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CHAPTER 2 Changes In The Area And Condition Of Samphire Marshes With Time

R. L. Glasson, H. T. Kobryn and R. D. Segal

2.1 Introduction

Aerial photography is especially suited to the study of vegetation, water resources and shoreline mapping (A.S.O.P, 1968). Air photographs provide a perspective of the earth's geographical features that are generally readily understood. Air photographs also provide a plan view that can be spatially compared to the knowledge an individual may have about a similar area. For those reasons aerial photographs frequently provide working documents for planners and managers. They are however, limited in spatial accuracy because the images suffer geometric distortions, particularly near photograph margins or when terrain varies in height. Also, a single aerial photograph rarely covers an entire study area. There are manual and computer assisted techniques of joining air photographs and also eliminating the geometric distortions within and between individual photographs. An assembly of aerial photographs is called a photo mosaic. Photo mosaics can be "controlled" or "uncontrolled", the former having the geometric distortions removed.

The amount of geometric distortions in an aerial photograph depends on many factors, including the physical optics of the camera and the orientation of the camera at the instant of exposure. Where the optical axis of the camera is near vertical (<3° from vertical), then the photograph is accepted as vertical. The point where the optical axis of the camera meets the earths surface is the "principal point" of the photograph. Vertical photographs are the most common type of "metric" aerial photograph, or one that is used to derive information about spatial measurements of geographical features. Geometric distortion of aerial photographs increases outwards from the principal point towards the margin. The distortions are increased if photography is acquired at low altitude, or with cameras using wide angle (>70°) and super-wide angle (>100°) lenses. Gross distortions of scale occur on individual photographs when terrain slope changes suddenly, as when a scarp, cliff or portion of a mountain is included in the photograph (Maling, 1989). Some of the distortions in vertical air photography can be avoided by using only central portions of each photograph.

Aerial photography is acquired in flight strips called "runs". Each photograph within a run overlaps the previous one by about 60% (endlap) to enable sufficient imagery to be acquired that is relatively distortion free, and to enable stereoscopic viewing of the imagery to aid in feature identification and interpretation. Each run is also overlapped to the adjacent run (sidelap), although usually by only 25-30% (Figure 2.1).

As an aid for interpretation, stereo pairs of photographs are viewed under a stereoscope. Stereo pairs share conjugate principal points, each principal point of each photograph is being visible on both photographs. The measured distance between the principal points is known as the "airbase"; which is a function of the ground speed of the aircraft and the interval between exposures. The stereoscope enables our eyes to view photographs from the same relative position as the airbase. This means that our eyes have the same optical separation as the air base, and stereoscopic depth of vision is greatly enhanced.

Interpretation of air photography is conducted in two stages. In the first stage the elements of the image are identified by attributes such as shape, size, spacing, shadow or silhouette, tone or colour , texture or association. The photographic appearance of these attributes can be affected by many factors including the amount of illumination and the reflectivity of the surface, as well as climatic factors and physical properties of the ground cover. These can quite often change the appearance of objects to resemble other features. For example shallow water stained brown with tannin, and inundating ground, can appear to be quite deep and extensive when using black and white photography.

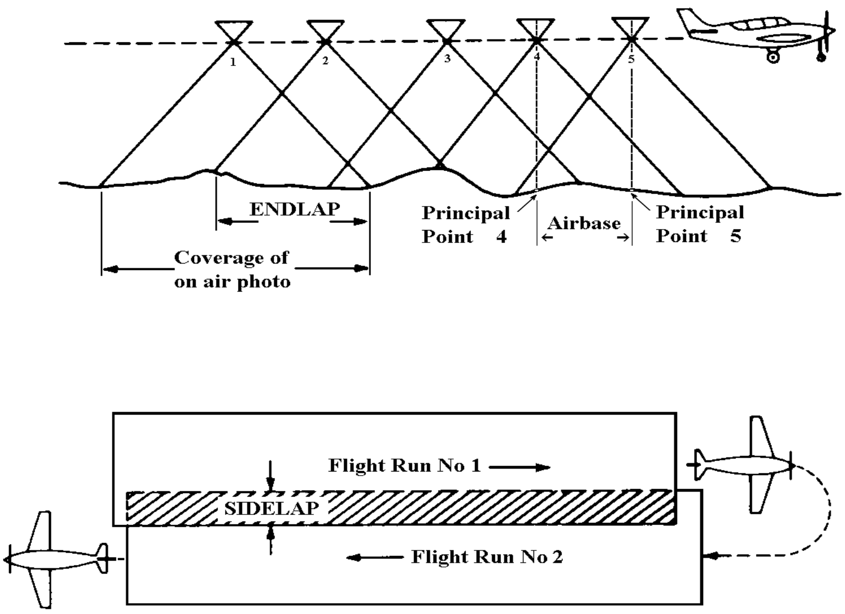

Figure 2.1. The acquisition of air photography. Aircraft fly in runs exposing film at a given intervals to photograph portions of the earth so that each successive photograph overlaps the next both along the direction of flight and between adjacent flight runs (Modified after Wolf, 1983).

The second phase consists of interpreting the factors in relation to the context for which the information is required. Interpretation may be carried out on individual photographs, in stereo pairs, on a composite photomosaic, or involving all of these procedures.

Physical assembly of a photomosaic by cutting and pasting is an exacting process in which failure can be very costly, as individual colour photographs cost about $20.00 and a mosaic may include some 50 photographs. By scanning photographs and using computer software, digital photo mosaics can be constructed and repeated without fear of costly failure. This investigation used the digital equivalent of a photo mosaic using computer software and scanned photographic imagery of the Peel-Harvey System.

A broad study into the samphire marshes of the Peel-Harvey System was initiated by the Peel Preservation Group to determine the extent and importance of these areas to the ecology of the Estuary. As part of this study a temporal perspective was required. No accurate mapping of these features existed nor had data been previously recorded about their locations or extent. To provide this historical perspective, existing archival air photography was combined with modern digital techniques to map the extent of samphire and temporal changes in the marsh.

A Peel-Harvey photo mosaic was prepared using ERDAS Imagine (*Imagine*) software on a Sun Sparc station IPX as part of the wider study of the samphire marshes. Air photographs covering the period 1957 to the present were used to determine temporal changes in samphire cover. The 1994 series of air photographs was provided by Department of Transport.

2.2 Method

The selection of images was based on approximately 10 yearly intervals, and on availability. Details of the acquired air photograph runs are presented in Appendix 1. The photographs selected had to lie within the boundaries of the Peel Harvey Estuary including Goegrup and Black Lakes. The 1957 photo set, however, did not include the Harvey River delta region at the southern end of the Harvey estuary as this was beyond the limit of existing photography. Portions of the Black Lakes region east of the Peel Inlet were excluded from the 1994 set, as this was also on the limit of the photography for that run.

A detailed technical description of the digital photo mosaic process is contained in Appendix 1. The air photographs for each date were scanned and then digitally joined, removing as much distortion as possible and orientating the photographs to conform with mapping conventions. The photographs were then interpreted to determine the extent of the samphire, which was then mapped over the digital images, enabling computer determination of the extent of samphire. As well as the completed mosaic of the entire area, smaller images were extracted for each date to enable comparison of special interest areas. The final mosaic images were compiled from some 80 sub-images, shown in Appendix 2. A flow diagram of the entire process is summarised in Appendix 3. A table showing file handling procedures is contained in Appendix 4.

