A GROWTH STUDY OF THE ALPINE BUTTERCUP *RANUNCULUS GODLEYANUS*

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Arthur's Pass

INTRODUCTION

The Godley buttercup, *Ranunculus godleyanus*, is an endemic alpine buttercup confined to high altitude sites in the Central Southern Alps between Mt Sefton in the south and Mt Hunt in the north (Fisher, 1965). It is usually found growing on moraines saturated with meltwater from snow or glaciers, on damp talus slopes, or on wet shaded rock bluffs. The Godley buttercup was first collected from Whitcombe Pass, between the Rakaia and Whitcombe catchments, and has been recorded from only about 20 separate locations between Mount Cook National Park and Arthur's Pass National Park. The species is regarded as rare (Cameron *et al.*, 1995) and appears to be under threat from introduced grazing/browsing animals, especially chamois and thar, throughout its range (Wilson, 1976).

The Godley buttercup is a showy plant with striking yellow flowers and glossy dark-green leaves. Healthy plants comprise more than 100 leaves, often measuring over 12 cm long and 10 cm wide and arranged in a basal rosette, and many flower heads on stalks up to 60 cm-high. Plants seed prolifically and seedlings readily germinate in favourable substrates, such as open gravels.

This report presents an analysis of the results of measurements on two separate populations of *Ranunculus godleyanus* between 1994 and 1996, and a third population between 1992 and 1996. The study was funded by the Yates Green Earth Threatened Plants Sponsorship, administered by the Royal Forest & Bird Protection Society. The primary purposes of the project were to record changes in numbers of plants and leaf area of populations of the Godley buttercup throughout its natural range, and to record any loss of leaf area to browsing at these sites.

METHODOLOGY

Observations, Measurements

Monitoring of the Godley buttercup was undertaken at three sites:

- Hawdon Valley (Rugged Peak), Arthur's Pass National Park, (grid reference NZMS 260:K33, 078-128) - the northern-most known population;
- Louper Stream (near Whitcombe Pass), Rakaia Catchment (NZMS 260:J34, 453-727); and
- Eric Stream (near the Scabbard Glacier), Havelock Valley, Rangitata Catchment (NZMS 260:I35: 202-533).

An attempt was made to examine a fourth site, at the southern end of the species' range, but no accessible populations were found in Mt Cook National Park, and there was insufficient time to visit other areas, such as the Godley Valley.

Sites were visited between January and April as time, weather, and river conditions permitted. Permanent datum points were established at each site by securing a permalap marker to the bedrock or to a large boulder. All plants within a 20 metre radius of this datum point were measured during each site visit, and the following information was recorded for each plant:

- distance from the datum point;
- direction (compass bearing) from the datum point;
- number of leaves on the plant (including browsed leaves);
- size of the leaves, in six leaf-size classes;
- estimated percentage of the leaf surface area removed by animal browse (and the nature of the browse);
- number of flower/seed heads; and
- whether seedlings were present nearby.

At the Hawdon site, where there are relatively few plants, the width and length of each leaf was measured (rather than allocating leaves to size classes) and individual plants were numbered. Where present, droppings and hoofprints of mammals were noted for each site and searches were made for further populations of the Godley buttercup in the vicinity. Two "control" *Ranunculus godleyanus* plants growing in pots at Arthur's Pass Village were monitored fortnightly through the 1995/96 summer to determine leaf area changes during the growing season.

Data Analysis

Monitoring data were analysed by calculating total leaf surface area (LA) for each site as follows:

- The average width of leaves in each size class was calculated by analysing leaf width measurements recorded in the first year of monitoring, to provide an average leaf size for each size class as follows:

  * Class 1: length < 25 mm = 20 x 15 = 300 mm^2
  * Class 2: length 25 - 39 mm = 33 x 27 = 891 mm^2
  * Class 3: length 40 - 59 mm = 50 x 35 = 1750 mm^2
  * Class 4: length 60 - 79 mm = 70 x 47 = 3290 mm^2
  * Class 5: length 80 - 99 mm = 90 x 61 = 5490 mm^2
  * Class 6: length > 100 mm = 120 x 80 = 9600 mm^2

  (At the Hawdon site the actual leaf length and width measurements were used.)

