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Alien trees, shrubs and creepers invading indigenous vegetation in the Hluhluwe-Umfolozi Game Reserve Complex in Natal

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ABSTRACT

The results of a survey and monitoring programme conducted in the Hluhluwe-Umfolozi Game Reserve Complex in Natal are presented. The area consists of 900 km² of savanna and forest vegetation.

Twenty alien tree, shrub and creeper species currently invading indigenous vegetation within the Complex are listed. Herbaceous aliens were not surveyed.

An analysis of the habitats being invaded by these alien plants is presented and it is concluded that riverine and forest-edge habitats are those most seriously threatened by alien plant infestations.

The distribution, nature and history of the infestations of each species are summarized. Distribution maps given for the eight species which are currently most important in the Complex. The potential threat posed by each species is estimated and the species are ranked in order of priority for control action.

The South American composite, *Chromolaena (Eupatorium) odorata,* is identified as being the alien species currently posing the greatest threat to natural vegetation in the Complex. The Asian tree, *Melia azedarach,* is considered the second most important alien species invading the area. It is concluded that both these species should be declared noxious weeds throughout the Republic and that research into their biological control is urgently required.

RÉSUMÉ

ARBRES, ARBUSTES ET PLANTES GRIMPANTES ÉTRANGÈRES ENVAHISSANT LA VÉGÉTATION INDIGÈNE DE LA RÉSERVE ANIMALE DU COMPLEXE DE HLUHLUWE-UMFOLOZI AU NATAL

Les résultats d'un inventaire et d'un programme d'observations suivies conduits dans la réserve animale du complexe Hluhluwe-Umfolozi au Natal sont présentés. La région consiste en 900 km² de savanne et de végétation forestière.

Vingt espèces d'arbres, d'arbustes et de plantes grimpantes étrangères qui envhaissent couramment la végétation indigène de ce complexe sont inventoriées. Les espèces herbacées étrangères n'ont pas été relevées.

Une analyse des habitats envahis par ces plantes étrangères est présentée et il en est conclu que les habitats riverains et de bordure de forêts sont ceux qui sont le plus sérieusement menacés par des infestations de plantes étrangères. La distribution, la nature et l'histoire des infestations de chaque espèce sont résumées. Des cartes de distribution sont données pour les huit espèces qui sont actuellement les plus importantes dans le complexe. La menace potentielle posée par chaque espèce est estimée et les espèces sont classées par ordre de priorité de lutte.

La composée sud-americaine, Chromolaena (Eupatorium) odorata, *est reconnue comme l'espèce étrangère posant la plus grande menace pour la végétation naturelle du complexe. L'arbre asiatique,* Melia azedarach, *est considéré comme la seconde espece en importance envahissant la région. En conclusion, ces deux espèces devraient être déclarées plantes nuisibles à travers toute la République et des recherches sur une lutte biologique contre elles est requise de toute urgence.*

INTRODUCTION

Alien plant species are widespread throughout Natal and a number of species have become naturalized and are competing successfully with the indigenous flora.

The overall impact that these aliens are having on the indigenous flora and fauna has never been assessed. However, as all plants compete for limiting resources (e.g. space, water, light, nutrients, pollination and dispersal vectors), it is safe to assume that any increase in an alien plant species can only occur at the expense of the indigenous flora. Any radical alteration of the flora is likely to be reflected in the fauna.

The overall management objective of the Hluhluwe-Umfolozi Game Reserve Complex (from now on called the Complex) is the long term maintenance of viable populations of as many of the indigenous species in the reserve as possible. This objective can only be achieved if the invasion of the area by alien plants is controlled. This study was carried out as part of the ongoing management of alien plant infestations in the Complex.

This paper condenses and updates information presented in an earlier more detailed report on the subject (Macdonald, 1978).

THE STUDY AREA

The Complex (see Fig. 1) is situated between latitudes 28°00' and 28°26' S and longitudes 31°43' and 32°09' E.

The environment and vegetation of the Complex are described by Whateley & Porter (1983). Plant species diversity is high with over 1 250 vascular plant species having been recorded of which 367 are woody trees and shrubs.

Faunal diversity is also high with the following number of species having been recorded from the

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area; Amphibia, 26 (Bourquin *et al.*, 1971; P. J. Birkenstock, pers. comm.); Reptilia, 60 (Bourquin *et al.*, 1971); Aves, 400 (Macdonald & Birkenstock, 1980); Mammalia, 84 (Bourquin *et al.*, 1971).

During and for some years prior to this study the Complex as a whole was subjected to heavy grazing and browsing pressures from indigenous ungulate populations that have increased in density since the area was proclaimed a protected area in 1895.

An important management practice in the Complex is the controlled use of fire to manipulate plant communities. In general fire is confined to the grassland and open woodland communities in the Complex with closed woodland and forests tending to exclude fire. Burning is generally carried out at the end of the dry season (July to September) and on average some 23% of the surface area of the Complex is burnt each year (Macdonald *et al.*, 1980).

METHODS

Information on alien plants in the Complex was obtained in the following ways:

