The distribution and abundance of *Lychnothamnus barbatus* in southeast Queensland, 2022

Report to Department of Transport and Main Roads, Queensland

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Cover photo: *Lychnothamnus barbatus in situ* in Wallaby Creek, 2022.

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Executive summary

The distribution and abundance of *Lychnothamnus barbatus,* the endangered 'Bearded Stonewort', was assessed via survey of suitable sites in south-east Queensland in December 2022. Approximately 45 separate sites were surveyed. The species was not found in Warrill Creek, nor in the adjacent tributary Washpool Gully. It was found to be still surviving in Wallace Creek at the end of C.Head Road off the Boonah-Rathdowney Road. The population in Wallace Creek was found to be healthy, although limited in extent (i.e. not found at additional crossings downstream, and occupying c. 100 m of stream upstream of C. Head Road (sites below C.Head Road were not surveyed due to a lack of permission). As part of the more comprehensive survey an additional site was found in Wallaby Creek at the Cec Krisanski Bridge on the D'Aguilar Highway. The extent of this second population was not fully assessed, but plants were growing both upstream and downstream of the bridge.
Based on the results of this study it is recommended that:

- Washpool Gully be considered for remediation (i.e. restoration of riparian vegetation, removal of weeds) and potential reintroduction of *L. barbatus*;
- The population of *L. barbatus* be more thoroughly surveyed downstream of C. Head Road in Wallace Creek;
- Wallace Creek be remediated via fencing and planting of appropriate native riparian vegetation in conjunction with the landowners to enhance habitat and potentially ensure survival of the population;
- Further surveys be undertaken to determine the extent of the population in Wallaby Creek and elsewhere in southeast Queensland.

Given that *L. barbatus* does not currently occur in Warrill Creek in the vicinity of the Mclean Bridge, bridge works are not likely to have a significant impact on the survival of the species at that location.

This study fulfils two of the recommendations in the approved conservation advice for *Lychnothamnus barbatus*: (i) Undertake survey work in suitable habitat and potential habitat to locate any additional populations/occurrences/remnants, and (ii) more precisely assess population size and distribution. Additionally, contact with landowners during the survey work raised awareness about the species and its conservation. Undertaking the above activities would work towards fulfilling the recommendations to

- *Ensure road widening and maintenance activities or other infrastructure or development activities, such as dams or weirs in areas where L. barbatus occurs, do not adversely impact on known populations;*
- *Minimise adverse impacts from land use at known sites, particularly farming, grazing and sand and gravel extraction upstream, which might increase turbidity and nutrient levels; and*
- *Investigate formal conservation arrangements such as the use of covenants, conservation agreements or inclusion in reserve tenure* (as outlined in the approved conservation advice).

Lychnothamnus barbatus

The species, its protection and aim of this study

Lychnothamnus is a genus in family Characeae (the stoneworts or *charophytes*), a group of green macroalgae that occur in fresh and brackish waters worldwide. This group of plants, charophytes, are important in freshwater ecosystem functioning. They provide food and habitat for invertebrates (food for fish and birds), they stabilise the sediment, they help to remove turbidity from the water and overall, are indicators of good water quality (Schubert et al. 2018).

The genus *Lychnothamnus* has a single extant species: *L. barbatus* (the Bearded Stonewort), as well as several fossil species that were widespread and abundant from 93 to 40 million years ago (Vincente et al. 2020). *Lychnothamnus barbatus,* as a species, has a fossil history extending back to the Cretaceous (c. 70 million years ago; Musaccio 2010), with Australian fossils occurring in the Gulf of Carpentaria from the Pleistocene (14–40 thousand years ago; García and Chvias 2006). The species is thought to be a relict species (similar to the Wollemi Pine), having co-existed with dinosaurs, with a unique lineage in the tree of life (Karol et al. 2017). The charophytes as a group are living relatives of the ancestors of all the land plants (Karol et al. 2000).

Lychnothamnus is clearly distinguishable from other charophytes on the basis of the arrangement of its reproductive structures and its overall morphology. Its status and relationships are also well supported by genetic studies (McCourt et al. 1999; Karol et al. 2017). The species is known to occur in Europe, North America and Australasia, although it is considered rare throughout its distribution (Casanova et al. 2003; Karol et al. 2017). *Lychnothamnus barbatus* was listed under the Environmental Protection and Biodiversity Act (Commonwealth of Australia 1999) as *Endangered,* and under the Queensland Nature Conservation Act (1992) as *Threatened*. Under a State and Commonwealth agreement to use a common method of assessment for threatened species it is proposed that there be a standardised listing for the species in the future based on IUCN criteria (IUCN 2001) which (based on the Area of Occupancy, Extent of Occupancy and location-based threats) is likely to be *Endangered* or *Critically Endangered*.

