19 Socio-Economic Impact and Assessment of Biological Invasions

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19.1 Introduction

Biological invasions have been object of ecological research for years. As one objective, natural scientists investigate the effects of invasive species on ecosystems and their functioning (Levine et al. 2003). However, impacts on ecosystems are also of relevance for society. Changes in ecosystems affect humans insofar as ecosystems provide goods and services, such as fresh water, food and fibres or recreation, which might be altered due to invasive species. Therefore, impacts of biological invasions should be an object of socio-economic interest, which is also demanded by the Convention on Biological Diversity (2002).

This chapter aims at providing elements for the analysis of impacts of invasive species from the socio-economic point of view. Such an analysis is politically relevant, since impacts are the focal point of every decision to establish an appropriate management regime. For an all-encompassing analysis, an integrative framework is needed to structure the information on impacts. For that purpose, the concept of ecosystem services (Chap. 13) is introduced (Sect. 19.2). Alternative decisions on the appropriate management of invasive species face trade-offs between outcomes and impacts. For handling such trade-offs, evaluation is needed. As discussed in Sect. 19.3, perception presents the prerequisite of an explicit evaluation. Finally, different evaluation methods are introduced so as to value the information about impacts during the decision-making process (Sect. 19.4).

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19.2 Impacts on Ecosystems from the Perspective of Human Wellbeing

Identifying the impacts of invasive species is required in order to evaluate the consequences of invasion processes and to implement management measures. The purpose of this section is to present an integrated framework for structuring the information on impacts in order to describe what happens if an invasion occurs. First, this is done by defining what type of impacts can be associated with bioinvasions. Second, the concept of ecosystem services is used for classifying these impacts. As humans depend on ecosystems and ecosystem processes, effects caused by biological invasions can be of high socio-economic relevance. Perceptions and assessment of these effects will determine policy-making.

From a socio-economic point of view, impacts caused by biological invasions are changes of recipient ecosystems which are perceived by humans. In addition to impacts on ecosystem services, biological invasions can have impacts on human-made goods and services, such as road systems or artificial waterways and reservoirs. Although damages to human-made infrastructure can be considerable, in the following the focus is on impacted services supplied by natural or semi-natural ecosystems (Kühn et al. 2004).

Two types of impacts can be identified. The first type includes direct impacts of invasions on ecosystem functions and on human wellbeing. The second type refers to indirect impacts which stem from the implementation of response actions, such as control costs or side effects of the introduction of biological control agents (Tisdell 1990). A comprehensive decision-making process demands reviewing both types of impacts. However, impact assessment studies do not always distinguish between the two.

By affecting the ecological processes at the level of genes, species and ecosystems, biological invasions modify the provision of ecosystem services. Defined as “the conditions and the processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life” (Daily 1997), ecosystem services are foundations of human wellbeing. Thus, ecosystem services encompass both ecological and socio-economic aspects of ecosystems, illustrating the human dependence on ecosystem functioning. Impacts of biological invasions on ecosystems are of socio-economic concern because they alter the benefits provided by ecosystems for human life.

The Millennium Ecosystem Assessment (2003) is based on a taxonomy of ecosystem services encompassing four main categories (Fig. 19.1):

1. Supporting services are those necessary for the production of all other ecosystem services;
2. Provisioning services refer to the products obtained from ecosystems;

