SOME PROBLEMS IN DETERMINING THE BOUNDARIES OF SEPP 14 WETLANDS

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INTRODUCTION

Since the introduction in New South Wales of State Environmental Planning Policy 14 - Coastal Wetlands (SEPP 14) more than 5 years ago, there has been an increasing tendency for planners to avoid designated wetlands when planning developments. Although designated wetlands are mapped under the policy, there are often disputes as to the accuracy of the mapped boundary of the wetlands.

Under such circumstances planners may seek clarification of the boundary by surveying the edge of the wetland. The author has been involved in a number of such cases in which the edge of the wetland was delineated on the ground with the assistance of a surveyor (Shortland Wetlands Centre 1987, 1988a, 1988b, 1989a, 1989b, 1990, 1991a, 1991b). This paper outlines some of the problems encountered in these cases.

The determination of the boundary of a wetland depends on both definition (identifying conceptual boundaries) and delineation (identifying physical boundaries).

DEFINITION

SEPP 14 Wetlands

State Environmental Planning Policy 14 prescribes a number of activities (clearing of vegetation, levee bank construction, draining and filling) which are deemed to be "designated" developments, requiring the preparation of an environmental impact statement (EIS), if proposed within wetland areas shown on maps which accompany the policy.

As SEPP 14 itself does not present a definition for the wetlands which are covered by the policy, there is no statutory definition of wetland which can be applied to determine suitability of wetlands for inclusion in the policy. However, the selection criteria which were used in the survey which resulted in the original maps for SEPP 14 were detailed in a report to the Coastal Council of NSW, which was published at the time of gazettal of the policy (Adam *et al.*, 1985). These criteria are set out in Tables 2 and 3 of the report (Adam *et al.*, 1985: 37-38), and are reproduced here as Appendix 1.

The lack of precision of these criteria suggests that they were intended only as a description of the selection and mapping process for the survey, but it appears that in the absence of a more formal definition they are used as a de-facto definition by the Department of Planning in its regular reviews of the wetlands included in the policy.

Whilst the report does not adopt a precise definition of wetland (Adam *et al.*, 1985 : 7), it would appear from the wetland types included in the survey, that the authors have relied on an informal biological definition, and have mapped a number of vegetation types which were considered to be wetland communities. The wetland components mapped by the survey (Adam *et al.*, 1985: Table 2) are listed as (1) mangroves, (2) saltmarshes, (3) *Melaleuca* forests, (4) *Casuarina* forests, (5) sedgelands, (6) brackish and freshwater swamps, and (7) wet meadows. The report mainly discusses the identification of these communities on aerial photographs, but does not define the communities.

The conceptual limits of the wetland communities which were mapped for the policy were mainly established by a number of "main exclusion criteria" (Adam *et al.*, 1985: Table 3), which sought to differentiate between the wetland communities included in the policy and closely allied communities. Unfortunately not all of the exclusion criteria are precisely defined and are subject to some interpretation, especially when attempting to apply the criteria to ground surveys.

Interpretation of Wetland Components Mapped in the Survey

The survey by Adam *et al.* (1985: 37) mapped seven broad wetland types. Whilst the survey largely identified these wetlands by analysis of patterns on aerial photographs, the interpretation of the wetland types presented below concentrates on characteristics which can generally be readily identified by the ground observer.

As these wetland types are based primarily on vegetation, they assume some understanding of the concept of "dominance". Unfortunately, this term is not rigidly defined in ecological literature and remains open to some degree of subjective interpretation. Following the lead of Specht *et al.* (1974) the author considers that a community is dominated by the life form that comprises the uppermost stratum, providing that it has a coverage of at least 10%. The numerically most common species in this stratum is considered to be the dominant species (often more than one species).

Mangroves

Although there are five species of mangroves known to occur in New South Wales, only two species (*Avicennia marina* and *Aegiceras corniculatum*) commonly dominate mangrove communities in the state. Consequently, identification of communities dominated by mangroves is relatively easy, and they are readily mapped with a high degree of confidence.

Saltmarshes

As with mangrove communities, the occurrence of saltmarshes is dependent on inundation by tidal waters. The vegetation and flora of saltmarshes in New South Wales is relatively well documented (e.g. Bridgewater, 1974; Adam, 1981; Adam *et al.*, 1988), making identification of communities dominated by halophytes relatively easy.

