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Monitoring *Phragmites australis* increases from 1937 to 1976 in the Siyai Lagoon (Natal, South Africa) by means of air photo interpretation

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ABSTRACT

The colonization of the Siyai Lagoon on the north coast of Natal by *Phragmites australis* was studied by means of air photo interpretation. It was possible to locate and estimate *P. australis* areas for 1957 (0,74 ha), 1965 (1,65 ha), 1969 (1,93 ha) and 1976 (2,94 ha). *Phragmites australis* first inhabited the shores of the middle section of the lagoon followed by rapid expansion in the lower section. The upper section was colonized only at its lower end by expansion from the middle section. It is suggested that *P. australis* was unsuccessful in this section because of competition by the *Hibiscus tiliaceus—Barringtonia racemosa* Lagoon Fringe Forest. This same community is shading out *P. australis* in some places. The notable increase in the rate of advance of land and littoral vegetation into the Siyai Lagoon was caused by sugar farming activities leading to erosion and sedimentation in the lagoon. A vegetation age gradient was observed from the upper section to the mouth region. The colonization of most of the Siyai Lagoon except the immediate mouth zone by *P. australis* Reedswamp and *Hibiscus tiliaceus—Barringtonia racemosa* Lagoon Fringe Forest, can be expected before the turn of the century. Dredging and mechanical control of vegetation will become necessary if major open water spaces are to be maintained.

RÉSUMÉ

CONTRÔLE DES ACCROISSEMENT DE PHRAGMITES AUSTRALIS *DE 1937 À 1976 DANS LA LAGUNE SIYAI (NATAL, AFRIQUE DU SUD) AU MOYEN D'INTERPRETATION DE PHOTOGRAPHIES AÉRIENNES*

La colonisation de la lagune de Siyai sur la côte nord du Natal par les Phragmites australis *a été étudiée au moyen d'interprétation de la photo aérienne. Il a été possible de situer et d'estimer les régions de* P. australis *pour 1957 (0,74 ha), 1965 (1,65 ha) 1969 (1,93 ha) et 1976 (2,94 ha).* Phragmites australis *habita d'abord les rivages de la section mediane de la lagune puis s'étendit rapidement à la section en dessous. La section supérieure fut seulement colonisée dans le dessous par expansion de la section médianne. Il est considéré que* P. australis *ne réussit pas à s'étendre dans cette section par suite de la concurrence avec l'*Hibiscus tiliaceus—Barringtonia racemosa *Lagoon Fringe Forest. Cette même communauté supplante* P. australis *dans certains endroits. L'accroissement notable de progrès de la végétation du littoral et de l'intérieur des terres dans la lagune Siyai fut causé par les activites agricoles sucrières conduisant à l'érosion et à la sédimentation dans la lagune. A part* P. australis *aucun autre macrophyte ne fut trouvé. Une inclinaison d'âge de la végétation fut observée de la section supérieure à la région de la bouche. La colonisation de la plupart de lagune Siyai, à l'exception de lazone immédiate de la bouche, par* P. australis *Reedswamp et* Hibiscus tiliaceus—Barringtonia racemosa, *Lagoon Fringe Forest, doit être attendue avant la fin du siècle. Le draguage et la lutte mécanique contre la végétation deviendront nécessaires si l'on veut maintenir de grandes étendues d'eau ouvertes.*

INTRODUCTION

An increase of reeds was observed on air photos when studying the dune advancement at Mtunzini (Weisser *et al.*, MS). The availability of air photo coverage for 1937–1979 offered the possibility to monitor the reed encroachment. Objectives of this work were to evaluate the adequacy of air photos in monitoring *P. australis* expansion; to provide baseline data on the Siyai Lagoon; to quantify the reed encroachment; to establish trends and extrapolate possible developments; and to offer possible management suggestions.

The Siyai drainage system is situated in Natal at latitude 28°58′ South and longitude 31°45′45″ East. The Lagoon is situated amidst a well-conserved, scenically beautiful, forested-dune landscape (Fig. 1). It has a surface of about 8 ha, an axial length of 2,5 km and a catchment of about 18 km^2 (Begg, 1978). Two streams are the main tributaries. In this work only the lagoon was studied and defined as extending from the confluence of the two tributaries to the Lagoon Mouth. Four sections were distinguished from south-west to north-east: upper section (from confluence to about 650 m north-east); middle section (inflexion area of watercourse); lower section (to watercourse constriction) and mouth section.

