

Invasive Alien Species (IAS) Environmental, economic and social impact Introduction to Risk analysis. Part 1

Rumen Tomov

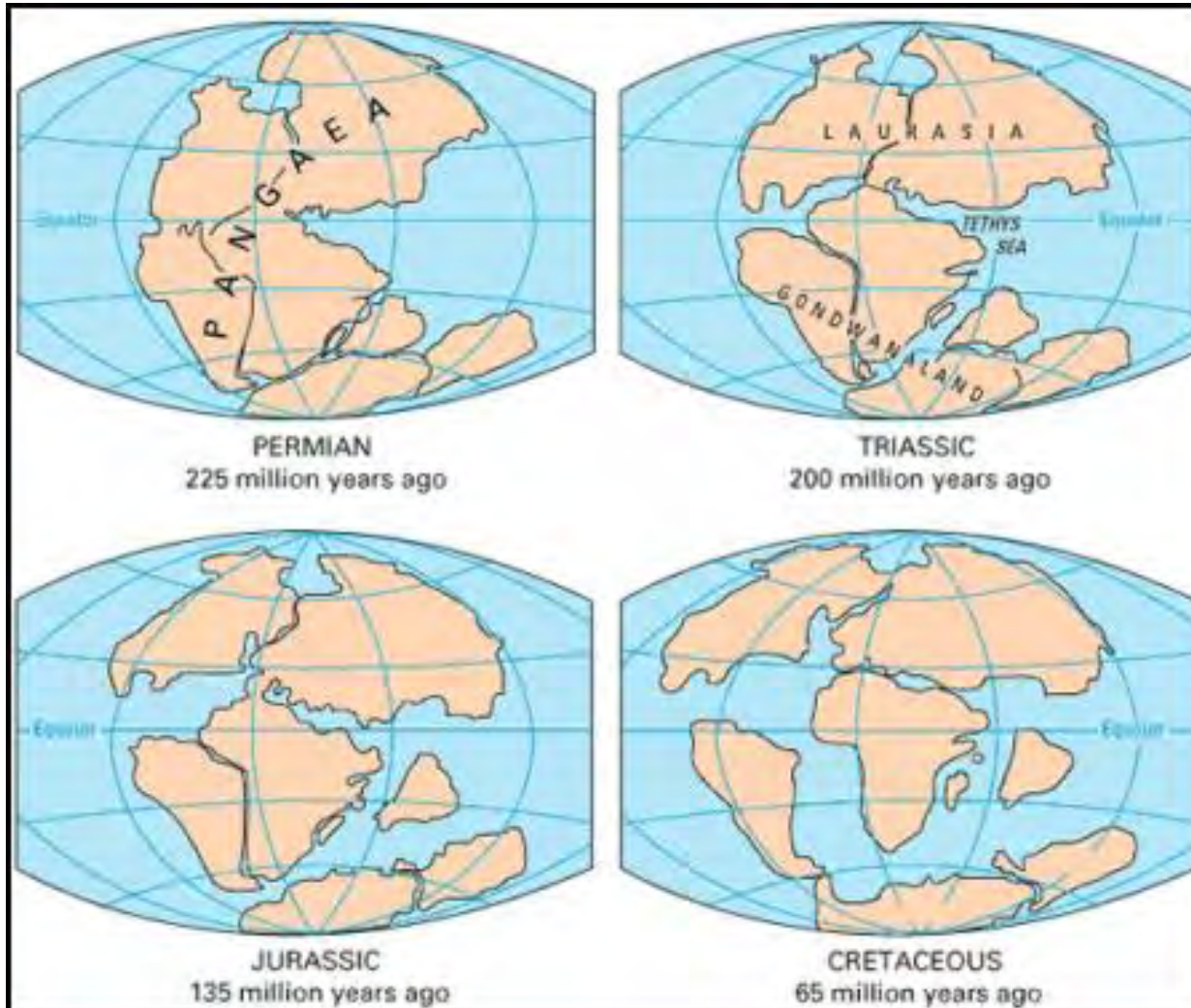


OUTLINE

- **Terminology**
- **Impact**
- **Introduction to Risk analysis**

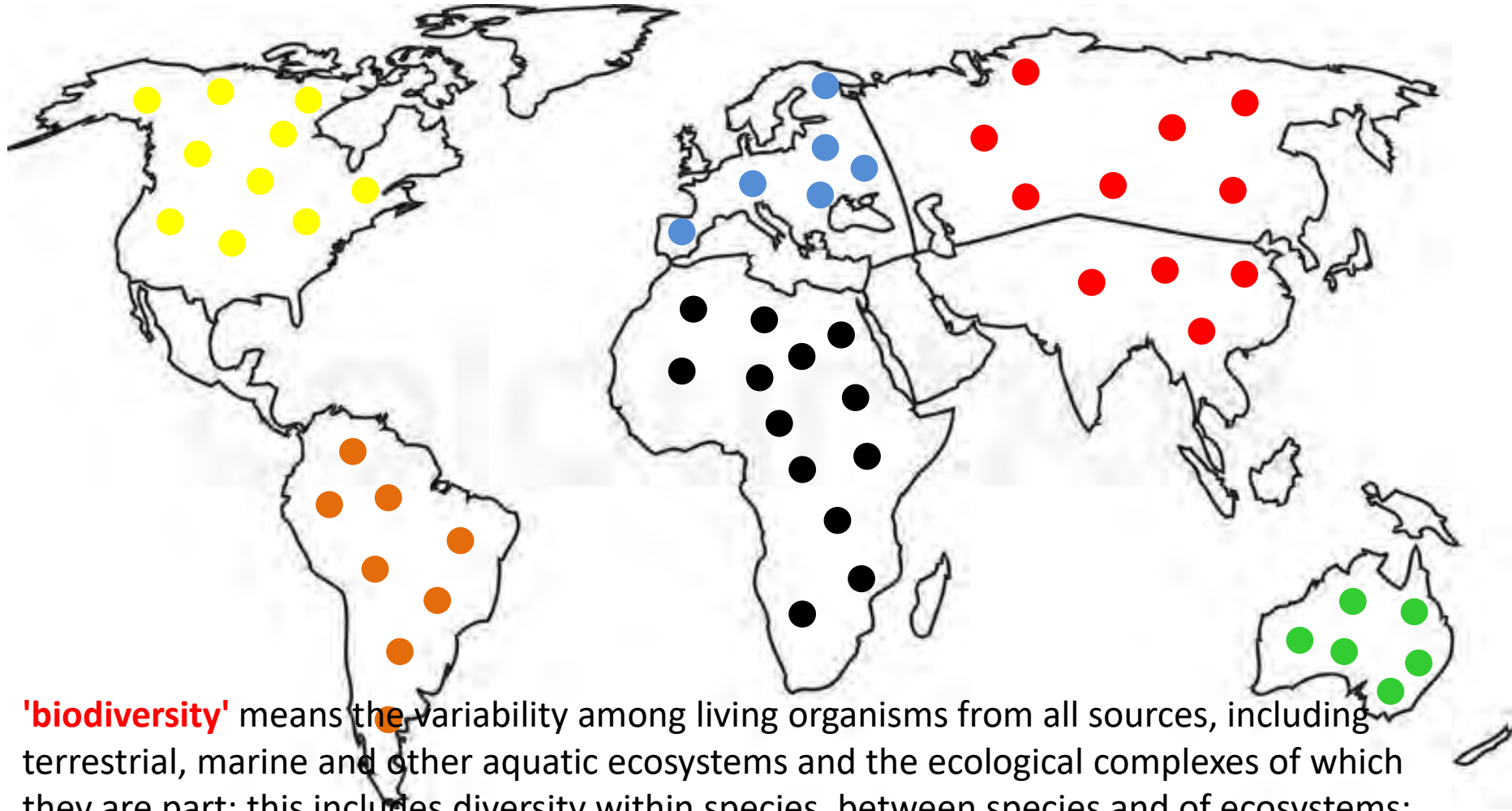
Terminology

Origin of species



Terminology

Biological diversity - result of the separate evolution of living forms and their adaptation to local conditions.;



'biodiversity' means the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems;

Ecosystem services

The direct and indirect contributions of ecosystems to human wellbeing

- “**supporting (habitat)**” (major ecosystem resources and energy cycles),
- “**provisioning**” (production of goods),
- “**regulating**” (maintenance of ecosystem processes),
- “**cultural**” (non-material benefits).



<http://www.fao.org/ecosystem-services-biodiversity/background/provisioning-services/en/>

Terminology

Supporting (habitat) services

- Highlight the **importance of ecosystems** to ensure soil formation and nutrient cycling, but also to provide habitat for migratory species and to maintain the viability of gene pools.
- Providing living spaces for plants or animals and maintaining a diversity of plants and animals, 'supporting services' are **the basis of all ecosystems and their services.**

Terminology

Provisioning services

- The material benefits **(products)** people obtain from ecosystems:
 - freshwater,
 - food,
 - genetic resources,
 - wood,
 - fibre
 - medicines.
- Many provisioning services are traded in markets.

Terminology

Regulating services

- The benefits obtained from the regulation of ecosystem processes such as:
 - Local Climate
 - Air Quality,
 - Carbon sequestration and storage
 - Moderation of extreme events,
 - Waste-water treatment,
 - Erosion prevention and maintenance of soil fertility,
 - Pollination,
 - Biological control,
 - Regulation of Water Flow

