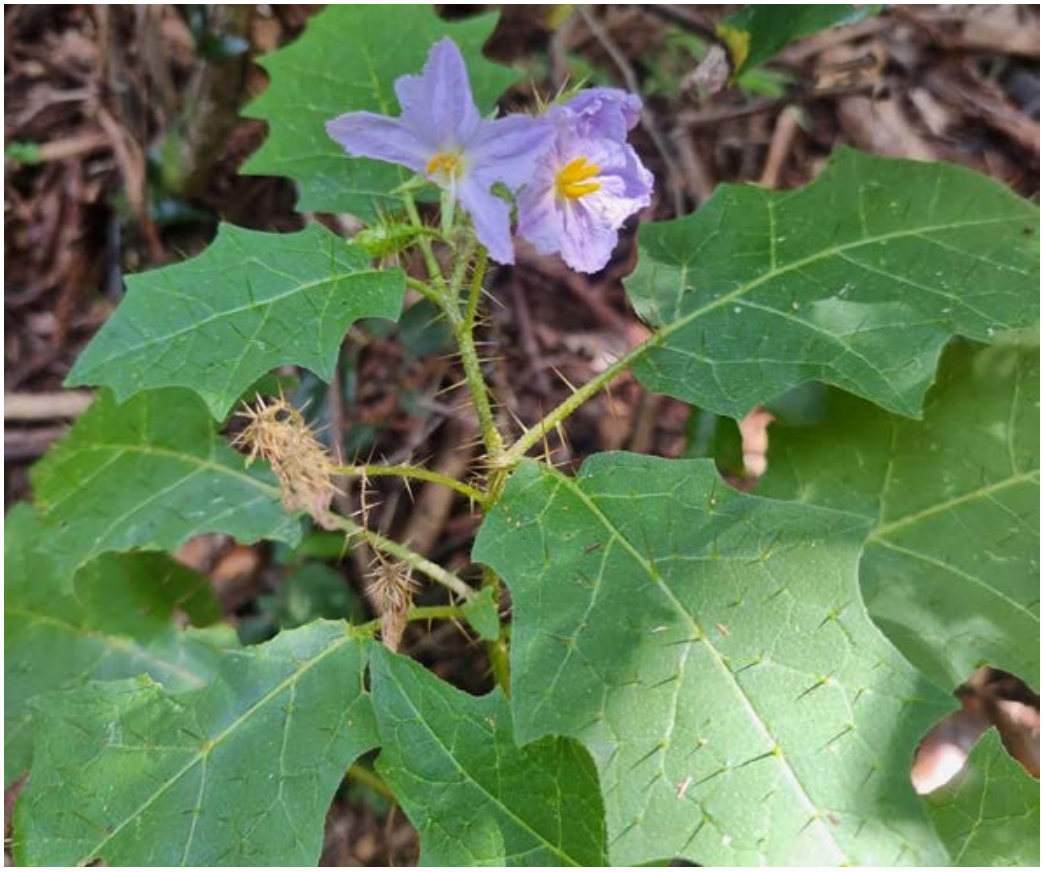
Bottom right: Small yellow-green fruit of *Solanum sulphureum*.

Bottom left: Habit of *Solanum sulphureum*. All photographs by Terry Inkson.

***Solanum vicinum*** is a prickly and erect native shrub which is mostly found in the North Coast and Northern Tablelands regions of NSW as well as South-Eastern Queensland. It has been recorded from Lake Macquarie in NSW to Gympie in Queensland. Its habitat includes evergreen rainforest, and wet eucalypt forest with rainforest understorey, or rainforest margins.

## How is this species different from tropical soda apple?

- Flowers are purple with a yellow centre
- Only grows to 90 cm high
- Leaves are generally shorter and narrower (7.5–14 cm long, 4–9.5 cm wide)
- Fruit is green or brownish when immature, turning purple when mature.



Top right: *Solanum vicinum* flower. Photograph by Lynn Bohs.

Top left: Habit of *Solanum vicinum*. Photograph by Reece Taverner.

Bottom left: Narrower leaves of *Solanum vicinum*. Photograph by Greg Tasney.

Bottom right: Ripe fruit of *Solanum vicinum*. Photograph by A.R. Bean.

# 5.2 Introduced species

**Devil's apple *(Solanum capsicoides)*** is an introduced species from Central America. It is found mostly in high-rainfall regions; largely in near-coastal areas north from Bulahdelah in NSW. It has been recorded as far north as Mackay in Queensland.

## How is this species different from tropical soda apple?

- Only grows to 1m high
- Fruit is similar when immature, but turns bright orange-red when mature
- Flowers are similar (white), but have yellow stamen (centre).

Top left: The different stages of devil's apple (*Solanum capsicoides*) fruit. Photograph by Terry Inkson.

Top right: Devil's apple (*Solanum capsicoides*) flower with yellow stamen (centre). Photograph by Terry Inkson.

Bottom right: Ripe fruit of devil's apple (*Solanum capsicoides*). Photograph by Shane Landrigan

Bottom left: Devil's apple (*Solanum capsicoides*) habit. Photograph by Terry Inkson.

**Giant devil's fig *(Solanum chrysotrichum)*** is a tall, introduced shrub from Central America. It mostly grows in wet eucalypt forest with rainforest understorey, or rainforest margins. This species is most common north of Casino, NSW to Caboolture, Queensland, and is scattered along the coast between Port Macquarie and Ballina. It is also found just south of Wollongong, on Sydney's Northern Beaches, and on the Central Coast of NSW.

## How is this species different from tropical soda apple?

- Can grow much taller (up to 4 m high)
- Fruit is smaller (1–1.5 cm diameter) and more numerous (in larger clusters)
- Fruit is green when immature and ripens to yellow or orange-yellow
- Flowers are similar (white) but have yellow stamen (centre) and in larger clusters (up to 50 flowers)
- Prickles are sparser on leaves (can be absent or on mid-vein only)
- Prickles are slightly curved
- Leaves are generally longer and wider (17–30 cm long, 12–20 cm wide).

Priority weed in some regions

Immature fruit (top) and mature fruit (above) of giant devil's fig (*Solanum chrysotrichum*). Both photographs by Sheldon Navie.

Curved prickles (top left), flowers (bottom right), and tall habit (bottom left) of giant devil's fig (*Solanum chrysotrichum*). All 3 photographs by Kim Curtis.

**Apple of Sodom *(Solanum linnaeanum)*** is an introduced shrub which is native to Africa and Europe. It is found in NSW, Queensland, Victoria, South Australia, and Western Australia and it prefers sandy soils.

## How is this species different from tropical soda apple?

- Flowers are pale purple-blue with yellow centre
- Only grows to 1.5 m high
- Leaves are more deeply lobed and irregularly shaped
- Leaves are smaller: 4–8 cm long, 3–6 cm wide.

Top right: Ripe fruit of apple of Sodom (*Solanum linnaeanum*). Photograph by Shane Landrigan.

Bottom right: Apple of Sodom (*Solanum linnaeanum*) flower. Photograph by Terry Inkson.

Left: Leaves and ripe fruit of apple of Sodom (*Solanum linnaeanum*). Photographs by Terry Inkson.

**Buffalo burr *(Solanum rostratum)*** is an introduced prickly, annual herb which is native to Mexico and the USA. It is found in cereal-growing regions of NSW, Queensland, Victoria, South Australia, and Western Australia. This weed species invades disturbed areas and overgrazed land.

## How is this species different from tropical soda apple?

- Flowers are yellow
- Only grows to 1 m high
- Leaves are smaller (2–10 cm long, 1–8 cm wide) and can appear greyish
- Fruit is smaller (10 mm diameter), covered in prickles and drying blackish with papery skin
- Seeds are dark brown or black.

Right: Buffalo burr (*Solanum rostratum*) in flower. Photograph by B. Trounce, NSW DPI © State of New South Wales.

Below: Flowers and prickle-covered fruit of buffalo burr (*Solanum rostratum*). Photograph by B.A. Auld and R.W. Medd © NSW Department of Primary Industries.

**Sticky nightshade *(Solanum sisymbriifolium)*** is an introduced erect annual or short-lived perennial herb with prickles abundant on most parts. This species is native to South America and is often observed as a weed of disturbed sites in Western Sydney, the Central Tablelands, and the Hunter region. It has also been recorded in Southern Queensland, Victoria, and Western Australia.

## How is this species different from tropical soda apple?

- Flowers can be similar (white) and/or pale blue with yellow centre (stamen)
- Only grows to 1.5 m high
- Fruit is smaller and ripens to bright red
- Leaves are generally shorter and narrower (5–14 cm long, 4–10 cm wide).

Priority weed in some regions

White and pale blue flowers (top left), immature green and ripe red fruit (top right), and shorter, narrower leaves (left) of sticky nightshade (*Solanum sisymbriifolium*). All photographs by Terry Inkson.

**Devil's fig *(Solanum torvum)*** is a tall, introduced perennial shrub from Central and South America. It is most commonly found in the coastal regions from Port Macquarie in NSW to Cooktown in Queensland. It has also been recorded in the Greater Sydney region of NSW, in the Northern Territory, Western Australia, and South Australia. It grows in woodland, forests, rainforest margins, riparian areas, pastures, and disturbed sites.

## How is this species different from tropical soda apple?

- Flower is similar (white) but with yellow centre (stamen)
- Flowers in larger clusters (15 to 100 flowers)
- Fruit is smaller (12 – 17 mm diameter) and is plain green (not mottled) when immature.
- Can grow taller (to 3 m high)
- Generally fewer and smaller prickles (3–7 mm long)
- Leaves are a similar size but are oval shaped or have more shallow lobes
- Underside of leaves are greyish.

Priority weed in some regions

Top left: Devil's fig (*Solanum torvum*) flowers and small green immature fruits. Photograph by joloei.

Top right: White flower with yellow stamen of devil's fig (*Solanum torvum*). Photograph by Paul Marynissen.

Bottom left: Oval shaped leaves of devil's fig (*Solanum torvum*). Photograph by Stewart Newman.

# 6. What are our legislative responsibilities?

In NSW, all landholders (public and private) have legislative responsibilities in relation to weeds biosecurity on land that they own or occupy. This includes all privately owned, leased, and occupied land and water. Public land owned or managed by government organisations is no exception, such as land under the control of local councils, Crown Lands, National Parks, Local Land Services, Transport for NSW, Forestry NSW, and RailCorp, for example. Weeds biosecurity in NSW is governed according to the NSW *Biosecurity Act 2015.*

## 6.1 The *NSW Biosecurity Act 2015*

The NSW *Biosecurity Act 2015* commenced on 1 July 2017 to manage biosecurity risks in NSW. The Biosecurity Act is centred around the principle that biosecurity is a shared responsibility – highlighting the importance of government, industry and the community working together to manage biosecurity risks such as tropical soda apple.

