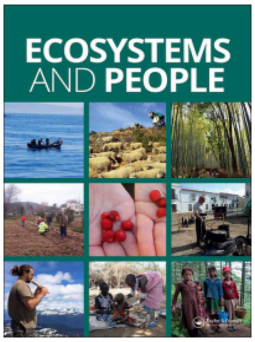

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The prevalence, uses and cultural assimilation of shrub and tree invasive alien plants in a biodiversity hotspot along the Wild Coast, South Africa

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ABSTRACT

Invasive alien plant species (IAPS) frequently offer both ecosystem services and disservices to rural communities with high livelihood dependency on local landscapes. However, biocultural relationships with IAPS may go deeper than just provisioning uses, as they may be assimilated into local belief systems manifest in them becoming embedded in cultural constructions such as naming, stories, songs and ceremonies. It is likely that IAPS that are culturally assimilated will represent a greater conflict of interest in the face of proposed controls of IAPS in biodiversity hotspots where conservation priorities are frequently deemed paramount by external agencies. Using a mixed-methods approach we undertook roadside surveys of 17 selected IAPS along the 250 km Wild Coast section of the Maputaland-Pondoland-Albany biodiversity hotspot, accompanied by questionnaire interviews with 48 local people. The mean number of IAPS per site was four, ranging from zero (only one site) to ten, and local inhabitants deemed the abundance of all but one of the species to be increasing. All species had been in the region for decades, had a vernacular name, and all but one had direct consumptive uses. Species with multiple uses were more widely recognised. However, there was only marginal incorporation of the IAPS into stories, songs and ceremonies, although medicinal uses of some IAPS were for cultural/spiritual needs rather than physical ailments per se. These results show that despite widespread use, there was as yet relatively limited cultural assimilation of the IAPS in the Wild Coast region.

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Introduction

Biodiversity hotspots are internationally recognised biogeographic regions of conservation significance and concern, characterised by both high levels of endemism and significant threats such as habitat loss and invasive alien species (Myers et al. 2000; Bellard et al. 2014). Consequently, biodiversity hotspots are an important strategy to prioritise conservation efforts globally and at more local scales (Wilson et al. 2006). Of the 34 globally recognised biodiversity hotspots, eight are located in Africa, including Madagascar, and experience a wide variety of pressures and threats (Mittermeier et al. 2004). One such threat, regarded as amongst the top three causes of biodiversity loss globally, is invasive alien species (Luque et al. 2014). For example, Early et al. (2016) found that '16% of Global Biodiversity Hotspots are highly vulnerable to alien invasive species'. However, McGeoch et al. (2010) and Witt et al. (2018) argue that in Africa the extent of research on the distribution and effects of invasive alien species is underdeveloped. Consequently, research, regulations and control measures are limited in most regions of Africa (Tuberlin et al. 2016), including in biodiversity hotspots, other than a few small-scale studies, and in South Africa. For example, Witt et al. (2018) listed 164 invasive alien plant species (IAPS) in eastern Africa, including transformer species in the Eastern Arc Mountains biodiversity hotspot. Perversely, many of those IAPS were deemed to have escaped cultivation from the Amani Botanical Garden (Witt et al. 2018). In the Guinean forest hotspot along the west African coast, Borokini (2011) described the extent of research on the species, distribution and impacts of IAPS in Nigeria as 'scanty'. Whilst many IAPS have uses to local communities, perceptions of benefits may change as the spatial extent of an IAPS increases, with consequent reductions to the flow of other valued ecosystem goods and services (Shackleton et al. 2007). For example, in the Afar region of Eastern Ethiopia, the proportion of households that viewed the IAPS *Prosopis juliflora* in a positive light declined from about 78% when it was first introduced to less than 1% approximately thirty years later as it reduced fodder and agricultural yields (Seid et al. 2020). Several localised studies have shown considerable conflicts of interest over the use and usefulness of IAPS in several African countries, such as *Prosopis juliflora* in northern Kenya (Swallow and Mwangi 2008) and the Afar region of Ethiopia (Rogers et al. 2017), or *Acacia dealbata* in Madagascar (Kull et al. 2007) and South Africa (Ngorima and Shackleton 2019).

