Chapter 7 — Vegetation

Plant communities as salinity indicators

Certain species are commonly found on salt-affected soils and can be useful for identifying salt outbreaks. Where plant species are identified that are salt-tolerant or that compete more effectively under saline conditions, salinity **may** be occurring at the site. Where species that are not salt-tolerant are present in surrounding areas but are absent from a location, this may also indicate soil salting. Further site investigations should be undertaken to determine whether salinity is in fact occurring, and to what extent.

Sources of information

- Other texts for identifying indicator species are listed in the appendix ***Salinity publications for further reference*** (page 145).

Native trees and shrubs

Tea tree (*Melaleuca* sp.) is commonly associated with many watertable salting occurrences in south-east and central Queensland; black tea tree (*Melaleuca bracteata*) particularly so. Historical data and current presence of tea tree indicate water levels were shallow prior to clearing in most areas now affected by watertable salting.

Some small areas may have perched watertables that are local and unconnected with regional groundwaters. Perched watertables often support a tea tree understorey beneath eucalypt forest, whereas permanently shallow regional groundwater levels usually support pure tea tree stands. Also, shallow regional groundwater levels occur in lowest landscape positions, whereas localised perched watertables can occur in higher landscape locations.

Where the presence of black tea tree, tea tree generally (*Melaleuca* sp.) and other local native vegetation species indicate the watertable is less than 6 m beneath the soil surface under native vegetation, there is a high risk of water rising to the surface if the vegetation is cleared.

Table 20. Plant species and communities that can indicate features of interest in salinity investigations.

Species or community	Indicates
Black tea tree (*Melaleuca bracteata*) Tea tree generally	shallow groundwater—potential discharge area
Melaleuca bracteata *Melaleuca nodosa* Brigalow (*Acacia harpophylla*)	saline soil
Melaleuca spp. generally Luxuriant grass and tree growth	poor drainage—potential discharge area or stream boundary
Softwood scrub *Angophora* sp. Cypress pine Silver-leaved ironbark Narrow-leaved ironbark	recharge areas

There is little published information relating trees and watertable depths. In areas in the Callide Valley where the watertable was 6 m below the soil surface under native vegetation, salting occurred after the vegetation was cleared (Hughes 1982a). In the Clermont area, watertable salting occurred in areas cleared of stands of black tea tree where the watertable was at a depth of 5 m to 6 m prior to clearing (Hughes 1982b).

Plants and plant communities which often indicate recharge and discharge areas are listed in Table 20.

Table 21 overleaf lists species that are useful indicators of local soil conditions in the lower Burdekin River–Elliott River area in north Queensland. These species are quite widely distributed in Queensland. Poplar box (*Eucalyptus populnea*) and gum-topped box (*E. polligaensis*) are commonly associated with sodic soils.

Pasture

In Queensland, the combination and relative abundance of species provides the best indication of salt levels, rather than the occurrence of any particular species. In general, poor pasture condition, including patchy growth, reduced vigour and loss of salt-sensitive plants, can indicate salinity.

A number of factors interact to determine species composition in a particular pasture. These factors include grazing regime, past management history (cultivation etc.), seed sources, soil conditions (such as compaction or low fertility) and seasonal influences. For instance, creeping saltbush (*Atriplex semibaccata*) can be a good indicator of salinity as it occurs on saline or disturbed soils (Christiansen 1993). However, this species is also generally absent from intensively grazed paddocks.

Table 21. Dominant tree and shrub species indicating salinity and sodicity in the lower Burdekin River–Elliot River area, north Queensland (Thompson 1977).

