2024-TSDC160 Bathurst bur seed bank management Waimea Plains

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REPORT FOR Tasman District Council

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1. Background

1. **Please give a short description that outlines the environmental management issue you are seeking advice on.**

The pest plant Bathurst bur was discovered in the Lower Queen St Richmond area of Tasman District in April 2016. At that time approximately 100 plants were located and removed. Subsequent monitoring between 2016 and 2019 identified more plants at different locations within the wider site, particularly where the ground had been disturbed. These plants were also removed.

The wider site is now being developed for residential housing and as a consequence extensive surface stripping and earthworks are being undertaken with surplus soil either stored on site (in later stages of the development) or moved to designated adjoining sites.

Council needs advice on the longevity of Bathurst bur seed specific to the Waimea Plains area and particularly related to the management of the soil stockpiles. Council also needs advice on options to minimise Bathurst bur seed longevity so that soil stockpiles can be managed to minimise the Bathurst bur seed viability and the length of monitoring/management required so soil can be safely redeployed once the seed life has expired.

2. **How will the advice grant allow you to positively address this issue to create benefit for your local community?**

Bathurst bur is a serious agricultural pest. It is toxic to farm animals and poultry and competes with agricultural crops. It is currently of very limited distribution within Tasman District and has been declared an Eradication Pest in the Tasman-Nelson Regional Pest Management Plan 2019-2029. As such the Tasman and Nelson councils have resolved that Bathurst bur meets the necessary criteria within the Biosecurity Act 1993 and its associated National Policy Direction 2015 and that the cost of intervention is well justified by the adverse impacts avoided.

3. **How do you intend to use this advice?**

Council will work closely with the developer to ensure that excess soil from the site is appropriately managed while the Bathurst bur seed is viable, that soil is retained at agreed/specified locations and is regularly inspected to ensure that any Bathurst bur seed germinating is quickly identified and removed before any further seed set occurs.

Instruments to ensure that the advice is given effect to include the use of an agreed Site Management Plan and the placing of conditions on resource consents associated with soil movement to ensure that appropriate management is undertaken.

2. Methods

A literature survey was carried out and the information from the international literature was combined with the personal knowledge of the author to obtain the conclusions presented here.

3. Results and Discussion

Due to the similarities of their burs (Figure 1) and the paucity of information of the fate of Bathurst burs, this report covers both Bathurst bur (*Xanthium spinosum*) and Noogoora bur (*X. Strumarium*). The burs of both species contain two seeds in a hard, fibrous case covered with hooked prickles.

Bathurst bur – circa 14 mm long

Noogoora bur – circa 19 mm long

Figure 1 burs of Bathurst bur and Noogoora bur. The distinguishing feature are the two long beaks on the top end of the Noogoora bur.

Flower morphology

Xanthium spp. are monoecious with the compound male flowers borne on the ends of the branches and the female flowers borne in the leaf and branch axils below (Figure 2). The

female flowers occur in pairs and an enlargement of the involucre encloses the two resulting seeds in a single, spiny and fibrous bur.

	
Male flowers of Bathurst bur	Female flowers of Noogoora bur

Figure 2 Flowering morphology of *Xanthium* spp.

Seed morphology

Bur production in Bathurst bur has been recorded as 150 per plant but this appears to be conservative. Comparatively, Noogoora bur has been reported to have over 2000 burs per plant but normally in the range 100-500.

The two seeds in each bur are not equal and are usually referred to as the upper and lower seeds or larger and smaller. Seed germination is governed by both the dormancy of the seeds and germination restrictions imposed by the bur. Seeds removed from the bur may germinate immediately but those that are in the bur require a certain amount of weakening (decay) of the bur before they germinate. As a result, burs that remain on the surface tend not to germinate. Optimum burial depth for germination is 1-4 cm while those burs below 8 cm tend not to emerge.

Most broadleaf weeds produce ‘hard’ seeds to ensure they do not all germinate at once but over a range of years, thus ensuring their survival as a species. Both Bathurst bur and Noogoora bur are summer growing annuals and although they don’t appear to produce hard seeds like other weeds, but they do have an adaptation to ensure survival. Usually only one of the two seeds in a bur will germinate in the first year while the second will germinate in the following year. Occasionally, both seeds will germinate in the same year (Figure 3).

Figure 3 Single and double seed emergence of Noogoora bur.

Seed dormancy and germination initiation

Seeds generally have two types of dormancy; primary or innate dormancy and secondary or induced dormancy.

Primary dormancy is the time between when the seed falls from the plant and when it can germinate under optimal conditions. This is also governed by the 'after ripening' period of the seed. Bathurst bur and Noogoora bur appear to have a short after ripening period, variously reported as 0-14 days although one report simply says that fallen seeds will not germinate until the next growing season.

Secondary dormancy occurs when various environmental factors force a seed back into dormancy for its own protection, i.e. to avoid it germinating in unfavourable conditions. Although there are a range of bio-chemical factors that can induce secondary dormancy, the three most common are; temperature, water and oxygen.

The effect of temperature is that the seed will not germinate if the temperature is too low or too high. The optimal temperature range for Noogoora bur appears to be between 10°C and 35°C with 25°C seen as optimal. This will be a factor when considering seed bank decline.

