

Monitoring the effectiveness of the keeled snail (*Tasmaphena lamproides*) management plan: 2016 Togari Block sampling



Kevin Bonham

Report to Forest Practices Authority

December 2016

(Cover photo: live *Tasmaphena lamproides* found in a streamside reserve at site 81.)

Summary

The keeled snail (*Tasmaphena lamproides*) occurs only in far north-western Tasmania and southern Victoria, and is listed as Rare on the schedules of the *Tasmanian Threatened Species Protection Act 1995*. Management of the species on State Forest and forested private land has been largely based on information obtained from a survey of the Togari Block and Bond Tier in 1992, plus a range of smaller surveys and informal sampling in other areas. Many coupes within Togari Block have since been converted to eucalypt plantation or clearfelled and silviculturally regenerated. The species is managed primarily by ensuring a contiguous network of native forest over 30 years old, and by ensuring retention in harvested areas.

A resampling of the original areas surveyed was undertaken in October 2013, finding broadly comparable levels of species presence in mature forest and older (>10 years) first-rotation plantations, but greatly reduced levels of presence and abundance in young (<20 years) native forest regrowth. However the difficulty of finding live specimens during that season, combined with the small number of sites and the diversity of forest treatments, created a need for further sampling. Therefore a further survey was conducted in October 2016.

The 2016 survey found the species alive at a much higher percentage of sites than in 2013, and indeed at a comparable rate to in 1992 in spite of a shorter survey time per site. The combined results of the three surveys suggest that keeled snails are largely eliminated by regeneration burns and recover slowly in at least the first 20 years after logging, although recovery is faster in plantations. Beyond this, there is no reliable evidence that logging has had longer-term impacts on the species within Togari Block.

The available evidence suggests that the existing management practices are generally appropriate for the species within Togari Block. It is the author's view that the Tasmanian population of *Tasmaphena lamproides* is not at realistic risk of extinction and that it would be reasonable to delist the species.

Background

The keeled snail (*Tasmaphena lamproides* (Cox, 1868)) is a large carnivorous land snail endemic to far north-western Tasmania and southern Victoria. The Tasmanian population is listed as Rare on the schedules of the *Threatened Species Protection Act 1995*, primarily because of its restricted range and low population density. The species has an estimated extent of occurrence in Tasmania of 770 km² and an estimated area of occupancy of 42,000 hectares (Fauna Strategic Group, 2006).

Very little was known about the status of Tasmanian populations prior to a survey of the Togari Block (plus two sites in Bond Tier) undertaken in 1992 (Bonham and Taylor, 1997). The survey established that the species occurred quite consistently in a range of wet forest habitats in the block, including rainforests, but was most common at the northern end of the block and in forests that were 60 years old or older. In other surveys it has sometimes been found in regrowth as young as 20 years (Bonham, 1999b), in 12-13 year old plantations near forest edges (Bonham, 2006) and rarely in unusual habitat types such as eucalypt scrub in the north-western corner of Woolnorth (Bonham, 2000) and coastal shrubbery at The Nut (Bonham, 1999a). The species may occur less frequently at sites with very sandy soils (Bonham, 2000).

Keeled snails can be found under and sometimes inside logs, and in leaf litter, twigs and bark on the ground. They are carnivorous and their known diet includes other land snail species and worms. They are noted for occurring at low population densities. Assuming an average undercount of 20% by the methods used in the 1992 survey, population density in most of Togari Block was around 10 live adults/hectare, rising to around 20 live adults/hectare in the north of the block, and to 60 live adults/hectare in some areas of unusually high density. However, surveying that uses smaller search sites has produced higher density estimates and it is probable that the undercounting rate (and hence the population density) is therefore higher.

Keeled snails are locally eliminated by land clearance for conversion to pasture and there have been very few records in young (<20 years) regrowth. A management approach was developed for activities covered by the Forest Practices Act in 1998 (Forest Practices Board, 1998). A draft management plan was then developed for State forest in 2000 (FT and DPIPWE 2000). This plan was developed from the modelling work of Regan *et al.* (1999; 2000; 2001) and delivered through the Threatened Fauna Adviser (Forest Practices Authority 2000, 2014). The primary objectives of the plan were:

- To provide for the long term survival of *Tasmaphena lamproides* on State forest in northwest Tasmania, by minimising impacts from threatening processes.

- To provide a strategic planning framework for the long-term protection and management of *T. lamproides* habitat within its known range on State forest.
- To limit the degree of plantation development within the range of the species such that a substantial network of native forest habitat is maintained throughout the species' range.
- To maintain or improve the conservation status of *T. lamproides* in an area subject to production forestry.
- To provide, for *T. lamproides*, a more strategic alternative to the current coupe-by-coupe based approach to threatened species management within production forests.

These objectives were to be achieved by retaining a contiguous network of native forest (including forest greater than 30 years of age) throughout the range of the species, ensuring adequate retention and contiguity of native forest especially in areas of intensive plantation development.

The plan area has been subject to intensive and extensive native forest harvesting and conversion to plantation since the plan was developed, but reporting by Forestry Tasmania indicates the management plan for this species has largely been complied with (Forestry Tasmania 2013).