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South Africa contains three of the global biodiversity hotspots, (Mittermeier et al. 2004), namely, the Maputaland-Pondoland-Albany, the Succulent Karoo and the Cape Floristic Region hotspots (Perera et al. 2011). The flora of South Africa is internationally recognised for its high diversity and the country contains nearly 10% of the world's plant species (UNDP 2004). The country is also considered one of the most threatened in terms of IAPS (Richardson et al. 2005; Tuberlin et al. 2016), which have the potential to detrimentally affect the diversity, composition, structure and functioning of native plant communities and consequently the ecosystem services they provide (Kieltyk and Delimat 2018; van Wilgen et al. 2022). For example, Le Maitre et al. (2016) estimated that IAPS affect around 150 million condensed hectares of South Africa and use close to 1.4 billion m^3 of water annually. Woody IAPS are of particular concern due to their often marked social, economic and ecological impacts (van Wilgen et al. 2022).

The 274 136 km^2 Maputaland-Pondoland-Albany biodiversity hotspot runs along the Indian Ocean coastal belt of South Africa and southern Mozambique and is recognised for high levels of endemism and species richness (Mittermeier et al. 2004). After the Cape Floristic Region, it is the second richest floristic region on the African continent, with 23% of plant species being endemic (Mittermeier et al. 2004). However, the hotspot is under threat from numerous pressures and changes, with only 25% of the original vegetation remaining. The Wild Coast region lies towards the southern end of this hotspot. The indigenous forests of the Wild Coast are the most species rich, non-tropical forests in the world (CEPF 2010). The area is also culturally rich and the rural populations along the Wild Coast make extensive use of local landscapes for a wide range of cultural and provisioning ecosystem services (Shackleton et al. 2007; Herd-Hoare and Shackleton 2022). Thus, they are highly susceptible to changes to the state of the surrounding natural capital (Steyn et al. 2018), including species losses or additions. Both additions and losses can be the result of the intentional or unintentional introduction of IAPS. Any net negative effects of IAPS are, however, generally more severe for poor households with high reliance on locally harvested ecosystem goods (Reynolds et al. 2020), as is the norm on the Wild Coast.

Berliner (2011) argues that IAPS are significantly impacting the biodiversity and ecosystem services of the Wild Coast, although little is known on the extent of their invasion and ecological, economic and cultural impacts (Richardson and van Wilgen 2004). Complimenting the national scale mapping in Henderson (2020), based on quarter-degree squares (that includes the Wild Coast), are a few spatially localised studies that report on one or more IAPS at specific sites, such as the extensive invasion by *Chromolaena odorata* and *Pereskia aculeata* around Port St Johns (UNDP 2004; Berliner 2011), and *Lantana camara* at Mazeppa Bay (Jevon and Shackleton 2015), or the importance of *Araujia sericifera* as a medicinal plant near Nqabara (Kierungi and Fabricius 2005). The presence of woody IAPS can affect local livelihoods, either positively or negatively, depending on the how they are used to satisfy local needs (Kull et al. 2011; Shackleton et al. 2019). For example, *Lantana camara* is used as a decorative hedge species, but escaped populations suppress recruitment of indigenous forest species (Jevon and Shackleton 2015). In the Waterberg district of Limpopo Province, South Africa, local inhabitants substitute the use of rare indigenous species with IAPS such *Schinus molle, Datura stramonium*, *Ricinus communis* and *Melia azedarach* to treat a variety of diseases such as chest complaints, blood purification, asthma, hypertension and infertility (Maema et al. 2016). Several declared IAPS are also used for medicinal purposes by communities in the Eastern Cape (Dold and Cocks 2000). The temporal evolution of such use is rarely documented and hence understandings of how IAPS are assimilated into livelihoods and cultures is opaque, even for many species that were introduced centuries ago. The embedding of local species (IAPS or otherwise) into local cultures, language, symbols and beliefs signifies a deep biocultural relationship well beyond just an economic dependency or species use just because it is present (Stryamets et al. 2021). Examples of such embedding of IAPS include the annual 'mimosa' (*Acacia dealbata*) festivals in southern France, the adoption of an IAS as the state flower or bird by several states in the USA (Pfeiffer and Voeks 2008), *Lantana camara* 'shrines' in southwestern India (Kannan 2011), and *Robinia pseudoacacia* in music and rituals in central Argentina (Martínez and Manzano-García 2019).

Within the above context, this study investigated the prevalence of 17 selected shrub and tree IAPS along the Wild Coast biodiversity hotspot, in conjunction with local peoples' knowledge, use and attitudes towards them. The study asked the following key questions: (1) Which shrub and tree IAPS are common along the Wild Coast? (2) How do local communities on the Wild Coast perceive trends in the prevalence of these IAPS? (3) Do local people make direct use of any of the 17 species and (4) Have any of the 17 species been incorporated into local cultures?

