A REVIEW OF THE GRASS SPECIES INTRODUCTIONS INTO THE TUSsock GRASSLANDS OF THE SOUTH ISLAND, NEW ZEALAND

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INTRODUCTION

THE EARLY SETTLERS and their stock moved into the inland South Island tussock grasslands in the 1850s. It was an area of rich Pasture and the official estimate of the time (1857) was that the superior grasses could carry one sheep to two acres, good grasses one sheep to three acres, and inferior one sheep to four to five acres (Beattie, 1947) .

One of the techniques used by the early runholders to provide fresh feed for stock was to burn the native grasses as soon as they were rank and dry enough to take fire. The folly of this was seen by Garvie (in Beattie, 1947) as early as 1858 and later Buchanan (1869) noted that "much of the grassland of Otago has been 'thus deteriorated since its occupation, by fire; and it is no wonder that many of the runs require eight acres to feed one sheep according to an official estimate". This statement was later disputed by Petrie (1912) who stated that in the mid-seventies the majority of the sheepruns in Central Otago carried "one sheep to three acres or somewhat less".

At the stage in the mid-seventies when the depletion from burning was threatening the runholders seriously, the country was overrun by rabbits (Beattie, 1947). This brought about a critical situation in which the sheep carrying capacity was seriously diminished without stocking rates being adequately reduced (Petrie, 1912). However it is important to note, as stated by Zotov (1938) , "that the rabbit is not in itself a major agent of depletion, and that at least without the aid of sheep and especially fire it would not have exerted any significant influence on the vegetation". Nevertheless, the result of this added impetus to depletion was that some runholders abandoned their land in the 1880s and others, such as Galloway Station near Alexandra (which in 1879 carried 75 000 sheep on 129 000 acres and in 1904 21 000) were forced to reduce stock numbers (Petrie,

1912). In wetter regions such as the Waimakariri Basin where rabbits were not a problem, there was no appreciable change in carrying capacity over the same period (Cockayne, 1916).

With the spread of the settlers came the spread of the exotic flora both as intentional and unintentional introductions. As Thomson (1874) points out, the English seedsman was in the habit of reselling seed purchased from foreign importers as well as that harvested in Britain itself. Consequently seed imported from Britain to New Zealand was commonly a diverse mixture of good and bad from many countries and one recorded instance in Southland in 1869 was of a pasture mixture comprising 21 species together with 37 weed species (Thomson, 1874). The first attempt to sow "English" grasses in the Mackenzie Country was in 1859 (Burnett, 1927).

The early natural spread of the imported grasses was recorded by Armstrong (1871) in Canterbury and by Thomson (1874) and Kirk (1877) in Otago. Some grasses such as Yorkshire fog colonized the tussock grasslands very quickly (Burnett, 1927). This superior colonizing ability of many of the imported grasses led to a replacement of many indigenous species and a gradual natural improvement of much of the tussock grasslands. *Danthonia pilosa* and *Danthonia semi-annularis* colonized much of the North Canterbury and Marlborough hill country and elsewhere these and the adventives, browntop, Yorkshire fog, sweet vernal and *Poa pratensis* dominated the former native grasslands, particularly in the more humid areas (Sadd, 1920; Hilgendorf, 1935; Allan, 1936).

The purpose of this review has been to bring together the results and recommendations of grass introduction work in the tussock grasslands. It relates to published evidence and unpublished Ministry of Agriculture and Fisheries files but does not report unpublished research of the other agencies such as DSIR divisions, the universities or catchment boards. Grass' species names are largely presented as listed by the authors in the original publication. Today some names have changed and others are synonymous with grasses listed as different species but the lack of detail in the initial descriptions has made it impossible to determine the modern nomenclature with certainty. Standard common names are used in the text where appropriate (N.Z. Weed and Pest Control Society, 1969). A list of the grass species introduced by the various research workers is given in the appendix, and the location of the major plant introduction sites in Fig. 1.

FIG. 1: The location of the major plant introduction sites in the South Island tussock grasslands.