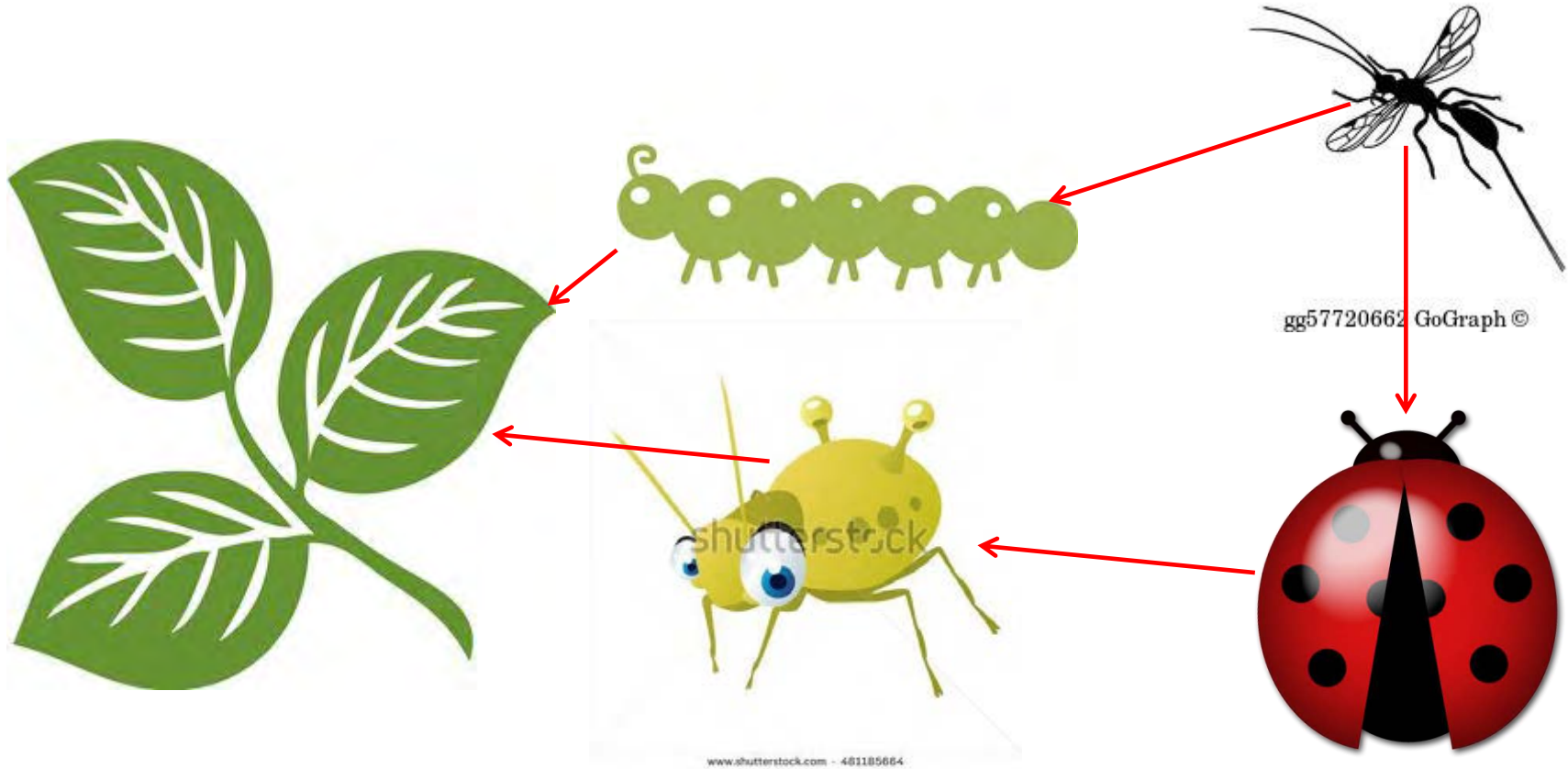
Terminology

Cultural services

- include opportunities for tourism and for recreation, religious, intellectual enrichment, aesthetic inspiration, cultural identity, sense of home, spiritual experience related to the natural environment and other **non-material benefits** that people obtain from ecosystems.
- are deeply **interconnected with each other** and often connected to provisioning and regulating services: Small scale fishing is not only about food and income, but also about fishers' way of life.
- **are among the most important** values people associate with Nature – it is therefore critical to understand them.

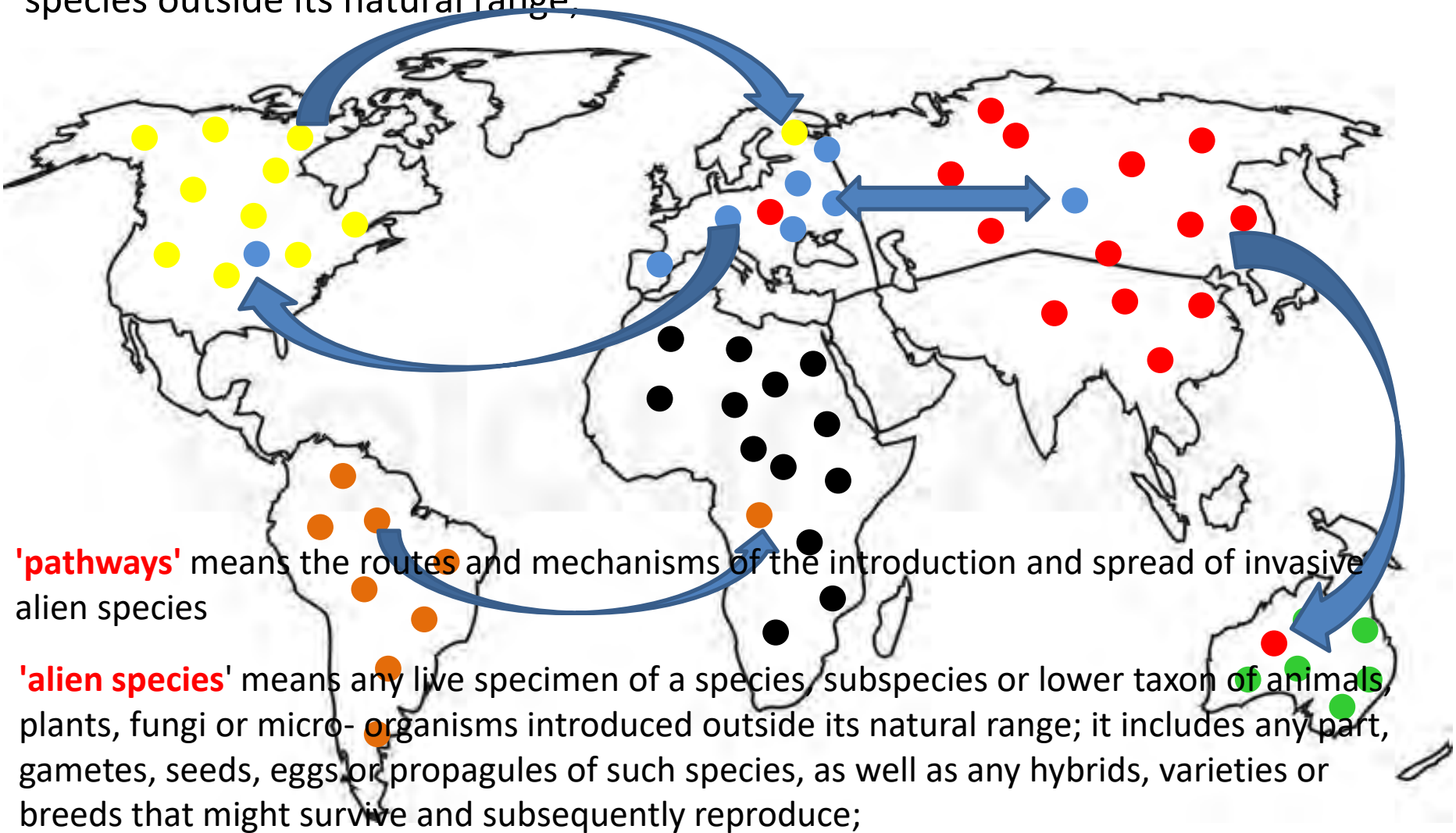
Terminology

Natural balance



Terminology

„**introduction**‘ means the movement, as a consequence of human intervention, of a species outside its natural range;