Study area

The Wild Coast is a colloquial and now tourist marketing name given to a roughly 250 km stretch of rugged and undeveloped coastline in the Transkei region of the Eastern Cape province of South Africa, named after the rough seas and inaccessible and inhospitable coastline that characterise the region (Dennison 2010). It is defined as the coastal area stretching between the Great Kei River (32° 40.5' S; 28° 22.9'E) in the south to the Mtamvuna River (31° 3.0'S; 30° 11.5 E) in the north (Steyn et al.

2018). The Indian Ocean and the rural interior define the Wild Coast's eastern and western extents, respectively (Steyn et al. 2018). The entire area area falls within the Maputaland-Pondoland-Albany biodiversity hotspot with high levels of endemism and threatened species (CEPF 2010).

A rugged coastline, dissected by multiple small rivers, defines the terrestrial landscape with rolling hills moving inland (Mucina and Rutherford 2006). The altitude ranges from 0–600 m (Mucina and Rutherford 2006). The Wild Coast includes portions of five of South Africa's nine vegetation biomes, with the grassland, savanna and forest biomes comprising the largest areas (UNDP 2004). The region has a warm, temperate and humid climate. Mean temperatures range between 27°C in summer (October – May) and 8°C in the winter (June – September) (Jevon and Shackleton 2015). Mean annual rainfall is approximately 1,000 mm and most occurs in the summer months, although on average, 36% falls in winter. The geology of the area is classified under the broader Karoo Supergroup. Glenrosa and Mispah soil types dominate the landscape making up shallow sandy and clay loams (Mucina and Rutherford 2006).

The land is under communal tenure and at the local scale is administered by a hierarchy of chiefs and headmen/women. Homesteads are mostly scattered along the higher ground and ridges (Timmermans 2002). Many locals identify as farmers of livestock and arable land (Shackleton and Hebinck 2018), although very few make a secure living from such. Thus, households have a diverse range of cash incomes and livelihood strategies, with government social grants being the most important source of cash for most households and harvesting of locally available provisioning ecosystem services (such as firewood, wild foods, building timber, medicinal plants and various plant fibres) being an underacknowledged mainstay (Herd-Hoare and Shackleton 2022). Within the South African context, it is one of the poorest regions, characterised by inadequate infrastructure, services and employment opportunities, and deep poverty. Approximately 75% of households live below the poverty line (Statistics South Africa 2012). The processes of deagrarianisation and migration to urban centres is advanced (Shackleton et al. 2019). isiXhosa is the most widely spoken language within the region (Steyn et al. 2018).

Methods

Data collection

Prevalence of shrub and tree IAPS

The distribution and abundance of IAPS is strongly influenced by the suitability of a habitat and dispersal corridors (Mortensen et al. 2009). Disturbed sites along roadsides are often characterised by plant invasions (Mortensen et al. 2009). Roadside surveys thus provide a useful means of assessment when the spatial, economic and temporal scope of a study is constrained (Rejmánek et al. 2016; Baard and Kraaij 2019). Roadside surveys are both practical and economically efficient (Shuster et al. 2005). They are also time efficient whilst allowing for the rapid collection of ecological and social data pertaining to IAPS (Baard and Kraaij 2019) and the identification of the most prominent ones (Henderson 1992; Rew and Pokorny 2006).

Roadside surveys were used to survey the length of the Wild Coast seaboard (Steyn et al. 2018). The travel route followed the network of untarred roads lying closest to the coast, thereby sampling within the Indian Ocean Coastal Belt biome of the Maputaland-Pondoland-Albany biodiversity hotspot. Samples were taken at approximately every 5 km distance along a road, starting in the south at the Great Kei River mouth. Stopping points were influenced by the need to observe road safety and also to approximate more-or-less a 5 km linear distance from the preceding sample point (i.e. some allowance was made if a section of road was windy with U-bends (such as going down a steep slope). There were 50 samples in total.

At each sample point a 200 × 200 m (4 ha) plot was delineated 10 m away from, and with one side parallel to, the road. The plot was always on the side of the road closest to the coast. Each plot was then surveyed for the presence or absence of 17 shrub and tree IAPS known to occur along the Wild Coast from authoritative field guides (Stirton 1985; Bromilow 2014; Henderson 2020), namely *Acacia mearnsii* De Wild., *Caesalpinia decapetala* (Roth) Alston, *Casuarina equisetifolia* L., *Cestrum laevigatum* Schltdl., *Chromolaena odorata* (L.) R.M. King & H. Rob., *Eucalyptus grandis* W. Hill ex Maiden, *Lantana camara* L., *Melia azedarach* L., *Morus alba* L., *Opuntia ficus-indica* (L.) Mill., *Plectranthus comosus* Sims, *Psidium guajava* L., *Ricinus communis* L., *Senna didymobotrya* (Fresen.) Irwin & Barneby, *Sesbania punicea* (Cav.) Benth., *Solanum mauritianum* Scop. and *Tecoma stans* (L.) Kunth. This list includes the eight most widespread IAPS on the Wild Coast reported by Zachariades et al. (2005) (i.e. *A. mearnsii*, *C. decapetala*, *C. laevigatum*, *C. odorata*, *Eucalyptus* spp., *L. camara*, *S. didymobotrya* and *S. mauritianum*).

