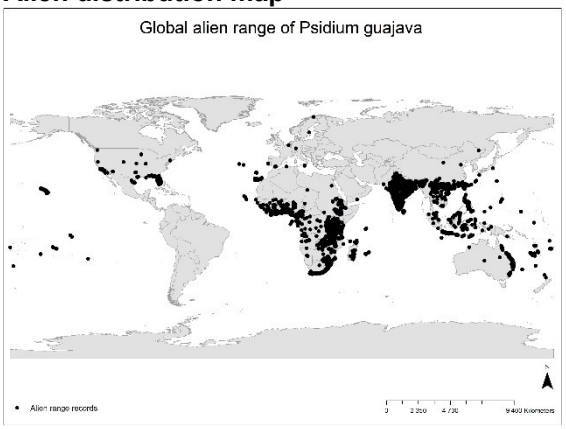
Risk Analysis Report

Taxon: *Psidium guajava* L.	***Area:*** South Africa
Approved by: The South African Alien Species Risk Analysis Review Panel on 27 March 2024	
Picture of *Taxon*  Photo: iNaturalist, (17 May 2022) https://www.inaturalist.org/observations/120012014	**Alien distribution map**  GBIF.org (17 May 2022) GBIF occurrence download, from: https://doi.org/10.15468/dl.azbacf

Risk Assessment summary:	**Risk score:**
Psidium guajava was introduced to South Africa mainly for its edible fruits. *Psidium guajava* is invasive in the higher rainfall areas of South Africa and is largely restricted to wetter sites (e.g., riverine areas). The seeds of *P. guajava* are mainly dispersed by fruit-eating birds and bats, but also by other animals and people. Information from South Africa and elsewhere in the world show that invasive populations of *P. guajava* can alter soil properties, change the composition and function of decomposers, and supress native flora.	High
Management options summary:	**Ease of management:**
Psidium guajava is relatively easy to manage and management can be achieved without substantial training. Guava fruit is valued both commercially and by communities. Access to peoples' gardens and guava farms for potential management would require permission. The regenerative abilities of *P. guajava* from suckers and resprouts suggest that repeated control efforts, even after herbicide application, are required.	Medium
Recommendations: Given the risks and impacts caused by *P. guajava* and the value of the fruit industry, regulation as category 2 appears warranted. Since the drier parts of the country are unsuitable, but the plant is still cultivated in gardens and where irrigated it is recommended that exemptions are made for the Free State, Gauteng, Northern Cape, the North-West, and the Western Cape. Notably, the current regulation in the North-West Province does not appear to be justified. It would be impractical to ban the use of guava for human consumption and subsistence livelihood and so exemptions seem warranted in these cases. Given these complexities, a national management plan is recommended as a priority particular given the need to raise awareness regarding *P. guajava* invasions and their impacts.	**Listing under NEM:BA A&IS lists of 2021:** Various (see Appendix MAN6) **Recommended listing category:** 2 (with exemptions see Appendix MAN6)

Suggested citation: SANBI (unpublished) Risk analysis of *Psidium guajava* L. for South Africa as per the risk analysis for alien taxa framework v1.2, approved by the South African Alien Species Risk Analysis Review Panel on 27 March 2024, pp 17, http://dx.doi.org/10.5281/zenodo.10888266

1. Background

BAC1–BAC3 Names and contact details of assessors and experts consulted are redacted	
BAC4 Scientific name of *Taxon* under assessment	
Taxon name: *Psidium guajava*	Authority: L.
Comments: *Psidium guajava* is the scientific name of the taxon under assessment. The taxonomic status of *Psidium guajava* has been accepted (Integrated Taxonomic Information System 2022).	
References: Integrated Taxonomic Information System (ITIS), 2022, *Psidium guajava* L., viewed 13 May 2022, from https://www.itis.gov/servlet/SingleRpt/SingleRpt#null.	
BAC5 Synonym(s) considered	
Synonyms: *Guaiava pyriformis* Gaertn. | *Guajava pumila* (Vahl) Kuntze | *Guajava pyrifera* (L.) Kuntze.	
Comments: Several synonyms (14–41) exist for *Psidium guajava*. There are no listed synonyms in the ITIS database (ITIS 2022). Therefore, this assessment considered the three synonyms listed above from the Global Biodiversity Information Facility (GBIF 2022) and World Checklist of Selected Plant Families (WCSP 2022) in its literature search.	
References: Global Biodiversity Information Facility (GBIF), 2022, *Psidium guajava* L., viewed 16 May 2022, from: https://www.gbif.org/species/5420380. Integrated Taxonomic Information System (ITIS), 2022, *Psidium guajava* L., viewed 13 May 2022, from https://www.itis.gov/servlet/SingleRpt/SingleRpt#null. World Checklist of Selected Plant Families (WCSP), 2022, *Psidium guajava* L., viewed 16 May 2022, from: https://wcsp.science.kew.org/namedetail.do?name_id=166741.	
BAC6 Common name(s) considered	
Common names: Guava | abas | goyavier | guabang | kuahpa | kautonga	
Comments: Six common names of *P. guajava* are listed in the ITIS database (ITIS 2022). This assessment only considered these common names in its literature search (noting that only “guava” is widely used in South Africa (Henderson 2020).	
References: Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266. Integrated Taxonomic Information System (ITIS), 2022, *Psidium guajava* L., viewed 13 May 2022, from https://www.itis.gov/servlet/SingleRpt/SingleRpt#null.	
BAC7 What is the native range of the *Taxon*?	
Response: Central America | South America	Confidence: Medium
Comments: In the Global Invasive Species Database (2022) and in Morton (1987), *P. guajava* is reported to be native to central America from Mexico to northern South America (Belize; El Salvador; Guatemala; Honduras; Mexico; Nicaragua; Panama; Colombia; Ecuador; and Venezuela). The confidence level is medium because the exact native range of *P. guajava* is uncertain.	
References: Global Invasive Species Database (GISD), 2022, *Psidium guajava* L., viewed 17 May 2022, from: http://www.iucngisd.org/gisd/speciesname/Psidium+guajava. Morton, J. F.,1987, *Fruits of warm climates* (pp. 91–102). Winterville, NC: Creative Resource Systems Inc.	
BAC8 What is the global alien range of the *Taxon*?	
Response: Africa | Asia | Europe | North America | South America | Oceania	Confidence: Medium
Comments: *Psidium guajava* has been recorded in numerous (over 50) countries (including Algeria, Australia, South Africa) outside of its native range (GBIF 2022; GISD 2022; CABI 2022). The confidence level is medium because the exact native range of *P. guajava* is uncertain.	
References: Global Biodiversity Information Facility (GBIF), 2022, *Psidium guajava* L., viewed 16 May 2022, from: https://www.gbif.org/species/5420380.	

Global Invasive Species Database (GISD), 2022, *Psidium guajava* L., viewed 17 May 2022, from: http://www.iucngisd.org/gisd/speciesname/Psidium+guajava.

CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141.

BAC9 Geographic scope = the *Area* under consideration

Area of assessment: South Africa

Comments: The geographic scope of this assessment is limited to South Africa.

BAC10 Is the *Taxon* present in the *Area*?