- The estimated total LA before browsing was then calculated for each plant;
- These plant LA measurements were then combined to provide a total LA figure for the whole sample population at that site;
- The loss of plant material to browsing was then calculated from the recorded percentage browse figures for each plant and combined to provide a total for the population sample at each site.

Note that this total leaf surface area estimate (LA) figure represents the area of a rectangular leaf. A formula to convert this measurement into the actual leaf area has not yet been calculated. This LA value has been used in the interim because the objective of this monitoring exercise is to measure *relative changes* in leaf surface area at each site from year to year, rather than the *actual* leaf surface area. Eventually the values should be transformed into closer approximations to reality.

RESULTS

Hawdon Site

Data were collected from the Hawdon site for five consecutive summers, from 1992 to 1996. However, in 1995 the site was visited very early in the season (January) when part of the sample population was still snow-covered and the snow-free plants had probably not attained their maximum size. Despite this, the overall trend at the Hawdon site has been an increase of 91% in biomass (as determined by leaf surface area measurements) from 1992 to 1996 - an average annual increase of 25% - as shown in Table 1 (below). Biomass loss to browsing each year ranged from 2.8% in 1994 to 37.1% in 1992, with an average annual loss of 19%. The number of plants increased from 27 in 1992 to 32 in 1996.

Table 1 Results - Hawdon Site

Date of Measurement	Total LA (mm^2)	Percentage change in LA	LA loss to browse (mm^2)	Percentage LA loss	Number of plants
14 March 92	566 879	n/a	210 334	37.1	27
27 March 93	657 065	+ 15.9	129 637	19.7	28
03 March 94	1 043 671	+ 58.8	29 734	2.8	30
20 January 95	671 675*	- 35.6 *	23 196	3.4	18 *
18 April 96	1 084 759	+ 61.5 *	345 607	31.9	32

* results affected by early (January) measurement in 1995; some plants still snow-covered.

Louper Stream Site

Data were collected from the Louper Stream site for three consecutive summers, from 1994 to 1996. Biomass increased by 14% from 1994 to 1996, with an average annual increase of 6.7%, illustrated in Table 2 (below). Biomass loss to browsing in 1994 was limited to very minor insect damage to some leaf margins and was not measured. Biomass loss to browsing in 1995 and 1996 was also confined to insect browse and was measured at less than 1% each year (average 0.43%).

Table 2 Results - Louper Stream Site

Date of Measurement	Total LA (mm^2)	Percentage change in LA	LA loss to browse (mm^2)	Percentage LA loss
28 March 94	7 454 775	n/a	0	not measured
23 April 95	7 949 432	+ 6.6	11 251	0.14
24 February 96	8 492 638	+ 6.8	61 232	0.72

Eric Stream Site

Data were collected from the Eric Stream site in 1994 and 1996. Flooded rivers prevented access to the site during the monitoring trip in March 1995. Biomass increased by 48% from 1994 to 1996, as illustrated below in Table 3. Biomass loss to browsing also increased from 5.4% in 1994 to 29% in 1996. Extensive