Knowledge, perceptions and attitudes towards woody plant IAPS

At each sample point an unstructured interview with a local respondent was held. The closest homestead to the stationary vehicle was selected and an interview conducted with any willing adult respondent. If there was nobody at home in the closest homestead, or they declined to be interviewed, the next nearest one was approached. Forty-eight interviews were conducted because at two points no willing adult was available. The interviews were conducted verbally with the assistance of an isiXhosa-speaking translator.

The interview (Appendix 1) covered respondents' knowledge, perceptions, experiences and attitudes towards the 17 IAPS and comprised of two sections. The first section gauged a respondent's knowledge, experiences, perceptions and attitudes towards each of the 17 listed IAPS on the Wild Coast. Photographs of each of the 17 IAPS were presented sequentially to each respondent, and for each one they were asked if they had seen it in their immediate area, and if it had a local name. Participants that indicated they did know the species and/or it was present locally, were asked further about each species they knew in terms of their experiences, perceptions and attitudes towards the particular IAPS, and its uses as well as mention in songs, and stories or significance during rituals and celebrations. The unstructured format allowed follow-up questions and discussions if the responses to particular questions were insightful. The second section of the questionnaire captured a respondent's characteristics, such as age, gender, occupation, home language, place of residency, education level and period of local residency. The research protocol and interview schedule were approved by the Rhodes University Ethical Standards Committee (no. 2019–0586–528). Verbal informed consent was obtained from all research participants, using the consent form approved by the ethics committee. The sample size was small due to the design of the interview. Specifically, we prompted a number of questions about 17 different IAPS, which required considerable time. Furthermore, most of the questions were open-ended, which allowed us to ask follow-up questions based on the initial responses of any respondent, especially in relation to uses and cultural adoption of IAPS. Depending on the number of IAPS a respondent knew, the duration of each interview was between 75 minutes and three hours. Given the small sample size, the results should be viewed as indicative, rather than representative. Nevertheless, they provide a first assessment of the local knowledge and cultural uses of IAPS in this internationally recognised biodiversity hotspot.

Data analysis

The data were entered in Microsoft Excel and imported into R Studio for analysis. The prevalence of each IAPS was determined by the frequency of the 50 sample sites where it was recorded. The information from the interviews was summarised via counts because there was limited information on cultural assimilation to warrant a more interpretative approach such as thematic analysis.

Results

Profile of respondents

The 48 respondents were equally distributed between males and females (i.e. 24 each). The age ranged from 19 to 99 years old, with a mean of 49. 6 ± 17.4 years. One-fifth of the respondents had three or fewer years of formal schooling, whilst the mean was 7.3 ± 4.2 years. The vast majority (86%) had lived their entire lives on the Wild Coast, and two-thirds (69%) had spent their whole lives in the village where we interviewed them. Almost half (48%) stated that they were unemployed (but some engaged in arable or livestock agriculture), and a third were retirees. The remainder were engaged in a variety of occupations such as construction work, tour guiding, cleaning, student, small-business and estate management.

Prevalence of selected shrub and tree IAPS along the Wild Coast

Nine of the 17 IAPS were recorded at 20% or more of the sample sites (Table 1). *Cestrum laevigatum* was the most prevalent, present at 78% of the sample sites, followed by *Psidium guajava* (58%) and *Lantana camara* (48%). Four species were recorded at only a single site, and *Tecoma stans* was not found at any of the sites (and hence is not discussed further in the paper). The number of species recorded per site ranged from zero to ten, with an average of 4.1 ± 2.36. At only one of the fifty sample sites were none of the 17 IAPS observed, whilst five sites had only one present.

The results from the interviews indicated a higher prevalence in the area of 12 of the 17 IAPS than recorded via the sample plots, whilst two were lower and three were in relatively similar proportions. The most common IAPS based on the interviews were *P. guajava*, *O. ficus-indica*, *E. grandis*, *C. laevigatum* and *C. decapetala*, which were all reported to be present at more than half the sample locations.

