Native plant recovery after the mechanical removal of invasive *Agave* spp. in coastal habitat in Almería, southeast Spain

Juan García-de-Lomas[1]*, Hedwig Schwarzer[1], Fernando J. Sanz[2] & Laura Fernández-Carrillo[1]

[1] *Environmental and Water Agency of Andalusia. C/Johann G Gutenberg 1, 41092, Seville, Spain*
[2] *C/Canónigo Molina 8, 04071, Almería, Spain*

SUMMARY

One year after mechanical removal of invasive *Agave* spp. in coastal sandy habitats in southeast Spain, the native plant composition showed partial recovery. However, the subsequent proliferation of *Agave* rhizome offshoots will require periodic rounds of manual, selective control.

BACKGROUND

Pre-desert deciduous scrub with *Ziziphus lotus* is a habitat of priority community interest in Europe, confined to arid southeastern Iberia. From 1940-1960, more than 600 ha of native scrub was replaced by plantations of *Agave sisalana* and *Agave fourcroydes* (hereafter *Agave* spp.) for fibre production. However, these plantations were soon abandoned, and *Agave* spp. have since become invasive in coastal sandy habitats (Badano & Pugnaire 2004). We report on the effectiveness of a novel control action of *Agave* spp. to enhance priority coastal habitats and aid recovery of the original habitat in a Special Area of Conservation in Almería, Spain.

ACTION

Control of *Agave* spp. was developed in the Special Area of Conservation 'Ramblas de Gérgal, Tabernas and Sur de Sierra Alhamilla' in Almería, southeast Spain (36º 51' N, 2º 19' W). From December 2016 to April 2017, approximately 1,500 MT of *Agave* spp. stands in a 16.8 ha area were removed using a wheeled excavator and mounted crane truck. The plants were left in situ for partial dehydration for one month before being transferred to landfill to save costs. In May 2018, one year after the action, the native plant composition was compared in invaded (untreated) plots (*Agave* spp. cover = 87%), treated plots, and reference plots (uninvaded areas with well-preserved native vegetation). This comparison of invaded, treated and reference plots provided evidence of the impact of *Agave* spp. on native plant assemblages. Sampled plots shared similar substrate, aspect and slopes, and supported plant assemblages typical of pre-desert scrub and sandy habitats (Figure 1, Table 1).

The presence of native plants was recorded in six subplots for each plot type, with each subplot consisting of 10 contiguous 1 m^2 quadrats, (N = 60 quadrats / plot type). Data were analysed using pairwise SIMPER and one-way ANOSIM multivariate analyses, with the software Past3 (Hammer 2001). SIMPER assesses which taxa are primarily responsible for an observed difference between groups (plot types or sites) whereas ANOSIM assesses the overall significance of the difference by reporting significance (p) and R values. R values close to 1 indicates high dissimilarity, while values close to 0 indicate no difference in community composition between sites (Clarke & Warwick 2001). In treated plots, rhizome offshoots were also counted in the same quadrats used for analysis of plant composition. Shrubs of more than 3 m diameter were excluded from sampling because they constitute different plant assemblages.

CONSEQUENCES AND DISCUSSION

The elimination of *Agave* spp. led to the recovery of the original scrub habitat (Figure 1). Areas invaded by *Agave* spp. favoured plants typical of stabilised dunes (such as *Helichrysum stoechas*, *Lygeum spartum* and *Phagnalon saxatile*) but reduced the abundance of *Cyperus capitatus* and *Reichardia tingitana* (Table 1).

The average dissimilarity between invaded and reference plots was higher (62%) than between invaded and treated plots (55%) or between treated and reference plots (45%) suggesting that mechanical removal enhanced the recovery of native plant assemblages typical of well-preserved conditions. Differences between treated and reference plots were significant ($p < 0.001$, $R = 0.44$, one-way Anosim). However, the lower R

Figure 1. Comparative pictures of the managed area, before (December 2016) and after (May 2017) *Agave* spp. removal.

* To whom correspondence should be addressed: juan.garciadelomas@juntadeandalucia.es

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Table 1. Results from SIMPER analysis showing the occurrence of each species in the different plot types, and the contribution of each species to the overall dissimilarity between plots. We only show taxa that represent ≥5% of total dissimilarity between any of the compared plots.

Taxon	Mean occurrence (%)			Contribution to dissimilarity between plots (%)		
	Invaded plots	Treated plots	Reference plots	Invaded vs. reference	Invaded vs. treated	Treated vs. reference
Helichrysum stoechas	62	17	0	7.4	6.3	-
Lygeum spartum	68	17	13	7.1	7.2	2.9
Phagnalon saxatile	75	25	37	4.6	6.9	3.1
Cyperus capitatus	0	2	37	4.6	0.2	5.8
Plantago albicans	48	68	37	4.5	5.3	7.4
Ononis spp.	57	82	35	4.4	4.3	8.2
Cynodon dactylon	12	53	42	4.2	6.1	3.6
Brassica tournefortii	13	55	33	3.0	5.7	3.6
Reichardia tingitana	12	48	38	3.5	5.0	3.6

statistic associated with this comparison, relative to between invaded and reference plots (0.90), or between invaded and treated plots (0.88), suggests that treated plots were more similar to reference plots than invaded plots. One year after removal, a mean density (± S.E.) of 2.4 ± 0.4 *Agave* spp. offshoots/m² (n = 60) emerged, suggesting that mechanical removal must be supplemented with subsequent periodic manual offshoot and regrowth removal to maintain effective control of *Agave* spp. Physical control is therefore an alternative to the use of herbicides (van Dinther *et al*. 2015), and can promote rapid recovery of native plant assemblages.

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