THE EFFECT OF AIRBORNE SALT DEPOSITION ON ACACIA REGENERATION NORTH KEPPEL ISLAND.

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" With them the Seed of Wisdom did I sow,

And with my hand labour"d it to grow.."

Omar Khayyam.

ABSTRACT.

The importance of airborne salt deposition in limiting Acacia regeneration on North Keppel island was first proposed by Brennan (1986). Observations of Acacia distribution and health tended to support this idea. In the salt exposed areas Acacia species were severely stunted and displayed a phyllode tip necrosis.

Airborne salt deposition was monitored throughout the grassland and forest zone. `Seedling´ development and symptoms were recorded at the various degrees of salt exposure. It was shown that actual salt deposition is a product of two interactive exposures, topographical and biological. Topographical exposure being based on the proximity to the sea and the extent of natural barriers. Biological exposure involves the general plant community and the degree of sheltering it offers. Acacia `seedling´ development under these parameters is significantly reduced in the topographically exposed hilltop sites. Within the less exposed gully site, there is little evidence of airborne salt deposition restricting regeneration success.

An investigation into other possible stresses was also undertaken. It was shown that soil nutrients were an important limitation to development. However soil salinity was seen to be of minor importance.

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INTRODUCTION.

North Keppel Island is located off the Central Queensland Coast (map 1.), 7.5 kilometers west of Yeppoon (map 2.). The Island is the second largest in the Keppel group, the most notable of which is Great Keppel. Although the vast majority of North Keppel Island is National Park, free hold leases do exist.

Over the past hundred years the Island has been constantly grazed and exposed to considerable human impact. Feral grazing has been recently removed from the Island as a part of National Parks and Wildlife Service management policy. A study into the success of Acacia regeneration currently occurring, will give some indication of the impact of past management decisions. The development of future policies may benefit as a direct consequence.

The possibility that airborne salt deposition is controlling Acacia regeneration on North Keppel Island was first put forward by Brennan (1986). Although studies into airborne salt deposition are rare in Australia, considerable work has been carried out in Europe and America. Airborne salt has been shown to play a major role in the distribution and success of coastal vegetation (Boyce 1954, Edward et al 1964, Goldsmith 1973 and Barbour 1978).

Initial observations on the Island tended to highlight the possibility of airborne salt deposition stress. Acacia species were distributed along the margins of the grasslands (map three), existing almost exclusively on the sheltered side of the main ridge system. Those few Acacia which extend past this zone are severely stunted in appearance (plate one). In the more topographically sheltered gully site Acacias are far less restricted. Seedling patches occur throughout the grassland with no evidence of plant stunting. The Acacia community is appears to be distributed where potential airborne salt deposition, would be expect to be reduced.

Acacia individuals in both the hilltop and gully grassland display distinct 'wind shaping' (plate two). Parsons et al (1968) concluded that asymmetric growth was direct related chloride toxicity, created by airborne salt deposition, continuously destroying the windward and terminal apices. Plant growth is derived from the lateral apical buds

on the leeward side of the branch, giving the plant its wind swept appearance (plate 2.).

Acacias occupying the grasslands and ecotonal areas were also shown to have a high incidence of phyllode tip necrosis. Studies by Parsons and Gill (1968) noted that tip necrosis symptoms were common in plants under airborne salt stress. Work by Goldsmith (1973) also suggested the possibility of soil salinity created by salt spray.

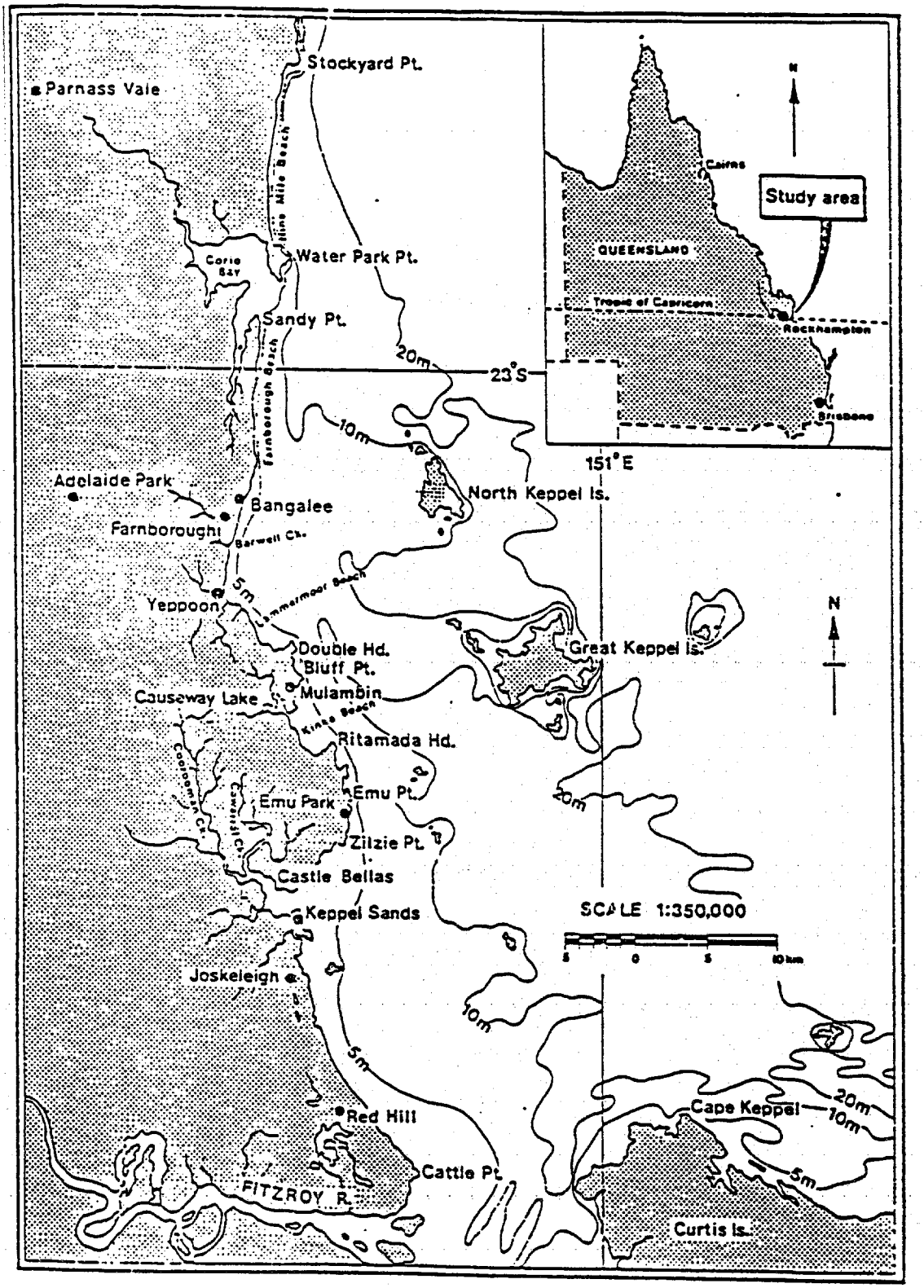
There is appears to be considerable field evidence to support the conclusions put forward by Brennan (1986). However it would be naive to ignore the possibility of other interactive stresses.

Soil type varies dramatically over the island, going from a loose textured black soil in the grassland to a compact clay in the forest. Acacia distribution may simply reflect differences in these soil type.

Fire and grazing should also be illustrated. Variation in fire characteristics have been shown to significantly alter regeneration success (Floyd 1966). Although grazing has been removed from the island, regeneration patterns visible today may be the product of selective grazing in the past. Plate 5 and 6 illustrate eroded zones in the gully site, possibly created by grazing pressures. Harrington (1979) reported that under grazing stress regeneration may be restricted and even totally removed.

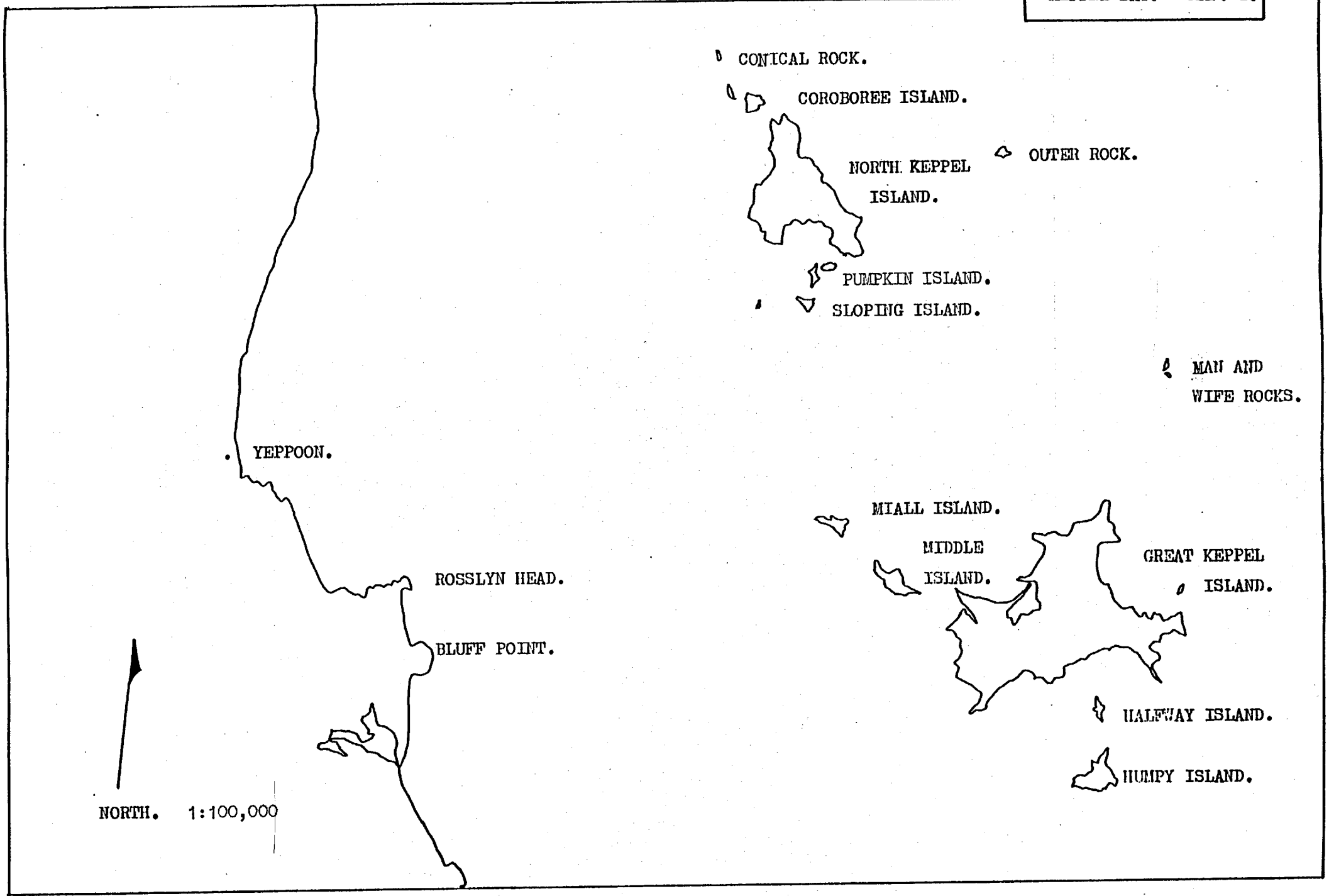
THE POSITION OF NORTH KEPPEL ISLAND.

MAP. 1.



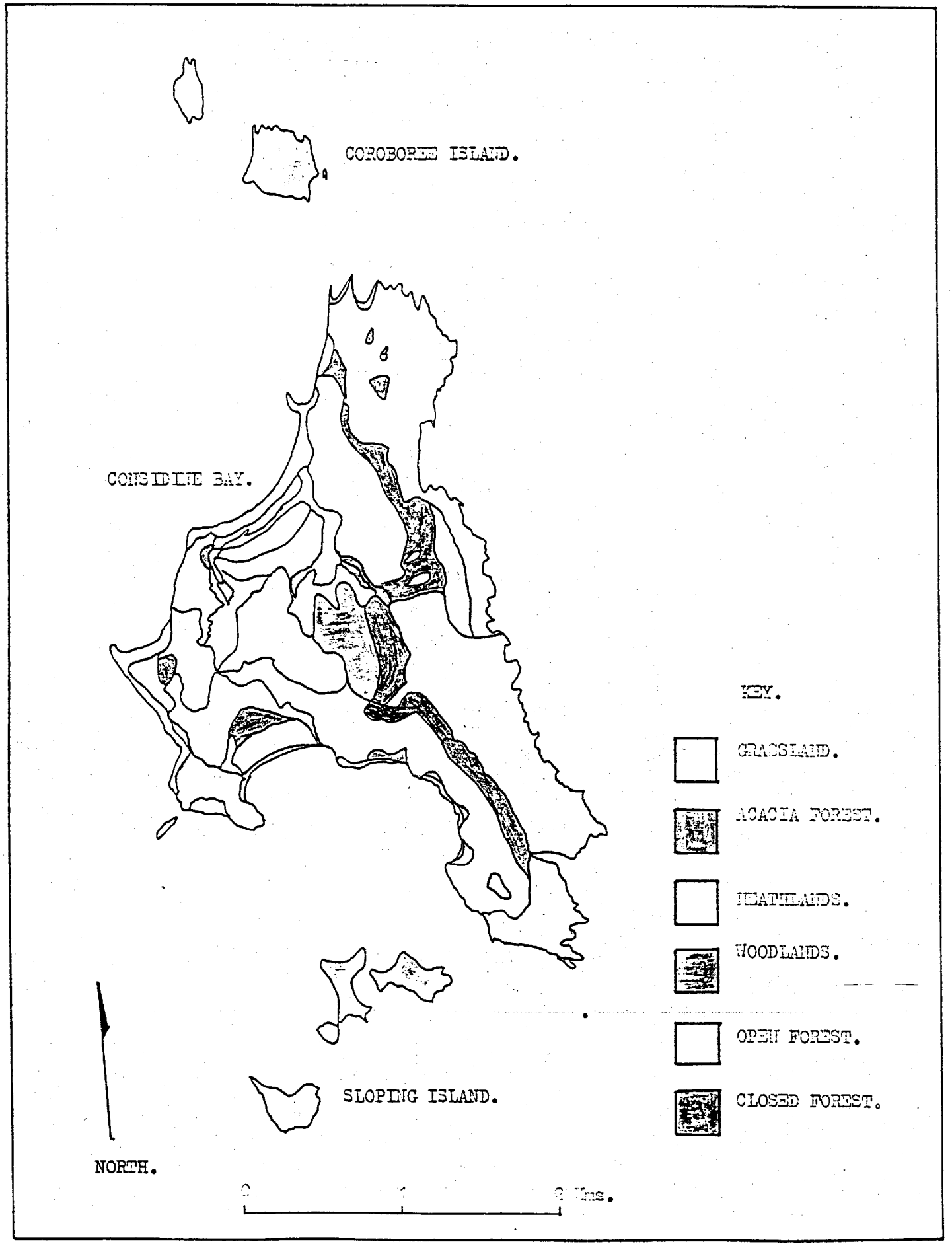
Extracted from Brennan (1986).

KEPPEL BAY. MAP. 2.

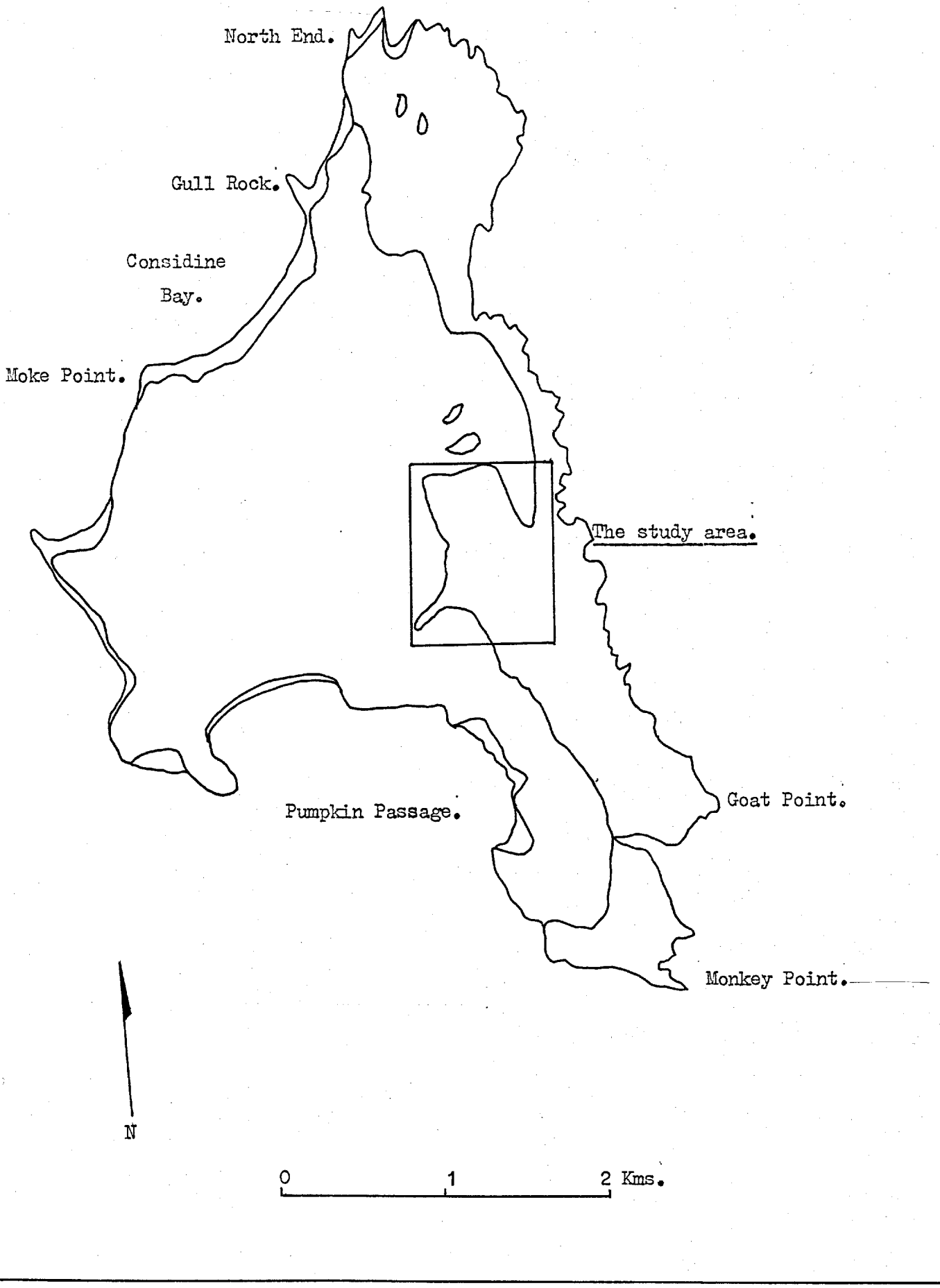


Modified fromC Creighton (1984).