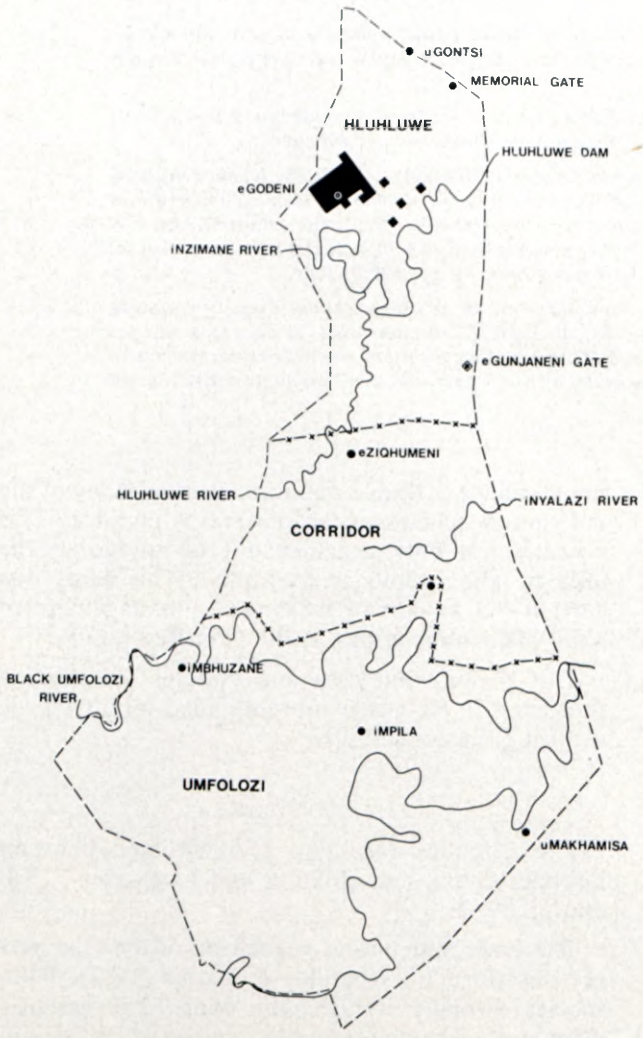

FIG 1.—Map of the Hluhluwe-Umfolozi Complex, showing the approximate position of the proclaimed boundaries of the two reserves, the location of camps and outposts, and the known distribution of *Solanum seaforthianum*, 1978–1981.

1. From February 1978 to June 1981 research and management personnel working in the Complex were requested to report all alien plant infestations seen in the course of their normal duties. From November 1978 this reporting was facilitated by the use of an Alien Plant Sighting Form (Appendix) which was filled in and returned by officers observing alien plants anywhere in the Complex. Annual Alien Plant Identification lectures were given to the game guards who patrol the Complex extensively.

2. Intensive searches of small areas were made by research staff over the period February to May 1978. In particular the areas surrounding each of 116 permanent vegetation monitoring points located systematically throughout the Complex were searched during March 1978.

3. Alien plants were recorded at 554 points at 200 m intervals along the entire road system in Hluhluwe and the northern Corridor during April 1980.

4. All gardens in the Complex were systematically searched for invasive alien plants during July 1980.

5. Information was obtained from Alien Plant Control Record Forms returned by management staff for completed control operations.

6. Information on the history of the infestations was obtained from herbarium specimens, from records of past control operations lodged in the Hluhluwe Research Centre and from the Hluhluwe Management Plan (Anon., 1975).

All reported infestations over the period 1978 to 1981 were plotted on 1 : 50 000 maps of the Complex using a 500 m by 500 m grid square as the mapping unit. Therefore the distribution maps presented in this paper give an exaggerated impression of the extent of alien plant infestations as many of the grid squares have been shaded on the basis of records of single or scattered plants. This mapping system was chosen as in some areas within the Complex it is difficult to locate an infestation more accurately than as being in a 500 m by 500 m grid. Also the system indicates the rough areas that will require sweeping during control operations if all outlying plants are to be removed.

RESULTS

The species of alien trees, shrubs and creepers that were found to be invading indigenous vegetation are listed in Table 1. The extent of the mapped distribution of each species as well as the number of Alien Plant Sighting Forms returned for each species are also shown to give some relative measure of the magnitude of the different species' invasions of the Complex.

In addition to these 16 species which are propagating themselves in the indigenous vegetation areas of the Complex (termed 'active invaders'), four species (*Acacia mearnsii*, Black Wattle; *Euphorbia pulcherrima*, Poinsettia; *Cereus peruvianus*, Queen of the Night Cactus; and *Musa sapientum*, Banana) were found in areas of indigenous vegetation, either as relics of disused habitation sites or as the result of the dumping of

TABLE 1.—The alien trees, shrubs and creepers found invading indigenous vegetation in the Hluhluwe-Umfolozi Complex, with two measures of the extent of their infestation. 1978–1981*

Species or genus	Local common names (English and Zulu)	Origin	No. of 500 × 500 grid squares in which recorded Feb. 78–June 81	No. of alien plant sighting forms returned Nov. 78–June 81
Agave sisalana	Sisal, uHalibhoma	Mexico	30	5
Caesalpinia decapetala	Mauritius thorn, uFenisi or uLozisi	Tropical Asia	15	16
Cassia didymobotrya	Peanut Cassia, —	Tropical East Africa	7	6
Cassia bicapsularis	Cassia, —	Tropical America	2	3
Chromolaena odorata	Trifid weed, Eupatorium, Sandanezwe	South America	154	84
Citrus limonia	Lemon, Lamula	S.E. Asia	5	2
Jacaranda mimosifolia	Jacaranda, —	South America	6	10
Lantana camara	Lantana, uBukhwebezana	Tropical America	2	1
Melia azedarach	Seringa, uMsilinga	S.W. Asia	88	39
Montanoa bipinnatifida	Montonoa, —	Mexico	5	7
Morus alba	Mulberry, uMbhombe	Asia	3	3
Opuntia spp.	Prickly pear, uMdolofiya	Central America	87	51
Psidium guajava	Guava, uGwava	Tropical America	29	18
Ricinus communis	Castor oil plant, uMhlakuva	?Tropical Africa	56	18
Solanum mauritianum	Bugweed, isiGwayana	Tropical Asia	52	38
Solanum seaforthianum	Potato creeper, uMbangandlala	Tropical America	29	25

* In addition to the above 16 species, 4 species have been found growing around habitation sites, but do not appear to be invading indigenous vegetation except where they have been 'dumped': *Acacia mearnsii*, Black wattle; *Euphorbia pulcherrima*, Poinsettia; *Cereus peruvianus*, Queen of the Night Cactus; and *Musa sapientum*, Banana.

garden refuse which had subsequently rooted and grown (termed 'passive invaders').

Information on the habitat types being invaded by the 16 actively invading species was extracted from returned Alien Plant Sighting Forms (Table 2). This is only an approximation to the actual habitat distribution shown by each species as no correction has been made for the differences in area of the various habitats within the Complex nor for variations in the intensity of searching within each habitat type. However, except for the two *Solanum* species (which are almost certainly commoner in forest and forest edge habitats than along streams and around current habitations as the records suggest) the results are in agreement with the author's subjective assessment of the situation.