Between 1937 and 1977, the mouth of the Siyai Lagoon moved about 740 m north-eastwards, at an average rate of 17,4 m/year (Weisser *et al.*, MS). The mouth is usually closed, being open for only very brief periods (of up to a week) after floods. The bar may be topped by high spring-tides and the mouth is not opened artificially (Begg, 1978).

Land encroachment into the Lagoon has increased markedly since sugar farming began in c. 1946. Changes in run-off and soil exposure caused extensive sedimentation reducing the depth to about 0,25 m in the upper zone of the Lagoon (Begg, 1978). Maximum depths of 1,5 and 2 m respectively were measured by the first author in June 1980 at the crossing of the nature trail (lower zone) and in the Lagoon mouth. Begg (pers. comm.) recorded a depth of 2,9 m in the middle section of the Lagoon.

METHODS

Information on the Siyai Lagoon and the reeds was obtained from air photos through direct inspection, enlargement and transference onto a base map using a Bausch & Lomb ZT–4 Zoom Transfer Scope (=ZTS). This instrument was also used to draw the 1:5 000 base map from the 1977 orthophoto maps

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FIG. 1.—The middle section of the Siyai Lagoon covered with *Phragmites australis* (June 1980). A photograph taken in 1964 shows only a few patches of reeds. The foreground shows leaves of *Hibiscus tiliaceus;* this plant and *Barringtonia racemosa* are the main components of the forest fringe. This community is encroaching into the *P. australis* stands.

2831 DD 21 'Mtunzini' and 2831 DC 25 'Ekuhleni'. Interpretation of the aerial photographs was aided by a Topcon Stereoscope.

The photographs used were Nos 54692 (Job 117, 1937.05.05), 9426 (Job 400, 1957.05.24), 8082 (Job 499/4, 1965.06.14), 5664 and 5609 (Job 608, 1969.08.18) and 161, 162 and 163 (Job 251, 1976.05.14). Areas were measured with an MOP–AMO2 Image Analyser. Ground truth and additional field data were gathered on the 21st and 22nd of March, 21st of May and the 8th and 12th of June 1980.

The potential and limitations of the use of air photos in vegetation studies have been discussed in literature, e.g. Edwards (1972) and Weisser (1979). Concerning this study, the following points should be borne in mind. The photographs are at different scales and were not taken at the same time of year. Another factor is the differing resolution of the air photos compared, the 1937 photographs having the poorest resolution. Also, the water levels of the Siyai Lagoon varied, therefore changing the area occupied. However, the Siyai Lagoon is situated between steep dune ridges, consequently changes in water levels have only a minor influence on the area inundated. The reed growth varies seasonally. There is a time lag between the establishment of reeds and their detection on air photos. Sometimes *P. australis* colonization may be below the detection limit of the air photo taken. The density of the *P. australis* stand also varies, being at its lowest in winter. This may affect its detection on the air photos.

RESULTS AND CONCLUSIONS

Field checking confirmed that the Siyai Lagoon was a good site for studying the colonization and expansion of *P. australis* Reedswamp. The period documented in the air photos was long enough to enable the reeds to cover all the available habitat in some sections of the river, whereas in others *P. australis* is still actively expanding. The observation time was also sufficient to allow succession to proceed, and in some areas *P. australis* Reedswamp is being displaced by other riverine vegetation (Fig. 1). The results deal first with the findings on *P. australis*, then with other aquatic or semi-aquatic vegetation, and finally with the Siyai Lagoon.

Adequacy of air photos to monitor P. australis *colonization*

It was possible to locate and estimate *P. australis* areas for 1957, 1965, 1969 and 1976 (Table 1 & Fig. 3). The resolution of the 1937 air photos is insufficient to give conclusive evidence. Difficulties were encountered in the interpretation of Job 291 (1977) and Job 329 (1979). Their scale (1:3 000) gives too few matching points in the optical field of the ZTS.