(1) Molesworth. (2) Waimakariri Basin (Broken River). (3) Mackenzie Country. (4) Tara Hills High Country Research Station. (5) Pisa Flat (Cockayne Plots nearby). (6) Alexandra (Earnsclough and Ophir areas).

GRASS INTRODUCTIONS

State action towards the rehabilitation of the tussock grasslands began in 1910 when trial areas were fenced and a total of 408 plot sowings made in the Mackenzie Country at Sawdon, Haldon and Simons Pass and in the Central Otago at Earnsclough near Alexandra (Anon., 1910; Macpherson, 1911, 1912a, b, 1913).

The grasses which showed the most promise in these trials were: tall oat grass, cocksfoot, prairie grass, *Agropyron repens*, *Bromus inermis*, *Phalaris commutata* and *Festuca dumeform* (Macpherson, 1913).

Ward (1923) extended the results of Macpherson's Haldon plots to include areas unprotected from stock and rabbits. He had encouraging results on the dark faces with Yorkshire fog, cocksfoot, and perennial ryegrass, with tall fescue noticeable in a protected area. Later observations of the Macpherson and Ward plots were made by McGillivray (1929) who found cocksfoot, *Poa pratensis* and some ryegrass plants still doing well in the latter's plots. At Haldon and Simons Pass, cocksfoot, tall oat grass, Chewings fescue, browntop, *Poa pratensis*, *Bromus inermis*, *Agrostis vulgaris* and *Festuca heterophylla* were still present.

In the same period *Agropyron pectinatum* and European *Festuca rubra* were thought to be useful as these were spreading in the semi-arid regions (Cockayne, 1911; Petrie, 1912; Taylor, 1914; Ward, 1923). In addition, Petrie (1912) suggested that stoloniferous grasses such as *Poa pratensis* and *Agropyron repens* and grasses from the arid areas of the United States and Australia such as *Buchloe dactyloides*, *Agropyron glaucum*, *Bouteloua oligostachya* and *Themeda australis* may be worth while. Further suggestions were put forward by the Royal Commission of 1920 on the southern pastoral lands who suggested the most suitable grasses for surface sowing were: cocksfoot, danthonia, Yorkshire fog, Chewings fescue, *Poa pratensis*, *Agrostis stolonifera*, *A. vulgaris* and *Agropyron scabrum* (Sadd, 1920).

Cockayne (1920a) also made use of Macpherson's plots when he conducted his palatability experiments at Earnscleugh. In reference to cocksfoot he concluded, "it now remains to discover the cheapest methods of establishing this splendid grass on the depleted hillsides". Cockayne (1922) considered that the objective of regrassing should be with species of high rather than low pasture value, a view also held by Zotov (1938). Cockayne established twelve plots on the depleted country near Cromwell in 1920 and 1921 (Cockayne, 1922). Cocksfoot, Chewings fescue, and tall fescue were the most promising grasses in the unstocked plots (Tennent, 1935) but following a period of prolonged and severe grazing there was an 'abrupt change in grass dominance to tall oat grass, *Poa pratensis* and Chewings fescue (Douglas, 1970).

Little further trial work was reported prior to the Second World War apart from a recommendation from Wilkie (1939)

that *Agropyron cristatum* would be a useful plant in Marlborough and Calder (1938) who suggested that tall oat grass could be used to replace the indigenous tussocks.

THE SOIL CONSERVATION MOVEMENT

The passing of the Soil Conservation and Rivers Control Act in 1941 led to the beginning of an organization with staff and land reserves specifically to find ways of reducing soil erosion. The history of this movement and its work has been recorded by McCaskill (1973), and in relation to this paper it led to further widespread testing of grass species.

A large number of grass species and strains were tested in the semi-arid zone at the Tara Hills High Country Research Station and the Pisa Flat Experimental Area near Cromwell. At Tara Hills in the 1950s research was directed towards soil conservation. Grasses were tested under severe grazing regimes and those which proved promising were: *Bromus inermis*, *B. popovii*, *Agropyron intermedium*, *Eragrostis curvula*, *Dactylis woronowii*, phalaris, tall fescue and tall oat grass (Soil Con. and Rivers Control Council, 1956, 1957).

