

(ms. received 4.8.72).

THE GENUS STIPA L. IN TASMANIA

PART 2 - DISTRIBUTION OF THE SPECIES

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(with seven text figures and five tables)

ABSTRACT

The distributions of nine species, *Stipa aphylla* (Rodway) Townrow, *S. compacta* Hughes, *S. mollis* R. Br., *S. nervosa* var. *neutralis* Vickery, *S. pubinodis* Trin. & Rupr., *S. semibarbata* R. Br., *S. teretifolia* Steud., and *S. variabilis* Hughes, are mapped, described and discussed in relation to altitude, rainfall and evaporation, mean January and July temperatures, geology and soils, and associated plant communities. Environmental factors which may be associated with the limits of distribution of these species are noted.

INTRODUCTION

A State wide survey of the distribution in Tasmania of species of *Stipa* was made during the growing seasons (October to late January) of 1966 to 1970. Bruny, Maria and Slopens Islands and an area centred about Buckland were chosen for detailed distribution studies in relation to soils, geology, altitude, vegetation associations, and several regimes of human activity. The major ecological zones of Tasmania, excluding the Bass Strait Islands, were included in the survey and the distribution of *Stipa* spp. in relation to altitude, rainfall and evaporation, and mean January and July temperatures was investigated on a broad scale.

Records were made along more than 1,600 km (1,000 miles) of collecting route (fig. 1, map ii). Some parts of the major highways e.g. between Bridgewater and Melton Mowbray, were avoided in the survey because of high traffic density, although the genus was present in quantity.

Stipa spp. have a marked pattern of distribution in Tasmania. Most of them grow along road verges and on roadside banks since they are very susceptible to grazing pressure particularly by sheep. Road travel therefore provided a convenient means of collection and recording throughout the State. Records were made of the *Stipa* spp. present at half mile and shorter intervals along the collecting routes (figs. 1, 2).

The relative abundance of the species was estimated for the Buckland area and Bruny Island (fig. 3) based on observations made on the full width of the road verges at each stop in an area extending about 20 m along both sides of the road, using the following standards:-

rare - 1 to 5 plants; occasional - more than 5 and up to 15 plants; abundant - more than 20 plants.

Broad trends in environmental factors associated with *Stipa* distribution have been derived from a study of numbers of localities in each environmental area, using the distribution maps (figs. 1, 2) and a series of overlay (transparent) maps based on published maps. The records used were suitably weighted to allow for unequal distances travelled in the environmental areas studied, and for comparative abundances of the species on Bruny Island and in the Buckland area. These are

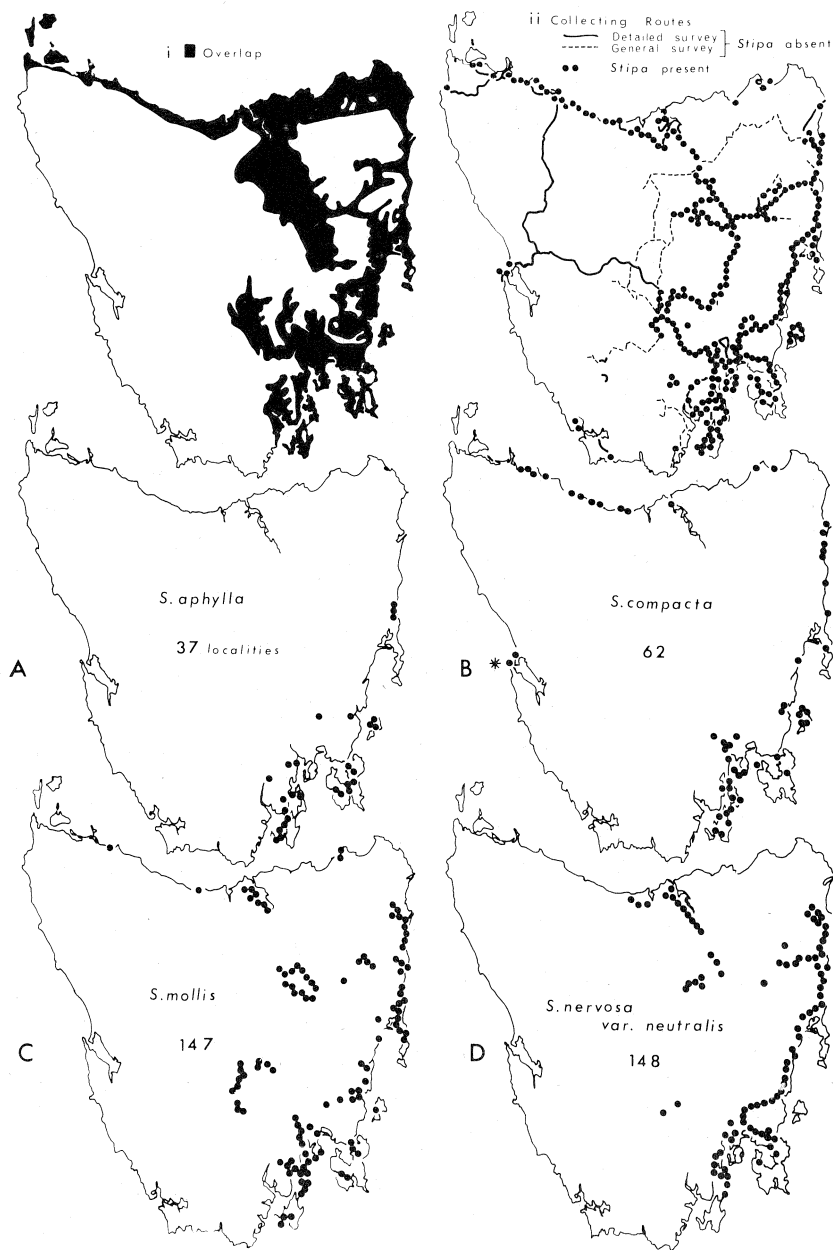
Distribution of *Stipa* Species in Tasmania

