Alien species in Switzerland

An inventory of alien species and their impact. Situation as of 2022

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Abstracts

This publication provides an inventory of the alien species that have become established in the environment in Switzerland, including those which may be detrimental to the environment (i.e. invasive alien species). In addition to outlining the regions of origin and introduction pathways, it shows how their numbers have evolved over time. A total of some 1,300 established alien species are known, of which 197 species are considered invasive. Selected species groups are discussed in more detail below. Example species are used to show the pathways through which they are introduced and the harm that can be caused by invasive alien species of the respective group.

Keywords:
alien species, invasive alien species, plants, fungi, animals, biodiversity, harm, environment

Diese Publikation gibt einen Überblick über die in der Umwelt etablierten gebietsfremden Arten der Schweiz einschliesslich jener Arten, die für die Umwelt relevante Schäden verursachen können (= invasive gebietsfremde Arten). Neben einer Übersicht über die Herkunftsregionen und Einbringungswege wird aufgezeigt, wie sich ihre Anzahl im Laufe der Zeit verändert hat. Insgesamt sind rund 1300 etablierte gebietsfremde Arten bekannt. Davon gelten 197 Arten als invasiv. Im Weiteren wird auf ausgewählte Artengruppen näher eingegangen. Anhand von Beispielarten wird aufgezeigt, über welche Wege sie eingebracht werden und welche Schäden durch invasive gebietsfremde Arten der jeweiligen Gruppe verursacht werden können.

Stichwörter:
gebietsfremde Arten, invasive gebietsfremde Arten, Pflanzen, Pilze, Tiere, Biodiversität, Schäden, Umwelt

Cette publication fournit un aperçu des espèces exotiques établies en Suisse dans l'environnement, y compris celles susceptibles de causer des dommages environnementaux (= espèces exotiques envahissantes). Outre une vue d'ensemble des aires d'origine et des voies d'introduction, elle précise comment le nombre de ces espèces a évolué au fil du temps. Quelque 1300 espèces exotiques établies sont connues actuellement, dont 197 sont considérées comme envahissantes. Certains groupes d'espèces sont décrits plus en détail ci-après. Pour chaque groupe d'espèces exotiques, des exemples illustrent les voies d'introduction et les dommages susceptibles d'être causés par les espèces envahissantes de ce groupe.

Mots-clés :
espèces exotiques, espèces exotiques envahissantes, plantes, champignons, animaux, biodiversité, dommages, environnement

La pubblicazione offre una panoramica delle specie esotiche insediate nell'ambiente in Svizzera, incluse le specie che possono causare danni ingenti all'ambiente (= specie esotiche invasive). Oltre a una sintesi delle regioni di origine e delle vie d'introduzione, viene illustrato anche l'andamento della loro presenza nel corso del tempo. Sono note in totale circa 1300 specie esotiche insediate, 197 delle quali sono considerate invasive. Verranno inoltre esaminati gruppi di specie selezionati e, sulla scorta di alcune specie di esempio, verranno illustrate le vie d'introduzione e i danni che le specie esotiche invasive dei vari gruppi possono causare.

Parole chiave:
specie esotiche, specie esotiche invasive, piante, funghi, animali, biodiversità, danni, ambiente

Foreword

Globalisation has led to unprecedented levels of international trade, transport and tourism. As a result of this growing activity, many animals, plants and fungi are introduced from their natural range into new areas that they could never have reached without the help of humans. While the majority of them integrate unobtrusively into our ecosystems as alien species, some can cause problems by displacing native species, causing economic damage or endangering human health. These are referred to as invasive alien species.

The International Union for Conservation of Nature (IUCN) estimates that invasive alien species are one of the 'greatest threats to the environment and economy'. Within the framework of the Convention on Biological Diversity (CBD), the international community has set itself the goal of preventing harm caused by invasive alien species. Aichi Target 9 in the Strategic Plan for Biodiversity 2011–2020 states that invasive alien species and their introduction pathways are to be identified and prioritised. As a signatory state to the CBD, Switzerland has also committed to this target.

In adopting the Swiss Strategy on Invasive Alien Species in 2016, the Federal Council created a national framework for implementing this international target. The first measure in the strategy involves updating the knowledge base on alien species. This inventory shows the results of this update and plays an important part in meeting Aichi Target 9.

The assessments presented here demonstrate that the number of alien species in Switzerland continues to increase. Among these, the number of invasive species is also on the rise, as is the harm they cause – as is to be expected. In order to achieve effective prevention, the other measures in the strategy also need to be implemented step by step. Up-to-date knowledge bases form an important basis for prevention work. By implementing all the measures, it will be possible to attain the strategy's aim, namely: alien species should pose no threat to human beings or the environment and have no negative impact on biological diversity, ecosystem services and their sustainable use.

Franziska Schwarz, Vice Director
Federal Office for the Environment (FOEN)

Summary

As travel and trade become increasingly globalised, not only goods, but living plants, animals, fungi and microorganisms are intentionally and unintentionally transported to areas they could not reach unaided by humans. These species, introduced by human activity into habitats outside their natural range, are referred to as alien. This report provides an inventory of the alien animals, plants and fungi of Switzerland, focusing on alien species established in the environment. Species that occur exclusively on agriculturally cultivated land or which can only thrive in hothouses or indoors are not considered here. For this inventory, the status of species is assessed from a national perspective, i.e. species that have been introduced into new habitats beyond their natural range within the country ('not native to the site') are not considered. Furthermore, only those alien species introduced into Switzerland after 1500 are considered in the assessment in order to have a common, reliable data basis across all species groups. Invasive alien species are identified from the totality of established alien species (Fig. 1). They are known to or can be expected to pose a threat to humans and the environment or to impair biodiversity, ecosystem services and their sustainable use.

There are currently 1,305 established alien species known in Switzerland (430 animals, 730 plants, 145 fungi). While the majority of these species integrate inconspicuously into our ecosystems, 197 of them (15%) are designated as invasive, namely 85 animals, 89 plants and 23 fungi (see list of species in the appendix). The figures and assessments in this publication reflect the current situation. It can be assumed that new (invasive) alien species will continue to be introduced into Switzerland and become established in the environment. The lists of species on which the report is based are periodically updated. The updated versions are available at *www.infospecies.ch/de/neobiota/informationen.html* (established alien species in Switzerland) and *www.bafu.admin.ch > Thema Biodiversität > Fachinformationen > Artenmanagement > Gebietsfremde Arten* (list of invasive alien species) (both sites available in German, French and Italian).

Development over time

The number of alien species in Switzerland, including invasive species, is steadily increasing (Fig. 2).

Fig. 1: Schematic representation of established and invasive alien species

This publication deals with the alien species established in the environment in Switzerland, including invasive alien species.

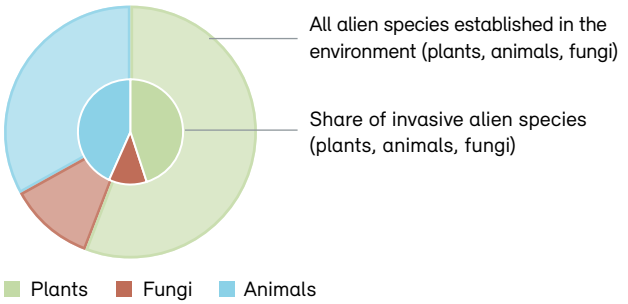
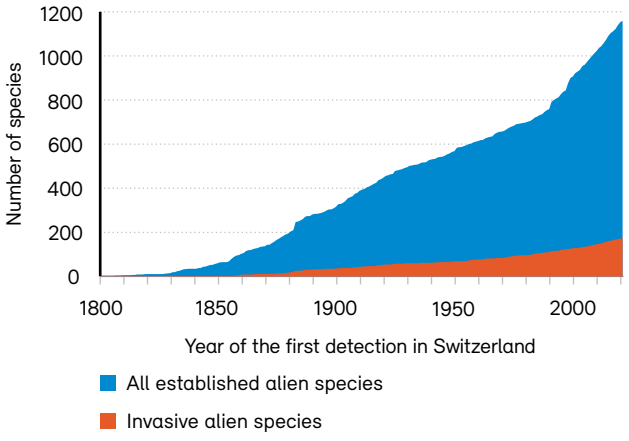


Fig. 2: Development over time of established and invasive alien species

Cumulative number of established and invasive alien species (from the date of first detection in Switzerland). For 1,159 of the 1,305 established alien species, the year of first detection is known. The year is known for 174 of the 197 invasive alien species.

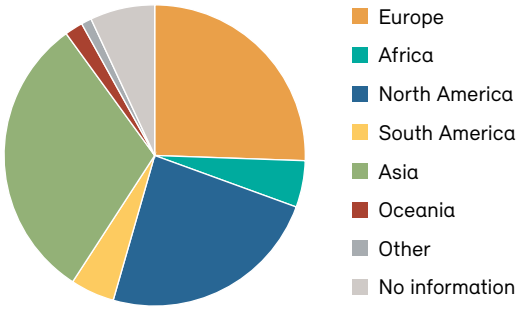


Origin

The majority of alien species established in Switzerland originate in Asia (31%), followed by Europe (26%) and North America (24%) (Fig. 3). The 'Other' category includes 18 species whose regions of origin span several continents (e.g. Palaearctic, Nearctic or Southern or Northern Hemisphere). No information is available on the original region of origin of 7% of established alien species.

If only invasive alien species are considered, Asia and North America have long been the two regions of origin from which the largest proportion of species come (Fig. 4), with Asia overtaking North America in recent decades. Asia is now the region of origin of 41% and North America of 30% of the total 197 invasive alien species. At 14%, the share of alien species of European origin that are invasive is significantly lower than that of all established alien species.

Fig. 3: Regions of origin of established alien species



Introduction pathways

There are many different ways in which humans can intentionally or unintentionally introduce alien species into new regions. The Convention on Biological Diversity (CBD) proposes a standard categorisation that can be applied to all species groups and habitat types (CBD 2014); the following assessment is based on this. The largest proportion of alien species established in Switzerland was deliberately introduced (40%) and subsequently escaped unintentionally into the environment (= 'Escape' introduction pathway in Fig. 5). A further 32% of established alien species were unintentionally introduced into new areas beyond their natural range with a specific commercial product (= 'Contamination'). For 237 of the established alien species (18%), there is no or incomplete information on the introduction pathway from the region of origin ('No information').

Also in the case of invasive alien species, the primary introduction pathway is 'Escape' at 45%, followed by species unintentionally introduced with a specific commercial commodity ('Contamination'; 20%). Compared to all established alien species, a remarkable proportion of invasive species have been deliberately introduced and then released in nature ('Release', 16%, esp. vertebrates), or have been unintentionally introduced via transport modes ('Stowaway') or artificial transport structures ('Corridor') (10%; esp. invertebrates).

Fig. 4: Development over time and region of origin of invasive alien species

Cumulative number of invasive alien species by region of origin (from the date of first detection in Switzerland).

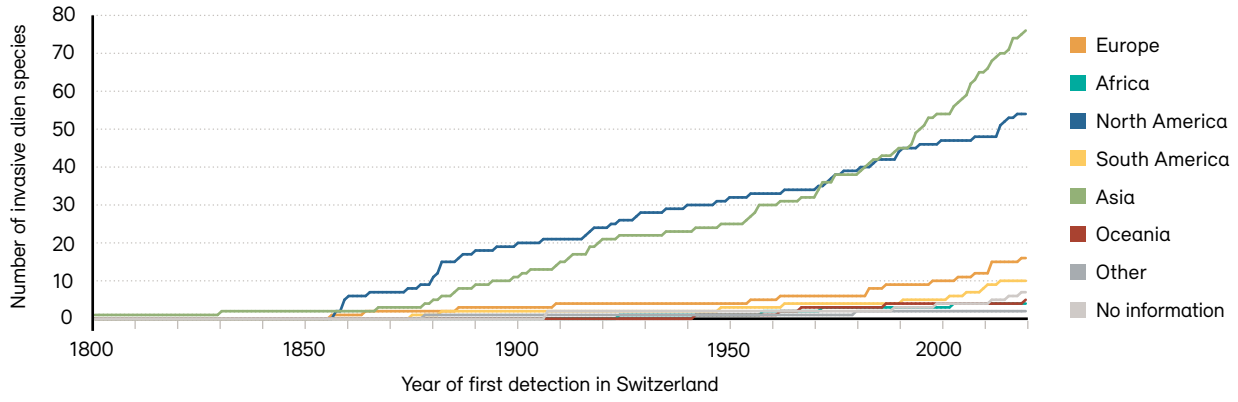
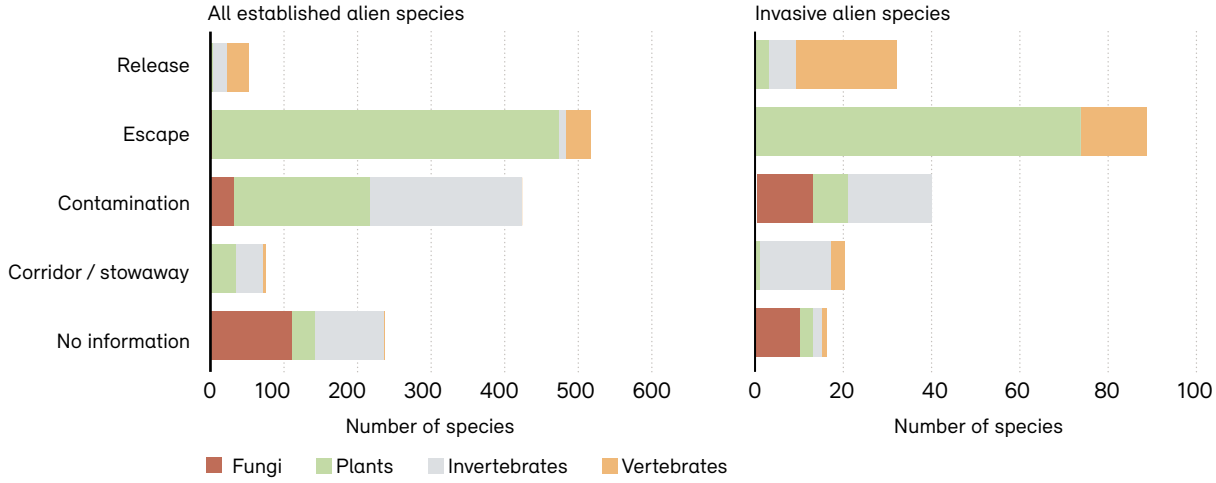


Fig. 5: Number of established and invasive alien species in Switzerland by introduction pathway from region of origin

Introduction pathways (in accordance with CBD), on which established (n = 1,305; left) and invasive (n = 197; right) alien fungi, plants and animals are introduced from their region of origin into habitats outside of their native range.



Impacts

The change in fauna and flora associated with the establishment of alien species does not necessarily create negative impacts (Kowarik et al. 2003). The majority of alien species integrate inconspicuously into our ecosystems. The widespread occurrence of an alien species does not necessarily mean that it causes harm. In some cases, however, the intentional as well as unintentional introduction of living organisms by humans has been clearly detrimental. Where it is known or must be assumed that alien species can impair biodiversity, ecosystem services and their sustainable use, or can endanger humans and the environment through their spread in Switzerland, the term invasive alien species is used. Invasive alien species can harm and impair the local ecology in a number of ways. For example, they displace native species or hybridise with them, thereby posing a threat to biodiversity. They can alter ecological factors, impair functions of native ecosystems and transmit diseases and parasites. Furthermore, they may emit toxic or allergenic substances that trigger health problems in humans. In addition to environmental harm, considerable economic damage can also be caused in agriculture and forestry or to buildings and infrastructure, e.g. through yield losses or additional costs for the maintenance of railway tracks, roads, protective structures and the banks of lakes and rivers. Depending on the type of damage caused, different stakeholders are affected by invasive alien species.

National strategy

In May 2016, the Federal Council adopted the Swiss Strategy on Invasive Alien Species (Swiss Confederation 2016). The main aim of this strategy is to prevent alien species from endangering human beings or the environment and from impairing biological diversity, ecosystem services and their sustainable use. The intention is to contain the spread of invasive alien species and prevent any reintroduction. Going forward, the national strategy will allow coordination and harmonisation between the stakeholders concerned and between activities regarding invasive alien species at national level.