## 6.2 Biosecurity (Tropical Soda Apple) Control Order 2022

Tropical soda apple poses a very high biosecurity risk to Australia. As a result, the *Biosecurity (Tropical Soda Apple) Control Order 2022* was established under the Biosecurity Act, to help eliminate the risk posed by this plant. The control order establishes mandatory control measures that must be implemented by people in NSW who have tropical soda apple on their property or who might move tropical soda apple plants from one location to another. This directs what landowners and occupiers must do to destroy and contain tropical soda apple.

Tropical soda apple infestation. Photograph by Bec Miller, NSW DPI © State of New South Wales.

Biosecurity Weeds Officers have a ‘power of entry’ and may need to inspect your property for tropical soda apple and other priority weeds

## 6.3 Obligations of owners and occupiers of land

As per the Biosecurity Control Order, all owners and occupiers of land in NSW must do the following in relation to tropical soda apple:

1. Notify the local control authority of any new infestations of tropical soda apple on the land.
2. Destroy all tropical soda apple plants (including fruit) on the land.
3. Ensure that the land is kept free of tropical soda apple by destroying all new plants that emerge.

**Where tropical soda apple is present or is likely to be present:**

4. Ensure that any carriers* of tropical soda apple (including fruit and seed) are not moved from the land.
5. Notify the local control authority before moving tropical soda apple (including fruit and seed) or a carrier*.

*Carriers of tropical soda apple could be livestock, vehicles, soil, or manure for example. For more detailed information, see what are carriers? on page 48.

## 6.4 Local control authority

The local control authority is responsible for weeds related functions under the Biosecurity Act. The local control authority is generally the council for your own local government area. The role of local control authority may be delegated to a county council or joint organisation, which manages multiple local government areas in a region.

## 6.5 Biosecurity Weeds Officers and compliance

Local control authorities appoint authorised officers under the Biosecurity Act to undertake various weed management functions across their area of operation. These people may be known locally as “Weeds Officers” or “Biosecurity Weeds Officers” and they are generally the person that you will meet when discussing weeds with your local control authority. The main objective of Biosecurity Weeds Officers is to assist landholders by providing best-practice advice to help minimise the impact that weeds have on the local community, environment, and economy.

**Help to minimise the impact of weeds on your local community**

A Biosecurity Weeds Officer will give you best practice advice on how to manage weeds

## 6.6 Property entry

One of the functions of a Biosecurity Weeds Officer is to inspect land for weeds that pose a risk to the local economy, community, or environment. Officers authorised under the Biosecurity Act have a 'power of entry' to any property to inspect for weeds.

Biosecurity Weeds Officers may need to inspect your property for the presence of tropical soda apple and other priority weeds. The local control authority will usually contact you to arrange a suitable time to conduct the inspection. It is advised that the property owner or occupier is at the property at the time of the inspection. This process will give you the opportunity to seek advice on the identification of weeds growing on your land and best practice management. A weeds inspection will also assist you in understanding your legislative responsibilities in relation to certain weed species.

## 6.7 Obligations in riparian zones

Tropical soda apple fruit and seed is easily spread by water and can be washed into riparian zones during floods, high tides, or weather events.

If the property you own or occupy contains a river, creek, or other waterbody you are responsible for managing tropical soda apple that appears in the riparian areas right down to the water's edge, as well as on any banks, sand bars or dry beds within the waterbody itself. If a river, creek or any other waterbody is situated between the land you occupy and another person's land then you are responsible to the middle line of the river, creek or waterbody

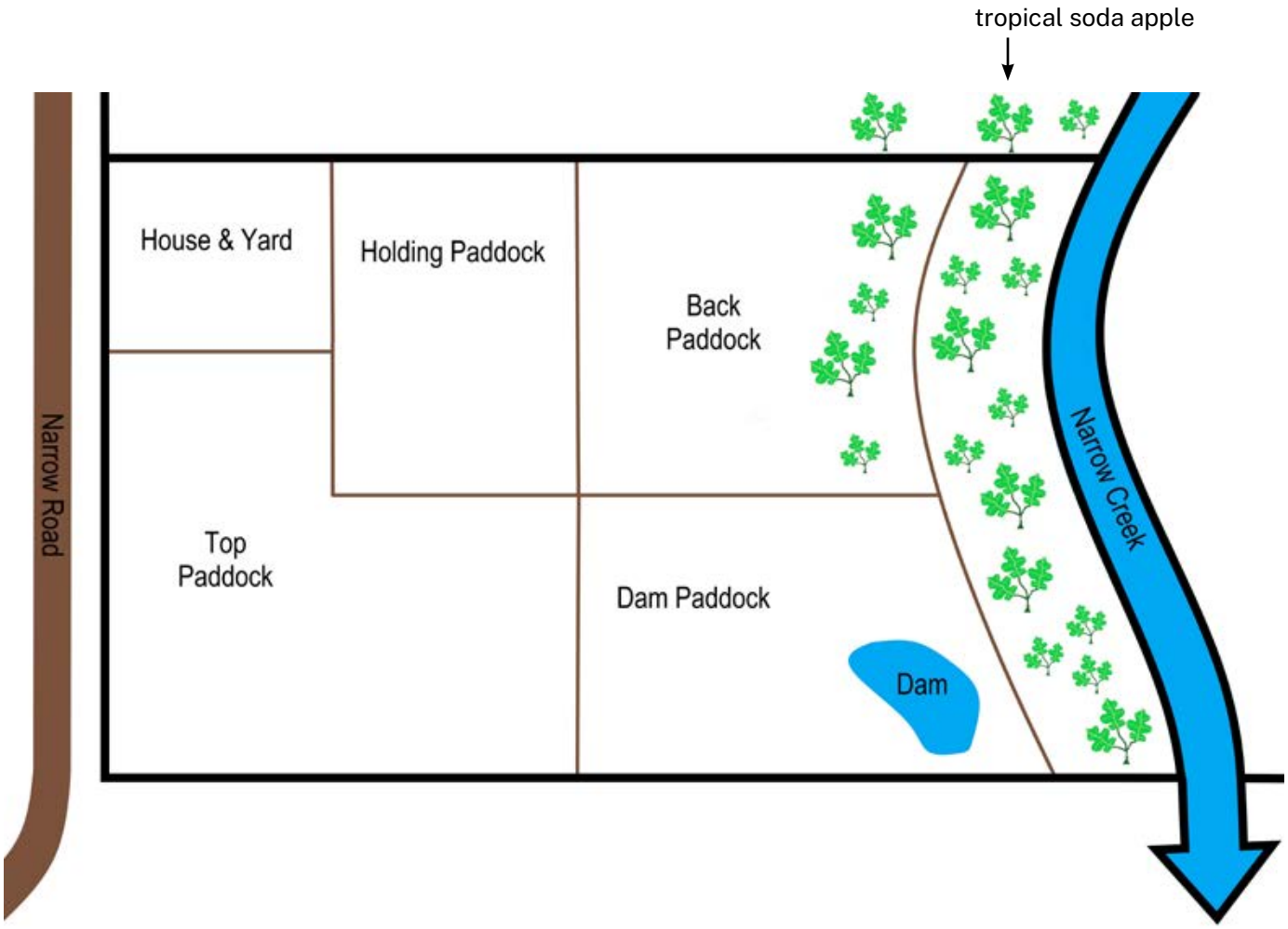
A fruiting tropical soda apple plant growing next to a creek. Photograph by Greg Egan.

If we all check our riparian areas for tropical soda apple the **whole community will benefit**

## 6.8 Case study 1

# Riparian zones

"Recently I noticed a prickly plant growing in the back paddock that I hadn't seen before. My neighbour told me that he had found a few new plants on his property too and he thought it might be tropical soda apple. I contacted Doug, the Weeds Officer from the Council, who came out to my property and confirmed that the plant was tropical soda apple. We inspected the rest of the property and found lots of tropical soda apple plants down along the creek where I've had it fenced off for years. I told Doug that I don't use any of that land and I shouldn't have to control weeds down along the creek. Doug said that I still have a legal obligation to control all the tropical soda apple on my property, including the fenced off riparian area. Apparently, it's my legal duty to control weeds right down to the water's edge and even to the middle line of the creek."



## 6.9 Queensland legislation

Your obligations for managing tropical soda apple in Queensland may be different from NSW. You can contact the Queensland Department of Agriculture and Fisheries for more detailed information, however below is a summary of Queensland legislative requirements relating to tropical soda apple. You must report all sightings of tropical soda apple to Biosecurity Queensland immediately: Report here

**Queensland Legislation**

- Tropical soda apple is declared as prohibited matter under the *Queensland Biosecurity Act 2014*
- You must not keep, grow, move, give away, sell, import or release into the environment
- You must not take any action reasonably likely to exacerbate the biosecurity risk posed by tropical soda apple
- You must take any action that is reasonably likely to minimise the biosecurity risk posed by tropical soda apple
- You must report all sightings to Biosecurity Queensland immediately.

For more information on tropical soda apple in Queensland click here: Tropical soda apple in Queensland

# 7. What if I find tropical soda apple?

In NSW, when you first find tropical soda apple, you must notify the local control authority immediately.

## 7.1 Know what you are dealing with

It is always best to have your local Biosecurity Weeds Officer confirm identification of the plant for you. There are several plants that can be confused with tropical soda apple. Once you have confirmed that you have tropical soda apple growing on your land, you should inspect the entire property to establish the full extent of the infestation. Taking photographs, making notes, or sketching a map are a good idea. This will help to determine the best weed management strategy for you moving forward.

Inspect your **entire property**
for tropical soda apple every **two months**

# 8. Controlling tropical soda apple

Your local Biosecurity Weeds Officer will provide you with best practice advice on how to destroy tropical soda apple on your property. Tropical soda apple grows quickly and seeds prolifically. A few plants can form a hectare sized thicket in just six months. Inappropriate control efforts can accidentally spread this weed and create a larger problem for you to deal with.

## 8.1 Who is responsible for controlling tropical soda apple?

The owner or occupier of land where tropical soda apple is present is responsible for controlling all tropical soda apple plants.

## 8.2 Inspecting for tropical soda apple

It is best practice to inspect your entire property at least every 2 months as tropical soda apple can produce fruit just 75 days after germinating. When inspecting for tropical soda apple, particularly focus on cattle camps, stock yards and riparian areas, where it is most likely to be found. You should regularly inspect for tropical soda apple to ensure that it is not able to set seed and produce more plants. This will reduce the amount of time, money, and resources that you will need to spend controlling tropical soda apple in the long run.