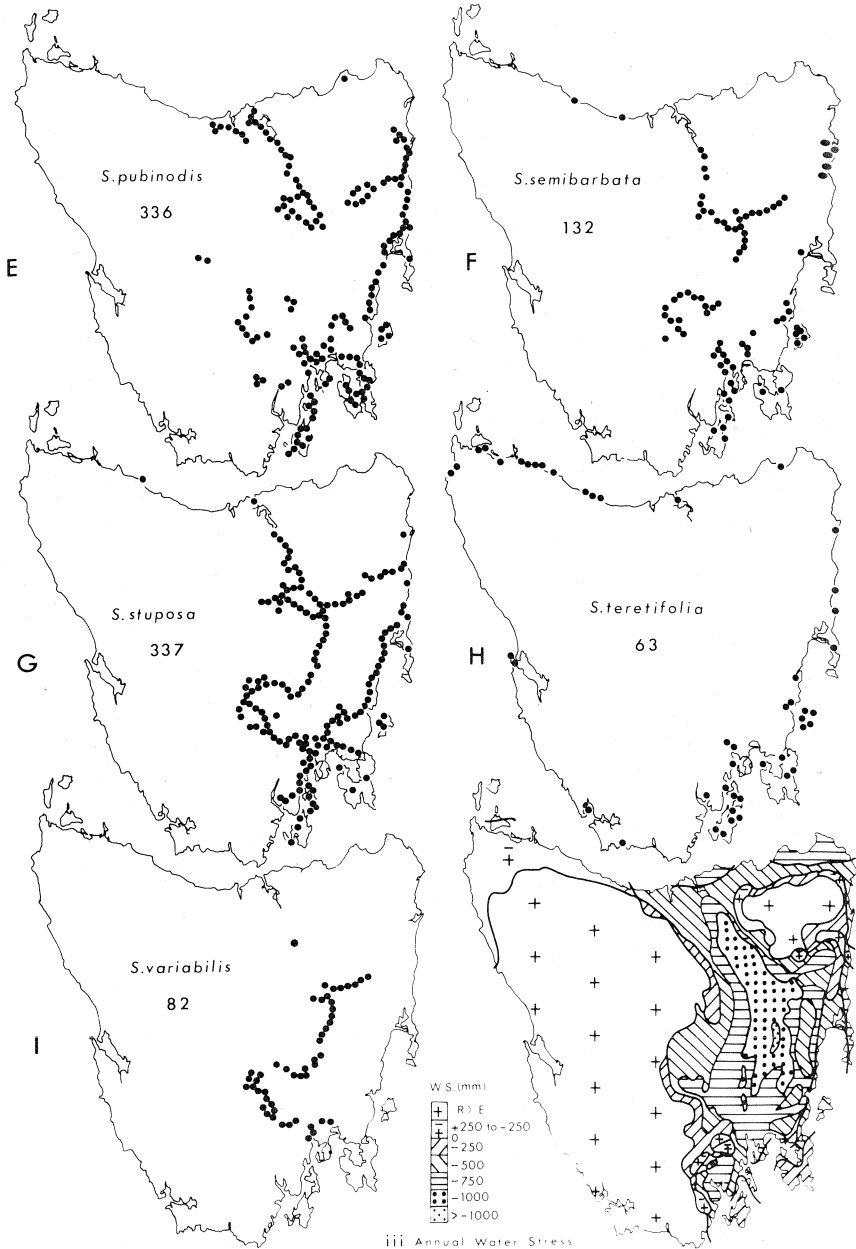
FIG. 1. - The distribution of *Stipa* species with totals of recorded localities.

Map i Areas of overlap between open woodland and scrub ("dry sclerophyll"), coastal heath, and cleared land which lie below 300 m with a mean annual rainfall of less than 1020 mm.

Map ii Survey collecting routes and the distribution of the species.

Map iii Annual Water Stress (Mean Annual Rainfall (R) - Mean Annual Evaporation (E)).

Maps A - I Distributions of individual species.



discussed for each species.

DISCUSSION

The most significant environmental factors determining the distribution of Tasmanian species of *Stipa* include rainfall, altitude, and incidence of grazing. The largest proportion of the *Stipa* population in Tasmania occurs in areas of low woodland, grassy woodland, open woodland and open scrub (the "dry sclerophyll" of Jackson 1965), coastal lowland open heath, and in cleared areas within those vegetation formations, where the annual rainfall is less than 1020 mm (vegetation formations and subformations defined by Specht 1970).


TABLE 1

THE OCCURRENCE OF *STIPA* SPECIES IN STRUCTURAL FORMS OF VEGETATION

FORMATION*	SUBFORMATION*	REPRESENTATIVE AREA	<i>STIPA</i> Species ↑ Increasing frequency of occurrence
Open Forest	Low open forest - margins	Maria Island south east of Darlington	<i>S. pubinodis</i> <i>S. mollis</i> <i>S. aphylla</i>
Woodland	Low woodland	East coast north of Bicheno; North Bruny Island	<i>S. pubinodis</i> <i>S. mollis</i> <i>S. stiposa</i> <i>S. nervosa</i> var. <i>neutralis</i> <i>S. aphylla</i>
	Grassy woodland	Tasman Highway south east of Copping	<i>S. pubinodis</i> <i>S. stiposa</i> <i>S. nervosa</i> var. <i>neutralis</i>
Open Woodland	With tussocks of <i>Lomandra</i> and <i>Danthonia</i>	Fingal Valley west of Fingal	<i>S. stiposa</i> <i>S. semibarbata</i> <i>S. variabilis</i> <i>S. pubinodis</i>
Open Scrub	Grassy open scrub	Midland Highway in vicinity of Conara	<i>S. stiposa</i> <i>S. variabilis</i> <i>S. semibarbata</i> <i>S. mollis</i> <i>S. pubinodis</i>
Open Heath	Coastal lowland	Great Bay, Bruny Island	<i>S. compacta</i> <i>S. stiposa</i> <i>S. pubinodis</i> <i>S. semibarbata</i> <i>S. mollis</i> <i>S. nervosa</i> var. <i>neutralis</i>
Coastal Dune		Cloudy Bay, Bruny Island	<i>S. compacta</i> <i>S. mollis</i> <i>S. stiposa</i>
Strandline		Maria Island	<i>S. teretifolia</i>
Salt Marsh		Little Swanport	<i>S. teretifolia</i>

* The system of classification used is defined by Specht, 1970.

Table 1 summarises the occurrence of the species in order of frequency in relation to their associated structural forms of vegetation.

The marked effect of grazing pressure is inferred from the rare occurrence of *Stipa* spp. in grazed areas, where it is confined to plants protected by clumps of *Lomandra longifolia* Labill. mostly within 20 m of boundary fences. Exceptional localities with extensive populations of *Stipa* are all on steep slopes ungrazed by sheep, usually associated with dolerite outcrops, e.g. the Domain, Hobart, the area occurring 2.8 km west of Buckland on the Tasman Highway indicated on the map (fig. 3) by , and the dolerite hilltop north of Mt. Spode called Clyde Hill (274 m) on the Hamilton to Pelham Road.

Areas of closer study

The four areas chosen for closer study present a range of habitats:-

- (a) The Buckland area has been cultivated for about 130 years. In earlier times mixed farming was usual, but now extensive pastoral farming predominates. The land has been partially cleared of its original low open forest and low woodland, and ranges in elevation from sea level to about 460 m. Soils include podzols on mudstone, sandstone or dolerite, brown soils, lateritic and alluvial soils, and soils on recent sands.
- (b) Bruny Island, isolated from the mainland by D'Entrecasteaux Channel, has soils based on rocks ranging from the Permian to the Quaternary (Recent sands). The tree vegetation varies from grassy woodland on North Bruny (annual rainfall 510 - 760 mm) to closed forest (Specht l.c.) on South Bruny (annual rainfall 1020 - 1270 mm). Altitudes range from sea level to 550 m. Large tracts of land recently cleared and grazed can be compared with areas cultivated in the late 19th century and now either abandoned or still farmed.
- (c) Maria Island, the site of early settlement, is now a nature reserve. Grazing and burning off, completely restricted since 1972, were responsible for some modification of the vegetation at the time of this survey (1968). The island has areas based on rocks ranging from the Devonian (granite) to the Quaternary (Recent sands). A fault running roughly north/south in the north end of the island has caused the juxtaposition of rocks of Permian and Jurassic age.
- (d) Slopene (or Sloping) Island, unmapped in detail, is 1.6 km long, 0.8 km wide, and isolated from the northern end of Tasman Peninsula by a channel 1.6 km wide. A single dwelling indicates the extent of former habitation and it is now visited only by fishermen and officers of the Serrated Tussock Eradication Campaign.

Geology and Soils

Studies on species distribution in relation to soils and/or geology in the Buckland area, and on Bruny and Maria Islands, indicate that *Stipa* spp. in Tasmania are most frequently associated with soils on recent sands (Quaternary), and podzolic and brown soils on dolerite (Jurassic) (fig. 4). Podzolic soils on dolerite are more frequently associated with *Stipa* spp. than podzolic soils on either Triassic sandstone or Permian mudstone. In the Glenora area *Stipa* spp. are noticeably more prevalent on dolerite based soils than on soils on basalt flows.

