Chapter 1[1]: Introducing biological invasions and the IPBES thematic assessment of invasive alien species and their control

Supplementary materials

[1] This is the final text version of the supplementary material of Chapter 1 of the IPBES Thematic Assessment Report on Invasive Alien Species and their Control (https://doi.org/10.5281/zenodo.7430682)

Supplementary material 1.1. Categorization of stakeholders

This description of all categories of (1) influencing stakeholder and (2) affected stakeholder groups complements **section 1.5.1**.

Influencing stakeholder group

Vector-stakeholders are stakeholders whose activities physically move an invasive alien species along an invasion pathway, intentionally or not, including, for example, logistics actors involved in the import-export of commodities, workers, and resource owners or users (e.g., livestock owners, fishers, recreationists) moving equipment or other material. A wide range of supply chains involving numerous stakeholders gradually aggregate towards a smaller number of logistics actors. Vector-stakeholders may be implicated in ongoing introduction-spread-introduction cycles, but they have no direct stake in later invasion stages.

Governors are stakeholders who set formal and informal rules or establish norms that guide and drive the behaviour and practices of others. Formal rules may flow from trade agreements or legislation, while informal rules may take the form of organizational guidance, industry best practice codes, standard operating procedures, or even marketing arrangements; but someone makes pivotal decisions about which actions are taken or not, thus defining the priorities intrinsic to biosecurity and invasive alien species management including surveillance regimes, inspection, phytosanitary practices, and resource allocation. Pre-pathway governors undertake a wide range of relevant policy-making and standard-development that set the context of invasions. As invasive alien species move towards and cross jurisdictional boundaries, local scale governors implement specific protocols and rules aimed at limiting the opportunities for invasive alien species movement and establishment. Further rules, guidance, and norms are involved as containment (see **Glossary**) and mitigation actions are undertaken, such as movement controls, outbreak management protocol development (often in concert with 'monitors'), and legal notification. When human adaptation is required (see **Chapter 6**, **section 6.2.3.5**), governors may generate rules that enable affected stakeholders to 'learn to live' with new species, managing impacts and adopting less vulnerable practices.

Monitors are stakeholders with the knowledge and skills necessary to predict, identify, and detect invasive alien species, and who organize surveillance, undertake tests to identify invasive alien species, deliver research, conduct surveillance, or share information. Pre-pathway, monitors may engage in knowledge generation and sharing, horizon-scanning, and risk analysis; later, monitors may design protocols, sanitation procedures, and data production protocols. Once invasive alien species are established, monitors are integral to targeted surveillance, diagnostics, and outbreak planning, and may engage in adaptive research and testing of management solutions. Finally, when humans must adapt to invasive alien species, monitors often have the capabilities to support the creation of resilient environments and effective mitigation measures.

Managers possess the skills, competencies, and technology required to undertake 'on-the-ground' responses to invasive alien species – including treatment of infested or infected material and all types of cultural, mechanical, manual, chemical, and biological control. **Chapter 5**, **sections 5.4.3** and **5.4.4** give an overview of several current and future technologies. Managers might come from public bodies, non-governmental organizations, and the private sector, and many are resource managers such as farmers and fishers. Manager behaviours and actions shift from preparedness (e.g., enabling biosecurity, see **Glossary**, through technology transfer) to sanitation and quarantine actions early in a pathway, through to invasive management (e.g., mitigation, eradication, and restoration). If long-term establishment of an invasive alien species occurs, some managers may be involved in ongoing mitigation of impacts, while other Managers could take action to establish and maintain socio-ecosystems that are resilient to invasive alien species.

Networkers are those stakeholders with the capacity to disseminate information and key messages between actors relevant to invasive alien species management. They can also play important bridging or 'Network Administrative' roles, connecting other stakeholders with differing perspectives and operating at different scales. Trade bodies and associations often occupy this position, as do government or non-governmental agencies; as invasions progress, there is considerable variation in relation to the nature of the information required, its scale of delivery, and its intended audience, a shift from preparatory behaviours at broad scales, such as engagement in risk analysis, creating or convening networks for consensus building, design of interventions, surveillance and coordination, to rapid dissemination of alerts at the point of potential introduction, and then to information sharing and facilitating collaboration where containment, eradication, or mitigation of an invasion is needed.

Affected stakeholder group

Many stakeholders may or may not have a functional role to play in biological invasions governance and management, but their interests are nevertheless directly or indirectly affected, as they experience either losses or gains from invasive alien species or from management actions.

Value losers are stakeholders for whom nature's contributions to people and good quality of life are reduced by invasive alien species or by management responses to invasive alien species. This category may consist of a very wide range of stakeholders, as invasive alien species may negatively affect the monetary or nature's-contributions-to-people value of natural resources, the cultural qualities of landscapes, and the biodiversity value of ecosystems.

Cost losers are those who bear the direct economic costs of responding to invasive alien species, such as paying for labour and materials required for eradication or containment, or for information dissemination. These direct costs can be incurred in addition to the loss of existing value (i.e., cost losers may often also be value losers). Cost losers commonly consists of landowners, residents, and public bodies that are legally responsible for the management of invasive alien species affecting their resources.

Collateral losers are those who lose value indirectly as a consequence of invasive alien species impacts or, importantly, their management. This can include, for example, reputational damage to contractors or public bodies resulting from poor invasive alien species policy or management, perceived or actual losses of nature's contributions to people or good quality of life due to non-target effects of management (such as from pesticide use), or reduced attractiveness (e.g., for tourism or recreation) of specific environments affected by invasive alien species. There are value losses prior to introduction, including biosecurity implementation costs (e.g., treatment of raw materials or transport media), and opportunity losses through exclusion of actors from import-export within known invasive source regions. At later stages, when invasive alien species have begun to impact on new environments or when management is implemented, new value losers and losses emerge, as can also occur as the need to live with an invasive alien species becomes clear (e.g., the need to invest in more resilient livelihoods, economic activities or biosecurity measures).

Outcome winners are those for whom invasive alien species, or their management, produce benefits. Some species are introduced because they provide nature's contributions to people for specific stakeholder groups, while other stakeholder groups are able to turn harm into benefit, for example by using invasive alien species for bioenergy. While invasive alien species management creates cost losers, managers may benefit by obtaining income from control work, manufacturing materials and equipment used in control, or selling chemicals and pesticides. Monitors may benefit through contracts to investigate invasive alien species and their impacts. 'Winner' stakes may be created by pre-pathway research, innovation and development processes, but are most obvious at later stages of invasion when the impacts and potential outcomes of invasion emerge.

Contributors are similar to outcome winners, but with generally fewer direct connections to and knowledge of invasive alien species. These are individuals and groups engaged in activities that are beneficial to them (particularly economic behaviours) that are implicated in invasions – particularly behaviours that drive supply chains and pathways. Contributory activities are broad and most obviously include trade and consumption. Perhaps the clearest examples are stakeholders engaged in the trade of commodities such as live plants or animals, but also those engaged in tourism. This stakeholder category perhaps does the most to highlight the importance of the widespread behaviours and values that are intrinsic to invasive alien species issues. Contributory behaviours occur primarily in the earliest stages of invasion – especially in value creation activities (demand creation and marketing) and consumer choice.