1 Introduction

The distribution of animal and plant species on Earth, largely determined by climate and geology, has long been maintained by natural barriers such as oceans, mountains, deserts and rivers (FOEN 2006). Coordinated communities have been able to develop within these long-separated habitats, establishing a balance between the species. As travel and trade become increasingly globalised, not only goods, but living plants, animals, fungi and microorganisms are intentionally and unintentionally transported to areas which they could not reach unaided by humans. These species, introduced by human activity into habitats outside their natural range, are referred to as alien. The globalised economy and society benefits from many of these species. Agriculture, forestry, fisheries, the pet trade, horticulture and landscape gardening, along with many industrial consumers of biological raw materials, now make use of species that originate in distant parts of the world (Swiss Confederation 2016).

When an individual species is removed from its community in its region of origin, it is no longer subject to natural control mechanisms that originally led to a balance between the species in that community, such as natural enemies. Not all introduced species can survive in the new region, and so disappear. Others can survive in the new habitat conditions, but remain inconspicuous. However, the lack of control mechanisms in the new region into which an alien species is introduced can also lead to its uncontrolled spread, affecting human, animal and plant health, causing economic damage and/or displacing native species, and thus negatively affecting local biodiversity and ecosystem services. Species with these characteristics are called invasive. Taking various examples of animal and plant species whose spread had already caused considerable harm in the early 20th century, in 1958 the English zoologist Charles S. Elton showed in his groundbreaking book what humans can do by introducing species intentionally or unintentionally (Elton 1958). Since then, and owing to an ever-increasing number of invasive alien species, invasion biology has established itself as a discipline within the natural sciences. The collective body of knowledge should allow us to identify invasive alien species, understand their impacts and identify possible control measures.

National strategy

The Federal Office for the Environment (FOEN) published the first inventory of alien species in Switzerland in 2006. This listed over 800 established alien species, of which 107 were identified as invasive alien species. Factsheets were drawn up on the latter (FOEN 2006).[1]

Since then, the number of invasive alien species in Switzerland has continued to increase, and in 2013 the FOEN was tasked with developing a national strategy in response to parliamentary postulate 13.3636 on preventing the spread of invasive alien species. In May 2016, the Federal Council adopted the Swiss Strategy on Invasive Alien Species (Swiss Confederation 2016). This national strategy allows measures to deal with invasive alien species at the national level to be better coordinated and harmonised with and between all actors going forward.

For the strategy to be implemented, up-to-date knowledge bases are of central importance. Reports of findings and information on alien species in Switzerland are managed by the national data and information centres for flora, fauna, fungi, mosses and lichens and are harmonised and made available by InfoSpecies (*www.infospecies.ch*). Under the strategy (Measure 1–1.1), an expert committee (with experts for all taxonomic groups) has been set up in cooperation with the national data and information centres to compile and update information on the various species.[2] This committee continuously compiles new national and international findings on alien species (ecological properties, introduction sites and pathways, distribution, harmfulness, measures) that are relevant to Switzerland.[3] This report is based on the most recent findings and information on established alien species (including invasive alien species), reflecting the knowledge available in 2021. The lists of species on which the report is based are

1 Because of the different methodologies used and the availability of better data for some species groups, the data from 2006 are not directly comparable with the figures in this publication. Figure 7 on page 15 shows how species numbers have changed over time.

2 See: *www.infospecies.ch/de/neobiota/akteure.html* > ExpertInnengremium für invasive gebietsfremde Arten

3 Global Invasive Species Database (GISD) by the IUCN Invasive Species Specialist Group (ISSG)
CBD Global Invasive Alien Species Information Partnership (GIASI Partnership)
Delivering Alien Invasive Species Inventories for Europe (DAISIE)
CABI Invasive Species Compendium

updated periodically. The most recent versions are available at *www.infospecies.ch/de/neobiota/informationen.html* (established alien species in Switzerland) and *www.bafu.admin.ch/bafu/de/home/themen/biodiversitaet/fachinformationen/erhaltung-und-foerderung-von-arten/invasive-gebietsfremde-arten.html* (list of invasive alien species) (both sites available in German, French and Italian).

International environment

By signing international agreements such as the Convention on Biological Diversity (CBD)[4] and the Bern Convention,[5] Switzerland has committed itself to addressing invasive alien species and to cooperating internationally. For example, under Article 8 letter h of the CBD, the Parties agree to prevent the introduction of, control or eradicate those alien species that threaten ecosystems, habitats or species as far as possible and as appropriate.

Aichi Target 9 of the CBD Strategic Plan 2011–2020 is of particular relevance to this publication (CBD 2010). Signatory countries are required, among other things, to identify and list according to priority invasive alien species and their introduction pathways by 2020. In order to comply with this international obligation, when the data was updated close attention was paid to an analysis of the introduction pathways. The assessments are presented in Section 2.3.

1.1 Alien species

1.1.1 What are alien species?

The national strategy defines as 'alien' any species introduced by human activity into a habitat outside its natural range. A national perspective was taken as the geographical frame of reference for the assessments made in this report; that is to say, assessments are made only on introduced species whose natural range is outside Switzerland. Species that are introduced into new habitats beyond their natural range yet within Switzerland are termed 'not native to the site' in the context of this report and are not considered in the assessments (see Section 1.1.2).

Species may be introduced by humans either intentionally or unintentionally. These are not species that migrate from their natural range under their own steam; since this occurs without the help of humans via an expansion (or shift) of the natural range, e.g. as a result of climatic changes, these species are not considered alien. For example, the golden jackal (*Canis aureus*) is not considered an alien species as it is expanding its natural range from Eastern Europe westwards without human support, colonising new areas in Central Europe. In other words, it is expanding its natural range. The grey squirrel (*Sciurus carolinensis*), however, is considered alien because its natural range is in North America and the species could only be brought to Europe by humans. Even though it could reach Switzerland from Italy by its own means, in doing so it would be expanding the alien territory into which it was introduced by human activity and not its natural range, which is restricted to the North American continent.

While many alien species cannot thrive for long under local conditions, others can become established in the environment over the longer term. A distinction is made between different stages of establishment: persistent, subspontaneous and fully established. Persistent alien species survive in the wild, but do not reproduce. The raccoon (*Procyon lotor*), for example, which has been observed in Switzerland since 1970, was considered persistent until evidence was found in 2020 that it reproduced. Subspontaneous alien species such as Chinese silver grass (*Miscanthus sinensis*), which sometimes reproduce in the wild, can only survive long term if released repeatedly. Alien species become fully established when they can exist in the wild without human intervention, reproduce regularly and are thus not dependent on repeated introduction. As the transition between the different stages of establishment may be fluid, they cannot always be clearly distinguished from each other. Because the persistent and subspontaneous species are seen as transitional stages towards establishment, in a prognostic approach, they were treated in the same way as the established alien species and so considered in the assessments (see Section 2).

4 Convention of 5 June 1992 on Biological Diversity, SR 0.451.43

5 Convention of 19 September 1979 on the Conservation of European Wildlife and Natural Habitats, SR 0.455

1.1.2 Which alien species are considered?

Those alien plants, fungi (incl. oomycetes) and animals that are established in the Swiss environment are considered in this report. Species that fall exclusively within the sphere of competence of other sectoral policies are not taken into account in the assessment, in particular:

- Cultivated plants that depend on the care of humans for survival in the environment
- Harmful organisms that only affect agricultural and forestry crops or cultivated plants
- Human pathogens and allergens that fall within the remit of the Federal Office of Public Health (FOPH)
- Animal diseases that exclusively affect farm animals and fall within the remit of the Federal Food Safety and Veterinary Office (FSVO).

The following are not considered:

- Species that depend on warm greenhouses or household interiors (e.g. stored product pests) for longer-term survival (e.g. overwintering), unless there is evidence that they can also become established in the wild.
- Species not native to the site: The natural range of some native species is restricted to certain regions of Switzerland because their natural distribution limit (e.g. the Alps) runs through Switzerland. In some cases, these native species can cause harm if introduced into other regions of Switzerland. For example, the Italian crested newt (*Triturus carnifex*), native to Ticino, has been released in Geneva, where it is displacing the Northern crested newt (*Triturus cristatus*). The same problem can also occur in other species groups, such as fish, if the same species is moved from one water catchment area in which it originates to another.
- Alien species can also be found among microorganisms such as algae, bacteria and protozoa, and some can cause considerable harm. For example, the bacterium *Erwinia amylovora*, which is found in Switzerland and originates in North America, causes fire blight, a disease which leads to widespread damage in fruit trees but can also infect certain wild plants such as hawthorn (*Crataegus* div. spec.).[6] *Xylella fastidiosa* is an example of a bacterium that has not been able to establish itself in Switzerland.[7] However, not enough is known about many such microorganisms, which is why they could not be considered here (with the exception of some fungi).

In order to have a common, reliable data basis across all species groups, only those alien species introduced into Switzerland after 1500 are considered. For many species groups, there is little or no older information on introduced species. The information on which the assessments are based is the latest available in each case. For example, as soon as it becomes apparent that a harmful organism originally restricted to cultivated plants can also establish itself in the wild, the species is counted as an environmentally relevant alien species.

6 Additional information: *www.agroscope.admin.ch/agroscope/de/home/themen/pflanzenbau/obstbau/feuerbrand/wirtspflanzen-feuerbrand.html*

7 Additional information: *www.blw.admin.ch/blw/de/home/nachhaltige-produktion/Pflanzengesundheit/schaedlingeundkrankheiten/quarantaeneorganismen/xylella.html*

1.2 Harm caused by invasive alien species

1.2.1 Which alien species are considered invasive?

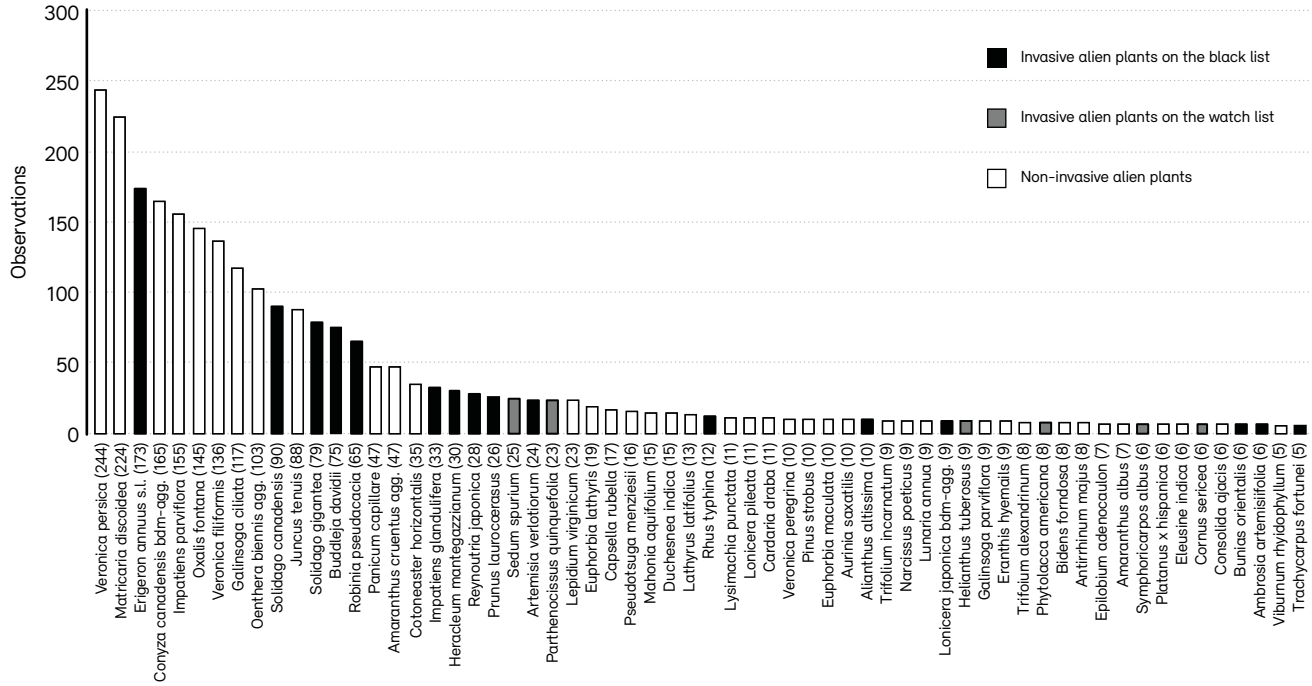
The change in fauna and flora that occurs when alien species become established does not necessarily create negative impacts (Kowarik et al. 2003). The majority of alien species integrate inconspicuously into our ecosystems. The widespread occurrence of an alien species does not necessarily mean that it causes harm. An evaluation of the frequency of occurrence of alien plants shows, for example, that the plant species most frequently observed are not necessarily those that cause or could cause harm (Fig. 6).

However, in some cases, when species are moved by human activity, this can create negative impacts. Where it is known or must be assumed that alien species, by spreading in Switzerland, can impair biodiversity, ecosystem services and their sustainable use, or can endanger human beings and the environment, the term invasive alien species is used. Invasive alien species can harm and impair the local ecology in a number of ways. For example, they displace native species or hybridise with them, thereby posing a threat to biodiversity. They can alter ecological factors, impair functions of native ecosystems and transmit diseases and parasites. Furthermore, they may emit toxic or allergenic substances that trigger health problems in humans. Considerable economic damage may also be caused in other areas such as agriculture and forestry or to buildings and infrastructure, e.g. through yield losses or additional costs for the maintenance of railway tracks, roads, protective structures and the banks of lakes and rivers (for examples see Section 3).[8] Depending on the type of damage, different stakeholders are affected by invasive alien species.

8 See Section 1.1.4 Swiss Strategy on Invasive Alien Species (*www.bafu.admin.ch/gebietsfremde-arten*)

Fig. 6: Frequency of occurrence of alien plants vs harmfulness

Info Flora[9] has compiled lists of alien plants that cause harm ('black list') or could cause harm ('watch list'). The figure shows the number of observations of alien plants, with species from the Info Flora black and watch lists highlighted (black and grey bars respectively). The frequency of occurrence of alien plants does not give any indication of the harm they might cause.



Source: M. Nobis (SKEW AGM 5.10.2010 – Bern), adapted

9 The National Data and Information Centre of the Swiss Flora (*www.infoflora.ch/en*)

1.2.2 Harmfulness assessment

In order to be able to prevent possible harm at a later stage, it is important to identify as early as possible those species that may have a significant negative impact on humans and the environment,[10] especially on native species, their communities and habitats. For this, it is essential to have sufficient understanding and information about the ecology, spread and impacts of the species concerned. However, since flora and fauna are constantly changing and alien species that initially appear harmless may cause harm only after a certain time (e.g. annual fleabane [*Erigeron annuus*]), regular monitoring and reassessment are necessary.

Impact classification system across species groups

The harm caused by an invasive alien species can be assessed in different ways (studies, risk assessment, expert knowledge, etc.). In order to be able to make a comparative assessment of the impact of alien species across different species groups, the IUCN proposes the EICAT classification system (Environmental Impact Classification of Alien Taxa) as a global standard (IUCN 2020). The EICAT classification procedure is standardised, transparent and fact-based. The alien species are assigned to one of five impact categories depending on the severity and reversibility of their impact on the environment and the biological organisation level (organism, population, community) affected (Blackburn et al. 2014). In addition to and analogous to EICAT, SEICAT (Socio-Economic Impact Classification of Alien Taxa) can also be used to assess and classify harmful impacts on human well-being (Bacher et al. 2018).

The list of invasive alien species (see Appendix) was compiled on the basis of the classification of ecological damage as transferable to Switzerland in EICAT. A SEICAT classification was only made for species where the socio-economic impacts outweigh the ecological impacts (e.g. allergenic potential of ragweed [*Ambrosia artemisiifolia*]). The impact assessment focused on natural resources as defined by environmental protection legislation (humans and the environment).[11] The impact of otherwise regulated resources such as production areas in agriculture and forestry was not taken into account, as this is covered by other sectoral policies. Should it become apparent that these species also have a significant impact on the environment, a reassessment will take place.

1.3 Document content and structure

This report updates the 2006 inventory of alien species (FOEN 2006) and shows how the number of established alien species, including invasive species, has changed in recent years.

In a section covering all species groups (Section 2), assessments are made of all established alien species in order to provide an overview of the regions of origin, introduction pathways and developments.

The following section (Section 3) looks at the species groups under 16 different headings. These short sections highlight characteristics of the respective species groups and provide an overview of the alien species established in Switzerland for each group. Examples are provided to illustrate the harm that can be caused by invasive alien species of the respective group. There is also a discussion of any measures being taken and existing knowledge gaps.