In 2013, most of the sites originally surveyed in 1992 were resurveyed (Bonham, 2013). The 2013 survey aimed to resurvey the exact sites of the 1992 survey to determine the impact of subsequent harvesting on populations of the species within the block. Eleven of the original 29 Togari Block sites had been harvested since 1992, with four of these being converted to plantation.

The 2013 survey found strong evidence that the species was much less prevalent at sites that had been regenerated as native forest between 2000 and 2012. Only one specimen (a live adult) was found at five such sites, which had yielded 24 specimens (nine alive) in 1992 prior to logging.

Aside from these regenerated sites, total specimen numbers were generally similar to in 1992 (especially once adjusted for the reduced survey time), but numbers of live specimens were lower. The species was very difficult to find alive at sites that had been "mature" (a classification which included regrowth forests estimated to be at least 60 years old) in both survey periods. This was particularly true for the 2013 surveys. Furthermore, the proportion of dead specimens that were juvenile was higher in 2013, probably making dead specimen numbers a less reliable indicator of habitat quality.

Because the species may be more or less cryptic in certain weather conditions, and because of the small numbers of specimens involved, it was not possible to draw reliable conclusions from the 2013 data about whether the species had actually

become less common at unharvested areas. Even had such conclusions been drawn, it would not have been clear whether such a change was temporary or permanent, or what could have caused it.

The 2016 survey was conducted to increase the number of sites, including regrowth of different ages and also streamside reserves, for which recent keeled snail survey data existed. It was also expected that further surveying would shed light on whether the apparent scarcity of live keeled snails at older forest sites in the 2013 survey was an anomaly.

Methods

1. Site Selection

Thirty-one sites were surveyed, all of them within Togari Block. Sites were selected from a list of possible sites prepared by Forestry Tasmania (FT) Conservation Planner in consultation with FPA Acting Research Biologist. Yee selected possible sites from spatial data derived from photo-interpretation, maintained by FT. A total of 68 possible sites were listed, of which 11 were later excluded based on forestry operation, access (fallen tree) and eagle nest issues. The author chose which of the remaining sites to survey based on criteria of accessibility, travel time, range of treatment types, and geographic coverage of Togari Block. In some cases, the supplied coordinates for a site represented a road intersection or creek crossing and in these cases the point to be surveyed was randomised in the field (example: toss a coin to determine a direction then head 50 metres from the road in that direction). In most other cases the supplied coordinates were located as closely as possible (usually to within 10 metres) by GPS to form the site centre. One site was moved because the extent of windthrow at the supplied coordinate made surveying the original site impractical, and because the original site was too close to a harvested edge to be representative in any case.

Sites to be surveyed were initially typed as Mature, Regrowth (age-specified and under 60 years old), Regrowth (age not specified and typically over 60 years old), Plantation and Streamside Reserve (SSR). In this report, sites have been broken down into six age bands: Fresh (logged within last five years and not yet burnt), 1-19 years (post-burn), 20-39, 40-59, 60 years and over and Mature. Sites have been classed as Mature if it is estimated that the forest growing at such sites was over 100 years old. The same classifications have been applied to the 1992 and 2013 sites for comparative purposes.

Table 1 shows how sites have been classified across the three surveys. For the 1992 and 2013 survey the few sites surveyed outside Togari Block (sites 30 and 31) were not included in analyses. Sites 12, 13 and 14 were not resurveyed in 2013 due to wedge-tailed eagle nest issues. Site 10 in the 1992 survey was originally recorded as 40-year old regrowth but this was considered incorrect based on the age of trees when

the site was revisited in 2013. Site 33 was surveyed in 2013 but was not included in analyses based on knowledge of this site from previous sampling as a high-density site and selection based on different criteria (long-term monitoring), and is not included in this report.

Table 1: 1992, 2013 and 2016 sites classified as Mature (100 yrs+), streamside reserve (SSR), plantation and five regrowth age bands.

	1992	2013	2016
Mature	3,4,9,13,14,16,18,19,21,23,24,26	3,4,9,18,23,26	48,55,69,71,91
R 60+	1,6,7,10,11,12,17,20,22,25,27,29	1,10,11,20,27,29	50,84,85,86
R 40-59	5,8	15,28	58,59,65,72,78
R 20-39	15,28	2	89,90,102
R 0-19	2	8,19,21,22,25	49,53,70,97
R Fresh		5,7	68
SSR		32,34	51,56,81,101,105,107
Plantation		6,16,17,24	54,88,96

2. Sampling

All sampled sites were surveyed for one hour by the author and one assistant. Three different assistants worked on the project - of these one had some prior experience of surveying for land snails. Assistant searchers found 41% of all keeled snails found during the project with little difference between the three - however this is significantly higher than the c.25% rate for previous assistants.

As in both previous surveys, all sites were surveyed by hand-searching within a 15 metre radius of a designated central point, as in the original survey. Available shelters were searched including the undersides of logs and rocks, and piles of leaf litter, bark or twigs (especially around the bases of trees and stumps or in deep ditches). Rotten logs were broken apart where this was easily possible to do by hand.