Supplementary material 1.2. IPBES conceptual framework

This description of the IPBES conceptual framework is extracted from Díaz et al. (2015) and complements **section 1.6.1**.

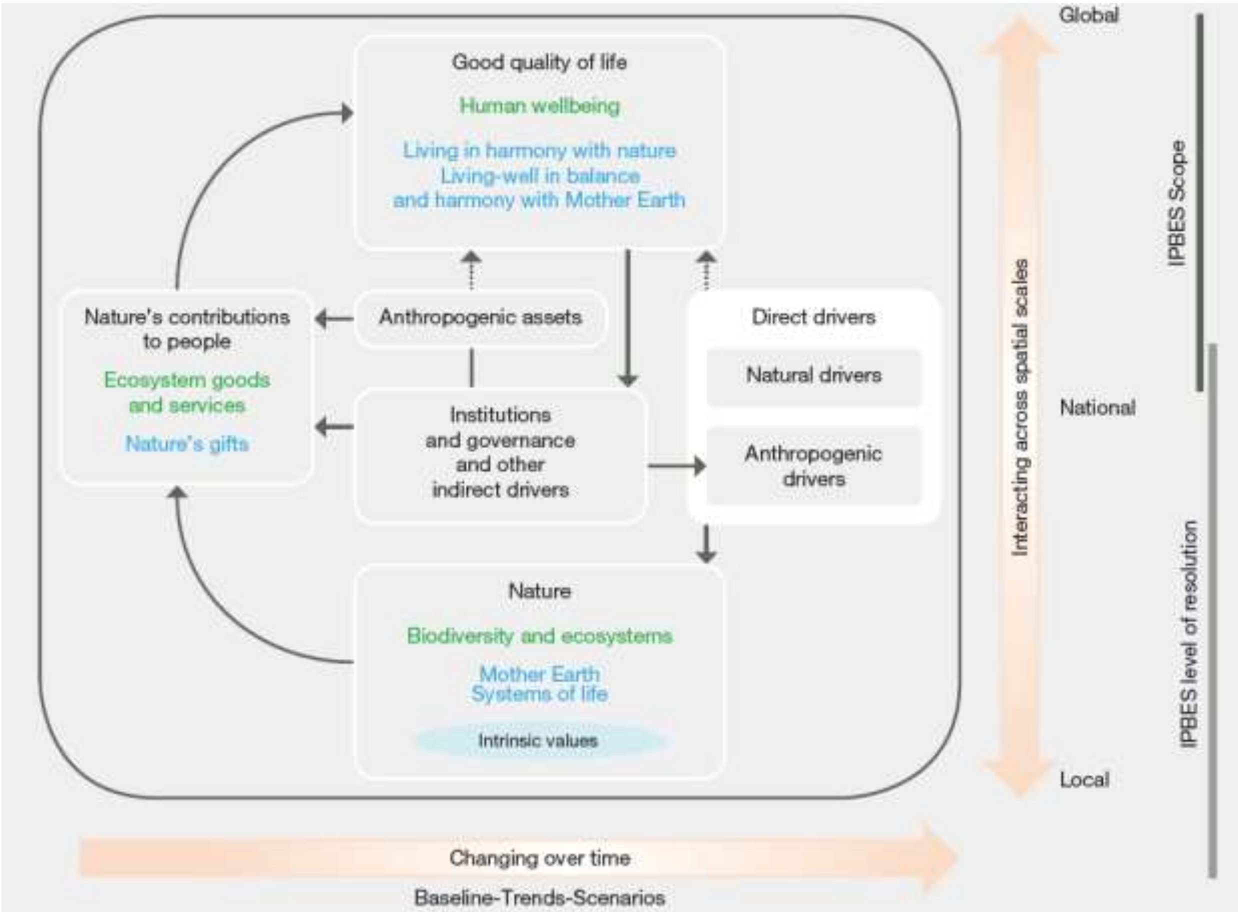

Figure SM.1.1. The IPBES conceptual framework. Source: Díaz et al. (2015), https://doi.org/10.1016/j.cosust.2014.11.002, under license CC BY-NC-SA 3.0.

The IPBES conceptual framework is a highly simplified model of the complex interactions between the natural world and human societies. The model identifies the main elements (boxes within the main panel outlined in grey), together with their interactions (arrows in the main panel), that are most relevant to the Platform's goal. "Nature", "nature's contributions to people", and "good quality of life" (indicated as black headlines and defined in each corresponding box) are inclusive categories that were identified as meaningful and relevant to all stakeholders involved in IPBES during a participatory process, including various disciplines of the natural and social sciences and the humanities, and other knowledge systems, such as those of Indigenous Peoples and local communities. Text in green denotes scientific concepts, and text in blue denotes concepts originating in other knowledge systems. The solid arrows in the main panel denote influence between elements, and dotted arrows denote links that are acknowledged as important, but that are not the main focus of the Platform. The thick coloured arrows below and to the right of the central panel indicate the scales of time and space, respectively. This conceptual framework was accepted by the Plenary in decision IPBES-2/4, and the Plenary took note of an update presented in IPBES/5/INF/24 and in decision IPBES-5/1. Further details and examples of the concepts defined in the box can be found in the **Glossary** and in **Chapter 1**.

Nature, in the context of the Platform, refers to the natural world, with an emphasis on biodiversity. Within the context of science, it includes categories such as biodiversity, ecosystems, ecosystem functioning, evolution, the biosphere, humankind's shared evolutionary heritage, and biocultural diversity. Within the context of other knowledge systems, it includes categories such as Mother Earth and systems of life. Other components of nature, such as deep aquifers, mineral and fossil reserves, and wind, solar, geothermal and wave power, are not the focus of the Platform. Nature contributes to societies through the provision of contributions to people.

Anthropogenic assets refers to built-up infrastructure, health facilities, knowledge (including indigenous and local knowledge systems and technical or scientific knowledge, as well as formal and non-formal education), technology (both physical objects and procedures), and financial assets, among others. Anthropogenic assets have been highlighted to emphasize that a good life is achieved by a co-production of benefits between nature and societies.

Nature's contributions to people refers to all the contributions that humanity obtains from nature. Ecosystem goods and services, considered separately or in bundles, are included in this category. Within other knowledge systems, nature's gifts and similar concepts refer to the benefits of nature from which people derive good quality of life. Aspects of nature that can be negative to people (detriments), such as pests, pathogens or predators, are also included in this broad category.

Nature's regulating contributions to people refers to functional and structural aspects of organisms and ecosystems that modify the environmental conditions experienced by people, and/or sustain and/or regulate the generation of material and non-material contributions. For example, these contributions include water purification, climate regulation and the regulation of soil erosion.

Nature's material contributions to people refers to substances, objects or other material elements from nature that sustain people's physical existence and the infrastructure (i.e., the basic physical and organizational structures and facilities, such as buildings, roads, power supplies) needed for the operation of a society or enterprise. They are typically physically consumed in the process of being experienced, such as when plants or animals are transformed into food, energy, or materials for shelter or ornamental purposes.

Nature's non-material contributions to people refers to nature's contribution to people's subjective or psychological quality of life, individually and collectively. The entities that provide these intangible contributions can be physically consumed in the process (e.g., animals in recreational or ritual fishing or hunting) or not (e.g., individual trees or ecosystems as sources of inspiration).