Melaleuca Forests

This wetland type comprises tree communities dominated by *Melaleuca* species. Whilst identification of these species is relatively easy, there are two major "grey" areas: (1) grading of *Melaleuca* communities into surrounding *Eucalyptus* communities; and (2) whether all communities dominated by *Melaleuca* are in fact wetlands. These questions were dealt with by Adam *et al.* (1985) in their "exclusion criteria", which are discussed below.

Casuarina Forests

In the narrow coastal strip covered by the survey, this wetland type comprises tree communities dominated by *Casuarina glauca*. Again, these communities are readily identified, although the "exclusion criteria" (see below) sought to exclude drier *Casuarina* forests.

Sedgelands

As used by Adam *et al.* (1985), this term appears to refer to communities which are dominated by sedges (family Cyperaceae) and restiads (family Restionaceae). Whilst some sedges and restiads occur in essentially dryland communities, they usually only dominate in communities which are inundated for extended periods.

Brackish and Freshwater Swamps

This term is much less precise than the preceding wetland types. As used by Adam *et al.* (1985) it appears to comprise wetlands which are semi-permanently or permanently inundated, and which are dominated by herbaceous vegetation, especially rushes, reeds and other graminoids.

Wet Meadows

This is also an imprecise term. It appears to include wetlands which are seasonally or intermittently inundated by shallow water, and are dominated by grasses and herbs. In coastal areas, such wetlands typically occur as the result of past clearing of floodplain forest communities for pasture.

Interpretation of Exclusion Criteria

Adam *et al.* (1985: 38) list seven exclusion criteria to differentiate between wetlands, as included in the survey, and communities which often occur adjacent to wetlands, but were not considered to be wetlands for the purposes of the survey. The interpretation of these criteria presented below is based on a number of studies involving mapping of SEPP 14 wetlands, both from aerial photographs and on the ground (Shortland Wetlands Centre, 1987, 1988a, 1988b, 1989a, 1989b, 1990, 1991a, 1991b).

Terrestrial *Melaleuca* Forests

This criterion appears to seek to differentiate between so-called *Melaleuca* swamp forests, which are generally inundated for extended periods of time, and other *Melaleuca* forests which occur on floodplains or on poorly drained soils on slopes, which may be temporarily inundated with water during periods of heavy rain or flood, but from which the surface water quickly drains away. The criterion does not define "terrestrial *Melaleuca* forest", although as in all of these criteria, it is reasonable to interpret vegetation structural terms, such as "forest", as being generally equivalent to the structural formations defined by Specht *et al.* (1974).

In applying this criterion, the author considers a "terrestrial *Melaleuca* forest" to be a community which, although dominated by *Melaleuca* spp., has an understorey and/or groundstorey composed chiefly (> 50% coverage) of plants which typically occur in terrestrial habitats, (i.e. plants which are not adapted to life in waterlogged soil conditions). Such a community would be expected to have poorly drained subsoil (high water table), thus encouraging the dominance of hydrophytic tree species such as *Melaleuca* spp., but would have a relatively well drained surface. Examples of understorey and groundstorey plants encountered by the author in *Melaleuca* forests on the central and lower north coasts are listed in Appendix 2.

Terrestrial *Casuarina* Forests

This criterion is similar to the preceding one, and seeks to exclude floodplain *Casuarina* forests, as distinct from *Casuarina* swamp forests. In application, this criterion has been interpreted similarly to the previous one in that a terrestrial *Casuarina* forest is considered to be a *Casuarina* forest which has an understorey and/or groundstorey composed chiefly (> 50% coverage) of terrestrial plant species. Examples of understorey and groundstorey plants of *Casuarina* forests encountered by the author in the central and lower north coasts are listed in Appendix 2.

However, due to the often thick litter layer of *Casuarina* 'needles', some such forests do not support much of an understorey or groundstorey, making interpretation even more difficult. In such cases it is necessary to make judgments on the frequency and duration of inundation based on surrounding landforms. In this regard the author sought to qualitatively compare the height of the substrate of the *Casuarina* forest with the height of the substrate and/or water level of nearby wetland communities to assess whether wetland groundcover species would be likely to grow in the subject area if the *Casuarina* trees were to be hypothetically removed.