Common name	Scientific name	Indicative of soil conditions
False sandalwood	*Eremophila mitchellii*	strongly sodic-saline, shallow topsoil, duplex soils or saline grey clays
Beefwood	*Grevillea striata*	moderately sodic soils
Broad-leaved tea tree	*Melaleuca* sp.	waterlogging, at the surface or in the soil profile; indicative on slopes of lateral groundwater movement and shallow watertable
Red bloodwood	*Eucalyptus intermedia*	sedentary soils with freely draining profiles; rock normally present in the profile
Cocky apple	*Planchonia careya*	soils underlain by watertable confined in a washed sand stratum; also common in sedentary skeletal soil situations along subsurface seepage lines
Pandanus	*Pandanus* spp.	deep sands, indicative of prior stream channel infills, and good quality water
Boree	*Acacia pendula*	saline grey clays

The composition of species in salt-affected areas of south-east Queensland is not dramatically distinct from those found on non-saline soils (Christiansen 1993). Gradual changes in vegetation occur across the transition from non-saline through marginal to saline soil. In south-east Queensland, Rhodes grass, green couch and wild aster generally persist in all but the most severely salt-affected patches.

In central Queensland, more defined transitions are evident. Marine couch (*Sporobolus virginicus*), green couch, brown beetle grass, samphire, creeping saltbush, pigweed (*Portulaca oleracea*), coastal pigface (*Sesuvium portulacastrum*) and soft roly-poly (*Salsola kali*) occur on severely saline soils, while on the less saline margins purpletop Rhodes grass (*Chloris inflata*), woodland lovegrass (*Eragrostis sororia*) and boobialla (*Myoporum acuminatum*) are found. Beyond this zone on relatively non-saline soils, black spear grass (*Heteropogon contortus*) communities commonly occur.

The following table (Table 22) lists plant species that can be used to detect soil salting. Few of these species can be considered true indicators of salinity because they also grow on non-saline soils. Some species are less common in non-saline areas due to competition with other, more vigorous species. If species known to have low salinity tolerance are found locally, their absence from areas of the landscape susceptible to salt outbreaks (see ***Landform feature identification*** page 39) may also indicate salinity. Such species include balloon cottonbush (*Asclepias physocarpa*), pitted bluegrass (*Bothriochloa decipiens*) and black speargrass (*Heteropogon contortus*).

Figure 29. Marine couch (*Sporobolus virginicus*) found growing on a salt flat near Rockhampton, Queensland.

Vegetation patterns on remote sensing images

Vegetation density and growth vigour usually reflect the available water regime. Potential recharge and discharge areas can often be deduced from remote sensing images, preferably obtained before natural vegetation was initially cleared.

Table 22. Plant species which, when dominant and in combination with other salinity indicators, indicate that further salinity investigations are warranted (after Christiansen 1993).

Common name	Scientific name	Indicates soil salinity level
Groundsel	*Baccharis halmifolia*	low to moderate
Buffel grass	*Cenchrus ciliaris*	
Barnyard millet	*Echinochloa crus-galli*	
Woodland lovegrass	*Eragrostis sororia*	
Spring grass/cup grass	*Eriochloa procera*	
Caustic weed; mat spurge	*Euphorbia dallachyana*	
Caustic weed; mat spurge	*Euphorbia drummondii*	
Common fingerrush	*Fimbristylis dichotoma*	
Gomphrena weed	*Gomphrena celesioides*	
Burr medic	*Medicago polymorpha*	
Boobialla	*Myoporum acuminatum*	
Paspalum	*Paspalum dilatatum*	
Wild aster	*Aster subulatus*	low to high
Mueller's saltbush	*Atriplex muelleri*	
Creeping saltbush	*Atriplex semibaccata*	
Pioneer Rhodes grass	*Chloris gayana*	
Purpletop Rhodes grass	*Chloris inflata*	
Green couch	*Cynodon dactylon*	
Sedges	*Cyperus* sp.	
Brown beetle grass	*Diplachne fusca*	
Ruby saltbush	*Enchylaena tomentosa*	
Curly windmill grass	*Enteropogon acicularis*	
Epaltes	*Epaltes australis*	
Samphire	*Halosarcia and Sarcoconia*	
African boxthorn	*Lycium ferrocisimum*	
Black tea tree	*Melaleuca bracteata*	
Hairy panic	*Panicum effusum*	
Pigweed	*Portulaca oleracea*	
Soft roly-poly	*Salsola kali*	
Prickly roly-poly	*Sclerolaena muricata*	
Sea purslane	*Sesuvium portulacastrum*	
Sand spurry	*Spergularia rubra*	
Marine couch	*Sporobolus virginicus*	
Giant pigweed	*Trianthema portulacastrum*	

Ground truthing must always be used to verify aerial photo interpretation. For instance, an area of increased vegetation density identified on an aerial photo of the Charters Towers area had in fact been invaded by rubber vine. In this case, the increased vegetation density identified on the photograph was not due to increased wetness and thus was not a potential discharge area.