# 9. Control options

Successful control of tropical soda apple requires repeated and regular follow up efforts. This means looking for new plants and killing or removing them before they fruit. The control options you choose will depend on the number and size of plants, but using a combination of control methods is usually the most effective. The following pages describe in detail the best practice control options for tropical soda apple.

## 9.1 Physical control

Physical removal of tropical soda apple is generally the better option when plants are found in fewer numbers and are younger and smaller. Areas where the soil is soft, loose, or sandy may also be more suited to this method. To avoid injuries from the prickles, wear heavy protective gloves and use pliers to grip the stems when removing plants.

**Directions:**

- Dig or pull smaller, younger plants where possible
- Lever bigger plants with a mattock or hoe and dig out roots with a trowel
- Make sure you get all the roots out to avoid regrowth
- Dispose of all plants and fruit properly to stop the spread – see plant and fruit disposal on page 42.

**Hint**: There is usually a sweet spot lower down on the stem that has less prickles
**Hint**: The cut-stump method is better for larger, deeper-rooted individual plants

**To avoid injuries from the prickles:**

- Wear heavy protective gloves when handling
- Use pliers to grip stems when removing plants.

## 9.2 Using herbicides

Always check that you have the correct herbicide for the target weed species and the situation you are using it in (e.g. pasture, riparian area, forest etc.). You must read the product label before using a herbicide and you must follow all instructions on the label carefully including wearing the appropriate personal protective equipment.

Some herbicides are approved for use in certain circumstances that are not specified on the label. This is only allowed under a specific “Off-label” permit which is approved by the Australian Pesticides and Veterinary Medicines Authority (APVMA). If using an off-label permit, then you must read and follow the instructions on the permit carefully.

Check NSW WeedWise for the most up-to-date herbicide options and current permits for tropical soda apple. If you are unsure about the use of herbicides, you can contact your local Biosecurity Weeds Officer for advice.

Several effective herbicides are permitted for use on tropical soda apple under permit PER12942. Some of these herbicides are not permitted for use within 5 metres of water bodies. The following pages contain directions for different methods using herbicides to control tropical soda apple.

**Using Herbicides**

- Make sure you have the right herbicide for the weed species and situation
- Always read the product label and permit (if applicable) before using
- Wear the appropriate personal protective equipment
- Some herbicides are **Not Permitted** for use within 5 metres of a waterbody
- Check NSW WeedWise for current herbicide options and permits for tropical soda apple
- If unsure ask your local Biosecurity Weeds Officer for advice.

Foliar spraying tropical soda apple with herbicide. Photograph by Reece Luxton.

## Cut-stump method

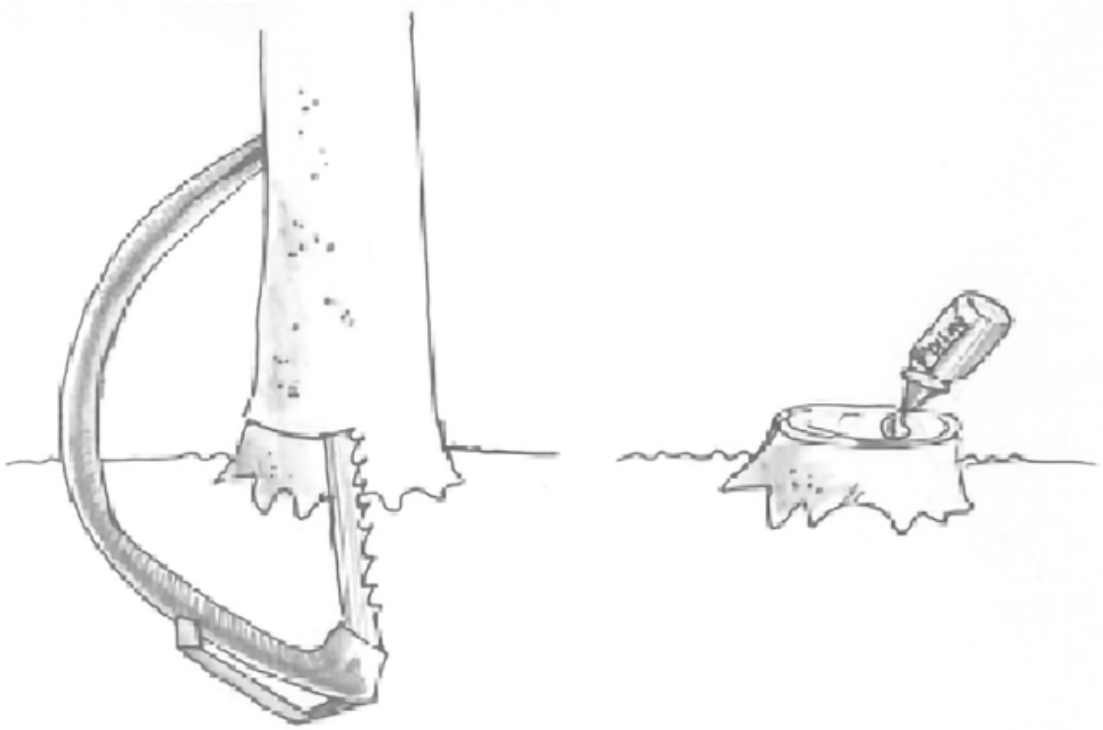
The cut-stump method is a good option for fewer, scattered, large or deep-rooted tropical soda apple plants or where the soil is too hard to physically remove smaller plants. If done correctly this will kill the whole root system of the plant. Two people can cut-stump over one hundred tropical soda apple plants in a day.

**Directions:**

- Cut stems close to the ground using long-handled loppers, secateurs, or a saw
- Immediately apply the herbicide to the stump (within 10 seconds)
- Leave the cut stump in the ground with the herbicide applied
- **Dispose of all plants and fruit properly to stop the spread** – see plant and fruit disposal on page 42.

**Hint:** Cut stems as close to the ground as possible to increase effectiveness.

Diagram showing the cut and paint method. Source: www.hunterregionalweeds.net.au



## Some herbicide options for using the cut-stump method:

1. Any herbicide containing Picloram 44.7 g/L + Aminopyralid 4.47 g/L (Vigilant II ® gel) undiluted.
2. Any herbicide containing Glyphosate 360 g/L (Various products). This will need to be mixed at a rate of 1 part per 1.5 parts of water before use (e.g. 100mL product in 150mL water). Read APVMA permit PER9907.

**See all current herbicide options at NSW WeedWise**

**Always read the label and associated permit before use and follow all instructions carefully**

## Foliar spot-spraying method

Foliar spot-spraying is generally more suitable for larger or dense infestations of tropical soda apple, where physical removal or the cut-stump method would not be practical. Follow up spraying will be required for any regrowth, to ensure all plants have been killed.

**Important:**
**To stop the spread, ideally spray plants before they fruit.**

**Directions:**

- Remove all fruit from tropical soda apple before spraying wherever possible
- Dispose of all fruit properly to stop the spread – see plant and fruit disposal on page 42
- If spraying within 5 metres of a waterbody, make sure you are using an approved herbicide
- Fill your spraying equipment with the appropriate mix of a suitable herbicide and wetter
- Spot-spray all leaves and stems to the point of run-off, ensuring you cover the entire plant
- Check the plants a week after spraying when the leaves have wilted to make sure that no fruits were missed. Remove and properly dispose of any more fruit found
- Follow-up spray any plants that show signs of regrowth.

**Hint:** If you don't cover the entire plant in herbicide, it will result in regrowth.
**Hint:** Use a suitable herbicide dye in your mix so that you know which plants have been sprayed.

## Some herbicide options for using the foliar spot-spraying method:

1. Picloram 100 g/L + Triclopyr 300 g/L + Aminopyralid 8 g/L (Grazon Extra®)

   Rate: 500mL in 100L of water plus a wetter.

   Read: APVMA permit PER12942 for all details.

   **Important notes:**

   - **Do not** use within 5m of a waterbody.
   - A wetter must be used at a rate of 500 mL per 100 L.
   - Ensure spray covers all foliage and stems as incomplete application will result in regrowth.

2. Glyphosate 360 g/L with Metsulfuron-methyl 600 g/kg (Only products registered for aquatic use)

   Rate: 2 L glyphosate plus 10g of metsulfuron-methyl in 100 L of water plus a wetter.

   Read: APVMA permit PER12942 for all details.

   **Important notes:**

   - **May be used** within 5 m of a waterbody
   - A wetter must be used at a rate of 500 mL per 100 L
   - Ensure spray covers all foliage and stems as incomplete application will result in regrowth.

**See all current herbicide options at NSW WeedWise**

**Always read the product label and associated permit before use and follow all instructions carefully**

"You cover a bigger area spraying, but you have to get them before they fruit"

Foliar spraying tropical soda apple. Photograph by Reece Luxton.

# 10. Plant and fruit disposal

The correct disposal of tropical soda apple plants and fruit is vital to ensure that you are not spreading it further. Tropical soda apple can regrow from stem and root fragments as well as reproduce via the seeds found inside the fruit. Disposing of all plant materials properly will save time and effort in the long run. If you move tropical soda apple plant materials from your property, you may be committing an offence.

"You get rid of that seed, and you stop the spread"

## 10.1 Remove the fruits before spraying where possible

Spraying tropical soda apple with herbicide correctly will kill the adult plant but will not kill the seed found inside the fruits. Where possible, all fruits should be removed from the plants before spraying. Fruits must be placed in a sealable plastic bag or container for later disposal or burning. Check the plants a week after spraying when the leaves have wilted and collect any fruits that were missed. Wear heavy protective gloves when removing fruit to avoid injury from the prickles.

Above: Removing and bagging tropical soda apple fruits. Photograph by Reece Luxton.

Below: Tropical soda apple fruits collected for storage and later disposal. Photograph supplied by Greg Egan.

## 10.2 Storing plants or fruit

If you need to store tropical soda apple plants prior to disposal or burning, you should keep them contained in an area away from flood zones, livestock, and other disturbances to avoid further spread. Fruit should be kept in a sealed plastic container to prevent animals from accessing and spreading further.

## 10.3 Burning

Plants and fruit can be burned in a very hot fire or incinerator. It is best practice to keep the same location for your burn site each time. This will allow for easier, regular checks for seedlings and regrowth, and minimise the risk of plants appearing elsewhere on your property. Where possible choose a location where tropical soda apple is already growing. Make sure that the fire site is away from flood prone areas, livestock and other disturbances that may cause further spread of plants, fruit, and seed.

## 10.4 Deep burial

Plants and fruit may be disposed of via deep burial at an approved council waste facility. You must inform the local control authority before moving tropical soda plant materials from the infested property.