These results show that the habitats most susceptible to invasion by alien plants are the riverine habitat followed by closed woodland and forest edge habitats. Undisturbed patches of forest appear able to exclude most of the alien plant species currently occurring in the area. Grassland and open woodland habitats, in which frequent fires occur, are also apparently less susceptible to invasion. Surprisingly, erosion sites were not found to hold extensive infestations of any alien plant species and only three species were recorded in this habitat. Possibly these sites are too xeric for most of the alien plant species occurring in the Complex. The significance of the disturbed ecosystems around current habitations as a source area for the invasion of the surrounding indigenous vegetation is clear. Disused habitation and road verges play a similar role but on a lesser scale. The results of the systematic survey along the roads in Hluhluwe and the northern Corridor (Table 3) indicate the extent of invasions in this portion of the Complex. The frequencies recorded are in agreement with subjective assessments of the extent of the infestations of the various species in this area.

Local sources of infestation

Of the 16 active invader species six (*Agave sisalana, Cassia bicapsularis, Jacaranda mimosifolia, Lantana camara, Montanoa bipinnatifida* and *Solanum seaforthianum*) have all their infestations in the Complex as a result of injudicious plantings of the species as garden plants and, in the case of *Agave sisalana* as a boundary 'hedge'. The four passive invaders (*Acacia mearnsii, Euphorbia pulcherrima, Cereus peruvianus* and *Musa sapientum*) also fall in this category.

A further seven species (*Caesalpinia decapetala, Cassia didymobotrya, Citrus limonia, Melia azedarach, Morus alba, Opuntia* spp, *Psidium guajava*) have also been planted as garden plants in the Complex and at least some of the infestations recorded are the result of these plantings.

In the case of ten of the active invader species, at least some of the infestations have arisen from disseminules entering the Complex from parent plants growing outside its boundaries. These species present management problems that will never be

TABLE 2.—The proportion× of reported infestations in the different major habitats of the Hluhluwe-Umfolozi Complex

	Major habitat types										
	Natural						Man-made				No. of habitat reports for each species
	Forest	Forest edge	Riverine	Closed woodland	Open woodland	Grassland	Erosion site	Road edge	Disused habitation	Current habitation	
Agave sisalana				,4	,1		,1		,3	,1	7
Caesalpinia decapetala		+	,9							,1	16
Cassia didymobotrya		,1	,3							,6	8
Cassia bicapsularis		,2	,2	,2						,4	5
Chromolaena odorata	,1	,1	,4	,1	,1	+		+		,2	86
Citrus limonia		,1	,2	,1					,1	,5	10
Jacaranda mimosifolia	+	,1		,1						,8	10
Lantana camara										1,0	2
Melia azedarach		+	,9			+			+	,1	44
Montanoa bipinnatifida		,1					,1			,8	8
Morus alba			,8							,2	4
Opuntia spp.			,7	,2	,1				+	+	52
Psidium guajava		,1	,2	,1	,1	,1		,1	+	,3	18
Ricinus communis			,9					+		,1	16
Solanum mauritianum	,1	,2	,4			+	+	+		,3	39
Solanum seaforthianum	,2	,2	+	,1				+		,5	22
Mean rating over all species	,025	,075	,369	,081	,025	,006	,012	,006	,025	,375	
Number of species	4	11	12	8	4	4	3	5	5	16	

+ = proportion less than ,05 or known to occur, but not reported on any form

× = all proportions have been rounded to sum to 1,0 for each species; rounding has in some cases been subjective and has been done so as to approximate more closely the intensity of infestations observed in different habitats.

completely solved until suitable buffer zones in surrounding areas are cleared of the species.

Individual species accounts

Agave sisalana, *Cassia bicapsularis*, *Citrus limonia*, *Lantana camara* and *Montanoa bipinnatifida* have all been observed to disperse only a short distance from their parent plants in the Complex. Total eradication appears possible given an adequate labour input over several years.

Jacaranda mimosifolia and *Solanum seaforthianum* have both only invaded indigenous vegetation in northern Hluhluwe from parent plants initially planted in the eGodini gardens.

Jacaranda mimosifolia was planted at a minimum of four outposts in the Complex, the earliest plantings being at Masinda and eGodeni, the latter in the late 1940's. By 1972 plants of this species were found growing in indigenous vegetation up to 2 km from the eGodini gardens. In the same year control operations in an area of approximately 40 ha around the eGodini gardens revealed a mean density of 300 seedlings and saplings/ha and their removal required approximately 16 manhours/ha (Anon., 1975: 39).

TABLE 3.—Frequency of occurrence of alien plants at 554 points systematically located at 200 m intervals along the entire road system in Hluhluwe Game Reserve and the northern Corridor. April 1980.

Species	Number of points at which the species was recorded
Chromolaena odorata	13
Solanum mauritianum	7
Solanum seaforthianum	5
Ricinus communis	4
Psidium guajava	3
Agave sisalana	2

Following the discovery of the invasion threat posed by *J. mimosifolia* strenuous efforts were made to remove all the individuals of this species from gardens. The species proved difficult to kill but complete eradication from garden areas should be achieved by 1982. Future control will consist of 'mopping-up' operations to remove individuals surviving in the surrounding indigenous vegetation.

The invasion of indigenous savanna and forest vegetation in southern Africa by *J. mimosifolia* has now been documented in several studies (e.g. Drummond, 1975; Petheram, 1979; Wells *et al.*, 1979). This species should never again be planted in a protected area.

Solanum seaforthianum is bird dispersed and its invasion of indigenous vegetation around eGodini has been extensive (Fig. 1). In some patches of low canopy forest on eGodini the relatively unpalatable *S. seaforthianum* was one of the dominant understory species by 1978. Intentional cultivation of this creeper in gardens was finally eliminated in 1980. However, by this time, fruiting was occurring so extensively in adjacent areas of indigenous vegetation that reinvasion of gardens is an ongoing problem.

FIG 2.—The known distribution of *Caesalpinia decapetala* in the Complex, 1978–1981.