Rainfall and Water relations

Stipa is associated with dry grasslands in other parts of the world including the Russian Steppes, and the Plains and Prairies of North and South America (Bor 1960, 1968, 1970; Caro 1966; Elias 1942; Hitchcock 1925, 1935; Komarov 1934; Matthei 1965). In Tasmania the genus is most closely associated with areas with an annual rainfall of less than 1270 mm, (93% of localities occur in areas receiving not more than 1020 mm p.a., and 72% where the rainfall is 760 mm p.a. or less).

Analysis of distribution in relation to water stress using a simple index (Water

Distribution of *Stipa* Species in Tasmania

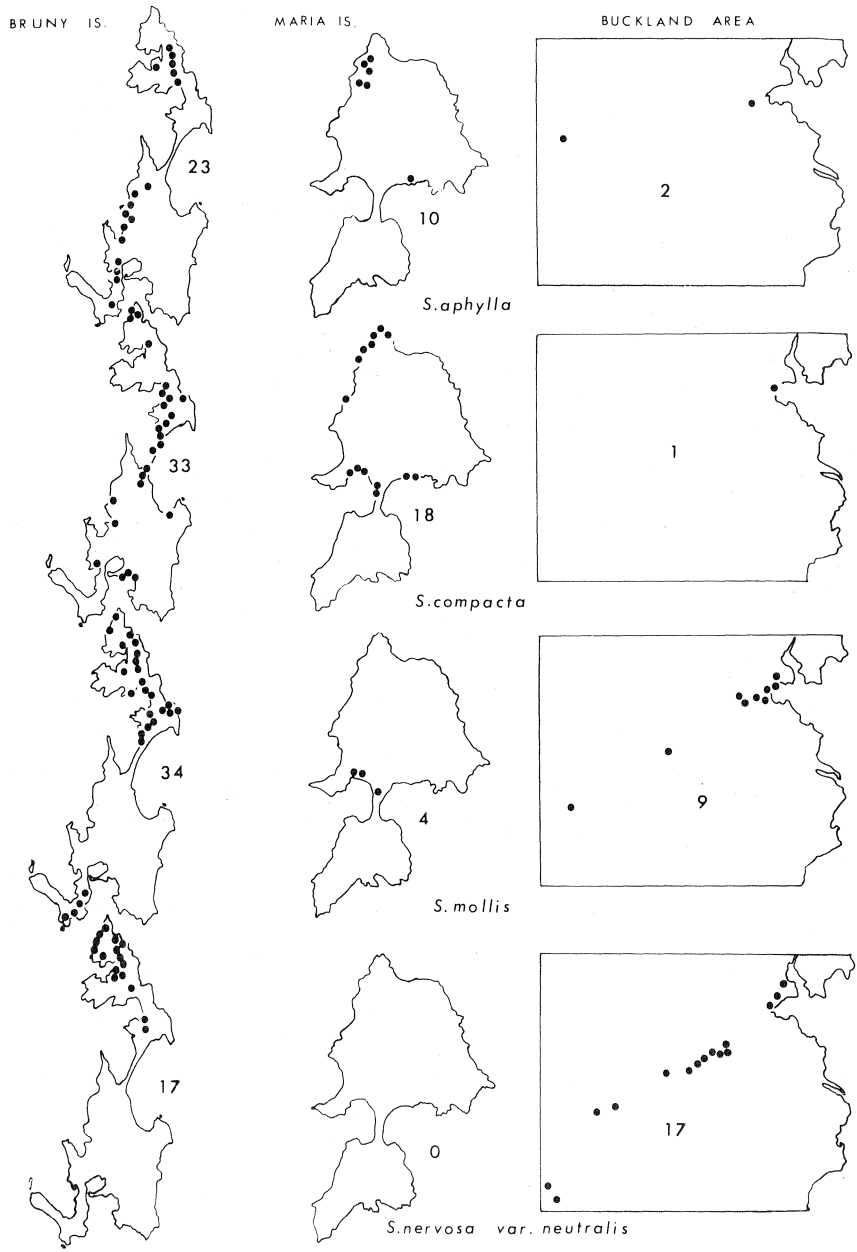
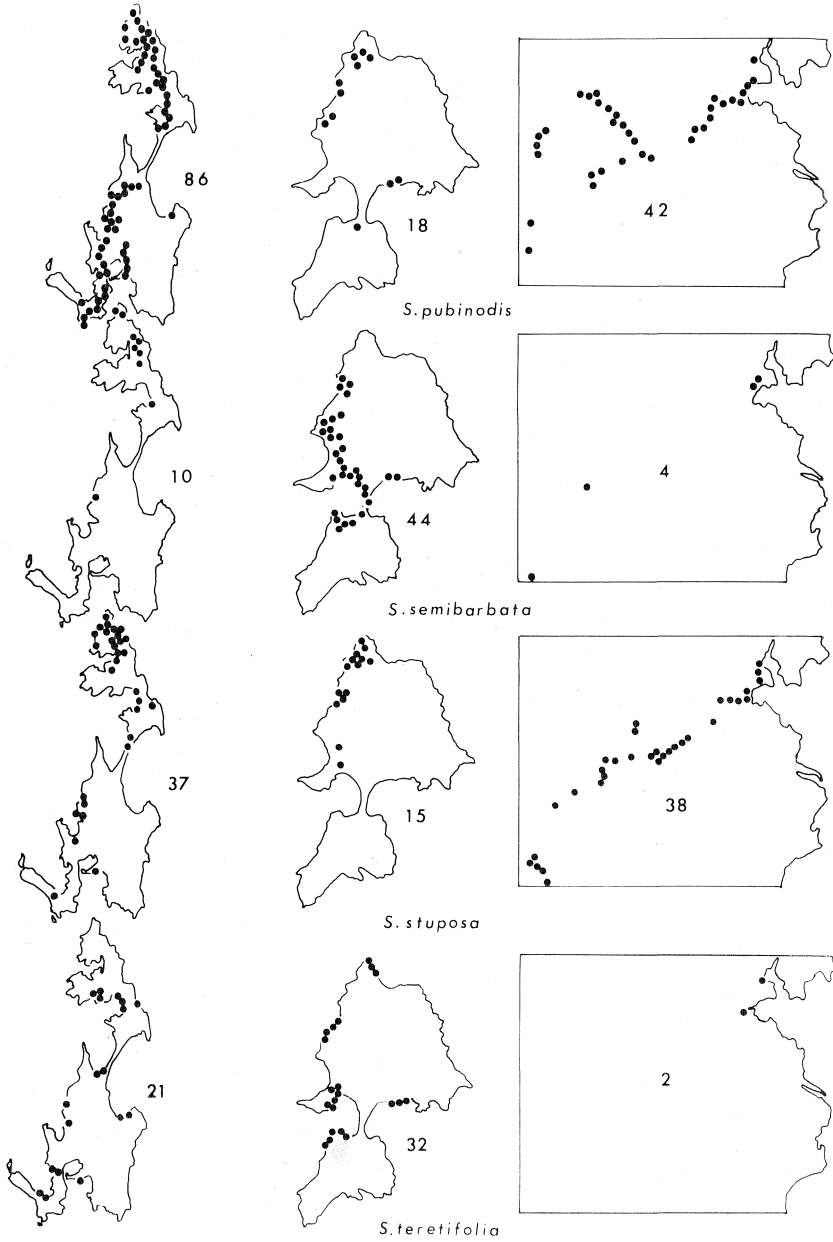


FIG. 2. - The distribution of *Stipa* species on Bruny Island, Maria Island and in the Buckland area, with totals of recorded localities.