In a later inspection of these plots, all the aforementioned grasses persisted with the exception of *Bromus popovii* (Dunbar and Douglas, unpubl., 1964). In the grazing nursery rows, cocksfoot, *Dactylis woronowii*, *Agropyron smithii*, *A. elongatum*, *Brachypodium pinnatum*, *B. phoenicoides*, tall fescue, Chewings fescue, browntop, and *Poa pratensis* had survived. Of the 45 species in the field sowings, cocksfoot, *Dactylis woronowii*, *Agropyron elongatum*, *A. intermedium* and *A. obtusiusculum* were given the highest productive ratings.

More recent research at Tara Hills has shown that cocksfoot and tall fescue were higher producing than perennial ryegrass, phalaris, prairie grass and *Bromus marginatus* when each was planted in association with lucerne (Douglas and Kinder, 1973).

At Pisa Flat, Calder (1944) considered tall oat grass, cocksfoot, danthonia, Chewings fescue, browntop, *Poa pratensis*, *Agropyron scabrum*, and *A. cristatum* showed the most promise. A later report by Lunn (1951) indicated that all these grasses except browntop and *Agropyron cristatum* but with the addition of phalaris and tall fescue, dominated the field sowings under a simulated winter run country stock management system.

The trials in Central Otago were extended from Pisa Flat to several other sites throughout the district (Saxby, 1957). From

this work cocksfoot, tall oat grass, *Bromus inermis* and *B. marginatus* appeared promising (Saxby, 1957). The last report of the nursery and experimental areas of Central Otago was by Ludecke (1962) who suggested cocksfoot, tall oat grass, tall fescue, *Dactylis woronowii* and *Bromus inermis* were the most promising grasses.

In 1944 Botany Division, DSIR, staff began nursery trials on a range of grasses at Molesworth from which the most promising species were considered to be *Agropyron cristatum*, *A. elongatum*, *A. intermedium*, *Bromus inermis* and *Dactylis woronowii* (Moore and Simpson, 1961). However, the authors noted that with the success being achieved with the oversowing of cocksfoot there was a waning interest in the less familiar grasses. Tall oat grass was also successful in the nursery sowing but it proved unpalatable to stock and later observations suggested that it could become a serious weed (McCaskill, 1970).

More recently research has been directed towards the regrassing of the high altitude erosion slopes. Fertilizers have been shown to be essential (O'Connor and Lambrechtsen, 1967; Dunbar, 1970a, b, 1971). Dunbar (1971) achieved a quicker plant cover using exotic species, particularly Yorkshire fog rather than native tussock species (Dunbar, 1970a) and O'Connor and Lambrechtsen (1967) showed that there were wide cultivar variations within a species in their reaction to frost heaving. For instance, the cocksfoot cultivar 'Grasslands Apanui' was considerably more resistant to frost heaving than the Australian winter active cultivar 'Currie'.

AGRICULTURAL DEVELOPMENT

In the 1950s in the more humid regions of the tussock grasslands there was a change in emphasis from conservation to productive potential of land which 'already had a covering of brown-top, Yorkshire fog, and sweet vernal. However, the earliest trials in the Waimakariri basin were sown without fertilizer and only inter-row cultivation of the plant nursery kept out the competitive adventive species.

In row trials at Craigieburn Station, Sewell (1952) found *Agropyron intermedium*, *A. dasystachyum*, *A. scabrum*, *Bromus carinatus*, and cocksfoot gave the best performance of the grasses he tested. Sowings into cultivated ground showed that these promising introductions were slower to establish than the native *Agropyron scabrum* and cocksfoot. In an unpublished report on

these studies, L. D. Bascand (1958, unpubl.) indicated that, at the completion of this research, cocksfoot, *Dactylis woronowii*, *Bromus marginatus*, *B. popovii*, *Festuca elatior*, *Agropyron intermedium* and the Roxburgh and Alexandra ecotypes of *Agropyron scabrum* were the most promising. Earlier, in addition to these species, *Bromus carinatus*, *Elymus glaucus* and *Festuca maieri* were considered promising (Bascand, unpubl.) .