Air photograph interpretation was carried out for each of the dates on the air photographs, using the keys contained in Appendix 5. Each photograph was interpreted independently by two interpreters, using stereoscopes to allow magnification and observation of the imagery in three dimensions. This enabled the use of terrain to assist in the identification of samphire marsh.

The subsets of special interest areas was focused on areas of conservation reserves. The geographical boundaries of each area are given in Table 2.1.

Table 2.1. Special Interest Area Boundaries (UTM Zone 50 (m)). Value of X represent eastings, whereas values of Y indicate northings.

COORDINATE/AREA	UPPER-LEFT X	UPPER-LEFT Y	LOWER-RIGHT X	LOWER-RIGHT Y
CREERY	378727	6398715	381879	6395165
LAKES	384272	6402524	388196	6395780
AUSTIN	381234	6390770	385091	6386599
ROBERTS	377316	6388819	381174	6384649
HARVEY	377121	6376654	381174	6370968
STUDY AREA	370900	6402500	388200	6370900

As field checking of classification accuracy is impossible for historical photography, only the 1994 photograph set was used to test for the accuracy of interpretation. One hundred sites were selected by the intersection of a grid overlay on the images, with areas that could reasonably be expected to contain samphire. Fifty sites of samphire cover and fifty sites of non samphire cover were used to determine by field checks for errors in the process of the interpretation.

2.3 Results

The mosaiced images for each date, including areas of samphire are shown in Figures 2.2 - 2.6. The red polygons indicate areas of samphire cover. The total area of samphire for each date and each area of interest are shown in Table 2.2. Red rectangles outlining boundaries of the special interest areas are shown in Figure 2.7. Temporal samphire changes for each special interest area are shown in Figures 2.8 - 2.12.

Table 2.2. Areas of samphire (ha) during the period 1957 - 1994 for the areas of interest, and the total over the entire Peel- Harvey study area.

AREA/DATE	1957	1965	1977	1986	1994
AUSTIN	35.286	30.308	23.395	31.851	37.758
CREERY	179.115	170.365	162.994	132.984	140.156
HARVEY	5.453*	131.099	87.652	106.995	144.783
LAKES	48.404	120.791	110.660	95.165	45.289*
ROBERTS	155.016	114.836	87.849	67.370	80.749
OTHER	252.900 •	432.771	271.783	190.327	181.405 •
TOTAL	676.174 •	1000.17	744.333	624.692	630.140 •

* - incomplete air photo coverage resulting in underestimate for area.

• - area underestimates (*) affect summed total estimates.

In attempting to describe changes that have occurred in saltmarsh coverage, two approaches can be made. One is to describe changes in a purely quantitative sense which concentrates on the magnitude of a particular change. The other is to describe the changes in qualitative terms which concentrates not only on the changes to the samphire itself but also how these changes affect the wider environment

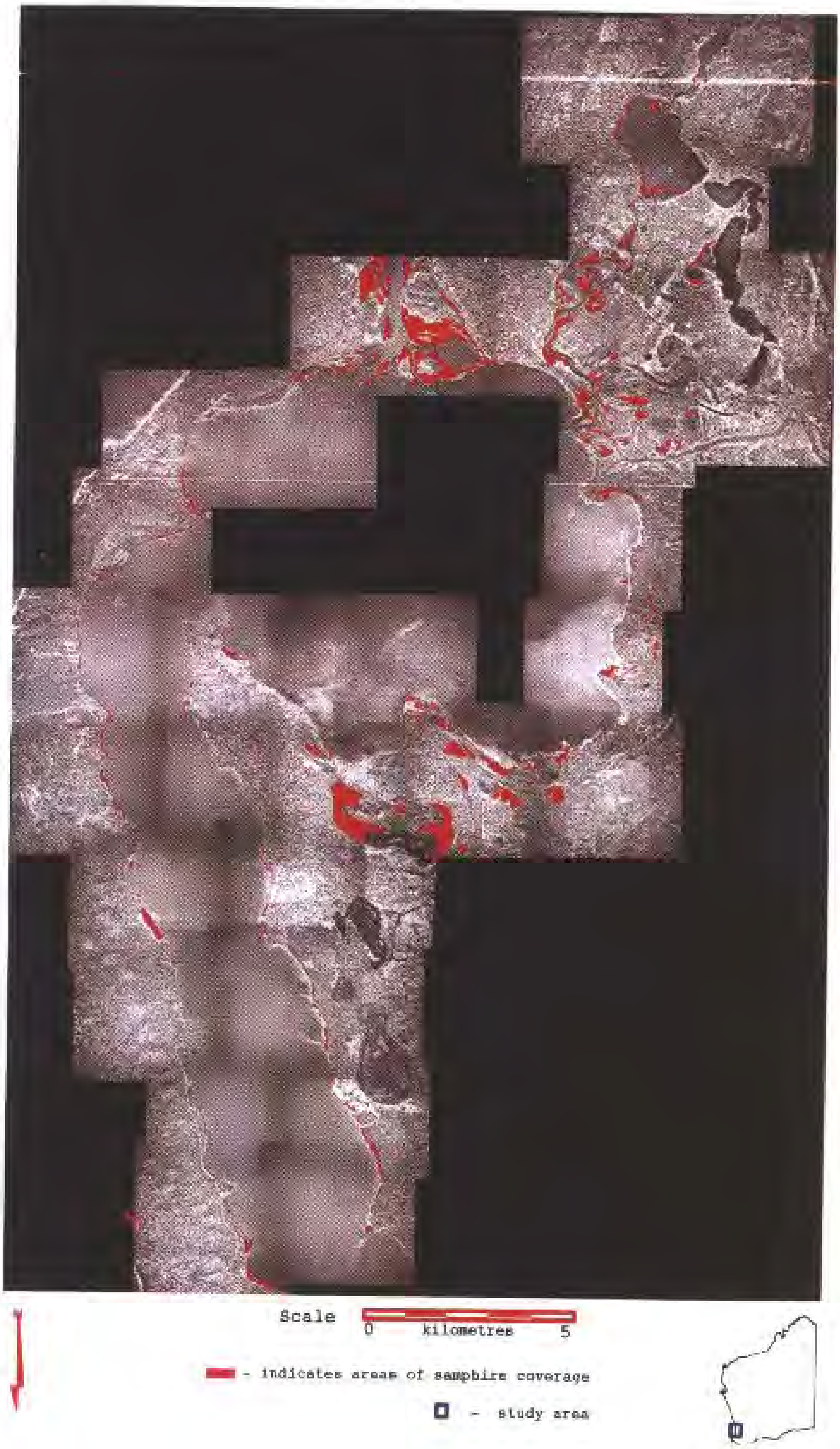

Figure 2.2 Samphire marsh distribution in 1957.