In their aerial photograph interpretation of terrestrial forests, Adam *et al.* (1985: 38) found that "non-wetland floodplain forests have a lower density than the wetland forests". This observation can also be helpful in separating terrestrial forests from wetland forests.

Melaleuca / Eucalyptus Forests

This criterion sets a precise boundary between *Melaleuca* forests and *Eucalyptus* forests, whereby communities in which the *Eucalyptus* species comprised 10% or more of the canopy cover were excluded from the survey. As Adam *et al.* (1985: 38) state, "this estimation can be fairly reliably made on aerial photographs", but is obviously more difficult to determine in ground surveys, with individual trees having a canopy spread of up to approximately 20 metres. An unfortunate side-effect of this criterion is that wetland communities dominated by Swamp Mahogany (*Eucalyptus robusta*) were excluded from the survey, and are therefore not covered by SEPP 14.

Whilst Swamp Mahogany is a species which is generally considered to be poorly conserved (e.g. Specht *et al.*, 1974), its similar appearance to other *Eucalyptus* species on aerial photographs has resulted in its exclusion from the peak wetland conservation planning instrument for coastal New South Wales, which has potentially serious implications for the conservation of wetland types dominated by this species.

Littoral Rainforest

Littoral rainforest often occurs in close proximity to coastal wetlands and may even have an emergent canopy of *Casuarina* or *Melaleuca* (Adam *et al.*, 1985: 38). Although it is not a wetland community, it can sometimes be difficult to separate littoral rainforest from adjacent swamp forests on aerial photographs. This is less of a problem in ground surveys.

Dune Thicket

As used by Adam *et al.* (1985) the term "dune thicket" refers to tall closed shrubs of tea-tree (*Leptospermum* spp.), which occur on sand dunes and are not wetland communities. This criterion was included because of the similarities in appearance on aerial photographs between dune thickets and some *Melaleuca* low swamp forests.

Wet Heath

Adam *et al.* (1985) did not include wet heath in their survey because it is "rarely associated with bodies of standing water" (Adam *et al.*, 1985: 38). The exclusion from the policy of wet heath, which is considered to be a wetland community by many wetland ecologists (e.g. Briggs, 1981; Pressey & Harris, 1988; Winning, 1989), is a significant inadequacy, especially in coastal areas with extensive sand dune systems such as Port Stephens Shire where the author has undertaken much wetland mapping, and has potentially serious implications for the conservation of this wetland type. In the absence of a definition of wet heath by Adam *et al.* (1985), the author has relied on a structural definition of heath as a mid-dense to dense (projective foliage cover of 30% - 100%) community dominated by shrubs less than 2 metres high (Specht *et al.*, 1974).

Wet scrub communities (mid-dense to dense shrubs ≥ 2 metres high) are not specifically mentioned in the exclusion criteria, but it appears that in assessing a wetland's suitability for inclusion in the policy, the Department of Planning treats such scrub communities as wet heath. For example, Campvale Swamp which lies near Grahamstown Reservoir north of Newcastle, was largely taken out of the policy apparently because it comprises a tall (2 to 3 metres) dense shrub community dominated by *Callistemon pachyphyllus* and *Melaleuca ericifolia*.

Disturbed / Modified Wetlands

The exclusion of a wetland from the survey because it was significantly disturbed was based on a set of specific indicators. An area was excluded from the survey if it exhibited all five of these indicators on aerial photographs - (1) presence of functional drains; (2) presence of fence lines; (3) paddock differentiation; (4) signs of reclamation, extensive clearing, or contraction of permanently inundated area; and (5) lack of a natural boundary (on at least one side) with bushland, estuary, or large waterway (Adam *et al.*, 1985: 38). This definition is reasonably precise and needs little interpretation, but it is necessary to assess these indicators from aerial photographs.

DELINEATION

Need For a Line on the Ground

As the criteria used by Adam *et al.* (1985) were obviously designed for interpretation of aerial photographs and subsequent mapping at a small scale (1 : 25,000), the resultant wetland boundaries at these scales are quite coarse. However, the demands of developers and planners usually require much greater precision, and ultimately require a surveyed line on the ground.