Terminology

Impact

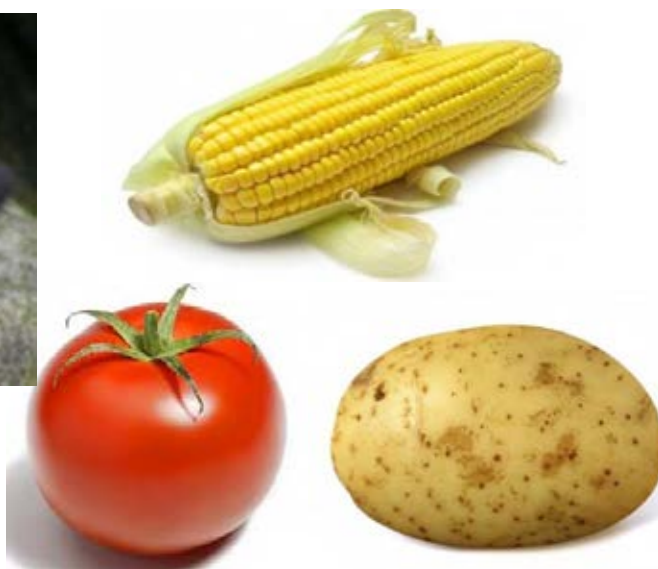
- **Positive for humans**
- **Negative**
 - Economic impact
 - Ecological impact (Environmental Impact)
 - Impact on ecosystem services;
 - Impact on human health;
 - Impact on human society
 - Socioeconomic impact

Positive Impact for humans

The introduction of alien species is also known to bring enormous **benefits** to specific sectors.

- Humans depend heavily on several non-indigenous organisms, used for agriculture, animal farming, fishery, wood production, medicine, aesthetic enjoyment, hunting or trade of ornamental plants.
- in some cases alien species can have **a positive role on the natural environment**, for example when they represent a basic food resource for native species, or when they replace some vegetation cover that had been previously destroyed.
- **the beneficial effects can still lead to long-term harm to the natural ecosystems.**

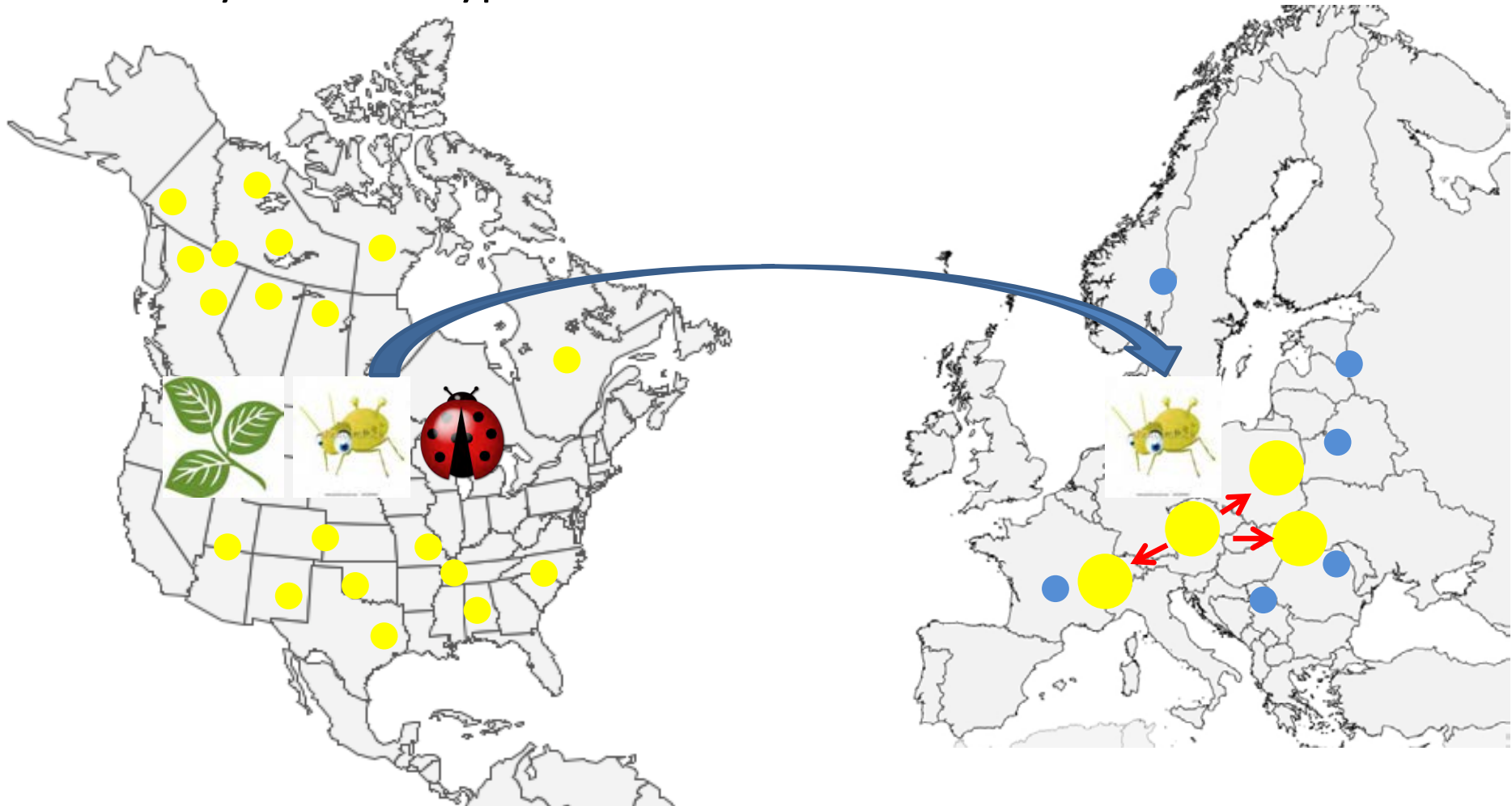
Positive Impact for humans



Negative impact

Why alien species are successful invaders?