As in the 2013 survey a time limit of one hour per site was applied. (In the 1992 survey, sites had been searched until there was confidence that all suitable and movable shelter had been checked, which took from 70 to 120 minutes per site.)

Sites were surveyed on the following dates:

10 Oct: 55, **11 Oct:** 59, 58, 56, 72, **12 Oct:** 65, 68, 70, 71, **13 Oct:** 51, 49, 50, 48, **14 Oct:** 54, 53, **17 Oct:** 69, 102, **18 Oct:** 89, 90, 88, 78, **19 Oct:** 107, 96, 97, 101, **20 Oct:** 85, 84, 81, 91, **21 Oct:** 86, 105.

Some informal searching outside the specified sites was also conducted at sites 55, 56, 58, 59 and 72 but no *T. lamproides* were found.

3. Data collection and analysis

A range of environmental variables were recorded (including aspect, slope, canopy cover, tree and groundcover species present, and extent of coarse woody debris, rocks and other shelters (see Appendix 3 for the field work data sheet) and have been recorded in a Microsoft Access database for the project. From this database a Microsoft Excel spreadsheet of all the data can be exported. Photographs of the vegetation and several of the live snails seen have also been taken and copies kept, including by the author, and photograph numbers are included in the database.

For each site keeled snails found were classified as live or dead and adult or juvenile. Specimens above 14 mm shell width were deemed adult. Very few such specimens were visibly sub-adult. The microhabitat in which each keeled snail was found was recorded.

In previous reports, the species has been classified as present at a site even if only dead specimens were found, except if only old dead shells were found. This classification method is avoided in this report because the combined 1992 and 2013 results very strongly suggest that the species is ubiquitous within at least old growth and older regrowth habitats within Togari Block. If no evidence of *T. lamproides* is found at a mature forest or older regrowth site, then this is probably a false negative rather than evidence that the species is actually absent from the site and its immediate surrounds. The species may well have been present within the site but not found during the time available. On the other hand, care needs to be taken in regarding dead shells as evidence of presence in habitat types with few live specimen records, especially if the shells could have been dead for several years. Therefore the focus of this report is mainly on live specimen totals.

For this survey, the freshness of each dead specimen located was recorded, on a "condition class" scale of 0-4, as follows:

4: A very freshly dead specimen with full shell colour and the animal still decomposing. (In one such case the entire animal was still present but clearly dead.)

3: A freshly dead shell with full shell colour but no remaining evidence of animal decomposition.

2: A somewhat worn shell with some original colour and possibly minor damage, of unclear age.

1: An old worn shell with most colour lost and/or substantial damage.

0: A very old shell that is very damaged, broken, disintegrated or a fragment, or that if entire is entirely whitened.

As with the 1992 and 2013 surveys, numbers of all land snail species (including both native and exotic slugs) were recorded. These were relevant because *Stenacapha*

ducani and *Helicarion cuvieri* are prey species for *Tasmaphena lamproides*, and *Victaphanta milligani* is another carnivorous species that displayed a negative correlation with *T. lamproides* numbers in the original survey. Numbers of native land snail species other than these four species should not be assumed to accurately indicate population densities, as some species have different microhabitat preferences, and some species are very small and less likely to be found while targeting *T. lamproides*.

Results

1. Results by site

Table 2 (next page) shows results by site with site types given, including both the breakdown into live/dead and adult/juvenile, and also the breakdown of condition classes for dead shells. Fifteen live adults, eight live juveniles, 46 dead adults and 13 dead juveniles of *Tasmaphena lamproides* were found. The species was found alive at 17 of the 31 sites surveyed (55%), compared to 15/29 Togari Block sites (52%) in 1992 and 8/28 (29%) recorded in Togari Block in 2013. However, the total number of live specimens was lower than in 1992 (23 compared to 30).

Some evidence of the species was found at 26 of 31 sites surveyed. Of the nine sites where only dead specimens were found, four had at least one very fresh or fresh specimen (condition classes 4 and 3). Sites with live specimens tended to have more dead specimens than those without, but this tendency was not very strong. There was virtually no difference in the average condition class of dead shells between sites where live keeled snails were recorded and those where they were not, but the condition class of dead specimens was more variable at the latter. (1.83 +/- 1.15 and 1.82 +/- 1.47 respectively).

Two sites that had only dead shells deserve specific comment. At site 70 (8 year old regrowth) the only evidence was two small fragments, apparently from the same juvenile shell, found together under a burnt log. This specimen could easily have pre-dated logging of the site and is clearly not reliable evidence of current presence at the site. At site 49 (13 year old regrowth) a dead adult shell with moderate wear (condition class 2) was found under a burnt log. It would be interesting if the species had recently lived at this site (given that it is 100 metres from the mature forest edge) but the shell found might pre-date logging or at least burning, and hence did not provide clear evidence that the site had been reoccupied by the species.

Unusually high specimen totals were recorded at three sites - 11 specimens at site 71 (oldgrowth wet eucalypt forest), nine at site 54 (22 year old *Eucalyptus nitens* plantation) and eight at site 102 (26 year old regenerating eucalypt/blackwood forest). None of these were in the northern part of the block, where similar totals have been sometimes recorded before. Except for one site at Three Hummock Island (where all 14 specimens found by a single searcher were dead), the 11 specimens at site 71 is the

most recorded in a one-hour search of a specific site anywhere, and also exceeds all site totals from the 1992 survey.