FIGURE 1 Hawdon Valley (Arthur's Pass NP) site

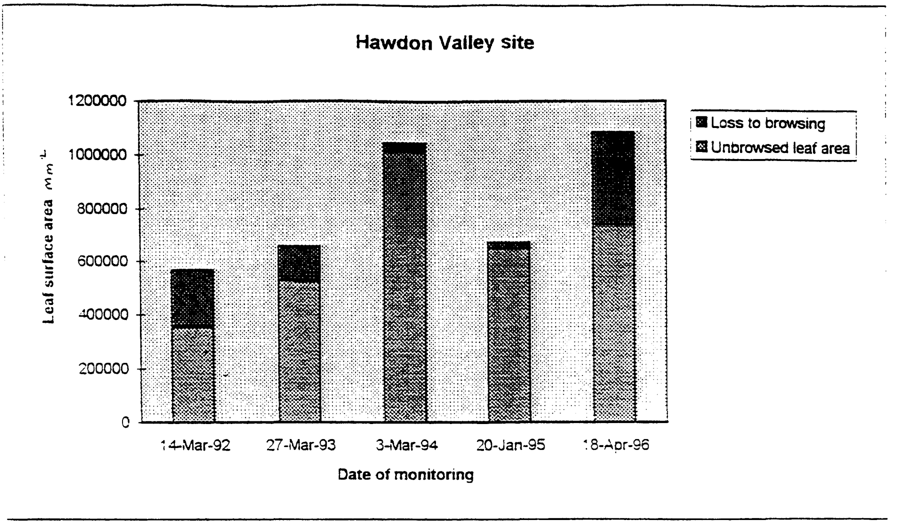
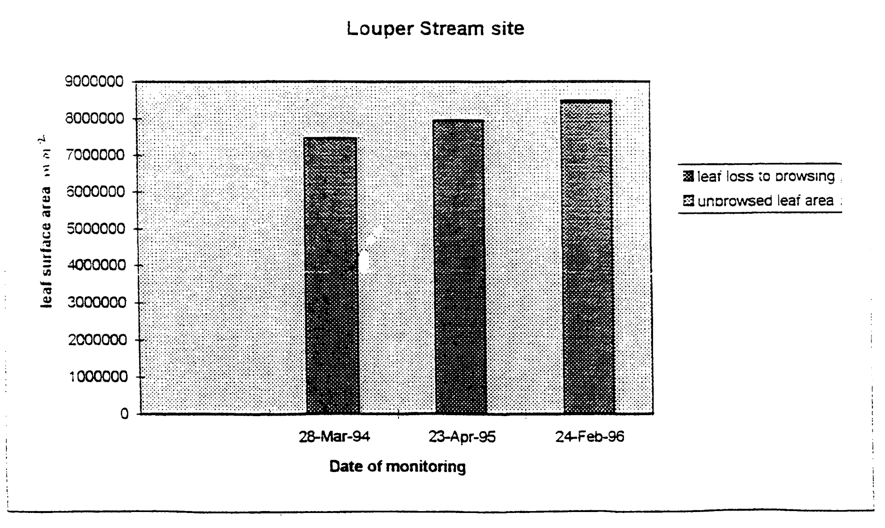


FIGURE 2 Louper Stream (Rakaia) site



browse by large mammals was very evident at the site in 1996 with many large plants, and most seedheads, almost completely removed by browsing. Also, in 1996 kea were observed removing leaves from *Ranunculus godleyanus* plants, and eating the fleshy petioles.

Table 3 Results - Eric Stream Site

Date of Measurement	Total LA (mm^2)	Percentage change in LA	LA loss to browse (mm^2)	Percentage LA loss
17 April 94	10 318 323	n/a	560 757	5.4
27 March 96	15 332 055	+ 48.6	4 444 381	29.0

"Control" Plants

Data were collected from the "control" plants at Arthur's Pass at about two week intervals from 19 November 1995 to 16 April 1996. Both plants attained maximum biomass (LA) during late December and early January as illustrated in Table 4 (below).

FIGURE 3 Eric Stream (Rangitata) site

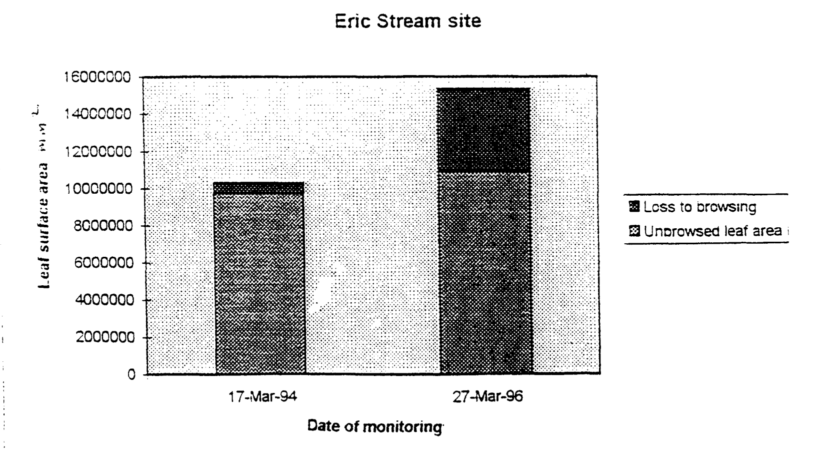


FIGURE 4 Control Plant 1 (Arthur's Pass village)