This species has shown itself capable of invading indigenous vegetation elsewhere in south east Africa (Ross, 1972: 309; Biegel 1977: 99; Ndumu Game Reserve, Natal, pers. obs.; Mkuzi Game Reserve, Natal, P. S. Goodman, pers. comm.). Its major impacts are likely to be competition for light, water and nutrients with other forest and forest edge species and for dispersal vectors with indigenous, bird distributed, plant species. Plants are often widely scattered and hand removal using lines of labourers sweeping infested areas appears the only practical control method. Repeated removal operations are necessary; in one case an area cleared in 1978 had been reinvaded to a density of 2 750 plants/ha by June 1979, when it was recleared, after which it was reinvaded to a density of 1 225 plants/ha by June 1981.

Caesalpinia decapetala is grown extensively as a hedge in adjacent farming areas where it has invaded indigenous vegetation. Fortunately it has only once been planted in a garden on eGodini from where it apparently has not spread. As a result of confusion with indigenous thorny creepers, e.g. *Entada spicata* and *Acacia schweinfurthii*, infestations of this species along the banks of the major inflowing rivers (the Hluhluwe, Black and White Umfolozi Rivers) were not detected until 1979 (Fig. 2). Extremely costly to remove and capable of massive seedling establishment (Petheram, 1979) this species forms impenetrable thickets which could have a major impact on the riverine areas of the Complex.

Cassia didymobotrya has been planted in gardens in and around the Complex and in adjacent farming areas has invaded indigenous vegetation extensively. Inside the Complex it has only been found invading indigenous vegetation in a limited area around the eGodini gardens and along the banks of the inflowing Nzimane River. First recognized as being an alien in 1978 *C. didymobotrya* has now been removed from all gardens in the Complex. Currently it is a minor threat but one that will require constant vigilance along influent rivers.

Chromolaena odorata is the most widespread alien invader in the Complex (Fig. 3) and is the alien plant currently posing the most serious threat to the long term maintenance of natural vegetation within the area. It is wind dispersed and capable of extremely rapid growth to form impenetrable tangles which eventually shade out all the indigenous vegetation. A particularly dangerous attribute of *C. odorata* is the plant's high flammability: it burns even when green in midsummer. The species forms dense thickets on the edge of forest and riverine forest, ecotones which are normally fire excluding. Following invasion by *C. odorata* fires burning in adjacent grassland and woodland areas cross this ecotone with ease and burn right into the canopies of fire sensitive forest trees. *C. odorata* coppices readily following fire and the bare areas formed after a thicket has burnt out provide suitable germination conditions for this species.

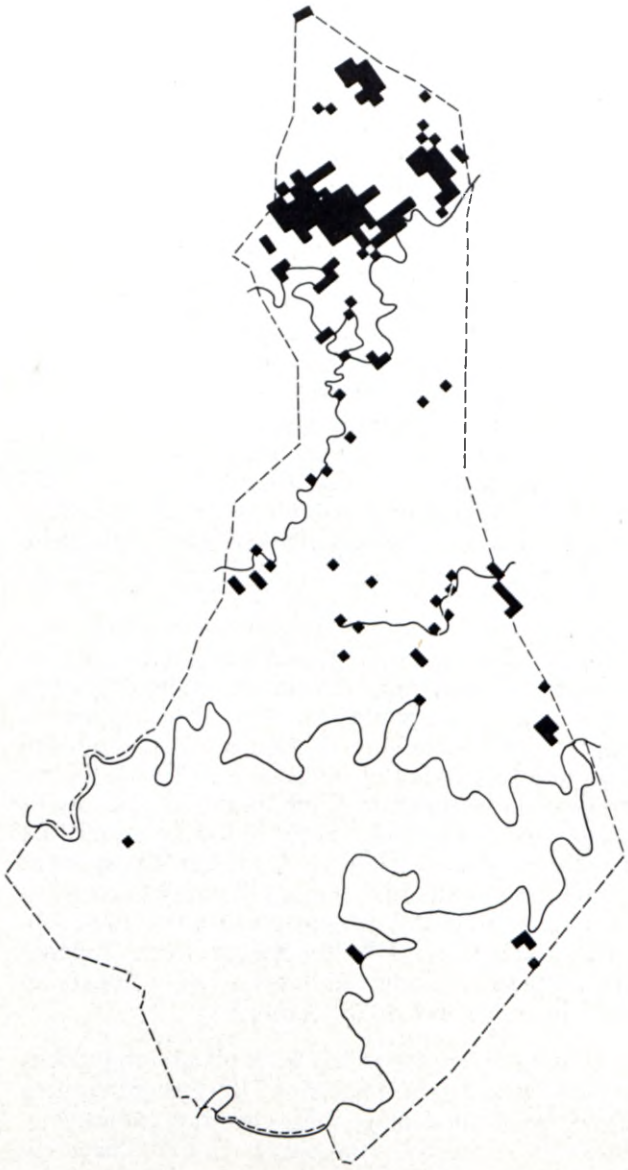

FIG 3.—The known distribution of *Chromolaena odorata* in the Complex, 1978–1981.

The conditions prevailing in northern Hluhluwe Game Reserve appear to be optimal for this species: a specimen with a basal stem diameter of 24 cms was removed from a forest edge infestation in 1978. Densities in excess of 48 000 plants/ha have been measured both from a riverine infestation in the south eastern Corridor in 1978 and, in 1981, from an area in Hluhluwe that had previously been 'cleared' of *C. odorata* on two occasions since 1977. A patchy infestation along a forest edge at eGodini covering some 83 ha had a mean density of 4 010 plants/ha and required an input of 47 manhours/ha for complete removal using mattocks and hand pulling. An extremely dense established thicket on a forest edge took 630 manhours/ha using the same methods.

First recorded in Hluhluwe in 1961, the species is just beginning the 'exponential' phase of its population increase in the Complex. Increases in the distribution and density of the species in Hluhluwe since 1978, in spite of an increased control effort, make the future prospect extremely bleak.

Already this species has had a massive deleterious effect on indigenous vegetation throughout the subtropical areas of Natal. Virtually all the protected areas in the region have already been invaded, some have been swamped e.g. Krantzkloof Nature Reserve. It is a matter of time before all the protected areas are invaded. It seems likely that the species, if unchecked, will continue its northward spread into Mozambique, the Eastern Transvaal and Zimbabwe.