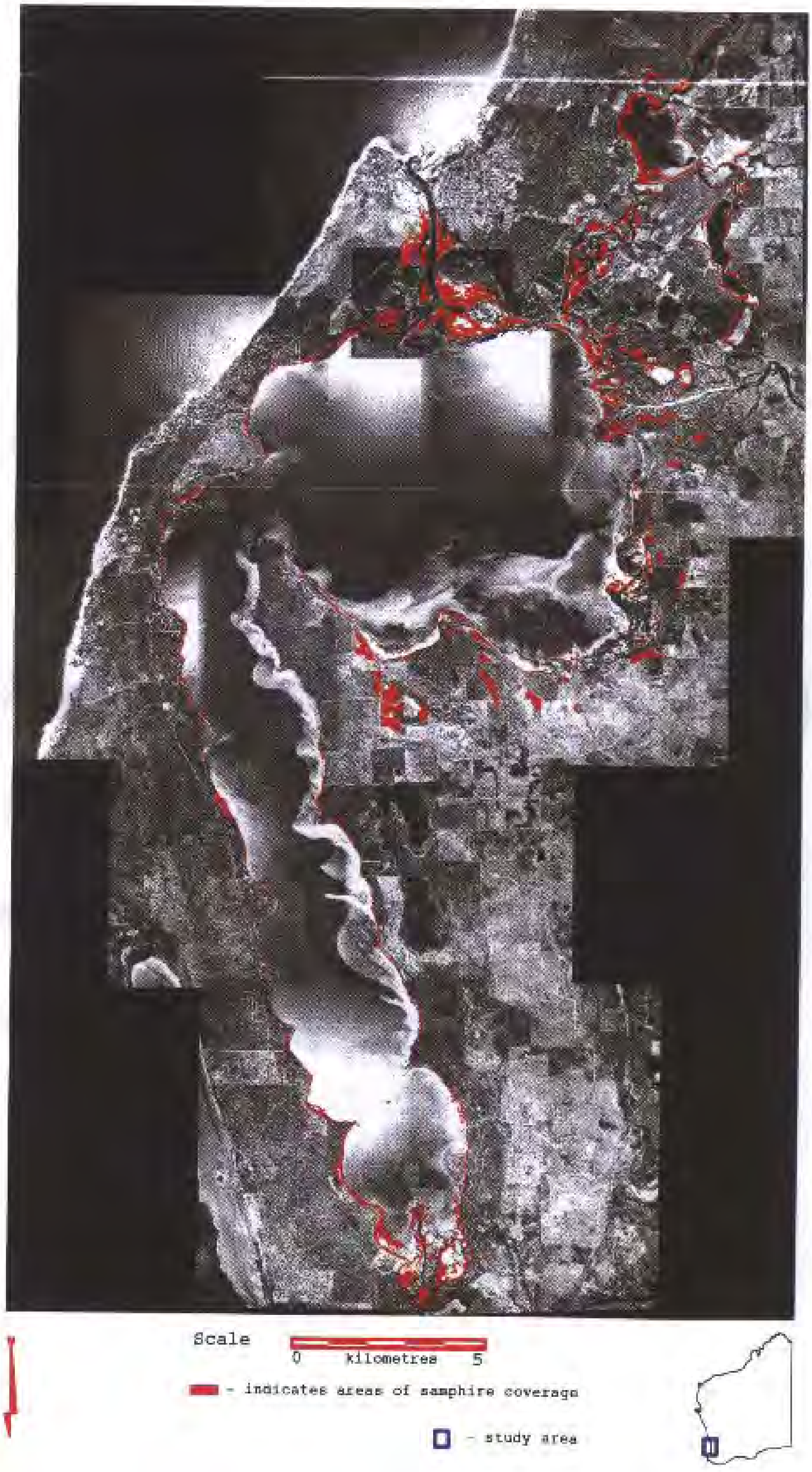

Figure 2. 3 Samphire marsh distribution in 1965.

Figure 2.4 Samphire marsh distribution in 1977.

Figure 2.5 Samphire marsh distribution in 1986.

Figure 2.6 Samphire marsh distribution in 1994.

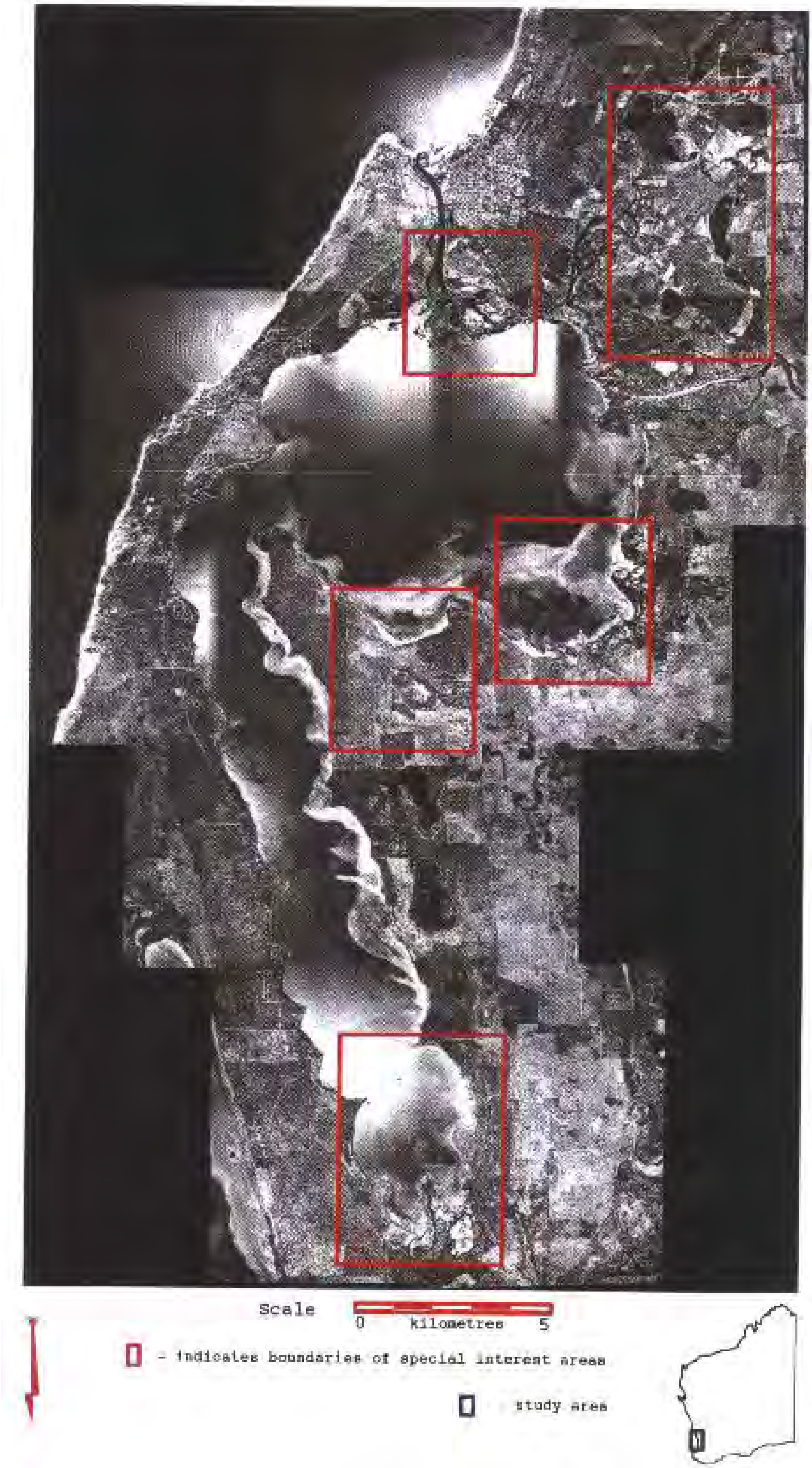

Figure 2.7 Boundaries of special interest areas.