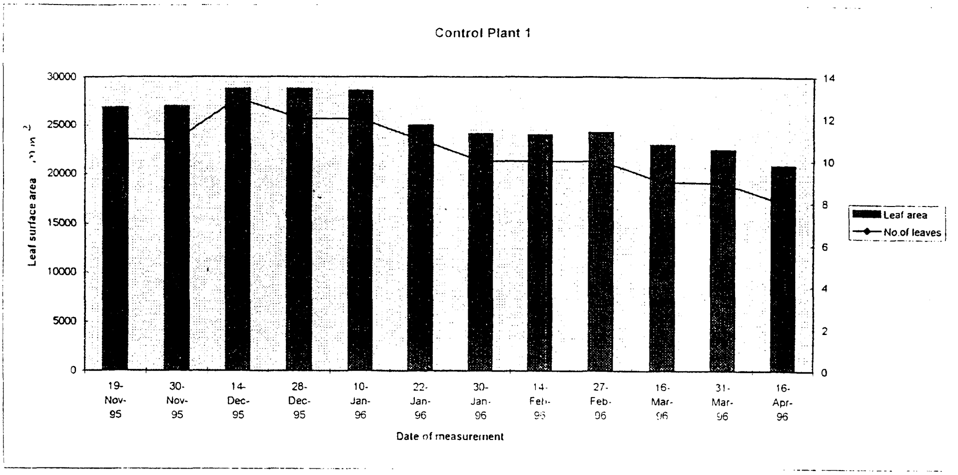


FIGURE 5 Control Plant 2 (Arthur's Pass village)

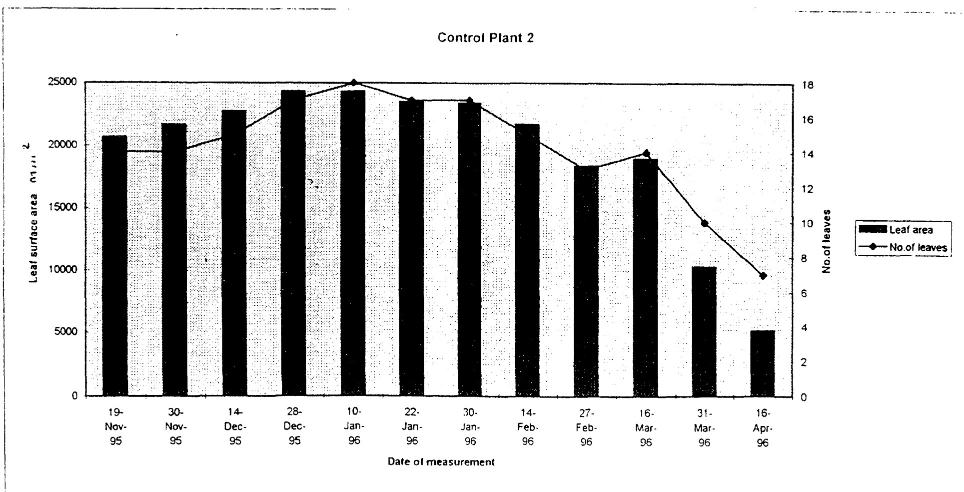


Table 4 Results - "Control" Plants, Arthur's Pass

Date of Measurement	Total LA (mm^2) Plant One	Percentage change in LA Plant One	Total LA (mm2) Plant Two	Percentage change in LA Plant Two
19 Nov 95	26 825	n/a	20 669	n/a
30 Nov 95	26 991	+ 0.6	21 647	+ 4.7
14 Dec 95	28 743	+ 6.5	22 730	+ 5.0
28 Dec 95	28 739	0.0	24 338	+ 7.1
10 Jan 96	28 593	- 0.5	24 319	- 0.0
22 Jan 96	25 087	-12.3	23 499	- 3.4
30 Jan 96	24 231	- 3.4	23 382	- 0.5
14 Feb 96	24 116	- 0.5	21 705	- 7.2
27 Feb 96	24 371	+ 1.0	18 351	-15.5
16 Mar 96	23 118	- 5.1	18 937	+ 3.2
31 Mar 96	22 658	- 2.0	10 369	-45.2
16 Apr 96	20 983	- 7.4	5 256	-49.3