Sources of information

- Aerial photos and Landsat imagery are both suitable for looking at vegetation patterns. If possible, obtain images taken before natural vegetation was initially cleared as well as recent images.
- Vegetation patterns can also be readily observed from vantage points in the catchment or by flights over the area, if either of these are available.

Interpretation

Bare or patchy areas on remote sensing images can indicate salted or scalded areas, particularly in relation to particular landforms (see ***Landform feature identification*** page 39) and rainfall pattern over time (see ***Moving average rainfall*** pattern page 56).

Increased density of native vegetation in areas of the landscape which are susceptible to salting is a reasonable indicator of increased wetness in the landscape. Such areas would be at risk of developing salting if vegetation were cleared in the catchment or other factors altered the hydrologic balance by increasing inputs or decreasing outputs.

Linear patterns in vegetation can reveal geological features such as dykes or faults. It may be possible to identify areas where specific indicator species dominate (see previous section). Changes in vegetation patterns around streams can indicate the extent of alluvium and/or restrictions to catchment outflows.

Plant response to salinity and specific ions

Most agriculturally important crops respond to total salinity as an osmotic effect. Some woody horticultural species are also susceptible to concentrations of specific ions. When these concentrations reach toxic levels, effects are most noticeable in the leaves, particularly in the leaf margins. Symptoms include necrotic spots, leaf bronzing and, in highly toxic cases, defoliation. (Details for a range of plants are given in Maas 1986.) The ions most often involved are sodium, chloride and boron.

For a given species, an assessment of plant salt tolerance will depend on the purpose of growing the plant. Plant salt tolerance for crops is defined as the ability of plants to survive and produce economic yields under saline conditions. For ornamental species, the ability to survive and maintain an aesthetic appearance may be more important than yield.

Sources of information

- Advice on observable symptoms can be obtained from the Department of Environment and Resource Management.
- Information on other toxicity effects is provided in the *Australian water quality guidelines for fresh and marine waters* (ANZECC 1992, currently being revised).

Additional information

There are essentially two types of plants which grow in saline soils: salt-resistant and salt-tolerant plants.

Salt-resistant plants (glycophytes) maintain growth in mildly saline soils by excluding salts at the roots (Greenway & Munns 1980). In extremely saline soils, glycophytes are unable to both exclude salt and obtain sufficient water for maintenance and the plant tissues are sensitive to high concentrations of salts.

Conversely, halophytes are those plants considered to be truly salt tolerant because growth continues despite high internal concentrations of electrolytes. As a result, the upper limit of soil salinity that can be tolerated is much lower for glycophytes than for halophytes. Some halophytes have adapted to ion uptake by secreting salts. Others cope with high internal ion concentrations by compartmentalising salts or increasing the volume within which the salts are dissolved. Adverse effects of ion uptake in non-adapted species include effects on metabolism, such as a decrease in CO_2 fixation.

Halophytes which exclude salts at the roots use mechanisms to avoid an internal water deficit. Non-adapted species in highly saline conditions are unable to both exclude salts and obtain sufficient water for maintenance, resulting in water stress. Most agricultural species fall into this category.

In reviewing the literature on relative salt tolerance for a wide range of crops, Maas and Hoffman (1977) found the normal response of plants to salinity appears to be that there is no yield decrement until a threshold level is reached, after which there is an approximately linear decrease in yield with increasing soil salinity. Maas and Hoffman grouped the response of relative yield to salinity into four salt-tolerance divisions, as shown in Figure 30.