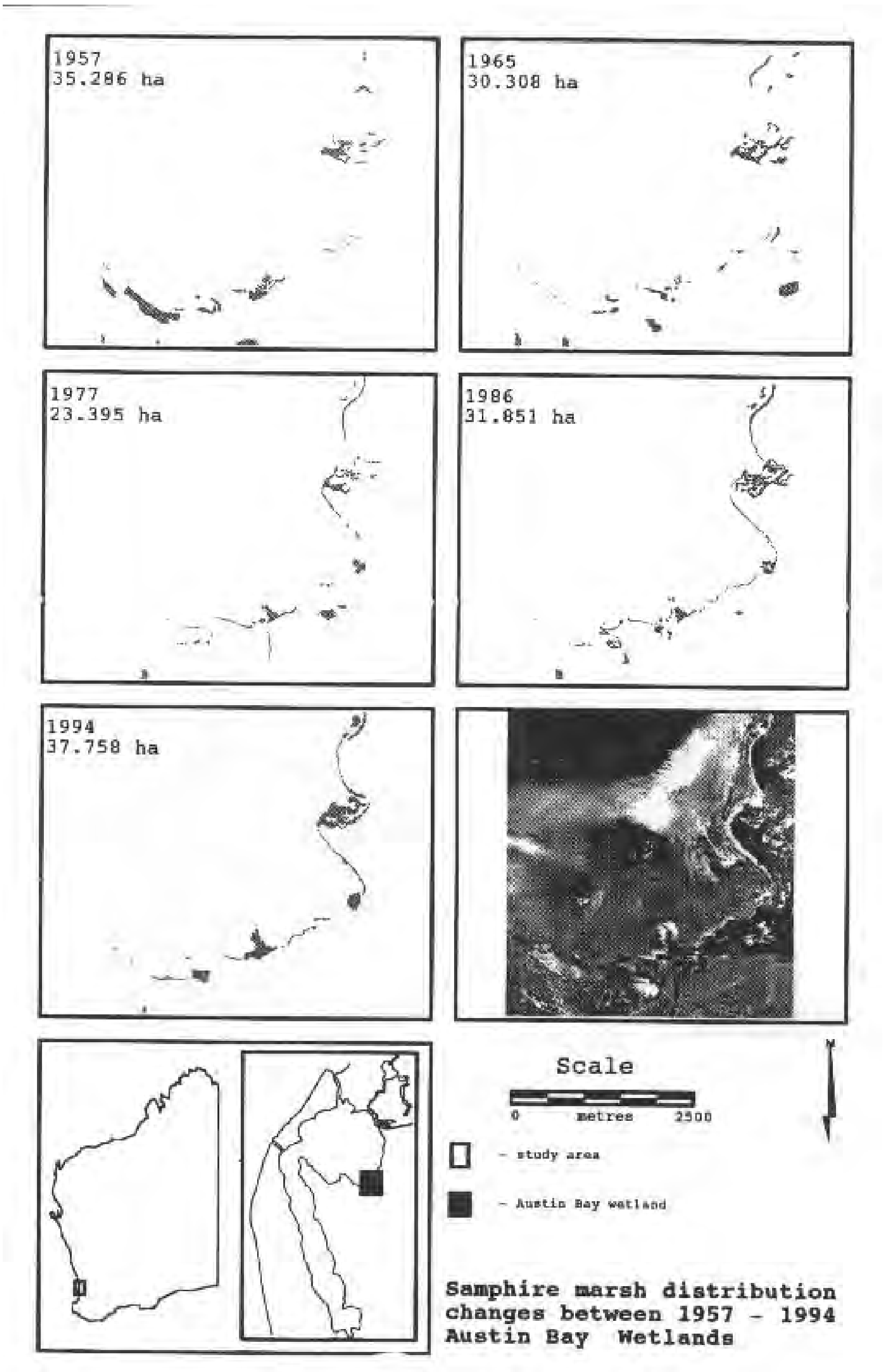

Figure 2.8 Samphire distribution in Austin Bay.