Table 2: Results by site including breakdown of live/dead and condition class of dead shells. In Type column, R = Regrowth, SSR = Streamside reserve, P = Plantation. Numbers in brackets indicate age in years. Letters in brackets for SSR indicate surrounding habitat type(s). LA = Live adult, LJ = Live juvenile, DA=Dead adult, DJ=Dead juvenile. On right of table, DC followed by number = dead specimens with condition class matching that number (higher condition class = fresher specimen, see p. 8 for definitions).

Site	Type (Age)	Description	LA	LJ	DA	DJ	Total	DC4	DC3	DC2	DC1	DC0
48	Mature	Mature wet eucalypt forest			2		2				2	
49	R(13)	Wet eucalypt regrowth			1		1			1		
50	R (c.100)	Wet eucalypt forest	2		2	1	5		1	1	1	
51	SSR(R)	Disturbed wet eucalypt forest					0					
53	R(8)	Wet eucalypt regrowth					0					
54	P(22)	Old E. nitens plantation	1	1	6	1	9		4	3		
55	Mature	Mature mixed forest	1		1		2				1	
56	SSR(P)	Oldgrowth rainforest	1		1		2		1			
58	R(48)	Wet eucalypt forest	1		1		2				1	
59	R(48)	Wet eucalypt forest			2	1	3	1	1			1
65	R(55)	Wet eucalypt forest	1	1	1		3			1		
68	R(Fresh)	Freshly logged forest		1			1					
69	Mature	Mature mixed forest			1		1	1				
70	R(8)	Wet eucalypt regrowth				1	1					1
71	Mature	Mature wet eucalypt forest		2	4	5	11		2	4	3	
72	R(55)	Eucalypt/blackwood forest	1		1		2				1	
78	R(45)	Wet eucalypt forest			4	2	6	1	1	1	1	2
81	SSR(R)	Wet eucalypt forest	1		4		5	2	1			1
84	R(c.80)	Eucalypt/blackwood forest			1		1				2	
85	R(c.80)	Wet eucalypt forest			2		2					1
86	R(c.60)	Wet eucalypt forest					0					
88	P(11)	E globulus plantation	1				1					
89	R(21)	Wet eucalypt regrowth			1	1	2		1	1		
90	R(26)	Wet eucalypt regrowth	1	1	2	1	5			1	1	1
91	Mature	Oldgrowth mixed forest	1		1		2			1		
96	P(16)	E globulus plantation					0					
97	R(16)	Wet eucalypt regrowth					0					
101	SSR(P)	Oldgrowth mixed forest	1				1					
102	R(26)	Wet euc/blackwood regrowth	1	1	6		8		2	3		1
105	SSR(P/R)	Disturbed blackwood forest	1		2		3					2
107	SSR(P/R)	Oldgrowth eucalypt forest		1			1					
All			15	8	46	13	82	5	14	17	13	10

2. Summary results by type, with comparison to previous samples

Table 3 gives summary results for live specimens only by site type for the 1992, 2013 and 2016 surveys. It should be stressed that direct comparison between the three years even for the same site type is extremely difficult because of:

- * the longer (and variable) search time per site in 1992
- * slight differences in the time of year when surveys were conducted
- * variability of weather within and between surveys
- * different success levels of different assistant searchers
- * geographic differences in areas surveyed - the north end of the block, which appears to support higher population densities, was more surveyed in 1992
- * differences in the proportion of available shelters that could be searched in the time available (especially applies to 2013 and 2016)
- * probably, differences in how cryptic the species is between different kinds of sites

To amplify the last two points, in plantation sites there are often few shelters except for bark piles around the base of eucalypts and any rotten wood pieces left over from windrowing or pruning. Older native forests may contain potential shelters that cannot be searched, including areas under hollowed-out roots of large trees, or under or inside logs too large to move or break apart.

Table 3 - summary statistics by site type for live specimens only from 1992, 2013 and 2016 surveys. R = Regrowth, SSR = Streamside Reserve, Live-At = number (or percentage on right) of sites at which the species was found alive. Numbers for live adults and live juveniles are totals.

Site Type	1992 Sites	1992 Live-At	1992 Live Adults	1992 Live Juv	2013 Sites	2013 Live-At	2013 Live Adults	2013 Live Juv	2016 Sites	2016 Live-At	2016 Live Adults	2016 Live Juv	Total Sites	Total Live-At	Total Live Adults	Total Live Juv	% Live-At	Ave Live Adults/site
Mature	12	8	8	7	6	1	2	0	5	3	2	2	23	12	12	9	52	0.52
R 60+	12	6	11	3	6	1	2	1	4	1	2	0	22	8	15	4	36	0.68
R 40-59	2	0	0	0	2	0	0	0	5	3	3	1	9	3	3	1	33	0.33
R 20-39	2	1	1	0	1	0	0	0	3	2	2	2	6	3	3	2	50	0.5
R 1-19	1	0	0	0	5	1	1	0	4	0	0	0	10	1	1	0	10	0.1
R Fresh	0	0	0	0	2	2	2	0	1	1	0	1	3	3	2	1	100	0.67
SSR	0	0	0	0	2	1	2	1	6	5	4	1	8	6	6	2	75	0.75
Plantation	0	0	0	0	4	2	2	4	3	2	2	1	7	4	4	5	57	0.57
Total	29	15	20	10	28	8	11	6	31	17	15	8	88	40	46	24	45	0.52

