Glossary - A conceptual framework for prioritization of invasive alien species for management according to their impact

Modified from Nentwig et al. 2010 and Kumschick et al. 2012

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Impact criteria for assigning alien taxa to different categories in the classification scheme

Six mechanisms have been identified by Nentwig et al. 2010 and Kumschick et al. 2012, by which alien taxa may cause environmental impacts in areas to which they have been introduced (Table 1). The categories for environmental changes are hybridization, competition, transmission of diseases to wildlife, herbivory/toxicity, predation, and ecosystem effects in general.

Changes to the environment can be **negative** or **positive**. Changes in the negative direction denote a decrease in an attribute of ecosystem function or native biodiversity compared to the state before the IAS was introduced and can range from no changes to the environment (score 0) to the maximum reduction possible (score 5). Positive effects can occur in systems previously altered by human-induced disturbance, e.g. alien species, land-use change, pollutants, eutrophication etc., but where an invader can fulfil some or many of the functions that previously existed or were fulfilled by species before perturbation. Thus, these scores can also range from very low changes (score +1) to the complete restoration of an expected, pre-invasion state of system functioning (score +5). Furthermore, positive effects can occur if an invasive species enhances a function still provided by other resident species.

Please note that "positive" and "negative" do not denote human values, but relate to the direction of environmental change after invasion relative to the pre-invasion state of the system: "positive" indicates changes towards the pre-invasion state, "negative" changes away from the pre-invasion state. Because a species might simultaneously cause positive and negative changes within the same category, but through different mechanisms, Nentwig et al. 2010 and Kumschick et al. 2012 score these positive and negative changes separately. Furthermore, it is possible that a stake-holder values positive and negative changes differently, so by keeping them separate, the categories might also be weighted differently.

Table 1: Impact Criteria

	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5
Herbivory/ toxicity negative Herbivory/	No impact known or detectable	Very low level of herbivory (animals) or toxicity (plants or animals) on at least one native species, no major damage reported	Herbivory or toxicity affecting several native species, without large impact on affected species or decline of their populations	Herbivory or toxicity affecting several native species, at least one native species declining	Herbivory or toxicity affecting many native species, several declining in population size, recorded community change reversible	Herbivory or toxicity affecting native species listed as vulnerable, endangered or critically endangered by IUCN, decline of these species, replacement or even extinction of species, recorded community change irreversible Complete
toxicity positive	No impact known or detectable	Very low level of herbivory or toxicity affecting at least one species degrading the ecosystem, no impact on performance of affected species recorded	Herbivory or toxicity affecting one or several species degrading the ecosystem, without large impact on affected species or decline of their populations	Herbivory or toxicity affecting one or several species degrading the ecosystem, at least one species declining, some/first indications that the ecosystem changes towards its historical functional state	Herbivory or toxicity affecting one to many species degrading the ecosystem, declining in population size, strong indications that the ecosystem changes towards its historical functional state	re-establishment of functional state of historical ecosystem that was degraded before invasion of alien species
Competition negative	No impact known or detectable	For animals, very low level of competition with at least one native species, exploitation competition; for plants, low abundance, native species richness not declining	For animals, competition with several native species by exploitation competition, without large impact on affected species or decline of their populations; for plants, moderate abundance, decrease in native species abundance but not richness	For animals, competition with several species, interference competition, at least one native species declining; for plants, high abundance, decrease in native abundance, at least one native species lost	For animals, competition with many native species, several declining in population size, competition for food and/or space, behavioural changes in out-competed species; for plants, high abundance, strong decline in both abundance and richness of native species, native species still able to recruit	For animals, competes with species listed as vulnerable, endangered or critically endangered by IUCN, decline of these species, replacement or even extinction of species; for plants, monodominant/near mono-dominant, with no or very few native species remaining; limiting native species recruitment options
Competition positive	No impact known or detectable	For animals, very low level of competition with at least one native species degrading the ecosystem, exploitation competition, no impact on performance of affected species recorded; for plants, no loss in abundance or richness of native species	For animals, competition with one or several native species degrading the ecosystem by exploitation competition, without large impact on affected species or decline of their populations; for plants, small increase in abundance of native species, no increase in species richness	For animals, competition with one or several species degrading the ecosystem, interference competition, at least one species declining, some indications that the ecosystem changes towards its historical functional state; for plants, increase in abundance of native species, small increase in species diversity	For animals, competition with one to many species degrading the ecosystem, declining in population size, strong indications that the ecosystem changes towards its historical functional state; for plants, increase in abundance of native species and in species diversity	For animals, completely re-establish functional state of historical ecosystem that was degraded before invasion of alien species; for plants, increase in abundance of native species and in species diversity, including threatened native species
Predation negative (not relevant for plants)	No impact known or detectable	Predation known but negligible, no decline of native species	Predation on several abundant species, without large impact on affected species or decline of their populations	Decline of one to several native species recognized, minor change in food web structure reported	Decline of many species, indirect impact by mesopredator release, clear changes in the food web	Preys also on endemic or species listed as vulnerable, endangered or critically endangered by IUCN, local extinction