Promising species from the Craigieburn nurseries were also sown in the Riversdale 'area on to both ploughed and pitchpole harrowed ground but the only species to compete successfully against the reinfestation of browntop and creeping fog were cocksfoot and tall oat grass (Basoend, 1955, unpubl.) .

Dingwall (1955) noted that it was difficult to establish grasses by oversowing grassland invaded by browntop and sweet vernal but he suggested that in good conditions cocksfoot and tall oat grass could often be established. Further research at Broken River on species evaluation by sod-seeding (Dingwall, 1956) also failed because of the inability of the sown species to compete with the resident browntop dominated sward.

Bascand (unpubl., 1956) in conjunction with Dr M. R. Love (University of California) found cocksfoot, *Phalaris coerulescens*, tall oat grass, *Danthonia californica* and *Bromus inermis* to be the most promising of 17 species, 4 months after sowing. Two *Poa* species three *Oryzopsis* species, and *Festuca idahoensis* used in the sowings showed poor establishment and growth.

O'Connor (1959) tested 65 species and strains of grasses with fertilizer additions. The outstanding species on tiller and leaf length rankings were *Agropyron scabrum*, *Bromus popovii*, perennial ryegrass, cocksfoot and Yorkshire fog.

The Holbrook trials in the Mackenzie Country were overdrilled into the tussock sward by L. W. Blackmore in 1948 and later reviewed by Sievwright (1956). Cocksfoot proved the most successful grass, with tall oat grass and tall fescue also prominent. *Agropyron cristatum* established in bare areas and while persistent it made only limited growth. Earlier unpublished reports suggested *Agropyron intermedium* was also worth while.

Results obtained by Sievwright (unpubl., 1957) at Mt. Hay Station, Tekapo, from plots sown in 1952 indicated cocksfoot and *Poa pratensis* were the best grasses, with *Bromus inermis* and tall fescue also worth while. Sweet vernal, *Danthonia pilosa* and *Eragrostis curvula* produced well but were not readily eaten by sheep. *Elymus glaucus*, *Agropyron intermedium* and *A. elongatum* were considered only fair in production and palatability. Earlier

reports by Sievwright indicated that *Elymus glaucus* was the most promising North American species under test but it was almost eliminated by the continuous set-stocking of the plots.

OBSERVATIONS ON SPECIES PALATABILITY

The earliest reports on the palatability of some of the introduced grasses were made by Cockayne (1920b, 1920c) who made observations of sheep grazing at Earnscliffe. Cocksfoot was considered to be highly palatable, and *Poa pratensis*, Yorkshire fog, Chewings fescue and tall fescue of medium palatability. Cockayne suggested perennial ryegrass, sweet vernal, tall oat grass, *Agrostis vulgaris*, *Phalaris commutata*, *P. bulbosa* and *Agropyron scabrum* were of low palatability under the existing conditions.

Little further attention has been paid to the palatability of the introduced species. Moore and Simpson (1961) and Douglas (1970) also reported the low palatability of tall oat grass, Saxby (1957) reported the low palatability of *Eragrostis curvula*, and Lunn (1951) that of *Brachypodium phoenicoides*. Unpublished results of Sievwright (1957) from his Mt Hay experiments suggested sweet vernal, *Danthonia pilosa* and *Eragrostis curvula* were not readily eaten by sheep.

More recently Douglas and Drew (1969) have drawn attention to the low feeding value of frosted cocksfoot, and Vartha and Clifford (1971) have shown that, while Yorkshire fog and perennial ryegrass gave superior growth, cocksfoot and tall fescue were of greater value for winter feed because they did not decompose as quickly as the former species when frosted.

Saxby (1950) suggested that the grass species most suitable for the tussock grassland conditions were tall oat grass, cocksfoot, phalaris, tall fescue, danthonia, *Poa pratensis*, *Agropyron scabrum*, and *Brachypodium phoenicoides*. Further reports by Hercus (1954), Thornton (1954) and Maclean (1957) recommended cocksfoot, tall oat grass and *Bromus inermis*. In addition, Hercus also recommended danthonia, and Thornton, tall fescue, *Agropyron intermedium*, *Elymus glaucus* and *Eragrostis curvula*.