The effect of water is that the seed will not germinate if there is insufficient water to maintain plant growth. This is determined in seeds by the presence of water-soluble chemicals that inhibit germination. With Bathurst bur and Noogoora bur, the two seeds (upper and lower seeds) general have different amounts of these water-soluble chemical inhibitors which explains why the two seeds tend to germinate at different times (years). Occasionally also, a seed will not germinate if there is too much water, but this is probably due to low oxygen (below).

Seeds will often not germinate if there is low oxygen. This factor, along with light, control the depths from which seed can germinate as oxygen levels decline with soil depth. Light

does not appear to be a factor for either Bathurst bur or Noogoora bur seed, i.e. it germinates readily in the dark. Light is generally more important for very small seed which need to germinate at or near the surface.

Bathurst bur seed survival

Compared to Noogoora bur seed (discussed below), Bathurst bur has a smaller, softer seed and in Australia it is reported that 98% of the upper seed germinate in the first year. However, the second seed may take several years to germinate and may require warmer temperatures to do so.

Noogoora bur seed survival

A study in Australia with Noogoora bur reported nearly all the seed in the soil seed bank had gone after 3 years and by 5 years all the seed had rotted.

Results from Italy show seed longevity increased in soil for two years with a burial depth lower than 10 cm and increased to three years with a burial depth of 30 cm. Seeds have the ability of emerging from a depth of 15 cm, but the bulk of emergence came from seeds buried at 2-5 cm. Seeds close to the soil surface showed a reduced germination ability. Seed emergence in the field was mainly recorded early in spring, continuing until summer. All these results suggest that in the case of high infestations with this species, it may be very useful to apply minimum tillage techniques associated to false seed bed preparation, which may strongly reduce the soil seed bank and, thus, potential infestation levels.

In Mississippi, USA weed seeds were buried at soil depths of 8, 23, and 38 cm. Depth of burial had little effect on seed longevity. Based on the averages of the means at the three depths, the percentage of seeds still viable after burial for 2.5 years was 18% but <1% after 5.5 years for Noogoora bur (Figure 4) The same burs showed 97% viability when stored in a dry environment for 5.5 years.

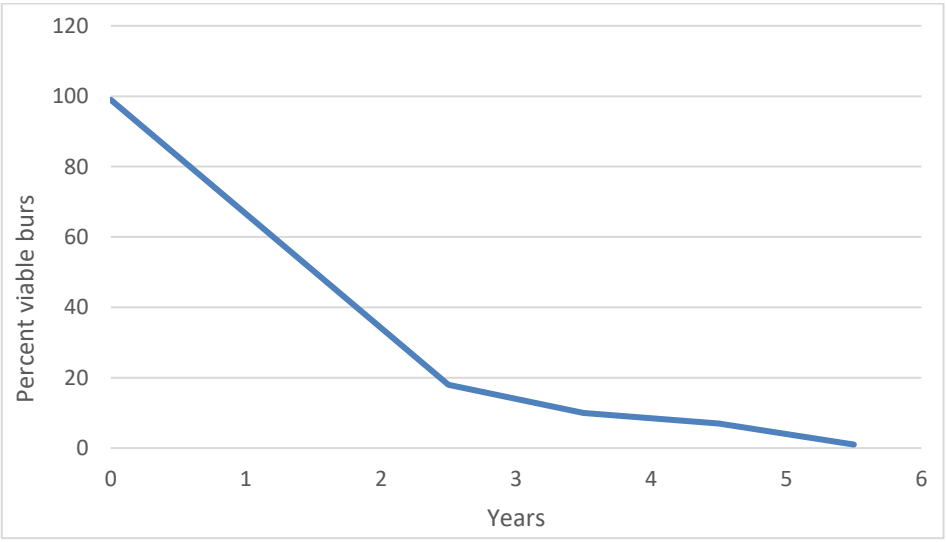

Figure 4 Reduction of viable Noogoora bur seed in the Mississippi buried seed trial.

4. Recommendations

Depletion of the soil seed bank clearly depends firstly on ensuring that no further seeds are added by comprehensive management of the Bathurst bur above ground. Following this the soil seed bank can be expected to decline at a fast rate over the next few years if environmental factors that induce secondary dormancy are avoided or mitigated.

To maximise this decline:

- The first step is to ensure the degradation (decay) of the bur itself. This will happen during the first winter so ensure the burs are in good contact with the soil (buried to a shallow depth) and are kept moist.
- Then in subsequent summers, the soil should be maintained in a moist condition, if there is insufficient rain is irrigation an option?
- Is the soil too wet (flooded) if so is drainage an option?
- Seed (burs) should not be deeply buried, if they are is there a process available (cultivation) to bring them closer to the soil surface?
- Is the soil attaining the required temperatures for germination, if the area is shaded can this be corrected?

The sites with Bathurst bur should be monitored for ≥6 years after the last known fruit is produced. Importantly, flowering is known to occur from December to March, flowering plants should be killed prior to fruiting. If there is any uncertainty about flowering and fruiting status at any stage monitoring should continue for longer. Deep burial of seeds can prevent germination and promote seed decline but possibly at a slower rate. Burial of contaminated soil is an option, provided that it will not be disturbed for ten years.

5. Acknowledgements

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