Conservation Adivce for Lychnothamnus barbatus was approved in 2008 (Commonwealth of Australia 2008) and consequently, under the EPBC Act, a referral should be sought if the species is likely to be significantly impacted by activities such as bridge-works. The Conservation Advice specifies an action to:

- Ensure road widening and maintenance activities or other infrastructure or development activities, such as dams or weirs in areas where *L. barbatus* occurs, do not adversely impact on known populations.

Given that the first known population of the species in Australia was found at a crossing on Warrill Creek at Aratula/Fassifern (now bridged by the Maclean Bridge on the Cunningham Highway) this project sought to determine:

- If *L. barbatus* was still present in its original locality,
- If other populations exist,
- If any other populations are secure, and if extinction of those populations is likely in the short or medium term.

These results can be used to determine if a referral or any mitigating activity need be undertaken during the necessary bridgeworks on the Maclean Bridge.

Description

Like all charophytes *L. barbatus* (Fig. 1) has a similar overall appearance to many water plants (e.g. *Ceratophyllum, Myriophyllum*), growing underwater with upright axes or stems, whorls of leaves or branchlets, and anchored in the soil by roots or rhizoids. *Lychnothamnus* is relatively easy to distinguish from other members of family Characeae, even when growing as part of a charophyte community (Fig. 2).

Instead of having multicellular organs (like flowers, leaves and roots), its stems and branchlets consist of single cells, joined end-on-end; and its reproductive structures are oogonia and antheridia instead of flowers (Fig. 3). *Lychnothamnus* is characterised by an incomplete stem cortex, ecorticate branchlets with long bract cells, oogonia and antheridia arranged side-by-side and gyrogonites on the oospores (Fig. 3).

Figure 1. *Lychnothamnus barbatus* from Wallace Creek. Plants are characterised by whorls of naked branchlets with long bract cells and scarcely corticated axes.

Figure 2. *Lychnothamnus barbatus* growing in Wallace Creek, 2022.