Using experimental data on salinity threshold and productivity decrease per unit of salinity concentration increase, it is possible to calculate the approximate salinity level at which a particular yield may be achieved, using the equation:

$$Y_r = 100 - B(EC_{se} - A) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 21$$

where

Y_r	is	relative yield
EC_{se}	is	the nominated or measured value of EC_{se}
B	is	per cent productivity decrease per dS/m increase above the threshold value
A	is	salinity threshold value of ECse.

An extensive listing of plant salt-tolerance data (productivity decrease and threshold values) for a range of crop, pasture, fruit, vegetable and ornamental species is provided in the appendix ***Plant salt-tolerance data*** (page 124) with calculated EC values which may be expected to result in 90% and 75% yields. When using this data, it is important to keep in mind the range of factors that influence plant salt-tolerance in the field.

Most quantitative salt-tolerance data have been derived from controlled laboratory or greenhouse experiments rather than under field conditions. In laboratory experiments, one factor (such as the salinity) is varied while other factors (such as soil type, nutrition, water) are usually kept constant. Obviously, many of these factors interact in the field; in addition, the distribution of salinity in field soil profiles will not be uniform as it is in most controlled experiments.

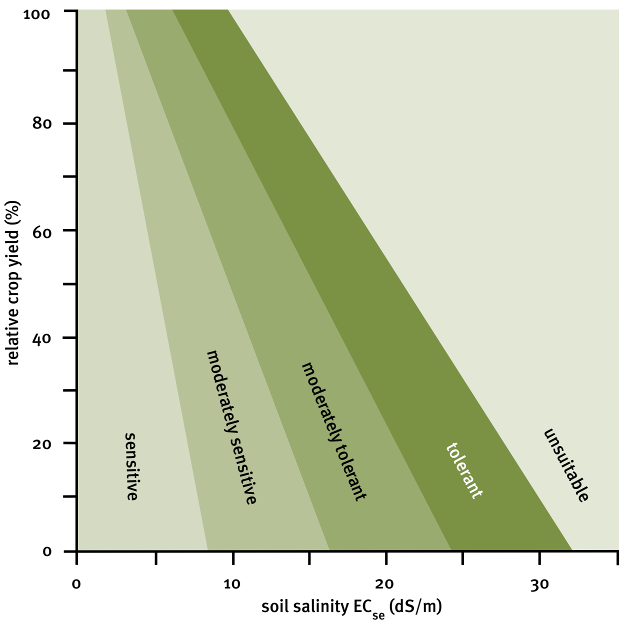
For these reasons, salinity information which is derived from controlled experiments is useful as a general guide, but can not be used to precisely predict plant behaviour under the wide variety of field conditions.

A number of the factors affecting salt tolerance in the field are described in this section.

Salinity in the root zone

In glasshouse investigations, soil properties and salinity are uniform throughout the root zone. In the field, however, this uniformity is unlikely to occur. Two measures of root zone salinity in the field are commonly used to relate to plant response: average root zone salinity, and water uptake weighted root zone salinity. (These two measures are described in more detail in ***Root zone salinity*** page 34.)

Figure 30. Relative crop yield in relation to soil salinity (ECse) for plant salt-tolerance groupings of Maas and Hoffman (1977).



Plant stage of growth

While some species are more susceptible to salinity at emergence than at later stages of growth, other species are in fact **less** susceptible at emergence. In these species, a crop that appears to have germinated successfully under saline conditions may fail at a later stage of growth. Hence, the effects of salt both on germination and yield should be considered when choosing crops for marginal conditions. (This is discussed further in ***Crop species*** page 103. Table 42 in that section lists some species for which Maas, 1986, collated available information on salt-tolerance differences between germination and seedling establishment phases.)

Management practices

Some species can tolerate higher salinity concentration in the soil than in water applied to the leaves. This is specifically relevant to crops under sprinkler irrigation. Management practices for using marginally saline waters include irrigating below the leaves (to avoid depositing salts on the leaves) and irrigating at night (to reduce salt on the leaves left by rapid evaporation during the day). (These practices are discussed in ***Marginal quality irrigation waters*** page 116.)