Response: Yes	Confidence: High

Comments: In South Africa, *P. guajava* is present in the Eastern Cape, Western Cape, Mpumalanga, KwaZulu Natal and Limpopo (iNaturalist 2022; SANBI 2016). It is recorded as an invasive species, where it tends to invade coastal areas, watercourses, forest margins, roadsides and abandoned agricultural land (GBIF 2022; Henderson 2020; Nel et al. 2004; Ruwanza & Dondofema 2019; SANBI 2016).

References:

Global Biodiversity Information Facility (GBIF), 2022, viewed 16 May 2022, from https://www.gbif.org/species/5420380.

Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266.

iNaturalist, 2022, 'Common Guava', viewed 24 May 2022, from:https://www.inaturalist.org/observations?place_id=any&subview=map&taxon_id=62859.

Nel, J.L, Richardson, D.M., Rouget, M., Mgidi, T.N., Mdzeke, N., Le Maitre, D.C., et al., 2004, 'A proposed classification of invasive alien plant species in South Africa: towards prioritizing species and areas for management action', *South African Journal of Science* 100, https://journals.co.za/doi/pdf/10.10520/EJC96213.

Ruwanza, S. & Dondofema, F., 2020, 'Effects of exotic guava (*Psidium guajava* L.) invasion on soil properties in Limpopo, South Africa', *African Journal of Ecology 58*(2), 272-280. https://doi.org/10.1111/aje.12675.

South African National Biodiversity Institute (SANBI), 2016, Botanical Database of Southern Africa (BODATSA), viewed 17 May 2022, from http://posa.sanbi.org/sanbi/Explore.

BAC11 Availability of physical specimen

Response: Yes	Confidence in ID: High

Herbarium or museum accession number:

Herbarium – PRE, Accession number – PRE0566346-0 (collected and identified by L. Henderson, 1997).

Herbarium – NH, Accession number – NH014161-0 (collected and identified by R. Lalla, 2013).

References:

South African National Biodiversity Institute (SANBI), 2016, Botanical Database of Southern Africa (BODATSA), viewed 17 May 2022, from http://posa.sanbi.org/sanbi/Explore.

BAC12 Is the *Taxon* native to the *Area* or part of the *Area*?

The *Taxon* is native to (part of) the *Area*.	No	Confidence: High
The *Taxon* is alien in (part of) the *Area*.	Yes	Confidence: High

Comments: *Psidium guajava* is native to central America from Mexico to northern and South America (GISD 2022; Henderson 2020; WCSP 2022). However, there is some uncertainty regarding the exact native range of *P. guajava*.

References:

Global Invasive Species Database (GISD), 2022, *Psidium guajava* L., viewed 17 May 2022, from: http://www.iucngisd.org/gisd/speciesname/Psidium+guajava.

Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266.

World Checklist of Selected Plant Families (WCSP), 2022, *Psidium guajava* L., viewed 16 May 2022, from: https://wcsp.science.kew.org/namedetail.do?name_id=166741.

BAC13 What is the *Taxon*'s introduction status in the *Area*?		
The *Taxon* is in cultivation/containment.	Yes	Confidence: High
The *Taxon* is present outside of cultivation/containment.	Yes	Confidence: High
The *Taxon* has established/naturalised.	Yes	Confidence: High
The *Taxon* is invasive.	Yes	Confidence: High

Comments: *Psidium guajava* was introduced to South Africa in the 1860s (Pereira et al. 2017) mainly for the edible fruits (Henderson 2020; Pereira et al. 2017). *Psidium guajava* is found outside of cultivation and is well established and invasive along watercourses, forest margins, and disturbed areas such as old agricultural fields, roadsides, and pastures (Henderson 2020; Nel et al. 2004; Ruwanza & Dondofema 2019).

References:

Global Biodiversity Information Facility (GBIF), 2022, *Psidium guajava* L., viewed 16 May 2022, from: https://www.gbif.org/species/5420380.

Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266.

Nel, J.L, Richardson, D.M., Rouget, M., Mgidi, T.N., Mdzeke, N., Le Maitre, D.C., et al., 2004, 'A proposed classification of invasive alien plant species in South Africa: towards prioritizing species and areas for management action', *South African Journal of Science* 100, doi https://journals.co.za/doi/pdf/10.10520/EJC96213.

Pereira, F.M.P., Usman, M., Mayer, N.A., Nachtigal, J.C., Maphanga, O.R. & Willemse, S., 2017, 'Advances in guava propagation', *Revista Brasileira de Fruticultura* 39.

Ruwanza, S. & Dondofema, F., 2020, 'Effects of exotic guava (*Psidium guajava* L.) invasion on soil properties in Limpopo, South Africa. *African Journal of Ecology 58*(2), 272-280. https://doi.org/10.1111/aje.12675.

South African National Biodiversity Institute (SANBI), 2016, Botanical Database of Southern Africa (BODATSA), viewed 17 May 2022, from http://posa.sanbi.org/sanbi/Explore.

BAC14 Primary (introduction) pathways		
Release	none	Confidence: Medium
Escape	horticulture	Confidence: High
	botanic garden/zoo/aquaria (excluding domestic aquaria)	Confidence: High
Contaminant	none	Confidence: Medium
Stowaway	none	Confidence: Medium
Corridor	none	Confidence: Medium
Unaided	none	Confidence: Medium

Comments: *Psidium guajava* was introduced to South Africa for its edible fruit (Pereira et al. 2017; Willemse 2021). Furthermore, *P. guajava* is present in some of South Africa's botanical gardens where it is spreading (Mbobo 2023).

References:

Mbobo, T., 2023, 'Drivers of fleshy-fruited plant invasions: insights from Myrtaceae', PhD thesis, Stellenbosch University, South Africa.

Pereira, F.M.P., Usman, M., Mayer, N.A., Nachtigal, J.C., Maphanga, O.R. & Willemse, S., 2017, 'Advances in guava propagation', *Revista Brasileira de Fruticultura* 39.

Willemse, S., 2021, 'Breathing new life into the guava industry', *Farmer's Weekly* 21035, 44-45, from https://hdl.handle.net/10520/ejc-farmweek_v2021_n21035_a14.

2. Likelihood

LIK1 Likelihood of entry via unaided primary pathways	
Response: Present in the country (p = 1)	Confidence: High
Rationale: *Psidium guajava* is currently present in the country. The likelihood of future re-introductions is high as the seeds could be spread by animals (birds and mammals), and humans (CABI 2022; Thabethe et al. 2015). There are records of *P. guajava* in neighbouring countries such as Mozambique and ESwatini (Borrel et al. 2011; GBIF 2022; iNaturalist 2022), and so it seems probable that *P. guajava* will spread to South Africa via unaided pathways such as seed dispersal over long distances by birds.	
References: Borrel, A., Brown, L. & Slater, K., 2011, 'Chemical control of invasive *Psidium guajava* in Swaziland: A preliminary assessment of costs and efficacy', *African journal of agricultural research* 6(14), 3291-3297. Global Biodiversity Information Facility (GBIF), 2022, *Psidium guajava* L., viewed 16 May 2022, from: https://www.gbif.org/species/5420380. iNaturalist, 2022, 'Common Guava', viewed 24 May 2022, from:https://www.inaturalist.org/observations?place_id=any&subview=map&taxon_id=62859. CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141. Thabethe, V., Wilson, A.L., Hart, L.A. & Downs, C.T., 2015, 'Ingestion by an invasive parakeet species reduces germination success of invasive alien plants relative to ingestion by indigenous turaco species in South Africa', *Biological invasions* 17(10), 3029-3039. https://doi.org/10.1007/s10530-015-0932-1.	