Colonization pattern

Phragmites australis first colonized the middle and lower sections of the Lagoon. It failed to establish itself in the immediate mouth zone and in the upper region with the exception of a 0,5 m_2 patch in the confluence (June, 1980). Both zones are at present

TABLE 1.—Area changes (in ha) in the Siyai Lagoon (1937–1976) as shown in the air photos

Year	*P. australis* area	Open water surface	Open water without new mouth regions	Total area of lagoon
1937	0,27 (?)	5,79	5,79	6,06
1957	0,74	5,58	5,41	6,33
1965	1,65	5,17	5,00	6,82
1969	1,93	5,04	4,69	6,97
1976	2,94	4,94	3,54	7,87

FIG. 2.—The mouth section of the Siyai Lagoon showing the *Phragmites australis* stand nearest to the sea. The dunes to the right are covered with dune scrub, and the young dunes on the left are colonized by the dune pioneer *Scaevola thunbergii*.

shallow. It seems that when silting increased drastically in the upper section, the already present woody fringe vegetation rapidly invaded the new habitat and ousted *P. australis*. In the lower section of the Lagoon, *P. australis* was able to establish itself and to expand in the direction of the Lagoon mouth.

Phragmites australis *Reedswamp area changes: 1937–1976*

The *P. australis* surface increases at the Siyai Lagoon are summarized in Table 1 and represented graphically in Fig. 3. Whereas from 1937 to 1957 there was an increase of only 0,47 (?) ha in the area covered by *P. australis*, the area increased by 2,20 ha between 1957 and 1976. Therefore expansion of *P. australis* in the Lagoon accelerated after 1957 (Fig. 3). The curve will flatten out as the available habitat diminishes. However, with the north-eastward advancement of the mouth, new areas suitable for *P. australis* colonization are being created (Fig. 2).

Probable causes of reedswamp increase

Reedswamp expansion is often a natural process in some lagoons. Conspicuous increases of reeds have been reported in lakes after lowering of water levels (e.g. Kopf, 1964, in Weisser 1970; Björk, 1974) or when siltation increases (Weisser, 1978). Begg (1980) states that reed encroachment is due to the Lagoon becoming shallower and less saline. We agree that sedimentation and consequent reduction in depth are the chief causes of the remarkable increase in *P. australis*. No records are available for assessing the influence of the salinity factor.

The sedimentation of the Siyai Lagoon has increased strikingly, becoming critical with the advent of sugar farming in the catchment area (c. 1946 *fide* Begg, 1978). This must be considered as the main reason for the deterioration of the Siyai Lagoon. Garland (pers. comm.) considers the clearing and cultivation of Swamp Forest and *Cyperus papyrus* Swamp (c. 1955) as being especially detrimental, because of the consequent elimination of the 'sponge' function of the vegetation.

Succession

In some areas of the middle section of the Lagoon, a replacement of *P. australis* Reedswamp by the *Hibiscus tiliaceus–Barringtonia racemosa* Lagoon Fringe Forest was observed, probably by shading. This community seems to be the following phase in the land reclamation process in this Lagoon. This corresponds with successional schemes proposed (Edwards, 1967; see also Ward, 1980).

Reduction of open water by increase of woody shore vegetation

An expansion of the Lagoon Fringe Forest formed mainly by *Hibiscus tiliaceus* and *Barringtonia*

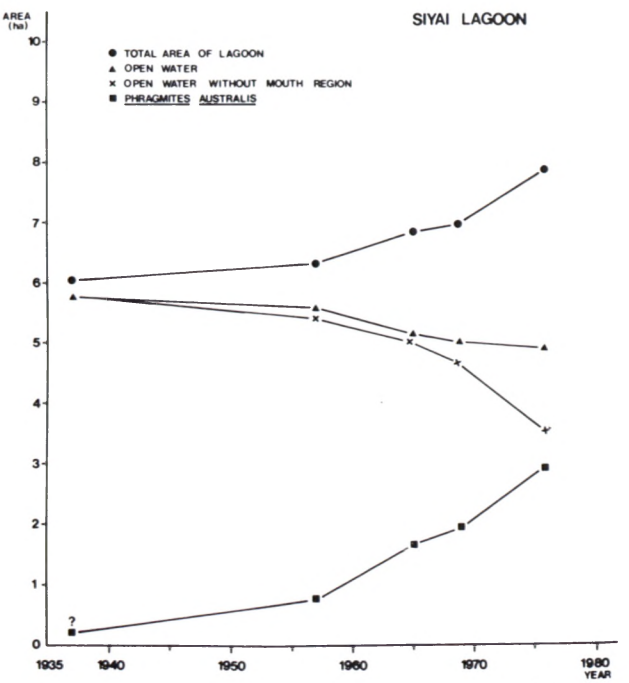

FIG. 3.—Area changes in the Siyai Lagoon 1937–1976 as shown by means of air photo interpretation.

racemosa on the upper section of the Lagoon was observed. This narrowed the Lagoon by occupying areas that were previously open water.