Other Godley buttercup populations

Several other populations of *Ranunculus godleyanus* were noted during monitoring expeditions (Table 5). Some of these populations have been recorded previously.

Table 5. Other Populations of *R. godleyanus* Observed During the Study

Location	Map NZMS 260	Grid ref.	Elevation (metres)	No of adult plants	Reference
Rugged Peak, APNP	K33	080-129	1420	c. 230	(Fisher 1965)?
Rugged Peak, APNP	K33	078-128	1300	32	Hawdon site
Walker Pass, APNP	K33	057-119	1460	c. 120	
Park Glacier, WP*	J34	446-755	1300	12	
Park Glacier, WP	J34	444-755	1370	c. 30	
Park Glacier, WP	J34	444-754	1400	c. 30	
northeast of WP	J34	457-751	1380	12	
north of WP	J34	453-752	1170	1	
just north of WP	J34	453-746	1210	c. 165	
Whitcombe Pass	J34	454-738	1250	c. 100	
just south of WP	J34	453-735	1220	10	type locality?
Louper Stream, WP	J34	453-733	1200	1	
Louper Stream	J34	453-727	1140	c. 250	Louper Stream site
Eric Stream, HR*	I35	202-533	1260	c. 250	Eric Stream site
Eric Stream, HR	I35	193-529	1260	c. 125	

*WP = Whitcombe Pass; HR = Havelock River

DISCUSSION

Monitoring Technique

The monitoring of the three sample populations of *Ranunculus godleyanus* has been largely successful. On only two occasions was the visit ineffective: the January 1995 survey of the Hawdon site, which was too early in the growing season; and the failed attempt to reach the Eric Stream site in March 1995. Otherwise, all populations were snow-free and healthy at the time of survey.

The monitoring of "control" plants at Arthur's Pass shows that plants, grown at 750 m a.s.l., have achieved their full growth potential for the season by December or January. However, it is clear from observations of natural populations over several years, that the full growth potential of plants growing within their normal altitude range (i.e. 1140 to 1460 metres) is achieved later in the season, probably during February or March, depending on the site. Certainly plants at most locations flower during February.

Plants appear to die away reasonably quickly once temperatures fall in the autumn months. Of the "control" plants at Arthur's Pass, Plant Two, which is growing in a shaded south-facing situation, died away in late March, whereas Plant One, growing in a sunnier north-facing situation, died away in early May. Again, the plants growing at higher altitudes in the wild respond differently, presumably dying away after experiencing either severe frosts or snowfalls. However, it is very apparent when a plant dies down, as the leaves progressively turn brown and then fall to the ground beside the plant. They frequently persist, as dead leaves, on the ground for some time.

Ideally sample populations should be measured at exactly the same time each year. However, foot access to all three monitoring sites is through difficult mountain terrain and subject to weather and river conditions. Both the Rakaia and Rangitata Rivers - the main access to the Louper Stream and Eric Stream sites respectively - are very difficult to cross during spring snow-melt or after heavy rain.

Also, it would be ideal if all leaves on all plants within the sample population could be measured, as was done at the Hawdon site. However, the population samples at each of the Louper Stream and Eric Stream sites include over 150 plants, some with more than 100 leaves, so it would be very time-consuming to measure each leaf. Estimating biomass by placing leaves in size classes should be sufficient to determine relative changes in biomass from year to year, particularly when site measurements are undertaken, or supervised, by the same person each year.

Furthermore, the use of a leaf surface area estimate (LA) should not significantly affect the results, as the purpose of the study is to measure relative changes in plant biomass from year to year, rather than the actual biomass at one time. Detailed investigation of plant biomass would require the development of a formula to calculate the actual leaf surface area from the leaf length-times-width measurement.