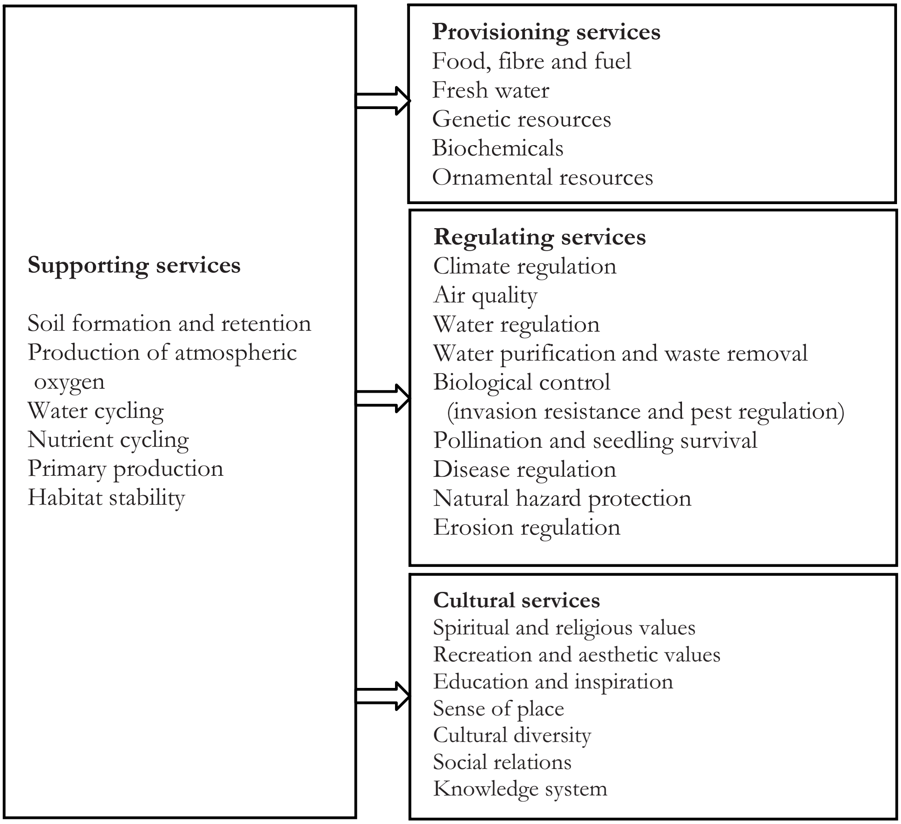

Fig. 19.1 Classification of ecosystem services according to the Millennium Assessment categories

3. Regulating services are benefits supplied by self-maintenance properties of ecosystems;
4. Cultural services generate non-material benefits derived from ecosystems.

Table 19.1 compiles examples illustrating the impacts of various well-known invasive species. It reveals the impacts of invaders on certain ecosystem services by describing their alteration.

As can be noted, there are many mechanisms by which biological invasions can impact different types of ecosystem services. The most evident examples are effects on the provisioning of food. For instance, agricultural and forestry yields are affected by pests such as the Russian wheat aphid (*Diuraphis noxia*; Brewer et al. 2005), the sirex wasp (*Sirex noctillo*) and the skeleton weed (*Chondrilla juncea*; Cullen and Whitten 1995). Other impacts, such as those caused by the zebra mussel (*Dreissena polymorpha*), affect human-made

Table 19.1 Impacts of biological invasions on ecosystem services

	Ecosystem service	Impact description/effect	Associated species (examples)	Reference
Supporting services	Soil formation	Changes in biochemical characteristics of soils	Grand fir (*Abies grandis*)	Griffiths et al. (2005)
		Increase in soil aggregation	Barb goatgrass (*Aegilops triuncialis*)	Batten et al. (2005)
	Nutrient cycling	Reduction of food and oxygen availability	Zebra mussel (*Dreissena polymorpha*)	Minchin et al. (2002)
		Alteration of soil nitrogen levels	Grand fir (*Abies grandis*)	Griffiths et al. (2005)
			Black wattle (*Acacia mearnsii*)	De Wit et al. (2001)
	Primary production	Alteration of biomass production of native plants	European purple loosestrife (*Lythrum salicaria*); black wattle (*Acacia mearnsii*)	Pimentel et al. (2005)
		Reduction in aquatic vegetation	Grass carp (*Ctenopharyngodon idella*)	Pimentel et al. (2005)
		Competition for grazing primary production	Horse (*Equus caballus*)	Beever and Brussard (2004)
	Habitat stability	Changes in vegetation cover affecting community assemblages	Green alga (*Caulerpa taxifolia* and *C. racemosa*)	Cavas and Yurdakoc (2005)
			Common reed (*Phragmites australis*)	Maheu-Giroux and Blois (2005)
Provisioning services	Food	Loss in commercial production and harvest (agriculture, forestry, fisheries, aquaculture)	Russian wheat aphid (*Diuraphis noxia*)	Brewer et al. (2005)
			Skeleton weed (*Chondrilla juncea*)	Cullen and Whitten (1995)
			Rice field rat (*Rattus argentiventer*)	Stenseth et al. (2003)
			Comb jelly (*Mnemiopsis leidyi*)	Knowler (2005)
	Fuel, wood	Loss of forest products	Gypsy moth (*Lymantria dispar*)	Sharov and Liebhold (1998)
	Fresh water	Losses in water catchments	Acacia (*Acacia longifolia*); black wattle (*Acacia mearnsii*)	Galatowitsch and Richardson (2005)
	Genetic resources	Threat to the viability of endangered species	Indo-Pacific soft coral (*Stereonephthya* aff. *curvata*)	Lages et al. (2006)
		Genetic hybridization	Baculoviruses (*Autographa californica nucleopolyhedrovirus*, AcNPV)	Hails et al. (2002)