The discovery of a biological control method for *C. odorata* is essential if the natural ecosystems occurring in the subtropical portion of Natal, and possibly further afield, are to be conserved.

Melia azedarach has in the past been intentionally planted in some of the gardens in the Complex. However, this error was soon recognized and efforts were first made to eliminate this species from gardens in 1963. By this time mature plants were established in surrounding areas of indigenous vegetation and reinvasion of gardens from this source is still occurring. The major infestations of this species now occur on the banks of the inflowing

FIG 4.—The known distribution of *Melia azedarach* in the Complex, 1978–1981.

rivers (Fig. 4), in particular the Hluhluwe and Umfolozi Rivers. There is an independent infestation along the Nyalazi River that rises inside the Complex, presumably these plants arose from seed dispersed from the Masinda outpost which was only cleared of *M. azedarach* in 1975.

In addition to being bird dispersed, it appears that the seeds are transported by water (cf. Van Wyk, 1972: 267) and major infestations are present on river bends where flood waters periodically inundate riverine *Phragmites* reed beds and *Ficus sycamorus* riverine forest. At Makhamisa on the White Umfolozi River in August, 1978, *M. azedarach* was present at a density of 120 trees/ha in a community where all the indigenous tree species had a combined density of only 105 trees/ha. At this locality *M. azedarach* contributed 4,94 m^2/ha to a total basal area of 14,55 m^2/ha for the entire tree community.

This species has shown itself capable of outcompeting indigenous vegetation in various localities throughout the naturally wooded regions of southern Africa (Van Wyk, 1972: 267; Palgrave, 1977: 381; Petheram, 1979; Wells *et al.*, 1979). The tree is long lived and can grow to a considerable size (10 to 15 m in height and canopy spread) and therefore has the potential to radically distort indigenous plant communities. That the community particularly threatened within the Complex is the riverine fringe, which is a community of limited extent (52,7 km^2 of the 900 km^2 area) and of critical significance to a wide variety of the area's fauna, makes the situation particularly serious.

As the species produces a large crop of fruits each year which persist on the tree for a long period and are avidly eaten by a wide range of frugivorous birds it is possible that uncontrolled infestations of this species could give rise to vector competition with less favoured indigenous fruiting species. In this respect, I have observed both Brown-necked parrots *Poicephalus robustus* and Rameron pigeons *Columbia arquatrix* leaving their normal forest haunts in the Natal midlands to visit fruiting *M. azedarach* trees growing in open grassland and thornveld situations.

The problem status of the species is exacerbated by its high germinability, rapid growth and the extreme difficulty with which established individuals can be killed. Wells *et al.* (1979) working in the central Transvaal found that *M. azedarach* 'is undoubtedly the most aggressive exotic, woody invader encountered'.

In the interests of conservation, it is time that this species was declared a noxious weed throughout the Republic of South Africa and research into its biological control should be initiated immediately.

Morus alba has also been grown in gardens in the Complex and it was only following its discovery as an invader of riverine forest along the White Umfolozi River in 1979 that its cultivation within the Complex was prohibited. Known to have invaded indigenous vegetation elsewhere in southern Africa (Palgrave, 1977: 100; Wells *et al.*, 1979) this species should not be cultivated in protected areas. Control of this species in the Complex is currently a minor problem.

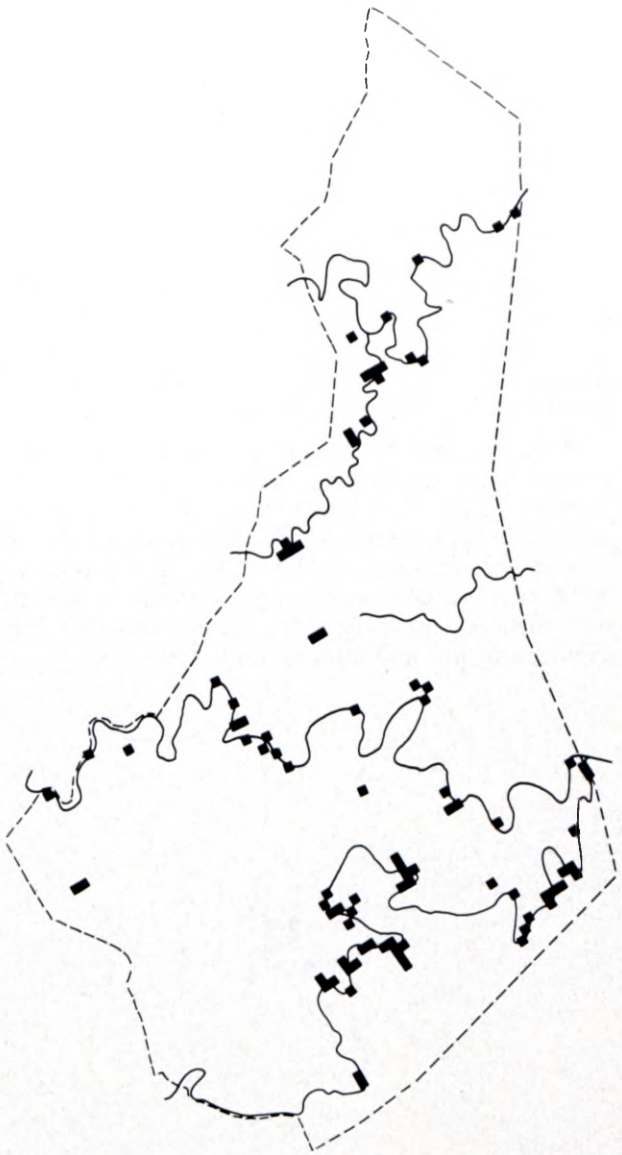

FIG 5.—The known distribution of *Opuntia* spp. in the Complex, 1978–1981.

Opuntia spp. have been found scattered throughout the Complex (Fig. 5) with the banks of the major inflowing rivers holding the highest density of infestations. Most of the infestations reported were of established plants forming clumps less than 100 m^2 in area. Many of the infestations have been known for years, have been subjected to repeated unsuccessful or only partly successful control operations and do not appear to be spreading rapidly. Only along the rivers, where cladodes are apparently deposited by flood waters, were young infestations found.

