NORWEGIAN BIODIVERSITY
INFORMATION CENTRE

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Guidelines for the Generic Ecological Impact Assessment of Alien Species

Version 4.4

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Contents

1. Introduction

1.1. Alien species

The spread of alien species as a result of human activity is a global problem with massive ecological consequences (Kumschick et al. 2015), leading to a homogenisation of nature (Dar and Reshi 2014). On a global basis, alien species are listed among the greatest threats to biodiversity (IPBES 2019, Pyšek et al. 2020). In IUCN's global Red List, alien species are identified as a threat to 41% of threatened amphibians, 33% of threatened birds and 24% of threatened fungi (IUCN 2021). In Norway, alien species are still listed as a threat to a relatively small (but increasing!) number of species (5%; Artsdatabanken 2021).

It has been estimated that, on a global basis, roughly 10% of newly introduced alien species will be able to establish, and that 10% of these will become problematic (Williamson 1996). These figures vary a lot both geographically and between different groups of organisms, and the validity of this 'rule' is contested (Lockwood et al. 2005). For Nordic environments, it has been estimated that 3–5% of introduced vascular plants become invasive (Fremstad et al. 2005). Repeated introductions increase the probability of establishment, and the size of the introduced population has a similar effect (Blackburn et al. 2009). On the other hand, there are examples of one fertilised female founding well-established and highly expansive populations (Zayed et al. 2007). Among the most important factors determining whether an alien species is able to establish in a new area, are its demographic and physiological characteristics (e.g. ability to utilise pioneer habitats, short generation time, high tolerance for environmental stochasticity, generalistic and opportunistic diet) as well as the availability of suitable habitats.

The climate in Norway is characterised by short growing seasons and long, cold winters. This may be a partial explanation for the fact that alien species still are a limited problem in comparison to many other countries. However, a milder climate may provide more favourable conditions for a number of alien species in the future (Fremstad et al. 2005, Iacarella et al. 2015, Dullinger et al. 2017), thus increasing their likelihood of surviving, establishing and spreading.

Alien species that establish in a new area may have considerable ecological effects locally, either by acting as a novel decomposer, herbivore, predator or parasite in ecosystems, but also by disrupting trophic interactions when constituting a novel resource. When filling the niche of a native species (spatially and/or trophically), or when having traits that negatively affect the viability of other species (e.g. through toxicity or transmission of infectious diseases), the population dynamics of native species can be changed, ultimately resulting in displacement (Williamson 1996). Alien species may also bring about changes in the condition and state of ecosystems, and thus modify their structure and threaten their diversity (Artsdatabanken 2018b). Finally, some alien species have the ability to transfer genetic material to other species (introgression). Such genetic contamination may affect the genetic constitution of native species, and thereby change their characteristics, ecology and evolutionary potential.

1.2. Ecological impact assessments of alien species in Norway

By ratifying the Convention on Biological Diversity (CBD 1992), Norway has committed itself to, as far as it is possible and practical, preventing the introduction of alien species, as well as controlling and eradicating alien species that may threaten ecosystems, habitats or species. These goals have been reinforced by Aichi Target 9 (CBD 2019) and the Sustainable Development Goal 15.8 (UN 2015). In Norway, these commitments have been followed up by national strategies and action plans (Miljøverndepartementet et al. 2007, Klima- og miljødepartementet 2015, Klima- og miljødepartementet et al. 2020) and implemented by laws and regulations (Naturmangfoldloven 2009, Forskrift om utsetting av utenlandske treslag 2012, Forskrift om fremmede organismer 2015, Forskrift om ballastvannbehandling på skip mv. 2017). This legal framework emphasises the importance of recording and assessing the impacts of alien species.

The ongoing impact assessment is the fourth such assessment of alien species in Norway carried out by the Norwegian Biodiversity Information Centre. The earlier assessments have been published in 2007, 2012 and 2018 (Gederaas et al. 2007, 2012, Artsdatabanken 2018a). During this process, the underlying method has been revised and improved. The qualitative criteria used in the first assessment (Gederaas et al. 2007), were replaced by a semi-quantitative set of criteria in 2012 (Sæther et al. 2010, Sandvik et al. 2013). The second round of assessments was followed by a broad evaluation of the needs and a revision of the methodology, based on the input from a scientific reference group and feedback from a variety of institutions and user groups. This process resulted in a fully quantitative method called GEIAA (*Generic Ecological Impact Assessment of Alien Species*; Sandvik et al. 2019a). GEIAA was used during the third round of assessments in Norway (Artsdatabanken 2018a, Sandvik et al. 2020), as well as in the first Swedish impact assessment of alien species (Strand et al. 2018).

The ongoing fourth round of assessments, too, follows the GEIAA protocol. The assessment criteria are unchanged, although some estimation methods and definitions have been adjusted (see page 46 for a list of changes). GEIAA is used to describe and quantify the risks associated with the establishment and expansion of alien species in Norway, and with the negative ecological effects they do or may exert on the natural diversity in Norway (i.e. on species and ecosystems). An assessment of non-ecological effects is beyond the responsibility of the Norwegian Biodiversity Information Centre.

The end product of the impact assessments has changed names several times: initially referred to as the 'Norwegian Black List' (2007), in 2012 it was called 'Alien species in Norway with the Black List'. From 2018 it has had its current name, 'Alien Species List of Norway'. The name was changed in order to reduce the possibility of misunderstanding the aim of the list. The Alien Species List does not in itself have any legal consequences for the species listed; it delivers the knowledge necessary for natural management authorities, researchers and the general public. It is not the responsibility of the Norwegian Biodiversity Information Centre to decide on or carry out measures against any species. This is the responsibility of the relevant management authorities. An assessment of the ecological risks posed by alien species is a crucial first step towards a prioritisation of management efforts, but it is not necessarily sufficient for deciding such priorities (which may have to take into account other aspects, such as economy, human health or cultural heritage).

The Norwegian Biodiversity Information Centre has established several expert groups, each of which risk-assesses the alien species within a certain taxon. The fourth round of assessments started with a horizon scan of potential door knockers in the autumn 2021 (see chapter 3). The impact assessments (see chapters 4 and 5) will be carried out during 2022, in a tailor-made web application, the AlienSpeciesDatabase. The result – an updated Alien Species List of Norway – will be published online (accessible via https://www.artsdatabanken.no/fremmedearter).

1.3. Verifiability as a general requirement

The impact assessments must be verifiable and testable. It is, therefore, a basic requirement that information is documented and referenced. This is especially important for all information that affects the scores and impact categories.

A criterion is thus not regarded as met unless documentation is available. This documentation may consist of scientific (peer-reviewed) articles or reports (in which case it is sufficient to reference these sources), but also of own observations and other unpublished data (as long as these are made available). It is a requirement that unpublished datasets are uploaded to the AlienSpeciesDatabase, at least when they contain essential information for verification of the assessment. Personal communications from other experts need to be documented with name, date and institution.

Documentation should include a clear description of the assessment methods the expert has used (including the assumptions which the assessment is based upon). Quantitative assessments pose higher demands to documentation than qualitative ones. The assessment of a given criterion may consist of a specific, numerical and referenced estimate. However, it may also consist of an expert judgement. Expert judgements do not conflict with a quantitative method *as long as they are documented and based on the threshold values* specified in the set of criteria. In such cases, documentation consists of substantiating that, or explaining why, the value is likely to lie between two specific thresholds, without the need to provide a numerical estimate. The experts are encouraged to exercise discretion and draw on their personal expertise.

For some species, there will be no documentation available on the invasion potential or on ecological effects in Norway. This is the case for many door knockers, but even some alien species that are already present in Norway – either because they are so new, hard to find, or poorly investigated. If there are insufficient data from Norway, documentation may consist of:

- data on the same species from countries that are bioclimatically comparable to Norway,
- data on the same species from countries that are bioclimatically different from Norway,
- data on a related species with a comparable lifestyle and demography.

This list is given in approximately prioritised order. There may be cases, however, were Norwegian data on a close relative give a better indication of the characteristics of the species than data from the area of origin of the species. Such decisions have to be based on the experts' judgement and to be described in the documentation.

1.4. Acknowledgements

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2. Definitions and delimitations

2.1. Alien species

The following general definition of alien species, based on CBD (2002), is used:

> A species, subspecies or lower taxon* is referred to as an *alien species* to an area if its presence is caused by intentional or unintentional anthropogenic transport, and it has not previously occurred naturally in the area.

The term includes any life stage or part of individuals that might survive. Thereby, the definition does not only comprise adult individuals but also seeds, eggs, spores or other biological material that might enable the production of new individuals of the species, or the transfer of genes. 'Natural occurrence' refers to parts of a species' range where it occurs *without* previous anthropogenic transport.

The terms 'transported' and 'introduced' are here used in a broad and neutral sense that does not imply intent. This includes the following mechanisms of dislocations of a species:

1) intentional *release*;
2) *escape* from confinement (such as breeding, cultivation, farming etc.);
3) *contaminants* (incl. parasites) introduced during transport of animals, plants or organic matter;
4) *stowaways* introduced during transport of people, equipment, bulk, vehicles or boats;
5) spread through man-made *corridors* (such as bridges, tunnels or canals);
6) *unaided* dispersal from areas where the species is alien.

On overview of pathways of introduction and their subcategories is provided in section 4.3. and Appendix II. The term 'introduction' is here used to indicate that the species ends up in *Norwegian nature* (as defined in section 2.4.):

> *Introduction* refers to any human activity that has the intended or unintended consequence that an alien species arrives in Norwegian nature.

The term 'alien species' (*fremmed art*) is now well established in Norway and is preferred over expressions such as 'non-native species', 'exotic species' or 'invasive species', which are potentially misleading. The term 'invasive' suggests a large potential to invade (i.e. to spread); however, not all alien species are invasive in this sense, and there are native invasive species, too. It should be mentioned that any 'alien species' consists of 'alien organisms' as defined by the Norwegian Nature Diversity Act**, so that these two terms may be regarded as equivalent.

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* A *taxon* (plural *taxa*) is any taxonomic entity (group of species or organisms). 'Lower taxon' refers to taxonomic entities below the species level (such as subspecies or varieties).

** «alien organism: an organism that does not belong to a species or population that occurs naturally in an area» (Naturmangfoldloven 2009: § 3, cf. Forskrift om fremmede organismer 2015: § 4)

2.2. Establishment

Establishment and *unaided reproduction* are key terms when it comes to alien species. The following definitions are used (altered from the previous version![*]):

> A species is regarded as *reproducing unaidedly* in Norway if and only if it produces viable offspring outdoors and without human management.
>
> A species is regarded as *established* in Norway if and only if it has, for a period of more than 10 consecutive years, maintained a population of more than 20 unaidedly reproducing individuals.

Offspring may be produced sexually or asexually (including vegetatively). Viable offspring refers to fertile offspring that survives (or is very likely to be able to survive) until maturity. Species that solely reproduce indoors or under human management, are *not* regarded as reproducing unaidedly (e.g. livestock; for delimitations, see IUCN 2022:8). A more detailed subdivision based on the establishment status of species is described in section 4.1.

2.3. Red-List assessed species

The assessments aim at quantifying the impact of alien species on natural diversity in Norway. The latter comprises ecosystems and species. As far as the impact on species is concerned, the assessments shall take into account *all species that are within the delimitations of the current Norwegian Red List for species*. This set of species is here referred to 'Red-List assessed species' and includes 'threatened species' as a subset:

> *Red-List assessed species* are species, subspecies or lower taxa that are listed as Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Regionally Extinct (RE) or Data Deficient (DD) according to the Norwegian Red List for species 2021 (Artsdatabanken 2021).
>
> *Threatened species* are species, subspecies or lower taxa that are listed as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) according to the Norwegian Red List for species 2021 (Artsdatabanken 2021).

For simplicity, Red-List assessed species are often referred to as native species.[**] However, Red-List assessed species consists of three different subsets (Artsdatabanken 2020:5–7):

- *native (indigenous) species*, i.e. species that are established in Norway (or have been so after 1799) and do not originate in anthropogenically transported individuals (meaning that most native species have immigrated to Norway without any human assistance, be it 1 or 10 000 years ago; a few native species have evolved in Norway, so-called *autochthonous* species);
- *visiting (migrating) species*, i.e. species that are not established in Norway, given they regularly use Norwegian territories (or have done so after 1799) with a population amounting to more than 2% of the species' global population size (cf. IUCN 2012b: 9, 16);
- *alien species that have been established in Norway by 1800* (cf. IUCN 2012b: 7, 34).

Species belonging to these three groups receive the same treatment in a Red-List context. Therefore, they also receive the same treatment during impact assessments of alien species.

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[*] Version 3 of the these Guidelines confusingly referred to unaidedly reproducing species as 'established'.
[**] Version 3 of the these Guidelines confusingly referred to Red-List assessed species as 'native'.

The definitions entail that a visiting species is *neither native nor alien*, because it is neither established nor introduced. On the other hand, a species may be *native to Norway*, whereas it is *alien to parts of Norway* (so-called 'regionally alien species', see p. 11).

2.4. Norwegian nature

The 'assessment area' for an alien species is here referred to as *Norwegian nature*:

> *Norwegian nature* encompasses any part of Norway that is outdoors (including strongly altered nature) and the Red-List assessed species occurring there; for production species, their production area does not count as Norwegian nature.
>
> A *production species* is a species that is used for production of goods or services in agriculture, forestry, horticulture, gardens, parks, aquaculture, farming, as pet, for hobby or leisure, or a species imported as food, fodder or bait.
>
> The *production area* of a given production species is the confined area that is allocated to the production of this species.

NB! *It follows from this definition that the extent of production area is always specific to a particular production species, and, consequently, that the extent of Norwegian nature is species-specific, too.*

The delimitation of production areas will often, but not always, be sharp (e.g. fences). If a species is known to have been observed within a buffer zone within the fringes of its production area, as wide as the individuals are high, this is still regarded as part of the production area.

The subdivision of Norwegian nature follows the 'NiN system' (*Nature in Norway*, Artsdatabanken 2022), which is briefly explained in section 4.5. and Appendix III. Please note that the term *Norwegian nature* as such is not based on NiN but is needed here in order to define the assessment area for the impact assessments.

It follows from the definitions above that *a species may be established before it is introduced.* For example, if a tree species reproduces (without direct management) on the species' own plantation, it will be regarded as established in *Norway* (cf. section 2.2.). However, because the reproduction did not happen in *Norwegian nature*, the species is not regarded as introduced (cf. section 2.1.). The rationale is that a species is very likely to be able to reproduce outside its production area (i.e., in Norwegian nature) when it is known to reproduce unaidedly outdoors.

2.5. Door knockers

Species that might become established in the future, are referred to as 'door knockers':

> A *door knocker* is an alien species that is not currently reproducing unaidedly in Norway, but can be expected to do so within 50 years.

Door knockers can roughly be divided into three groups:

- alien species that are already present in Norway, but do not currently reproduce, or currently only reproduce indoors or under management (e.g. garden plants, aquarium fish, species that live in residential buildings, greenhouses, barns, storerooms and the like) – species in this group may start reproducing unaidedly outdoors when the climate or environment changes;

- alien species that are already present in neighbour countries and may reach Norway without further anthropogenic assistance, i.e. by unaided spread or through corridors;
- alien species that are absent from Norway, but that may reach Norway by means of existing and relevant pathways (intentional or unintentional import or transport, see section 4.3.) from an area that has similar bioclimatic conditions to the destination.

A door knocker should be risk-assessed if it is sufficiently likely that it establishes and/or exerts ecological effects. This is decided during a horizon scan (see chapter 3). Door knockers are to be risk-assessed for Norwegian conditions, also when using data from abroad.

2.6. Delimitations

Not all species that meet the definition of alien species (see section 2.1.) are included in the impact assessments. The subset of alien species that *are* to be risk-assessed is specified using the following four *delimitations* in time and space, ecology and taxonomy.

2.6.1. Historical delimitation

According to the general definition, species introduced in the Upper Palaeolithic are regarded as alien. However, knowledge about the native flora and fauna in Norway before c. 1800 is rather incomplete. Using a too early demarcation line would therefore introduce a great deal of uncertainty about the nativeness of species. For this reason, the year 1800 is used as the historical delimitation for impact assessment, while fully acknowledging the arbitrariness of this date. The same delimitation is used as an inclusion criterion in the Norwegian Red List.

An alien species is *not* to be risk-assessed if it was established in Norway by 1800.

In accordance with the definition in section 2.2., a species must have reproduced unaidedly for a period of more than 10 consecutive years, in order to be regarded as established. If this period *began* in 1790 or earlier (so that the species had been reproducing for at least 11 years in 1800), the species is Red-List assessed and must not be risk-assessed. This has the following implications:

1) Species that have been introduced to Norway *after* 1800 and had not previously been established in Norway, *are* to be risk-assessed.
2) Species that have been introduced to Norway before 1800 *and* established before 1800, are Red-List assessed and thus *not* to be risk-assessed.
3) Species that have been introduced to Norway before 1800, but did *not* establish before 1800, *are* to be risk-assessed.
4) Species that had been established in Norway before 1800, but went *extinct after 1800*, are Red-List assessed, and are therefore *not* to be risk-assessed even if they are re-introduced.
5) Species that had been established in Norway before 1800, but went *extinct before 1800*, *are* to be risk-assessed if they are re-introduced.

If species that have been *introduced* before 1800 are risk-assessed, this needs to be justified (by documenting that establishment happened only after 1800). If the time of *establishment* is uncertain, the species should be risk-assessed if it is more likely that the species was established after 1800 than before 1800. In both cases, an explanation should be provided.

2.6.2. Geographical delimitation

The general definition of alien species applies to all occurrences outside the species' natural range but does not specify any minimum distance. For the purpose of impact assessment, the following delimitation is applied:

> An alien species *is* to be risk-assessed as alien if it has (or had) to cross national borders or the boundaries of the Norwegian Economic Zone during its transport. Other species *may* be risk-assessed as regionally alien species.

A species that is Red-List assessed in Norway and has been introduced to novel areas within Norway due to human activity, is thus not regarded as *alien to Norway* (although it may be assessed as a *regionally alien* species, see below). A species that is Red-List assessed in mainland Norway but introduced to Norwegian islands in the Arctic (Svalbard or Jan Mayen), is considered alien to these islands – and vice versa.

Norway's national borders are its borders towards Sweden, Finland and Russia plus the outer boundaries of the Norwegian waters as specified below. Species that have entered Norway from Sweden and/or Finland (unaidedly or via corridors) are regarded as alien to Sweden and Finland following the same definitions and delimitations as for Norway. Species that have entered Norway from Russia may be regarded as alien even if they have been spread internally within Russia, especially if the anthropogenic displacement was over huge geographical distances and/or across biogeographical regions.

The impact assessments cover Norwegian areas on the Northern Hemisphere, i.e.:

- the Norwegian mainland (consisting of the mainland itself and nearby islands; c. 324 000 km^2);
- Svalbard (Spitsbergen and surrounding islands, including Bjørnøya and Hopen; c. 61 000 km^2);
- Jan Mayen (377 km^2);
- maritime waters around mainland Norway, consisting of Norwegian territorial waters (within 12 nautical miles) and the Norwegian Economic Zone (c. 933 000 km^2 in total);
- the Fishery Protection Zone including territorial waters around Svalbard (c. 806 000 km^2);
- the Fishery Zone including territorial waters around Jan Mayen (c. 293 000 km^2).

Regionally alien species

The impact assessment covers species that are alien *to Norway*. In addition, the possibility exists to risk-assess selected *regionally alien* species in Norway.

> Regionally alien species are species that are Red-List assessed in Norway, but that have been introduced to novel areas within Norway. Occurrences in the species' natural range (past or present) are referred to as *natural*; occurrences outside these species' natural range are referred to as *regionally alien*.

If the term *alien species* is used without the qualifier 'regional', it is meant to refer to species that are *alien to Norway* as a whole. The impact assessment of a regionally alien species is confined to the Norwegian areas that do not hold natural occurrences of the species. The sub-populations assessed may originate from:

- individuals from Norwegian sub-populations that have been introduced to novel areas; or
- individuals that have been introduced to Norway from abroad, but that belong to a species that occurs naturally in Norway.

