

Impact of Terrestrial Invasive Grazing on Bonaire: case study

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Long periods of isolation and small island size make island ecosystems highly vulnerable to degradation and invasive species are one of the most significant threats (Cronk, 1997). Due to their role as livestock, introduced species such as sheep, goats, pigs, cows and donkeys are some of the most common invasive species worldwide (Island conservation, 2015). Introduced grazing species consume island vegetation at a rate faster than it is able to regenerate, and islands with invasive grazers are characterised by few, small trees of limited species, and low grass, herb, and shrub cover (Dahlin et al., 2014).

Terrestrial degradation caused by invasive grazing species can impact coastal ecosystems. Degraded vegetation has fewer roots, which would otherwise anchor soils, and has reduced surface complexity, leading to increased sediment run-off. For coral reef ecosystems sediment run-off is associated with coral mortality, reduced coral growth rates, and changes in reef fish populations (Fabricius, 2005). High sediment loads reduce visibility for SCUBA divers. With many islands, including the Dutch Caribbean islands, drawing much of their revenue from marine based tourism, it is therefore in economic interest of the islands as well as the interests of conservation managers to recognise the threat posed by invasive grazing species.

Although the ecological impacts of invasive grazing species are well documented, funding and lack of social acceptability for the most cost effective solutions are key factors limiting effective conservation action (Roberts et al., manuscript in preparation). On Bonaire the local Government backed projects, which are now being funded by the Dutch Ministry of Economic Affairs under their *Nature Fund* initiative, seek to address this funding gap and tackle the issue of feral pigs (page 16) and to eradicate goats from the Washington Slagbaai National Park (Table 1).

Table 1: Nature Funding projects on terrestrial invasive grazing species control.

Nature Funding projects

As part of the 2013-2017 Nature Policy Plan for the Caribbean Netherlands, 22 projects that promote coral reef conservation, sustainable use of nature or the synergy of sustainable use of nature in combination with agriculture and tourism were approved to receive funding through the Nature Fund allocated by the Ministry of Economic Affairs for the BES islands. Ten projects received funding on Bonaire, 7 on Saba and 5 on St. Eustatius.

The following projects focus on terrestrial invasive grazing species control:

Project	Islands	Lead scientist(s)	Goal	Activities
Goat buy-back program	SAB	Government of Saba: Randall Johnson	Protecting nature and agriculture by significantly decreasing the amount of roaming goats.	Shooting/ slaughtering, storing, selling and/or exporting the meat.
Feral Pig Control	BON	Echo: Julianka Clarenda DRO: Frank van Slobbe	Recovery of habitats so they are better able to provide services for people and nature, improved conditions for agriculture and increased community support for invasive species management.	Feral pig density assessment, pig eradication, raising awareness and support, monitoring program for evaluation of interventions.
Goat eradication and control in Washington Slagbaai National Park	BON	STINAPA DRO: Frank van Slobbe	Draw the goat population down to a manageable level within 3 years so that the vegetation can recover	Bringing the number of goats down in Slagbaai and Washington, practice and train locals and park staff to effective goat control, monitoring program for evaluation of interventions, developing long-term control programme, outreach and communication.

Bonaire's vegetation is severely under threat due to grazing pressure from introduced species. Vegetation surveys of Bonaire have shown that across the island trees are in low abundance, with limited species richness, and small size (Roberts 2017a).

The densities of free roaming goats, pigs and donkeys vary spatially and seasonally across the island. Hotspots of goat density have been identified in the north and east of Bonaire (Figure 1). During the wet season (from November to March) donkey populations are concentrated in the east and around the town of Rincon, with no hotspots identified in the dry season (Figure 1). Pig density is low across the island.

This variation in grazer density is associated with changes in vegetation ground cover. Not surprisingly, the presence of grass has a negative

relationship to pig presence and goat density. Combined grass and herb percentage cover is negatively related to donkey density during the dry season (Roberts et al., 2017a). Tree characteristics do not vary with grazing pressure, indicating that grazing pressure already exceeds that of tree recovery island-wide. (Roberts et al., 2017a).

The degradation caused to terrestrial ecosystems by invasive grazing species is associated with changes in coral reef characteristics on Bonaire. Coral cover below depths of 10m has a positive relationship to ground cover and tree biomass of the associated watershed (Roberts et al., 2017a). In light of the negative relationship of ground cover to donkey density, conservation efforts aimed at controlling donkey grazing can be expected to lead to improvements in coral cover.