You may be able to bury plants and fruit on your property providing you follow the following directions:

- Bury plants and fruit at least half a metre deep
- Bury away from flood zones, livestock, and other disturbances
- Check burial sites regularly for regrowth and seedlings.

The local control authority may have other options to dispose of tropical soda apple plants and fruit in your area. Contact your local Biosecurity Weeds Officer for advice.

- Always follow the advice of your local rural fire service when planning to burn
- Check the fire danger ratings and for total fire bans before burning
- Only carry out burns under suitable weather conditions.

A tropical soda apple fire site. Photograph by Shane Landrigan.

## 10.5 Case study 2

# Control program

“At first, I wasn’t too worried about the tropical soda apple and didn’t do anything about it. Then the weeds officers from the Council came and did an inspection. They said it was a bad weed and they educated me about it. They told me all the options to put a control program in place with the right chemicals. They gave me a Biosecurity Direction with a list of ways I had to comply. That was better than being fined off the Control Order.

I realised the tropical soda apple was a big problem and for the sake of my property, I had to take action. I regret not just doing it from the start. I was determined that by the time those officers came back, there was going to be no fruit on any plants and all the plants would be killed.”

# 11. How is seed spread?

Tropical soda apple seeds are found within the fleshy fruits. Each individual fruit can contain over 400 seeds which remain viable (able to germinate) for several years. Understanding how the seed can spread will help you minimise the risk of tropical soda apple being introduced to your land. If you already have tropical soda apple on your property, it is important to establish exactly where it is growing and how it can spread from one area to another.

## 11.1 Livestock

The main vector for the spread of tropical soda apple seed is cattle. In NSW, new infestations of tropical soda apple have been successfully located by tracing cattle movements from infested properties using the National Livestock Identification System database.

Tropical soda apple fruits smell sweet, and livestock will actively seek them out and consume them along with the seed inside. Cattle can spread viable seed in their manure for up to 6 days after consuming the fruit. After 6 days any consumed seeds that are passed through the digestive system are no longer viable.

Dung piles are suitable environments for seedling growth providing fertilizer, moisture, and resistance from grazing by cattle. Horses have also been observed eating the fruit and tropical soda apple seedlings have been found emerging directly from horse manure.

Goats will consume the entire plant including the fruits, stems, and leaves. In the USA, it is proposed that some form of poisoning may occur in goats that eat all parts of the plant, however more research is needed in this area to confirm this.

Cattle feeding on tropical soda apple fruits.
Photograph by Reece Luxton.

Tropical soda apple seedlings germinating in cattle manure.
Photograph provided by NSW DPI.

## 11.2 Water and floods

Tropical soda apple fruit is extremely buoyant and can be moved significant distances when floating in water. During floods, high tides, or weather events, fruit and seed can be washed into new areas. When the water recedes, the seeds will germinate, and tropical soda apple plants will emerge. Infestations are therefore common along waterways, drainage lines, in riparian areas, and flood zones.

Sometimes following a flood, tropical soda apple will appear because the soil is scoured out to a shallower depth where buried seed is able to germinate.

## 11.3 Vehicles and machinery

Tropical soda apple seeds are sticky and can easily attach to vehicles, trailers, or machinery directly. Seed can also be found in any soil, manure, or vegetation that is attached to the vehicle. Moving a machine or vehicle with tropical soda apple seed attached to it is highly likely to introduce the plant to a new area, and you are committing an offence if you do. If you use machinery or vehicles in areas where tropical soda apple is present, it is important to know when and how to clean them properly to stop the spread (see page 55).

Tropical soda apple growing on a creek edge. Photograph by Stuart Mackay.

A tropical soda apple seedling growing on a machine contaminated with seed. Photograph by Shane Landrigan.

## 11.4 Contaminated produce

Tropical soda apple seeds can be moved in contaminated fodder and produce including hay, silage, compost, grass seed, soil, mulch, and other materials such as sand and gravel.

## 11.5 Other potential vectors

Birds, deer, feral pigs, and rats are known to consume tropical soda apple fruits. However, it is unknown whether these animals spread viable seed in their faeces. The sticky seeds can also attach to your clothing and boots, and the fur and feathers of feral animals, birds and domestic pets.

Top: A feed out area with tropical soda infestation, which was likely introduced via contaminated fodder. Photograph by Eddie Hayward.

Bottom right: Tropical soda apple growing next to hay bales. Photograph by Candice Appleby.

Bottom left: Feral pigs. Photograph © NSW Department of Primary Industries

# 12. What are carriers?

A carrier is anything that has, or could have any plant materials on it, attached to it, or contained within it. This includes any fruit, seed, roots, stems, flowers, or leaves.

Examples of a carrier:

- Livestock
- Soil, sand, mulch, gravel, rock, or other materials
- Machinery and equipment
- Vehicles
- Manure and paunch
- Hay and silage
- Crops and other plants
- Green waste and wood chippings
- Animals (domestic and wild).

## 12.1 Guidelines for carriers

If you own or occupy land where tropical soda is present or is likely to be present, then you must not move a carrier from the land until you have taken the appropriate steps to ensure that tropical soda apple is not being moved along with it.

If you are planning on moving tropical soda apple plants, fruit, seeds or a carrier of tropical soda apple materials then you must notify the local control authority before you do. This will ensure that you are complying with the Tropical Soda Apple Control Order and avoiding fines or prosecution.

Examples of when you may have to move tropical soda apple plant materials or a potential carrier:

- For deep burial of plants and fruit at an approved waste facility
- Moving a vehicle or machine from an infested property
- Selling hay from an infested property
- Moving cattle manure from an infested property.

## 12.2 Case study 3

# Carriers (cattle)

“The past few years I’ve had tropical soda apple on my property and not too long ago I sold some cattle to a mate of mine down south. He recently found some tropical soda apple plants on his property because the cattle were eating the fruit and were full of seed. Now it’s spread all over his land. I didn’t know anything about the livestock holding period if you have tropical soda apple on your property. But since then, I’ve made changes and always hold my cattle for 6 or 7 days in a clean paddock before I move them anywhere.”

It is an offence to knowingly move tropical soda apple plants, fruit, seed or a carrier

# 13. Stop the spread

There are several best practice measures that you can implement to minimise the risk of introducing and spreading tropical soda apple on your property or to other 'clean country' in your area. It is an offence to knowingly move tropical soda apple plants, fruit, seed, or a carrier from an infested property without first notifying the local control authority.

## 13.1 Identify infested areas

To successfully manage tropical soda apple on your property you must first establish the exact location of the infestation. Wherever possible, remove and restrict any potential means of spread from the area such as livestock, vehicles, machinery, and other animals. It is best practice to utilise existing fencing or erect new or temporary fences to ensure that the tropical soda apple is not disturbed or spread further. If your property is visited regularly by others and their vehicles or machinery it is recommended that you place signage indicating that access to the infested area is not permitted.

## 13.2 Restrict livestock

If you have tropical soda apple on your property, restricting livestock from the infested area will significantly reduce the risk of spread. Use temporary fencing to restrict animal access while you work on a control program. Keep all animals away from any plants or fruit that you may have treated, piled, or stored, ready for disposal. Restrict livestock from tropical soda apple burn sites and burial sites on your property. Maintaining 'clean paddocks' with no tropical soda apple is very important in the successful management of the weed, especially if you have livestock.

**Restrict livestock** from infested areas using temporary fencing to minimise the spread

Poor management practice: cattle kept in a paddock infested with tropical soda apple. Photograph by Joel Crispin.

## 13.3 Buying, selling, and moving livestock

It is illegal to knowingly transport the seeds of tropical soda apple inside an animal, or to knowingly buy or sell an animal that contains seeds. The movement of seed in livestock is traceable via the National Livestock Identification System database. Knowingly moving seeds in animals or buying or selling animals containing seeds can result in prosecution and fines. It is always best practice to have a specified “holding paddock” free of tropical soda apple for quarantining livestock that are going to be sold or have recently been purchased.

**Stop the spread**

Keep livestock in a clean paddock at least:

- 6 days before selling
- 6 days after buying
- 6 days before moving.

## 13.4 Preparing for the sale of livestock

If you have tropical soda apple growing on your property, you must ensure that livestock is held in a paddock which is free of the plant for at least 6 days prior to selling. This will make sure that any tropical soda apple fruit and seeds that the animals have consumed will be passed through the digestive system and will not be spread to another property.

## 13.5 Case study 4

# Buying livestock

"I had tropical soda apple come up on my place a few years ago from cattle I bought in. I let them out onto my 50 acres as soon as they got off the truck. I had seen the warnings around about holding livestock for 6 days but just thought it wouldn't happen to me. The first time I saw them coming up I was surprised at how many plants there were. Every cow pat had loads of seedlings growing right out of it. I had also been using my neighbours place and one day she called me to let me know she had found it coming up where my cows had been grazing. She told me she had called the Council to let them know about the plants, and they'd be out the next day.

This was about 12 months after I bought those cows and my place had hundreds of plants on it. My neighbour made me realise the impact it was having on her place and how I have spoiled my own. Not to mention through my actions, she may have been fined. I was lucky I hadn't sold any of my stock as I would have been contaminating many other properties.

The Council fellas gave me a control program to follow, and I've managed to get on top of it. Now I make sure I hold any new stock in a clean paddock for a week before letting them out."

Photograph by Reece Luxton.

## 13.6 Preparing for the purchase of new stock

Ensure that you have a clean holding paddock, free of tropical soda apple that can be thoroughly inspected for weeds. Keep new cattle, horses, sheep, and goats for at least six days in the holding paddock immediately after purchase. After 6 days, any excreted tropical soda apple seeds won't germinate. Inspect the holding area for seedlings regularly as the seeds are viable for a long time.

## 13.7 Moving livestock between properties

If you have tropical soda apple on your property and are planning on moving livestock to another location, then you must also keep these animals in a clean holding paddock for at least six days prior. This includes if you are taking the animals for a short period only, such as for a rural show, race meeting or equestrian event.

Ensure you have a clean holding paddock, free of tropical soda apple

## 13.8 Case study 5

# Transporting livestock

"I've been in the livestock industry for over twenty years as a livestock carrier. A couple of years after tropical soda apple was found growing here, we didn't know much about it, and it was just business as usual transporting livestock from different vendors.

It wasn't until I completed a job for a mate of mine that I found out first-hand how devastating this weed can be. The property where the cattle came from was infested with tropical soda apple.

About eight weeks after I'd transported the cattle to my mate's property, he noticed tropical soda apple growing everywhere, even up in his steep country along the ridge lines and cattle camps.