10 Natural resources as defined by environmental protection legislation (cf. Art. 1 para. 1 Federal Law on the Protection of the Environment, SR 814.01)

11 In the interests of efficiency, species which are not known to have an impact were not classified.

2 Assessments

2.1 Inventory of established alien species

The number of both alien species and invasive alien species is steadily increasing (Fig. 7). This trend is expected to continue. Model calculations assume an additional 2,500 alien species for Europe by 2050 (Seebens et al. 2020).

Currently, a total of 1,305 established alien species are known in Switzerland: 430 animals, 730 plants and 145 fungi (Table 1). Vascular plants form the largest group with 714 terrestrial and 11 aquatic species. Among animals (430 species in total), most of the established alien species are invertebrates: insects are the most numerous group, with 296 species.

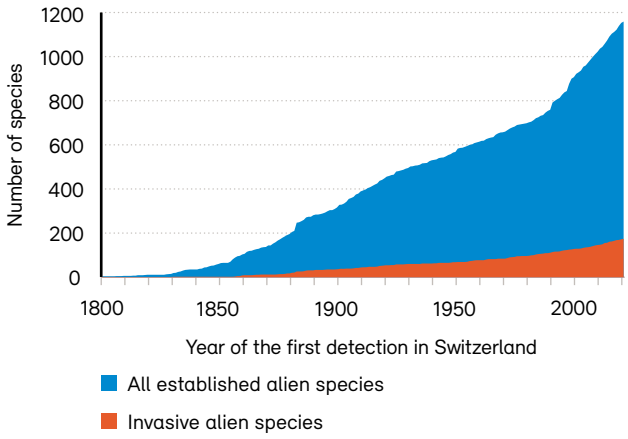
Of the 1,305 established alien species, 197 (15%) are considered invasive, namely 85 animals, 89 plants and 23 fungi. Among the invasive alien species, vascular plants are again the most widely represented, with 80 terrestrial and 8 aquatic species. Among animals, vertebrates and invertebrates are represented fairly equally, with 42 and 43 species respectively.

A distinction is made between invasive alien species that have been proven to cause harm (basis for (S)EICAT classification exists) and those which can be assumed to cause harm (potentially invasive), even if there is not yet a basis for (S)EICAT classification (Table 2).

Taking a prognostic approach, the list of invasive alien species includes information on the invasiveness of 40 further species that do not yet occur in Switzerland or that have been completely removed by eradication measures but whose (re-)occurrence in Switzerland cannot be ruled out. Examples include the grey squirrel (*Sciurus carolinensis*), which has not yet reached Switzerland, and salamander chytrid fungus (*Batrachochytrium salamandrivorans*), a highly infections skin fungus affecting salamanders and newts, which is already present in Europe in the Netherlands, Belgium and Germany. In 2020 it was also found to be present in Bavaria (Auf der Maur et al. 2020). The list of as yet absent species is not exhaustive and only includes well-known examples. As no conclusive

Fig. 7: Temporal increase in established and invasive alien species

Cumulative number of established and invasive alien species (from the date of first detection in Switzerland). For 1,159 of the 1,305 established alien species, the year of first detection is known. The year is known for 174 of the 197 invasive alien species.



Tab. 1: Number of established and invasive alien species in different taxonomic groups

Taxonomic group	Established	Of which invasive
Animals	**430**	**85**
Vertebrates	66	42
Invertebrates	364 (of which insects: 296)	43 (of which insects: 23)
Plants	**730**	**89**
Terrestrial vascular plants	714	80
Aquatic vascular plants	11	8
Mosses	5	1
Fungi	**145**	**23**
Total	**1,305**	**197**

Tab.2: Number of invasive alien plants, fungi and animals

	Plants	Fungi	Animals	Total
Species that have been proven to cause harm	57	20	55	132
Species which are presumed to cause harm	32	3	30	65
Total	**89**	**23**	**85**	**197**

horizon scanning has yet been undertaken, the following assessment only looks at species occurring in Switzerland.

2.2 Regions of origin

The majority of alien species established in Switzerland originate in Asia (31%), followed by Europe (26%) and North America (24%) (Fig. 8). The 'Other' category includes 18 species whose regions of origin span several continents (e.g. Palaearctic, Nearctic or Southern or Northern Hemisphere). No information is available on the original region of origin of 7% of established alien species.

Among the 197 invasive alien species, Asia (41%) and North America (30%) dominate as regions of origin, which can also be seen from the temporal development of the number of species per region of origin (Fig. 9). Asia has gained in importance over North America in recent decades. The proportion of species of European origin is significantly smaller for invasive alien species than for all established alien species, totalling 14%.

2.3 Introduction pathways

The introduction of alien species is due, to human activities per se. Without human intervention, these species would not succeed in reaching regions that are outside their natural dispersal capacity. Once there, they can survive, multiply and spread without further human intervention.

There are many different ways in which humans can intentionally or unintentionally introduce alien species into new regions. In order to enable comparable information on introduction pathways at the international level, the Convention on Biological Diversity (CBD) proposes a standard method of categorisation that can be applied to all species groups and habitat types (CBD 2014, see Table 3).

Fig. 8: Regions of origin of established alien species

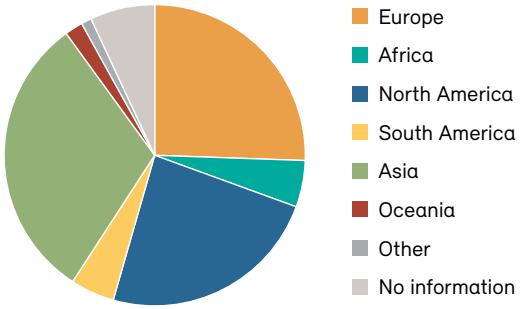
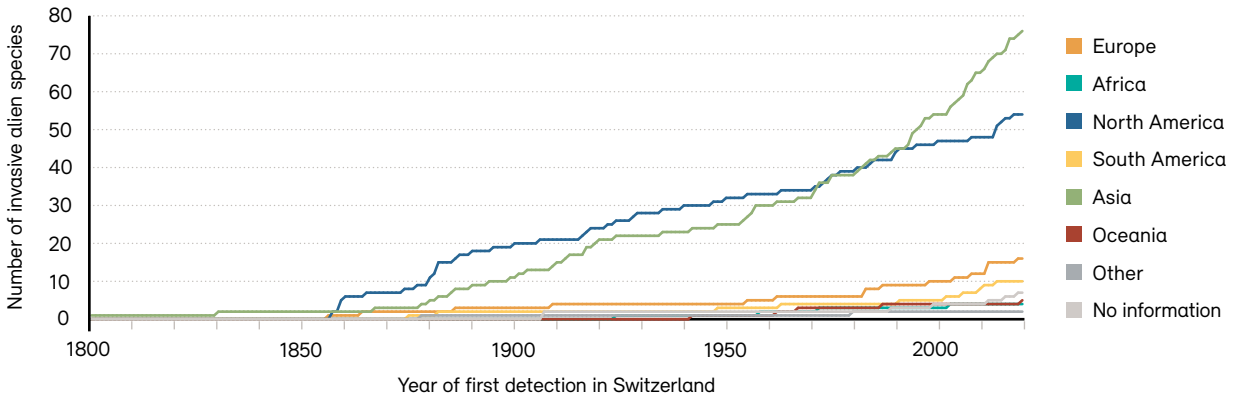


Fig. 9: Temporal increase and region of origin of invasive alien species

Cumulative number of invasive alien species by region of origin (from the date of first detection in Switzerland).



Tab. 3: Introduction pathways according to the CBD (2014)

Mechanism	Introduction pathways[12]	Description[13]	Sub-categories (examples)[12]
Movement of Commodity	(1) Release in nature ('release')	Intentional import as a commodity for release in nature	· Biological pest control · Erosion control · Fishery · Hunting · ...
	(2) Escape from confinement ('escape')	Intentional import as a commodity but unintentional escape into the environment	· Botanical garden / animal park (zoos, enclosures, public aquaria) · Pets, aquarium and terrarium species · Farmed animals / aquaculture / fur farms · Agriculture (incl. biofuel feedstocks) / forestry / horticulture · Live food and live bait · ...
	(3) Contaminant	Unintentional introduction with a specific commodity	· Contaminated nursery material · Food contaminant (incl. of live food) · Contaminant in or on animals / on living plants · Contaminants of seed, feed, bait or similar · Contaminants of transported soil, wood or similar · ...
Vector	(4) Stowaway	Unintentional introduction attached to or within a means of transport	· Ships / ballast water / fouling, accumulation on ship's hull · Aircraft · Vehicles (cars, trains, ...) · People and luggage (especially tourism) · Organic packaging material (especially wood) · ...
Spread	(5) Corridor	Transport infrastructures allow organisms to spread to regions from which they were previously cut off	· Natural dispersal along canals or waterways between river basins / seas · Natural dispersal along terrestrial transport infrastructures (e.g. roads, railway lines, tunnels, land bridges)
	(6) Unaided	Natural dispersal from a neighbouring region into which the alien species was introduced via one of the other introduction pathways (1–5).	

12 Terms taken from: Rabitsch et al. (2018): Analysis and prioritisation of pathways of unintentional introduction and spread of invasive alien species in Germany in accordance with Regulation (EU) No 1143/2014. BfN-Skripten 490: 1–103.

13 According to Hulme, P. E., et al. (2008)

Information on the introduction pathways was compiled for Switzerland's established alien species and assigned to the standard categories according to Table 3 so that meaningful statements could be made about the most frequent introduction pathways and in order to ensure international comparability. A distinction was made between the pathway by which a species was introduced from its region of origin into habitats outside its natural range (introduction pathway from the region of origin) and the introduction pathway into Switzerland. For example, the harlequin ladybird (*Harmonia axyridis*) was deliberately introduced and released into various European countries for biological pest control, i.e. introduction pathway from the region of origin is 'Release in nature'. The species has subsequently spread independently to Switzerland from neighbouring countries and has become established. The introduction pathway into Switzerland then corresponds to the CBD category 'Unaided'.

Introduction pathways from region of origin

Most of the alien species established in Switzerland (40%) were deliberately introduced from their region of origin to regions outside their natural range and were subsequently introduced unintentionally into the environment. These are assigned to the 'Release' introduction pathway (Fig 10). The majority (91%) of these species are plants. A further 32% of all established alien species (primarily invertebrates and plants) have been unintentionally introduced during the transport of a specific commercial good ('Contamination' introduction pathway). For about 18% – a total of 237 of established alien species (primarily fungi and invertebrates) – there is no information or no clear information on the introduction pathway from the region of origin ('No information').

The 'Escape' pathway is also the primary introduction pathway among invasive alien species, at 45%. Plants are again the most strongly represented group, but the share of vertebrates in this introduction pathway is significantly larger for invasive species than when all established alien species are considered. 20% of invasive alien species were unintentionally introduced with a specific commodity ('Contamination'), with invertebrates accounting for the largest share (47%). Compared to all established alien species, a remarkable proportion of invasive species have been deliberately introduced and then released in nature ('Release', 16%, esp. vertebrates), or have been unintentionally introduced via transport modes ('Stowaway') or artificial transport structures ('Corridor') (10%; esp. invertebrates).

Fig. 10: Number of established and invasive alien species in Switzerland by introduction pathway from region of origin

Introduction pathways (in accordance with CBD), on which established (n = 1,305; left) and invasive (n = 197; right) alien fungi, plants and animals are introduced from their region of origin into habitats outside of their native range

Introduction pathways into Switzerland

A look at the introduction pathways of established alien species into Switzerland shows that the situation is very similar to the introduction pathways from the region of origin (Fig. 11). Once again, 'Escape' is the pathway by which most of alien species are introduced, both for established alien species (39%) and for invasive alien species (44%). There are two main differences to the introduction pathway from the region of origin.

Firstly, not all alien species are introduced directly into Switzerland from the region of origin (cf. Roques 2010); some migrate to Switzerland from a neighbouring country into which they were previously introduced ('Unaided' introduction pathway). This is the case for 41, or 3%, of all established alien species (mostly invertebrates, followed by vertebrates). In the case of invasive alien species, the proportion of species that enter the country unaided (8%) is greater than for established alien species as a whole, accounted for primarily by vertebrates.

Secondly, no information is available on the route of introduction into Switzerland for a large number of species. In the case of established alien species, the proportion is 26%; for invasive alien species, 17%. The largest species group for which no information is available is fungi.

It is essential to know the pathways via which alien species are introduced into a country in order to be able to apply appropriate prevention measures. This is particularly important in the case of invasive alien species which, once established in a habitat, are very difficult to remove (e.g. aquatic invertebrates such as the quagga mussel (*Dreissena bugensis*), whose spread into as yet uninfested lakes in Switzerland is to be prevented by means of boat cleaning measures).

2.4 Knowledge gaps

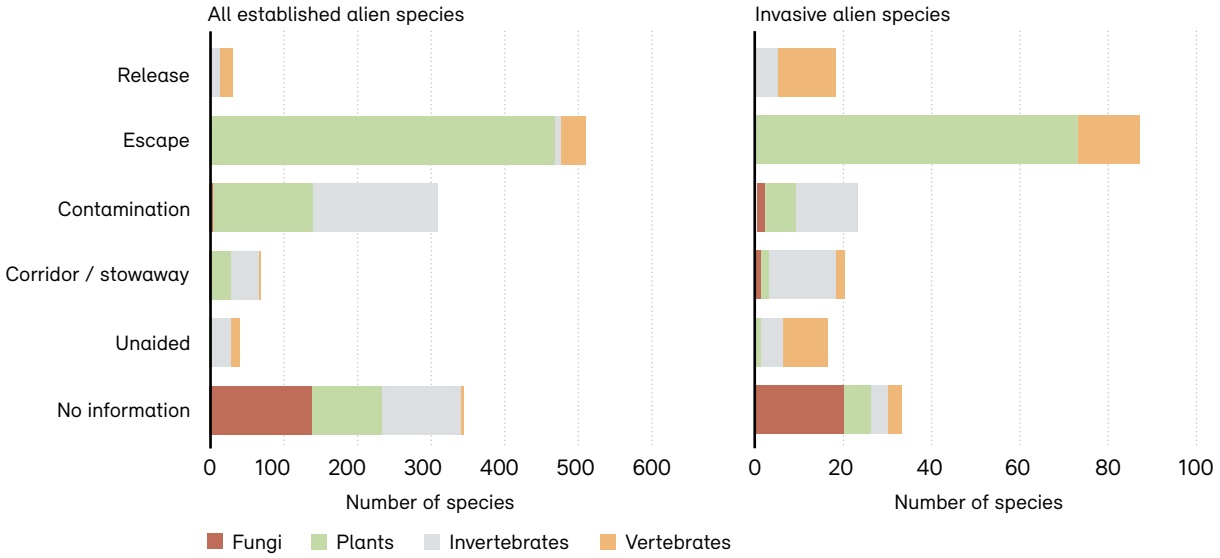
The state of knowledge about alien species differs greatly between the different taxonomic groups. While a great deal is known about many of the vascular plants, for example, there is much less understanding of less well-studied, very species-rich terrestrial invertebrate orders, such as Hymenoptera, true bugs (Hemiptera), nematodes (Nematoda) and mites and ticks (Acari).

There is also a considerable lack of knowledge about some orders among our native species: while a total of 45,890 native species[14] are known in Switzerland, experts estimate that there are likely to be a further 20,000, including 9,000 species of fungi and 8,000 insects (Cordillot & Klaus 2011).

14 Single-celled algae or those with few cells, slime moulds and protozoa not included.

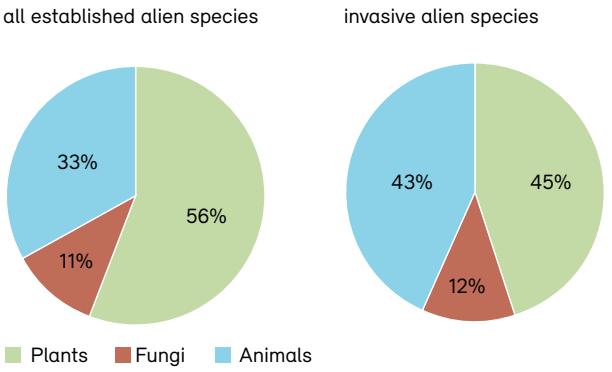
Fig. 11: Number of established and invasive alien species in Switzerland by introduction pathway into Switzerland

Introduction pathways (in accordance with CBD), on which established (n = 1,305, left) and invasive (n = 197; right) alien species have been introduced into Switzerland.