Regionally alien species are only risk-assessed in selected cases, based on the decision of the relevant group of experts. As outlined above, species that are spread from mainland Norway to the Norwegian islands in the Arctic (or vice versa) are regarded as alien, not as regionally alien.

2.6.3. Ecological delimitation

The following ecological delimitations apply:

> Alien species *are* to be risk-assessed if they reproduce unaidedly in Norway. A horizon scan decides whether additional alien species should be risk-assessed.
>
> Impact assessments are *only* to include negative ecological impacts on Norwegian nature.

Please note that, for production species, Norwegian nature is species-specific (cf. section 2.3.). Alien production species that occur on the production area of *another* (native or alien) species, have thus entered Norwegian nature and are to be risk-assessed. The following rules apply for production species:

- When estimating the area of occupancy or the invasion potential of production species, their own production area is *disregarded*.
- Ecological effects that production species exert on their own production area, and that remain confined to this area, are *disregarded*.
- Ecological effects that production species have outside their own production area, on the other hand, *are* to be considered during impact assessment. Such effects include
  - occurrences and effects of *self-maintaining populations* outside the production area;
  - effects of *escaped individuals* outside their production area (even without reproduction);
  - *distance effects* (effects that have a spatial scale exceeding the production area, even if the species has not left this area) – examples are genetic contamination wind pollination, or population declines in visiting pollinators caused by toxic nectar.

Alien species that are excluded by the ecological delimitation for all their occurrences, may still undergo a horizon scan (see chapter 3); if they already occur outdoors in Norway, they should undergo a horizon scan. This step determines whether an alien species should be risk-assessed as a *door knocker* (cf. section 2.5.) or as a *non-reproducing alien species with ecological effects*. Alien species that have previously been risk-assessed as door knockers, will be risk-assessed again.

2.6.4. Taxonomic delimitation

The definition of alien 'species' does not distinguish between taxa on the species level and taxa at lower taxonomic levels. This necessitates the following delimitation:

> Alien taxa *are* to be risk-assessed if they are ranked as a species and are multicellular. Alien taxa below the species level and unicellular organisms *may* be risk-assessed if needed.

Taxa below the species level include subspecies, varieties, cultivars, hybrids and other categories. Genetically modified organisms (GMO) are *not* included in this impact assessment (as these are assessed by the Norwegian Scientific Committee for Food and Environment, VKM). Species that form mycelia or thalli (i.e. fungi sensu lato and macroalgae) are here considered as multicellular. Unicellular species will not be risk-assessed in their entirety, although selected species may be risk-assessed. No specific species concept is adopted for the impact assessment (cf. Ghiselin 1997, Hull 1997). In order to decide whether a taxon constitutes a species, one should simply follow the accepted taxonomic practice for the group in question.

Alien taxa below the species level are risk-assessed along the same lines as alien species, although this will only be done if the available information and the difference from the remainder of the species are sufficient for separate assessments. This applies irrespective of whether the species to which the taxon belongs is alien. Therefore, two situations have to be distinguished:

- Non-assessed alien taxa below the species level belonging to a species that is *alien* to Norway, are automatically assumed to share the impact category of that species.
- Non-assessed alien taxa below the species level belonging to a species that is *Red-List assessed* in Norway, are simply treated as 'not risk-assessed'.

2.6.5. Summary and examples

For a taxon to be risk-assessed,

- it has to be alien according to CBD's definition (section 2.1.), *and*
- it must not have been established in Norway in 1800 (section 2.6.1.), *and*
- it must have crossed a national border (or be introduced to/from Svalbard; section 2.6.2.), *and*
- it must currently reproduce unaidedly in Norway (section 2.6.3.), *and*
- it has to be a multicellular taxon at the species level (section 2.6.4.).

In addition, a taxon *may* be risk-assessed, if relevant or needed, if it:

1) is a regionally alien species (section 2.6.2.); *or*
2) has passed the horizon scan or has earlier been risk-assessed as a door knocker (2.6.3.); *or*
3) is a taxon below the species level that is sufficiently distinct, or is unicellular (2.6.4.).

The definitions and delimitations are here illustrated with some examples:

- *Leucanthemum vulgare* [oxeye daisy] has most likely been introduced anthropogenically to Norway with agriculture. In any case, it has been established long before 1800. It is therefore assessed for the Red List and *not* to be risk-assessed.
- *Streptopelia decaocto* [Eurasian collared dove] has not been established in Norway prior to 1800, but arrived during the 20th century. Because it has immigrated unaidedly, it is assessed for the Red List and *not* to be risk-assessed.
- *Ovibos moschatus* [muskox] is regarded as alien to Norway. It is 30 000–100 000 years ago that *O. moschatus* was part of the Norwegian fauna, and the current population was introduced anthropogenically during the 20th century. It is therefore to be risk-assessed.
- *Perdix perdix* [grey partridge] is extinct as a breeding bird in Norway. Nevertheless, it is Red-List assessed in Norway, because its original establishment happened without human involvement, and it went extinct later than 1800. The species is therefore *not* to be risk-assessed if it should be re-introduced.
- *Acer pseudoplatanus* [sycamore] has, as far as is known, been introduced to Norway for the first time around 1760. The first reports of escaped occurrences seem to be from the 1890's, however. In this case, the species was *introduced before 1800*, but *established only after 1800*, and is thus to be risk-assessed.
- *Sus scrofa* [wild boar] has had a native population in Norway some thousand years ago. It is to be risk-assessed as alien to Norway, even though it immigrated unaidedly from Sweden. The reason is that the species has been *introduced to Sweden after 1800*, and that it is thus alien to Sweden according to the delimitations used in Norway (irrespective of the fact that Swedish regulations define *Sus scrofa* as native to Sweden).
- *Inula britannica* [British yellowhead] has most likely been introduced anthropogenically to Norway with ballast soil around 1902, and was established with several subpopulations at least from the 1940s to 1970s. Since it is now extinct, it is excluded by the ecological delimitation. However, since it has demonstrated the ability to reproduce unaidedly under Norwegian conditions, it should undergo horizon scanning and potentially be risk-assessed as a door knocker.
- *Paralithodes camtschaticus* [red king crab] has not been released in Norway but has spread unaidedly from the Russian to the Norwegian part of the Barents Sea. However, because

the Russian source population has been released anthropogenically, the species is regarded as alien to Norway. While the species is not alien to Russia (it occurs naturally at the Kamchatka Peninsula), an intended transport over more than 5 000 km, from the Pacific Ocean to the Barents Sea, is a clear instance of anthropogenic introduction. The species is therefore to be risk-assessed.

- *Balaenoptera musculus* [blue whale] and *Chlidonias niger* [black tern] are examples of species that are not established in Norway but may occur as visitors. Because they reach Norway without anthropogenic involvement, they are not to be risk-assessed. While *B. musculus* is a regular visitor (migrant) and is therefore Red-List assessed, *C. niger* is an irregular visitor (vagrant) and is thus neither Red-List assessed nor risk-assessed.
- *Larix sibirica* [Siberian larch] has likely been introduced to Norway after 1850. In this case, it is to be risk-assessed as an alien species. Because it is a production species, however, its production area is to be disregarded in the impact assessment. Unaided reproduction on *L. sibirica*'s own plantations is considered as establishment, but not as spread, and is thus to be excluded from estimates of expansion speed. Along the same lines, ecological effects that *L. sibirica* might have on its own production area are disregarded during impact assessment. Effects outside *L. sibirica*'s production area, on the other hand, are part of the impact assessment. This includes ecological effects within the production area of *other species*, e.g. if it should displace native species on the production area of *Ovis aries* [sheep].
- Species that do not reproduce unaidedly are still to be risk-assessed if they occur in Norway and exert ecological effects. No such species was recorded in the Alien Species List 2018, but conceivable and realistic examples include alien tree species whose toxic nectar poisons threatened pollinators; plants that can lead to genetic contamination of Red-List assessed species by means of wind-dispersed pollen; or a crayfish that occasionally escapes from farming installations and transmits a fungal disease to Red-List assessed lobsters. Since these species do not reproduce unaidedly, they would have to undergo a horizon scan first.

2.7. Quantifying the presence and state of populations

The presence of individuals of a species can be measured in a number of ways, including population size, area of occupancy and extent of occurrence. These measures capture different aspects of presence. The state of a species can be described using demographic parameters such as generation time, population growth rate and carrying capacity. These terms are defined below.

2.7.1. Individual

Individuality is an intuitive and unproblematic concept for instance in arthropods or vertebrates. In other taxa, the concept may be more difficult to implement. As a general definition, we assume:

> An *individual* is an anatomically, physiologically, behaviourally and/or reproductively autonomous organism.

In clonal, colonial or modular organisms, these different delimitations will not necessarily be congruent, rendering the definition potentially ambiguous (Wilson 1999). What is counted as an individual will in such circumstances have to be treated pragmatically. The crucial criterion should be that individuals form units that can *reproduce independently from each other*. An important concept is, therefore, that of the mature individual:

> A *mature individual* is an individual that, judging from its state (such as age, size etc.) is able to reproduce.

This definition applies irrespective of the means of reproduction (e.g. sexual or asexual, allogamous or autogamous). In clonal organisms, each separate unit (*ramet*) is counted as a mature individual (*not* the *genet*; cf. IUCN 2022: 26–29). For fungi, lichens and mosses, special guidelines have been devised, which define individuals based on the overgrown area and/or the number of localities (Brandrud et al. 2021, Haugan et al. 2021, Høitomt et al. 2021).

2.7.2. Population size

In accordance with IUCN's (2012a: 10, 2022: 25) usage, *population* is defined as follows:

> A species' *population* in Norway (or in a specified area) refers to the total number of individuals of that species in Norway (or in the specified area).

When estimating population *size*, however, only *mature* individuals are to be counted (IUCN 2012a: 10, 2022: 25):

> A species' *population size* in Norway (or in a specified area) is measured as the number of mature individuals of that species in Norway (or in the specified area).

Population size as such does not constitute a criterion in impact assessment. However, it is important background knowledge that describes the species' presence in Norway. In addition, population size may be one of the parameters entering into the estimation of population lifetime (criterion A).

2.7.3. Occurrence

Standardisation across taxa of the term *occurrence* is not trivial. This is solved as follows:

> An *occurrence* of a species is here defined as a grid cell of 2 km × 2 km that is inhabited by individuals of the species, and that is essential for the survival or reproduction of these individuals.

Cases of vagrancy are not counted as occurrences in this sense. A grid cell is regarded as 'essential' if the species reproduces, forages, finds shelter, overwinters in it, etc. If several separate subpopulations of a species occur in one grid cell, they are only counted as one occurrence.

2.7.4. Area of occupancy

The *area of occupancy* (AOO) is an estimate of *the specific area which is inhabited by the species and which is essential for its individuals* (Figure 1c). In accordance with IUCN's (2022:52–61) recommendations and the above definition of occurrence, the area of occupancy is to be understood as the number of occurrences multiplied by the area of the grid cells (4 km^2):

> Area of occupancy = number of occurrences × 4 km^2

This definition is to be used for all habitat types (including 'linear' habitats such as rivers, coastline etc.). Areas of occupancy should be based on the standardised 2 km grid defined by Statistics Norway (SSB2KM; Strand and Bloch 2009).

2.7.5. Extent of occurrence

The *extent of occurrence* (EOO) "measures the spatial spread of the areas currently occupied by the taxon" (IUCN 2012a: 11–12, 2022: 49–50):

> The *extent of occurrence* is the area of the smallest convex* polygon that can be drawn to encompass all occurrences of the species (Figure 1b).

Since the extent of occurrence may include grid cells that are not actually occupied by the species, it can never be smaller than the area of occupancy.

Under special circumstances, the extent of occurrence may be divided into several polygons. This may be appropriate in cases of disjunct distributions (e.g. a species that only occurs in Eastern Finnmark and Southern Norway); or of separate reproductive areas and wintering areas. In such cases, the extent of occurrence is estimated as the sum of these polygons. Such divisions need to be documented.

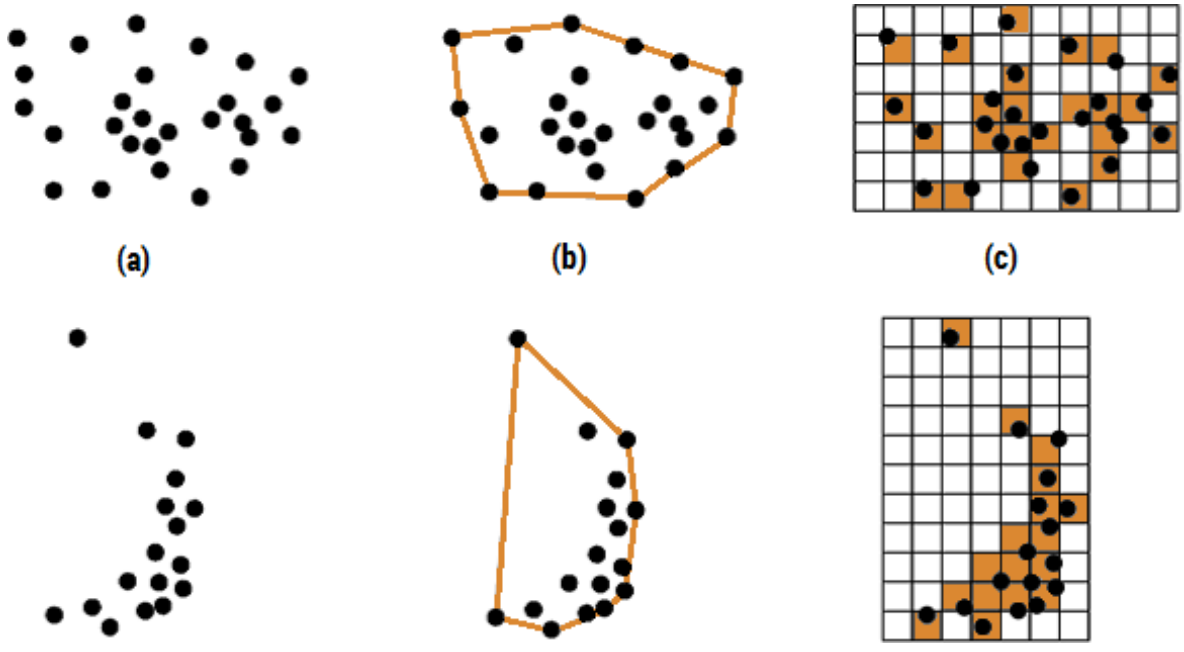

Figure 1: AAO and EOO. (a) Two populations are illustrated using points for each subpopulation. (b) The lines delimit the populations' *extents of occurrence* (EOO). (c) The sums of the orange squares (symbolising occupied grid cells of 2 km × 2 km) determine the populations' *areas of occupancy* (AOO). (Source: IUCN 2012a, modified)

* A polygon is *convex* if none of its interior angels exceeds 180°.

2.7.6. Generation time

Generation time is a crucial demographic parameter and is here defined as follows:

> *Generation time* is the average age of reproducing individuals (in years).

'Reproducing individuals' is here understood as individuals that actually produce viable offspring (not the mean age at maturity). Generation time may be difficult to estimate in certain taxa. A few guidelines may be useful here (cf. IUCN 2022: 29–31):

- In *semelparous* species (which only reproduce once in their lifetime), generation time equals the average age at reproduction.
- In *iteroparous* species (which reproduce several times in their lifetime), generation time T is larger than the age α at first reproduction and lower than the age ω at last reproduction. Note that α is usually larger than the age at maturity.
  - If a life table exists for a species, generation time can be estimated rather precisely.* Otherwise, generation time has to be approximated.
  - For species with an annual adult mortality rate m that is known and (more or less) age-independent, $T \approx \alpha + m^{-1}$ is a convenient approximation of generation rime (where $0 < m \leq 1$).
  - For plants with seed banks, the half-life of seeds should be included in estimates of generation time.
- For fungi, lichens and mosses, special guidelines have been devised, which define generation time based on the lifestyle (1 to 33 years; Brandrud et al. 2021, Haugan et al. 2021, Høitomt et al. 2021).
- It will often be possible to infer generation time from closely related species.

Generation time does not as such affect the impact assessments. However, it is essential for describing the species' reproductive potential. Furthermore, the time frame of ecological effects is defined as five generations (for species with generation times between 10 years and 60 years; otherwise, the time frame is 50/300 years for species with shorter/longer generation times, respectively).

2.7.7. Population growth rate

Population growth rate is a parameter describing the (potential) *mean annual increase in population size*:

> The multiplicative population growth rate $\boldsymbol{\lambda}$ (lambda) is defined as $\boldsymbol{\lambda} = N_t / N_{t-1}$.

Here, 'N_t' signifies population size in a given year, and 'N_{t-1}' population size one year earlier. A stable population is characterised by $\lambda = 1$, i.e. population size neither increases nor decreases. An increasing population has $\lambda > 1$. A decreasing population has $\lambda < 1$. An annual population growth of 10% thus corresponds to $\lambda = 100\% + 10\% = 1.1$. These guidelines only refer to the *multiplicative* growth rate λ. The demographic literature often prefers the *intrinsic* population growth rate r, which is defined as the natural logarithm of λ ($r = \ln\lambda = \ln N_t - \ln N_{t-1}$).

Population growth rate is an important demographic parameter. It is here used in two different contexts: First, it the population lifetime of an alien species (criterion A). Second, if an alien species reduces the population growth rate of a Red-List assessed species (by means of predation, competition etc.), this constitutes an ecological effect of the alien species according to criteria D and E. A reduction in population growth rate means that the population experiences

---

* As $T = \sum_{x=\alpha}^{\omega} x p_x f_x / \sum_{x=\alpha}^{\omega} p_x f_x$ where the summation is over the cohorts with age x, p_x is the survival rate from birth to age x, and f_x is fertility at age x.

a downward trend, which will ultimately result in extinction (Figure 2a). As far as Red-List assessed species are concerned, population growth rate is thus used as a measure of the *actual* (or *future*) long-term population trend.

For alien species, however, the *potential* annual population growth is the relevant figure. This is the growth rate under optimal conditions (e.g. in the absence of density regulation, see next section). The potential population growth rate can only be estimated using time series with population counts. In the absence of such data, estimates of λ should be sought in the peer-reviewed literature; if necessary, from closely related species.

2.7.8. Carrying capacity

The carrying capacity of a population is the size at which the population is stable, i.e. at which there is an equilibrium between factors that increase population size (i.e. growth rate) and factors that decrease population size (so-called density regulation). A formal definition of carrying capacity (usually abbreviated *K*) is therefore:

> Carrying capacity *K* is the population size at which density regulation balances population growth.

Density regulation entails that the population growth rate is often negatively related to density (number of individuals per area). This may be due to decreasing fertility or increasing mortality, caused by intraspecific competition.

If an alien species reduces the carrying capacity of a Red-List assessed species (by means of predation, competition etc.), this constitutes an ecological effect of the alien species according to criteria D and E. A reduced carrying capacity means that the population fluctuates at lower average numbers, which increases the risk of extinction (Figure 2b).

