THE COCKAYNE PLOTS OF CENTRAL OTAGO

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SUMMARY: The Cockayne plots were sown in 1920 near Cromwell, Central Otago, on depleted country in a 15-inch rainfall zone. The initial growth of the sown species in the 13 enclosures showed that productive herbage species could be established, if not grazed. Pine and eucalypt species were also successfully grown.

The plots were opened to grazing in the 1930s, following which there was a change in plant composition from palatable to unpalatable species.

Since the control of the rabbit in the early 1950s and the closing of the plots to grazing there has been a marked regeneration from the original trees.

These changes are discussed in relation to the agricultural development of the region and the Central Otago landscape.

INTRODUCTION

One of the characteristics of Central Otago is the desert-like appearance of the "dry core" centred on Alexandra and Cromwell, where much of the landscape is still dominated by scabweed (*Raoulia* spp.) (Lister 1965). This particular vegetation developed after long and continued abuse of the original grassland formation, mainly through the combined effects of burning and grazing compounded by low rainfall (Mark 1965).

The story of these tussock grasslands and the investigations of Dr. Leonard Cockayne which led to a series of regrassing experiments have already been fully described (Cockayne 1919–1922). Macpherson (1913) had shown, in earlier experiments at Earnscleugh, that pasture plants could be established on dry depleted sites, provided they were sown into well-prepared seed beds and kept ungrazed. Initially, his surface-sowing treatments were considered inferior by comparison with his drilled plots, but by 1920 all plots were well covered and formed the basis of Cockayne's palatability experiments (Cockayne 1920 a and b).

Further afield, Cockayne (1920) observed regeneration of grassland in areas protected from domestic stock and rabbits. However, at that time he was not sure whether regeneration arose largely from seed or from existing plants. Even where natural regeneration was possible, Cockayne felt it was desirable to establish a higher proportion of palatable introduced species in the sward.

