Ecological Economics 112 (2015) 68–77

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Alien invasions and livelihoods: Economic benefits of invasive Australian Red Claw crayfish in Jamaica

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ARTICLE INFO

Article history:
Received 9 July 2014
Received in revised form 10 February 2015
Accepted 13 February 2015
Available online 21 February 2015

Keywords:
Invasive alien species
Invaded ecosystems
Small-scale fishery
Ecosystem services
Wild-harvest products

ABSTRACT

Invasive species have caused widespread economic and environmental disruption, which have been widely studied. However, their potential benefits have received much less attention. If invasive species contribute to livelihoods, their eradication may negatively impact wellbeing. Failing to value these benefits may lead to an undervaluation of invaded ecosystems. We assess the potential economic benefits of an invasive species within an artisanal fishery in Jamaica. We monitored catches over 259 fisherman-days, and conducted 45 semi-structured interviews, with 76 fishermen. We show that the invasive Australian Red Claw crayfish (*Cherax quadricarinatus*) is an important source of income for fishermen within the Black River Lower Morass of Jamaica and supplement incomes during periods when native shrimp (*Macrobrachium* spp.) catches decline. We also show that full-time fishermen and those who have no alternative occupations expend the greatest fishing effort. We use the intra-annual variation of fishermen's harvest effort between seasons (when catch per unit effort changes) as a proxy for dependence. Using this measure, we found that the least wealthy appear to be the most dependent on fishing, and consequently benefit the most from the invasive crayfish. Our results demonstrate the importance of considering the potential benefits of invasive species within integrated landscape management.

1. Introduction

There is strong evidence that invasive alien species (IAS) have damaged ecological and economic systems around the world (McGeoch et al., 2010; Pejchar and Mooney, 2009; Sala et al., 2000). Yet, there is little research investigating the potential economic benefits of IAS (Young, 2010; Pejchar and Mooney, 2009). Of the few studies that have explored the economic benefits of IAS (e.g., Shackleton et al., 2006; de Neergaard et al., 2005; Geesing et al., 2004; Jakubowski et al., 2010) even fewer have quantified the income that they generate (Schlaepfer et al., 2011, but see: Shackleton et al. (2011b); Pascual et al., 2009; Ackefors, 1999; Southwick and Southwick, 1992). It is unclear whether this is because IAS are near-universally destructive or because of a bias within the academic community (Stromberg et al., 2009; Gurevitch and Padilla, 2004).

A lack of appreciation of the potentially positive role of some IAS in human livelihoods may lead to a number of undesirable outcomes. First, undervaluing the benefits of IAS may lead to excessive investment in their removal. For instance, *Lantana camara* L. is a widely studied invasive shrub (van Wilgen et al., 2004), considered to be among the top ten worst invasive species in the world (GISIN, 2012). The majority of studies conducted to determine the economic and ecological costs and benefits of removal have not quantified the positive role this species can play as a harvestable resource for communities, such as a source of firewood or craft materials (e.g., Marais and Wannenburgh, 2008; Le Maitre et al., 2002, but see Patel, 2011). The costs associated with *Lantana* probably still exceed the benefits of its presence. However, incorporating the benefits that accrue to local communities may change the optimal distribution of removal effort across the landscape. Second, this lack of awareness of the potential positive economic value of IAS may lead to underestimation of the value of invaded ecosystems, which may bias spatial conservation planning.

Pimentel et al. (2001) estimate that 20–30% of IAS in the US, UK, Australia, India, South Africa and Brazil are considered pests and only a minority of these are likely to be serious pests (also see Lodge, 1993). It is possible that among the remaining species, an important portion may be socially and economically beneficial. Whether an IAS is beneficial depends on characteristics of the IAS, and of the ecosystems and social groups that are affected by it (García-Llorente et al., 2008). In Northern Ethiopia, invasive eucalyptus is used and sold as a building material and to construct farming tools; this species performs better in

Abbreviations: IAS, invasive alien species; BRLM, Black River Lower Morass; GLMM, generalised linear mixed model; GLM, generalised linear model; AIC, Akaike information criterion; AICc, corrected Akaike information criterion.

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http://dx.doi.org/10.1016/j.ecolecon.2015.02.012
0921-8009/

water- and nutrient-poor soils than indigenous species, and as a result is commonly grown in farmers' woodlots (Jagger and Pender, 2003). However, in South Africa, eucalyptus is being removed from riparian areas to help restore natural water resources and increase the availability of potable water to communities (Marais and Wannenburgh, 2008). It follows that the impact and role of IAS, and therefore control measures, are context specific. Part of this context relates to the socio-economic factors that influence the relationships between IAS and communities.

Similarly, the benefits of IAS vary within human communities as well as between them. The link between individuals' socioeconomic characteristics and their non-timber forest product harvesting behaviour has been well studied (e.g., Gavin and Anderson, 2007; Lacuna-Richman, 2002; McSweeney, 2002; Barham et al., 1999). For instance, although it was once believed that those living in extreme poverty are particularly dependent on wild foods for subsistence (Scoones et al., 1992), the relationship is often more complex (e.g., Wilkie et al., 2001). In some situations, wealthier households have greater capacity to hunt, consume and sell wild products (de Merode et al., 2004). The same complexities may also apply to the use of IAS, making the economic implications of removing an invasive species unclear. For example, communities bordering the Chitwan National Park in Nepal use a number of invasive species, including the plant *Mikania micrantha*. Rai et al. (2012) found that household socioeconomic characteristics influence *M. micrantha*'s perceived value. Those families that were more dependent on forest products incurred more of both the costs and benefits associated with *M. micrantha* than less forest-dependent families. The value of ecosystem services often varies spatially and temporally; the management of invasive species that contribute to ecosystem services should therefore reflect this variability (Hershner and Havens, 2008).