Temporal dynamics

Most, if not all, of the IAPS have been present along the Wild Coast for decades because the responses from the most elderly respondents (>64 years; $n = 10$) indicated that 11 of the 17 species were present in local landscapes from their earliest memories as young children. This also applied with respect to the other five species, but the number of elderly respondents commenting on these five species was low (<4). Moreover, most respondents (not just the elderly) opined that the abundance of most of the target

Table 1. The proportion (%) of sites and interviews in which each of the 17 target shrub and tree IAPS were recorded.

Species	Family	% of sites ($n = 50$)	% of interviews ($n = 48$)
Acacia mearnsii	Fabaceae	28	48
Caesalpinia decapetala	Fabaceae	36	52
Casuarina equisetifolia	Casuarinaceae	2	26
Cestrum laevigatum	Solanaceae	78	60
Chromolaena odorata	Asteraceae	22	6
Eucalyptus grandis	Myrtaceae	24	92
Lantana camara	Verbenaceae	48	44
Melia azedarach	Meliaceae	6	16
Morus alba	Moraceae	2	46
Opuntia ficus-indica	Cactaceae	8	92
Plectranthus comosus	Laminaceae	2	48
Psidium guajava	Myrtaceae	58	94
Ricinus communis	Euphorbiaceae	12	26
Senna didymobotrya	Fabaceae	24	46
Sesbania punicea	Fabaceae	2	3
Solanum mauritianum	Solanaceae	36	62
Tecoma stans	Bignoniaceae	0	0

IAPS has increased over the last decade (Table 2), indicating that they are still in an expansive phase. The exceptions were *S. punicea*, which was deemed to have reduced dramatically and *T. stans*, which was not known by the respondents nor found in the field samples. There was a positive, although marginally unsignificant, relationship between the percentage of sites occupied by each IAPS and the proportion of respondents stating that a given species was increasing ($r^2 = 0.229$; $p = 0.061$).

Given their long presence in the area, all the species had local vernacular names (Table 3), generally describing some physical feature of the species, such as the spines or the way it grows. Most were also used for one or more purposes (Table 4). More than 50% of the respondents reported using *E. grandis*, *M. azerdarach*, *P. comosus* and *R. communis* medicinally (Table 4) and more than 85% of respondents relished the fruits of *P. guajava*, *O. ficus-indica* and *M. alba*. However, more than 50% of respondents stated that *C. decapetala, S. didymobotrya* and *C. odorata* have no uses. There was a significant positive relationship between the number of use categories that a species fulfilled (Table 4) and the proportion of respondents who knew the species ($r^2 = 0.271$; $p = 0.038$), indicating that more useful species were more widely known. The widespread use and naming of most of the species did not extend into their use in specific ceremonies or incorporation into local songs or stories. Amongst the 48 respondents, only seven mentions were made of IAPS being used for specific ceremonies or celebrations. *Acacia mearnsii* was mentioned by one respondent as being used during the construction of pens where sacrificial goats would be slaughtered. Two mentions were made of using *E. grandis* to ward off evil spirits, with one other respondent saying that *P. guajava* was used for the same purpose. One respondent said that *P. comosus* was used by diviners, but he did not know for what purpose, whilst *C. decapetala* was used to bathe newborn twins (one respondent) and also planted on grave sites to ward off animals (one respondent). Two reports were made regarding IAPS being mentioned in traditional songs or stories, one for *O. ficus-indica* and one for *S. didymobotrya*.

Despite the numerous and widespread uses, most of the respondents were concerned about the increasing spread of the different IAPS and

Table 2. Local perceptions towards changes in the prevalence of shrub and tree IAPS over the last decade (Note: the number of respondents varies per species).

Species	Increased (%)	No Change (%)	Decreased (%)
Acacia mearnsii	87	9	4
Caesalpinia decapetala	76	16	8
Casuarina equisetifolia	75	17	8
Cestrum laevigatum	90	7	3
Chromolaena odorata	100	0	0
Eucalyptus grandis	86	7	7
Lantana camara	76	19	5
Melia azerdarach	50	38	12
Morus alba	59	9	32
Opuntia ficus-indica	48	36	26
Plectranthus comosus	91	4	5
Psidium guajava	89	9	2
Ricinus communis	67	25	8
Senna didymobotrya	77	18	5
Sesbania punicea	0	0	100
Solonum mauritianum	69	17	14
Average	**71 ± 24**	**14 ± 11**	**15 ± 24**

Table 3. Local names and meanings of shrub and tree IAPS on the Wild Coast.