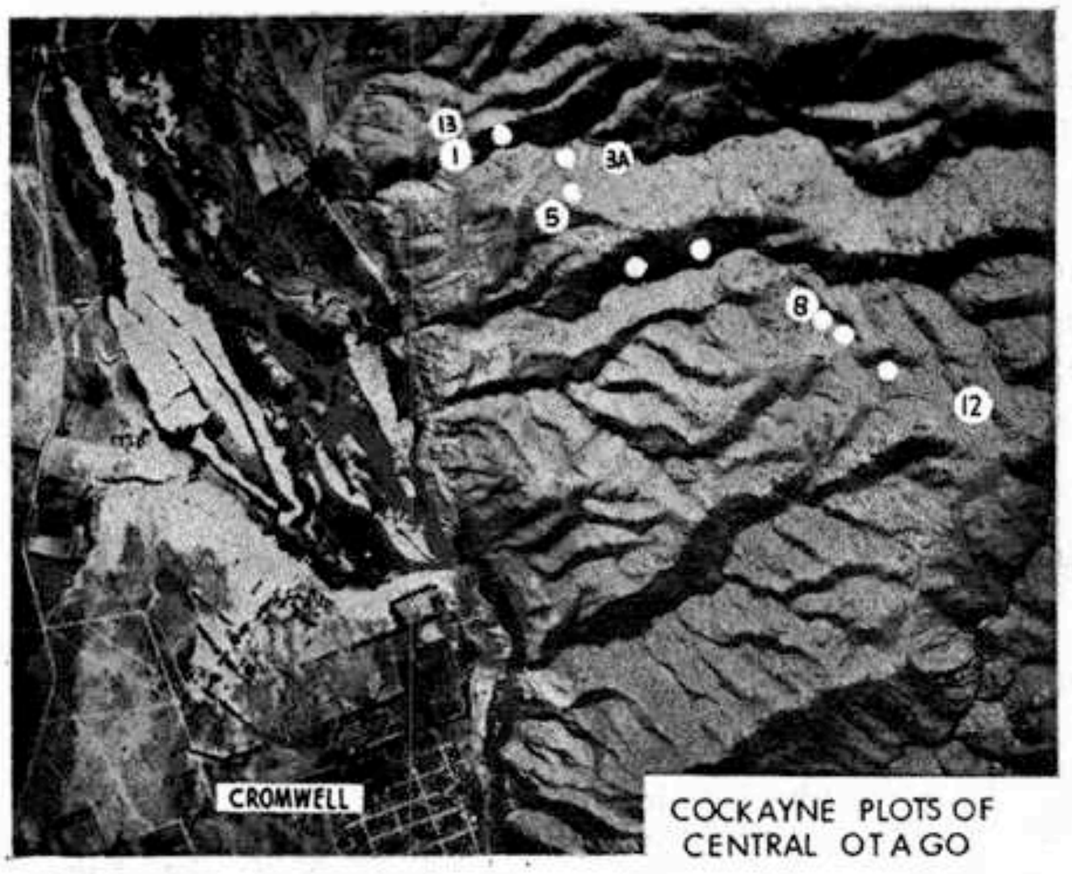

FIGURE 1. *Cockayne plots to the east of the Clutha River between Cromwell and Lowburn. Un-numbered plots number from left to right. Plot 1, altitude 1,100 ft.; Plot 5, 1,500 ft.; Plot 8, 2,000 ft.; Plot 12, 2,600 ft.*

[*Photo — Dept of Lands and Survey*]

THE EXPERIMENT

Cockayne sowed his plots on Northburn Station on the western side of the Dunstan Range near Cromwell, in a rainfall zone of about 15 inches a year (Fig. 1).

Twelve quarter-acre rabbit-proof plots were fenced throughout the depleted country which ranged from 1,000 feet to 3,000 feet, the lowermost limit of existing tussock. The object was to determine whether the land could be regrassed at reasonable cost if the causes of depletion were removed (Cockayne 1922a).

Seed of various species (see Appendix) was sown, either by broadcasting or broadcasting and

raking (simulated harrowing), both inside and outside the enclosures, in May and September 1920 and in March 1921. At each plot one section was devoted to planting pasture species and trees, raised in nurseries, to determine whether they could survive. A special plot (No. 13) was laid down next to plot 1 to gauge the effect of sheep trampling and harrowing on plant establishment.

Another plot (3A) was established in 1948 when the fences of plots 1 and 3 were removed. This plot was then oversown (see Appendix for seed mixture), some of the seed also being sown on part of plot 4. At the same time zig-zag clover (*Trifolium medium*) was transplanted throughout plot 5 from a nucleus patch and plots 6, 7, 8 and 11 were oversown with 4 lb. per acre of lucerne (*Medicago sativa*) and crested wheat grass (*Agropyron cristatum*). This sowing largely failed.

The plots were ungrazed during the first 10 years but were opened to grazing during 1930–1956, after which they were closed again to stock. However, deterioration in the fencing has since allowed some grazing by rabbits and goats.

No fertiliser has ever been applied to these plots.

FIGURE 2. *Part of Plot 4 in 1967. One mature eucalypt* (E. tasmanica) *with 39 seedlings. Vigorous sheep's burnet, with some cocksfoot and lucerne. Some* Pimelea aridula *bushes present.* [*Photo — J. A. Douglas*]

RESULTS

Initial responses: At higher altitudes where some tussocks were growing in 1920, though heavily grazed, spelling was followed by fairly rapid regeneration; but on the lower plots where no plants were present in 1920 it accomplished nothing (Cockayne 1922). By broadcasting seed inside these lower plots, good pasture establishment was obtained within 15–18 months, both on sunny and dark slopes. The best results were achieved on the deeper soils of dark and semi-dark faces (Cockayne 1922b, Gibbs *et al.* 1945). Early spring sowing gave better results on shaded slopes, whereas late autumn sowings proved better on sunny slopes. On plot 13 broadcasting followed by sheep trampling gave satisfactory establishment (Cockayne 1922b).

The most successful of the sown species were lucerne, cocksfoot (*Dactylis glomerata*), tall fescue (*Festuca arundinacea*), Chewing's fescue (*Festuca rubra* subsp. *commutata*), yarrow (*Achillea millefolium*) and chicory (*Cichorium intybus*) (Cockayne 1922b, Tennent 1935). A feature of the plots in 1930 was the vigorous and seeding lucerne (Tennent 1935).

The effects of grazing: The experiments were officially completed in 1930 and the plots were then handed over to the runholder who used them to study the effects of grazing. The plots were grazed by sheep and rabbits almost continuously for the next five years. After two and a half years Tennent considered that with more judicious grazing it would be quite practical to retain the palatable species as pasture. Nevertheless, by 1935 the majority of the plots were dominated by tall oat grass (*Arrhenatherum elatius*), *Poa pratensis*, Chewing's fescue, yarrow and some zig zag clover.

