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IASON

Black Sea
CROSS BORDER
COOPERATION

IASON Project, BSB 1121

D.T1.1.1

Literature & Data Review on IAS

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1. Introduction

With this report we provide a literature review for all project partners in the IASON Project as a knowledge-basis that will help finding and using the necessary information for the preparation of many different outputs. This literature review can also be used by the management authorities from investigation areas (and other protected areas) to enhance their knowledge regarding invasive alien species, climate change impacts and adaptation options.

In the application form of the IASON Project this output is described as an analysis of literature concerning the invasive alien species and assessment of climate change impacts in Black Sea deltaic protected areas and an analysis of relevant national legislation, informal management guidelines and management plans. With the support of all project partners and investigation areas we collected relevant sources and tried to relate them to different chapters of this report, though some publications contain information on different subjects which made the allocation difficult.

Because of the huge number of publications on invasive alien species (IAS) and climate change impacts this review cannot claim to cover all information available. If one enters the words “invasive alien species” into Google, it responds with 10.600.000 results; or ”climate change” leads to 510.000.000. findings. And even in Google Scholar, that only lists scientific articles the search for “invasive alien species” leads to 146.000 findings and for ”climate change” leads to 3.680.000. findings. We tried to focus on information that is most topical and that is closest to the topics of the IASON Project. It seems necessary to monitor available databases for more up to date information that might be published during the time span of this project. Future publications concerning invasive alien species (IAS) and climate-change related topics will be distributed via internal communication of the IASON Project.

Terminology

Invasive non-native plants are those "naturalized plants which produce offspring, often in large numbers, at considerable distances from the parent plants and on large areas" (Anastasiu, P., et al., 2013).

The approximate scale for assessing the invasion phenomenon (Richardson, D.M., et al., 2000): "> 100m / 50 years for taxa that spread through seeds or other propagules and over 6m / 3 years for taxa that spread through roots, rhizomes, stolons and / or creeping stems". The *Azola* water fern (*Azolla filiculoides*) can be considered a good example of this. First mentioned more than 90 years ago in the Danube Delta, *Azola* now covers significant areas of water, especially in the south of the country, affecting native species and habitats (Anastasiu, P., et al., 2013).

Please note that, in accordance with Article 8 of the Convention on Biological Diversity, invasive alien species means an alien species whose introduction and / or spread threatens biological diversity, not just a species that succeeds in producing offspring at a great distance from the original site. of the introduction.

Those invasive plants that "change the character, condition, shape or nature of ecosystems over a substantial area in relation to the extent of those ecosystems" are called "transformers". False indigo bush (*Amorpha fruticosa*) can be considered as such. Where they settle, they often form monodominant communities (Doniţă, N., et al., 2005) and completely change the invaded ecosystem.

1.1 Objectives

The overarching objective of this literature review is to provide an overview on relevant literature about IAS related subjects. That includes literature about already observed and projected IAS impact, literature about impacts of IAS presence on different sectors like agriculture, forestry or nature conservation and literature on specific impacts on habitats and local species in protected areas.

The objectives of the review of scientific literature about IAS related subjects are:

- to give an overview about the state of research and discussions in national and international scientific communities, with focus on habitat types and on specific impacts of IAS in different countries;
- provide a basis for information exchange between participating countries about existing experiences and research results on impacts of IAS on habitats;
- to identify subjects and habitats of common interest on which further research may focus.

Therefore, this literature review provides information about habitat types that are already well investigated, which IAS effects are considered relevant and what kind of measures for adaptation in protected areas are already discussed. It compiles information on IAS related problems existing in protected areas and shows, what problems are already visible or are expected in the future and which differences exist in different countries. With the content of this review we want to make sure those actions and outputs of the IASON Project cover all relevant problems currently discussed in science and literature.

Beside the review of scientific publications and policy papers it is an additional objective to compile information about the relevant national legislation, informal management guidelines and management plans.

The objectives of the review of national legislation and management guidelines are

- to identify the legal basis for the management of protected areas for further analysis;
- to identify national management guidelines to protected areas for later integration of climate-change aspects.

The information about existing management plans for the participating investigation areas contains data about the legal framework for the management of protected areas which might have to be revised in order to allow adaptation measures inside the protected areas. With the information about national and federal laws, rules and guidelines which are:

- important for the management of protected areas;
- deal with impacts of IAS on natural environment and could be used as a basis for mitigation and adaptation measures.

The sources gathered in chapter 5 "Legislation and guidelines concerning climate change and nature conservation" provide basic information for the adaptation and revision of legislation in order to integrate IAS and adaptation requirements into the legal framework. The information about national legislation and management guidelines will be provided by different project partners from the participation countries.

1.2. Relevance for other work packages and outputs of the IASON Project

The present action refers to the collection and review of literature and historical data **1.** on IAS with the aim to build a sound information baseline regarding IAS presence and status in the Black Sea Basin and in specific at the deltas of the project area.

For this purpose, information about IAS will be derived from (a) scientific literature (b) monitoring programmes of habitat and species mapping in the project areas (c) IAS information databases. In particular, the scientific literature review will rely on publications on scientific journals that deal with the issue of IAS in the project area as well as other studies coming from the academia (dissertations etc). This kind of information will be gathered not only in relation to past occurrences of IAS in the project area, but potential distributions of IAS under future climatic scenarios will be also appreciated. Monitoring programmes of habitat and species mapping in the project areas may also reveal information of IAS threats on them. For example, the Joint Danube Survey (2013), the Joint Programme of Measures of the Danube River Basin Management Plan (2009, 2015) and the Update of the International Commission for the Protection of the Danube River (ICPDR) Strategy on Adaptation to Climate Change (2018) contain valuable information about IAS in the Danube River Basin. Other relevant IAS information will be also recorded such as their ecology, invasion pathways, impacts of IAS on ecological and socio-economic parameters, management and control programmes carried out, legislation and strategic plans etc. As a second step, information on IAS will be derived from other sources such as IAS information databases. There are several IAS networks existing in a global and European level. Existing networks for Invasive Alien Species Prevention and Management are: - European Alien Species Information Network (EASIN) system launched by European Commission's Joint Research Centre (JRC) to support the new IAS Regulation 1143/2014 (EU 2014) and to enhance the knowledge base on biological invasions - Delivering Alien Invasive Species In Europe (DAISIE) and North European and Baltic Network on Invasive Alien Species (NOBANIS) - The European and Mediterranean Plant Protection Organization (EPPO) list on plant IAS - East and South European Network for Invasive Alien Species (ESENIAS) - Danube Region Invasive Alien Species Network (DIAS) - Global Invasive Alien Species database (GISG) based on IUCN Species Survival Commission Search results of these examples of IAS databases will be cross-examined with the literature review. A set of criteria will be developed among the specialists of the partner countries so as to conclude with the 'worst' invasive species with serious impacts on biological diversity and human activities. The review will contain a preliminary assessment to reach a draft IAS list according to the assessment of existing bibliographic data. This draft IAS list will be later presented to stakeholders (Activity AT1.2). **2.**

The literature and data review on IAS will contain a sum of all the recorded literature as well as of data on IAS (historical and predicted) from existing IAS databases. Any spatial information will be also recorded. All the information will be inventoried in the form of a bibliographic database. Also, the review will contain a preliminary assessment, though a methodological selection of criteria, in order to reach a draft IAS list according to the assessment of existing bibliographic data.

1.3 Method of literature review

To get an overview on the state of research in different participating countries of the Habit-Change Project, we asked for country-specific literature. Detailed bibliographic information was collected for every resource. Because some literature is only available in national language, we also asked for a translation of the title.

Project partners were asked to assign the relevant legislation to the following categories:

- legal basis for protected areas
- property laws that protect rights of landowners, users and stakeholders
- forestry legislation relevant for the management of protected areas
- agricultural legislation relevant for the management of protected areas
- water legislation relevant for the management of protected areas
- nature conservation legislation relevant for the management of protected areas
- other relevant legislation e. g. laws addressing climate change, mitigation and adaption

Even though a large share of information provided by our project partners is available in English, there are some publications only available in national languages. They will be included in the review because they are of great value for the managing authorities of protected areas in the respective participating countries. If literature is only available in national language you will find information about the language in brackets, for example for articles in Romanian language you find [Romanian] at the end of the bibliographical information.

In a second step the information received from project partners will be completed with additional literature we searched for in online data-bases. We put a focus on literature that is easily assessable via internet and that is published in English, so all project partners can make use of it. For literature that can be downloaded from the internet we added the hyperlink. Especially with journal articles we included the abstract in the review. This was not possible for all articles but it will make it easier to decide whether certain resources really contain the expected information.

Differing from former plans to structure the literature review by participating countries of the IAson Project, we decided to choose a structure that assigns the sources to different topics. That way it will be easier to search the review for literature dealing with a certain topic. Please consider that most articles and publications do not focus on one subject only. We tried to identify the main content in order to locate the publication in the fitting chapter of this report. If you're looking for information on a certain subject it might be useful to search other chapters of this report for relevant content, too.

2. Impact of Invasive Alien Species on Biodiversity

2.1 Impact on ecosystems

According to IUCN, the World Conservation Union, states that the impacts of alien invasive species are immense, insidious, and usually irreversible. They may be as damaging to native species and ecosystems on a global scale as the loss and degradation of habitats.

Hundreds of extinctions have been caused by invasive alien species. The ecological cost is the irretrievable loss of native species and ecosystems.