Regulating services	Water regulation	Choking waterways	Hydrilla (*Hydrilla verticillata*)	Pimentel et al. (2005)
	Water purification	Reduction of water quality	Acacia (*Acacia longifolia*); black wattle (*Acacia mearnsii*)	Galatowitsch and Richardson (2005)
		Increase in water filtration	Zebra mussel (*Dreissena polymorpha*)	Minchin et al. (2002)
	Waste regulation	Colonization of industrial waste dumps	Bacterivorous nematodes (*Acrobeloides nanus*; *Panagrolaimus rigidus*)	Hánel (2004)
	Biological control	Displacement of native and endemic species	Brown trout (*Salmo trutta*)	Quist and Hubert (2004)
	Pollination	Reduction in the reproductive success of flora	Argentine ant (*Linepithema humile*)	Blancafort and Gomez (2005)
	Seedling survival	Depression of the diversity and abundance of seedlings	Shrub (*Lonicera maackii*)	Webster et al. (2005)
	Disease regulation	Infection of native fauna	Chytrid fungus (*Batrachochytrium dendrobatidis*)	Beard and O'Neill (2005)
		Production of toxic substances	Green alga (*Caulerpa racemosa*)	Cavas and Yurdakoc (2005)
		Vectors of human and livestock diseases (e.g. dengue)	Mosquito (*Aedes aegypti*)	Takahashi et al. (2005)
	Natural hazard protection	Disruption in flood control mechanisms	Salt cedar (*Tamarix* sp.)	Lesica and Miles (2004)
		Increase predisposition to fires	Cheat grass (*Bromus tectorum*)	Vitousek et al. (1996)
	Erosion regulation	Intensification of soil erosion	Goat (*Capra aegagrus hircus*)	Pimentel et al. (2005)
Cultural services	Recreational	Reduction of recreational use of rivers and lakes	Black wattle (*Acacia mearnsii*)	De Wit et al. (2001) Quist and Hubert (2004)
		Emerging sport fisheries	Brown trout (*Salmo trutta*)	
	Aesthetics	Changes in the character of rural and urban landscapes	Rhododendron (*Rhododendron ponticum*)	Dehnen-Schmutz et al. (2004)
			Horse chestnut leaf-miner (*Cameraria ohridella*)	Gilbert et al. (2003)
		Use as ornamental flora	Salt cedar (*Tamarix ramosissima*)	Knowler and Barbier (2005)
		Residential weeds	Dandelion (*Taraxacum officinale*)	Pimentel et al. (2005)
	Education	Threat to the value of protected areas	Salt cedar (*Tamarix ramosissima*)	Lesica and Miles (2004)
	Cultural diversity	Loss of subsistence fisheries which shaped local cultures	Brown trout (*Salmo trutta*)	Quist and Hubert (2004)

goods and services, damaging many different hydraulic infrastructures worldwide (Minchin et al. 2002). Further examples and discussion on these issues are provided by Chaps. 13 and 18.

Table 19.1 also illustrates that one single species can have a variety of effects. For instance, the black wattle (*Acacia mearnsii*) affects the regional water table, local vegetation cover, i.e. species composition, and also alters the recreational function of the Cape region in South Africa, since people gain less access to rivers and lakes (Galatowitsch and Richardson 2005).