O'Connor (1960) suggested that for general purposes in the immediate future *Agropyron scabrum*, browntop, sweet vernal, Yorkshire fog, cocksfoot, tall oat grass, tall fescue and ryegrass would be the most valuable under conditions of improved fertility. He found no other native or exotic grasses he had tested were capable of high production under improved fertility conditions.

At a seminar on grass introduction into the tussock grasslands it was suggested that further research, be conducted on the following species (Anon., 1964) :

- (a) Semi-arid zone; new strains of cocksfoot, tall oat grass, tall fescue and some species of *Agropyron*.
- (b) Sub-humid zone; *Agropyron* sp. and Chilean sp. of *Festuca* and *Deschampsia* and strains of tall fescue and *Bromus* sp.
- (c) Humid zone; new strains of tall oat grass.

For aerial oversowing of the tussock grasslands, cocksfoot has become the major recommendation (Douglas, 1966). It has been advocated for the semi-arid, the sub-humid; and large areas of the humid zone of the tussock grasslands (Anon., 1964).

DISCUSSION AND CONCLUSIONS

In 'excess of 150 different grass species of 50 different genera have been sown in trials in the tussock grasslands, the results and recommendations of which must be considered in relation to the overall changes in the region.

The degradation of the tussock grasslands by burning, overstocking and rabbits began with the settlers. The indiscriminate burning was denounced by Buchanan (1869) and Cockayne (1910) and although burning became more confined to autumn and spring periods (Cockayne, 1916), control did not come until the Soil Conservation Act of 1941 led to the establishment of catchment boards and the requirement of a permit to burn (McCaskill, 1973). Control of rabbits was not put on a sound basis until the introduction of the "killer" policy in 1947 (Howard, 1959). In addition, application of fertilizer to the South Island range country became practical only with the advent of aerial topdressing and the high wool prices of the early 1950s gave incentive for improvement. Concomitant with the use of fertilizers came the swing to legumes rather than grasses for surface sowing, with the adventive grasses browntop, Yorkshire fog, sweet vernal and *Poa pratensis* completing the sward.

Thus the 1950s were the turning point in the pastoral use of the tussock grasslands. The discipline of productive capability of the land replaced that of soil conservation and an era of spectacular improvement began.

With these dramatic changes many of the earlier grass species recommendations no longer relate to the improved conditions

since the productive potential of the grasses was never measured nor suitable fertilizers added so they could fully express their potential. In addition, many species failed to establish, and overall the failure of a grass in these earlier trials cannot be taken as implying the species would not be useful in the environment.

Plant growth in the semi-arid zone is governed more by climatic conditions than soil fertility as it is in the humid regions and because of this the earlier trials without fertilizer tend to give a more accurate picture in this former zone. Consequently, the species recommendations for Central Otago and the drier regions of the Mackenzie Country could be looked upon as a reasonable guide. Cocksfoot (*Dactylis glomerata*) is already the most important grass in this region, this being well founded in the earlier trials, and further research to evaluate the productive potential of a range of its cultivars and other *Dactylis* species appears worth while. In addition, the selection of a more palatable tall oat grass would be beneficial because of the ease with which the species establishes and further investigations of the potential of tall fescue and some *Bromus* species such as *Bromus inermis* need to be considered.

In the humid zone of the tussock grasslands the results of the research appear of little value at least until fertilizers were used in species evaluation (Dingwall, 1956; O'Connor, 1959). Given adequate fertilizer, one could expect the reaction of species in the humid tussock grasslands to be similar to those on the developed humid coastal plains and downlands. This is borne out by O'Connor (1959) who showed that the downland species of ryegrass, cocksfoot and Yorkshire fog were amongst the most highly rated grasses when fertilizer was applied. It was further amplified by O'Connor in 1961 (1961a, b, c) who showed the dominant limiting factor to high production in the humid tussock grasslands was a lack of fertilizer. Consequently there appears little need to continue species evaluation research in the humid regions of the tussock grasslands except for specific purposes.