Growing global trade and communication are directly contributing to the mixing of wildlife across biogeographical boundaries.

Species that appear in new environments may fail to survive but often they thrive, and become invasive. In fact, native species are likely to be unprepared to defend themselves against the invaders. This process, together with habitat destruction, has been a major cause of extinction of native species throughout the world in the past few hundred years.

Although in the past many of these losses have gone unrecorded, today, there is an increasing realization of the ecological costs of biological invasion in terms of irretrievable loss of native biodiversity.

Introductions of alien species are among the most important, least controlled, and least reversible of human impacts on the world's ecosystems, strongly affecting their biodiversity, biogeochemistry, and economic uses. Indeed, the ecological, economic, and evolutionary changes caused by alien species are so profound that some biologists have suggested that we are entering a new era, the Homogocene (a term apparently coined by Gordon Orians in the mid-1990s – Rosenzweig, 2001), in which all of the continents are connected into a "New Pangaea" through human activities.

The ecosystems of the Homogocene will be different from the ecosystems that freshwater ecologists have become familiar with, and will pose important challenges to both scientists and managers (David L. Strayer, 2010).

2.1.1 Impact on forest ecosystems

According to FAO – Food and Agriculture Organization of the United Nations (http://www.fao.org/3/j6854e/J6854E06.htm):

An integral part of sustainable forest management is measures to protect forests from natural threats such as fire, insects and diseases. Increasingly, an additional and more severe threat has been affecting the forest sector worldwide - invasive species. Invasive species are any species that are non-native to a particular ecosystem and whose introduction and spread causes, or are likely to cause, socio-cultural, economic or environmental harm or harm to human health.

The increasing global movement of people and products is also facilitating the movement of alien species around the world. These species may be unintentionally introduced to new environments in shipments of food, household goods, wood and wood products, new and used tires, animal and plant products, containers, pallets, internal packaging materials and humans. In the absence of their natural predators, competitors and pathogens, they can prosper in new environments and spread at the expense of native species, affecting entire ecosystems.

Not all invasive species have been inadvertently introduced, however. Particularly challenging to natural resource management are non-native species that have been intentionally introduced into an ecosystem to provide economic, environmental or social benefits. Many species of plants, trees and animals have been introduced outside their native ranges as ornamentals for gardening or for the pet industry. These species have escaped to become serious problems in forests and other ecosystems. This is a considerable concern in the forest sector since many of the tree species used for agroforestry, commercial forestry and desertification control are alien or non-native to the area. It is vital to ensure that such species serve the purposes for which they were introduced and do not escape to cause negative effects on native ecosystems.

While the definitions and impacts of invasive species on the forest sector are still debated and need reviewing in the context of forest management, a number of initiatives, programmes and activities have been initiated. Most programmes focus on damage caused to local forest ecosystems, or to a particular species or group of species, by a given pest[*] over a period of time. There is an overall lack of information on invasive species and the forest sector at the global scale. Information sharing is necessary in the planning and implementation of any strategy for the management of invasive alien species.

The FAO Forestry Division is addressing the pressing global issue of invasive species in the following ways.

- A **review of forest insect pests and diseases** (including invasive species) in both naturally regenerating forests and planted forests was carried out in 25 countries representing Africa, Asia and the Pacific, Europe, Latin America and the Caribbean and the Near East.
- **Profiles** on a number of important pest species impacting forests and the forest sector worldwide were prepared.
- A publication on global forest health, including insect pests, diseases and invasives species has been prepared: ***Global review of forest pests and diseases***.
- With the financial support of the FAO-Netherlands Partnership Programme, the FAO Forestry Department carried out a number of **fact-finding studies to assess the extent and intensity of invasiveness by forest trees**.

- The data gathered in the global review of the status of invasiveness of forest tree species outside their native habitat is available in **database** format.
- FAO has documented the benefits and drawbacks of *Prosopis* **spp.** which have been introduced in many countries, especially in dry and semi-arid zones, because of its capacity to survive in harsh environments and its potential in the restoration of degraded lands.
- FAO offers assistance to countries not only in response to pest outbreaks and emergencies but also in establishing **long-term prevention and forest protection strategies**.
- FAO serves as a **neutral forum**, bringing countries together to discuss technical and policy issues related to invasive species and the forest sector.
- FAO has also helped establish regional networks dedicated to the issue of invasive species and the forest sector.
- FAO is a member of the Inter-agency Liaison Group on Invasive Alien Species (IALG-IAS) of the Convention on Biological Diversity (CBD) which facilitates cooperation among relevant organizations to support measures to prevent the introduction and mitigate the impacts of invasive alien species.

Ukraine

Highly active invasive species have a wide distribution range in Ukraine and, respectively, the uniqueness of species composition in different botanical and geographical regions of Ukraine and latitudinal zones is low. In the forest belt of Ukraine, 60 invasive species were found with the following distribution: Transcarpathian forests — 48 species, Carpathian forests — 26, Ciscarpathian forests — 47, forests of Roztochia — 27, forests of Western Ukraine – 33, Little Polissia – 25, Western Polissia — 50, Right-Bank Polissia — 42, Left-Bank Polissia — 55, Central

Urkaine forests — 30 (Protopopova, 1973; Burda, 2003; Tokachuk et al., 2012; Dvirna, 2014; Karmyzova, 2014; Burda et al., 2015; Shevera et al., 2017; Borsukevich, 2019; Protopopova and Shevera, 2019).

At the end of the 20th century, the role of ornamental plants among alien invasive weeds was growing considerably. We can mention such taxa as *Impatiens glandulifera, Echinocystis lobata, Reynoutria japonica*, species of the genus *Helianthus*, and *Padus serotina* (=*Prunus serotina*). In forest communities and in marginal habitats, we often observe new patterns of intensive spread of shrubs and trees with edible fruits, such as *Amelanchier ovalis* Medik., species of the genus *Rubus* L., *Elaeagnus angustifolia*, and *Hippophae rhamnoides* L. Introduction of cultivated shrubs *Amorpha fruticosa* and *Caragana arborescens* Lam., and, in the late 1920s, of woody species *Ulmus pumila* L., *Quercus palustre*, and *Q. rubra* L. promoted their invasions in forest plant communities. Practically all invasive American trees and shrubs were originally cultivated in Ukraine for ornamental, forestry and other purposes.The main types of invasive trees: *Acer negundo* L., *Acer sacharinum* L., *Ailanthus altissima* (Mill.) Swingle, *Robinia viscosa* Vent., *Robinia pseudoacacia* L., *Quercus rubra* L., *Celtis occidentalis* L., *Populus italica* (Du Roi) Moench, *Juglans cinerea* L., *Juglans regia* L., *Juglans mandshurica* Maxim., *Fagus sylvatica* L., *Picea abies* (L.) H. Karst., *Pinus banksiana* Lamb., Fraxinus lanceolata Borkh., *Gleditschia triacanthos* L., *Larix decidua* Mill., *Phellodendron amurense* Rupr, *Ginkgo biloba* L., *Gymnocladus dioicus* (L.) K. Koch., *Ulmus pumila* L., *Elaeagnus angustifolia* L., *Salix fragilis* L., *Quercus rubra* L. For example, *Amorpha fruticosa* forms mixed *A. fruticosa* – *Populus nigra* communities in riparian parts of river valleys in the forest-steppe and steppe zones of Ukraine. This highly invasive species in the lower reaches of the Danube forms monodominant communities and also is a component of the associations *Hippophae rhamnoides* + *A. fruticosa*, *Salix alba* + *A. fruticosa*, and some others, and poses a serious threat for unique tree and shrub vegetation complex of Danube Biosphere Reserve (Shelyag-Sosonko & Dubyna, 1984; Dubyna et al., 2015). *Acer negundo* plays a similar role in floodplain forests of the forest-steppe zone;

Elaeagnus angustifolius occupies a well-determined econiche in the southern regions of Ukraine.

The shrubs, which impact the forests ecosystems in Ukraine are: *Sorbaria sorbifolia* (L.) A. Braun., *Spiraea × vanhouttei* (Briot) Zabel., *Physocarpus opulifolius* (L.) Maxim., *Amelanchier ovalis* L., *Amelanchier canadensis* L., *Ptelea trifoliata* L., *Rhus typhina* L., *Amorpha fruticosa* L., *Cotinus coggygria* Scop., *Mahonia aquifolium* (Pursh) Nutt,.*Lycium barbarum* L., *Salix purpurea* Moor., *Parthenocissus quinquefolia* Planch), *Celastrus flagellaris* Rupr.

In last century, there are 30 invasive insect species are recorded as pests of the forests and parks in Ukraine (Uzhevska, 2017). The brown marmorated stink bug (*Halyomorpha halys*) and citrus flatid planthopper (*Metcalfa pruinosa*) are recorded as pest of wide spectrum of tree species; both actively spread the ranges in last decade. Among the aggressive invaders, which could affect the forest ecosystems, only one species of mammals is recorded, i.e. raccoon dog *Nyctereutes procyonoides* (Zagorodniuk, 2010). But, this species inhabits not in every type of forests. It occurres mainly near the river banks and lake shores, in humid forests. Therefore it has negative impact on the flood forests ecosystems.

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Turkey

There are some invasive species in Turkey that has negative impact in forest ecosystems, be indicated in Table 1, with information about the geographical origin (NR), the life span (LS) and the growth form (GF).