Given the legal definition of SEPP 14 areas as the areas enclosed by the "outer edge of the heavy black line on the map" (the lines represent a width of approximately 25 metres), it is in theory only necessary for planners to survey this line.

However, in a number of cases it has been found that there are significant differences between a wetland boundary as mapped for the policy and ground observations of the edge of the wetland. Such differences can result from the actual position of the boundary on the map being in error, due to error in aerial photograph interpretation and/or mapping, or to a lesser extent, differences in interpretation of the wetland boundary from aerial photographs compared to ground observations. Planners may seek to clarify these discrepancies by obtaining an accurate ground survey of the edge of the wetland for comparison with the mapped SEPP 14 boundary.

In undertaking such surveys, the author has sought to apply on the ground, the criteria used by Adam *et al.* (1985). In addition to dealing with the conceptual boundary problems discussed above, such surveys were also confronted with the physical boundary problems typically associated with any attempt to delineate boundaries of natural communities.

Problems in Drawing a Line on the Ground

In situations where there are abrupt topographic changes between a wetland and the surrounding dryland community, it is relatively easy to mark and survey an edge for the wetland. These situations are especially evident in areas subject to significant past disturbances, such as clearing or sand mining.

However, in many natural situations, gently sloping land along the edge of a wetland results in gradual changes in vegetation from wetland species to dryland species with increasing height of the land. These situations most typically occur (at least in the areas most familiar to the author) where wetland forest (i.e. *Melaleuca* or *Casuarina* swamp forest) grades into the surrounding "non-wetland" forest (i.e. terrestrial *Melaleuca* or *Casuarina* forest). In such grey areas it is probably preferable to say that the wetland does not have a true 'edge', and any surveyed boundary would be more of a 'line of best fit' rather than an edge.

The difficulties in surveying such boundaries are obvious, even when precisely defined criteria are used, and some subjectivity becomes unavoidable, although it is important that, as far as possible, a high degree of consistency be maintained within individual surveys by using the same personnel for the whole survey.

Extent of Mapping Errors in SEPP 14

Given the extent of coverage of SEPP 14 (most of the New South Wales coastal strip) and the limited amount of ground truthing which could be undertaken during the preparation of the original maps, it must be expected that there are errors in wetland mapping for the policy. Evaluation of the extent of these errors is obviously a monumental task requiring extensive ground truthing, and has therefore generally only been undertaken for wetlands in which there is some development interest.

The results of extensive fieldwork undertaken by the author on the Tomaree Peninsula (Shortland Wetlands Centre, 1988b; 1990) is presented here by way of example of the extent of error in the mapping in a small area near Port Stephens.

The Tomaree work initially (SWC 1988b) involved the verification of SEPP 14 boundaries within an area covered by one of Port Stephens Shire Council's 1: 8,000 map sheets (an area of approximately 3,600 ha), including 17 wetlands ranging in size from less than 3 ha to more than 200 ha. Assessment of wetland boundaries for this work was based on aerial photograph interpretation with extensive ground truthing (much more than would have been possible for the original mapping for SEPP 14). This work identified some discrepancies in the boundaries of all wetlands within the study area, with some whole wetlands being omitted from the SEPP 14 mapping. In total, SEPP 14 mapped some 715 ha of wetlands within the study area, whilst the author mapped 790 ha. Approximately 55 ha of the wetland areas which were mapped for SEPP 14 were not considered by the author to satisfy the

selection criteria for the policy, and the author mapped an additional 130 ha (approx.) which were not mapped by SEPP 14 that were considered to satisfy the criteria for the policy.

Subsequent more detailed fieldwork by the author (SWC, 1990) sought to survey a small sample of these wetland boundaries on the ground, using the SEPP 14 criteria. The results of these ground surveys were compared with the aerial photograph mapping undertaken by the author for the same wetlands within the sample area. Whilst the surveyed boundaries were comparable to those mapped remotely, some discrepancies were recorded. Approximately 15 ha of the 176 ha of wetlands mapped remotely were not identified on the ground as satisfying the criteria, and the ground survey included 14 ha of wetlands which were not identified from the aerial photographs as satisfying the mapping criteria.

These results suggest that there may be substantial errors in the SEPP 14 mapping, and they further suggest that the accuracy of mapped boundaries is proportional to the amount of ground truthing which is undertaken.