To this day, Steve is continuing to control this dreaded weed that I had unknowingly brought to his property. It's costing him a lot of time and money to keep on top of it.

My livestock transportation business had to change because of tropical soda apple. Now I ask all buyers and sellers to hold their livestock in clean paddocks for at least 6 days before and after moving them. I always wash my truck at home or at the saleyard washdown area to avoid spreading this weed any further."

Photograph: NSW DPI © State of New South Wales.

# 13.9 Keep vehicles and machinery clean

It is extremely important to thoroughly clean vehicles and machinery that have been in areas where tropical soda apple is present or is likely to be present. Tropical soda apple seed is sticky and can easily attach to vehicles and machinery directly. Seed can also be hidden within soil, manure or vegetation that becomes lodged in or stuck to various parts of a vehicle, trailer, or machine.

If transporting livestock that may have been in contact with tropical soda apple, you must ensure that you thoroughly clean inside trailers and floats after each trip.

If a vehicle, trailer, or machine has been taken into areas where tropical soda apple is present or is likely to be present, then you must clean it thoroughly before moving it elsewhere.

Best practice weed hygiene for vehicles and machinery is:

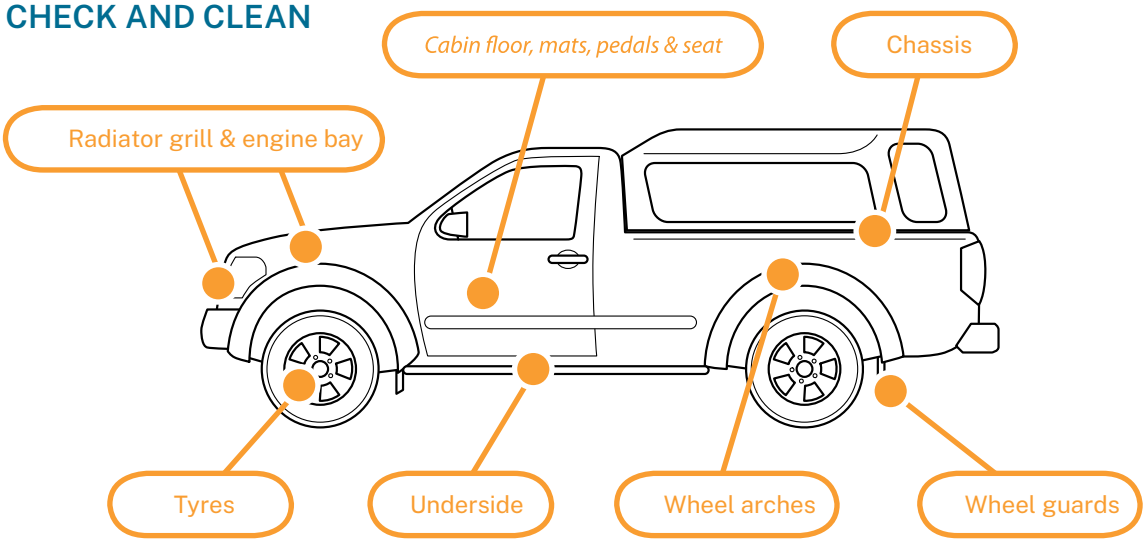
- Wherever possible, do not allow vehicles or machinery into infested areas
- Have a specified, dedicated washdown area for cleaning vehicles and machinery
- Ensure that the washdown area is outside of flood zones
- Create a raised mound or barrier around the outside of the washdown area to catch seed
- If possible, locate the washdown area at the entry of your property
- Direct vehicles to stay on designated roads or tracks only
- Have a high-pressure hose, broom, and brushes available for use at the washdown area
- Clean the entire outside of the vehicle or machine with water if available
- Use brooms and brushes if no water is available
- Don't forget areas where seed or soil might be hidden such as under the vehicle, around tyres, wheel arches, mud guards, behind the bull bar, and radiator grill
- Make sure that all material including soil and vegetation is removed
- Brush off the cabin floor, floor mats, seats, and pedals
- Use a vacuum cleaner or leaf blower if needed to get seed out of smaller areas.

Left: Washing down a backhoe.
Right: Blowing down a slasher.

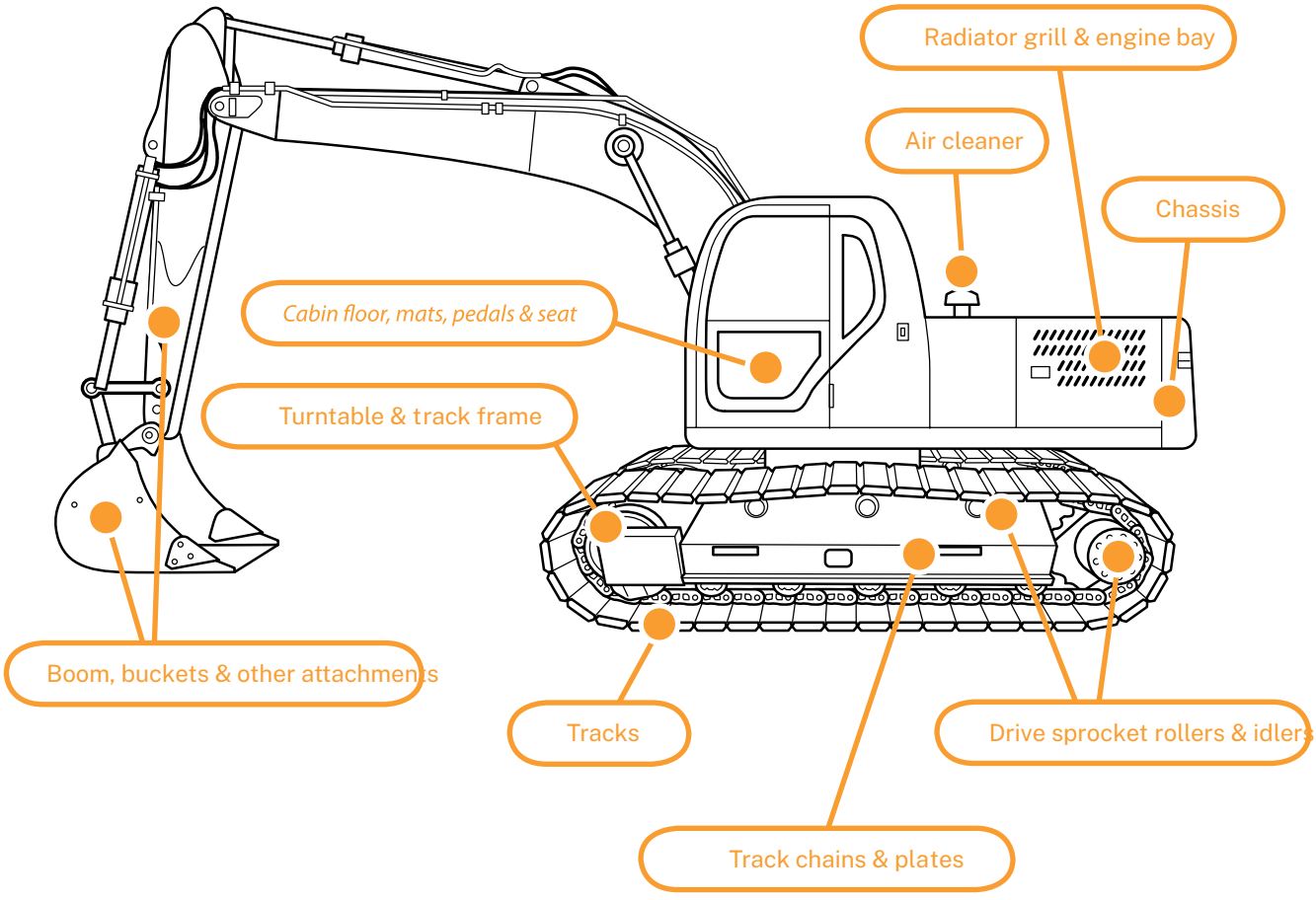
Source: Hunter Regional Weeds
www.hunterregionalweeds.net.au

The following diagrams show the key spots on vehicles and machinery to clean, and check are free of seed, vegetation, soil, and other materials that may contain seed.

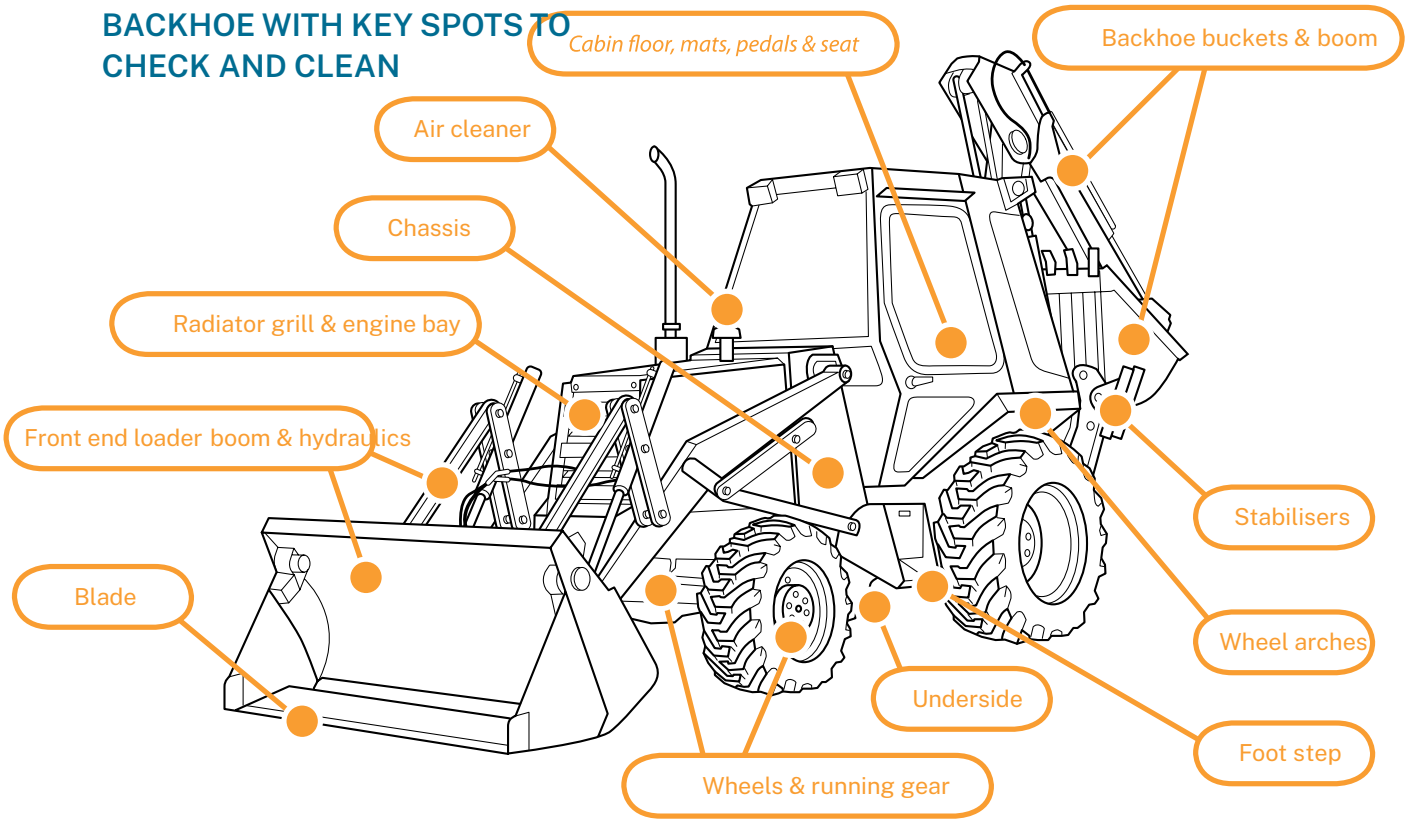
## 4WD VEHICLE WITH KEY SPOTS TO CHECK AND CLEAN




## EXCAVATOR WITH KEY SPOTS TO CHECK AND CLEAN




Source: NRM South https://nrmsouth.org.au/wp-content/uploads/2023/04/keeping_it_clean.pdf