Prolonged and severe grazing resulted in an abrupt change from the upright palatable species to the unpalatable, rhizomatous, and stoloniferous species. Tall oat grass in particular became dominant on most plots, a species which the late Dr. H. H. Allen described as unpalatable, even to rabbits (Allen, unpubl. report 1936).

In 1936 the plots were again sealed against rabbits and grazing was limited to winter, the extent of grazing depending on the vigour of the plots. Even with this treatment plots continued to be overgrazed because of their attraction.

THE PRESENT STATE OF THE PLOTS

The pasture species: It seems that the palatable species never recovered from the severe treatment of the 1930s and the recurring rabbit and sheep

FIGURE 3. *Plot 5 in 1949. Five eucalyptus* (E. coccifera) *and three pines* (Pinus nigra, P. ponderosa). *The plot shows little improvement from outside. Compare with Figure 4.*

[*Photo — Dept. of Agriculture*]

FIGURE 4. *Plot 5 in 1967. Two eucalypt and 21 pine seedlings have established. Sheep's burnet,* Poa pratensis, *lucerne, zigzag clover and some native tussocks are present.*

[*Photo — J. A. Douglas*]

grazing during the 1940s. Since the rabbit has been controlled and the plots enclosed again there has been an increase of such palatable species as lucerne, cocksfoot, and sheep's burnet (*Poterium polygamum*), mainly by reseeding. However, overall, tall oat grass, Chewing's fescue, *Poa pratensis* and yarrow remain dominant.

Most species within the plots seed freely, but dispersal outside is hampered by grazing. Tall oat grass has spread at least a quarter of a mile from some plots but it remains largely ungrazed. Other species such as sheep's burnet and cocksfoot may be found short distances outside the fence line but they tend to be severely overgrazed. In some of the wetter gullies tall fescue occurs and sweet clover (*Melilotus* spp.) has spread outside plot 3A.

The two plots, 1 and 3, which had their fences removed in 1948 have returned to the scabweed association.

FIGURE 5. *Plot 10 taken in 1920, reproduced from the N.Z.J. Agric. 25, page 9. Compare with Figure 6.*

[*Photo — W. D. Reid*]

FIGURE 6. *Plot 10 in 1967. One eucalypt and four mature pine trees* (Pinus ponderosa) *with 165 seedling pines. Chewing's fescue, tall oat grass,* Poa pratensis, *blue tussock, yarrow, cocksfoot and lucerne are present.*

[*Photo — J. A. Douglas*]

The tree species: Cockayne established both pine and eucalyptus species on most plots by transplanting seedlings raised in nurseries. He also obtained successful seedling establishment from *Pinus radiata* seed dibbled into plot 1 (Cockayne 1922).

Since the control of rabbits and the closing of the plots to grazing there has been a marked regeneration from the original trees (Table 1). The number of seedlings varies from plot to plot, those with more open swards tend to have more. This is in agreement with Benecke's work with *Pinus contorta* (Benecke 1967).

TABLE 1. *Pine and eucalypt seedlings at four sampling dates on the Cockayne plots.*

PLOT	NUMBER	SPECIES, MATURE TREES	SEEDLINGS 1954	1956	1963	1967
Eucalypts:						
3	2	*E. gunnii*	—	—	—	1
4	1	*E. tasmanica* (or *E. coccifera*)	2	7	30	39
5	5	*E. coccifera*	2	—	5	2
6	2	*E. gunnii* + *E. coccifera*	—	—	9	2
8	1	*E. gunnii*	—	—	6	4
Pines:						
5	3	*P. ponderosa, P. nigra*	2	4	20	21
6	2	*P. radiata, P. nigra*	—	—	1	2
8	2	*P. radiata, P. nigra*	—	—	19	26
9	6	*P. ponderosa, P. nigra*	1	—	6	12
10	4	*P. ponderosa*	9	25	80	165
11	2	*P. nigra*	—	1	17	25

All three pine species have reseeded. On plot 10, one of the largest *Pinus ponderosa* seedlings was 15 years old in 1967. Seedlings four years old were bearing cones.

The largest eucalypt seedling on plot 4 was about 15 years old in 1967 and 15 feet high. The decline in numbers of eucalypt seedlings on some plots (Table 1) appears to be related to severe browsing by goats.

The regeneration of these trees suggests that these dry regions could support forest of one sort or another. Failure to do so is governed by severe grazing and the lack of a seed source of adaptable species. The only seedlings growing outside the plots have established in rock crevices out of reach of browsing animals.

