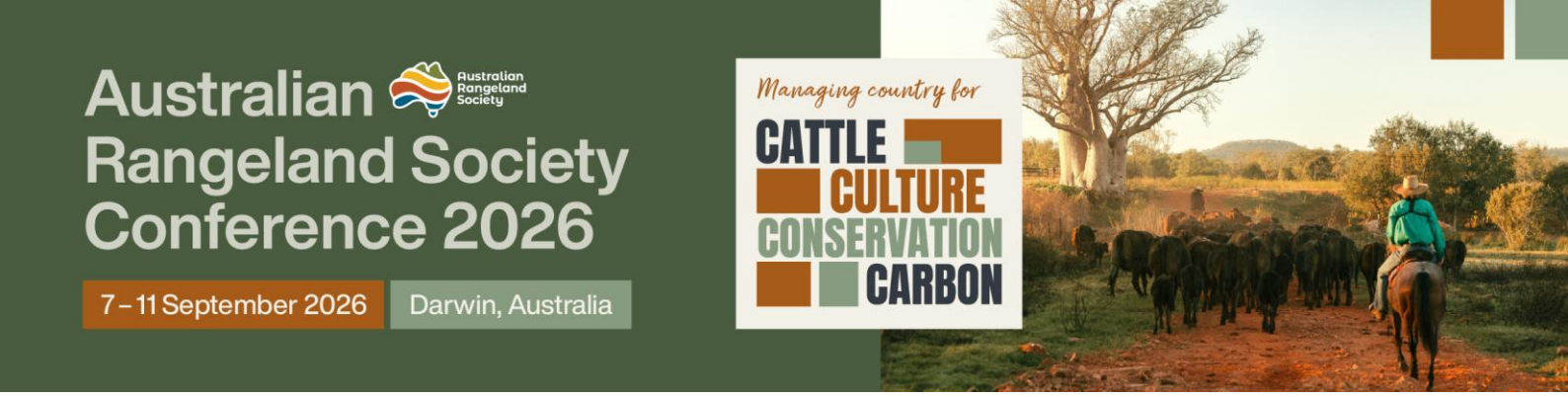


DRAFT PROCEEDINGS

23rd Biennial Australian Rangeland Society Conference

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7-11 September 2026

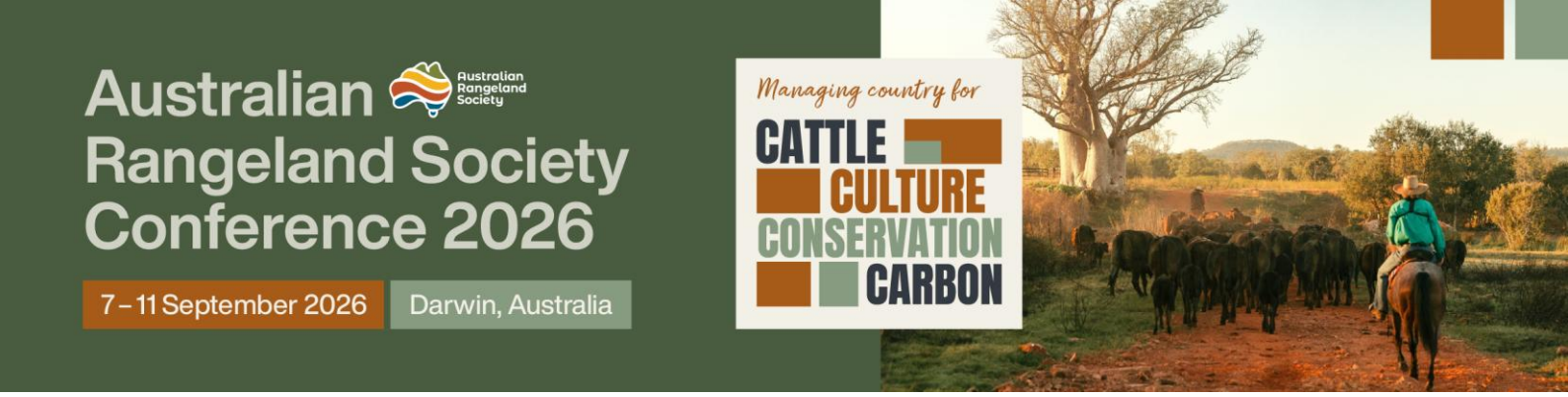
Darwin, Northern Territory

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The assistance of many colleagues not listed here is gratefully acknowledged.