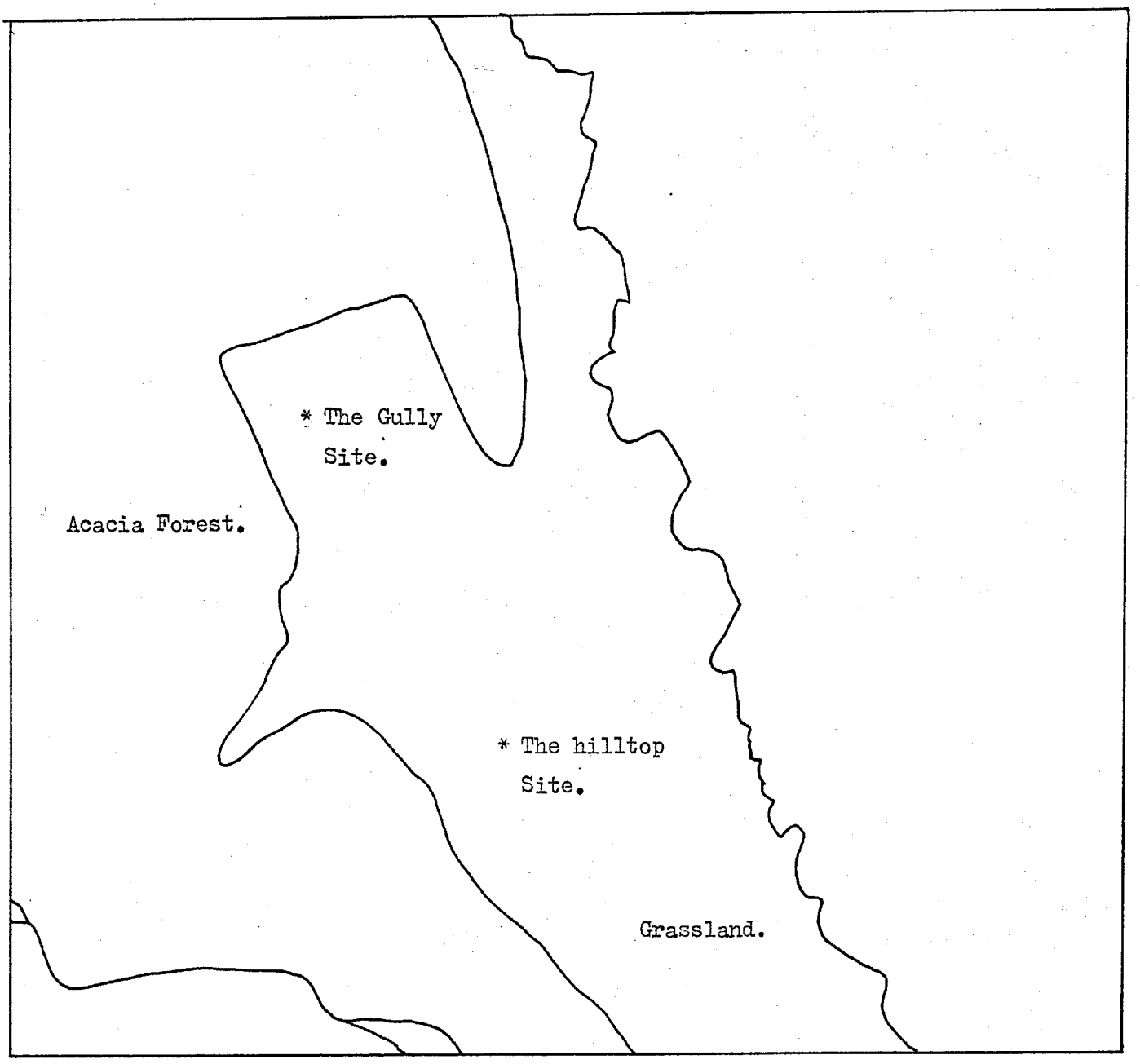
MAP. 3. A VEGETATION MAP OF NORTH KEPPEL ISLAND AND SURROUNDING ISLANDS.



MAP. 4. THE LOCATION OF THE STUDY SITES. (North Keppel)



MAP. 5. THE STUDY SITES. (North Keppel)



Two study sites were used, these were located in the hilltop and gully areas. These sites were chosen as they illustrated different geographical exposures. The gully site being the more sheltered of the two.

CLIMATE.

1.1 TEMPERATURE.

Temperature and humidity values for Yeppoon (the closest weather station) are presented in table 1. January is the hottest month, reaching a mean daily maximum temperature of 29.4 c, July is the coolest month only reaching 21.8 c. Creighton (1984) reported that diurnal temperature changes were between 7 and 9 c with this range being reduced in the summer months.

1.2 RAINFALL.

Rainfall patterns display a distinct seasonality, with the majority of the rain occurring in the summer months (table 2). September is the driest month, conceding only 2.5% of the yearly rainfall. January being the wettest month however, receives nearly 18.8% of the yearly rainfall. In addition to this there is a marked spatial variation in rainfall throughout the region (Creighton 1984). As Yeppoon is the closest weather station to the Island, it represents the most reliable data. However such spatial variation must be appreciated in the interpretation of the meteorological information presented.

1.3 WIND.

The wind is mainly from the south east, representing 28% occurrence. Southern winds are the next common contributing to 18% occurrence. Winds from the mainland (south west and north west) represent less than 8% of the yearly exposure.

The wind is generally moderate to fresh in strength. Creighton (1984) reported that velocities generally exceed 20 km/hr for at least 50% of the time. A more detailed breakdown of wind velocity is given in figure 1. Note that the most severe velocities correlate with those most commonly experienced, that is the south easterly and easterly directions.

It is believed that a strong seasonality of wind velocity and direction also exists. During the summer months wind was observed to be

gemerally south eastern and eastern in direction. However in the wimter, wind velocities tended to be reduced originating mainly from the maimland.

TABLE 1. THE DAILY MAXIMUM AND MINIMUM TEMPERATURES FOR YEPPOON STATION (^{O}C).
(Supplied by The Bureau of Meteorology. 1986.)

STATION. YEPPOON	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Max. Temperature	29.4	28.8	28.0	26.3	23.7	21.8	21.0	22.2	23.9	26.2	28.2	29.0	25.7
Min. Temperature	23.0	22.8	21.9	18.9	15.3	11.9	10.6	11.8	14.7	18.6	20.6	22.1	17.7

TABLE 2. THE RAINFALL AND HUMIDITY VALUES FOR YEPPOON STATION (mm).

Mean Rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Rainfall	252	243	192	106	82	74	48	36	34	64	76	143	1344
Median Rainfall	175	179	137	72	57	42	27	21	20	41	51	112	1227
Mean No's Raindays	11	11	11	8	6	5	4	4	4	5	6	8	83
Humidity 9am.	73	76	77	75	78	73	73	71	67	70	70	70	73
Humidity 3pm	70	73	72	69	69	63	64	63	63	69	67	68	68

Rainfall data is based on 1891 to 1985.
Supplied by the Bureau of Meteorology.

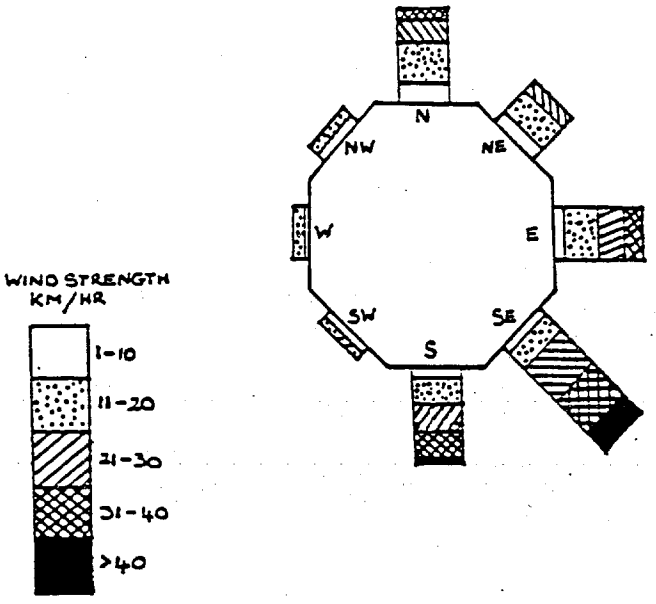
TABLE. 3.

RAINFALL DATA FOR YEPOON 1987.

	MONTH OF THE YEAR.					
	MAR	APR	MAY	JUN	JUL	AUG
TOTAL RAINFALL (mm)	42.5	167.2	24.4	24.0	42.0	37.4
NUMBER OF RAINDAYS	6	11	9	9	7	5

NOTE: INFORMATION FOR AUGUST IS ONLY UP TO THE 19th.

FIGURE 1. WIND DIRECTION AND VELOCITY.
Yeppoon.



This figure demonstrates the relationship between wind velocity and wind direction.
Extracted from Brennan (1986).

HISTORY OF NORTH KEPPEL.

North Keppel Island has a long history of human impact. Ganter (1985) suggested that a permanent aboriginal population had existed on the island for at least 400 years. Particularities in speech and customs between Island and Mainland populations expressed by Ganter gives grounds to suspect a more extensive period. Normal hunting practices of the aboriginal people usually included fire, the impact of which, on native vegetation has been widely acknowledged. It is believed that such practices may have been undertaken on North Keppel Island, and that they were in part response for the existence of the grassland areas.

Early European exploration of the Capricorn coast was carried out by Captain Matthew Flinders in 1802, although Captain James Cook had visited the area in 1770. Sightings of the Island's grassland, were the first step in that would eventually be extensive grazing programs. Goat populations were initially introduced in the 1880's, with cattle and sheep in the 1920's.

In 1938 a large percentage of the Island was declared a National Park. Feral grazing continued, with large areas of the grasslands being stripped of all vegetation. Erosion finally became a significant problem in the steep slopes. In 1975 as a part of the Queensland National Parks and Wildlife management policy all feral goats were removed from the Island. However it wasn't until 1984 with the eradication of feral cattle that grazing was total elimated. Two years later (Aug 23 1986) a major wildfire occurred on the Island.

METHODS AND OBSERVATIONS.

To establish the importance of airborne salt deposition requires an understanding of ecological, physiological and biochemical processes. The individual and interactive complexity of which, must delimit the certainty of conclusions. To overcome such limitations airborne salt deposition must be questioned at each level. Although it is impossible for such a goal to be achieved within this thesis, confident conclusions can be derived within a less extensive framework.

By utilising a multiple level analysis procedure it becomes monitoring to use several experiments. Although evidence concluded from each experiment may not be conclusive, in combination they form a self supporting argument.

THE MONITORING OF AIRBORNE SALT DEPOSITION LEVELS.

AIMS.

1. To investigate the actual salt deposition load
2. To test if a relationship exists between Acacia distribution and salt deposition.

METHODS.

The investigation of airborne salt deposition has been carried out through several experimental procedures.

A. SALT TRAPS.

1.Design.

Airborne salt deposition was measured by exposing a filter paper disc to the prevailing wind, in a similar technique to that used by Oosting (1945), Boyce (1954) and Randall (1974).

A small nine centimeter disc was placed within a shallow open ended plastic tube, to protect against rainfall. On the under surface of the tube a series of large holes were made. This was necessary to maximize the airflow within the tube, and therefore achieve a more realistic

expression of deposition (Grace 1977). Each tube was permanently attached to a wooden stake, position thirty centimeters above the grass or forest canopy.

Salt traps were set up in a series of transect lines, all facing in a south easterly direction (uniformity of orientation was pointed out by Grace (1977) to be critical).Each one of the eight transect lines was further divided in to five sample points : exposed (the eastern facing ridge), hilltop (the ridge top), sheltered (the western facing ridge), forest understorey and forest overstorey.

Salt traps were also randomly placed throughout the hilltop and gully sites. At each site four recording points were established, in an attempt to highlight deposition differences between the hilltop and gully.

Salt deposition was measured over two time periods, short term (2 days) and long term (28 days). The short term monitoring of deposition was designed to highlight distribution differences. Long term monitoring however was aimed at investigating depositional changes in respect to direction and height.

2.Analysis.

Exposed filter papers were analyzed through electro-conductivity recordings, a technique used by both Goldsmith (1973) and Barbour (1978). Each filter paper was cut into small pieces and placed into 10 milliliters of distilled and deionized water of known electro-conductivity. Each solution was covered and shaken regularly and after 2 days conductivity readings were taken.These conductivity values were subtracted from the initial conductivity of the solution. Because there is also a possibility that the filter paper itself may contain salts, electro-conductivity was taken for a clean filter paper. The conductivity values of the exposed filter paper were then subtracted from this value. The resulting values can therefore be directly equated to salt deposition.

B. FLAGS.

1.Design.

The use of flags as an indicator of 'windiness' has been previously been used in experiments in Europe (Goldsmith 1973). By placing flags of known dimensions throughout the Island and monitoring the level of fraying, an indication of wind strength can be achieved. As salt deposition is proportional to wind velocity (Oosting 1945 , Clayton 1972 and Barbour 1978) the more wind sheltered a site the lower the salt deposition potential.

The positioning of flags was the same as that outlined for the salt traps. This experiment however was set up as long term monitoring of wind, with flags being left on the island for six months

THE MONITORING OF ACACIA 'SEEDLING' DEVELOPMENT IN RESPECT TO AIRBORNE SALT DEPOSITION.

AIMS.

To investigate the importance of salt deposition on 'seedling' development in the field.

METHODS.

Acacia 'seedlings' development was monitored under normal, and artificially modified exposure level. Plant response was determined through relative changes in height

A. LOCATION OF PLOTS.

Field plots were set up in both the hilltop and gully sites (see map 4 and 5). These two sites were chosen as they displayed potentially different deposition load.

The actual position of treatment within either site was predetermined. Randomization was avoided because of the possibility of treatment interaction. The location of plots was based around two conditions. Firstly plots had to be in linear perpendicular series to the prevailing wind. By doing this, the possibility of a treatment altering the airborne environment of neighbouring plots is avoided. Secondly plots had to be set up perpendicular to the slope. Possible interaction created by run-on run-off can therefore also be avoided. These two conditions coupled with low 'seedling' density necessitated some form of compromise to be made. The ultimate plot positions are illustrated in the appendix. This experiment was established as a short term monitoring of plant development, with treatment applied over a six month period (March to August).

B. TREATMENT.

Four different treatment were established at each site, these being: sheltering, fertilized, cleared, and control. Treatments were contained within a 1.5 x 1.5 meter plot, including ten Acacia 'seedlings'. 'Seedlings' were selected based on a predetermined height range. All

Acacia 'seedlings' were tagged and their position mapped. Treatment are outlined below.

1. SHELTERED: The idea of the sheltered treatment was to exclude airborne salt deposition. To do this, the plots was totally screened off using a fine fly screen material supported by wooden posts. The screen was at least forty centimeters taller than the seedling heights.

2. FERTILIZER: A general N.P.K. slow release fertilizer was applied to the base of each of the ten 'seedlings'. Apart from an initial application, a second was applied three months later.

3. CLEARED: This treatment was designed to have the opposite to that of the sheltered treatment. All plants less the ten acacia 'seedlings' were removed from the plot. In doing so, biological sheltering is reduced a the potential for salt deposition increased.

4. Control: No treatment was applied.

Although the inclusion of the sheltered and cleared treatments is self evident, the fertilizer treatment should be explained. It was initially hoped that results from this treatment could be compared to the nutrient experiment. However after the treatment was set up it was discovered that all 'seedlings' were joined by a common root system. Different fertilizer treatment would therefore have no effect as deficiencies could easily be supplemented. This treatment was continued however to determine exactly what the plant response might be.

THE DISTRIBUTION OF TIP NECROSIS

AIMS.

To establish the occurrence, extent and distribution of Acacia tip necrosis.

METHODS.

Acacia's throughout the eastern side of the Island were mapped and classified in terms of age (girth), height, topographical and biological exposure. The degree of tip necrosis was assessed by randomly selecting Acacia individuals.

INTERNAL CHLORIDE ANALYSIS OF ACACIA PHYLLODES.

AIMS.

1. To determine whether there is a relationship between tip necrosis and internal chloride concentration ?
2. Do Acacia phyllodes in the more exposed areas possess a higher internal chloride concentration ?

METHODS.

Acacia phyllodes of various degrees of tip necrosis and plant exposures were collected from a variety of exposed and non exposed site on the Island. Chloride analysis was then carried out to determine the internal chloride concentration.

A. THE SELECTION OF PLANT MATERIAL.

Mature Acacia phyllodes were selected based on the degree of tip necrosis they displayed and the level of plant exposure.

TIP NECROSIS: Five different levels of necrosis were used (nil, 0-10%, 10-40%, 40-50%, >50%). These were based on the area of the phyllode displaying necrosis. Ten phyllodes were collected for each class

EXPOSURE: Two different levels of exposure were observed, topographical and biological. To test these, phyllodes were collected from hilltop and gully grassland sites, using both adult and seedling plants. Phyllodes were also collected from the forest zone to further the comparison.

The concept of topographical and biological exposure will be referred to fairly extensively in the text. For this reason their definition should be made clear.

1. TOPOGRAPHICAL EXPOSURE.

Goldsmith (1973) and Barbour (1978) both reported that topography was very important in the determination of airborne salt loads. The closer the proximity to the sea and the lower the geographical sheltering, the greater deposition will be. For example, if a plant existed on the eastern seaward facing slopes it would have high topographical exposure. Conversely, if it was present on the sheltered western ridge side it would have low topographical exposure.

2. BIOLOGICAL EXPOSURE.

The importance of biological exposure has also be widely accepted. Boyce (1954) reported that in coastal communities, canopy surface roughness was proportional to salt deposition. Those plant which project above the general plant canopy experience higher salt deposition levels (Malloch 1972). The greater the projected height the larger the actual salt deposition load (Grace 1977). For example, those plant within the plant canopy , be it grassland or forest, experience high biological sheltering. However if the plant protudes above the general canopy, deposition and therefore biological exposure will be increased.