The varying degree of knowledge is also reflected in the data available for this publication: of the 1,305 known established alien species, over 50% are plants (Fig. 12), while animals are represented to a much lesser degree at 33%, and fungi at 11%. The availability of data means it has been possible to record many subspontaneous species among plants, for example, which is not the case for many more mobile, smaller species, as there are fewer experts for these and significantly fewer observations are reported. Among invasive alien species, there is greater balance between taxonomic groups.

Fig. 12: Proportion of plants, fungi and animals in the total number of established or invasive alien species assessed



2.5 From assessing harmfulness to classifying invasive alien species according to the five-level concept

Invasive alien species are to be classified according to the five-level concept unless already covered by specific legislation (e.g. Epizootic Diseases Ordinance, Plant Health Ordinance) and provided the corresponding measures can adequately contain the harm to be expected in the environment.[15] To this end, a decision model for prioritising invasive alien species is being developed as part of the implementation of the Swiss Strategy on Invasive Alien Species (see Measure 1–4.1), on the basis of which proportionate measures and recommendations for legally binding action can be assigned to the respective species. Besides harmfulness, other species-specific characteristics (e.g. current distribution and spread potential of the species in Switzerland) and the availability of efficient and proportionate control measures feature in the decision model.

The decision model will ultimately result in a classification proposal for invasive alien species; this will then be discussed and reviewed with the cantons at national level. In particular, this proposal will reflect practical considerations regarding feasibility and implementation. Work on this is currently under way and coincides with the steps being taken to revise the Environmental Protection Act.

In a prognostic approach, the idea is to include in the classification invasive alien species that are already found in neighbouring countries but which have not yet reached Switzerland. Invasive alien species that once occurred in Switzerland but have been completely removed thanks to eradication measures are also included. The list of invasive alien species also includes known examples of species that are not yet present or have been completely removed, so that swift action can be taken should they (re)appear in Switzerland. The list of these species that are currently not (or no longer) found in Switzerland is not exhaustive (see Annex).

15 See Swiss Strategy on Invasive Alien Species p. 31

3 Species groups

The following sections were written by the corresponding authors listed in the publication details.

Fungi and lichens

145 alien species of fungi have become established in the environment. Of these, 23 species are considered invasive. Among lichens, which often have a large natural range, no alien species is known for Switzerland.

The rapidly increasing transfer of goods resulting from globalisation is the main reason why more and more fungal species are being introduced into regions where they are not originally native. Some species manage to become established in the new region and may pose a threat to the native flora and fauna. The majority of alien fungal species originate in Asia and North America, both of which are regions with high plant and fungal diversity. The main **introduction pathways** include tree nurseries, ornamental plant nurseries, garden centres, DIY stores, packaging, timber and furniture wood and humans themselves. Once established, these species of fungi are very difficult to control.

One of the most devastating invasive alien fungi in Switzerland is *Hymenoscyphus fraxineus*, which is responsible for **ash dieback** and was only discovered here in 2008. Most likely imported with the Manchurian ash (*Fraxinus mandshurica*), this small fungus threatens the native common ash (*Fraxinus excelsior*) and all organisms dependent on it.

In extreme cases, entire forest ecosystems can be destabilised by the mass spread of an invasive fungus. This has happened in the case of **chestnut blight** (*Cryphonectria parasitica*), which within 40 years has pushed the American chestnut (*Castanea dentata*), a tree species that is native to the eastern USA and was once very widespread, to the brink of extinction. Today little more than puny shoots growing from root bases remain of an estimated four billion trees that once existed. Both ash dieback and chestnut blight destroy the vascular tissue of the host tree, thereby cutting off the transport of water and sugars and so killing the tree. In Europe and Switzerland, the sweet chestnut (*Castanea sativa*) is also attacked by chestnut blight, but here a virus that infects the chestnut blight itself mitigates the effects of this fungus.

Plants are not the only species group to be attacked by invasive fungi. A particularly insidious fungus that will probably be found in Switzerland in the future is **salamander chytrid fungus** (*Batrachochytrium salamandrivorans*). In the Netherlands, Belgium and Germany, this fungus has wiped out numerous salamander populations. Until now, the fungal disease was primarily present in the Netherlands, Belgium and the neighbouring German states, but it is spreading rapidly and was detected in Spain in 2018 and in Bavaria in 2020.

The **crayfish plague** (*Aphanomyces astaci*), an oomycete that was introduced by (partially) resistant North American crayfish species and is transmitted to native crayfish, has been present in Switzerland for quite some time. In the native species, the disease is almost always fatal.

Since control of invasive fungi in nature is only possible in individual cases, **prevention** is of great importance. Controlling the global transfer of goods to a greater extent is crucial to prevent further new and potentially dangerous alien fungi entering Switzerland in future. Climate change is likely to exacerbate this threat, as introduced fungi can become established more easily on stressed native organisms.

A major challenge lies in detecting fungi that do not cause visible symptoms on imported host plants and in identifying as yet unknown species. There is also a great need for research into the question of whether introduced mycorrhizal fungi such as the already established slippery white bolete (*Suillus placidus*) or saprobiontic fungi such as the octopus stinkhorn (*Clathrus archeri*) can displace native fungi through competition.

Fig. 13: Examples of alien fungi

Ash dieback**, which is caused by the fungus* Hymenoscyphus fraxineus *(top left), and **salamander chytrid fungus Batrachochytrium salamandrivorans *(bottom); these two invasive alien fungus species can cause considerable harm to the environment. Neither the **octopus stinkhorn*** Clathrus archeri *(top right) nor the **slippery white bolete*** Suillus placidus *(centre right) are currently known to have a negative impact on the environment.*

Photos: Ash dieback (top left): L. Beenken, octopus stinkhorn (top right): M. Wilhelm, slippery white bolete (centre right): M. Danz, salamander chytrid fungus (bottom): F. Pasmans

Mosses

Among the approximately 1,100 known moss species in Switzerland, there are five established alien species, one of which is considered invasive. Because they are so small, alien mosses usually remain undiscovered for a long time. Only rarely do they occur in larger populations and cause problems.

Detecting alien mosses is not easy because they are small and so often inconspicuous. As there are only a few moss experts, a new alien species can remain undiscovered for a long time. When an alien species is found to be in a new region, it is usually difficult to say how long it has been present there and how it got there. Spores or the mosses themselves may be transported on imported wood. Only the crescent-cup liverwort (*Lunularia cruciata*) is known to have arrived in Switzerland in flower pots.

It can be assumed that most alien moss species integrate into the Swiss flora and do not cause any problems. However, one of the five alien species is considered invasive, namely **heath swan-neck moss** (*Campylopus introflexus*). The species can form dense carpets spreading over several square metres on open, acidic soils, making it impossible for other native species to become established. In Switzerland, the heath swan-neck moss occurs in numerous habitats: in forests and bogs, on areas of cleared forest, on road embankments, flat roofs and in patchy meadows. It is particularly problematic in raised bogs, where it can very quickly colonise open patches of peat soil and thus prevent the reintroduction of native mosses and flowering plants. In other countries, heath swan-neck moss causes considerable harm, especially in dunes, because it is highly competitive on open sandy areas. It is therefore conceivable that the species may also colonise sandy alluvial plains along rivers in Switzerland. This is another sensitive habitat to which various rare species are adapted (ground beetles, mosses, flowering plants, etc.). It would cause considerable problems if *Campylopus introflexus* were to spread to these areas.

At present, the spread of the heath swan-neck moss in Switzerland continues to be monitored and observations reported (*www.swissbryophytes.ch*). In addition, there is a need to conduct monitoring in sensitive habitats with known occurrences of the species, and to train experts in recognising mosses in order to improve the detection of alien moss species going forward.

Fig. 14: Heath swan-neck moss (*Campylopus introflexus*)

Left: in summer in a dry condition, right: in autumn with new shoots, in a wet condition.

Photos: H. Hofmann

Fig. 15: Mass occurrence of heath swan-neck moss on open peat soil near Les Ponts-de-Martel (NE)

The species forms extensive dense carpets in which no other species can thrive.

Photos: N. Schnyder

Vascular plants

Around 730 alien vascular plants occur in the wild in Switzerland. Currently a total of 88 of these species are considered invasive, with 56 species demonstrably causing harm and 32 species likely to cause harm (potentially invasive).

Alien vascular plants are extraordinarily diverse, distributed over a hundred families, with composite plants (Asteraceae) and grasses (Poaceae) clearly dominating. The way they behave and their ecological characteristics are also diverse. The list of established alien plants is limited to species that have become established in Central Europe since 1,500 (= neophytes). In the case of previously introduced species (= archaeophytes) – often companion plants for cultivated crops such as the cornflower or the corn poppy – experience shows that they do not pose any greater risk than native species. The number of alien plants has increased significantly in recent decades and is likely to rise further.

For most alien species, the introduction pathways, mechanisms of dispersal and impact on native biodiversity are known. **Intentionally introduced** species include ornamental plants, plants which attract bees and agricultural species. For example, exotic ornamental plants were planted in gardens and parks in the mild conditions around the lakes in the southern Alps; these then escaped and became invasive. Examples are the Chinese windmill palm (*Trachycarpus fortunei*) and the kudzu vine (*Pueraria lobata*). Other species, such as giant hogweed (*Heracleum mantegazzianum*) and the goldenrods (*Solidago* spp.), were introduced as bee-attracting plants and are now invasive neophytes. The very robust and durable wood of the black locust (*Robinia pseudoacacia*) was used in mining and for avalanche barriers, and was important in Ticino as the material used for stabilising the embankments on the Gotthard railway. The Armenian blackberry (*Rubus armeniacus*), a very tasty garden blackberry, is one of the alien crop plants that has established itself very successfully in nature. Although the majority of alien plants are found at lower altitudes, some have managed to establish themselves at higher altitudes, such as the invasive garden lupin (*Lupinus polyphyllus*), which was introduced as an ornamental plant and can spread widely in mountain meadows, where it changes the soil properties (through nitrogen fixation) and is also toxic to livestock.

Quite a number of species have been **unintentionally introduced by humans**. Seeds of the poisonous narrow-leaved ragwort (*Senecio inaequidens*) were introduced with sheep wool from South Africa. The plant first spread around ports and then along transport routes. Common ragweed (*Ambrosia artemisiifolia*) seeds came to us with sunflower seeds, either as contamination in bird feed or in seeds

for agricultural crops. Plant reproductive organs, such as rhizomes and nodules, have also been introduced via soil, such as the root nodules of the edible chufa sedge (*Cyperus esculentus*) in ornamental plant soil.

Terrestrial plants

The vast majority (almost 90%) of alien plants established in Switzerland are classified as harmless to humans and the environment. Among them are very common species such as creeping speedwell (*Veronica filiformis*) and Persian speedwell (*Veronica persica*), and species that are some of the 'oldest' neophytes and were often introduced as companion plants, such as autumn Adonis (*Adonis annua*) and hairy marshmallow (*Althaea hirsuta*). Alien plants also include species that have entered Switzerland via agriculture and are now major forage plants, such as Italian ryegrass (*Lolium multiflorum*) and common sainfoin (*Onobrychis viciifolia*), and more recently observed species such as Danish scurvygrass (*Cochlearia danica*), which has been identified spreading from the west in low-yield pastures and along traffic routes, and rescuegrass (*Bromus catharticus*), which is also spreading along traffic routes.

The **invasive** alien plant species best known to the general public include common ragweed (*Ambrosia artemisiifolia*), giant hogweed (*Heracleum mantegazzianum*), American goldenrod (*Solidago gigantea* and *S. canadensis*), Asian knotweeds (*Reynoutria* spp.) and Himalayan balsam (*Impatiens glandulifera*).

Aquatic plants

So far, 11 alien aquatic plants have become established in Swiss waters, and a further 7 are already occurring in surrounding countries and could also reach Switzerland. Most of these alien aquatic plants can spread rapidly and form dense mats in waterbodies, which are a problem for native biodiversity (and often also for recreational activities). Moreover, it is particularly difficult to contain or control the species in waterbodies. Aquatic plants include submersed or floating species. All were deliberately introduced by humans as ornamental plants for biotopes in gardens or as aquarium plants, and were then released into watercourses and ponds, often with mistakenly good intentions. This was the case with the giant salvinia (*Salvinia molesta*), a floating fern that suddenly appeared in some small biotopes in southern Ticino (Mangili et al. 2020). Thanks to the quick intervention of the cantonal authorities, the fern could be suppressed. Today, the Canadian and Nuttal's waterweeds (*Elodea canadensis* and *E. nuttallii*) are among the most widespread submersed aquatic plants in Swiss lakes and streams.

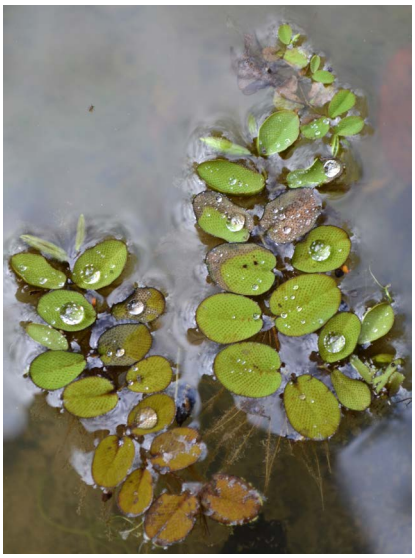
Fig. 16: Chinese windmill palm (*Trachycarpus fortunei*)

In Ticino, the Chinese windmill palm forms dense, impenetrable stands, especially in the undergrowth of the alluvial forests, but also in other habitats. In recent years, the species has also been increasingly found in forests north of the Alps.

Photo: B. Marazzi

Fig. 17: Giant salvinia (*Salvinia molesta*)

According to the IUCN, this is one of the world's 100 worst invasive alien species. Often used as an aquarium plant, until now it has only been found in the wild in southern Ticino.



Photos: S. Mangili

Aquatic molluscs (snails and mussels)

Six established alien snail species and five alien mussel species are currently known, five of which are considered invasive. While the New Zealand mud snail is not known to have a negative impact, there are fears that the quagga mussel, which is spreading rapidly in Switzerland, will damage the infrastructure of water supplies and displace other species.

Most mussels filter their food from water. They do not need to move in order to feed or to reproduce. With their tongue-shaped foot, they can only move very slowly. In order to colonise new habitats, the larval stages are often very mobile, either drifting as plankton larvae (e.g. *Dreissena* spp.) or hitching a ride as parasites on the gills of fish (e.g. Unionidae). Water snails also benefit from shipping and material transport between waterbodies and can so reach new areas.

After the zebra mussel (*Dreissena polymorpha*), the Ponto-Caspian **quagga mussel** (*Dreissena bugensis*) is the second species of this genus to have arrived in Switzerland and is spreading rapidly in rivers and lakes. Both species attach themselves to boats and solid substrates such as stones and wood by means of adhesive filaments (byssus), allowing them to be carried from one waterbody to another. The quagga mussel in particular attaches itself in large quantities to the aquatic plants on lake and river banks. Each of these species can gather so densely on bivalves that the latter are harmed or even die. *D. bugensis* goes much deeper in lakes than *D. polymorpha* and causes considerable damage by clogging the water supply pipes. A survey in 2021 showed that the muddy substrates of Lake Neuchâtel are heavily colonised down to a depth of 140m (> 200 individuals/m^2, pers. comm. P. Stucki). This means that they do not only colonise the banks (as does *D. polymorpha*), but the whole lake bottom down to great depths.

Two species of Asian **clam** were first brought to North America and from there to Europe with ship ballast water. The more common Asian clam (*Corbicula fluminea*) is predominant in fine sediment habitats on the banks of lakes and rivers. Apart from competition for space and food, no adverse effects on native species are known to date.

The **Chinese pond mussel** (*Sinanodonta woodiana*) was first recorded in Switzerland in 2009 in the canton of Zurich and two further populations have since been found in the cantons of Zurich (2019) and Lucerne (2020). It is larger than any other bivalve in Switzerland. Its thick-shelled, bulbous valves grow up to 30cm long. It was introduced into Europe with stocks of Asian fish species, e.g. grass carp. The species, which is also available in pet shops, eventually made its way into our waters. It is adapted to muddy, warmer waters, where among the native large mussels mainly the swan mussel (*Anodonta cygnea*) lives. The Chinese pond mussel's mass-produced larvae can infest smaller fish to such an extent that they die. Apart from competing with other species for food and space, no further negative impacts are known. There are other species of Asian pond mussel. It is suspected that *Sinanodonta lauta* has also been introduced into Germany and that it could appear in some places in Switzerland.