The Enemy Release Hypothesis



Negative impact - risk

Unexpected size



Unexpected shape

Negative impact - risk

- Unexpected relationships



Terminology

Economic Impact - can be valued as financial costs

- In Europe, most expenses generated by invaders are in the **form of management costs**, including eradication, control, monitoring, and environmental education programs targeting emblematic natural areas for which there was specific funding
- In addition to management costs, information on **losses to provisioning services** is occasionally available, primarily for the agricultural, forestry, and fisheries sectors.
- In Germany, the estimated minimum costs of losses in stored grain – attributable to only three damaging arthropods – might be as high as **€12 million per year** (Reinhardt et al. 2003).
- In the region surrounding Milan, Italy, an attempt to eradicate populations of an invasive Asian long-horned beetle (*Anoplophora chinensis*) resulted in the removal of 2000 trees, at a cost of **€1.06 million**, apparently without success (van der Gaag 2007)

Terminology

Environmental Impact

From reducing genetic variation and eroding gene pools, through the extinction of endemic species, and by altering habitat and ecosystem functioning (Hulme 2007).

A measurable change to the properties of an ecosystem caused by an alien taxon.

This definition applies to all ecosystems—whether largely natural or largely managed by humans—but explicitly considers only effects that have impacts on the native biota or the ecosystem functions that derive from that environment. (Hawkins et al. 2015)

Terminology

Impact mechanisms (EICAT)

- **Competition** – the alien taxon competes with native taxa for resources (e.g. food, water, space), leading to deleterious impact on native taxa.
- **Predation** – the alien taxon predated on native taxa, either directly or indirectly (e.g. via mesopredator release), leading to deleterious impact on native taxa.
- **Hybridisation** – the alien taxon hybridises with native taxa, leading to deleterious impact on native taxa.
- **Transmission of disease** – the alien taxon transmits diseases to native taxa, leading to deleterious impact on native taxa.
- **Parasitism** – the alien taxon parasitizes native taxa, leading directly or indirectly (e.g. through apparent competition) to deleterious impact on native taxa.
- **Poisoning/toxicity** – the alien taxon is toxic, or allergenic by ingestion, inhalation or contact to wildlife, or allelopathic to plants, leading to deleterious impact on native taxa.

Terminology

- **Bio-fouling** – the accumulation of individuals of the alien taxon on wetted surfaces leads to deleterious impact on native taxa.
- **Grazing/herbivory/browsing** – grazing, herbivory or browsing by the alien taxon leads to deleterious impact on native plant species.
- **Chemical, physical or structural impact on ecosystem** – the alien taxon causes changes to either: the chemical, physical, and/or structural biotope characteristics of the native environment; nutrient and/or water cycling; disturbance regimes; or natural succession, leading to deleterious impact on native taxa.
- **Interaction with other alien species** – The alien taxon interacts with other alien taxa, (e.g., through pollination, seed dispersal, habitat modification), facilitating deleterious impact on native species. These interactions may be included under other impact mechanisms (e.g., predation, apparent competition) but would not have resulted in the particular level of impact without an interaction with other alien species

Terminology

Environmental Impact

A pragmatic solution for comparing diverse environmental impacts was recently developed: the Environmental Impact Classification for Alien Taxa, or EICAT (Blackburn et al. 2014, Hawkins et al. 2015)

OPEN ACCESS Freely available online

PLOS BIOLOGY

Essay



A Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts

Tim M. Blackburn^{1,2,3*}, Franz Essl⁴, Thomas Evans⁵, Philip E. Hulme⁶, Jonathan M. Jeschke⁷, Ingolf Kühn^{8,9}, Sabrina Kumschick¹⁰, Zuzana Marková^{11,12}, Agata Mrugała¹², Wolfgang Nentwig¹³, Jan Pergl¹¹, Petr Pyšek^{11,12}, Wolfgang Rabitsch¹⁴, Anthony Ricciardi¹⁵, David M. Richardson¹⁰, Agnieszka Sendek⁸, Montserrat Vilà¹⁶, John R. U. Wilson^{10,17}, Marten Winter⁹, Piero Genovesi¹⁸, Sven Bacher¹⁹

Diversity and Distributions, (Diversity Distrib.) (2015) 21, 1360–1363



Framework and guidelines for implementing the proposed IUCN Environmental Impact Classification for Alien Taxa (EICAT)

Charlotte L. Hawkins¹, Sven Bacher², Franz Essl³, Philip E. Hulme⁴, Jonathan M. Jeschke^{5,6}, Ingolf Kühn^{7,8}, Sabrina Kumschick^{9,10}, Wolfgang Nentwig¹¹, Jan Pergl¹², Petr Pyšek^{12,13}, Wolfgang Rabitsch¹⁴, David M. Richardson⁹, Montserrat Vilà¹⁵, John R. U. Wilson^{9,10}, Piero Genovesi¹⁶ and Tim M. Blackburn^{1,17,18,*}

