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Valuing local perspectives on invasive species management: Moving beyond the ecosystem service-disservice dichotomy

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ABSTRACT

This paper uses the concept of ecosystem disservices to explore and understand how rapid environmental change associated with an invasive plant species is framed and understood by different stakeholders. Through a focus on narratives, the paper explores how socially-differentiated populations understand the causes and consequences of a plant invasion and express preferences for often contrasting management interventions. The research design uses a workshop format to instigate a series of conversations with socially-differentiated groups of people to explore how people perceive and respond to the impact of *Prosopis juliflora* (a species of mesquite) in the dry-lands of Ethiopia. The results show that preferences for interventions differs by age, gender, location and li-velihood and also by primary and secondary stakeholder. Different sets of values underpin people's views and these contribute to the variation in the preference for different management interventions. To understand complex issues associated with alien invasive species, we find that the dichotomy between ecosystem services and disservices is artificial and call for a more dynamic and graduated view of ecosystem outputs. More prac-tically, our research shows that *P. juliflora* management options need wider consideration of socially-differ-entiated implications and trade-offs and this requires greater efforts to engage with primary stakeholders.

1. Introduction

Native to the Americas, *Prosopis juliflora*, a species of mesquite, now occurs in almost all the world's hot arid and semi-arid regions. Facilitated by the movement of people around the world, the thorny shrub has come to be one of the most widely known and recognised invasive plants (Shackleton et al., 2014). *P. juliflora* is associated with a number of negative impacts on ecosystems and human populations that rely upon those ecosystems for their livelihoods. Such impacts include altering soil ecology and water hydrology, reducing biodiversity, causing injury to people and livestock, and impeding movement and access to water sources for example (Patnaik et al., 2017). The plant also has widely recognised positive impacts and is commonly used for fuel, fodder, and as a construction material, for shade, and to stabilize soil (Pasiecznik et al., 2001). In Ethiopia, *P. juliflora* is considered an invasive alien species and has been identified as a significant threat in the arid and semi-arid lands, prompting efforts by government and other agencies to attempt to control and limit its spread (Government of Ethiopia, 2017). A recent study by Shiferaw et al. (2019) found that 35 years after its introduction *P. juliflora* has invaded 1.17 million hectares at varying coverage densities which equates to 12.3% of the total land cover in the Afar region. Both the study by Shiferaw et al. (2019) and other analyses for Afar (for example Haregeweyn et al., 2013; Wakie et al., 2014) model increasing densities of the shrub in lightly invaded areas and its continuing expansion within its ecological niche in the future.

Invasive species are often labelled as 'alien', but, nonetheless, they are inherently part of the ecology of the areas they inhabit with the potential to transform their surroundings, impacting on native species and habitats, and reshaping ecological functions that affect animal, plant and human communities (Shackleton et al., 2014; Vaz et al., 2017). Despite the well-attested benefits ecosystem services bring to human wellbeing, we cannot ignore that there are also, in some instances, negative ecological consequences on populations. Alien species, such as *P. juliflora*, are a case in point and impact on the wellbeing of people living in areas experiencing invasion (Potgieter et al., 2017).

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Just as elements of ecosystems have been articulated as 'services' so we have to recognise that there can be elements that function as 'disservices' (Vaz et al., 2017). Despite this, knowledge and understanding of ecosystem disservices, and their relationship to human wellbeing, remain under-attended in comparison to work on ecosystem services (Von Döhren and Haase, 2015). Moreover, the links between ecosystem services and the ways in which they are imbued with values through people's lived experiences, position within society and broader social and cultural filters have been inadequately addressed in the literature to date (Howe et al., 2014; Vaz et al., 2017).

We are embedded within our social, political and ecological environment and this has a profound impact on how we see the world around us. Concepts of ecosystem services and disservices are discursive structures, and, as such, they both draw on, and generate, narrative constructions (Barnaud and Antona, 2014). These narrative constructions, or frames, guide what we see and how we understand the world around us. In so doing, they privilege certain explanations whilst disallowing alternative interpretations of a problem or solution, often reflecting pre-existing systems of political and economic control (Bryant, 1998; Raymond et al., 2010). By exploring how issues are discursively constructed we can explore and critique the motivations that underpin notionally apolitical activities (Robbins, 2004). Understanding and revealing the underlying rationale for certain actions is of paramount importance when power asymmetries between actors are large, and represent a risk of exploitation and social injustice (Kull et al., 2015).

Using the invasion of *P. juliflora* in the southern Afar (Awash Fentale and Amibara Woredas) region of Ethiopia as a case study, this paper explores how the invasive species is perceived and discussed by stakeholders. The stakeholders include different levels of government, local manifestations of international non-governmental organisations (NGOs), locally-based organisations and directly affected (though comparatively disempowered) communities. The case study focuses especially on the management of 'Prosopis' (as it is referred to hereafter in the paper, reflecting how it is generally known in the country), and how perspectives on that articulate with the idea of differentiated narratives associated with ecosystem services and disservices. The paper is structured as follows: the next section reviews the literature on narratives of Prosopis and on ecosystem disservices. The scenario-based methodology used to generate the empirical data is then described, followed by the presentation of the results. The discussion section then analyses the scenario results using the insights presented in the literature review. Specifically, we focus on ecosystem disservices, trade-offs and the role of narratives in structuring the way problems are framed and preferences for different solutions are articulated. The conclusion argues for greater incorporation of affected populations into decision-making processes that have a tangible impact on their lives and for a more dynamic view of ecosystem outputs that recognises the influence of social differentiation on the values ascribed to those outputs.

2. Literature review

2.1. Narratives of prosopis

The ways in which issues are discursively constructed structures ways of thinking and acts to legitimize or delegitimize a specific position or course of action (Goffman, 1974; Schön and Rein, 1994; Bryant, 1998). These storylines or narratives help people to understand and explain a complex phenomenon, position actors in relation to it (either positively or negatively) and attribute 'specific ideas of "blame" and "responsibility", and of "urgency" and "responsible behaviour"' (Hajer, 1995: 64-65). Analytically, understanding the narratives or frames that actors employ is useful as it offers an entry point to begin to explore the assumptions that underpin apparently neutral and objective positions about specific issues, such as Prosopis. Put another way, by analysing the way in which issues are communicated discursively one can shed light on the positions' actors adopt and how often radically different views can be maintained whilst drawing on the same or similar sources of information.

Research on Prosopis in Ethiopia has tended to focus on understanding and describing the impacts (Rettberg, 2010; Mehari, 2015; Wakie et al., 2016b; Rogers et al., 2017; Zeray et al., 2017), mapping the spread and rate of change (Haregeweyn et al., 2013; Wakie et al., 2014; Ayanu et al., 2015; Shiferaw et al., 2019) and developing effective interventions (Shiferaw et al., 2004; Ilukor et al., 2016; Wakie et al., 2016a; Tilahun et al., 2017). Within this corpus of work there are a number of elements that discursively draw upon four framings of Prosopis. At either end of the spectrum are two more stringent perspectives (Prosopis as 'menace' and Prosopis as 'resource') (see for example Tiwari, 1999; Fre and Pasiecznic, 2015; Patnaik et al., 2017; Arumugam et al., 2018). Between these two poles are an additional two frames (Prosopis as 'sufferable', and Prosopis as 'utilisable') that are becoming increasingly common as understanding about Prosopis matures. These framings are now described below.

The first narrative portrays Prosopis purely as a menace (see, for example Rettberg, 2010). In this framing the negative impacts of the plant are so significant that they completely outweigh any benefits. Prosopis is harmful to indigenous flora, damaging the native ecology of the rangelands and threatens already vulnerable populations (Ayanu et al., 2015; Mehari, 2015). The often-unspoken implication of this argument is that the invasion needs to be eradicated and completely removed from the environment, thus helping to return the rangelands to a previous (imagined?) state that is more sympathetic to the populations' needs. As this representation of events tends to draw upon the hardships experienced by local populations (communities), the state or external agents are held partly responsible as they are linked with the introduction of the plant initially and also seen as failing to effectively manage it thereafter.

In contrast, the second narrative focuses on utilization and highlights the significant benefits that Prosopis can bring to environments that are portrayed as unable to support such vigorous vegetative growth without significant artificial inputs. These benefits include the plants restorative ability for degraded and salinized rangeland, its ability to grow in almost any conditions and 'green' the desert, and the opportunities it provides for livelihoods (see Fre and Pasiecznic, 2015 for good examples of elements of this narrative). Rather than frame the problem around the aggressive and invasive characteristics of the plant as impeding populations' ability to practice livelihoods, this narrative identifies the central strand of the problem as the population's inability to see and exploit the plant as a resource. A key element of this way of seeing is the focus on utilization – so rather than seeking to eradicate the plant attention is directed towards how livelihood systems can adapt and respond to make use of the resources and opportunities that are now available (Tsegay et al., 2015; Pastoral Environment Network in the Horn of Africa (PENHA) 2016a,b). Solutions that flow from framing the issue as a resource tend to revolve around incentivising actors to better harness the plant as an asset, thereby controlling its spread whilst deriving livelihood benefits.