Distribution of *Stipa* Species in Tasmania

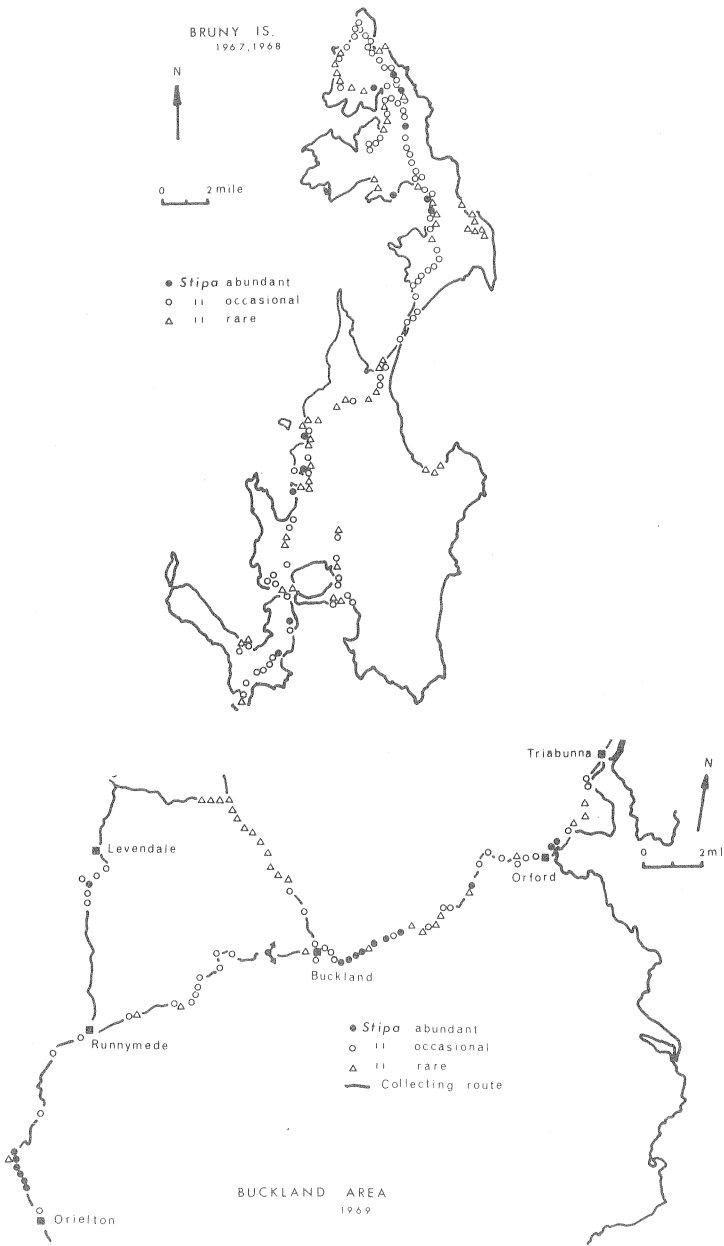


FIG. 3. - Relative abundance of the genus on Bruny Island and in the Buckland area. Each symbol represents a locality where *Stipa* occurs; estimates of abundance were made along 20 m stretches of roadside; abundant = more than 20 plants; occasional = more than 5 and up to 15 plants; rare = 1 to 5 plants.

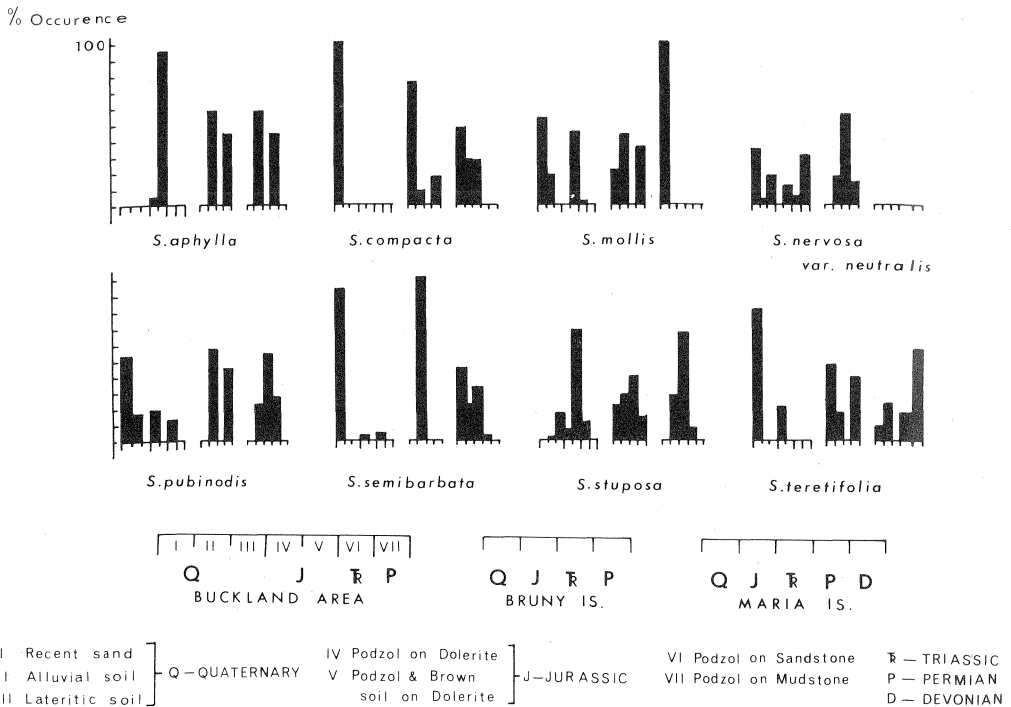


FIG. 4. - The distribution of the species in relation to soils & geology, comparing the Buckland area (soils and geology), Bruny and Maria Islands (geology only). "Occurrence" = the number of localities weighted to allow for the unequal distances of the collecting routes over the component sorts of soils and age of rocks, and also for the comparative abundance of the spp. in the Buckland area and on Bruny Island.

Stress Index, W.S.I.) equal to Annual Precipitation minus Annual Evaporation produced data supporting the general observation that *Stipa* is adapted to dry environments. Insufficient data on Tasmanian conditions precludes the application of more meaningful indices of available water such as that of Prescott (1948-49). The maps of Mean Annual Rainfall and Mean Annual Precipitation from the publication "Climate of Tasmania" 1971 edn., are combined in a map of "Annual Water Stress" (fig. 1, map iii). A comparison of this map with the maps of species distribution shows some trends in tolerance of possible water stress; 95% of *Stipa* localities occur where the water stress index (W.S.I.) is negative, i.e. where evaporation exceeds rainfall; 58% are associated with W.S.I. values ranging from -510 mm to -1020 mm, the drier end of the range; only 2% occur where rainfall exceeds evaporation.

Species such as *S. variabilis* and *S. semibarbata*, which from a study of herbarium material are typical of the drier parts of the Mainland of Australia, occur mostly in areas of greater annual water deficit in Tasmania (fig. 1, W.S.I. of -760 mm to -1020 mm). *S. aphylla*, a species endemic to Tasmania, is more typical of areas where the annual water deficit is less intense (fig. 1, W.S.I. 0 to -250 mm).

Studies of monthly average rainfall and evaporation in relation to distribution of *Stipa* spp. suggest that differences in species water requirements and/or species tolerance of water stress are present over a year's growth cycle.

