A review of the impacts of invasive alien species in South Africa.

Biological Invasions

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Online Resource 1. Studies that have reported on the nature and extent of impacts associated with biological invasions in South Africa (studies are listed chronologically within each impact category by the date of the first study to report the impact). See methods section for a description of the impact categories.

Category of impact	**Recorded impact**	**Alien species responsible for impact (and life form)**	**References**
Competition	Reduction of native plant cover, species richness, and plant density after afforestation.	*Pinus radiata* (tree)	Richardson and van Wilgen (1986) Mostert et al. (2017)
	Significant reductions in native plant richness with increases in alien plant cover.	*Hakea sericea* (tall shrub), *Pinus radiata* (tree), *P. pinaster* (tree) and *Acacia saligna* (tree)	Richardson et al. (1989)
	Reductions in grazing capacity	*Stipa capensis* (grass)	Steinschen et al. (1996).
	Reduction in native plant species richness, cover and frequency	*Acacia saligna* (tree)	Holmes and Cowling (1997) Mostert et al. (2017)
	Reductions in the diversity of freshwater benthic communities	*Pontederia crassipes* (freshwater aquatic plant)	Midgley et al. (2006) Coetzee et al. (2014)
	Competition for light resulting in shading out of native trees	*Schinus molle* (tree)	Iponga et al. (2008)
	Reduces abundance of native plants in situations with elevated nitrogen	*Avena fatua* (grass)	Sharma et al. (2010)
	Elimination of grasses, reducing grazing capacity by 34%.	*Prosopis glandulosa* (tree)	Ndhlovu et al. (2011)
	Reduced abundance or local elimination of native ant species through combined effects of alien trees and alien ants	*Linepithema humile* (terrestrial invertebrate) Trees in the genera *Eucalyptus* and *Pinus*	Schoeman and Samways (2011, 2013)
	Reduces abundance of native wetland species	*Glyceria maxima* (grass)	Mugwedi (2012)

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	Reductions in species richness, diversity and structural attributes of native plant species.	*Eucalyptus camaldulensis* (tree)	Tererai et al. (2013)
	Changes to composition of some native invertebrate assemblages, and displacement of some native species.	*Tarebia granifera* (estuarine mollusc)	Miranda and Perissinotto (2014a, b)
	Reductions in native species richness, and mortality in native *Vachellia erioloba* trees.	*Prosopis glandulosa* (tree)	Schachtschneider and February (2015) Shackleton et al. (2015)
	Reductions in native plant species richness and cover	*Pinus pinaster, P. radiata* and *Acacia longifolia* (trees)	Fill et al. (2018)
	Elimination of grasses, reducing grazing capacity, from 2 to 8 ha required to support one large stock unit.	*Acacia mearnsii* (tree)	Yapi et al. (2018)
	Changes to native plant species composition and decreases in species richness	*Tamarix ramosissima* and *T. chinensis* (trees)	Setshedi and Newete (2020)
	Decreases in native plant diversity.	*Solanum mauritianum* (tree)	Ruwanza (2021)
Predation	Population reduction and local extinction of breeding seabirds on islands	*Felis catus* (mammal)	van Aarde (1981) Berruti (1986) Watkins and Cooper (1986)
	Predation of seabirds nesting on sub-Antarctic islands	*Mus musculus* (mammal)	Jones and Ryan (2010)
	Changes to sandy shore community structure	*Sagartia ornata* (marine invertebrate)	Robinson and Swart (2015)
	Marked declines or local extinction of native fish, amphibian, and aquatic invertebrate species.	*Oncorhynchus mykiss* (freshwater fish) *Salmo trutta* (freshwater fish) *Micropterus salmoides* (freshwater fish) *Micropterus dolomieu* (freshwater fish)	Shelton et al. (2015) Karssing et al. (2012) Jackson et al. (2016) Avidon et al. (2018) Weyl et al. (2010) Woodford et al. (2005) Kimberg et al. (2014)
	85% reduction of native invertebrate biomass on sub-Antarctic islands	*Mus musculus* (mammal)	McClelland et al. (2018)
	Large reduction in number of small mammals, birds, reptiles and invertebrates	*Felis catus* (mammal)	Seymour et al. (2020)