Between these two poles are two other (shared) perspectives that have many similar characteristics but differ in terms of the focus on control or utilization. Prosopis as either sufferable (e.g. Tegegn, 2008; Finighan, 2012; Worku and Zewde, 2013; Government of Ethiopia, 2017), with mainly negative impacts that can be managed to lessen the harm, or as utilisable (e.g. Food and Agriculture Organisation, 2008), focusing more strongly on the positive characteristics that bring (potential) benefits to the people and the landscape. In both framings, eradicating Prosopis is regarded as highly unlikely, and so the focus of attention switches to minimising the harm that the invasion causes by trying to control its spread through different measures (Wakie et al., 2016b; Rogers et al., et al., 2017; Zeray et al., 2017). In both of these problem structures, proponents are international NGOs or government ministries and blame is apportioned to nature (the characteristics of the plant and the environment) and a wider set of constraints (such as poor

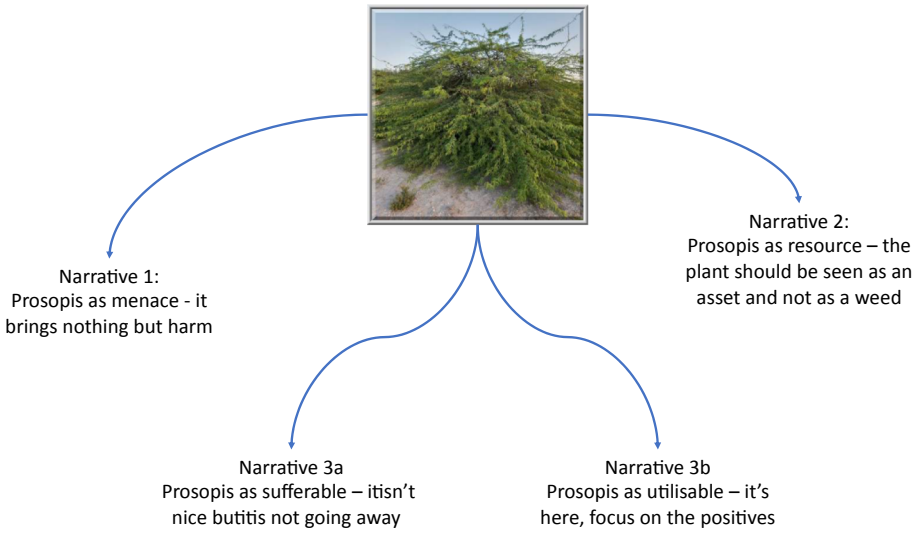

Fig. 1. Framings of Prosopis.

infrastructure, inability to access markets, and lack of buy-in from local populations to address the problem).

Taken together, elements of these four views of Prosopis (see Fig. 1) are evident in much of the literature and, we argue, structure approaches to generating knowledge and its subsequent application. There has therefore been a tendency towards more managerial and technocratic approaches that rely on experts to frame the problem and define the solution space. The voices of populations affected by the Prosopis have, on the whole, been deprioritised, disregarded or excluded. Approaches that rely on experts tend to flatten local distinctiveness and social variation (homogenise communities) and rarely capture the significance of social, cultural and value-based judgements made by people on the ground who are living with particular risks (O'Brien and Wolf, 2010). The first-hand experience (and expertise) of lay people in perceiving and living with risk is crucial to understanding those risks and to identifying the interventions necessary to bring about positive changes in their lives and livelihoods (Forsyth, 2003; Raymond et al., 2010).

2.2. Ecosystem disservices and trade-offs

Thinking on and conceptualisations of the links between ecosystem services and human wellbeing has tended to focus on benefits ('goods' and services) without sufficient consideration about how people can also be harmed through ecosystem outputs ('bads' and disservices) (Few, 2013; Rasmussen et al., 2017; Vaz et al., 2017). Moreover, ecosystem outputs, whether positive or negative, are mediated by social as well as ecological processes. The functioning of an ecosystem and the services or disservices that are derived from it can and does mean different things to different people depending on world views, the societal context, and the scale of analysis (Lazos-Chavero et al., 2016; Rasmussen et al., 2017; Spake et al., 2017). Trade-offs exist in any complex socio-ecological system and are the norm rather than the exception (McShane et al., 2011). Trade-offs are commonly described in terms of exchanges between and within ecosystem service categories. For example, they can include trading the loss of a regulating service for greater provisioning (Bennett et al., 2009), sacrificing longer-term productivity benefits at the expense of shorter-term gains, or valuing more local benefits at the expense of landscape level coherence and continuity (Rodriguez et al., 2006; Daw et al., 2015). Despite the widespread use of trade-offs and ecosystem services as a means to conceptualise human – environment interactions, challenges remain. Notable among these challenges is the tendency to portray communities in aggregate and ecosystem services or outputs as immutable.

A key weakness in much of the literature on ecosystem services and trade-offs is the failure to deal adequately with social differentiation. Populations are commonly conceptualised in aggregate without exploring the differences of who benefits, how and why (Daw et al., 2011; Lele, 2013; Brown and Fortnam, 2018). People and social groups within populations experience ecosystems differently. For example, in many countries, women have very specific gendered roles in terms of collecting water and wood for house construction that shapes their perception of the ecosystems compared to men. Elderly men are often in more privileged positions compared to all other social groupings and, though they may be considered the decision makers within a community, it does not mean that their voice is representative of all community members (Brown and Fortnam, 2018; Dawson et al., 2018). Therefore, when evaluating trade-offs and understanding who or what is likely to win or lose as a result of an intervention or change, the consideration of gender and other forms of intersecting social difference are key considerations.

Trade-offs are often portrayed as static allied to a view of ecosystem services as universal and depoliticised; the underlying assumption being that their value is commonly accepted and agreed upon (Lazos-Chavero et al., 2016). Such a view downplays the importance of issues such as personal preference, discursive power, where one is situated within society, and cultural and societal norms that mediate how one interprets the world (O'Brien and Wolf, 2010; Howe et al., 2014; Daw et al., 2015; Vaz et al., 2017). For example, Van Wilgen and Richardson (2014) refer to people's value systems as influencing the nature and types of conflicts that exist in regard to alien tree species, and Reilly and Adamowski (2017) state that the way in which people framed changes to ecosystem services in relation to the proposed removal of a dam strongly influenced their support or otherwise of the intervention. The values that people hold critically shape awareness of ecosystem functioning and mediate how people perceive and understand trade-offs. As people have varying perspectives about what is important and why, then an ecosystem functioning can be ascribed with a plural set of values that differ substantially. In such circumstances, seemingly universally-valued ecosystem services become instead sites of contestation.

3. Methodology

3.1. Participatory scenario analysis (PSA) method

The main data was generated through an approach called participatory scenario analysis (PSA), blending and refocussing aspects from a range of existing deliberative methods (see Hatzilacou et al. (2007);

Tompkins et al. (2008); Rinaudo et al. (2012); Milestad et al. (2014); Wesche and Armitage (2014); Butler et al. (2016)). During the PSA, stakeholders are guided through a structured and facilitated process that addressed different elements linked to the issue of Prosopis invasion within a coherent workshop structure. Through this approach participants were supported to explore the positive and negative trade-offs associated with different scenarios or visions of the future. The determination of what was considered positive and negative was left to the interpretation of the participants as they evaluated the different strengths and weaknesses of the scenarios and impacts of Prosopis. Stakeholders are engaged in separate workshops so as to better explore and deliberate group-specific challenges. The process explicitly targets disempowered stakeholder groups (in addition to other stakeholders) that have traditionally not been able or given an opportunity to think through and voice their opinions on issues or challenges that affect their daily lives and livelihoods. Specifically, we worked with participants from three communities and with separate sets of representatives from NGOs and from local government. The real value of the method lies in stimulating critical discussion at the grassroots level, to foreground differentiated valuations of ecosystem outputs and how these may change under different management interventions.

The PSA method uses a workshop format and includes 7 components (see Table 1), with each component introducing one issue or topic for discussion that builds on the previous components. In the communities, the workshop was held over two days. For most of the discussions the participants were split into four groups: older women, older men, younger women and younger men. This was to ensure that people felt more at ease to speak freely, rather than deferring to others whose age and gender traditionally affords them greater social standing. The logic underpinning the disaggregation was to understand if there were any key differences in perception according to age or gender and to recognise and manage, to some extent, the power asymmetries present during social interactions (Greenbaum, 1998; Carey and Asbury, 2012).

The first day focused on introducing issues and generating understanding about the nature of the problem, its impacts and how it had changed up to now, before looking at how the situation might continue to change in the future. The second day of the workshop focused on analysing and evaluating each scenario in turn and then identifying barriers and enablers preventing or supporting the implementation of a management intervention. The evaluation component included ranking each scenario (four votes for the most preferred, three for second best, two for the third best, and one for the least) according to personal preference. These results were aggregated for each socially-differentiated group (based on age and gender) to create group scores, which were discussed further by the participants as a whole. Our findings combine the statistics from the scoring (number of votes cast, and the first and second-choice preferences) with key points arising from the discussions. The separate workshops with representatives from NGOs and government followed a similar format but took place over one day and groups were not based on socially-differentiated criteria.