DISCUSSION

This paper has identified three major problems in the application and interpretation of SEPP 14 mapping criteria: (1) the exclusion of some wetland types of potential conservation significance to coastal areas; (2) the lack of precision of the selection criteria used for the original mapping for the policy and subsequent amendments by the Department of Planning; and (3) the likely extensive errors in the SEPP 14 mapping.

Exclusion of Specific Wetlands Types

There is no general acceptance within New South Wales or Australia of what comprises a wetland, and various approaches have been used by different authors. The "definition" adopted for SEPP 14 is relatively narrow compared to others which have been used in Australia, excluding several community types which are considered to be wetlands by most other authors (see Appendix 3). It has already been mentioned that SEPP 14 excludes wet heaths and *Eucalyptus* dominated swamp forest communities, both of which would be considered to be wetlands by most Australian wetland scientists. Some of the other communities which have been excluded by SEPP 14, such as shallow fresh lakes, fresh ponds and floodplain forests, are considered to be wetlands by many wetland scientists but are often excluded from wetland surveys.

The exclusion of wet heaths and Swamp Mahogany (*Eucalyptus robusta*) communities from SEPP 14 has particular significance for coastal wetland conservation. Both wetland types typically occur in coastal sand dunes, often as part of a complex mosaic with other wetland communities. Separation of wet heaths and Swamp Mahogany communities from other adjacent wetland communities can result in artificial division of an integrated wetland ecosystem. Extension of SEPP 14 to cover these wetland types would greatly enhance the effectiveness of the policy in conserving coastal wetlands.

Precision of Selection Criteria

The selection criteria used by Adam *et al.* (1985) for their original survey of wetlands for SEPP 14 were apparently not intended as a set of criteria for on-going assessment of the suitability of wetlands for the policy. However, in the absence of a more precise set of criteria, they have generally been used for this purpose, although some interpretation of the criteria is necessary. In order to facilitate better application and understanding of SEPP 14, it is desirable that the criteria used to assess wetlands for the policy be standardised and be as precise as possible. The author does not propose in this paper to recommend a form for the criteria, but the problems outlined above which have been identified in the application of the policy could be of assistance in this matter.

The experience of wetland identification and delineation in the United States could provide some useful guidelines. The present U.S. Environmental Protection Agency's (1989) manual for delineation of wetlands defines four criteria for identifying wetlands, based on hydrology, vegetation, soils and growing season. These criteria are precisely defined, although they need to be accompanied by supplementary lists, such as a list of plant species indicating whether the species are obligate wetland, facultative wetland, facultative upland or obligate upland, which is used in a frequency analysis of all species within an area which is the subject of investigation. The manual has a legal standing in the U.S. equivalent to a regulation made under an act in NSW.

Under the present situation in New South Wales, it is important to note that there is no statutory requirement for the Department of Planning to refer to the Adam *et al.* (1985) selection criteria in recommending amendments to the policy, and it is technically the decision of the Minister, on the advice of the Director of Planning, as to which wetlands are included in the policy. Although there are probably many legal arguments for and against their inclusion within the policy itself, it is desirable that 'users' of the policy have access to a set of selection criteria or a definition which has some legal standing.

Errors in SEPP 14 Mapping

This paper suggests that there may be many errors in the wetland boundaries mapped for SEPP 14, resulting primarily from misinterpretation of aerial photographs and the small scale of original mapping (1 : 25,000). However, checking and correcting all of the mapped wetlands would be a massive and expensive exercise. Even if errors are detected by local councils, developers or community groups, the boundaries can only be corrected by a formal gazettal of an amendment to the policy, which is usually a lengthy process.

These errors and the lack of flexibility in the policy can result in a development within a wetland not requiring an EIS because the wetland is not properly mapped, or conversely can result in a developer being required to prepare an EIS for an area of dryland simply because it incorrectly occurs within a mapped SEPP 14 boundary.

In acknowledgment of the difficulty, if not impossibility, of ensuring the SEPP 14 maps are entirely accurate, it is suggested that these problems could be overcome by making the policy more flexible. This could be achieved by allowing the Director of Planning to waive the requirement for an EIS if it can be shown that a mapped SEPP 14 area, or part of a SEPP 14 area, which is the subject of a development proposal does not actually comprise a wetland community which satisfies the criteria for the policy (this would of course require that the criteria be given a precise legal standing as suggested above).

