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AN ECOLOGICAL STUDY OF RUSHES IN PASTURE  
THE SPECIES OBSERVED, THE ENVIRONMENT, AND  
THE INFLUENCE OF MANAGEMENT IN RUSH CONTROL.

By "Cider".

*D.M.F. May.*

[1934?]

C O N T E N T S.

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AN ECOLOGICAL STUDY OF RUSHES IN PASTURE. THE SPECIES  
OBSERVED, THE ENVIRONMENT, AND THE INFLUENCE  
OF MANAGEMENT IN RUSH CONTROL.

INTRODUCTION:

The Dominion of New Zealand is dependent on its primary products. There is no need to statistically prove this fact; it is obvious to anyone who troubles to read and think.

The marketable value of the Dominion's Dairy Produce, Wool and Frozen Meat, largely determines the economic welfare of the Country.

The significant feature is that these primary products are all of grassland origin. Home Consumption of primary products is limited, and the prosperity of the Dominion depends almost entirely on its exportable balance. Attractive markets are distant and competition keen.

The marketing of Dominion products suffers disability through distance and transportation, but this is compensated largely by natural climatic advantages, the climate being exceedingly mild and equable, so that depasturing of stock may be continued throughout the year on grassland, or with the assistance of supplements of hay and ensilage conserved in springtime from surplus grass growths.

It is vitally important that the greatest care and attention should be devoted to maintaining clean and nourishing pasture if increased productivity and incidentally prosperity is to result.

Much research work has been conducted along the lines of selection, and, latterly, of breeding superior pasture grasses, but there does not seem to have been the same attention paid to the control or eradication of weeds, some of which are slowly but surely increasing in existing pastures, in many pastoral districts.

Weed growth in grassland pasture is a curse to the average farmer, and among the most common weeds are rushes.

The control of rushes in pasture is a very serious problem affecting many districts in the Dominion. The late Dr. L. Cockayne, an eminent ecologist, realised the damaging effects of weeds in pastoral lands. In advocating measures for weed control (1)\* he emphasises the point thus, "The better known are its habits, its likes and its dislikes in relation to soil and climate, its special plant and animal enemies, its methods of dissemination, its seasonal changes, and last but not least its actual distribution, the easier will it be to set up satisfactory means for its downfall."

In Nature plants flourish according to environment. Rushes are no exception. Their environment must be made uncongenial, they must be controlled, and if possible eradicated.

With this purpose in view the writer has

\* (Reference by number is to Literature cited)

given the subject close study and the following detail is the result of such careful observance.

OBJECTS AND AIMS OF THE INVESTIGATION:

1. A short review of the information connected with a study of rushes.
2. A description of *Juncus* species noted in their pasture habitats.
3. An experimental examination, and analysis of some observed environmental features relating to rush growth.
4. A review of probable effects induced by systems of management, considered with the aim of rush control.

GENERAL NOTE:

In the classification and notes on general distribution of the species observed, Cheesman's work (3 & 4) has been freely consulted. The descriptions following on after classification of the species are purely the result of personal observation within the stated areas.

SECTION I.A REVIEW OF GENERAL INFORMATION RELATING TO THE  
STUDY OF RUSHES.LITERATURE:

In this country there is little direct information bearing on the problem of rush control. In countries of the Old World the study of rushes, more particularly from a purely botanical aspect, has received some attention. Thus recourse for present information has been mainly from the following sources:

1. Scientific Periodicals. These have been chiefly of New Zealand publication,
2. Agricultural College Records.

CLASSIFICATION:

A recent study of the Juncaceae by the Plant Research Station, Palmerston North, has added considerably to the previous knowledge of this family. The establishment of the identity of several new species not recorded by Cheesman as occurring in New Zealand, has been observed in the later descriptions of the species *Juncus effusus*, and *Juncus luxurians*.

REFERENCES OF INTEREST FROM PERIODICALS:

The transactions of The New Zealand Institute have often contained references of historical interest, relating to the occurrence of *Juncus* species in this country. Short extracts of the most interesting portions have been used to precede species descriptions in Section II. Another source of frequent reference has been The New Zealand Journal of Agriculture, whence the originals of the following extracts are located.

(a) Myers (5) in an article dealing with the cattle tick, *Haemaphysalis bispinosa*, which is found in the North Auckland district, believes that in the particular field to which he refers, rushes sheltered a heavy population of nymph ticks throughout the winter, and provided a vantage point from which they could climb on to cattle in the spring.

(b) Replying to a correspondent, the Fields Division of the Department of Agriculture (6) advised drainage, manuring and cattle control for the elimination of rushes.

(c) The Marton Experimental Farm of the Department of Agriculture (7) has been the source of an interesting result. This will be described more completely in a later section.

(d) Deem (8) has given the results of experimental evidence which show the killing power of Sodium and Calcium Chlorates, when applied for weed control. He also mentioned the possibility of similar applications to the control of such weeds as rushes.

In a communication with Deem (27) on this point the information was obtained that to that date, the Department of Agriculture had not proceeded with experimental work to the stage where any pronouncement could be made as to the efficacy of sodium chlorate, in the eradication of the common rush.

From a record of a meeting of sheep-breeders (9) a question from a member of the audience to the lecturer drew the following reply, concerning methods to adopt for rush control. The speaker advised strong pasture competition, effected by top dressing, the sowing of suitable strains of grasses, drainage and the cutting of rushes by mower.

The most notable of overseas authorities who have contributed to a knowledge of the Juncaceae are:

- (a) Irmisch (12) who in 1855 described the morphology of the common rush.
- (b) Buchenau (13) a systemitist to whom some specimens of the New Zealand species of *Juncus* were forwarded by Cheesman for identification.
- (c) Blau (14) who has studied and described the anatomical structure of European species of *Juncus*.
- (d) Laurent (15) who studied the embryology and anatomical structure of germinating *Juncus* seeds. His work is of interest in that he shows that the first formed leaf is similar in all species, and that the internal structure of the *Juncus* seed, by virtue of its internal and external integument, exercises an essentially protective function in development. He also states that the reserve material and the mucilagenous coat of the germinating *Juncus* seed, are each of considerable physiological importance.

Mrs. Arber (16) has studied the morphology of the monocotyledon leaf, and concludes that in many monocotyledons it is a phyllode structure. She regards the cylindrical radially symmetrical leaf found in many Liliaceae and Iridaceae, as a petiolar phyllode. In support of her theory, Mrs. Arber refers to certain species of *Juncus* figured by Buchenau (17) in which she stated phyllode leaf anatomy has been observed.

Adamson (11) has made a detailed anatomical study of the leaf structure of a number of species of *Juncus*.

Professor M. Alpine, an eminent authority on weeds, has made the following observations, in a special article (18) dealing with rushes. He states that the air shoots originate either from an elongated horizontal underground stem, as in creeping rushes, *J. lamprocarpus*, or from a contracted underground stem, tufted rushes, and that this underground stem is often as much as 3 feet deep. He has also stated that sprout rushes (jointed rushes) are often cut and turned to good account for litter and winter feed.

#### REFERENCES FROM COLLEGE RECORDS:

The Field Register (19) has been employed to obtain information of the treatment and results of cultivations de-

-signed to eliminate rush growth.

GENERAL IMPORTANCE OF RUSHES:

In the past, rushes have been of some slight industrial use. On the authority of the Encyclopaedia Britannica (20) they have been used for the weaving of mats, the manufacture of rush hats, and for the fashioning of articles of apparel for primitive peoples. Baskets and chair bottoms have been constructed from rush stems, while the pith of a certain species has been used for wicks in open oil vessels, and tallow candles. From this unique application the term rushlight was derived.

While in New Zealand rushes are believed to have no industrial application, they have sometimes been put to considerable use by enterprising farmers. The main scope of their employment has been for thatching, a practice now largely superseded by the use of more permanent roofing, such as proofed canvas or iron.

To the sheepfarmer rushes have still some small utility. It is considered that during the lambing period, the presence of tufts of rushes affords very necessary shelter, especially in times of adverse weather.

In addition the writer has noted that rushes have been put to use by dairy farmers. The complete plants, together with the adherent soil retained by their tufted roots, have been used to form a barrier ring, by which the earth coverage for pressure in the case of stack silage, could be effectively retained.

SUMMARY:

It is apparent that rushes have attracted very little attention in the past, other than from purely botanical interests. The need for further information which can be applied in their control has been sought. Rushes are of little or no economic value. Further, the flower is both unattractive, and without smell or honey.

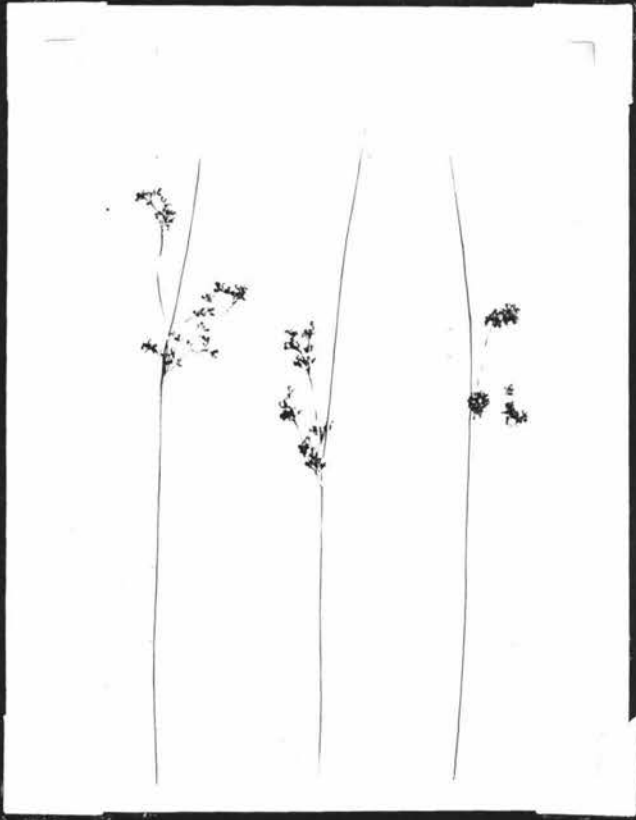
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P L A T E    I

(a)<sup>\*</sup> Inflorescence of *Juncus polyanthemos*.

(b) Seed of *Juncus polyanthemos*.

<sup>\*</sup>  
( This illustration, and subsequent illustrations of the species described, have been photographed from the one position, so that size relationships would be comparable. )



SECTION II.RUSH SPECIES RECORDED IN PASTURE.GENERAL NOTE:

Other than where particular reference is made, the following observations refer to the presence of the respective species in the Manawatu:

JUNCUS POLYANTHEMOS: Buchen.

FAMILY: JUNCACEAE:

This family is of world wide distribution, In all, there are about 280 species, comprising 7 or 8 genera. Many of the species are widely distributed in temperate, and extropical regions.

GENUS: JUNCUS:

These are perennial or more rarely annual herbs, of which there are about 200 species, 17 of which are said to exist in New Zealand. Four have a wide range in the Northern Hemisphere. Several are found only in Australasia, while others extend throughout Asia, to China, Japan and South America.

Those species which have been recorded in pastoral land in this locality are relatively few, while those of economic importance number no more than 7 or 8.

GROUP: GENUINI:

Plants with tall stems produced beyond the cyme to an acute point, and with sheaths encircling the stem base. True leaves are wanting, or, if present, they are terete like the stem.

SPECIES: JUNCUS POLYANTHEMOS:

This species is also of world wide distribution.

AUTECOLOGY:LIFE FORM:

Individual plants examined were found to be closely tufted. En masse, the stems of apparently young plants were a uniform deep green colour. In other plants, apparently older, the impression gained was that the stems were of a brownish, or yellowish green appearance, and this character was due to the large number of completely dead, or dying stems, encompassed by the living growth. Often the central portion of a plant, especially when it was growing in a very wet habitat, had an interior clump of completely dead stems. In some circumstances more or less symmetrical Juncus communities were formed, evidently by radial migration of the rhizomes. The interior of these communities was then usually of ungrazed pasture, and this was encircled by the extending rush.

SHOOT SYSTEM:

Shooting was seen to take place from the upper surface of the underground rhizomes. Shoots were stiff, erect, green, and when young, needle-like. On development

they formed a clump of mature stems, of which the parent plants had many hundreds. Shooting was almost entirely confined to the outer margins of plants, thus facilitating an outward spread.

#### ROOT SYSTEM:

From the lower surface of the rhizome a large number of small diameter roots were found. In the subsoil these were observed to branch freely. The entire root system was extensive, and root penetration was deep. A later description covers the root structure of *J. polyanthemus* in more detail.

#### REPRODUCTIVE SYSTEM:

The reproductive system was composed of an unattractive inflorescence, laterally borne, and at a short distance below the stems apical tip. There was wide variation in the character of the inflorescence, both as regards distance from the stem tip, and density, or number of flowers per head. The individual flowers were borne on much branched cymes. They were approximately 1/10th. of an inch long, pale chestnut, and were scattered along the branches of the cyme. Of the perianth segments, these were noted to be apiculate, acute, green when immature, and equalled by, or slightly longer than the seed capsule in length. The seed capsule, or fruit, was globose, trigonous, often bluntly obtuse at the tip, and of pale brown colour. The seeds were numerous, small yellowish brown, obovoid, and roughly apiculate.

#### DISTRIBUTION:

In New Zealand plants of this species have wide distribution. They are confined neither to one soil type, nor to one geographical location. Though undoubtedly most common in low lying, damp and swampy areas, they have been observed at considerable elevation. On the East Coast route, (North Gisborne) *J. polyanthemus* has been observed growing freely on undulating to hilly sheep country. Similar conditions prevail on the area of regrassing experiments of the Department of Agriculture, which were carried out in the Wangamomona Country, Taranaki. These experiments have been reported on from time to time in New Zealand Journal of Agriculture, and together with the accompanying illustrations, show some cases where rushes are growing freely on this hilly country after the pasture swards have been subjected to intensive grazing by sheep and cattle.

In the Manawatu district, *J. polyanthemus* is a frequent pasture weed, particularly on poorly drained land of heavy soil type.

In the waikato there is a marked prevalence of this rush on the extensive peat and other swamp land, where it appears to follow in the succession after the land is cleared of its manuka association. In this situation the control of *J. polyanthemus* is often difficult.

Conversely to the general opinion that only wet habitats will support *Juncus* species, the occurrence of *J. polyanthemus* has been noted on a light, weathered, pumaceous soil, right on the ridge of a hill, where it is considered most improbable that the roots could penetrate to any layer of subsoil water. To sum up, the distribution of this species is often wider than one might anticipate,

both climatologically and edaphically.

MORPHOLOGY:

STEM:

(a) External features:

The stems examined were cylindrical, green, 1½ - 3 feet in length, and tapered to a sharp, needle-like point. Measured one inch from their basal rhizome attachment (all stem measurements given for subsequent species have been made from this point) the average diameter of a number of stems was  $\frac{1}{8}$  inches. They were erect, stiff and wiry, with fine parallel striations over their entire length. The basal sheaths, of which there were 4 - 5, enfolded the lower portion of each stem. The colour ranged from a straw tint in the upper portion, through glossy red tinged browns, to ebony black below. Occasionally sheaths of green colour above ground, similar to the stem, were noted. The inflorescence was borne laterally from the uppermost portion of the stem, though a number of stems had no inflorescence.

(b) Internal features:

When split open, the interior portion of each stem contained a spongy white pith. This was interrupted by intercellular air spaces, a condition which was observed to be a general characteristic of *J. polyanthemus*.

ROOT:

As later described under Section IV.

SPECIAL FEATURES:

(1) Date of flowering:

While under observation in the season 1933 - 34, flowering of *J. polyanthemus* commenced late in the month of September. The main body of anthers were exerted in November, and flowering continued on to early January. Occasional odd flowers occurred throughout the year, even in winter.

(2) Effect of cutting on flowering:

From August, and extending over the summer months, stems cut to the ground level were found to make a rapid regrowth. So free was the growth at this period, that after only one month's interval, these cut stems had often produced 1 foot of new growth. Some even had developed a fresh inflorescence which was just commencing to open at the end of that time.

(3) Seed and Seed dispersal:

Towards the middle of February the fruit ripened. The capsule segments, under the drying influence of the summer sun, gradually parted. The minute, yellowish brown seed could then be readily shaken from the seed head with the slightest breeze. In quantity, the seed appeared to be a uniform

brick brown colour. When viewed beneath a lens, each seed was obovoid, and finely patterned, The apical end was roughly tipped, while to the basal region a few adherent, ashy grey scales, of membranous tissue, marked the region of previous attachment within the capsule. The central portion of the seed surface was often a bright canary yellow colour, and this merged imperceptible into darker shades of brown, near the seed extremities, Of a number of seeds measured, there was noted variation in length. Average seed size was approximately 0.4 mm. The maximum width was usually half the length. The seed was so small that it could be readily wind borne, and thus have a wide radius of effective dispersal.

(4) Quantity of seed shed:

From an average sized seed head matured under indoor conditions and from which the seed was completely threshed, and an estimate made by counting 500 seeds in a weighed fraction of the total sample, it was revealed that there were no fewer than 8,000 individual seeds present. When this evidence is taken in conjunction with the vast number of seed heads borne per plant, it is more than probable that each plant disperses annually several million seeds.

(5) Hybridisation:

Cockayne (2) states that *J. polyanthemus* hybridises with *J. vaginatus*, but he adds that there is need for further genetic study to substantiate this point.

It is probable that hybridisation was the cause of noted variation of the specimens examined from the general type of *J. polyanthemus*, as defined in such botanical work as recorded by Cheesman.

(6) Stock injury:

Little or no stock injury, on the particular fields which were kept under close observation, was apparent. Sheep browsed right to the base of plants, but seldom nibbled developing stems, even in the heart of winter, when herbage was extremely scarce. The writer was informed that horses would frequently graze rush shoots, especially if confined to one small area. No opportunity to observe this effect was presented. On occasional farms, even where feed was not particularly scarce, it was noted that dairy cattle had often grazed rushes of this species. Such plants, it was evident, had been frequently nibbled, but the plants were never denuded to ground level. However, this desire on the part of some few animals for rush vegetation does not appear to be of sufficient moment as a likely means in rush control.

(7) Insect injury:

It was noted that many stems had small perforations above ground and visible externally, near their basal portions. When these stems were split open, they were found

to contain a number of small white grubs attacking the central pith. The resistance to injury of the affected stems and plants was such that no noticeable difference could be detected between normal and affected growth.

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P L A T E    II

Inflorescence    of    *Juncus*    *effusus*.



<u>JUNCUS EFFUSUS:</u>	Linn.
<u>FAMILY:</u>	Juncaceae.
<u>GENUS:</u>	Juncus.
<u>GROUP:</u>	Genuini.
<u>SPECIES:</u>	Juncus effusus.

Although this species is credited with a wide distribution, its presence in New Zealand has only recently been confirmed from studies by the Plant Research Station. Cheesman (3 & 4) while recognising the presence of an aberrant form (Appendix) found insufficient evidence to allow of the separation of what are now classified as two distinct species, *J. effusus* and *J. polyanthemus*. In his first work (3) Cheesman established the identity of *J. effusus* under which classification New Zealand specimens latterly found to belong to the species *J. polyanthemus* were also included. In the later work of the same author (4) this order was reversed and the species present in New Zealand was classified as *J. polyanthemus*, from which it was then found impossible to separate the species *J. effusus*. This apparently anomalous situation is believed to have been caused by a misunderstanding on the part of Buchenau, to whom New Zealand specimens of *Juncus* were sent for identification. He had evidently overlooked some specimens, which eventually lead to a confusion in nomenclature.

AUTECOLOGY:LIFE FORM:

A feature of plants of this species is the uniform dark olive green colour of their stems. Frequently these have rusty brown surface markings. Perennial, and tufted, most plants have been found singly rather than in communities of the one species. In height a variation of from  $1\frac{1}{2}$  - 4 feet was noted.