Age gradient of woody shore vegetation

In the upper section of the Lagoon, the woody fringe vegetation consists of dense tall trees (about 9 m), whereas the woody vegetation downstream is less dense, lower and formed by young trees. In the lower section, the woody shore vegetation is only 2 to 3 m high, discontinuous and limited to isolated seedlings of *Hibiscus tiliaceus* and *Barringtonia racemosa*. Therefore, an age gradient for the Lagoon fringe vegetation from the upper Lagoon section to the Lagoon mouth can be assumed (see also Weisser *et al.*, MS).

A few patches of dead woody fringe vegetation were noted in the lower section of the Lagoon. The preceding high water levels have been suggested as the cause by Garland (pers. comm.).

Area changes of the Siyai Lagoon

The surface covered by the Lagoon including reeds, but excluding the *Hibiscus tiliaceus—Barringtonia racemosa* Lagoon Fringe Forest has increased from about 6,06 ha (1937) to 7,87 ha (1976). This increase is mainly due to accretionary processes in the mouth region, which has advanced about 740 m northwards (1937–1977), therefore occupying areas previously covered by dunes (Figs 2 & 3).

The area of open water has decreased since 1937, mainly owing to the reedswamp encroachment and the expansion of the Lagoon fringe vegetation. However, the advancement of the Lagoon mouth has produced new open-water areas, compensating partially for the loss to the reed beds and the *Hibiscus tiliaceus—Barringtonia racemosa* Lagoon Fringe Forest. If the values are corrected by subtracting the new open-water areas of the mouth section, the real loss of open-water surface becomes evident (Table 1 & Fig. 3).

Sedimentation

The sedimentation has been heaviest in the upper zone of the Lagoon. The dense *P. australis* stand in the middle zone probably acts as a sediment trap partly protecting the lower section of the Lagoon from sedimentation.

If sedimentation is not controlled, the accelerated filling up of the bed will continue. This could eventually lead to the water breaking through and forming another bed.

Prognosis

Because of sedimentation, the colonization by *P. australis* Reedswamp and *Hibiscus tiliaceus–Barringtonia racemosa* Lagoon Fringe Forest of most of the Siyai Lagoon, except the immediate mouth zone, can be expected probably before the turn of the century. Any management action tending to diminish sedimentation, e.g. erosion control upstream, should be encouraged. Reeds could be controlled locally by repeated underwater cutting. The opening of a new river course may occur in the long term owing to filling up of the existing Lagoon bed. Dredging and mechanical control of vegetation will probably become necessary if major open-water spaces are to be maintained at the Siyai Lagoon.

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UITTREKSEL

Indringing deur Phragmites australis *in die Siyai Strandmeer aan die Natalse noordkus is bestudeer deur middel van lugfoto-interpretasie. Dit was moontlik om* Phragmites australis *stande uit te wys en die oppervlaktes daarvan te skat t.o.v. die jare 1957 (0,74 ha), 1965 (1,65 ha), 1969 (1,93 ha) en 1976 (2,94 ha), maar nie vir 1937 nie.* Phragmites australis *het eers net op die middelseksie van die strandmeer se oewers voorgekom, maar het vinnig uitgebrei na die stroom-af seksie. Die stroom-op seksie is alleenlik laer af ingedring deur uitbreiding van die middelseksie. Dit word veronderstel dat* P. australis *nie beter in laasgenoemde seksie kon slaag nie weens die kompetisie wat die* Hibiscus tiliaceus—Barringtonia racemosa *Strandmeer-oewerwoud bied. Laasgenoemde plantgemeenskap oorskadu* P. australis *in sommige plekke. Die merkwaardige toename in die tempo van verdringing van die Siyai Strandmeer deur slik en oewerplantegroei word veroorsaak deur suikerboerdery wat lei tot verspoeling en toeslikking. 'n Plantegroei-ouderdomsgradiënt vanaf die stroomopseksie tot by die monding is waargeneem. Indringing van die grootste gedeelte van die Siyai Strandmeer deur* P. australis *Rietmoeras en* Hibiscus tiliaceus—Barringtonia racemosa *Strandmeeroewerwoud kan voor die einde van die eeu verwag word. Indien daar noemenswaardige oopwaterruimtes instand gehou moet word, sal baggerwerk en meganiese beheer van die plantegroei noodsaaklik wees.*

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