2. ANALYSIS PROCEDURE.

Acacia phyllodes were washed in distilled water to remove external salt, then oven dried. 0.200 grams of dried material was then finely ground and added to 20 milliliters of distilled and deionized water. (When total phyllode dry weight was less than 0.200 grams, 0.100 grams

was used, all other treatments were reduced accordingly). Two drops of 1m nitric acid was then added to aid cell breakdown. The solutions were then covered and left for two days, being shaken at regular intervals. A sample was then analyzed using the Corning-eel model 920 chloride meter, standard procedures as designated in the service manual were adopted. Each solution was analyzed five times, with a mean value being recorded in each case.

THE ARTIFICIAL APPLICATION OF AIRBORNE SALT SPRAY.

AIMS.

1. TO ESTABLISH THE RELATIVE SENSITIVITY OF ACACIA SPECIES TO AIRBORNE SALT DEPOSITION
2. TO OBSERVE VISUAL SYMPTOMS GENERATED BY ARTIFICIAL SALT APPLICATION.

METHODS.

Acacia leiocalyx and Acacia leptostachya , along with two comparison species, Casuarina equisetifolia and Rhynchelytrum repens , were subjected to various treatments. Treatment involved applying salt solutions of various concentrations to the plant foliage. Monitoring of plant response was by means progressive mortality and final dry weight.

1. EXPERIMENTAL COMPONENTS.

A. PLANT SELECTION.

Two Acacia species were selected for this experiment, Acacia leiocalyx and Acacia leptostachya. Both species occurred naturally on the Island, with Acacia leiocalyx representing the main regenerating species. To establish if a sensitivity exists, a comparison of response with other species is essential. For this reason Rhynchelytrum repens (a grass species from North Keppel) and Casuarina equisetfolia (a salt tolerator) were included.

B. MATERIAL.

Each species was grown from seed and later transplanted into pots (R.repens though, was sown directly into pots). With the exception of Acacia leptostachya, all seed stock were obtained locally. Although it would have been more desirable to collect seed from the Island, this was impractical at the time.

C. PLANT REPLICATES.

Although numerous attempts were made to have a uniformity of replicates, poor seed viability and high seedling mortality made this difficult. Rhynchelytrum repens proved to be particularly troublesome. The result was a unfortunate replicate difference between species.

Listed below are the final replicate values for each salt concentration treatment: A leptostachya (15 plants), A leiocalyx (10 plants), C equisetifolia (10 plants), E repens (5 plants).

D. GROWTH CONDITIONS.

A THE POTTING MEDIUM.

The potting medium consisted of a river sand and a brown loam mixture (1:1 proportions). This combination was used for two reasons. Firstly pre-experimental trials with just the brown loam produced surface crusting problems. Secondly the possibility of soil salinity could minimized through improved soil drainage.

B ENVIRONMENTAL CONDITIONS.

All species were grown under glasshouse conditions, with pot position being randomized every three weeks.

2. EXPERIMENTAL PROCEDURE.

Plants were subjected to one of six salt spray treatments (distilled water control, 25% sea water, 50% sea water, 75% sea water, 100% sea water, 200% sea water) where each treatment consisted of a different sea water concentration. The salt solution was applied to the plant foliage through hand spray, until leaf wetness was achieved. This treatment was carried out twice weekly for just under four months. Throughout the experiment progressive recordings of plant mortality, and plant symptoms were taken.

A SUBTRACTIVE NUTRIENT EXPERIMENT.

AIMS.

TO ESTABLISH THE NUTRIENT STATUS OF THE ACACIA FOREST AND GRASSLAND SOIL, AND TO INVESTIGATE THE POSSIBLE INVOLVEMENT OF SOIL NUTRIENTS IN ACACIA DISTRIBUTION AND REGENERATION SUCCESS

METHODS.

Acacia leiocalyx and Acacia leptostachya were grown in several different soil types collected from the Island. One of eight different nutrient solution were applied to each of the soil types. After four months seedlings were harvested and plant response measured.

1. EXPERIMENTAL COMPONENTS.

A. PLANT SELECTION.

Both Acacia species occurred naturally on the Island, with Acacia leiocalyx representing the main regenerating species.

B. SOIL.

Collection.

Soil was collected from four sites on the island, the gully grassland, the gully forest, the hilltop grassland and the hilltop forest. The position of these collection points were the same as that used in the field experiment (see map 5). Within individual sites, soil was collected from a further ten sample points. In doing so, variation in soil type within a site could be minimized. Soil removed at each of these sample points consisted of the top two to three centimeters of the soil horizon.

Preparation.

Soil from each site was dried and thoroughly mixed. All organic debri was removed and the soil sieved such that a 1:3 (2mm:1mm) particle ratio was produced. The sieving of the soil was seen as a necessary step to uniform soil texture. Approximately 200 grams of soil was then placed into small foam pots.

2. EXPERIMENTAL PROCEDURE.

Acacia seedlings were transplanted into pots two weeks after germination. Three seedlings were placed in each pot with a total of nine seedlings per individual nutrient solution. Eight different nutrient solutions were used, six lacking a specific element (-N, -P, -K, -S, -Mg, -Ca), one with all other elements removed (-TRACE) and a complete solution (All on). Treatment was initiated one week after transplanting and was maintained on a weekly basis. The delay in application allowed transplant mortality to be overcome and uniformity of replicates maintained. Each pot received 10 milliliters of the nutrient solution, the constituents and concentration of which are given in the appendix. The trial was run for fifteen weeks.

It was appreciated that given the time available, growth differences between treatments could be small. To maximize potential differences, attempts were made to reduce nutrient soil nutrient supply but at the same time increase nutrient demand. By using small soil volumes the natural nutrient supply could be easily reduced. Nutrient demand was increased by optimizing plant growth rate. To achieve this plants were grown under 13 hour illumination periods. Watering (distilled water only) was applied in small volumes on a daily basis. Pots were also randomized every three weeks.

RESULTS.

THE MONITORING OF AIRBORNE SALT DEPOSITION.

TABLE 4 THE RESULTS OF THE SHORT TERM SALT TRAPS

SITE	SALT DEPOSITION uMHO's	WINDINESS (mm fraying)
exposed grassland	13.53	3.2
hilltop grassland	12.13	3.0
sheltered grassland	9.63	2.2
forest overstorey	14.69	2.4
forest understorey	5.34	3.6

The level of salt deposition appears to decrease with geographical sheltering. Statistical analysis however failed to demonstration any significant difference between these values. In the forest understorey there is a significant ($P>0.05$) reduction in the level of salt deposition compared to the forest overstorey.

The monitoring of wind failed to illustrate any significant difference in wind exposure.

TABLE 5.

A COMPARISON OF SALT DEPOSITION BETWEEN HILLTOP AND GULLY

SHORT TERM SALT DEPOSITION.

SITE	SALT CONCENTRATION uMHO"s	S.D.	NUMBER OF SAMPLES
HILLTOP GRASSLAND	12.9500	7.5767	4
HILLTOP FOREST	7.5000	6.6467	4
GULLY GRASSLAND	10.8500	12.8300	4
GULLY FOREST	7.2750	31.2692	4

There is no statistical difference between salt deposition values in the hilltop and gully sites. This appears to be created by the high variance in the gully. Within sites however, salt deposition is significantly lowest (P>0.05) where biological sheltering is maximal . That is, the forest zone in both gully and hilltop sites have reduced salt deposition loads to that of the grasslands.

TABLE 6.

THE RESULTS OF THE FLAG EXPERIMENT EXPERIMENT.

SITE	LEVEL OF MATERIAL FRAYING (mm)	S.D	NUMBER OF SAMPLES
HILLTOP GRASSLAND	3.00	0.50	5
HILLTOP FOREST	1.60	0.30	5
GULLY GRASSLAND	4.00	0.50	5
GULLY FOREST	1.80	1.70	5

Using this technique there is no statistical difference in wind characteristics between hilltop and gully sites. This situation is also supported by salt deposition levels. However grasslands in both hilltop and gully sites have significantly higher (P>0.05) levels of wind stress to that found in the forest. Although no distinction between wind velocity and the frequency of high wind frequency can be made, the grassland must be considered to have a higher salt deposition potential.

INTERNAL CHLORIDE CONCENTRATION OF NON NECROTIC ACACIA PHYLLODES.

TABLE 7.1 A COMPARISON BETWEEN SITES.

SITE	MEAN CHLORIDE CONCENTRATION	NUMBER OF SAMPLES
GULLY GRASSLAND	1.66	10
GULLY FOREST	1.53	10
HILLTOP GRASSLAND	2.56	10
HILLTOP FOREST	2.06	10

Chloride concentration is expressed in mEqCl/l.

Acacia present in the hilltop grassland site possess significantly ($P>0.05$) higher internal chloride concentration than those in the gully site. Although there is also a significant ($P>0.01$) difference between hilltop grassland and gully forest, differences between grassland and forest with a site are not statically supported.

TABLE 7.2 A COMPARISON OF PLANT AGE.

SITE	PLANT AGE	MEAN CHLORIDE CONCENTRATION	NUMBER OF SAMPLES
GULLY	ADULT	1.66	10
GULLY	YOUNG	1.43	10
HILLTOP	ADULT	2.56	10
HILLTOP	YOUNG	1.96	10

Chloride concentration is expressed in mEqCl/l.

Samples were only taken from the grassland.

Adult Acacia in the hilltop site possess significantly ($p>0.01$) higher internal chloride concentration than those in the gully site. For this to be the case salt deposition would have to be greater in the hilltop. In the hilltop plant age also has a important effect on internal chloride levels. Adult Acacia have significantly ($P>0.10$) higher internal chloride levels to that of the `seedling'. This difference, however is not statistical shown in the gully site.

THE MONITORING OF ACACIA 'SEEDLING' DEVELOPMENT IN THE FIELD.

TABLE 8.

'SEEDLING' GROWTH IN RESPECT TO EXPOSURE TREATMENTS.

SITE	TREATMENT	MEAN % GROWTH	S.D.	NUMBER OF SAMPLES
GULLY	CONTROL	44.10	852.32	10
GULLY	SHELTERED	51.00	293.33	10
GULLY	FERTILIZED	59.40	858.48	10
GULLY	CLEARED	49.60	1246.04	10
HILLTOP	CONTROL	54.50	1496.72	10
HILLTOP	SHELTERED	67.20	1123.95	10
HILLTOP	FERTILIZED	56.00	555.77	10
HILLTOP	CLEARED	25.70	60.90	10

Plant growth is expressed as the percentage change between initial and final plant heights.

Acacia 'seedling' growth is unaffected by treatment in the gully site. Within the hilltop site however, the cleared treatment causes a significant ($P>0.05$) reduction in plant growth rate. The standard deviation values for the clear treatment are noticeably reduced. This tends to further illustrate the uniformity of the stress. The fertilizer treatment had no significant effect on plant growth.

THE DISTRIBUTION OF ACACIA TIP NECROSIS.

Distribution of Acacia tip necrosis is difficult to interpret as of a consequences of exposure and age variability. Although adults tend to display symptoms more severely, further analysis is required. To overcome this, plant exposure was grouped into two categories, topographical and biological. These two exposures are then divided into two different intensities, that is, high and low. Field observations are then classified according to which exposure class they correlate to.

A SUMMARY OF FIELD OBSERVATIONS.

The relative significance of airborne salt deposition is apparent through the distribution of Acacia, the density of Acacia populations and the occurrence of tip necrosis.

FIGURE 2.

THE DISTRIBUTION OF TIP NECROSIS.

(BIOLOGICAL EXPOSURE).	HIGH	LOW
LOW		VERY LOW TO MILD
HIGH	SEVERE	MILD TO SEVERE

(TOPOGRAPHICAL EXPOSURE).

FIGURE 3.

THE DISTRIBUTION OF THE ACACIA COMMUNITY.

DENSITY.

(TOPOGRAPHICAL EXPOSURE).

HIGH	LOW	
	MOST	LOW
VERY FEW	MODERATE TO LOW	HIGH

(BIOLOGICAL EXPOSURE).

FIGURE 4.

THE DISTRIBUTION OF ACACIA HEIGHTS.

ADULT PLANTS ONLY.

(TOPOGRAPHICAL EXPOSURE).

HIGH	LOW	
	300CM TO 400CM	LOW
50CM TO 100CM	200CM TO 300CM	HIGH

(BIOLOGICAL EXPOSURE).

The data incorporated into these three models are the product of general observations. They clearly demonstrate that variation in exposure influences plant success. Not only in terms the presences of necrosis, but also distribution and developmental.

To incorporate salt deposition values in to this model is much harder. The illustration of airborne salt distribution was established from several experiments, (salt trap experiment, wind monitoring and internal chloride analysis of Acacia phyllodes) each testing a different parameter. Figure 4 is a simple combination of results presented. It is evident from the figure that salt deposition levels are compatible with plant responses shown in figure 2, 3, 4.

FIGURE 5. THE LEVEL OF SALT DEPOSITION.

(TOPOGRAPHICAL EXPOSURE)

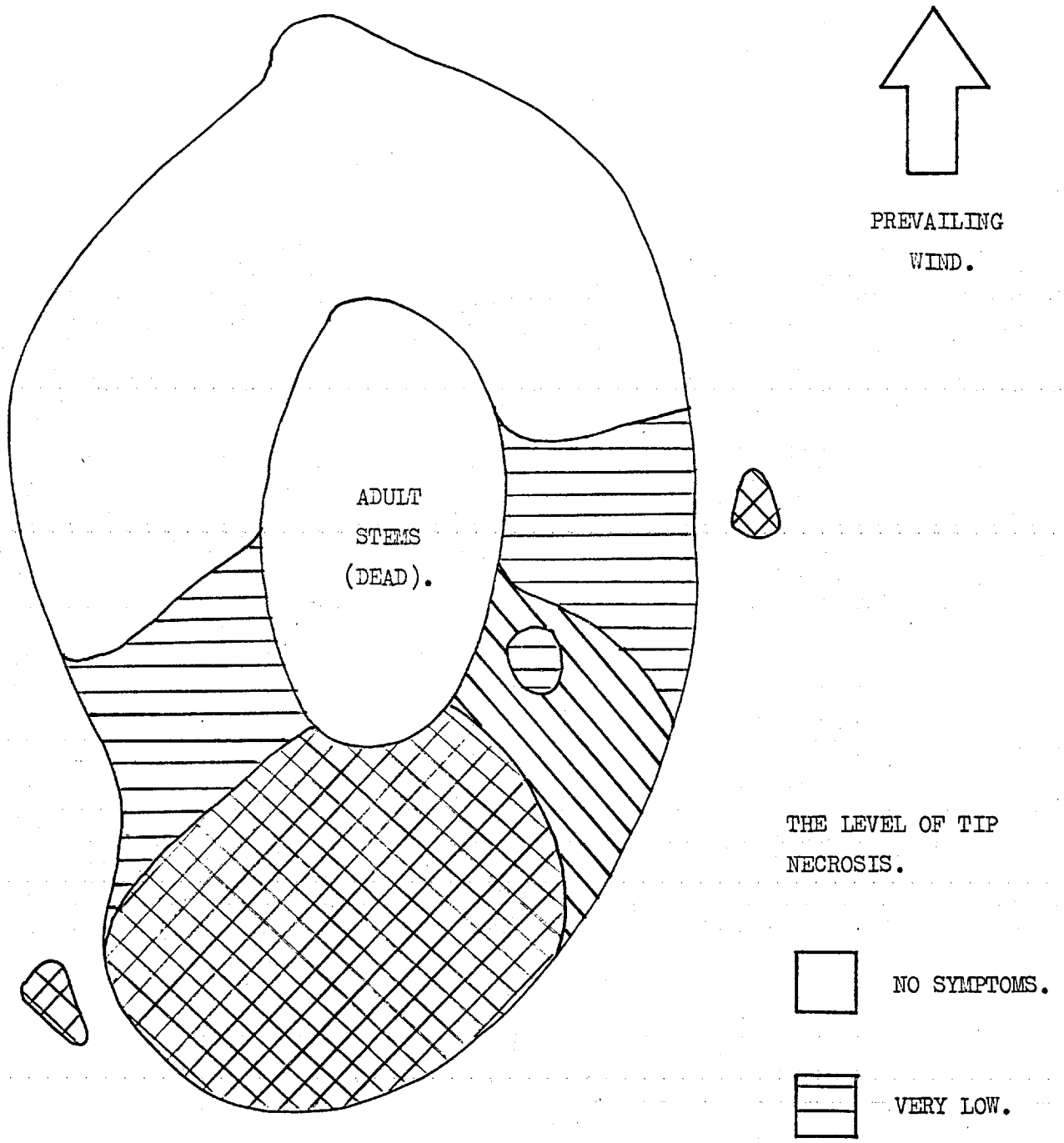
	HIGH	LOW	
	(LOW)		
	STD: 7.50 uMHo's A FE : 1.60 mm A ICCS: 2.06 mEqCl/l X ICCA: 1.96 mEqCl/l X	STD: 7.28 uMHo's A FE : 1.80 mm A ICCS: 1.53 mEqCl/l Y ICCA: 1.43 meqcl/l X	LOW
	(HIGH)	(MODERATE)	(BIOLOGICAL EXPOSURE).
	STD: 12.95 uMHo's B FE : 3.00 mm B ICCS: 2.56 mEqCl/l X ICCA: 2.56 mEqCl/l Y	STD: 10.85 uMHo's B FE : 4.00 mm B ICCS: 1.66 mEqCl/l Y ICCA: 1.66 mEqCl/l X	HIGH

STD : Salt trap deposition. (From table 5)
FE : Flag experiment. (From table 6)
ICCS: Internal chloride analysis (based on location). (From table 7.1)
ICCA: Internal chloride analysis (based on age). (From table 7.2)

The letter used in after each value indicates the relationship. Those values which have same letters (within the same experiment) are not statistically different. However where the letter differs a statistical difference does exists.
The salt deposition and flag experiments illustrate the importance of biological exposure, where as internal chloride analysis illustrate topographical exposure.

FIGURE 6.

THE DISTRIBUTION OF PHYLLODE TIP NECROSIS WITHIN A SINGLE ACACIA SEEDLING PATCH.



VERY LOW = LESS THAN 10% OF THE PHYLLODES AFFECTED.

MILD = BETWEEN 10% AND 30% OF PHYLLODES AFFECTED.

SEVERE = GREATER THAN 30% OF PHYLLODES AFFECTED.

FIGURE 6.

THE DISTRIBUTION OF TIP NECROSIS WITHIN A SINGLE 'SEEDLING' PATCH.

The level of tip necrosis was mapped in a seedling patch located in the gully ecotone. On the leeward side of the patch, seedlings were free from necrosis. However on the windward side necrosis was both severe and frequent.

THE DETERMINATION OF INTERNAL CHLORIDE CONCENTRATION OF ACACIA PHYLLODES.

TABLE 9. TIP NECROSIS VERSES INTERNAL CHLORIDE CONCENTRATION.