By structuring the information about impacts using the ecosystem services categories, two general characteristics can be outlined: (1) the variety of impacts caused by invasive species, and (2) the complexity of impacts on ecosystem services. Ecosystem services and impacts on these are not only manifold but also complex, as can be illustrated with the example of the Nile perch (*Lates niloticus*). Its intentional introduction to Lake Victoria in Africa for aquaculture and sport fishing resulted in the extirpation of 200 native fish species (Kasulo 2000). This led to a shift of the whole ecosystem, as the availability of phytoplankton changed, altering the local fish species composition (Chu et al. 2003). This introduction favoured a prospering fish industry in the vicinity of the lake, due to increased profits from perch exports. However, relatively cheap native fish was no longer available, and local inhabitants could not afford the more expensive perch and, therefore, could not complement their diet. Additionally, the availability of fuel wood decreased because this was used to dry the perch, necessary to preserve it. By contrast, the smaller native fish could be sun-dried, rather than being smoked. In this example, the intentional modification of an ecosystem to improve the services of recreation (sport fishing) and the provisioning of food for exports (aquaculture) had important side effects, such as the decrease of habitat stability. Furthermore, cultural practices and social relations changed, and the basic diet of the local inhabitants deteriorated, rather than being improved (www.darwinsnightmare.com).

The Nile perch example serves to highlight the complexity of affected ecosystem services. It also shows the interlinked ecological and socio-economic dimensions of impacts – in this case, some impacts show a direct influence on human wellbeing, such as the alteration of the provisioning service of food and fuel.

19.3 Perception as a Prerequisite for Valuation

Invasive species cause manifold effects. How these are valued depends on human perception at a given point in time. Interests embedded within cultural contexts and production patterns configure the personal attribution of either a positive or negative character to a given effect. Thus, when including these individual or collective appraisals into the decision-making process, their context dependency should be taken into account (Sect. 19.4).

Certain impacts of invasive species are of public concern, such as health problems, e.g. asthma and allergies caused by the rag weed (*Ambrosia artemisiifolia*; Zwander 2001). Others, such as alterations in ecosystem integrity, are not a subject of public discussion. For instance, ecosystem integrity in Canada is strongly affected by the common reed (*Phragmites australis*; Maheu-Giroux and Blois 2005). Although this changes habitat conditions, these impacts generally lie outside the set of social concerns. As the linkage between these impacts on the ecosystem and human wellbeing is not obvious, people who are not involved in conservation issues care little. Indeed, invasions in waters take place mostly in a hidden manner (Nehring 2005). Lack of social concern about the ecologically damaging green alga *Caulerpa racemosa* is a good example (Cavas and Yurdakoc 2005; Piazzi et al. 2005; Ruitton et al. 2005). In fact, plant invaders (not only aquatic) which affect ecosystem integrity are often not of public concern.

Another aspect of perception is that, from a utilitarian point of view, not all the effects are damages. For instance, soil aggregation is enhanced by barb goatgrass (*Aegilops triuncialis*; Batten et al. 2005), and black wattle (*Acacia mearnsii*) increases nitrogen levels in soils (De Wit et al. 2001; Le Maitre et al. 2002). Whereas ecologically concerned people may regard these changes as undesirable, farmers might take advantage of them. In fact, many introduced species are valued both positively and negatively by different stakeholders. An example is brown trout (*Salmo trutta*), which displaces native species and affects cultural practices dependent on these but also promotes economic activities related to recreational angling (Quist and Hubert 2004). Indeed, invasive fish species favouring emergent sport fisheries are often associated with a positive public rating, and this despite their adverse ecological impacts. This example illustrates that personal or social interest can give importance to some effects of an invasive species but neglect others.

As explained above, valuation is dependent on perception. The perception of impacts is heterogeneous, context-dependent and dynamic. The alien invasive acacia (*Acacia* sp.) was introduced for pulp production and tanning-compound extraction in plantations in South Africa (De Wit et al. 2001). Its spread out of control has been associated with changes in water regulation. Different positions taken by the stakeholders reflect the heterogeneous character of this species' impacts – on the one hand, communities suffer from water scarcity and, on the other, they benefit from increased access to fuel wood and timber for building materials. The example also shows the dynamic and context-dependent character of valuation. The effects of acacia growth on water regulation is a main concern of the affected communities. Information on the problem allowed the creation of social partnerships for the control of the acacia. In South Africa, the fight against plant invaders has been boosted by means of the Working for Water Program (www.dwaf.gov.za/wfw) – in this case, information evidently led to higher awareness.