SHOOT SYSTEM:

Numerous shoots, apparently similar to those of *J. polyanthemus*, were densely crowded on the rhizome.

ROOT SYSTEM:

In all essentials this appeared to be also similar to that of *J. polyanthemus*.

REPRODUCTIVE SYSTEM:

The lateral inflorescence was often very effuse. A striking feature was the extraordinary length of stem top above the inflorescence, this being as much as  $1\frac{1}{2}$  feet in some specimens. Lax cymes, much branched, and of unequal length, bore large numbers of small chestnut coloured flowers. These were slightly smaller than those of *J. polyanthemus*. The perianth segments when young, were green. They exceeded the capsule in length. The capsule was ovoid, trigonous and obtuse, brownish in colour and contained few small brown seed. This appeared to be a contrasting feature to related species.

DISTRIBUTION:

Though local specimens only have been gathered, a general distribution is indicated by specimens obtained from various parts of New Zealand and preserved in the Plant Research Herbarium. In this locality *J. effus* occurs to minor extent compared with the presence of *J. polyanthemus*.

MORPHOLOGY:STEM:

## (a) External features.

The stems examined had a dull dark green colour. They were  $1\frac{1}{2}$  to  $4\frac{1}{2}$  feet in length, and were approximately  $\frac{1}{2}$  in. in diameter. They were erect, stiff but not wiry, and had fine parallel striations. Basally each stem had 3 - 5 enfolding sheaths. These were straw coloured above, and dull reddish brown or black below, in contrast to the shiny sheaths of *J. polyanthemus*.

## (b) Internal features.

While the stems were easily split, the interior was filled with white, soft, uninterrupted pith.

ROOT:

In character and form individual roots were apparently similar to those of *J. polyanthemus*.

SPECIAL FEATURES:

## 1. Date of flowering.

Although flowering commenced early in November, the main flowering extended later into the summer than did that of any other species,

## 2. Seed and seed dispersal.

Very little seed was obtained from heads examined even as late as March. There appears to have been a high degree of sterility in the specimens examined. Seed length was approximately 0.45 mm. The seed was of pale yellowish brown colour, apiculate and obovoid.

## 3. Stock injury.

Although the shoots were soft and succulent, they were nibbled but little, either by grazing sheep or by cattle. In effect, only slight injury, insufficient to check plant development, was noted.

---

P L A T E    III

Inflorescence    of    *Juncus luxurians*.



<u>JUNCUS LUXURIANS:</u>	Col.
<u>FAMILY:</u>	Juncaceae.
<u>GENUS:</u>	Juncus.
<u>GROUP:</u>	Genuini.
<u>SPECIES:</u>	Juncus luxurians.

This species which has recently been established as occurring in New Zealand, has also been recorded in European countries.

HISTORICAL:

The presence of *Juncus luxurians* was first recorded in New Zealand by Colenso (21). In reference to the specimens he observed, south of Norsewood, County of Waipawa, in 1855, Colenso states that he was led to suspect a species nova on first acquaintance. The plants he observed had an extreme softness and tenderness, unusual in a rush, a great height, and a prostrate habit, features which were in contrast to other species which he had noted. The situation where they were found, and where they were growing plentifully, was an undisturbed forest swamp, and also in the hollows between the afforested hills. Owing to the softness and tenderness of the stems, they had been much browsed on by cattle.

Though Cheesman (3 & 4) refers to *J. luxurians* only under the description of *J. polyanthemos*, a recent investigation of the Plant Research Station has established the identity of, and separated this species as distinct from the above named species.

As this classification is based on the most recent work the present description relates to *J. luxurians*.

AUTECOLOGY:

LIFE FORM:

The extremely prostrate habit as described by Colenso has not been noted in field specimens, probably due to a changed environment, though the long stems ranging up to 4½ feet in length, have often shown a flexed condition. *J. luxurians* shows a close similarity in general features to (those of) *J. polyanthemos*. Striking points of difference in the former species from the latter species are in the colour of the stem, which in *J. luxurians* is a light bluish green, and the inflorescence also notable for its extreme density, and the large number of capsules borne to each seed head.

SHOOT SYSTEM:

As in related species the shoots developing from the underground rhizome are both vigorous and numerous.

ROOT SYSTEM:

An extensive root system which originates from the under surface of the rhizome appears to be identical in general structure, to that of *J. polyanthemos*.

REPRODUCTIVE SYSTEM:

Of the morphological characters, the inflorescence is easily the most striking feature of this species. Typical to name, it is luxuriant, dense and composed of a large number of flowers, borne on much branched cymes, of unequal length. The branches of the cyme ranged in length to 3 inches, and were 12 to 15 inches below the stem tip. The individual flowers were numerous, 1/10th. in. long, pale chestnut, and freely distributed along the branches of the cyme. Singly, their perianth segments were straw coloured, acute, equalling or being slightly longer than the seed capsule. The capsule was globose or obovoid, slightly obtuse and of brownish colour. A large number of yellowish brown seeds were matured.

DISTRIBUTION:

Specimens of this species are by no means uncommon, yet so far as has been observed, they favour the damper situations, where they are then able to develop their typical luxuriant growth. That the species has a general distribution in New Zealand is also indicated from specimens in the Plant Research Herbarium.

MORPHOLOGY:STEM:

## (a) External features.

Stems were cylindrical, of light bluish green colour, especially when young, and were 1½ - 4 feet in length. Young stems were soft and papery, so easily would they tear. When fully grown their diameter was approximately ¼ inch. Even at this mature stage stems were much less wiry than those of *J. polyanthemus*, while both species had fine, parallel external striations. The sheaths, of which there were 4 - 5, encircled the basal portions of the stems for distances up to 10½ inches from the rhizome. They were straw coloured above, gradually and imperceptibly changing shade, to a dark, shiny ebony black below ground.

## (b) Internal features.

The pith was so open and interrupted that little mechanical support to the stems could be afforded. This probably was the reason why stems of this species were more flexed than the stems of *J. polyanthemus*.

ROOT:

The roots were wiry, brown in colour, and approximately 1/10th. in. in diameter. (This measurement was made at ¼ in. from the rhizome, at a point at which all root measurements have been made.)

SPECIAL FEATURES:

## 1. Date of flowering.

The general period of flowering was from early in November to early December.

## 2. Injury.

Little injury by

grazing stock was observed, though the plants could be easily cut with sharpened shears. Where this species occurs in pasture, it could be cut without difficulty by mower, so tender are the stems.

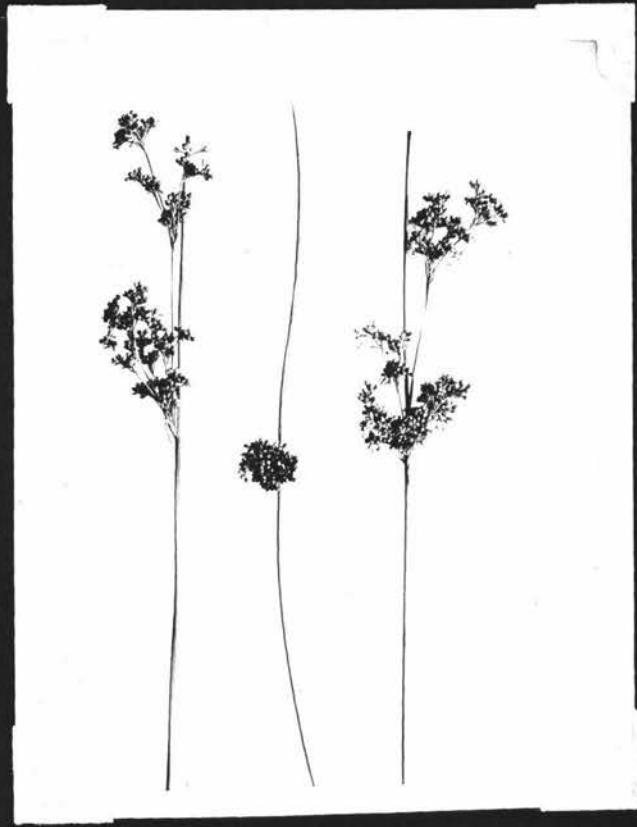
### 3. Seed and seed dispersal.

Specimens of the matured seed were collected late in February. When examined under a lens, the seed was seen to be longer and narrower than that of *J. polyanthemos*, though in colour and other external characteristics a general similarity was found. Average length of measured seed was 0.57 mm. and width 0.16 mm.

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P L A T E IV.

Inflorescence of *Juncus vaginatus*.



JUNCUS VAGINATUS: R. Br.  
FAMILY: Juncaceae.  
GENUS: Juncus.  
GROUP: Genuini.  
SPECIES: Juncus vaginatus.

This species is not confined to New Zealand, but has a general and wide distribution.

AUTECOLOGY:

LIFE FORM:

Plants usually form densely tufted groups, 2 - 3 feet in height, with stiff, erect green stems. Individual plants, or groups of plants, were frequently distributed amongst the Juncus vegetation in the fields examined. The general size of the plant, diameter of stems, and character of inflorescence, were found to be features which would readily distinguish this species from *J. polyanthemus*

SHOOT SYSTEM:

This was strongly developed, and shooting appeared to be directly favoured in the wetter positions, where there was little or no pasture.

ROOT SYSTEM:

Numerous wiry roots, of apparently the same general character as those of *J. polyanthemus* were noted.

REPRODUCTIVE SYSTEM:

The inflorescence was borne at an approximate distance of 9 inches from the stem tip. It was lateral, composed of grouped, globose, many flowered heads, borne on a branched cyme. Flowers were numerous, and slightly larger than those of the *J. polyanthemus* inflorescence. The perianth segments were lanceolate, acute and were equal to, or slightly less in length than the capsule. The capsule was globose, trigonous, and obtuse at the tip. The seed was numerous, and dusty brown in colour.

DISTRIBUTION:

This species was found to be less abundant than *J. polyanthemus*. Cheesman states that it has a wide distribution in New Zealand. In relative importance *J. vaginatus* was considered second only to *J. polyanthemus*. The writer has observed *J. vaginatus* growing in a number of districts in the North Island, while in the Manawatu it is particularly prevalent. Its presence in the South Island has been established from herbarium specimens collected from that source.

MORPHOLOGY:

STEM:

(a) External features.

Stems measured 2 - 3 feet in length, were green, wiry and 1/6th. in. in diameter.

Fine parallel striations ran the length of the stem. Basally the stem was encircled by 4 - 6 straw coloured papery sheaths, which merged in colour through stages of brown, to a shiny, dark reddish brown, in their lower limits.

(b) Internal features.

The stems were hollow, or nearly so, there being a characteristic absence of internal pith. This is a feature contrasting with that of *J. polyanthemus*.

ROOT:

The rhizome was approximately  $\frac{3}{8}$  in. in diameter. It was woody, and wiry. Roots from this rhizome were numerous, and averaged  $\frac{1}{16}$ th. in. in diameter. They extended a considerable distance from the parent plant before narrowing, and branching. Individual rhizomes have been traced back from a short living portion, for a distance of several yards. This indicates the power of advancement, and spread of the plants, where conditions are favourable.

SPECIAL FEATURES:

(1.) Date of flowering.

November was the month of principal flowering. Scattered stems, however, were noted to flower throughout the year.

(2.) Seed and seed dispersal.

Mature seed was obtained in quantity in the second week in February. A measure of individual seed showed an average seed length of 0.35 mm.

(3.) Hybridisation.

Cockayne (2) has stated, as previously noted, that this species is believed to hybridise with *J. polyanthemus*. An internal variation in the stem structure was observed, in which some stems showed a complete absence of pith, while in others pith occurred in slight measure. It is believed that this feature could be an effect of hybridisation.

(4.) Stock injury.

There has been no noted stock injury to this species. Stems are tough, and would thus resist injury.

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P L A T E V .

Inflorescence of *Juncus pallidus*.



JUNCUS PALLIDUS: R. Br.  
FAMILY: Juncaceae.  
GENUS: Juncus.  
GROUP: Genuini.  
SPECIES: Juncus pallidus.

HISTORICAL:

Colenso (22) in 1885 noted the occurrences of a rush to which he gave the name *Juncus macrostigma*. His observations in the County of Waipara in 1882, led him to state that this species was not numerous, as were others of the Juncaceae. Later Cheesman found that *Juncus macrostigma* could not be separated from the species *Juncus pallidus* to which it was found to bear a close similarity.

AUTECOLOGY:LIFE FORM:

Features which most readily distinguish this plant from related species are its comparative tallness, thickness of stems, and general sturdiness. In pasture specimens stand out in bold definition, contrasting with other species of smaller stature, and less robust growth.

SHOOT SYSTEM:

This is strongly developed. Shoots were stiff, erect and hardy.

ROOT SYSTEM:

The roots were numerous, long, wiry and woody.

REPRODUCTIVE SYSTEM:

The lateral inflorescence carried on the strong stem was often compact, rather than effuse. In comparison with *J. polyanthemus*, individual flowers were much larger, being approximately  $\frac{1}{8}$  in. in length, while the lanceolate perianth segments were exceeded by the brown, ovoid, trigonous, and bluntly obtuse capsule. Each capsule matured a large number of minute dusty brown seed.

DISTRIBUTION:

It has been common to note isolated plants in pasture, in contrast to groups of plants of other species. While its distribution is general, *J. pallidus* is by no means as common as *J. polyanthemus*.

MORPHOLOGY:STEM:

## (a) External features.

The mature stems were of dull green colour, finely striated, cylindrical, approximately  $\frac{1}{4}$  in. in diameter. Their range of length was up to

5 feet. Each was strong, erect and tapered off to a sharp point. Basally 4 - 5 membranous sheaths of pale green colour, or straw coloured above, and dark brownish black below, enfolded the stem.

(b) Internal features.

When split open the internal features of the stem disclosed a soft, white and continuous pith.

ROOT:

Individual roots of which there were many were brown, tough and wiry, and approximately  $\frac{1}{12}$ th. in. in diameter. The rhizome from which they took origin was also extremely hard and woody, and approximately  $\frac{3}{8}$  in. in diameter.

SPECIAL FEATURES:

1. Flowering.

Although the main period of flowering was in November, plants of the species *J. pallidus* were the first in which flowering was noted.

2. Seed.

Early in February it was possible to collect seed, which was quite numerous. Matured seed was of yellowish brown colour, spiculate and obovoid. The approximate average length of a number of measured seeds was 0.5 mm.

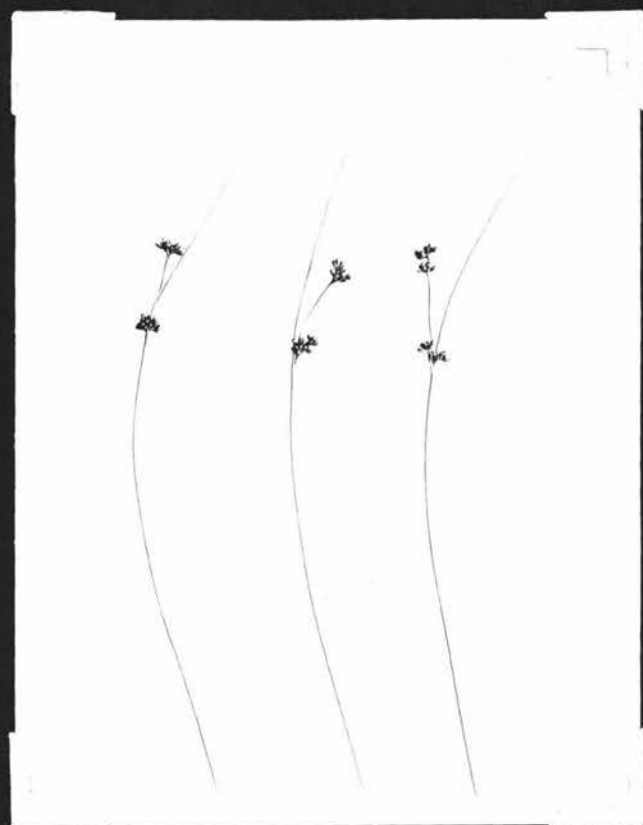
3. Stock injury.

The extremely robust, and woody character of plants of this species, adequately protected them against any injury which was liable to be caused through the agency of stock.

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P L A T E VI.

Inflorescence of *Juncus pauciflorus*.



JUNCUS PAUCIFLORUS: R. Br.  
FAMILY: Juncaceae.  
GENUS: Juncus.  
GROUP: Genuini.  
SPECIES: Juncus pauciflorus.

These plants have no leaves. The capsule is ovoid, trigonous, and conspicuously longer than the perianth.

HISTORICAL:

The first reference to the occurrence of *Juncus pauciflorus* in New Zealand was given by Kirk (24) in 1876. He had collected specimens in the South Island at Broken River, Canterbury, at an altitude of 2,000 feet. In 1882 Kirk (26) proposed to change the name of the plants he had observed to *Juncus brevifolius*, as the name he had previously applied had been used by Bentham to what Kirk believed, was another distinct species. However, it was later found that both collections were of the same species. In 1882 further specimens of *Juncus pauciflorus* were observed by a swamp in the Thomas River District, Canterbury, also at an altitude of 2000 feet.

AUTECOLOGY:

LIFE FORM:

Communities of this species have been found on lowland, and undulating sheep pasture country where its presence is relatively frequent. In general, such plants have not grown to a greater height than 1 foot. Viewed in their entirety, they were of yellowish green appearance, with large numbers of individual small wiry stems.

SHOOT SYSTEM:

There was a copious growth of shoots, though individual shoots differed from the larger species on the score of size and robustness.

ROOT SYSTEM:

As an allied species of *Juncus* there was copious root attachment to the under surface of the rhizome. The rhizome was approximately  $\frac{1}{4}$  in. in diameter.

REPRODUCTIVE SYSTEM:

A lateral inflorescence was borne below the stem tip. This had but few branches, while the cymes were open, lax and spreading. Of the few flowers, each was approximately  $\frac{1}{10}$ th in. long, pale chestnut, or brown. The capsule which formed a readily distinguishable feature because of its length, was ovoid, trigonous, and usually bluntly obtuse. Invariably it was much longer than the perianth. Segments of the perianth were brown, acute and lanceolate. Within the capsule numerous seeds were matured.

DISTRIBUTION:

Cheesman is of the opinion

that this species was introduced with grass seed in the early days of colonization, so wide is its present distribution. In this district it is frequently seen even on land of relatively light soil type, and its presence has also been noted as a frequent weed of the heavier soil types.

MORPHOLOGY:

STEM:

(a) External features.

In isolated clumps measured stems of 3 feet in length have been secured, though it is usual for the plant's stature to be considerably less. Individual stems, because of their small diameter in comparison to their length, were often flexed. They were wiry and finely striated. The stems tapered to a needle like point. Basally there were 4 -- 5 ensheathing membranes, of a shiny red brown colour, being of lighter colour above ground. These sheaths were finely grooved.

(b) Internal features.

While the majority of stems were practically solid, some few had a small finely interrupted pith.

ROOT:

Individual roots were approximately 1/10th. in. in diameter. They were yellowish brown. In the surface soil there were few fibrous secondary rootlets, though deeper in the soil there was free division, giving rise to an extensive root system.

SPECIAL FEATURES:

(1.) Date of flowering.

The main phase of the flowering was in November.

(2.) Seed.

There was variation in seed length. The approximately average length was 0.4 mm. The seed was obovoid, apically tipped, and of predominately brownish yellow colour.

(3.) Plant injury.

To all intents, there was little or no injury inflicted by grazing animals.

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P L A T E VII.

Inflorescence of *Juncus tenuis*.



JUNCUS TENUIS: Willd.  
FAMILY: Juncaceae.  
GENUS: Juncus.  
GROUP: Graminifolii.

The plants of this group have leafy stems, the leaves being flat, or semi-terete within.

SPECIES: Juncus tenuis.

Cheesman considered this species as a doubtful native of New Zealand. It is also abundant in parts of America and Europe.