SITE	DEGREE OF NECROSIS	MEAN CHLORIDE CONCENTRATION	NUMBER OF SAMPLES
GULLY (G)	NIL	1.66	10
GULLY (F)	NIL	1.53	10
GULLY (G)	1-10%	2.94	10
GULLY (G)	10-40%	3.28	10
GULLY (G)	40-50%	3.22	10
GULLY (G)	>50%	3.79	10

Chloride concentration is expressed in mEqCl/l.

(G)= The Grassland site.

(F)= The Forest Site

Acacia phyllodes which illustrate tip necrosis symptoms have significantly ($P>0.01$) higher internal chloride concentrations. Even minor necrotic symptoms equate to appreciably higher chloride concentrations. However there does not appear to be any statistical correlation between the degree of tip necrosis and the absolute chloride concentration.

TABLE 10.

A COMPARISON OF INTERNAL CHLORIDE CONCENTRATIONS OF MAINLAND ACACIA, WHICH LACK NECROTIC SYMPTOMS.

SITE	MEAN CHLORIDE CONCENTRATION	S.D	NUMBER OF SAMPLES	APPROX DISTANCE FROM SEA.
BYFIELD	1.400	0.260	5	2 km
YEPPOON	1.240	0.028	5	2 Km
6KM	1.320	0.492	5	6 Km
MT JIM CROW	1.200	0.200	5	15 Km
ROCKHAMTON	1.080	0.012	5	40 Km

Chloride concentration is expressed in mEqCl/l.

The internal chloride concentration of Acacia phyllodes failed to show any statistical differences nor was there any evidence of tip necrosis. Internal chloride levels of Acacia present on the coastal areas were the same as those present in Acacia 40 kilometers inland. Using internal chloride concentrations of the two most in inland sample points, some indication of the 'normal' chloride levels can be established. The term 'normal' meaning internal chloride concentrations in the absence of airborne salt deposition. The mean chloride concentration of these was 1.347 mEqCl/l.

OTHER PLANT RESPONSES.

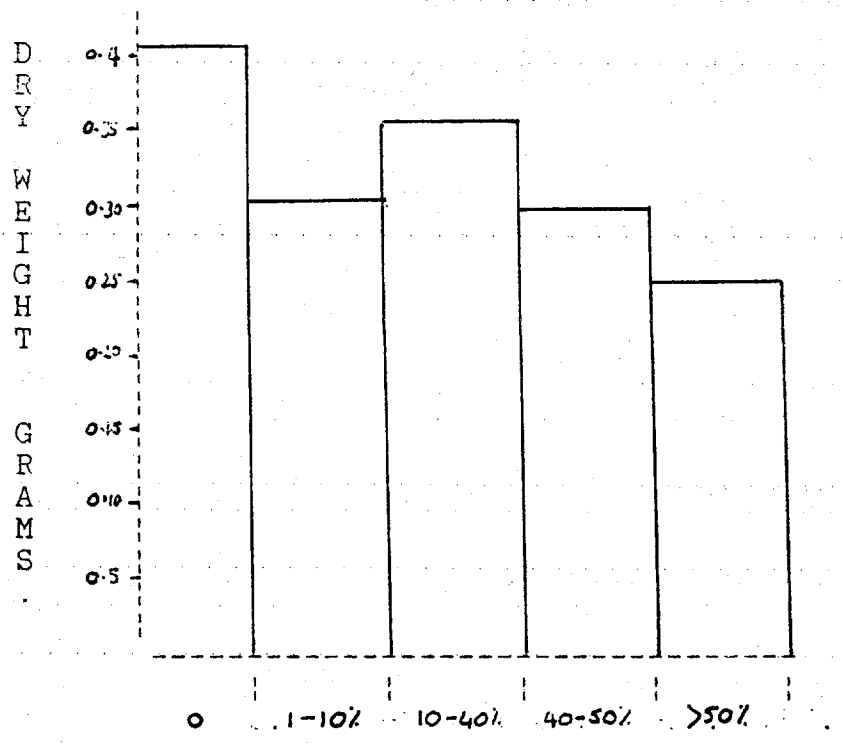
Although tip necrosis was the most noticeable response to high internal chloride concentration, it is unlikely to be the only response. A comparison of phyllode dry weight was also undertaken to investigate the possibility of dry weight reductions.

OTOTHER PLANT RESPONSES.

Although tip necrosis was the most noticeable response to high inimternal chloride concentration, it is unlikely to be the only response. A A comparison of phyllode dry weight was also undertaken to investigate ththe possibility of dry weight reductions.

FFIIGURE. 7.

A A COMPARISON OF PHYLLODE DRY WEIGHT TO DEGREES OF TIP NECROSIS.



There is a trend towards reduced phyllode dry weight as the percentage area of necrosis increases. Although this overall trend is not consistently supported by statistically analysis, such a visual trend might be expected. As chloride concentration rises within the phyllode , the potential for plant development must be more restricted. It would be misleading to suggest that phyllode dry weight is directly effected by internal chloride concentration. However it is hypothesis that such a relationship may be found with further investigation.

THE ARTIFICIAL APPLICATION OF AIRBORNE SALT SPRAY.

FIGURE 8. THE ARTIFICIAL APPLICATION OF AIRBORNE SALT: PLANT MORTALITY RATE.

These series of graphs illustrate the plant mortality resulting from the application of various salt concentration solutions. Although it is clear that plant mortality is directly related to solution concentration, it is impossible to determine differences in species sensitivity.

TABLE 11. A COMPARISON OF SURVIVING PLANT DRY WEIGHTS

DRY WEIGHTS ARE EXPRESSED AS A PERCENTAGE DIFFERENCE TO THE CONTROL. THE CONTROL IN EACH CASE REPRESENTS 100% .

TABLE 11.1 . TOTAL DRY WEIGHT.

SPECIES	25% SALT SPRAY (GRAMS)	N	50% SALT SPRAY (GRAMS)	N
A.LEIOCALYX	121.5	10	69.2	10
A.LEPTOSTACHYA	117.6	14	86.3	10
CASUARINA. spp	122.2	10	108.8	10
GRASS. spp	76.2	5	64.4	4

*N= The number of individuals surviving in each treatment.

The grass species is the only one to demonstrate a reduction of total dry weight in the lowest salt concentration. In the 50 % salt treatment all species, with the exception of Casuarina, are now displaying growth reductions. Growth responses of this nature tend to suggest that the grass species is the more salt sensitive, and that Casuarina species is the more salt tolerant. The two Acacia species appear to show moderate salt tolerance, existing between these two extremes. When the Acacia species are compared, there is little difference in their response. It maybe considered then, that their share an ability to cope with airborne salt deposition stress.

TABLE 11.2. . A COMPARISON OF SURVIVING PLANT DRY WEIGHTS. EXPRESSED AS A PERCENTAGE DIFFERENCE TO THE CONTROL.

(SHOOT DRY WEIGHT).

SPECIES	MEAN DRY WEIGHT (25% SALT SPRAY)	N	MEAN DRY WEIGHT 50% SALT SPRAY	N
A.LEIOCALYX	130.5	10	64.3	10
A.LEPTOSTACHYA	117.2	14	83.4	10
CASUARINA. spp	121.2	10	104.9	10
GRASS. spp	87.2	5	66.1	4

A comparison of shoot dry weight displays the same trends as that previously reported. That is, Acacia are moderate salt tolerators, C.equisetifolia is a salt tolerator, and the grass species is a salt sensitive .

TABLE 11.3. . A COMPARISON OF SURVIVING PLANT DRY WEIGHTS. EXPRESSED AS A PERCENTAGE DIFFERENCE TO THE CONTROL.

(ROOT DRY WEIGHT).

SPECIES	MEAN DRY WEIGHT (25% SALT SPRAY)	N	MEAN DRY WEIGHT 50% SALT SPRAY	N
A.LEIOCALYX	106.4	10	77.4	10
A.LEPTOSTACHYA	118.3	14	92.3	10
CASUARINA. spp	124.9	10	117.1	10
GRASS. spp	59.5	5	61.7	4

A comparison of root dry weight again supports the data presented in table 11.1. and table 11.2

Figure 8.1 THE ARTIFICAL APPLICATION OF AIRBORNE SALT.

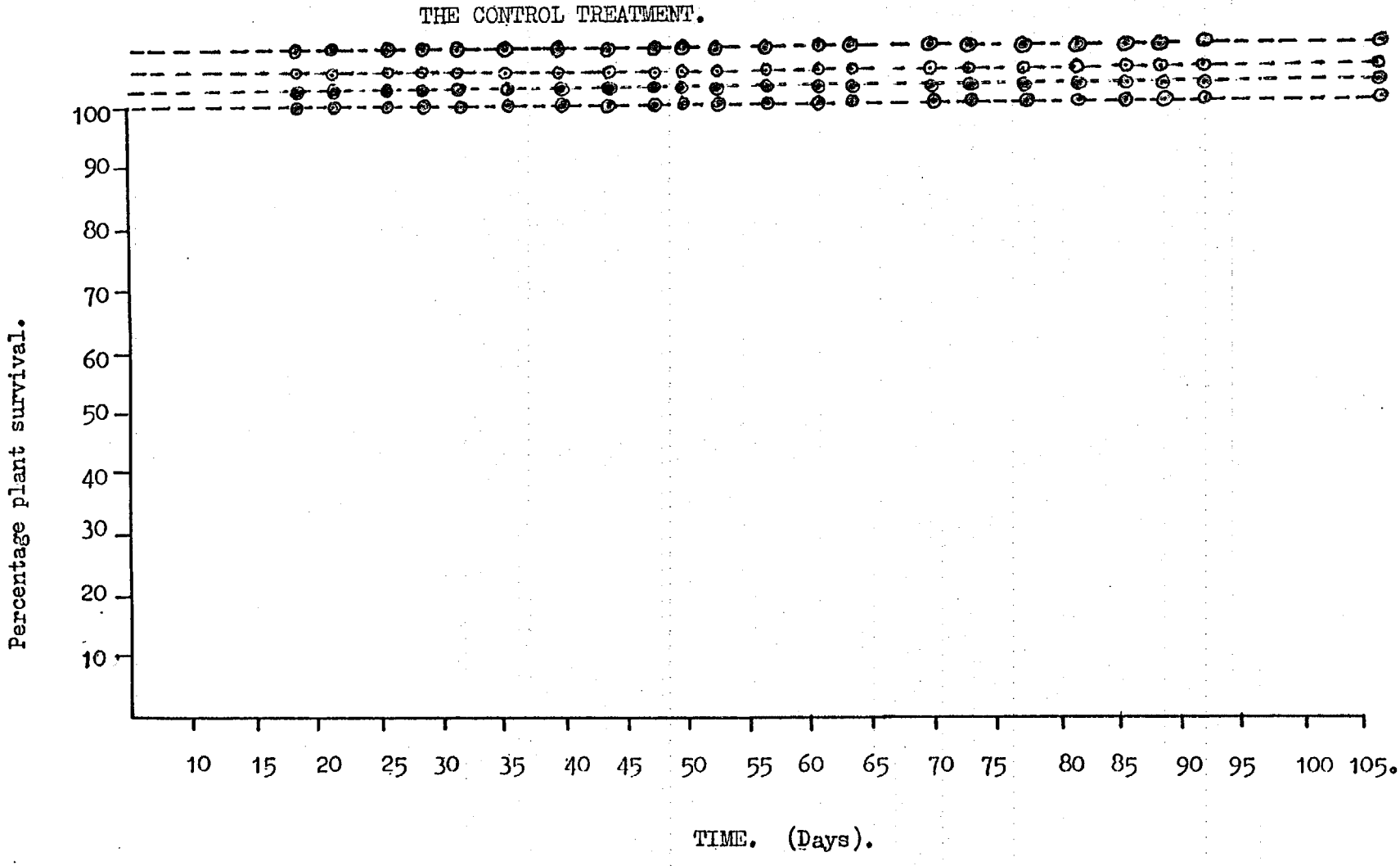


Figure 8.2 THE ARTIFICAL APPLICATION OF AIRBORNE SALT.

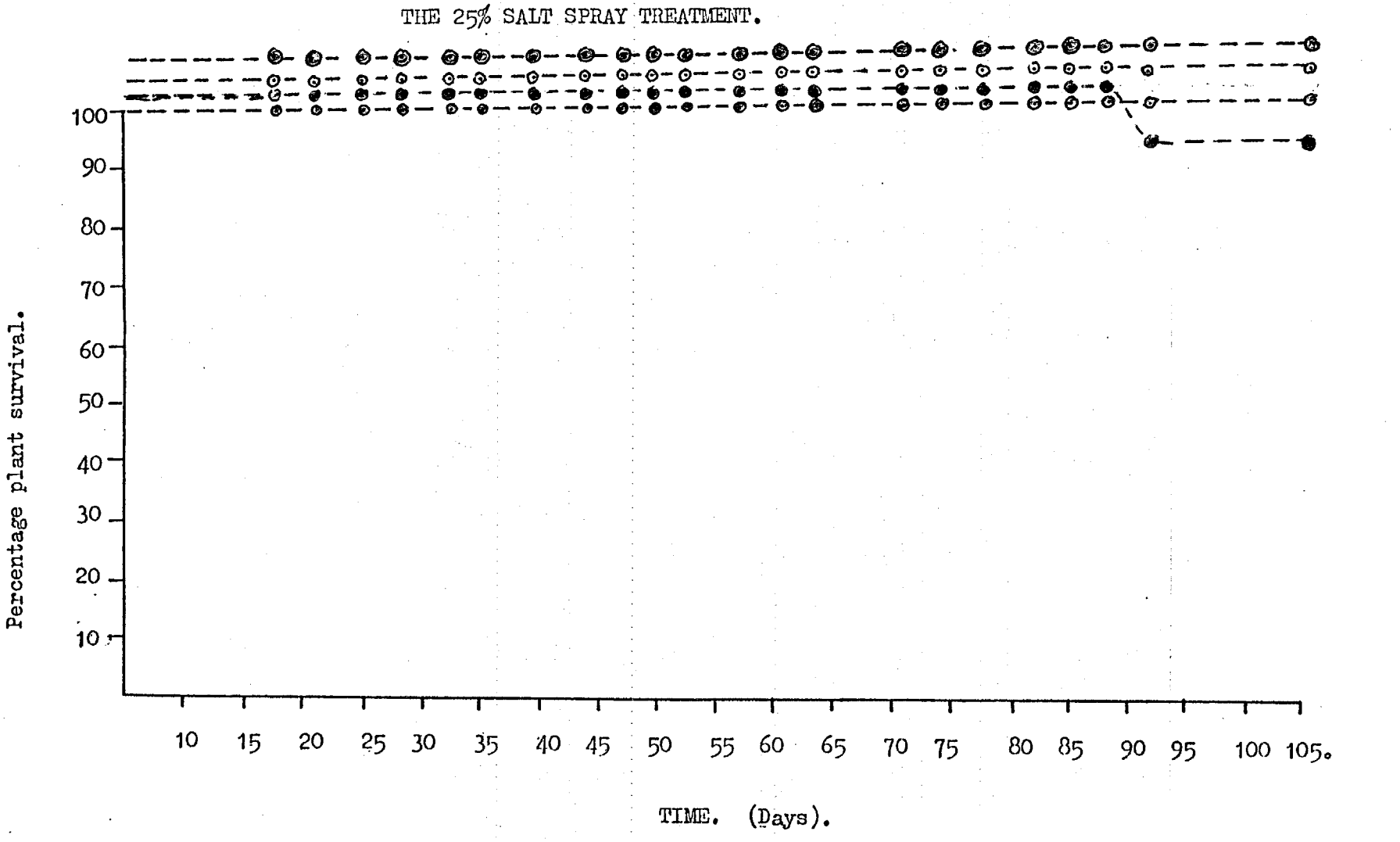


figure 8.3 THE ARTIFICAL APPLICATION OF AIRBORNE SALT.

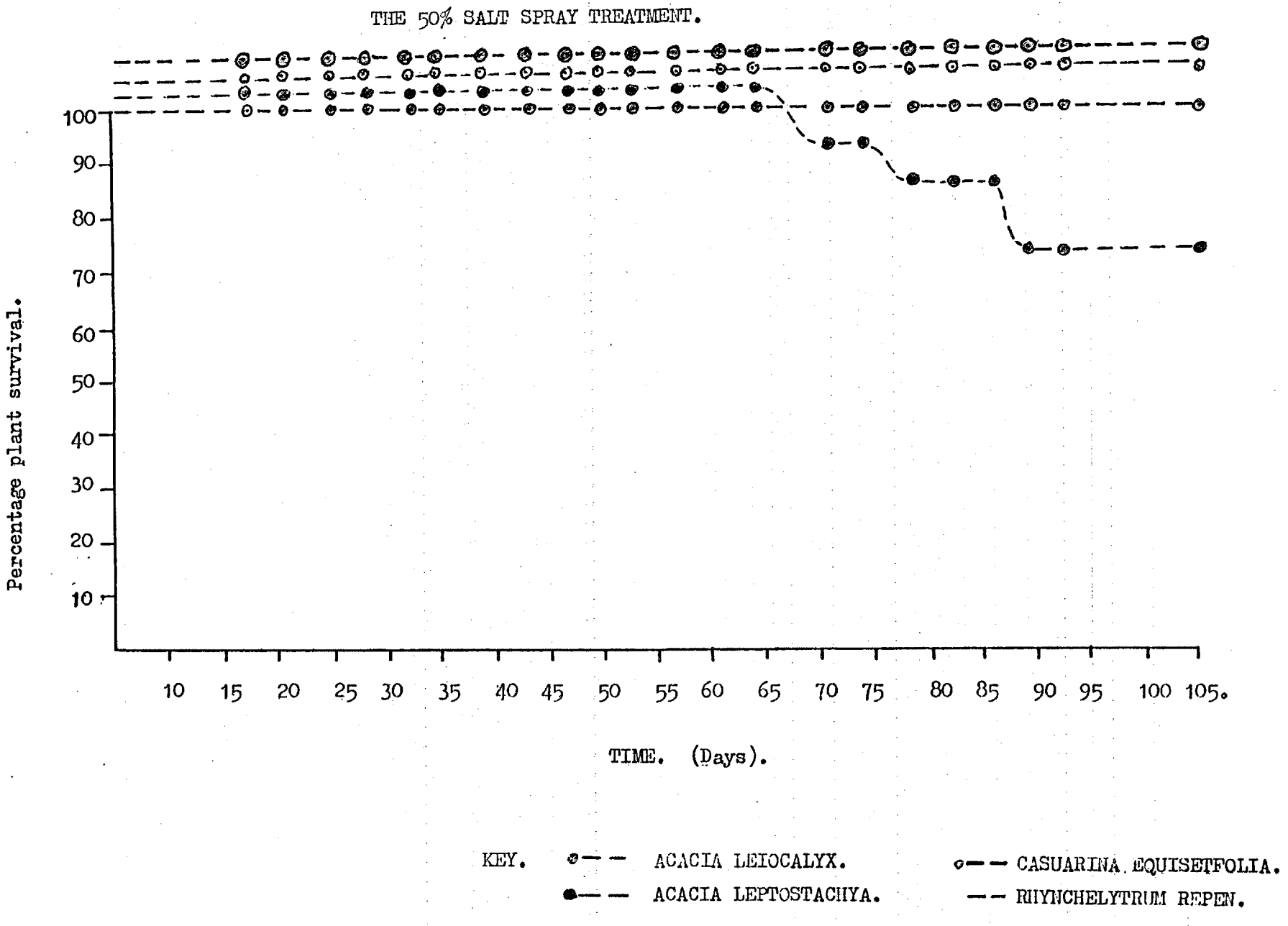


Figure 8.4 THE ARTIFICAL APPLICATION OF AIRBORNE SALT.