Drivers of change refers to all those external factors that affect nature, anthropogenic assets, nature's contributions to people and good quality of life. They include institutions and governance systems and other indirect drivers, and direct drivers (both natural and anthropogenic).

Institutions and governance systems and other indirect drivers are the ways in which societies organize themselves and the resulting influences on other components. They are the underlying causes of environmental change that are exogenous to the ecosystem in question. Because of their central role, influencing all aspects of human relationships with nature, they are key levers for decision-making. “Institutions” encompasses all formal and informal interactions among stakeholders and the social structures that determine how decisions are taken and implemented, how power is exercised, and how responsibilities are distributed. To varying degrees, institutions determine the access to and control, allocation and distribution of the components of nature and of anthropogenic assets and their contributions to people. Examples of institutions are systems of property and access rights to land (e.g., public, common-pool or private), legislative arrangements, treaties, informal social norms and rules, including those emerging from indigenous and local knowledge systems, and international regimes such as agreements against stratospheric ozone depletion or for the protection of endangered species of wild fauna and flora. Economic policies, including macroeconomic, fiscal, monetary or agricultural policies, play a significant role in influencing people’s decisions and behaviour and the way in which they relate to nature in the pursuit of benefits. However, many of the drivers of human behaviour and preferences, which reflect different perspectives on a good quality of life, work largely outside the market system.

Direct drivers, both natural and anthropogenic, affect nature directly. “Natural drivers” are those that are not the result of human activities and are beyond human control. These include earthquakes, volcanic eruptions and tsunamis, extreme weather or ocean-related events such as prolonged drought or cold periods, tropical cyclones and floods, the El Niño/La Niña Southern Oscillation and extreme tidal events. The direct anthropogenic drivers are those that are the result of human decisions, namely, of institutions and governance systems and other indirect drivers. Anthropogenic drivers include habitat conversion, e.g., degradation of land and aquatic habitats, deforestation and afforestation, exploitation of wild populations, climate change, pollution of soil, water and air and species introductions. Some of these drivers, such as pollution, can have negative impacts on nature; others, as in the case of habitat restoration, or the introduction of a natural enemy to combat invasive species, can have positive effects.

Good quality of life is the achievement of a fulfilled human life, a notion which varies strongly across different societies and groups within societies. It is a context-dependent state of individuals and human groups, comprising access to food, water, energy and livelihood security, and also health, good social relationships and equity, security, cultural identity, and freedom of choice and action. From virtually all standpoints, a good quality of life is multidimensional, having material as well as immaterial and spiritual components. What a good quality of life entails, however, is highly dependent on place, time and culture, with different societies espousing different views of their relationships with nature and placing different levels of importance on collective versus individual rights, the material versus the spiritual domain, intrinsic versus instrumental values, and the present time versus the past or the future. The concept of human well-being used in many western societies and its variants, together with those of living in harmony with nature and living well in balance and harmony with Mother Earth, are examples of different perspectives on a good quality of life.

Reference

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J. R., Arico, S., Báldi, A., Bartuska, A., Baste, I. A., Bilgin, A., Brondizio, E., Chan, K. M., Figueroa, V. E., Duraiappah, A., Fischer, M., Hill, R., … Zlatanova, D. (2015). The IPBES Conceptual Framework—Connecting nature and people. *Current Opinion in Environmental Sustainability*, *14*, 1–16. https://doi.org/10.1016/j.cosust.2014.11.002

Supplementary material 1.3. IPBES units of analysis

Table SM.1.1. IPBES units of analysis: complement to **section 1.6.5**.
Source: IPBES (2019)

Unit (Terrestrial)	**Definition**
1. Tropical and subtropical dry and humid forests	Includes humid and dry broadleaf forests centred between the tropics and subtropical latitudes, and tropical and subtropical coniferous forests. Humid forests are characterized by low variability in annual temperature and high levels of rainfall (>2,000 mm annually); forest composition is dominated by evergreen and semi- evergreen tree species. Dry forests occur in climates that are mostly warm year-round, with annual rainfall ranging from 200 to 1,500 mm. There is a well-defined dry season which can last several months and vary with geographic location. Semi-deciduous and deciduous trees predominate in these forests. Tropical and subtropical coniferous forests are found predominantly in North and Central America. They experience low levels of precipitation and moderate variability in temperature. They are characterized by diverse species of conifers, whose needles are adapted to deal with the variable climatic conditions.
2. Temperate and boreal forests and woodlands	Boreal and temperate forest biomes experience a continental climate, with growing seasons of <130 days and >140 days, respectively. Both can be of coniferous (spruce, fir, larch, or pine) and/or deciduous (broad-leafed, angiosperm) trees. At high latitude montane forests and in the north, these forest biomes border on the tundra. Both forest types are disturbance-driven, mostly from fires, wind, and insect infestations. In the boreal where fire return intervals vary widely (<50 years to >500 years), these result in a large-scale mosaic. Temperate deciduous forests are divided into sub-classes depending on the relative amount of annual rainfall. Temperate rain forests are characterized by mild winters, with abundant precipitation, mostly as rain. They are seldom subject to catastrophic wildfires, therefore often attain the climax stage of old-growth forests. In northern temperate rain forest, coniferous trees are dominant, whereas in the southern hemisphere deciduous species are also common or dominant.
3. Mediterranean forests, woodlands and scrub	Mediterranean forests, woodlands, and scrub are fire-prone ecosystems with typically dry (and generally hot) summer and rainy (and generally mild) spring and winter. They occur across 22 countries in five continents: southern Europe and northern Africa (Mediterranean Basin), South Africa (Western Cape), Northwestern America (e.g., California chaparral), Southern America (Chilean matorral), and Southern Australia. Vegetation types include coniferous or (mostly evergreen) broadleaf forests and woodlands, savannahs and grasslands, scrublands and mosaic landscapes, resulting from a strong interaction between heterogeneous environmental conditions and a long-lasting influence of human activities and wildfires. Mediterranean ecosystems

	support an extremely high diversity of unique animal and plant species, most of them adapted to the stressful conditions of long, hot, and dry summer.
4. Tundra and high mountain habitats	Tundra is an ecological community of mosses, lichens, herbs, and dwarf shrubs living under extreme conditions of cool summers and very cold winters. In the treeless plains of Arctic Europe, Asia, and North America, arctic tundra is underlain by a permanently frozen subsoil hundreds of meters deep (permafrost) which is absent under the mountain tundra found at high altitudes of the world's mountains. Mountain tundra is found at altitudes above the treeline and may include extensive grasslands. Shrubs are characteristic plants of tundra but these become smaller and are even absent at high latitudes and high altitudes. Plant production is relatively high in arctic tundra because permafrost restricts drainage and thus keeps surface layers moist. Migratory animals such as caribou/reindeer, fish, and millions of geese and other birdlife take advantage of summer plant growth and few predators to reproduce and grow in the arctic tundra. *Similarities with Notes in relation to other units:* this unit is distinguished from the cryosphere as being characterized by vegetation cover.
5. Tropical and subtropical savannas and grasslands	This unit comprises large expanses of land in tropical and subtropical latitudes characterized by a discontinuous tree canopy in a continuous grass layer, although tree cover is highly variable, ranging from few scattered trees to fairly dense woodlands. Annual rainfall ranges between 350-1,500 mm, concentrated in the warm season. However, there may be great variability in soil moisture throughout the year. Herbivory by large- and medium- sized mammals that have evolved to take advantage of the ample forage, as well as periodic fires are distinctive features of these habitats. *Notes in relation to other units:* subtropical shrublands are included in unit 7 (Deserts and Xeric shrublands). Some parts of these two units may overlap, as it is common for some areas of the subtropical savannas to be described as xerophytic shrublands.
6. Temperate grasslands	Temperate grasslands occur where seasonal climates and soils favour the dominance of perennial grasses and related life forms. They are distributed mainly in the middle latitudes with differing names across continents. Steppes, prairies, pampas, and veld areas, but also including (semi-) natural (ancient or primary) grasslands and forest-steppes, wood-pastures, temperate savannas, and open shrublands in the regions of Temperate and Boreal broadleaved, mixed, and coniferous forests; Mediterranean regions; and of mountains below the timberline.