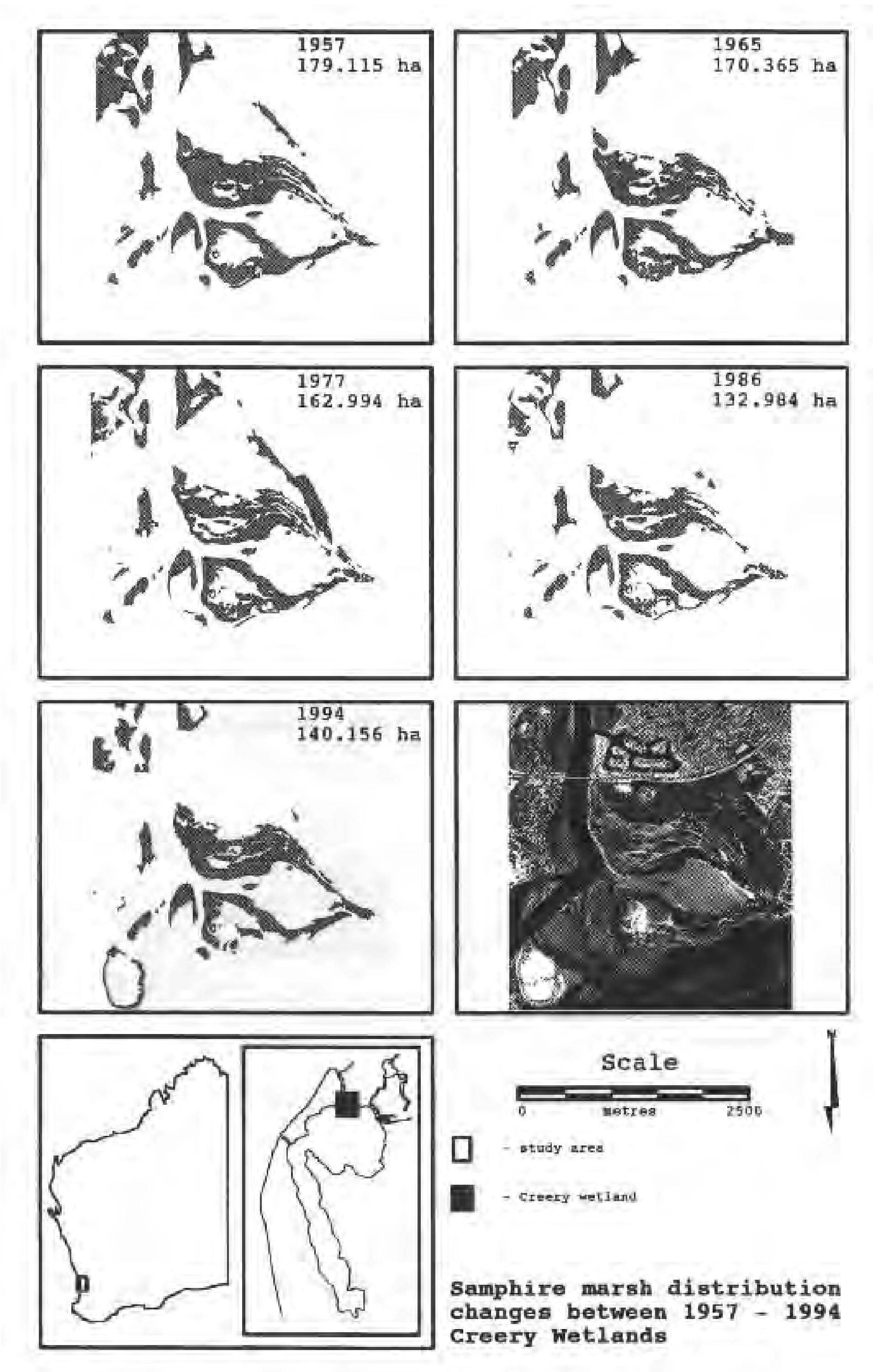

Figure 2.9 Samphire distribution in Creery Wetlands.

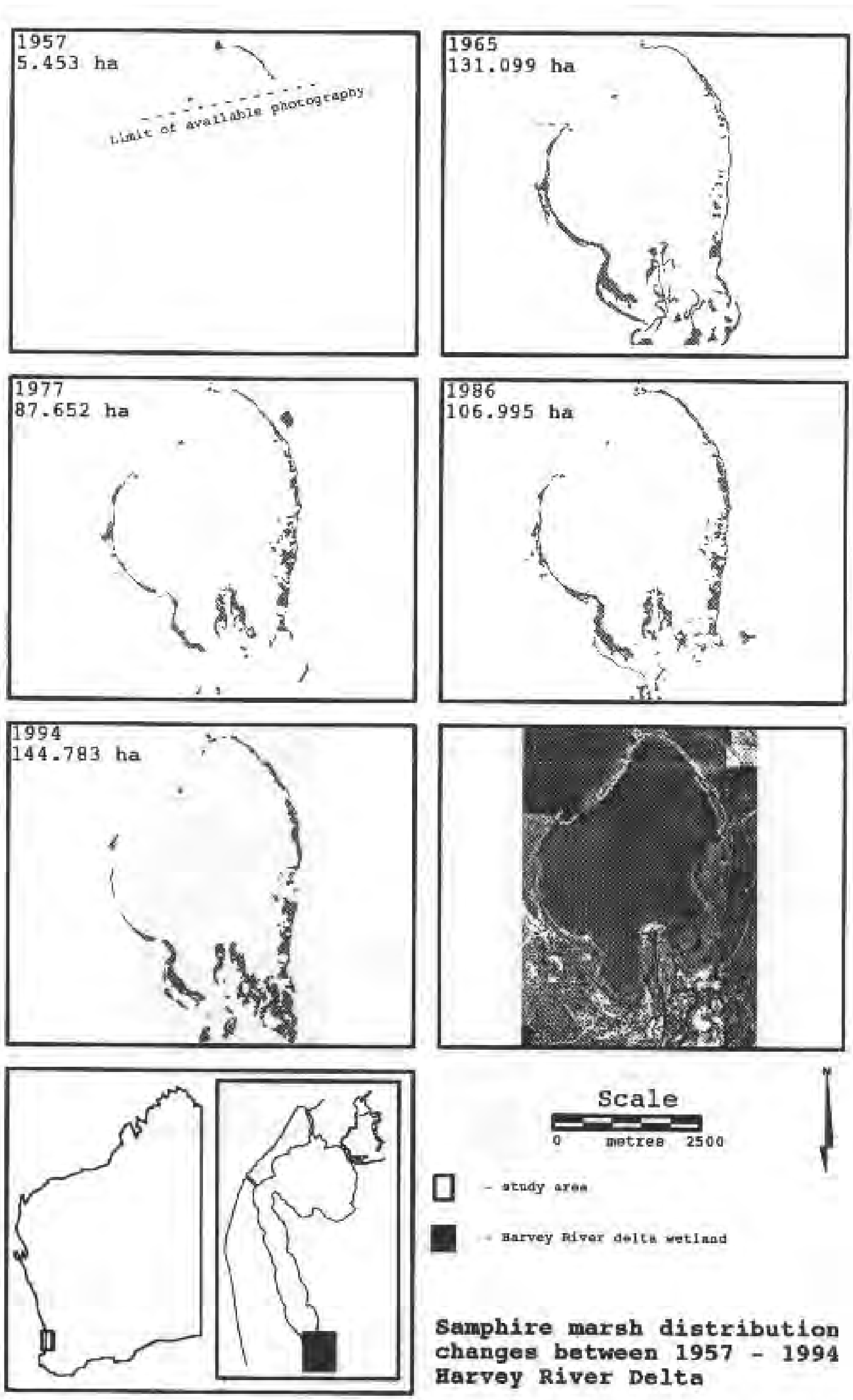

Figure 2.10 Samphire distribution in Harvey River Delta.