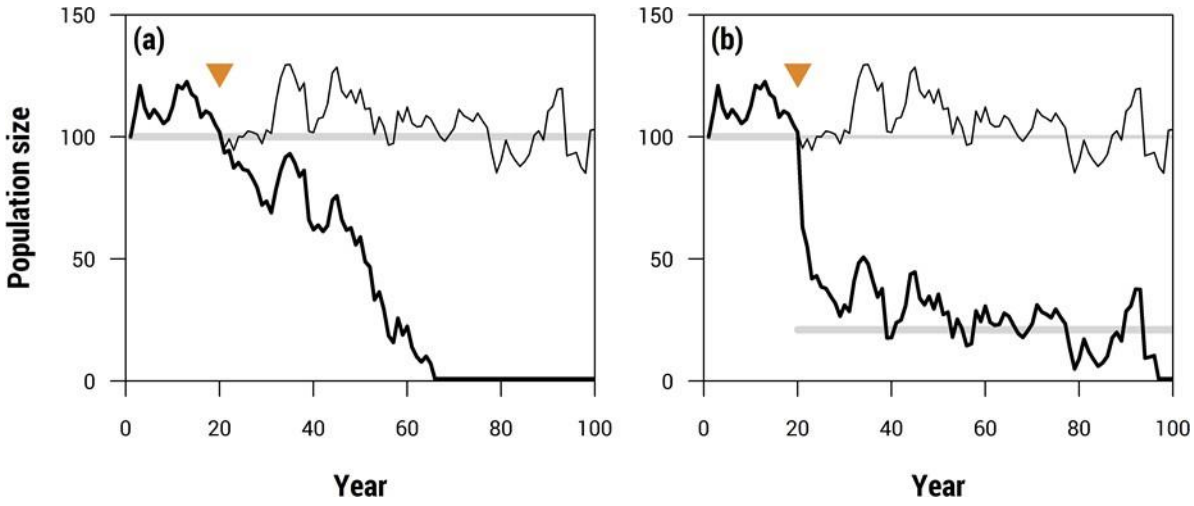

Figure 2: Illustration of population growth rate and carrying capacity. The curves show the population dynamics of a population. The thin line indicates the population trajectory in the absence of disturbance (e.g. by an alien species). The thick line indicates the population trajectory when (a) the population growth rate is reduced and (b) the carrying capacity is reduced. The change in growth rate / carrying capacity occurs at the time marked by the orange arrowhead. The horizontal grey lines indicate the respective populations' carrying capacities. A negative growth rate will inevitably lead to extinction; a reduced carrying capacity will do so only if the population fluctuations (or the environmental variance) are sufficiently large.

2.8. Ecological impact

Impact assessments of alien species are meant to quantify the alien species' *negative ecological impact on Norwegian nature*. The ecological impact exerted by alien species on nature is proportional to the area colonised, the density attained on this area, and the per-capita effect on Norwegian nature (Parker et al. 1999):

$$\begin{aligned}\text{Impact} &= \text{area} \times \text{density} \times \text{per-capita effect} \\ &= \text{area} \times \text{per-locality effect}\end{aligned}$$

Population density and per capita effect can be integrated into a measure of ecological effect 'per locality', so that impact becomes a product of two entities. A species' impact will be small as long as one of those factors is small, irrespective of how large the other one is. This is the rationale behind the two-dimensional impact matrix chosen (see Figure 4 on page 32).

The colonisation of Norwegian nature is a dynamic process. Therefore, impact is not estimated from the area currently occupied by an alien species, but from its *expansion speed*, i.e. from the *rate of increase* of the area occupied (measured as the *annual increase of the radius*, see section 5.1.2.).

What is to be assessed is the negative ecological impact of alien species on Norwegian nature. This means that the impact assessment is *not* meant to take account of

- *positive* ecological effects,*
- negative or positive *anthropocentric* effects, e.g. on human health, economy or aesthetics.

As far as *ecosystem services* are concerned, their ecological dimension is captured by the effect criteria (D–I). The monetary dimension, on the other hand, like other economic and anthropocentric aspects, falls outside the scope of the impact assessments. To the degree that information about positive ecological effects is available, it may be described in the summary. However, such effects do not affect the impact assessment.

2.9. Uncertainty, risk and dark figures

2.9.1. Uncertainty

All empirical evidence is always imbued with uncertainty (cf. Popper 1934), this includes all estimates and measurements. There are, however, three very different sources of uncertainty: *natural variability*, *measurement or observation error* and *semantic uncertainty* (Akçakaya et al. 2000):

- The parameter one tries to estimate *actually* takes different values at different times or places. To illustrate this with examples from alien species, expansion speed of a single species may vary over time, and its ecological effects may differ between northern and southern Norway. This may be due to environmental or demographic stochasticity (noise), or due to environ-

* The effect of a species can be regarded as positive if, seen in isolation, it increases the survival or fertility of a Red-List assessed species (facilitation) or if it stabilises an ecosystem. At the *community level*, the situation will be more complex, however, rendering facilitation a somewhat controversial concept. Since positive ecological effects are not assessed here (and are not weighed against negative ones), this question does not affect the assessments.

mental gradients and similar factors. A single measurement, even if it were perfectly precise, will thus not necessarily be representative of other points in space or time.

- In addition, all estimates are subject to measurement or observation error, which may be reduced, but not entirely removed, using improved methods. The time of first introduction of a species will for instance usually be unknown – it may take several decades before an introduced species is reported for the first time. Along the same lines, an estimate of the area of occupancy or of population size is a function of two factors: (1) whether the species is actually present at a given locality (presence), and (2) whether the species is discovered *given that* it is present at that locality (*observability*). In reality, observability is always less than 100%.
- The uncertainty that lies in ambiguous wording is referred to as semantic (e.g. unclear definitions, vague questions, imprecise threshold values). By using a purely quantitative set of criteria, the semantic uncertainty is reduced to a minimum in this impact assessment (see Sandvik 2017 for elaborations).

To conclude, uncertainty is always *present*, but it will vary greatly in *magnitude*. This fact can be difficult to disseminate to users, who may mistake uncertainty for ignorance. It is crucial for the scientific integrity of the impact assessment, however, that uncertainty is quantified and reported. This is here done by reporting two figures:

1) The best available evidence should be presented in terms of the *median* (or 50th percentile*).
2) Uncertainty surrounding the best estimate should be presented in terms of the *interquartile range* (or 50% confidence interval).**

In Figure 3, the median and the interquartile range are illustrated using vertical lines and shaded areas, respectively. All criteria of the impact assessment (and some other measures, such as AOO) shall be reported in terms of the median, lower quartile and upper quartile. There are three different ways of accomplishing this:

- In some cases, the median and the quartiles can be *estimated*. This applies e.g. to criteria A and B (depending on the method chosen). In such cases, the median and quartiles are reported as they emerge from the empirical estimates.
- In other cases, it is necessary to provide an expert opinion on a continuous variable. This applies e.g. to the area of occupancy. The *median* is best elicited by determining a value x such that the true value is equally likely to be less than or greater than x. The *lower quartile* (or *upper quartile*, respectively) is best elicited by determining a new value y (or z) such that it is equally likely that the true value is less than or greater than y (or z), supposing the true value had turned out to be below (or above) the assessed median x (Garthwaite et al. 2005: 685).
- Finally, some criteria require non-continuous answers. This applies mainly to the effect criteria (D–I). In such cases, uncertainty is reported by indicating all relevant alternatives. The most likely alternative (out of four possible scores) is indicated as the best estimate. Every additional alternative that has a cumulative likelihood of at least 25% (and that is adjacent to the best estimate) is indicated as uncertainty.

These three methods have in common that the uncertainty interval (the interquartile range) contains the true value with a confidence of 50% (or more). The reason for choosing 50% confidence intervals is that it has been shown to be extremely difficult to provide reliable expert opinions on 95% confidence intervals (Garthwaite et al. 2005).

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* The *n*th *percentile* is the smallest number that is greater than, or equal to, *n*% of the values in a set or a probability distribution. The median is thus the 50th percentile (or second quartile) of a distribution.

** The *interquartile range* is the interval between the *lower quartile* (25th percentile) and the *upper quartile* (75th percentile) of a distribution, and is thus equivalent to the 50% confidence interval of the distribution.

It is important to emphasise that uncertainty – even though it is always *present* – will not always *affect* the score assigned to the species. This may be illustrated using criterion B:

- If expansion speed is estimated to be 100 ± 40 metres per year, the entire confidence interval (60–140 metres per year) lies within score 2 (i.e., *between* the threshold values of 50 and 160 metres per year, respectively). The impact assessment is in this case unaffected by the uncertainty.
- If expansion speed is estimated to be 150 ± 20 metres per year, the confidence interval (130–170 metres per year) overlaps with two scores; i.e., the threshold delimiting score 2 from 3 (160 metres per year) is within the confidence interval. In this case, the impact assessment is affected by the uncertainty.

It may be important to point out that confidence intervals can be asymmetrical. In many ecological contexts, distributions are skewed to the right (Figure 3b). In such cases, the median will be closer to the lower quartile than to the upper quartile. It is also very possible that uncertainty includes a higher score than the median, but not a lower score (or vice versa).

2.9.2. Risk

The *risk* of an event is in general defined as the *product of the consequences (magnitude, damage, cost) and the probability of the event*:

Risk = consequences × probability

Therefore, the risk of an event is zero (or infinitesimal) if its probability is zero (or infinitesimal), even if the consequences are huge. Likewise, the risk of an event is zero (or infinitesimal) if its consequences are zero (or of infinitesimal magnitude), even if the probability is high. For a risk to be significant, both the magnitude of its consequences and its probability have to be greater than zero, and at least one of them must be large.

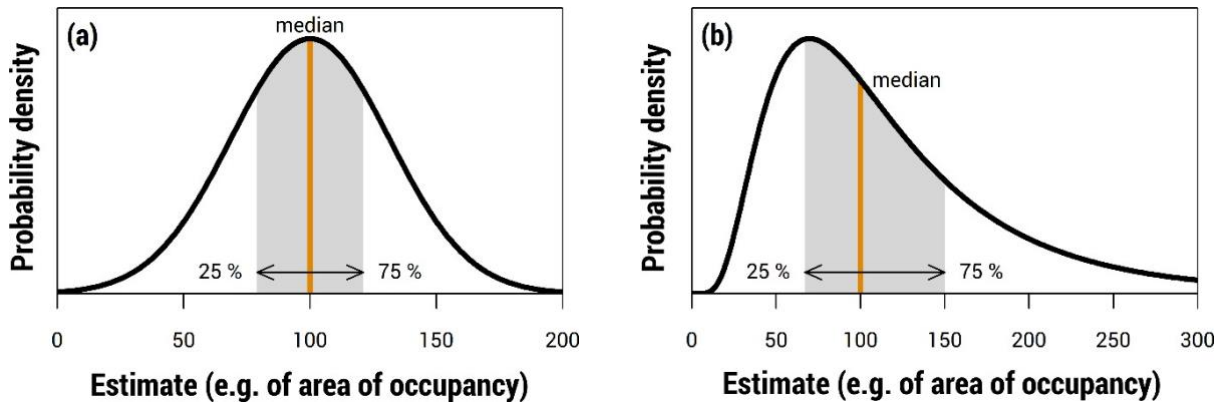

Figure 3: Examples of probability distributions. Estimates of empirical quantities follow a probability distribution, here exemplified by (a) a symmetrical (normal distribution) and (b) an asymmetrical (log-normal) distribution. The vertical line shows the median (entailing that it is equally likely that the true value is above and below this value). The grey area emphasises the interquartile range (or 50% confidence interval), i.e. the interval that contains the true value with a likelihood of 50%. The interquartile range is enclosed by the 25th percentile (lower quartile) and the 75th percentile (upper quartile).

The risk that is assessed when it comes to alien species, is the ecological damage they can do to Norwegian nature. The impact matrix used (Figure 4 on page 32) distinguishes between ecological effect and invasion potential, which must not be confused with the definition of risk. Both axes of the impact matrix express risks: the *risk of invasion* (magnitude × probability of invasion) on the *x*-axis and the *risk of ecological effects* (magnitude × probability of ecological effects) on the *y*-axis. The final impact category expresses the *risk of impact on Norwegian nature*, which can be seen as the product of two risks:

risk of impact
= risk of invasion × risk of effect
= (probability of invasion × magnitude of invasion) × (probability of effect × magnitude of effect)
= (probability of invasion × probability of effect) × (magnitude of invasion × magnitude of effect)
= probability of impact × magnitude of impact

All the variables that affect the impact assessment are uncertain, and the abovementioned rules on uncertainty thus apply (cf. section 2.9.1.). Many magnitudes of damage are thinkable, and they will follow a (normally unknown) probability distribution. The impact assessment should be based on the consequences (i.e., the ecological effects or the invasion potential) that lie – or are estimated to lie – within the 50% confidence interval (interquartile range) of this distribution. This means that the upper and lower 25% of the distribution should be discounted. Therefore, the assessments should not be based on rather improbable consequences, even if their magnitude is large.

2.9.3. Dark figures

The detectability of organisms is below 100% (see section 2.9.1.), and the *known* AOO is thus always lower than the *real* AOO. Estimates of the real values are important, because it is the actual population that affects nature, not merely its known fraction. The known values are important, too, since these are documented and constitute the basis for estimates of the real value. Therefore, both values shall be reported. The ratio between these two values is referred to as dark figure:

> A *dark figure* is the factor by which the *known* number/area has to be multiplied in order to obtain the *estimated total* number/area (total = known × dark figure).

In order to estimate the total AOO, knowledge of known occurrences need to be combined with information on the species' habitat requirements and the areas of relevant habitats. The estimate should also take the sampling effort into account (the more underreported a species is, the larger its total AOO must be relative to the known AOO).

3. Horizon scan

The most cost-efficient management of alien species is to prevent their introduction or establishment. Such efforts need to be targeted at door knockers (p. 9). The difficulty lies in determining which species may be subject to future introductions, and what their characteristics are.

The delimitations described in section 2.6. allow unequivocal and testable decisions on whether an alien species reproducing in Norway is to be risk-assessed. For door knockers, such delimitation is not equally clear-cut. The pool of species that may conceivably end up being introduced to Norway is potentially inexhaustible. At the same time, risk-assessing all species in the world is not an option. Earlier Norwegian impact assessment did not have any clear guidelines on which (potential) door knockers to risk-assess. This question is now addressed by carrying out a *horizon scan*.

3.1. Selection of species

An infallible delimitation of which species to include in a horizon scan is not possible. Any attempt at reducing the pool of species (e.g. by omitting all tropical or subtropical species) increases the likelihood that one misses certain species that might have coped under Norwegian conditions. There is thus a trade-off between two concerns that cannot be minimised simultaneously, namely of not missing any potential door knocker, and of not wasting too much time on unnecessary assessments. If more species are assessed, the more certain one will be to have included all relevant species, but the more resources will have been spent on species that never make it to Norway (Sandvik 2020b).

The best approach is therefore to use existing databases and lists from neighbouring countries, and to supplement these with species reported via surveillance projects or similar channels. The following list of sources of potential door knockers is thus non-exhaustive:

- existing international databases on alien species;
- alert lists from nearby countries with bioclimatically comparable conditions;
- literature searches in the scientific and "grey" literature;
- species listed in catalogues of garden centres etc.;
- existing knowledge on pathways of introduction (one may expect most introductions of novel species along the pathways that have recently been overrepresented in this regard; cf. Hendrichsen et al. 2020 and the monitoring of imported horticultural plants, e.g. Westergaard et al. 2020); and
- the experts' own experience.

3.2. Criteria

The horizon scan is used to determine whether an alien species that does not currently reproduce unaidedly in Norway (but meets the historical, geographical and taxonomic delimitations described in section 2.6.), should undergo a full impact assessment. The decision is based on two criteria: the *potential for establishment* and the *ecological effect* of the species.

3.2.1. Potential for establishment

The potential for establishment is evaluated using a simplified version of criterion A of the impact assessment (cf. section 5.1.1.):

> The potential for establishment of an alien species is recorded as an expert opinion on the number of occurrences that the species might be able to establish within 10 years of its first introduction to Norwegian nature – i.e. on how many colonised 2 km × 2 km grid cells might have their origin in the first introduction. Possible answers are: 0, 1 and ≥ 2 occurrences.

The possible answers distinguish between the cases that, 10 years after its introduction, the species has gone extinct (0 occurrences), that it has expanded (2 or more occurrences), or that it has neither gone extinct nor expanded (1 occurrence). Potential management measures are to be disregarded. If the species is expected to disappear within 10 years only if it is actively eradicated, this should thus not count as an extinction.

It should be emphasised that the potential for establishment is *not* an attempt to estimate the *likelihood of introduction* of the species within 10 years, nor does it address the *number of introduction events* during 10 years. Rather, the question posed is the *number of occurrences* a species might have established within 10 years, *conditional on the assumption that it has been introduced*. A period of ten years has been chosen because it is a time frame that is comparatively easy to handle, and because 10 years corresponds to the first threshold value of criterion A. The time frame for the assessment as such is 50 years from now, e.g. regarding climatic conditions, as it is for the effect criteria. This means that the question may also be worded as follows:

> *Assuming* that the species will be introduced to Norwegian nature for the first and only time 40 years from now (= 50 **years** − 10 years), how many occurrences might it have established 50 years from now?

The number of individuals may be crucial for the success of an introduction. It should therefore be assumed that the number of individuals introduced is sufficiently large for the species to survive under favourable conditions at its original site of introduction, unless such an abundance is unrealistically high for an actual introduction.

3.2.2. Ecological effect

Some species may cause a lot of harm within a short period of time, even if they are unable to establish a self-sustaining population in the long run. To take such species into account, the horizon scan needs a qualitative criterion covering effects:

> The question to be answered is whether the species has any significant negative ecological effects. Possible answers are: "no", "yes, but only while the species is present", and "yes, and these effects will persist after the species is gone".

A non-exhaustive list of negative ecological effects includes predation, competition, parasitism, transmission of parasites or diseases, and modifications of ecosystems. Effects are regarded as (biologically) 'significant' if they result in a measurable decrease in population size of at least one Red-List assessed species, or in a measurable state change in at least one ecosystem. Some of these effects may persist even after the species has gone extinct or has been removed from Norwegian nature. Effects may be documented from another country and/or assumed to be likely in Norway. The time frame for effects is 50 years into the future.

3.2.3. Conclusion

The answers given to the two questions of the horizon scan determine whether the species should undergo an impact assessment (Table 1). This applies to two groups of species, namely door knockers (which are likely to reproduce unaidedly in Norwegian nature, given the chance) and species exerting ecological effects despite not reproducing unaidedly.

Even some species that do not currently qualify for a full impact assessment, may eventually reach Norwegian nature, and potentially turn out to be harmful. If a species is subsequently recorded in Norwegian nature, it should be assessed anew. However, the likelihood that such species pose a high risk is comparatively low, since this would mean that it has been misjudged on both criteria of the horizon scan.

Table 1: Conclusion of the horizon scan. Should the species undergo a full impact assessment as a door knocker or as a species exerting ecological effects despite not reproducing unaidedly?

	Occurrences?		
Significant ecological effect?	0	1	≥ 2
No	*no*	*no*	YES
Yes, while the species is present	*no*	YES	YES
Yes, lasting effects	YES	YES	YES

4. Species information

This chapter is about the background information that is recorded for each risk-assessed alien species. Although it is not part of the impact assessment as such, the species information recorded may influence the scores of some assessment criteria, and is needed as documentation for others. In any case, the information is crucial for a successful management of the species. The sub-chapters are arranged in the same order as the panes of the AlienSpeciesDatabase.

4.1. Species status

Establishment category

Alien species may be represented in Norway by sporadic, ephemeral occurrences, by populations that are locally self-sustaining or strongly expanding. The terminology of this field has varied a lot, including terms such as *casual*, *naturalised* and *invasive* (Richardson et al. 2000, Pyšek et al. 2004). Current best practice is to categorise alien species according to the 'unified framework' introduced by Blackburn et al. (2011), which is summarised in Table 2. Establishment categories are to be provided for all species that are handled in the AlienSpeciesDatabase, and they may determine whether a species is to be risk-assessed. In addition, establishment categories are important knowledge for management authorities and for international reporting.

Table 2 is sorted in descending order of establishment categories (from E to A). Each species is assigned to the *highest* relevant establishment category. In other words, one starts at the top of the table and, working down, stops at the *first* definition that is met by the species. Lower categories are ignored (even though they often may be met, too!).

All terms in Table 2 follow the definitions of chapter 2. Establishment category C3 coincides with the definition of establishment, whereas C2 coincides with the definition of unaided reproduction (section 2.2.) and thus with the ecological delimitation of the impact assessment (section 2.6.3.). Category B3 is not used for alien species in Norway, because any species released in Norwegian nature (B3) will necessarily meet one of the higher establishment categories (at least C0). In such cases, the latter category is to be provided, (whereas information about release will follow from the pathways specified, see section 4.3.). B2 is only used for production species.

Production species

Production species (see section 2.4.) need to be registered as such. This is important because several choices during the impact assessment are only available for production species.