Table 3 shows that thus far, the species has been found alive more often and in higher average numbers in all of streamside reserves, freshly logged areas and plantations compared to mature forest sites. However (i) the sample size for all these site types (8, 3 and 7 sites respectively) is small, and (ii) the point made above about ease of

searching applies to plantations and often also to freshly logged areas. So it should not be concluded yet that these areas are more supportive than mature forest, or even necessarily as supportive.

3. Microhabitats

Appendix 1 gives a breakdown of all *T. lamproides* specimens found by the microhabitats where they were found. In the 2016 survey specimens were most often found under twigs and litter in the open (27), under logs (17), under bark, twigs or litter around the bases of eucalypts (9) and in litter along the edge of logs (9). Regarding "twigs and litter in the open", dense piles of twigs and litter often produced specimens, especially in regrowth eucalypt forests. Only one specimen was found in litter in a ditch or depression, although in the 1992 and 2013 surveys specimens were found about as often in ditches and depressions as in the open. The level of variation between surveys in which microhabitats produce the most specimens appears surprising.

4. Other snails

Appendix 2 gives a breakdown of results for all other snail species. There was only a weakly positive relationship ($r^2 = 0.06$) between numbers of *T. lamproides* and combined specimen numbers of the prey species *Stenacapha ducani* and *Helicarion cuvieri*. Numbers of *Stenacapha ducani* were almost as high as in 1992 despite the longer search times in that survey, and much higher than in 2013. 67 of 457 *S. ducani* were alive in the 2016 survey, compared to 16 of 136 in 2013.

Helicarion cuvieri was much more common in the 2016 survey (288 specimens including 40 alive) than in the 1992 survey (142 of which 3 alive) or 2013 (117 of which 10 alive). Also, *H. cuvieri* was found plentifully at some young regrowth sites in this survey, unlike in 2013.

Victaphanta milligani was surprisingly scarce in the 2016 survey. Only 39 specimens were found, of which only one was alive (compared to 97 of which 15 alive in 2013 and 174 of which many were alive in the mostly older forest sites surveyed in 1992.) Furthermore most dead *V. milligani* specimens found were long-dead shells in poor condition. More surveying is required, but it is possible the species (a western Tasmanian wet forest endemic) was adversely affected by the hot dry 2015-6 summer.

Results for other native species were similar to the previous surveys, with none found in significant numbers. The most notable find was a single dead shell of *Dentherona subrugosa* at a streamside reserve site on Cannells Road (site 51). This find was 150 km out of the known range of this common eastern/northern Tasmanian species. It is very likely that the species was translocated into the area during logging. This was probably also true of the single live *Bischoffena bischoffensis* recorded at site 1 in

1992 (the species has never been recorded in Togari Block, or within 70 km of it, since.)

Exotic species records included a single very large live *Cornu aspersum* (common garden snail) at a freshly logged site (site 68). A colour discontinuity on the shell suggested it had been living at the site for some time after presumably being brought in during logging. The specimen was removed. No previous such records of *C. aspersum* from Tasmanian logging coupes distant from settlement are known.

A more significant result was the presence of an extremely dense infestation of *Arion intermedius* (hedgehog slug) in a 16-year old *Eucalyptus globulus* plantation (site 96). No *T. lamproides* were recorded at this site. Similar infestations have not been recorded at other Tasmanian plantation sites before; for example in a survey of 46 plantation sites in north-west Tasmania in 1999, only 124 specimens of *A. intermedius* were recorded (Bonham, Mesibov and Bashford, 2002). It is unclear whether the abundance of *Arion intermedius* could be an indirect cause (or alternatively, a result) of the absence of *Tasmaphena lamproides* from this site. The species is a live-plant feeder and fungivore that might compete with native fungivorous snails which *T. lamproides* eats.

5. Miscellaneous

Tasmaphena lamproides was observed eating *Stenacapha ducani* at two sites during this survey (sites 58 and 91).

Discussion

Overall, this survey is consistent with the main conclusions of the 2013 survey. The 2013 survey found that recovery in the first 20 years of regrowth (following a regeneration burn) appears to be very slow, but that the species appears to be substantially present in other age classes, including plantations that are at least 12 years old. This survey also finds evidence of substantial presence in streamside reserves, and indeed finds no evidence that regrowth between 20-60 years old is less supportive than older regrowth or mature forest.

The 2016 results also suggest that the low success rate in finding live specimens in the 2013 survey was anomalous. The cause of the 2013 anomaly, if any, is unknown, as weather data for Smithton for 2013 do not reveal anything unusual. In the 2016 survey, live specimens were found at a similar proportion of sites to the 1992 survey, in spite of a greater proportion of sites being impacted by logging within the last 60 years, shorter surveying time, and a lower proportion of sites being in the northern end of the block. Overall, the results from previous surveys indicated that the northern end of the block appears to support higher densities of *T. lamproides* on average. However, the few northern sites examined in this survey did not support higher densities than the other sites to the south.