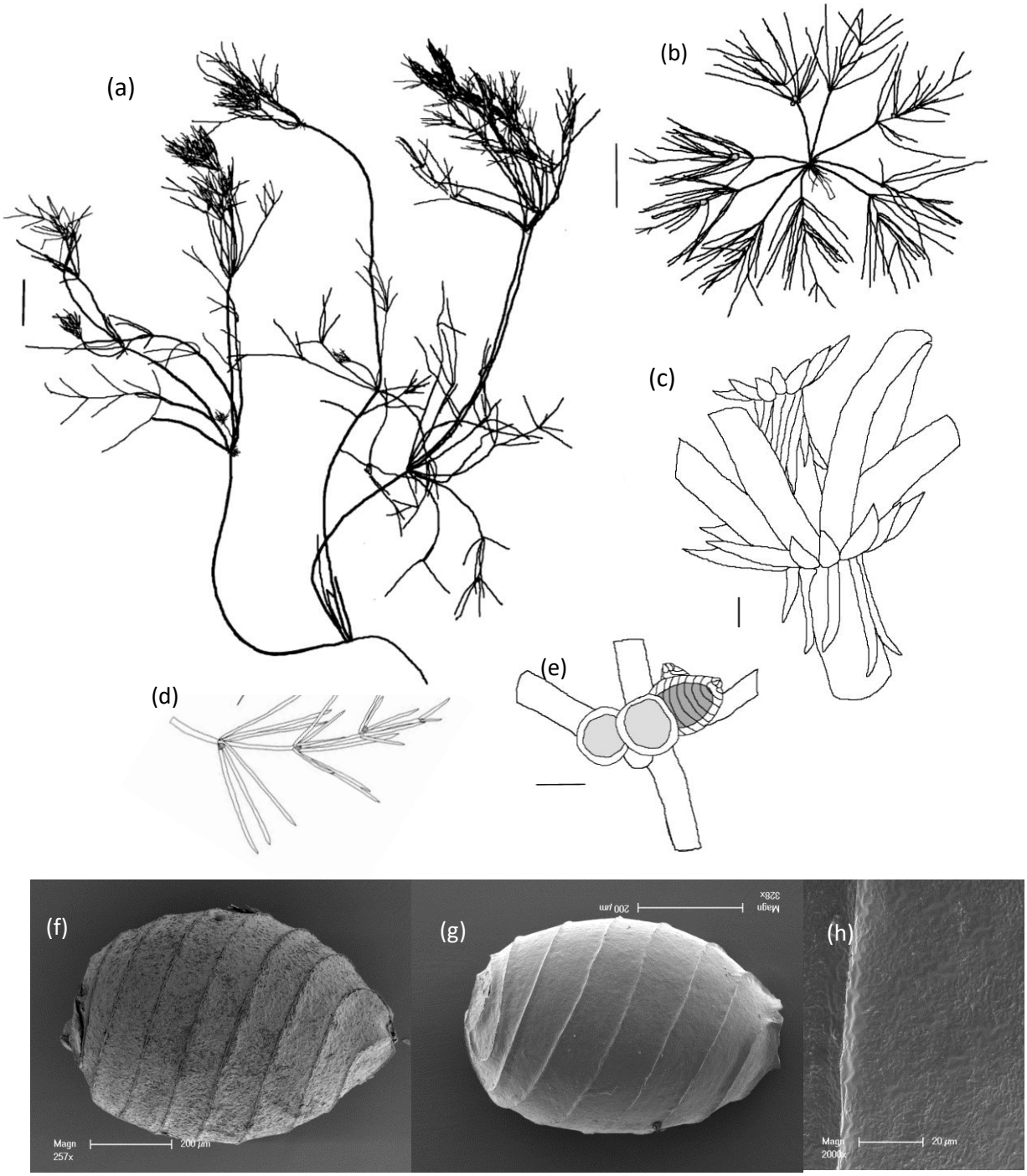

Figure 3. ***Lychnothamnus barbatus*****. a) Overall morphology of the plant. b) Whorl of branchlets seen from above. c) Morphology of nodes showing incomplete cortication and single row of stipulodes. d) A single branchlet showing whorls of long bract cells. e) Gametangia arranged side-by-side at a branchlet node, two antheridia and two oogonia. f) Gyrogonite (calcified oospore covering). g) Oospore in side-view. h) Detail of oospore wall (after Casanova and Karol in press).**

Methods

Between 7 December and 21 December 2022, approximately 45 separate sites in south-east Queensland were surveyed for *Lychnothamnus barbatus,* the Bearded Stonewort (Fig. 4). Sites were selected on the basis of locality (in the vicinity of previous collections; in areas with a similar geology and climate) or the occurrence of charophytes in the past (based on collections deposited in herbaria or recorded in the Atlas of Living Australia), or general appearance and apparent water quality in a stream or wetland.