First record

The year of the first recorded observation of an alien species must be provided for each relevant establishment category. It may be the case, for instance, that a species was recorded indoors many years before it was recorded in Norwegian nature, whereas unaided reproduction was documented even later.

4.2. Species characteristics

The species characteristics recorded include the lifestyle (terrestrial, freshwater and/or marine), global distribution, reproduction (sexual and/or asexual) and generation time (see section 2.7.6.). The global distribution distinguishes between the natural distribution (without anthropogenic transport of the species) and the total current distribution (including areas where it has been introduced anthropogenically). For terrestrial and freshwater species, the relevant combination of continent and climate zone is to be specified. See Appendix I for delimitations of biogeographic regions and climate zones.

4.3. Pathways of introduction and spread

Means, mechanisms or events that result in an alien species being introduced to, or spread within, Norwegian nature, are referred to as pathways. Knowledge of pathways is crucial for effective management measures (but it does not affect the impact categories). Relevant pathways (includ-

Table 2: Establishment categories for alien species in Norway. The system is based on Blackburn et al.'s (2011) 'unified framework', operationalised following Sandvik et al. (2019b). Each species is assigned to the highest relevant establishment category. The main difference from the following (lower) category is emphasised using boldface. B3 is not used in Norway. Italicised terms are defined in the sections provided in square brackets.

Establishment category	Definition
E	After its *introduction* [2.1.], the species has spread unaidedly to, and *established* [2.2.] in, at least ten additional *occurrences* [2.7.3.] in *Norwegian nature* [2.4.].
D2	After its *introduction* [2.1.], the species has spread unaidedly to, and *established* [2.2.] in, at least one additional *occurrence* [2.7.3.] in *Norwegian nature* [2.4.].
D1	The species is *established* [2.2.] in *Norwegian nature* [2.4.] and has spread unaidedly to at least one additional *occurrence* [2.7.3.].
C3	The species is *established* [2.2.].
C2	The species *reproduces unaidedly* [2.2.] outdoors.
C1	The species can survive the winter outdoors and without human help.
C0	The species has been documented in *Norwegian nature* [2.4.].
(B3)	(The species has been released directly in Norwegian nature.)
B2	The species occurs outdoors on its own *production area* [2.4.].
B1	The species occurs in indoor environments.
A	The species does not occur in Norway.

ing past and future ones) are to be provided for all species that are risk-assessed. All alien species have at least one pathway of *introductions to Norwegian nature*. For species that are able to spread secondarily after introduction, pathways of *spread within Norwegian nature* are to be provided. For species that reach Norway via their production area (e.g. fish farm, field) or an indoor environment (e.g. storehouse, pet shop), pathways of *entry* are to be provided as well.

4.3.1. Pathway categories and subcategories

Following an international standard (Hulme et al. 2008, CBD 2014), pathways are divided into six main categories (release, escape, contamination, stowaway, corridor and unaided spread)* and several subcategories. It is important that the pathways are correctly identified, which may be done using the flow chart provided in Table 3.

Table 3: Flow chart for main pathway categories. The diagram consists of dichotomous statements. The correct pathway is identified by following the fulfilled statements downwards. Although statements are made in past tense, they also apply to the present and future. (Following Harrower et al. 2020)

<table>
<tr><td colspan="4">The species was transported by humans.</td><td colspan="2">The species has dispersed itself.</td></tr>
<tr><td colspan="2">The transport of the species was intentional.</td><td colspan="2">The species was moved unintentionally during transport of other species or objects.</td><td>The dispersal was aided by manmade structures.</td><td>The dispersal was not aided by manmade structures (but from an area where the species is alien).</td></tr>
<tr><td>The species was intentionally released directly in Norwegian nature (outside the species' production area, if applicable), with the purpose that the species should survive in nature.</td><td>The species was intentionally transported to an indoors environment or its confined production area, but without the original purpose that the species should end up in Norwegian nature; this includes dumping and 'liberation' of animals.</td><td>The species had a specific ecological association with the species or the organic substrate transported.</td><td>The species had an accidental association with the goods or objects transported, or to the vehicle/ vessel itself.</td><td></td><td></td></tr>
<tr><td>Release</td><td>Escape</td><td>Contaminant</td><td>Stowaway</td><td>Corridor</td><td>Unaided</td></tr>
<tr><td colspan="6">→ decreasing human involvement →</td></tr>
</table>

* It may be noted that Norwegian legislation operates with broader terms, in that «utsetting» (release) refers to both *release* and *escape*, «vektor» (vector) to both *contaminants* and *stowaways*, and «sekundær introduksjon» (secondary introduction) to both *corridor* and *unaided spread* (Miljøverndepartementet 2009, naturmangfoldloven § 3, forskrift om fremmede organismer § 4, forskrift om utsetting av utenlandske treslag § 3).

The pathway subcategories are listed in Appendix II. The subcategories have now also received concise, non-overlapping definitions (Harrower et al. 2020). This means that any specific event of introduction or spread fits into exactly one subcategory. If different subcategories *seem* to fit to a single event, it is recommended to have a close look at the definitions in Appendix II, so that the correct one can be identified.

4.3.2. Entry, introduction and secondary spread

Relevant pathways of (1) *entry to Norway*, (2) *introduction to Norwegian nature* and (3) *secondary spread within Norwegian nature* are to be provided separately. Therefore, these three classes of events need to be distinguished carefully:

1) *Entry* refers to any (a) intentional or unintentional transport of a species from abroad to indoor environments (e.g. warehouses, shops, private homes) and (b) intentional import of a species from abroad to a production area of this specific species (se section 2.4.). Entry thus entails that the species arrives *in Norway*, but *without* reaching *Norwegian nature*. The entry stage is only relevant for some alien species. Entry can only happen along the pathway categories 'escape', 'contamination' and 'stowaway'. (In case of the other categories, entry and introduction are the same event, in which case only the introduction is recorded.)
2) *Introduction* refers to any human activity which has the intended or unintended consequence that individual(s) of an alien species arrive *in Norwegian nature* (p. 9). Introductions may happen without or after a separate entry event, and along all six pathways categories.
3) *(Secondary) spread* refers to any further transport, dispersal or expansion *within Norwegian nature* (i.e. *from* Norwegian nature *to* Norwegian nature). Secondary spread cannot happen as escape. (By definitions, escape always amounts to an introduction, because the escapee escapes from its production area or an indoor environment.)

4.4. Distribution

The area of occupancy (AOO, see section 2.7.4.) is an important attribute of an alien species. Depending on the estimation method chosen, the AOO may affect criterion A and/or B. In any case, AOO contains important information for management authorities.

4.4.1. AOO of unaidedly reproducing species

The *known* AOO may be imported directly from Norway's Species Map Service (https://artskart.artsdatabanken.no) to the AlienSpeciesDatabase. If it is, the information needs to be checked and the AOO to be corrected, if necessary. There are several reasons why occurrences reported in the Species Map Service may have to be excluded, among others:

- The species may have been misidentified.
- In mobile species, not every observation is necessarily an occurrence (see section 2.7.3.).
- In ephemeral species, an older occurrence may have gone extinct.
- In managed species, an older occurrence may have been eradicated.
- In production species, an observation may be from the species' production area (see sections 2.4. and 2.6.3.).

The *assumed current total* AOO cannot be smaller than the known AOO. Usually, the assumed total AOO will be larger – often considerably so – than the known AOO (meaning that AOO will have a dark figure > 1, see section 2.9.1.). The assumed current total AOO is based on an educated opinion. It should take the known AOO and the sampling effort into account (cf. section 2.9.1.), combining this knowledge with the species' habitat requirements and the area of the relevant habitats. As an aid to estimating areas of relevant habitats, the areas of bioclimatic zones and sections of Norway are provided in Table 4.

The *assumed future total* AOO is meant to be an educated opinion on the situation 50 years from now. It should take the assumed current total AOO and the species' expansion potential into account, combining this knowledge with predicted climatic changes. As an aid to approximating the temperature increase by 2072, some average projections are provided in Table 5. Similar projections are available for other climate parameters (e.g. precipitation, length of growing season) from the Norwegian Climate Service Centre (https://klimaservicesenter.no/climateprojections).

Table 4: Area of bioclimatic zones and sections in Norway. All figures are in km^2. (Source: NiN)

Bioclimatic sections	Bioclimatic zones					Sum
	boreo-nemoral	south bor.	middle bor.	north boreal	alpine	
Strongly oceanic	4 300	6 500	6 500	3 900	200	21 400
Typically oceanic	14 000	18 800	27 500	20 000	10 700	91 000
Weakly oceanic	11 100	11 400	20 200	32 100	22 100	96 900
Transitional section	2 300	9 200	12 100	38 100	26 800	88 500
Weakly continental	0	0	100	9 300	16 700	26 100
Sum	31 700	45 900	66 400	103 400	76 500	323 900

Table 5: Temperature increase in Norwegian regions until 2072. All figures are provided in °C and indicate by how much the average temperatures in 2072 are projected to have increased relative to those in 1971–2002, based on two different emission scenarios (cf. Hanssen-Bauer et al. 2015). In accordance with the precautionary principles, estimates should mainly be based on scenario RCP8.5. (Source: klimaservicesenter.no)

	RCP4.5			RCP8.5		
Region	whole year	summer	winter	whole year	summer	winter
Østlandet	2.2	1.9	2.3	3.3	2.9	3.6
Vestlandet	1.9	1.9	2.1	3.1	3.0	3.2
Midt-Norge	2.4	1.8	2.4	3.4	3.0	3.7
Nordland/Troms	2.9	2.3	3.1	4.0	3.7	4.4
Finnmarksvidda	3.4	2.4	3.9	4.9	3.8	5.7
Varanger	3.4	3.1	4.0	5.0	4.5	5.5

4.4.2. AOO of door knockers

Most door knockers will not at present have any occurrences in Norwegian nature. Therefore, the distribution of door knockers is quantified not in terms of current AOO, but in terms of *potential* AOO. This is accomplished using two questions:

1) How many grid cells (2 km × 2 km) will the species be able to colonise in the course of 10 years, based on a single introduction to Norwegian nature?
2) How many additional times can the species be expected to get introduced to Norwegian within the same 10-year period?

Please note that the first question does *not* ask how many occurrences the species will have *in 10 years from today*. The question is how many occurrences the species will have *10 years after its first introduction*. The answer is thus supposed to be the number of occurrences that *originate in the first introduction*, assuming this introduction happened 10 years earlier (cf. section 3.2.1.). Since the time frame of assessments is 50 years (considering e.g. that climate is changing), one can envisage the first introduction to happen between 2022 and 2062, and that the species thereafter expands for 10 years, if it is has the ability to do so. Assessments of potential AOO may be guided by Table 4 and Table 5.

The second question is needed in order to clarify whether the species expands by spreading from its first assumed occurrence, or whether one may have to expect additional introductions at a relevant frequency (at least once per decade in addition to the assumed first introduction). The answers to the two questions are used to calculate the potential AOO after 10 years (Sandvik 2020b).

4.5. Ecosystems

It is important to know in which ecosystems an alien species has been observed, and which ecosystems constitute potential habitats for the species in Norway. All ecosystems that are of importance for the survival of the species (e.g. if the species utilises different habitats during different life stages) are to be indicated.

The system used to classify ecosystems in the AlienSpeciesDatabase is based on *Nature in Norway* (NiN, version 2.3). A summary of NiN is provided in Appendix III. Relevant ecosystems can be chosen from three different lists:

- red-listed ecosystems – these are based on the *Norwegian Red List of land-cover types 2018* (Artsdatabanken 2018b) and may affect criteria C and F (see sections 5.1.3. and 5.2.2.);
- all major and minor ecosystem types – these are based on the type system of NiN (Halvorsen et al. 2020, Artsdatabanken 2022) and may affect criteria C and G (see sections 5.1.3. and 5.2.2.), unless they are 'strongly altered' (see Appendix III);
- microhabitats – for the time being, these are based on version 1.0 of NiN and do not affect any assessment criteria.

5. Impact assessment

The impact assessment aims to quantify the *negative ecological impact* that alien species have on Norwegian nature (see section 2.8. for the definition of impact, and section 2.9.2. for the definition of risk). Assessments follow the GEIAA protocol (Generic Ecological Impact Assessment of Alien Species; Sandvik et al. 2019a), which uses nine criteria (Table 6), each of which belongs to one of the two axes in the impact matrix – the invasion axis and the effect axis (Figure 4). By applying quantitatively defined threshold values, the set of criteria contributes to the transparency, repeatability and testability of the assessment results (see Sandvik 2017).

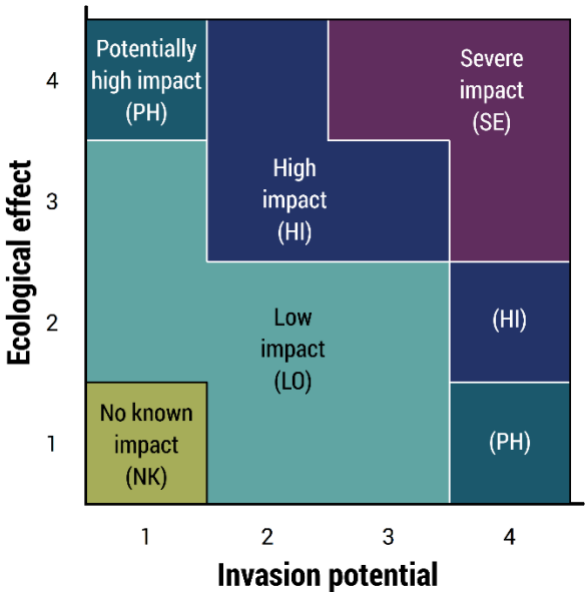

Figure 4: The impact matrix. The two axes of the impact matrix, the invasion axis and the effect axis, have four scores each (1–4). The scores of a species are determined by its invasion potential (Table 7) and its ecological effect (Table 11 and Table 12). The *impact categories* of a species (NK, LO, PH, HI, SE) are assigned based on the scores obtained.

Table 6: Overview of the criteria used in risk-assessing the negative impact of alien species on Norwegian nature.

Criterion	Title of criterion	Axis
A	median population lifetime	invasion axis
B	expansion speed	
C	colonisation of ecosystems	
D	effects on threatened or keystone species	effect axis
E	effects on other Red-List assessed species	
F	effects on threatened or rare ecosystems	
G	effects on other ecosystems	
H	transfer of genetic material	
I	transmission of parasites or pathogens	

5.1. Invasion potential

Invasion potential is quantified using three criteria (Table 7). Of these, criterion A measures the *viability* of alien species and criterion B their *expansion*, while criterion C addresses invasion separately for the *ecosystem(s)* affected. Viability and expansion cannot be treated in isolation, because a species cannot have a significant impact unless it is able both to establish itself and to expand in Norway. For this reason, criteria A and B are coupled, so that a species cannot be assigned a high invasion potential when one of the criteria receives the minimum score (Table 7). Criterion C, on the other hand, is independent of A and B: if C obtains a higher score than A and B, it is C's score that determines the placement of the species along the invasion axis.

5.1.1. Criterion A: median population lifetime

> [A] The higher the median population lifetime of an alien species in Norway, the higher the species scores on the invasion axis. 'Median population lifetime' refers to the time when it is 50% likely that the population in Norway has gone extinct. The threshold values are defined as 10, 60 and 650 years, respectively (Table 7, Figure 5).

The aim of criterion A is to express the likelihood of a species maintaining a viable population in Norway over time. The lower the *likelihood of extinction*, the higher is the species' *lifetime* in Norway. A high estimated population lifetime thus signifies that it is unlikely for the species to disappear by itself.

The likelihood of extinction is employed by the Red List criterion E (IUCN 2012a). It has always to be specified relative to a time interval (e.g. 'within 10 years', for critically threatened species). The current criterion A specifies the thresholds in terms of population lifetime rather than likelihood of extinction. However, both measures describe the same phenomenon and can be readily converted into each other, as shown in Table 8.

Table 7: Criteria, scores and threshold values for the classification of the invasion potential of alien species. All criteria are to be evaluated, and the highest score obtained by any of the criteria A–C determines the placement along the invasion axis. [Due to additional conditions (see square brackets and notes below), criteria A and B are dependent on each other.]

Criterion	A	B	C
Score for invasion potential	Median population lifetime	Expansion speed	Colonisation of ecosystems
1	< 10 years	< 50 m/a	< 5%
2	≥ 10 years [*AND* B ≥ 2]*	≥ 50 m/a	≥ 5%
3	≥ 60 years [*AND* B ≥ 2]*	≥ 160 m/a [*AND* A ≥ 2]*	≥ 10%
4	≥ 650 years [*AND* B ≥ 3]**	≥ 500 m/a [*AND* A ≥ 3]*	≥ 20%

* If the additional condition is *not* fulfilled, the score is to be *reduced by one.*

** If the additional condition is *not* fulfilled, the score is defined as the *score of criterion B plus one.*

NB! *The additional conditions do not apply to species exerting ecological effects despite not reproducing unaidedly.*

Population lifetime is a statistical quantity. It is, of course, impossible to predict population trajectories many years into the future. Therefore, one cannot foresee the exact population lifetime of a species, but merely the *likelihood* that a species obtains a certain population lifetime. The *median lifetime* is the population lifetime that has a cumulative likelihood of 50% – so that it is 50% likely that the species has gone extinct within the median population lifetime. The likelihood distribution of population lifetime is strongly skewed to the right, so that the *expected lifetime* (the arithmetic mean of the distribution) is higher than the median lifetime (Table 8).

The population lifetime of a species (or its likelihood of extinction) is an unknown quantity, but there are several ways of estimating it. The following three methods, which are explained in more detail below, are supported by the AlienSpeciesDatabase:

(a) *Simplified estimation* – the median population lifetime is estimated automatically, based on the area of occupancy provided for the species.

(b) *Numerical estimation* – this alternative requires demographic key parameters of the population under Norwegian conditions (mainly population size, population growth rate and environmental variance).

(c) *Population viability analysis* – this alternative requires a time series with annual population sizes from Norway.

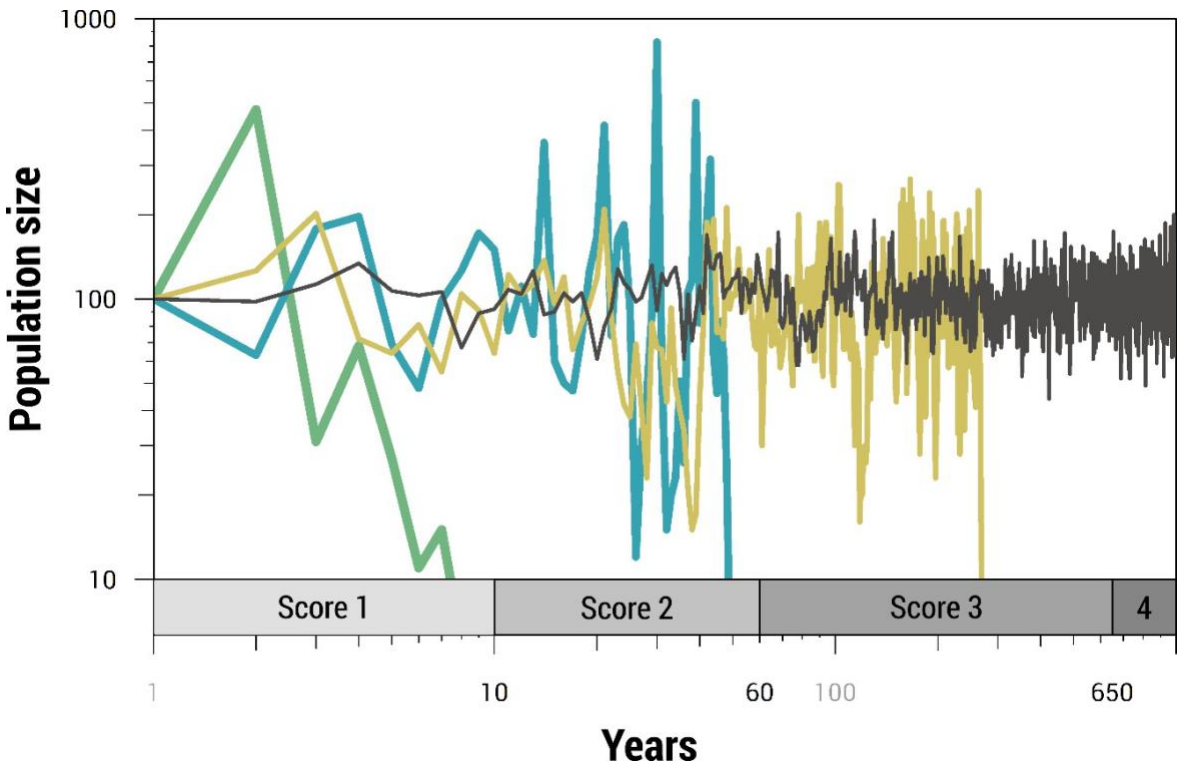

Figure 5: Illustration of criterion A. Example trajectories of population size over time, and time periods used as threshold values for population lifetime. The yellow/green/blue species have a population lifetime of < 10/60/650 years, respectively; the black species of > 650 years. The significance of fluctuations is apparent from the figure: the larger the amplitude of the fluctuations (i.e., the larger the environmental variance), the shorter is the lifetime of the species. The four species have *identical* population growth rates ($\lambda = 1.6$), carrying capacity ($K = 100$) and demographic variance ($\sigma^2_d = 0.1$), but *different* environmental variance ($\sigma^2_e = 1.2, 0.8, 0.5, 0.2$, respectively). NB: Both axes are on log-scale.