Overall, the improvements in the tussock grasslands have led to considerably increased production but this has mainly been confined to the spring-summer period and as a consequence the gap between summer and winter feed availability has widened. O'Connor (1961a) and Douglas (1966) both suggested a need for further research on cool season active species and Douglas and Drew (1969) have drawn attention to the low feeding value of frosted cocksfoot and suggested an investigation of grasses with high nutritive value as foggage was needed.

Perhaps the most striking 'aspect of this review is the lack of production data which exists for individual species growing in the tussock grasslands environment. (Production figures: swards — O'Connor, 1959, 1960, 1961a; four grasses — Vartha and Clifford, 1971; lucerne/grass mixtures — Douglas and Kinder, 1973.) In addition, it is worth while reflecting that, even after considerable trial work and the introduction of numerous grasses, the dominant introduced species throughout the tussock grasslands region are the self-spreading naturalized grasses, brown-top, Yorkshire fog, sweet vernal and *Poa pratensis*, and the two main agricultural species of New Zealand, perennial ryegrass and cocksfoot. For stock numbers to rise and equate more closely with the feed produced, there is a pressing need to know how much feed a species produces, when it is produced, and whether overall production can be increased by changing from one grass species to another. Without this long overdue information the environment cannot be used efficiently.

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APPENDIX

Grass Species Sown in some Plant Introduction Trials
in Tussock Grasslands

Each grass has been named as it was given in the original work. Today some names have changed and others are synonymous with grasses given in the list as different species.

Key

Each number given below identifies the trial reference and when referred to the list gives the species sown by the particular officer or at that particular research station.

- (1) Cockayne, L. (1922), Douglas, J. A. (1970).
- (2) Macpherson, A. (1912a, b), Anon. (1910).
- (3) Moore, L. B., Simpson, M. J. A. (1961).
- (4) O'Connor, K. F. (1950s), unpubl. Dept. of Agriculture files.
- (5) Pisa Flat Experimental Area (1940s), unpubl. Dept. of Agriculture files.
- (6) Sievwright, H. M. (1956), unpublished files.
- (7) Sewell, T. G. (1950), unpubl. Dept. of Agriculture files.
- (8) Tara Hills Research Station (1940-50), unpubl. Dept. of Agriculture files.
- (9) Ward, F. E. (1923).
- (10) Ophir Experimental Area (1950s), unpubl. Dept. of Agriculture files.
- (11) Bascand, L. D. (1950s), unpublished files.
- (12) Dingwall, A. R. (1956).

*Denotes failed to establish.

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<i>Agropyron caninurn</i>	5*
<i>A. ciliare</i>	
<i>A. crispatum</i>	1 3 4 5 6 7" 8 10
<i>A. dasystachyum</i>	3 5" 6 7 8 10*
<i>A. desertorum</i>	3' 5" 6 7
<i>A. elongatum</i>	1 3 5* 6 7 8 10 11
<i>A. glaucum</i>	3' 10*
<i>A. inerme</i>	3 4 5* 7 8 10"
<i>A. intermedium</i>	3 4 5 6 7 8 10 11 12
<i>A. kirkii</i>	7 12
<i>A. obtusiusculum</i>	8
<i>A. pauciflorum</i>	5"
<i>A. pectinatum</i>	2 5 8
<i>A. riparium</i>	10
<i>A. repens</i>	5*
<i>A. rigidum</i>	10
<i>A. scabrum</i>	2 4 5 6 7 8 1 0
<i>A. scabrifolium</i>	3* 7 8
<i>A. semicosfatum</i>	5
<i>A. sibiricum</i>	3 5"
<i>A. smithii</i>	3 5 7* 8 10*
<i>A. spicatum</i>	1 3 4 5 6 7 8 10*
<i>A. trachycaulum</i>	3 4 5* 7 8 12
<i>A. trichophorum</i>	5 10 11
<i>Agrostis alba</i>	
<i>A. castellana</i>	8
<i>A. gigantea</i>	2
<i>A. stolonifera</i>	1 2
<i>A. tenuis</i>	1 4 5 6 8 1 0
<i>Aira caespitosa</i>	2*
<i>Alopecurus pratensis</i>	5
<i>Andropogon furcatus</i>	5*
<i>A. gerardi</i>	8*