It is not possible yet to draw reliable comparative conclusions about the relative habitat value of mature sites compared with the various regrowth classes over 20 years old, streamside reserve sites and plantation sites. Despite the increased volume of data, such conclusions are not possible because of the relatively small number of samples for a species that occurs in low population densities, apparent geographic variations in abundance, differences in the extent to which sites can be searched fully in a standardised time period, possible weather-related variation in availability, and differences in capture rates for assistant searchers. What can be concluded is that the snail is substantially present in all of these habitat types.

A provisional finding of the 1992 survey (based on very limited data) was that the species was less prevalent in regrowth between ages 30 and 60 years than in older forest. With the addition of further data this provisional finding is not clearly supported and may not actually be valid. Two 26-year old sites produced high numbers of specimens. More sampling of regrowth between 15 and 25 years old, especially, would be needed to refine estimates of the age at which the species recovers in significant numbers.

It was noticed during surveying that there are differences between regrowth sites within the Block. Older regrowth sites preceding development of pulp markets have many large logs, some sites have some older retained seed trees, and some sites were fenced to protect blackwood seedlings (for example). No obvious impact of different regeneration techniques, however, is apparent with the current data set.

It is proposed that the recovery of land snail prey in regrowth forests is not the sole trigger, and perhaps not even a major trigger, for *T. lamproides* to also recover. Although *T. lamproides* has been observed eating *Stenacapha ducani* several times, correlations between numbers of *T. lamproides* and numbers of prey snails are weak, and both *S. ducani* and *Helicarion cuvieri* repopulate younger regrowth more readily than *T. lamproides* appears to do. Also, *T. lamproides* occurs at some sites where prey snails are uncommon, suggesting that prey snails may be only a small proportion of its diet (but one that it consumes more slowly and more obviously because of their shells). The faster recovery of the species in plantations (where litter accumulates more rapidly than in regenerated native forests) suggests that development of the litter layer might be independently important for the species.

Only three plantation sites were sampled in 2016. The species was present alive at two of them (one 22 years old and one 11 years old), but it was absent at one 16-year-old plantation, which was infested with the slug *Arion intermedius*. Litter formation at the two *Eucalyptus globulus* plantations sampled appeared more limited than in *E. nitens* plantations of similar ages that have been sampled in the past. It is possible on this basis that *E. nitens* plantations are more supportive of the species than *E. globulus* plantations of similar age, but this would require further study. The ability of *T. lamproides* to occur at plantation sites well away from any native bush (over 100 metres) has still not been demonstrated, but such sites represent a small proportion of the total area of plantation within the Togari Block.

Population Density

Table 3 shows that an average of 0.52 live adults per site have been found at the Togari Block sites surveyed since 1992. This rises to 0.58 live adults per site if

regrowth forests less than 20 years old and plantations less than 10 years old are excluded. As each site covers an area of 0.07 hectares, if there was no undercounting these figures would imply an average population density at the surveyed sites of 7.4 live adults/hectare, or 8.3 live adults/hectare excluding the recently cleared sites. However, undercounting is inevitable. Assuming an undercount rate of 20% for the 1992 survey and 40% for the 2013-6 surveys (with their shorter survey times) the average for all surveyed Togari Block sites (including young regrowth) rises to 11 live adults/hectare.

If it is considered useful to refine this estimate, then as well as compiling figures on the coverage of different site types within Togari Block (as some would have been over- or under-represented in surveying), it would also be useful to conduct some matched testing of smaller (eg 10 x 10 m) sites also searched for one hour each. Such a test could show that the rate of undercounting in 15-metre radius sites is much greater than previously assumed.

An extreme example of the potential for significant (and variable) undercounting rates when searching for one hour per site is site 71. No live adults were found at this site. Two live juveniles were found in the last five minutes of searching, while nine dead specimens had been found through the hour. The amount of potentially suitable litter at the site was such that searching could have usefully continued for perhaps another two hours.

Management

While further research questions for the species can always be generated and explored, the author's view is that the Tasmanian population of *Tasmaphena lamproides* is not at realistic risk of extinction and that it would be reasonable to delist the species. When first listed, the species was very poorly reserved and it was believed plantation conversion would eliminate it. Even in the absence of species-specific conservation measures there is no longer any credible reason to doubt that the species would survive within the state.

On the assumption that the species remains listed, however, existing management practices remain generally appropriate for the species within Togari Block. The current 30 year age threshold for forests to qualify as part of contiguous retained habitat might be reasonably lowered to 25 years, but this might require more analysis of the data to confirm. In addition, more sampling would be needed to justify lowering it further.

