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Local knowledge regarding ecosystem services and disservices from invasive alien plants in the arid Kalahari, South Africa

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ABSTRACT

Across the globe, many invasive alien plants were purposefully introduced because of their usefulness. These plants continue to provide multiple goods and services, such as fodder, fuelwood, medicines, fruits, shade and aesthetic appeal. However, as they invade negative impacts arise. This often leads to conflicts of interests and trade-offs between the benefits and costs of these species and, ultimately, the environment and local livelihoods. Traditionally, invasive plant species research in dryland systems has tended to focus on the impacts of these species on large-scale natural systems, primarily rangelands and river courses. Limited work has been undertaken regarding the role of these species in providing services and disservices within homesteads and settlements in these harsh environments. Such knowledge is important with regards to management. The primary aim of this study was therefore to assess the assimilation of invasive plant species into the lives of households in several small farming settlements in the arid Kalahari region of the Northern Cape, South Africa. Specific objectives were to: 1) assess the diversity, prevalence and size structure of invasive plants in resident's homesteads; 2) identify sources, local practices, knowledge and beliefs related to the invasive plants present as well as local management practices; and 3) understand residents' perceptions of the ecosystem services and disservices these species deliver. To do this, we used household and 'drive-past' surveys, in-depth interviews and measurement of plants in homesteads. From the 'drive-past' survey, we identified 12 officially listed and one proposed invasive plant species in the settlements, 10 of which were covered in the household survey. Eight native tree species were also present, but these were at much lower frequency and density than introduced species. Thirteen different goods and services from the invasive plants were recognised with the most common being shade, aesthetics and fuelwood. Some species, such as *Morus alba* and *Opuntia ficus-indica*, were important for fruit, while eight species were mentioned as being used for fodder. Respondents also mentioned that *O. ficus-indica*, *Prosopis* spp., *Leucaena leucocephala* and *Melia azedarach* imposed costs. These disservices included reductions in water supply, damage to buildings and human health impacts. Some of these species were also perceived to be spreading beyond homesteads in some settlements and invading rangeland. Less than a quarter of households had no invasive plants in their yards, and these were mainly new dwellings in the growing informal areas around the settlements. Invasive plants were obtained from variety of sources suggesting various pathways of introduction. We conclude by discussing some options for management focusing on *Prosopis*, as the invasive plant perceived to most rapidly expanding and generating the most disservices. We also highlight what further research is needed with regard to filling research gaps on invasive plant species within social-ecological systems in arid areas.

1. Introduction

Driven by greater acknowledgement of the complexity, historical dimensions and dynamics of human-environment relations, we are seeing the emergence of a more nuanced interpretation of the conflicting roles of introduced (non-native, exotic or alien) invasive

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plant species in both threatening and supporting ecosystem services and human well-being (Shackleton et al., 2007; Pfeiffer and Voeks, 2008; Vas et al., 2017). Indeed, it is now widely argued that, in order to understand plant invasions and before implementing control programmes, it is necessary to appreciate the negative and positive impacts of these plants on people and the economy, as well as their role in both providing and undermining ecosystem services at different scales (Bardsley and Edward-Jones, 2007; Pejchar and Mooney, 2009; Kull et al., 2011; van der Wal et al., 2015). As Simberloff et al. (2013) assert: "The full range of ecological, economic and sociological consequences should be considered when an invasion impact is evaluated".

Globally, it is well documented that invasive plants pose a significant threat to biodiversity and the delivery of ecosystem services, with serious consequences for local economies and ecosystems (Pejchar and Mooney, 2009; Simberloff et al., 2013). In South Africa, invasive plants, especially trees, have been shown to negatively impact grazing potential, affect nutrient cycles, alter plant community structures, modify fire regimes and reduce water supply (Richardson and van Wilgen, 2004). Consequently, South Africa's flagship invasive plant management programme, Working for Water (WfW), has already spent R 3.2 billion in the last 15 years to control numerous invasive plants across the country, especially where these impact water supply (van Wilgen et al., 2012). However, such considerations of the impacts of invasive plants are primarily focused at a regional, landscape or catchment scale and on biodiversity or ecosystem effects. Less attention has been paid to the local scale (homesteads and settlements) and to the benefits (ecosystem services) and drawbacks (disservices) of these species for livelihoods, especially amongst low income, natural resource dependent communities (Shackleton et al., 2007; Dos Santos et al., 2014).

Consequently, how local people relate to and benefit from invasive plants is becoming an important part of place-based invasive plant research. Recent studies have shown that people's views are shaped by the negative and positive attributes of the invasive plant species (such as its usefulness), the local social-economic and ecological context, and a set of other more individual factors (Shackleton et al., 2007; Kull et al., 2011). Specifically, these contexts and factors might include perceived levels of invasion and nuisance; whether the plants are 'wild' or domesticated; primary livelihood activities and other socio-economic factors such as poverty, land tenure and environmental policy; climate, natural vegetation and other biophysical factors; the goods and services obtained from the plants; the costs of management; and lastly personal values, local knowledge, risk perceptions and familiarity with the species (Shackleton et al., 2007; Mwangi and Swallow, 2008; Pfeiffer and Voeks, 2008; Kull et al., 2011; Dos Santos et al., 2014; Estévez et al., 2015; Shackleton et al., 2015).