LIK2 Likelihood of entry via human aided primary pathways	
Response: Present in the country (p = 1)	Confidence: Low
Rationale: *Psidium guajava* is currently present in the country. *Psidium guajava* was introduced for the edible fruits and there is a current demand for the fruit; hence it could be re-introduced for this purpose (Henderson 2020). However, there is significant supply in the country and re-introduction is thus unlikely (p = 0.027).	
References: Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266.	

LIK3 Habitat suitability	
Response: Probable (p = 1)	Confidence: High
Rationale: "*Psidium guajava* thrives in both humid and dry climates at altitudes of 0–1500 m" (CABI 2022). In the alien range, *P. guajava* is mostly found along roadsides, in riparian habitats, agricultural lands and forest edges (Cronk & Fuller 1995). In South Africa, *P. guajava* invades watercourses, forest margins, and disturbed areas such as old agricultural fields, roadsides, and pastures (Henderson 2020; Ruwanza & Dondofema 2020). Therefore, it is probable that *P, guajava* can establish self-sustaining population because of the available suitable habitats.	
References: CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141. Cronk, Q.C.B. & Fuller, J.L., 1995, *Plant invaders: the threat to natural ecosystems*, London, UK: Chapman & Hall. Global Invasive Species Database (GISD), 2022, *Psidium guajava* L., viewed 17 May 2022, from http://www.iucngisd.org/gisd/speciesname/Psidium+guajava. Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266. Ruwanza, S. & Dondofema, F., 2020, 'Effects of exotic guava (*Psidium guajava* L.) invasion on soil properties in Limpopo, South Africa', *African Journal of Ecology* 58(2), 272-280. https://doi.org/10.1111/aje.12675.	

LIK4 Climate suitability	
Response: Probable (p = 1)	Confidence: High
Rationale: *Psidium guajava* grows in a range of climatic conditions that are found in South Africa. Being a tropical plant, *P. guajava* prefers tropical and subtropical climates, with annual rainfall between 1000 and 2000mm (CABI 2022). Climate models show that the south coast from Port St John's through to the east coast of South Africa has suitable climates for *P. guajava* (Mbobo 2023). Moreover, Mpumalanga and Limpopo, and to a lesser extent the Western Cape, also have suitable climates (Mbobo 2023). The naturalised populations in the Western Cape tend to occur mostly along hot water springs, streams and close to roadsides (Mbobo 2023)..The predicted climatically suitable area is ~20% (Mbobo 2023), see Appendix LIK4.	
References: CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141. Mbobo, T., 2023, 'Drivers of fleshy-fruited plant invasions: insights from Myrtaceae', PhD thesis', Stellenbosch University, South Africa.	

LIK5 Unaided secondary (dispersal) pathways	
Response: Probable (p = 1)	Confidence: High
Rationale: *Psidium guajava* seeds can be dispersed by birds and mammals (CABI 2022; Jordaan et al. 2011). Therefore, it is probable (p = 1) that *P. guajava* seeds can be dispersed over long distances (> 50km in 10 years).	
References: CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141. Jordaan, L.A., Johnson, S.D. & Downs, C.T., 2011, 'The role of avian frugivores in germination of seeds of fleshy-fruited invasive alien plants', *Biological Invasions 13*(8), 1917-1930. https://doi.org/10.1007/s10530-011-0013-z.	

LIK6 Human aided secondary (dispersal) pathways	
Response: Probable (p = 1)	Confidence: High
Rationale: *Psidium guajava* is an important fruit tree that is cultivated in many households in the country. In addition, *P. guajava* is found in parks and botanical gardens (CABI 2022; Henderson 2020). It is probable (p = 1) that *P. guajava* could be moved by humans because *P. guajava* is present in places easily accessible by humans and humans consume the edible fruits.	
References: Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266. CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141.	

3. Consequences

CON1 Environmental impact	
CON1a: Competition	
Response: Moderate (MO)	Confidence: Medium
Rationale: *Psidium guajava* covers large areas of the Galapagos Islands where it outcompetes native forest species (Cronk & Fuller 1995). In Hawaii, *P. guajava* threatens the survival of endangered plant species (US Fish & Wildlife Service 1995). "*Psidium guajava* is known for forming dense thickets that can suppress the growth of native species" (CABI 2022). Mamba and Singwane (2019) noted that, in Eswatini, *P. guajava* trees grow very tall and close to each other, forming a continuous canopy, thereby overshadowing native plants, and outcompeting them for sunlight. Because of the monospecific stands formed by *P. guajava*, the understory of the invaded sites are largely lacking (Mamba & Singwane 2019).	
References: Cronk, Q.C.B. & Fuller, J.L., 1995, *Plant invaders: the threat to natural ecosystems*, London, UK: Chapman & Hall. CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141. Mamba, H.S. & Singwane, S.S., 2019, 'Effects of *Lantana camara* and *Psidium guajava* on the chemical properties of the soil in Eswatini - a case of Ngudzeni area', *International Research Journal of Applied Sciences,* 1(1), 1-16. US Fish and Wildlife Service, 1995, 'Recovery plan for the Kauai Plant Cluster', In: Recovery Plan for the Kauai Plant Cluster: US Fish and Wildlife Service, pp. 270.	
CON1b: Predation	
Response: Data Deficient (DD)	Confidence: High
Rationale: *Psidium guajava* is a plant species that is not predatory	
References:	
CON1c: Hybridisation	
Response: Data Deficient (DD)	Confidence: Low
Rationale: There is no record of hybridisation between *P. guajava* and native South African species. There are no native *Psidium* species, making hybridisation unlikely.	
References:	
CON1d: Transmission of disease	
Response: Data Deficient (DD)	Confidence: Low
Rationale:	
References:	
CON1e: Parasitism	
Response: Data Deficient (DD)	Confidence: High
Rationale: *Psidium guajava* is not a parasitic plant	
References:	
CON1f: Poisoning/toxicity	
Response: Data Deficient (DD)	Confidence: Low
Rationale:	
References:	
CON1g: Bio-fouling or other direct physical disturbance	
Response: Data Deficient (DD)	Confidence: Low
Rationale:	
References:	
CON1h: Grazing/herbivory/browsing	
Response: Data Deficient (DD)	Confidence: Low
Rationale: *Psidium guajava* is a plant species that does not graze or browse.	
References:	
CON1i: Chemical, physical or structural impact on ecosystem	
Response: Moderate (MO)	Confidence: Low
Rationale: In South Africa, *P. guajava* invasions can affect soil properties by increasing soil pH, soil moisture, water infiltration and repellence (Ruwanza & Dondofema 2020). "*Psidium guajava* has allelochemicals inherent in it which inhibits germination and growth of some native species" (Kawawa	

et al. 2016). This study was conducted under laboratory settings, but Smith (1998) did suggest that *P. guajava* may have allelopathic effects on other plants.