This species is considered to have been first introduced during the Nagana campaign (approximately 1930 to 1963) and a number of infestations are at old Nagana camps. *Opuntia* spp. were the first alien plants to be controlled in the indigenous vegetation areas of the Complex (1963 in Hluhluwe and 1967 in Umfolozi). Most of the control operations have involved physical removal of the plants, with a number of herbicide treatments also having been tried. In 1974 the biological control agent, cochineal *Dactylopius opuntiae,* was intro-

duced into some of the larger infestations in Umfolozi, but has failed to control these completely. The cochineal is apparently unable to reach all the scattered infestations and, of forty infestations for which its presence or absence was recorded, only five were infected, of which one was the site of an original introduction in 1974.

These species are known to form dense thickets where not controlled (Henderson & Anderson, 1966: 220; Stirton, 1978: 112) and their potential impact on the Complex is serious. An effective control strategy, based on the recent research conducted in the eastern Cape, should be implemented as soon as possible.

Psidium guajava is also a species that was introduced, in ignorance of its invasive potential, to numerous gardens in the Complex. However, it has invaded indigenous vegetation throughout the Natal coastal belt and it is unlikely that all the present infestations in the Complex are the result of garden introductions, although the worst area is that surrounding the eGodini gardens (Fig. 6).

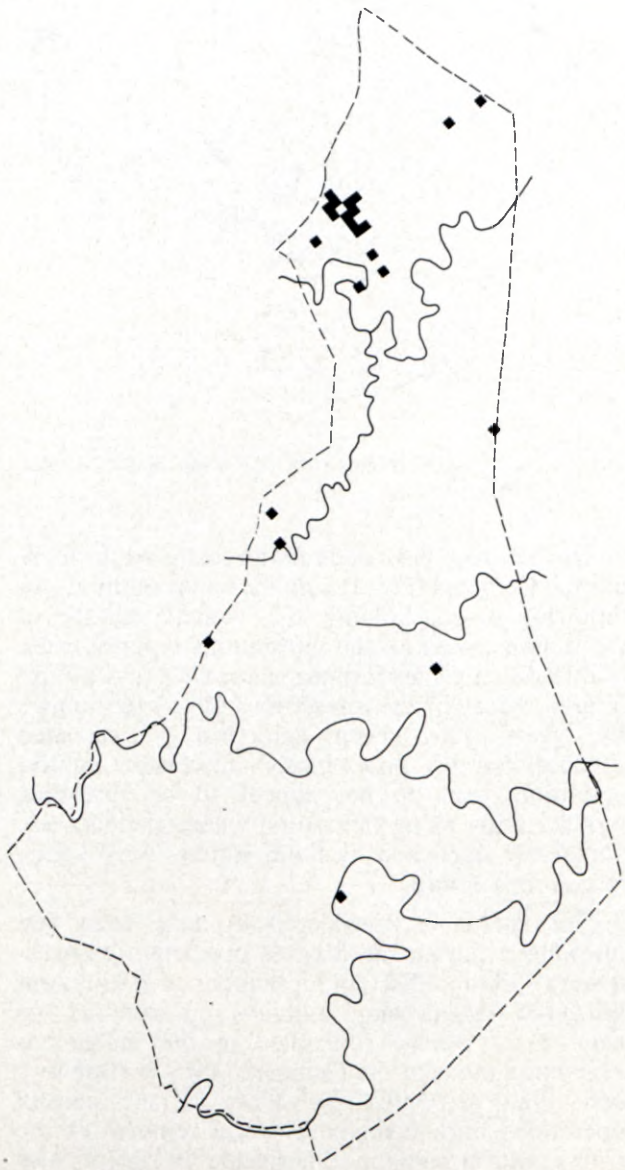

FIG 6.—The known distribution of *Psidium guajava* in the Complex, 1978–1981.

This species is an extremely dangerous alien being able to outcompete indigenous vegetation over a wide range of habitats in Natal, Eastern Transvaal and Zimbabwe (Drummond, 1975). The invasion of the Natal coastal belt is already extensive and in the Ndumu Game Reserve the species now dominates the dryland fringe of the riverine forest along the Pongola River. The habitats most threatened in the Complex are the forest edge and riverine fringe.

Fortunately, control operations, initiated in 1970 in Hluhluwe and in 1975 in Umfolozi, have greatly limited the fruiting of this species in the Complex. *P. guajava* has proven almost impossible to kill. All the herbicides tested so far have failed. Physical removal is only partly successful as the species suckers readily from root remnants. Research into an effective control method is essential if the species is to be controlled indefinitely.

P. guajava is another species that should never again be intentionally introduced to a protected area.

Ricinus communis is now so widespread in indigenous vegetation in Natal that many people have assumed that this alien is in fact indigenous. The first known record of the species in the Complex is a collection made by C. J. Ward in 1955 when its distribution was 'localized'. The species was not subjected to control operation till 1978, although its cultivation in gardens was prohibited from 1972. *R. communis* is still localized to areas of disturbed soil along rivers, roads and around habitation (Fig. 7). It does not seem to be able to invade indigenous vegetation except where this has been artificially disturbed. Its only significant impacts would appear to be through competition with indigenous ruderals, particularly on recently exposed silt deposits along riverbanks and in dry riverbeds, and through its alteration of the natural feeding ecology of doves, particularly Tambourine doves *Turtur tympanistria* (McLachlan & Liversidge, 1978: 230). If uncoltrolled, large infestations of this species could alter the feeding ecology of these birds.

Solanum mauritianum is present mainly in the moister northern parts of Hluhluwe with scattered individuals recorded from river banks and habitation sites further south in the Complex (Fig. 8). The first record of this species from the Complex is a collection made in Hluhluwe by P. Hitchins in 1971 when it was said to be 'frequent' in occurrence. Photographs taken in 1949 of a site on eGodini which was heavily infested by 1978 showed *S. mauritianum* to be absent at this date. The species was not subjected to control operations till 1978 although its cultivation in gardens was prohibited in 1972.