	Notes in relation to other units: this unit excludes tundra and grasslands above the timberline (unit 4). Many temperate grasslands have been transformed into agricultural grasslands, which are included in unit 10 (cultivated areas).
7. Deserts and xeric shrublands	This unit comprises large expanses of land in tropical and subtropical latitudes characterized by sparse often discontinuous vegetation and large portions of bare soil. Deserts and xeric habitats are characterized by severe shortage of water. Two sub-units can be distinguished: deserts with annual rainfall below 200 mm and steppe or shrublands with annual rainfall that ranges between 200 and 350 mm, concentrated in the cool season. Both steppe and deserts can have a dense herbaceous/grassy vegetation after the rains for a relatively short period of the year. Deserts may be hot or cold, mainly dependent on altitude. High mountain deserts can be found in the rain shadows of the Himalayas and Andes regions. Herbivory by large- and medium-sized mammals that have evolved to accommodate to these dry and sparse vegetation conditions is a distinctive feature of these habitats. *Notes in relation to other units:* this unit excludes Antarctica (unit 12, cryosphere), though it meets some of the criteria of a cold desert.
8. Wetlands – peatlands, mires, bogs	Wetlands are permanent or temporary, freshwater, brackish, and marine areas not deeper than 6 m (bogs, swamps, marshes, estuaries, deltas, peatlands, potholes, vernal pools, fens, and other types, depending on geography, soil, and plant life). Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year. Water saturation by groundwater, precipitation, surface waters, and ocean tides largely determines how frequently or continually the soil is inundated and develops and the types of plant and animal communities living in and on the soil. These are neither aquatic nor terrestrial systems, but transitional ones. Includes natural and constructed permanent forest-covered inland marshes and wet meadows (dominated by herbaceous plants), swamps (dominated by shrubs), wooded swamps (dominated by trees), seasonal freshwater wetlands (playa lakes, vernal pools, potholes, marshes), seawater and freshwater tidal swamps and marshes, estuaries, areas linked to estuaries or beyond the upper edges of tidal salt marshes where the influence of salt water ends, and unforested mires such as bogs, fens, and other peatlands.
9. Urban/Semi-urban	Although urban and semi urban areas are a tiny fraction of the world's surface, they are the nexus of human activity with >50% of the population and 70 - 90% of economic activity. The functional urban area (FUA) is defined as a city plus its commuting zone by the European Union and the Organisation for Economic Co-operation and Development (OECD). This was formerly known as larger urban zone (LUZ). Urban and semi-urban areas are places dominated by the built environment, including all non-vegetative and human-constructed elements, of a given landscape unit. In general, global urban area lacks a consistent, unambiguous definition. There are approaches from different perspectives that draw on a combination

	of satellite imagery, census information, and other maps. In this assessment the unit is mapped from European Space Agency (ESA) Climate Change Initiative (CCI) Land Cover dataset (value=190).
10. Cultivated areas (incl. cropping, intensive livestock farming etc.)	Cultivated systems can be defined as areas in which at least 30% of the landscape is in croplands, shifting cultivation, or confined livestock production in any particular year. These can include farms, orchards, rangeland, and other agricultural concerns. The defining characteristic is the level of alteration. Very heavily managed agro-ecosystems involve the planting of non-native crop species or rearing of livestock, the introduction of non-native plants often to the detriment of native species, irrigation to augment water, and boosting of production by nutrient addition through fertilizers. There are also less heavily managed agro-ecosystems, often based on local rainfall and few nutrient inputs, which do allow native wildlife species to thrive alongside those species introduced for commercial purposes, and shifting cultivation systems. Rangelands grade into natural grasslands depending on intensity of use/alteration, and may include a mix of densely populated areas with areas used for pasture. *Notes in relation to other units:* fishery production areas and commercial forests are not included in this Unit. Fisheries occur in the ocean units (14, 15, and 16) as well as in aquaculture areas (unit 12). Commercial forests cannot be discriminated on a global scale from natural forests (units 1 and 2), so cannot reliably be mapped separately, even though by their characteristics would fit in this unit.
11. Cryosphere	The cryosphere consists of regions where the temperature is so low that water exists primarily in a frozen state most of the time, that is, the polar regions, glaciers, and alpine regions. It also includes non-ice-covered areas where temperatures are below freezing. It contains many highly unique habitats / ecosystems such as sea ice, ice shelves, the extreme cold and dry regions of Antarctica including the Antarctic dry valleys and the sub- glacial/ice sheet lakes (e.g., Lake Vostok). Organisms inhabiting sea ice overlap in terms of species occurrences considerably with Shelf ecosystems and Open ocean pelagic systems. *Notes in relation to other units:* Permafrost (permanently frozen subsoils) are included in the tundra and high mountain unit (4). The cryosphere (unit 11) includes sea ice and ice shelves, but the sea below or adjacent to them falls into unit 15 or 16 (according to the position of the compensation depth).
12. Aquaculture areas	Aquaculture is the farming of aquatic organisms and involves direct intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while those exploitable as a common property resource are the harvest of fisheries. Aquaculture areas are thus any area of land, freshwater, or marine water that is used in the production of cultured aquatic organisms.