Source: NRM South https://nrmsouth.org.au/wp-content/uploads/2023/04/keeping_it_clean.pdf

## Stop the spread by keeping machines and vehicles clean

Washing down an excavator on site. Source: Hunter Regional Weeds www.hunterregionalweeds.net.au

# 13.10 Receiving silage, hay or other fodder

If you receive hay, silage or other fodder onto your property then it is best practice to be cautious of potential contamination with weeds. This is particularly important if you receive fodder from areas where tropical soda apple is present, was previously present, or is likely to be present. To minimise the risk of introducing tropical soda apple and other weeds to your property, take the following steps:

- Ask your supplier to provide a Fodder Vendor Declaration Form (see page 59)
- Check all feed and fodder for contamination
- Restrict feeding areas to smaller, isolated areas at the same location
- Monitor feeding areas, water points and cattle camps for new plants
- Identify any new plants that appear
- Know how to identify tropical soda apple
- If tropical sods apple is found contact the local control authority immediately
- Control weeds quickly before they produce fruit and seed.

**Ask your supplier if the product is free of tropical soda apple and other weeds**

A tropical soda apple infestation introduced by contaminated fodder. Photograph by Brent Turner.

# Fodder Vendor Declaration Form

**VDF No.: _____**
**Contract No. _____**

| **1. Vendor's Details** | **2. Buyer's Details** |
|---|---|
| Vendor's name: | Buyer's name: |
| Address: | Address: |
| Tel: Fax: | Tel: Fax: |

| **3. Production Details** If vendor not the producer, provide corresponding producer's VDF No. | |
|---|---|
| Paddock identification: | Delivery date: |
| Commodity: | Cutting date: |
| Is 95% free of genetically modified organisms: **Yes** ☐ **No** ☐ | Other: |

| **4. Fodder Quality** | Analysis: Lab Reference no.: |
|---|---|
| Product description: | Dry matter: % |
| Species: | Crude protein: % of DM |
| (if mixed include estimate of percentage) | Metabolisable energy: MJ/kg of DM |
| Quantity: Bale size: | Other: |

**5. Weeds Biosecurity**

Is it likely that this fodder contains weed material / seeds? **Yes** ☐ **No** ☐

If Yes, please list what weed species may be present:

_____ _____ _____ _____ _____

**6. Testing and Chemical Status**

This form only applies to a single "lot" of hay (see Sampling Protocol on pressure sheet)

Has the fodder sample been taken according to AFIA Sampling procedure? *(one test per 200 tonne lot or paddock)* **Yes** ☐ **No** ☐

Has the fodder been tested for ARGT **Yes** ☐ **No** ☐

or Prussic acid? **Yes** ☐ **No** ☐

*If yes name, the Laboratory…… Case or Sample No……and Result ……..*

Has the fodder been tested for pesticide residues? **Yes** ☐ **No** ☐

*If yes, attach details of testing results on the delivered product*

Has the crop been grown on a property with either an organochlorine (OC) status classification, or under quarantine because of OC residues, within the past 12 months? *If yes give details* **Yes** ☐ **No** ☐ **Do not know** ☐

Does the property from where the fodder is grown carry accreditation under an independently audited QA program? **Yes** ☐ **No** ☐

*If yes give name of program*

Has the fodder crop been subject to spray drift during its production? **Yes** ☐ **No** ☐ **Do not know** ☐

*If yes attach a list of chemicals applied to neighbouring crops, the date sprayed and application rates*.

If selling fodder to a client, operating within a livestock QA program, who require a full list of chemical names, rates and dates both applied to the fodder crop, as well as those applied to neighbouring crops within 100 metres, please attach the details to this form.

**6 Declaration**

*I/We ……..……..……..…… (name of fodder supplier)*

declare that I/we have the systems in place to ensure that the fodder complies with all State and Federal laws and the requirements relating to chemical and pesticide residues and specified Government designated maximum residue levels. These systems include:

(i) any chemical treatment applied to any component of this consignment during storage on our premises or otherwise in our possession was applied as per product label approved by the National Registration Authority for Agriculture and Veterinary Chemicals and that the withholding period specified on that label has been observed; and

(ii) In relation to the sourcing of raw materials:

a) the property on which the fodder was grown, or the storage facility in which the fodder has been stored, carries accreditation under a recognised, and independently audited QA program, which includes chemical residue management provision, **OR**

b) has been purchased under a contract in which the supplier warrants that the fodder complies with all State and Federal laws and requirements relating to chemical and pesticide residues and specified Government designated maximum residue levels, **OR**

c) in relation to direct farm purchases that the supplier of the fodder has attested to the effect that any pesticides/insecticides used on the fodder have been applied in accordance with the registered labels of these chemicals, at rates not exceeding the maximum rate set out on the label of these chemicals and the appropriate withholding periods have been observed.

I/we further declare that this consignment at the time of the sale:

1. Is free from animal material as defined and required under State legislation and
2. It is otherwise fit for the purpose of feeding to the category of livestock indicated in the product description above.

Intended Use/Purpose: ……..……

**VENDOR'S SIGNATURE**_____ **DATE**_____

* AFIA Ltd does not accept responsibility or any liability for the information contained in this declaration. January 2017

Source: Australian Fodder Industry Association. https://afia.org.au/vendor-declaration-form

# 13.11 Receiving manure or paunch

If you receive manure or paunch onto your property, then it is best practice to be cautious of potential contamination with weeds. This is particularly important if you receive manure or paunch from areas where tropical soda apple is present, was previously present, or is likely to be present. To minimise the risk of introducing and spreading tropical soda apple on your property, take the following steps:

- Follow Environment Protection Authority (EPA) and industry guidelines for spreading and turning materials
- Define the paunch site parameters, install fencing, and display signage to clearly identify where the paunch is located
- Exclude livestock from paunch disposal sites
- Identify any new plants that appear
- Know how to identify tropical soda apple
- If tropical soda apple is found contact the local control authority immediately
- Control weeds quickly before they produce fruit and seed.

Photograph by G. Johnson, NSW DPI © State of New South Wales.

# 14. Response to natural disasters

Tropical soda apple is more likely to appear on your property following certain natural events occurring in the area. It is important to know when and where to look for new plants emerging so that you can manage smaller infestations before the plants reproduce, spread, and become more difficult to eradicate.

## 14.1 Floods

Tropical soda apple plants, fruit and seed can be moved significant distances during a flood event. This can result in new infestations appearing in places that have not previously had tropical soda apple present. Following a flood, it is best practice to inspect for new weeds on your entire property. Tropical soda apple is particularly likely to be found around waterways, drains, gullies, floodplains, and any other areas where flood debris has settled.

## 14.2 Bushfires

Tropical soda apple can quickly dominate areas following a bushfire by vegetative regeneration or 'regrowth' if the fire intensity is low and the plants are not severely damaged. A bushfire can also induce germination of seeds that are dormant in the soil.

In South Africa, studies have shown that smoke water enhances seed germination and seedling vigour of tropical soda apple. Although there needs to be more research in this area, tropical soda apple has been observed germinating in large numbers in areas impacted by bushfires in Australia.

Monitoring an infested area closely after a fire and controlling seedlings as they appear will assist in depleting the seed bank in the soil and ultimately help your tropical soda apple control program.


Left: Tropical soda infestation found growing in a wet gully following a flood. Photograph by Reece Luxton.

Bottom right: Many tropical soda apple seedlings emerging following a fire. Photograph by Andy Hughes

# 15. Industry best practice guidelines

Several industries and specific practices are considered particularly high-risk of introducing and spreading tropical soda apple to uninfested areas or 'clean country'. By ensuring that these best practice guidelines are implemented, the risk of you or your business being responsible for spreading tropical soda apple will be significantly reduced and potential fines and prosecution are likely to be avoided. Note: These guidelines are in addition to the general best practice advice and legislative requirements listed elsewhere in this manual.

