Management in non-agricultural land

Silverleaf nightshade can be found in a range of non-agricultural and urban situations including roadsides, fence lines, footpaths, median strips, along waterways and channels, around buildings, in urban parklands and home gardens, and around amenity and utility areas. In some cases, it is a surviving remnant of infestations established previously while the land was used for cropping and grazing. It can also be moved during earthworks and new infestations can occur along new roads. Most roadside infestations in rural areas appear to have established from transport or droving of contaminated livestock, and can be further spread by grading. Silverleaf nightshade in these situations is generally not actively managed, because it is not perceived as a significant problem or threat. Spot treatments are sometimes used and soil-residual treatments can be safely used in some situations. In others glyphosate is most commonly used, to avoid persistent bare soil patches and minimise damage to desirable vegetation.

Roadsides

Weed control along roadsides can be complicated because roadside native vegetation is valued for a range of reasons (e.g. biodiversity, reducing erosion, wildlife corridor, aesthetic value). Roadsides can be under the jurisdiction of a number of government authorities, and permitted weed control activities may vary between regions and locations. Options are often constrained by the need to preserve roadside native vegetation. Land managers are encouraged to negotiate with relevant government authorities before applying herbicides to weeds on road reserves, or fence lines that border road reserves (Fig. 52).

A combination of mowing and herbicides is often used for general weed management on roadsides. However, silverleaf nightshade should be mowed before it flowers, to avoid spreading seed. The use of non-selective herbicides (e.g. glyphosate) is not ideal for roadside silverleaf nightshade control, as it will create bare ground and reduce competition with silverleaf nightshade. Fluroxypyr, 2,4-D, picloram or their mixtures are often used instead, allowing grasses to re-establish to compete with silverleaf nightshade. Picloram should not be used near desirable roadside vegetation. Non-selective herbicides however are sometimes used to maintain the narrow margin of bare ground adjacent to the roadway to allow water movement and preserve line of sight for motorists.

Fence lines

The best practice management for internal fence lines (Fig. 53) is to apply the 'Dual Action' strategy, including the use of grazing as the first action, before flowering. Picloram-based products can be spot sprayed for rapid results and root-bank control. Landholders should discuss planned weed control options and treatments on fence lines with adjoining neighbours.

FIGURE 52. Silverleaf nightshade along a roadside in Central Victoria.

FIGURE 53. Silverleaf nightshade can move from one paddock to the next under fence lines, further invading cropping and grazing land.

Physical control – cultivation, slashing, mulching, burning and competition

Physical control methods can be used as a tactic to prevent flowering and seeding, however they cause little damage to perennial root reserves and are ineffective for reducing shoot density over time.

Cultivation and slashing to reduce shoot density in Australia are generally ineffective. Cultivation is ineffective in Australia because most of the roots and shoot buds are below the depth of cultivation and new plants may also establish from transplanted fragments. Australian research has found that a combination of slashing or cultivation, combined with herbicide application, did not improve control above the level of herbicides alone. Mulching and burning have little effect due to the large energy reserves in the root system.

Vigorous crops and pastures, especially those based on perennial summer-growing species (Fig. 54), can significantly suppress silverleaf nightshade growth. Competitive grasses such as Bambatsi panic, Premier digit grass, Strickland finger grass, Currie Cocksfoot, Sirolan Phalaris, Wallaby grass, Red grass, Cotton Panic, Green Panic, Topcut Rhodes grass have been effective in reducing silverleaf nightshade growth in NSW experiments (Bob Thompson, unpublished). The use of competitive grasses will also allow the application of broadleaf herbicides to target silverleaf nightshade roots in autumn. Dense and vigorous lucerne stands provide competition deep in the soil profile, and can reduce silverleaf nightshade growth and vigour. Similarly, canola can delay shoot emergence and reduce silverleaf nightshade vigour because it has deep tap roots that can extract moisture from deep in the soil profile.

Demonstration trials in SA and NSW suggest that several *Eucalyptus* spp. have some ability to control silverleaf nightshade growth within the canopy drip-line through allelopathy – where growth retarding chemicals exuded from the trees stunt the growth of silverleaf nightshade. This management approach may be suited to silverleaf nightshade that has spread to inaccessible areas in rocky hilltops or along creeks. These areas can become nursery areas, producing seed that can re-infest clean paddocks. A number of *Eucalyptus* species from the Kalgoorlie region of WA are known to have allelopathic effects on silverleaf nightshade, including Gimlet, Swamp Mallee, Dundas Blackbutt and Dundas Mahogany (Stanton et al., 2008).