The **New Zealand mud snail** (*Potamopyrgus antipodarum*) has been spread to almost everywhere in the world via ship ballast water. In Central Europe, it is one of the most common water snail species and forms large populations in some places.

When many species are introduced in a short time, this destabilises ecosystems (e.g. in the Upper and High Rhine) and threatens native species. Where native species have already become rare owing to anthropogenic influences such as habitat loss, the presence of invasive alien species can lead to complete extinction on a local level.

Once introduced, it is very difficult to stop the **spread** of these species in aquatic ecosystems, at least not without disproportionate effort. It is therefore essential to block introduction pathways as far as possible. Native species such as the painter's mussel that are imported from distant areas in Europe can also negatively alter the gene pool of native locally adapted genotypes.

Fig. 18: The New Zealand mud snail (*Potamopyrgus antipodarum*) (left) and the zebra mussel (*Dreissena polymorpha*) (right)

Photos: P. Stucki (left); H. Vicentini (right)

Fig. 19: The Asian clam (*Corbicula fluminea*) (left) and the Chinese pond mussel (*Sinanodonta woodiana*) (right)

Photos: P. Stucki (left); H. Vicentini (right)

Amphipods

Until now, ten alien amphipod species have become established in Switzerland, of which five are considered invasive. These species are partly predatory or are filter-feeding and can reach very high densities. Until now they have only been found in larger bodies of water, however.

Forty amphipod species have been identified in Switzerland to date (Altermatt et al. 2019), of which thirteen are considered non-native. The largest number of species in Switzerland can be observed in the Rhine, in particular in the Basel area. Non-native species have mainly been detected in larger waterbodies (Alther & Altermatt 2018) and exclusively in surface waters. So far, no alien amphipod species have been found in Alpine lakes (Alther et al. 2017).

Several factors allow alien species of amphipod to thrive. Among other things, they can be spread relatively easily because of their simple development. Furthermore, they are often very fertile. As ecological generalists, they have a competitive advantage; this is particularly true of species originating from brackish water habitats. Most alien amphipod species in Switzerland originate in the Ponto-Caspian region. Colonisation by other species from this region (*Pontogammarus*, *Obesogamarus*) can also be expected in Switzerland. The best-known examples of successful alien amphipods are species of the genera *Dikerogammarus* and *Chelicorophium*.

The **killer shrimp** (*Dikerogammarus villosus*) is the most common alien amphiphod in Switzerland, where it is found in many large waterbodies. The species has not yet been found in smaller waterbodies (Altermatt et al. 2016). *Dikerogrammarus villosus*, which has occurred widely in Switzerland since 1998, has almost completely displaced *Dikerogammarus haemobaphes*, which was found in the country shortly prior to this. The *Dikerogammarus* genus is easily recognised by the two prominent dorsal tubercles at the end of the back (urosomes). The species favours hard substrate and often lives in company with the zebra mussel (*Dreissena polymorpha*). Its aggressive and omnivorous diet (Dick & Platvoet 2000), combined with a high reproductive rate, explain why the species has such a large impact on the entire aquatic ecosystem (Rey et al. 2004; Gergs & Rothhaupt 2015). Pronounced negative effects on native amphipods have often been observed. According to recent studies, however, *D. villosus* feeds less predatorily than originally assumed (Koester & Gergs 2014). The species was probably introduced by recreational boats or diving equipment (De Ventura et al. 2016). Subsequently, the rivers below the lakes (e.g. Rhine, Limmat, Reuss, Aare, Glatt and Rhone) were colonised practically throughout.

The initially very high population densities of *D. villosus* in Switzerland (over 100 individuals per m^2; Steinmann 2006) have been on the decline since around 2010. This may be explained by the adaptation of predators to *D. villosus*. Natural pathogens also appear to be spreading and having an impact. Further spread, for example into Lake Lucerne, seems possible in principle. However, there have been only isolated cases of *D. villosus* over several years in Lake Alpnach and it has not yet been observed in Lake Walen, which suggests that the average temperature of these lakes acts as a natural barrier to the species. It has, however, been found in Lake Lugano, where it was first recorded in 2018.

The **Caspian mud shrimp** (*Chelicorophium curvispinum*) lives in tunnels in the mud or sand in the lake floor or riverbed and filters particles from the water with its second pair of antennae. First recorded in the Rhine in 1987, the species spread rapidly and became the dominant macroinvertebrate species in many places (Van den Brink & Van der Velde 1991; Van Riel et al. 2006a). In 1995, *C. curvispinum* was found in the High Rhine near Basel (Rey & Ortlepp 2002), and later also in Lake Geneva (Lods-Crozet & Reymond 2006). Where population densities are extremely high (200,000–750,000 individuals/m^2), this can alter the substrate structure at the bottom of the watercourse or -body. Tolerance to poor water quality gives the species a competitive advantage (Van den Brink et al. 1993). *Chelicorophium curvispinum* competes for food with other filter-feeding species, e.g. the zebra mussel *Dreissena polymorpha* (Borza et al. 2018). The initially very high population densities were greatly reduced by the appearance of *D. villosus* (Van Riel et al. 2006b). Further spread into larger, slow-flowing waters seems possible, but has not been observed so far. Colonisation at higher altitudes is rather unlikely.

No special **measures** have been taken so far with regard to alien amphipod species. As these are relatively mobile macroinvertebrates, specific efforts regarding selected species are also likely to fail. However, regular monitoring and improving water protection in general should at least help to slow further spread. Water temperatures will probably continue to rise as a result of climate change, so only measures relating to water quality and preventing spread by humans appear to be possible starting points.

The impact of alien amphipod species on aquatic communities is fairly well studied. However, much less is known about their impact on ecosystem functions, especially their long-term effects.

Fig. 20: Killer shrimp

*The killer shrimp (*Dikerogammarus villosus*) grows up to 30mm in size and displays conspicuous colour polymorphism. It has two distinct dorsal humps (tubercles) on the urosome segments. In larger waterbodies,* D. villosus *is often found together with the zebra mussel.*

Photos: M. Grabowski (left); P. Steinmann (right)

Fig. 21: Caspian mud shrimp

*The Caspian mud shrimp (*Chelicorophium curvispinum*) is a relatively small species (5–8mm). Like all species of the genus* Chelicorophium*, it is easily recognised by the greatly enlarged second antennae and the flattened body. The dense colonies of mud or sand tubes in which it lives change the physical structure of the bottom relief.*

Photos: P. Rey

Decapods

The populations of native decapods are drastically declining due to the spread of invasive alien species. The main reason for this is the crayfish plague, which was transported from the American continent to Europe with the invasive alien species. In Switzerland, there are isolated findings of two alien species, while four invasive species have become established. Three other species live in the immediate vicinity and it is expected that they will spread to Switzerland.

Four native crayfish species of the Astacidae family and four invasive alien species of the families Astacidae and Cambaridae currently occur in Switzerland. All native species are on the Red List and have experienced drastic population declines in recent decades due to the spread of invasive species.

Alien crayfish were imported into Europe as edible crayfish in the 20th century. Other major **import routes** are the aquarium trade and private illegal imports. Many of the introduced species show strong population growth with a corresponding impact on habitat and fauna (reduction of macrophytes, direct and indirect reduction of small animal fauna in waterbodies, competition). Some species display burrowing activity and so can also affect banks and other natural habitat structures. Valuable habitat structures may disappear and infrastructure may be undermined (e.g. dams).

Furthermore, a major problem associated with the spread of invasive crayfish is the **crayfish plague**, a disease caused by the oomycete *Aphanomyces astaci*, which entered Europe with the introduced crayfish species. American crayfish, as well as other decapod crustaceans, can be carriers of the crayfish plague pathogen without contracting it themselves and thus act both as a reservoir and a vector for the disease. The mortality rate among native crayfish is in most cases 100% (depending on pathogen type and size of the waterbody). Of the four invasive alien crayfish species in Switzerland, three originate in North America: spiny-cheek crayfish (*Faxonius limosus*), American signal crayfish (*Pacifastacus leniusculus*) and red swamp crayfish (*Procambarus clarkii*). They pose a constant threat to native crayfish stocks. The signal crayfish in particular is currently spreading very rapidly. The two American species calico crayfish (*Faxonius immunis*) and marbled crayfish (*Procambarus fallax virginalis*), which occur in Baden-Württemberg, pose a threat similar to that posed by the invasive species living in Switzerland. The considerable negative impact of both species on aquatic habitats of various Red List species (including amphibians and dragonflies) has also been documented. It is expected that they will also spread to Switzerland.

All non-native crayfish species have been considered undesirable under federal fisheries legislation since the early 1990s. The import, keeping or use of live individuals in waterbodies, containers or aquariums is only permitted with a permit from the competent federal office. This preventive **regulation** is important, but it has not been enough to prevent the occurrence of invasive species and is not effective against their spread along waterbodies (e.g. signal crayfish in the Three Lakes region and in the Aare). Some cantons implement protection measures for native crayfish populations (crayfish barriers in waterbodies and at fish ladders) and control measures against invasive species populations by draining waterbodies, trapping and introducing predators. Raising awareness about the problem among the general public and user groups at waterbodies (lectures, excursions, media work, leaflets, websites) is also very important. At European level, a number of research projects into the crayfish plague are being conducted (including virulence of pathogen strains and immunity of native species to *A. astaci*).

Fig. 22: Signal crayfish and spiny-cheek crayfish

*Left: The signal crayfish (*Pacifastacus leniusculus*) is currently colonising numerous waters in Switzerland with great success. Right: The spiny-cheek crayfish (*Faxonius limosus*) is found throughout Switzerland..*

Photos: T. Stucki

Fig. 23: Crayfish plague and a possible remedy

Left: Crayfish plague (pathogen: Aphanomyces astaci*) gives American crayfish species a considerable competitive advantage. Right: Crayfish barriers are designed to prevent the spread of invasive crayfish into valuable habitats of native species at selected sites.*

Photos: T. Stucki (left); C. Tesini (right)

Other aquatic invertebrates

Other aquatic invertebrates include alien species of different taxonomic groups such as cnidarians, turbellaria and polychaetes (bristle worms). Ten of these species are established in Switzerland, three of which are considered invasive.

Cnidaria

Two alien species of cnidarians are known in Central Europe: The peach blossom jellyfish (*Craspedacusta sowerbii*) and the freshwater hydroid (*Cordylophora caspia*) came to Central Europe from Western China and the Ponto-Caspian region respectively.

The **peach blossom jellyfish** (*Craspedacusta sowerbii*) originates in the Yangtze Valley in western China (Karaouzas et al. 2015). From there, the species has been able to spread globally aided by humans. It can colonise almost all types of freshwater ecosystem: it inhabits streams, rivers, ponds, lakes and reservoirs (Karaouzas et al. 2015). It is the only freshwater jellyfish in Central Europe (Müller et al. 2018). The sting of *C. sowerbii* can penetrate human skin and cause mild skin irritation (Müller et al. 2018). If environmental conditions are ideal for *C. sowerbii*, mass emergence may occur in warmer seasons (Karaouzas et al. 2015). Mass occurrences can have a negative effect on the number and composition of zooplankton, which in turn can affect the whole food web. However, overall there is still too little data available to make conclusive statements about the impact of *C. sowerbii* on the ecosystem (Schifani et al. 2019).

The **freshwater hydroid** (*Cordylophora caspia*) is a colony-forming brackish water species that attaches itself to hard substrate, such as stones, plant stems and mussel shells (Folino-Rorem & Indelicato 2005). The species is found in coastal areas, but can penetrate far into the mainland and colonise lakes and rivers (Schuchert 2021). *Cordylophora caspia* has settled in Central Europe since the middle of the 19th century, having entered Europe from the Ponto-Caspian region (first recorded in the Netherlands in 1874) (Bij de Vaate et al. 2002). Its distribution was practically global as early as 1924 (Arndt 1989). Ballast water, small boats, water plants (Bij de Vaate et al. 2002) and water birds were the likely vectors. The species colonises not only natural substrates but also structural surfaces such as tunnels, filters and condensers, which become clogged in the event of mass occurrence and have to be cleaned at great expense (Folino-Rorem & Indelicato 2005). Where *C. caspia* occurs en masse, freshwater sponges and triangular mussels may also be displaced (Weiss, undated). In Switzerland, no adverse effects of *Cordylophora caspia* on water drawn from waterbodies have been reported so far. Given the known negative impacts in other countries, it is important to understand more about the distribution of the species in Switzerland.

Turbellaria

Since the beginning of the 20th century, the turbellarian *Girardia tigrina*, which originated in North America, has been spreading in Europe. Since the mid-1990s, the species *Dendrocoelum romanodanubiale* has also migrated from the Danube into the Rhine.

Girardia tigrina (syn. *Dugesia tigrina*) is a species of dugesiid native to North America. It is a predator that feeds on small invertebrates (Ilić et al. 2018) and on carrion (Müller et al. 2018). *G. tigrina* inhabits streams and standing water and often attaches itself to plants (Ilić et al. 2018). *G. tigrina* was first recorded in Europe in Germany and England at the beginning of the 20th century (Stocchino et al. 2019). Since *G. tigrina* attaches itself to plants, it may well have been introduced by aquarists (Oscoz et al. 2010). It is able to establish itself well in foreign territories thanks to its tolerance of unfavourable environmental conditions and its broad food spectrum (Stocchino et al. 2019). *G. tigrina* tends to mass propagate in disturbed waters in particular (Müller et al. 2018). As it is thermophilic, climate warming also has an impact on its spread (Müller et al. 2018). At present, no displacement of native species by *Girardia tigrina* is known in colonised waterbodies.

In Switzerland, ***Dendrocoelum romanodanubiale*** has only been recorded in the Rhine as yet. The species originates in the Ponto-Caspian region and was first recorded on the German stretch of the Danube in 1994 and in the Rhine near Bingen in 1997 (Schleuter & Schleuter 1998). In Switzerland, it seems to occur only in the Rhine. Apart from *Dendrocoelum romanodanubiale*, no other Tricladida species are currently expected in the Rhine and Rhone catchment areas.

Bristle worms

In Switzerland, only *Hypania invalida*, a member of the Ampharetidae family, is known. As it tends to multiply en masse, harm to the environment cannot be excluded.

Hypania invalida is a Ponto-Caspian species originating in Romania, which found its way to Central Europe via the Danube, Rhine and Vistula rivers (Zoric et al. 2011). In the 1950s and 1960s, *H. invalida* was introduced as fish food into the Volga Basin (Zoric et al. 2011), from where it spread westwards. Like many other invasive species, it is carried upstream in the ballast water of ships (Straka et al. 2015). As *H. invalida* has a short generation time, has no food preferences and has a large salinity and temperature tolerance range, it can inhabit a wide range of different habitats (Wozniczka et al. 2011, Zoric et al. 2011). It tends to mass propagate, which results in possible competition for space (Müller et al. 2018).

Arachnids

In many cases very little is known about arachnids; only the number of spider species in Switzerland is known. Eleven alien species are considered established, but none of these species is currently known to be invasive.

The arachnids (Arachnida) of Switzerland essentially comprise the orders spiders (Araneae), daddy long-legs (Opiliones), scorpions (Scorpiones), book scorpions (Pseudoscorpiones) and the subclass mites (Acari). Common to all these is a body organised in two parts, although this is sometimes difficult to see in mites. Alien arachnid species can be unintentionally introduced in travel luggage or packaging. Especially after camping holidays or when bringing in garden items, spiders frequently hitch a ride and are actively or passively released into our country. These animals can usually survive as individuals but cannot reproduce. The scorpion species *Euscorpius flavicaudis* (introduced with luggage) and the Spanish funnel-web spider (*Macrothele calpeiana*; introduced with olive plants) are two such species. However, there are alien species among both spiders and daddy long-legs that are now spreading rapidly. They originate in areas outside Europe (e.g. American dwarf spider *Mermessus trilobatus*) as well as from Southern Europe (e.g. spiny false wolf spider *Zoropsis spinimana*).

The **American dwarf spider** (*Mermessus trilobatus*), which is about 2mm in size, was first recorded in Europe in 1982. Today, just 40 years later, it is widespread throughout Europe and often occurs in large numbers. Its impact on native fauna as a predator and/or competitor should therefore be assumed to be considerable, even though little is formally known about the species as yet.