Species	isiXhosa names on Wild Coast	% of respondents mentioning the name	Meaning or origin of local name
Acacia mearnsii	uBlekwana	50	No specific meaning
	Ndywabasini	35	Describes the weak structure of the tree
Caesalpinia decapetala	Lubobo	80	Refers to the thorns
Casuarina equisetifolia	Bhompisi	25	No specific meaning
Cestrum laevigatum	Uminki	91	Refers to the dark juice ('ink') of the fruits
Chromolaena odorata	Sandanezwe	100	Describes its spreading nature
Eucalyptus grandis	Umgamtriya	89	Gum tree
Lantana camara	Utywala bentaka	29	Birds relish the fruits like some people relish alcohol
Melia azerdarach	Msilinga	75	No specific meaning
Morus alba	Umqunube	55	No specific meaning
Opuntia ficus-indica	Tolofiya	100	Refers to the spines
Plectranthus comosus	LiBoza	26	No specific meaning
Psidium guajava	Igwava	93	An adaptation of the English common name for the fruits (guava)
Ricinus communis	Umcakuva	75	No specific meaning
Senna didymobotrya	Umbadlalanga	45	It describes the sound made by the pods when they shake
Sesbania punicea	Fenisi	100	No specific meaning
Solonum mauritianum	Umbangabanga	87	Refers to the way the plant grows

Table 4. Reported uses of 16 shrub and tree IAPS on the Wild Coast (values are % of respondents).

	Use category									
Species	Medicine (humans)	Medicine (animals)	Cultural	Aesthetics	Fruit	Timber	Fuelwood	Hedge	Other	No Use
A. mearnsii	35	5	0	0	0	26	52	9	0	0
C. decapetala	4	4	7	0	7	0	4	11	7	59
C. equisetifolia	0	0	0	0	0	50	17	8	25	25
C. laevigatum	6	6	0	9	0	0	25	44	3	19
C. odorata	0	0	0	0	0	0	0	0	33	67
E. grandis	71	0	0	0	0	50	25	10	4	0
L. camara	0	0	0	0	47	0	0	5	0	43
M. azerdarch	63	0	13	0	0	0	0	13	13	13
M. alba	8	0	0	0	88	0	0	0	0	0
O. ficus-indica	13	4	0	0	88	0	0	2	4	0
P. comosus	75	0	0	8	0	0	0	4	0	13
P. guajava	25	0	0	0	92	0	2	0	0	0
R. communis	17	67	0	0	0	0	0	8	0	8
S. didymobotrya	9	0	0	9	0	0	0	0	9	70
S. punicea	0	0	0	100	0	0	0	0	0	0
S. mauritianum	16	6	3	0	3	0	22	0	6	34

therefore most (85%) would welcome some sort of management initiatives, ranging between 75% for *M. azedarach* to 100% for six of the species. Of those advocating for management, 52% favoured some sort of control on the spread and where the IAPS can be grown and the remaining 48% argued for their complete removal. This was because of some species 'taking over' and/or having negative effects or risks (such as being thorny, poisonous, itchy, giving cover to snakes, roots damaging walls or using 'too much' water). Nobody stated that they should be managed or controlled because they were not native to South Africa. Indeed, very few respondents knew that one or more species were not native, ranging from 0% for *C. odorata*, *M. azedarach*, *M. alba*, *R. communis* and *S. punicea*, to 25% for *C. equisetifolia*. Nearly all (94%) stated that local residents should be in charge of any management or control strategies. The minority felt that it was the responsibility of government, or a partnership between government and locals.

Discussion

This study investigated the prevalence and extent of cultural assimilation of 17 tree and shrub IAPS in a globally recognised biodiversity hotspot. We found that most of the targeted IAPs were common along the Wild Coast (except *T. stans*, which was not recorded at any of the sample sites), with most sites harbouring multiple IAPS. Secondly, the targeted IAPS were widely known by local people and all had vernacular names and all had one or more direct uses. Local respondents stated that the extent of all but one of the IAPs (*S. punicea*) was expanding. Despite their long history in the region, their continued increasing abundance and their multiple uses amongst local communities, there was relatively little cultural assimilation into songs, stories and ceremonies or rituals as indicators of deeper biocultural relationships.

However, given a lack of similar studies it is difficult to assess this lack of cultural assimilation.