Table 1. List of invasive alien plants in the Black Sea forest

Family	Species	NR	LS	GF	Impact	Reference
Fabacese	*Acacia dealbata* Link	Australia	Perennial	Tree	Prevents the spread of natural species	Brundu et al., 2011
Aceraceae	*Acer negundo* L.	N./S. America	Perennial	Tree	Prevents the spread of natural species	Merceron et al., 2016
Simarubaceae	*Aiilanthus altissima* (Miller) Swingle	N.. China	Perennial	Tree	Prevents the spread of natural species	Brundu et al., 2011
Amaranthaceae	*Amaranthus chlorostachy* L.	N.America	Annual	Herb	Causes loss of yield	Brundu et al., 2011
Asteraceae L	*Ambrosia artemisiifolia* L.	N. America	Annual	Herb	Decreases biological diversity. It is allergic for humen healt	Önen et al., 2015**a**
Amaranthaceae	*Amaranthus retroflexus* L.	S. America	Annual	Herb	Threats biological diversity	Saberali et al. (2012)**,** Gholamhoseini et al. (2013)**,** Amini et al., 2014.
Asteraceae	*Artemisia verlotiorum* Lamotte	E. Asia	Perennial	Herb	Prevents the spread of natural species	Brundu et al., 2011
Asteraceae	*Bidens frondosa* L.	N. America	Annual	Herb	Threats biological diversity	Brundu et al., 2011**;** Tad et al., 2015
Rutaceae	*Citrus trifoliata* I.(Benth.) S.Moore	China	Perennial	Tree	It adversely effects wildlife. Threatens natural resources.	Önen, 2015
Commelinaceae	*Commelina communis* L.	China	Annual	Herb	It spoils the structure of the soil. It disrupts the food cycle. Hosts some viral diseases.	Brundu et al., 2011**;** Farooq et al., 2015
Asteraceae	*Crassocephalum crepidioides*	Africa	Annual	Herb	Causes loss of yield. Hosts some viral diseases. Harmful to animals	Önen, 2015

Family	Species	NR	LS	GF	Impact	Reference
Asteraceae	*Erigeron annuus* L	N. America	Annual	Herb	Decreases biological diversity.	Brundu et al., 2011
Asteraceae	*Conyza canadensis* (L.) Cronquist	S. America	Annual	Herb	Hosts some viral diseases	Önen, 2015
Verbenaceae	*Lantana comara* L	N/S America	Perennial	Shrub	Threats biological diversity.	Brundu et al., 2011
Caprifoliaceae	*Lonicera japonica* Thunb	E Asia	Perennial	Vine	Decreases biological diversity. It prevents the survival and development of other species by using the nutrients in the soil.	Brundu et al., 2011
Poaceae	*Microstegium vimineum* (Trin) A Camus	E Asia	Annual	Herb	It reduces the variety and abundance of species. Cause monoculture	Brundu et al., 2011
Onagraceae	*Oenothera glazioviana* Micheli	N America	Biennial	Herb	Threats biological diversity.	Kalnikova and Palpurina, 2015
Poaceae	*Paspalum dilatatum* Poiret	S America	Annual/perennial	Herb	Threats biological diversity. Harmful to animals	Brundu et al., 2011
Poaceae	*Paspalum distichum* L.	N/S America	Perennial	Herb	Decreases biological diversity	Önen, 2015
Polygonaceae	*Persicaria perfoliata*(L.) H. Gross	E Asia	Perennial	Herb	It reduces the density of the species. The species suffocates. It causes deforestation.	Önen et al., 2015**a,b,c**
Phytolaccaceae	*Pyhtolacca america* L	N America	Annual/Perennial	Herb	Decreases biological diversity. Harmful to human and animals	Brundu et al., 2011**,** Akyol et al., 2015
Pinaceae	*Pseudotsuga menziesii* (Mirb) Franco	N America	Perennial	Tree	Prevents the spread of natural species	Brundu et al., 2011
Fabaceae	*Robinia pseudoacacia* L	N America	Perennial	Tree	Prevents the spread of natural species. Harmful to animals	Brundu et al. 2011

Family	Species	NR	LS	GF	Impact	Reference
Cucurbitaceae	*Sicyos angulatus* L	America	Perennial	Vine	Threats biological diversity. Hosts pathogens	**Onen et al., 2015**
Asteraceae	*Solidago canadensis* L.	N America	Perennial	Herb	Prevents plants from germinating. It is allergic for human health	Önen, 2015
Commelinaceae	*Tradescantia fluminensisd* Vell	S America	Annual	Herb	Prevents plants from germinating. Change the nutrient cycle.	Önen, 2015
Asteraceae	*Xanthium strumarium* L	Cosmopol	Annual	Herb	Threats biological diversity.	Brundu et al., 2011

<u>Georgia</u>

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2.1.2 Impact on grassland ecosystems

Semi-natural grasslands are important habitats for biodiversity conservation in European agricultural. For centuries, these habitats have been used primarily for animal husbandry; however, this function has recently become less important due to decreasing livestock. As a consequence, many semi-natural grasslands have been abandoned, afforested or converted into arable land or intensively managed grasslands. Changes in land use and in the management of semi-natural grasslands have led to the encroachment of trees and shrubs and to the expansion of alien or native competitors, which tend to dominate ecosystems (Marta Czarniecka-Wiera, Zygmunt Kącki, Milan Chytrý & Salza Palpurina, 2019).

Several studies have suggested that alien species invasions cause a decline in species richness (henceforth SR) of native plant. This phenomenon is linked to the ability of alien species to become dominant in a plant community outside its native range and to locally replace native. The evolution of increased competitive ability suggests that once separated from their natural enemies, alien species evolve to use more resources to develop competitive traits, e.g. larger size and increased fecundity.

However, the relative abundance of native species can also increase in the changing environment. For example, after cessation of mowing and grazing in grasslands, species which represented a low proportion of the biomass of the managed grasslands can expand and attain dominance, resulting in a decrease in community SR (Marta Czarniecka-Wiera, Zygmunt Kącki, Milan Chytrý & Salza Palpurina, 2019).

The effect of dominant species on SR depends on the sampling scale because species interactions tend to be intense within small areas, but weakening in larger areas where environmental heterogeneity tends to separate different species in space, thus reducing direct contact between plant. This scale-dependent effect is observable in studies on the impact of alien species' dominance on biodiversity: fine-scale studies more often suggest that invasive species are a threat to biodiversity, whereas coarse-scale studies tend to report a negligible impact. This scale-dependent effect of invasive species on SR to the species–area relationship (SAR). They sampled paired forest plots with and without invasive species and found that the decline in the number of species at the invaded sites, compared with that at non-invaded sites, was larger in smaller plots than in larger plots. However, many studies have highlighted that the SAR depends on the plant community. It is, therefore, unclear whether the pattern observed is valid in other community types, such as grasslands (Marta Czarniecka-Wiera, Zygmunt Kącki, Milan Chytrý & Salza Palpurina, 2019).

Ukraine

The level of adventization of some steppe communities reaches 12% (Protopopova et al., 2002, 2003).In the forest steppe belt, the number of highly active invasive species is 56 with the following distribution: Volyn Forest Steppe — 21, Western Forest Steppe — 42, Right-Bank Forest Steppe — 48, Left-Bank Forest Steppe — 49, Kharkiv Forest Steppe — 45. In the steppe belt, 50 invasive species were revealed with the following distribution: Right-Bank Grass Mead-ow Steppe — 44, Left-Bank Grass Meadow Steppe — 29, Starobilsk Grass Meadow Steppe — 42, Donetsk Grass-Meadow Steppe — 43, Right bank Grass Steppe — 43, Left bank Grass Steppe — 33, Wormwood Steppe — 21. In the Crimea the number of invasive species is 42 with the following distribution: Crimean Forest Steppe — 28, Crimean Mountains — 8, Crimean southern coast — 35. In the Black Sea Biosphere Reserve, the most dangerous alien plants in sandy steppe habitats are Cenchrus longispinus and Verbesina encelioides (Cav.) Benth. et Hook.f. ex A.Gray (Ximenesia encelioides Cav.) (Kozhevnikova and Rubtzov, 1971; Protopopova, 1973; Burda et al., 2015).

In coastal habitats in the lower reaches of the Dnieper, dense colonies of Xanthium albinum cause insularization of native populations. Disappearance of populations of the endemic West Pontic species Centaurea margarita-alba along the Black Sea Coast was promoted by massive distribution of Centaurea diffusa, Xanthium albinum and Grindelia squarrosa on habitats where this endemic species previously grew (Protopopova et al., 2002, 2003).

In Podilski Tovtry National Park, alien plant species represent 13.5% of the total number of species of vascular plants. Among them, such species as Artemisia annua and Phalacroloma septentrionale promote pauperization of meadow plant communities; and Artemisia absinthium, Carduus nutans, Centaurea diffusa, and Eleagnus angustifolium do the same in the steppe communities.

Steppe zone of Ukraine, the disturbed plant communities are actively colonized by Grindelia squarrosa, Anisantha tectorum (L.) Nevski, Centaurea diffusa Lam. and many other species. This species in grass and forb communities sometimes comprises up to 30% of the projective cover. The tendency of penetration of this species in steppe and petrophytic steppe communities is evident even in plant associations where typical steppe species dominate (e.g., Festuca sulcata (Hack.) Nyman), Stipa lessingiana Trin. et Rupr., Salvia nutans L.). Such species as Centaurea diffusa, Anisanta tectorum (=Bromus tectorum), Ambrosia artemisiifolia, and Cenchrus longispinus also demonstrate high invasiveness in the steppe zone.