Table 1 - Continued from previous page

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Predation	Score 0 No impact	Score 1 Predation on	Score 2 Predation on one	Score 3 Decline of one to	Score 4 Decline of one to	Score 5 Completely
positive	known or	species degrading	or several species	several native	many species	re-establish
(not	detectable	the ecosystem	degrading the	species degrading	degrading the	functional state
relevant for	detectable	known but	ecosystem,	the ecosystem	ecosystem, clear	of historical
plants)		negligible, no	without large	recognized, minor	changes in the	ecosystem that
piants)		decline of species	impact on	change in food	food web, strong	was degraded
		decime of species	affected species	web structure	indications that	before invasion of
			or decline of	reported, some	the ecosystem	alien species
			their populations	indications that	changes towards	anen species
			their populations	the ecosystem	its historical	
				changes towards	functional state	
				its historical		
				functional state		
Transmission	No impact	Host (plant or	Occasional	Many native	Transmits	Transmits
of diseases	known or	animal) for	transmission of	species affected,	harmful diseases	harmful diseases
to wildlife	detectable	non-specific	more or less	frequent	to several native	to many species
negative		parasites,	harmless	transmission of	species or more	and/or species
		occasional	diseases, several	more or less	or less harmless	listed as
		transmission of	native species	harmless diseases	diseases to	vulnerable,
		more or less	affected. No or	or harmful	endemic or	endangered or
		harmless diseases	only minor	diseases	species listed as	critically
		to one native	population	transmitted to	vulnerable,	endangered by
		species. No	decline in native	one native	endangered or	IUCN by direct
		population	species. If a	species. Minor	critically	transmission,
		decline in native	plant, species	population	endangered by	decline of these
		species. If a	may be a	decline in native	IUCN. Moderate	species or
		plant, species is	breeding ground	species. If a	population	extinction. If a
		not a breeding	for wildlife	plant, may be a	decline in native	plant, a major
		ground for	disease vectors,	more significant	species. If a	breeding ground for wildlife
		wildlife disease vectors	but no more so	breeding ground for wildlife	plant, a major breeding ground	for wildlife disease,
		vectors	than native plant species	disease vectors	for wildlife	outbreaks due to
			apecies	than native plant	disease vectors,	species presence
				species	outbreaks due to	certain
				Species	species presence	
					uncertain	
Transmission	No impact	Occasional	Occasional	One to many	Transmits	Completely
of diseases	known or	transmission of	transmission of	species degrading	harmful diseases	re-establish
to wildlife	detectable	more or less	more or less	the ecosystem	to one to several	functional state
positive		harmless diseases	harmless	affected, frequent	species degrading	of historical
-		to one species	diseases, one or	transmission of	the ecosystem.	ecosystem that
		degrading the	several species	more or less	Moderate	was degraded
		ecosystem; no	degrading the	harmless diseases	population	before invasion of
		population	ecosystem	or harmful	decline in	alien species.
		decline in	affected. No or	diseases	species, strong	Massive positive
		species. Potential	only minor	transmitted to	indications that	effect on health
		positive effect on	population	one species	the ecosystem	of wildlife caused
		health of wildlife	decline in species.	degrading the	changes towards	by species
		(direct: e.g.	Occasional, small	ecosystem. Minor	its historical	
		potential	positive effect on	population	functional state.	
		medicinal	health of wildlife	decline in	Regularly leading	
		species; indirect:		species, some	to larger positive	
		e.g. antagonist of		indications that	effect on health	
		a health threat),		the ecosystem	of wildlife	
		but not yet		changes towards		
		reported		its historical		
				functional state.		
				Regularly small		
				positive effect on		
				health of wildlife,		
				or occasional,		
				larger positive		
				effect on health		
Harbarial 41	N = :	TI-Laidi	Haladidia (1)	of wildlife	Haladin of	Dial- of a 11 11
Hybridization	No impact	Hybridization	Hybridization is	Hybridization is	Hybridization common with	Risk of extinction
negative	known or detectable	possible in captivity, but	more common in the wild, no	more common, with offspring,	fertile offspring	of endangered species
	actectable	only rarely in the	offspring, but	but not fertile	101 the onspring	species
		wild	constraints to	but not tertile		
		WIIG	normal mating			
Hybridization	No impact	Hybrids are	Hybrids are able	Some/first	Strong	Completely
positive	known or	capable of coping	to cope with	indications that	indications that	re-establish
	detectable	with degraded	degraded	hybrid changes	hybrid changes	functional state
	Levellable	ecosystem	ecosystem	the ecosystem	the ecosystem	of historical
		process(es), e.g.	process(es) in the	towards its	towards its	ecosystem that
		shown in	field	historical	historical	was degraded
I				functional state	functional state	before invasion of
		laboratory				
		laboratory experiments but				
		experiments, but no indications are				the hybrid species