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Hybridization	Hybridization with native shrubs (*Rubus rigidus* and *R. pinnatus*)	*Rubus bergii* (shrub)	Spies et al. (1987)
	Hybridization with several native tilapias (*Oreochromis* species)	*Oreochromis mossambicus* (freshwater fish);	D'Amato et al. (2007)
	Hybridization with native African wild cats (*Felis lybica*)	*Felis catus* (mammal)	Le Roux et al. (2015)
	Hybridization with native *Tamarix usneoides*	*Tamarix* species (trees)	Mayonde et al. (2015)
	Hybridization with native *Rubus longepedicellatus*	*Rubus cuneifolius (shrub)*	Sochor et al. (2018)
	Hybridization with the native Yellow-billed Duck (*Anas undulata*)	*Anas platyrhynchos* (bird)	Stephens et al. (2020)
	Hybridization with the native Cape mountain zebra (*Equus zebra*)	*Equus asinus* (mammal)	Measey et al. (2020)
	Hybridization with the native Cape platanna (*Xenopus gilli*)	*Xenopus laevis* (amphibian)	Measey et al. (2020)
Disease transmission	Mortality in wild herbivores and carnivores by bovine tuberculosis. Long-term impacts on populations not clear.	*Mycobacterium bovis* (bacterium)	De Vos et al. (2001) Rodwell et al. (2001) Renwick et al. (2007)
	Widespread mortality in native and introduced trees	*Euwallaceae fornicatus* (terrestrial invertebrate) in symbiotic relationship with *Fusarium euwallaceae* (fungus)	Paap et al. (2018) Department of Agriculture, Forestry and Fisheries (2020)
Parasitism	Reduction in fitness of some native fish populations	*Chilodonella hexasticha*; *C. piscicola* (protozoans) *Schyzocotyle acheilognathi* (tapeworm)	Smit et al. (2017)
Direct physical disturbance	Injury to livestock (long awns puncturing the skin, eyes, mouth and throat)	*Hordeum murinum* (grass)	Todd (2008)
Toxicity	Rinderpest epidemic that killed vast numbers of wild ungulates, with knock-on effects on ecosystems	*Morbillivirus* species (virus)	Vogel and Heyne (1996)
	Impeding the recruitment of native grasses due to allelopathic effects	*Parthenium hysterophorus* (annual herb)	van der Laan (2006)
	Vomiting and diarrhoea in dogs and cattle	*Brugmansia candida* (shrub) *Euphorbia marginata* (herbaceous annual)	Moshobane et al. (2020)