Recognising this, Shackleton et al. (2007) developed a framework to aid in understanding local uses and perceptions of invasive plant species in rural areas that incorporates costs, benefits, abundance of the species, and the vulnerability levels of local communities. Initially, useful invasive plant species may be seen to have high benefits, but as invasion densities increase costs are likely to rise, potentially impacting other aspects of livelihoods and the supply of ecosystem services. This could potentially increase vulnerability. Various other authors have similarly argued for the need to explore the factors that drive local perceptions and awareness of the services and disservices of invasive plants, especially where there is high dependence on these species and conflicting values and perspectives (Eiswerth et al., 2011; van der Wal et al., 2015). Furthermore, the value of local ecological knowledge on invasive plant species and their management has generally been poorly acknowledged (Jevon and Shackleton, 2015). Since natural resource dependent people have lived with many non-native and invasive plants over decades, they have an intimate knowledge of their dynamics, life cycles and how they negatively impact on or support what matters in local livelihoods (Dos Santos et al., 2014). In particular, invasive plants can have significant positive benefits in harsh, tropical arid and semi-arid environments, like the Kalahari, where native species are naturally of low density and diversity. There are examples of the important role of invasive plant species in the livelihoods of low income communities from the drylands of Mexico (Blanckaert et al., 2007), Brazil (Dos Santos et al., 2014), South Africa (Shackleton et al., 2011, 2015), Madagascar (Kaufmann, 2004), Kenya (Mwangi and Swallow, 2008) and Ethiopia (Kull et al., 2011; Argaw, 2015). In such environments, invasive plant species provide a variety of direct benefits or provisioning services such as fuelwood, timber, fruit, forage and medicine, as well as non-consumptive benefits or regulating and cultural services such as shade, dust control, sand stabilisation, heat amelioration and aesthetic beauty (Mwangi and Swallow, 2008; Dickie et al., 2014). Indeed, many plant species were purposefully introduced into their non-native environments because of their usefulness or beauty (Mack, 2003). Approximately 20 of the 50 most prominent invasive plants in South Africa were introduced deliberately due to their beneficial nature and desired attributes (Macdonald et al., 1986). Therefore, it is not surprising that some species provide benefits to local communities and the economy, especially in arid areas.

A recent cost benefit study undertaken for *Prosopis* in the arid north-west of South Africa has shown that at current densities the benefits this tree provides through fuelwood, medicine and fodder provision marginally outweigh its costs of water uptake and grazing impacts, but invasions will likely become a net cost in the near future as densities increase (Wise et al., 2012). Benefits from the sale of fruits from the cactus *Opuntia ficus-indica* in the semi-arid thicket region of the Eastern Cape provides a cash injection for local traders, accounting for 9.2% of total household yearly income (Shackleton et al., 2011). Shackleton et al. (2007) found that respondents in two villages in the Eastern Cape would have preferred a greater abundance of *O. ficus-indica* in their local environment due to the benefits these plants provide. Similar results are also observable elsewhere. A study in the dry regions of Malawi showed that 44% of households rely on *Prosopis juliflora* for cash income (Chikuni et al., 2004). In the arid and semi-arid lands of Kenya, *P. juliflora* has both positive and negative impacts, with the latter beginning to outweigh the numerous benefits (charcoal, fodder, building material, fencing, cash from sales) this plant brings (Mwangi and Swallow, 2008; Maundu et al., 2009). In India, *Prosopis* provides up to 70% of household fuelwood needs in dry regions (Pasiecznik et al., 2001), while in Ethiopia this same genus provides a host of benefits, although the drawbacks of higher densities of this tree are becoming evident (Tessema, 2012; Argaw, 2015). *Acacia saligna* is an important agroforestry species in the dry Tigray region of Ethiopia where it helps people survive droughts and provides fodder, soil fertility and wood (Kull et al., 2011). In the dry southwest of Madagascar several species of *Opuntia* are of critical importance for pastoralists as stock feed (as well as other uses), especially since herders have become more sedentary (Kaufmann, 2004). In fact herdsmen manage and cultivate these plants, especially *O. monocantha*, in living fences for fodder and as a source of water for their livestock. Similarly, in Tigray, Ethiopia, both the spiny and spineless varieties of *O. ficus-indica* are a critical source of fodder for livestock, as well as being used for live fencing, windbreaks, erosion control, bee forage and fruit (Musimba and Bariagabre, 2003).

However, while invasive plant species such as *Opuntia* spp., *Prosopis* spp. and *Acacia* spp. provide benefits to local people, they also induce costs both locally and at societal level as highlighted

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