The **spiny false wolf spider** (*Zoropsis spinimana*) was first recorded for Switzerland in 1994 and is now found in all inhabited areas at lower altitudes. This spider is very large (body length 2,5cm) and becomes sexually mature within a year. Breeding experiments have shown that their prey consumption is vast (Hänggi & Zürcher 2013). Findings from bird nesting boxes indicate that the species also occurs outside of human settlements. A further problem is that its bite can penetrate human skin. Although the bite is only comparable to that of a mosquito, spiders have a great potential to frighten people, which may trigger the need for doctors' appointments.

Generally, **very little is known about this species group** as yet. Mites, daddy long-legs and book scorpions are not even recorded in the national data and information centres (InfoSpecies). Much more information and data is required to gain a more complete picture of alien arachnids.

Fig. 24: *Mermessus trilobatus*, male (left) and *Zoropsis spinimana*, female (right)

Photos: P. Oger (left), H. Höfer (right)

Lepidoptera

More than 50 species of alien Lepidoptera have already been found in Switzerland, of which about half (21) are currently established. Alien Lepidoptera are generally introduced accidentally with their host plants or stored foodstuffs, and they are mainly found in anthropised environments. The box tree moth and the horse-chestnut leafminer are considered invasive.

At present, more than 50 species have certainly or probably been introduced into Switzerland by human activities, including many Gracillaridae and Pyralidae. In the vast majority of cases, these are unintentional **introductions**, resulting from imports of ornamental or cultivated plants (e.g. the Oriental fruit moth *Grapholita molesta* or the South American tomato leafminer *Tuta absoluta*) or of foodstuffs and stored goods (e.g. some synanthropic species, such as the Indianmeal moth *Plodia interpunctella* or the common clothes moth *Tineola bisselliella*). There are exceptions, however, including some particularly notable species that have escaped from farms (ailanthus silkmoth *Samia cynthia*, used in silk farming) or that have been voluntarily introduced (e.g. the Spanish moon moth *Graellsia isabellae* and the southern swallowtail *Papilio alexanor*).

There are 21 alien species that have become **established** in Switzerland. Most of the alien Lepidoptera species seem to become established in environments that have been strongly influenced by humans (crops and orchards, urban parks, dwellings, etc.) and few colonise natural environments. While their economic impact can be significant, their ecological impact remains largely unknown.

The **box tree moth** (*Cydalima perspectalis*), of Asian origin, has been present in Switzerland since at least 2007 (Leuthardt et al. 2010). It has rapidly invaded lowland areas where its caterpillars feed exclusively on boxwood (*Buxus sempervirens*). The damage to both cultivated and wild boxwood is spectacular, to the extent that box is disappearing from gardens and there are fears for its survival and that of related species. In Europe, more than 60 species of insects and fungi have been recorded on boxwood alone (Mitchell et al. 2018).

First reported in Switzerland in 1998 (Kenis & Forster 1998), the **horse-chestnut leafminer** (*Cameraria ohridella*) causes severe defoliation of horse chestnuts (*Aesculus hippocastanum*) in cities and urban parks, but also occasionally attacks sycamore maple (*Acer pseudoplatanus*) (Péré et al. 2010a). In addition, the presence of the horse-chestnut leafminer seems to have a negative effect locally on the abundance of some native leaf miners (Péré et al. 2010b).

Fig. 25: Indianmeal moth

*Virtually cosmopolitan, the Indianmeal moth (*Plodia interpunctella*) is frequently found in homes, where it attacks foodstuffs in particular.*

Photo: R. Bryner

Fig. 26: Box tree moth

*The box tree moth (*Cydalima perspectalis*) is easily recognisable. Its caterpillars can completely defoliate box trees.*

Photo: R. Bryner

Fig. 27: Horse-chestnut leafminer

*The horse-chestnut leafminer (*Cameraria ohridella*) causes significant damage to horse-chestnut trees planted in urban areas but also attacks the sycamore maple.*

Photo: R. Bryner

Beetles

There are 102 alien beetle species that have become established in Switzerland. Although their environmental or economic impacts are often still poorly understood, some beetles are particularly feared, such as the Asian long-horned beetle, which was eradicated in Switzerland in 2019, or the Japanese beetle. The Plant Health Ordinance (PHO) requires mandatory control measures for both species. In total, 11 species of beetles are listed as invasive alien species.

More than 260 beetle species have been found at least once on Swiss territory and their alien origin attested or considered probable. Most of these species arrived in Switzerland accidentally, mainly via imports and movements of cultivated or ornamental plants, such as the Portuguese firefly *Luciola lusitanica*, or via stored goods, such as the sawtoothed grain beetle *Oryzaephilus surinamensis*. International transport of sawn or cut timber and the use of wooden packaging and pallets have also led to a large number of the introductions recorded, the Asian long-horned beetle *Anoplophora glabripennis* being a good example.

There are more than 100 alien beetle species that have become **established** in Switzerland. Their economic and environmental impacts are still too often unknown, especially in the case of less dramatic species and/or species that develop in decomposing plant materials (compost, litter, etc.), as is the case for many Latridiidae (minute brown scavenger beetles), Hydrophilidae (water scavenger beetles) and Staphylinidae (rove beetles).

However, some alien beetles are particularly feared in agriculture and forestry, especially for the economic losses they can cause. This is the case of the **Asian long-horned beetle** (*Anoplophora glabripennis*), which has been eradicated in Switzerland since 2019. The larva of this Asian long-horned beetle attacks healthy trees of many hardwood species, mainly in urban areas. The **Japanese beetle** (*Popillia japonica*) is a newcomer to southern Ticino. The adults cause damage by eating the leaves, flowers and fruits of a wide range of plants, both wild and cultivated, while the larvae attack the roots. Significant resources have been committed to combating these species, both in Switzerland and in Europe. The example of the Asian

long-horned beetle (*Anoplophora glabripennis*) shows that with the right tools (early detection of infestation, control strategies, etc.) the establishment of certain species can be prevented.

For other species, on the other hand, it is probably too late and no further action can be taken to prevent their expansion. This is the case of the **harlequin ladybird** (*Harmonia axyridis*), a ladybird voluntarily introduced into Europe for biological control of aphids (Brown et al. 2008). First detected in Switzerland in 2004 (Klausnitzer 2004), it is now widespread throughout the country. Highly competitive and polyphagous, it has adverse effects on some native ladybirds, through competition and predation (Kenis et al. 2010, Roy et al. 2012). In Switzerland, it is responsible for the decline of at least one species, the two-spot ladybird (*Adalia bipunctata*) (Kenis et al. 2020).

Fig. 28: Asian long-horned beetle

*The larva of the Asian long-horned beetle (*Anoplophora glabripennis*) develops in various healthy deciduous trees. Upon emergence from the wood, the adult leaves a characteristic cylindrical hole.*

Photo: D. Hölling

Fig. 29: Japanese beetle

*The Japanese beetle (*Popillia japonica*) was first caught in June 2017 in the south of Ticino.*

Photo: Agroscope, M. Waldburger

Fig. 30: Harlequin ladybird

*The harlequin ladybird (*Harmonia axyridis*) displays an exceptionally wide range of colours, and sometimes congregates in large numbers near houses, especially before overwintering.*

Photo: Agroscope, M. Waldburger

Other terrestrial invertebrates

The group of other terrestrial invertebrates includes various lesser-known systematic groups. In some cases, these belong to the most species-rich groups and also make up a large proportion of the alien fauna. This group comprises a total of 193 established alien species, 13 of which are considered invasive. Some of the groups are presented in more detail below.

Diptera
There are currently 35 alien species of the Diptera order established in Switzerland. Diptera are typically divided into the two sub-orders mosquitoes and flies.

The best-known representative of the alien and invasive mosquitoes is the **Asian tiger mosquito** (*Aedes albopictus*). Originating in Southeast Asia, it colonised the whole world within a few decades thanks to the trade in used tyres. In Switzerland, the Asian tiger mosquito is mainly distributed in the canton of Ticino and in the Italian-speaking part of Graubünden. It has also been found in isolated cases north of the Alps, particularly along transport routes.[16] Unlike native mosquito species, the Asian tiger mosquito also bites during the day and sometimes occurs in swarms, which makes it a particular nuisance. However, it is known and feared mainly because it can transmit disease. Its spread has therefore been closely monitored since it was first observed in Switzerland (in 2003 in Ticino). All members of the public can help to stop the spread of the Asian tiger mosquito by emptying all vessels containing standing water (for example rainwater or irrigation water). It is also important to know that no danger is posed by flowing water, ponds or biotopes.

There are also well-known, established alien fly species in Switzerland. These include the **spotted wing drosophila** (*Drosophila suzukii),* a fruit fly first detected in Ticino in 2011 which has spread almost everywhere in Switzerland at lower altitudes. The species causes problems in agriculture because it attacks the healthy fruit of a large number of host plants, making them inedible. Recent studies indicate that the spotted wing drosophila is also likely to cause ecological damage in the environment.[17]

Hymenoptera
There are currently 25 species in the hymenoptera order on the list of alien species established in Switzerland. These include species of bee, wasp and ant, but also a number of other extremely small, diverse and little-known groups.

The **Asian hornet** (Vespa *velutina nigrithorax*) causes particular concern to beekeepers. It has become widespread, especially in France and increasingly in Germany and Italy. It is therefore to be expected that it will also increasingly colonise Switzerland in the coming years, especially at lower altitudes. The Asian hornet was first detected in Switzerland in 2017. Since then, there have been individual recordings of the species in several cantons.

Ants are also frequently a cause for concern, especially when they appear in large numbers in buildings. Currently, the species of the *Tapinoma nigerrimum* complex are attracting attention because they appear in large numbers, bite people and can become rampant in populated areas. Originally from the Mediterranean region, it was almost certainly introduced with potted plants and has appeared in several cantons in recent years. Despite increased research, no effective control measure has yet been found.

Hemiptera
The Hemiptera order includes Sternorrhyncha (lice), Auchenorrhyncha (cicadas) and Heteroptera ('true bugs'). Ninety-two established alien species are known.

There are some species of **Heteroptera** that are also commonly known. In the colder months of the year, the western conifer seed bug (*Leptoglossus occidentalis*) and the brown marmorated stink bug (*Halyomorpha halys*) are now frequently found indoors seeking shelter from the cold outside. The brown marmorated stink bug originates in East Asia and has been found in Switzerland on both sides of the Alps since 2004. It is considered a major pest, especially in agriculture, as it attacks a wide range of different plants such as fruit trees, berries, vegetables, maize, soya and vines; this makes it particularly difficult to control.

16 *www.swisstph.ch/en/topics/asian-tiger-mosquito*

17 *www.wsl.ch/en/newsseiten/08/the-spotted-wing-drosophila-also-a-major-forest-pest.html#tabelement1-tab2*

Gastropods

Besides the various insect groups, other invertebrate species include terrestrial molluscs, of which there are 13 established alien species. Gastropods (slugs and snails) are often hermaphrodites, which may facilitate their ability to spread.

Cornu aspersum, the **common garden snail**, is the smaller relative of the native Roman snail (*Helix pomatia*). It originates in the Mediterranean region (Southern Europe, North Africa) and is therefore rarely found at over 1000 m. a. s. l. The species was bred and kept for food in many places. Through intentional and unintentional introduction, it has been able to spread outside its natural range and can now be found in all regions of Switzerland. The common garden snail is mainly found in gardens and greenhouses, where it is considered a pest.

Arion vulgaris, the **Spanish slug**, is an invasive species. It is believed to have originated in western France or Spain. The species was first observed in Leimern (BE) in 1955 and has since spread throughout Switzerland. The species was unintentionally introduced with contaminated soil material from ornamental and garden plants. It is an economically relevant pest in agriculture as well as in gardens. The fact that the Spanish slug can form hybrids with native species makes species identification difficult, except by means of genetics. This makes it virtually impossible to take targeted action against this invasive species.

The group of other terrestrial invertebrates includes – besides the examples described above – alien species in other taxonomic groups, for example cockroaches and termites (Blattodea), barklice (Psocoptera) and flatworms (Plathelminthes), which are not discussed in detail here.

The list of alien terrestrial invertebrates is far from complete. Often, too little is known about entire species groups to be able to make any statements at all about the group or the alien species present.

Fish and cyclostomes

There are currently 20 alien species of fish established in Switzerland with many more species on our doorstep that could colonise Swiss waters very quickly. Some of these species, particularly those that have recently proliferated such as gobies, are likely to have a considerable impact on the environment. In total, 17 alien fish species are considered invasive.

The **popularity of fishing** has led to the introduction of many non-native species into Swiss waters. These are the brook trout (*Salvelinus fontinalis*) and the Canadian lake trout (*Salvelinus namaycush*). Their introduction into closed environments has been legally authorised. The rainbow trout (*Oncorhynchus mykiss*) was once widely introduced into Swiss rivers because it was wrongly assumed that it would not reproduce there. The sander (*Sander lucioperca*), whose introduction is only possible in sites with well-defined characteristics, and the largemouth black bass (*Micropterus salmoides*), whose introduction into Swiss waters is prohibited, as is the case for all the other species listed in Annex 3 of the Ordinance to the Federal Act on Fish (FishO).

The presence of some of these non-native species are fish for **aquariums** that were introduced deliberately or unintentionally or fish accidentally contained in batches of fish imported as bait for fishing, including goldfish (*Carassius auratus*), Prussian carp (*Carassius gibelio*), European three-spined stickleback (*Gasterosteus aculeatus*), pumpkinseed (*Lepomis gibbosus*), stone moroko (*Pseudorasbora parva*) and black bullhead catfish (*Ameiurus melas*). The large-scale Asian loach *Paramisgurnus dabryanus*, which only occupies a closed waterbody but not open water, was probably introduced by an aquarium owner. Although reproducing successfully, the expansion of this loach remains unlikely.

Other species have colonised Swiss waters by migration through **new artificial waterways** and introductions, such as the asp (*Aspius aspius*) or by fluvial transport and trade, particularly barge ballast tanks, such as the Kessler's goby (*Ponticola kessleri*) and the round goby (*Neogobius melanostomus*). As the latter two species are highly invasive and prolific, there is a risk of their widespread dissemination throughout the Swiss Rhine basin.

Of the 20 alien fish species, the non-native status of the crucian carp (*Carassius carassius*) remains a matter of debate, as its natural range borders on Swiss territory in the Rhine downstream of Basel. In contrast, this carp is clearly a non-native species in the Rhone and Po basins, where it has been introduced, probably deliberately, as it is valued as bait for recreational fishing.

Some non-native species, such as Asian carp (*Ctenopharyngodon idella*, *Hypophthalmichthys molitrix* and *H. nobilis*) could well vanish since our latitudes are not conducive to their reproduction. These species were voluntarily introduced to combat the proliferation of invasive aquatic vegetation in the 1970s. The likelihood of their near disappearance is welcome because these species can proliferate exponentially in favourable environmental conditions.

It should be noted that none of these non-native species are actually cyclostomes; they are exclusively fish.

Fig. 31: Round goby (*Neogobius melanostomus*)

Photo: B. Zaugg

Amphibia

The Italian pool frog and species of the lake frog group are established and considered invasive in Switzerland. Another invasive alien amphibian species, the American bullfrog, may well be found in Switzerland in future.

Invasive amphibians were either deliberately released or were introduced for frog leg production and research and later escaped. Many species were introduced from Eastern Europe. When these species were first identified in Switzerland, they were still considered an enrichment of the native fauna.

The **water frogs** of the genus *Pelophylax* are among the best-known amphibian species in Switzerland, as they stage the well-known frog concerts at ponds in spring and summer. That fact that several invasive species live alongside native species in Switzerland is less well known. It is difficult to differentiate between species based on their calls and appearance, even for specialists. It is further complicated by the fact that the native species form a hybrid complex, and this also forms hybrids with the invasive species.

Water frogs are relatively large amphibians and are happy to eat smaller amphibians; notably, juvenile water frogs avoid waterbodies inhabited by adults. Invasive water frogs have a negative impact on populations of native amphibian species inhabiting the same habitats. In Aargau, it has been shown that populations of native species are reduced by 50% to 90% by the presence of invasive water frogs.

Control of invasive water frogs is difficult because of their similar appearance, hybridisation and the complex genetics of the hybridogenetic mode of reproduction. However, it is possible to design new waterbodies in such a way that they are less attractive for these invasive species.