Overall, this study provides a broad picture of the prevalence of 17 shrub and tree IAPS along the Wild Coast section of the Maputaland-Pondoland-Albany biodiversity hotspot. Following Henderson (2020), it shows that most of the IAPS are widely distributed and that individual sites frequently harbour several species. Only one of the fifty sample sites had none of the 17 IAPS present. The respondent interviews indicated a greater prevalence of most of the target IAPs than was enumerated via the plots, which is likely to be a consequence of their knowledge of a wider area than just the 4 ha plot that we sampled per site. This indicates the value of a mixed-methods approach. Not only were the IAPS widespread, but the majority of local respondents were of the opinion that, firstly, they had been in the area for several decades, and secondly, that the abundance of all but one of the species (*S. punicea*) had increased over the last decade. It is possible that the perceived decline in *S. punicea* is the result of biocontrol agents (Hoffman and Moran 1991). Additionally, there was a hint that the more widely distributed a species was, the more people felt it was increasing, substantiating the concerns voiced by Berliner (2011) a decade ago. These results indicate that any implications for ecosystem services and livelihoods on the one hand, and biodiversity conservation in this hotspot on the other, are increasing and are likely to intensify in the short- to medium-term in the absence of any control programmes. This may be exacerbated through interactions with the effects of climate change (Hellman et al. 2008). Particularly pertinent is the recent work of Reynolds et al. (2020) in South Africa showing that the poor, and those most reliant on locally harvested ecosystem services, are most detrimentally affected by IAPS. Communities along the Wild Coast fit this profile and thus are likely to experience increasing impoverishment if the IAPS continue to spread unchecked, despite local-scale use of the species. Thus, the spread of IAPS in the region should not be solely an ecological or conservation concern, but also a human wellbeing one if, and when, disservices come to outweigh services (Shackleton et al. 2007, 2019; Reynolds et al. 2020).

Consideration of any control programmes would have to include the availability of substitute species to provide the current benefits obtained from most of the IAPS surveyed in this study. For example, the hedging benefits of *L. camara* and *P. comosus*, the relatively large and tasty fruits of *M. alba*, *O. ficus-indica* and *P. guajava* or the use of *A. mearnsii* for firewood and construction. Additionally, it is not just that these IAPS offer such benefits, but also that they grow relatively fast and are hardy, which makes them attractive options compared to many native species. Nevertheless, despite their widespread use for one or more purposes, local respondents voiced some concerns about their increasing spread and felt that some degree of control was necessary, not because they were non-native species, but because they caused some perceived ‘harm’ to other species or livelihoods. Similar difficulties in weighing up the ecosystem services and disservices provided by IAPS have been reported elsewhere in the Eastern Cape province (Shackleton et al. 2007; Ngorima and Shackleton 2019) and globally (Chikuni et al. 2004; Rai and Scarborough 2015).

The introduction of an effective management or control program will also require a significant amount of human and financial capital. Seeing that the Wild Coast region is largely impoverished (Statistics South Africa 2012), it is likely that the funding for such a program will have to come from the South African Government or private sector. The South African government initiated public work programmes, such as the Working for Water (WfW) programme (van Wilgen et al. 2022), have the potential to empower local residents in terms of achieving their conservation goals whilst also providing employment, skills training and income. Furthermore, it is also in the interest of national and international conservation bodies to support the control of IAPS species in the region. However, the majority of the respondents cited that they would like to control any IAPS management activities and it is therefore crucial that they are engaged as meaningful stakeholders and partners. This could range from citizen science initiatives to map and monitor IAPS (such as in the Hudson River Valley in the USA (Garretson et al. 2022)) to involvement in actual clearing or removal. However, Kalnicky et al. (2019) show that active engagement in actual control of invasive alien species is influenced by prior ‘experience with and exposure to’ the target species. The desire to be active partners and even control any clearing initiatives echoes the sentiments of private land-owners and managers in the Western Cape province (Urgenson et al. 2013).

South Africa is widely recognised as a biodiverse country, and also one affected by hundreds of different IAPS (Bennet and van Sittert 2019; van Wilgen et al. 2022). The country has robust research and monitoring programmes, along with strong legislation, around IAPS generally and the national government has allocated significant finances to clear IAPS, especially in riparian zones and water scarce catchments (Bennet and van Sittert 2019; van Wilgen et al. 2022). This has been accompanied by media and education campaigns. However, very few of the respondents in our study knew that the species we were asking about where not native to South Africa. A similar observation was reported by Shackleton and

Shackleton (2016) amongst urban residents, and Shackleton et al. (2007) reported that the respondents in a particular rural village were quite upset when informed that *Opuntia ficus-indica* was not native to South Africa, declaring that it was a 'plant of their ancestors'. Thus, if government and/or conservation agencies are going to enlist the cooperation of landowners and the public in any efforts to check particular IAPS, it is clear that more vigorous education and awareness programmes are necessary and must include remote communities, and those in biodiversity hotspots, such as along the Wild Coast.