<i>A. hallii</i>	5 10'
<i>A. intermedius</i>	5* 10*
<i>A. ischaemum</i>	5 8' 10"
<i>A. saccharoides</i>	5
<i>A. scoparius</i>	5 8*
<i>A. suparimo</i>	5*
<i>A. tricharoides</i>	5'
<i>Anthoxanthum odoratum</i>	2 4 6
<i>Aristida uniplumis</i>	8*
<i>Arrhenathrum elatius</i>	1 2 3 4 5 6 8 9 10 11 12
<i>A. elatius</i> var. <i>bulbosum</i>	5
<i>A. erianthum</i>	8
<i>Bouteloua curtipendula</i>	2 3 5" 10"
<i>B. eriopoda</i>	5*
<i>B. filiformis</i>	8*
<i>B. gracilis</i>	1 3 5 7* 8 10*
<i>B. oligostachya</i>	2*
<i>Brachypodium phoenicoides</i>	5 8 10
<i>B. pinnatum</i>	8
<i>B. pinnatum</i> var. <i>glabrum</i>	
<i>Bromus breviaristatus</i>	6
<i>B. carinatus</i>	3 4 5 6 7 8
<i>B. catharticus</i>	2 4 5
<i>B. coloratus</i>	4 8 10
<i>B. inermis</i>	1 2 3 4 5 6 7 8 10 11 12
<i>B. marginatus</i>	3 4 7 8 10 11 12
<i>B. maritimus</i>	3 7
<i>B. mollis</i>	4 10
<i>B. popovii</i> (probably <i>B. sitchensis</i> , M. B. Forde, pers. comm.)	4 7 8 10 12
<i>Buchloe dactyloides</i>	2* 3 5* 7* 8 10*
<i>Chaetochloa cuudata</i>	2
<i>Chionochloa rigida</i>	8
<i>Chloris cucullata</i>	5*
<i>C. gayana</i>	2 5*
<i>Cottea pappophoroides</i>	5*
<i>Cynodon plectosiachyus</i>	5*
<i>Cynosurus cristatus</i>	1 2 4 5 6 7
<i>Dactylis glomerata</i>	1 2 4 5 6 7 8 9 10 11 12
<i>D. woronowii</i>	3 7 8 10 12
<i>Danthonia californica</i>	11
<i>D. kirkii</i>	7
<i>D. pilosa</i>	1 2* 5 6 8 10 12
<i>D. semiannularis</i>	2
<i>Deschampsia caespitosa</i>	7
<i>Deyeuxia avenoides</i>	7 8
<i>D. jorsteri</i>	8
<i>Dichelachne crinita</i>	4 7 8 10
<i>Ehrharta calycina</i>	3 5* 6 7 8
<i>Elymus augustus</i>	10*
<i>E. canadensis</i>	3 5 6 7 10*
<i>E. giganteus</i>	8 10*
<i>E. glaucus</i>	3 5 6 7 8 10