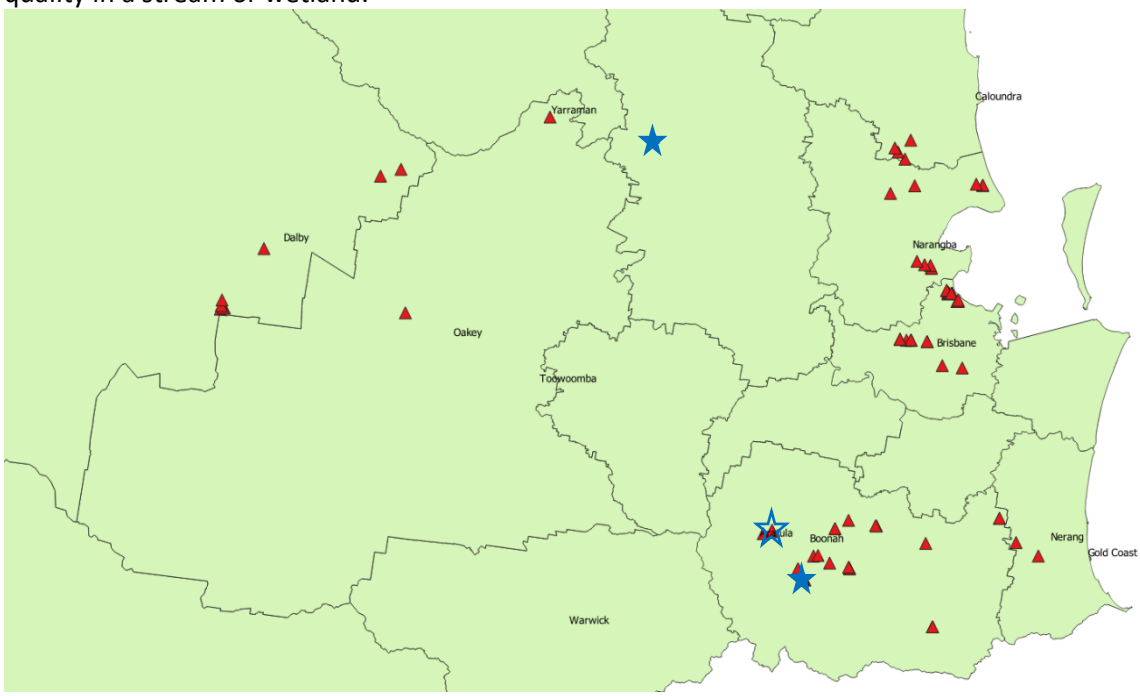

Figure 3. Sites (red triangles) in southeast Queensland that were surveyed for *Lychnothamnus barbatus.* The species has been found in the sites marked with a star. Empty stars indicate where the species occurred in the past but was not present at the site at the time of the survey, filled stars represent sites where *Lychnothamnus* was collected in this survey.

On arrival at a site the investigators undertook a safety assessment and then proceeded to survey for water plants. If charophytes were detected a numbered collection was made, retained in water from the site in a plastic zip-loc bag, the locality was recorded, along with depth of collection. Collected charophytes were rinsed, pressed on paper (3 replicates). Some of the remaining material was placed in twirl-pac bags with water from the site for longer-term culture, and/or also preserved in 70% alcohol in a vial or jar. All samples were labelled with the collection number.

Pressed material was thoroughly dried, inserted into acid-free plastic sleeves and duplicates have been deposited at Queensland Herbarium (BRI), the National Herbarium of Victoria (MEL) or the William and Lynda Steere Herbarium of the New York Botanical Garden (NY). Cultured and spirit preserved material are retained by the author pending further study.

Survey results

Lychnothamnus barbatus was found in two sites of the c. 45 surveyed: Wallace Creek at C.Head Road and Wallaby Creek on the D'Aguilar Highway at the Cec Krisanski Bridge.

Historical sites: Warrill Creek/Washpool Gully

- Warrill Creek at Aratula (Maclean Bridge) is a site where *L. barbatus* was initially recorded (1960; Wood 1972), and later collected (1996; Casanova et al. 2003). On the basis of the

number and appearance of herbarium specimens from 1960, stored in CANB, NY, BM, PC, NE and AD, the species was healthy and abundant, and co-occurred with several other charophyte species (*Chara* and *Nitella* spp).

When it was collected in October 1996 (Casanova et al. 2003) a single plant was growing at the confluence of Washpool Gully and Warrill Creek, along with species of *Nitella* and *Chara*. Sufficient material was collected to confirm its identity, send for genetic analysis and create an herbarium specimen. Seed bank was also collected and examined for oospores (propagules of *Lychnothamnus*). The same site was visited on 15 Dec. 1996 and the species was no longer found. Oospores were not detected in seed bank samples obtained from the site. Additional sites on Warrill Creek were surveyed at that time and no occurrences of *L. barbatus* were recorded.

- Warrill Creek (along with Washpool Gully) was comprehensively surveyed again in Dec. 2022. Despite extensive searches no charophytes were collected in Warrill Creek, although several species of *Nitella* and *Chara* were collected in Washpool Gully.

In 2022 Warrill Creek had a smooth, sandy and stony, flat bottom, with a relatively high flow rate of clear water. There were signs of eutrophication in places (presumably from agricultural runoff of nutrients from surrounding agricultural land).

Historical sites: Wallace Creek, C.Head Rd

- In Dec. 1996 *Lychnothamnus barbatus* was discovered in Wallace Creek at the end of C. Head Road off the Boonah Rathdowney Road. Approximately 15 different sites had been surveyed in the region before *L. barbatus* was collected (including sites on Oakey, Wallace, Reynolds Creeks, Teviot Brook and Washpool Gully, as well as several unnamed streams). At that time Wallace Creek was recorded as 'an upland stream with a sinuous channel approximately 1 m wide, with areas of deposition, erosion, pools, runs and riffles. The surrounding vegetation consisted of pasture grasses and native trees and shrubs (*Casuarina cunninghammii*, *Callistemon viminalis* and *Eucalyptus tereticornis*). The water was slightly turbid with a conductivity of 1430 μScm^{-1} and a pH of 7.5.' (Casanova et al. 2003).
- In 2022 at C.Head Road we had permission from local landholders to survey the creek more thoroughly. The distribution of *L. barbatus* was mapped (Fig. 4) and the condition of the population was recorded. The stream condition appears to be similar to the report in 1996, except that the surrounding vegetation appeared to be somewhat degraded (only adult trees of *C. cunninghamii*, occasional adult trees of *Melaleuca lanceolata,* no *C. viminalis*) and more thoroughly grazed by cattle. *Lychnothamnus* coexists in the creek with several other charophyte species including *Nitella hyalina, Chara globularis* and *Chara contraria*.