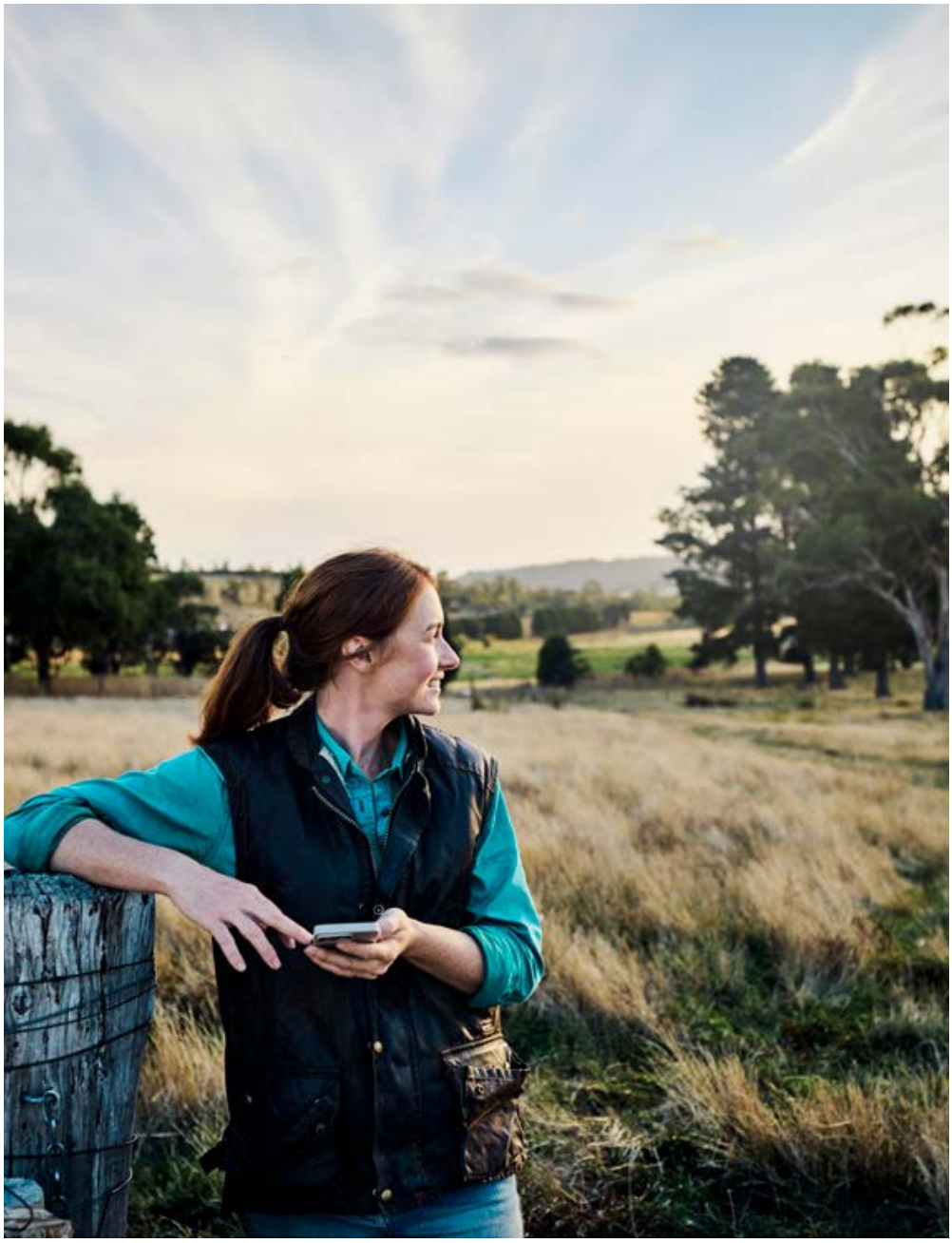

Positive tropical soda apple signage outside a property. Photograph by Greg Egan.

## 15.1 Production of silage, hay or crops

The following are best practice guidelines for all land where silage or hay is produced or where cropping occurs. These guidelines are particularly important for properties where tropical soda apple is present, was previously present, or is likely to be present:

- Inspect the entire property for tropical soda apple regularly (every 2 months)
- Tropical soda apple must be reported to the local control authority immediately
- Always check thoroughly for tropical soda apple prior to slashing, ploughing, baling, cutting, mulching, or disturbing an area
- Any areas where tropical soda apple is present must not be slashed, ploughed, cut,or disturbed without permission of the local control authority
- All tropical soda apple plants must be removed or destroyed, and all fruit removed before slashing, ploughing, baling, cutting, mulching or other disturbance of an area occurs. See plant and fruit disposal on page 42
- Any bales or crops containing tropical soda apple materials must remain on the property and be used at the property they were produced on
- Complete a Fodder Vendor Declaration Form (see page 59) to declare to your buyer that your product is unlikely to contain weeds
- **Note**: You will need to obtain a biosecurity permit before moving materials contaminated with tropical soda apple to another property
- Any machinery, vehicles or equipment used in the production of bales or crops must be thoroughly cleaned before leaving the infested area or property. See keep vehicles and machinery clean on page 55
- Keep detailed sales records of hay, silage and fodder including who, where, and how much
- Implement a tropical soda apple management plan for the property which includes control program, inspections, monitoring, record keeping, and machinery hygiene.

Slashing is one of the quickest ways to spread tropical soda apple



## 15.2 Case study 6

### Selling fodder

"I grow fodder & produce silage bales on my farm to help pay the bills. I've seen tropical soda apple in some of my paddocks but didn't have the time to inspect my crops before baling. I sold 40 bales to a bloke down river who now has a new infestation of tropical soda apple on his land. He called me up and gave me an earful saying he will never buy my bales again. I didn't realise how serious it was until I found out I could be fined. In the future I'll inspect my paddocks prior to baling to ensure I comply with the Biosecurity Act and make sure I don't spread it again."

# 15.3 Saleyards and abattoirs

The following are best practice guidelines for saleyards and abattoirs where livestock and waste (manure and paunch) can carry and spread seeds. These guidelines apply in areas where tropical soda apple is present, was previously present, or is likely to be present:

- Inspect the entire property for tropical soda apple regularly (every 2 months)
- Tropical soda apple must be reported to the local control authority immediately
- Exclude access to areas infested with tropical soda apple
- Store manure and paunch in specified bunded storage areas or bins, outside of flood zones and away from waterways
- Pasteurise manure and paunch, according to industry guidelines provided on page 65, to make any seed unviable before transporting from the property
- **Note**: You will need to obtain a biosecurity permit before moving contaminated materials to another property
- Thoroughly clean all machinery and vehicles used to load or transport livestock, manure, or paunch after each use. See keep vehicles and machinery clean on page 55
- Ensure that loads are contained, covered, and sealed to prevent spillage when transporting manure or paunch
- Only take manure or paunch to designated, approved sites
- Keep records of the date, amount, and site where manure or paunch is transported to
- Unload manure or paunch in designated areas only
- Ensure that loads are fully emptied at the site and check vehicles are free of any debris before leaving
- Implement a tropical soda apple management plan for the property which includes control program, inspections, monitoring, record keeping, and machinery hygiene.

## Pasteurisation process

Where high risk materials such as manure or animal waste potentially containing tropical soda apple seed are to be used offsite, a pasteurisation process should be implemented to minimise the risk of spreading tropical soda apple. The following steps are summarised from the Northern Rivers Livestock Exchange's (NRLX) pasteurisation process:

1. Following screening and removal of foreign matter, windrows are constructed by forming brown waste (manure and hay) into a long pile with a triangular cross-section with a base width of 4 m and a height of 2.5 m.
2. The apex and sloping sides promote water-shedding and prevent the manure from becoming too wet.
3. Piles that are too low will not heat up, and piles that are too high may heat up excessively, particularly if they are not well compacted or contain wet manure.
4. Windrows should be spaced at least 5 m apart with room at the ends to allow vehicle movement and turning equipment (excavator).
5. Green material is acquired from within the local site or imported to the site.
6. All green waste material is mulched onsite to a particle size of less than 100 mm for the first phase of mulching and placed in separate windrows to the brown waste.
7. The green material is reprocessed for a second time through a smaller 50 mm minus screen and again placed in separate windrows to the brown waste.
8. Brown and green waste is blended throughout the mulching process to produce the final product specification. A target range of 25-40 Carbon to 1 Nitrogen is required.
9. Moisture content should remain between 40% and 60% and be monitored using a soil moisture and temperature probe. Water can be added to the material if the soil moisture reaches below 40%.
10. The material should reach above 55°C within the first 24 to 72 hours. During the pasteurisation process it is important to ensure the heap does NOT exceed 68°C. Before the pile reaches these temperatures, it will require turning to cool the material or alternatively adding more water.
11. To monitor temperatures, insert temperature probe into the pile across 5 evenly spaced locations within each pile, as close to the middle of the pile as probe will allow.
12. Record the temperatures, date and time of measure for each location during the pasteurisation process.
13. Once all five locations have reached above 55°C for three consecutive days, the pile is to be turned. Use an excavator to lift the pile and transfer it into new rows ensuring the materials on the outside of the pile are rotated toward the centre of the new pile or row.
14. Adequate space is to be left to allow the excavator to transfer each row into an entirely new row with sufficient rotation and aeration.
15. Steps 12-13 are to be repeated five (5) times to ensure the pile has been above temperature for a minimum of 15 days and turned a minimum of five (5) times.
16. If the pile does not reach above 55°C in all three (3) locations for three (3) consecutive days, the temperatures are to continue to be recorded until the pile reaches above 55°C for three consecutive days.

## 15.4 Quarries

The following are best practice guidelines for all land where rock, sand, gravel, or other materials are extracted from the ground. These guidelines apply where tropical soda apple is present, was previously present, or is likely to be present:

- Inspect the entire property for tropical soda apple regularly (every 2 months)
- Tropical soda apple tropical soda apple must be reported to the local control authority immediately
- Thoroughly clean all machinery and vehicles used to load or transport quarried materials after each use. See keep vehicles and machinery clean on page 55
- Ensure that loads are contained, covered, and sealed to prevent spillage when transporting quarried materials
- Keep records of the date, amount, and site where materials are transported to
- Ensure that loads are fully emptied, and check vehicles are free of any debris before leaving
- Exclude access to tropical soda apple infestations and install signage indicating that access to the infested area is not permitted
- Do not allow any materials to be excavated in areas where tropical soda apple is found
- **Note:** You will need to obtain a biosecurity permit before moving contaminated materials to another property
- Monitor high-risk areas for tropical soda apple such as disturbed areas, nearby watercourses, riparian zones or bushland, as well as roads, paths, or tracks used by vehicles and machinery
- Implement a tropical soda apple management plan for the property which includes control program, inspections, monitoring, record keeping, and machinery hygiene.

## 15.5 Forestry and logging

The following are best practice guidelines for all land where timber and forestry practices occur. These guidelines apply where tropical soda apple is present, was previously present, or is likely to be present:

- Inspect the entire property for tropical soda apple regularly (every 2 months)
- Tropical soda apple must be reported to the local control authority immediately
- Thoroughly clean all machinery and vehicles used to load or transport timber after each use. See keep vehicles and machinery clean on page 55
- Keep records of the date, amount, and site where timber is transported to
- Ensure that loads are fully emptied, and check vehicles are free of any debris before leaving
- Exclude access to tropical soda apple infestations and install signage indicating that access to the infested area is not permitted
- Do not allow any trees to be felled in areas where tropical soda apple is found
- Monitor high-risk areas for tropical soda apple such as disturbed areas, nearby watercourses and riparian zones, roads, paths, and tracks used by vehicles and machinery
- Implement a tropical soda apple management plan for the property which includes control program, inspections, monitoring, record keeping, and machinery hygiene.