3.2. Scenarios

The scenarios were developed by the joint UK and Ethiopia research teams (with extensive experience of working in dryland and pastoral environments) through a detailed literature review of published and grey literature focusing primarily on sources addressing the issue of Prosopis in Ethiopia. The purpose of the scenarios was to develop a set of plausible management interventions that would stimulate conversations and discussions amongst the workshop participants (see Fig. 2 and Appendix 1 for a more detailed explanation of each scenario). The underlying rationale was to use the scenarios as a methodological tool to facilitate deliberative engagement with workshop participants. This approach necessitated the development of scenarios that were plausible enough whilst ensuring that the likely range of interventions were adequately represented without necessarily replicating exactly past (or potential future) interventions. Underpinning the scenarios was a set of assumptions concerning the inability to completely eradicate Prosopis, and of key trends within the region around continuing population growth, anthropogenic climate change, increase in commercial agriculture, livelihood diversification, increased levels of migration and villagization (see Table 2). These assumptions were held the same for each of the scenarios.

Once the scenarios were developed, images were created (Fig. 2) to facilitate engagement and to act as an aide-memoire during the workshops. To improve the robustness of the scenarios and the communication material and approach, feedback was gained from a group of stakeholders not involved in the workshops and through a pilot workshop held in a community of similar characteristics to those engaged through the PSA process. Following feedback received from the stakeholders and the pilot workshop, minor changes were made to the images and the translated scenario descriptions.

3.3. Sites and sampling

The study was conducted in the Middle Awash Valley (MAV) in Awash Fentale and Amibara *woredas* from the south of Afar National Regional State (AfNRS). Awash Fentale and Amibara *woredas* are predominantly semi-arid or arid with the majority of the population practising pastoral and agro-pastoral livelihoods. The area is exposed to frequent drought and flood hazards, is affected by issue of food insecurity, and is showing signs of substantial ecological disturbances (such as changes in hydrology and invasion of alien species). The case study area has been the subject of a number of development interventions (irrigated sugarcane and cotton plantation for example) over a sustained period and is also seen as a potential site for expansion of government and private investment opportunities, commercial livestock and crop production (Shiferaw et al., 2004; Müller-Mahn et al., 2010; Rettberg, 2010; Ayanu et al., 2015).

Five workshops were held in total, one in each of the communities of Alola, Bedula'ali, and Gonita Birka (see Table 3 and Fig. 3) and two further workshops in Awash Sabat Kilo with representatives of NGOs and local government respectively. Each community workshop involved 20 individuals disaggregated into four groups ($n = 5$) by age and gender. Participants were purposively selected to match the age/gender profiles. Though identification of participants was managed by the local research team in partnership with local contacts in the villages. An initial group of participants was identified with selection based on pre-agreed criteria related to age and status. Every effort was made to work with people who were not considered part of the elite within the communities where the workshops were taking place. This expectation was managed through effective communication with local contacts and through discussions with prospective workshops participants concerning their roles within the community (for example, potential participants were excluded if they were a member of any decision-making body within the community). Whilst we were not able to eliminate bias linked to participant selection and subsequent data generation we are confident that these issues were managed satisfactorily to ensure the integrity of the data collection process. NGO ($n = 7$) and government organisations ($n = 12$) were selected based on organisational experience and expertise in relation to rural livelihoods and development, farming and pastoralism and expertise on the management of Prosopis[1].

[1] Only limited details about the organisations and departments that the NGO and governmental participants are drawn from is provided to protect participants' anonymity.

Table 1
Major discussion components of a Participatory Scenario Analysis workshop.

Component	Purpose
Impacts of Prosopis	• Introduce the issue of Prosopis • Understand the present-day impacts of Prosopis on participants and their local community
Drivers of change	• Elicit views about the drivers of change that have impacted on the availability of pasture/pasture scarcity
Future change	• Explore how the situation may change in the future • Introduce the risks/opportunities brought about by that change
Introducing the scenarios	• Introduce four scenarios of the future • Introduce to the participants the idea that the future can evolve in different ways • Seek feedback on the scenarios
Analysing the scenarios	• Understand the elements of the scenarios that are or are not valued, and by whom • Explore trade-offs implied by the scenarios between social and environmental goals and between the interests of different social groups • Reveal which evaluation criteria the socially differentiated groups value
Scenario evaluation	• Enable individuals to think about their preferred scenario and the reasons why it is preferred • Explore personal preferences for individual scenarios • Rank each scenario according to preference
Barriers and enablers	• Understand the main barriers preventing the realisation of a scenario • Understand the main enablers to support the realisation of a scenario • Explore the extent to which the participants feel they have agency (power and influence) to bring about change

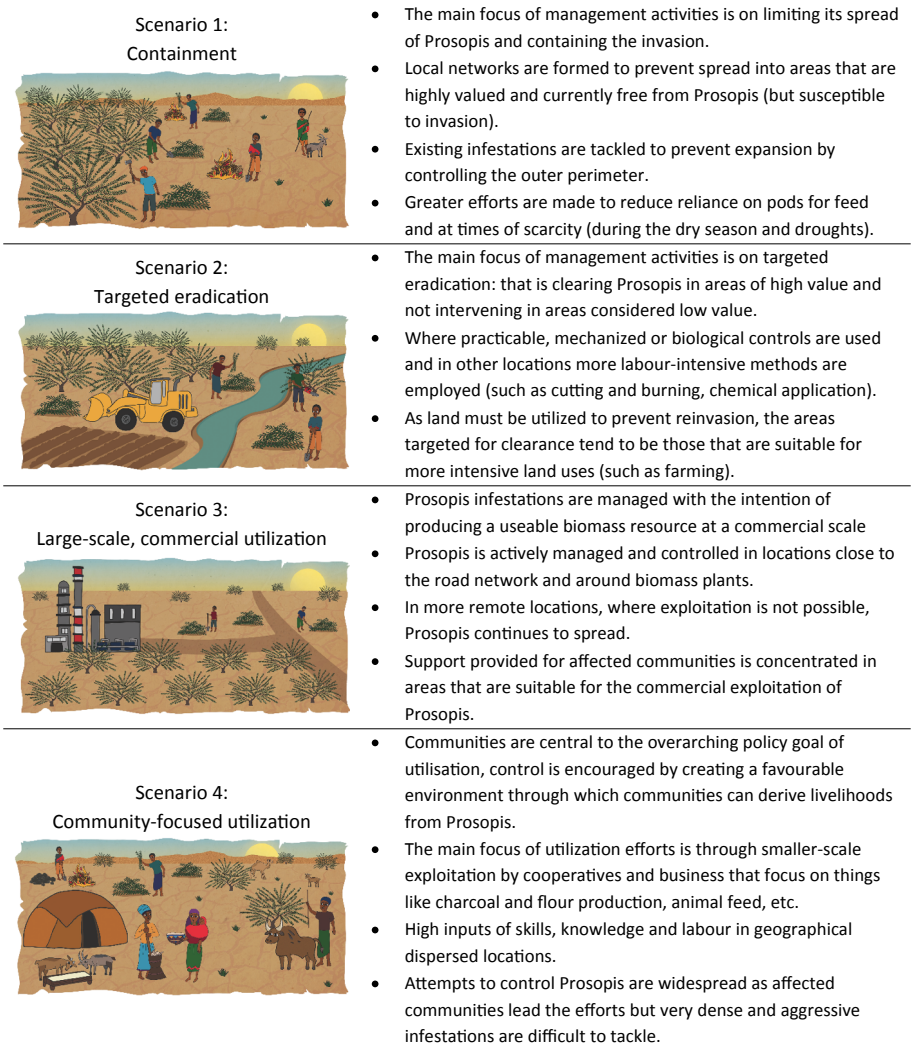

Fig. 2. The four scenarios used to explore preferences for different management interventions.

4. Results

4.1. Perceived impacts of Prosopis

The negative impacts of Prosopis reported by communities relate primarily to crops and livestock, access to resources and human health (see Fig. 3). The participants primarily highlighted impacts that directly touched upon their wellbeing. Four out of the five most commonly cited impacts related to the health and productivity of livestock or farmland, the injuries to people brought about by Prosopis and the disruption as paths were blocked or access to water bodies was impeded. The only commonly cited impact that related more directly to the ecological

Table 2
Key trends that apply to all scenarios.

Key trends	Supporting literature
• The presence of Prosopis is accepted as inevitable and considered impossible to completely eradicate • Population growth • Increasing uncertainty regarding the future climate in terms of aridity and extreme events • Growth in large-scale commercial agriculture • Diversification underpins many current pastoral livelihoods • Increased levels of human migration • Increasing villagisation (resettlement of pastoralists into fixed-location sites)	Haregeweyn et al. (2013); Aberra and Abdulahi (2015); Cervigni and Morris (2016); Jenet et al. (2016)

Table 3
Characteristics of the study sites/*kebeles*.