S. mauritianum is an aggressive invader of forest edge communities, particularly where these are disturbed (Henderson & Anderson. 1966: 278) and by 1978 dense infestations were present in these situations throughout the eGodini area of Hluhluwe.

S. mauritianum is bird distributed, germinates readily, grows rapidly and can form dense stands up to 5 m in height which preclude indigenous forest

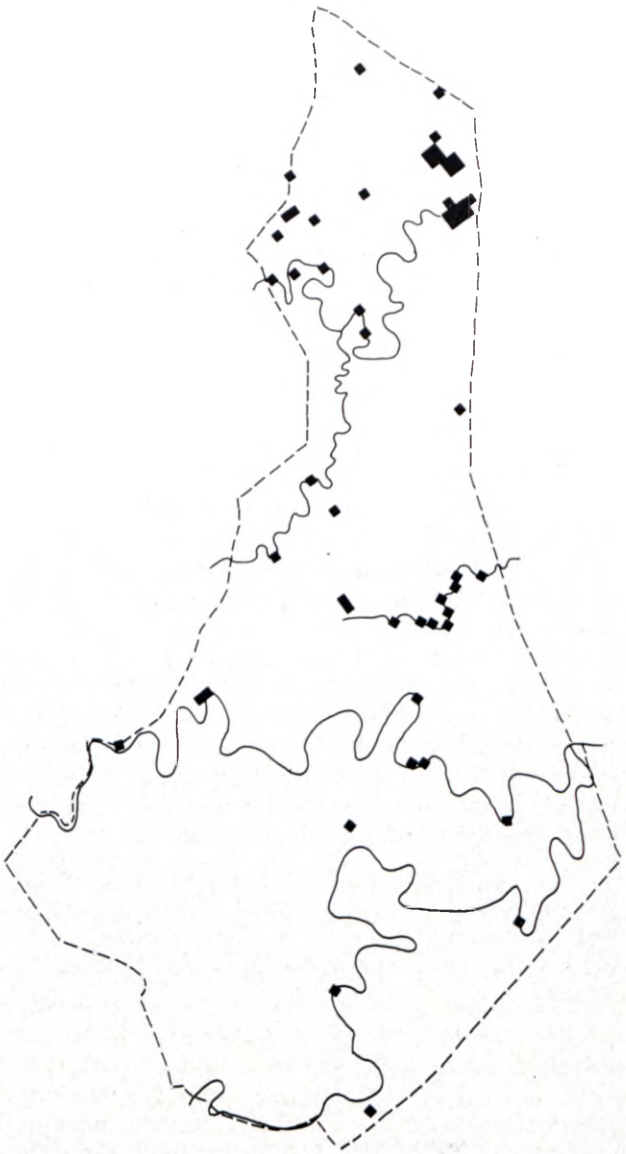

FIG 7.—The known distribution of *Ricinus communis* in the Complex, 1978–1981.

edge plants such as *Trema orientalis,* an important species for avian frugivores, and *Dombeya burgessiae,* an important species for honey bees. Individuals of *Solanum mauritianum* are relatively long-lived reaching basal stem diameters in excess of 15 cm without showing any signs of senescence.

The possible indirect effects of the invasion of forest edge habitats by this species are numerous: Its fruits which it produces prolifically all the year round are eaten avidly by most indigenous avian frugivores. Already these fruits have radically altered the feeding ecology of the Rameron pigeon *Columba arquatrix* in the Natal Midlands (Oatley, 1980) and this could have serious consequences for indigenous forest plants which were formerly dispersed by this species (Phillips, 1927). The foliage of *Solanum mauritianum* is not eaten by indigenous ungulate browsers in the Complex, the forest species of which feed extensively in edge situations. Dense infestations of *S. mauritianum* could significantly reduce browse availability for these species. Already it has been observed that the Bushbuck *(Tragelaphus spekei)* population in the eGodini area of H. G. R. has declined markedly since the 1950's and, although there are several possible explanations for this decline, the increase in *Solanum mauritianum* infestations might have been a contributory factor.

Control measures

The following actions have been taken to eliminate or reduce the threat posed by alien plants in the Complex:

1. All alien plants, excluding a small list of selected "permissible" species are being phased out of gardens in the area. No further introductions of any new alien plant species to these gardens is allowed. A policy of growing only species indigenous to the Complex is being actively encouraged (Macdonald *et al.*, 1979).

2. The introduction of a continuous monitoring system using the Alien Plant Sighting Form (Appendix) enables control operations to be implemented on the basis of the most up to date information available on the distribution and extent of infestations.