Several species are considered as aggressive invaders, e.g. Amaranthus retroflexus L., Anisantha tectorum (L.) Nevski, Apera spica-venti (L.) P. Beauv., Arrhenatherum elatius (L.) J. Presl. et C. Presl., Artemisia absinthium L., Asclepias syriaca L., Ballota nigra L., Cannabis ruderalis Janisch, Capsella bursa-pastoris L. Medik, Cardaria draba (L.) Desv., Carduus acanthoides L., Cenchrus longispinus (Hack.) Fernald, Centaurea diffusa Lam., Chenopodium hybridum L., Coniza canadensis (L.) Cronq., Cyclachaena xanthiifolia (Nutt.) Fresen., Datura stramonium L., Descurainia sophia (L.) Webb ex Prantl, Digitaria ischaemum (Schreb) Muehl., Echinochloa crusgalli (L.) P. Beauv., Echinocystis lobata (Michx.) Torr. & A.Gray, Erigeron canadensis L., Galinsoga parviflora Cav., Helianthus tuberosus L., Heracleum mantegazzianum Sommier & Levier, Heracleum sosnowskyi Manden, Hordeum murinum L., Impatiens glandulifera Royal., Impatiens parviflora DC., Lactuca serriola Torner, Lepidium densiflorum Schrad., Oenothera rubricaulis Klebahn., Ornithogalum umbellatum L., Phalacroloma annuum (L.) Dumort., Phytolacca americana L., Setaria pumila (Poir.) Roem. et Schult., Setaria viridis (L.) P. Beauv., Sisymbrium loeselii L., Solidago canadensis L., Tribulus terrestris L., Vicia villosa Roth., Conium maculatum L.

Other examples of invasive American grasses now activelyively spreading in Ukraine are Echinochloa microstachya (Wieg.) Rydb. (= E. muricata [P.Beauv.] Fern. var. microstachya Wieg.), Eragrostis pectinacea [Michx.] Nees (which seems to displace the native species E. pilosa), Hordeum jubatum L. (spreading mostly along railroads), Panicum capillare L. and P. dichotomiflorum Michx.

In Ukraine, the invasive animal species with threat for grassland ecosystems are not recorded. Among the species with some impact on the steppe ecosystem we can mention the European rabbit Oryctolagus cuniculus and red sheep Ovis orientalis (Zagorodniuk, 2006).

The European rabbit was introduced to Ukraine at the beginning of 19th century, to be acclinased in different regions, e.g. Northern Black Sea coast, Crimea and Slobodzhanshchina. But, most of the introductions were unsuccesfull, except of the southern parts of the Odessa and Mykolaiv regions. The species is ussualy not recognized as invasive, because intentionally introduced and used by human. For example, in the Odessa Oblast, the artificial pastories for the rabbits are organized as canals with holes.

The red sheep was first introduced as hunting object to Crimean in 1915. Now it is known for Askania Nova, Dzharylgach Island, Zalissia Reserve. But, the main populations inhabit the mountain part of Crimea and Northern Azov coasts, expecially the Biryuchyi Island. The total value of the population is about 1200 individuals. Most of red sgeep populations are isolated from each other and inhabit hunting grounds (Zagorodniuk, 2006).

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Turkey

The grasslands are high-quality forage source for ruminants and natural life areas for wild animals worldwide. Stockbreeding is very important for many countries and mainly depends on rangelands. Unfortunately, rangelands in Turkey have been destroyed within the last 70 years, decreasing from 45 million hectares to 14.6 million hectares (TUIK, 2015).

Almost 30 percent of the Turkey's flora is comprised of endemic species and 1.5 percent of the country's flora is exotic plants (Onen and Farooq, 2015). Moreover, nearly 55 percent of the forest lands comprise of coniferous species and remain part is deciduous forest (Sirtioglu, 2010). Around 40 percent of forests are degraded, and 99 percent of the forests are owned by the state where the remainder is owned by public or private sector. Private sector also owns approximately 10000 Ha of forest lands and according to General Directorate of Forestry (GDF), total growing stock is 1.2 billion m^3 in state forests of Turkey (Sirtioglu, 2010).

The flora of Turkey has a rapid increase in recent years (Arslan et al., 2015). Based on the GDF data collection results, new taxa are frequently being established by introduction of invasive alien species. Nevertheless, there is not any national database for determination of invasive alien species in Turkey. Although there have been some other databases such as European and Mediterranean Plant Protection Organization (EPPO) and Delivering Alien Invasive Species Inventories for Europe (DAISIE) reported the occurrence of invasive alien plants dispersal in Turkey, there is still urgent need of a comprehensive local database (Arslan et al. 2015; Brundu et al., 2011; Lambdon et al., 2008). The EPPO list is reported in Table 2 which indicates invasive alien plants recorded in Turkey (Arslan et al., 2015).

Table 2. European and Mediterranean Plant Protection Organization (EPPO) list of invasive alien plants in Turkey and their native ranges (Arslan et al. 2015)

Plant name	Family name	Life	Origin
Ailanthus altissima	Simaroubaceae	Perennial	China
Ambrosia artemisiifolia	Asteraceae	Annual	North America
Azolla filiculoides	Azollaceae	Perennial	America

Plant name	Family name	Life	Origin
Carpobrotus edulis	Aizoaceae	Perennial	South Africa
Cortaderia selloana	Poaceae	Perennial	America
Eichhorni crassipes	Pontederiaceae	Perennial	Amazon
Ludwigia peploides	Onagraceae	Perennial	America
Miscanthus sinensis	Poaceae	Perennial	East Asia
Oxalis pes-caprae	Oxalidaceae	Perennial	South Africa
Paspalum distichum	Poaceae	Perennial	America
Polygonum perfoliatum	Polygonaceae	Perennial	East Asia
Sicyos angulatus	Cucurbitaceae	Annual	North America
Solanum elaeagnifolium	Solanaceae	Perennial	South Africa

Furthermore, the presence of invasive plants in Turkey has been recorded since 1965 due to their rapid colonization and rich diversity of the country (Davis, 1970). The long history and establishments of various colonies in Turkey importantly impacted the dispersal of vegetation including invasive alien species around the country (Davis, 1970). Some exotic crops like papaya, kiwi, tea, banana, and avocado are well-established in the country which shows that pertinent habitats exist for various types of terrestrial and aquatic invasive alien plants (Onen and Farooq, 2015). Another example is three alien species survey in both Artvin and Trabzon provinces, *Sporobolus fertilis* (Steud.) W.D. Clayton (Gramineae), *Physalis pubescens* L. (Solanaceae), and *Abrosia elatior* L. (Compositae) which were newly introduced to northeastern Anatolia. During the surveys, the results showed that these species have occurred for a long time with more than a hundred populations, and indigenous plants have been prominently threatened by these invasive alien species (Byfield and Baytop, 1998).

The tea cultivation lands of Trabzon region in Turkey tend to be occupied by invasive alien plants due to commodities required for tea processing imported from neighbor countries (Brundu et al., 2011). For this reason, roadside surveys were conducted in the Trabzon province and as a result, 81 invasive alien plants were observed and recorded adjacent to forested lands (Brundu et al., 2011) (Table 3).

Table 3. The 81 invasive alien plants recorded by Brundu et al. 2011 on the Black Sea Region of Turkey (NR: geographical origin, LS: the life span and GF: growth form) (Brundu et al. 2011)

	Family	Species	NR	LS	GF
1	Malvaceae	*Abutilon theophrasti* Medik.	W. Asia	Annual	Herb
2	Fabaceae	*Acacia dealbata* Link.	Australia	Perennial	Tree
3	Euphorbiaceae	*Acalypha australis* L.	E. Asia	Annual	Herb
4	Aceraceae	*Acer pseudoplatanus* L.	W. Asia	Perennial	Tree
5	Agavaceae	*Agave americana* L.	C. America	Perennial	Tree-Like
6	Simarubaceae	*Ailanthus altissima* (Miller) Swingle	N. China	Perennial	Tree
7	Fabaceae	*Albizzia julibrissin* Durazzo	Asia	Perennial	Tree
8	Amaranthaceae	*Amaranthus chlorostachys* L.	N. America	Annual	Herb
9	Amaranthaceae	*Amaranthus graecizans* L.	Paleotrop	Annual	Herb
10	Amaranthaceae	*Amaranthus hybridus* L.	N. America	Annual	Herb
11	Asteraceae	*Ambrosia artemisiifolia* L.	N. America	Annual	Herb
12	Fabaceae	*Amorpha fruticose* L.	N. America	Perennial	Shrub
13	Asteraceae	*Artemisia annua* L.	W. Asia	Annual	Herb
14	Asteraceae	*Artemisia verlotiorum* Lamotte	E. Asia	Perennial	Herb
15	Asteraceae	*Bidens frondosa* L.	N. America	Annual	Herb
16	Poaceae	*Bromus tectorum* L.	Doubtful	Annual	Herb
17	Buddlejaceae	*Buddleja davidii* Franchet	China	Perennial	Shrub
18	Cannaceae	*Canna indica* L.	S. America	Perennial	Herb
19	Cupressacae	*Chamaecyparis lawsoniana* (Murray) Parl.	N. America	Perennial	Tree
20	Euphorbiaceae	*Chamaesyce nutans* (Lag.) Small	N. America	Annual	Herb
21	Euphorbiaceae	*Chamaesyce prostrate* (Aiton) Small	N. America	Annual	Herb
22	Chenopodiaceae	*Chenopodium botrys* L.	Paleotrop	Annual	Herb
23	Commelinaceae	*Commelina communis* L.	China	Annual	Herb
24	Cyperaceae	*Cyperus esculentus* L.	Tropical	Perennial	Herb
25	Solanaceae	*Datura stramonium* L.	America	Annual	Herb
26	Poaceae	*Digitaria sanguinalis* (L.) Scop	Cosmopol	Annual	Herb
27	Ebenaceae	*Diospyros lotus* L.	Asia	Perennial	Tree
28	Poaceae	*Echinochioa erecta* (Pollacci) Pign.	E. Asia	Annual	Herb
29	Poaceae	*Eleusine indica* (L.) Gaertn.	Africa	Annual	Herb
30	Asteraceae	*Erigeron annuus* L.	N. America	Annual	Herb