Study site/*Kebele*	*Woreda*	Livelihood type	Further information
Alola	Awash Fentale	Pastoral	Located close to main town of Awash Sabat Kilo. Prosopis is present in the area but is yet to form very dense thickets proximate to the settlement
Bedula'ali	Awash Fentale	Agro-pastoral	All households have been allocated farmland and the land is used more intensively with irrigated sugar cane and cotton plantations close to the settlement. The area around the settlement is densely invested with Prosopis
Gonita Birka	Amibara	Pastoral	More remote settlement and the one most reliant on pastoralism. Land around the settlement is rangeland of which large areas are infested with Prosopis. In some areas this is impeding movement and migration corridors

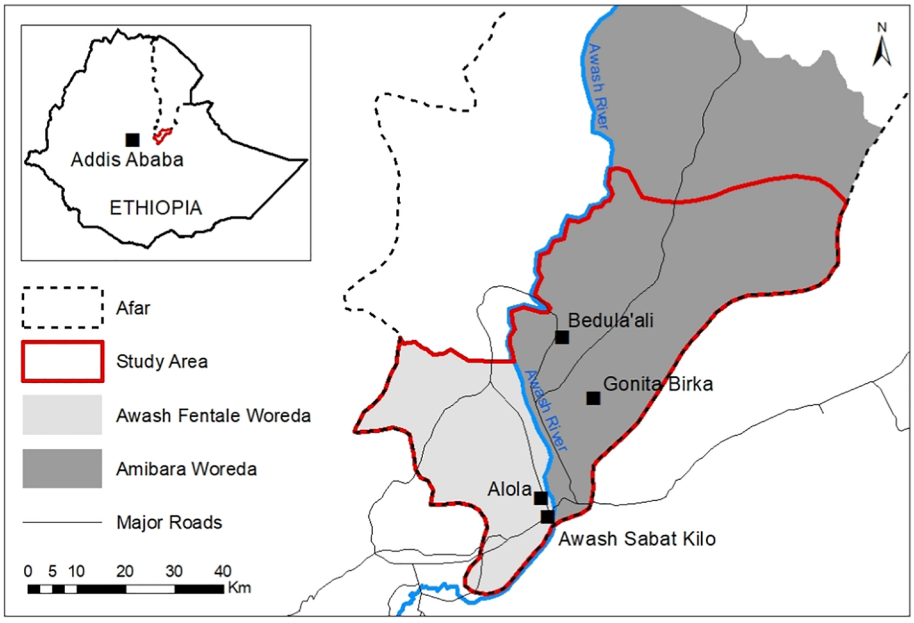

Fig. 3. Map of study area showing locations of the three community workshops and the NGO and government workshop.

changes arising from the invasion of Prosopis was the loss of native flora. Implicit in many of the impacts highlighted by the participants relates to the drain on people's resources (time and energy) that is due to the increased prevalence of Prosopis. One group talked about the amount of time and effort required to keep areas free from invasion. However, this cost is also implicit within many other of the impacts given. For example, native flora were preferred for house construction yet these are becoming less available and harder to access, thus increasing the amount of time and energy required to collect them. Water is another case in point in terms of the increase in time and effort it takes to collect, as are the costs to herders in regard to the time taken to access pasture that is becoming more scarce and harder to reach. Although not shown on Fig. 3, representatives from government and NGOs identified a similar set of negative impacts but tended to relate them more to the ecological and environmental changes brought about by Prosopis, these changes were then linked to impact on livelihoods.

As alluded to above, the impacts of Prosopis are not felt equally within populations. Participants reported that herders were away for longer and had to migrate further to access pasture and water as traditional migration routes were becoming blocked and pasture availability was decreasing. Women were particularly affected as they have responsibility for house construction and water and firewood collection. All of these activities were negatively impacted on by Prosopis. The elderly members of populations were regarded as more at risk of injury from the plant, especially at night. One participant reported that there were instances when people had become lost in dense thickets of Prosopis. Children were also considered more vulnerable. Participants report that the invasion of the plant into settlements reduced the safe places for play for children, who are often barefoot. Furthermore, concern about dense cover for large predators increased the anxiety amongst parents and had curtailed the willingness of them to let their children move far from the settlement.

Notwithstanding the negative impacts, a range of positive attributes were also associated with *Prosopis*. Table 4 shows those attributes that

Table 4
Positive attributes as cited by at least two socially-differentiated groups (n = 12 groups).

Use	# of groups	Comment
Fencing to demarcate dwelling boundaries and for animal enclosures	5	Not preferred as supports expansion of plant
House construction	6	Not as durable as native woods
As shade for people and animals	4	Native species are preferred
Firewood	8	Not viewed as favourably compared to native species.
Charcoal making	7	Not viewed as favourably compared to native species and prohibited by AfNRS policy.
Animal feed (Prosopis pods)	3	Utilised only in times of scarcity
Soil conservation	2	Disputed within the proponents' groups

were identified within the communities by at least two socially-differentiated groups. The most commonly listed uses related primarily to livelihoods (such as firewood, charcoal making, and as animal feed) or people's wellbeing (house construction and shade for example). Despite the identification of these uses as positive, many of the respondents stated that native flora was still preferred and the use of Prosopis was occurring due to the scarcity of more traditional resources (brought about in part by the continued expansion of Prosopis).

The positive attributes identified by the government and NGO representatives bear interesting comparison with those identified by the community participants. The more frequently cited benefits of Prosopis were associated with the landscape more generally and included the plants' ability to control soil erosion and wind erosion and flooding, to address high levels of salinity, to support nutrient cycling and to provide year-round greenery and as a sink for carbon dioxide. These attributes relate much more closely to the regulating and supporting functions of the ecosystem rather than the provisioning benefits identified by the community participants.

4.2. Overall preferences/voting patterns

Across the three communities, scenario 3 (commercial utilization) and scenario 2 (targeted eradication) scored the highest (see Fig. 5) and received the greatest number of first-choice preferences (see Appendix 2, Fig. A1). In Alola, scenario 3 was scored the highest by each of the socially-differentiated groups and received the most first-choice preferences. In Bedula'ali there was slightly more variation in scoring and in the preferences exhibited by the socially-differentiated groups compared to Alola, but, overall, scenario 2 scored the highest and received the greatest number of first-choice preferences. The voting patterns in Gonita Birka were much more uniform compared to the other two communities. Scenario 2 was scored the highest by all four socially-differentiated groups. Interestingly, scenario 3, which scored the highest in Alola and the second highest in Bedula'ali was scored the lowest in Gonita Birka.

First-choice preference voting reveals distinctions based on age in the communities of Alola and Bedula'ali. In these communities, the groups of younger men and younger women exhibited a preference for scenario 3. In contrast, the groups of older men and women universally favoured scenario 2 (in the case of Bedula'ali) or exhibited more mixed preferences split between scenarios 2, 3 and 4. The most likely explanation for this divergence is linked to the perceived distribution of benefits amongst the socially-differentiated members of the community. All groups in Alola felt that the younger generation were more likely to benefit from scenario 3 as they have more skills (linked with higher educational attainment) and labour and are better placed to take advantage of the sorts of opportunities that would arise through the development of a commercial operation. Similarly, in Bedula'ali, the main reason given for selecting scenario 3 was that the younger generation thought it would lead to more livelihood and income-generating activities. By way of contrast, the group of older men showed much more scepticism and questioned whether their community would benefit from this sort of livelihood and income-generating development.

In terms of scoring and first choice preference the intention of the government group most closely matched the overall preferences of the communities in selecting scenario 2 (see Fig. 6 and Appendix 2, Fig. A2 respectively). In contrast, the NGO representatives favoured scenario 4. Interestingly, this scenario was not the favoured scenario in any of the community workshops. The difference may be related to the strong advocacy for community-focused intervention that is central to many of the NGOs.

4.3. Pros and cons of control methods

Two of the four management scenarios ('containment' and 'targeted eradication') focused primarily on controlling Prosopis. The

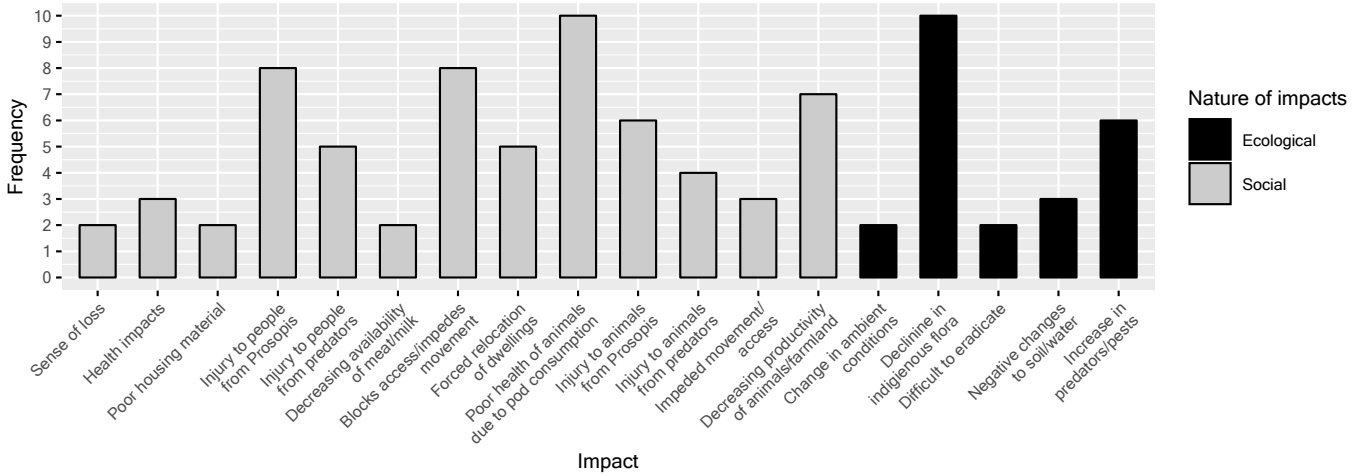

Fig. 4. Negative impacts of Prosopis elicited through socially-differentiated group discussions in Gonita Birka, Bedula'ali and Alola (n = 60). Impacts disaggregated into social (impacting on people and their wellbeing) or ecological (changes to the flora and fauna) categories.