Climate

According to some researchers (for example, Maas 1985), climate may influence plant response to salinity more than any other factor. Plants are able to tolerate salt better when the weather is cool and humid than when the weather is hot, dry or windy. In plants which are sensitive to high levels of specific ions, the leaves may contain toxic amounts of ions (such as Na or Cl) for weeks without exhibiting leaf necrosis until the first bout of hot, dry weather.

Fertility

Published data on the interaction between fertility and salinity present contradictory conclusions. A range of experimental results were reviewed by Feigin (1985), who explained the contradictions in terms of the different experimental procedures.

Crops growing on infertile soils can actually show higher salt tolerance than crops of the same species grown on highly fertile soils. This is because salinity is not the main limitation to growth in this situation.

Symptoms of salinity and specific ion effects on plants

The most common indications of salinity occur when plants are stunted, grow slowly, or do not grow at all. In some cases, leaves may be a darker green and more succulent than usual. However, in most cases, the only indication will be reduced yield; dry matter production may be affected less than yield. Salt-tolerant species such as pioneer Rhodes grass and green couch are often more productive in areas where watertables are close to the surface due to increased moisture availability.

Some plants which are osmotically stressed by salt show no distinctive symptoms apart from the ones mentioned in the previous section and others related to normal water stress. Salt stress for most plants is an additional stress to water stress because the plant cannot develop sufficient energy to extract water.

Woody species tend to show more leaf damage than herbaceous species. In woody species, leaf burn and even defoliation can indicate salinity. These symptoms tend to result more from the accumulation of specific ions (such as sodium or chloride) than from total salt concentration.

In addition, other elements not related to salinity, such as heavy metals, can cause a number of symptoms that are similar to salinity and specific ion effects.

Sodium

Excess sodium accumulates in the leaves, causing leaf burn, necrotic patches and even defoliation. (This is an effect of plants' response to high levels of a specific ion rather than to salinity in general.) Poor physical conditions in the soil (caused by sodicity) will limit plant growth (the major effect). Plants may experience calcium and magnesium deficiencies because of reduced availability.

Excess sodium will degrade the physical properties of a soil. Sodic soils tend to disperse readily, affecting air and water permeability, and form hard, dense clods when the soil dries. These physical effects prevent adequate root development and increase the difficulties of soil management. Limited root exploitation can result in nutritional deficiencies and greater likelihood of water stress. Sodicity problems occur less often on sandy soils and are compensated to some extent by swelling and shrinkage on cracking clay soils (discussed in more detail in ***Soil stability and sodicity*** page 23).

Under continued irrigation with strongly sodic waters, the exchangeable cations on the clay mineral surfaces of the soil are gradually replaced by sodium until a new equilibrium is established. Deficiencies of calcium tend to arise because it precipitates out of solution as $CaCO_3$ as the sodium exchanges onto the clay in alkaline soils. This occurs to a greater extent if the irrigation waters contain high levels of bicarbonate. Waters containing sodium bicarbonate (residual alkali) can develop soil pH up to 10.0, creating significant nutritional problems. (Refer to ***Irrigation water salinity and sodicity classification*** page 82 for further discussion of residual alkali.)

Chloride

Plants affected by chloride toxicity exhibit similar foliar symptoms to sodium, such as leaf bronzing and necrotic spots in some species. Defoliation occurs in some woody species.

Chloride behaves similarly to sodium. However, salinity impacts on citrus yield, long attributed to chloride levels in waters, have recently been found to be more closely related to EC. The evidence for specific yield reduction in citrus in relation to chloride or osmotic effects is a matter of debate. The current evidence strongly indicates that osmotic effects are the primary cause of yield reduction.

Boron

Symptoms, such as yellowing margins, crumpling, blackening and distortion, appear first in the youngest leaves. The level at which a particular plant will find boron toxic depends on a variety of factors, particularly whether the boron originates in the soil or in the irrigation water. Boron toxicity is uncommon in Queensland, except in some areas of the south-west (Wreczycki 1968).

Figure 31. Leaf damage due to salinity on a young pine tree near Bundaberg, Queensland.