HISTORICAL:

The first recorded description of Juncus tenuis falls to Kirk. In 1876 he described an apparently similar plant, under the name of Juncus involu-cratus. Later, in the year 1876 Cheesman (27) gave notice of the occurrence of Juncus tenuis within New Zealand. Cheesman's specimens had been collected in January, 1875, near Omana, bordering the Northern Wairoa river. According to Cheesman, plants were found on marshy ground, not far from the banks of the river.

AUTECOLOGY:

LIFE FORM:

The plant is a small laxly tufted perennial. It occurs singly, or in small groups, though its presence might easily be overlooked, through the plant's diminutive form.

SHOOT SYSTEM:

Numerous shoots are borne from the upper surface of the rhizome. The stems are leafy about their base. The stems themselves bear leaves. Shoots thus belong to two systems, the first from the rhizome giving rise to the stems, and those on the stems, giving rise to the leaves.

ROOT SYSTEM:

As the rhizome is very short and tufted the roots are fine, though numerous. The extent of the root system appears to be in keeping with the general size of the plant. The size of the roots is thus much less than those of the taller growing species of Juncus, while there appears also to be a greater number of fibrous roots within the surface soil.

REPRODUCTIVE SYSTEM:

Terminal cymes, lax, and overtopped by 2 - 3 leafy bracts, bore the flowers, which were single, or clustered. Singly these flowers measured approximately  $\frac{1}{8}$  in., and were featured by lanceolate perianth segments, exceeding the capsule in length. The capsule was ovoid, or more nearly globose, and obtuse. Numerous minute seeds were matured within, and were later freed when the

capsule segments parted.

MORPHOLOGY:

STEM:

(a) External features.

Stems of this species were laterally compressed, being more or less ovoid,  $1/16$ th -  $1/20$ th. ins. in the shorter diameter, and with delicate parallel striations. In length they were from 1 to  $1\frac{1}{2}$  feet, bore wiry leaves, and were basally ensheathed. Both stems and leaves were a uniform dark green colour.

(b) Internal features.

Stems when split were nearly solid, but had a small quantity of un-interrupted white pith.

LEAVES:

The leaves were long and narrow, flat or more generally involute. They were approximately 6 ins. long, and their general shape was somewhat similar to that of a blade of grass.

ROOT:

The roots were of chrome-yellow colour. They were finely fibrous, and extremely wiry. But for this latter feature, they bore a close resemblance to the roots of a fibrous rooted grass.

SPECIAL FEATURES:

1. Date of flowering.

November was the month in which flowering occurred.

2. Seed.

This was numerous of yellowish brown colour, obovoid, apiculate and seeds were approximately 0.45 mm. in length.

3. Injury.

No apparent injury from stock was manifest. Growth in pasture appeared to be weakened by shading from the taller species of *Juncus*.

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P L A T E VIII.

Inflorescence of *Juncus lamprocarpus*.



JUNCUS LAMPROCARPUS: Ehr.  
FAMILY: Juncaceae.  
GENUS: Juncus.  
GROUP: Articulati.

Plants of this group are characterised with stems leafy at the base, these often extending upwards. The leaves are terete, and are septate within.

SPECIES: Juncus lamprocarpus.

Although a common plant in many parts of the North Temperate Zone, in the Southern Hemisphere it is apparently restricted to New Zealand. Cheesman considers that it may not be truly indigenous, though it is now of widespread distribution within this country.

HISTORICAL:

The occurrence of this species in New Zealand was first noted by Kirk (23) in 1874. He found specimens growing near Wellington, where it occurred only in wet swampy places. At Invercargill the same writer found specimens not only in swamps, but also in places where it was scarcely moist. Its occurrence on railway tracks, was a habitat peculiarity which this botanist attributed as being due to the greater amount of atmospheric moisture available there. In noting the occurrence of the New Zealand specimens, Kirk concluded that the reason why the plant had been so long overlooked in this country, was due to the avidity with which it was eaten by cattle.

AUTECOLOGY:

LIFE FORM:

While individual plants were less strongly tufted than other Juncus species the most usual distribution was for a number of plants to be found together, rather than single plants. In a group of plants, the numerous, succulent, and decumbent stems, formed a dense mat of growth, almost like a sward of grass. When the inflorescence of the plant was borne in summer, it provided an easily indentifiable and characteristic feature.

SHOOT SYSTEM:

The shooting system developing basally from a creeping rootstock, produced both stems and leaves. Shoots were green, soft, and tubular. From the nodes of the stems and about their base, leaves were borne.

ROOT SYSTEM:

From the creeping rootstock a large number of succulent roots, of creamy white hue, took form. Root development was also observed from the nodes of decumbent stems in contact with the moist soil surface.

REPRODUCTIVE SYSTEM:

The reproduction

system was strikingly distinct from that of related species of *Juncus*. The upper portion of the stem was branched, and bore compound terminal cymes, each of which carried up to 7 small, brown flower heads, either terminally or axillary. Individual flowers were dark brownish black, and approximately  $\frac{1}{8}$  in. in length. The lanceolate perianth segments were of lighter shade, and were exceeded by the dark brown coloured capsule. This was trigonous, and unilocular. The seed ripened was much less numerous than the amount which was found in the capsules of the species *J. polyanthemus*.

DISTRIBUTION:

While of minor importance in connection with pasture problems, this weed has been found confined almost solely to boggy drains, and bordering small valley streams. On river alluvium it appears to have a habitat admirable suited to its needs and the plants of this species flourish there in practically pure association. In evidence of its now widespread distribution, the writer collected specimens at an elevation of 3,000 feet, near a roadside, in the heart of the Urewera forest, (Waikaremoana - Rotorua main route.)

MORPHOLOGY:

STEM:

(a) External features.

Examination showed that the stems were dark green, and of approximately  $\frac{1}{12}$ th. in. in diameter. Of the leaves, these were borne from positions near the nodes of stems, and were usually about 3 ins. in length. They were tubular, and strongly septate internally. The leaf sheaths enfolded the stems, and each had two auricles. At the base of the stem, 3 - 4 membranous sheaths, each of distinctly reddish colour, enfolded the stems for upwards of  $\frac{1}{2}$  ins.

(b) Internal features.

The nodes were of solid structure, between which a succulent uninterrupted pith, was noted in the stem interior. The leaves were septate internally.

ROOT:

The root system conveyed the impression that it was of a surface type. Individual roots were of creamish colour,  $\frac{1}{20}$ th. in. in diameter, and took origin from a creeping rootstock,  $\frac{1}{6}$ th. in. in diameter. This was also of creamish white colour, and was externally covered by small, scale like membranous sheaths.

SPECIAL FEATURES:

1. Flowering.

As a probable consequence of their general moist habitat, it was observed that the main flowering occurred early in November. The flowering period extended for only a short time.

## 2. Seed.

Of the comparatively few seed produced, an examination in February showed each seed to be of yellowish brown colour, obovoid, and externally finely patterned. The average seed length was 0.5 mm.

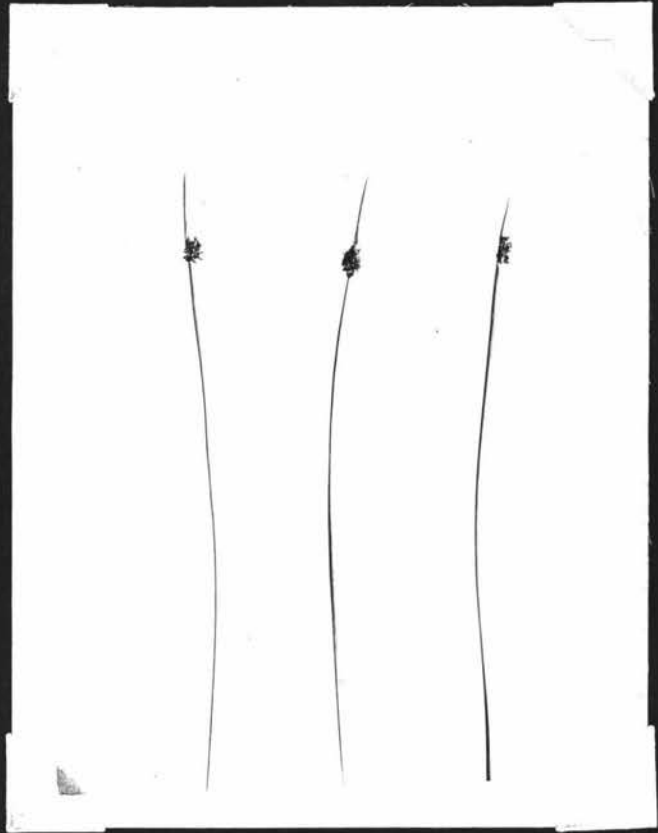
## 3. Stock injury.

Though Kirk maintains that the plant is relished by stock, the present indication has been that plants were left untouched, both by sheep and cattle, even in months of drought, when there was a general scarcity of pasture.

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P L A T E IX.

Inflorescence of *Scirpus nodosus*.



SCIRPUS NODOSUS: Rottb.

SPECIAL NOTE:

Although *Scirpus nodosus* is not a member of the Juncaceae it has been included in this study because of its rush like growth habit, and its presence in pasture on the coastal belt of the Manawatu.

FAMILY: Cyperaceae.

A very large family found in all parts of the world, both temperate and tropical, and abundant in marshes, or by the margins of lakes and rivers. It is stated that in all, there are about 3,500 species, comprising 68 genera.

GENUS: *Scirpus*.

The spikelets are usually many flowered, flat or compressed. Flowers are hermaphrodite, hypogenous, and have no bristles. Cheesman states that of the 13 species found in New Zealand, 4 are generally distributed in both the Northern and Southern Hemispheres. Two only are endemic.

SPECIES: *Scirpus nodosus*.

This species has a wide distribution. It is found in the Pacific Islands, Australia, South Africa, South America and other countries.

AUTECOLOGY:

LIFE FORM:

Plants were tufted, or freely spreading, 1½ - 4½ feet in height, with numerous rigid, yellow green stems. The plants showed almost a complete absence of dead stems, and the living stems made very vigorous growth.

SHOOT SYSTEM:

Shooting from the rhizome was free. In the sandy soil type there was evidence that plants of this species were capable of rapidly invading the sparse pasture. In the early stages, shoots were creamy white. On further development they became extremely wiry, and rigid. In their earliest stages of development from the rhizome, surface shoots were protected by furry, brown scale like membranes.

ROOT SYSTEM:

The rhizome was exceedingly woody, and gave rise to a large number of wiry roots of deep penetration.

REPRODUCTIVE SYSTEM:

The seed head was solitary, globose, brown, ¼ - ¾ in. in diameter, and composed of numerous, densely crowded spikelets, laterally borne. The seed head was 1 to 2 ins. below the stem tip, the spikelets were ovoid, 1/5th. in. in length, and were many flowered. The seeds, or more accurately nuts, were

numerous, much larger, but fewer in number per head, than that of the Juncaceae.

DISTRIBUTION:

In the coastal areas of sandy soil, this species is found to the exclusion of practically every other rush, with the exception of *J. tenuis*, in which association it has been observed. The distribution of *Scirpus nodosus* on sandy soil seems to be a habitat peculiarity, in that its position there is one in which rush growth might least be expected. There is an apparent lack of free water, while the sandy soil itself appears incapable of water retention. This would lead to the assumption that the rooting system must be both deep and extensive, as the more shallow rooting pasture grasses have their growth severely checked by summer drought while that of the *Scirpus nodosus* appears to be little affected. *Scirpus nodosus* has been noted in estuaries flooded by brackish water. Here also is found *Juncus maritimus* which appears to be practically confined to this habitat.

MORPHOLOGY:

STEM:

(a) External features.

The stems were cylindrical, or nearly so, being sometimes slightly flattened. Their range of length was from  $1\frac{1}{2}$  to  $4\frac{1}{2}$  feet. They were yellowish green, finely striated and tapered to an acute and firm point. Stems examined were extremely wiry, stiff, erect and were approximately  $\frac{3}{8}$  in. in diameter. There was a complete absence of leaves, though 4 - 5 sheaths of brownish colour encircled the basal portion of each stem for a distance of up to 4 ins. from the rhizome. The stem tips were conspicuous, especially after flowering, when their colour changed from a green to a canary yellow colour.

(b) Internal features.

Stems were completely solid. The central portion was filled with a watery translucent pith, yielding free liquid when compressed.

ROOT:

The rhizome had an average diameter of  $\frac{3}{8}$  in. From its under surface numerous small roots approximately  $\frac{1}{16}$ th. in. were found. The root colour was greyish brown. There was an abundance of root hairs almost immediately beneath the rhizome.

SPECIAL FEATURES:

1. Date of flowering.

When this locality was visited early in November, the greatest proportion of the stems had flowers.

2. Seed and seed dispersal.

Mature seed was ob-

-tained in the second week in February. In length it was approximately 1.3 mm. and had a width of approximately 0.75 mm. The shape was obovoid. The apical end was pointed. Each seed was trigonous, the flat faces having a light brown colour. Owing to its much larger size than the seed of the Juncaceae, it is likely that wind distribution over a wide area would be less probable than with most species of Juncus.

### 3. Quantity of seed.

From a number of seed heads ripened indoors, and which were later completely threshed, a counted average revealed 120 seeds per head.

### 4. Stock injury.

The extremely wiry and evidently unpalatable nature of the plants has secured for them complete immunity from damage by stock.

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S E C T I O N IIIENVIRONMENTAL FACTORS.CLIMATIC:RAINFALL.

The situation from which these observations relating to rush growth have been recorded has an annual rainfall lying between the limits of 30 - 45 ins. per annum. An exact average for any number of years is unavailable, owing to incomplete meteorological data. Compared with many other portions of New Zealand the total rainfall is low, though it is well distributed over a large number of days per annum. The summer period is one of slightly less precipitation than the winter, but a fairly even distribution is maintained throughout the year. These features are illustrated from the weather records of season 1933-34, data being obtained from the College station.

<u>MONTH</u>	<u>RAINFALL</u> (Inches)	<u>NUMBER OF</u> <u>RAINY DAYS.</u>
January.	1.73	15
February.	2.59	14
March.	2.88	8
April.	3.58	17
May.	4.62	14
June.	2.97	13
July.	3.09	19
August.	2.52	14
September.	2.69	15
October.	1.76	13
November.	2.39	14
December.	2.78	11
	<hr/>	<hr/>
	33.60	167
	<hr/>	<hr/>

TEMPERATURE:

The temperature variations figured below have been taken from the N.Z. Official Year Book (28) and represent averages for this locality, from recordings which have extended over a number of years.

Mean daily maximum	61.2 F in shade.
Mean daily minimum	46.3 F " "
Approximate mean Temperature	53.8 F " "
Absolute maximum	91.0 F " "
Absolute minimum	23.0 F " "

Temperature has a general effect on practically every function of the plant. The moisture absorbing capacity of the air increases with increasing temperature, though the volume of air saturated at any time is dependent also upon wind. Though this particular region is not one of temperature extremes, high winds are often experienced. This is probably a factor

aiding pollination and hybridisation, besides facilitating a large effective radius for seed dispersal. It is probable that *Juncus* communities can withstand rigours of climate in far greater severity than exist in this district. Their distribution in the South Island of New Zealand, where greater temperature extremes are experienced would in itself lead to this conclusion.

#### LIGHT:

From their position in the field it is evident that *Juncus* vegetation is not tolerant of shade. Wind, and high summer temperatures, appear to have little drastic effect on *Juncus* foliage. This is probable due to the restricted transpiration surface. Wilting has never been observed. Due to the clumped nature of the stem growth, individual stems are always more or less shaded. They are thus protected from strong light and wind.

#### PHYSIOGRAPHIC:

##### TOPOGRAPHICAL FEATURES:

Rushes have been observed growing both on wet swampy areas and on dry upland situations. There is an undoubted preference for a wet habitat. Topographical features control to a large extent the soil water relationships. The appearance of rushes on apparently well drained soils, suggests that the popular belief that rushes are plants only of waterlogged land, is not entirely correct.

#### EDAPHIC:

##### THE PHYSICAL NATURE OF THE SOIL:

This is not thought to be a primary factor conditioning the presence or absence of rush vegetation. The moisture retaining capacity of the soil, be it caused through a high organic fraction, or a high colloid content, is believed to be of much more importance. There is an apparent anomaly however to any such hypothesis when *Scirpus nodosus* is considered. It thrives on a free draining sandy soil. The clays, loams, organic and peaty soils, although of vastly different physical nature, all have a high water retaining capacity.

In illustration of the markedly different habitats where *J. polyanthemus* has been observed, the following two mechanical analyses are included. Although the second analysis shows a rather high difference figure, the point at issue, the marked difference in soil type, is quite well brought out.

Soil "A" is from the top 9 ins. of the field from which, in a later section, the root structure of *J. polyanthemus* was studied. Sample "B" was from a free draining upland soil, where *J. polyanthemus* was seen, its occurrence in this position having already been noted. Both soil types supported *Juncus* communities, though that of soil type "A", undoubtedly provided the superior habitat.

<u>FRACTION:</u>	<u>SOIL "A"</u> %	<u>SOIL "B"</u> %
Gravel and coarse stones,	--	--
Coarse sand remaining on 0.2 mm. sieve.	1.98	33.52
Fine sand estimated by sedimentation.	41.50	31.43
Silt: estimated by pipette method.	21.75	10.50
Clay: " " "	21.00	3.60
Moisture retained in air dry soil.	2.74	4.46
Loss by solution.	2.30	5.80
Loss on ignition.	12.20	14.62
Difference figure.	3.47	6.07

#### SOIL DIFFERENCE:

Although these two soils both show a somewhat similar figure for loss on ignition, that of the clay soil "A" was probably largely due to the partial removal of the combined water of the clay colloid, while that of type "B" was undoubtedly due to a high organic content. This feature, which was apparent from the soil texture, and colour, probably directly influenced the accuracy of the resultant analysis, and helped to cause a high difference figure in soil "B".

#### WATER CONTENT:

The water content of soil of type similar to "A" has been examined at monthly intervals, results of which will be later discussed. The maximum water holding capacity of this soil was investigated by the "Sticky-point" method. The average of a number of determinations gave a moisture content of 61.75% of moisture at sticky point, reckoned on the oven dry weight of the soil.

Coutts (29) studied a range of South African soils, and found that their saturation capacity was almost identical with the calculated sticky points. If in this soil investigation the sticky point is assumed to be the approximate maximum soil water holding capacity, then it will be possible, by the monthly records of soil moisture, similarly reckoned, to compare the degree of soil saturation for moisture at any period of the year, with the experimentally obtained maximum water holding power. Field results show, that, even under conditions where the soil appeared to be thoroughly waterlogged, no value as high as that of the sticky point determination was recorded, though, on several occasions, a near value was shown for the 0 - 3 in soil sampling.

#### p H of soil.

<u>SOIL "A"</u>	<u>SOIL "B"</u>
5.38	4.48

As both soils had an acidic reaction, it was assumed that rushes and particularly the species *J. polyanthemos*, was tolerant of an acidic soil condition.

#### BIOTIC:

#### DUE TO MAN'S INFLUENCE.

Management in all its phases is of the greatest importance in modifying a habitat so that it becomes tenable, or untenable, to any plant. The influence of management will be more fully discussed in Sec. V.

P L A T E X

Field "A" of narrative. Rush communities on hill top, with practically rushless knolls and slopes behind, and to sides of figure.

Photo: W.M. Hamilton.