FIGURE 54. A well-watered perennial pasture, in this case kikuyu lawn in SA (left), can suppress silverleaf nightshade growth (centre). The silverleaf nightshade is growing in the dry pasture (right) but outside of the sprinkler zone it is short and stunted.

Biological control

BIOLOGICAL CONTROL IS BEING ACTIVELY RESEARCHED, BUT IT IS A LONG-TERM PROJECT.

There was a determined research effort against silverleaf nightshade in Australia during the 1970s and 1980s. This effort declined as researchers had little success with herbicides, and the next hope was a break-through in biological control. In the intervening 30 years silverleaf nightshade has continued to spread, and in 2016 work began on the biological control agent, silverleaf nightshade leaf beetle (*Leptinotarsa texana*).

Silverleaf nightshade was declared a target for biological control in Australia by the Standing Committee on Agriculture in February 1986, in response to an application from the Victorian Department of Conservation. A range of potential agents was identified from southern USA (Wapshere, 1988) and a benefit:cost analysis for biological control in 2006 estimated a benefit of $140 million over a 30 year period, providing a benefit to cost ratio of 58:1 (Kwong et al., 2006). However, as of 2018 there has not been any release of an agent for silverleaf nightshade control in Australia. One potential biological control agent, the leaf-galling nematode *Ditylenchus phyllobius*, was tested in Australia under quarantine in the late 1980s but it was rejected due to its unacceptably broad host-range, including eggplants and thirteen native Australian solanums. South African scientists were also testing agents throughout the 1980s and early 1990s, and released four biological control agents in that country.

The most successful of the South African introductions was the silverleaf nightshade leaf beetle, *Leptinotarsa texana* (Fig. 55). Encouraging results from South Africa combined with continued spread of silverleaf nightshade in Australia, and the limitations of current control methods, prompted renewed interest in classical biological control. An assessment of the suitability of the silverleaf nightshade leaf beetle for introduction to Australia began in 2016. A national team imported the beetle into quarantine and conducted extensive host specificity testing. In late 2017 it was confirmed that a group of potato varieties, along with a group of native Australian *Solanum* plants, were attacked under laboratory conditions. Due to the seriousness of the threat posed a decision was made by the research team that *Leptinotarsa texana* was not suitable for release in Australia. At the time of writing (2018) a second national research project is underway to evaluate other candidate agents for silverleaf nightshade, and also to explore Argentina for potential agents.

Kwong et al., (2006) discussed a number of potential agents from South America, and encouraged further exploration of areas with similar climates to southern Australia. New research began in 2016 to consider other potential agents from poorly explored regions in central Argentina, particularly the Buenos Aires and Pampa provinces, and in the central regions of Chile (Greg Lefoe, pers. comm). A recent genetic analysis of silverleaf nightshade populations from Australian and around the world informed planned natural enemy surveys throughout the weed's range, possibly including Argentina and Chile. Risk analysis for silverleaf nightshade biological control in Australia is inherently complex, due to the large number of closely related native, ornamental and crop species that occur in Australia. Considerable research effort will therefore be necessary to assess the risk of off-target damage of prospective agents. A number of naturally-occurring insect species have been observed attacking silverleaf nightshade berries and lower stems throughout Australia. In some cases, localised damage can be significant but none of the species has caused significant reductions in silverleaf nightshade density.

FIGURE 55. An adult silverleaf nightshade leaf beetle (*Leptinotarsa texana*) feeding on silverleaf nightshade leaf (Photo: Greg Lefoe).

Economics of silverleaf nightshade control

Silverleaf nightshade is a perennial weed that can only be controlled through persistent efforts over at least 5 years. Accordingly, assessments of the economic benefits of control need to consider costs and returns over many years. Across southern Australia, from Narrogin in WA to Mudgee in NSW, there are many different enterprises and farming systems. Each property will have its own particular economic circumstances, and the analysis of the economics of silverleaf nightshade control will be unique to each farm or region.

The best that we can do is to consider a range of case studies (Section 4), and to analyse "average" or "generic" data. These snapshots and analyses will give a "ball park" feel for the potential costs and returns associated with silverleaf nightshade control. Of course the seasonal conditions and commodity prices will vary unpredictably from season to season and this can greatly influence outcomes over any particular time period.