The **American bullfrog** (*Rana catesbeiana*) is a particularly large amphibian species that can reach a head-torso length of up to 20 centimetres. There have been indications that the American bullfrog is present in Switzerland, but these have not yet been confirmed.[18] Because of its size and the fact that it eats everything it can overpower, the American bullfrog poses a particular threat to other amphibian species that share its habitat.

Fig. 32: Water frog of the genus *Pelophylax*

Photo: A. Meyer

18 CSCF Nouvelles No 28 / hiver 2004/05: *www.unine.ch/files/live/sites/karch/files/Doc_a_telecharger/News/NEWS28.pdf*

Reptiles

Alien reptile species are very rarely observed in Switzerland, with the exception of aquatic turtles. A total of 10 alien reptile species have currently been detected in Switzerland, of which 4 can be considered invasive.

Few alien reptile species have been introduced and almost none have become established in Switzerland. The best known of the alien reptile species introduced into Switzerland is the **red-eared slider** (*Trachemys scripta elegans*), which is considered one of the 100 most damaging invasive species in the world (Lowe et al. 2004). This species, as well as many other aquatic turtles, are released by private individuals when they become too large. Locally, they can form large populations.

Currently, red-eared sliders and all other aquatic turtles have a limited **impact** on the only native aquatic turtle species, the European pond turtle (*Emys orbicularis*), as it has a small range in Switzerland. Moreover, alien turtles do not yet seem to breed every year in our country; however, as summer temperatures steadily rise, an increasing number of hatchlings will hatch, leading to a much greater likelihood that these species will persist in the coming decades. The presence of alien aquatic turtles in Switzerland could be reduced or even eliminated through specific control by capturing the adults and destroying the eggs before they hatch. These measures must be rapid and effective before it is too late once global warming inevitably increases the turtles' reproductive success.

The problem with reptiles is more complex, however, since individuals of several native species were displaced and introduced outside their natural range up to the middle of the last century, leading to the creation of many viable populations. Some of these populations have a considerable impact on other native species.

Fig. 33: European pond turtle and red-eared slider

Only one species of aquatic turtle is indigenous to Switzerland: the European pond turtle (left). However, other species, such as the red-eared slider (right), are often observed in waterbodies.

Birds

For centuries, exotic bird species have been imported, kept in aviaries and bred. Escape was common, and still is to this day. There have also been repeated attempts to introduce so-called 'ornamental poultry' to enrich the local fauna in the open. Foreign species of hen in particular were released as game. Twenty-three alien bird species are established in Switzerland, of which eleven are considered invasive.

In Switzerland, 408 wild bird species have been recorded so far, of which 163 were released from captivity. But it is often difficult to decide whether a bird species originates in captivity and is alien or not. Some migratory birds that are able to fly several hundreds of kilometres reach us under their own power. Even species arriving from Siberia or North America are then not considered alien. Breeding areas can also naturally expand, even across continents. The danger then soon arises that native species are classified as alien. For example, the cormorant is still sometimes wrongly described as an alien species. There are also species that regularly occur in Switzerland as migratory birds and winter visitors – i.e. are considered native – but whose breeding populations in Switzerland originate from escaped individuals or from deliberately introduced species. Examples of this are the mute swan and the greylag goose, which are considered native in our country according to the Hunting Act. Feral pigeons and common pheasants, however, are not considered as part of the native fauna since they originate from domestic and carrier pigeons or were released as game.

Mandarin ducks (*Aix galericulata*) and parakeets, for example, are usually seen as an enrichment because of their bright colours. But alien bird species can hybridise with native species or compete with them for food, breeding sites and habitats. Even inconspicuous bird species can thus become a threat. The most prominent example is the **ruddy duck** (*Oxyura jamaicensis*), native to North America, which came into contact with the highly endangered white-headed duck (*Oxyura leucocephala*) in Spain. The females found the males of their black-headed fellow species all too attractive. The resulting hybridisation seriously endangered the white-headed duck, which was already very rare. A Europe-wide action plan to combat the ruddy duck became necessary;[19] they are also shot in this country as part of this action plan.

In Switzerland, 225 native and at least 21 alien bird species – almost 10% of the total – are known to breed in the wild. Not all exotic species succeed in making the step from individual broods to fully established populations. In Switzerland, this has been achieved by the common pheasant (*Phasianus colchicus*), the mandarin duck, the Egyptian goose (*Alopochen aegyptiacus*) and the ruddy shelduck (*Tadorna ferruginea*). Now it is becoming increasingly evident that **conflicts** with native species can occur. The ruddy shelduck can drive barn owls (*Tyto alba*) and common kestrels (*Falco tinnunculus*) out of nest holes with too large openings. Their triumphant march through Central Europe started in Switzerland, and now the white-cheeked pintail (*Anas bahamensis*) threatens to do the same, the first European broods having been recorded in the Geneva area. Unless something is undertaken, the barnacle goose (*Branta leucopsis*), Canada goose (*Branta canadensis*), rose-ringed parakeet (*Psittacula krameri*) and vinous-throated parrotbill (*Sinosuthora webbiana*) could soon become permanent residents; meanwhile, the African sacred ibis (*Threskiornis aethiopicus*) is already knocking at Switzerland's southern border. Precautions should be taken to avert this potential threat to our native species in time. Compared to other species, this is comparatively easy with birds. However, unless our neighbouring countries take the same stance, containing such species in our country will be a costly, ongoing task.

19 *www.rm.coe.int/2020-rec-209e-ruddy-duck/1680a09aca*

Fig. 34: A burst of colour

Rose-ringed parakeet (top left), mandarin duck (top right), Egyptian goose (middle right) and ruddy shelduck (bottom).

Photos: S. Werner

Mammals

*Nine alien mammal species are established in Switzerland, eight of which are considered invasive. Two other species (*Sciurus carolinensis, Callosciurus erythraeus*) are present in the neighbouring region, but have never been observed on Swiss territory. The presence of these species in Switzerland is mainly due to the arrival of individuals dispersing from populations in neighbouring countries. To date, most of these species do not cause significant economic or ecological damage in Switzerland.*

Of the 69 species of terrestrial mammals currently known in Switzerland, 10 are considered alien. With the exception of the Siberian chipmunk (*Tamias sibiricus*) and the fallow deer (*Dama dama*), all these species have appeared in Switzerland as a result of colonisation from neighbouring countries. There are no fallow deer populations in the wild in Switzerland. As fallow deer can be hunted, the few isolated individuals that escape from enclosures are usually soon shot. The Swiss population of the European mouflon (*Ovis gmelini musimon*) is confined to the Chablais region in Valais, with an estimated population of about two hundred individuals. The population of these mountain sheep, which can be hunted, is regulated by shooting individuals. With the exception of the European mouflon and the fallow deer, all other species are considered invasive.

The **sika deer** (*Cervus nippon*) is only found in Switzerland north of the Rhine in the cantons of Schaffhausen and Zurich. The species may be hunted with an annual kill count fluctuating within a range of 100 to 150 animals for an estimated 250 individuals.

The **raccoon dog** (*Nyctereutes procyonoides*) is native to eastern Asia. The species was introduced to western Russia in the 1940s and 1950s, and spread quite rapidly to the west. The first raccoon dog seen in Switzerland in 1997 was found dead as roadkill near Leuggern AG. About 30 sightings have been recorded since then until 2019, but there is no evidence of breeding. The species may be hunted in Switzerland. It is a potential vector of rabies and scabies.

The **raccoon** (*Procyon lotor*) originates in North America. The species has been reported in Switzerland since the 1970s. These raccoons came from Germany, where the species had been present since the 1930s. Since then, the species has been observed in most parts of Switzerland, with the exception of the southern and south-eastern regions. In 2020, the first evidence of breeding was recorded in the canton of Aargau, but the population remains at a very low level. The species may be hunted in Switzerland. It is a potential vector of rabies and distemper.

The **brown rat** (*Rattus norvegicus*), which originates in Asia, appeared in Europe at the time of the Industrial Revolution. It has been reported in Switzerland since the beginning of the 19th century and mainly colonises the urbanised areas of the lowland regions situated on the banks of lakes or along large rivers. The species is declining in Switzerland as a result of rodent control and the disappearance of open dumps. The species can transmit several zoonoses and diseases.

The **coypu** (*Myocastor coypus*) originates in South America. Towards the end of the 19th century, it was introduced into France and Germany for fur farming. Many individuals escaped and gave rise to the populations present in Europe today. The first sightings in Switzerland date back to the 1950s. Today the coypu is sporadically observed in Ajoie, in the Geneva basin; towards Basel, along the Rhine; and more recently in Bolle di Magadino in Ticino. However, these animals are fairly systematically eliminated to prevent their spread in Switzerland. Coypu can degrade and undermine riverbanks. They can also carry diseases that are transmissible to humans, such as leptospirosis.

The **muskrat** (*Ondatra zibethicus*) originates in North America. The species was introduced into Eastern Europe (Czech Republic) at the beginning of the 20th century and later into other European countries for fur farming. In the 1930s, several hundred individuals escaped from a breeding farm in the Belfort region and gave rise to the population in Switzerland, where they settled from the 1980s. The species is now present in Ajoie, on the Birs, the Rhine up to Chur and on the Aare up to Olten. Like the coypu, the muskrat can degrade and undermine riverbanks and can transmit leptospirosis.

The **eastern cottontail** (*Sylvilagus floridanus*) originates in North America. It can quite easily be confused with the wild rabbit. Its presence in Europe is mainly due to introductions. Observed in Switzerland since the 2010s, the only known population of the species is found inthe southern part of the Ticino in the Mendrisiotto. The eastern cottontail can carry several diseases that are transmissible to other lagomorphs, such as pseudotuberculosis, and it can resist myxomatosis while carrying this disease.

In the case of the **Siberian chipmunk** (*Tamias sibiricus*), only the canton of Geneva is home to a few small populations, located in the large parks on the right bank of Lake Geneva.

Fig. 35: Raccoon and coypu

Raccoon (left); coypu (compared to the beaver, the coypu can be recognised by bright white, long whiskers, and an elongated, round tail) (right).

Photos: S. Hummel (left); J. Gilliéron (right)

Glossary

Archaeophytes
Alien plant species introduced by humans, intentionally or unintentionally, before 1492 (discovery of America), which were able to establish themselves in an area where they did not occur naturally.

Alien species
Plants, animals or other species introduced by human activity into habitats outside their natural range.[20]

Colour polymorphism
The occurrence of different colourations of the external appearance of an animal species. A number of factors (for example food supply) can lead to a different appearance within the same species.

Cosmopolitan
Which has a very wide geographical distribution, almost worldwide.

Established
Used to describe those alien species that exist in the wild without human intervention, reproduce regularly and are thus not dependent on repeated release.

Generalists
Animals that do not have a high degree of specialisation in terms of environmental requirements. For example, generalists can tolerate major fluctuations in temperature, changes in food supply, or habitat pollution.

Hermaphrodite
An individual that has both male and female gametes or sex organs. Both sexual organs can occur at the same time (hermaphroditism) or the individual forms the different sexual organs one after the other (dichogamy). In dichogamy, a distinction can be made as to whether the individual is first male and then female (proterandry, considerably more common among animals) or first female and then male (proterogyny).

Halieutics
The practice of fishing.

Horizon scanning
Structured process of systematically identifying emerging species that could be of high relevance for the environment.[21]

Host
In a parasitic relationship, the organism exploited by the parasite.

Hybridogenesis
A form of hybridisation observed in water frogs of the genus *Pelophylax* whereby half of the genome is eliminated during the formation of eggs and sperm.

Invasive alien species
Those alien species that are known or must be assumed ('potentially invasive') to be able to impair biological diversity, ecosystem services and their sustainable use or to endanger human beings and the environment by spreading in Switzerland.

Macroinvertebrates
Invertebrates that live in freshwater and are visible with a magnifying glass or to the naked eye. Collective term for snails, worms, insect larvae, crustaceans and other groups of organisms.

Mycorrhizal fungi
Fungi that grow in symbiosis with plants and exchange nutrients with them.

Native species
Species whose natural range in the past or present is wholly or partly in Switzerland.

20 The scope of the Release Ordinance (RO; SR814.911) covers alien organisms whose natural range is neither in Switzerland nor in the other EFTA or EU member states (excluding overseas territories), and which have not been bred for use in agriculture or horticulture in such a way that their ability to survive in nature is reduced (cf. Art. 3 para. 1 let. f RO).

21 Adapted from: *www.umweltbundesamt.de/horizon-scanning-trendanalyse*

Neophytes
Alien plant species introduced by humans, intentionally or unintentionally, after 1492 (discovery of America), which were able to establish themselves in an area where they did not occur naturally.

Omnivore
Animal that ingests a range of different organic substances and therefore cannot be clearly classified as a carnivore, herbivore or detritivore.

Ophiophagus
Feeding or alimentary behaviour of animals which hunt and eat snakes.

Parasite
Organism that lives on/in other living organisms and obtains nutrients from them.

Persistent
Describes individuals of an alien species that survive in the wild without reproducing.

Phytophagus
Feeding on plants.

Polyphagous
Feeding on a range of different foods.

Rhizome
A continuously growing horizontal underground stem system of lateral shoots, nodes and short internodes for the purposes of substance storage, overwintering and vegetative reproduction.

Saprobiontic fungi
Organisms that feed on dead organic material such as wood or litterfall.

Subspontaneous
Describes alien species that sometimes reproduce in the wild, but are transient, i.e. they rely on repeated release.

Synanthrope
Animal that lives in close association with people and benefits from their surroundings and activities. Species that occur exclusively in a human environment are eusynanthropic, and species that find the optimal conditions in a human environment are hemisynanthropic.

Thermophilic
Describes organisms that thrive in warm temperatures.

Urosome
The last three body segments on the abdomen of amphipods, each with a pair of uropods (jumping legs).

Virulent (of pathogens)
Contagious or harmful.

Zoonosis
Naturally occurring infectious disease that can be transmitted between vertebrates and humans.

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Appendix

List of invasive alien species in Switzerland

Status as of 2021[22]

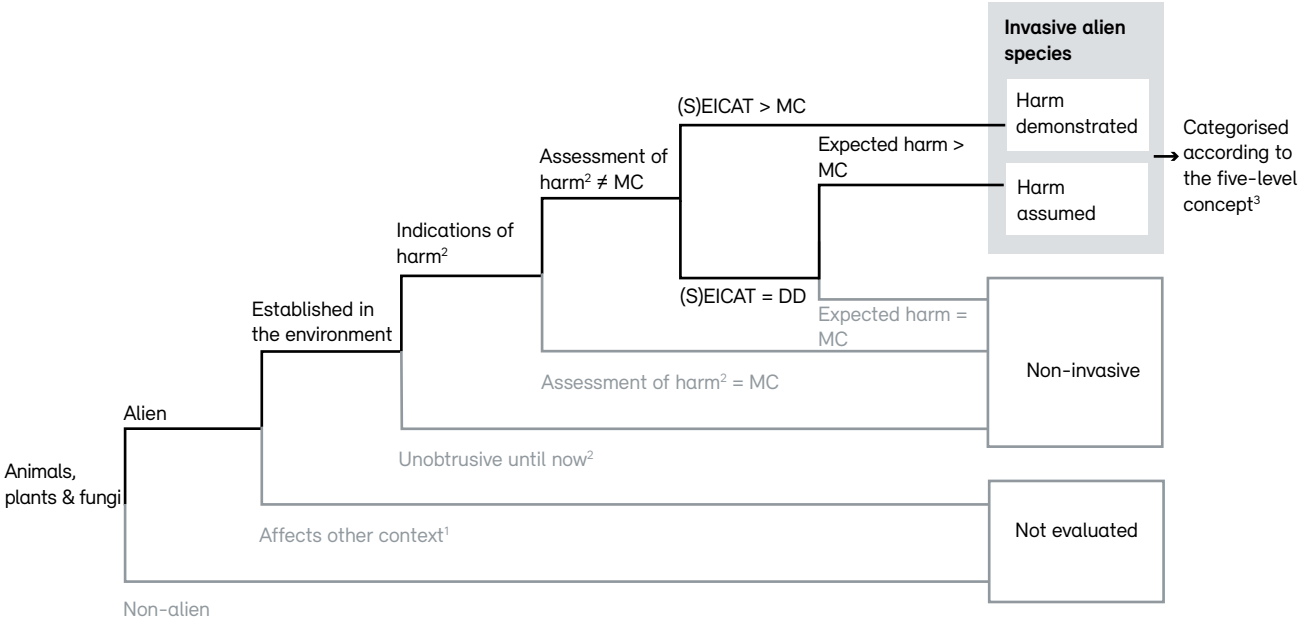
Approach

Of the alien animals, plants and fungi established in the environment, those species are taken into account for which there are indications of harm to protected natural resources as mentioned in environmental protection legislation (Fig. 36). Meanwhile, in the interests of proceeding efficiently, species for which no evidence of harm is known so far are not further assessed (= unobtrusive to the environment until now). The assessment of harm is based on the international EICAT classification system (for ecological impacts, see IUCN 2020; Blackburn et al. 2014) or SEICAT (for socio-economic impacts, see Bacher et al. 2018).