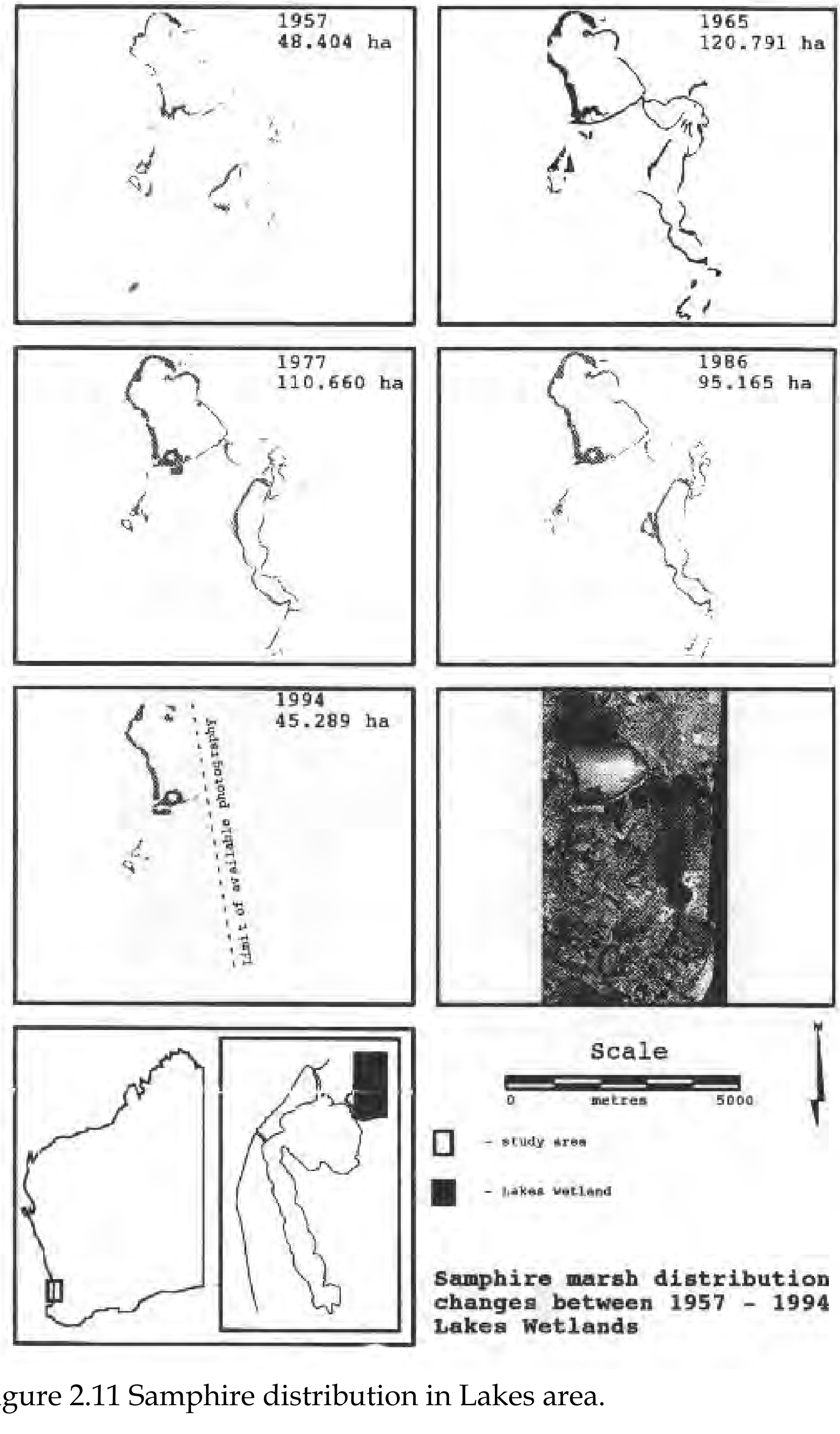

Figure 2.11 Samphire distribution in Lakes area.

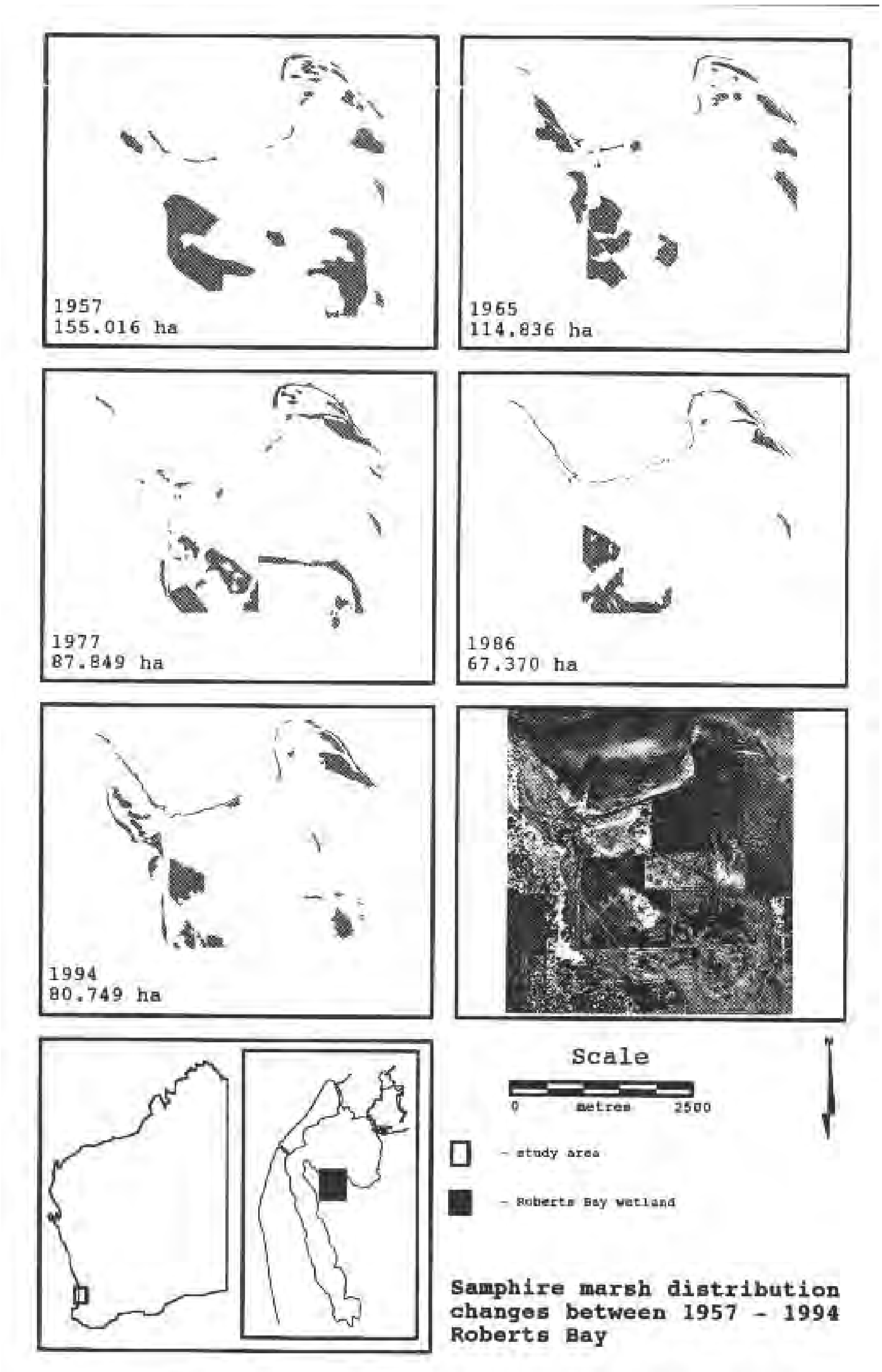

Figure 2.12 Samphire distribution in Roberts Bay.

2.3.1 Quantitative Changes

The areas of samphire are based on the number of pixel's classified as samphire in accordance with the image interpretation, in which the areas are based on pixel units of 20.25 square metres. A decline in the area of samphire marsh took place from 1965 onwards. The greatest percentage loss of saltmarsh cover between 1965 and 1994 (≈58% or 251 ha) occurred outside reserve areas. The greatest percentage loss from an area of interest was in the Lakes area (≈63% or 75 ha) and in Roberts Bay (≈48% or 75 ha). The physical distribution of samphire cover is dynamic and changes for all dates which is consistent with current understanding of the dynamic nature of marsh distribution. Total samphire loss was 36.9% (370 ha) between 1965 and 1994, the greater part of this loss occurring between 1965 and 1986 (376 ha or 37% of the cover of 1965).