	Family	Species	NR	LS	GF
31	Asteraceae	*Erigeron bonariensis* L.	C. America	Annual	Herb
32	Asteraceae	*Erigeron canadensis* L.	N. America	Annual	Herb
33	Asteraceae	*Erigeron sumatrensis* Retz.	S. America	Annual	Herb
34	Rosaceae	*Eriobotrya japonica* (Thunb.) Lindley	E. Asia	Annual	Herb
35	Myrtaceae	*Eucalyptus camaldulensis* Dehn.	Australia	Perennial	Tree
36	Asteraceae	*Galinsoga ciliate* (Raf.) S.F.Blake	S. America	Annual	Herb
37	Asteraceae	*Helianthus annuus* L.	C./N. America	Annual	Herb
38	Saxyfragaceae	*Hydrangea macrophylla* (Thunb.) Ser.	E. Asia	Annual	Herb
39	Sapindaceae	*Koelreuteria paniculate* Laxm.	China	Perennial	Tree
40	Aizoaceae	*Lampranthus roseus* (Willd) Schwantes	S. Africa	Perennial	Subshrub
41	Verbenaceae	*Lantana comara* L.	C./S. America	Perennial	Shrub
42	Oleaceae	*Ligustrum japonicum* Thunb.	Asia	Perennial	Tree
43	Caprifoliaceae	*Lonicera japonica* Thunb.	E. Asia	Perennial	Vine
44	Asteraceae	*Matricaria discoidea* DC	N./E. Asia	Annual	Herb
45	Poaceae	*Microstegium vimineum* (Trin) A.Camus	E. Asia	Annual	Herb
46	Meliaceae	*Melia azedarach* L.	Asia	Perennial	Tree
47	Nyctaginaceae	*Mirabilis jalaba* L.	C./S. America	Annual	Forb/Herb
48	Oxalidaceae	*Oxalis corniculate* L.	Cosmopol	Annual	Herb
49	Oxalidaceae	*Oxalis stricta* L.	S. America	Annual	Herb
50	Vitaceae	*Parthenocissus quinquefolia* (L.)	Planch. N. America	Perennial	Vine
51	Poaceae	*Paspalum dilatatum* Poiret	S. America	Annual/perennial	Herb
52	Scrophulariaceae	*Paulownia tomentosa* (Sprengel) Steud.	Asia	Perennial	Tree
53	Poaceae	*Pennisetum sp.*	Tropical	Annual/Perennial	Herb
54	Arecaceae	*Phoenix canariensis* Chabaud	Canary Is.	Perennial	Tree
55	Verbenaceae	*Phyla nodiflora* (L.) Greene	S. America	Perennial	Forb/Herb
56	Poaceae	*Phyllostachys aurea* Carr./A.&C.Riv.	Asia	Perennial	Herb
57	Phytolaccaceae	*Pyhtolacca america* L. (Zehirliii)	N. America	Annual/Perennial	Herb
58	Pinaceae	*Picea abies* (L.) Karsten	Eurosib	Perennial	Tree
59	Polygonaceae	*Polygonum perfoliatum* L.	Asia	Perennial	Vine
60	Salicaceae	*Populus nigra L. subsp. Italica* (Duroi)	Asia	Perennial	Tree
61	Salicaceae	*Populus* x *canadensis* Moench	Hybrid	Perennial	Tree
62	Portulacaeae	*Portulaea oleracea* L.	Cosmopol	Annual	Herb
63	Pinaceae	*Pseudotsuga menziesii* (Mirb.) Franco	N.America	Perennial	Tree
64	Euphorbiaceae	*Ricinus communis* L. (Zehirliii)	Africa	Annual/Perennial	Shrub
65	Fabaceae	*Robinia pseudoacacia L.*	N. America	Perennial	Tree
66	Fabaceae	*Robinia pseudoacacia* L. cv"Purple Robe"	N. America	Perennial	Tree

	Family	Species	NR	LS	GF
67	Poaceae	*Setaria faberi* F. Herm.	Cosmopol	Annual	Herb
68	Poaceae	*Setaria vericillata* (L.) Beauv.	Cosmopol	Annual	Herb
69	Poaceae	*Setaria viridis* (L.) Beauv	Cosmopol	Annual	Herb
70	Cucurbitaceae	*Sicyos angulatus* L.	America	Perennial	Vine
71	Solanaceae	*Solanum luteum* Miller	Euri-Medit	Annual	Herb
72	Solanaceae	*Solanum hycopersicon* L.	C./S. America	Annual	Herb
73	Solanaceae	*Solanum nigrum* L.	Cosmopol	Annual	Herb
74	Poaceae	*Sorghum halepense* (L.) Pers.	Cosmopol	Perennial	Herb
75	Asteraceae	*Symphyotrichum squamatum* (Spreng)	C./S. America	Annual	Herb
76	Asteraceae	*Tagetes minuta* L.	S. America	Annual	Herb
77	Bignoniaceae	*Tecomaria capensis* (Thunb.) Spach	S. Africa	Perennial	Herb
78	Arecaceae	*Trachycarpus fortuneri* (Hook.) H.Wendll.	E. Asia	Perennial	Tree
79	Asteraceae	*Xanthium spinosum* L.	S. America	Annual	Herb
80	Asteraceae	*Xanthium strumarium* L.	Cosmopol	Annual	Herb
81	Poaceae	*Zea mays* L.	C./S. America	Annual	Herb

Global Invasive Species Database (GISD) also reported 19 different invasive alien plants prevalent in Turkey and these species were defined as threats for environmental health of ecosystem (Table 4). In addition, new invasive alien taxa have been introduced specifically from east to west of the country which leads to a dramatic increase in the establishment and thrive of invasive plants and substantial alterations in the indigenous flora (Terzioğlu and Karaer, 2009).

Table 4. Occurrence of invasive alien plants that are reported by GISD in Turkey (http://www.issg.org/database).

Plant Name	**Family Name**	**Growth Form**	**Habitat**	**Origin**
Acacia saligna	Fabaceae	Tree	Terrestrial	Australia
Ailanthus altissima	Simaroubaceae	Tree	Terrestrial	China
Ambrosia artemisiifolia	Asteraceae	Herb	Terrestrial	U.S.
Carpobrotus edulis	Aizoaceae	Perennial	Terrestrial	South Africa
Cortaderia selloana	Poaceae	Perennial	Terrestrial	South U.S.
Cyperus rotundus	Cyperaceae	Sedge	Terrestrial	Africa
Eupatorium cannabinum	Asteraceae	Herb	Terrestrial	Europe
Halophila stipulacea	Hydrocharitaceae	Seagrass	Aquatic	Indian Ocean

Plant Name	Family Name	Growth Form	Habitat	Origin
Imperata cylindrica	Poaceae	Grass	Terrestrial	Southeastern Asia
Lantana camara	Verbenaceae	Shrub	Terrestrial	U.S.
Microstegium vimineum	Poaceae	Grass	Terrestrial	South Asia
Oxalis pes-caprae	Oxalidaceae	Herb	Terrestrial	South Africa
Paspalum distichum (P. paspalodes)	Poaceae	Grass	Terrestrial	Terrestrial
Persicaria perfoliata	Polygonaceae	Vine,	climber	Terrestrial Asia
Robinia pseudoacacia	Fabaceae	Tree	Terrestrial	Southeastern U.S.
Sicyos angulatus	Cucurbitaceae	Herb	Terrestrial	U.S.
Solanum sisymbriifolium	Solanaceae	Herb	Terrestrial	South U.S.
Sorghum halepense	Poaceae	Grass	Terrestrial	Europe and Africa
Trachycarpus fortunei	Arecaceae	Palm	Terrestrial	China

The excessive use of invasive alien plants for ornamental aspects has detrimentally impacted many forest lands, especially close to urban sites in Turkey. For instance, there have been various invasive alien plants such as *Amorpha fruticosa* L., *Albizia julibrissin* Durazz, *Broussonetia papyrifera* (L.), and *Lonicera japonica* Thunb which were imported to be introduced for ornamental or recreational aspects around parks and house gardens (Onen and Farooq, 2015). As an example of ornamental invasive plant, *Eichhornia crassipes* can demolish watersheds and water sources, poison some of the native fish species, cause water loss due to respiration, and compete with surrounding vegetation (Uludağ and Ertürk, 2013). The colonization and distribution of invasive weed species in Turkey has negatively affected the agricultural lands. For instance, some of alien weeds such as *Amaranthus spp*., *Conyza spp*., and *Physalis spp*. have reduced the cotton production in Turkey. These weeds have additionally been threatening the summer crops and orchards in the country (Uremis et al., 2012). Another monitored invasive weeds in the edges of fields were *Diplachnea fusca*, *Chondrilla juncea*, and *Bromus spp*. which were adapted to the country due to excessive weed control practices and the plant transfers between neighbor countries (Demirci et al., 2012). *Centaurea solstitialis* L. which was originally introduced from *Ricania simulans* is a causes harm in almost all plants that grow along the Eastern Black Sea coast. The chemicals used to control this pest are prohibited in this region due to tea cultivation.