	Notes in relation to other units: in some other schemes, freshwater aquaculture is included in cropland (unit 10), but the coverage of terrestrial, freshwater, and marine for the Global Assessment makes it more consistent to group in this unit.
13. Inland surface waters and water bodies/freshwater	Inland waters are permanent above-ground freshwater, deeper than 6 m water bodies (e.g., lakes, rivers, reservoir/ponds, reservoirs, water courses) including their littoral zones, supporting a natural community of both plants and animals. Littoral zones include those parts of banks or shores that are sufficiently frequently inundated to prevent the formation of closed terrestrial vegetation. *Notes in relation to other units:* inlets, estuaries and temporary seasonal, or intermittent rivers, lakes, and flooded areas are NOT included in this definition of inland waters (see units 8 (wetlands/peatlands/bogs) and 14 (shelf, marine ecosystems)).
14. Shelf ecosystems (neritic and intertidal/littoral zone)	In-shore pelagic and benthic systems extending from the coastline to the 200 m depth contour, entirely within the photic zone where Net Primary Production is positive. At the coast the unit includes the intertidal/littoral zone to the Mean High Tide Water Line including estuaries and inlets. The boundary with open ocean systems at the 200 m contour is a gradient rather than a discrete transition. In Antarctica, the 500 m depth contour is a more natural boundary for this unit. The unit contains many highly productive and biodiverse pelagic and benthic habitats intensively used by people for multiple services, including food, shelter, and transport, such as coral reefs, seagrass meadows, and mangroves. *Notes in relation to other units:* inshore polar regions with permanent ice are placed in the cryosphere (unit 11), floating above, or beside, this unit; freshwater coastal rivers/lakes and wetlands (units 8 and 13) may form a boundary with estuaries in this unit; shelf systems intensively/multiply used by man are separated from this unit into unit 17.
15. Open ocean pelagic systems (euphotic zone)	This unit covers the open ocean beyond the 200 m depth contour on the seabed (500 m in Antarctica), and from the surface to 200 m deep. The 200 m limit is known as the maximum for the compensation depth, where sunlight is reduced to 1% of surface levels. Above this, phytoplankton growth is sustained depending on nutrient supply and surface water stratification. In this so-called euphotic zone Net Primary Production is positive, supporting almost the entire marine food web. Open ocean pelagic systems include highly productive and oligotrophic (low productivity) waters, as well as sea-ice-covered polar seas. *Notes in relation to other units:* the boundary between this unit and shelf ecosystems (unit 14) is a gradient rather than a discrete transition. Units 15 and 16 are vertically layered throughout their range, and are linked by biogeochemical pelagic-benthic coupling and vertical migration of organisms. The boundary between them is of significant ecological but low physiological

	relevance since species are specifically adapted to pressure (http://www.marinespecies.org/deepsea/). The cryosphere (unit 11) includes sea ice and ice shelves, which may extend over this unit. The sea ice is habitat of a variety of marine organisms ranging from microorganisms to birds and mammals.
16. Deep sea	The permanently dark off-shore open ocean beyond and deeper than the 200 m depth contour on the seabed (beyond 500 m in Antarctica). The unit is entirely below the compensation depth, where no light-dependent Net Primary Production occurs. The deep sea includes the dark pelagic zones and the upper 1 m of the sea- floor sediment. It comprises a variety of different habitats such as continental slopes, vents, and seamounts. *Notes in relation to other units:* partially overlaps with shelf ecosystems (unit 14) because most boundaries between marine ecosystems are gradients rather than discrete transitions. Units 15 and 16 are vertically layered throughout their range, and are linked by biogeochemical pelagic-benthic coupling and vertical migration of organisms. The boundary between them is of significant ecological but low physiological relevance since species are specifically adapted to pressure (http://www.marinespecies.org/deepsea/).
17. Coastal areas intensively and multiply used by human	Coastal zones are the land-sea interface and defined as “a strip of land and sea of varying width depending on the nature of the environment, human uses and management needs”. Currently, 2.5 billion people live within 100 km of the coast, placing a disproportionate stress on coastal and marine ecosystems. Intense multiple uses result in physical and biological restructuring mainly through (i) urban expansion and increased human population density, (ii) the fishing and aquaculture industry, (iii) maritime transport and associated infrastructure, and (iv) tourism and associated accommodation and facilities. These developments are associated with protection infrastructure (breakwaters, groynes, sea walls, etc.) as a reaction to the dynamic nature of the shoreline. *Notes in relation to other units*: heavily-altered and multiply-used areas that are focused on biological function for aquaculture are included in unit 12, Aquaculture areas. There may be some difficulty in separating this unit from unit 9, Urban/semi-urban, as many of the structures defined here will be contiguous with it. Operationally, this unit will be mapped as a linear feature of the coastline, based on the adjacency of units 9 (urban/semi-urban areas), 10 (cultivated areas) and 12 (aquaculture), and a human coastal proximity index. It lies at the boundary between terrestrial units and unit 14, shelf ecosystems.

Reference

IPBES. (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. https://doi.org/10.5281/ZENODO.3831673

Supplementary material 1.4. Illustrative examples of invasive alien species across IPBES units of analysis

Table SM.1.2. Illustrative examples of invasive alien species within terrestrial, freshwater, brackish, and marine environments spanning all the IPBES units of analysis around the world. Examples given were chosen to represent an animal and a plant with ecological or socio-economic impact selected from the most cited papers.[2] See IPBES units of analysis in **supplementary material 1.3**.

Notes: No examples of impact were found for Cryosphere and Deep Sea. Mechanism of impact was described based on Environmental Impact Classification for Alien Taxa (EICAT) and Socio-Economic Impact Classification for Alien Taxa (SEICAT) categories (**Chapter 4, Box 4.2**).

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
Terrestrial	Tropical and subtropical dry and humid forests	*Cenchrus setaceus* (fountain grass)	Asia and the Pacific (Sub-region: Oceania)	Chemical impact on ecosystem (nutrient cycling): changes in the sequestration of carbon in aboveground biomass	(Litton et al., 2006)
		Lissachatina fulica (giant African land snail)	Americas (Sub-region: South America)	Competition: competes with native molluscs for space and food Negative impacts on economic sectors (agriculture sector): a pest in ornamental gardens, vegetable gardens, and small-scale agriculture Negative impact on human health: an intermediate host of *Angiostrongylus*	(IPBES, 2020a, 2020b; Thiengo et al., 2007)