The flowering periods of each species determined from collection data and growth records of bucket grown specimens are given in fig. 5.

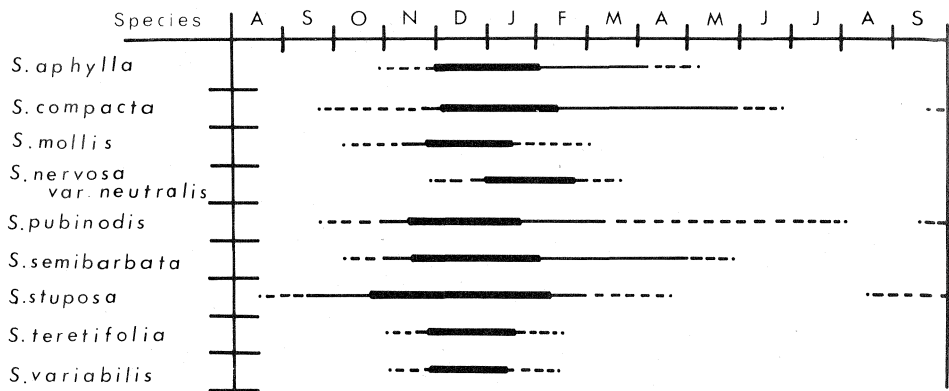


FIG. 5. - Flowering periods of the *Stipa* species.

Figure 6 is based on a comparison of the species distribution maps with maps of monthly average rainfall (drawn using the figures of revised mean monthly averages 1970 supplied by the Hobart Meteorological Bureau) and maps of mean monthly evaporation (Meteorological Bureau, Melbourne).

The range of rainfall (R) and evaporation (E) values which coincide with the margins of distribution of each species are taken to be limiting to that distribution.

In figure 6 the monthly range of R (maximum and minimum) is represented by hatched columns, the range of E by lines sloping from minimum to maximum values, and the water stress index (W.S.I.), the resultant of R-E, by unhatched columns.

Where R exceeds E then the W.S.I. has a positive value. This is taken to indicate the absence of a water-deficit stress. Conversely where E exceeds R, the W.S.I. has a negative value and a water-deficit stress may be present. The areas of the columns representing W.S.I. are taken as a measure of W.S. The sum of these areas (Σ W.S.I.) is used to compare species tolerance of W.S. over the twelve months period.

From figure 6 it can be deduced that some relationship exists between negative W.S.I. and flowering. The onset of flowering in most of the species seems related to months when E starts to exceed R. Those species with a more marked Mainland distribution such as *S. variabilis*, *S. mollis* and *S. nervosa* (see below) have a flowering period confined to those months where E exceeds R, whereas those with a predominantly Tasmanian distribution such as *S. pubinodis*, *S. aphylla* and *S. stuposa* (see below) continue to flower when R begins to exceed E.

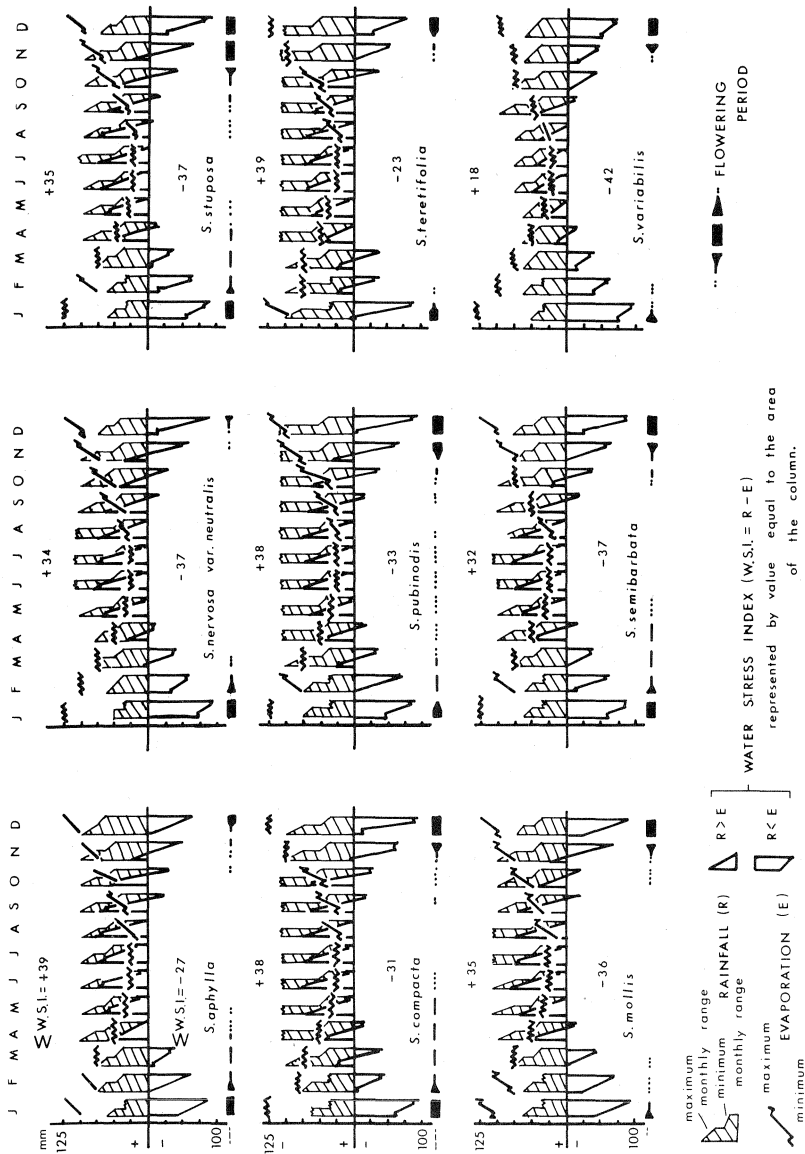


TABLE 2

A COMPARISON OF SPECIES TOLERANCE OF WATER STRESS OVER A 12 MONTHS CYCLE

(BASED ON FIG. 6)

Species	i { <u>W.S.I. for 12 months</u>			ii <u>No. months in year when W.S.I. =</u>					iii <u>No. months in year with rain-fall of</u>			iv <u>Months flowering</u>
	-ve	+ve	sum of -ve +ve	-75mm or more	+ve	-ve	range from +ve to -ve	-ve or range from +ve to -ve (c + d)	115mm	up to 100mm	>100mm	
	(a)	(b)	(a + b)			(c)	(d)	(c + d)	(e)	(f)	(e + f)	
<i>S. teretifolia</i>	-23	+39	+16	3	6	3	3	6	9	3	12	3.5
<i>S. aphylla</i>	-27	*+39	+12	4	5	4	3	7	0	9	*9	7
<i>S. compacta</i>	-31	+38	+ 7	4	4	4	4	8	7	3	10	9.5
<i>S. pubinodis</i>	-33	*+34	+ 1	5	4	*3	*5	8	9	1	10	11
<i>S. mollis</i>	-36	+35	- 1	5	4	4	4	8	2	6	8	*5
<i>S. stuposa</i>	-37	+35	- 2	5	4	4	4	8	1	7	8	10
<i>S. nervosa</i> <i>var. neutralis</i>	-37	+34	- 3	5	4	4	4	8	3	4	7	*4
<i>S. semibarbata</i>	-37	+32	- 4	5	4	5	3	8	1	5	6	8
<i>S. variabilis</i>	-42	+18	-23	6	4	6	2	8	0	1	1	3.5

In Table 2 the species are compared in relation (i) to W.S.I. over a twelve month period, (ii) to various values of W.S.I., (iii) to the number of months in the year with a rainfall of 100 mm and over, and (iv) to the length of the flowering period.