Georgia

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10. Georgian Biodiversity Database http://biodiversity-georgia.net/

2.1.3 Impact on wetland ecosystems

Wetlands seem to be especially vulnerable to invasions. Even though ≤6% of the earth's land mass is wetland, 24% (8 of 33) of the world's most invasive plants are wetland species. Furthermore, many wetland invaders form monotypes, which alter habitat structure, lower biodiversity (both number and "quality" of species), change nutrient cycling and productivity (often increasing it), and modify food webs. Wetlands are landscape sinks, which accumulate debris, sediments, water, and nutrients, all of which facilitate invasions by creating canopy gaps or accelerating the growth of opportunistic plant species. These and other disturbances to wetlands, such as propagule influx, salt influx, and hydroperiod alteration, create opportunities that are well matched by wetland opportunists. No single hypothesis or plant attribute explains all wetland invasions, but the propensity for wetlands to become dominated by invasive monotypes is arguably an effect of the cumulative impacts associated with landscape sinks, including import of hydrophytes that exhibit efficient growth (high plant volume per unit biomass)

Many wetland plants fit the definition of "invasive plants" as species or strains that rapidly increase their spatial distribution by expanding into native plant communities. Such invasive plants not only affect biodiversity and ecosystem functioning but also human use and enjoyment of wetlands.

The susceptibility of communities to invasion needs more attention. Why are so many of the worst weed's invaders of wetlands? Also, why do so many wetland plant invaders form monotypes rather than simply adding to native plant richness? Wetlands are vulnerable to invasion in part because wetlands are landscape "sinks" that accumulate materials resulting from both terrestrial and wetland disturbances (excess water, nutrients, sediments, salts, heavy metals, other contaminants, and debris). Nearly every disturbance to an upland watershed causes some change downstream. For example, sediments that flow into wetlands transform topographically heterogeneous sites, such as tussocky meadows, into flat plains that support few plant species. In addition, debris that floats downstream tends to accumulate in wetlands, where it can smother vegetation and create canopy gaps. It propose that the accumulation of materials in wetlands makes them particularly vulnerable to invasion, while at the same time supplying invaders with the resources they need to form monotypes. Below we discuss a selection of invasive wetland plants and the wetlands they invade. Wetland invaders differ from many upland invaders in that (1) seeds are often dispersed via water; (2) whole plants and plant fragments can be dispersed via flotation; (3) abundant aerenchyma (air tissue) protects belowground plant tissues from flooding and anoxic soils, as well as allowing efficient use of carbon in above- and belowground growth; and (4) rapid nutrient uptake, allowing rapid growth.

Many invaded wetlands differ from invaded uplands in having, among other consequences of being landscape sinks, (1) through-flowing water, (2) frequent canopy gaps due to inflowing materials, (3) anoxic soils, and (4) ample nutrient influxes. While several hypotheses have been proposed to explain causes and consequences of invasions, we focus on five for which experimental data are available; these concern enemy release, broader tolerance, efficient use, hybrid vigor, and allelopathy. We then describe several “opportunity–opportunist matches” that help explain the tendency for low-lying wetlands to support invasions.

Ukraine

The rich variety of landscapes and biotopes of wetlands of Ukraine creates conditions for the existence of not only aboriginal organisms, but also for the active penetration of invasive species. One of the richest such landscapes is the Danube Delta, where many species of animals came in different ways and eventually naturalized. Their artificial connection with the sea led to an increase in salinity in water bodies and the invasion of the Black Sea fauna, partially or completely displacing the Ponto-Caspian (Khadzhibey, Tyligul, Dniester Estuary, etc.).

On the territory of the Ukrainian Carpathians, new localities of previously known and new species have been identified: *Ch. contraria* A. Braun ex Kütz., *Ch. globularis*

Thuill., *Ch. rudis* (A. Braun) Leonh., *Ch. virgata*, *Ch. vulgaris* L. and *N. flexilis* (L.) C. Agardh. The main bodies of water in this area are lakes, ponds, ditches, puddles, springs and rivers. At present, the species diversity of chara algae in the Ukrainian Carpathians is represented by 8 species found in 26 localities. The most common species are the cosmopolitan *Ch. vulgaris* and *Ch. globularis* (48 and 30% of all localities, respectively). Also rare for the reservoirs of the Ukrainian Carpathians and Ukraine in general *Chara braunii, Ch. virgate* and *N. tenuissima*. For the first time on the territory of Ukraine the algae *Chara rudis* was found (Fig. 2.1.3.)

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Fig. 2.1.3. *Chara rudis* (A.Braun) Leonhardi, nom. illeg. 1863, the invader on the territory of Ukraine (2015)

In many places, the terrestrial plant communities are extremely impoverished because of the spread of alien plants. Populations of alien plants in similar habitats are stable and self-renewing. The number of species becoming permanent components of such communities constantly increases. Just 50 years ago, only *Acorus calamus* L. and *Salix fragilis* L. were common alien species occurring in natural riparian and coastal plant communities. Along river banks, *Heracleum mantegazzianum*, *Impatiens glandulifera, Bidens frondosa, Echinocystis lobata, Reynoutria japonica*, and several species of *Helianthus* form large, often monodominant, populations. Alluvial sites recently released from water is occupied by *Xanthium albinum, Bidens frondosa* L., *Sagittaria latifolia* Willd., *Artemisia annua* L. and other species, which sharply reduces the species diversity of alluvial habitats (Pashkevych et al., 2018). Large colonies of alien species cause insularization of populations of native species. Especially vulnerable and affected are linear ("ribbon-like") populations along the rivers and plant communities of the zonal flora that now have the "island" distribution pattern (Shelyag-Sosonko & Dubyna, 1984). Some fragmented populations disappear.

The separation by dams of individual areas or the estuary as a whole led to the formation of freshened zones captured by freshwater and Ponto-Caspian benthic fauna (settlement of *D. polymorpha* in the freshened part of the Great Adhzalyk Estuary and rich fauna of freshwater and Ponto-Caspian mollusks in Lake Sasyk). Such changes in the ecosystems of estuaries also made them zones of mass settlement of exotic species such as marine (*Anadara* sp., *Corambe obscura* (Verill, 1870), *Rapana venosa* (Valenciennes, 1846), *Mya arenaria* (Linnaeus, 1758), *Mytilopsis leucophaeata* (Conrad, 1831)) and freshwater (*S. woodiana, P. antipodarum, Physella* spp., etc.) origin (Son, 2007, 2009, 2010).

The terrestrial animals also show impact on the wetland ecosystems. The threat species are red-eared slider *Trachemys scripta*, raccoon dog *Nyctereutes procyonoides*, muskrat *Ondatra zibethicu*, and partly nutria *Myocastor coypus* (Zagorodniuk, 2006; Кurtyak and Kurtyak, 2013).

Several non-native species had negative impact on populations of wetland inhabiting species in past, i.e. the brown rat *Rattus norvegicus* was introduced from Asia and displaced the local black rat *Rattus rattus* in human settlement and in wetlands (Girenko, 1950; Zagorodniuk, 1996). Then, the introduction of the muskrat *Ondatra zibethicus* resulted in displacement of the European water vole *Arvicola amphibius* (Lavrov, 1957; Grinchenko and Dulitsky, 1984). Intential introduction of the American mink *Mustela vison* and its releases from the farms are resulted in displacement of the European mink *Mustela lutreola* (Dulitskiy, Kormilitsina, 1975; Dulitsky et al., 1992; Panov, 2002). The golden jackal *Canis aureus* started to form the local populations in the places of extinction of the walf *Canis lupus* (Volokh et al., 1998; Rozhenko and

Volokh, 1999, 2000; Volokh, 2004; Potish, 2006; Domnich et al., 2009; Redinov, 2015; Rozhenko, 2006, 2017). The predatory raccoon dog *Nyctereutes procyonoides* is able to eradicate the wetland animals, especially land-nesting birds (Korneev, 1954; Sokur, 1961). Also, it is a vector of rabby infection.

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Turkey

Wetlands are of great importance with regards to their features and host of species richness for sustainability of the ecological balance. Invasive species cause habitat loss in wetlands and threatens native species as well as endangered species which are crucial part of the wetlands. There are 14 reported invasive species for wetlands in Turkey (Table 5).