[2] Data management report available at: https://doi.org/10.5281/zenodo.5518254

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				cantonensis (rat lungworm), a nematode that can cause meningoencephalitis in people, and it may be a potential host of *Angiostrongylus costaricensis*, a zoonosis which causes abdominal angiostrongylosis. Negative impact on Indigenous Peoples and local communities: Snails consume plants and cause a considerable threat to agriculture. Farmers may have to abandon their farms if the snails have consumed all of their crops. They have the potential to be harmful to human health in Antigua.	
		Cenchrus ciliaris (buffel grass)	Americas (Sub-region: Mesoamerica)	Negative impacts on economic sectors (animal production): have lower net primary productivity Negative impact on Indigenous Peoples	(Franklin et al., 2006)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				and local communities: limit Aboriginal people's access to country in Kimberley region, blocking access to important cultural ceremonial sites, hunting sites, recreation sites. Disrupts cultural burning regimes by changing the fuel load and negatively affecting people's ability to collect bush foods.	
		Homalodisca vitripennis (glassy winged sharpshooter)	Americas (Sub-regions: North and South America)	Negative impacts on economic sectors (agriculture sector): important pests in commercial agriculture, as they transmit the bacterial plant pathogen *Xylella fastidiosa* (Pierce's disease of grapevines). *Xylella fastidiosa* induces diseases of grapevines, citrus, coffee, almond, alfalfa, stone fruits, landscape ornamentals, and native hardwoods	(Redak et al., 2004)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				for which there is no cure.	
	Temperate and boreal forests and woodlands	Several (13) plant species (e.g., *Reynoutria sachalinensis* (giant knotweed), *Heracleum mantegazzianum* (giant hogweed), *Lupinus polyphyllus* (garden lupin))	Europe and Central Asia (Sub-region: Central and Western Europe)	Competition: competes with native species for space. Physical impact on ecosystem: change in light regime for native species because of the cover and height of invading species	(Hejda et al., 2009)
		Lumbricus terrestris (lob worm), *Bimastos rubidus* (European barkworm), *Octolasion tyrtaeum* (woodland white worm)	Americas (Sub-region: North America)	Physical impact on ecosystem: mixing of soil layers Chemical impact on ecosystem (nutrient cycling): a net loss of C from the soil, affects on N cycling Structural impact on ecosystem: alteration of the soil foodweb, soil structure, humus forms, plant communities, and soil biota, e.g., microarthropods (mites, collembolans), enchytraeids	(Bohlen et al., 2004)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				(potworms), or nematodes	
		Pueraria montana (kudzu)	Americas (Sub-region: North America)	Physical impact on ecosystem: change in light regime for native species Negative impact on well-being and sustainable development: loss of recreational activities, aesthetic attraction, touristic value	(Forseth & Innis, 2004)
		Solenopsis invicta (red imported fire ant)	Americas and Asia and the Pacific (Sub-regions: North America and Oceania)	Negative impacts on economic sectors (agriculture sector): damage crops Negative impact on human health: bites people Negative impact on human infrastructure: infests electrical equipment. Negative impact on Indigenous Peoples and local communities: frequently bites and inflicts severe pain, necessitating	(IPBES, 2020a; Morrison et al., 2004)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				hospitalization on occasion. People's lifestyles have been impacted as a result of this in Australia.	
	Mediterranean forests, woodlands and scrub	*Acacia longifolia* (golden wattle)	Europe and Central Asia (Sub-region: Central and Western Europe)	Chemical impact on ecosystem (nutrient and water cycling): accumulates higher litter densities with greater N contents and lower C/N ratios than the native areas, which corresponds to lower C/N ratio and to higher potential rates of nitrification in the invaded soils; alters the soil properties with increased levels of organic C, total N and exchangeable cations resulting in higher microbial biomass, basal respiration, and b-glucosaminidase activity	(Marchante et al., 2008)
		Pheidole megacephala (big-headed ant)	Americas; Europe and Central Asia; Asia and Pacific	Predation: predator to native species such as ants, other insect species, snails, spiders, and centipedes	(Wetterer, 2012)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
			(Sub-region: North America; Central and Western Europe; Oceania)	Indirect impact: predation on insects cause the reduction in population and extinction of insectivorous birds Negative impacts on economic sectors (agriculture sector): household and agricultural pest	
		Centaurea solstitialis (yellow starthistle)	Americas (Sub-region: North America)	Chemical impact on ecosystem: has caused losses of soil moisture reserves Negative impact on well-being and sustainable development (hindering local and regional sustainable development with respect to water security): the value of the lost water may range from 16 to 75 million dollars per year in the Sacramento River watershed alone	(Gerlach, 2004)
		Aedes albopictus (Asian tiger mosquito)	Europe and Central Asia (Sub-region: Central and	Negative impact on human health: injuries, transmission of diseases as an	(Abramides et al., 2011)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
			Western Europe)	important vector of several arboviruses, such as dengue, chikungunya virus, yellow fever, and several other types of encephalitis	
	Tundra and High Mountain habitats	*Pinus mugo* (mountain pine)	Europe and Central Asia (Sub-region: Central and Western Europe)	Competition: competes with grassland for space, nutrient, and light	(Dullinger et al., 2003)
		Poa annua (annual meadowgrass)	Antarctica	Competition: competes with the native vascular plants, exerting a negative impact on their physiology and biomass	(Bajwa et al., 2019; Chwedorzewska et al., 2015; Maharjan et al., 2019)
	Tropical and subtropical savannas and grasslands	*Prosopis glandulosa* (honey mesquite)	Americas (Sub-region: North America)	Competition: competes with native grass for space and nutrients	(Brown & Archer, 1999)
		Felis catus (cat)	Asia and Pacific (Sub-	Predation: declines in mammal	(IPBES, 2019; Woinarsk