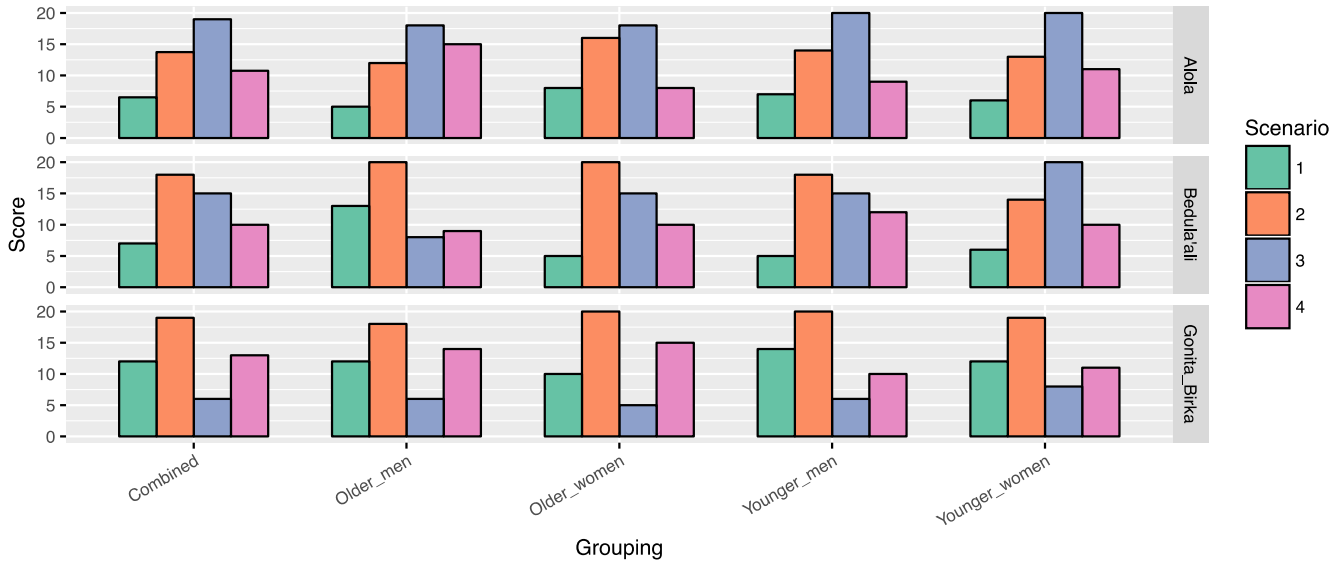

Fig. 5. Scenario scoring ($n = 20$), combined scores show mean of four sub-groups.

'containment' scenario was the least favoured of all the management interventions in each of the communities. The most positive attributes of the scenario were the focusing of containment efforts on areas considered high value such as water points, settlements and migration corridors; this was highlighted as particularly beneficial to pastoral livelihoods hence the slightly stronger support in Gonita Birka. However, in all three communities (across the majority of socially-differentiated groups) and in the groups of Government and NGO representatives, two of the main elements of the scenario (limiting the spread of Prosopis by controlling the movement of livestock and people and, in areas already infested, managing the perimeter of the infestation) were considered unworkable on a large scale. Livestock mobility is essential to livelihoods, preventing the animals from consuming *Prosopis* pods aiding dispersing is not feasible. Similarly, trying to limit spread of existing invasions through locally-targeted activities is considered ineffective as the plant is so prevalent in the environment.

One of the key concerns highlighted by the community participants was associated with the method of clearance. All communities had extensive experience of manual clearance, considering it highly demanding physically and carrying a significant risk of injury. Furthermore, the plant coppices exceptionally well enabling it to grow back rapidly, nullifying previous attempts at control. The participants from Bedula'ali described how the area around their settlement was very densely colonized by the plant and manual approaches to clearing had become largely ineffective. In contrast, and while acknowledging that containment was a failure and unable to control the spread of Prosopis, government representatives saw value in implementation at a community level as it required little equipment and was cheap to implement. Similarly, in the NGO workshop, participants discussed the need to create incentives to encourage the local populations to work more intensively to tackle the problem of Prosopis, some even claiming that communities in Afar lack a culture of hard work. Such views perhaps help to explain why the promotion of a manual clearance approach continues to persist.

Scenario 2 (targeted eradication) was the most favoured scenario in two (Gonita Birka and Bedula'ali) of the three communities and with government representatives. The participants highlighted the importance of maintaining access to water points for animals and domestic use, keeping the most productive rangeland and farmland free from Prosopis, ensuring that access routes and movement corridors were actively managed and keeping areas within and around settlements clear of the plant. The near universal preference for scenario 2 in

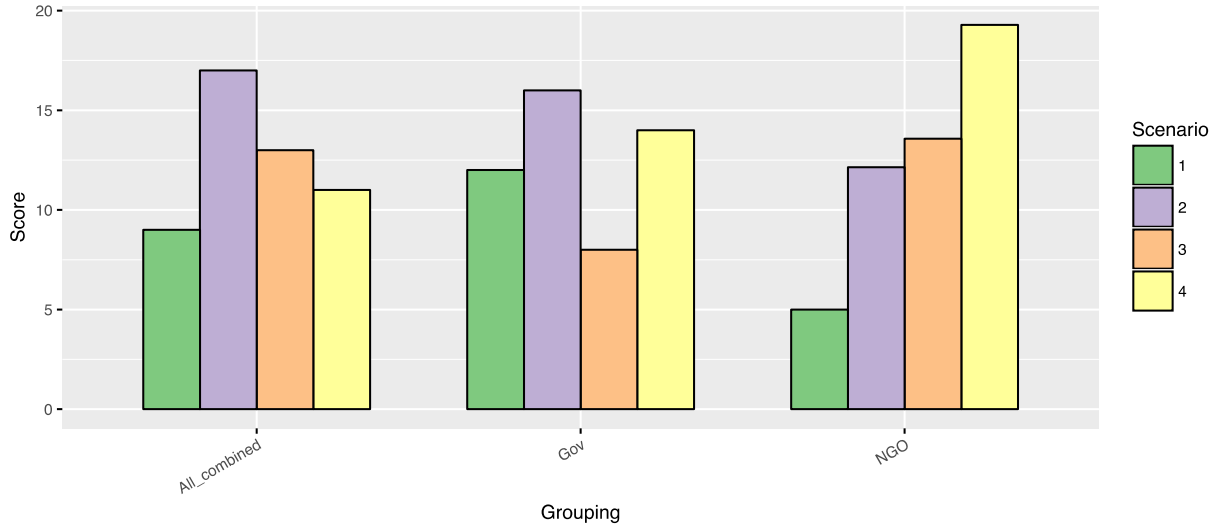

Fig. 6. Scenario scoring (community $n = 60$, Gov. $n = 12$, NGO $n = 7$), combined score shows mean of all community participants. Weighted to enable comparison.

Gonita Birka could, in part, be attributed to the purely pastoral livelihoods and remoteness when compared to the other two communities. The participants felt this scenario offered the greatest potential to support the pastoral livelihoods by maintaining *and* reclaiming access to rangelands and water resources. For Bedula'ali, scenario 2 offered potential to support the ongoing transition into agro-pastoralism. The participants in Bedula'ali felt that this approach would support their existing livelihoods while also helping them to develop alternative ones focused on farming. The continued transition of the community from one of pastoralism to agro-pastoralism was a theme underpinning many of the elements considered strong in this scenario. Conversely, participants from Alola, which is proximate to Awash Sabat Kilo, felt that this scenario would be less likely to benefit them. They did not perceive their location to be 'high value' as it lacks a source of water to support irrigation and they felt it would therefore be excluded from the targeted eradication measures.