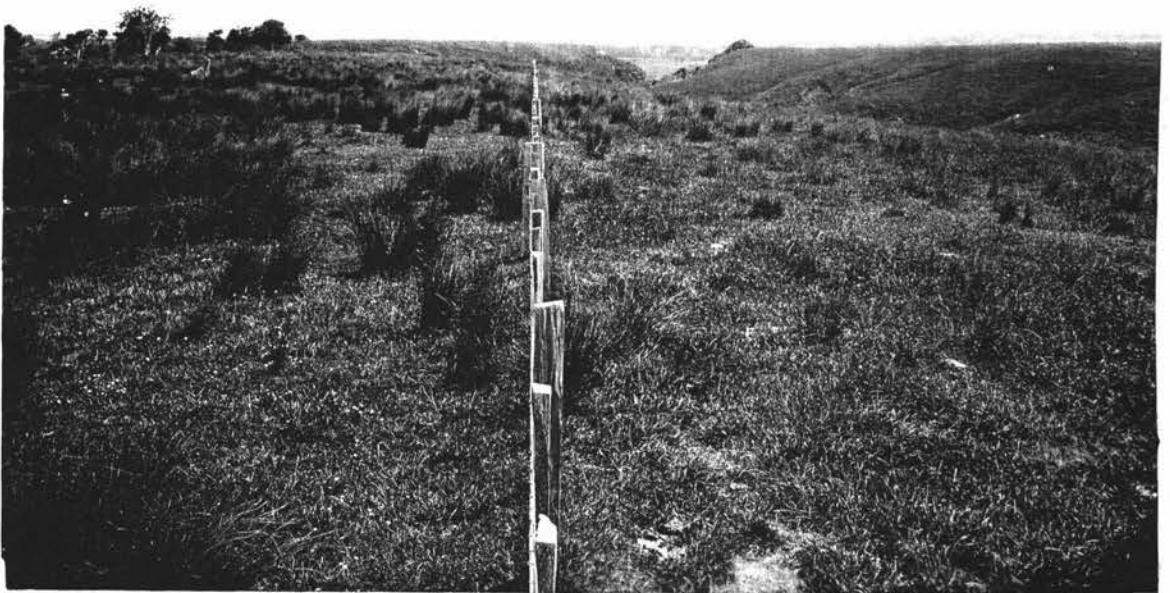


P L A T E XI.

- (a) Field "A" of narrative in foreground. Area "D" to right of fence line.

Photo: W.M. Hamilton.

- (b) Field "B" to left of fence line and "C" to right.



S E C T I O N IV.THE ENVIRONMENT AND ECOLOGICAL METHOD.INTRODUCTORY:

Though there are numerous rush covered areas in this district, a comparatively small section of the College farm, comprising some 40 - 50 acres, was selected for detailed observational studies of the growth phases, and other features, of the *Juncus* flora. The observations were collected from a full seasons study.

An exact knowledge of the conditions to which these particular fields had been subjected was traceable for the 7 years of the present tenure. The location was perhaps more suited than any other then available from this fact, together with the noted variation in rush density, peculiar to particular positions in these fields, and the adjacent land of private ownership. A number of striking fence line differences have been availed of, reflecting the effect of environmental influences, as they have so modified the vegetation.

SOIL TYPE:

While the analysis already cited in Section III is generally indicative of the respective soil fractions to a depth of 9 inches, the underlying pan influences drainage over the whole area to such an extent that, in the winter, this heavy loam is particularly wet, and apparently waterlogged. In summer, to the contrary, the soil dries out, when it becomes extremely hard and exhibits surface cracking.

PLANT COVERING. GENERAL:

The pasture on this portion of the college land is generally of poor quality, open and weedy. In positions where moisture determinations have shown to be usually drier and where there is no rush growth, Ryegrass and other of the more valued pasture grasses are found. On the wet land there is a marked seasonal growth of White Clover, and Trefoil. When these clovers disappear in winter, the sward is often extremely open. Practically the whole of this wet area supports a heavy rush growth, in which the following species occur; *J. polyanthemus*, *J. effusus*, *J. pallidus*, *J. luxurians*, *J. pauciflorus*, *J. tenuis* and *J. lamprocarpus*. The first named of these species has easily the largest coverage, while the others are found in minor proportion. The adjacent land of private ownership, though still in poor pasture, has been less intensively grazed over a number of years, and here much less rush growth has developed. In several positions which have been more or less inaccessible to grazing animals, there is a tall rank growth of pasture, with an almost complete absence of rushes.

PARTICULAR LOCATIONS. THEIR COVERING AND HISTORY:

The history of FIELD A which had not been previously ploughed, has shown that over the last 7 years it has been heavily grazed, principally by sheep, though to less extent by cattle. It had been mole drained a full season before the commencement of these observations. The greater proportion of the rushes present were in symmetrical communities, appearing to be<sup>n</sup> an apparently stable form. A very noticeable feature, and generally

characterised over a very wide area of country in this locality, was the complete, or almost complete, absence of rushes on knolls and the sloping land bordering gullies. This feature is visible to the left of, and behind the figure, Plate X.

Some seven months after the commencement of the collection of data, Field A was unexpectedly brought under cultivation, thus interrupting further study there.

FIELD B illustrated as the left hand section of Plate XI b, is of a similar general soil type. It has neither been drained, cleared of timber nor cultivated, though it has received a small top-dressing of phosphatic fertilizer in the past, equivalent to that also received by Field A. There is on Field B a dense rush growth and little pasture. The ground is sodden and wet in winter, and cuts up badly. Sheep and cattle have closely grazed the sward, though very little feed appears to be available at any period of the year.

FIELD C adjoining B, and divided by a fence line, has received no cultivation, but has been grazed almost solely by cattle for the last 14 years. It is of private ownership. The pasture is obviously undergrazed, a condition probably existant over a number of years, and it shows a striking reduction in rush growth from that of Field B.

SECTION D appears to the right of the fence line in Plate XI a. It partly adjoins Field A on its northern boundary, and is separated from A by a fence line. This particular section is bounded on the off side by a precipitious cliff face. Being practically unused the section supports a rank growth of Brown Top, and Tall Fescue, (*F. aurundenaceae*), the rush growth being almost completely smothered and obliterated. There is a contrast in rush growth when Section D is compared with the adjoining field on the left of the fence, where the pasture has been continuously and closely grazed over a long period.

#### EXPERIMENTAL:

On the above described fields and in positions more accurately defined later, pasture analyses and soil moisture determinations have been made. On portion of Field A an exccaration was made to study the rooting habit of *J. polyanthemos*, while on Field B a series of cutting trials was commenced, in an endeavour to trace the period of maximum growth of the above named rush.

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SOIL MOISTURE DETERMINATIONS:GENERAL:

That soil moisture is one of the major factors determining the existence of a plant in any environment has universal recognition. Moisture is essential for the functioning of the plant's vital processes. An excess may be as detrimental as an insufficiency, particularly to those plants not adapted to such moisture extremes.

Of rushes it had been noted that growth was possible in a waterlogged habitat. With an excess of available water, plants assumed a clumped appearance, and showed little inclination towards an outward spread, or radial migration, while where the habitat was but seasonally wet, extension was free, taking the form of either a rapid rhizome growth in one direction, or the apparently more stable communities of ring appearance. Plate XIIIb.

The moisture relationships have been obtained from results of determinations of moisture content of samples from four field locations, although of these, three only have been taken to completion.

OBJECTS:

Under a subsection dealing with the location, history and rush coverage of the experimental fields, it has been shown that a number of different conditions have evidently influenced the amount and density of rush coverage on these various sections. In fact, even where two fields have been separated only by a fence line, marked differences in rush growth are visible. It was with the object of determining the importance of the soil moisture factor in influencing these conditions, that the moisture determinations were made in the undermentioned locations.

EXPERIMENTAL:

A strip 50 feet in length was permanently pegged in each of the following positions, for a study of soil moisture relationships:

(1) On Field A, on mole drained land. The greatest proportion of rushes here were in communities of ring growth. This was not taken to completion, through the enforced intervention of a period of cultivation.

(2) Also on Field A, but on a completely rush free knoll.

(3) On land seasonally wet, heavily rush covered, in Field B. The rushes here were showing an unmistakable tendency to spread.

(4) Within Field C, parallel to Strip 3, and approximately 20 feet apart. This position was indicative of the general condition of the field, which was lightly rush covered.

SAMPLING, TECHNIQUE, AND DETERMINATION OF RESULTS:

Samples were taken monthly. The period of sampling extended over twelve months. Samples were taken concurrently with pasture analyses and from nearby positions.

Ten representative soil cores were taken from each strip, at approximately similar positions on each sampling date. The soil sampling tube had an internal diameter of  $\frac{3}{8}$  in. Duplicate samples from two depths, 0 - 3 ins. and 3 - 6 ins., were taken. They were immediately removed in glass jars having close fitting stoppers; the soil was weighed and oven dried to constant weight, at 98 C. Results have been expressed as percentage moisture on oven dried weight, and have been averaged from the duplicate samples, either of which has shown a variation from the other of up to 1 %, or occasionally slightly over.

#### SAMPLING DEPTHS:

Except in particular circumstances the usual depth of soil sampling for moisture determinations is 9 ins. the 0 - 3 in. level was chosen for the following reasons:

The rush rhizomes had been found usually within 3 ins. of the soil surface, and in winter an appreciable stem growth was seen to be taking place, which was probably aided by the moistness and soft condition of the immediate soil covering. Together with the fact that the trampling of grazing animals was noted to have most effect on the surface soil, particularly as regards retention of water through puddling, it was believed investigation of this 0 - 3 in. level would be fruitful. Conversely, beneath the rhizome, root examinations had shown that before the vertical descent of the roots deep into the subsoil, the greater aggregation of new and old roots, was within 6 to 12 ins. of the soil surface. When stem development from the marginal shoots was occurring, most of the new roots were within the first 6 ins. Whether the immediate subsoil was wetter than the surface soil, through the impidence of soakage, was a question also considered worthy of examination.

#### IRREGULARITIES:

In no case has the observed recordings of moisture in the 0 - 3 ins. level given a result as high as the maximum water holding capacity of the soil, previously determined by the sticky point method. Observations in the middle of winter, appeared to indicate that the surface soil was practically saturated, as free water was often present, especially in puddled hoof impressions. On several occasions it became impossible to make a sampling from the exactly required position. At these times positions nearby were sampled.

#### RESULTS:

As previously stated, cultivation in Field A was responsible for incomplete results from this strip; the results of strips 2, 3, & 4 are included, complete, in the soil moisture table, while results of principal importance have been graphically illustrated.

#### DISCUSSION OF RESULTS:

The following points appear from the experimental results:

- (1) The 3 - 6 in. level is, at all periods, in each strip, of lower moisture content than the surface soil.
- (2) From August to November, (late Winter - early Summer) the soil moisture of the rush-free strip 2, 0-3 ins. is nearly similar to that of the

rush-covered Strip 3, but in every case is slightly less. In the summer, December to April, it is considerably drier.

(3) Throughout the year the 3 - 6 in. level of the rush free strip is drier than at the same level of the rush covered strip. This is very markedly so in the summer.

(4) The 0 - 3 in., and 3 - 6 in. levels of the rush covered, and the lightly rush covered Strips, (3 and 4) throughout the year, do not show a significant difference in moisture content, although there are minor fluctuations.

(5) In so far as results have been obtained for Strip 1 soil moistures did not differ greatly from those of positions on Strips 3 and 4.

Although the precipitation over this whole area was likely to be similar, or nearly so, the rush free portion, in virtue of its position, had better natural drainage, which would be of advantage at periods of heavy downpour. The last sampling of this rush free portion has indicated a moisture value slightly above that of either of the other strips. This may be accounted for by the longer growth of grass on this strip, through light grazing. There had been heavy rain in the period prior to the sampling. It is reasonable to believe that this surface sward checked the natural run off, thus retaining more moisture in the surface soil.

The difference in moisture content between Strips 3 and 4, besides being due in slight measure to experimental error, could be effected by the vegetation shading, and preventing evaporation after rainfall, and alternatively by the roots drawing on moisture reserves in the soil during periods of drought, thereby decreasing the soil moisture.

#### CONCLUSIONS:

From the evidence of the difference in moisture content between the rush free, and the rush covered portions, it has been concluded that moisture is one of the major factors conditioning rush establishment, and successful growth. When, however, the moistures of the rush covered strip are compared with the moistures of the lightly rush covered portion, which is closely adjacent, and which is separated merely by a few feet, although in a different field, it must be assumed, due to their apparent equality in moisture content, that factors other than moisture are responsible for this practically rush-less condition. Here it is probably that the effect of grazing, and the density of the sward are complementary factors, which partially obscure the moisture effect alone.

There can be little doubt that the moist condition of the surface soil in Strip 3 was directly favourable to the shooting and spread of rushes, as is apparent in this field.

The evidence obtained is interpreted to substantiate the need for drainage, so that the environmental conditions will become more favourable for pasture, and less favourable for rush growth.

SUMMARY OF SOIL MOISTURE DETERMINATIONS

% moisture reckoned on oven dry weight at 98° C.  
Average of duplicate determinations.

STRIP	DEPTH - INCHES	Aug. 3.	Sep. 5.	Oct. 2.	Nov. 6.	Dec. 5.	Jan. 10.	Feb. 12.	Mar. 13.	Apr. 7.	May 9.	Jun. 8.	Jul. 9.
		I	0-1-3"	51.42	54.06	46.21	41.84	23.44	31.28	FIELD UNDER CULTIVATION			
	3-6"	41.48	35.01	30.92	26.35	19.75	21.60						
2	0-1-3"	49.14	49.30	49.18	44.61	14.96	24.66	24.60	27.92	15.85	41.34	49.76	60.05
	3-6"	31.96	34.55	32.26	21.32	10.72	14.46	13.68	14.33	11.77	17.45	22.83	28.90
3	0-1-3"	52.25	50.63	52.54	45.68	22.35	31.15	31.52	40.33	28.38	46.07	49.32	56.69
	3-6"	44.91	41.36	36.37	28.40	17.44	20.64	21.38	29.80	22.75	33.23	34.72	39.74
4	0-1-3"	55.32	51.51	45.52	41.69	21.37	33.89	32.33	39.53	25.93	46.09	48.83	53.18
	3-6"	44.65	38.53	32.82	25.40	17.18	24.95	25.80	30.25	23.50	33.84	34.41	38.90

MOISTURE DETERMINATIONS WITHIN AND WITHOUT JUNCUS COMMUNITIES:GENERAL:

An endeavour was made to take soil samples for moisture determinations from the above locations, in rings of growth, where pasture analyses had previously been made. It was found that the large number of dead roots encountered within the groups, materially affected the result. (See Plate XIII)

CONCLUSIONS:

Without direct experimental evidence it has been concluded that the outer margins, of spreading rush clumps are more favoured as regards moisture, than within the clumps. This conclusion has been made from the following observations.

1. The central portion of a ring of growth is usually elevated, and contains numerous dead roots immediately beneath the soil surface.

2. Grazing animals tread around the margins of the plants, in many cases causing noticeable depressions. Run off water is retained in these natural depressions, and also in the hoof impressions left by animals browsing around the rush clumps.

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PASTURE ANALYSES:"A". FROM FIELD POSITIONS.OBJECT:

To trace any relationship which might exist between the openness of the sward and the rush vegetation thereon.

Previous observation had established the fact that there was little spread of rush growth on Field A, whereas on Field B, there was both a heavy rush coverage and every indication that the habitat was favouring rush extension. In the adjoining Field C, which had been obviously undergrazed, no attempt was made to carry out a detailed pasture analysis. This area had been lightly grazed by cattle for a number of years, a condition which was amply reflected in the rank growth of herbage, found at all periods of the year. It was considered here, that grazing was providing no special influence likely to facilitate the development of an extremely open sward.

METHODS OF PASTURE MEASUREMENT:

The older methods employed in charting vegetation (33 & 34) have proved to be both tedious and slow, while in addition the areas examined were often considerable damaged.

The Point Method of Pasture Analysis (10) although of comparatively recent origin, has received high commendation (32) by recognised authorities. It is admirable suited for employment on grazed pastures, or those of dense down like swards.

This method has been employed for tracing the growth changes and the comparative relationships of 3 strips of pasture. The method has proved eminently satisfactory.

TECHNIQUE, LOCATION AND ESTIMATION OF RESULTS:

Between two pegs, each 30ft. apart, monthly analyses of pasture have been made. The 3 positions chosen for analyses were near similar strips from which soil moisture determinations were made. These have previously been described under headings 1, 2, 3, in that subsection. Initially great care was exercised in choosing the positions for these pasture strips from which analyses were to be made. This was necessary so that no abnormal condition would result, such as pasture injury which might be expected if the strips were crossed by, or in proximity to sheep tracks.

While it was not desired to trace the detail of the finer pasture constituents, about 300 points were examined on each strip at every analysis. This number of points was considered adequate, as only the main pasture changes were required, and more particularly the condition of sward openness. Levy and Madden (10) have stated that analyses each of 100 points are sufficient, where only the major pasture constituents are desired, but 400 - 500 points are required for the detail of the minor pasture constituents.

The method of determining the percentage cover each species was contributing to the total coverage, a figure in which the results have been

derived from the formula employed for the standard 100 point analysis. i.e.,

$$\frac{\text{Number of times a species is hit per 100 points examined} \times (100 - \text{percentage of bare ground})}{\text{Total times vegetation is hit per 100 points examined}}$$

### RESULTS:

The tabulated results of each section analysis have been separately listed, while the sward openness has been graphically represented also.

### CONCLUSIONS:

1. The most important result of the 3 pasture analyses is derived from a comparison of the sward openness of each strip at different periods of the year. It is believed that in their application to rush control these results must be interpreted along with concurrent soil moisture determinations.

2. The most striking difference between the heavily rush covered strip and the rushless strip, is the comparative openness of the latter over the summer. This feature commenced in November and extended to May.

3. The rush covered strip, probably due to its greater soil moisture, retained a close sward during the summer. The seasonal growth of clover and trefoil aided this condition.

4. At the commencement of pasture recordings in August, both strips, rush covered and non-rush covered, had open pastures, while the former exceeded the latter in this respect.

5. In the period from March to July, the sward openness on the rush free strip began to decrease, while that of the rush covered strip showed an increase.

6. The results from April for the rush free strip, (dotted lines on graph.) are not comparable, because the strips were not then under comparable grazing conditions.

7. As far as results for Strip 1 have been obtained, where rush growth was present but not in an actively extending form, a somewhat intermediate condition between Strips 2 and 3 was recorded.

8. When the sward openness of Strip 2 is compared with the corresponding soil moisture determinations it is seen that the very open sward here during the summer is most likely due to the dry soil condition. The comparative dryness of this soil has been experimentally shown. This strip analysis records a predominately Ryegrass pasture. In early spring the openness of the pasture fell to half of the previous figure. Further falls occurred up to November. By December, <sup>Conditions</sup> here were drier than in either of the other strips. The Ryegrass had made its early summer flush of growth, and from then to March, pasture growth was retarded by a lack of moisture. Continued grazing was probably a complementary factor causing this condition.

9. Disregarding the periods of greatest growth of pasture grasses and weeds of each strip,

it is clear that the positions of most active rush growth were also those where pasture was open in winter, and where the soil had the greatest moisture content.

10. The actual pasture of Strip 2 was superior to that of Strip 3 which showed a larger proportion of weeds.

11. Interpreted in conjunction with the soil moisture determinations, it is believed that the non-appearance of rushes on Strip 2 was due both to the drier condition of the soil, and a closer sward of grass in winter, as opposed to a sward of flat weeds and grass, grazed to its maximum.

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SUMMARY OF PASTURE ANALYSES: STRIP I

Percentage cover contributed by each constituent to sward from approx. 300 points per month.