References:

Kawawa, R.C., Obiri, J.F., Muyekho, F.N., Omayio, D.O., Agevi, H., Mwaura, A., et al., 2016, 'Allellopathic potential of invasive *Psidium guajava* L., against selected native tree species in Kakamega Tropical Forest, Western Kenya', *Journal of Pharmacy and Biological Science* 11(5), 80-86. https://doi.org/10.9790/3008-1105028086.

Ruwanza, S. & Dondofema, F., 2020, 'Effects of exotic guava (*Psidium guajava* L.) invasion on soil properties in Limpopo, South Africa', *African Journal of Ecology* 58(2), 272-280. https://doi.org/10.1111/aje.12675.

Smith, C.W., 1998, *Pest Plants of Hawaiian Native Ecosystems*, University of Hawaii, USA: Department of Botany.

CON1k: Indirect impacts through interactions with other species

Response: Data Deficient (DD)	Confidence: Low

Rationale:

References:

CON1 Maximum environmental impact

Response: Moderate (MO)	Confidence: Medium

Rationale: Where invasive, *P. guajava* is known to form dense thickets that can suppress the growth of native species (CABI 2022). For example, in the Galapagos Islands *Psidium guajava* covers large areas where it outcompetes native forest species (Cronk & Fuller 1995). In Eswatini, *P. guajava* trees grow very tall and close to each other, forming continuous canopy, thereby overshadowing native plants, and outcompeting these plants for sunlight (Mamba & Singwane 2019). Because of the monospecific stands formed by *P. guajava*, invaded sites lack understorey plants. In South Africa, *P. guajava* is known to alter soil properties, change composition, and function of decomposers (Ruwanza & Dondofema 2020).

References:

Cronk, Q.C.B. & Fuller, J.L., 1995, *Plant invaders: the threat to natural ecosystems*, London, UK: Chapman & Hall.

CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141.

Mamba, H.S. & Singwane, S.S., 2019, 'Effects of *Lantana camara* and *Psidium guajava* on the chemical properties of the soil in Eswatini - a case of Ngudzeni area', *International Research Journal of Applied Sciences,* 1(1), 1-16.

Ruwanza, S. & Dondofema, F., 2020, 'Effects of exotic guava (*Psidium guajava* L.) invasion on soil properties in Limpopo, South Africa', *African Journal of Ecology* 58(2), 272-280. https://doi.org/10.1111/aje.12675.

CON2 Socio-economic impact

CON2a: Safety

Response: Data Deficient (DD)	Confidence: Low

Rationale:

References:

CON2b: Material and immaterial assets

Response: Minor (MN)	Confidence: Medium

Rationale: *Psidium guajava* reduces space available for grazing (Ruwanza & Thondhlana 2022)

References:

Ruwanza, S. & Thondhlana, G., 2022, 'People's perceptions and uses of invasive plant *Psidium guajava* in Vhembe Biosphere Reserve, Limpopo Province of South Africa', *Ecosystems and People* 18, 64-75. https://doi.org/10.1080/26395916.2021.2019834.

CON2c: Health

Response: Data Deficient (DD)	Confidence: Low

Rationale:

References:

CON2d: Social, spiritual and cultural relations

Response: Minor (MN)	Confidence: Medium

Rationale: *Psidium guajava* produces fruits, that if not consumed, fall to the ground, creating litter and attracting problematic animals, and sometimes produces fruits which sometimes attract

problematic animals e.g. monkeys, snakes, and birds, whilst malaria-causing mosquitos are attracted by rotten *P. guajava* fruits (Ruwanza & Thondhlana 2022).

References:

Ruwanza, S. & Thondhlana, G., 2022, 'People's perceptions and uses of invasive plant *Psidium guajava* in Vhembe Biosphere Reserve, Limpopo Province of South Africa', *Ecosystems and People* 18, 64-75. https://doi.org/10.1080/26395916.2021.2019834.

CON2 Maximum socio-economic impact

Response: Minor (MN)	Confidence: medium

Rationale: *Psidium guajava* reduces space available for grazing and produces fruit which sometimes attract problematic animals e.g., monkeys, snakes, and birds, whilst malaria-causing mosquitos are attracted by rotten *P. guajava* fruits (Ruwanza & Thondhlana 2022).

References:

Ruwanza, S. & Thondhlana, G., 2022, 'People's perceptions and uses of invasive plant *Psidium guajava* in Vhembe Biosphere Reserve, Limpopo Province of South Africa', *Ecosystems and People* 18, 64-75. https://doi.org/10.1080/26395916.2021.2019834.

CON3 Closely related species' environmental impact

Response: Not scored as CON1 scored	Confidence:

Rationale: There is information to score CON1, so CON3 does not need to be scored as per the framework

References:

CON4 Closely related species' socio-economic impact

Response: Not scored as CON2 scored	Confidence:

Rationale: There is information to score CON2, so CON4 does not need to be scored as per the framework

References:

CON5 Potential impact

Response: Major (MR)	Confidence: Medium

Rationale: Ruwanza and Dondofema (2020) showed that *P. guajava* alters soil properties, suggesting the possibility of change in composition and/or function of decomposers once the plant is established. Furthermore, it is suggested that *P. guajava* has allelochemicals, which inhibits germination and growth of some native species (Kawawa et al. 2016; Smith 1986). There are several sites across the country where *P. guajava* is well established and there are no understorey plants (Mbobo 2023). *Psidium guajava* is a highly competitive plant, with the ability to crowd out other plant species, and prevent regeneration of native plant species. If left unmanaged, the same impact in South Africa is expected, as observed in other regions of the world, like Hawaii (US Fish and Wildlife Service 1995).

References:

Kawawa, R.C., Obiri, J.F., Muyekho, F.N., Omayio, D.O., Agevi, H., Mwaura, A., et al., 2016, 'Allellopathic potential of invasive *Psidium guajava* L., against selected native tree species in Kakamega Tropical Forest, Western Kenya', *Journal of Pharmacy and Biological Science* 11(5), 80-86. https://doi.org/10.9790/3008-1105028086.

Mbobo, T., 2023, 'Drivers of fleshy-fruited plant invasions: insights from Myrtaceae', PhD thesis', Stellenbosch University, South Africa.

Ruwanza, S. & Dondofema, F., 2020, 'Effects of exotic guava (*Psidium guajava* L.) invasion on soil properties in Limpopo, South Africa', *African Journal of Ecology 58*(2), 272-280. https://doi.org/10.1111/aje.12675.

Smith, C.W., 1998, *Pest Plants of Hawaiian Native Ecosystems*, University of Hawaii, USA: Department of Botany.

US Fish and Wildlife Service, 1995, 'Recovery plan for the Kauai Plant Cluster', In: Recovery Plan for the Kauai Plant Cluster: US Fish and Wildlife Service, pp. 270.