In addition, to allow for those wetland communities which are not properly included within the policy, it would also be necessary to include a provision which would require that applications for developments, which are proposed for low-lying land in the vicinity of mapped SEPP 14 areas, to include verification that wetlands satisfying the criteria do not occur on the development site. If included as part of the policy, this requirement could be readily incorporated into local councils' existing development application processes, which generally already require the provision of some information on the possible environmental impact of major developments. This process could be enhanced in most council areas by the preparation of a reconnaissance wetland survey indicating low-lying areas or areas of wetland occurrence, rather than attempt precise wetland boundaries, which could then aid council planners in determining the need for any development application to be accompanied by further information on wetland occurrence (such a survey could be included in a Development Control Plan or similar instrument). Many such low-lying areas are prone to flooding, and would therefore be areas in which councils would be concerned about the potential environmental impacts of proposed developments, regardless of the presence of wetlands.

Whilst these suggestions would have the effect of extending the influence of SEPP 14 to cover low-lying coastal lands not presently included in the policy, the degree of environmental reporting required for these additional areas would be relatively minor, and its cost is considered to be outweighed by the flexibility provided by the suggested changes, which would effectively allow for a relatively quick and inexpensive verification of the SEPP 14 boundary within the area of a proposed development, without the need for the preparation of a possibly unnecessary and costly EIS.

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APPENDIX 1 - Mapping Criteria Used by Adam *et al.* (1985)

(a) WETLAND COMPONENTS MAPPED IN THE SURVEY

Wetland Type	Aerial Photographic Interpretation Notes
Mangroves	All mangrove stands (except single-row gallery stands) were mapped. On the aerial photographs, estuarine mangroves appear coarse textured and dense, with usually a much darker colour then the terrestrial vegetation. River mangroves (*Aegiceras*) are lighter in colour than the estuarine stands (*Avicennia*) but have a similar texture.
Saltmarshes	All saltmarsh communities were mapped. Although variably coloured they are very distinctive on the aerial photographs, especially at high magnification where they resemble an irregular carpeted surface.
***Melaleuca* Forests**	*Melaleuca* forests are light olive in colour and have a smooth textured appearance on the aerial photographs. These forests are widespread as pure stands in areas of perennially high water table on the North Coast and Central Coast. They occur less frequently on the South Coast.
***Casuarina* Forests**	On aerial photographs *Casuarina* forests are dark coloured and have a fine texture. On the North Coast a belt of *Casuarinas* is often found on the landward side of mangrove/saltmarsh communities. They sometimes mix with the mangroves to form mosaic communities. On the Central Coast and South Coast, *Casuarina* forests extend upstream from the estuaries and are commonly associated with floodplain wetlands.
Sedgelands	On the aerial photographs sedgelands appear as low, smooth areas with variable green/brown colouring and sharp boundaries. They occur in estuarine wetlands, sand dunes and floodplains.
Brackish and Freshwater Swamps	These swamps are characterised by the occurrence of rushes and reeds which give them a light coloured, grassy appearance on the aerial photographs. They are often associated with *Melaleuca* forests.
Wet Meadows	On the aerial photographs wet meadows resemble pasture in texture but are further characterised by dark discolourations which are caused by a combination of high water table, peaty soil and a predominance of littoral grasses and herbs. Small clumps of trees often occur within wet meadows.

(b) MAIN EXCLUSION CRITERIA

Vegetation/Land Cover Type	Aerial Photographic Interpretation Notes
"Terrestrial" *Melaleuca Forest*	On the North Coast and Central Coast *Melaleuca* forests occur very widely and characterise not only wetlands but also floodplain forests. Floodplain forest is regarded as a non-wetland type and is excluded in this survey. The boundary between

floodplain forest and wetland forest is rarely easy to discern on aerial photographs because of the density of the vegetation.

"Terrestrial" *Casuarina* Forests

On the South Coast *Casuarina* forests occur as floodplain forests as well as being associated with wetlands. The non-wetland floodplain forests have a lower density than the wetland forests and this difference can be identified on the aerial photographs.