The reasoning presented above demonstrates the need of identifying the stakeholders and their roles as prime perceivers and promoters of impacts. Due to the reflexive nature of the invasion processes (new relevant attributes are continuously added to the relationship between people and invasive species), the participation of stakeholders in both the identification of outcomes and the analysis of priorities is needed in the evaluation processes. The advantage of the concept of ecosystem services lies in the structuring of information about impacts. Further analysis can be done to discuss stakeholder perception of the impacts. Such impacts can be taken into account in the valuation concerning the appropriate management of the species.

By revealing the direct and indirect influence of invasive species on human wellbeing, the ecosystem service concept also supports a reflection on uncertainty and ignorance. Uncertainty exists if outcomes are known but the distribution of probabilities cannot be identified. Ignorance can be defined as the situation where the probability neither of the potential outcome nor of the outcome itself is known. In other words, "we don't know what we don't know" (Wynne 1992). One key feature of invasive species processes is often the lack of knowledge. Due to the complexity of interlinked ecological processes, the predictive power of information available about dispersal rates, traits and ecological behaviour is small (Williamson 1996). Furthermore, often there is no such information available, especially not on the social impacts of invasive species. However, for decision making it is necessary to structure the available information on impacts. The use of the ecosystem services concept can serve this aim because this reveals whether the information about impacts is available or not. Under conditions of uncertain outcomes and irreversible effects, a precautionary approach should be employed concerning management decisions on invasive species.

19.4 Alternatives for the Evaluation of Impacts: from Valuation to Deliberation

Decision making requires evaluation because trade-offs between different management options occur, e.g. if a certain management option promotes one impact and concurrently diminishes another. For instance, eradicating the black wattle (*Acacia mearnsii*) in the Cape region on the one hand implies diminished access to fuel wood for the local population and, on the other, it increases fresh water availability. Furthermore, decisions about invasive species management should take the perceptions of affected people into account. The acceptance and outcome of these decisions will be highly dependent on the individual or social perception of the impacts caused by invasive species.

Table 19.2 Overview of evaluation approaches for the management of invasive species

	Risk assessment	Cost-benefit analysis	Cost-effectiveness	Multi-criteria analysis	Scenario development
Management purpose	Introduction	Introduction and/or control	Control	Introduction and/or control	Introduction and/or control
Purpose of the evaluation	Risk level	Ranking (optimisation)	Ranking (optimisation)	Deliberation and ranking	Deliberation and prospective storylines
Type of impacts	Associated with invasion species (hazards)	Caused directly by invasive species and those derived from management responses (cost of damage, cost of control and benefits)	Associated with management responses (cost of control)	Associated with invasive species and/or those derived from management (criteria)	Associated with invasive species and/or those derived from management (reference indicators)
Type of information used	Quantitative and qualitative	Quantitative (monetary)	Quantitative (monetary and physical units)	Quantitative and qualitative	Quantitative and qualitative
Participation potential	Low	Low/medium	Medium	High	High
Consideration of uncertainty	Uncertainty reduced to probability or precautionary approach	Sensitivity analysis	Sensitivity analysis	Robustness analysis, accounting for fuzzy data	Integrated set of assumptions
Operative constraints	Low cost and time requirement	Low–medium cost and time requirement	Low–medium cost and time requirement	Medium–high cost and time requirement	Medium–high cost and time requirement
Methodological constraints	Intrinsic uncertainties, risk thresholds	Trade-offs between natural capital and human-made capital, use of discount rate	Definition of thresholds	Definition of thresholds	Lack of precise results, non-replicable results
References	OTA (1993), Landis (2003), Andersen et al. (2004), Simberloff (2005)	Bertram (1999), De Wit et al. (2001), Le Maitre et al. (2002), McConnachie et al. (2003), Pimentel et al. (2005)	De Groote et al. (2003), Buhle et al. (2005), Dehnen-Schmutz et al. (2004)	Maguire (2004), Monterroso (2005)	Chapman et al. (2001), Rodriguez-Labajos (2006)

Management is essentially concerned with how to deal with impacts of biological invasions. This takes place at different stages of the invasion process, either preventing an introduction (accidental or intentional) or managing an invasive species once it is established. Uncertainties linked to the process will vary depending on the invasion stage. A sound decision-making process should also reflect on this (Born et al. 2005).