THE 75% SALT SPRAY TREATMENT.

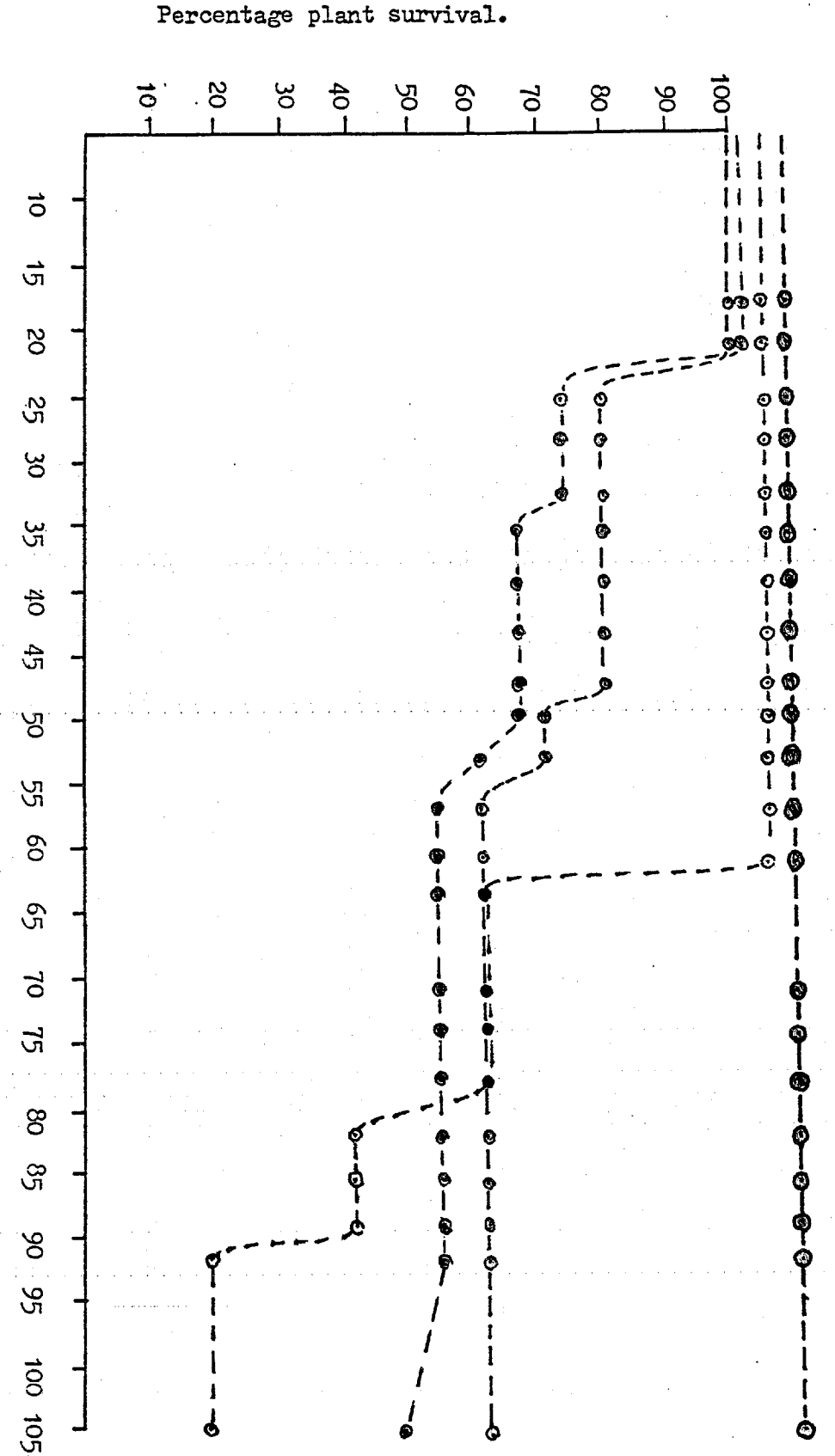


Figure. 8.5 THE ARTIFICAL APPLICATION OF AIRBORNE SALT.

THE 100% SALT SPRAY TREATMENT.

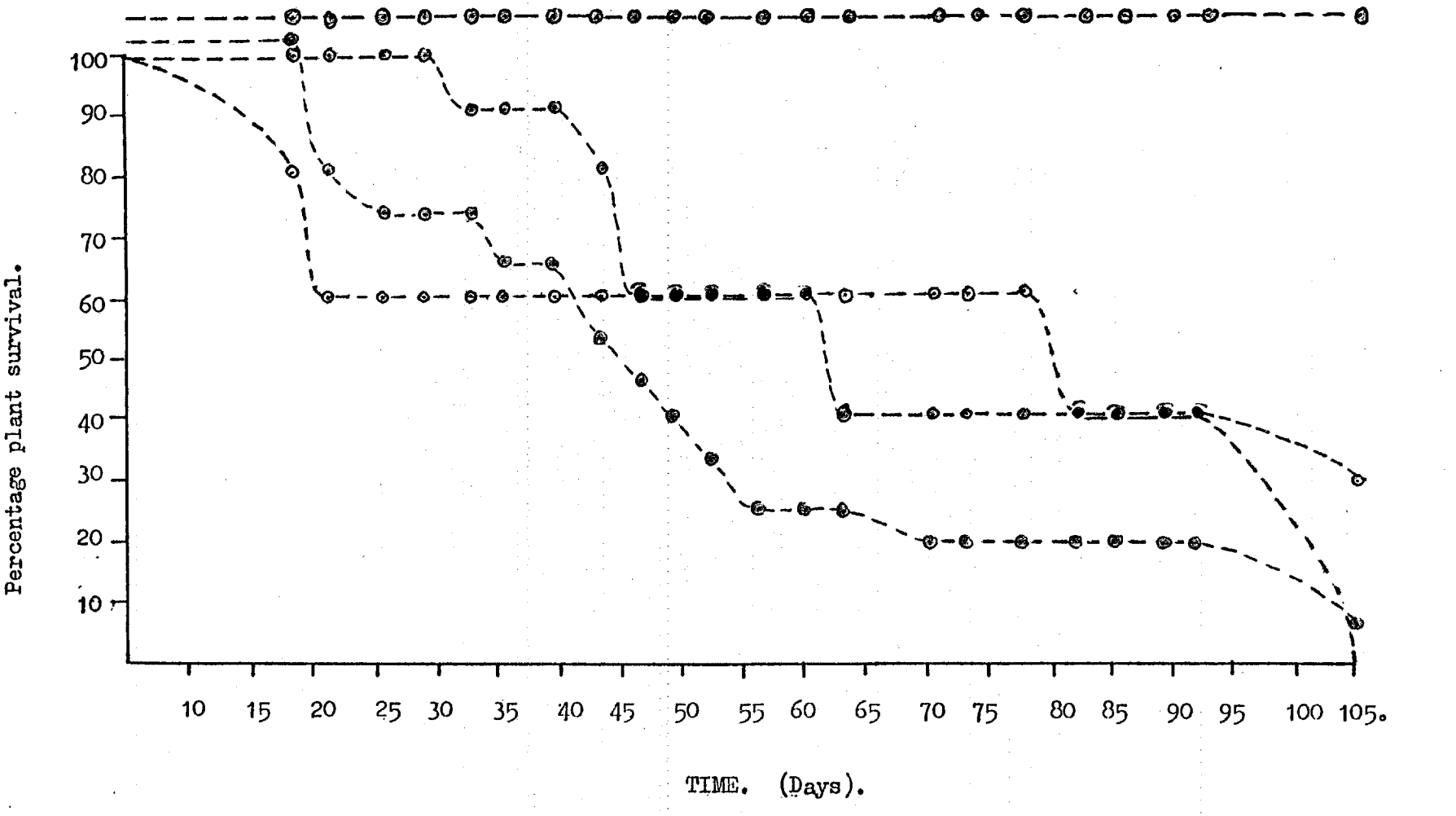
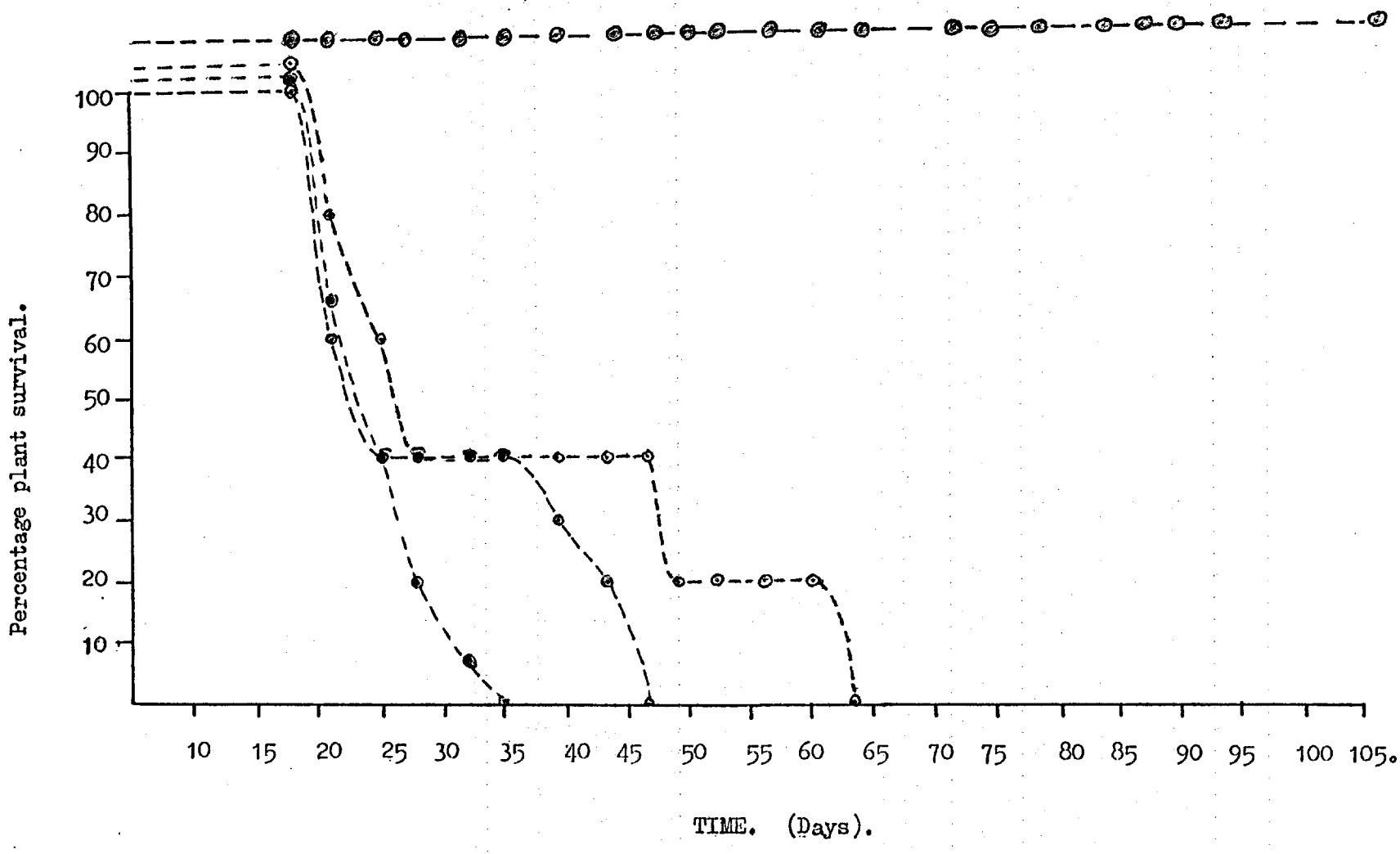


Figure 8.6 THE ARTIFICAL APPLICATION OF AIRBORNE SALT.

THE 200% SALT SPRAY TREATMENT.



THE SUBTRACTIVE NUTRIENT EXPERIMENT.

FIGURE 9. THE SUBTRACTIVE NUTRIENT EXPERIMENT: ACACIA PHYLLODE AREA.

For each treatment phyllode area was recorded. The results are graphically illustrated.

FIGURE 10. THE SUBTRACTIVE NUTRIENT EXPERIMENT: ACACIA TOTAL DRY WEIGHT.

Total dry weights were recorded for each treatment. The results are displayed in the same manner as that of Acacia phyllode area.

As these tables series investigate the same situation there will be commented on jointly.

Each graph represents one of the four soil types used. All treatments are graphically illustrated in terms of the 'all on' treatment. Only those values which exceed the the lower L.S.D. (least significant difference) are statistically important. These value are collectively illustrated in table 11.

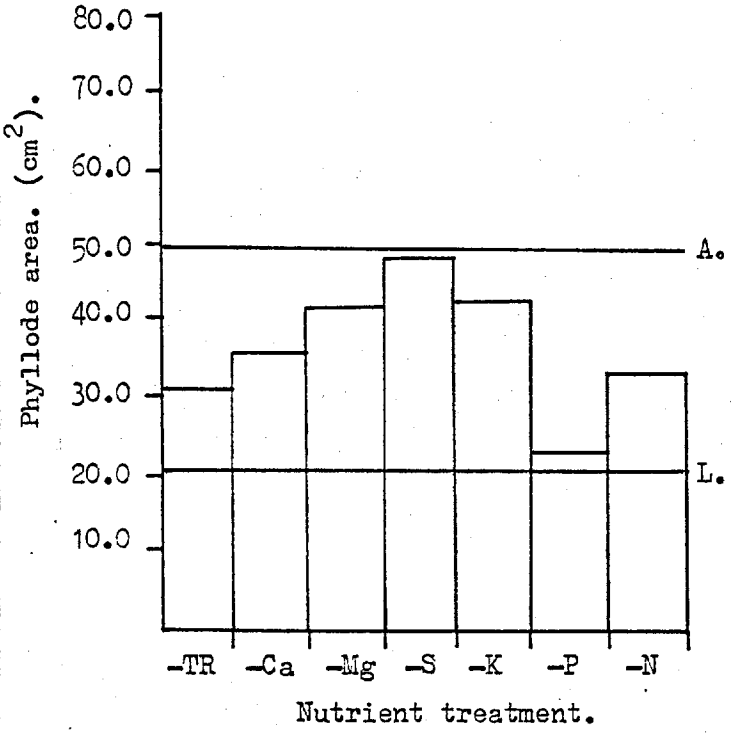
There are several treatment which exceed the upper L.S.D. value. This relationship tends to directly suggest that nutrient toxicity has occurred. However such a situation is unlikely. Excess response tends to demonstrate several trends: In A.leiocalyx it occurs more frequently in the forest site. In A.leptostachya it tends to occur more often in the grassland sites.

This situation clearly requires further investigation to determine whether these apparent patterns are real of the produce of a unidentified experimental error.

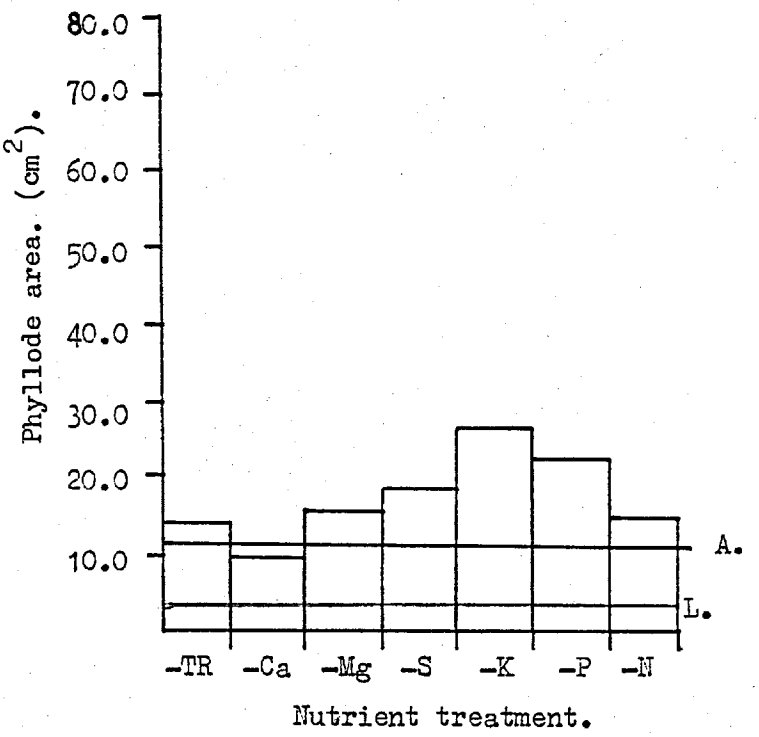
FIGURE 9a. NUTRIENT EXPERIMENT: ACACIA PHYLLODE AREA.

GULLY GRASSLAND SITE.

ACACIA LEIOCALYX.