Example suggested citation:
Bastin GN, Cowley RA (2026) Reduced landscape leakiness shows recovery of formerly degraded rangeland in the Victoria River District, Northern Territory. In: 'Managing Country for Cattle, Culture, Conservation, Carbon. Proceedings of the 23rd Australian Rangeland Society Biennial Conference, Darwin'. (Eds G. Bastin, D. Walsh, S. McDonald, M. Friedel, I. Watson, A. Liedloff) 5 pages. (Australian Rangeland Society: Darwin, NT)

Post-fire observations of Siam weed seed viability

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Key words: invasive; fire; weed; germination

Abstract
Siam weed (*Chromolaena odorata*) has been found in the wet and dry tropics in Queensland since 1994 and the Northern Territory since 2019. Many dispersal mechanisms allow this highly invasive large shrub to build up large infestations in remote areas, where broadscale management options include fire.

Observations were collected on the viability of seed (achenes) after controlled burns (in June, August and October) and small research plot fires (June, July and August) of different years at several locations. *Chromolaena odorata* was scorched but not consumed by a fire in early October (2008) on the Pinnacles near Townsville, and the same percentage of viable seeds were present on scorched and unscorched plants after the fire. Highly viable seed was collected from a plant in the wet tropics near Mossman, which was scorched by a burn in mid-August (2013). No developed seeds were collected from scorched stems from a fire on Mount Stuart near Townsville in early June (2022).

Small plots of six to eight *C. odorata* plants were raised at Charters Towers and burnt in 2022 and 2023. No viable seed was recovered from plants scorched by a fire in late June. Viable seeds were recovered from less than half of the plants burnt in plots in mid-August (2022). Another plot was burnt in mid-July (2023), and viable seeds were present before and after the fire on three of the six plants.

The observations were used to build a pattern of seed viability after fires between June and early October. Two fires in June prevented the development of viable seed. Early 'cool season' fires prevent viable *C. odorata* seed forming. However, viable seed can be present on burnt and unburnt plants after mid-July. Viable seed may be present even if plants are scorched by fires from August onwards.

Introduction

Chromolaena odorata (L.) King & Robinson (Siam weed) is a large multi-stemmed perennial shrub in the Asteraceae family. It has long been recognised as one of the most invasive plants of tropical and subtropical regions of Africa, Asia and Oceania (Zachariades *et al.* 2009). *Chromolaena odorata* was first discovered on mainland Australia in 1994 on the tropical coast of northeast Queensland, with further discoveries made in several other northeast tropical coastal river catchments and drier inland tropical river catchments (Jeffery 2012). *Chromolaena odorata* was discovered in the Northern Territory in 2019 (Price 2022) and in Brisbane in 2024. Beyond the wet tropical coast of Queensland *C. odorata* occurs in drier tropical woodland habitats where fire is a tool utilized to manage weeds, fuel hazards, biodiversity and grazing resources (Vitelli and Pitt 2006). Many dispersal mechanisms (Brooks *et al.* 2017, Price 2022) allow this highly invasive large shrub to build up large infestations in remote areas, where broadscale management options such as fire will be a component of weed, and broader land management activities.

In northern Australia most planned fires are conducted during the drier part of the year from May to November, with fire intensities broadly increasing as the grass load cures towards the start of another summer wet season (Cheney and Sullivan 1997). Cooler burns, earlier in the year, produce low intensity fires and reduce the hazards from greater intensity burns later in the dry season. Smaller *C. odorata* plants can be controlled by the fire (Williams *et al.* 2004). In assessing the effects of fires in October 2008 and August 2011, *C. odorata* was observed to suffer scorch damage and die back to ground level, then reshoot (S. Brooks unpublished data). In north Queensland, *C. odorata* predominantly flowers in early May and seed be viable from late July onwards (authors, unpublished data).

The possibility has been raised that fires earlier in the year may reduce the plant-borne seed load if scorched stems die back and *C. odorata* seed formation is prevented (Witkowski and Wilson 2001). To determine the effect of fires on seed on *C. odorata,* post burn seed samples were taken across different sites and months and tested for viability.

Methods

Sites, burn dates and pre and post burn sample dates are listed in Table 1.

Table 1. Burn and sample or visit dates of locations used in assessing post burn viability of *Chromolaena odorata* seed.