Terminology

EICAT translates impacts caused through different mechanisms into five ranked categories of impact from **minimal to massive**;

EICAT is receiving increasing international support and has recently been adopted by the IUCN

(<https://portals.iucn.org/congress/motion/014>)

Terminology

Impact on ecosystem services (Binimelis et al., 2007)

How well do we understand the impacts of alien species on ecosystem services? A pan-European, cross-taxa assessment

135

Montserrat Vilà^{1*}, Corina Basnou², Petr Pyšek³, Melanie Josefsson⁴, Piero Genovesi⁵, Stephan Gollasch⁶, Wolfgang Nentwig⁷, Sergej Olenin⁸, Alain Roques⁹, David Roy¹⁰, Philip E Hulme¹¹, and DAISIE partners¹²

Recent comprehensive data provided through the DAISIE project (www.europe-aliens.org) have facilitated the development of the first pan-European assessment of the impacts of alien plants, vertebrates, and invertebrates – in terrestrial, freshwater, and marine environments – on ecosystem services. There are 1094 species with documented ecological impacts and 1347 with economic impacts. The two taxonomic groups with the most species causing impacts are terrestrial invertebrates and terrestrial plants. The North Sea is the maritime region that suffers the most impacts. Across taxa and regions, ecological and economic impacts are highly correlated. Terrestrial invertebrates create greater economic impacts than ecological impacts, while the reverse is true for terrestrial plants. Alien species from all taxonomic groups affect “supporting”, “provisioning”, “regulating”, and “cultural” services and interfere with human well-being. Terrestrial vertebrates are responsible for the greatest range of impacts, and these are widely distributed across Europe. Here, we present a review of the financial costs, as the first step toward calculating an estimate of the economic consequences of alien species in Europe.

Front Ecol Environ 2010; 8(3): 135–144, doi:10.1890/080083 (published online 20 Apr 2009)

Terminology

Impact on ecosystem services Binimelis et al. (2007)

SUPPORTING

- S1. Modification of soil and sediments (*Spartina anglica*)
- S2. Alteration of nutrient cycling (*Dreissena polymorpha*)
- S3. Community changes (*Procambarus clarkii*)
- S4. Refugia changes (*Caulerpa taxifolia*)
- S5. Changes in primary production (*Coscinodiscus wailesii*)

PROVISIONING

- P1. Loss or gain in food, fuel, or fiber (*Anoplophora chinensis*)
- P2. Threat to endangered native species (*Trachemys scripta*)
- P3. Alteration of genetic resources (*Oxyura jamaicensis*)

Terminology

Impact on ecosystem services Binimelis et al. (2007)

REGULATING

- R1. Alteration of biological control (*Harmonia axyridis*)
- R2. Changes in pollination services (*Opuntia stricta*)
- R3. Infection to native fauna and flora (*Aphanomyces astaci*)
- R4. Vectors of diseases (*Aedes albopictus*)
- R5. Production of toxic substances (*Chattonella verruculosa*)
- R6. Causing injuries (*Ambrosia artemisiifolia*)
- R7. Natural hazard protection (*Cortaderia selloana*)
- R8. Alteration of erosion regimes (*Myocastor coypus*)
- R9. Water regulation and purification (*Elodea canadensis*)
- R10. Bioaccumulation (*Ensis americanus*)

CULTURAL (**Impact on society**)

- C1. Changes in recreational use (*Heracleum mantegazzianum*)
- C2. Effects on ecotourism (*Rhopilema nomadica*)
- C3. Changes in the perception of landscapes (*Rosa rugosa*)
- C4. Aesthetics (*Cameraria ohridella*)

Terminology

- EICAT scheme - **Invasive alien taxon** - An alien taxon whose introduction and/or spread threatens **biological diversity**. This definition follows the Convention on Biological Diversity (<http://www.cbd.int/decision/cop/?id=7197>).
- The requirement that an invasive alien taxon cause threat or harm is common in **policy usage**, but less so in **scientific usage** where “invasive” usually simply implies that the taxon has spread widely from the point of establishment
- Regulation 1143 - 'invasive alien species - an alien species whose introduction or spread has been found to threaten or adversely impact upon **biodiversity and related ecosystem services**

Terminology

Regulation 1143

- 'invasive alien species of Union concern' means an invasive alien species whose adverse impact has been deemed such as to **require concerted action at Union level pursuant to Article 4(3)**;
- 'invasive alien species of Member State concern' means an invasive alien species other than an invasive alien species of Union concern, for which a Member State considers on the basis of scientific evidence that the adverse impact of its release and spread, even where not fully ascertained, **is of significance for its territory, or part of it, and requires action at the level of that Member State**;

Negative impact

EEA Technical report | No 16/2012

The impacts of invasive alien species in Europe

ISSN 1725-2237

Examples of IAS negative impact

- **impacts of IAS on biodiversity;**
 - **impacts of IAS on ecosystem services;**
 - **impacts of IAS on human health;**
 - **impacts of IAS on economic activities.**
- (EEA Technical report No 16/2012)

(EEA

Multiple impact (EEA Technical report No 16/2012)

Table 3.2 The selected alien species and their multiple impact

	Competing with local species	Predating local species	Transmitting or causing diseases or harm to local species	Hybridising with native species	Affecting habitats	Interfering with supporting services	Interfering with provisioning services	Interfering with regulating services	Interfering with cultural services	Disease vectors	Health impacts	Damaging infrastructure	Damaging landscapes	Damaging agriculture
American mink	X	O	O				O		O	O				
Bullfrog	X	O	O											
Brook trout	O	X		O			O		O					
Common slider	O	X	O							O	O			
Red swamp crayfish	O	O	X		O	O								
Chytrid fungus			X						O					
Canada goose	O		O	X		O		O	O	O	O			O
Ruddy duck				X					O					
Rabbit	O				X			O	O				O	O
Killer alga	O				X		O	O	O				O	
Japanese knotweed	O				O	X	O	O	O			O	O	
Ice plant	O				O	X	O	O	O			O	O	
Pontic rhododendron	O				O		X	O	O				O	
Spanish slug	O	O		O	O		X		O					O
Water hyacinth	O				O	O	O	X	O			O	O	
Yellow-legged hornet	O	O	O				O	X			O			
Killer shrimp	O	O					O		X					
Tree of heaven	O				O		O	O	X		O	O	O	
Asian tiger mosquito	O								O	X				