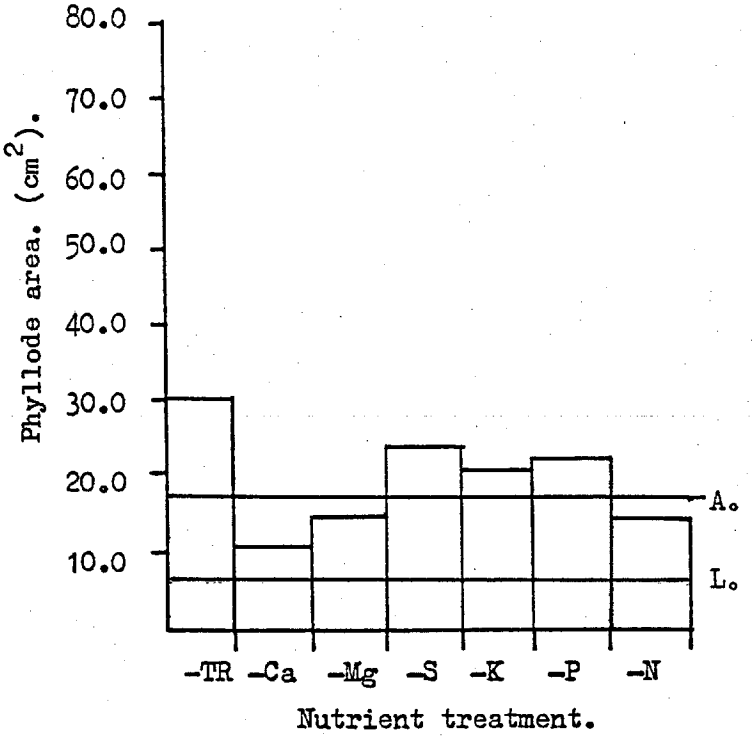


ACACIA LEPTOSTACHYA.

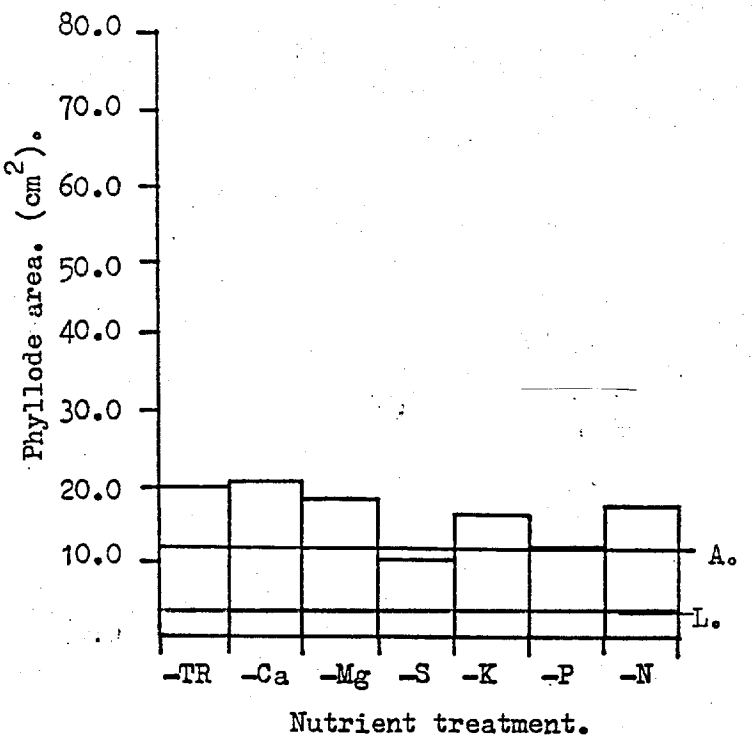


GULLY FOREST SITE.

ACACIA LEIOCALYX.



ACACIA LEPTOSTACHYA.



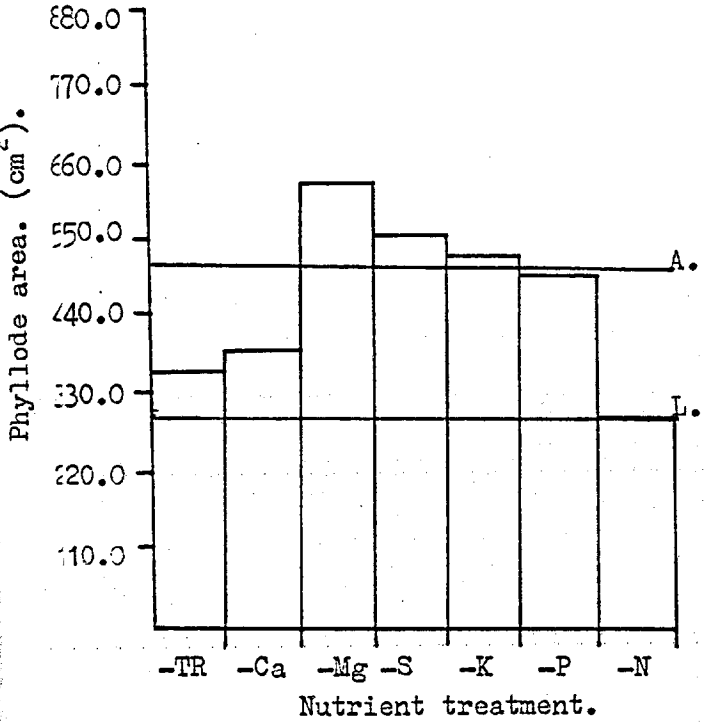
A= The all on treatment.

L= The least significant difference.

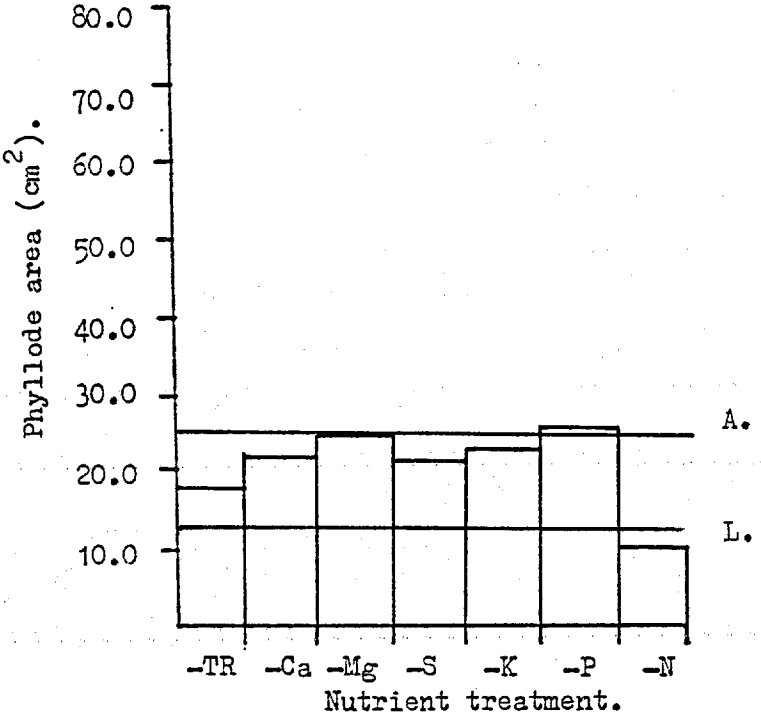
FIGURE 9b. NUTRIENT EXPERIMENT: ACACIA PHYLLODE AREA.

HILLTOP GRASSLAND SITE.

ACACIA LEIOCALYX.

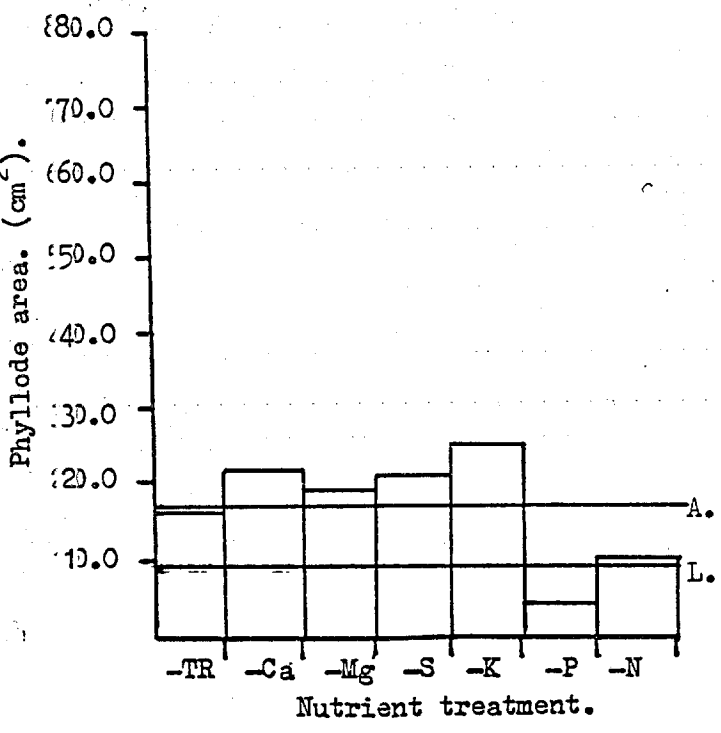


ACACIA LEPTOSTACHYA.

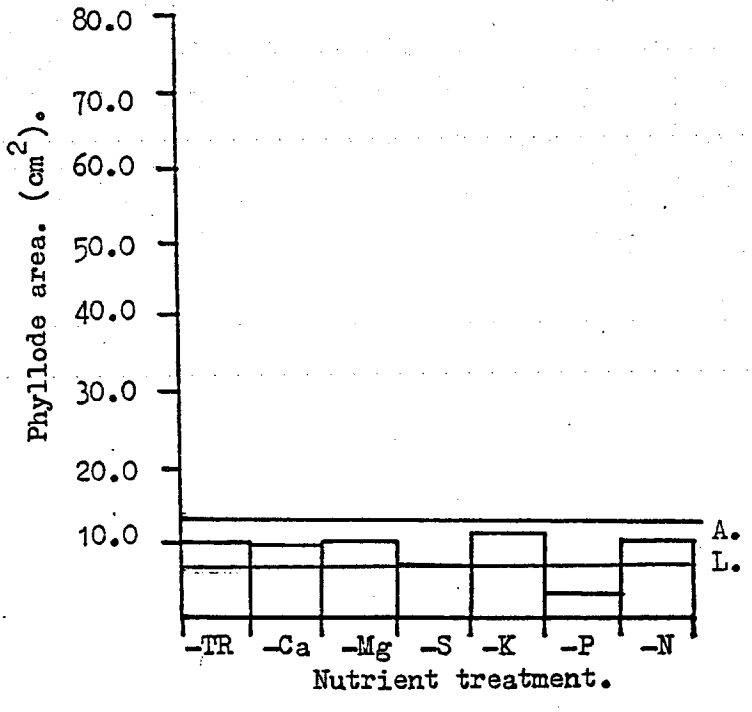


HILLTOP FOREST SITE.

ACACIA LEIOCALYX.



ACACIA LEPTOSTACHYA.



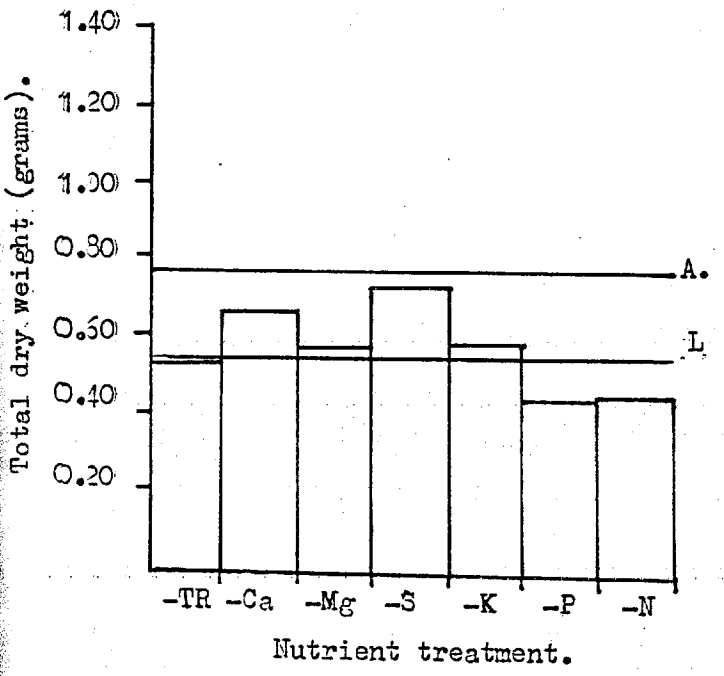
A= The all on treatment.

L= The least significant difference.

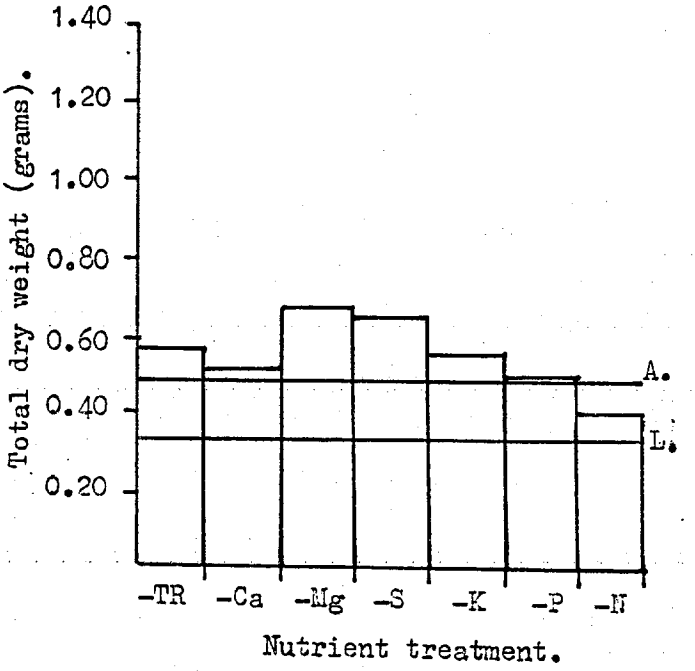
FIGURE 10a. NUTRIENT EXPERIMENT: TOTAL DRY WEIGHT.

GULLY GRASSLAND SITE.

ACACIA LEIOCALYX.

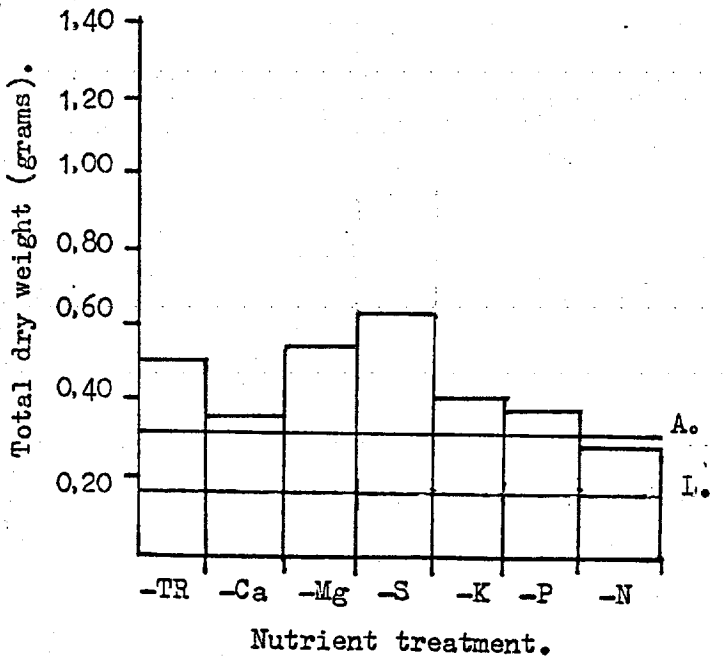


ACACIA LEPTOSTACHYA.

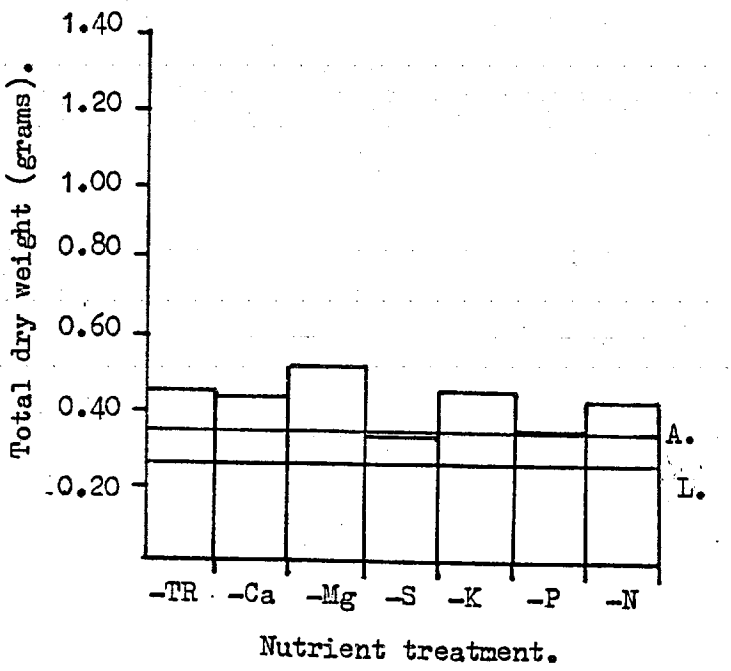


GULLY FOREST SITE.

ACACIA LEIOCALYX.



ACACIA LEPTOSTACHYA.



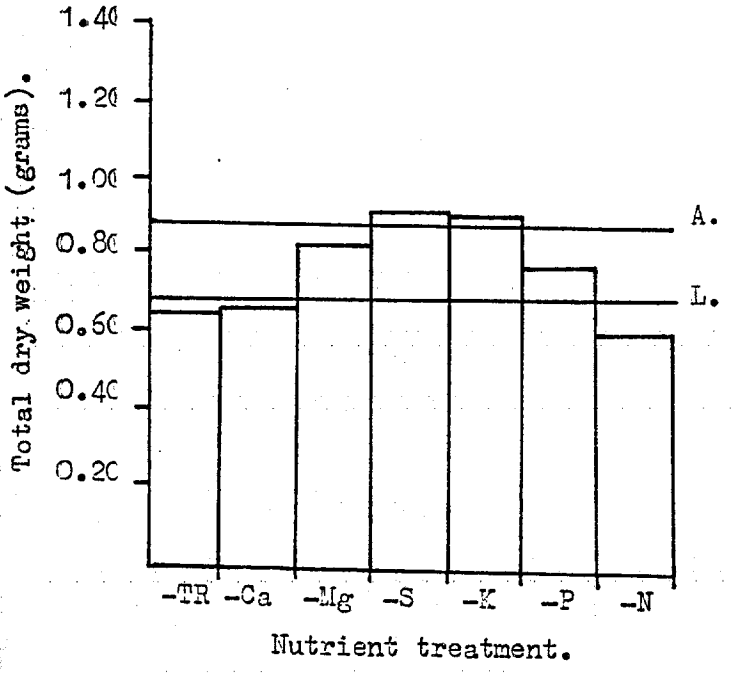
A= The all on treatment.

L= The least significant difference.