Figure 4. Distance surveyed (red line) and localities (orange dots) of *Lychnothamnus* plants in Wallace Creek upstream from C.Head Road crossing.

Additional sites in the Boonah-Peak Crossing District

Lychnothamnus barbatus was not found in any other sites in the Boonah/Peak Crossing district, despite thorough searching. Sites on Wallace Creek where access was allowed were thoruoughly surveyed (Fig. 5).

Figure 5. Sites on Wallace Creek examined for the presence of *Lychnothamnus* in 2022.

Additional Sites: Vicinity of Bunya Mountains

As part of a more opportunistic survey for charophytes in southeast Queensland (taking advantage of being in Queensland with time, staff and equipment) we undertook a general survey for charophytes between Brisbane, Dalby and Bribie Island, including areas in the Bunya Mountains, Tamborine Mountain, Beaudesert, Toowoomba, Glasshouse Mountains, Sandbanks, Enoggera Reservoir, Freshwater, Enoggera and Ithaca Creeks, choosing sites on the basis of previous charophyte collections (in the 1890s-1900s by Bancroft, Tryon, White and Hamlyn-Harris; Wood 1972) and access. *Lychnothamnus barbatus* was opportunistically found in a single site (Wallaby Creek at a crossing on the D'Aguilar Highway at the Cec Krisanski Bridge). We did not have permission to survey more extensively at this site, however *L. barbatus* was abundant and co-occurring with other charophyte species. The creek was wide and rocky, with deep pools and riffles, the water clear, and surrounded by dense vegetation including *Eucalyptus, Casuarina, Leptospermum* and *Callistemon* (see cover photo).

Habitat critical to survival in Australia

At the present time, the habitat critical to the survival in Australia, based on vouchered specimens, is Wallace Creek and Wallaby Creek. The total extent of the populations in these creeks is largely undocumented due to accessibility and permits, however, where Wallace Creek has been surveyed *L. barbatus* extends for c. 100 m upstream of C.Head Road crossing, on private property. It has not been found downstream at sites where the road crosses, nor on private property adjacent to the village of Wallaces Creek.

Threats

Based on assessment by the TSSC and staff at Department of Environment, Water, Heritage and the Arts (2008) the following threats are identified (Table 1).

Table 1 threats: threats are noted in approximate order of highest to lowest impact, based on available evidence on the vouchered sites where *L. barbatus* occurs. There are two additional sites on Cape York reported (García and Chivas 2006) for which vouchers have not been seen, and these are not included in the assessment.

Threat	Status	Evidence
Cattle grazing and erosion of banks by cattle	• Timing: current/future • Confidence: observed • Likelihood: almost certain • Consequence: major • Trend: increasing • Extent: unknown, but at least 50% of populations.	The site where *L. barbatus* occurs at C.Head Road is largely on private property and open to cattle grazing. There appears to be significant erosion of the banks where cattle drink and cross the creek (as well as natural erosion from variable flows).
Habitat loss, disturbance and modification	• Timing: current/future • Confidence: observed • Likelihood: almost certain • Consequence: major • Trend: increasing • Extent: not determined	Where *L. barbatus* occurs at C.Head Road there appears to be little reestablishment of native vegetation to shade the creek and the standing trees and shrubs are all mature. The site on Wallaby Creek was only accessed where the highway crosses, the land tenure on upstream and downstream has not been determined.
Altered water quality caused by anthropogenic activities	• Timing: current/future • Confidence: observed • Likelihood: likely • Consequence: major • Trend: increasing • Extent: across the entire range	The catchment of all stream sites is in highly utilised agricultural landscape. There is evidence of runoff from agricultural land along Warrill Creek, potentially leading to eutrophication. There is a quarry downstream of C.Head road and some evidence of increased turbidity resulting from runoff.
Altered water regimes	• Timing: past • Confidence: inferred • Likelihood: possible • Consequence: moderate • Trend: stable • Extent: Warrill Creek	Development of onstream weirs or dams has occurred or been proposed in the past for Warrill Creek.
Road works and bridge works	• Timing: current/future • Confidence: observed	Repair or creation of bridge works has occurred at two