Table 5. The 14 invasive alien species reported from wetlands of Turkey

	Family	Species	Origin
1	Ictaluridae	*Ameiurus nebulosus* (Fish)	North America
2	Clariidae	*Clarias gariepinus* (Fish)	Africa
3	Poeciliidae	*Gambusia affinis* (fish)	North America
4	Poeciliidae	*Gambusia holbrooki* (fish)	North America
5	Loricariidae	*Pterygoplichthys disjunctivus* (fish)	South America
6	Echimyidae	*Myocastor coypus* (mammal)	South America
8	Asteraceae	*Eupatorium cannabinum* (herb)	Europe
10	Poaceae	*Imperata cylindrica* (grass)	Asia
11	Poaceae	*Microstegium vimineum* (grass)	South-east Asia
12	Polygonaceae	*Persicaria perfoliata* (Grass)	Asia
13	Verbenaceae	*Lantana camara* (shrub)	America

Brown bullhead catfish, *Ameiurus nebulosus* Lesueur, (1819), is a fish of the family Ictaluridae which is widely distributed in the North America. The species introduced to a number of other countries around the world as a game fish and for culture purposes. It is a hardy species that can tolerate a wide range of environmental conditions, including water pollution, allowing it to successfully establish outside of its native range. Some concern has been raised over its invasive potential, but there is a lack of information on its effects. Brown bullhead catfish have a direct impact on native fish species through competition for food and predation. *A. nebulosus* may increase physical disturbance within freshwaters due to their benthivorous feeding habits. Its introduction could possibly lead to competition for food or space and predation on small fishes, invertebrates or other small food items.

African catfish, *Clarias gariepinus* Burchell, (1822), is a widespread freshwater fish species found in most part of the Africa and in the Middle East. African catfish mainly inhabits natural lakes, ponds, streams and shallow waters. The species in naturally found in some of the river systems in Turkey but translocated to different freshwater bodies. African catfish is a threat to endemic aquatic fish. Besides, introduction of the species has negative effects on macro invertebrate community which was reflected by decrease in diversity and richness. There is also community-level impact of introduction that results variation in macroinvertebrate composition in the rivers. Stomach contents of *C. gariepinus* revealed that the species feed on Fish, Arthropod, Mollusca and with vegetation to a considerable extent. Therefore, introduction of *C. gariepinus* in dams, rivers, lakes, and wetlands can cause food competitions with native fish and make irreversible changes in the fish community and cause loses of native fish (Turan and Turan, 2016).

The Western Mosquito Fish, *Gambusia affinis* (Baird and Girard, 1853) and the Eastern Mosquito Fish (*Gambusia holbrooki* Girard, (1853)), are small fish species native to the fresh waters of the North America. They have become a pest in many waterways around the world following initial introductions early last century as a biological control agent for mosquitoes. In general, they are considered to be no more effective than native predators of mosquitoes. While easing the Human life, the highly predatory mosquito fish eats the eggs of economically desirable fish and preys on and endangers rare indigenous fish, amphibian and invertebrate species. Mosquitofish have extremely high tolerance to different aquatic bodies and a wide habitat preference, and can thus adapt to very different environments including marsh, lakes, wetlands, rivers, and lagoons (Pyke, 2005). Mosquito fish are difficult to eliminate once established, so the best way to reduce their effects is to control their further spread. One of the main avenues of spread is intentional release by mosquito-control agencies.

Mosquito fish have been recorded from different waterbodies and regions of the inland waters of Turkey including Balık Lake (Samsun), Gelemen State Hatchery Canals (Samsun), Aras River (Iğdır), Yuvarlakçay (Mugla), Taflan River (Samsun), Lake Van, and many more localities (Kurtul and Sarı 2020). Incidences of mosquito fish praying of fish larvae and eggs have been reported previously in Turkey in different studies (Atıcı et al., 2018; Kurtul and Sarı, 2017).

Ornimantal aquatic animal and plant trade is another important vector for aquatic invasive species (Strecker et al., 2011). Armored sailfin catfish species *Pterygoplichthyes pardalis* and *P. disjunctivus* are ornamentally important fish species native to south America that have been introduced to numerous countries on different continents. These catfish species can tolerate water pollution, low dissolved oxygen and their body is covered with predation defence tools such as spinyu fins and thick external armour which help them to successfully invade different types of freshwater ecosystems including wetlands. These species are herbivores and eat algae on submerged surfaces. One of the main possible negative impact on the ecosystem is that their grazing behavior may alter the food web. Beside being herbivores, they also feed on demersal eggs and may out-compete other herbivore species. Specimens of *P. pardalis* and *P. disjunctivus* have been reported from the Asi River (Southern part of Turkey) (Yalcin Ozdilek, 2007), Pinarbasi Stream (Emiroğlu et al., 2016).

The nutria, also known as coypu (*Myocastor coypus* Molina, (1782)) is a semiaquatic large rodent, native to South America. The species is introduced to various part of the world for fur farming. Animals escaping from farms let to the formation of invasive populations in wild including Turkey. Coypu is first reported from the Armenian-Iran border of Turkey (Mursaloglu, 1973) and since then it has been recorded from different localities (Özkan, 2013) including the Black Sea region. In many areas of introduction this species is considered a pest because of the damage it causes by feeding on natural vegetation and crops and by its burrowing activity that undermines riverbanks and dikes (Bertolino et al., 2005). Their devastating impact on native plant communities have been reported from different part of the world (Gosling et al., 1988). Despite the invasive potential and possible negative effect of the species, there is no study on controlling the spread of the coypu in Turkey. On the contrary, seen specimens and their habibat is taking under protection (Solak, 2020).

Hemp-agrimony, *Eupatorium cannabinum*, is a woody perennial herb of the daisy family that prefers to inhabit and invade moist habitats such as swamps, marshes and wetlands. It forms dense monotypic stands that compete with and eventually crowd out native species. This species also has the ability to alter the nutrient structure of habitats it invades. *Eupatorium cannabinum* has been listed as an alien species for Turkish wetlands (Atasoy and Çorbacı, 2018; Mumcu and Korkmaz, 2018) but there are no information on regard of their possible negative effects on the environment.

Cogon grass, *Imperata cylindrica*, is a common grass species of the humid tropic regions of Southeastern Asia and spread to the warmer temperate zones worldwide (Atasoy and Çorbacı, 2018). Cogon grass is considered to be one of the top ten worst weeds in the world. This grass species can adapt to poor quality soil, can tolerate drought, fire adaptable which make it a successful invasive species. Increases in cogon grass concern ecologists and conservationists because of the fact that this species displaces native plant and animal species and alters fire regimes. Possibility of interspecific hybridization with durum wheat *Triticum durum* (Çeliktaş et al., 2015) also threats the genetic integrity of durum wheat.

Japanese stiltgrass, *Microstegium vimineum*, is an annual grass native to Asia. It grows quickly, produces abundant seed and easily invades habitats that have been disturbed by natural and anthropogenic sources. Microstegium vimineum occupies wetlands, riparian habitats, lawns, woodland thickets, damp fields and roadside ditches. It is usually found under moderate to dense shade in moist conditions, but it does not persist in areas with periodic standing water, or in full sunlight. Japanese stilt grass alters the structure of natural plant communities and reduces biodiversity by displacing indigenous herbaceous vegetation through its dense growth, which rapidly forms monocultures that are sometimes acres in extent. *Microstegium vimineum*, was reported from the wetlands in Giresun, a city in a Black Sea coast of Turkey (Scholtz and Byfield, 2000).

Persicaria perfoliata is a herbaceous, annual, trailing vine of the buckwheat family (Polygonaceae) that is native to Asia. It generally colonizes open and disturbed areas, along the edges of woods, wetlands, stream banks and roadsides. It also occurs in environments that are extremely wet with poor soil structure. Available light and soil moisture are both integral to the successful colonization of *P. perfoliata*. Birds are probably the primary long-distance dispersal agents, but water is also an important mode of dispersal, especially during storm events when high water may spread the plant throughout watersheds. *P. perfoliata* is also spread by the transporting of nursery stock. *Persicaria perfoliata* L. is a troublesome invasive vine which has already invaded the considerable areas within the Eastern Black Sea region of Turkey (Önen, 2015).

Common lantana, *Lantana camara,* is a species of flowering plant native to the American tropics, of which there are some 650 varieties in over 60 countries. It is established and expanding in many regions of the world, often as a result of clearing of forest for timber or agriculture. It impacts severely on agriculture as well as on natural ecosystems. The plants can grow individually in clumps or as dense thickets, crowding out more desirable species. In disturbed native forests it can become the dominant understorey species, disrupting succession and decreasing biodiversity. At some sites, infestations have been so persistent that they have completely stalled the regeneration of rainforest for three decades. Its allelopathic qualities can reduce vigor of nearby plant species and reduce productivity in orchards. Lantana camara has been the focus of biological control attempts for a century, yet still poses major problems in many regions.

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9. Georgian Biodiversity Database http://biodiversity-georgia.net/

2.1.4 Impact on freshwater ecosystems

Biological invasions are numerous in fresh waters around the world. At least hundreds of freshwater species have been moved outside of their native ranges by vectors such as ballast water, canals, deliberate introductions, and releases from aquaria, gardens, and bait buckets. As a result, many bodies of fresh water now contain dozens of alien species (David L. Strayer, 2010).

Invasions are highly nonrandom with respect to the taxonomic identity and biological traits of the invaders, the ecological characteristics of the ecosystems that are invaded, and the geographical location of the ecosystems that supply and receive the invaders. Some invaders have had deep and pervasive effects on the ecosystems that they invade. Classes of ecologically important invaders in fresh waters include 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 strong engineering effects and affect the quality and quantity of primary production, and diseases, which probably have been underestimated as an ecological force (David L. Strayer, 2010).