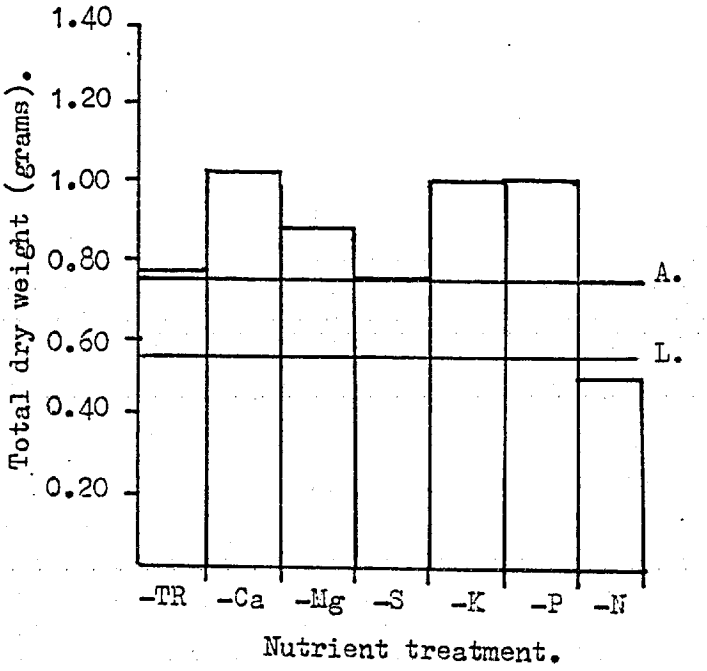
FIGURE 10b. NUTRIENT EXPERIMENT: TOTAL DRY WEIGHT.

HILLTOP GRASSLAND SITE.

ACACIA LEIOCALYX.

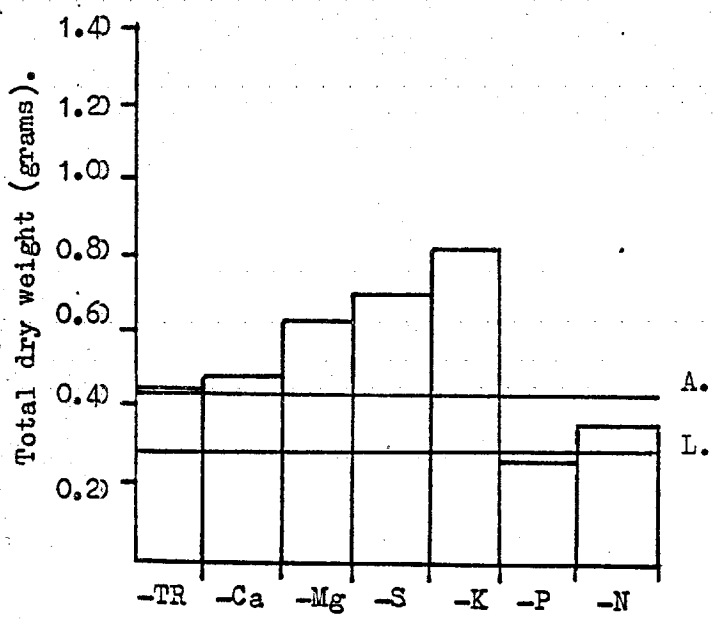


ACACIA LEPTOSTACHYA.



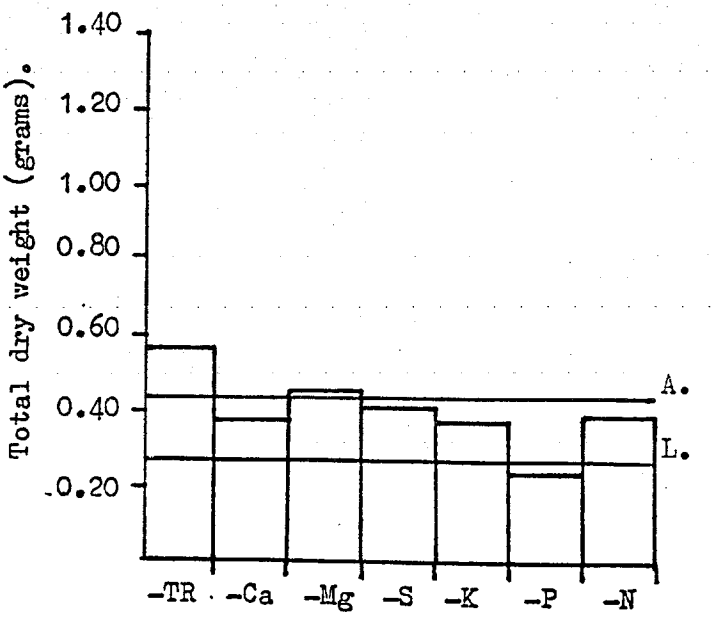
HILLTOP FOREST SITE.

ACACIA LEIOCALYX.



A= The all on treatment.

ACACIA LEPTOSTACHYA.



L= The least significant difference.

TABLE 12.

A SUMMARY OF NUTRIENT DEFICIENCIES.

The grassland sites in both gully and hilltop, demonstrate clearly nutrient deficiencies. In the forest however only phosphorus was seen to be deficient, and only in the hilltop site. Deficiencies are most clearly demonstrated in the dry weight analysis, phyllode area although a less effective form of detection correlated exactly.

FIGURE 11.

A COMPARISON OF THE ALL ON TREATMENTS FOR THE FOUR SITES.

When the 'all on ' treatments for each site are compared, it is evident that total dry weight achieved, is far greater in the grassland sites. Phyllode area displays the same general tend, but to a lesser extent. Plant development is therefore greater in the grassland even though several nutrient deficiencies have been illustrated.

TABLE.12.1 A SUMMARY OF NUTRIENT DEFICIENCIES.

TABLE 12.1 ACACIA LEIOCALYX

SITE.	PHYLLODE AREA	TOTAL DRY WEIGHT
GULLY GRASSLAND.	NIL	-N -P -TRACE
GULLY FOREST.	NIL	NIL
HILLTOP GRASSLAND.	-N	-N -Ca -TRACE
HILLTOP FOREST.	-P	-P

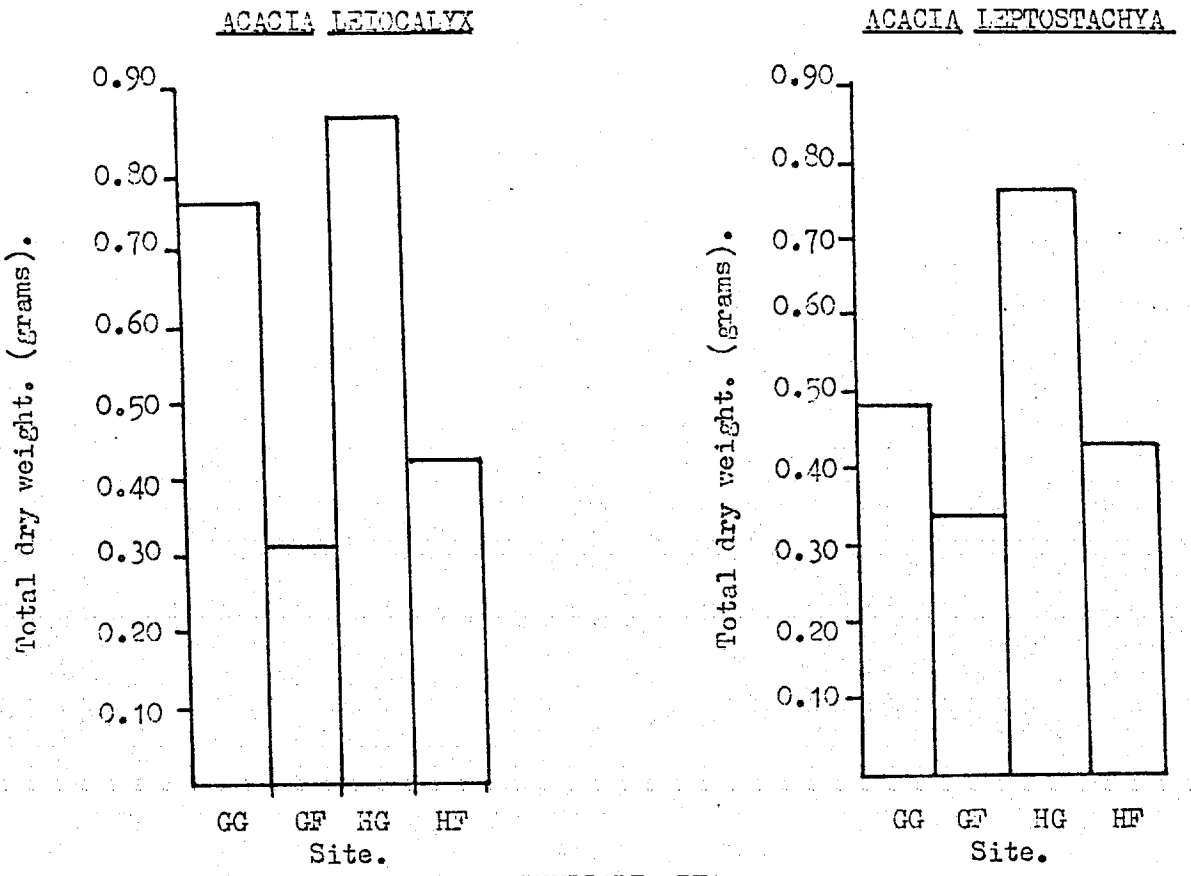
TABLE 12.2 ACACIA LEPTOSTACHYA

SITE.	PHYLLODE AREA	TOTAL DRY WEIGHT
GULLY GRASSLAND.	NIL	NIL
GULLY FOREST.	NIL	NIL
HILLTOP GRASSLAND.	-N	-N
HILLTOP FOREST.	-P	-P

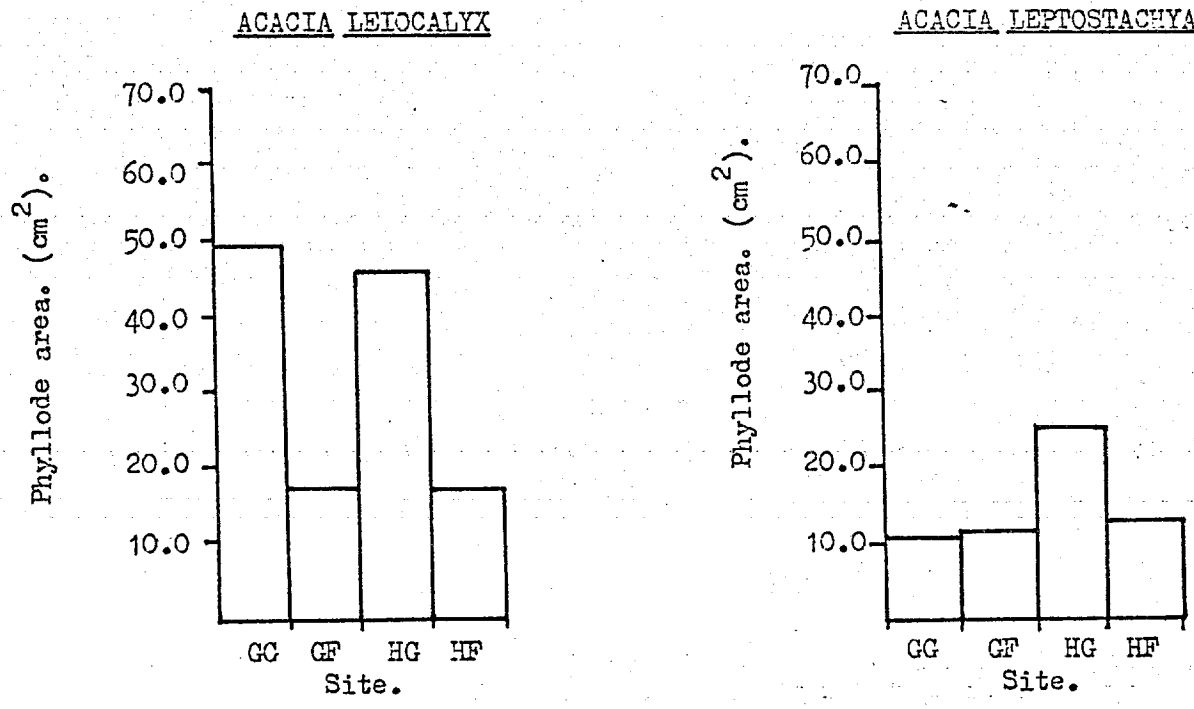
Note. -TRACE is a collective term, absent are all untest elements.

FIGURE 11. A COMPARISON OF THE ALL ON TREATMENTS FOR THE FOUR SITES.

TOTAL DRY WEIGHT.



PHYLLODE AREA.



Site.

GG= Gully Grassland. HG= Hilltop Grassland.

GF= Gully Forest. HF= Hilltop Forest.

DISCUSSION.

CHAPTER ONE. THE MONITORING OF AIRBORNE SALT DEPOSITION.

1. The Ridge System.

Salt deposition and wind velocities were the same in both exposed and sheltered sides of the main ridge system (table 4). There is no evidence to support the hypothesis that Acacia distribution along the ridge system is correlated with salt deposition stress. Salt deposition loads on the ridge system were highly variable. Similar observations have also been made in Europe (Barbour 1978). This variability is probability created by wind turbulence. The significant reduction ($P > 0.05$) of salt deposition in the Acacia understorey is a product of biological sheltering. The dense Acacia forest reduces internal wind velocities and therefore salt deposition potential. Individuals within the Acacia forest are experiencing reduced salt deposition to those existing in the grasslands.

2. Hilltop Verses Gully.

Based on salt deposition (table 5.) and wind velocities (table 6.) there is no evidence to suggest a difference in salt stress between hilltop and gully sites. There is however a significant reduction in salt deposition stress, going from grasslands to forest. This is further evidence of the importance of biological sheltering.

When the internal chloride analysis of non necrotic Acacia phyllodes is considered (table 7.1), differences between hilltop and gully grassland sites are highlighted. Acacias' present in the hilltop site have significantly ($P > 0.05$) higher internal chloride levels to those in the gully site. It has been widely reported that in coastal systems internal chloride levels of leaves closely reflect their salt exposure (Boyce 1954, Parsons and Gill 1968 and Clifford et al 1979). It is concluded that for such differences to exist, Acacia in the hilltop must experience higher salt deposition loads. Therefore geographically the hilltop site can be considered the more salt exposed habitat.

A comparison of internal chloride levels between adult and 'seedling' Acacia (table 7.2) in the grasslands further demonstrates the importance of biological sheltering. In the hilltop, adults which protrude above the general grass canopy, illustrate significantly higher ($P > 0.10$)

internal chloride concentrates. 'Seedlings' existing within the grass canopy, and therefore in a state of biological sheltering, demonstrated reduced internal chloride levels.

The importance of biological exposure is correlated with geographical exposure (table 7). When biological sheltering is removed in the less exposed gully site, internal chloride levels of Acacia phyllodes remain statisticaly the same. As overall salt deposition is reduced in the gully, variations in biological sheltering appear to be less important. In the hilltop site (table 7.2), geographical exposure is higher and therefore the level of biological sheltering more important.

The seasonality of airborne salt deposition has been a overlooked possibility, and clearly requires further investigation. Boyce (1954) reported that most of the vegetative damage created, correlated with infrequent coastal storms. On North Keppel Island such storms are restricted to the summer months. Art et al (1974) however also acknowledged the importance of "dry fallout". The potential for this being strongly correlated with wind velocity. "Dry fallout" would be expected to be more predominate in the autumn months. The seasonality of salt deposition, and its' relationship to plant growth periods clear requires further research.

3. Summary

The level of airborne salt deposition is based on two factors, that is, geographical and biological exposure. The actual salt deposition stress created, is a correlation of these two exposures. Salt deposition being more severe in the hilltop site (map 5.).

CHAPTER TWO. THE SUCCESS OF ACACIA 'SEEDLINGS'.

1. DEVELOPMENT.

Normal Acacia 'seedlings' development is similar in both the hilltop and gully grassland sites (table 8.). As 'seedlings' are at least partially confined to the grass canopy, biological sheltering appears to have removed salt deposition differences created by topography. When 'seedlings' were artificially sheltered, there was no statistical change in plant development. The efficiency of biological sheltering in reducing salt deposition is therefore very high. Once this biological

sheltering is removed, 'seedlings' were placed under geographical exposure limitations. The severe growth retardation demonstrated in the hilltop site (plate 1.) is evidence of salt deposition differences created by geographical exposure. In the more exposed hilltop site, the removal of biological sheltering, places 'seedlings' under high salt deposition stress. The growth retardation illustrated (table 8.), is a response to this fact. However in the gully site geographical exposure is reduced, with the removal of biological sheltering having no effect on development.

If biological sheltering is removed naturally, as would be the case with growth, the same response is likely to occur. Plant retardation should be demonstrated in the hilltop site with little evidence in the gully site. Field observations of plant stunting (fig 4 and 5.) tend to support this conclusion.

The potential stress created by the removal of biological sheltering, must also be considered in terms of plant height. The greater the canopy protrusion, the higher the salt deposition potential (Grace 1977). Differences in plant height (stunting) created by salt deposition can be expected to reduce this effect. Although plant stunting is a stress response, it must have positive benefits in terms of further deposition stress.

Acacia development is based on geographical and biological exposure. The relationship between the two act to restrict growth in the hilltop site (fig 3.).

2. SYMPTOMS.

Previous studies have outlined a range of plant responses including, increased fresh weight to dry weight ratio (Parsons et al 1968), increased palisade cell size (Boyce 1954), reduced water content of the tissue (Gates 1972) and leaf tip necrosis (Parson et al 1968). Acacias on the island frequently displayed the tip necrosis symptoms. Dry weight analysis of necrotic phyllodes further demonstrated a general reduction in weight with increased degrees of necrosis (fig 7)

Although necrosis appears to be a 'classic' symptom of airborne salt deposition, it may also be expressed as a consequence of other stresses. It is necessary then, to examine the relationship between necrosis and salt deposition.

2.1 Tip Necrosis.

The Distribution of Necrotic Acacia Phyllodes.

A. Hilltop Verses Gully Site.

It is difficult to compare the incidence of tip necrosis between the two sites because of differences in Acacia numbers. Although necrosis is more severe towards the hilltop region, there are progressively fewer individuals to monitor. A summary presented in figure 2 tends to correlate necrosis with deposition stress.

B. Forests Verses Grasslands.

Acacia present in the exposed grasslands displays necrosis more severely. Within the sheltered Acacia forest necrosis is reduced, restricted to only the very upper canopy.

C. Adult Verses Young.

In the grasslands, adult Acacia readily display tip necrosis. However necrosis was never observed in 'seedlings' present within the grass canopy. This is a simple expression of biological sheltering, where 'seedlings' are not experiencing salt stress and therefore can not display symptoms.