4. Management

MAN1 What is the feasibility to stop future immigration?	
Response: Low	Confidence: Medium
Rationale: *Psidium guajava* is already present in South Africa and in neighbouring countries including Mozambique and Eswatini (GBIF 2022; iNaturalist 2022). Since the seeds of *P. guajava* are dispersed by frugivores (Somarriba et al. 1986; Thabethe et al. 2015) long distance dispersal is possible and chances of future immigration are high. It should be feasible to prevent intentional introductions through strict laws and processes of *P. guajava* imports, although, the seeds of *P. guajava* are available for sale online (Dave's Garden 2023). Therefore, it is likely that stopping future immigration might prove difficult.	
References: Dave's Garden, 2023, *Psidium guajava* L., viewed 14 November 2023, from Searching Dave's Garden (davesgarden.com). Global Biodiversity Information Facility (GBIF), 2022, *Psidium guajava* L., viewed 16 May 2022, from https://www.gbif.org/species/5420380. iNaturalist 2022, Common Guava, viewed 24 May 2022, from https://www.inaturalist.org/observations?place_id=any&subview=map&taxon_id=62859. Somarriba, E., 1986, 'Effects of livestock on seed germination of guava (*Psidium guajava* L.)', *Agroforestry Systems* 4(3), 233-238. https://doi.org/10.1007/BF02028357. Thabethe, V., Wilson, A.L., Hart, L.A. & Downs, C.T., 2015, 'Ingestion by an invasive parakeet species reduces germination success of invasive alien plants relative to ingestion by indigenous turaco species in South Africa', *Biological invasions* 17(10), 3029-3039. https://doi.org/10.1007/s10530-015-0932-1.	

MAN2 Benefits of the Taxon	
MAN2a Socio-economic benefits of the *Taxon*	
Response: High	Confidence: High
Rationale: *Psidium guajava* is commercially grown in South Africa for fruit (Henderson 2020; Willemse 2021). Moreover, guava is harvested for subsistence use in many households across South Africa (Msomi 2008; Ruwanza & Thondhlana 2022). People also harvest guava fruit from plants outside of cultivation to sell on roadsides to support their families (Mbobo 2023). *Psidium guajava* is also grown for medicinal purposes, including treatment of diarrhoea and diabetes (Gutiérrez et al. 2008; Msomi 2008; Naseer et al. 2018; Okamoto et al. 2009; Takeda et al. 2023), provides firewood, and shade (Msomi 2008; Ruwanza & Thondhlana 2022).	
References: Gutiérrez, R.M.P., Mitchell, S. & Solis, R.V., 2008, '*Psidium guajava*: a review of its traditional uses, phytochemistry and pharmacology', *Journal of ethnopharmacology* 117(1), 1-27. https://doi.org/10.1016/j.jep.2008.01.025. Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266. Mbobo, T., 2023, 'Drivers of fleshy-fruited plant invasions: insights from Myrtaceae', PhD thesis, Stellenbosch University, South Africa. Msomi, E.T., 2008, 'The potential impact of the CARA legislation (for guava as an invader species) on selected disadvantaged communities in Kwazulu-Natal', Master of social science thesis, Pietermaritzburg (South Africa), University of KwaZulu-Natal. Naseer, S., Hussain, S., Naeem, N., Pervaiz, M. & Rahman, M., 2018, 'The phytochemistry and medicinal value of *Psidium guajava* (guava)', *International journal of Phytomedicine and Phytotherapy* 4, 32. https://doi.org/10.1186/s40816-018-0093-8. Okamoto, M.K.H., Kato, E.T.M. & Bacchi, E.M., 2009, 'Morphoanatomic aspects of *Psidium guajava* L. (Myrtaceae)', *Latin American Journal of Pharmacy* 28, 599–603. Ruwanza, S. & Thondhlana, G., 2022, 'People's perceptions and uses of invasive plant *Psidium guajava* in Vhembe Biosphere Reserve, Limpopo Province of South Africa', *Ecosystems and People* 18, 64-75. https://doi.org/10.1080/26395916.2021.2019834. Takeda, L.N., Laurindo, L.F., Guiguer, E.L., Bishayee, A., Araújo, A.C., Ubeda, L.C.C., Goulart, R.A., & Barbalho, S.M., 2023, '*Psidium guajava* L.: A systematic review of the multifaceted health benefits and economic importance', *Food Reviews International*, 39:7, 4333-4363. https://doi.org/10.1080/87559129.2021.2023819.	

Willemse, S., 2021, 'Breathing new life into the guava industry', *Farmer's Weekly* 21035, 44-45, from https://hdl.handle.net/10520/ejc-farmweek_v2021_n21035_a14.
MAN2b Environmental benefits of the *Taxon*
Response: Low | Confidence: Medium
Rationale: There are no recorded environmental benefits of *P. guajava*.
References:

MAN3 Ease of management	
MAN3a How accessible are populations?	
Response: 1 (moderately accessible)	Confidence: Medium
Rationale: In South Africa, *Psidium guajava* is found along roadsides, botanical gardens, private land, and open forests (Henderson 2020; Willemse 2021). Therefore, the response is moderately accessible because some populations may pose operational difficulty (e.g., private land, natural forests etc.), but it does not require specialised processes.	
References: Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266. Willemse, S., 2021, 'Breathing new life into the guava industry', *Farmer's Weekly* 21035, 44-45, from https://hdl.handle.net/10520/ejc-farmweek_v2021_n21035_a14.	
MAN3b Is detectability critically time-dependent?	
Response: 0 (No)	Confidence: Medium
Rationale: *Psidium guajava* is a shrub or small tree, up to ten meters tall, with a smooth, green to red-brown bark (CABI 2022). The fruit is fleshy, green to yellow in colour and is aromatic (PIER 2022; Pommer & Murakami 2009). It is fairly easy to spot *P. guajava* even without flowers or fruits, though easier during flowering and fruiting stages (from late March through to October in South Africa).	
References: CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141. Pacific Island Ecosystem at Risk (PIER), 2022, *Psidium guajava* L., Myrtaceae, viewed 20 May 2022, from: http://www.hear.org/pier/species/psidium_guajava.htm. Pommer, C.V. & Murakami, K., 2009, Breeding guava (*Psidium guajava* L.)', In *Breeding plantation tree crops: Tropical species* (pp. 83-120). Springer, New York, NY.	
MAN3c Time to reproduction	
Response: 1 (1-3 years)	Confidence: Medium
Rationale: *Psidium guajava* "reproduces mainly by seed, but it can also reshoot from stumps and produce suckers from near the base of the trunk" (BioNet-Eafrinet 2022). When *P. guajava* is grown from seed it produces fruit in two to four years, with a life expectancy of 30 to 40 years (GISD 2022).	
References: Global Invasive Species Database (GISD), 2022, *Psidium guajava,* viewed 17 May 2022, from: http://www.iucngisd.org/gisd/speciesname/Psidium+guajava. BioNet-Eafrinet, 2022, keys and fact sheets: *Psidium guajava* (guava), viewed 17 May 2022, from: https://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Psidium_guajava_(Guava).htm.	
MAN3d Propagule persistence	
Response: 1 (1-5 year)	Confidence: Medium
Rationale: "*Psidium guajava* seeds retain their viability for approximately 1 year at 8°C and low humidity" (CABI 2022). Somarriba (1986) reports a large variation in seed germination between years, but no explicit mention of how long the seeds stay viable in the soil. Therefore, the confidence is scored medium .	
References: CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141. Somarriba, E., 1986, 'Effects of livestock on seed germination of guava (*Psidium guajava* L.)', *Agroforestry Systems* 4(3), 233-238. https://doi.org/10.1007/BF02028357	
MAN3 Ease of management	

Response: Medium	Confidence: Medium
Rationale: The management of *P. guajava* can be achieved without substantial training. However, because *P. guajava* can regenerate vegetatively from suckers (Smith 1998), repeated control efforts, even after herbicide application, can be required.	
References: Smith, C.W., 1998, *Pest Plants of Hawaiian Native Ecosystems*, University of Hawaii, USA: Department of Botany. http://www.botany.hawaii.edu/faculty/cw_smith/aliens.htm.	