(a) Simplified estimation

Based on the area of occupancy (AOO) of a species, it is possible to infer a simplified estimate of the median population lifetime (Table 9). The underlying assumption is that, other things being equal, a species will have a higher population lifetime, the more occurrences it has.

A well-established alien species may be expected to meet the criteria for the Red List category Least Concern, which translates into a score of 4 for criterion A. Under almost all realistic scenarios, this would apply to a species that has more than 20 occurrences and is expected to expand. Only if the species undergoes (or is expected to undergo) a significant decrease in its AOO for natural reasons, or if it has very few occurrences, one can obtain a score below 4. A score of 1 (median lifetime below 10 years) is restricted to species whose expected AOO in 50 years is 0 (Table 9), i.e. species that are expected to go extinct by themselves in the immediate future.

Table 8: Conversion of population lifetime to likelihood of extinction. The threshold values of criterion A are expressed in terms of *median population lifetime* (the 50th percentile of lifetime; the time after which it is 50% likely that the population has gone extinct). The *expected population lifetime* (the arithmetic mean over the likelihood distribution of lifetime) or the *likelihood of extinction* within a certain time frame (as used by the Red List criterion E) are equivalent measures. With the help of this table, the values are readily converted into each other. Bold numbers indicate the threshold values of criterion A (median lifetime) and of Red List criterion E (likelihood of extinction).

Threshold		Pop. lifetime		Likelihood of extinction within			
Criterion A	Red List	expected	median	10 years	20 years	50 years	100 years
1/2	CR/EN	14 years	10 years	50%	75%	97%	100%
2/3	EN/VU	90 years	60 years	11%	20%	43%	67%
3/4	VU/NT	950 years	650 years	1%	2%	5%	10%

Table 9: Simplified estimation of scores for criterion A, based on area of occupancy (AOO). Bold figures indicate the default score, italic figures indicate scores that are available for selection. The scores depend on the expected AOO 50 years from now, and on the expected change of the AOO during that period. Square and round brackets indicate closed [inclusive] and open (exclusive) intervals, respectively. AOOs are necessarily multiples of 4 km² (the area of one grid cell).

AOO 50 years from now	AOO is expected to...			
	increase	decrease [0–80) %	decr. [80–95) %	decrease ≥ 95 %
0 km²	[not possible]	[not possible]	[not possible]	1–*2*
4 km²	2–*3*–*4*	2–*3*–*4*	2–*3*–*4*	2–*3*
[8–16] km²	*2*–3–*4*	*2*–3–*4*	2–*3*–*4*	2–*3*
[20–80] km²	*3*–4	*3*–4	*2*–3–*4*	2–*3*–*4*
≥ 84 km²	4	*3*–4	*2*–3–*4*	2–*3*–*4*

Not all species will meet the assumptions which the default of Table 9 is based on. For example, a species that has four occurrences at opposite sides of the country (EOO >> AOO) will differ from a species that has four adjacent occurrences (EOO = AOO). The latter will have a shorter median population lifetime, because it is more likely to be driven to extinction by a single event (such as an extraordinarily cold winter or dry summer). Another case in point is a species whose population size fluctuates a lot (i.e., a high environmental variance, see below). If one has reason to believe that the default estimate is misleading, it is possible to override it. The scores available in such cases are shown in italics in Table 9.

Door knockers have exactly one occurrence at the time of their introduction. The simplified estimate of their population lifetime is inferred from the expected AOO 10 years after introduction (Sandvik 2020b). In this case, the score of criterion A can be read off the first column ('increase') of Table 9, except for the case of 0 occurrences, which results in a score of 1.

(b) Numerical estimation

If data on the demographic key parameters of a species are available, population lifetime can be estimated numerically (Leigh 1981, Lande et al. 2003:38–40). Relevant demographic key parameters, to be explained in more detail below, include:

- current population size (N),
- population growth rate (λ),
- environmental variance (σ^2_e),
- other parameters, if available (e.g. demographic variance, carrying capacity, quasi-extinction threshold).

The population lifetime of an alien species is affected by a number of factors, mainly by the size and growth rate of the population, but also by its temporal variability (Lande et al. 2003). Initially, the population size of alien species is determined by the *propagule pressure*, i.e. by the frequency of introduction events and the abundance per introduction event (Lockwood et al. 2005, Colautti et al. 2006, Blackburn et al. 2009). The growth rate is determined by demographic rates such as fertility, age at maturity and survival. Variability is mainly due to demographic or environmental noise.

Among population parameters, growth rate λ and carrying capacity K (see sections 2.7.7. and 2.7.8.) are of obvious significance: the higher the growth rate, and the higher the carrying capacity, the higher the population lifetime. Especially the *population growth rate* is of utmost importance for the viability of the species: if a population has a negative long-term growth rate, it will decrease and ultimately go extinct (see Figure 2a on page 18). If the long-term growth rate is positive, the population lifetime is determined by other factors. Newly introduced species will normally have population sizes far below carrying capacity (except when Norwegian conditions are too marginal for the species to prosper). For this reason, *carrying capacity* is often less relevant (in addition to being more difficult to estimate).

On the other hand, stochastic (random) fluctuations can be of central importance. Species that experience extreme population fluctuations are more likely to go extinct due to purely random events. The magnitude of such stochastic effects is quantified using the *variance*[*] of population size. One needs to distinguish between environmental and demographic variance. *Environmental variance* is due to variations in environmental conditions, which affect survival and reproduction of all individuals of a subpopulation alike (environmental stochasticity). Environmental variance is of key importance for population lifetime. As can be seen from Figure 5, environmental variance is a measure of the amplitude of the population fluctuations, which, in turn, determines the probability of the population 'falling over the edge' of extinction.

[*] *Variance*, commonly abbreviated as σ^2 («sigma-squared»), measures the extent of variation in a dataset.

Certain environmental changes have such a large spatial extent that all individuals of a subpopulation die during the same event. Examples of such 'catastrophes' are wildfires, frost or dry spells, or human interference (such as the removal of a compost heap that harbours the entire population). Environmental variance is thus affected by the ecology of the species, but also by the number of subpopulations it has been able to establish. If a species has many subpopulations that are distributed over a large area, and possibly many different habitats, the environmental variance for the total population will be drastically reduced (entailing a very high lifetime). An estimate of environmental variance is, therefore, crucial for quantifying population lifetime.

Demographic variance is due to random variation in the survival and fecundity of individuals (demographic stochasticity). The significance of demographic variance will decrease with increasing population size, because the demographic chance events will tend to cancel each other out. For this reason, demographic variance can often be ignored, except in very small populations.

Most species need a certain minimum population size in order to survive. For example, species with sexual reproduction need at least one individual of each sex, and usually much more than this (e.g. when mates are hard to find). If the population drops below a certain size, it will go extinct by itself (so-called negative density dependence, or Allee effect). This critical population size is known as the *quasi-extinction threshold*.

An R script performing the calculations required is available at the URL http://www.evol.no/hanno/12/lifetime.htm. The script does not assume any prior knowledge of R, but requires that R is installed on your computer. R is a free and open language and environment for statistical computing and graphics (R Core Team 2021). The above link provides instructions on installation and use.

For some species, it may be difficult to find reliable estimates of the demographic parameters. Especially as far as alien species in Norway are concerned, few data are available. For most of the variables (although not for current population size), it will be sufficient to use estimates from populations in other countries, or even from related species, as long as their demography, ecology and life history are sufficiently similar.

(c) Population viability analysis

Population viability analyses (PVA) estimate the likelihood of extinction based on modelled population trajectories. This is the most robust and reliable among the three approaches; however, it requires empirical data on the population dynamics of the species, i.e. counts over a longer period. The observed population variability over time allows the estimation of demographic parameters, and hence the extrapolation of population trajectories into the future.

PVA is a collective term for several methods. It does not matter which model, or which software, is used, as long as the results are verifiable, i.e. repeatable. There are some good introductions into the topic (Beissinger and McCollough 2002, Morris and Doak 2002), more in-depth treatments (Brook et al. 2000, Bakker et al. 2009, Pe'er et al. 2013), as well as several software packages that perform the calculations required (e.g. Akçakaya and Root 2013, Stubben et al. 2020, Lacy and Pollak 2021). A few examples include PVAs on birds (Sandvik et al. 2014), insects (Schultz and Hammond 2003), vascular plants (Menges 2000, Skarpaas and Stabbetorp 2011) and mammals (Bakker et al. 2009).

Preferably, stochastic PVAs should be used, i.e. models that take account of environmental stochasticity (Lande et al. 2003). The magnitude of environmental stochasticity (i.e., the environmental variance) is one of the parameters that can be estimated from the observed population dynamics (at least if the time series is sufficiently long). By including environmental stochasticity, it is possible to provide prediction intervals for future population sizes (Figure 6). These prediction intervals are useful in quantifying the uncertainty of the lifetime estimate (cf. Sandvik et al. 2014).

5.1.2. Criterion B: expansion speed

> [B] The higher the expansion speed of an alien species, the higher the species scores on the invasion axis. 'Expansion speed' here refers to the annual increase in the radius of the area of occupancy (estimated under the assumption of a circular area). The threshold values are defined as 50, 160 and 500 metres per year, respectively (Table 7, Figure 7).

Expansion of a species is to be understood as the *number of new occurrences per time interval*, where 'occurrences' are colonised 2 km × 2 km grid cells (see section 2.7.3.). Expansion, as it is defined here, is thus a measure of *how fast the occurrences of a species increase in Norwegian nature*. That implies that expansion comprises *any form of movement or spread of the species*, including

- active natural dispersal (i.e., locomotion, migration),
- passive natural dispersal (by wind, water, animals etc.),
- anthropogenic displacement (intentional or otherwise),
- separate reintroductions (intentional or otherwise).

This entails that expansion speed is not normally identical with dispersal velocity. Whenever anthropogenic transport (including reintroduction) is a significant factor, for example, expansion can be substantially faster than natural dispersal due to seed dispersal, migration etc. On the other hand, expansion may be far slower than the maximum dispersal distance per year, when the latter does not take account of establishment success.

Expansion speed is measured as a *change in radius*, i.e. in *metres per year* (Sandvik 2020a). The change in area of occupancy (AOO) is thus converted into a change in radius. This can be illustrated by imagining that the total area of occupancy of the species in Norway is transformed into one circular area, so that expansion speed corresponds to the yearly increase of this circle's

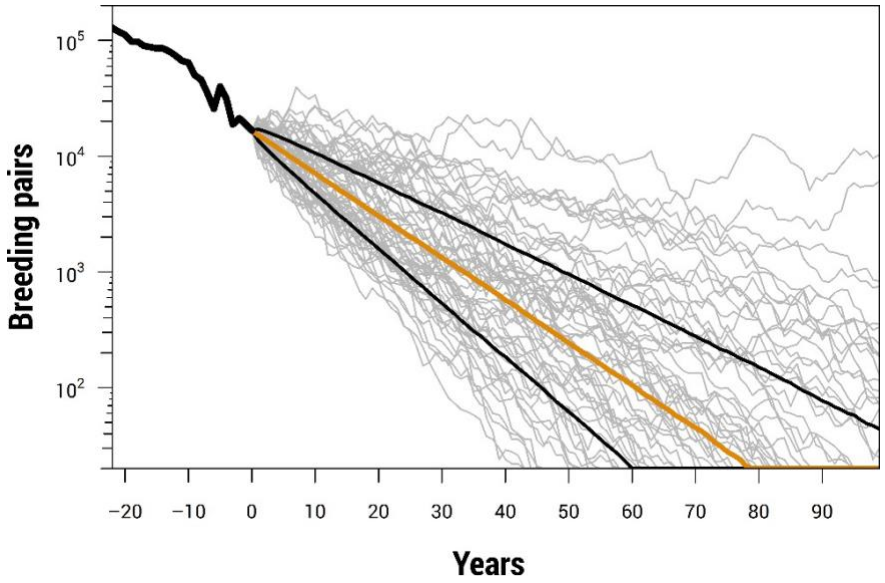

Figure 6: Example of a population viability analysis. Observed population numbers up to 2010 (negative years) and simulated numbers thereafter (positive years). Thin grey lines show some examples of simulated future trajectories. The three bold lines show the quartiles (lower and upper quartile in black, median in orange) of all simulated trajectories. Population lifetime is equivalent to the number of years until quasi-extinction, i.e. until the population crosses the quasi-extinction threshold (which was here set to 20 breeding pairs). The population is estimated to go extinct within 60 to 112 years (lower/upper quartile), with a median population lifetime of 79 years. Please note that the y-axis is on the logarithmic scale. The example is one population of *Rissa tridactyla*. (Source: Sandvik et al. 2014, modified)

radius. This is merely a way of *standardising* expansion speed, however; a coherent circular area is not an actual *requirement* for estimating expansion speed (Sandvik 2020a).

If expansion speed varies a lot over time, its estimate should be based on the *highest realistic* value that is measured, estimated or reported. For example, expansion speed is often low early or late in an expansion process (during an initial lag-phase or when expansion is completed, respectively), compared to a species in the middle of its expansion. Likewise, eradication measures against a species will reduce its expansion speed. The relevant measure is how fast the species is *able* to expand under optimal conditions (for the species). That is why expansion speed should be estimated from the steepest part of its expansion (the *highest* realistic value).

On the other hand, one should avoid using point estimates derived from very few years, which may be affected by observation error, measurement error or very special (and non-representative) conditions. Instead, an average expansion speed should be estimated over a period of several years (the highest *realistic* value).

The following two estimation methods are available for expansion speed:

(a) based on a spatio-temporal dataset of observations of the species over at least ten years;
(b) based on the known or estimated increase in the area of occupancy of the species.

(a) Spatio-temporal datasets of observations

If a reliable geo-referenced dataset of observations is available, these data can and should be used to estimate expansion speed (including uncertainty, i.e. interquartile range). This requires ten or preferable more years of data, where the year and coordinates are reported for each observation. The necessary estimations can be performed using a web application available at the URL https://view.nina.no/expansion/ (Sandvik 2021). The website provides further instructions. The application estimates expansion speed alongside a measure of detectability (Sandvik 2020a). To some degree, this method corrects for underreporting.

NB! *The estimate of expansion speed is affected by the dark figure of the area of occupancy*. The estimate can be improved considerably by providing an expert judgement of this dark figure.

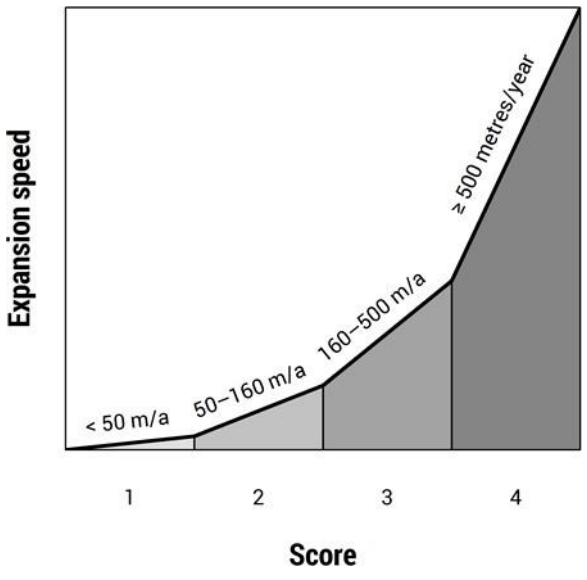

Figure 7: Illustration of criterion B. The score according to this criterion is based on expansion speed, defined as the annual rate at which the area of occupancy increases.

(b) Estimated increase in AOO

In the absence of a spatio-temporal dataset, expansion speed is estimated from the increase in the AOO of the species. This method is less robust than method (a), e.g. because it cannot correct for changes in the detectability (Sandvik 2020a).

For alien species reproducing unaidedly in Norway, the increase can be estimated from the known AOO at two points in time. Preferably, there should be 10 to 20 years between the two dates (in order to minimise random noise and ensure that the period is representative for the current situation). For many species, the current year (2022) will be a natural endpoint. However, there are cases in which an earlier period should be chosen, so that the steepest part of the expansion process is included. This may be the case when a species has more or less completed its expansion, or expansion speed has recently declined for other reasons (e.g. eradication).

For species that have been observed for the first time less than 10 years ago, the estimate is based on the expected AOO 50 years from now. For door knockers, the estimate is based on the expected AOO ten years after an assumed successful introduction.

5.1.3. Criterion C: colonisation of ecosystems

> [C] The larger the area of an ecosystem colonised by an alien species, the higher the species scores on the invasion axis. 'Area colonised' here refers to the proportion of the total area of the ecosystem(s) affected that will contain occurrences of the species within 50 years. This proportion is to be assessed separately for the ecosystems affected, and the largest proportion determines the score. The threshold values are defined as 5%, 10% and 20%, respectively (Table 7, Figure 8).

This criterion measures the invasion potential separately for the ecosystems concerned. It is included to take account of the fact that certain ecosystems can become colonised by an alien species which evades criteria A and B. This might for instance be the case when an alien species is specialised on a relatively uncommon ecosystem. Such a species may pose a threat to this specific ecosystem, even when its population lifetime and expansion speed are not known to be especially high.

The definition and delimitation of ecosystems follows *Nature in Norway* (see section 4.5.). Strongly altered nature is *not* to be taken into account when assessing criterion C.

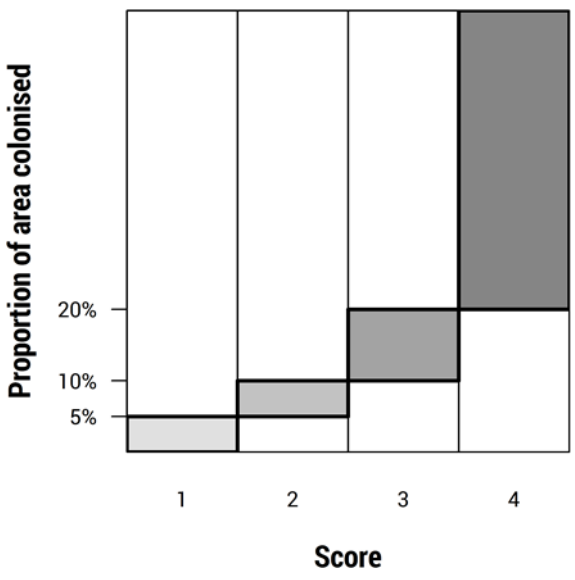

Figure 8: Illustration of criterion C. The score according to this criterion is based on the proportion of the area of an ecosystem colonised by the alien species.

5.2. Ecological effect

The ecological effects of alien species comprise effects on Red-List assessed species and effects on ecosystems. Only negative effects are included in the assessment; neutral and positive effects are disregarded (see section 2.8.). The criteria on the effect axis (D–I) make use of a couple of key terms that are explained in Table 10 (and italicised in the criterion descriptions).