# 15.6 Utility easements and transport corridors

The following are best practice guidelines for all land where utility easements or transport corridors are accessed or managed by a service provider such as electricity, water, sewerage, gas, and railway and road corridors. These guidelines apply on land where tropical soda apple is present, was previously present, or is likely to be present:

- Inspect the entire property for tropical soda apple regularly (every 2 months)
- Tropical soda apple must be reported to the local control authority immediately
- Thoroughly clean all machinery and vehicles used to access, slash, or maintain the land. See keep vehicles and machinery clean on page 55
- Check vehicles are free of any debris before leaving the infested site
- Exclude access to tropical soda apple infestations and install signage indicating that access to the infested area is not permitted
- Do not slash, mow, mulch or disturb areas infested with tropical soda apple
- Keep records of date accessed, type of work completed, vehicle or machine used, contractor used, machinery cleaning, and other sites visited (where possible complete work at an infested site at the end of the day)
- Monitor high-risk areas for tropical soda apple such as disturbed areas, nearby watercourses and riparian zones, bushland, roads, paths, and tracks used by vehicles and machinery
- Implement a tropical soda apple management plan for the property which includes control program, inspections, monitoring, record keeping, and machinery hygiene.

Tropical soda apple growing on a powerline easement. Photograph by Shane Landrigan.

# 16. Latest research and development

Although much is now known about tropical soda apple, there are areas where research continues to be undertaken to assist with the management of this invasive species in Australia.

## 16.1 Seed germination and longevity

There is a considerable amount of research on germination rates of tropical soda apple seeds, particularly from the USA. Germination rates are generally quite high in the USA (average of approximately 70%) depending on environmental conditions.

In Australia, recent studies have shown that the viability of tropical soda apple seed is >90% and the seed can persist for more than three years in the local environment. Tropical soda apple will germinate at various depths however, germination is significantly lower when the seed is buried at 10 cm or more. It has been demonstrated that tropical soda apple will survive and germinate under a broad range of conditions including temperature, rainfall, and soil pH. This makes it particularly suited to eastern Australia and its suitable range is only expected to increase with predicted climate change.

## 16.2 Biological control studies

The CSIRO have completed initial research studies on a leaf feeding beetle (*Gratiana boliviana*) which has been successfully employed as a biological control agent against tropical soda apple in Florida, USA. Although the beetle has been extensively tested for safety in the USA on closely related native and agriculturally important plants, no studies had previously been undertaken on Australian native species, so it was not known if it was safe for release into the Australian environment.

In quarantine facilities, a project was undertaken to assess the suitability of the beetle as a biological control in Australia. During the testing, some feeding and limited egg-laying by the beetle, occurred on a few native Australian *Solanum* species. Further research is therefore required to better measure the risk to these species. Research in this area continues, with ongoing collaborations between the CSIRO, the University of Queensland, and the University of Florida.

For more information on this research go to: research.csiro.au/tsa.

Tropical soda apple seeds found inside the fruit. Photograph by Eddie Hayward.

# References


Akanda, R. U., Mullahey, J. J., & Shilling, D. G. (1996). Environmental Factors Affecting Germination of Tropical Soda Apple (*Solanum viarum*). Weed Science, 44(3), 570–574. https://doi.org/10.1017/S0043174500094352

Bean, A.R. (2023). *Solanum species of eastern and northern Australia*. Version: 25th January 2023. DELTA – DEscription Language for Taxonomy. https://www.delta-intkey.com/solanum/index.htm

Bryson, C. T., & Byrd, J. D. (1994). *Solanum viarum* (Solanaceae), New to Mississippi. SIDA, Contributions to Botany, 16(2), 382–385.

Bryson, C. T., & Byrd, J. D. (2007). Biology, Reproductive Potential, and Winter Survival of Tropical Soda Apple (*Solanum Viarum*). Weed Technology, 21(3), 791–795. https://doi.org/10.1614/WT-06-206.1

Bryson, C. T., Reddy, K. N., & Byrd, J. D. (2012). Growth, Development, and Morphological Differences among Native and Nonnative Prickly Nightshades (*Solanum spp.*) of the Southeastern United States. *Invasive Plant Science and Management*, 5(3), 341–352. https://doi.org/10.1614/IPSM-D-11-00062

Charlton, S., Henderson, R., McGowen, I., Dominiak, B., & Michelmore, M. (2016). In the Footsteps of Cows: Using Livestock Tracing Technology to Trace and Predict New Weed Incursions of Tropical Soda Apple (*Solanum viarum*) in Australia. *Invasive Plant Science and Management*, 9(1), 55–59. https://doi.org/10.1614/IPSM-D-14-00079.1

Cook, T. (2011). Tropical Soda Apple Herbicide Trial and Herbicide Resistance. *Proceedings of 16th NSW Weeds Conference, Coffs Harbour, July 2011* (pp. 161-166). https://wsnsw.net.au/wp-content/uploads/2021/07/16th-Biennial-Conference.pdf

CSIRO (2020). *Tropical soda apple biological Control*. Commonwealth Scientific and Industrial Research Organisation. https://research.csiro.au/tsa/our-research/

Diaz, R., Manrique, V., Hibbard, K., Fox, A., Roda, A., Gandolfo, D., Mckay, F., Medal, J., Hight, S., & Overholt, W. A. (2014). Successful Biological Control of Tropical Soda Apple (Solanales: Solanaceae) in Florida: A Review of Key Program Components. *The Florida Entomologist,* 97(1), 179–190. https://doi.org/10.1653/024.097.0124

Duursma, D. E., Gallagher, R. V., Roger, E., Hughes, L., Downey, P. O., & Leishman, M. R. (2013). Next-generation invaders? Hotspots for naturalised sleeper weeds in Australia under future climates. *PloS One, 8*(12), e84222–. https://doi.org/10.1371/journal.pone.0084222

Ensbey, R., Hosking, J., Verbeek, B., & Cook, T. (2011). *Tropical soda apple weed alert*. New South Wales Department of Primary Industries. Australia. https://www.aabr.org.au/images/stories/resources/ManagementGuides/WeedGuides/Tropical-soda-apple-weed-alert.pdf

Kandari, L. S., Kulkarni, M. G., & Van Staden, J. (2011). Effect of Nutrients and Smoke Solutions on Seed Germination and Seedling Growth of Tropical Soda Apple (*Solanum viarum*). *Weed Science*, 59(4), 470–475. https://doi.org/10.1614/WS-D-10-00108.1

Macquarie University. (2019). *Solanum viarum Species Profile*. Weed Futures. http://www.weedfutures.net/species.php?id=2173

Medal, J., Bustamante, N., Overholt, W., Diaz, R., Stansly, P., Roda, A., Amalin, D., Hibbard, K., Gaskalla, R., Sellers, B., Hight, S., & Cuda, J. (2010). Biological Control of Tropical Soda Apple (*Solanaceae*) in Florida: Post-Release Evaluation. *The Florida Entomologist*, 93(1), 130–132. https://doi.org/10.1653/024.093.0121

Mullahey, J., Cornell, J., & Colvin, D. (1993). Tropical soda apple (*Solanum viarum*) control. *Weed Technology*, 7(3), 723–727. https://doi.org/10.1017/S0890037X0003760X

Mullahey, J., Shilling, D., Mislevy, P., & Akanda, R. (1998). Invasion of tropical soda apple (*Solanum viarum*) into the U.S.: lessons learned. *Weed Technology*, 12(4), 733–736. https://doi.org/10.1017/s0890037x00044638

Mullahey, J. J., & Cornell, J. (1994). Biology of tropical soda apple (*Solanum viarum*) an introduced weed in Florida. *Weed Technology*, 8(3), 465–469. https://doi.org/10.1017/S0890037X0003952X

NRM South. (2010). *Keeping it Clean: A Tasmanian field hygiene manual to prevent the spread of freshwater pests and pathogens.* NRM South, 313 Macquarie Street South Hobart TAS 7004. https://nrmsouth.org.au/wp-content/uploads/2023/04/keeping_it_clean.pdf

Officer, D., Asaduzzaman, M., Morris, S., & Wu, H. (2023). Germination Biology of Tropical Soda Apple (*Solanum viarum*). Unpublished manuscript, NSW Department of Primary Industries, Grafton Primary Industries Institute, Trenayr, NSW Australia. Approved for publication in Weed Research.

Patterson, D. T., McGowan, M., Mullahey, J. J., & Westbrooks, R. G. (1997). Effects of temperature and photoperiod on tropical soda apple (*Solanum viarum* Dunal) and its potential range in the U.S. *Weed Science*, 45(3), 404–408. https://doi.org/10.1017/S004317450009305X

PlantNET. (n.d.). The NSW Plant Information Network System. Royal Botanic Gardens and Domain Trust, Sydney. https://plantnet.rbgsyd.nsw.gov.au

Porter, M.B., MacKay, R.J., Uhl, E, Platt, S.R., & de Lahunta, A. (2003). Neurologic disease putatively associated with ingestion of *Solanum viarum* in goats. *Journal of the American Veterinary Medical Association* 223, 501–504.

Rafter, M. A., Moore, K., & Minteer, C. (2021). No-choice risk assessment of *Gratiana boliviana*, a potential biological control agent of *Solanum viarum* in Australia. *Biocontrol Science and Technology*, 31(12), 1267–1282. https://doi.org/10.1080/09583157.2021.1944606

Salaudeen, T., Thomas, M., Harding, D., & Hight, S. D. (2013). Economic Impact of Tropical Soda Apple (*Solanum viarum*) on Florida Cattle Production. *Weed Technology*, 27(2), 389–394. https://doi.org/10.1614/WT-D-12-00027.1

State of New South Wales (n.d.) *Manning Yellow Solanum* – profile. Office of Environment & Heritage. https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20295#

State of New South Wales. (n.d.). *NSW WeedWise*. NSW Department of Primary Industries. https://weeds.dpi.nsw.gov.au/


NSW
GOVERNMENT


clarence
VALLEY COUNCIL


Forestry
Corporation


COFFS HARBOUR
CITY COUNCIL


TENTERFIELD
SHIRE COUNCIL


MIDCOAST
council


KEMPSEY
Shire Council


New England County Council T/A
NEW ENGLAND WEEDS
AUTHORITY


nsw
FARMERS


Nambucca
Valley Council


BELLINGEN
SHIRE COUNCIL


ROUS
COUNTY COUNCIL


PORT MACQUARIE
HASTINGS COUNCIL


Queensland
Government

# Contacts

New South Wales Department of Primary Industries
weeds@dpi.nsw.gov.au

NSW Invasive Plants and Animals Enquiry Line
1800 680 244

Queensland Department of Agriculture and Fisheries
www.daf.qld.gov.au/contact

13 25 23 (Biosecurity Queensland)