Economic modelling research conducted in NSW as part of a Meat and Livestock Australia project (Stanton et al., 2010) made a series of assumptions and estimates to analyse expected outcomes from three different control strategies over ten years. Two livestock enterprises were compared - wool production and prime lamb production. The three strategies considered were 1) do nothing; 2) use current practices (one early application of glyphosate at 1080 g active ingredient/ha); and 3a) and 3b) use the Dual Action, Best Practice Management (BPM) approach advocated in this manual for a) dense populations, and b) sparse populations. The results of this analysis are shown in Table 7.

The model assumed that doing nothing would result in a steady increase in silverleaf nightshade density, and that a single annual application of glyphosate would decrease the density very slowly. The Best Practice Management scenario assumed a steady decrease in density, with significant control gained within five years.

Initially, using Best Practice Management, the costs were higher and associated profits were lower. However, over the ten-year modelling time this management scenario had the highest profits, with the early costs of control off-set by bigger profits later. Table 7 shows that not controlling silverleaf nightshade results in the lowest profits for both enterprises. Applying glyphosate once annually is profitable, but still results in significant losses. Best Practice Management was predicted to be the most profitable approach, returning 2 to 3 times the profit compared to doing nothing. The modelling also shows that the most profitable management for both enterprises is to control silverleaf nightshade early, before populations become dense.

As an example, consider a Prime Lamb enterprise in North East Victoria with a gross margin of $137/ha and a dense silverleaf nightshade infestation. The modelling shows that each year Best Practice Management has a direct control cost of $31/ha (herbicide, lost production, labour and machinery) and generates a net profit

TABLE 7. Cost and profit analysis of silverleaf nightshade management, comparing three strategies in two livestock enterprises (cumulative profit/ha over ten years).

		WOOL ENTERPRISE			PRIME LAMB ENTERPRISE		
	Stocking rate (DSE/ha)	8.9			7.8		
	Gross margin ($/DSE)	$13			$16		
	Gross margin ($/ha)	$106			$137		
STRATEGY		**$ LOST PRODUCTION**	**CHEMICAL COST**	**ACTUAL PROFIT**	**$ LOST PRODUCTION**	**CHEMICAL COST**	**ACTUAL PROFIT**
1	No control	$711	$0	$396	$919	$0	$512
2	Current Practice (glypho x1)	$286	$229	$593	$370	$229	$833
3a	BPM:dense (>10 stems/m²)	$69	$217	$822	$89	$217	$1,126
3b	BPM:sparse (<2.5 stems/m²)	$51	$63	$994	$66	$63	$1,303

ECONOMIC MODELLING PREDICTS THAT RETURNS CAN BE INCREASED BY C. $160/HA/YEAR.

of $113/ha, while the Current Practice (single annual glyphosate application) management costs growers $60/ha with a profit of $83/ha. In this example over a ten-year period, the Best Practice Management returns an extra $59/ha each year compared to a single annual glyphosate application. The increase in profits would have been even higher if silverleaf nightshade had been tackled early, before it became dense (Stanton et al., 2010).

A recent economic modelling study, projecting 20 years into the future (Behrendt et al., 2018, under review), found similar benefits from using Best Practice Management for silverleaf nightshade. When Best Practice Management is used during both the cropping and pasture phases of the rotation, returns are predicted to increase by $57-116 per ha. each year at Parkes (NSW) and $96-131 at Ungarie (NSW), compared to Current Practice. When Best Practice Management was compared to No Management, the increases to returns were even higher – $136-195 at Parkes and $147-182 at Ungarie.

BREAKOUT 7

BACK OF THE ENVELOPE – $5,000 EXTRA PROFIT FOR CROP PADDOCK

The economics of silverleaf nightshade control to protect crop yields will vary from region to region, and will ultimately be influenced most by winter-spring rainfall during crop growth. As a simplified example, consider a 100 ha sandy-loam paddock that is 50% covered by dense silverleaf nightshade. If not sprayed in the summer/autumn prior to sowing wheat, a 30% yield reduction might be expected in those areas. If the wheat yield was 2.5 t per ha in clean areas, at a price of $200 per tonne, then the whole paddock would return $50,000 if there were no silverleaf nightshade. However, the yield losses (30% lower, compared to sprayed paddocks, over 50 ha) would cost $7,500. The cost of herbicide treatment during the preceding summer-autumn ($25 ha-1, over 100 ha) would be $2,500, resulting in $5,000 extra return for the paddock. There may also be an additional return from controlling other summer weeds present before sowing crops.

IMAGE: Spraying SLN during the summer and autumn before cropping can conserve valuable sub-soil moisture and return greater profits.