D. A Seedling Patch.

In reference to figure 6 the distribution of Acacia tip necrosis was shown to be more severe on the windward side of a seedling patch. The further towards the leeward side of the patch , the less severe the incidence of necrosis . This correlation with the wind direction is clear evidence of necrosis being created by airborne of salt deposition stress. However salt deposition must be expressed as 'potential' deposition. Although it is logical to assume such distribution of salt deposition, no experimental verification has been carried out.

E. Plant.

Plate 3 illustrates that phyllodes on the windward side of the branch display necrosis more severely. Necrosis is also shown to be more common in the older phyllode, where the age is an expression of exposure time. At the plant level, the distribution of tip necrosis also correlates with potential airborne salt deposition.

Although tip necrosis may be created by various different forms of stress, it has been widely reported in terms of airborne salt deposition (Boyce 1954, Grace 1977). The degree of distributional correlation over the numerous levels of observation, strongly support a direct relationship to salt deposition stress.

Artificial application of salt spray to Acacia seedlings also created the phyllode necrosis symptom. Investigating necrosis further, it was established that necrotic phyllodes had significantly higher internal

chloride levels (table 9), compared to non necrotic phyllodes. Boyce (1954) and Waisel (1972) reported that such an increase in internal chloride concentration is a direct consequence of salt spray. There is little doubt that phyllode tip necrosis is in fact a direct stress response to airborne salt deposition.

BACKGROUND SUMMARY.

When plants are subjected to airborne salt deposition, salt particles enter through the foliage (Boyce 1954). Entering being either through abrasions created in the deposition (Boyce 1954,Waisel 1972) or by passive diffusion through cuticle, stomatal pore and epidermal hairs (Grace 1977). Once inside the leaf salt particles accumulate, raising the internal chloride concentration. Once the chloride level exceeded some critical tolerance value, necrotic symptoms are illustrated.

2. PHYLLODE DRY WEIGHT.

Necrotic phyllodes are shown to have a significantly ($P>0.05$) reduced total dry weight. This is most likely a direct response to high internal chloride levels interfering with plant development. Further research into plant responses may illustrate more subtle effects of airborne salt deposition. In doing so this will enhance the ability to predict physiological responses.

3 SUMMARY.

Acacia individuals displaying symptoms can be considered to have a reduced state of health. The specific ecological consequence of this are unclear. Although a decrease in flower production was observed in these individuals, in the absence of further research it is impossible to correlate it with deposition stress.

It is hypothesised that individuals demonstrating salt symptoms are less stress resilient. The more severe the symptoms the greater the chance of plant mortality. As symptoms were common in the hilltop site Acacia present in this zone would be more stressed. Regeneration success, based on 'seedling' development and health, is considered to be highest in the gully site.

4 SPECIES SENSITIVITY.

The ability to tolerate airborne salt deposition varies between species. It was concluded from table 11 that Acacia leiocalyx (the principal regenerating species) and Acacia leptostachya were moderate salt tolerator, C. equisetifolia the first comparison species was a high salt tolerator and R. repens was salt sensitive.

It is interesting to note that R. repens, a salt sensitive species can exist on the island without displaying any stress symptoms. However when biological sheltering is considered, this is easily explained. Grass exists within a dense closed community structure , which has been shown (Grace 1977) to significantly reduce internal wind and therefore potential salt deposition. In the glasshouse experiment, this biological sheltering was absent. The grass species can therefore exist in the same habitat as Acacias, because of the reducing effect biological sheltering has on actual salt deposition load.

Plant success appears to be based on the level of actual salt deposition experienced. Factors such as biological sheltering which modify salt deposition load, play an important role in plant development. However salt deposition may also be affected by individual characteristics. Woodcock (1953) illustrated that per unit leaf area, salt deposition was highest on long narrow leaves. Increased salt deposition has also be shown to be created through leaf flexibility (Grace 1977), cuticle characteristics (Boyce 1954, Winter et al 1981) and possibly leaf orientation. The position of the vegetative apex must also be considered, especially when comparing grass and woody dicot species.

Airborne salt deposition is primarily based on geographical exposure. Biological sheltering created by the surrounding vegetation modify this deposition potential. Characteristics of the individual plant further influence salt deposition loads experienced. Plant success being determined by both genetic and structural characteristics

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CHAPTER THREE. OTHER POSSIBILITIES.

1. INTRODUCTION

The ability to exist under airborne salt stress may also be considered to be the general product of plant health. If a plant is already under stress, then its ability to tolerate further stresses must

also be reduced. Sensitivity to airborne salt deposition expressed through distributional, habit and symptom responses may be the consequence of some unidentified stress. This hypothetical stress could reduce plant health, allowing salt deposition symptoms to be demonstrated. If it was removed, plant health would increase and salt deposition limitations would be removed.

There is also the possibility that distributional and developmental plant responses, illustrated in the last chapter, is the product of unknown stresses. Field observations highlighted the possibility of water relations and soil characteristics being involved, although soil depth and salinity can not be over looked. Of these, soil characteristics specific, soil nutrient status and salinity were examined. As work was not carried out on water relations this must be held unaccounted as possibility.

2. SOIL NUTRIENT STATUS.

There appears to be a distinct difference in nutrient status between grasslands and forest soils (fig 9 and 10). Although the Acacia forest tends to show only phosphorous deficiency (table 12), grasslands were far more impoverished, demonstrating nitrogen, phosphorous, calcium and trace deficiencies. Deficiency responses of this type tend to suggest that forest soils are far more favourable to Acacia development, however this is not the case.

The presence of grassland nutrient deficiency are the product of uneven nutrient demand created by experimental conditions. The more rapid the growth is, the greater nutrient demand becomes. As soil supply is finite, increased nutrient demand will quicken the illustration of nutrient deficiencies. Acacias grown in grassland soils in the glasshouse, achieve the greatest total dry weight (fig 11) and therefore displaying the largest growth rate. As a consequences of this, they experiences nutrient deficiencies earlier. Acacias grown in the forest soil are restricted by some unknown soil condition, where plant growth and therefore nutrient demand are reduced. Natural soil nutrient supply remained above the plant demand.

Although soil deficiencies exist, plant development is clearly more limited by some unknown condition. Field observations tend to indicate soil structure as being a strong possibility. Forest soils were primarily compact clays, grassland soils however consisted of loose textured black earths. It is suspected that differences in resulting soil texture, through their effect on soil aeration and soil water

drainage may be creating this difference. Although attempts were made to overcome this in the glasshouse experiment, differences in soil compaction were also observed.

It is predicted that soil compaction created in the forest soil is responsible for plant growth retardation and that soil nutrients are of less importance. As plant growth is highest in the grassland soils (fig 11) there is no reason to suspect that soil type is involved regeneration success. In fact soil characteristics present in the grasslands appear to be more beneficial to Acacia development.

There was however superficial evidence of increased plant sensitivity to salt deposition. Acacias' present in the bare zone gully site (plate 5 and 6) displayed necrosis symptoms more severely than those in the adjacent grassland. This maybe evidence of reduced plant health, created through soil compaction, increasing salt sensitivity. However this is purely conjecture, with the possible importance of low biological shelter on salt deposition and soil water evaporation being untested. Further research is again clearly necessary, not only to establish the possible existences, but also the ecological consequences of underlining stresses.

3. SOIL SALINITY.

Soil salinity was only monitored very superficially. However salinity values were consistently low, with the highest values appearing in the Acacia forest. Although soil salinity restriction have been underlined by Goldsmith (1973) there is little reason to suspect that it is an important factor on the Island. Further research is necessary to verify this conclusion.

4. GRAZING.

The detrimental effects of grazing on Acacia regeneration have been widely reported (Harrington 1979). Comparison of aerial photographs of the Island (1973 to 1982) clearly illustrated a reduction in grassland zones being correlated with the removal of grazing, particular in the geographically sheltered areas. Grazing may affect regeneration success in several ways, the most obvious of which is direct seedling consumption. However selective consumption of the grass species may also have an important affect. Partial or total removal of the grass canopy will reduce biological sheltering and therefore increased salt

deposition potential. Grass removal may also lead to soil erosion, the potential for which is highlighted by Island topography.

It is suggested that past Acacia regeneration was closely controlled by grazing pressures. The removal of grazing has increased the success of Acacia regeneration. The consequence of which, appear to be the invasion and ultimate exclusion of all geographically sheltered grassland zones.

5. FIRE

The importance of fire characteristics in shaping plant communities is well established (Gill 1981). However to determine the role of fire, not only singularly but also interactively, is beyond the scope of this project. As such, fire must be considered an untested possibility. The necessity for further research being strongly stressed.

CHAPTER FOUR . CONCLUSION.

Airborne salt deposition is based on geographical and biological exposure. In combination they modify the salt deposition potential. Under biological sheltering Acacia 'seedling' development is unaffected by salt deposition stress. However once biological sheltering is removed, plant development becomes a function of geographical exposure. Those Acacia in the exposed hilltop site being severely affected. Acacia distribution, and regeneration success in this site is restricted as consequence. Successful Acacia regeneration is most likely to occur in the sheltered gully site.

Passed grazing pressure was suggested to have an appreciable impact on Acacia development. The removal of this stress was the first step in the establishment of successful Acacia regeneration.

The restriction to Acacia development created by airborne salt must also be considered in light of other stresses. Limitations created by soil characteristics and water supply may interact to effect Acacias resilience. In doing so, they may be considered to represent underlying stresses, where the sensitivity to airborne salt deposition increased.

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PLATE. ONE. 'Plant Stunting'

Acacia in the exposed hilltop site display severe stunting.

PLATE. TWO. 'Wind Pruning'

The Acacia above clearly demonstrates the effect of salt deposition on plant form. The wind direction is right to left.

PLATE. THREE. 'Tip Necrosis'
This Acacia demonstrates not only the existence of phyllode necrosis, but also its' relationship to age. The older phyllodes clearly illustrate necrosis more severely.

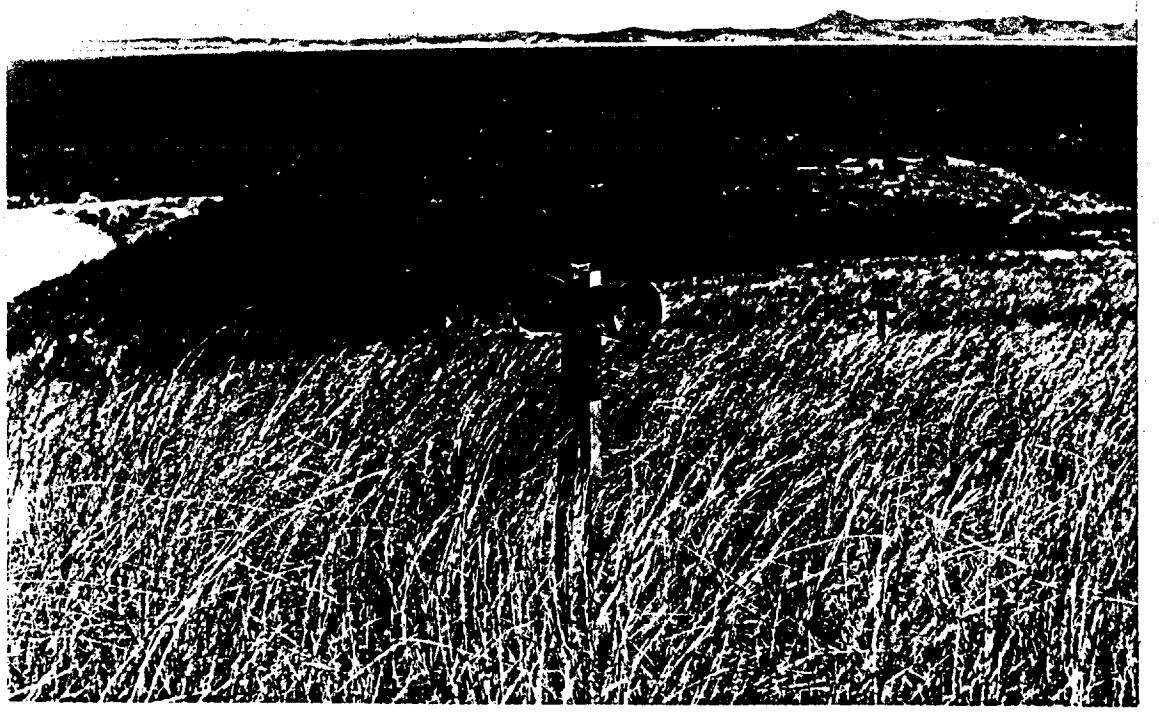

PLATE. FOUR. 'Salt Trap Design'
The salt traps used in the monitoring of airborne salt deposition are displayed above.

PLATE. FIVE. 'The Gully Site'
This area was one of the two test sites used. The degree of Acacia invasion is demonstrated.

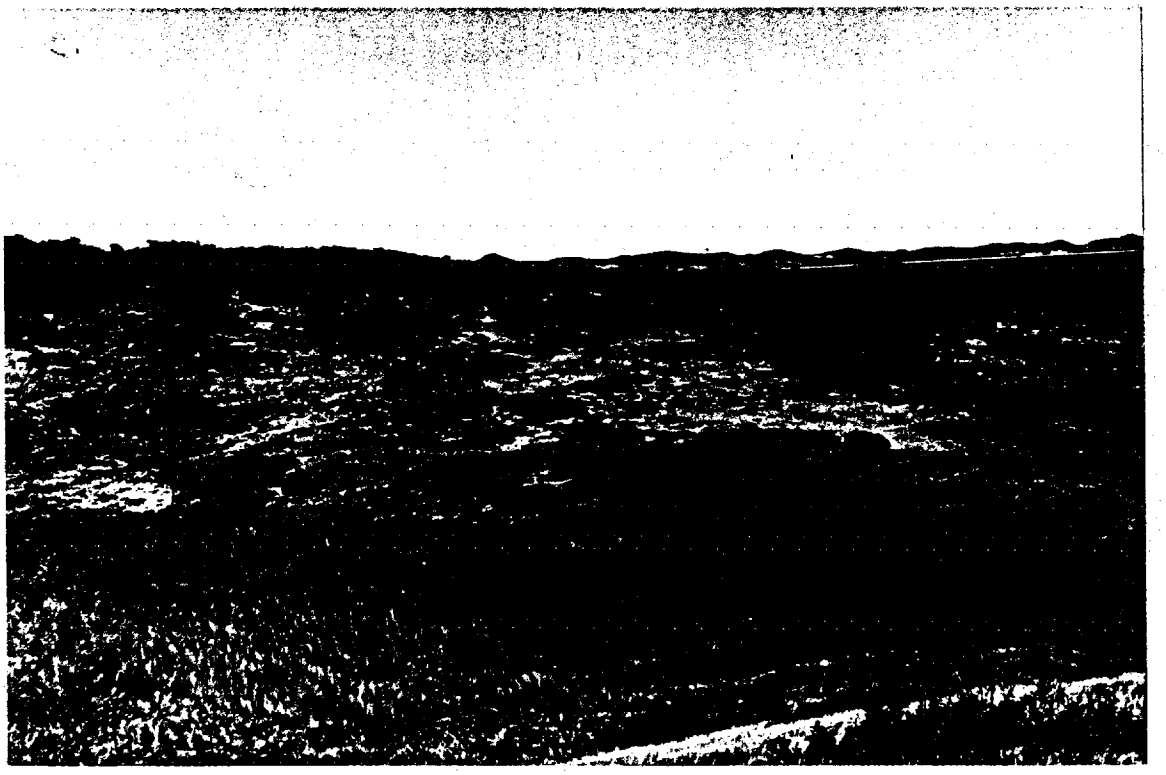

PLATE. SIX. 'The Gully Site'
Acacia regeneration in the gully site is by means of 'seedling' patches dispersed over the grassland.

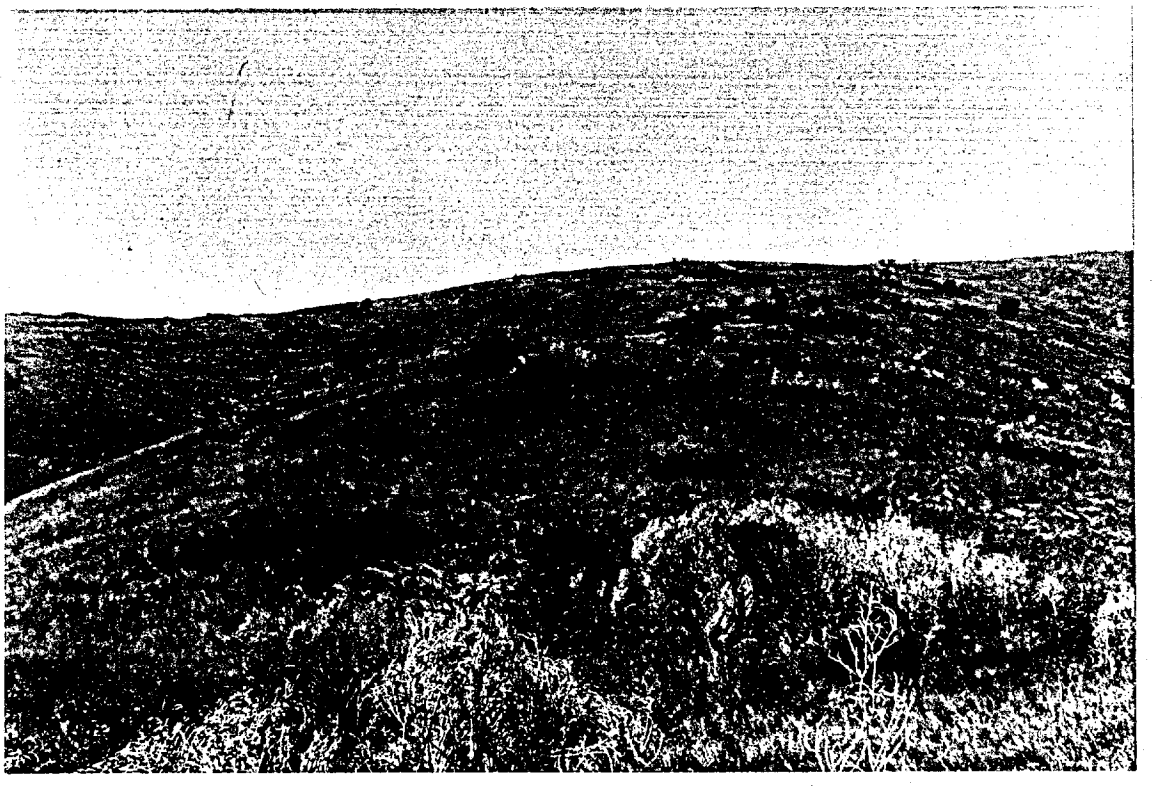

PLATE. SEVEN. 'The Western Ridge'

The western ridge is located between the hilltop and gully sites. The extent of 'seedling' patch regeneration is displayed above.