MAN4 Has the feasibility of eradication been evaluated?	
Response: No	Confidence: Medium
Rationale: There has not been a formal evaluation of eradication feasibility of *Psidium guajava* in South Africa. However, given the widespread occurrence and many invasive populations across the country, eradication is not a reasonable management goal.	
References:	

MAN5 Control options and monitoring approaches available for the *Taxon*
Response: In South Africa, no management and/or control goals or plans have been set. In Hawaii, the Galapagos, and Eswatini management actions and approaches include pulling up of seedlings and cutting down adult plants and treating the cut stump with herbicides, have been implemented (Borell et al. 2011; Cronk & Fuller 1995; GISD 2022).
References: Borrel, A., Brown, L. & Slater, K., 2011, 'Chemical control of invasive *Psidium guajava* in Swaziland: A preliminary assessment of costs and efficacy', *African journal of agricultural research* 6(14), 3291-3297 Cronk, Q.C.B. & Fuller, J.L., 1995, *Plant invaders: the threat to natural ecosystems*, London, UK: Chapman & Hall. Global Invasive Species Database (GISD), 2022, *Psidium guajava*, viewed 17 May 2022, from: http://www.iucngisd.org/gisd/speciesname/Psidium+guajava.

MAN6 Any other management considerations to highlight?	
Response	Yes (see Appendix MAN6)

5. Calculations

Likelihood = Probable

Parameter	Likelihood	Stages	Final assessment
LIK1	1	P(entry) = 1	P (invasion) = 1
LIK2	1		
LIK3	1	P(establishment) = 1	
LIK4	1		
LIK5	1	P (spread) = 1	
LIK6	1		

Consequence = Moderate

Parameter	Mechanism/sector	Response
CON1a	Competition	MO
CON1b	Predation	DD
CON1c	Hybridisation	DD
CON1d	Disease transmission	DD
CON1e	Parasitism	DD
CON1f	Poisoning/toxicity	DD
CON1g	Bio-fouling or other direct physical disturbance	DD
CON1h	Grazing/herbivory/browsing	DD
CON1i	Chemical, physical, structural impact	MO
CON1k	Indirect impacts through interactions with other species	DD
CON1	Maximum environmental impact	MO
CON2a	Safety	DD
CON2b	Material and immaterial assets	MN
CON2c	Health	DD
CON2d	Social, spiritual and cultural relations	MN
CON2	Maximum socio-economic impact	MN
CON3	Environmental impact of closely related taxa	Not scored as CON1 scored
CON4	Socio-economic impact of closely related taxa	Not scored as CON2 scored
CON5	Potential impact based on traits, experiments, or models	MR

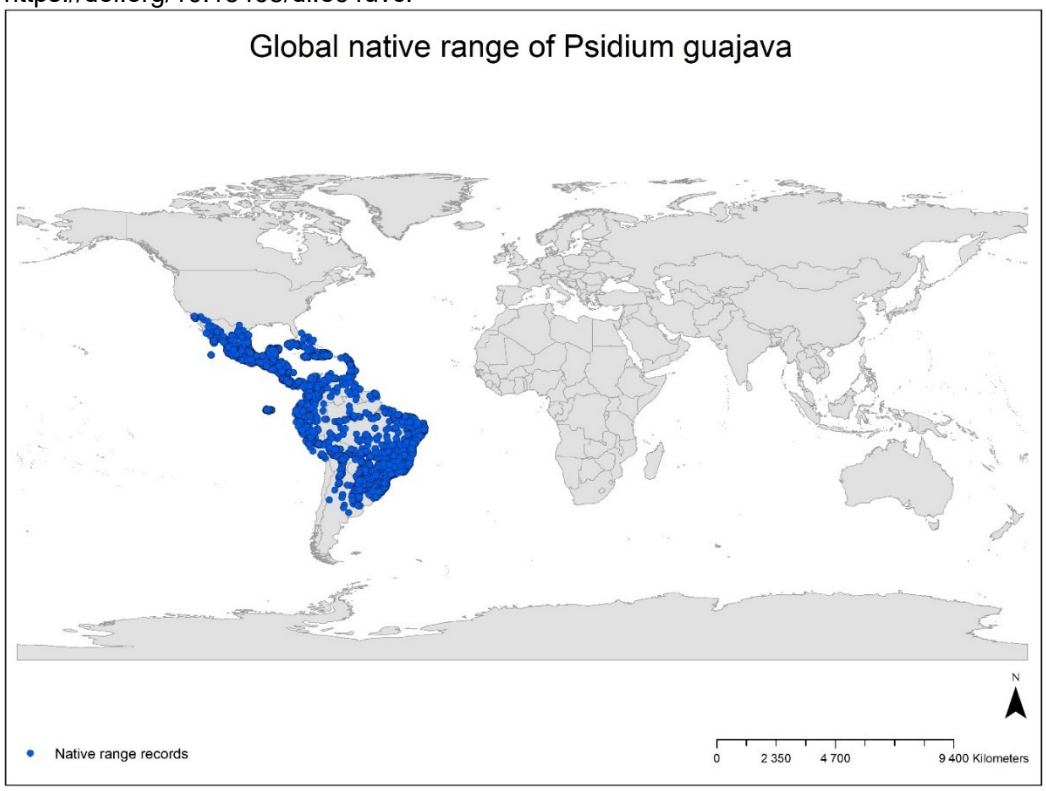
Risk score = High

		Consequences				
		MC	MN	MO	MR	MV
Likelihood	Extremely unlikely	low	low	low	medium	medium
	Very unlikely	low	low	low	medium	high
	Unlikely	low	low	medium	high	high
	Fairly probable	medium	medium	high	high	high
	Probable	medium	high	high	high	high