There was some divergence with regard to the clearance methods. Though the mechanised removal techniques (using machines like bulldozers) were seen, on the whole, as a strength of the scenario (ability to clear large areas of land quickly with low risk of injury), community participants highlighted that such approaches were indiscriminate and removed native flora in addition to Prosopis. The community participants were hesitant to comment in much detail on biological and chemical measures, as they had little direct experience of them (especially in comparison to mechanised clearance), although they did express significant caution in using technological approaches with potentially negative side effects. In contrast, the discussion of chemical and biological approaches was discussed in more detail by government and NGO representatives and viewed more favourably and of lower risk. One other notable difference was that the community participants, particularly from Gonita Birka, highlighted the risk of land appropriation following large-scale clearance. In contrast, the government and NGO representatives did not perceive there to be a significant risk that communities would lose usage rights to land during or immediately after it had been cleared.

4.4. Pros and cons of utilisation methods

Across the three communities, the preferences for scenario 3 (large-scale, commercial utilisation) exhibited the greatest variation. The perception that the younger generation were more likely to benefit helps to explain the divergence in Alola whereby both younger groups unanimously supported this scenario compared to the groups of older people who showed more mixed preferences. Similarly, in Bedula'ali, the scenario was the preferred choice of the younger generation who felt that it would lead to more livelihood opportunities and income-generating activities. As with the participants in Alola, the participants also thought that the commercial activities would bring improvements in infrastructure (roads for example) and the provision of services (water points and better health and education provision). In contrast to the views expressed in the other two community workshops, the participants in Gonita Birka felt that scenario 3 would more likely serve the interests of others. Some of the most common viewpoints expressed were that people who work in the factory would come from outside the area, utilization of Prosopis would not benefit pastoralists and might result in its continued expansion rather than greater control, and the village might be displaced should a factory be located nearby. Underpinning these concerns was a distrust of government: many participants felt that state actors could not be trusted to prioritise the needs of the community. The NGO and government representatives also highlighted similar concerns to those raised in Gonita Birka and, to a lesser extent, in Bedula'ali – the likelihood that opportunities associated with the development would go to people outside of Afar.

Scenario 4 received some support in the three communities, particularly in Gonita Birka. For example, the participants responded positively to the emphasis on training, skills and financial support to enable them to utilize and generate livelihoods from Prosopis. In Gonita Birka, the scenario was more favoured by the groups of older men and older women in particular. The scenario was seen to provide the greatest level of community control and self-determination, minimising the risk that external actors would seek to gain control of critical land and water resources (to be seen in light of the comments made in regard to scenarios 2 and 3). Whilst the benefits of a community-focused approach were acknowledged, it was also the source of the greatest concerns. In all three communities, participants emphasised that the additional time, energy, and resources that would be required to make the scenario succeed are substantial. For example, in Alola, both the female groups argued that women would lose out due to the increased labour demands on them to collect Prosopis pods. In Bedula'ali, similar sentiments to those in Alola were expressed but not differentiated by gender, with men and women both expecting to have to work harder to generate benefits. Underpinning many of the viewpoints on this scenario was the belief that, although the scenario would support livelihoods, it would not, ultimately be successful in controlling the underlying problem. For example, the younger women in Bedua'ali explained that the scenario will not be effective in addressing highly infested areas and the older women in Gonita Birka thought it would not be as effective in managing Prosopis spread as Scenario 2 (targeted eradication).

Scenario 4 was viewed more positively by representatives from government and NGOs in particular. As with the community views, the key strengths of this scenario centred on the participatory and inclusive approach that placed the community at the centre of the management intervention. The training and financial support would increase livelihood opportunities and help the community to develop. A key risk for this scenario related to the level and nature of external support required and that it might create dependencies on external actors. Concern about the support was not an issue that was raised for any of the other scenarios, even those that required extensive capital investment, suggesting that it was the nature of training support required, and the difficulty in providing it (to dispersed, rural and highly mobile communities) that was the key problem, rather than the cost burden directly implied by use of the technology.

5. Discussion

The results presented above describe the main impacts of Prosopis on the environment and people's livelihoods and wellbeing, summarised the voting preferences for the different scenarios and then set out the perceived strengths and weaknesses for different approaches to the control and utilisation of Prosopis. We now discuss these results in relation to ecosystem disservices, trade-offs and the framing of the problem and solutions.

5.1. Ecosystem disservices

The research highlights the strongly negative perceptions that communities had in regard to the invasion of Prosopis. The results showed a range of negative impacts (see Fig. 4) on the lives and livelihoods of populations and on the ecology of the drylands, lending weight to the calls for greater recognition of ecosystem disservices especially in relation to invasive species (Potgieter et al., 2017; Vaz et al., 2017).

Within the literature, ecosystem services and disservices are often portrayed as apolitical and universally accepted outputs and not open to contestation (Kull et al., 2015). Howe et al. (2014) argue that different groups of people derive differing benefits from ecosystem services and value these services differently. Therefore, when including stakeholders in the assessment of trade-offs between ecosystem services (and, by implication, human wellbeing), the values the stakeholders have become 'intrinsic' or embedded within ecosystem outputs (Howe et al., 2014: 264). If one accepts the importance of values, social and

cultural norms, and where one is positioned within society as influencing what is considered as an ecosystem service, then it becomes increasingly difficult to maintain the argument that an ecosystem service or disservice is as universal and static as portrayed. As values change so the ways in which an ecosystem service or disservice is perceived will also change suggesting that an ecosystem output is much more dynamic than can be portrayed in the literature.

Second, the nature of ecosystem services and disservices debate is often presented as a dichotomy (Von Döhren and Haase, 2015; Saunders and Luck, 2016; Schaubroeck, 2017). Our data has shown that an ecosystem output can be both a service and disservice concurrently suggesting a much stronger and mutually constituted relationship for some ecosystem outputs, depending on the context and framing, the scale of analysis, and who is being asked. For example, government and NGO representatives highlighted the value of Prosopis at a landscape scale in terms of its ability to reduce soil erosion and promote nutrient cycling, address excess levels of soil salinity and manage flood risk. Local community members tended to focus more on negative personal impacts, emphasising the loss of native grazing and browsing resources and the associated implications of this on their lives and livelihoods. Similarly, Prosopis is used as fencing for *bomas* but this usage supports the continued spread of the plant highlighting simultaneously its value (fencing) and detrimental effect (supporting the expansion of the plant into settlements). More recent scholarship on ecosystem outputs argues for a more malleable and dynamic conceptualisation of ecosystem outputs (Lazos-Chavero et al., 2016; Shackleton et al., 2016; Rasmussen et al., 2017; Vaz et al., 2017), and our study lends empirical weight to these calls.

5.2. Trade-offs: between and within stakeholder groups

The results show that the preferences for scenarios vary according to intersecting elements of social difference. The preferences for individual scenarios are influenced by location, for example, with proximity to urban areas resulting in more development-focused choices (commercial utilisation with assumptions that this will lead to improvements in infrastructure and provide greater paid employment opportunities). Similar divisions also appear within communities, for example, by age, with the younger participants leaning towards those options that offered greater potential for diversifying livelihoods, and by livelihood, with agro-pastoralists and pastoralists differing in which scenario they preferred. Together, these preference patterns show the differentiated environmental, social, and economic nature of communities and community members. What this means is that any blanket application of a Prosopis management measure is likely to lead to conflicting effects on different groups, in other words creating trade-offs of one amenity against another (Small et al., 2017).

In this light, it is interesting to reflect on how benefits of Prosopis were viewed by different stakeholders. In terms of impacts, differences between perceptions were more apparent with regard to positive uses of the plant. Within the communities, the most commonly cited positive impacts were related to the increased availability of material for fuel (firewood and charcoal), house construction and fencing. Government and NGO representatives emphasised the benefits of the plant to the landscape in terms of its ability to 'green the desert', for nutrient cycling and soil fertility, to prevent flooding and as a sink for carbon dioxide. This supports the reasoning of Daw et al. (2015), who argues that such a divergence arises, in part, from the focus of secondary stakeholders on system-level objectives set against the more differentiated and intersectional set of values that contribute to the wellbeing of primary stakeholders. Similar divergences, although not the focus of this paper, are also likely to be present when looking at the ways in which scientific experts frame issues and consider certain types of knowledge as more legitimate than other types (O'Brien and Wolf, 2010; Ingold et al., 2012)

Implicit within the preferences that people have are different conceptions of what is important and why (Costanza et al., 2017). In acknowledging these differences, trade-offs become at once more tangible and intractable. The notion of achieving 'win–win scenarios' predicated on aggregated notions of wellbeing and commonly accepted and understood ideas about specific ecosystem services, appears an impossible goal (Daw et al., 2011; McShane et al., 2011). Trade-offs are widely recognised within ecosystem service literature and have tended to focus on changes in ecosystem services over time and space. Our research has shown that differences in how advantages and disadvantages accrue arise through the intersection of age, gender, livelihood and location, and between primary and secondary stakeholders, supporting more recent work by Daw et al. (2015), Galafassi et al. (2017) and Few et al. (2017), for example. However, and despite the importance of understanding these sorts of trade-offs, they remain relatively marginal to mainstream literature (Howe et al., 2014).