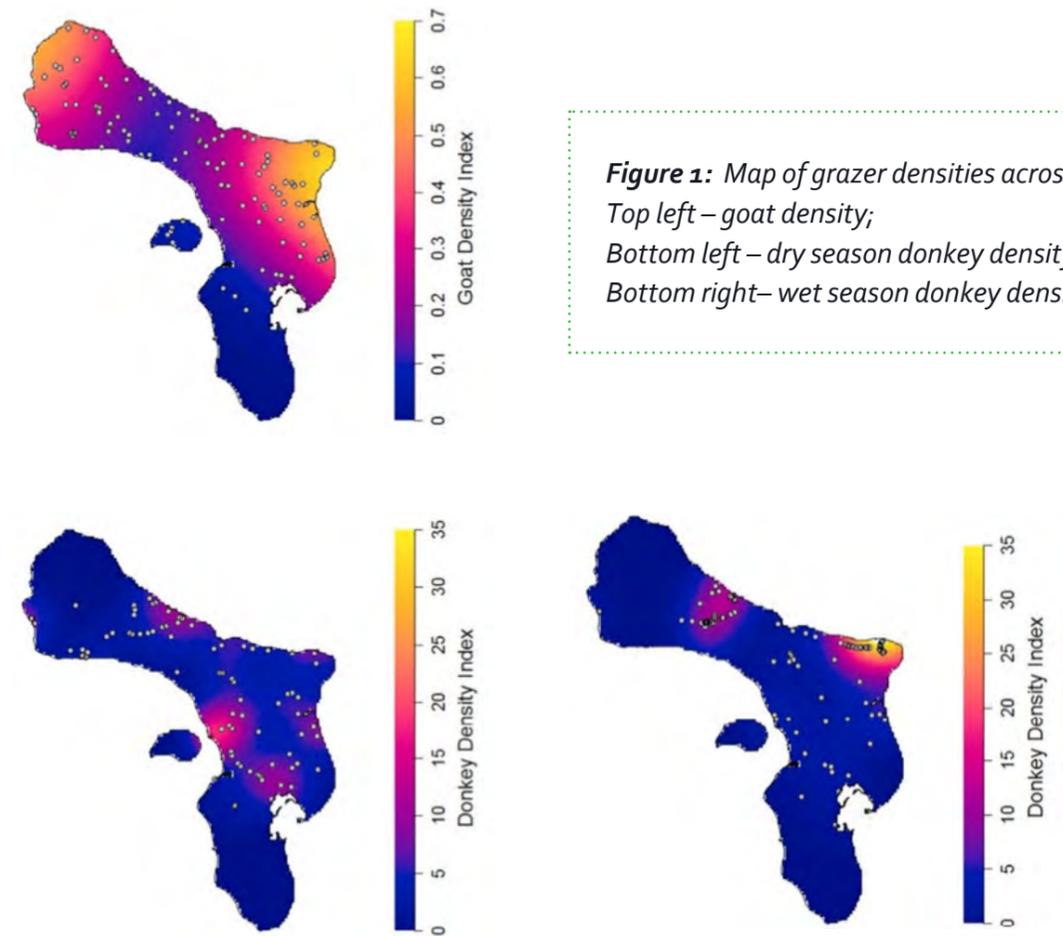


Figure 1: Map of grazer densities across Bonaire. Top left – goat density; Bottom left – dry season donkey density, Bottom right – wet season donkey density.



Donkeys on Bonaire
(Photo credit: Michaela Roberts)

Table 2: Trade-offs between fencing and eradicating donkey populations for recovery of the dry-forest and coral reef.

	Fencing	Eradication
Median ground cover (current 4%)	14%	18%
Median coral cover (current 46%)	85%	90%
Economic costs	\$2.5 million	\$8.8 - \$12.9 million
Length of control	10 years	Permanent
Social acceptability (0 to 2)	1.48	0.8

An overgrazed hillside on Bonaire (Photo credit: Michaela Roberts)



On Bonaire the effects of donkey grazing could be reduced either through creation of fenced areas, or by controlling or eradicating donkey populations. Using the relationships described above it is predicted that both measures would have a positive impact on both ground cover and coral cover, with larger impacts seen for eradication (Table 2) (Roberts et al., manuscript in preparation).

Studies on the control of invasive grazing species on Bonaire indicate that eradications are likely to have the greatest positive impact on both the terrestrial and marine ecosystems (Roberts et al., 2017a). However, low social acceptability may preclude this option in the short term. Although the cost of fencing is initially lower than eradication, the lifespan of only 10 years means that total costs exceed that of eradication within 30 years (Roberts et al., manuscript in preparation).

For long-term improvements in environmental conservation on Bonaire it would therefore be in the interests of managers and policy makers to develop a program to increase social acceptability of donkey eradication (Roberts et al., manuscript in preparation).

The connection between grazer caused degradation within the terrestrial ecosystem and degradation on the coral reef through sediment run-off may present the opportunity to secure additional funding for conservation through increasing the existing SCUBA diver fee. Surveys conducted with SCUBA divers estimate a willingness to pay of \$83/diver/year for reef improvements expected to arise through fencing, and \$93/diver/year for eradication (Roberts et al., 2017b). This would exceed the estimated costs of control programs (Roberts et al., 2017b).