Time frame for ecological effects
As far as ecological effects are concerned, assessments do not only have to take account of the past and the present, but also of effects that, based on documented evidence, can be expected to occur in the future. The time frame for the assessment of ecological effects is set to *50 years or five generations* (whichever time period is longest), but not more than 300 years, into the future.

The prediction of future effects is necessarily more uncertain than the description of current effects. However, future effects are only to be included when it can be documented or substantiated (e.g. using evidence from other countries or from closely related species) that they are likely to occur. Such predictable effects include:

- the expansion of the area of occupancy and/or extent of occurrence of the species (and, thereby, the possible colonisation of ecosystems that up till now are unaffected);
- age dependent, density dependent or frequency dependent effects (effects that have not yet been observed in Norway *because the species has not been here for a sufficiently long time*, but that are documented elsewhere and transferable to Norwegian bioclimatic conditions);
- effects that become more likely under a changed climate (effects that have not yet been observed in Norway *because the climatic conditions have prevented them from occurring*, but that are documented in countries with a climate comparable to the one Norway is projected to have in the future).

For climate projections for Norway, see Table 5 (p. 30) and klimaservicesenteret.no.

5.2.1. Criteria D and E: effects on species

Effects on Red-List assessed species, meaning *negative interactions with Red-List assessed species*, include mainly competition with, herbivory or predation of, and parasitism on Red-List assessed species, but also allelopathy and indirect effects (e.g. so-called apparent competition or trophic cascades; White et al. 2006). The *strength* of interactions is described as 'weak', 'moderate' or 'displacement'; the *geographic extent* of interactions is described as 'confined' or 'large-scale'. These key terms are defined in Table 10. An effect is described as '*absent*' if the alien species does not have interactions of the relevant kind. The criteria are defined as follows:

> [D] The stronger the negative ecological interactions that an alien species has with *threatened* or *keystone species*, the higher it scores on the effect axis. A *weak* interaction is scored as 3; an interaction that is at least *moderate*, is scored as 4; if *weak* or *moderate* interactions are *confined*, the score is reduced by one (Table 11).
>
> [E] The stronger the negative ecological interactions that an alien species has with other Red-List assessed species (that are neither *threatened* nor *keystone*), the higher it scores on the effect axis. A *moderate* interaction is scored as 2; *displacement* is scored as 4; if *moderate* interactions or *displacements* are *confined*, the score is reduced by one (Table 11).

Table 10: Definitions of key terms used to describe ecological effects. Effects must be documented in Norway; or be documented elsewhere (or for a closely related species) *and* be likely to occur in Norway within 50 years. (AOO = area of occupancy; EOO = extent of occurrence)

Term	Definition
Species	
Threatened	Species that is listed as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) according to the *Norwegian Red List for species 2021* (Artsdatabanken 2021)
Keystone species	Species that, despite being relatively rare* (in terms of biomass), can have a large effect on the abundance, distribution or diversity of other species (based on Power et al. 1996; for applications of this definition, see Libralato et al. 2006, Valls et al. 2015)
Ecosystems	
Threatened	Ecosystem that is listed as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) according to the *Norwegian Red List of land-cover types 2018* (Artsdatabanken 2018b)
Rare	Ecosystem that is listed as Near Threatened (NT) due to restricted geographical distribution (i.e. Red-List criterion B) according to the *Norwegian Red List for land-cover types 2018* (Artsdatabanken 2018b)
Strength of interaction	
Weak	Interaction that will have *less than* moderate negative consequences on the population size of Red-List assessed species
Moderate	Interaction that results (*or* will result) in a reduction of *at least* 15% in the population size of *at least* 1 subpopulation of a Red-List assessed species over a 10-year period, but *without* displacing any Red-List assessed species (a population decline of 15% per decade corresponds to a reduction in carrying capacity K of 15% per decade or in the annual multiplicative growth rate λ of 2%)
Displacement	Reduction of the AOO *or* EOO of any Red-List assessed species by *at least* 1% through interactions with an alien species
Substantial	State change brought about in an ecosystem that encompasses *more than* a third of the elementary segments that are defined for the relevant environmental variable, *or* that amounts to one well-defined (countable) elementary segment (see p. 56)
Geographical extent of interaction	
Confined	Effect that affects (*and* that most likely will remain constrained to) *less than* 5% of the population size *and* AOO *and* EOO of any Red-List assessed species
Large-scale	Effect that affects (*or* will affect) *at least* 5% of the population size *or* AOO *or* EOO of any Red-List assessed species

* Please note that common species do not fulfil this specific definition of keystone species. The rationale is that common species cannot go extinct as rapidly as threatened or rare species.

5.2.2. Criteria F and G: effects on ecosystems

Alien species can also have effects at the ecosystem level, e.g. by overgrowing an open landscape, eutrophicating a lake, changing the number of tree layers in a forest, or thinning a forest. Such effects may be measured as state changes in the ecosystems affected, i.e. as changes in in local environmental variables, species composition or spatial structure (see section 4.5. and Appendix III).

> [F] The larger the area of *threatened* or *rare* ecosystems in which an alien species brings about a *substantial* state change in at least one environmental variable, the higher the species scores on the effect axis. 'Area' refers to the proportion of the total area of the ecosystem(s) affected. This proportion is to be assessed separately for the ecosystems affected, and the largest proportion determines the score. The threshold values are defined as 0%, 2% and 5%, respectively (Table 11).
>
> [G] The larger the area of other ecosystems in which an alien species brings about a *substantial* state change in at least one environmental variable, the higher the species scores on the effect axis. 'Other ecosystems' refers to ecosystems that are neither threatened nor rare nor strongly altered. For 'area', see criterion F. The threshold values are defined as 5%, 10% and 20%, respectively (Table 11).

5.2.3. Criterion H: transfer of genetic material

> [H] The larger the consequence of an alien species genetically contaminating at least one Red-List assessed species, given that this is documented or likely to happen, the higher the species scores on the effect axis. 'Genetic contamination' here refers to introgression. Documented or likely introgression is scored as 3; if the recipient species is *threatened* or a *keystone species*, the score is increased by one; if the introgression only has *confined* effects, the score is reduced by one (Table 12).

Please note that the transfer of genetic material to the gene pool of a Red-List assessed species presupposes *introgression*. Mere hybridisation does not fulfil this definition. Genes are considered transferred when there is backcrossing between hybrids and the Red-List assessed species.

Table 11: Criteria, scores and threshold values for the classification of the ecological effect of alien species, criteria D–G. Key terms are defined in Table 10; Table 12 contains criteria H/I. All criteria are to be evaluated, and the highest score obtained by any of the criteria D–I determines the placement along the effect axis.

Criterion	D	E	F	G
Score for ecological effect	Documented or likely effect within 50 years on			
	Red-List assessed species		ecosystems	
	threatened or keystone species	other species	threat./rare	other
1	absent	weak	0 %	< 5 %
2	weak AND confined	moderate*	> 0 %	≥ 5 %
3	weak AND large-scale	confined displacement	≥ 2 %	≥ 10 %
4	moderate* OR displacement	large-scale displacement	≥ 5 %	≥ 20 %

* If the effect is moderate *and confined*, the score is to be *reduced by one*.

5.2.4. Criterion I: transmission of parasites or pathogens

> [I] The criterion is used if it is documented or likely that an alien species might act as a vector for parasites (including pathogens such as bacteria or viruses) to Red-List assessed hosts. If this transmission entails an increased prevalence of existing parasites to a Red-List assessed species that already functions as a host for the same parasite, the effect is scored as 2. If transmission is to a Red-List assessed species that has not been a host for this parasite, the vector is scored as 3. The score is increased to 4 under two conditions: if the alien species acts as a vector for a parasite that is itself alien to Norway; or if at least one of the novel hosts is a *threatened* or a *keystone species*. If the transmission of existing parasites remains *confined* geographically, the score is reduced by one. In any case, the score of the host is constrained upwards to the maximum score for ecological effect that is (or would have been) assigned to the parasite transmitted (Table 12).

Criterion I is meant for assessing the *host* species of parasites/pathogens and *not* for assessing parasite species or pathogens. The ecological effect of parasites is to be assessed using criteria D–H. Note that a host cannot get a higher score according to criterion I than its parasite/pathogen has (or would have) got according to criteria D–H. For example, if the only effect of a parasite/pathogen is a moderate interaction with a Red-List assessed species of least concern (i.e., score 2 according to criterion F), its host cannot receive a higher score than 2 according to criterion I (even if the parasite/pathogen is alien to Norway).

If the parasite/pathogen is alien, its score for ecological effect should be based on the impact assessment of that species. If the parasite/pathogen is not risk-assessed, e.g. because it is native to Norway, its score must be estimated using the terms 'weak', 'moderate' or 'displacement' and 'confined' or 'large-scale', as defined in Table 10, and the threshold values for criterion D or E (for threatened/keystone or other hosts, respectively), as provided in Table 11. (Criteria F to I will not normally be relevant to describing the ecological effects of parasites/pathogens.)

Table 12: Criteria, scores and threshold values for the classification of the ecological effect of alien species, criteria H and I. Key terms are defined in Table 10; Table 11 contains criteria D–G. All criteria are to be evaluated, and the highest score obtained by any of the criteria D–I determines the placement along the effect axis.

Criterion	H	I
Score for ecological effect	Documented or likely transmission of	
	genetic material	parasites or pathogens**
1	absent	absent
2	confined	existing parasites to existing hosts such that prevalence increases*
3	large-scale	existing parasites to novel hosts*
4	to threatened or keystone species*	existing parasites to novel threatened or keystone hosts* *OR* of alien parasites

* If the effect is *confined*, the score is to be *reduced by one.*

** The score of the host must not exceed the score that the parasite obtains for ecological effect.

5.3. Climate effects

As described above, projected climatic changes should be included in the impact assessment:

- The description of the future distribution of alien species should be based on the likely situation 50 years from now, which entails a changed climate (cf. section 4.4.).
- Likewise, the assessment of the ecological effects of alien species has a time frame of 50 years (or five generations) ahead, which includes effects that are not yet observed in Norway, but are likely to occur under a changed climate (cf. p. 41).

Cases in which the invasion potential or ecological effect of an alien species would have been lower in the absence of climate change, should be described in the AlienSpeciesDatabase. The baseline for comparison is the climatological standard normal 1971–2000. This entails that one needs to take into account both the climatic changes that have already happened (until 2022) and those that are predicted (until 2072). As regards temperature, the change from 1971 to 2022 amounted to an increase of 1.4°C (+1.2°C for summer only, +1.5°C for winter only); as regards precipitation, the increase from 1971 to 2022 has been 5% on average for the whole of Norway (data from https://klimaservicesenter.no). Predicted changes until 2072 are summarised in Table 5 (p. 30).

5.4. Geographical variation

The impact category of an alien species has to describe the largest (documented or likely) impact on Norwegian nature. Norway is a long country, however, exhibiting a huge variation in bio-climatic and other environmental variables (cf. Table 4). Any species with a certain extent of occurrence will thus experience varying environmental conditions and – in response to these – itself display varying characteristics. In some cases, this variation would have resulted in a lower impact category in parts of a species' range. Such cases should be described, in particular:

- cases in which the invasion potential or the ecological effect decreases along a bioclimatic gradient (e.g. from south to north if temperature is the relevant parameter, or from west to east if precipitation is the relevant parameter);
- cases in which the negative effect on Red-List assessed species is confined to a subset of the ecosystems in which the alien species occurs or can occur (whereas ecosystems in which the alien species *cannot* occur, are irrelevant in this context);
- cases in which the ecological effect of the alien species solely consists of interactions with a certain Red-List assessed species, and where the range of the latter species (or the zone of overlap between the species) is far smaller than the range of the alien species.

6. List of changes

In order to facilitate comparisons with the 2018 assessments (based on version 3.5 of the guidelines, as of November 2017), this chapter provides a brief overview of the changes in method and criteria. A more detailed explanation and justification of changes is provided elsewhere (Sandvik 2022).

Guidelines and user manual
The guidelines have been divided into the present document and a new user manual. Practical guidance related to the AlienSpeciesDatabase is moved to the latter document.

Set of criteria
The criteria and threshold values of the impact assessment have remained unchanged. The available estimation methods for criteria A and B do no longer include Red List criteria (A) or literature estimates (B). Simplified estimation methods based on areas of occupancy have been introduced instead.

Horizon scan
Potential door-knocker species are now subjected to a horizon scan (chapter 3). This step decides whether a species should undergo a full-scale impact assessment.

Definitions
The following definitions have been adjusted:

- The term *alien species* has received an improved definition (p. 7).
- Species previously called 'established' are now referred to as *reproducing unaidedly* (p. 8).
- Species previously called 'native' are now referred to as *Red-List assessed* (p. 8).
- 'Production species' and 'production area' have received improved definitions (p. 9).
- Ecological effects previously called 'local' are now referred to as *confined* (p. 42).

Delimitations
The set of species previously referred to as 'traditional production species' are no longer exempted from impact assessments (although they may still be excluded by other delimitations).

Background information
Several changes affect the background information recorded on alien species:

- Establishment status is provided following the 'unified framework' (see Table 2 on p. 27).
- All pathways of introduction and spread have received unambiguous and non-overlapping definitions (see pp. 28 and 49).
- Affected ecosystem services are no longer recorded.

7. Appendices

I. Biogeographical regions

When registering the natural and current distribution of species (cf. section 4.2.), the continent and the climate zone are to be described. The climate zones to be used are based on a simplified

Table I-1: Definition of climate zones and relation to ecozones. The Table shows how climate zones can be translated into the Köppen–Geiger classification and (in conjunction with continent) into biogeographical regions. The latter are abbreviated as An (Antarctic), Au (Australasia), Cp (Cape region), NA (Nearctic), NT (Neotropic), PA (Palaearctic) and PT (Palaeotropic).

Climate zone	Köppen–Geiger classification	Eur.	Asia	Afr.	N./C. Am.	S.Am.	Oc.
Polar							
(ant)arctic, alpine	EF, ET	PA	PA	—	NA	An	—
Temperate							
boreal	Dfc, Dfd, Dsc, Dsd, Dwc, Dwd	PA	PA	—	NA	—[4]	—
nemoral	Cfb, Cfc, Dfa, Dfb, Dsa, Dsb, Dwa, Dwb	PA	PA	Cp[4]	NA	NT	Au
arid	BSk, BWk	PA	PA	Cp[1,2]	NA	NT	—[1,2]
Subtropical							
mediterranean	Csa, Csb, (BSk)[1]	PA	PA	PA	NA	NT	Au
humid	Cfa	PA	PA	Cp[4]	NA	NT	Au
arid	BSh, BWh, (BWk)[2], Cwa	—	PT	PT	NA	NT	Au
mountainous	Cwb, Cwc	—	PT	PT	NT	NT	—
Cape region	(BSk), (BWk), (Csa), (Csb)[3]	—	—	Cp	—	—	—
Tropical							
rain forest, savanna, monsoon climate	Af, Am, Aw	—	PT	PT	NT	NT	Au

[1] BSk is here regarded as mediterranean if bordering to Csa or Csb.
[2] Minor occurrences of BWk (outside Cape region) are here regarded as arid subtropical climate.
[3] BSk, BWk, Csa and Csb in Lesotho, Namibia and South Africa are here regarded as Cape region.
[4] Potential occurrences (outside Cape region) are here regarded as mountainous subtropical climate.

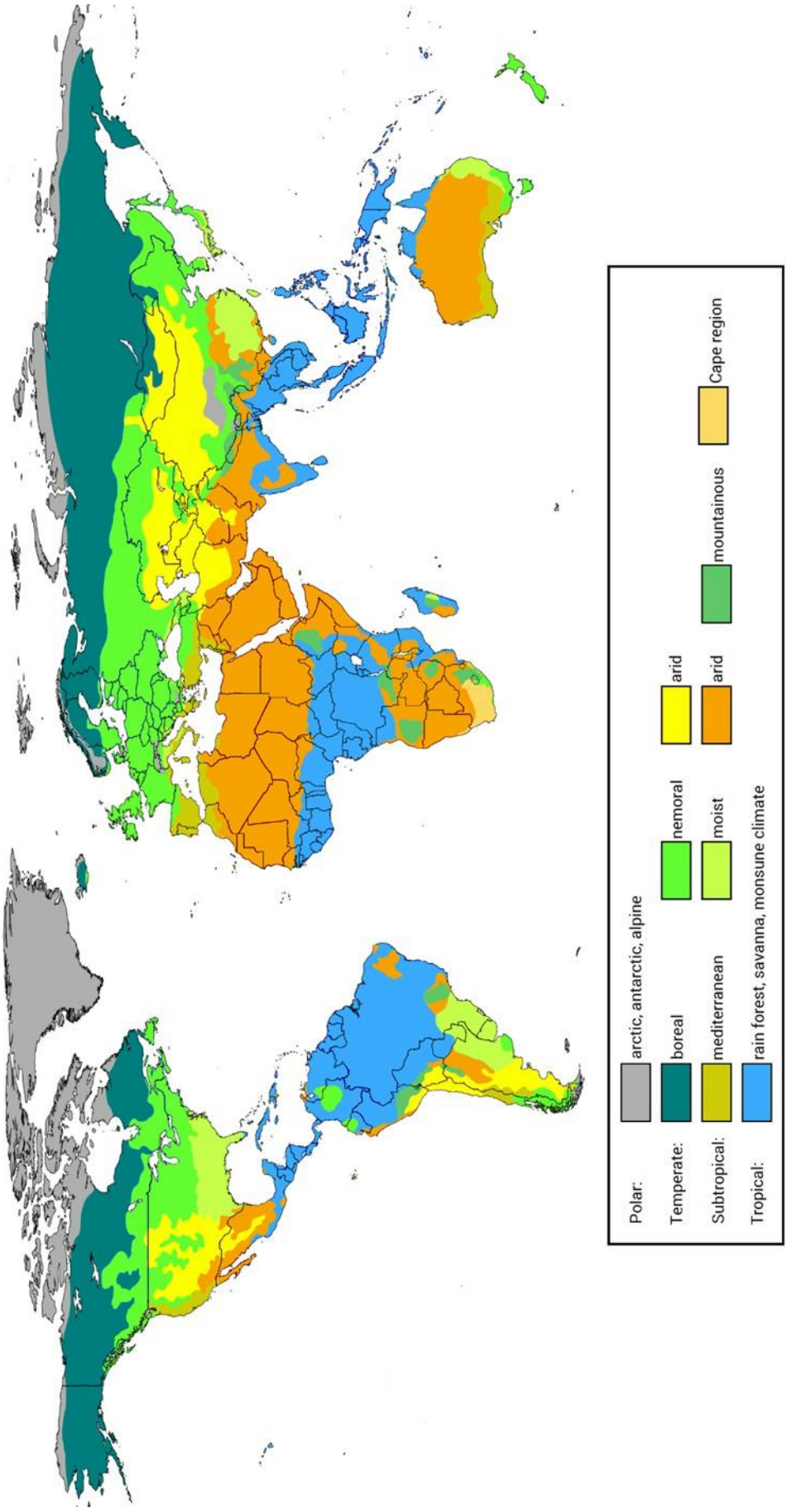

Figure I-1: Climate zones. (Source: Peel et al. 2007, modified and simplified)

version of the Köppen–Geiger classification (Peel et al. 2007). With the help of Table I-1 and Figure I-1, climate zones plus continents can be translated into biogeographic regions (ecozones, floral kingdoms etc.).

Whenever possible, the subdivisions of subtropical climate should be used. The reason is that certain subtropical regions can have conditions that are very similar to temperate climate (especially in humid and mountainous regions; there are even occurrences of such climate in tropical latitudes). When unknown, one may tick off 'unspecified subtropical climate'.

II. Pathways of introduction and spread

Pathways of introduction and spread are classified according to the CBD pathway categorisation scheme (Hulme et al. 2008, CBD 2014). Subcategories have not previously had concise definitions, but these have recently been provided by Harrower et al. (2020). The following list contains all main and subcategories (slightly modified) with brief definitions:

1) Release

The species was intentionally released directly in Norwegian nature (outside the species' production area, if applicable), with the purpose that the species should survive in nature.