Table 1 - Continued from previous page

	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5
Impact on	No impact	Change in	Moderate change	Major change in	Severe changes in	Massive changes
ecosystem	known or	chemical (e.g.	in chemical,	chemical,	chemical,	in chemical,
(other than	detectable	eutrophication,	physical and/or	physical and/or	physical and/or	physical and/or
mentioned		nutrient-cycling),	structural	structural	structural	structural
before, i.e.		physical (e.g. soil	characteristics,	characteristics,	characteristics,	characteristics,
chemical,		compaction,	only slight	change in fauna	decline of species	endemic species
physi- cal or		structure,	impact on	and flora and/or	and/or change in	and/or species
structural		hydrology)	performance of	successional	species	listed as
changes)		and/or structural	natives or	processes,	composition,	vulnerable,
negative		(e.g. felled trees,	successional	reversible	strong impact on	endangered or
		burrows,	processes		successional	critically
		disturbance			processes, but	endangered by
		dynamics)			likely to be	IUCN affected,
		characteristics			reversible	decline of species
		detectable, but				and/or change in
		no impact on				species
		performance of				composition, very
		natives or				strong impact on
		successional				successional
		processes				processes, loss of
						habitat
						characteristics,
						damage of sites
						of conservation
						importance,
	37				ļ	irreversible
Impact on	No impact	Change towards	Moderate change	Major change	Severe changes in	Complete change
ecosystem positive	known or detectable	historical state of the ecosystem in	towards historical state of	towards historical state of	chemical, physical or	towards historical state of
positive	detectable	chemical (e.g.	the ecosystem in	the ecosystem in	structural	the ecosystem in
		eutrophication,	chemical.	chemical.	characteristics,	chemical.
		nutrient-cycling),	physical or	physical or	major decline of	physical or
		physical (e.g. soil	structural	structural	species	structural
		compaction,	characteristics,	characteristics,	responsible for	characteristics,
		structure,	only slight	decline of	the ecosystem	removal of
		hydrology) or	decline of	populations of	degradation or	species
		structural (e.g.	populations of	species	severe change	responsible for
		felled trees,	species	responsible for	towards	the ecosystem
		burrows,	responsible for	the ecosystem	historical state of	degradation,
		disturbance	the ecosystem	degradation,	the ecosystem in	re-establishment
		dynamics)	degradation or	major change	species	of historical
		characteristics	successional	towards	composition or	habitat
		detectable, but	processes	historical state of	successional	characteristics
		no decline of	1	the ecosystem in	processes	and successional
		populations of		fauna and flora		processes
		species		or successional		
		responsible for		processes		
		the ecosystem		_		
1	I.	degradation or	1	l	I	I
1		degradation or				
		successional				