<i>E. junceus</i>	5 8 10*
<i>E. sabulosus</i>	10"
<i>E. triticoides</i>	10*
<i>E. sibiricus</i>	10
<i>E. virginicus</i>	3 5* 6 7 8 10*
<i>Eragrostis abyssinica</i>	7 10*
<i>E. chloromelas</i>	8
<i>E. curvula</i>	3 5 6 7 8 1 0
<i>E. lehmanniana</i>	3 5 8
<i>E. plana</i>	3 8*
<i>E. superba</i>	8"
<i>E. trichodes</i>	3* 8
<i>Eriochloa annulata</i>	9 (may not have been sown)
<i>Eustachys paspaloides</i>	5 7* 10"
<i>Festuca arenaria</i>	2
<i>F. arundinacea</i>	4 5 6 7 8 9 10 12
<i>F. dumetorum</i>	2
<i>F. duriuscula</i>	2
<i>F. elatior</i>	13 7 12
<i>F. elatior</i> var. <i>alta</i>	7
<i>F. heterophylla</i>	2'
<i>F. idahoensis</i>	3 5' 11
<i>F. longifolia</i>	2
<i>F. maierei</i>	3 5 7 10 12
<i>F. matthewsii</i>	4
<i>F. novae zelandiae</i>	4 5 7 8
<i>F. ovina</i>	2 3 5*
<i>F. ovina</i> var. <i>duriuscula</i>	2 8
<i>F. pratensis</i>	4 5
<i>F. rubra</i>	1 2 3 4 5 6 1 0
<i>F. rubra</i> var. <i>fallax</i>	2 8
<i>F. rubra</i> var. <i>genuina</i>	8
<i>F. tenuifolia</i>	5
<i>Hyparrhenia hirta</i>	5 8* 10*
<i>Hilaria jamesii</i>	5*
<i>H. belangeri</i>	5*
<i>Holcus lanatus</i>	1 4 5 6 9
<i>Hordeum bulbosum</i>	8
<i>Ischaemum glaucostachyum</i>	9 (may not have been sown)
<i>Leptochloa dubia</i>	2*
<i>Lolium multiflorum</i>	4 5 12
<i>L. perenne</i>	14 5 8 9 10 12
<i>Notodanthonia racemosa</i>	4
<i>N. thomsoni</i>	4 10
<i>N. setifolia</i>	4
<i>Oryzopsis hymenoides</i>	11
<i>O. miliacea</i>	8 11
<i>O. stiparyopsis</i>	11
<i>Panicum antidotale</i>	5* 8
<i>P. bulbosum</i>	2*
<i>P. laevifolium</i>	9 (may not have been sown)
<i>P. maximum</i>	5 7* 9 10*
<i>P. obtusum</i>	5*

<i>P. plenum</i>	2
<i>P. virgatum</i>	3" 5* 7
<i>Paspalum simplex</i>	5 6 10'
<i>Paspalidium retiglume</i>	5*
<i>Pennisetum cinroides</i>	9 (may not have been sown)
<i>Phalaris aquatica</i>	8
<i>P. arundinacea</i>	4 8
<i>P. canariensis</i>	
<i>P. coerulescens</i>	4 8 11
<i>P. commutata</i>	2
<i>P. tuberosa</i>	4 5 6 8 10 12
<i>P. tuberosa</i> var. <i>hirtiglumis</i>	11
<i>P. tuberosa</i> var. <i>stenoptera</i>	8 11
<i>Phleum nodosum</i>	4
<i>P. pratense</i>	4 5 7 1 2
<i>Poa ampla</i>	3 5* 7 8 10 11
<i>P. bulbosa</i>	5*
<i>P. caespitosa</i>	4 5 6 8
<i>P. colensoi</i>	2 4 5
<i>P. compressa</i>	3
<i>P. pratensis</i>	1 2 4 5 6 7 8 9 1 0
<i>P. scabrella</i>	11
<i>P. secundn</i>	3*
<i>P. trivialis</i>	5'
<i>Puccinellia</i> species	5
<i>Secale cereale</i>	3
<i>Setaria glauca</i>	9 (may not have been sown)
<i>S. woodii</i>	5 7" 10*
<i>Sporobolus airoides</i>	3'
<i>S. cryptandrus</i>	2 3* 5* 10'
<i>S. fimbriatus</i>	8*
<i>S. fteuosus</i>	2*
<i>S. wrightii</i>	2*
<i>S. species</i>	6* 7'
<i>Stipa viridula</i>	3 10*
<i>Themeda triandra</i>	5*
<i>Tricholaena rosea</i>	2
<i>Triodia exigua</i>	7
<i>T. nuda</i>	2
<i>Trisetum antarcticum</i>	8
<i>T. kurtzii</i>	7
<i>Urochloa pullulans</i>	5 7" 10*
<i>Vulpia dertonensis</i>	4 10