The general trend for the whole study area is a significant loss between 1965 and 1986 consisting of a rapid decline between 1965 and 1977 and a slower rate of loss between 1977 and 1986. Between 1986 and 1996 the loss was arrested, and there was a insignificant increase in overall cover (0.8%). Roberts, Lakes, and Creery interest areas showed increased rates of loss between 1977 and 1986. Since 1986 four of the special interest areas have shown increases in cover from previous dates; Austin 18%; Creery 5%; Harvey 35%; and Roberts 20%. Percentage changes are based on the percentage change from the previous period for that specific area, rather than the total area of all marsh.

Some areas behaved differently from the general trends; for instance the Harvey Delta and Austin Bay showed a steady increase in area of samphire since 1977, while all other areas showed decline. The Lakes area showed a marked decline in 1986-1994 period while all other areas of interest showed increased cover. The Lakes area was the only special interest area to show consistent loss since 1965 and its rate of loss is increasing. Overall the trend is seen to be one of rapid decline from 1965 to 1986 and static to 1994.

2.3.2 Qualitative changes

In Creery wetlands the cover continuity of the samphire marsh declined since 1957. This largest single portion of samphire in the study area showed increasing damage from human contact. Increasing numbers of vehicle tracks divided largely continuous samphire marsh. The 1994 image shows a highly disturbed area broken by many tracks. The construction of Boundary Island (south of Creery wetlands) provided an area for samphire colonisation, and samphire invasion is observed in the 1994 image Increasing human disturbance of this wetland will lead to further decline in ecological quality. (See chapter 6).

The Lakes area showed an increasing rate of decline over the period of the study. The 1994 results for this area are inconclusive due to the lack of photography, but the trend of loss is clear from the middle reaches of the Black lakes chain, particularly in the area of the Goegrup Lake entrance. The cause of decline is not clear from the air photography data.

The Harvey Delta showed increased area of samphire in the south-eastern portion, with smaller separate patches of samphire increasing and consolidating their cover. This may be due to different tidal regimes and successional invasion onto the increasingly exposed soil (See chapter 6).

The Roberts Bay area is very dynamic, areas in the north eastern sector showing more continuous cover, while areas in the southern portion showed evidence of rapid and extensive change due to changing land use, especially on private land.

Austin Bay samphire showed consolidation along the shoreline, with smaller patches in the north and eastern sector growing in embayments and increased cover.

Overall the ecological quality of the samphire marsh areas is typically dynamic, individual areas showing evidence of ephemeral changes and succession.

2.3.3 Accuracy Assessment

The interpretation identification error results obtained from comparison of field sites and the interpretation are included in Table 2.3.

Table 2.3 Estimation of identification errors of samphire.

INTERPRETATION/ACTUAL	SAMPHIRE	NO SAMPHIRE
SAMPHIRE	41 (82%)	9 (18%)
NO SAMPHIRE	12 (24%)	38 (76%)

Samphire was correctly identified with an accuracy of more than 80%, with an 18% chance of overlooking its presence. Where samphire was interpreted not to be present, but was, occurred in 24% of cases. The correct identification of absence of samphire occurred in 76% of cases, and so overall it can be concluded that the interpretations were conservative in estimates and that actual presence of samphire is likely to be higher than reported here.

2.4 Discussion

Where areas of samphire have consolidated cover with time, it is assumed that the ecological niche of the samphire is assured. Conversely where large continuous areas are fragmented then continued presence of the samphire communities and its dependant species may be threatened. In all areas, the distribution of samphire is changing even though total areas may have remained similar. This is accounted for in the ephemeral nature of some of the species occupying the marsh and seasonal differences of biomass of perennial species (See chapter 3 & 6).

Differing water levels between the dates of photography influence the identification of samphire. The 1957 photography was taken at a period of high water, and this influenced the extent of cover estimation. This was particularly evident for the Lakes region. Some areas were clearly flooded in 1957 and were not classified as samphire. The same areas were exposed and identified as samphire in later photo sets. The 1965, 1977, 1986 and 1994 photography was taken during low water levels. It is probable that high water levels tend to mask areas of samphire leading to underestimates of their extent and the converse is also true. This may partially explain the increase in area seen in 1965, and also the relative increase in the rate of loss for 1986, but it is not an explanation for the overall loss trend as this was consistent, with 1965, 1977 and 1994 all being years of low water levels.

The Lakes area for 1957 showed high water levels, and the 1957 estimation is underestimating the samphire for this area. Since 1965 the total samphire for this area declined, but the subset images show that the loss was centred on the middle reach of the Black Lakes area (Figure 2.11). At this point a stream flows in from the north east, and it is possible that this stream has in the recent past either provided a increased flow of fresh water, altering the salinity regime, or is a source of excess nutrients to a competitive species, upsetting competitive relationships causing a decline in the prevalence of samphire.

The altered tidal and water level regimes of the Estuary since the permanent breaching of the Mandurah Channel (1977-1986) may be the reason for the rapid decrease in the area of samphire, and it would be expected that this loss should be arrested when vegetational succession has stabilised. This also appears to be the case for the recent small losses, in the 1986-1994 period. Further disruption to vegetation cover can be expected with the recent opening of the Dawesville channel, which should lead to further successional changes in the vegetation cover as a result of water level changes. Vegetation loss due to changing hydrology and other factors has already observed by catchment management authorities (George and Bradby, 1993).

Increased opportunities for saltmarsh invasion have occurred with the construction of Boundary Island south of the Creery wetlands. This accounts for the increase shown in the Creery area in 1986 -1994.

Another influence on the estimation of samphire is the cyclic water level changes experienced over the study period. During 1965, 1977 and 1994 the rainfall for the preceding months prior to the air photography was below average. For 1986 and 1957 the rainfall was well above average. Prior to 1977, rainfall would have had an effect on the water levels of the Estuary, as the only channel was prone to closure. This explains the low coverage seen in the Lakes area due to the elevated water levels in 1957 and the high levels in 1965 where the water level is low. This indicates that the levels of samphire recorded in 1965 and 1977 are maximised as the water levels would favour the interpretation. This implies that 1977 provides a good estimate of the total samphire both due to the favoured water levels and the infra-red photography.

Even if adjustment is made for the lack of photographic cover over the Harvey delta, and it is assumed that the area in the Harvey delta remained constant between 1965 and 1977 then there has been a steady decline in the total area of samphire since 1957. The overall loss is worrying but the parallel decline in quality of remaining areas is also of great concern. This is particularly so in the Creery wetland area which presents one of the largest contiguous areas in the whole system. Its present accessibility (and therefore threatened position) also means it's future planning demands the highest priority for management consideration (See chapter 7).

The scanning and initial photo mosaic of the orthophotographs has shown that the spatial accuracy of the orthophotographs is questionable. Enquires of DOLA reveal that a spatial accuracy of 12.5 m is obtained in the initial modelling of the orthophotographs. Measured mismatching of the edges of the orthophotographs revealed inconsistencies in both X and Y directions. This was initially thought to be the result of scanning errors introduced by the physical method used for orthophoto scanning. Consequently the images were rescanned at a higher resolution, and at the same time a comparison was made with a scan of a calibration image supplied to the scanning agency by DOLA.