Examples of IAS negative impact

- **impacts of IAS on biodiversity;**
- **impacts of IAS on ecosystem services;**
- **impacts of IAS on human health;**
- **impacts of IAS on economic activities.**

(EEA Technical report No 16/2012)

Negative impact

Competition

Lithobates (Rana) catesbeianus EU concern

- Native to North America .
- **Biodiversity or the related ecosystem services:** it has serious negative impacts on native species through predation and competition, as well as disease transmission.
- In particular, it may have a major impact on many species of threatened native amphibians due to the role as vector of the chytrid fungus.



Negative impact

Competition

American mink *Neovison vison*

- Major threat to many endangered indigenous animals, including the European mink and the European polecat. The way this generalist and opportunistic predator is affecting such species is **through competition**, and sometimes by direct aggression.

In particular, the American mink is suspected of displacing the European mink



Negative impact

Competition

Sciurus carolinensis

- Native to North America
- The grey squirrel **is replacing the native red squirrel (*Sciurus vulgaris*)** in IE, IT and UK through resource competition. Replacement is also disease-mediated, as the species act as a **reservoir host to a squirrel poxvirus that causes high mortality in red squirrels**. The grey squirrel is also impacting biodiversity by bark stripping and predation of eggs and fledgling of birds.
- **Economy:** It causes damage to the timber industry through bark stripping. It can damage crops. The species is also reported to be a garden pest by digging and can damage properties, chewing timber, wires and stored goods.



Negative impact

Predation

Common slider *Trachemys scripta*

Biodiversity or ecosystem services: the species represents **a threat to local turtle species** including endangered species as the European pond turtle (*Emys orbicularis*) and *Mauremys leprosa* .

The diet of this opportunistic predator changes progressively from highly carnivorous in juveniles to omnivorous in adults. As a result, common sliders feed on several species of plants and animals, from insects and other invertebrates to vertebrates, including amphibians and reptiles, small mammals and birds, in practice, every kind of animal they can capture. Also due to its parasitic load, the species could be a key stressor to endemic turtle species.

Human health: they are reservoirs for Salmonella, and a source of human salmonellosis



Negative impact

Hybridisation

Ruddy duck

Oxyura jamaicensis

- ruddy duck hybridises and thereby threatens the White-headed Duck, an endangered species native to the Mediterranean and central Asia.



Branta canadensis (Canada goose)

- Hybridising with native species



Negative impact

Transmission of disease

Procambarus clarkii

- The species is competing with native crayfish and transmitting crayfish plague to them, which is leading to the demise of native crayfish populations.
- It is adversely impacting freshwater ecosystems and wetlands (borrowing activities, predation and competition with native species) and causes important changes in composition and habitat structure in wetlands.
- The species causes large changes in species composition and habitat structure, including in European designated sites.



Economic: It damages rice cultivations as well drainage/irrigation systems. It undermines bank stability leading to leakages and/or collapse (greater damage than with signal crayfish), and damage to agriculture (rice fields) and irrigation systems.

Economic cost of damage amounts to over 100 million euros per year across Europe.

Negative impact

Bio-fouling

Dreissena polymorpha



Negative impact

Chemical, physical or structural impact on ecosystem

excellent example of the **complex effects that** an introduced mammalian may exert on the ecosystems to which it has been introduced.

One of the most negative impacts showing the role of rabbits as key drivers of ecosystem change, includes habitat degradation following overgrazing, which in turn is responsible for altering the composition and local abundance of both animals and plants

Oryctolagus cuniculus



Negative impact

Interaction with other alien species

Originates from Asia. The larvae of box tree moth feed on leaves of the box tree (*Buxus sempervirens*) but can also attack the bark of the trees. The moth totally defoliates the infested plants in all invaded regions

Cydalima perspectalis



Negative impact

Impact on ecosystem services

- Ecosystems supporting (habitat) services

Fallopia japonica - Japanese knotweed

Transforming species diversity and physico-chemical properties and the structure of invaded sites.

By building up **large and dense monodominant stands** it reduces light availability to the understorey, inhibiting growth of woody seedlings and shading out other plants, which results in a delayed succession



Negative impact

Impact on ecosystem services

- provisioning services



Rhododendron ponticum - Pontic rhododendron very **competitive and shades out plants** wherever it grows, except for those trees that have grown above the rhododendron canopy.

Seedlings of these trees, however, **cannot establish beneath** rhododendron and so in the long term forests are transformed to monodominant rhododendron stands

Negative impact

Impact on ecosystem services

- provisioning services

Arion vulgaris - Spanish slug



More than 100 different host plants have been observed. In Norway, more than 50 % yield loss in strawberry fields is reported. It can reach very high densities above 100 animals per square meter, which really annoys people and forces them to withdraw their gardening activities

Negative impact

Impact on ecosystem services

Regulating services

Eichhornia crassipes Water hyacinth

Biodiversity or related ecosystem services: the plant grows in **thick floating mats reducing light and leading to oxygen depletion**, thus seriously disturbing aquatic ecosystems, causing loss of species and habitats. It is considered as the most damaging aquatic weed in the world.

Human health: infestations can intensify mosquito problems.