Subcategories: release for (or as)...

1a. *hunting:* species released for commercial or recreational hunting
1b. *fishery:* species released for commercial or recreational fishing
1c. *biological control:* species released to reduce/control the population of another species
1d. *conservation:* species released either because it is threatened in its native area, or because it provides food, shelter etc. for a threatened species
1e. *stabilisation and barriers:* species released in order to change the physical environment, e.g. for erosion control, dune stabilisation, windbreaks
1f. *aesthetic improvement:* species released because of its decorative or other aesthetic properties
1g. *other use:* species released for its utility, which is not covered by 1a–1f, e.g. edible species, medical plants, pollinators or decomposers
1h. *other release:* releases that are not covered by 1a–1g and cannot be considered dumping

2) Escape

The species was intentionally trasnported to an indoors environment or its confined production area, but without the original purpose that the species should end up in Norwegian nature; this includes dumping and 'liberation' of animals. Subcategories 2a–2m are only applicable to production species.

Subcategories: escape from (or of)...

2a. *agriculture:* crop species escaped from fields
2b. *forestry:* tree species escaped from plantations
2c. *commercial plant trade (horticulture):* escape of cultivated plants from commercial nurseries, garden centres, greenhouses, flower shops etc.
2d. *public parks:* escape of plants used for ornamental purpose in public spaces

2e. *gardens:* escape of ornamental, garden or hobby plants from private use
2f. *garden waste:* dumping of plant waste or plant parts from private gardens
2g. *farmed animals:* escape (or dumping) of animals kept to produce food or other resources (except fur), for riding, as pack animal or for other commercial reasons
2h. *fur farms:* escape (or dumping) of animal kept to produce fur
2i. *aquaculture:* species escaped (or dumped) from aquaculture, mariculture, fish ponds etc.
2j. *pet animals:* escape (or dumping) of pet animals kept by private individuals and not covered by 2g–2i, or of aquatic plants kept by private aquarists
2k. *live food for pet animals:* escape (or dumping) of species kept as food for pet animals
2l. *live food and live bait for animals (other than pet):* escape (or dumping) of species kept as food or bait for animals other than pet
2m. *live food for humans:* escape (or dumping) of species kept as food for humans
2n. *botanical gardens and zoos:* escape (or dumping) of species kept for public display in botanical or zoological gardens or aquaria
2o. *research:* escape (or dumping) of species kept for research or education, e.g. from laboratories or experimental plantations
2p. *other escape:* escape (or dumping) not covered by 2a–2o

For entry, the subcategories for escape are somewhat modified:

- Subcategories 2e, 2f and 2k are unavailable as pathways of importation.
- Subcategory 2j is named "*[importation] to pet shop (including aquarium plants)*".
- Subcategories 2l and 2m start with "*[importation] to sale of ...*".
- Subcategory 2p is named "*[importation] with other purpose*".
- The remaining subcategories start with "*[importation] to ...*".
- Two additional subcategories are available only as pathways of entry:

2q. *private importation:* alien species imported by private persons in their personal luggage
2r. *to end user by mail:* alien species mailed to private persons from abroad

3) Contaminant

The species was moved unintentionally during transport of other species or the organic substrates (vectors) with which it had a specific ecological association.

Subcategories: contaminant of...

3a. *animals (as parasite):* pathogen or parasite transported in or on animals, provided the animal is a (primary or secondary) host
3b. *of animals (except parasites):* species transported in or on living or dead animals, animal products (e.g. fur, leather, wool) or the accompanying substrate (e.g. water, soil, straw), provided the animal is not a host
3c. *plants (as parasite):* pathogen or parasite transported in or on plants, provided the plant is a (primary or secondary) host
3d. *nursery material (except parasites):* species transported in or on living or dead plants or the accompanying substrate (e.g. soil, turf, mulch), provided the transport is part of commercial nursery trade and the plant is not a host; also excluded are transport of seeds and timber
3e. *plants (except parasites and except commercial trade):* species transported in or on living or dead plants or the accompanying substrate (e.g. soil, turf, mulch), provided the transport is not part of commercial nursery trade and the plant is not a host; also excluded are transport of seeds and timber
3f. *seed (not food):* species transported in or on seed, except seed for human consumption

3g. *timber:* species transported with timber, wood or wood products (e.g. firewood, saw dust, furniture)
3h. *food or bait for animals:* species transported in or on food (except seeds) or bait for pet or wild animals
3i. *food for humans:* species transported in or on food for humans (including seeds)
3j. *habitat material:* species transported in soil, mulch, straw etc., provided this material is the focus of the trade (contamination of habitat material transported with plants is covered by 3d/3e!)
3k. *other contaminant:* contaminants not covered by 3a–3j

4) Stowaway

The species was moved unintentionally during transport of goods, objects, vehicles or vessels with which it had a more or less accidental association,

Subcategories: stowaway with (or as)...

4a. *people and their luggage:* species on or in travellers (e.g. tourists, workers, researchers) or their personal shoes, clothes, luggage etc.
4b. *container and bulk cargo:* species on or in containers, bulk freight etc.
4c. *machinery and equipment:* species on or in heavy machinery and equipment (e.g. construction, agricultural, military, rescue machinery), provided the latter are transported (rather than driven, which is covered by 4j)
4d. *packing material:* species in or on boxes, pallets, bags, baskets, spools etc., provided the species does not rely on the packing material as its habitat (which is mainly covered by 3g)
4e. *fishing equipment:* species on equipment used by creational anglers or professional fisher-(wo)men
4f. *ballast water:* species transported with ballast water
4g. *ballast sand or soil:* species transported with ballast sand or ballast soil
4h. *hull fouling:* species transported as hull fouling on ships and other watercraft
4i. *ships (excluding cargo, ballast water, hull fouling etc.):* species 'hitchhiking' on ships or other watercraft and not covered by 4a–4h
4j. *land vehicles (except cargo etc.):* species 'hitchhiking' on cars or other land vehicles and not covered by 4a–4e
4k. *airplane (except cargo etc.):* species 'hitchhiking' on airplanes or other aircraft and not covered by 4a–4e
4l. *other stowaway:* stowaways not covered by 4a–4k

5) Corridor

The species has dispersed itself, but aided by, or via, manmade structures.

Subcategories: spread through/via/with...

5a. *artificial waterways:* species spread through canals, water tunnels, fish ladders etc. to water-bodies that they could not have reached otherwise
5b. *tunnels and bridges:* species spread over bridges, through tunnels, along roads etc. to areas that they could not have reached otherwise
5c. *anthropogenic floating debris:* species spread attached to anthropogenic floating debris (e.g. marine litter, plastic waste) to areas that they could not have reached otherwise

6) Unaided

The species has dispersed itself, but unaided by humans, and not via manmade structures. It is important that species spreading unaidedly are not considered as alien to Norway unless they are alien to the source area of the unaided dispersal. Unaided dispersal is not divided into sub-categories.

6a. *natural dispersal:* species spreading themselves via purely natural mechanisms (e.g. migration, wind-, water-, animal-supported dispersal)

III. Nature in Norway

Ecosystem types are relevant both for the description of the ecology of alien species (see section 4.5.) and for the impact assessment (via the criteria C, F and G). All references to ecosystems are based on NiN (*Nature in Norway*, version 2.3; see NiN's online version). This Appendix provides an overview of NiN, defines the terms *threatened*, *rare* and *strongly altered* nature, and explains how state changes in ecosystems can be quantified.

Overview of Nature in Norway

Nature in Norway (NiN) is a system for classifying and describing all variation in nature. The *type system* allows a subdivision of nature in Norway into well-defined land-cover types. The *attribute system* consists of variables covering the variation that exists both within and between land-cover types.

A typification of nature can be accomplished at different scales or levels. NiN's primary diversity level – and the only one to be used in relation to alien species – is the level of ecosystems (NiN's remaining diversity levels are landscapes and microhabitats). An *ecosystem* is defined as a "more or less uniform area with all organisms, the total environment they live in and are adapted to, and the processes that regulate relations among organisms, and between organisms and the environment (natural, or dependent on or shaped by human activities)" (Halvorsen et al. 2020: App. S1, p. 2).

The typification on the ecosystem level is completely contiguous, and it covers the natural variation at the ecosystem level on a relatively fine spatial scale, which allows mapping at scales between 1 : 500 and 1 : 20 000. Ecosystem types are organised into a hierarchy consisting of three levels: major-type group, major type and minor type. For terrestrial and wetland systems, NiN offers 'mapping units 1 : 5 000' as an additional level between the major and minor type. The eight major-type groups on the ecosystem level are:

- *terrestrial systems* (T) with 45 major types (e.g. forest, boreal heath, tidal meadow) and 351 minor types;
- *wetland systems* (V) with 13 major types (e.g. bog, mire and swamp forest, wet snow-bed and snow-bed spring) and 91 minor types;
- *marine seabed systems* (M) with 15 major types (e.g. aphotic marine rock, euphotic marine sediment, coral reef seabed) and 196 minor types;
- *marine waterbody systems* (H) with 4 major types (e.g. oceanic waterbody, circulating fjord and rock pool waterbody, anoxic marine waterbody) and 18 minor types;
- *lake-bed systems* (L) with 17 major types (e.g. euphotic stable lake bed, helophyte freshwater swamp) and 99 minor types;

- *river-bed systems* (O) with 7 major types (e.g. stable river bed, freshwater-spring bed) and 82 minor types;
- *limnic waterbody systems* (F) with 13 major types (e.g. stratified fully circulating water masses with fish, unstratified naturally fishless water masses, turbid water masses) and 88 minor types;
- *snow and ice systems* (I) with 2 major types (permanent snow and ice, polar sea ice) without minor types.

The attribute system handles all the variation there is in nature. NiN distinguishes between local environmental variation and other sources of variation. *Local environmental variation* is defined as "variation along environmental variables that represent conditions which are typically more or less stable over centuries and that vary on spatial scales typically finer than 1 km" (Halvorsen et al. 2020: App. S1, p. 4). It is described using a set of local environmental (complex) variables. Examples of these are exposure to erosion intensity (ER), organic matter content (IO), natural manuring (NG), oxygen deficiency (OM) and water saturation (VM). Local environmental variables are used to define ecosystems.

The remaining variation is described using *sources of variation* that are not captured by the local environmental variables (either because they vary on a different spatial or temporal scale, or because the magnitude of variation is too low to be captured by the type system). Some of these are relevant for alien species:

- *Regional environmental variation* (e.g. bioclimatic zones, bioclimatic sections) affects the distribution of alien species.
- *Landforms* (e.g. alluvial deposits, fluvial erosion landforms) are eligible for red-listing and are relevant for criterion F to the degree they may be altered by alien species.
- *Man-made objects* (buildings) define what is meant by 'indoor Norway'.

Four sources of variation contain variables that may undergo change due to alien species:

- *species composition* (describing the occurrence and quantity of species),
- *short-term variation* (eutrophication, acidification etc.),
- *spatial structure* (vertical stratification of crown layers in a tree stand, lake depth etc.),

Both the type system and the attribute system are used in connection with the impact assessment of alien species. The type system is used in order to describe the distribution of alien species. The attribute system is mainly used in order to quantify the effects that alien species have on nature.

Threatened and rare nature

The Norwegian Red List of land-cover types (Artsdatabanken 2018b) lists threatened ecosystems and threatened landforms. The list contains:

- 31 vulnerable ecosystems and 12 vulnerable landforms,
- 22 endangered ecosystems and 1 endangered landform (dripstone),
- 6 critically endangered ecosystems and 2 critically endangered landforms (earth pillar, tufa).

In addition, 2 ecosystems (upper sublittoral and mesopelagic mixed or mud sediments in Skagerrak, tidal meadow on Svalbard) and 1 landform (limestone ridge) are regarded as *rare*. This means that they are near threatened according to Red List criterion B.

Strongly altered nature

The assessment area for the invasion potential and effects of alien species is basically the whole of Norway. However, there are two general exceptions from this rule (see section 2.6.3.):

- Indoor occurrences are to be disregarded in the assessments.
- For production species, their production area is likewise to be disregarded.

For three of the criteria – and only these – there are some additional ecosystems that are to be disregarded:

> Criteria C, F and G must not be used to assess occurrences or effects of alien species in or on strongly altered nature.

NiN defines *strongly altered nature* as ecosystems "characterised by anthropogenic disturbances so strong that the resulting ecosystems are no longer integral, lacking important components such as food webs, diaspore bank, mycorrhizas and other biotic interactions, etc." (Halvorsen et al. 2020: App. S2, p. 12). Strongly altered systems are distinguished from semi-natural systems by the latter having a lower intensity of anthropogenic disturbance, so that they are not thoroughly changed and do not cease to be a coherent system. Anthropogenic disturbance includes, among other factors, *land management*, defined as "recurrent, regular human activities that maintain specific types of nature through disturbance, such as mowing, livestock grazing, prescribed burning, ploughing, tree-cutting, application of pesticides, artificial fertilisation and/or irrigation, sowing and harvesting of the tree and/or the understory layers" (Halvorsen et al. 2020: App. S2, p. 12).

Strongly altered nature is in NiN described using different local environmental variables, namely MB (topsoil tilling), MK (chemical human impact), MY (physical human impact), SX (strongly altered ground), SY (strongly altered water masses), as well as HI (land-management intensity; elementary segments f–j only).

Five of these variables (MB, MK, MY, SX and SY) are defining variables for a set of ecosystems, which are listed in Table III-1. These ecosystems are always regarded as strongly altered and are *never* to be included in assessments of criteria C, F and G. (However, if an ecosystem has been *turned into* F11 or F13 *because of* the alien species under assessment, this is regarded as a substantial state change, see p. 56.)

Land-management intensity (HI) is different from MB, MK, MY, SX and SY in that the former is a continuous variable, and that it is applicable across different ecosystems. An ecosystem is regarded as strongly altered if its land management is intense (HI elementary segments f–j). If land management is absent (HI-0), consists of grazing only (HI-a) or is of low intensity (HI elementary segments b–e), the ecosystem is regarded as natural or semi-natural (see Halvorsen et al. 2020: App. S4, p. 54). This means that, in principle, land-management intensity needs to be assessed for each occurrence of relevant ecosystems. Ecosystems with land management of high intensity are not to be included when assessing criteria C, F and G.

The remaining criteria (A/B, D/E, H/I) are unaffected by all this. In other words, the estimation of, e.g. expansion speed (B), or the assessment of negative effects on threatened species (D) are to be based on occurrences of the alien species in *all* ecosystems, including strongly altered ones.

Table III-1: Strongly altered nature. Occurrences or effects that alien species might have in or on the ecosystems in this list, *are to be disregarded when assessing criteria C, F and G*. The same applies to other ecosystems if they are characterised by intense land management. Please note that 'strongly altered' is abbreviated as 'SX'.

Code	Name	Example
F9	Artificial lake waterbodies	water dam
F10	Chemically modified lake waterbodies	irreversibly polluted lake
F11	Lake waterbodies characterised by introduction or loss of keystone species	lake with alien top predator
F12	Chemically modified river waterbodies	heavily acidified river water
F13	River waterbodies characterised by introduction or loss of keystone species	stream with recently lost top predator
H4	Strongly altered or artificial marine waterbody	fish farm
L14	Strongly altered or artificial lake-bed	dammed-up previous terrestrial system
L15	Newly created lake-bed originating in river-bed	dammed-up previous river
L16	Physically modified lake-bed	heavily regulated lake
L17	Chemically modified lake-bed	irreversibly polluted lake-bed
M14	Strongly altered or artificial hard marine substrate	oil rig
M15	Strongly altered or artificial marine sediment	sea disposal site
O6	Physically modified river-bed	heavily regulated river
O7	Chemically modified river-bed	irreversibly polluted river-bed
T35	Extracted or deposited surficial deposits	gravel tip
T36	Drained wetland and terrestrialised freshw. sediment	SX systems on previous wetland
T37	Artificial soft substrate	household waste deposit
T38	Tree plantation	monoculturally forested area
T39	Strongly altered or artificial hard substrate	concrete surface
T40	SX ground with semi-natural grassland character	deposits with similarities to grassland
T41	Agriculturally improved grassland with semi-nat. char.	old fields
T42	Landscaped patch or field	flowerbed
T43	Landscaped grassland	park, roadside, airfield
T44	Arable field	tilled and seeded farmland
T45	Agriculturally improved grassland	manured, sowed, watered system
V11	Peat quarry	exposed peat
V12	Drained mire	irreversibly drained peat
V13	Artificial wetland	flooded previous non-wetland site

State changes in ecosystems

The criteria F and G are supposed to capture the effect of alien species on ecosystems. Such effects are quantified in terms of the *proportion of the total area of an ecosystem that undergoes 'substantial' state changes* due to the presence and activity of the alien species (cf. Table 11 on page 43). If more than one ecosystem undergoes substantial changes, the score is based on the largest proportion recorded in any ecosystem. This type of effect demands definitions of the terms 'state change' and of 'substantial'.

> *State changes* in an ecosystem can be defined, by reference to NiN's attribute system, as a change in (a) its local environmental variables, (b) its short-term variation, (c) its species composition or (d) its spatial structure.

Table III-2 provides an overview of the environmental variables that might be affected by alien species. Each of these is divided into specifically defined elementary segments. The thresholds between elementary segments are described in the table, too.

> A state change is regarded as *substantial* if it encompasses more than a third of the elementary segments that are defined for the relevant environmental variable. However, if the variable has well-defined (countable) elementary segments, a change by one elementary segment is sufficient.

The minimum number *n* of elementary segments required for a state change to be substantial, varying from one to five, is provided in the 'ES' column of Table III-2. If states are undergoing change for other reasons, the effect of the alien species is regarded as substantial only if the change amounts to *n* elementary segments *more* than it had been in the absence of the alien species.

The variables are shortly explained in Table III-2. A detailed description can be found elsewhere (Halvorsen et al. 2020: App. S3, S4). Some examples of effects on ecosystems are that the alien species

- eutrophicates a lake (7EU – eutrophication; potentially OM – oxygen deficiency),
- leads to erosion (ER – erosion intensity),
- reduces the number of tree layers (9TS – vertical stratification),
- changes the vegetation cover in the shrub layer (1AG – species-group composition),
- overgrows of an open landscape (7RA – rapid succession; SS – sand stabilisation),
- thins a forest (7SN – natural tree-stand mortality), or
- overbrowses a kelp forest or terrestrial vegetation (7UB – imbalance between trophic levels).

Table III-2 is not necessarily exhaustive. If other effects of an alien species on ecosystems can be documented, this should be described. If an alien species causes an ecosystem to shift minor type or even major type (i.e., if the alien species transforms one ecosystem into another), this auto-

Table III-2 (opposite page): Variables in NiN's attribute system that can help quantifying the effects of alien species on ecosystems. An alien species is regarded as having a substantial effect if it changes any of the variables listed here by at least as many elementary segments as indicated in the 'ES' column (if an ecosystem is already undergoing change for other reasons, the change caused by the alien species must consist of as many elementary segments *more* than it had been in the absence of the species). For details, see Halvorsen et al. 2020 (App. S3, S4). The list is not necessarily exhaustive – experts are encouraged to consider other variables that may be affected by alien species (except 7FA and 7SB-FY-FB, see text).