Aug.12.Sep.12.Oct.13.Nov.13.Dec.8.Jan12

Bare ground.	18.42	19.93	12.55	4.93	4.54	11.42
<u>SPECIES:</u>						
Brown Top.	20.24	19.16	21.22	21.56	22.14	23.19
Perennial Rye.	17.04	13.19	11.62	8.58	9.24	8.40
Sweet Vernal.	14.06	13.19	13.28	17.74	12.51	20.83
Crested Dogstail.	8.31	11.57	10.70	9.54	11.93	8.06
Yorkshire Fog.	5.76	1.63	3.14	7.05	5.58	5.05
Danthonia pilosa.				0.18		0.34
Poa annua.			0.18		0.19	
Timothy.			1.29	1.71	0.19	
Cocksfoot.		0.18	0.18	0.18	0.19	
Fescue (fine leaved)		0.18				
White Clover.	2.13	6.20	7.46	6.49	4.62	5.04
Suckling Clover.	1.70	3.20	4.34	9.35	8.86	0.34
Catsear & Hawkbit.	9.37	7.59	9.05	9.53	17.13	13.78
Dandelion.		0.18	0.74	0.18		0.17
Field Daisy.	1.06	0.54	0.74	0.37	0.19	0.17
Buttercup.	0.21		0.37	0.37		0.17
Piri-piri.				0.18		
Plantain-N&B-leaved	0.21	1.27	2.03	0.75	0.96	2.02
Speedwell.				0.18		
Pennyroyal.	0.64	1.45		0.95	1.73	0.34
Mouse-eared Chick-Weed.	0.42	0.18	1.11			0.17
Scotch Thistle.						0.51
Moss.	0.42			0.18		
Juncus lamprocarpus		0.36				
<u>CONDITION:</u>	a	a	a	b	b	b
	c	c	c	c	d	d

Field under cultivation.

SUMMARY OF PASTURE CONDITION

- a. Closely grazed.
- b. Poorly grazed - rank growth.
- c. Green.
- d. Dried.

SUMMARY OF PASTURE ANALYSES. STRIP 2 .

SUMMARY OF PASTURE CONDITION.

- a. Closely grazed.
- b. Poorly grazed - rank growth.
- c. Green.
- d. Dried.

1933 - 34.

Percentage cover contributed by each constituent to sward from approximately 300 points per month.

	Aug. 11.	Sep. 15	Oct. 13	Nov. 15	Dec. 6	Jan. 11	Feb. 15	Mar. 12	Apr. 5	May 10	Jun. 7	Jul. 10
Bare ground.	23.05	11.80	9.28	8.27	21.15	27.81	27.85	30.54	21.01	14.38	11.09	9.25
<u>SPECIES:</u>												
Brown Top.	4.65	7.29	7.67	7.10	6.70	8.77	9.06	8.57	9.90	6.30	5.93	5.63
Perennial Rye.	45.25	45.66	54.23	47.98	47.26	47.88	49.86	46.85	52.55	52.75	54.68	58.18
Sweet Vernal.	0.41	1.04	1.68	1.73	1.34	0.92	0.57	1.82	1.62	1.08	0.88	0.84
Crested Dogstail.	1.21	1.39	0.19	0.77	0.77	0.92	0.76		0.18	0.76	1.09	0.63
Yorkshire Fog.	7.48	9.03	6.55	9.60	9.58	5.66	4.16	4.56	4.84	10.74	11.21	11.41
Danthonia pilosa.		0.52		0.19	0.38		0.19		0.18			
Poa annua.		3.30	3.55	2.11	0.19	0.18						
Timothy.			0.19	0.19		0.18						
Bromus hordeaceus.					0.19							
Cocksfoot.	5.46	5.38	4.86	5.18	4.98	4.75	5.10	3.28	3.23	6.29	5.86	4.67
White Clover.	2.02	3.65	3.93	2.69	0.38	0.37	1.32	1.28	1.62	2.61	2.10	1.83
Suckling Clover.	0.20	0.52	0.38	5.56	4.40	0.18			0.54	0.66		
Catsear & Hawkbit.	1.82	1.57	0.56	4.22	1.72	1.65		1.09	2.34	2.73	2.46	2.09
Field Daisy.	0.61	0.17	0.19						0.18		0.40	0.63
Buttercup.	1.42	1.04										
Speedwell.				0.57	0.38			0.19				
Pennyroyal.				0.19				1.09	0.54	0.38	1.69	1.44
Mouse-eared Chickweed.	6.47	7.61	6.36	3.46	0.58	0.73	0.38	0.73	1.26	1.32	2.42	3.50
Scotch Thistle.			0.38	0.19			0.57				0.19	
							0.19					
<u>CONDITION:</u>	a	a	a	a	a	a	a	a	b	b	b	b
	c	c	c	c	d	d	c	c	c	c	c	c

(44)

SUMMARY OF PASTURE ANALYSES. STRIP 3.

SUMMARY OF PASTURE CONDITIONS.

- a. Closely grazed.
- b. Poorly grazed.
- c. Green.
- d. Dried.

Percentage cover contributed by each constituent to sward from approximately 300 points per month.

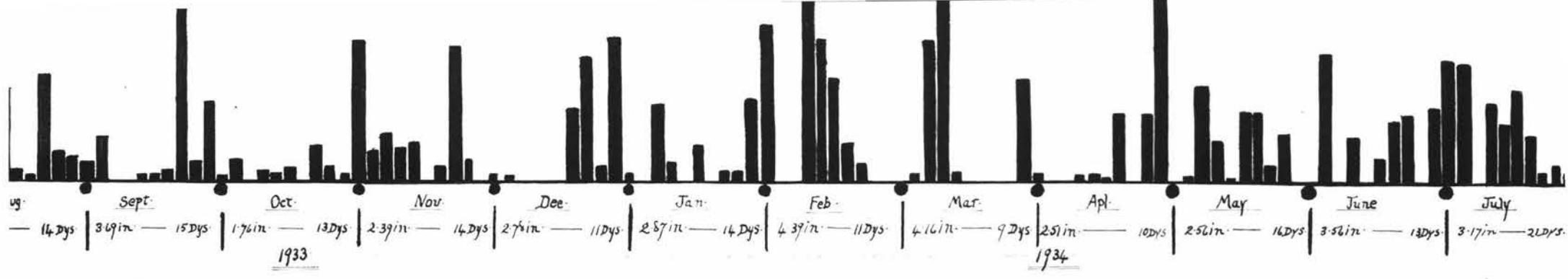
1933 - 34

	Aug.11	Sep.15	Oct.12	Nov.14	Dec.7.	Jan.13	Feb.15	Mar.12	Apr.4	May.10	Jun.7	Jul.10
Bare ground.	29.43	22.12	10.0	6.30	7.69	5.18	11.18	7.27	5.94	13.75	24.13	30.25
<u>SPECIES:</u>												
Brown Top.	7.87	14.25	12.48	10.59	8.84	8.38	13.23	14.29	18.67	16.71	12.41	11.53
Perennial Rye.	6.09	7.03	5.03	7.36	6.58	8.98	4.98	8.06	10.41	8.92	7.67	7.36
Sweet Vernal.	2.16	2.28	8.01	7.36	5.26	9.58	10.82	10.08	7.90	4.26	3.15	3.97
Crested Dogstail.	16.92	12.54	12.11	12.56	11.47	13.97	15.29	12.46	10.78	14.36	13.75	12.56
Yorkshire Fog.	4.72	0.57	1.49	1.60	1.69	2.0	2.07	2.02	2.51	3.17	4.26	4.81
Timothy.	0.20	0.95	1.12	0.18	0.36		0.17					
Bromus hordaceous.					0.18	0.20						
White Clover.	15.93	19.07	25.15	26.92	22.75	27.08	19.56	18.87	19.95	17.02	15.14	12.37
Suckling Clover.	0.40	6.18	8.01	9.15	11.66	2.06	0.20	2.56	2.31	1.03	0.42	
Catsear and Hawkbit.	9.64	7.03	9.51	12.56	17.30	17.57	14.78	15.94	13.28	13.77	12.47	11.76
Field Daisy.	2.16	0.57	1.86	1.08	1.15	0.60	1.89	2.94	2.33	2.21	1.89	1.87
Pennyroyal.	2.95	3.80	2.24	1.80	1.88	2.60	3.09	2.94	2.87	2.63	2.62	2.21
Mouse-eared Chickweed							0.17	0.37				
Self Heal.	0.20		0.56	0.18	0.94				0.54		0.36	
Dandelion.	0.59	0.95	0.56	0.36	0.75	0.80	0.51	0.37	1.07	0.95	0.72	0.36
Moss.	1.97	0.38	0.19				0.17					
Juncus vaginatus.		0.19										
Plantain N&L leaved.	0.79	2.09	1.68	1.80	1.50	1.0	1.89	1.83	1.44	1.22	1.08	0.95
<u>CONDITION:</u>												
	a	a	a	a	a	a	a	a	a	a	a	a
	c	c	c	c	c	c	c	c	c	c	c	c

SWARD      OPENNESS

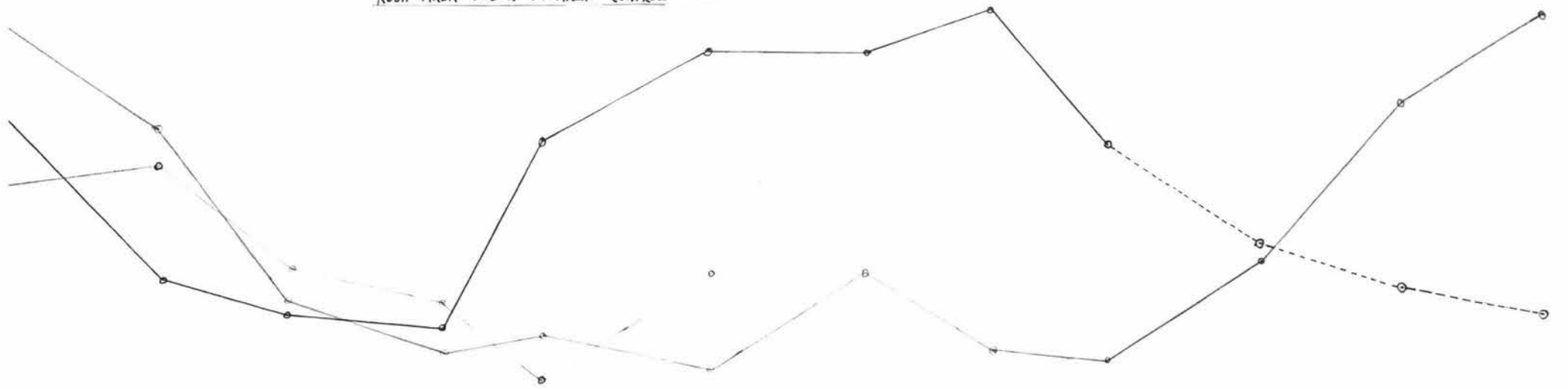
Summarised from pasture analyses<sup>1,2,3</sup>  
of individual strips, i.e. %  
bare ground.

STRIP NO.	CONDITION	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
1	Little apparent spread of rush growth.	18.42	19.93	12.55	4.93	4.54	11.42	<u>FIELD UNDER CULTIVATION</u>					
2	No rush growth.	23.05	11.80	9.28	8.27	21.15	27.85	27.85	30.53	21.01	14.38	11.09	9.25
3	Dense rush growth.	29.43	22.12	10.0	6.30	7.69	5.18	11.18	7.27	5.94	13.75	24.13	30.25



— SWARD OPENNESS —

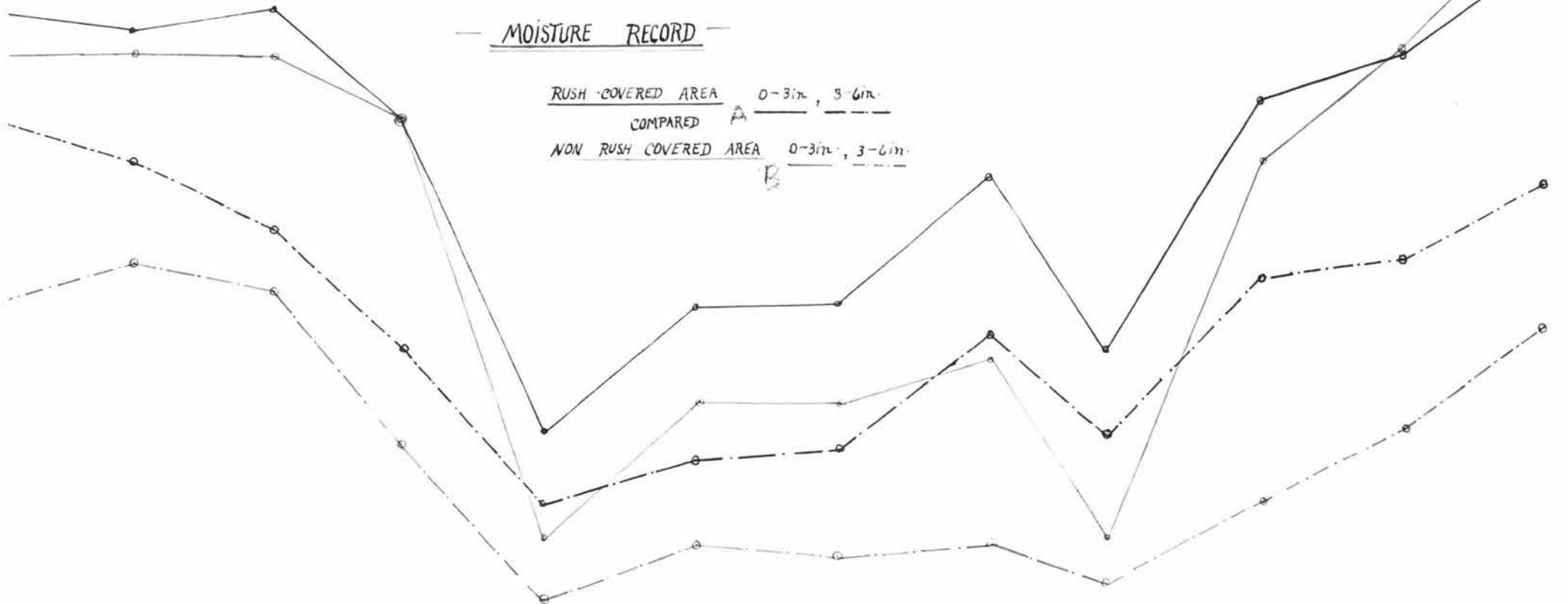
NO RUSH —  
 HEAVY RUSH —  
 RUSH AREA UNDER APPARENT CONTROL —



ug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July

— MOISTURE RECORD —

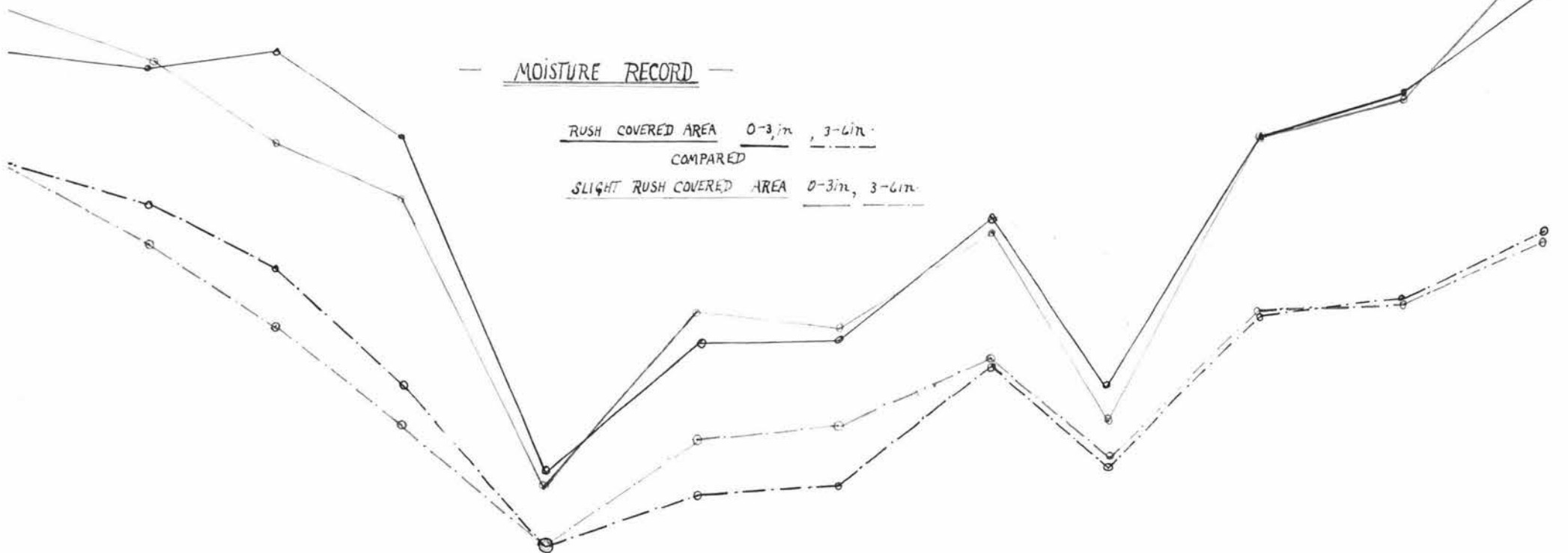
RUSH COVERED AREA 0-3in, 3-6in.  
 COMPARED A  
 NON RUSH COVERED AREA 0-3in, 3-6in.  
 B



ug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July

— MOISTURE RECORD —

RUSH COVERED AREA 0-3in, 3-6in.  
 COMPARED  
 SLIGHT RUSH COVERED AREA 0-3in, 3-6in.



PASTURE ANALYSES:"B" CONFINED TO THE CENTRAL AREAS,  
AND EXTERNAL TO JUNCUS COMMUNITIES.GENERAL:

A number of more or less symmetrical communities of rush growth are often found on old pasture land (Plate XIII<sub>b</sub>). An outer ring of rush growth then encloses a small circle of pasture. These rings of growth gradually extend. Many have a diameter of 4 feet or more.

In grazing sheep invariably prefer to nibble close up to the outer margins of these growth rings of rushes, rather than penetrate to the less accessible pasture within. By their selective grazing they are probably aiding the outward migration of new rush growth.

OBJECT:

1. To determine the constituents of the pasture and the openness of the sward within these communities, and at the external margins, as evidence for the likelihood of a tendency towards the outward spread, rather than the inward growth of new rush shoots.

2. A general observation to note the grasses actually invading the rush and probably providing, by competition, a check to its further growth.

EXPERIMENTAL:

Ten 100 point pasture analyses were made in each of the two positions, within and without communities of *Juncus polyanthemus*, on Field A. The communities selected were 3 - 4 feet in diameter, in which rush vegetation occurred only on the outer circumference, while the interior portion was in pasture. The inner pasture was analysed in several directions across the diameter, while the pasture immediately external to the rush ring was measured as near as possible to this outer margin, where new rush shoots were emerging. The state of the pasture within the community, and that immediately without, were thus secured.

ESTIMATION OF RESULTS:

The results of the pasture analyses have been expressed as the percentage each species was contributing to the total area, just as with the previous strip pasture analyses.

RESULTS:

From the analyses summarised from these recordings the following facts are presented:

1. In every case a greater percentage of Brown Top was recorded within the communities than without.

2. In 8 of the 10 communities examined the percentage of Sweet Vernal was greater within the rings than without, (exceptions, Communities 6 & 8).

3. Where Cocksfoot was recorded it was always within the community.

4. In 7 of 10 examinations a greater percentage of bare ground was recorded externally. The average percentage of bare ground of the 10 communities was greater externally than internally.

5. Crested Dogstail occurred within communities in only 3 cases, and 10 cases externally, each of which in the interior position was less than that in a corresponding external position.

6. None of the minor constituents of the pasture, such as Moss, *Poa annua* or Dandelion, were recorded in the central area of communities.

7. The average occurrence of White Clover was greater outside than within the community, (exceptions, Communities 7 & 8.)

8. In all cases (possible exception Community 4) Catsear and Hawkbit were in far greater proportion on the outside of the communities.

9. Yorkshire Fog within was less in 8 of the 10 communities examined. The average occurrence of Yorkshire Fog was treble externally to the communities.

#### INTERPRETATION OF RESULTS:

The following conclusions have been drawn:

1. That selective grazing has had a marked influence on the sward openness of the examined communities. In the outer position the sward was more open than in the inner position.

2. That the more open condition externally was probably a factor favourable for the outward spread of the plants.

3. That selective grazing had favoured pasture elements within the communities, and induced a large proportion of weeds external to the communities.

4. That the spread of the plants in an outward direction was also favoured by the shading effect in the central portion, with its taller grass growth and closer sward.