Changes in Total Biomass

The biomass of all sample populations measured as the original (before browsing) leaf surface area estimate (LA) increased over the monitoring period. For the 1994 to 1996 period, biomass increased gradually at the Hawdon and Louper Stream sites (4% and 14% respectively), and dramatically at the Eric Stream site (48%). It appears that, within each sampled population, individual plants are increasing in size or vigour, and more plants are becoming established. These changes are most apparent at the Hawdon site, where the sample population has been studied in more detail and for a longer period (five years). Here, plant numbers increased from 27 in 1992 to 32 in 1996, and leaf area increased (over the five years) by 91%. Good seedling recruitment was evident at all three sites, though the monitoring of individual seedlings at the Hawdon site showed that many seedlings do not survive their first winter.

It is difficult, from the results of this study, to determine why biomass is increasing at each sampled site. One possible explanation is that sampled populations are still re-establishing after former depletion. Evidence in support of this includes the fact that introduced animal populations in the central Southern Alps have formerly been much higher, that most *Ranunculus godleyanus* populations are close to (and partly located on) inaccessible bluffs which may have provided refugia for plants during times of high browsing pressure; and, that the most dramatic increase in biomass (and biomass loss) has occurred at the Eric Stream site, where thar numbers were formerly very high. Another possible explanation is that short (or long) term climate change may be creating more favourable conditions for plant growth.

Loss of Biomass to Browsing

The loss of plant biomass to browsing varied considerably between sites. At the Hawdon site, biomass loss was high (37%) in 1992; moderate (20%) in 1993; low (c. 3%) in 1994 and 1995; and high (32%) in 1996. At the Louper Stream site, biomass loss was consistently low (less than 1%). And, at the Eric Stream site, biomass loss was low (5%) in 1994, but high (29%) in 1996. There is no consistent trend across all sample populations and, in any case, more than three years' monitoring would probably be required to confirm any trend.

A possible explanation for the variation in biomass loss for each sample population is its location. The Hawdon site is located mostly on a talus slope which provides good access (for grazing mammals and people) to Trudge Col from the Hawdon Valley. The plants, especially the larger ones, stand out on the talus slope and would be very obvious to passing animals. The Louper Stream site is on gentler slopes, away from the main riverbed access up the valley, and largely surrounded by dense tussock grassland. The Eric Stream site is on relatively stable lateral moraine, surrounded by scattered herbfield or open talus. Plants at this site, as at the Hawdon site, are obvious to passing animals.

Biomass loss to browsing appears likely to be caused by one of three agents: insects; birds (kea); and large mammals (chamois or thar). Biomass loss to hares was not observed at any of the monitoring sites.

Plants in all sample populations, and the "control" plants at Arthur's Pass, were affected by insect browse. This browse was always observed as relatively minor (usually less than 1%) loss of leaf lamina, usually at the margin. Plants grown at Arthur's Pass were also affected by a sap-sucking insect.

Kea were observed eating the fleshy petioles of *Ranunculus godleyanus* leaves at the Eric Stream site in 1996. The birds clipped the leaves off cleanly at the base of the lamina and then ate the fleshy portion of the leaf petiole. The leaf lamina was typically left on the ground beside the plant, and the petiole left stripped and ragged but still attached to the plant. Birds concentrated on individual plants, leaving some almost entirely defoliated. Evidence of kea browse is distinctive, and this was the only occasion that it was observed during the three-year monitoring period.

Chamois were observed browsing *Ranunculus godleyanus* plants at the Hawdon site in 1996, and chamois sign (other than browse) was observed at this site on most monitoring visits. No large animal sign of any type was observed at the Louper Stream site. No large animal sign (apart from browse) was observed at the Eric Stream site. Biomass loss at the Hawdon and Eric Stream sites was almost entirely due to large mammals. Chamois appear to be responsible for the biomass loss at the Hawdon site, as thar are not present in that area, but it was not possible to ascertain whether chamois or thar were responsible for the biomass loss at the Eric Stream site.

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