Acknowledgements

This project was funded by the FPA with in-kind contribution by FT. I thank Marie Yee (FT) for transport, field assistance, mapping and site selection assistance; Kirsty Kay (FPA) and Sue Jennings (FT) for transport and field assistance, Perpetua Turner (FPA) for project coordination, feedback and field assistance, Sarah Munks (FPA) and Lachie Clark (FT) for securing funding and project coordination and FT, Smithton district staff for helpful advice. Referee comments on the 2013 report have been taken into account in the preparation of this report. Work was conducted under permit TFA16247 and FPA permit TFA 16090. Thankyou to Sarah Munks, Perpetua Turner and Peter Volker for additional comments on earlier drafts of this report.

References

- Bonham K. (1992) *Tasmaphena lamproides* (Cox 1868) in the Togari Forest Block. Unpublished report to Forestry Commission of Tasmania. 19 pp.
- Bonham, K (1999a) Distribution, habitat and conservation status of the land snail *Miselaoma weldii* (Pulmonata: Punctidae) *Tas. Nat.* **121**: 2-12
- Bonham, K (1999b) Range boundary survey for the keeled snail *Tasmaphena lamproides* Unpublished report to Forestry Tasmania.
- Bonham, K. (2000) Distribution and habitat characteristics of *Tasmaphena lamproides* (keeled snail) on private land. Unpublished report to Forest Practices Board and Threatened Species Section, DPIWE. 6 pp.
- Bonham K. (2006) *Keeled Snail Coupe And Plantation Surveys December 2006*. Unpublished report to Forestry Tasmania, Smithton. 4 pp.
- Bonham, K. (2013) Monitoring the effectiveness of the keeled snail (*Tasmaphena lamproides*) management plan. Report to Forest Practices Authority. Published online at http://www.fpa.tas.gov.au/data/assets/word_doc/0004/114727/Keeled_Snail_monitoring_report_2.docx 19 pp.
- Bonham K, Mesibov R and Bashford R (2002) Diversity and abundance of some ground-dwelling invertebrates in plantation vs native forests in Tasmania, Australia. *Forest Ecology and Management* **158**: 237-247
- Bonham K. & Taylor R. (1997) Distribution and habitat of the land snail *Tasmaphena lamproides* (Pulmonata: Rhytididae). *Tasmania. Molluscan Research* **18**, 1-10.
- Fauna Strategic Group (2006) Strategic plan for *Tasmaphena lamproides* (Keeled Snail) in areas subject to a Forest Practices Plan in North West Tasmania. Forest Practices Authority, Hobart 39 pp.
- Forest Practices Board (1998) Threatened Fauna Manual. Forest Practices Board, Hobart, Tasmania.
- Forest Practices Authority (2000 and 2014) Threatened Fauna Adviser decision support system. Expert Rule program, Forest Practices Authority, Hobart.
- Forestry Tasmania. (2013) Implementation of strategic recommendations for threatened fauna - State forest in Togari block. Report for the Forest Practices Authority prepared by FT Sustainability Branch and Murchison District, Hobart.

- Forestry Tasmania & DPIPWE. (2000) Draft management plan for *Tasmaphena lamproides* (keeled snail) on State forest in north west Tasmania. A draft Public Authority Management Agreement between Forestry Tasmania and the Department of Primary Industries, Water and Environment, Hobart.
- Regan T., Bonham K., Regan H., Taylor R., Tuson D. & Burgman M. (1999) Forest Management and Conservation of *Tasmaphena lamproides* in North-west Tasmania: Use of Population Viability Analysis to Evaluate Management Options. Forestry Tasmania, Hobart.
- Regan T. J., Regan H. M., Bonham K. J., Taylor R. J. & Burgman M. A. (2001) Modelling the impact of timber harvesting on a rare carnivorous land snail (*Tasmaphena lamproides*) in northwest Tasmania, Australia. *Ecological Modelling* **139**, 253-64.
- Regan T. J., Taylor R. J. & Burgman M. A. (2000) Investigation of Harvest Scheduling Options for Forest Management: Implications for the Carnivorous Land Snail, *Tasmaphena lamproides* in Northwest Tasmania. Forestry Tasmania, Tasmania.

Appendix 1 Microhabitat breakdown for *T. lamproides* specimens

site	LA	LA	LA	LA	LA	LA	LA	LA	LA	LJ	LJ	LJ	LJ	LJ	LJ	LJ	LJ	LJ	DA	DA	DA	DA	DA	DA	DA	DA	DA	DA	DJ	DJ	DJ	DJ	DJ	DJ	DJ	DJ	DJ
	under log	inside log	litter in ditches/depressions	litter alongside logs	litter under sedges	litter under ferns	litter/twigs in the open	bark/litter/twigs around eucalypts	other	under log	inside log	litter in ditches/depressions	litter alongside logs	litter under sedges	litter under ferns	litter/twigs in the open	bark/litter/twigs around eucalypts	other	under log	inside log	litter in ditches/depressions	litter alongside logs	litter under sedges	litter under ferns	litter/twigs in the open	bark/litter/twigs around eucalypts	other	under log	inside log	litter in ditches/depressions	litter alongside logs	litter under sedges	litter under ferns	litter/twigs in the open	bark/litter/twigs around eucalypts	other	
48																																					
49																			1																		
50	1						1																													1	
51																																					
53																																					
54								1								1											2	2							1		
55	1																			1																	
56	1																						1														
58							1													1																	
59																				1									1								
65							1									1									1												
68												1																									
69																				1																	
70																																					
71													2							1						3		1					3		1		
72	1																			1																	
78																				2																1	
81							1																	2	1	1											
84																								1													
85																					2																
86																																					
88								1																													
89																										1											1
90							1										1									2										1	
91				1																																	
96																																					
97																																					
101	1																																				
102							1					1															4	2									
105	1																																				
107													1																								
sum	3	3	0	1	0	0	5	3	0	0	0	0	3	2	0	2	1	0	11	2	1	3	2	3	15	5	4	3	0	0	2	3	0	5	0	0	