Location	Type of burn	Burn date	Pre-burn sample	Post burn samples
Charters Towers	Research plot 1	28/6/22	none	21/7, 5/8 29/8/22
Charters Towers	Research plot 2	27/7 and 10/8/22	21/7, 4/8/22	29/8/22
Charters Towers	Research plot 3	10/8/22	21/7, 4/8/22	29/8/22
Charters Towers	Unburnt plot 4	none	21/7, 4/8/22	29/8/22
Charters Towers	Research plot 5	17/7/23	16/7/23	16/8/23
Mt Stuart (Townsville)	Controlled burn	Early June 2022	9/6/22 (visit)	16/9/22
Mossman	Controlled burn	18/8/13	none	19/8/13
Pinnacles (Townsville)	Controlled burn	2/10/08	23/9/08	24/9/13

A controlled burn was conducted on Mt Stuart (S19º 11', E146º 48') near Townsville in early June 2022 (Table 1). The area was visited on 9/6/22 with scorched *C. odorata* waypoints recorded. The same area was revisited on 16/9/22 and seeds collected from two waypoints with unscorched plants and six waypoints with unscorched stems on scorched plants. Subsamples of three lots of 20 seeds were germinated from each waypoint. There were no flower heads to collect on scorched stems.

Six to eight plants were raised from seed in pots and established in grassed 3 x 3 m plots in a research enclosure at Charters Towers (S20º 05', E146º 16'). Different plots were burnt on 28/6/22, 10/8/22 and 17/7/23 (Table 1). Plot 2, burnt on 27/7/22 did not burn very well and was relit on the 10/8/22. A further plot (4) was retained as an unburnt reference plot. The most advanced flower head was removed from a plant in plots 1 to 4 on 21/7 and 4/8/22, and from all plants in plots 1 to 4 with a mature flower head on 29/8/22. Seeds in each flower head were counted (typically 20-30) and germinated. All reproductive material was removed from plots 1 to 4 on 29/8/22, and a further two samples of 50 seeds per plant were germinated from each mature plant in plots 2 and 3. The stage of flower head development was recorded fortnightly between 25/5 and 29/8/22 for each plant in plots 1-4. Development was based on a photographic 0-6 scale of; 0 - no flowers, 1 - initial flower heads, 2 - longer white flower heads, 3 - purple with some anthers, 4 - most flower heads with anthers, 5 - anthers withered, 6 - seed heads 'puffed out'. Not all plants developed flowers in plots 1 to 5. A single flower head per plant was sampled from plot 5 on 17/7/23 (pre-burn) and two samples of 50 seeds were germinated from each of five mature plants when all flower heads were removed on 16/8/23.

A heavily scorched plant was found on the Cassowary Range near Mossman (S19º 29', E 145º 24') on 19/8/13 following a planned burn and a sub sample of 3 x 50 seeds were tested for viability.

As part of a larger trial, a controlled burn was lit by aerial incendiaries in the 'Pinnacles' west of Townsville (S19º 23', E 146º 16') on 2/10/08 (Table 1). Pre and post fire seed samples were collected on 23/9/08 and 10/10/08 respectively. Post burn samples were split between 10 plants with 100% scorch damage and 8 plants with 0-30% scorch damage. Two samples of 50 seeds were germinated for each post fire sample plant.

Seed germination processes were the same for each site and sample date. Pre and post burn seed samples were germinated in lots of 50 at 30/20ºC 12-hour day/night temperature and light cycles in 90 mm petri dishes on inverted watch glasses and moist filter paper in a Thermoline® incubator. Germination was assessed every 3 to 6 days and then non-germinated seed was subjected to a physical test of viability. Overall seed viability is reported.

Results

When the Mt Stuart seed samples were collected in September 2022 after an early June fire, the scorched stems had no seeds to assess, as scorched stems had died back and prevented flower heads from

developing. The average viability of seeds from unscorched stems was 56.8%, (n=6, range 40 to 90%) and viability from unscorched plants was 43.3% (n =2).

The earliest fire in plot 1 (28/6/22) scorched six plants and flower development was curtailed such that they produced no viable seed at any of the later assessments. One smaller plant had no flowers before and after the fire. One plant suffered 30% leaf scorch damage, and viable seeds were recorded on 21/7/22 and the two later assessment times (Table 1).