Assessing a confidence score

For each alien taxon that is assessed and for which adequate data exist to allow for classification, the assessor should place it in the most likely of the five impact categories (Score 0, 1, 2, 3, 4 or 5) and assign a level of confidence to this placement according to the availability and reliability of evidence, the type of data used to make the assessment, the spatial scale over which data were recorded, and whether or not the evidence is contradictory.

Confidence is categorized into five levels:

- Very confident (80-100%) should be assigned when there is relevant direct observational evidence to support the assessment; the data are reliable and of good quality; impacts are recorded at the typical spatial scale at which original native communities can be characterized; and all evidence points in the same direction.
- Somewhat confident (60-80%) should be assigned when there is relevant direct observational evidence to support the assessment and all evidence points in the same direction, but some of the data are inferred (e.g. impact estimated from mathematical models); impacts are recorded at a spatial scale which may not be relevant to the scale over which original native

communities can be characterized but extrapolation or downscaling of the data to relevant scales is considered reliable, or to embrace little uncertainty.

- Medium confidence (40-60%) should be assigned when there is some direct observational evidence to support the assessment, but some of the data are inferred (e.g. impact estimated from mathematical models); impacts are recorded at a spatial scale which may not be relevant to the scale over which original native communities can be characterized but extrapolation or downscaling of the data to relevant scales is considered reliable, or to embrace little uncertainty; and/or there is some degree of ambiguity in the direction or magnitude of the impact.
- Somewhat not confident (20-40%) is defined as no direct observational evidence to support the assessment, for example only data from other species have been used as supporting evidence; or data are of low quality or strongly ambiguous; or impacts are recorded at a spatial scale which is unlikely to be relevant to the scale at which original native communities can be characterized and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties.

Assessing the reliability of the data

Nentwig et al. 2010 and Kumschick et al. 2012 suggested including information about the reliability of the data source used for scoring:

- Low: mentioned in paper, no reference, speculation, expert judgment
- Medium: evidence in literature, observational
- **High**: demonstrated evidence in peer-reviewed literature, experimental.

This also deals with the fact that an impact score of 0 can be both, "no impact known" and "no impact detectable". Including a certainty level enables to distinguish these possibilities (e.g. Low: no information. High: demonstrated evidence in peer-reviewed literature, experimental). These certainty levels and data reliability are to be communicated to the decision maker and can potentially influence the final decision making. Furthermore, they can identify research needs (e.g., species with large effects with low certainty).

References

- [1] Kumschick, Sabrina and Bacher, Sven and Dawson, Wayne and Heikkilä, Jaakko and Sendek, Agniezska and Pluess, Therese and Robinson, Tammy and Kühn, Ingolf (2012). A conceptual framework for prioritization of invasive alien species for management according to their impact, *NeoBiota*, 15(69).
- [2] Nentwig, Wolfgang and Kühnel, Elfi and Bacher, Sven (2010). A Generic Impact-Scoring System Applied to Alien Mammals in Europe, *Conservation Biology*, 24(1):302–311.