The scan of the calibration image revealed a measured error of 4 mm over a diagonal distance of some 1200 mm. Measured mismatch errors between scan overlap of adjacent orthophotographs revealed distance discrepancies of up to 60 m. This discrepancy was not distributed evenly across the length of the orthophotograph but was randomly distributed along the adjoining edges. This error would result from the original orthophoto image production, and so the 12.5 m spatial accuracy for the production of orthophotographs by DOLA can be considered the goal rather than the achieved result. The displacement of the same feature can be measured where the orthophoto image files overlap. The maximum measured displacement was 60 m. The maximum measured error of 60 m is not considered to be the achieved accuracy of the overall orthophoto, as the true geographical location of displaced GCP's could only be measured in the field after considerable effort. It was assumed that a spatial accuracy of one half of this distance (by assuming each GCP is incorrect and therefore both have to be moved to merge) or 30 m should be used as the overall accuracy.

The scanned aerial photographs were resampled to conform with the orthophotos. This process achieved a better than 0.6 RMS (root mean squared) error in pixel relocation. Scanned photos therefore are considered to be within 1.2 m accuracy **of the orthophoto image.** In conclusion, a spatial accuracy of (±) 31 m can be assumed for the photomosaic image.

Different scales of photography contributed to some problems in photo interpretation. The 1965 set at a 1:40000 scale proved particularly difficult. This was also due to this set being black and white photography with relatively poor contrast. Some small areas of samphire were very difficult to resolve at that scale. Prior to 1977 black and white photography was the standard and hence was the only available option. Misinterpretation is more likely to occur with the black and white photography due to the inherent difficulty of vegetation discrimination based on colour or tone. Conversely the infra red photography of 1977 enabled a more precise estimation of vegetation cover and type. Comparison of samphire cover over the differing dates is therefore constrained by the limitations of the differing photography used in the study.

In the 1994 photography, low sun angle resulted in a large degree of shadow within areas of vegetation, which produced greatly contrasted images. This was to some degree a trade off for water penetration which was very good, and which reduced the specular reflection off water. In 1965 photography on the other hand, solar angle was high and large areas of solar reflection are apparent (Figure 2.3).

The air photographs were taken with a 25% edge overlap and a 60% forward overlap. The 25% overlap was insufficient for edge matching of raster files where the runs are not north/south or east/west. During georeferencing images are geometrically altered to conform with mapping conventions (that is north is the top of the page). The insufficient overlap results from the image being resampled at an angle after georeferencing, which produces edge triangles of null data as shown in Figure 2.13. To obtain image files without null data values requires the production of two sub-images for each air photograph. This was required because of a problem in the software, which does not allow elimination of null file values from the edge overlap reduction. The problem is being investigated by software supplier, ESRI.

Contrast matching of the final image was attempted but resulted in an as yet unidentified error with the software. This resulted in the corruption of the file statistics of the 80 images of the final mosaic. The file statistics were individually recalculated for the entire set and the final images were produced without contrast matching. Contrast matching was achieved to some degree during the cubic convolution resampling process of the smaller 8 Mb files so these images are aesthetically the best. The greatest detail resolution (about 3 m on the ground) is maintained in the ≈ 200 Mb files.

2.5 Recommendations/Conclusions

Samphire areas within the Peel-Harvey estuary are declining both in quality and quantity. The greatest areal loss has occurred outside reserve areas. Reserve areas and those of special interest are showing evidence of decline in quality of samphire cover. Decline in the quality of samphire can further accelerate loss and degradation of vegetation and animal species. The loss of samphire from the Creery wetlands presents a urgent case for management consideration due to the proximity to urban development and development pressures in general and also because this area represents one of the largest remaining contiguous areas of samphire. This should not be interpreted that other areas are less deserving of management consideration but that Creery wetland represents unique opportunities for preservation and conservation and its current land tenure requires urgent management consideration. Its conservation and preservation should be considered a high priority.

If serious spatial mapping considerations are part of the photo mosaic process then the Orthomax component of *Imagine* should be used to increase the rectification capacity of the air photograph images. This will allow a greater portion of each air photograph to be included in the final mosaic resulting in decreased file space requirements and time.

Any spatial accuracy of the final product will depend to a large degree on the spatial accuracy of the georeferenced database. Orthophotographs provide a reasonably accurate and cost effective method of providing this spatial information providing that the error associated with the **individual** orthophoto is known. That is the error inherent **within** each orthophoto and **between** orthophotographs when more than one is used. Where spatial accuracy is to be greater than that of the available orthophotographs then other methods should be investigated. This requirement may be negated by the procurement of orthophotographs at a larger scale than the final scale for study area where the study area size and file space requirements permit this and were possible procurement of orthophotographs is in the required digital format.

The contrast of any photography used is important in the aesthetic value of the final composite mosaic. This is most apparent where imagery which is used was flown for specific purposes such as high water penetration and the low incident solar angle results in hot spots or large shadow effects in areas of vegetation. Where large areas of the image are water and specular effects are apparent then this can detract greatly from the final aesthetic value of the mosaic. This may be avoided where large overlaps are available and cost is not determinant in the procurement of photography so that all photographs may be used rather than every second photograph.

Differing colour balance between individual photographs may occur if all photographs of the study area are not purchased at once. Where this is not possible and colour balance is a problem, provision of existing photography to the film developer can enable correct matching.

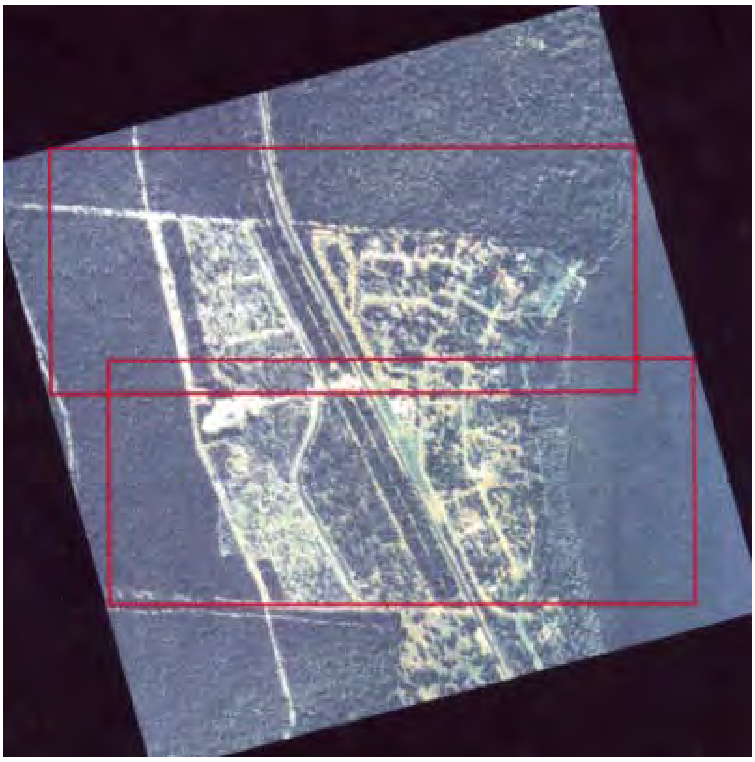

Figure 2.13. Air photograph raster image after georeferencing and resampling showing image portions of null data (in black) as a result of flight lines other than north/south or east/west. Red rectangles represent areas of subset images excluding the null file values.

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