Economy: it has serious impacts on agriculture due to increased water loss due to evapotranspiration. It can also suppress crops and inhibits germination. The plant also disturbs drainage, it damages hydropower plants, hampers recreation and disrupts fisheries.



Negative impact

Impact on ecosystem services

Regulating services

Vespa velutina nigrithorax Asian hornet



Biodiversity or ecosystem services: **predating honey bees**, social wasps, other Hymenoptera, several types of Diptera, and various unclassified insects, several of which are likely to provide unmanaged pollination services. Pollinator services will be adversely affected if predation by Asian hornets significantly reduces their numbers.

Human health: although hornets are usually defensive, they may be considered a nuisance to recreational activities and cause health issues.

Economy: damage to managed honey bees, damage to ripe fruit, impact on crop yields due to impact on pollination.

Negative impact

Impact on ecosystem services

Cultural services

Ailanthus altissima Tree of heaven

- used for ornamental purposes and stabilisation of soil. The Tree-of-heaven grows more rapidly than native plant species, and thus, it changes the structure and composition of plant communities.
- Destroy roads and walls.
- Changes in soil quality



Negative impact

Impact on ecosystem services

Cultural services

In the 1970s, the nomadic jellyfish entered the Mediterranean Sea via the Suez Canal.

Local municipalities along the Aegean and Levantine coastlines reported a subsequent **decrease in the number of tourists** frequenting the beaches, because of concerns over the painful stings this jellyfish can inflict (Galil and Zenetos 2002).

Rhopilema nomadica



Negative impact



Environmental Evidence

This Provisional PDF corresponds to the article as it appeared upon acceptance. Fully formatted PDF and full text (HTML) versions will be made available soon.

What evidence exists for changes in the occurrence, frequency or severity of human health impacts resulting from exposure to alien invasive species in Europe? A systematic map protocol

Environmental Evidence (2015) 4:10

doi:10.1186/s13750-015-0037-4

Helen R Bayliss (h.r.bayliss@bangor.ac.uk)
Stefan Schindler (stefan.schindler@umweltbundesamt.at)
Franz Essl (franz.essl@umweltbundesamt.at)
Wolfgang Rabitsch (wolfgang.rabitsch@umweltbundesamt.at)
Andrew S Pullin (a.s.pullin@bangor.ac.uk)

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Negative impact

Impact on human health

- **Vectors of disease**



Tiger mosquito- *Aedes albopictus*

Transmits more than 20 pathogens on humans

Negative impact

Impact on Human health

Heracleum persicum - The plant can create **large stands** and have a negative impact on native species as they can totally replace native populations and have an impact on associated fauna.

Human health: these plants have very negative health consequences as their sap can **photosensitize skin and cause severe burning.**

Heracleum sosnowskyi - these plants also have very negative health consequences as their sap can photosensitize skin and cause **severe burning.**



Negative impact

Impact on Economy

- Infrastructure
- Landscape
- Agriculture

Negative impact

Impact on Economy

- **Infrastructure**

Myocastor coypus - Coypu



Biodiversity or the related ecosystem services: the coypu has major impacts on native species and ecosystems and it is likely to decrease the conservation status of wetlands.

Human health: the species can be a vector of diseases.

Economy: it causes massive damage to agriculture and river banks. IT reported 10 million euro of river bank damage, more than 900,000 euro of damage to agriculture and 2.6 million euro control costs. UK spent 5 million euro to eradicate the IAS.

Negative impact

- **Impact on landscape**

Example for harmful but Not regulated species

Cydalima perspectalis



Training Course 'Impact of invasive alien species on biodiversity and ecosystem services in extreme environments' 03 – 04 April 2017, Sofia, Bulgaria

Negative impact

Crop pests



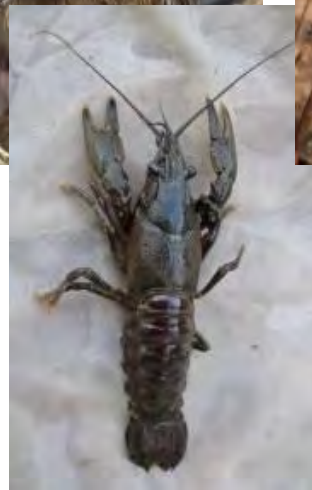
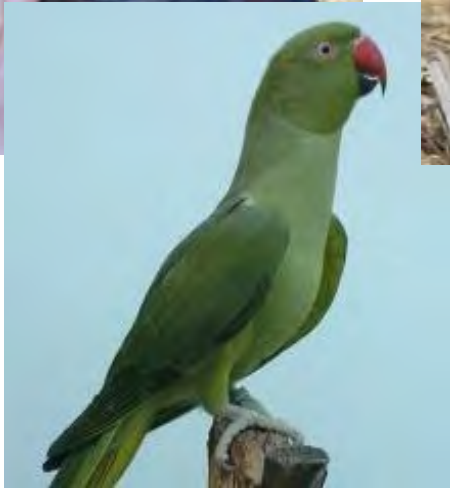
Negative impact

socio-economic impacts OR cultural ecosystem services

- Many alien taxa are known to cause **socio-economic impacts** by affecting the different constituents of human well-being
 - security;
 - material and immaterial goods for a good life;
 - health;
 - social, spiritual and cultural relations;
 - freedom of choice and action.

CONCLUSION

- Invasive alien species (IAS) are now considered to be the second cause of global biodiversity loss after direct habitat destruction and have adverse environmental, economic and social impacts from the local level upwards. (European Strategy on Invasive Alien Species)



Acknowledgements

The project: “East and South European Network for Invasive Alien Species – a tool to support the management of alien species in Bulgaria (ESENIAS-TOOLS)” is funded under the Programme BG03 “Biodiversity and Ecosystem Services” within the Financial Mechanism of the European Economic Area (2009-2014)

Thank you for your attention!