5.3. Framing the problem and identifying solutions

Differently positioned actors draw upon unique sets of experiences and values to understand the world around them. These experiences influence how actors see and make sense of events, they act as filters through which some things are considered more 'right' and believable and other things more 'wrong' and to be disregarded (Hajer, 1995). Such schemes of understanding are evident in relation to Prosopis and influence what (and who) is considered important and what solutions are most likely to succeed. As such, these narratives are crucial in structuring debates around courses of action, making certain trade-offs visible and masking others, and identifying those with expert knowledge and the authority to make judgements (Forsyth, 2003).

Within the communities, different narratives around Prosopis were present. Although Prosopis was regarded as a threat to people's way of life in all communities, this was most viscerally expressed in Gonita Birka, the community for which pastoralism was the single most important livelihood. Scenario 2, which was perceived to provide the greatest opportunities for pastoralism, was the most preferred overall. Additionally, the participants were resistant to scenarios that implied greater intervention by government and other (linked) actors, fearing that it would lead to a loss of control and a further erosion of the viability of their livelihoods and culture. In justifying these choices, the participants drew predominantly on the narrative that portrays a view of Prosopis as a menace. In this framing, the pastoralist way of life as fundamentally threatened and under attack from multiple sources (Prosopis, government agents, drought, etc.) (Rettberg, 2010; Rogers et al., 2017). Actions by the government were viewed with distrust and the community would prefer, in an ideal world, to see Prosopis eradicated from the environment. At the other end of the spectrum was the recognition that Prosopis has the potential to be beneficial. Greater utilization of Prosopis would lead to a range of ancillary infrastructural and social developmental benefits highlighting that presence of the plant can lead to positive outcomes if approached in the right way. Underpinning this line of reasoning was a modernising agenda which advocates a transition away from lifestyles associated with mobile pastoralism (for a more indepth analysis of this issue see Makki and Geisler, 2011; Makki, 2012; Mosley and Watson, 2016). This framing of events, drawing on the narratives of Prosopis as either a resource or as utilisable was present within two of the three communities (more so with the younger groups) as well as with the representatives from government and NGOs.

Whilst the use of narratives that see Prosopis as a resource or utilisable were employed by some community members and representatives from government and NGOs there was a notable divergence around blame and attribution. Community proponents were more critical of actors responsible for introducing the plant to the area and the weak response in attempting to bring the invasion under control. In contrast, many government and NGO representatives attributed blame to the native population, arguing that they lacked a culture of hard work necessary to control the plant's spread. In identifying different

factors as responsible for the problem it follows that different solutions are favoured (Forsyth, 2003: 98-99; Müller-Mahn et al., 2010). In the case of the government and NGOs there was some support for existing measures (encapsulated in the containment scenario) but with additional incentives to address the alleged weak motivation within the Afar population. In contrast, community responses were directed towards a more engaged state and the development of markets to support utilization.

Narratives or problem framings help to set boundaries about what can be discussed and provide a means through which actors coalesce and, more fundamentally, are an expression of discursive power (Bryant, 1998; Castree and Braun, 2001). In the case of Prosopis, we see evidence of socially-differentiated groups drawing on different narratives to help attribute responsibility, understand cause and consequence, and promote potential solutions. Any attempts to generate knowledge on impacts of Prosopis and potential interventions needs to be cognisant of these broader discursive structures and the ways in which they influence who or what is privileged, the trade-offs that are made visible, and the extent to which the priorities of social groups drawing on subaltern views of the world are valued (Van Wilgen and Richardson, 2014).

6. Conclusion

In this paper we affirm the threat that Prosopis presents to livelihoods in the Afar region of Ethiopia and the management intervention preferences of socially-differentiated groups. We argue that issues of alien invasive species strengthen the need for a greater focus on ecosystem disservices in addition to ecosystem services. Moreover, we argue that the current ecosystem services and disservice dichotomy is unhelpful and that ecosystem outputs must be reconceptualised as dynamic, mutually constituted and differentiated. The value ascribed to these outputs depends as much on the ecosystem as it does on the population that experiences its services or disservices. People's values change over time and vary between and within populations, demonstrating that an ecosystem output should not be seen as apolitical and uncontested. The concept of ecosystem services is inherently anthropocentric but, we argue, further focus on the 'social' drawing on a plurality of methodologies from across the natural, social and arts and humanities disciplines is still required to enhance the understanding and insights that can be generated. Once a population is recognised as socially-differentiated then values, cultures, contexts and power assume greater significance, and the foundations upon which the more apolitical framings that much ecosystem services literature rely on become untenable.

The views and perspectives of affected communities must be included within decisions on the most appropriate ways and means to manage environmental change. In the context of Prosopis, this is important because the invasive plant does result in ecosystem disservices and that these will be distributed unevenly across affected populations. Policy and action cannot rely on decontextualized narratives and aggregated notions of wellbeing that pre-define and structure how institutional actors see, understand and, by implication, frame solutions. Affected populations experience the impacts of Prosopis in socially-differentiated ways and, crucially, have a plurality of views and opinions on the most appropriate responses to the issue in hand. When dealing with complex issues, the plural positions of affected populations and their situated understanding of risk and reward may not match the perspectives of more remote institutional actors who notionally speak on their behalf. Any intervention will produce trade-offs, exposing and making these trade-offs explicit, particularly those that affect marginalised populations, can aid institutional actors identify not only which interventions are preferred, but by whom and at what cost or benefit.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1. Scenarios

Scenario 1: Containment

The main objective therefore focuses on containment and limiting the spread of *P. juliflora* by early detection and rapid response. As resources are constrained, efforts to contain the spread are based on local needs, the degree or infestation and the how aggressively it is spreading. Local networks of actors are established to identify, assess and rapidly remove *P. juliflora* from areas that are not currently invaded. Movement of people, livestock and things (e.g. vehicles) from areas of *P. juliflora* to areas at risk are controlled/restricted (Breithaupt, 2008: 23; Government of Ethiopia (GoE), 2017: 13–16). Concurrently, efforts are made to contain *P. juliflora* in areas that are already invaded through active control of the outer perimeter of infestations (Shackleton et al., 2017: 7). Additionally, efforts are made to reduce reliance on *P. juliflora* pods by increasing access to fodder and feed resources at times of drought. As resources to tackle *P. juliflora* are constrained, those areas that are of highest value are controlled first (for example in areas with irrigated farming potential, drought reserve and land of high value to pastoralists and in important migration corridors) (Afar Environmental Protection, Rural land use and Administration Agency (AEPRLUAA) 2015). Access routes through areas that are invaded are actively maintained (GoE, 2017: 13–17). Limited livelihoods are derived directly from *P. juliflora* although the current more traditional uses persist.

- Eradication of *P. juliflora* is accepted as impossible
- The main focus of management activities is on limiting its spread of *P. juliflora* and containing the invasion.
- Local networks are formed to prevent spread into areas that are highly valued and currently free from *P. juliflora* (but susceptible to invasion)
- Existing infestations are tackled to prevent expansion by controlling the outer perimeter
- Greater efforts are made to reduce reliance on pods for feed and at times of scarcity (during the dry season and droughts)
- Weather becomes more uncertain and less predictable

Scenario 2: Targeted eradication

The presence of *P. juliflora* is accepted as inevitable and considered impossible to completely eradicate (Haregeweyn et al., 2013: 7538). The main objective is targeted eradication: that is eradicating *P. juliflora* in specific high-value areas using a range of different approaches dependent on the type and nature of the infestation (e.g. density); and adopting an approach of no active intervention in other areas if they are deemed to be of low value. In locations where infestation is high and aggressive (GoE, 2017: 19) more mechanised approaches are considered (such as with bulldozers, tractors/chaining etc.) or even biological control (e.g. beetle). In locations where a mechanised or biological approach is considered impracticable, more labour-intensive approaches such as cutting and burning, chemical application, digging out the root ball of individual plants is pursued (GoE, 2017: 18). The more labour-intensive methods tend to take longer and are not as effective (Shackleton et al., 2014: 10). However, they do create more employment opportunities (through the eradication process, and in charcoal production or harvesting of seed pods) than those that rely on machinery. Furthermore, they can prevent other types of land degradation as well (Shackleton et al., 2017: 7). In all cases the risk of reinvasion is high if the land is not used immediately following clearance (Labrada, 2008: 30-32; GoE, 2017: 18).

- Eradication of *P. juliflora* is accepted as impossible
- The main focus of management activities is on targeted eradication: that is clearing *P. juliflora* in areas of high value and not intervening in areas considered low value
- Where practicable, mechanized or biological controls are used and in other locations more labour-intensive methods are employed (such as cutting and burning, chemical application etc.)
- As land must be utilized to prevent reinvasion, the areas targeted for clearance tend to be those that are suitable for more intensive land uses (such as farming)
- Weather becomes more uncertain and less predictable

Scenario 3: Large-scale, commercial utilization

An overarching policy goal of utilisation is adopted. Infestations are managed with the intention of producing a useable energy resource at a commercial scale (biomass/gasification) with some existing uses also supported (such as for construction, fencing, charcoal) (Tsegay et al., 2015: 21; Bekele, 2008: 59-67). Affected communities receive some training and awareness raising on activities required to manage infestations but only small amounts of additional resources are made available to help them to tackle *P. juliflora* as the priority lies with commercial exploitation (Breithaupt, 2008: 23; GoE, 2017: 13–16). At a larger scale, control mechanisms start to function effectively, infestations are better managed (through stand management for example) to produce a biomass resource that can be used for fuel etc. (Pasiecznik et al., 2001; Haregeweyn et al., 2013; Worku and Zewde, 2013: 15-17). Ultimately, this scenario is focused at the commercial scale and the majority of derived benefits accrue to large private or state-run institutions. At a landscape level, in some areas *P. juliflora* is effectively controlled and managed (these are areas deemed to have a high value). In other areas, more remote from key communication and biomass infrastructure *P. juliflora* is increasingly evident: the area colonized expands and the density also increases.