***Melaleuca/Eucalyptus* Forests**

Often the *Melaleuca* forest of a wetland system merges into the surrounding *Eucalyptus* forest without a sharp boundary. In such cases, for the present survey, boundaries were drawn where the density of *Eucalyptus* trees was estimated to be 10% of the whole stand. This estimation can be fairly reliably made on aerial photographs because the canopy of the *Eucalyptus* has a much larger, open appearance than that of *Melaleuca*.

Littoral Rainforest

Littoral rainforest is a subtype of subtropical rainforest which occurs rather infrequently along the coast as small pockets. Generally its appearance is distinctive on aerial photographs but in a few cases there is an emergent canopy of *Casuarina* or, less frequently, *Melaleuca*. Stereoscopic interpretation is essential in such cases to detect topographic difference which separate these types from wetlands.

Dune Thicket

Tall closed shrublands of tea-tree have similar appearance on aerial photographs to some *Melaleuca* low swamp forests, but can be differentiated on the basis of their occurrence on sand dunes and their elevation above the floodplain.

Wet Heath

Wet heath often occurs on the upstream side of swamps and sedgelands and forms part of the same drainage system. Although it is a vegetation form occurring in areas of impeded drainage a wet heath is rarely associated with bodies of standing water and is dominated by shrubs. On aerial photographs the boundary between wet heath and wetland types is often indistinct and stereoscopic interpretation is needed to discern the change in elevation which characterises the landform on which the wet heath grows.

Disturbed/Modified Wetlands

These are areas which, had they been in an undisturbed condition, would have been included in the survey. However, they were excluded from the survey because in most cases they appear to be in the process of being converted into agricultural lands. To secure the greatest possible consistency of approach in the survey, judgments about disturbed and modified wetlands were made on the basis of a set of specific indicators. An area was excluded from the survey if it exhibited all the following attributes on the aerial photographs:

- Presence of functional drains;
- Presence of fence lines;
- Paddock differentiation (colour/texture differences along fence lines);
- Signs of reclamation, extensive clearing, or contraction of permanently inundated area; and
- Lack of a natural boundary (on at least one side) with bushland, estuary, or large waterway.

APPENDIX 2 - Examples of Plant Species Which Occur in the Understorey or Groundstorey Strata of *Melaleuca* and *Casuarina* Forests on the Central and Lower North Coasts of NSW.

This list includes examples of species commonly encountered as understorey or groundstorey plants in *Melaleuca* and *Casuarina* forests on the central and lower north coasts of NSW. The separation of the plants into "wetland species" and "terrestrial species" reflects their habitat preference as inferred by the author.

Wetland Species	Terrestrial Species
Acacia elongata	*Acacia longifolia*
Banksia robur	*A. parramattensis*
Baumea juncea	*Adenophora ageratina*
B. rubiginosa	*Adiantum aethiopicum*
B. teretifolia	*Andropogon virginicus*
Blandfordia grandiflora	*Breynia oblongifolia*
Blechnum indicum	*Centella asiatica*
Callistemon citrinus	*Commelina cyanea*
C. pachyphyllus	*Culcita dubia*
Cotula longipes	*Cupaniopsis anacardioides*
Drosera binata	*Dianella caerulea*
Empodisma minus	*Dodonaea triquetra*
Gahnia clarkei	*Entolasia marginata*
G. sieberana	*Erechtites valerianifolia*
Gleichenia dicarpa	*Glochidion ferdinandi*
Gonocarpus micrantha	*Hypolepis muellerii*
Hemarthra uncinata	*Imperata cylindrica*
Ischaemum australe	*Lantana camara*
Lepidosperma longitudinale	*Leptospermum attenuatum*
Lepironia articulata	*L. flavum*
Leptospermum arachnoides	*Lomandra longifolia*
L. juniperinum	*Omalanthus populifolius*
L. liversidgei	*Oplismenus imbecillis*
Leptocarpus tenax	*Pteridium esculentum*
Lobelia alata	*Themeda australis*
Melaleuca sieberi	*Viola hederacea*
Pseuodraphis paradoxa	
Restio pallens	
R. tetraphyllus	
Schoenus brevifolius	
Villarsia exaltata	
Viminara juncea	