The purpose of this section is to introduce five approaches to the evaluation of management alternatives concerning invasive species. In this context, operational implications of assessing impacts of biological invasions by means of these approaches are discussed. Table 19.2 presents the main characteristics of each approach. However, it is important to note that every approach features a variety of specific methodologies and techniques. Therefore, specific processes and operational constraints can differ depending on the specificities of the implementation process. Alternatively, a combination of methods is sometimes advisable.

19.4.1 Risk Assessment

One of the approaches most used as a predictive tool concerning biological invasions is risk assessment. This aims at measuring risk by determining the likelihood of an introduction and the potential adverse effects, given available knowledge about alien invasive species and the recipient ecosystem. Risk assessment for invasive species is generally adopted in order to assess decisions regarding the introduction of potentially invasive species, their pathways and vectors before establishment. However, it might also be used for allocating resources to management measures once the species is already established. For instance, the US Environmental Protection Agency developed a framework for using three main steps: (1) problem formulation; (2) analysis of exposure and effects, and (3) risk characterisation (EPA 1998). For invasive species exposure, the analysis involves estimating the likelihood of introduction, establishment and/or spread, taking into account the quantity, timing, frequency, duration and pathways of exposure as well as number of species, their characteristics and the characteristics of the recipient ecosystem (Andersen et al. 2004). As this approach is based on expert judgement, participation of other interested groups is not foreseen. Results from the assessment can be both quantitative and qualitative, although the former is usually the goal (Simberloff 2005). Expenditure and time requirements usually remain low, since mainly standard procedures are involved (e.g. guidelines established by the European and Mediterranean Plant Protection Organization, EPPO, www.eppo.org).

19.4.2 Cost-Benefit Analysis

Cost-benefit analysis is the traditional evaluation instrument within the framework of welfare economics analysis. It assesses current and future costs and benefits in monetary units, associated with a range of alternatives, projects or policy instruments. It intends to consider all impacts of invasive species which can be valued in monetary terms, including the direct costs and benefits of invasives. This implies that the valuation of environmental damages as well as of environmental services has to be conducted in monetary units, guaranteeing the substitutability between ecosystem services and human-made goods and services, even if no markets exists for the service at hand. This method provides an "optimal solution" by ranking the alternatives. Participation of social groups is not necessary but might be considered, for instance, in the assessment of their willingness to pay. Time and cost requirements will depend on the specific techniques employed in the assessment. For instance, carrying out a contingent valuation (assessing the willingness to pay or willingness to accept) will be associated with increased costs, compared to the use of secondary source data. A representative example of this method is the extensive work on the fynbos biome of the Cape Floristic Region in South Africa, where cost-benefit analysis was used to investigate the consequences of plant invasions (e.g. *Acacia* sp., *Eucalyptus* sp.) on water supply (Enright 2000; De Wit et al. 2001; McConnachie et al. 2003). Another contribution consistent with this approach is the highly referenced work developed by Pimentel et al. (2005). To consider all impacts, again uncertainty must be ruled out. Essentially, cost-benefit analysis is a monetisation of risk assessment to generate substitutability. Thus, it allows one to obtain optimal solutions.