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
			region: Oceania)	populations in Australia	i et al., 2015)
		Andropogon gayanus (tambuki grass)	Asia and Pacific (Sub-region: Oceania)	Negative impact on well-being and sustainable development (Restrictions concerning aesthetic values and natural heritage): invasion threat is posed by a number of high-biomass non-native grasses; due to impacts on fire regimes in the World Heritage site (Kakadu National Park) Negative impact on Indigenous Peoples and local communities: limits Aboriginal peoples' access to country in Kimberley region, blocking access to important cultural ceremonial sites, hunting sites, recreation sites. Disrupts cultural burning regimes, by changing the fuel load, and negatively affecting peoples'	(Bach et al., 2019; Setterfield et al., 2013)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				ability to collect bush foods.	
		Bubalus bubalis (Asian water buffalo)	Asia and Pacific (Sub-region: Oceania)	Negative impact on well-being and sustainable development (Restrictions concerning aesthetic values and natural heritage): buffalo graze and browse in a region of significant biological and cultural importance, adversely affecting ecosystem functioning by trampling and soil compaction, and overgrazing native species Negative impact on Indigenous Peoples and local communities: dig up the billabongs, change the appearance and damage important cultural sites of Ngukurr aboriginals, in Arnhem land.	(Ens et al., 2016; Petty et al., 2007)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
	Temperate Grasslands	Several plant species (e.g., *Pinus radiata* (radiata pine), *Pinus patula* (Mexican weeping pine))	Southern hemisphere countries	Structural impact on ecosystem: by causing shifts in life-form dominance, reduced structural diversity, increased biomass, disruption of prevailing vegetation dynamics, and changing nutrient cycling patterns	(Richardson, 1998)
		Rattus rattus (black rat), *Rattus norvegicus* (brown rat)	Asia and Pacific (Sub-region: Oceania)	Indirect impact: predators, by affecting the movement of their key prey, indirectly influence the structure and function of above- and below-ground communities (number of seabirds, especially petrels and shearwaters decrease) Negative impact on Indigenous Peoples and local communities: have devastating effects on native biota that can be important for food, cultural heritage practices	(Fukami et al., 2006; Peltzer et al., 2019)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				and expressions, and tribal identity to the Māori community, New Zealand	
		Several species (e.g., *Bromus tectorum* (downy brome), *Euphorbia esula* (leafy spurge))	Americas (Sub-region: North America)	Competition: competes with native grass for water and nutrients Negative impacts on animal production: by lowering yield and quality of forage, interfering with grazing, poisoning animals, increasing costs of managing and producing livestock, and reducing land value	(DiTomaso, 2000)
		Several microorganisms, terrestrial plants, terrestrial invertebrates, amphibians and reptiles, and mammals	Asia and Pacific (Sub-region: North-East Asia)	Various negative impacts on economic sectors: direct economic losses to agriculture, forestry, stockbreeding, environment, and public facilities Negative impact on human health	(Xu et al., 2006)
		Bromus tectorum	Americas (Sub-	Chemical impact on ecosystem (nutrient	(Evans et al., 2001)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
		(downy brome)	region: North America)	and water cycling): impact N availability by changing litter quantity and quality, rates of N_2-fixation, or rates of N loss	
	Deserts and xeric shrublands	*Canis lupus dingo* (dingo)	Asia and Pacific (Sub-region: Oceania)	Predation: impacts on livestock production through predation on stock and its role as an ecosystem engineer	(Letnic et al., 2012)
		Vachellia nilotica (gum arabic tree)	Asia and Pacific (Sub-region: Oceania)	Structural impact on ecosystem: increases soil erosion, impedes stock access to water, and increases water loss through transpiration Negative impacts on economic sectors: reduces pasture production, increases mustering times and costs	(Kriticos et al., 2003)
		Sus scrofa (feral pig)	Americas (Sub-region: South America)	Physical impact on ecosystem (e.g., disturbance): has strong negative effects on the superficial soil	(Caruso et al., 2018)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				layers due to its rooting behaviour Negative impacts on economic sectors: (an agricultural lands) cause economic impacts in the region	
	Wetlands – peatlands, mires, bogs	Several species (e.g., *Reynoutria japonica* (Japanese knotweed), *Sporobolus anglicus* (common cordgrass), *Mimosa pigra* (giant sensitive plant))	Global	Structural impact on ecosystem: they can alter soil nutrient regimes. They can also inhibit the natural regime of flood pulsing or flammable woody plants and litter can increase fire frequency and intensity. Negative impact on Indigenous Peoples and local communities: In Senegal, the *Mimosa pigra* has an impact on water flows, navigation, and agriculture. Mimosas take over areas and alter ecosystems, causing damage to property, plants, and animals. Mimosa also reduces wildlife's grazing range.	(IPBES, 2020a, 2020b; Zedler & Kercher, 2004)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				When the plant is touched, it shrinks and folds its leaves in order to expose its thorns, which are poisonous. It also has an impact on people because it limits livestock's access to water. It also makes fishing difficult. It also reduces agriculture, which can cause to hunger in Zambian communities. In Canada, invasive plants are displacing native wetland species, including medicinal plants, and altering ecosystem functions in wetlands, aquatic and, terrestrial habitats.	
		Procambarus clarkii (red swamp crayfish)	Europe and Central Asia (Sub-region: Central and Western Europe)	Predation: predates on aquatic stages of amphibians and can cause their populations to decline Competition: affects amphibian communities through loss of suitable breeding sites and loss of	(Ficetola et al., 2011)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				fitness if breeding occurs in invaded sites	
		Phragmites australis (common reed)	Americas (Sub-region: North America)	Structural impact on ecosystem: decreases in plant biodiversity, declines in habitat quality for fish and wildlife Negative impact on human infrastructure: causes difficulties for drainage water removal, irrigation water supply, and recreational or commercial fishing access Negative impact on Indigenous Peoples and local communities: make it difficult to gather food and medicine from wetlands, and it can change the habitat. There are significant impacts on culture and traditions of the Mohawk community of Kahnawà in Montreal, Canada.	(Hazelton et al., 2014; Reo et al., 2017)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
		12 apple snails e.g., *Pomacea canaliculata* (golden apple snail)	Asia	Predation: alters benthic community structure Herbivory: altered macrophyte community structure in natural and managed wetlands through selective herbivory Negative impacts on economic sectors: they have become major pests of aquatic crops, including rice Negative impact on Indigenous Peoples and local communities: Farmers report that native snail populations were reduced. *Pomacea canaliculata* also damages many other cultivated and non-cultivated plants in Ifugao Rice Terraces, Philippines. Snails consume the young leaves and stems of newly transplanted rice seedlings,	(Horgan et al., 2014; Joshi et al. 2001; IPBES, 2020)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				necessitating their replanting. While farmers raised their seed investments, rice yields dropped by more than half. In the ricelands, approximately six species of edible snails, mudfish, and one edible weed have vanished in Tabuk Cordillera Region, Philippines.	
	Urban/Semi-urban	*Parthenium hysterophorus* (parthenium weed)	Asia and Pacific (Sub-region: South Asia)	<u>Negative impact on human health:</u> causes skin allergy, rhinitis, and irritation to eyes of the residents in the vicinity <u>Negative impact on Indigenous Peoples and local communities:</u> in the Gangetic plain (Tarai region in the south) of central Nepal, *Parthenium hysterophorus* is considered as harmful, with no fodder value	(Kohli et al., 2006; Shrestha et al., 2019)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
		Passer domesticus (house sparrow), *Sturnus vulgaris* (common starling), *Columba livia* (pigeons)	Americas (Sub-region: North America)	Competition with native species for food and nests	(Shochat et al., 2010)
		Linepithema humile (Argentine ant)	Americas (Sub-region: North America)	Indirect impact: reduces the number of native ants, and thereby availability of food resources for *Phrynosoma coronatum* (Coast Horned Lizard).	(Suarez & Case, 2002)
		Lonicera maackii (Amur honeysuckle), *Lonicera tatarica* (Tatarian honeysuckle)	Americas (Sub-region: North America)	Negative impacts on economic sectors (on forestry sector): reduced forest cover	(Borgmann & Rodewald, 2005)
		Aedes albopictus (Asian tiger mosquito)	Americas (Sub-region: North America)	Negative impact on human health: transmits the endemic eastern equine encephalitis, is a significant vector of re-emerging	(Rochlin et al., 2013)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				arthropod-borne viruses such as chikungunya, dengue, and West Nile	
	Cultivated areas (incl. cropping, intensive livestock farming etc.)	Several species (e.g., *Artemisia vulgaris* (mugwort), *Centaurea diffusa* (diffuse knapweed))	Americas; Asia and Pacific; Europe (Sub-region: North America; Oceania)	Chemical impact on ecosystem: inhibitory effects on whole plant growth of both herbaceous and woody species through their allelopathic activity	(Weston & Duke, 2003)