Viable seed was present in the single flower head samples from plot 2 on the 22/7/22, 4/8/22 and two of the eight plants sampled on 29/8/22. The larger re-assessment of all flower heads removed on 29/8/22 found viable seed on four of these plants.

Plot 3 had viable seed in flower heads sampled on 21/7 and 5/8/22. After the fire, one plant of eight had viable seed in smaller and larger post burn samples removed on 29/8/22.

Viable seed was present in the unburnt control plot (4) at the sample dates shown in Table 1, including the flower head sampled on the 21/7/22 and on six of the eight plants sampled on 29/8/22.

One day prior to research plot 5 being burnt (17/7/23), 4 of 8 plants had viable seed in single flower heads. Two of those plants and one other had viable seed (9-19%) when the larger post burn samples removed on 16/8/23 were germinated.

Highly viable seed (average 80.2%) was collected off a single scorched field plant after a fire near Mossman on the 19/8/13. Whilst only one plant was sampled, it adds to the evidence that fires in August or later have less or no influence on seed viability.

After the Pinnacles fire (October 2008), over 60% of the seed on scorched plants was viable (Table 2). Post fire sampling of scorched stems showed that the plant borne seeds remained viable.

Table 2. *Chromolaena odorata* mean seed viabilities (± SE) from different collections in the Pinnacles fire trial area.

Collection dates	Number of plants	Samples germinated	Mean seed viability (%)	Seed viability range (%)
Bulked collection, pre-burn 23/9/08	> 25	10 x 50	75.8 ± 2.2	64.8 to 84.5
Post fire plants				
Scorched plants	10	20 x 50	61.5 ± 3.3	42.8 to 77.7
Un-scorched plants	8	16 x 50	62.2 ± 4.8	28.3 to 75.8

Discussion

A controlled burn in early June on Mt Stuart and a research plot burn in late June 2022 prevented the development of viable seed. However, viable seeds were recovered on plants burnt in mid-July and August in the research plots and after controlled burns in August and October. Our observations suggest that early 'cool season' fires in June prevent viable *C. odorata* plants from producing viable seed. Depending on local rainfall and temperatures earlier fires are likely to be conducted under cooler and damper conditions, and produce safer low-intensity fires, which may suit plans for early hazard reduction burns.

There are many environmental, production and safety aspects to consider when conducting controlled burns. Early dry season burning (before mid-July), conducted with consideration of other land management objectives, serves to curtail *C. odorata* seed production. Fires in August and October did not lower the viability of the *C. odorata* seeds, even where plants were scorched. Seedling counts after the Pinnacles fire (Table 1) showed high levels of wet season *C. odorata* seedling recruitment on burnt ground (S. Brooks unpublished data).

It was anticipated that fires would lower seed viability on scorched plants, but the seeds may not have been exposed to heat for long enough to be rendered unviable. Mbalo and Witkowski (1997) reported that *C. odorata* seed was rendered unviable by exposure to 100ºC for one minute, but this was the lowest temperature and duration of exposure they tested. It is possible seed viability would be lowered by

higher levels of fire damage where parts of the stems were consumed, however the post burn damage observed after seven fires recorded scorching damage on *C. odorata*, and very little plant material was consumed. The post burn samples were collected from scorched plants. Waiting for hotter and drier conditions in late October or November may increase the fire intensity, but also the risks of damage to other vegetation, cancellation, or escape.

Although the single flower head per plot and per plant samples were small and with variable viability, they showed viable seed was present on unburnt plants from the middle of July in 2022 and 2023. This finding was reflected in viable seed recorded on 27/7/22 on potted *C. odorata* specimens at the same Charters Towers research facility (authors unpublished data). Viable seed was recovered from the potted specimens two weeks after flower heads had anthers visible (stage 5) and well before stage 6 when seed is dispersed usually in October.

The production of viable seed was curtailed by fires which scorched *C. odorata* stems in June. Viable seeds were recorded on burnt and unburnt stems after mid-July. Early dry season fires were observed to prevent the production of *C. odorata* seed and are a management tool that will assist in reducing the spread of *C. odorata* infestations across northern and eastern Australia.

Acknowledgements
This research was conducted with the support of the Federally funded '*Advancing the detection, control and management of Siam weed in northern Australia' project* and internal funding from Biosecurity Queensland. Dave Green sampled and photographed the post-burn Mossman plant. Melissa Setter reviewed the manuscript.

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