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		Nerium oleander (shrub) *Phoenix sylvestris* (palm tree)	
Herbivory	Consumption of native plants	*Theba pisana* (terrestrial mollusc)	van Elden et al. (2015)
	Reduction in the occurrence and diversity of submerged macrophytes	*Ctenopharyngodon idella* (freshwater fish)	Weyl and Martin (2016)
Changes to ecosystem functioning	Reductions in surface water runoff of over 300 mm rainfall equivalent	*Eucalyptus grandis* (tree); *Pinus patula* (tree)	van Lill et al. (1980)
	Increases in above-ground biomass and nutrient inputs through increased litterfall	*Acacia cyclops*, A. saligna (trees)	Milton (1981) Milton and Siegfried (1981) Yelenik et al. (2004) Yelenik et al. (2007)
	50% reduction in the supply of wind-driven sand, resulting in beach erosion	*Acacia cyclops* (tree)	Lord et al. (1985) Lubke (1985)
	Increases in above-ground biomass and 50 – 60% increases in fuel loads in Mediterranean-climate fynbos shrublands	*Acacia saligna* (tree) *Hakea sericea* (tall shrub)	van Wilgen and Richardson (1985)
	Reductions in surface water runoff of between 350 and 500 mm rainfall equivalent	*Pinus radiata* (tree)	van Wyk (1987)
	Increased fire intensity and soil damage followed by erosion.	*Pinus radiata* (tree); *Acacia cyclops* (tree)	Scott et al. (1998) van Wilgen and Scott (2001)
	Up to 600 mm increase in evaporation, resulting in decreases in water runoff	*Acacia mearnsii* (tree)	Dye and Jarmain (2004)
	Mortality of fire-sensitive native plants following invasion by an alien grass that allowed a previously fire-free ecosystem to burn	*Pennisetum setaceum* (grass)	Rahlao et al. (2009)
	Fivefold difference in transpiration between alien *Prosopis* trees (554 mm yr^{-1}) and native *Vachellia karoo* trees (91 mm yr^{-1}) at a stand scale.	*Prosopis glandulosa* (tree)	Dzikiti et al. (2013)
	Increases in invertebrate biomass and diversity in an urban estuary following invasion by an alien reef-building polychaete. Total biomass from 0.3 tons in 1942 to over 56.8 tons in 2012.	*Ficopomatus enigmaticus* (polychaete worm).	McQuaid and Griffiths (2014)
	Decrease in soil carbon	*Acacia mearnsii* (tree)	Oelofse et al. (2016)
	Water losses of 2 ML ha^{-1} yr^{-1} from invaded rivers	*Eucalyptus camaldulensis* (tree)	Dzikiti et al. (2016)

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	Increases in soil carbon, phosphorus, gravimetric soil moisture and water repellency.	*Lantana camara* (shrub)	Ruwanza and Shackleton (2016)
	Elevation of soil nitrogen levels	*Acacia saligna* (tree)	Nsikani et al. (2017)
	Increases in annual evapotranspiration (to 338 mm) following invasion of a riparian zone by a deciduous tree (noting that this was significantly lower than rates of evapotranspiration recorded for evergreen alien trees).	*Populus canescens* (tree)	Ntshidi et al. (2018)
	Increased fuel consumption and fire intensity in large wildfires	Trees in the genera *Acacia*, *Pinus* and *Eucalyptus*	Kraaij et al. (2018)
	Increases in soil nutrients and decreases in soil moisture content.	*Solanum mauritianum* (tree)	Ruwanza (2021)
Indirect impacts through species interactions	Disruption of mutualistic ant-plant seed dispersal mechanism	*Linepithema humile* (terrestrial invertebrate)	Bond and Slingsby (1984) Witt et al. (2004) Witt and Giliomee (2004) Witt and Giliomee (2005) Witt (2006)
	Reduction of ant community diversity after afforestation.	*Pinus radiata* (tree)	Donnelly and Giliomee (1985)
	Many instances of reductions in native invertebrate community numbers and diversity. Studies were often (but not exclusively) in ecosystems afforested with invasive alien trees.	*Chromolaena odorata*, *Lantana camara, Hakea sericea, H. drupacea* (shrubs) *Acacia dealbata, A. longifolia, A. mearnsii, A. saligna, Cupressus arizonica, Pinus roxburghii, P. patula, P. pinaster, P. radiata, Populus* species, *Prosopis glandulosa, Eucalyptus camaldulensis, E. conferruminata*, *E. diversicolor, E. grandis, Solanum mauritianum* (trees) *Opuntia stricta* (succulent shrub)	Samways and Moore (1991) Samways et al. (1996) Steenkamp and Chown (1996) Kinvig and Samways (2000) Ratsirarson et al. (2002) Samways and Taylor (2004) Coetzee et al. (2007) Mgobozi et al. (2008) Robertson et al. (2011) Roets and Pryke (2012) Magoba and Samways (2012) Maoela et al. (2016)

