

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 stakeholder 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	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
Herbivory/ 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	Complete 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, mono-dominant/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

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

Table 1 – Continued from previous page

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

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, Agnieszka 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.