		Mustela vison (American mink)	Europe and Central Asia	Predation: have a significant effect on ground-nesting birds, rodents, and amphibians Competition: competes with European mink and the Eurasian polecat for prey Negative impacts on economic sectors (indirect impact through predation): trout and salmon farms and hatcheries, rabbit and sheep farms	(Bonesi & Palazon, 2007)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
		Numerous Australian *Acacia* species (e.g., *Acacia longifolia* (golden wattle), *Acacia salicina* (cooba))	Global	Structural impact on ecosystem: reduces water resources by increasing evapotranspiration, impacting the hydrological and carbon cycles; Decreases species diversity, as its dense coverage lowers the soil temperature and light penetration	(Richardson et al., 2011)
		Nosema bombi (microsporidian parasite)	Americas (Sub-region: North America)	Negative impacts on economic sectors (on agriculture sector): threat to native bumble bee populations	(Meeus et al., 2011)
Aquatic (marine and freshwater)	Cryosphere				
	Aquaculture areas	*Undaria pinnatifida* (Asian kelp), *Eucheuma* and *Kappaphycus* species	26 countries in the Pacific, east Africa and the Caribbean, the Mediterranean	Structural impact on ecosystem: causes changes to the composition of native macroalgal communities	(Schaffelke et al., 2007)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
		Magallana gigas (Pacific oyster), *Magallana ariakensis*, *Magallana angulata* (Portuguese oyster), *Crassostrea virginica* (eastern oyster), *Ostrea edulis* (European oyster), *Saccostrea glomerata* (Sydney rock oyster)	Worldwide to 73 countries	<u>Structural impact on ecosystem</u>: decrease of biodiversity, change of population and food-web dynamics and nutrient cycling, habitat degradation, disease, poor water quality, and detrimental species interactions	(Ruesink et al., 2005)
		43 taxa of macroalgae (e.g, *Sargassum muticum* (wire weed), *Undaria pinnatifida* (Asian kelp))	Europe and Central Asia (Sub-region: Central and Western Europe) Asia and Pacific (Sub-region: Oceania)	<u>Negative impacts on economic sectors: algae</u> proliferate in oyster aquaculture facilities (pillars, ropes, and oysters) and thus reduce available light, water circulation, and nutrient supplies to the detriment of oyster growth and a loss of revenue <u>Negative impact on Indigenous Peoples and local</u>	(IPBES, 2020b; Verlaque, 2001)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				communities: *Sargassum muticum* is a growing problem in Fiji, yet there is almost no literature on its impacts.	
		Several animals (e.g., *Carassius gibelio* (Prussian carp), *Pacifastacus leniusculus* (American signal crayfish), *Procambarus clarkii* (red swamp crayfish))	Europe and Central Asia Americas (Sub-region: South America)	Structural impact on ecosystem: outcompeting native species and altering habitat structure (i.e., crayfish plague dissemination, bioaccumulation of pollutants (storage and magnification of toxic substances in tissues), community dominance, competition, predation on native species, and habitat modifications), Food web alteration: generally causing changes in the energetic budget of the invaded ecosystem (e.g., by removing key-stone species, primary producers, etc.) Hybridization: salmonids (e.g., *Salvelinus fontinalis* (brook trout)) often	(Aigo & Ladio, 2016; Savini et al., 2010)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				cause genetic impairment of native stocks by hybridization <u>Transmission of disease:</u> cyprinids (e.g., herbivorous carps) are vectors of diseases and parasites <u>Negative impact on Indigenous Peoples and local communities:</u> Salmonids displace the native fish almost completely in the Mapuche communities of Puel, in the Neuquén province of Argentina. Socio-cultural change that goes hand in hand with the arrival of the white man.	
	Inland surface waters and water bodies/freshwater	Various alien species of plants and animals (e.g., *Potamogeton crispus* (curlyleaf pondweed), *Cyclotella cryptica* (diatom),	Americas (Sub-region: North America)	<u>Competition</u>: competes with native species for space, food, light <u>Predation</u>: predate on native species <u>Structural impact on ecosystem:</u> impacts on the structure of	(Mills et al., 1993)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
		Dreissena polymorpha (zebra mussel), *Dreissena rostriformis bugensis* (quagga mussel), *Gambusia affinis* (western mosquitofish))		freshwater ecosystems as a result of its filter-feeding activities. <u>Negative impacts on economic sectors:</u> in losses to commercial Great Lakes fisheries	
		Various alien species (e.g., *Aphanomyces astaci* (crayfish plague), *Myxobolus cerebralis* (whirling disease agent), *Lythrum salicaria* (purple loosestrife), *Myriophyllum spicatum* (spiked watermilfoil), *Phragmites australis* (common reed))	Americas (Sub-region: North America)	<u>Competition:</u> competes with native species for food and space <u>Predation:</u> predates native benthic species <u>Disease transmission:</u> parasitic infection for aquatic species <u>Structural impact on ecosystem:</u> molluscs that are primary consumers and disrupt the food web from its base, fishes that disrupt the food web from its apex or centre, decapods that act as powerful omnivores, aquatic plants that have	(Strayer, 2010)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				strong engineering effects and affect the quality and quantity of primary production, and diseases, which probably have been underestimated as an ecological force; habitat alteration	
		Pontederia crassipes (water hyacinth)	Americas (Sub-region: North America)	Chemical impact on ecosystem: decreases dissolved oxygen, nitrogen, phosphorous. Structural impact on ecosystem: decreases phytoplankton production, changes diversity of aquatic invertebrates, increases habitat heterogeneity and structural complexity Negative impacts on economic sectors: greatly affects fishery through changes in fish community composition, or changes in catchability of harvested species; fish catch rates have	(Villamagna & Murphy, 2010)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				decreased because water hyacinth mats block the access to fishing grounds, delay access to markets and increase costs (effort and materials) of fishing Negative impact on well-being and sustainable development: direct impacts are to boating access, navigability and recreation; and to pipe systems for agriculture, industry and municipal water supply, access to fishing grounds and fish catchability	
		Dreissena polymorpha (zebra mussel)	Americas (Sub-region: North America)	Structural impact on ecosystem: transformed freshwater food webs and biogeochemistry (caused planktonic food webs to wither and littoral food webs to flourish), reduce dissolved oxygen in the water column	(Strayer, 2009)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				Negative impact on human infrastructure: alters power plants and municipal drinking-water plants through fouling of pipes Negative impact on well-being and sustainable development: collapses of sport fisheries	
	Shelf ecosystems (neritic and intertidal/littoral zone)	*Sargassum muticum* (wire weed)	Europe and Central Asia (Sub-region: Central and Western Europe)	Structural impact on ecosystem: habitat forming species, change community structure and species composition	(Buschbaum et al., 2006)
		Carcinus maenas (European shore crab), *Hemigrapsus sanguineus* (Asian shore crab)	Americas (Sub-region: North America)	Competition: competes for food resources with native grapsid crabs	(Jensen et al., 2002)
		Mytilus galloprovincialis (Mediterranean mussel)	South African coast	Structural impact on ecosystem: competitive displacement of indigenous species and a dramatic	(Robinson et al., 2005)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
				increase in intertidal mussel biomass	
	Open ocean pelagic systems (euphotic zone)	*Pterois volitans* (red lionfish) and *Pterois miles* (lionfish)	Atlantic coral reefs	Predation: on a wide variety of marine fauna including juvenile mesopredators; overconsumption of small native reef fishes	(Hixon, 2011)
	Deep-Sea				
	Coastal areas intensively used for multiple purposes by humans	Several species (e.g., bryozoan *Membranipora membranacea*, *Carcinus maenas* (European shore crab), *Batillaria attramentaria*	Americas (Sub-region: North America)	Predation: predates on native species (mussels) Competition: competes with native species for food resources, space	(Grosholz, 2002)

Ecosystem	Unit of Analysis	Example taxa	IPBES Region where species is alien	Examples of impact*	Reference
		(Japanese false cerith))			
		Perna perna (brown mussel), *Teredo bartschi* (shipworm pecies) and *Teredo furcifera* (Deep-cleft shipworm)	Americas (Sub-region: North America)	Negative impact on human infrastructure: fouling problems on natural and man-made structures; damage to untreated wooden structures	(Kennish, 2002)
		Several species (e.g., *Sargassum muticum* (wire weed), *Caulerpa racemosa* (green algae), *Caulerpa taxifolia* (killer algae))	Mediterranean	Negative impacts on economic sectors (Negative impacts on animal production including fisheries and aquaculture): possess toxic metabolites	(Boudouresque & Verlaque, 2002)
		Carcinus maenas (European shore crab)	Asia and Pacific (Sub-region: Oceania)	Negative impacts on economic sectors: decreases juvenile abundance of *Katelysia scalarina* (sand cockle)	(Walton et al., 2002)

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