With one or two exceptions (marked *) the order of species for increasing negative values of W.S.I. (column ii) and for decreasing number of months with 100 mm rainfall (column iii) is the same. With the notable exceptions of *S. mollis* and *S. nervosa* the species with the shortest flowering periods appear at both ends of column iv. *S. teretifolia* is a special case (see below). Those with the longest flowering periods tend to occur towards the middle of column iv.

Altitude above sea level

The genus is found predominantly at altitudes between sea level and 90 m; 50% of localities are below 180 m, 30% between 180 m and 300 m, and only 12% above 300 m. The highest recorded locality is at about 700 m, that of *S. pubinodis* near Derwent Bridge, but the genus is rarely found above 400 m. Three of the Tasmanian species (*S. semibarbata*, *S. stuposa*, *S. variabilis*) grow predominantly in areas of between 180 m and 300 m altitude. The other species occur mostly in areas below 180 m although a few including *S. mollis* and *S. pubinodis* may extend into areas of higher altitude than the three first mentioned (fig. 7A).

Temperatures

The species show distinct differences in distribution in relation to temperature. Most populations grow in areas with a mean maximum January temperature range of 21 - 23°C, and a mean minimum July temperature range of 3 - 5 °C (figs. 7B,C).

The distribution of the species may be limited by various environmental factors differing for each species. The parameters suspected to be most significant for each species are listed in Table 3.

TABLE 3
ENVIRONMENTAL PARAMETERS ASSOCIATED WITH THE LIMITS OF DISTRIBUTION OF *STIPA* SPP.

Species	Altitude	Mean Max. Jan.Temp.	Mean Min. July Temp	Mean Annual Rainfall	Mean An.Evap.
	m	°C	°C	mm	mm
<i>S. aphylla</i>			2(lower limit)	1270 to 510	
<i>S. compacta</i>	90(upper limit)		2 " "	1400 to 510	
<i>S. mollis</i>				1270	1650 to 1020
<i>S. nervosa</i> var. <i>neutralis</i>	300 " "	19(lower limit)		1270	1650 to 1020
<i>S. pubinodis</i>				1270	1520
<i>S. semibarbata</i>				1270	1520
<i>S. stuposa</i>				1270	1520
<i>S. teretifolia</i>	90 " "				1520 to 1020
<i>S. variabilis</i>		21 " "		1020	

THE DISTRIBUTION OF THE SPECIES

Stipa aphylla (Rodway) Townrow

This endemic species is restricted to coastal and near-coastal areas of low woodland and margins of low open forest in south-eastern Tasmania (fig. 1, map A, fig. 2). Less closely associated with roadsides than other *Stipa* species, it occurs at the

margins of more open areas of *Eucalyptus obliqua* L'Herit., *E. viminalis* Labill., *E. linearis* Dehn. and *E. amygdalina* Labill.. The fine, cane-like leafless stems and delicate inflorescences often grow up through the coarse foliage of *Lomandra longifolia* Labill.

The species seems able to survive scrub clearing operations for a limited time, persisting in missed strips for a season or two. Most localities occur between altitudes of 90 and 180 m on dolerite or mudstone-based podzols. The species is notably absent from soils on Triassic Sandstone. The absence of records in areas with mean minimum July temperatures below 2°C suggests that this species is frost susceptible (fig. 7).

Stipa compacta Hughes

S. compacta (fig. 1, map B) has a distinctly coastal distribution, occurring predominantly below elevations of 30 m on low stabilised dunes, sandy beach ridges, sandy road verges and in cleared or treeless coastal heath areas. No Tasmanian localities occur above 180 m.

The species flowers between September and June with peak flowering between the end of November and the beginning of February (fig. 5). Its limits of distribution may be set by rainfall. The critical upper limit lies between 1020 mm and 1270 mm per annum, a higher limit than that of any of the other Tasmanian species except *S. teretifolia*. (See map B, fig. 1 for critical locality (*) at Cape Sorell). *S. compacta* may be frost susceptible as it is absent from areas with mean minimum July temperatures below 2°C.

Stipa mollis R. Br. and *S. semibarbata* R. Br.

The taxonomic status of these two entities is not clear. They may be distinct species or may represent the two ends of a cline. My examination of herbarium material (K., N.S.W., MELB., AD., AD.W., CANB. CSIRO, CANB. BG.) indicates that there has been considerable confusion in the naming of the two entities by past botanists. From the prevalence of each in the collections and their localities, the general indications are that on the mainland of Australia *S. mollis* occurs through Victoria to areas north of Sydney, N.S.W., and westwards to Adelaide, S.A., while *S. semibarbata* has a wider distribution extending further into the drier areas of the Eastern States. The latter also grows in Western Australia.

In Tasmania both are confined to the eastern half of the island. They occupy distinct but overlapping ecological niches so are considered together. (See table 1; fig. 4). A small number of specimens intermediate in adaxial leaf ornamentation and lemma characters have been collected (Hobart, Old Beach, Orford).

Superimposition of the distribution maps (fig. 1, maps C,F) demonstrates clearly that their localities alternate e.g. *S. mollis* is frequent along the Tasman Highway (East Coast) while *S. semibarbata* is rare or altogether absent; *S. semibarbata* occurs in the absence of *S. mollis* from Tunbridge to Cleveland (Midland Highway). In regions of close distribution overlap *S. mollis* occurs in the gaps left by *S. semibarbata*. *S. mollis* tends to occur on the flatter higher areas (60% in the Buckland area were recorded at altitudes between 180 and 210 m), while *S. semibarbata* is more frequent on the steeper lower slopes (78% in the Buckland area were at altitudes below 60 m). In the Hamilton/Bothwell area *S. semibarbata* extends lower in the valleys than *S. mollis*.

Comparisons of the distributions of *S. mollis* and *S. semibarbata* in relation to mean maximum January and mean minimum July temperatures (fig. 7), mean annual rainfall and annual W.S.I. (fig. 7), monthly average rainfall and monthly W.S.I. (fig. 6), and soils (fig. 4) all suggest that *S. semibarbata* is adapted to drier and more sandy areas with hotter summers and cooler winters than *S. mollis*, and this is reflected in the distribution of the two species on the mainland.

In Tasmania *S. mollis* flowers from October to March (5 months) while *S. semibarbata* flowers from October to May (8 months) (fig. 5).

Both species are represented in early Tasmanian herbarium collections, e.g. *S. mollis* Gunn No. 1452, Hobart Town, 4.12.1840; *S. semibarbata* Type Specimen, Brown, Port Dalrymple (George Town) 1804, so that both were probably present prior to white settlement.

S. mollis, at present more closely associated with wooded areas (see table 1) and the sites of abandoned settlement (e.g. Slop Island, Maria Island, and Variety Bay North Bruny Island), appears to be adversely affected by scrub clearing, while *S. semibarbata*, originally more associated with open woodland and open scrub, is not much affected by clearing (table 4).

TABLE 4
INCIDENCE OF *S. MOLLIS* AND *S. SEMIBARBATA*
IN RELATION TO WOODED AND CLEARED GROUND.

	<i>S. mollis</i>		<i>S. semibarbata</i>	
	Wooded	Cleared	Wooded	Cleared
Tasmania	45%	16% ↑	40%	47% ↑
Bruny Island	42%	58%*	78%	22%
Buckland area @	84%	16%	36%	64%
Maria Island	100%	-	72%	28% Δ

* Much of the ground in question has only recently been cleared (1971 - 1972), and is now used for sheep grazing.