19.4.3 Cost-Effectiveness Analysis

When benefits of control actions of invasive species are difficult to assess, economics can use cost-effectiveness analysis to find the policy instrument or alternative best suited to avoid surpassing a given threshold of invasion. To reach the defined goal, several alternatives are compared so as to obtain an optimal solution by evaluating the direct and indirect costs associated with the implementation of these management options. The costs of keeping the invasion below the threshold are expressed in monetary units but the threshold itself is in physical terms (Baumol and Oates 1988). Assuming the objective is to diminish the presence of an invasive species by 50 %, this method reveals the cheapest control option – the most "cost-effective instrument" – to decrease current infestation level to this socially desired threshold. Reduction thresholds are established from outside strict economic reasoning, so this approach can require a higher level of participation. Expenditure and time associated with the implementation of this method may vary according to the techniques employed. This approach has been used by Dehnen-Schmutz et al. (2004) to analyse private and public expenditure allocated to different control options to manage *Rhododendrum ponticum* in the British Isles. All ignorance/uncertainty around the definition of the threshold lies outside the methodology. For the impacts of the management options, again uncertainty is assumed not to exist (otherwise, no well-defined optimum exists).

19.4.4 Multi-Criteria Analysis

Limitations in achieving monetary accountings of impacts, existence of conflicting values and uncertainties inherent to the invasion and the decision-making process are challenging conditions to assess invasive species. A methodological response is multi-criteria analysis, a family of methods rooted in operational research. This compares different alternatives by contrasting the performance of a set of alternatives according to different criteria (Munda 2004). In the context of invasive species, alternatives exist concerning the choice of management options to encounter impacts. The multi-criteria approach allows us to incorporate multiple dimensions of effects, and to include both qualitative and quantitative information associated with impacts of invasive species and those related to the implementation of management responses. Results from most multi-criteria methods provide a ranking of feasible alternatives. These can be achieved either by a vertical approach where no compensability exists (i.e. no trade-offs; e.g. lexicographic methods) or by a horizontal approach which encompasses varying degrees of compensability (e.g. multi-attribute theory, outranking methods). This approach has been used by Maguire (2004) to analyse trade-offs among conflicting objectives for controlling feral pigs (*Sus scrofa*) in Hawaii. In multi-criteria evaluation, the selection of alternatives and criteria may be decided during a participative deliberation exercise; therefore, attention is placed on the learning process and achieving a compromise solution, rather than an optimal solution. Application will usually require longer time periods and higher costs.

19.4.5 Scenario Development

Another analytical technique which has been used to face uncertainty and to integrate different values is scenario development. As opposed to predictions implying no uncertainties, this method is designed to deliver results in situations characterized by uncertainty. A variety of methods employ the term "scenario" referring to possible outcomes of different management alternatives. However, scenario development is also a method in itself. In this approach, scenarios are descriptions of alternative images of the future, created from mental models which reflect different perspectives on past, present and future events (Rotmans et al. 2000). These provide representations of plausible futures and typically include a narrative element called storyline, sometimes supported by quantitative indicators (Berkhout et al. 2002). Impacts of alien invasive species and effects associated with the implementation of response measures can be included when conducting deliberation on causal processes and outcomes of biological invasions. Social participation is desired to increase internal coherence of scenario development and to incorporate different perspectives. Its main purpose is to decrease uncertainty by discourse-based decisions. Cost and time requirements can vary depending on the specific process – as in other methods which pursue participation, these can be high. For instance, Chapman et al. (2001) used this approach to analyse different management scenarios of invasive species in South Africa to improve decision support.

19.5 Concluding Remarks

This chapter illustrates impacts of invasive species from the socio-economic point of view, within the integrative framework of ecosystem services. This framework facilitates a comprehensive review of the variety of impacts caused by invasive species. It links ecological effects of invasive species with the foundations of human wellbeing, as humans are dependent on ecosystems and their functioning in supplying special services to society. Invasive species can disrupt such ecosystem services.

Throughout the variety of examples displayed in the chapter, it can be seen that both the effects and the response impacts are perceived differently by various social groups. Individual or social perception is considered to be a prerequisite for the valuation of impacts in the context of decision making for appropriate management. Using ecosystem service categories helps to organize impacts when presenting information to interest groups, and it can help to include many perspectives during the valuation processes. In this way, the multidimensional character of impacts is highlighted.

Additionally, assessment approaches deal with impacts differently. Every method has different potentials and constraints which shape its use for supporting decision making. Choosing the most suitable approach may rest on different reasons, such as the type of information employed, the participation potential, the consideration of uncertainty and, especially, the type of impacts which are taken into account. In fact, the further away the impact is from holding a market price, the more relevant is social participation in the deliberation process.

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