Variable	Code	ES	Description / definitions and thresholds of levels											
Erosion intensity	ER		the mass balance (whether material is added or removed) in relation to flowing water describes the exposure to erosion											
		2	without		weak		clear		disruptive					
Oxygen deficiency	OM		oxygen availability in standing water (per. = periodically)											
		2	oxic		per. hypoxic		per. anoxic		anoxic					
Sand stabilisation	SS		stabilisation of sand dunes as a result of primary succession (from sand-dominated foreshore via 11 levels to normal forest)											
		5	0	a	b	c	d	e	f	g	h	i	j	k	+
Water saturation	VM		median soil moisture (per. = periodically)											
		2	well-drained		per. moist		moist		wet					
Single-species composition	1AE		proportion of the alien species (measured as frequency/occurrence/coverage) in an ecosystem; only one specially defined threshold value is used for this purpose (see p. 58)											
		1	< 25%				> 25%							
Species-group composition	1AG		proportion or coverage of a functional/structural/taxonomic species group (e.g. tree layer, shrub layer, bottom layer etc.)											
		3	< 2.5%	> 2.5%		> 5%		> 10%		> 25%		> 50%		> 75%	> 90%
Relative species-group composition	1AR		proportion or coverage of partial species groups within a larger species groups (e.g. proportion of herbs in the field layer, or of crinoids in the sessile megafauna)											
		2	< 12.5%		> 12.5%			> 25%			> 50%			> 75%
Eutrophication	7EU		ecoclinal proportion variable (r.=relatively)											
		3	none		weak		r. weak		intermed.		r. strong		strong		extreme
Rapid succession	7RA		ordered factor variable describing the state of succession (regr. = regrowth, succ. = succession)											
in boreal heath	7RA-BH	2	intact			early succ.			late succ.			post-succ.		
on semi-natural terrestrial land	7RA-SJ	2	intact		fallow			early regr. succession			late regr. succession		post-succ.	
on semi-natural wetland	7RA-SM	2	intact			succession			post-succession					
in natural ecosystems	7RA-US	2	initial phase			early succ.			late succ.			post-succ.		
Natural tree-stand mortality	7SN		proportion of the standing cubic mass of a forest dying due to ungulates (7SN-HJ), insects (7SN-IN) or fungi (7SN-SO)											
		3	< 2.5%	> 2.5%		> 5%		> 10%		> 25%		> 50%		> 75%	> 90%
Imbalance between trophic levels	7UB		proportion of 4 m^2 cells with clear evidence of overbrowsing etc.											
		3	< 6.25%		> 6.25%			> 12.5%			> 25%			> 50%		> 75%
Vertical stratification	9TS		number of well-defined crown layers in a tree stand											
		1	0			1			2			≥ 3		

matically qualifies as a substantial effect. This applies to the strongly altered ecosystems F11 and F13, but may also apply to others.

NB! *The variables 7FA (alien species) and 7SB-FY-FB (silvicultural measures with alien coniferous trees) are* not *to be used here.* Whereas 7FA describes the *presence* of alien species in an ecosystem, it would be circular and flawed to use the same variable for characterising the *effect* of an alien species on an ecosystem. Criteria F and G are supposed to measure the effect of alien species, not their presence. The same is valid for the variable 7SB-FY-FB.

State changes in the species composition

Alien species may lead to a radical shift in the species composition of an ecosystem. Such a shift goes beyond the effects on single Red-List assessed species (which are captured by criteria D and E), and it is therefore possible to describe it as a state changes in an ecosystem. The relevant variables are 1AE, 1AG and 1AR (Halvorsen et al. 2020: App. S3, pp. 34–37). The levels for these variables are provided in Table III-2, and some more explanations are given here:

- *Single-species composition (1AE):* This variable is *only to be used if the alien species itself becomes dominant* (or co-dominant or sub-dominant) in a certain locality. A single level of 25% is defined for this specific purpose. In other words, if an alien species obtains a frequency, coverage or biomass of 25% or more in any ecosystem (based on the quantity that obtains the largest percentage), this is regarded as a substantial state change in the ecosystem affected.
- *Species-group composition (1AG):* This variable is used to describe changes in the frequency, coverage or biomass *between* functional, structural or taxonomic groups of species. Examples of species groups are the tree, shrub, field and ground layers in terrestrial systems; or the macroalgal canopy, macroalgal understorey, algal crust and sessile megafauna in freshwater beds and marine seabeds. Examples of substantial state changes are thus a reduction of the cover of the tree layer from > 75% to < 25% to the benefit of the shrub layer; or an increase in the biomass proportion of sessile megafauna from < 10% to > 50% at the expense of the macroalgal canopy layer.
- *Relative species-group composition (1AR):* This variable is used to describe changes in the frequency, coverage or biomass *within* the abovementioned functional, structural or taxonomic groups of species. Examples of substantial state changes are thus a reduction of the broadleaf deciduous tree fraction within the tree layer from > 25% to < 12.5% to the benefit of the boreal deciduous tree fraction (or of the herb fraction in the field layer to the benefit of the graminoid fraction, or of the lichen fraction in the ground layer to the benefit of the bryophyte fraction); or an increase in the sea-pen (Pennatulacea) fraction within the sessile megafauna from < 25% to > 50% at the expense of the sponge fraction.

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9. Glossary

Italicised terms have entries of their own.

Abundance	Number of *individuals* (e.g. at a location or per event).
Alien species	A species, subspecies or lower *taxon* whose presence in an area is caused by intentional or unintentional *anthropogenic* transport, and that has not previously *occurred naturally* in the area. The term includes any life stage or part of individuals that might survive. See section 2.1.
AlienSpeciesDatabase	A web application designed by the Norwegian Biodiversity Information Centre that archives the impact assessments of *alien species* and the supporting data.
Allelopathy	Production and secretion of chemical substances by one (here: *alien*) species that reduces the growth, reproduction or survival of other (here: *Red-List assessed*) species.
Anthropocentric	Being focussed on human interests (such as economy, health).
Anthropogenic	Being an intended or unintended (side) effect of human activity.
Area of occupancy (AOO)	The number of *occurrences* multiplied by 4 km^2. See section 2.7.4.
Bioclimate	The totality of climatic factors that influence the distribution and population dynamics of species. Bioclimatic conditions are here described using bioclimatic zones (along a temperature gradient) and bioclimatic sections (along a humidity gradient). See Table 4 for an overview, and *NiN* for a detailed description.
Carrying capacity *(K)*	*The population size* at which density regulation balances *population growth*. See section 2.7.8.
Category	See *impact category* and *score*.
Colonised	Inhabited by, i.e. containing at least one *occurrence* of, the species.
Confidence interval	Numerical interval that contains the true value of an estimated parameter with a specified likelihood (e.g. 50%, 95%).
Confined	An *ecological effect* that affects (and that most likely will remain constrained to) less than 5% of the *population size* and *AOO* and *EOO* of a *Red-List assessed species*.
Contaminant	An *alien species* that is *introduced* (unintentionally) during transport of life or dead organisms or organic material with which it has a specific ecological association.
Corridor	Man-made interconnections (e.g. waterways, land bridges) or other structures that aid the *unaided spread* of species.

Criterion	(Here:) The condition that, in conjunction with a set of *threshold values*, determines the impact *score* of an *alien species*. There are three criteria that determine the *invasion potential* (A–C) and six criteria that determine the *ecological effect* (D–I).
Dark figure	Factor by which the known number/area has to be multiplied in order to obtain the estimated total number/area (total = known × dark figure). See section 2.9.3.
Delimitation	(Here:) historical, geographic, ecological and taxonomic criteria that demarcate the subset of *alien species* that are to be risk-assessed (but without narrowing down the definition of *alien species*).
Demographic variance	The magnitude of random variation in the survival and reproduction of *individuals* (demographic stochasticity). See section 5.1.1.
Dispersal	Ways of *expansion* (active or passive) that do not involve human activity. (Wind dispersal of seeds, migration of animals, etc.)
Displacement	Reduction by at least 1% of the *AOO* or *EOO* of a *Red-List assessed species* due to *interactions* with an *alien species*.
Distance effect	*Ecological effect* of a species that extends beyond the specific area occupied by the species (e.g. *production area*), even if the species does not leave this area. See section 2.6.3.
Door knocker	*Alien species* that is not currently *reproducing unaidedly* in Norway, but is likely to do so within 50 years. See section 2.5.
Ecological effect	Consequences that the presence of an *alien species* has for the biotic and abiotic environment, including negative *interactions* with or genetic contamination of *Red-List assessed species* and *state changes* in *ecosystems*.
Ecosystem	A "more or less uniform area with all organisms, the total environment they live in and are adapted to, and the processes that regulate relations among organisms, and between organisms and the environment (natural, or dependent on or shaped by human activities)" (Halvorsen et al. 2020). See Appendix III. The classification and description of ecosystems follows *NiN*; red-listing of ecosystems follows Artsdatabanken (2018b).
Effect	See *ecological effect*.
Entry	Any (a) intentional or unintentional transport of a species from abroad to an indoor environment (e.g. shop, private home, warehouse) or (b) intentional import of a species from abroad to the *production area* of this specific species. See section 4.3.2.
Environmental variance	The magnitude of random environmental variation that affects all *individuals* of a population simultaneously (environmental stochasticity). See section 5.1.1.
EOO	See *extent of occurrence*.

Escape	*Introduction* caused by an *alien species* unintendedly leaving the confined area (*production area* or indoors environment) to which it intentionally had been transported. (This includes dumping and 'liberation' of *production* animals.)
Establishment	Maintenance of a *population* of more than 20 *unaidedly reproducing individuals* for a period of more than 10 consecutive years.
Expansion	Increase in the *area of occupancy*, irrespective of the mechanism involved (*introduction*/*dispersal*, *anthropogenic*/natural, active/passive). See section 5.1.2.
Expansion speed	The annual increase in the *area of occupancy* (measured as the annual increase in the radius of a circle of the same areas as the AOO, i.e. in metres per year). See section 5.1.2.
Expert judgement	A judgement that is based on personal expertise and discretion, yet documented. This documentation does not have to provide a precise numerical value, but may consist in substantiating that the value lies between two specified *threshold values*. (Expert judgements are thus subjective, but nevertheless testable.) See section 1.3.
Extent of occurrence (EOO)	The area of the smallest convex polygon that can be drawn to encompass all *occurrences* of the species. See section 2.7.5.
Extinction threshold	See *quasi-extinction threshold*.
Generation time	The average age of reproducing individuals (in years). See section 2.7.6.
Genet	Group of genetically identical *individuals (ramets)* that has been formed by asexual reproduction.
Growth rate	See *population growth rate*.
Habitat	The place or type of site where an organism or population naturally occurs (CBD 1992).
Horizon scan	Selection of the alien species that are to undergo a full impact assessment, even if they are not currently *reproducing unaidedly*.
Impact	*Invasion potential* of an *alien species* multiplied by its per-locality *ecological effect*. See section 2.8.
Impact category	One of the five categories 'no known *impact*' (NK), 'low impact' (LO), 'potentially high impact' (PH), 'high impact' (HI) and 'severe impact' (SE). The impact category of an alien species is determined by the 16 possible combinations of the maximum *score* along each axis of the impact matrix (Figure 4).
Indirect effect	An *effect* exerted by species A on species B via a third (or more) species, e.g. if A increases the *abundance* of predators or *parasites* of B (apparent competition), or if A reduces the *abundance* of predators of predators of B (trophic cascade).
Individual	An anatomically, physiologically, behaviourally and/or reproductively autonomous organism. See section 2.7.1.

Interaction	Mutual or one-sided effect of one (here: *alien*) species on another (here: *Red-List assessed*) species, including predation, *parasitism*, competition for space, competition for food, *allelopathy* and *indirect effects*. (Neutral or positive interactions are not assessed.)
Interquartile range	The numeric interval enclosed by the lower and upper *quartile*. Synonym: 50% *confidence interval*.
Introduction	Any human activity that has the intended or unintended consequence that an *alien species* arrives in *Norwegian nature*. See section 2.1.
Introgression	Transfer of genetic material between species (e.g. by hybridisation and subsequent back-crossing with a *Red-List assessed species*). See section 5.2.3.
Invasion potential	Ability to succeed with *establishment* and *expansion*.
Invasive species	The term 'invasive species' can have different connotations (a: species having a huge *invasion potential*; b: species having severe *ecological effects*; c: *alien species*; d: a+b; e: a+c; f: b+c; g: a+b+c) and is therefore not used in these guidelines.
Keystone species	Species that, despite being relatively rare (in terms of biomass), can have a large effect on the abundance, distribution or diversity of other species (based on Power et al. 1996; see Libralato et al. 2006, Valls et al. 2015). Examples: beaver, woodpecker, top predator.
Lambda (**λ**)	See *population growth rate* and section 2.7.7.
Large-scale effect	An *ecological effect* that affects (or will affect) at least 5% of the *population size* or *AOO* or *EOO* of a *Red-List assessed species*.
Lifetime	See *population lifetime* and section 5.1.1.
Locality	A geographically or ecologically distinct area where a single threat may quickly affect all *individuals* of a species (IUCN 2022). (Global warming is not regarded as "a single threat" in this sense.)
Mature individual	*Individual* that (judging by its state, age, size etc.) is capable of reproducing sexually and/or asexually (incl. vegetatively).
Median	The numerical value that divides a set of numbers or a probability distribution into two equally large parts. Synonyms: second *quartile*; 50th *percentile*.
Moderate ecological effect	*Interaction* with a *Red-List assessed* species that results (or will result) in a decline in *population size* of at least 15% in at least one *subpopulation* of the species over a ten-year period, but that does not result in *displacement* of the species. (A population decline of 15% per decade corresponds to a reduction in *carrying capacity* of 15% per decade or in the *population growth rate* of 2%.)
Native species	Indigenous species; a species, subspecies or lower *taxon* that is *established* in Norway (or has been so after 1799) and does not originate in *anthropogenically* transported *individuals*. (See *Red-List assessed species*.)

Natural occurrence	The parts of a species' range where it occurs without previous *anthropogenic* transport. (For nationally *alien species*, the appropriate geographical scale is countries; for *regionally alien species*, another convenient scale is chosen, such as occurrences, bioclimatic zones, waterbodies or drainage basins.)
NiN (Nature in Norway)	"Nature in Norway" (https://artsdatabanken.no/NiN), a system for classifying and describing all variation in nature in Norway.
Norwegian nature	Any part of Norway that is outdoors (including *strongly altered nature*) and the *Red-List assessed species* occurring there; for *production species*, their *production area* does not count as Norwegian nature. See *ecosystem* and sections 2.4. and 2.6.3.
Occurrence	Grid cell sized 2 km × 2 km that is inhabited by individuals of the species, and that is essential for the survival or reproduction of these individuals. See section 2.7.3.
Other ecosystems	*Ecosystems* that are neither *threatened* nor *rare* nor *strongly altered*.
Other species	*Red-List assessed species* that are neither *threatened* nor *keystone species*.
Parasite	Organism living of another organism (the host), thereby harming or impairing, but not normally killing, the latter (at least if it is the primary host). (Unicellular parasites are also referred to as *pathogens*.)
Pathogen	Organism or agent that causes diseases. (Multicellular pathogens are also referred to as *parasites*.)
Pathway	Forms, mechanisms, means and routes along/by which *introduction* and/or *spread* of *alien species* can happen. These pathways are categorised into six categories and several subcategories (see section 4.3. and Appendix II).
(*n*th) Percentile	The smallest number that is greater than or equal to *n* % of the values in a set or a probability distribution.
Population growth rate (**λ**)	The (potential) mean annual increase in *population size*. See section 2.7.7.
Population lifetime	The time until the (modelled, projected or assumed) extinction of the population of a species (in years). See section 5.1.1. (The likelihood that the population goes extinct within the *median* population lifetime, is 50%.)
Population size	The total number of *mature individuals* of a species (either in a specified area or, if nothing else is stated, in Norway). See section 2.7.2.
Prevalence	Proportion of a population that is infected with a specific pathogen or parasite.
Production area	The confined area that is allocated to the production of a given *production species*. (Note that this entails that production area is species-specific!) See section 2.4.

Production species	Species that is used for production of goods or services in agriculture, forestry, horticulture, gardens, parks, aquaculture, farming, as pet, for hobby or leisure, or a species imported as food, fodder or bait. See sections 2.4. and 2.6.3.
Propagule pressure	The number of *individuals introduced*, estimated as the average *abundance* per *introduction* event multiplied by the frequency of such events.
Quartile	The smallest number that is greater than or equal to 25% (lower quartile), 50% (median) or 75% (upper quartile) of the values in a set or a probability distribution. Synonyms: 25th, 50th and 75th *percentile*, respectively.
Quasi-extinction threshold	The *population size* at which the species has no practical chance of evading extinction. See section 5.1.1.
Ramet	Part of a *genet* that constitutes an anatomically and reproductively more or less autonomous *individual*.
Rare ecosystem	*Ecosystem* that is listed as Near Threatened (NT) according to criterion B for the red-listing of ecosystems (Artsdatabanken 2018b).
Red-List assessed species	A species, subspecies or lower *taxon* that is listed as Least Concern (LC), Data Deficient (DD), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR) or Regionally Extinct (RE) according to the Norwegian Red List for species 2021 (Artsdatabanken 2021). (Note that not all Red-List assessed species are *native species*, see section 2.3.)
Regionally alien species	Species that is *Red-List assessed* in Norway, but has been *introduced* to novel areas within Norway. Such species thus have both *natural occurrences* and regionally alien *subpopulations*. See section 2.6.2.
Release	Direct *introduction* of a species to *Norwegian nature* (outside the species' *production area*, if applicable), with the intent that the species should survive in nature.
Risk	The consequences (such as magnitude, damage, cost) of an event multiplied by its probability. See section 2.9.2.
Score	The numbers 1, 2, 3 or 4 that are assigned to an *alien species* for each of the nine *criteria*. The species' placement along the two axes of the impact matrix (invasion axis and effect axis, see Figure 4) is determined by the highest score on each axis (and determines in its turn the *impact category* of the species).
Secondary introduction / secondary spread	*Dispersal* from populations in a neighbouring country or area, where the presence is due to intentional or unintentional *anthropogenic introduction*.
Spread	'Spread' can either denote all forms of movement of a species (this is here referred to as *expansion*) or merely 'natural' forms of spread (this is here referred to as *dispersal*).
State change	Change in the local environmental variation, the condition or state, the species composition, or the spatial structure of an *ecosystem*. See p. 56.

Stowaway	An *alien species* that is *introduced* (unintentionally) during the transport of people, goods, bulk, vehicles or boats with which it does not have a specific ecological association.
Strongly altered nature	*Ecosystems* whose defining local environmental variables according to *NiN* are 'MB', 'MK', 'MY', 'SX' or 'XY' (see Table III-1 for a list of these) or that are characterised by intense land management.
Subpopulation	Distinct groups (of *individuals*) between which there is little demographic or genetic exchange (< 1 successful migrant or gamete per year; IUCN 2022).
Substantial effect	*State change* brought about in an *ecosystem* that encompasses more than a third of the elementary segments that are defined for the relevant environmental variable, or that amounts to one well-defined (countable) elementary segment. See Table III-2.
Taxon	Species, group of related species or subdivision of a species. Here mainly used for taxonomic entities below the species level (subspecies, varieties, cultivars, hybrids etc.).
Threatened ecosystem	An *ecosystem* that is listed as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) according to the Norwegian Red List of land-cover types (Artsdatabanken 2018b).
Threatened species	A species, subspecies or lower *taxon* that is listed as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) according to the Norwegian Red List for species 2021 (Artsdatabanken 2021).
Threshold value	Numerical or verbal descriptions of *effect* sizes that separate the different *scores* for a given *criterion*.
Unaided reproduction	Reproduction (sexual or asexual, including vegetative) occurring outdoors and without human management, and resulting in *viable offspring*.
Unaided spread	Any active or passive *introduction*, *dispersal* or *expansion* that is unaided by humans, and not via manmade structures.
Variance ($\boldsymbol{\sigma}^2$)	Measure of the magnitude of variation around the mean of the values in a set or a probability distribution; square of the standard deviation (σ).
Vector	(Here used in its parasitological sense:) organism that transmits a *parasite* or *pathogen* to other organisms or areas.
Viable offspring	Offspring that survives (or is likely to be able to survive) until *maturity*.
Visiting species	A species that is present in Norway, but is neither *established* nor *introduced*. Visiting species are thus neither *native* nor *alien*. Some visiting (migrating) species are *Red-List assessed*.
Weak ecological effect	*Interaction* with a *Red-List assessed* species that does not (and will not) result in a decline in *population size* of at least 15% in at least one *subpopulation* of the species over a ten-year period (as opposed to a *moderate effect*).

Cover image: the fungus *Auricularia auricula-judae* [jelly ear] was in 2018 assessed to have low impact.
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