Δ The cleared areas on Maria Island were deforested in the latter part of last century and subsequently were subjected to very intermittent sheep grazing and visits by nature lovers.

@ The Buckland area, now depressed agriculturally, has been subjected to extensive pastoral and mixed farming practices since the early days of settlement. The figures for the two species show opposite trends in cleared and wooded areas.

↑ The balance of localities occur in areas of coastal dune and heath.

Stipa nervosa var. *neutralis* Vickery

Vickery (1951) described the distribution of *S. nervosa* as "common on the coast and parts of the tablelands of New South Wales" but made no comment on the distribution of the variety *neutralis*. Studies of herbarium material in the herbaria (K., N.S.W., MELB., AD., ADW., CANB. CSIRO, CANB. BG) indicate that the species has a more northerly distribution than the variety. The variety is more common in central and southern Victoria and unlike the species extends into Tasmania.

In Tasmania it is associated with coastal areas between 30 m and 180 m altitude with an annual rainfall below 1020 mm (fig. 1, map D). It grows along roadsides in cleared areas occasionally extending into the more open parts of low woodland and

grassy woodland.

S. nervosa var. *neutralis* has a short flowering period (end of November to early March) with a later flowering peak than the other *Stipa* species in Tasmania (fig. 5). It may be adapted to withstand high degrees of water stress although it seems to be associated with areas having a more even distribution of rainfall over the wet months of the year (3 months with 115 mm, plus 4 months with 100 mm rain) than is required by the other species (table 2). The variety is less closely associated with soils derived from dolerite than the other Tasmanian *Stipa* spp. and in the Buckland area is the only one occurring on podzolic soils on mudstone (Permian) (fig. 4). A comparison of its distribution with the geological map of Tasmania (Department of Mines, 1961) suggests a strong correlation with Permian formations.

S. nervosa var. *neutralis* may be a fairly recent introduction to Tasmania from the mainland where it extends north into New South Wales. Its present distribution in Tasmania suggests that it is spreading inland from the highways of the East Coast and the West Tamar Highway and south along the Channel Highway across to North Bruny Island (figs. 1, 2). It has not yet been recorded on Maria Island (1970). The later dates of collection of herbarium specimens and the gradual spread of their localities with time also suggests a late arrival in Tasmania:-

1895 L. Rodway, Dromedary; 1926 R.A. Black, Pittwater; 1932 C.T. White, Kingston; 1945 W.M. Curtis, East Coast between Cape Bernier and Cockle Bay; 1948 W.M. Curtis, Devonport; 1949 N.T. Burbidge, Mt. Barrow road 9.6 km east of Launceston.

The single specimen collected before the year 1900 came from what might have been the first locality of the variety in Tasmania - the country residences of Hobart Town citizens in the Dromedary area.

Stipa pubinodis Trin. & Rupr.

Stipa pubinodis, formerly misidentified as *S. pubescens* R. Br. (Townrow 1970) and one of the two most common *Stipa* species in Tasmania, also occurs in South Australia and Victoria. It is the most widely distributed of the species in Tasmania (fig. 1, map E) and grows along roadsides in the flatter areas of woodland scrub and heath (table 1), extending sparsely off the roadsides into more open woodland, at altitudes mostly below 270 m. Its most westerly record is at Derwent Bridge near Lake St. Clair at an altitude of 724 m (2,376 ft, figure supplied by the Lands Department, Hobart) above sea level, the highest record for any species of *Stipa* in Tasmania. The species flowers for 11 months in the year (fig. 5). It is found on podzolic (dolerite or sandstone but not mudstone-based) and sandy or alluvial soils (fig. 4), but rarely on brown or black earth soils. Its distribution is contained within areas receiving 115 mm rain for 9 months in the year plus a further month with 100 mm rain, and where the net annual W.S.I. is most nearly zero (fig. 6). Over 90% of localities occur in areas with less than 1020 mm annual rainfall. *S. pubinodis* may be adapted to a greater range of mean maximum and minimum temperatures than those it encounters in Tasmania (fig. 7).

The trend in percentage localities of the species in relation to dry sclerophyll and cleared land (table 5) suggests that *S. pubinodis* decreases when woodland is cleared.

A curious absence of the species from the Midland Highway near Oatlands may be due to high elevation (400 m (1,324 ft); figure for elevation of Oatlands above sea level supplied by the Lands Department, Hobart) and/or the early date of clearing (early 19th century).

TABLE 5

S. PUBINODIS IN RELATION TO UNCLEARED AND CLEARED LAND

Area	% localities	
	Uncleared	Cleared
Tasmania	63	24
Buckland	65	35
Bruny Island	63	37
Maria Island	78	22

Stipa stuposa Hughes

S. stuposa, the commonest speargrass in Tasmania, and apparently an endemic species, is found along the major highways and roadsides of the eastern half of the State, where it is associated with open areas in low and grassy woodland, and open woodland, scrub and heath (fig. 1G; table 1). An isolated westerly locality at Table Cape Lighthouse may be attributed to chance introduction.

It occurs over a wide altitude range from 360 m near the Penstock Lookout at Poatina, down to sea level, but is most frequently associated with altitudes of 30 - 180 m. The species flowers from August to May (10 months) and seems well adapted to dry conditions. 50% of localities are in areas with less than 510 mm annual rainfall; 74% grow where the net annual W.S.I. ranges from -510 to -1020 mm (figs. 5, 7). *S. stuposa* usually grows on podzolic soils on dolerite or sandstone, rarely on mudstone-based podzols of Permian origin (fig. 4). Its distribution may be limited by lower mean maximum January temperatures and higher mean minimum July temperatures (fig. 7).

Unlike the other endemic species *S. aphylla*, *S. stuposa* seems favoured by tree clearing. Higher percentages of localities occur on cleared land than in scrub and woodland in Tasmania generally, and in the Buckland area and on Bruny Island in particular.

Stipa teretifolia Steud.

This species is a strandline xerophyte with heavily cutinised, needle-like leaves, which grows in salt-sprayed rock crevices usually at or just above sea level and in salt marshes. It occurs sporadically all round the coast of Tasmania (fig. 1, map H) and extends beyond Australia to New Zealand. The type specimen was collected by Banks and Solander from the North Island of New Zealand in 1769-70.

S. teretifolia extends into areas with a rainfall exceeding 1140 mm p.a. Its short flowering period of 3.5 months (early November to mid February) is similar to that of *S. variabilis* which is adapted to the driest habitats, (see below), (fig. 5).

Factors influencing its local distribution are obscure. The species is present in some localities and absent from other apparently equally suitable localities. It grows on hard rocky outcrops, including Precambrian, metamorphosed Precambrian, Cambrian, Devonian granite, metamorphosed Permian mudstone and Jurassic dolerite, but not on unmetamorphosed sandstone or mudstone. It rarely grows in the vicinity of coastal sand dunes supporting boobyalla (*Acacia sophorae* (Labill.) R. Br.). It seems likely that some quality of substrate stability determines the successful establishment of *S. teretifolia* in any particular locality.