It is widely acknowledged that exotic plants (including some IAPS) are common components of ethnoparmacopoeia and food plants around the world (e.g. Bennett and Prance 2000). We considered the extent of integration of the 17 IAPS into local knowledge and culture beyond just the direct uses for food, medicine and construction. All of the IAPS had a vernacular isiXhosa name, although not all respondents knew the vernacular name for each species. Naming of places and species in a landscape is the very basis of biocultural relationships (Fagúndez and Isco 2016; Stryamets et al. 2021), although as Strymets et al. (2021) showed, local communities can still make use of particular species even if they do not know the name of the species they are using. The results showed that the species with the most uses were the most recognised by the survey respondents, echoing the findings of dos Santos et al. (2014) regarding the use of IAPS in Brazil. However, there was little evidence of deeper biocultural relationships, with only seven mentions of some of the IAPS (six different species, i.e. only 1–2 mentions per species) being used for specific ceremonies or celebrations, and even fewer regarding their mention or incorporation into traditional songs and stories. However, some of the medicinal uses did relate to cultural/spiritual uses rather than to cure or alleviate physical ailments. The use of multiple medicinal plant species for ritual purification is particularly strong amongst the amaXhosa of the Eastern Cape (Cocks and Dold 2006), including both alien and IAPS (Dold and Cocks 2000). Albuquerque (2006) interprets the widespread use of exotic plant species as a process of diversification rather than acculturalisation.

The low assimilation into all facets of local culture is in contrast to their widespread use and begs the question whether their absence from deeper cultural phenomena is due to them being relative 'newcomers' in the landscape (albeit many decades ago) or cultural resistance? Do the few mentions recorded in our research represent the very start of a deeper cultural assimilation, or are they simply 'anomalies' that will not advance any further? Studies of the ethnobotany of human migrants shows that there is considerable adaptability in the use of species previously unknown to them that are found in their new homes, but also a strong continuity of use of the same or similar species available in the previous 'homeland' (e.g. Fonesca and Balick 2018).

In conclusion, the roadside survey employed in this study revealed that most of the 17 shrub and tree IAPS are widespread along the Wild Coast, an internationally recognised biodiversity hotspot. Roadsides are known to be high disturbance sites, but establishment of IAPS along roadsides allows further dispersal away from roadsides with time. Indeed, the interviews with the local residents indicated a higher presence of most of the IAPS than was recorded via the roadside surveys. The long history and widespread distribution of the IAPS in the region have facilitated the emergence of local vernacular names and knowledge regarding particular livelihood uses for most of the species. However, there was only nascent deeper cultural assimilation into stories, songs and rituals. The widespread presence of numerous IAPS in a biodiversity hotspot characterised by remote, rural communities raises conservation and livelihood concerns. Given the extent and poor accessibility of large parts of the Wild Coast, some sort of triage approach (van Wilgen et al. 2022) will be required in planning of any integrated control or management initiatives in partnership with local communities.

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Appendix 1: Interview Prompt Sheet (** for questions reported in this paper; i.e. the prompt sheet had additional questions that have been removed)

Site no: **Date:**

IAPS Name: **Survey No:**

Questions

(1) Do you know of any local names for this plant?
(2) If so, what are they?
(3) Do any of the names have a specific meaning?
(4) When did you first observe this particular plant species in this area?
(5) Do you think the local abundance of this plant is changing?
(6) If so, do you think its presence has increased or decreased over the last 10 years?
(7) Have you seen this plant in any other areas along the Wild Coast?
(8) If so, where?
(9) Do you know of anyone from the area who makes use of this plant?
(10) If so, how do they make use of it?
(11) Do you think this plant is useful?
(12) If so, why?
(13) If not, why?
(14) Is the plant used in any specific ceremonies or celebrations?
(15) If so, how is it incorporated?
(16) Is the plant a part of any local songs or stories?
(17) If so, how is it incorporated?
(18) Do you think the growth of this plant should be managed?
(19) If so, how do you think it should be controlled?
(20) If so, who do you think should be in charge of controlling it?
(21) If so, do you think the plant should be removed from your local area?
(22) Are you aware that this plant is not originally from South Africa?

Age: Gender: Home language:
Occupation: Highest Level of Education: Place of residency:
No. of years spent living on the wild coast: No. of years living near this site?