THE AGRICULTURAL SIGNIFICANCE OF THE PLOTS

These plots were sown and managed without the use of fertiliser, and today the results may appear artificial in the knowledge that plant growth, particularly that of legumes, was limited on Central Otago soils by an acute deficiency of sulphur. However, some of the brown-grey earth soils of the region have subsoil accumulations of sulphur which are available to deep-rooted plants (Blakemore *et al* 1969). Lucerne was obviously able to reach such a supply at the Cockayne plot sites but it is probable the more shallow-rooted

FIGURE 7. *Plot 11 in 1949. The sward is dominated by tall oat grass, Chewings fescue, yarrow and* Poa pratensis. *Two pine trees* (P. nigra) *are present. Compare with Figure 8.*
[*Photo — Dept. of Agriculture*]

FIGURE 8. *Part of Plot 11 in 1967. The sward has similar species as in 1949 (Fig. 7) but with 25 seedling pines.*
[*Photo — J. A. Douglas*]

red and white clovers were at a disadvantage. Today, an application of superphosphate can correct the deficiency; but even so, lucerne still remains the most productive legume (Ludecke 1962). A discussion of the significance of the results from the Cockayne plot sowings is therefore justifiable.

These plots have not conveyed a true picture of their potential agricultural value since they were overgrazed in the early 1930s. Zotov (1938) argued that to successfully re-clothe scabweed country the tussocks first had to be re-introduced, even if this meant re-sowing them on sites where a seed source was lacking. Once this was accomplished, the second stage of introducing palatable species would be comparatively simple. He stressed the importance of maintaining an unpalatable tussock to form a micro-climate. Calder (1938) suggested this could be done by using tall oat grass instead of the indigenous tussock species.

However, it is from the vigorous lucerne and cocksfoot association of the first decade that we must draw our conclusions. The subsequent degradation and change in dominance can be taken as an effect of mismanagement of a once productive association. In more recent times, lucerne and cocksfoot have become the recommended pasture species for dry areas of Central Otago (Ludecke 1962. Douglas 1966). If these two species were established on these hills it is debatable whether the native tussocks would be a help or a hindrance to their production.

Cocksfoot establishes well on scabweed after oversowing provided grazing pressure is removed (Douglas 1966); but little work has been done on lucerne oversowing since Cockayne's early experiments. Trials in progress in the Upper Waitaki basin indicate that lucerne oversowing could become a practical venture (Douglas unpubl.).

Results from these establishment studies tend to support the arguments of Cockayne (1922). It should be easier to establish desirable species on bare ground than in other vegetative associations. Thus, the natural improvement of the country since the rabbit has been controlled may, in fact, be curtailing the ultimate use of the most productive species by creating a difficult, if not insurmountable, barrier to their establishment. This natural improvement may, however, give a more favourable environment for the establishment of red and white clovers rather than for lucerne.

Once established, the life of associations such as lucerne and cocksfoot are dependent on the husbandry they receive. Only by a careful policy of stock management on a rotational or semi-rotational basis will such palatable legume-grass associations be maintained. The grazing of the Cockayne plots showed very quickly how intolerant these species were of inflexible management.

Plant breeders today have bred species, such as creeping rooted lucerne, which should be capable of withstanding more grazing pressure than the upright hay types. While this may mean greater survival, productivity may be negligible if it is not properly exploited. Production of a sward is dependent on the species in it and the management to which they are subjected. If production is the keynote of these grasslands, then the management must be such as to suit the growth patterns of the most desirable species.

After the decline of the Cockayne plots a new philosophy arose whereby it was apparent that pasture species had to fit the *status quo* to be suitable for introduction on this country. They had to be capable of enduring overgrazing of sheep and rabbits. This point of view developed through the interest in conservation at a time when the control of the rabbit appeared unlikely. Consequently, mat-forming species were suggested (Gibbs, *et al.* 1945) and trials were made under severe grazing to find grasses which would survive such conditions. (Calder 1944, Lunn 1951, Soil

Conservation and Rivers Control Council Reports 1956 and 1957). It is no wonder that the recommended grasses were the unpalatable and rhizomatous ones. In the absence of suitable legumes resistant to hard grazing, Zotov (1938) suggested that *Carmichaelia* species should be sown to maintain soil fertility. Later observations of the Cockayne plots showed zig zag clover had some merit (Lunn 1951).