5. It was noticed that Brown Top entered into strong competition with the rush plant. Many rush clumps were completely invaded by Brown Top. In the summer months White Clover had some power of penetration, but its growth was seasonal. In winter, White Clover was usually in minor proportion in the pasture, compared with its practical dominance in summer.

While it is suggested from this study that the extreme openness of the pasture at the outer edge of the rush growth, caused by the close grazing is one factor aiding the rush in its outward spread it must not be considered to be the sole factor. Other and supplementary factors will be discussed later.

ANALYSES OF GRASSES WITHIN AND WITHOUT RUSH COMMUNITIES

W I T H I N

Percentage cover each species contributes to sward from approximately 100 points at each position, within and without.

<u>COMMUNITY:</u>	<u>NO.</u>	<u>I</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>TOTAL</u>	<u>AVERAGE</u>
Bare Ground.		23.88	23.68	26.39	23.19	29.73	23.37	23.07	26.46	20.83	29.16	249.76	24.98
<u>SPECIES:</u>													
Brown Top.		28.85	54.0	30.92	39.32	39.52	34.14	44.08	38.52	49.26	40.35	398.96	39.90
Perennial Rye.		26.44	13.02	7.27	7.32	3.52	13.85	5.18	5.25	7.92	5.38	95.15	9.52
Sweet Vernal.		10.42	3.72	28.20	24.68	25.37	15.70	15.56	11.38	14.07	18.84	168.04	16.80
Cocksfoot.		1.60		3.62	4.58		1.85	6.91	0.87		5.38	24.81	2.48
Crested Dogstail.				0.90			4.62		2.63			8.15	0.81
Yorkshire Fog.			0.93			1.76	1.85	1.76	4.38	0.88	0.89		
Tall Fescue.				0.90				0.86				1.76	0.18
Poa annua.													
White Clover & Trefoil.		1.60	0.93				0.92	1.72	4.38	0.88		10.43	1.04
Catsear & Hawkbit.		4.01	1.86	0.90	0.91		1.85		6.13	2.64		18.30	1.83
Field Daisy.										0.88		0.88	0.09
Scotch Thistle.										2.64		2.64	0.26
Mouse-eared Chickweed.		1.60					1.85	0.86				4.31	0.43
Self-heal.		1.60	1.86	0.90								4.36	0.44
Moss.													
Dandelion.													

ANALYSES OF GRASSES WITHIN AND WITHOUT COMMUNITIES.

Percentage cover each species contributes to sward from approximately 100 points at each analysis, within and without.

W I T H O U T

COMMUNITY NO:	I	2	3	4	5	6	7	8	9	10	TOTAL	AVERAGE
Bare Ground.	29.48	29.26	22.39	26.47	29.85	27.27	26.02	32.35	36.67	23.28	283.04	28.30
<u>SPECIES:</u>												
Brown Top.	18.08	24.42	16.69	33.74	22.52	12.99	25.45	15.61	14.68	20.34	204.52	20.46
Perennial Rye.	16.27	21.05	7.51	11.24	11.26	12.12	10.34	11.27	18.54	6.47	126.07	12.61
Sweet Vernal.	8.14	2.53	4.17	9.52	18.19	16.45	11.14	19.80	2.32	6.47		
Crested Dogstail.	4.52	8.42	5.85	5.19	5.20	6.06	7.16	6.07	6.95	21.26	76.68	7.67
Tall Fescue.						2.60					2.60	0.26
Poa annua.				1.73					0.77		2.50	0.25
White Clover & Trefoil.	4.52	1.69	5.0	4.33	4.32	0.86	0.80	1.73	2.32	1.85	27.42	2.74
Catsear & Hawkbit.	17.18	9.26	26.70	0.86	5.20	9.53	3.18	7.81	16.98	12.02	108.72	10.87
Field Daisy.			7.51					0.87			8.38	0.84
Mouse-eared Chick- weed.				0.86			1.59				2.45	0.24
Self heal.			1.68	1.73						1.85	5.26	0.53
Moss.		3.37					0.80			4.62	8.79	0.88
Dandelion.					0.86			0.87		0.92	2.65	0.26

RUSH CUTTING EXPERIMENTS:GENERAL:

In many of the better pastures where rushes occur, the feasibility of cutting by mower, as an aid in control, appeared to warrant a little consideration. Yet when information from practical sources was sought on the probable results of this treatment, the conflict of opinion was such that no definite conclusion could be drawn. The general opinions were that one cutting could not be considered effective, either in killing the plants or checking their development, and that more frequent cutting would probably result in accelerating the growth of the cut plants, thus effecting a further spread in pasture.

OBJECTS OF RUSH CUTTING:

1. To determine the effects of one cutting or several cuttings on rushes.

2. To note the period of greatest regrowth of cut plants. Here it was thought that by adopting a cutting technique, a clue might be provided to the period when rushes were making their most active growth. Further it was believed that this evidence might also indicate just when uncut rushes were best capable of spreading in pasture.

3. To note whether cutting before the November flowering would prevent stem development in that vegetative season, so that a later flowering and seed setting might be checked.

If it was found possible to completely check seed setting by one cutting, the possibility of checking rush establishment from dispersed seed could then be considered by this treatment.

4. To ascertain whether cutting alone could be considered a likely means of control, and whether plants frequently cut would succumb as a result of their injury.

METHOD:

In order to more definitely investigate the second object, and to compare the growth response from month to month, a plan was adopted whereby the regrowths of cut rushes were measured after intervals each of 32 days. The plants chosen for experimental investigation were all of the one species, *Juncus polyanthemos*, and in an apparently similar habitat. They were then cut with sharpened hedge shears to a uniform height above ground level, i.e., 2 - 3 ins. Two immediate difficulties were recognised.

(a) That fresh plants would have to be cut at each period, as the effect of the first cutting would probably affect regrowth after subsequent cuttings.

(b) That if there were large individual variations in regrowth of different plants of the one species, a large number would have to be cut, in order to obtain a reliable mean of their growth, as it was proposed to

compare the regrowths of separate groups of cut plants.

As a trial 30 mature plants of *J. polyanthemos* were cut for the first time, in December. It was found that by careful manipulation the cutting of the regrown stems after a 32 day interval, (early January) was possible to within  $\pm 1/10$ th. in. of the level of the first cutting. The many dead stems which had been sheared down to a uniform level by the first cut, provided a base for the second cutting of regrown stems. Only stems bearing marks of cutting at both ends were measured. Thus, any new stem growth which had not been sheared at the first cutting was readily distinguishable and was consequently rejected.

The small errors introduced through the impossibility of cutting exactly to the first level, and the errors likely in measurement, which was made to the nearest  $1/10$ th. in. for each stem, have been regarded as cancelling out.

The further important fact was demonstrated that the frequency curve of the regrowths of these cut rushes agreed with what is known as "the normal curve of error," and that therefore certain statistical formulae could be employed to estimate the variance of the results.

Of the 30 plants so cut, the stems of each plant were kept separate. Fifty stems of each of 25 plants were selected at random, and measured. Five plants were discarded from the trial because of a minor shortage in the required number of stems. The data was examined statistically, and the mean length of the regrown stems of each of 25 plants was determined.

This technique was seen to involve three problems:

(a) Was the measurement of a sample of 50 stems sufficiently representative on which to obtain a mean for each of the 25 plants examined?

(b) Was the measurement of the means from 25 plants a sufficient number on which to base conclusions for the whole population, under similar conditions?

(c) Was a sample of 600 stems chosen at random from the mixed stems of the 25 plants in substantial agreement with the mean of the sum of the means, of each of 25 plants, from which the previous 50 stems per plant had been taken for sampling?

#### RESULTS OF PRELIMINARY TRIAL:

The mean stem regrowth of each of 25 plants of *Juncus polyanthemos* are recorded. Fifty stems from each plant were measured.

6.22 $\pm$ 0.066	inches.	7.18 $\pm$ 0.136	inches.
6.34 $\pm$ 0.138	"	7.18 $\pm$ 0.172	"
6.42 $\pm$ 0.074	"	7.24 $\pm$ 0.156	"
6.44 $\pm$ 0.130	"	7.24 $\pm$ 0.165	"
6.46 $\pm$ 0.059	"	7.24 $\pm$ 0.170	"
6.48 $\pm$ 0.110	"	7.26 $\pm$ 0.166	"
6.70 $\pm$ 0.123	"	7.32 $\pm$ 0.209	"
6.72 $\pm$ 0.138	"	7.50 $\pm$ 0.170	"
6.88 $\pm$ 0.145	"	7.54 $\pm$ 0.20	"
6.92 $\pm$ 0.162	"	7.84 $\pm$ 0.170	"
7.02 $\pm$ 0.159	"	7.94 $\pm$ 0.163	"
7.04 $\pm$ 0.165	"	8.32 $\pm$ 0.107	"
7.08 $\pm$ 0.155	"		

The individual plants show an expected variation in regrowth rates. A sampling of 50 stems per plant, appears to have been a sufficient number for the analysis of the mean of each plant.

The measurement of the re-growth of 25 plants has been accepted as satisfactory, though in each case of the following period examinations a minimum of 30 cut plants have been taken.

The mean of the sum of the means of these 25 individual plants is

$7.07 \pm 0.073$  ins. This represents a measurement of a total of 1,250 stems.

A random sample of 600 stems of the same group of 25 plants gave a mean of

$7.024 \pm 0.05$  ins.

These two means were within the limits of their probably errors. The figure for the mean obtained from the measurement of 600 stems was thus taken as being significant.

#### PRELIMINARY TRIAL CONCLUSIONS:

The above experimental evidence was viewed as confirming the ability to compare the regrowth rates of each group of rushes, with those of another group, cut after a definite time interval, but in a succeeding month.

#### FINAL CUTTING RESULTS:

On the basis of measuring stems of groups, each having a minimum of 30 plants, and re-cut after an interval of 32 days, the following results are presented:-

<u>DATE OF FIRST CUT.</u>	<u>DATE OF CUT OF REGROWN STEMS.</u>	<u>NUMBER STEMS MEASURED.</u>	<u>MEAN.</u> ins.	<u>COEFFICIENT OF VARIABILITY.</u> ins.
29:9:33	31:10:33	400	$7.570 \pm 0.056$	$23.20 \pm 0.55$
31:10:33	2:12:33	400	$7.375 \pm 0.059$	$24.04 \pm 0.59$
9:12:33	10: 1:34	600	$7.024 \pm 0.05$	$26.11 \pm 0.51$
10: 1:34	11: 2:34	600	$5.092 \pm 0.039$	$29.36 \pm 0.57$

When the fifth group of 30 plants was cut in March, 1934, it was then found that the stems of all the cut plants were considerably less than the required number 600. Many individual plants had made little or no growth. Those which had regrown stems showed wide variation in the lengths of these. Cutting was then abandoned as a means of further indicating the growth response.

#### DISCUSSION OF RESULTS:

The greatest regrowth from cutting appears to be in the first month, i.e. October to November. There is no statistical difference between the regrowth for this month and the succeeding two months, although the regrowth rates of the last month show a significant difference when compared with any previous month.

From the first cutting measure-

-ments to the last, a rise in the coefficient of variability is shown. This is quite consistent with the observation at the last and unmeasured cut, when it was seen that although few stems were produced, their variation in length was great.

The fact that it would be ultimately impossible to secure the requisite number of stems for measurement, might have been predicted at an earlier period, when it was found from the 30 plants, that there was variation in the numbers of stems produced per plant, and the ideal of 50 stems was met by only 25 of these. The fact that more plants might produce fewer stems was at that time overlooked.

#### GENERAL CONCLUSIONS:

1. The experimental evidence has been taken to show that *Juncus polyanthemos*, in this habitat, made its maximum regrowth after cutting between the months of November and January. After cutting early in January further growth fell away rapidly.

2. That cutting would probably not completely prevent seed formation. This was noted from the fact that after regrowth for a period of 32 days, cut stems grew to a stage where a second inflorescence was often borne. However, the main seed crop could be prevented by early cutting. One cutting cannot then be taken as completely checking seeding.

3. Other plants frequently cut throughout the year, but at no set dates, have not been killed by cutting, though development has been severely checked.

4. Subsequent observation has shown that the period of greatest vegetative regrowth determined from cut plants, is not necessarily the period when the most active shooting is taking place. In this connection only the results of observation are available. It has been noted that shooting continues throughout the winter, when pasture growth is practically at a standstill. From April to September on these wet open pastures, the rush plants are unobtrusively shooting at their outer margins. With the advent of warmer conditions, both pasture and rush growth is stimulated, though the rush has an undoubted advantage, as it has already established a large number of shoots. These shoots, which rapidly develop into sturdy stems, can then easily survive pasture competition. Thus the rush has made an advance which might be impossible but for its winter shoot growth. The need for careful pasture control in rush areas, especially in winter, is then strongly advisable, otherwise their spread is likely.

5. Cut rushes were observed to shoot actively at their outer margins. This in effect stimulates an outward spread. Plate XVII a illustrates this point. Here is seen the result of an individual rush in a field which was subjected to one cut by mower. This particular area on the College farm had regrown rushes after a previous cultivation, from which it had been sown down to permanent pasture.

The regrowth of cut rushes is so rapid in the early summer months that even if they were cut by mower, and the field closed for hay, the pasture competition would be insufficient to exert control by possible smothering. Where plants are relatively few in number, it is believed that the best expedient would be to chip them out, rather than attempt to control by mowing. Chipping can be done at any period of the year, and is a positive means of eradicating individual plants. Mowing, which confers an extremely doubtful benefit, requires to be done at the height of the farmer's busy season.

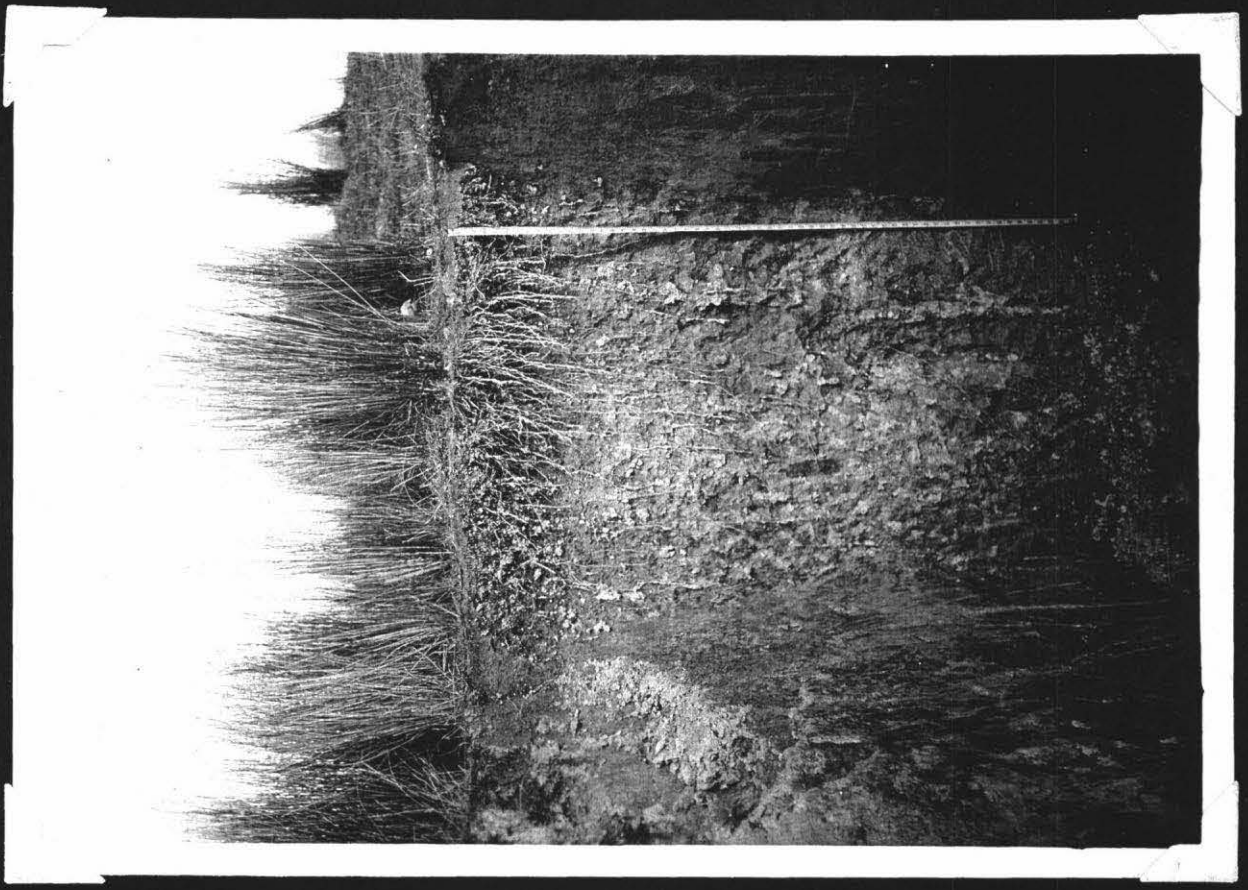
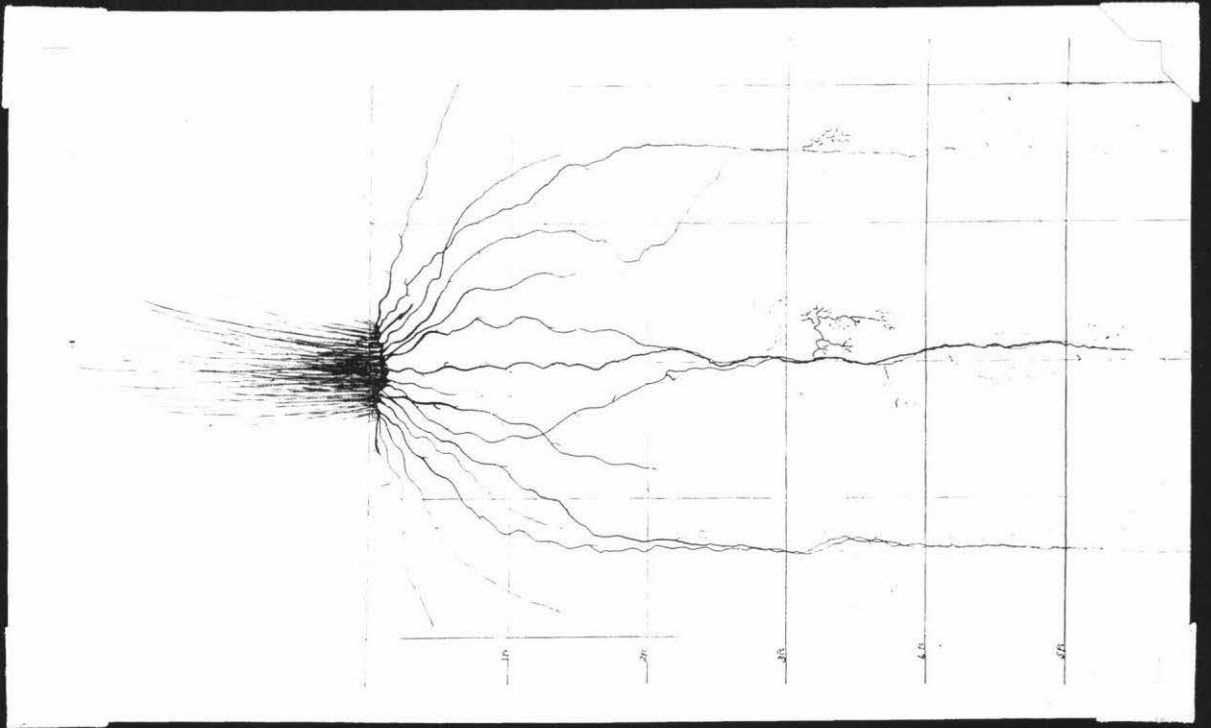
P L A T E XII

- (a) Root system of *Juncus polyanthemus* from a sketch showing the positions of roots in one plane. The continuity and mode of descent of the root system is illustrated.

Photo: W.M. Hamilton.