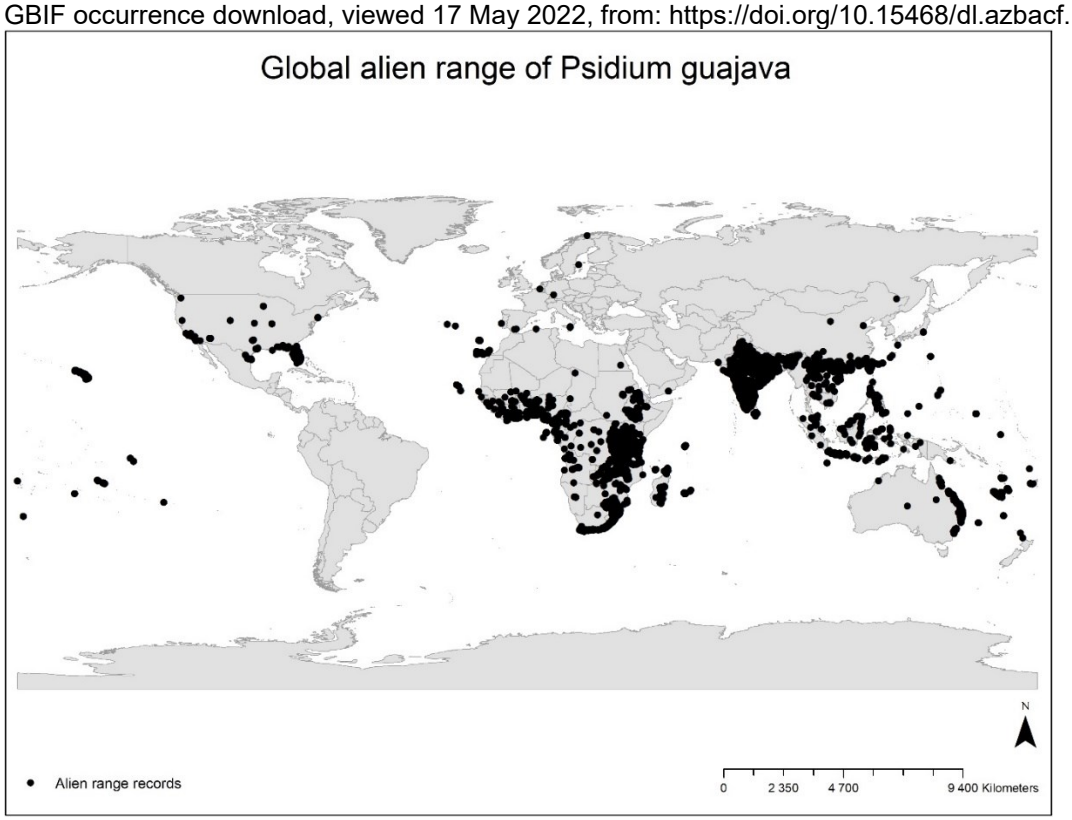
Ease of management = Medium

Parameter	Question	Response
MAN3a	How accessible are populations?	1
MAN3b	Is detectability critically time-dependent?	0
MAN3c	Time to reproduction	1
MAN3d	Propagule persistence	1
MAN3	**SUM**	3

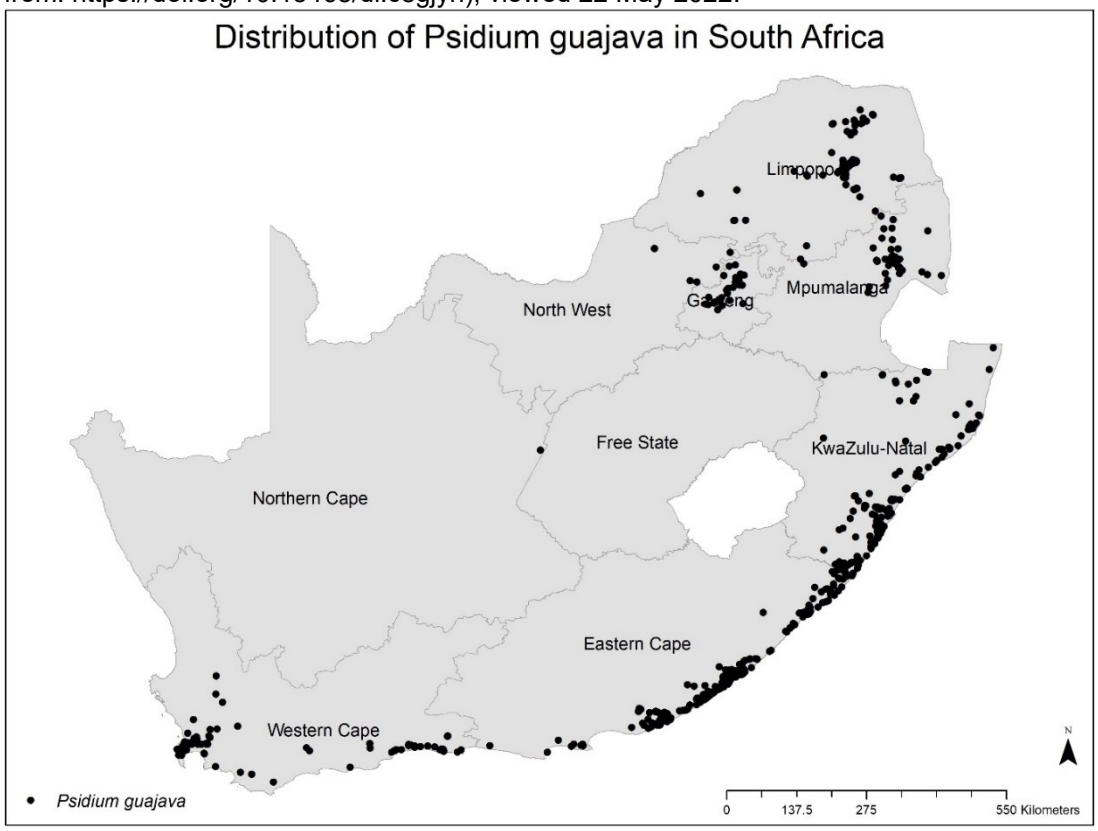
Appendix BAC7: Native range of *Psidium guajava*, noting the native range of *P. guavaja* is uncertain. Locality data sourced on GBIF occurrence download, viewed 17 May 2022, from: https://doi.org/10.15468/dl.e64uvc.



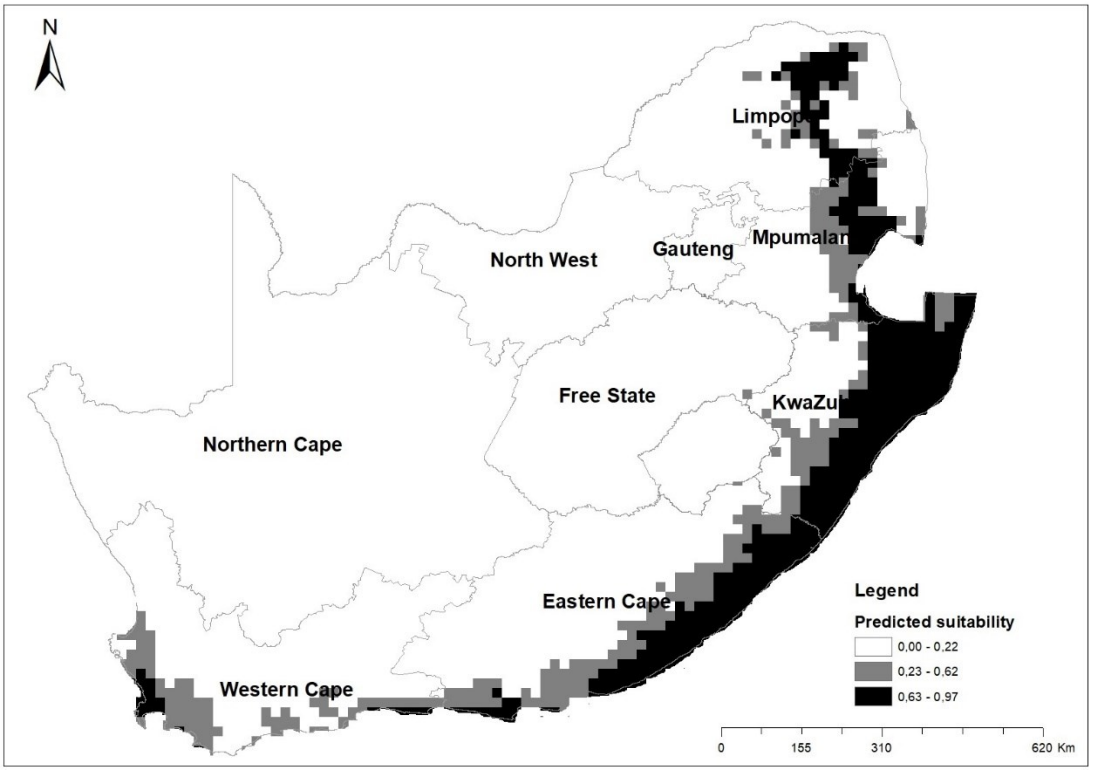
Appendix BAC8(a): Global distribution range (alien) of *Psidium guajava*. Locality data sourced on GBIF occurrence download, viewed 17 May 2022, from: https://doi.org/10.15468/dl.azbacf.