All species whose impacts on human well-being and the environment are classified as greater than Minimal Concern (MC) according to (S)EICAT are included on the following list as species that are known to cause harm (first part of the list). However, species classified as Minimal Concern may be considered a 'nuisance' but are not on the list of invasive alien species. Also not included on the list of invasive alien species are species that are established in the wild but which cause harm less to the environment (natural resources under environmental protection legislation) than to otherwise regulated resources such as production areas in agriculture and forestry. Should it become apparent that these species also cause significant harm in the environment, a reassessment would be carried out – as is the case with species that have so far been considered.

Fig. 36: Schematic representation of the selection process for compiling the list of invasive alien species

((S)EICAT: MC = Minimal Concern; DD = Data Deficient)



1 Organisms harmful to agricultural or ornamental plants, species that can only thrive in hothouses or indoors, animal pathogens exclusively affecting farm animals, ...;
2 Concerning protected natural resources as defined by environmental protection legislation (human well-being & environment);
3 Subject to requirements under special legislation (e.g. Plant Health Ordinance PHO, Epizootic Diseases Ordinance EzDO).

22 Aktualisierung unter *www.bafu.admin.ch > Thema Biodiversität > Fachinformationen > Artenmanagement > Gebietsfremde Arten*

For some species, the data basis for a (S)EICAT classification is not (yet) sufficient ((S)EICAT = Data Deficient [DD]), but harm by the species can be assumed (expected harm > MC).

In the list of invasive alien species below, these species are categorised in the second part as species that are assumed to be harmful.

Species list

1. Species that are known to be harmful to the environment*

**Harm caused to protected natural resources as defined by environmental protection legislation; species that cause harm solely in production areas e.g. agriculture and forestry are not recorded here (see e.g. PHO, EzDO).*

	Scientific name	Common name
Animals		
Mammals	*Cervus nippon*	Sika deer
	Myocastor coypus	Coypu
	Nyctereutes procyonoides	Raccoon dog
	Ondatra zibethicus	Muskrat
	Procyon lotor	Common raccoon
	Rattus norvegicus	Brown rat
	Sylvilagus floridanus	Eastern cottontail
	Tamias sibiricus	Siberian chipmunk
Birds	*Alepochen aegyptiaca*	Egyptian goose
	Branta canadensis	Canada goose
	Branta leucopsis	White-cheeked Goose
	Cairina moschata	Muscovy duck
	Cygnus atratus	Black swan
	Oxyura jamaicensis	Ruddy duck
	Psittacula krameri	Rose-ringed parakeet
	Tadorna ferruginea	Ruddy shelduck
	Threskiornis aethiopicus	African sacred ibis
Reptiles	*Trachemys scripta*	Red-eared slider, yellow-bellied slider, Cumberland slider
Amphibians	*Pelophylax bergeri*	Italian pool frog
	Pelophylax ridibundus aggr. *(P. ridibundus, P. bedriagae, P. kurtmuelleri)*	Marsh frogs
Fish	*Carassius auratus*	Goldfish
	Carassius auratus	Goldfish
	Carassius gibelio	Prussian carp
	Ctenopharyngodon idella	Grass carp
	Hypophthalmichthys molitrix	Silver carp
	Hypophthalmichthys nobilis (syn. *Aristichthys nobilis*)	Spotted tolstolob
	Lepomis gibbosus	Sunfish
	Micropterus salmoides	Largemouth black bass
	Neogobius melanostomus	Round goby
	Oncorhynchus mykiss	Rainbow trout
	Ponticola kessleri	Kessler's goby
	Pseudorasbora parva	Stone moroko
	Salvelinus fontinalis	Brook trout
	Salvelinus namaycush	Canadian lake trout
	Sander lucioperca	Sander

	Scientific name	Common name
Insects	*Aedes albopictus*	Asian tiger mosquito
	Cydalima perspectalis	Box tree moth
	Dryocosmus kuriphilus	Chestnut gall wasp
	Harmonia axyridis	Harlequin ladybird
	Lasius neglectus	–
	Popillia japonica	Japanese beetle
	Tapinoma nigerrimum aggr.	–
	Vespa velutina	Asian hornet
Large crustaceans	*Astacus leptodactylus*	Galician crayfish
	Faxonius limosus	Spinycheek crayfish
	Pacifastacus leniusculus	Signal crayfish
	Procambarus clarkii	Red swamp crayfish
Small crustaceans	*Chelicorophium curvispinum*	Caspian mud shrimp
	Dikerogammarus villosus	Killer shrimp
	Hemimysis anomala	Bloody-red shrimp
Molluscs	*Arion vulgaris*	Spanish slug
	Corbicula fluminea	Asian clam
	Dreissena bugensis	Quagga mussel
	Dreissena polymorpha	Zebra mussel
	Sinanodonta woodiana	Chinese pond mussel
Plants		
Mosses	*Campylopus introflexus*	Heath swan-neck moss
Vascular plants	*Acacia dealbata*	Mimosa
	Ailanthus altissima	Tree of heaven
	Ambrosia artemisiifolia	Common ragweed
	Amorpha fruticosa	Bastard indigo bush
	Artemisia verlotiorum	Chinese mugwort
	Asclepias syriaca	Common milkweed
	Aster novi-belgii aggr. *Aster ×salignus* *Aster ×versicolor* *Aster lanceolatus* *Aster novi-belgii* *Aster parviflorus*	New York aster Common Michaelmas daisy Late Michaelmas daisy Narrow-leaved Michaelmas daisy New York aster Tradescant's aster
	Broussonetia papyrifera	Paper mulberry
	Buddleja davidii	Butterfly bush
	Bunias orientalis	Turkish rocket
	Celastrus orbiculatus	Asian bittersweet
	Cornus sericea	Red-osier dogwood
	Cotoneaster horizontalis	Jerusalem cherry
	Elodea canadensis	Canadian waterweed
	Elodea nuttallii	Nuttall's waterweed
	Erigeron annuus	Annual fleabane
	Galega officinalis	Goat's rue
	Glyceria striata	Fowl mannagrass
	Helianthus tuberosus	Jerusalem artichoke

	Scientific name	Common name
Vascular plants	*Heracleum mantegazzianum*	Giant hogweed
	Impatiens glandulifera	Himalayan balsam
	Lagarosiphon major	Curly waterweed
	Lonicera henryi	Vine honeysuckle
	Lonicera japonica	Japanese honeysuckle
	Ludwigia ×kentiana	Kent's Hampshire purslane
	Ludwigia grandiflora	Water primrose
	Lupinus polyphyllus	Garden lupin
	Myriophyllum aquaticum	Parrot feather watermilfoil
	Myriophyllum heterophyllum	Broadleaf watermilfoil
	Parthenocissus quinquefolia aggr. *Parthenocissus inserta* *Parthenocissus quinquefolia*	Virginia creepers False virginia creeper Virginia creeper
	Phyllostachys aurea	Golden bamboo
	Polygonum polystachyum	Himalayan knotweed
	Prunus laurocerasus	Cherry laurel
	Prunus serotina	Wild black cherry
	Pseudosasa japonica	Arrow bamboo
	Pueraria lobata	East Asian arrowroot
	Reynoutria japonica aggr. *Reynoutria japonica* *Reynoutria ×bohemica* *Reynoutria sachalinensis*	Knotweeds Japanese knotweed Bohemian knotweed Giant knotweed
	Rhus typhina	Staghorn sumac
	Robinia pseudoacacia	Black locust
	Rubus armeniacus	Armenian blackberry
	Rubus phoenicolasius	Japanese wineberry
	Sedum spurium	Caucasian stonecrop
	Sedum stoloniferum	Stolon stonecrop
	Senecio inaequidens	Narrow-leaved ragwort
	Sicyos angulatus	Bur-cucumber
	Solidago canadensis	Canadian goldenrod
	Solidago gigantea	Giant goldenrod
	Toxicodendron radicans	Poison ivy
	Trachycarpus fortunei	Chinese windmill palm
Fungi[1]		
	Aphanomyces astaci	Crayfish plague
	Batrachochytrium dendrobatidis	Chytrid fungus
	Clitocybe amoenolens	Paralysis funnel
	Coleosporium solidaginis	Goldenrod rust
	Cryphonectria parasitica	Chestnut blight
	Cryptostroma corticale	Sooty bark disease
	Dothistroma pini	Red band needle blight
	Dothistroma septosporum	Red band needle blight
	Erysiphe alphitoides	Oak powdery mildew

1 incl. oomycetes

	Scientific name	Common name
	Erysiphe corylacearum	Asian hazelnut powdery mildew
	Hymenoscyphus fraxineus	Ash dieback
	Lecanosticta acicola	Brown spot of pine
	Melampsoridium hiratsukanum	Alder rust
	Ophiostoma novo-ulmi	Dutch elm disease
	Ophiostoma ulmi	Dutch elm disease
	Petrakia liobae	*Petrakia* beech leaf blight
	Phytophthora alni	Root disease of alder
	Phytophthora cambivora	Chestnut ink disease
	Phytophthora cinnamomi	Chestnut ink disease
	Puccinia lagenophorae	–

2. Species that are assumed to be harmful to the environment *('potentially invasive')*

**harm affects protected natural resources as defined by environmental legislation; species that cause harm solely in production areas e.g. agriculture and forestry are not recorded here (see e.g. PHO, EzDO)*

	Scientific name	Common name
Animals		
Birds	*Anas bahamensis*	White-cheeked pintail
	Sinosuthora webbianus	Vinous-throated parrotbill
Reptiles	*Natrix natrix persa*	Grass snake
	Podarcis siculus	Italian wall lizard
	Pseudemys concinna	River cooter turtle
Fish	*Carassius carassius*	Crucian carp
	Cyprinus carpio cultivated forms	Koi, Eurasian carp and similar cultivated forms
Insects	*Aedes japonicus*	Asian bush mosquito
	Aedes koreicus	Korean bush mosquito
	Cameraria ohridella	Horse chestnut leaf miner
	Cyclorhipidion bodoanum	–
	Drosophila suzukii	Spotted wing drosophila
	Gnathotrichus materiarius	American utilizable wood bark beetle
	Halyomorpha halys	Brown marmorated stink bug
	Ips duplicatus	Double-spined bark beetle
	Leptoglossus occidentalis	Western conifer seed bug
	Lyctus cavicollis	Shiny powerpost beetle
	Xyleborinus attenuatus	–
	Xyleborinus saxesenii	Fruit-tree pinhole borer
	Xylosandrus crassiusculus	Asian ambrosia beetle or granulate ambrosia beetle
	Xylosandrus germanus	Black timber bark beetle
	Xylotrechus stebbingi	–
Small crustaceans	*Chelicorophium robustum*	–
	Chelicorophium sowinskyi	–
	Echinogammarus ischnus	Scud
	Jaera istri	Ponto-Caspian isopod

	Scientific name	Common name
Molluscs	*Corbicula fluminalis*	Asian clam
Other invertebrates	*Caenoplana variegata*	Yellow-striped flatworm
	Hypania invalida	–
	Obama nungara	–
Plants		
Vascular plants	*Abutilon theophrasti*	Velvetweed
	Actinidia chinensis	Kiwi
	Akebia quinata	Chocolate vine
	Ambrosia trifida	Giant ragweed
	Aralia elata	Japanese angelica tree
	Azolla filiculoides	Mosquito fern
	Bassia scoparia	Burning bush
	Bromus riparius	Meadow brome
	Chorispora tenella	Blue mustard
	Cyperus esculentus	Yellow nutsedge
	Diospyros lotus	Date plum
	Elodea densa	Common waterweed
	Erigeron karvinskianus	Mexican fleabane
	Euonymus fortunei	Fortune's spindle
	Impatiens balfourii	Kashmir balsam
	Lonicera pileata	Privet honeysuckle
	Miscanthus sinensis	Chinese silver grass
	Nassella tenuissima	Mexican feather grass
	Oenanthe javanica	Water dropwort
	Opuntia humifusa	Eastern prickly pear
	Opuntia phaeacantha	Tulip prickly pear
	Paulownia tomentosa	Princess tree
	Phytolacca americana	Pokeweed
	Rosa multiflora	Multiflora rose
	Sagittaria latifolia	Broadleaf arrowhead
	Solanum carolinense	Carolina horsenettle
	Solidago graminifolia	Grass-leaved goldenrod
	Sorghum halepense	Johnson grass
	Sporobolus indicus	Rat tail grass
	Symphoricarpos albus	Common snowberry
	Viburnum rhytidophyllum	Leatherleaf viburnum
	Vitis riparia	Riverbank grape
Fungi		
	Erysiphe salmonii	Asian ash powdery mildew
	Erysiphe vanbruntiana	Elderberry rust
	Puccinia malvacearum	Hollyhock rust

Species not present in Switzerland

The species on the list of invasive alien species (see above) will in future be classified according to the five-level concept (see Swiss Strategy on Invasive Alien Species). In a prognostic approach, the classification system will also be applied to invasive alien species that are not yet present in Switzerland or have been completely removed by eradication measures but may (re)appear in the country. Well-known examples of such species are listed below; the list is not exhaustive.

Species that do not yet occur in Switzerland or have been eradicated thanks to control measures but whose (re-)appearance in Switzerland cannot be ruled out (examples, list not exhaustive)

	Scientific name	Common name
Animals		
Mammals	*Sciurus carolinensis*	Grey squirrel
Reptiles	*Chelydra serpentina*	Common snapping turtle
	Elaphe schrenckii	Amur rate snake
Amphibia	*Lithobates catesbeianus*	American bullfrog
Fish	*Babka gymnotrachelus*	Racer goby
	Leuciscus idus	Ide
	Micropterus dolomieu	Smallmouth bass
	Neogobius fluviatilis	Monkey goby
	Proterorhinus semilunaris	Western tubenose goby
	Umbra spp.	Mud minnows
Insects	*Aethina tumida*	Small hive beetle
	Agrilus anxius	Bronze birch borer
	Agrilus planipennis	Emerald ash borer
	Anoplophora chinensis[2]	Citrus long-horned beetle
	Anoplophora glabripennis[2]	Asian long-horned beetle
	Aromia bungii	Red-necked long-horned beetle
	Dendrolimus sibiricus	Siberian silkmoth
Large crustaceans	*Atyaephyra desmaresti*	Freshwater shrimp
	Orconectes virilis / Faxonius virilis	Virile crayfish
	Faxonius immunis	Calico crayfish
	Procambarus fallax virginalis	Marbled crayfish
Small crustaceans	*Gammarus tigrinus*	Tiger scud
Other invertebrates	*Bursaphelenchus xylophilus*	Pine wood nematode
Plants		
Vascular plants	*Ambrosia confertiflora*	–
	Ambrosia psilostachya	Cuman ragweed
	Cabomba caroliniana	Fanwort
	Crassula helmsii	Australian swamp stonecrop

2 establishment prevented thanks to eradication measures (PHO) (species considered eradicated in Switzerland)

	Scientific name	Common name
Vascular plants	*Echinocystis lobata*	Bur cucumber
	Humulus japonicus (syn. *H. scandens*)	Japanese hop
	Hydrocotyle ranunculoides	Floating marsh pennywort
	Ludwigia peploides	Floating primrose willow
	Nassella trichotoma	Serrated tussock grass
	Pennisetum setaceum	Fountain grass
	Polygonum perfoliatum	Asiatic tearthumb
	Salvinia molesta	Giant salvinia
Fungi[1]		
	Batrachochytrium salamandrivorans	Salamander chytrid fungus
	Fusarium circinatum	Pitch canker
	Heterobasidion irregulare	Heterobasidion root disease
	Phytophthora kernoviae	Kernoviae beech dieback
	Phytophthora ramorum[2]	Sudden oak death

1 incl. oomycetes
2 establishment prevented thanks to eradication measures (PHO) (species considered eradicated in Switzerland)