	• Likelihood: likely • Consequence: moderate • Trend: stable • Extent: across the entire known range	sites, and will occur in the future due to those sites being on highway crossings. The site on Wallace creek has a number of small fords where erosion can occur.
Climate change and severe weather	• Timing: future • Confidence: inferred • Likelihood: unknown • Consequence: moderate • Trend: increasing • Extent: across the entire known range	Lower water levels due to altered surface run-off during drought – raised water temperature, decreased water quality, longer and lower low-flow events, new instream barriers (increasing fragmentation). Higher, more prolonged high-flow events – removing populations, removing soil-seed bank, preventing reestablishment due to local extirpation
Invasion of and competition with exotic species	• Timing: future • Confidence: possible • Likelihood: unlikely • Consequence: moderate • Trend: not determined • Extent: not known	There is no evidence that *L. barbatus* is excluded due to competition from exotic species in Australia.

[a]Timing—identifies the temporal nature of the threat
Confidence—identifies the nature of the evidence about the impact of the threat on the species
Likelihood—identifies the likelihood of the threat impacting on the whole population or extent of the species
Consequence—identifies the severity of the threat
Trend—identifies the extent to which it will continue to operate on the species
Extent—identifies its spatial context in terms of the range of the species

Categories for likelihood are defined as follows:
Almost certain – expected to occur every year
Likely – expected to occur at least once every five years
Possible – might occur at some time
Unlikely –known to have occurred only a few times
Unknown – currently unknown how often the threat will occur

Categories for consequences are defined as follows:
Not significant – no long-term effect on individuals or populations
Minor – individuals are adversely affected but no effect at population level
Moderate – population recovery stable or declining
Major – population decline is ongoing
Catastrophic – population trajectory close to extinction

Table 2 Risk Matrix

Likelyhood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain				Cattle grazing and erosion, Habitat loss	
Likely			Road works and bridge works		Altered water quality
Possible			Altered water regimes		
Unlikely			Exotic species		
Unknown			Climate change and severe weather		

Risk Matrix legend/Risk rating:

Low Risk	Moderate RIsk	High Risk	Very High Risk

Discussion

Based on the absence of any sign of *L. barbatus* (or any other charophyte species) in Warrill Creek it is reasonable to conclude that the site does not provide a suitable habitat for the species at the present time. Agricultural run-off and stream-bank erosion could have contributed to its absence in Warrill Creek, but the scouring effect of high flows in recent floods cannot be discounted. No other charophyte species were detected in Warrill Creek in 2022, despite their presence in 1996 and 1960. This indicates that the stream might either be no longer be a good quality habitat for charophytes, or charophytes have had insufficient time to reestablish after the floods.

Lychnothamnus barbatus was found in Wallace Creek, along with three other species of charophytes. However, the population could be in decline, as the plants were not as abundant or tall as in the past, and although there was debris in the trees above the stream, *L. barbatus* was not present in the debris (this is in contrast to the situation in 1996 when the fences and branches above the creek were strewn with stems and propagules of *L. barbatus*). The creek had been sampled (almost to the day) at the same time of year as previous surveys, so population differences are not likely to be due to seasonal variation.

The discovery of a new site for the species on the D'Aguilar Highway provides evidence of a wider distribution in suitable habitat in southeast Queensland. However, its presence at a highway crossing means that if bridgeworks are planned for that site (Cec Krasinski Bridge) mitigation works should be considered.

In order to secure the species in Australia remediation works should be considered:

- Wallace Creek appears to have experienced some degradation of riparian vegetation since 1996, so (i) creation of stable crossings, (ii) restoration of the vegetation and (iii) fencing, along with provision of off-stream water sources for cattle should be considered.
- At Warrill Creek eutrophication, turbidity and/or the continuous high flow (via the flows from Moogerah Dam for irrigation) might be unsuitable for this species to re-establish or persist.

- Washpool Gully provides habitat for a number of charophyte species, including some that cooccur with *L. barbatus*, so establishment of healthy riparian vegetation and fencing to exclude stock could create a habitat suitable for *L. barbatus*. Once stream health is improved in Washpool Gully transplantation of *Lychnothamnus* could be considered to further protect the species.

These results invite further survey and research into this species in Queensland. The role of substrate condition, high flows and disturbance by cattle should be investigated. Habitats are markedly different to those recorded in Europe, so comparison of populations could enhance our knowledge of this rare and endangered charophyte.

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