- (b) Excavated root system of *Juncus polyanthemus*. Portions of the main root system are seen to the full depth of the excavation.

Photo: W.M. Hamilton.



P L A T E XIII

- (a) Rushes, principally *Juncus polyanthemus*, showing tendency to rapid invasion on Field "B". Note free extension of rhizomes which will later probably thicken out to clump development.

- (b) Symmetrical community, or growth ring of *Juncus polyanthemus*, Field "A", and as described in narrative. Note new growth at the outer plant margins particularly in left foreground.



ROOT AND STEM DEVELOPMENT OF JUNCUS POLYANTHEMOS:ROOT STRUCTURE. GENERAL.

*Juncus polyanthemus* is the chief species of rush on these pastures. An excavation made to study the root structure is illustrated by Plate XII b.

NATURE OF SOIL AND SUBSOIL:

The surface soil was a heavy clay loam as previously described and analysed. On excavation it was revealed that this merged to an ashy grey colour before meeting the true subsoil. The depth of surface soil was about 1 foot. The subsoil was extremely hard, of general yellowish white colour, and fissured. Though no gravelly pan was encountered here, nor within the 6 foot depth of excavation, water percolation was confined within the subsoil to the fractures planes, which were filled with a soft interstitial clay, probably leached from the surface layers. These layers were streaked in characteristic colours by oxides of iron, and through this clay the roots penetrated, principally vertically though, to a small extent, horizontally.

THE RHIZOME:

The surface nature of the rhizome was revealed by its position 1 to 1½ ins. deep. Of other plants examined this was the usual depth. The rhizome growth was in a horizontal plane. Mature and living rhizomes were approximately ¼ in. in diameter, and tapered to 9 in. behind the growing point. The whole structure was woody, and externally covered with membranous scale like sheaths. Near the tip these were of light brown hue, smooth and glossy, while further back they deepened in colour and assumed a furry appearance. The upper surface of the rhizome was thickly studded with stems, and shoot buds. The lower half gave rise to an equal number, or a larger number of primary roots than aerial stems. Arching of the rhizome over some portions of previous growth, was taken to indicate either an adaption of its depth below the surface, or of successive season's growth.

In other positions than at the point of excavation, a single rhizome has been traced back from a small growing point for a distance of 6 feet. The dead portions to which the living segment was attached, indicated the power of advancement of the rhizome, under favoured conditions. Near watercourses and in waterlogged positions the rhizomes were closely clumped. The ability to spread under these conditions appeared to be considerably constricted.

Apart from the main, or primary rhizome, the excavated plant showed considerable lateral rhizome development, which, together with stems borne from the main axes, gave the plant a clumped appearance. Such lateral rhizome growth appeared to be subtended at a definite angle to the main rhizome axis. Besides giving the complete rhizome system a clumped appearance, these secondary extensions allowed a radial outward growth from an assumed central point, growth being more or less equal in every direction, or, as seen in some cases, a greater growth along one direction. Thus, where the sward was open and the soil wet, it was probable that rhizomes from a parent plant would not extend to the same extent in every direction. If one section of the rhizome was particularly favoured it might make greater advance in its direction of growth. It was thus moving outward and forward from the point at which

the parent plant originally commenced growth. If a number of rhizomes of any plant or plants extended in this manner and did not thicken out to form clumped growth, it was probable that the pasture would become rapidly invaded by the rush species, Plate XIII a. If development in each direction in which the rhizome was advancing was slow, it was likely that the plant would retain a clumped appearance. This condition was seen where the soil was continuously waterlogged. When conditions seemed to become more favourable the plants still retained a clumped appearance, though they were gradually extending outwards in an ever widening circle. In time the central stems attached to the oldest portions of rhizome perished, and a ring of growth was then formed, Plate XIII b.

#### THE ROOTS AND ROOT SYSTEM:

As the apical shoot buds and shoots of the rhizome were progressively developed, so also did the rooting system extend. The youngest roots appeared from the under surface of the foremost developed shoot on the rhizome. The root bud was first visible when the shoots were about  $\frac{1}{4}$  in. long. On further development these immature roots were seen to be of creamish white colour in their early stages, and dark brown when fully mature. There were numerous new roots when this root examination was made in July. At that time a number of these roots were found to extend 1 foot in a horizontal direction from the rhizome, and were penetrating in an oblique plane to the soil surface, being then 6 inches deep. These young roots averaged  $\frac{1}{16}$ th. in. in diameter. They were soft and succulent, and strongly pointed at the tip, over which the transparent root cap cells extended. At a distance of approximately 2 inches from the tip, many minute root hairs, each no longer than  $\frac{1}{20}$ th. in. gave the rootlet a woolly appearance. These root hairs were retained backwards from their origin behind the point of the root for 2 - 3 ins.

The mature roots had an average diameter of  $\frac{1}{12}$ th in. at their point of origin from the rhizome; they were woody, and curved outwards before descending vertically. The roots extended laterally on either side of the parent plant for 1 - 2 feet. Many fully developed roots tracing back to the rhizome were lifeless, indicating a period probably analagous to that of the rhizome and stem life periods. Within the first 2 feet of surface soil little or no branching of the primary roots was observed. Of the few permanent adventitious roots noted here, the general length was only  $\frac{1}{4}$  to  $\frac{1}{2}$  in. Below the 2 ft. level there was extensive lateral root branching, but along the fissures of the subsoil clay only. In these positions roots were thickly clustered, many being strongly flattened, a probable adaption caused by their penetration between the surfaces of the extremely hard clay. A number of living and dead roots, followed the same cleavage planes. Although the excavation was continued to 6 ft. the limit of the descent of the fine rootlets had not been reached.

The illustration, Plate XII a, is from a drawing, showing in one plane the unbroken root structure from a soil face of about 2 in. depth.

#### MODIFICATIONS OF THE ROOT SYSTEM:

Weaver and Clements (33) record wide variation in root systems according to the plant's habitat. They say that root development is retarded by lack of aeration, and that the characteristic root type on one situation may be so modified on another that the association of a particular type of rooting system with that

of a plant of the one species is almost impossible. It is probable that this was the case where *Juncus* plants were growing in waterlogged positions. The roots were then often closely clumped beneath the rhizome. This could have been due to insufficient soil aeration which did not permit deeper penetration.

#### STEM DEVELOPMENT:

The youngest stems, and stem buds, were at the margins of the rhizome. Working back from the terminal bud, stems were borne alternately in rows. The position of each stem appeared to be at a definite angle to the longitudinal axis of the rhizome. On the young rhizome there were primarily 2 rows of stems with buds at the outer stem margins. On each piece of mature rhizome there was often a number of rows of stems. In every case buds were borne at the outer tips, behind which were the youngest growth. The developing stems were protected by a number of papery white sheaths, which later appeared above ground, along with the stem.

Stem growth was from the rhizome. A number of equidistant points were marked with Indian ink on young stems. In all cases these points remained as originally marked, definitely showing that additions were being made below the basal marking.

In Field A the position of new stems on a number of plants was marked. In seven months growth from August these plants had produced an average of 6 new stems from each marked position. This was the extent of radial migration of these plants for the above mentioned period.

While actual stem elongation appeared to be most rapid in the early spring, shoot formation seemed to progress evenly and was particularly noticeable in the winter when the ground was soft, waterlogged and pasture was short.

#### CONCLUSIONS:

Examination has shown the rush to be a normally deep rooted plant, although the rhizome itself was at no great depth. It is from this rhizome that both stems and roots had their origin. Removal of the rhizome from the ground would thus bring to an end the vegetative means whereby the plant perpetuated itself. Owing to the deep rooting system the rush was not likely to suffer through extremes of drought, which would provide a severe check to the development of less deeply rooted plants.

The mechanism of stem development was seen to allow plants to assume either a tufted or a free growth, according to the environment. The first condition appeared in waterlogged soils. In more favourable positions the rush slowly extended to form in time a symmetrical community. The most favourable conditions resulted in a rapid growth and the rhizome could spread along any one or in a number of directions. The rush could thus gain maximum coverage in the minimum of time. Later thickening out to a tufted growth form was probable.

Where new growth was smothered by the surrounding pasture, only few etiolated rush stems persisted at any time. These were often attached to a length of perished rhizome, as the plant was unable to thicken out and form a clumped growth.

Thus is observed the importance of a close sward, moderately grazed, as opposed to an open pasture, as a means in rush control.

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P L A T E X I V.

(a) This field was swamp ploughed, later re-swamp ploughed turning the previously buried rushes to the surface. Note the abundant rush growth.

(b) This adjoining field was first swamp ploughed and then re-ploughed to the ordinary depth. Note sparse rush growth in foreground, but appearance in the background, delineating treatment as recorded in text.



SECTION V.MANAGEMENT INFLUENCE IN RUSH CONTROL.INTRODUCTORY:

In order to gain a more detailed knowledge of the problem of rush control, the writer visited a number of farms in the Manawatu district. As a consequence the opinion is essayed that a pre-eminent factor in rush control is farm management.

With the larger areas incidental to most sheep holdings a greater difficulty was experienced in maintaining land in a rush free condition. On the coastal areas, however, even where holdings were of small acreage, a problem was presented quite different from those further inland, and on the heavier soil types. This sandy type has not been investigated to the stage where it might be held that recommendations for heavier soil types may also apply to it.

On the heavy loams and clay loams the opinions of farmers regarding the best means to combat rushes, when once established, were much divided. From the many farms where there is no, or inappreciable rush growth, it appears that were cultivation is possible and after management suitable, rush growth can be eliminated. Alternatively, where cultivation has been along incorrect lines, or where poor management has allowed the opening up of the pasture an abundant rush coverage was evident.

In swamp land where it is impossible to cultivate because of submerged timber, free water, and lack of consolidation, it is also impossible to apply any system aimed at rush control, until the land can be brought within the sphere of agricultural practice.

The following practical illustrations will show the results obtained by certain methods of procedure, together with some of the factors which it is thought would be most likely of benefit in rush control.

CULTIVATION AND CROPPING PERIOD PRIOR TO THE PASTURE LEV; THE EFFECTS ON RUSH RE-GROWTH.

GENERAL.

In pursuance of a progressive policy of management, land in dominant rush growth was being cultivated to pasturage on the college farm. By a trick of circumstance the original cultivation plan could not be followed, thereby a splendid example of the effect of a variance in management was reflected in the subsequent developments, especially those leading to a re-establishment of rushes.

SOIL TYPE.

The heavy clay loam of the surface soil of this area is underlain by a still more impervious clay, drainage being impeded by the nature of the soil, and the fact that an iron pan at no great depth, completely prevents further percolation.

PREVIOUS CONDITION.

When possession of the area

was first assumed by the College, rushes were the dominant growth, with indications of rye-grass, Trefoil and Dogstail. Timber had to be cleared before cultivation was possible.

#### TREATMENT.

To obtain clarity of description only essential treatments will be described.

The complete block comprising 36 acres was swamp ploughed in June, 1929, to a depth of 9 ins. Subdivision fences were later erected and this large area was divided into a number of smaller areas, on each of which selected crops were grown. One particular subdivision, on which most attention has been focussed, was further cultivated and sown down in November, 1929, to rape, with a manurial dressing of phosphate and sulphate of ammonia. In April, 1930, after the rape had been fed off, it was decided to recultivate and sow this section down to permanent pasture. However, in the late autumn, the surface soil had become so hardened after a drying summer, that ploughing to the ordinary depth, about 4 ins. became impossible. The share of the light plough would neither penetrate, nor would it remain below the hardened soil. When a section of ploughing had been completed with great difficulty, it was decided to again bring into use the heavy swamp plough, which was then used to complete ploughing. There were thus two distinct sections, one turned to 4 ins by the light plough, and the other to the original 9 in. level by the swamp plough. The complete field was levelled, rolled disced and harrowed, to provide a suitable seed bed for the following first class mixture:

	<u>No. 1</u>	
Perennial Rye. Certified Hawkes Bay.	16	lbs.
Italian Rye.	4	"
Cocksfoot. Akaroa.	8	"
Timothy.	3	"
Meadow Foxtail.	2	"
Dogstail.	2	"
Cowgrass.	3	"
White Clover.	2	"
Alsike.	2	"
	<hr/>	
	<u>42</u>	lbs per acre

At this time eighteen acres, or half the original block was sown. No manure was included at sowing. In June, 1930, a further subdivision of this sown area into 4 separate paddocks was effected. Two were used for controls, and two for manurial treatments, the manure being distributed over a year from the date of the sowing. These paddocks were mole drained. Although detailed investigation discloses that all 4 paddocks of this latter subdivision received differential manurial treatments, no significant influence due to this difference alone could be determined on examination in November, 1933. At that time, however, there was an appreciable and marked difference in the density and amount of rush growth on those portions which had been reploughed to respective depths of 9 ins. and 4 ins. This effect was traceable across the paddocks latterly subdivided, one of which was a control, and the other a manurial trial. The illustrations show this effect. Plate XIV b shows the section ploughed to the depth of 4 ins; Plate XIV a the swamp ploughed section.

The adjoining 18 acres, or the counterpart of the first subdivision, was also cultivated. It was under cultivation longer than the previous area, before being sown down to pasture. In December, 1929, it was sown in swedes,

then after further cultivation portions were sown in Chou-Moellier, Kale, Oats, Barley and Tares, and Oats alone. Each crop received a manure requisite to its special requirements. Subdivision followed. One portion was worked for the third time in March, 1931, and about the middle of that month was sown down to pasture. Two seed mixtures were used on different sections, these being drilled with 3 cwt. of superphosphate per acres. The seed mixtures were:

		<u>No. 2</u>			
		"A"		"B"	
Perennial Rye.	Certified Hawkes' Bay.	16	lbs.	8	lbs.
Italian Rye.		4	"	4	"
Cocksfoot.	Akaroa.	8	"	16	"
Timothy.		3	"	3	"
Meadow Foxtail.		2	"	2	"
Dogstail.		2	"	2	"
Cowgrass.		3	"	3	"
Alsike.		2	"	2	"
White Clover.	N.Z. best. Certified.	2	"	2	"
		42		42	
		<u>PER ACRE.</u>			

The field was mole-drained in July, 1932, and various surface topdressing treatments were applied

The second subdivision or part of this block was in cultivation until March, 1932, when it was sown down with the following seed mixture.

		<u>No. 3</u>	
Perennial Rye.	Certified first harvest H.B.	16	lbs.
Italian Rye.		4	"
Timothy.		3	"
Cowgrass.		3	"
Cocksfoot.		8	"
Crested Dogstail.		2	"
White Clover.		2	"
Poa trivialis.		$\frac{1}{4}$	"
		40 $\frac{1}{4}$	
		<u>PER ACRE.</u>	

Manure at the rate of 3 cwt. superphosphate and 3 cwt. carbonate of lime per acres were sown concurrently. The field had not been mole drained when the observations were made.

#### DISCUSSION OF RESULTS:

The entire block of 36 acres broken from its uncultivated rush-covered state in June, 1929, by swamp ploughing has been variously subdivided, cropped, manured and eventually re-sown to pasture. The seed mixtures in the final leys have varied, as has also the times of inter-cultivation prior to sowing. After sowing, a further manurial programme has been carried out. The bulk of the area has been mole drained, only one small area remaining undrained. Yet of all these treatments rushes are to be found only on the one section re-sown after 10 months cultivation. The portion cultivated to the original depth of swamp ploughing, 9 ins., has now a heavy rush growth, the other normally cultivated, a sparse rush growth.

#### CONCLUSIONS:

1. The evidence favours the hypothesis that rushes buried for a period of 10 months have re-established, probably by shooting from their

damaged rhizomes, after being returned to the surface. It would seem that a second growth phase has been facilitated.

2. While the possibility of establishment from seed on both sections cannot be overlooked the fact that rushes are growing to slight extent on the portion of the field cultivated according to intention, however established, would indicate that sowing to grass after one cropping period, allows incomplete and insufficient cultivation for the complete subsequent control of rushes.

3. That the various seeds mixtures used have been suitable where cultivation has been along correct lines, as even on the non-mole-drained area, no rushes have come away following several cultivations.

4. That the varied manurial treatments after both efficient cultivation and the sowing of suitable seeds mixtures have shown no effects which of themselves would favour the conclusion that particular fertilizer treatment had induced subsequent rush growth.

A somewhat parallel case of regrowth of rushes after cultivation was incidenced from one of the farms visited. The owner had ploughed his heavily rush covered field by ordinary plough, cultivated and sown the area down to a root crop. This was followed by a second cultivation within the year, when the field was sown down to permanent pasture. The ultimate result was that within three years of cultivation the field was in as bad a condition as prior to cultivation. This evidence is taken as an additional support for the need of thorough and continued cultivation prior to the permanent pasture seed's ley.

From successful measures of control by cultivation the following recommendations are made:

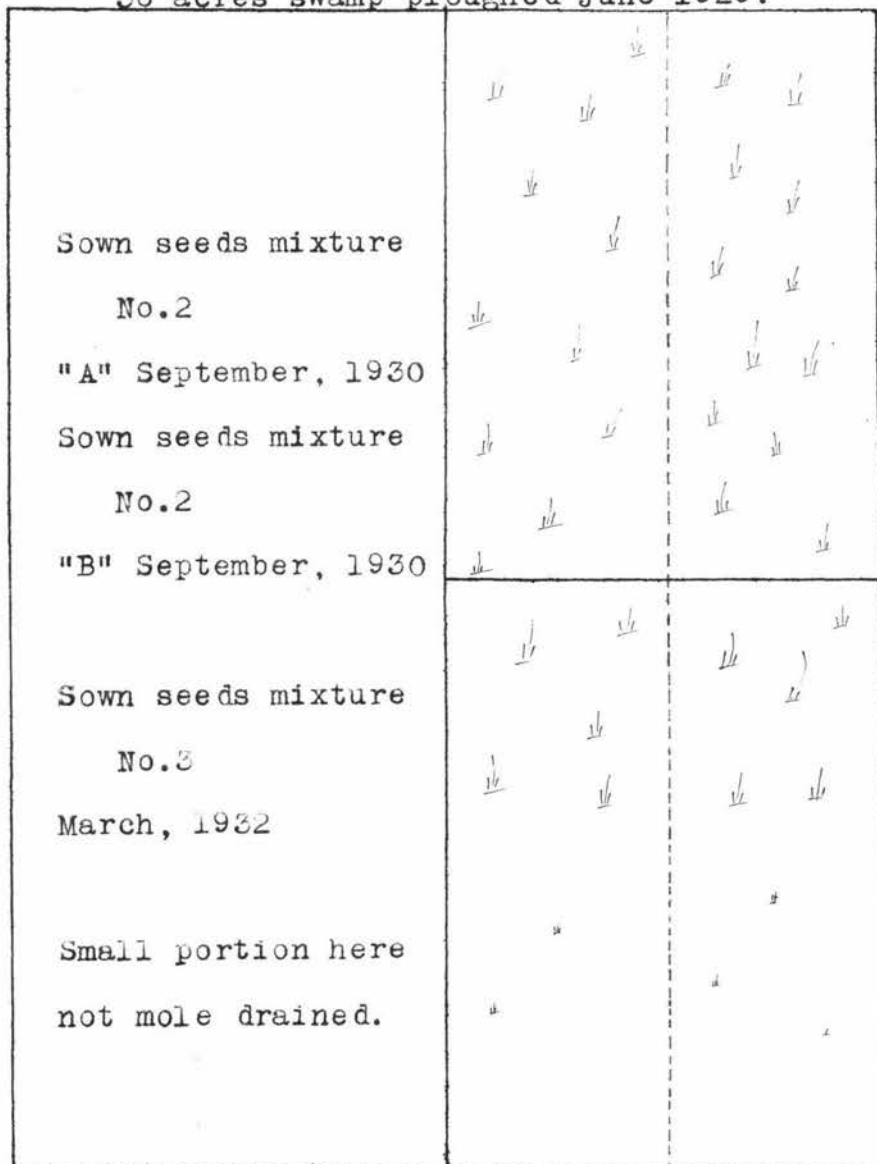
1. Rushes to be turned under by swamp ploughing.
  2. Surface cultivation and cropping for a period of at least 2 years before sowing to permanent pasture.
  3. The sowing of a suitable and high grade seeds mixture.
  4. After cultivation never to be to the original depth, so that rhizomes ploughed under will not be turned again to the surface.
-

PLAN OF TREATMENTS AND SUBDIVISIONS: (Pages 60-61 of narrative)as seen at November 1933.