Such species were recommended to suit a situation which has now changed with the control of the rabbit and the widespread use of fertiliser. Work on rehabilitation should again be focussed on palatable and productive species.

CONCLUSION

Human intervention, and the combined effects of fire, overgrazing and heavy infestations of rabbits, brought about the deterioration of tussock grasslands in dry regions to a scabweed formation. So, too, it is human intervention in the form of the imposed management which controls its revegetation. An example of this is the Cockayne plots where three eras can be named, each associated with a change in management:

1. 1920–1930 Ungrazed plots dominated by palatable species.
2. 1930–1956 Grazed plots dominated by unpalatable and rhizomatous species.
3. 1956 to present day. Ungrazed plots with significant establishment of forest species.

Cockayne showed that this country could support a more palatable association than the native grasslands if seed of suitable species were oversown and the country spelled during the establishment period. The conclusions of the local committee for the Cockayne plots, which consisted of two runholders and a Department of Agriculture representative, published in 1923 (Middleton *et al.* 1923), still hold true today. They were:

"1. No improvement is possible without subdivision, exclusion of rabbits, and a regular system of spelling the country.
2. Immense improvement can be effected in a comparatively short time by surface sowing, if rabbits and sheep are excluded and the country spelled systematically.
3. By spelling without surface sowing great improvement will take place, but progress will be slower."

Failure to appreciate the significance of the correct grazing needed has largely nullified application of this work.

The three eras of the Cockayne plots indicate that the whole character of the Central Otago landscape could change. With the rabbit and the use of fire controlled, the ultimate vegetation will depend upon what species are present or introduced and the subsequent management they receive.

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APPENDIX

Species sown and planted on the Cockayne plots (Cockayne 1922b).

(a) SPECIES SOWN

Grasses
- Chewings fescue (*Festuca rubra* L. spp. *commutata* Gaud.)
- Cocksfoot (*Dactylis glomerata* L.)
- Crested dogstail (*Cynosurus cristatus* L.)
- Danthonia (*Notodanthonia* sp.)
- *Poa pratensis* L.
- Tall fescue (*Festuca arundinacea* Schreb.)
- Tall oatgrass (*Arrhenatherum elatius* (L.) Beauv.)
- Perennial ryegrass (*Lolium perenne* L.)
- Yorkshire fog (*Holcus lanatus* L.)
- Creeping bent (*Agrostis stolonifera* L.)
- Browntop (*Agrostis tenuis* Sibth.)

Legumes
- Lucerne (*Medicago sativa* L.)
- *Lotus angustissimus* L.

Herbs
- Chicory (*Cichorium intybus* L.)
- Yarrow (*Achillea millefolium* L.)
- Catsear (*Hypochaeris radicata* L.)
- Narrow leaved plantain (*Plantago lanceolata* L.)
- Sheep's burnet (*Poterium polyganum* Waldst. Kit.)

(b) SPECIES PLANTED

Grasses
- *Poa laxa*
- Sweet vernal (*Anthoxanthum adoratum* L.)
- Blue tussock (*Poa colensoi* Hook f.)
- Couch (*Agropyron repens* (L.) Beauv.)
- Blue wheatgrass (*Agropyron scabrum* Beaux.)

Legumes
- Red clover (*Trifolium pratense* L.)
- White clover (*Trifolium repens* L.)
- Subterranean clover (*Trifolium subterraneum* L.)

Herbs
- Perennial sow thistle (*Sonchus arvensis* L.)

Note

Zig zag clover (*Trifolium medium* L.) is not mentioned in the early lists but was apparently established from these sowings.

Species sown onto plot 3A and part of plot 4 in 1948

Grasses
- Chewings fescue (*Festuca rubra* L. spp. *commutata* Gaud.)
- Cocksfoot (*Dactylis glomerata* L.)
- Tall oat grass (*Arrhenatherum elatius* (L.) Beauv.)
- Crested wheat grass (*Agropyron cristatum* (L.) Gaertn.)
- *Agropyron elongatum*
- *A. spicatum*
- Blue grama (*Bouteloua gracilis*)
- Smooth Brome (*Bromus inermis*)

Legumes
- Lucerne (*Medicago sativa* L.)
- Subterranean clover (*Trifolium subterranean* L.)
- Sweet clover (*Melilotus alba* Med.)

Herbs
- Yarrow (*Achillea millefolium* L.)