Stipa variabilis Hughes

In this survey *S. falcata* (recorded twice for Tasmania) has been included with *S. variabilis*. The *S. variabilis* complex, predominantly mainland in its distribution, is well adapted to dry habitats. In Tasmania, the southern limit of its range, local-

ities are restricted to comparatively dry areas of open woodland and open scrub in the Southern and Central Midlands (fig. 1, map I; table 1). It grows along roadsides in cleared land, mostly between 180 and 300 m above sea level. Seventy percent of localities are in areas with less than 500 mm mean annual rainfall, where for a possible eight months in the year evaporation figures exceed precipitation and only one month out of the twelve may receive 100 mm rain (fig. 6; table 2). The comparatively short flowering period of 3.5 months commences after the onset of drier conditions at the beginning of November (fig. 5).

TABLE 6

METRIC CONVERSION TABLE - ENVIRONMENTAL FACTORS

<u>Feet</u>	<u>Metres</u>	<u>Inches</u>	<u>mm</u>	<u>°F</u>	<u>°C</u>
600	180	10	250	32	0
1,000	300	20	510	35	2
		30	760	38	3
		35	890	41	5
		40	1020	64	18
		45	1140	67	19
		50	1270	70	21
		55	1400	73	23
		60	1520		
		65	1650		

All localities are in areas experiencing the Tasmanian extreme of mean maximum January temperatures ($> 21^{\circ}\text{C}$), and 88% are in areas with the lowest mean minimum July temperature ($< 2^{\circ}\text{C}$).

S. variabilis is almost equally distributed in areas based on Tertiary (non-marine, and basalt), Jurassic dolerite and Triassic Formations, but is notably absent along Permian based sections of roadside e.g. New Norfolk to Westerway (fig. 4). In the Macquarie Plains/Glenora area it is conspicuously more abundant on soil on low dolerite outcrops than on basalt and other volcanic materials.

The species is among Gunn's collections (No. 1487) and in J. Hooker's Herbarium dated 1867, so is unlikely to be a recent introduction to Tasmania.

SUMMARY

1. The distribution of the genus in Tasmania is very nearly contained within the overlap of those areas of open woodland and scrub, coastal heath or cleared land which receive less than 1140 mm rainfall p.a. and have an altitude below 360 m.
2. *Stipa aphylla*, which occurs in low woodland and on the margins of open forest, *S. semibarbata*, open woodland, open scrub and coastal lowland open heath, and *S. variabilis* in open woodland and open scrub are confined to areas with an annual rainfall of less than 1140 mm at or below 300 m.
3. *S. mollis*, *S. nervosa* var. *neutalis*, *S. pubinodis* and *S. stuposa* extend into areas of slightly higher altitudes than the species in 2, though still with an annual rainfall below 1140 mm.
4. *S. compacta* grows in areas with slightly higher annual rainfall than the species in 2 and 3, while *S. teretifolia* has a distribution unaffected by higher annual rainfall. Both species have a coastal distribution and are absent from areas above 90 m

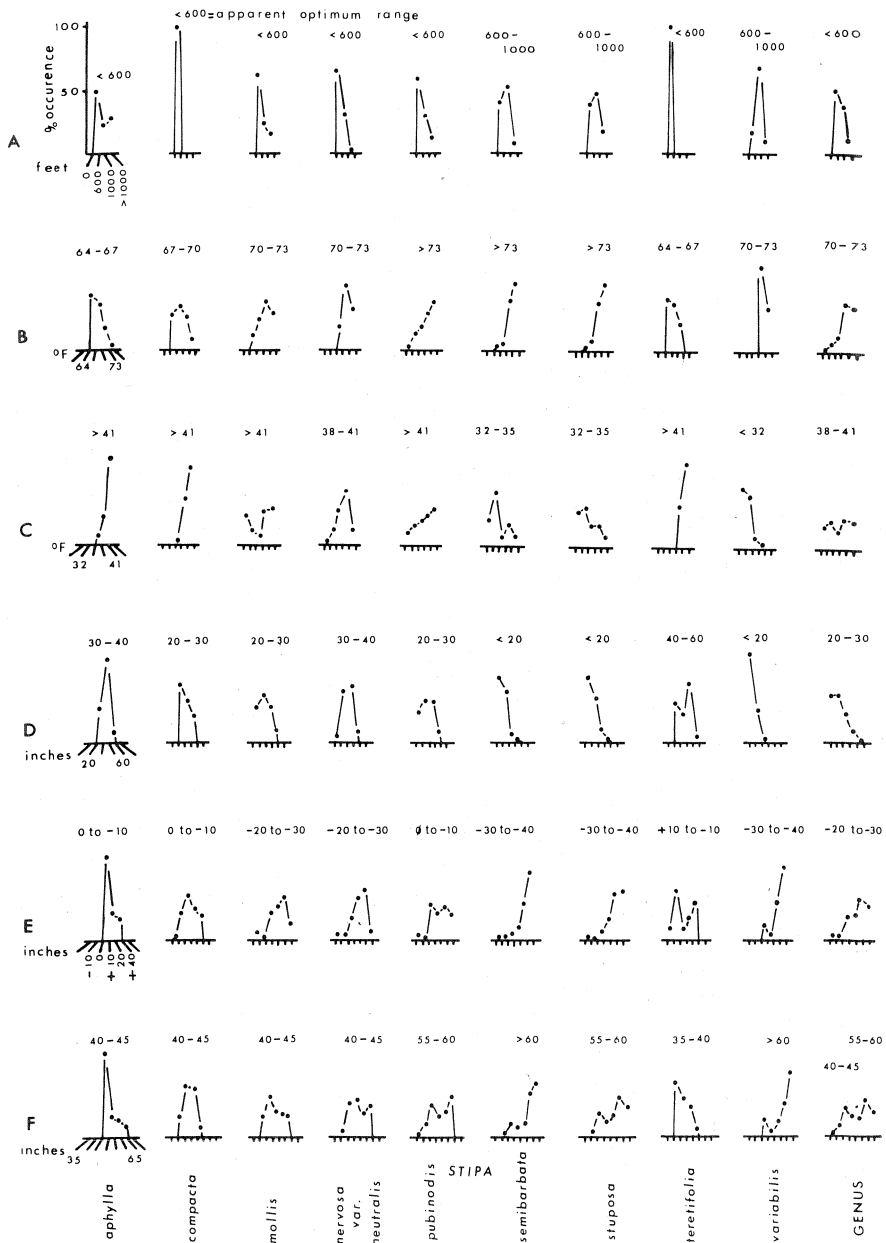


FIG. 7. - A summary of trends in distribution of *Stipa* in relation to some environmental factors:-
 the percentage of localities in relation to
 A : altitude above sea level
 B : mean maximum January temperature
 C : mean minimum July temperature
 D : mean annual rainfall
 E : annual water stress
 F : mean annual evaporation

altitude above sea level.

5. The percentage distribution of localities of each species in relation to altitude above sea level, mean maximum January and mean minimum July temperatures, mean annual rainfall and evaporation, and annual "water stress" are summarised in figure 7. Environmental parameters associated with the limits of distribution of each species are listed in table 3.

6. Light requirements of *Stipa* have not been investigated in this survey. The availability of light may well be the limiting factor for *Stipa* growth in areas of higher rainfall.

ACKNOWLEDGEMENTS

I am indebted to Mr. P. Broughton of the Mapping Division, and Mr. R. Preston both of the Hydro Electric Commission, Hobart, for help and advice in the manufacture of overlay maps and preparation of figures, and to Drs. J.J. Yates, L.P. Jones and R. Jones and Mr. M.R. Banks for much helpful criticism.

My sincere thanks are due to Sir George Taylor and Dr. W.D. Clayton of the Royal Botanic Gardens and Herbarium, Kew for permission to examine and borrow from the Australian collections of *Stipa* held in England.

The work was supported by a post graduate research scholarship from the University of Tasmania.

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