Appendix BAC8(b): South African distribution range (alien) of *Psidium guajava* L. Locality data sourced from Mbobo (2023), iNaturalist (Observations · iNaturalist), and GBIF occurrence download from: https://doi.org/10.15468/dl.c8gjyh), viewed 22 May 2022.



Appendix LIK4: Predicted climatic suitability for *Psidium guajava* in South Africa (Mbobo 2023). Locality data sourced from Mbobo (2023), iNaturalist, and GBIF occurrence download from: https://doi.org/10.15468/dl.c8gjyh), viewed 22 May 2022.



Appendix MAN6: Proposed permitting options and exemptions to the listing of *Psidium guajava* (L) under NEM:BA A&IS Regulations

Current listing as per NEM:BA A&IS list of 2020

Taxon: *Psidium guajava* (L)

Common name: Guava

Category:

a. 2 for plantations in Eastern Cape, KwaZulu-Natal, Limpopo, Mpumalanga and North-West.
b. 3 elsewhere in Eastern Cape, Kwazulu-Natal, Limpopo, Mpumalanga and North-West.
c. The fruit of the guava is not listed if used for human consumption.
d. Not listed elsewhere.

Exemptions and Prohibitions: None

Rationale

Psidium guajava was introduced to South Africa in the 1860s (Pereira et al. 2017) for commercial reasons (Henderson 2020; Pereira et al. 2017). *Psidium guajava* is invasive in coastal areas, watercourses, forest margins, roadsides and abandoned agricultural land (GBIF 2022; Henderson 2020; Nel et al. 2004; Ruwanza & Dondofema 2019; SANBI 2016). *Psidium guajava* poses environmental risks by: (1) covering large areas and outcompeting native forest species (Cronk & Fuller 1995); (2) forming dense thickets that can suppress the growth of native species (CABI 2022); and (3) having allelochemicals which inhibits germination and growth of some native species (Kawawa et al. 2016). *Psidium guajava* is also an important commercial (including informal trade) fruit producing species that cannot easily be replaced by native species.

Potential criteria for permits

Currently, only six permits have been issued for guava production in South Africa although guava is regulated in five provinces. Providing permits for commercial production appears warranted given the size of the industry and the demand. However, as guavas are dispersed by birds and animals, it is unlikely that permits will be effective in stopping invasions where the threat of invasion and/or impacts is high (i.e., next to open forests, riparian zones, and areas where *P. guajava* is recorded as invasive and/or is predicted to become invasive) (Mbobo 2023).

Potential criteria for exemptions

Harvesting the fruit of guava for subsistence livelihoods should be exempted as permitting would be infeasible and a ban unreasonable.

Overall recommendation

Given climate and habitat requirements, it is recommended that *P. guajava* be regulated as category 2 with specific exemptions for provinces and for the consumption of fruit elsewhere (including informal trading). Notably the North-West Province should be removed from the list of regulated provinces because it has been shown to be climatically unsuitable for *P. guajava* invasions (Mbobo 2023; Appendix LIK4). Also, there are very few records of *P. guajava* in the province, and the existing records are cultivated records (GBIF 2022).

Recommended listing

Taxon: *Psidium guajava* (L)

Common name: Guava

Category: 2

Exemptions:

a) The fruit of guava is not listed if used for human consumption; and
b) Guava is exempt in the Free State, Gauteng, Northern Cape, North-West Province, and the Western Cape.

References

CABI, 2022, 2022, *Psidium guajava* (guava), viewed 17 May 2022, from: https://www.cabi.org/isc/datasheet/45141.

Cronk, Q.C.B. & Fuller, J.L., 1995, *Plant invaders: the threat to natural ecosystems,* London, UK: Chapman & Hall.

Global Biodiversity Information Facility (GBIF), 2022, *Psidium guajava* L., viewed 16 May 2022, from: https://www.gbif.org/species/5420380.

Henderson, L., 2020, Invasive alien plants in South Africa, Plant protection research institute handbook No 21, Department of Environment, Forestry and Fisheries of South Africa: Natural Resources Management Programmes (DEFF: NRMP), pp 266.

Kawawa, R.C., Obiri, J.F., Muyekho, F.N., Omayio, D.O., Agevi, H., Mwaura, A., et al., 2016, 'Allelopathic potential of invasive *Psidium guajava* L., against selected native tree species in Kakamega Tropical Forest, Western Kenya', *Journal of Pharmacy and Biological Science* 11(5), 80-86. https://doi.org/10.9790/3008-1105028086.

Mbobo, T., 2023, 'Drivers of fleshy-fruited plant invasions: insights from Myrtaceae', PhD thesis, Stellenbosch University, South Africa.

Nel, J.L, Richardson, D.M., Rouget, M., Mgidi, T.N., Mdzeke, N., Le Maitre, D.C., et al., 2004, 'A proposed classification of invasive alien plant species in South Africa: towards prioritizing species and areas for management action', *South African Journal of Science* 100, (1), pp.53-64 https://journals.co.za/doi/pdf/10.10520/EJC96213.

Pereira, F.M.P., Usman, M., Mayer, N.A., Nachtigal, J.C., Maphanga, O.R. & Willemse, S., 2017, 'Advances in guava propagation', *Revista Brasileira de Fruticultura* 39.

Ruwanza, S. & Dondofema, F., 2020, 'Effects of exotic guava (*Psidium guajava* L.) invasion on soil properties in Limpopo, South Africa', *African Journal of Ecology* 58(2), 272-280. https://doi.org/10.1111/aje.12675.

South African National Biodiversity Institute (SANBI), 2016, Botanical Database of Southern Africa (BODATSA), viewed 17 May 2022, from http://posa.sanbi.org/sanbi/Explore.