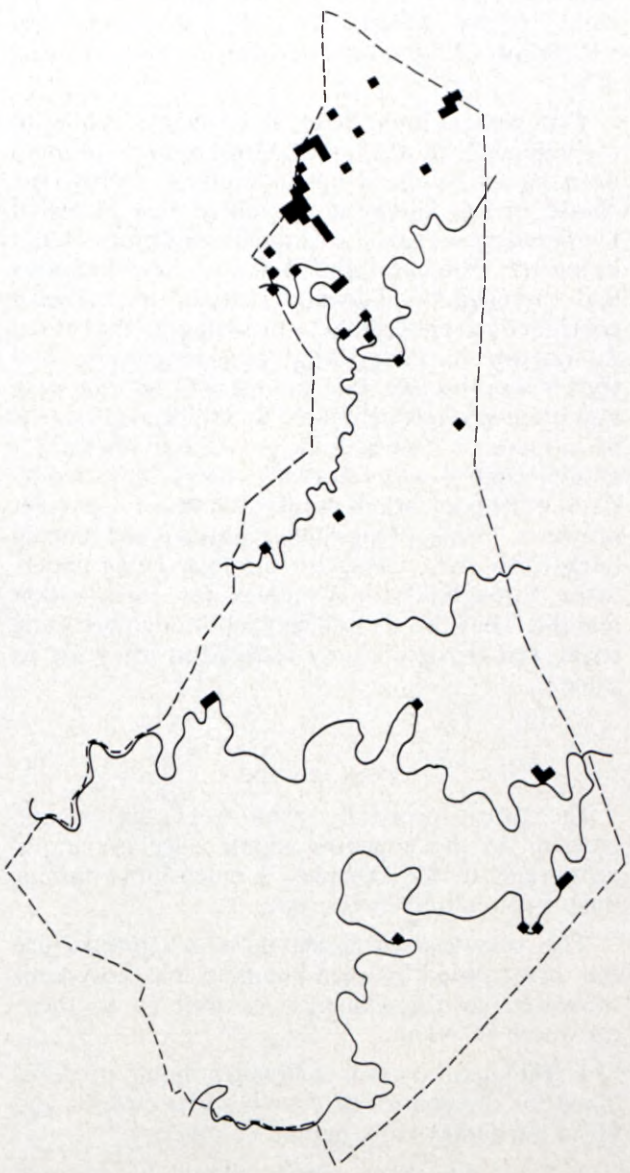

FIG 8.—The known distribution of *Solanum mauritianum* in the Complex, 1978–1981.

3. All alien plant control operations in the Complex have now been put on a systematic basis with an annual planning meeting being held at the start of each year. All completed control operations are recorded on Alien Plant Control Record Forms which will enable the efficiency of these operations to be evaluated and, hopefully, improved.

4. A greatly increased financial allocation has been made for alien plant control work.

5. The alien plant species have been ranked in the following order of priority for control operations: *Chromolaena odorata, Melia azedarach, Psidium guajava, Caesalpinia decapetala, Solanum mauritianum, Lantana camara* (due more to its potential threat than to its currently realised threat), *Opuntia* spp., *Solanum seaforthianum, Cassia didymobotrya, Jacaranda mimosifolia, Morus alba, Ricinus communis, Montanoa bipinnatifida, Citrus limonia, Cassia bicapsularis, Agave sisalana, Acacia mearnsii, Cereus peruvianus, Euphorbia pulcherrima* and *Musa sapientum.*

6. Further trials have been initiated on the chemical control of some of the alien species that have proven difficult to kill e.g. *Caesalpinia decapetala, Chromolaena odorata* and *Melia azedarach.*

One general point needs to be made relating to the urgency with which the control of some of these alien plants needs to be undertaken. During the course of this survey it was noted that plants of *Chromolaena odorata, Jacaranda mimosifolia, Melia azedarach, Opuntia* spp. *Solanum seaforthianum* and particularly *Lantana camara* were being controlled to some extent by browsing. In the case of *L. camara* plants growing outside gardens this control was absolute. Infestations of *C. odorata* were also often severely defoliated by browsers (18 out of 33 infestations for which the presence or absence of natural control was recorded). Large scale reductions in the populations of two of the most important browsers, nyala (*Tragelaphus angasi*) and impala (*Aepyceros melampus*), are currently being undertaken throughout the Complex for conservation reasons. Thus this natural control through browsing could well be significantly reduced in the years to come.

CONCLUSIONS

The threat posed by alien trees, shrubs and creepers to the longterm maintenance of natural ecosystems in the Complex is much more serious than was realized in the past.

The following actions should be taken to reduce the threat posed by alien plants to the ecosystems conserved in the Complex as well as to those elsewhere in Natal.

1. Biological control techniques should be developed for the control of *Chromolaena odorata* and *Melia azedarach* as a matter of urgency.

2. Both the above species should be declared noxious weeds throughout the republic of South Africa. The current situation whereby a garden enthusiast could intentionally introduce *Chromolaena odorata* to, say, the Eastern Transvaal is intolerable. If the controlling authorities of land outside the protected areas of Natal are not forced to control infestations of these two species on their land the protected areas will be fighting a never ending battle to control infestations within their boundaries. The damage these two species are causing to indigenous vegetation in both the protected and unprotected areas of Natal is already so great that our failure to act decisively against them now will be considered a dereliction of duty by future generations.

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APPENDIX

ALIEN PLANT SIGHTING FORM

SPECIES: .....

GRID SQUARE: .. ..

GRID QUARTER: _____

N.B. (1) Note each infestation and each species on a separate form

(2) Note all infestations you have not reported this year

(3) Indicate the appropriate categories by placing an 'X' in the space provided.

RELOCATION INSTRUCTIONS: .....

.....

.....

HABITAT: Forest ..... Forest edge ..... Riverine ..... Closed woodland ..... Open woodland ..... Grassland ..... Road edge .....

Old habitation ..... Current habitation ..... Erosion site ..... Other (specify) .....

DID YOU REMOVE THE INFESTATION? Yes ..... No .....

INFESTATION DETAILS

(1) AREA: .....m X .....m OR .....ha OR ..... m of riverine strip infested — Measured ..... Estimated .....

(2) NUMBER OF PLANTS: ..... in total OR ..... per unit area (m^2 or ha) OR ..... per unit length of riverine strip infested. — Measured ..... Estimated .....

(3) HEIGHT OF PLANTS: Maximum .....m, Mean .....m. — Measured ..... Estimated .....

(4) BASAL STEM DIAMETERS: Maximum .....cm, Mean .....cm. — Measured ..... Estimated .....

(5) REPRODUCTIVE STATE: Offspring present ..... Signs of previous fruiting ..... Currently flowering ..... Currently fruiting .....
Considered to be of reproductive size ..... Not yet reproductive size .....

(6) NATURAL CONTROL: Are the plants showing signs of being controlled naturally? — Yes ..... No .....
If so specify means (i.e. inundation, browsing, disease, etc.) .....

(7) PREVIOUS CONTROL: Are there signs of previous control operations? — Yes ..... No .....
If so (a) what percentage of treated plants have been killed? .....% — Measured ..... Estimated .....
(b) are the living plants now mostly coppicing ..... suckering from roots ..... or seedlings .....
(c) does the regrowth from treated plants appear to be unhealthy? — Yes ..... No .....

(8) FUTURE CONTROL: How many labourers (.....) working for how many days (.....) do you estimate would be required to control the infestation using what method (.....)?

Date observed: ..... Date completed form: .....

Observers name: ..... Compiler's name: ..... (where different)

To your knowledge has this infestation been reported on in previous years? Yes ..... No .....

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