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		Linepithema humile (terrestrial invertebrate)	
	Reductions in bird species richness and numbers.	*Pinus radiata* (tree)	Armstrong and van Hensbergen (1994)
	Reductions in grassland-dependent bird species populations	*Pinus patula* (tree) *Eucalyptus grandis* and *E. saligna* (trees) *Acacia mearnsii* (tree)	Allan et al. (1997)
	Reduced numbers of ants compared to native fynbos shrublands	*Acacia saligna* (tree)	French and Major (2001)
	Soil temperatures in buried nest sites of the Nile crocodile (*Crocodylus niloticus*) are lowered through shading, changing the sex ratio of hatchlings as well as resulting in a shortage of suitable nesting sites.	*Chromolaena odorata* (shrub)	Leslie and Spotila (2001)
	Reductions in native bird species richness	*Acacia cyclops* (tree) *Prosopis glandulosa* (tree)	Winterbottom (1970) Fraser et al. (1985) Dean et al. (2002)
	Mass mortality induced in a native species of swimming crab. Increases in habitat complexity and species richness on rocky intertidal habitats, with some local displacement of native species.	*Mytilus galloprovincialis* (marine invertebrate)	Sebastián et al. (2002) Branch and Steffani (2004) Robinson et al. (2007) Hanekom (2008) Sadchatheeswaran et al. (2018)
	Reduced numbers of earthworms compared to natural forest or grassland	*Eucalyptus grandis, Pinus elliottii. Acacia mearnsii* (trees)	Haynes et al. (2003) Dlamini and Haynes (2004).
	Reduction in the number of native tsetse flies.	Trees in the genera *Eucalyptus* and *Pinus*	Esterhuizen et al. (2005)
	Increases in above-ground biomass and facilitation of invasion by other alien species	*Arundo donax* (tall grass)	Guthrie (2007)
	Reduction in species richness of frogs (from a mean of 13 to a mean of 3 species on sampled sites).	*Eucalyptus* species (trees)	Russell and Downs (2012)

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	Reduced pollination in native species due to pollinators switching to alien species	*Acacia saligna* (tree)	Gibson et al. (2012; 2013)
	Reduced capacity to pollinate specialized native plants in invaded sites	*Lantana camara* (shrub) *Acacia mearnsii* (tree) *Ageratum conyzoides* (shrub)	Grass et al. (2014)
	Provision of bridging habitat to allow native invertebrate herbivores to disperse to isolated native host plants	*Acacia mearnsii* (tree)	van der Colff et al. (2015)
	Reduction in lizard richness, abundance, and diversity due to lower thermal quality of the environment and food resources.	*Pinus radiata* (tree)	Schreuder and Clusella-Trullas (2016)
	Reductions in populations of native birds.	*Eucalyptus camaldulensis* (tree)	Mangachena and Geerts (2017)
	Invasion reduces the diversity of pollinator species for native plants	*Rubus cuneifolius* (shrub)	Hansen et al. (2017)
	Decrease in large mammal richness, abundance and diversity following invasion, and recovery following clearing	*Chromolaena odorata* (shrub)	Dumalisile and Somers (2017)
	Reductions in numbers of native marine invertebrate species, resulting in increased predation pressure on remaining native species	*Mytilus galloprovincialis* and *Semimytilus algosus* (marine invertebrates)	Skein et al. (2018)
Safety	Communities at risk from wildfires of increased severity due to alien plant invasions	Trees in the genera *Acacia*, *Pinus* and *Eucalyptus*	Kraaij et al. (2018)
Material or immaterial assets	Declines in returns on investment by both small-scale and commercial cattle farmers	*Parthenium hysterophorus* (annual herb); *Chromolaena odorata* (shrub)	Wise et al.(2008)
	Farmers unable to maintain livelihoods in invaded areas, resulting in widespread economic downturn.	*Opuntia ficus-indica* (succulent spiny shrub)	van Sittert (2002)
	Damage to infrastructure	*Prosopis glandulosa* (tree)	Shackleton and Shackleton (2018)
Health	Allergic reactions	*Melia azedarach* (tree)	Shackleton and Shackleton (2018)

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