LA = Live adult, LJ = Live juvenile, DA = Dead adult, DJ = Dead juvenile. Other:
site 50 - dead on ground, site 54 - 2 specimens under bark on raised log, site 81 -
litter at base of *Olearia argophylla*

Appendix 2 Results for all snails

Site Number	Victaphanta milligani	Tasmaphena lamproides	Prolesophanta sp "Togari"	Prolesophanta dyeri	Punctidae sp "Micro Cripps"	Paralaoma halli	Allocharopa taravillensis	Dentherona subrugosa*	Pernagera kingstonensis	Oreomava johnstoni	Thryasona cf marchianae	Thryasona diemenensis	Stenacapha ducani	Cystopelta bicolor	Helicarion cuvieri	Native species*	Native specimens*	Arion intermedius	Deroceras reticulatum	Lehmannia nyctelia/valentiana	Limax maximus	Cornu aspersum	Exotic species	Exotic specimens
48	10	2											18		8	4	38						0	0
49		1											1		18	3	20						0	0
50	4	5		1			4						12	1	1	7	28						0	0
51	3			2			1	1		2			13		1	7	23						0	0
53					1								13		4	3	18						0	0
54		9											11		18	3	38						0	0
55		2	1		1		2		1	1			7		5	8	20						0	0
56		2											12		3	3	17						0	0
58		2											37		11	3	50						0	0
59	3	3											18		5	4	29						0	0
65		3		2					1	3			2		3	6	14						0	0
68	4	1											21		3	4	29					1	1	1
69	2	1											11	2	5	5	21	5		1			2	6
70		1											16		1	3	18						0	0
71		11		1									30			3	42						0	0
72		2											1	1	5	4	9						0	0
78		6		1						1			11		28	5	47						0	0
81	10	5		1									36		9	5	61						0	0
84		1								1			1		11	4	14						0	0
85	1	2													18	3	21						0	0
86													15		35	2	50						0	0
88		1											4	1		3	6	5					1	5
89	1	2									1		21	1	5	6	31	1					1	1
90		5								1			4		35	4	45						0	0
91		2			1				1				24		12	5	40						0	0
96													12			1	12	650	1	8			3	659
97						1							23		15	3	39	15					1	15
101	1	1								3	1		17		1	6	24						0	0
102		8											4		21	3	33						0	0
105		3									1		46		6	4	56						0	0
107		1					1			3			16		1	5	22						0	0
sites	10	26	1	6	3	1	4	1	3	8	1	2	30	5	28	31		5	1	2	0	1	6	
spec	39	82	1	8	3	1	8	1	3	15	1	2	457	6	288		915	676	1	9	0	1		687

Notes to Appendix 2 on next page

Notes to Appendix 2:

1. *Tasmaphena lamproides* (keeled snail) and prey species *Stenacapha ducani* and *Helicarion cuvieri* are shown in bold. *T. lamproides* has also been observed eating *Prolesophanta dyeri* but this species is very small and uncommon, and would not be a significant diet item.
2. Number of *Arion intermedius* at site 96 is an estimate based on extrapolation from five minutes of counting by both searchers.
3. An asterisk is used for *Dentherona subrugosa* as "native". The species is native to Tasmania but has not been recorded within 150 km of Togari Block. It is probable that it was introduced to Togari Block during logging.

Appendix 3 Keeled snail field work data sheet

Date _____ Site # _____
Observer _____

E _____ N _____ Alt

Search time _____ Aspect _____ Slope _____

Floristic Forest Code: _____

Riparian plot? Y / N Width of SSR where applicable (both sides of
stream): _____ m

Condition (disturbed/slightly disturbed/undisturbed)

Moisture condition (dry/damp/moist/wet)

Forest type outside SSR (where
applicable): _____

Forest age/growth structure outside SSR (where applicable): mature / regrowth /
<20y, other: _____

Overstorey species _____
%cover _____

Understorey species:

%cover _____

Ground cover species:

%cover _____

Average depth of leaf litter _____ (cm) % leaf _____ % Twig
(<10cm diam) _____

% Moss cover _____ % Rock cover _____ % CWD (> 10 cm diam) _____

% Bark cover _____ % Ground cover _____ %
 Other.....

Picture Taken: Y / N Picture Name: _____

Species	Present?	Comments (keep a tally of alive 'A' and dead 'D' animals)
Keeled snail	Y / N	
	Y / N / NA	
	Y / N / NA	
Other comments:		

Appendix 4 Photo of keeled snail with eggs



Live adult keeled snail apparently incubating eggs inside rotten log at site 101. Some eggs to right of shell are broken and empty (hatched?)