↓ = Heavily rush covered.

\* = Sparcely " "

36 acres swamp ploughed June 1929.

TREATMENTS:

The above section of 18 acres was sown first in Swedes. In September 1930 it was ploughed to ordinary depth. Seeds mixtures No.2 "A" & "B" were sown in March 1930 on the top section. The bottom section was sown with Chou Moellier, Kale, Oats, etc. and in March 1932 to permanent pasture with seeds mixture No.3.

The above section also of 18 acres was cultivated and sown in Rape in November 1929. It was later re-swamp ploughed (where heavy rush growth is indicated) and by ordinary plough (where few rushes are shown.)

P L A T E    XV.

(a)\*    Rush establishment on a disused pathway. The result of one season's growth.

(b)\*    Rush establishment on plot sown with Type 3 Perennial Ryegrass.

\*    Positions of rush stems are indicated by red ink crosses.



P L A T E XVI

(a) Free rush establishment on plot sown with Type 5  
Perennial Ryegrass.

(b) Showing the failure of rushes to establish on  
plot sown with Type I Perennial Ryegrass.



EFFECT OF STRAIN IN THE GRASS LEY AND ITS RELATIONSHIP TO RUSH CONTROL:

Apart from the fact that incomplete cultivation may have an effect in aiding the subsequent development of a rush flora, there appears to be sound evidence for believing that the strains of the grass species sown, have some influence in the problem of rush control.

In this connection some strain trials with Ryegrass will be discussed.

LOCATION, SOIL AND PREVIOUS TREATMENT:

The plot trials from which this material has been collected are at the Plant Research Station, Palmerston North. The site was acquired by the present occupiers in 1927. At that time, practically the entire block was rush covered. Since then the whole area has been cultivated, and there have been no rushes in evidence for at least six years. In addition, the section now occupied by these Ryegrass plots was thoroughly cultivated in 1932, when a root crop was grown. In April, 1933, various strains of Ryegrass from many locations were sown down in small plots. At frequent intervals control plots of Type I Ryegrass, the most valued present selection, were also included. Throughout, the complete series of trials have been subjected to similar treatment, and the initial seeding and manuring was the same in each case.

RESULTS:

The plots were examined and photographed in April, 1934, just one year after they had been sown down. A number of striking differences were evident. It was noted that where there had been a poor take, through failure of the Ryegrass to establish, the sward was extremely open. In many of these plots with the poorer strains of Ryegrass, there was a liberal growth of young rushes, while in the better quality strains there was little or no rush growth. The agronomist had classified the strains of Ryegrass in these plots into definite types. His true Perennial, Type 1 plots (Plate XVI b) showed no rush invasion. The poorest type (Plate XVI b) showed in every case a large number of developing rushes. These plots were of Type 5 Ryegrass. The intermediate Type 3 plots showed a slight rush invasion especially in positions where plants were poorly established. (Plate XV b).

Plate XVa illustrates the abundant rush growth which had sprung up on a little used path adjoining these plots.

CONCLUSIONS:

1. In the interpretation of this evidence the conclusion that only the best types of Perennial Ryegrass should be sown, has been drawn. This must become increasingly important where it is necessary to establish a close, dense sward, to check invasion of either rushes or weeds.

2. That the seed from which these rush plants have established has probably lain dormant in the soil for no less than 6 - 7 years. This assumption has been drawn from the two facts that this particular area is now remote from other areas of rush growth, making the possibility of establishment from wind borne seed less likely, and also, that no rush seeding has occurred here in

that time.

Of the two species of rush present the taller, though bearing no inflorescence, is believed to be *J. polyanthemus*, and the minor species, *J. lamprocarpus*.

The superior strains of Perennial Ryegrass of high production are also of high persistancy. Low production rather than low persistancy of grasses, especially during the winter, would probably be an important factor aiding weed and rush invasion.

An additional factor which must not be overlooked in strains of any grass is the ability of the seed to germinate. What is required are strains of high germination capacity, rapid establishing power, persistancy and reasonable palatability. Though this latter point is often overlooked, the fundamental importance of pasture to the grazing animal must merit close attention.

N.B. To facilitate indentification of rush shoots in the accompanying illustrations their positions have been located by a small red cross.

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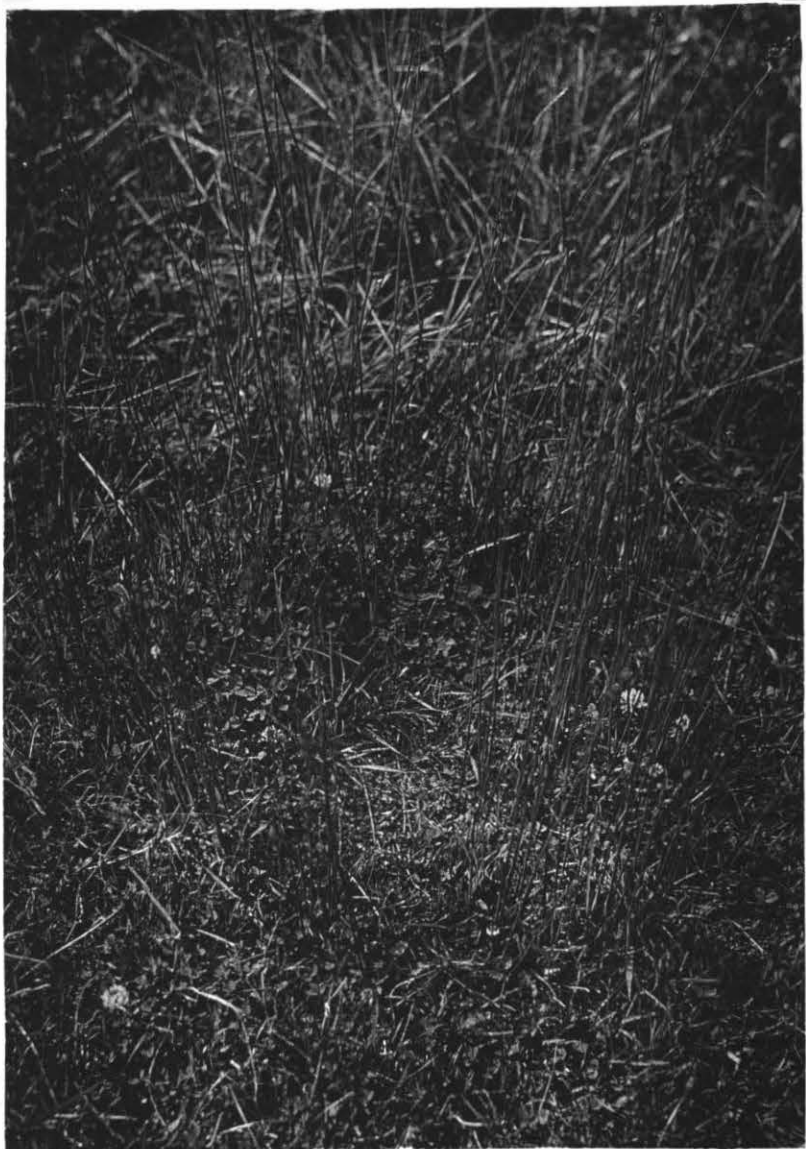
P L A T E XVII

- (a) This rush plant which had re-established after the field had been sown to permanent pasture has been cut once by mower. Note the tendency towards an outward invasion.

- (b) The central strip now covered by rushes was sown with Canary-grass (*Phalaris bulbosa*). From the Marton Experimental Farm, Department of Agriculture.

Photo by courtesy Director, Fields Division,  
New Zealand Department of Agriculture.

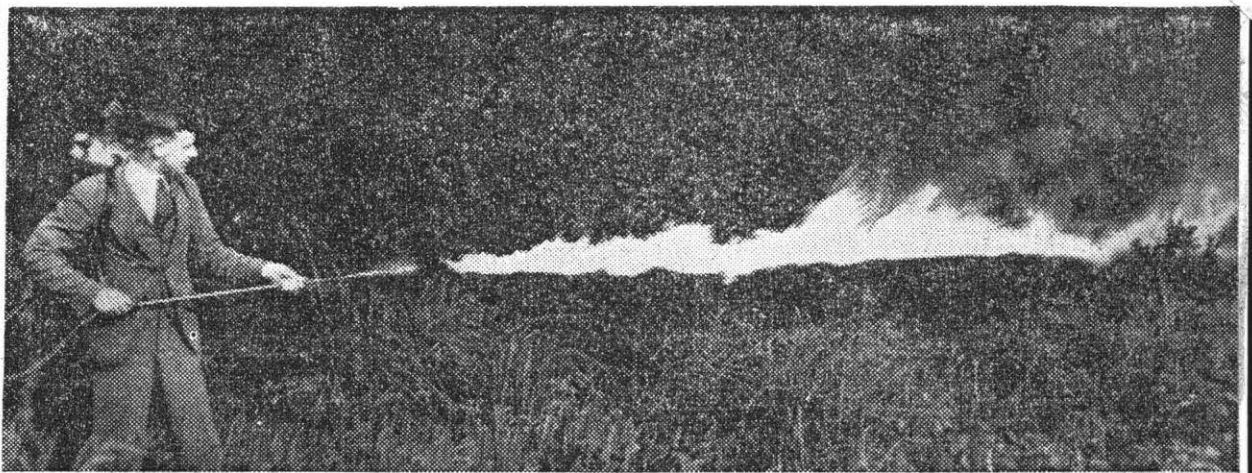
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P L A T E XVIII

A scrub burning device which has also been applied to the destruction of rushes.

Auckland Star: 14/4/34.



**SCRUB BURNING IN THE MARLBOROUGH DISTRICT.**—This device, quite new to New Zealand and particularly suitable to our scrub conditions, is being used in the Marlborough district for burning off scrub country. It is set in operation in about two minutes and throws a flame of from 10 to 15 feet.

THE GRASS SOWN AND ITS PROBABLE RELATIONSHIP TO PALATABILITY AS  
A FACTOR IN RUSH CONTROL:

The experimental material bearing on this aspect of the general problem of rush control has previously been published by the Department of Agriculture (7) from results obtained at the Marton Experimental Farm.

The rush covered strip in the central portion of the illustration (Plate XVII b) had been sown down in 1924 with Canary Grass, *Phalaris bulbosa*. On either side are strips sown with White Clover.

The explanation given by the Department of Agriculture was to the effect that rush establishment was conditioned by the lack of palatability of the Canary Grass.

The writer visited the area in November, 1933. At that time the field had been closed for hay. Rushes were still present on the strip where they had originally come away so freely, though there had been no cultivation in the intervening period. There was much less rush growth than originally, and many of the clumps persisting had a central dead mass of stems, surrounded by a few etiolated and living stems. The species then present were *J. pauciflorus*, and *J. polyanthemus*.

CONCLUSIONS:

1. The explanation advanced offers a feasible and likely hypothesis of the reason for the occurrence of rushes in that pasture. With its acceptance the desirability of precluding such unpalatable grasses in the seeds mixture, must be seriously considered.

2. That when once rushes are established it is necessary to adopt cultivation or other measures for their control. Over a period of 10 years, without the adoption of special measures, the rushes established have not been eliminated.

Canary grass is a "top" grass. In this particular strip it is probable that in the early stages of its growth it was completely ungrazed owing to its lack of palatability. As grazing increases the tillering capacity of grasses, the likely effect on this ungrazed section would be an open sward. This factor together with the lack of trampling of grazing animals, would, it is believed, facilitate the growth of the rush seedlings.

THE EFFECT OF CUTTING ESTABLISHED RUSHES:

A number of rush plants in an open pasture were frequently cut throughout the period of a year. No set time for cutting was adhered to, and up to fifteen re-cuts per plant were effected for the year. This injury was not sufficiently drastic to kill such cut plants. Although very much weakened, they still persisted, while new shoots were actively produced at the margins of the plants.

As such severe injury through frequent cutting would be an impracticable means of control in the farmer's hands, the conclusion has been reached that the only

useful purpose of this method would be in the control of seed formation. One cutting in November would largely achieve this result.

The method of "chipping" has been practiced with success on a number of the smaller holdings where this has been practicable. A sharp spade is run beneath the rhizome, and the complete rush clump lifted. These clumps should be collected and burnt in order to destroy viable seed. It is advisable to surface sow grass seed on these bare patches, otherwise weeds, or rushes establishing from seed, will quickly colonize such spots.

#### OTHER MEANS OF RUSH CONTROL:

A device called a "Fire-Gun," Illustration XVIII has recently been marketed for the purpose of burning off scrub and surface growth. While the writer has not seen this apparatus in use, it was learned that it had been applied in the Waikato in the control of rushes. The results were disappointing, as it was found that the seared plants had not been killed, but were still capable of actively shooting, and thus could redevelop new growth.

When it is realized that new growth is from the rhizome in rush plants, the futility of surface destruction as a means to completely eliminate them will show that such means as the above cannot be practicably employed to kill rushes.

#### MANURING. LIKELY EFFECTS IN RUSH CONTROL:

In the short time available it has not been possible to experiment in this direction. It is quite obvious, nevertheless, that where fertilizers will stimulate pasture growth, either in the establishment of pasture, or on established pasture, considerable benefit will be derived. Manuring aids the development of a close grass sward, and excludes weed invasion, or greatly minimises the weed development.

On closely cropped areas, such as bowling greens, special measures are used to eliminate unwanted flat weeds. Heavy applications of nitrogenous fertilizers sear the leaf foliage of the weed, while the grass constituents are little affected and are stimulated to greater growth.

The application of nitrates under field conditions for this purpose is impracticable, both on the score of expense and because of undesirable secondary reactions which are likely to develop. However the application of phosphate fertilizers and other suitable manures, will, by their growth stimulating effect on the pasture, indirectly help to smother weed growth.

On clay soils the desirability of liming must be seriously considered. The mechanical condition of a heavy soil can often be improved. Besides drainage and aeration can be improved by liming, and the habitat made more suitable for pasture growth and less suitable for rush growth. It may be necessary to work into heavy soils heavy applications of lime, to provide marked mechanical alteration.

#### DRAINAGE:

Previously it has been shown that rushes can grow in both drained and undrained positions.

Successful pasture growth is impossible under waterlogged conditions. The first step in any system of rush control must be to provide adequate drainage. An immediate effect of drainage is to facilitate soil aeration, a necessary condition for pasture growth. Cannon (35) who has studied the question of soil aeration has found that when the concentration of oxygen was reduced to 2% in the soil, growth ceased, or was retarded in most species of plants, whereas with plants inhabiting wet soils such as *Juncus*, growth was but slightly affected.

Lundergaradh (31) shows that as the water table recedes on certain continental areas during the dry season, so also does the rush vegetation decline. This also is probably due to increased aeration or drainage.

It is of interest to note that in Central Otago where irrigation has been practiced, over-watering of this arid soil has in some places caused the appearance of rushes. Especially is this noticeable in portions of the Ida Valley, (30).

Whatever is the cause favouring the incoming of rushes to pasture land, the need for drainage is one of the biotic factors which is plainly necessary, where rush control is attempted. In this manner the habitat is made more suitable for the desirable plants and less favourable for weeds, under which classification rushes fall.

#### GRAZING:

Pasture analyses have shown that in the more open pastures, where overgrazing has been practiced, the greatest rush spread is to be seen.

The desirability of carefully controlling grazing, especially in the winter, when the sward is liable to open, and surface puddling from stock trampling is likely, is of great importance.

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GENERAL SUMMARY.

1. Rushes occurring in pasture may be considered as weeds. They have little or no agricultural or economic value; they occupy space at the expense of pasture, and may aid in the spread of stock parasites.

2. Little evidence for measures in rush control is available, though the botanical character and anatomical structure of the species has been previously studied and described.

3. The species of rush common in pasture in this locality are *J. polyanthemus*, *J. effusus*, *J. luxurians*, *J. vaginatus*, *J. pallidus*, *J. pauciflorus*, *J. tenuis*, and, to minor extent, *J. lamprocarpus*. *Scirpus nodosus* has been observed only on coastal belts.

4. The effect of environment on rush growth has been discussed from recorded results.

5. Ecological factors have been studied. Experimental moisture determinations, and pasture analyses have shown that two factors associated with free rush growth in pasture, are, abundant moisture and an open sward.

6. Pasture analyses within and without symmetrical communities, have shown the respective growth, the competitive grasses, and factors likely to favour extension of growth.

7. A root examination has disclosed that the rush is a deep rooting plant. The position of the rhizome, its depth, and the mechanism of stem development have been examined in relationship to the ability of the plant to spread.

8. The effect of cutting as a possible weapon in control has been tried. The conclusion that it is of little use in this respect has been offered.

Factors of management, illustrated where possible by actual examples, have been given. The effect of cultivation prior to the seeds ley, the effect of strain, and palatability of grass sown, have been examined also. Conclusions have been drawn of the probable effects of manurial treatments, drainage, grazing, cutting and chipping.

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ACKNOWLEDGMENTS

The writer is particularly grateful to Mr. E.B. Levy, Agristologist, Department of Agriculture who initially suggested this study, to other members of the Department for their response to several enquiries, and also to Mr. W.M. Hamilton for photographic assistance, (where specially acknowledged.)

The illustration of rush growth on the Marton Experimental Farm, Plate XVII b, has been included with the kind permission of The Director of Fields Division of the Department of Agriculture (Deem). It has previously appeared in the New Zealand Journal of Agriculture. (7).

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APPENDIX

In connection with the change of name of the species previously called *J. effus* to that of *J. polyanthemos* Cheesman (3) states:- "Under the name of *J. effusus* I have for the present placed several forms, though not exactly agreeing with the typical *J. effusus*, appear to be too close to it to be considered as distinct species. One of these has the tall soft stems, with continuous pith, lax, pale inflorescence, and small, broadly obovoid, almost retuse capsule of the typical state, and to my mind cannot possibly be separated from it. A second and more abundant variety has more slender, rigid and wiry stems, with interrupted pith and the capsule is rounded and imperfectly three-celled. This I take to be the *J. polyanthemos* of Buchenau. Closely allied to it is a still more slender form, with the inflorescence split up into small rounded glomerules, almost after the fashion of *J. vaginatus*, (*australis* Hook.f.), but differing altogether in habit in the small capsule. Buchenau in his monograph of the order, placed it under *J. pauciflorus*, as var. *Cheesmanii*, although wanting the ovoid exserted capsule of that species. He now refers it to his *J. polyanthemos*. How far I am correct in merging the above, together with other less prominent varieties, under one species, can only be determined by a leisurely and comprehensive study of the whole of the N.Z. forms, based upon more numerous specimens than have hitherto been collected and checked by observations in the field. *J. effus*, as ordinarily understood, is almost cosmopolitan in its distribution."

Cheesman (4) states in describing

*J. polyanthemos*:-

"The most abundant species of the genus in N.Z., everywhere to be seen by the margins of swamps, or in undrained soils that are wet in winter. Whether it is identical with Buchenau's plant is not quite certain; but the common N.Z. form, easily distinguished by the slender, rigid and wiry stems, with interrupted pith and with the capsule rounded, and imperfectly three-celled, agrees so closely with his description, that I am unable to separate them. But apparently Buchenau has doubts on the subject, for, in his recent monograph of the family (*Das. P.flanzenreich*, Heft. 25 p. 142) he remarks that *J. polyanthemos* is abundant in most of the Australian colonies, and especially so in Queensland, while in N. Z. only variety *Cheesmanii* is known. His position on this point is puzzling, seeing that he was provided with abundant specimens, and does not allude to them, either in his description of *J. polyanthemos*, or under any of the allied species."

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