The relationship between biodiversity and ecosystem services is complex (Cameron, 2002). However, higher biodiversity is generally positively correlated with higher ecosystem service value in warm climates (Cardinale et al., 2012; Naeem et al., 2009; Costanza et al., 2007; Balvanera et al., 2006). The effect of IAS species on biodiversity and habitat function is also complex (Hector and Bagchi, 2007; Schwartz et al., 2000). Although the majority of the literature investigating the ecological impact of invasive species concludes that they are detrimental to native biodiversity, there are some examples where IAS assist native species, for instance through positive habitat modification (Rodriguez, 2006). Similarly, the impact of IAS can change over time (Strayer et al., 2006). The invasive fire ant *Solenopsis invicta* in southern USA initially reduced the populations of other insects when first introduced in the 1980's. However, 12 years later *S. invicta* populations substantially declined and native arthropod species recovered to pre-invasion levels (Orrison and Loyd, 2002). In this case, total arthropod biodiversity appears to have increased without compromising the population sizes of native species over the long term. It is plausible to suggest that in some instances, perhaps where there are empty niches (e.g., on some islands), the addition of IAS may increase biodiversity, ecosystem function & resilience and the value of ecosystem services (Young, 2010, 2012; Hershner and Havens, 2008). The absolute socioeconomic costs and benefits of invasive species are hard to estimate because of the complex impact that they have on invaded ecosystems and species. However, arguably, this applies equally to the valuation of native species within wider ecosystems.

In order to explore these issues, we studied the economic benefits of the invasive Australian Red Claw crayfish, *Cherax quadricarinatus* (von Martens), within fishing communities of the Black River Lower Morass (BRLM) of southwest Jamaica (Fig. 1). This study aims to answer three questions: a) can this invasive alien species provide an economically significant source of gross revenue, b) how are the economic benefits distributed over time and c) who within these communities benefits the most?

Increased household revenue is expected to contribute to increased consumption. Additional earnings may be particularly important for those that subsist on relatively low incomes, who are anticipated to have greater marginal utility from income (Ellis, 1994). The temporal distribution of household liquidity is also important, especially in the absence of precautionary saving or functioning credit markets. Temporary or seasonal fluctuations in income may lead to corresponding changes in consumption. This may lead to periods of cyclical poverty (Dercon and Krishnan, 2000). Finally other socioeconomic characteristics may influence the capacity for individuals to mobilise resources or otherwise influence harvesting behaviour. Identifying the distribution of economic benefits across different groups is also useful for contextualising the benefit of additional revenue. For example, those with no alternative occupations would have a higher opportunity cost from not engaging in harvesting, than those that do. As a result, they may be the most dependent on the income derived from harvesting activity.

Fig. 1. The Black River Lower Morass in the Saint Elizabeth Parish, in southwest Jamaica.

The study does not determine if there is a net economic benefit associated with the invasive crayfish to the communities within the BRLM. Instead it seeks to encourage landscape managers to consider possible economic benefits, as well as costs, within invaded ecosystems and compared to more pristine ecosystems. Accounting for the possible benefits, as well as costs, may improve conservation resource allocation within landscape management and improve the accuracy of ecosystem valuation.

1.1. Study Site

The Black River Lower Morass is situated within the parish of St. Elizabeth (Fig. 1). The parish is described by Campbell et al. (2011) as the ‘breadbasket of Jamaica’, owing to its importance as a domestic source of agricultural produce. The agricultural sector is dominated by small-scale farmers, which are deemed to be relatively prosperous relative to national living standards (McGregor et al., 2009). Fishing, using traditional gear, is a common occupation in the Black River Lower Morass Ramsar site. Although a few individuals specifically target either native shrimp (*Macrobrachium* spp.) or invasive crayfish (*C. quadricarinatus*) with specialist gear, the vast majority catch both using the same harvesting equipment: homemade shrimp pots. Fishing is one of the most common occupations in the four target communities of the BRLM who operate from two landing stages in Community 1 and Community 2. Village names, and details that could be used to identify those villages, were kept anonymous because of the sensitive nature of some activities, including Marijuana cultivation. Fishermen from another village, further south in the BRLM, often use wire mesh traps that specifically target the invasive crayfish as opposed to traditional shrimp pots for native shrimp, and were not included in the study. All caught shrimp and crayfish are sold to local women who then cook and sell them along roadsides throughout the country. The fishery requires relatively low capital inputs and has few barriers to entry. Of these barriers the most significant appear to be the purchasing of fish pots at c. USD$1.20 per pot, for those unable to construct their own, and the construction and maintenance or borrowing of dugout canoes.

Low flow and drought events, such as those found during the dry season within the BRLM, reduce hydrological connectivity and pool volumes. They also lower water quality (reduced dissolved O_2 as the result