- Eradication of *P. juliflora* is accepted as impossible
- *P. juliflora* infestations are managed with the intention of producing a useable biomass resource at a commercial scale
- *P. juliflora* is actively managed and controlled in locations close to the road network and around biomass plants
- In more remote locations, where exploitation is not possible, *P. juliflora* continues to spread
- There is not much support provided for affected communities outside of areas that are suitable for the commercial exploitation of *P. juliflora*
- Weather becomes more uncertain and less predictable

Scenario 4: Community-focused utilization

Similar to above method but approach places communities more centrally within the utilization plans via cooperatives and lower tech, smaller-scale businesses (charcoal, seeds for flour and animal feed (only if ground) etc.) (Tegegn, 2008; Haregeweyn et al., 2013: 7539; Tsegay et al., 2015: 21). Some of these activities (particularly associated pod products) will need additional assistance with start-up costs, marketing and other support to increase profitability (Tegegn, 2008; Wakie et al., 2016). Activities linked to clearing areas of *P. juliflora* that have been identified as critical by communities. Clearing of *P. juliflora* is focused at a community level (Shackleton et al., 2014: 10; Shackleton et al., 2017: 7) and success is dependent on high-levels of inputs at a local level in terms of skills, knowledge and labour. However, there are risks that the community-level attempts to control and remove the *P. juliflora* are unsuccessful as, ultimately, success depends on utilization and the ability of communities to derive sustainable livelihoods from *P. juliflora* (facilitated through a favourable policy and institutional environment). At a landscape level, attempts to control *P. juliflora* are more widespread than in the previous scenario but it is more difficult to tackle high density infestations over large areas.

- Eradication of *P. juliflora* is accepted as impossible
- Communities are central to the overarching policy goal of utilisation, control is encouraged by creating a favourable environment through which communities can derive livelihoods from *P. juliflora*
- The main focus of utilization efforts is through smaller-scale exploitation by cooperatives and business that focus on things like charcoal and flour production, animal feed, etc.
- High inputs of skills, knowledge and labour in geographical dispersed locations
- Attempts to control *P. juliflora* are widespread as affected communities lead the efforts but very dense and aggressive infestations are difficult to tackle
- Weather becomes more uncertain and less predictable

Underlying trends that are a feature of all scenarios

- The presence of *P. juliflora* is accepted as inevitable and considered impossible to completely eradicate (Haregeweyn et al., 2013: 7538)
- Population growth (Cervigni and Morris, 2016; Cervigni et al., 2016)
- Increasing uncertainty re climate in terms of aridity and extreme events (Cervigni et al., 2016: 69-73)
- Growth in large-scale commercial agriculture
- Diversification underpins many current pastoral livelihoods
- Mobility (almost all citations)
- Increasing villagisation

Cf Cervigni and Morris (2016), Jenet et al. (2016), Aberra and Abdulahi (2015), Haregeweyn et al. (2013)

The PSA work was part of and underpinned by a wider programme of research on responses to environmental change in East Africa under the Adaptation at Scale in Semi-Arid Regions project. In addition to the cited literature, the development of scenarios draw on a body of knowledge of Awash Fentale and Amibara Woredas generated through 45 semi-structured group interviews, 14 household-level interviews, 8 rural appraisal activities (mobility and social mapping), and 25 key informant interviews. Further insights were derived through 15 key informant interviews at national and sub-national levels. All data collected between October 2015 and December 2016.

Appendix 2. First choice preferences

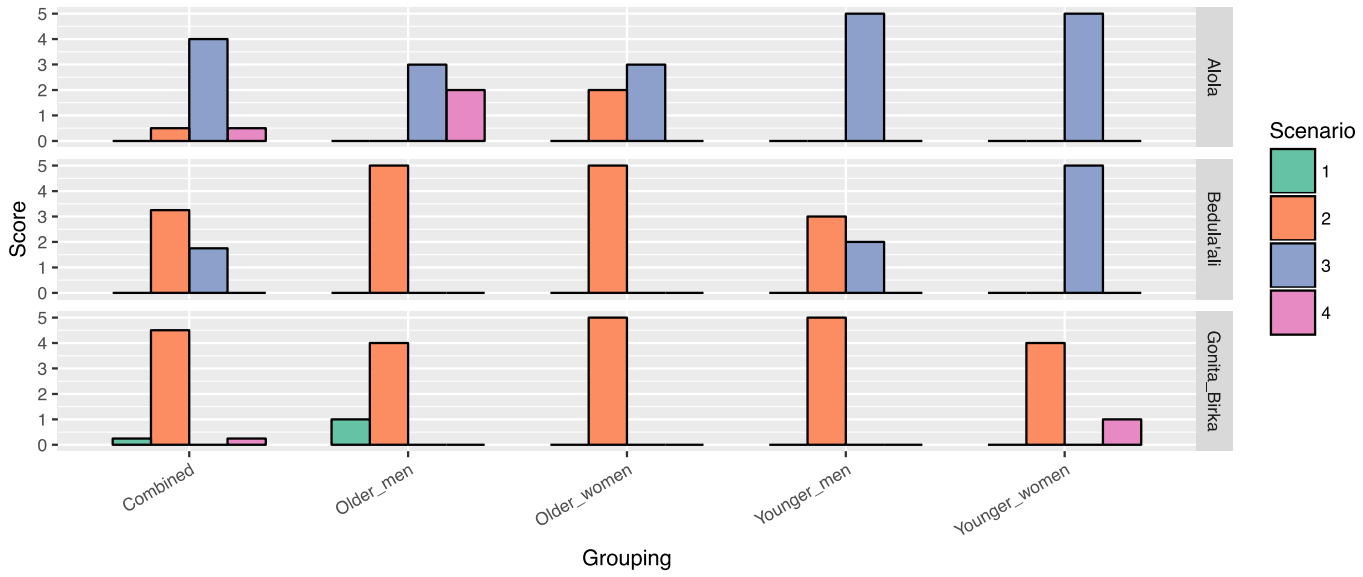

Fig. A1. First choice preferences ($n = 20$), combined preference show mean of four sub-groups.

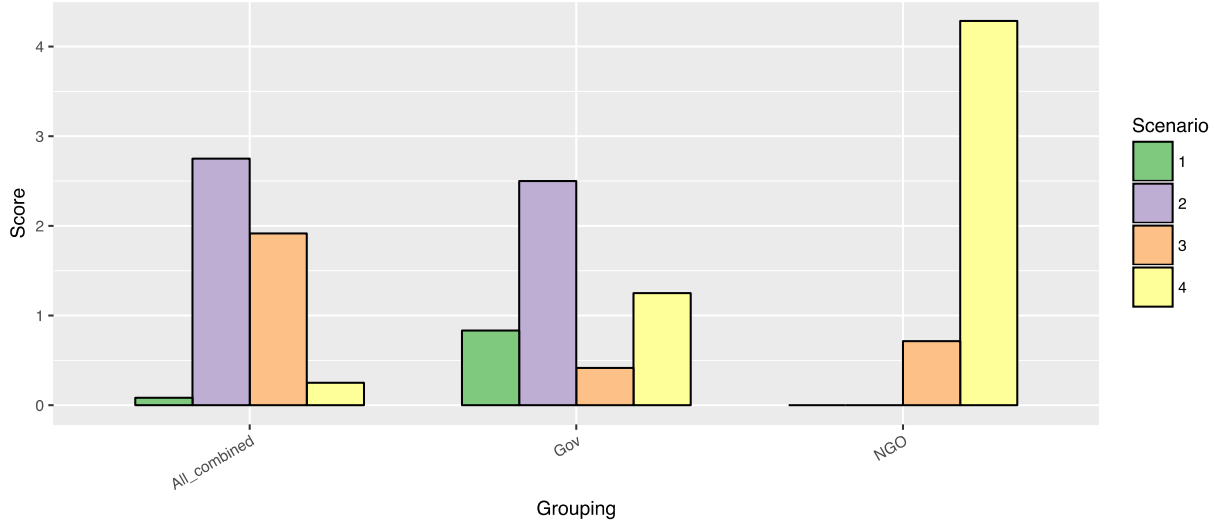

Fig. A2. First choice preferences (community $n = 60$, Gov. $n = 12$, NGO $n = 7$), combined preference shows mean of all community participants. Weighted to enable comparison.

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