The number of alien species in freshwater ecosystems will increase in the future as new aliens are moved outside of their native ranges by humans, and as established aliens fill their potential ranges. Alien species create “no-analogue” ecosystems that will be difficult to manage in the future. We may be able to reduce future impacts of invaders by making more serious efforts to prevent new invasions and manage existing invaders (David L. Strayer, 2010).

Thematic implications: interactions between alien species and other contemporary stressors of freshwater ecosystems are strong and varied. Because disturbance is generally thought to favour invasions, stressed ecosystems may be especially susceptible to invasions, as are highly artificial ecosystems. In turn, alien species can strongly alter the hydrology, biogeochemical cycling, and biotic composition of invaded ecosystems, and thus modulate the effects of other stressors. In general, interactions between alien species and other stressors are poorly studied (David L. Strayer, 2010).

Ukraine

Among the macrophytes the main inpact on the aquatic ecosystem is provided by the water plague, *Elodea canadensis*. Cenopopulations of *Elodea* in the Middle Dnieper Region are being distributed by biotopes of a wide range of nutrients; *Egeria denza* and *Elodea nuttalli*, in comparison with *Elodea canadensis* are characterized by a wider ecological valence in terms of the content of compounds of nitrogen in water, in particular ammonium. The ecological preferences of *Elodea canadensis* are located in the oligo-mesosaprobic and mesoeutrophic water; the excess of phosphates is acted as a limiting factor for the development of cenopopulations of this species. For *Elodea nuttallii* increase concentrations of mineral nitrogen and reduction of content of phosphate **c**an be considered as limiting factors for the production of biomass. The most productive cenopopulation of *Elodea* have been formed in conditions of floodplain waters that save natural hydrological regime and now undergo of washing action of flood. The lowest are marked – for small ponds in park and urban reclamation channels. The increasing of biological productivity of water bodies to level of hypertrophy is causing a decrease in the production indicators of cenopopulations of *Elodea*. Cenopopulations of alien submerged plants are exhibiting a wide morphometric variability (the range of values varies from 20 to 100 %), that evidence about plasticity and the passage of the processes of active adaptation of species. The increasing of biological productivity of water bodies is leading to decrease of production indicators of cenopopulations of *Elodea***.** High values of phytomass are forming under conditions of moderate content of compounds of mineral nitrogen and lower water temperature. The effect of phosphate in water on production indicators is lower. Elongation of plants, reduction of leaf width in *Elodea canadensis* and reduce or «sealing» the appearance and increase the width of the leaf in *Elodea nuttalli* are an indicator of the growth of eutrophication of the biotope. Elongation and the intense branching of *Elodea nuttalli* are the confirmation of high water quality and/or reophilic conditions of the biotope. For naturalization in the modern conditions of the Middle Dnieper Region are capable all types of *Elodea*. The increasing of anthropogenic eutrophication of hydrotops of urbanized water bodies, at the expense of nitrogen-containing biogenes, is promoting the introduction of alien species.

The spread of the ornamental species (aquarial release) deserve special attention. Most of the ornamental species are tropical or subtropical in origin. As a rule, they survive in the natural conditions of the study area, being sensitive to lower temperatures; some aquarium species are able to form long-term populations in artificial reservoirs (Son, 2006; Aleksandrov et al, 2007). Neighboring alien species were primarily introduced from adjacent biogeographic territories, such as the Ponto-Caspian, into the European-Siberian region through the cascades of reservoirs and inland waters of Crimea, after the activation of river navigation, dredging of canals, creation of reservoirs, after deliberate introduction. The influence of alien species of macrozoobenthos on freshwater ecosystems is mainly in their competition with native fauna. During the construction of reservoirs, when the natural ecosystem is actually destroyed, the invaders (first of all, the Ponto-Caspian fauna) will form a fundamentally new ecosystem, they enter into competition with native species in the process of colonizing new reservoirs and forming new communities of artificial ecosystems. Thus, the almost complete disappearance of *Gammarus lacustris* G.O. Sars, 1864 in the upper part of the Dnieper basin, as well as a sharp decrease in the number of aboriginal gammarids *G. lacustris* and *Gammarus pulex* (Linnaeus, 1758) in the reservoirs of the Dnieper are associated with the constantly increasing abundance of Ponto-Caspian gammarids and, in particular, *Dikerogammarus villosus* (Sowinsky, 1894) (Semenchenko et al., 2015; Usov and Oberemchuk, 2015). The influence of *Dreissena polymorpha* (Pallas, 1771) is the displacement of the native Unionid species. Invaders of macrozoobenthos actively overgrow ships and hydraulic structures (*Cordylophora caspia* (Pallas, 1771), *Urnatella gracilis* Leidy, 1851), produce a complex effect by transforming the substrate (*Chelicorophium curvispinum* (GO Sars, 1895)), influence the formation of the food base of fish (*Hemimysis anomala* Sars, 1907), are an intermediate host of fish parasites (*Lithoglyphus naticoides* (C. Pfeiffer, 1828)). The negative aspect of the colonization of alien species of the cascade of reservoirs is not so much in local environmental impacts as in the risk of their further dispersal to new regions (Semenchenko et al., 2015).

Among the most problematic fish species of aliens are *Carassius gibelio, Pseudorasbora parva, Lepomis gibbosus, Perccottus glenii* (Kvach & Kutsokon, 2017). The most adverse effects of the impact of non-indigenous fish species in new surroundings are competition for food resources, invasion of habitats and spawning sites used by native fish species (Zorić et al., 2014). Thus, the introduction of *C. gibelio* into the Danube basin more than half a century ago led to the virtual disappearance of the native goldfish and a decrease in the number of carp and tench. In the Ukrainian section of the Danube, *C. gibelio* is now fully naturalized in the ecosystem and is one of the main commercial species. In the Danube water bodies, the introduction of *Ctenopharyngodon idella* can lead to local destruction of aquatic vegetation, significantly worsening the habitat and spawning conditions for phytophilous fish species. Other species (*P. parva, L. gibbosus, P. glenii*) can cause damage by eating eggs and juveniles of native fish species. In addition, invading species can also be carriers of new diseases and parasites (Kvach et al., 2018).

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Turkey

Freshwater ecosystems are one of the most threatened and poorly protected ecosystems on Earth (Saunders et al., 2002). Introduction of invasive species represent a primary threat to the preservation of biodiversity. The spread and establishment of alien species in new environments can cause irreversible biological and ecological impact, economic damage, and also can threated public health (Aydin et al., 2011). The impact of invasive species on native species, communities and ecosystem is widely known phenomena.

Turkey is a hotspot of freshwater fish diversity with many endemic species. Currently 78 endemic species are recognized but 65 of which were classified as Critically Endangered or Endangered in IUCN red lists. Beside habitat degradation, pollution and overfishing, introduction of invasive fish species are among the biggest threats to ichthyofauna of Turkey (Tarkan and Marr, 2015). List of the major non-native and translocated fish species that reported from inland waters of Turkey is presented in Table 6.

Table 6. Non-native and Translocated fish species reported from inland waters of Turkey (Tarkan and Marr 2015).

	Family	Species	Origin
1	Percidae	Sander lucioperca	Translocated
2	Percidae	Perca fluviatilis	Translocated
3	Cichlidae	Coptodon zillii	Non-native
4	Cichlidae	Oreochromis niloticus	Non-native
5	Gobidae	Knipowitschia caucasica	Translocated
6	Moronidae	Morone sp	Non-native
7	Centrarchidae	Lepomis gibbosus	Non-native
8	Coregonidae	Coregonus lavaretus	Non-native
9	Salmonidae	Oncorhynchus mykiss	Non-native
10	Salmonidae	Salmo salar	Non-native
11	Salmonidae	Salvelinus alpinus	Non-native
12	Salmonidae	Salvelinus fontinalis	Non-native
13	Clariidae	Clarias gariepinus	Translocated
14	Heteropneustidae	Heteropneustes fossilis	Non-native
15	Loricariidae	Pterygoplichthys disjunctivus	Non-native
16	Siluridae	Silurus glanis	Translocated

Pikeperch, Sander lucioperca is a piscivorous freshwater fish with a native range extending through much of Europe, from Germany to Central Russia (Maitland, 2004).

Sander lucioperca is recognized as an invasive species in Turkey which translocated by the government agencies (DSİ; National Water Institute) to improve fisheries resources. Diet of the species consists of macroinvertebrates and fish. Prey size increases as the size of the fish increase. Piscivorous fish play an important role in regulating the structure of aquatic food-web (Nolan and Britton, 2018). Alien piscivorous fish that are introduced to enhance fish stocks and/or to improve fisheries resources exert substantial top-downforces on fish communities, resulting in impacts including reduced prey abundances and decreased species diversity (Pelicice and Agostinho, 2009). This was the case in Lake Egirdir following the *S. lucioperca* where 10 fish species were wiped out (Sarıhan, 1970) and 7 native fish species were disappeared (Balık et al., 2006).

Silver crucian carp, *Carassius gibelio*, is an omnivorous fish species. There is an ongoing debate on its natural distribution range. Native range of the species is thought to be far East Asia. The species is now widely distributed in Turkish inland waters as an invasive species (Yerli et al., 2014). The effects of *C. gibelio* invasion on native species have recently been recognized. The decline of native cyprinid populations in Europe and Turkey is associated with habitat degradation caused by the *C. gibelio* which in turn also effects the native cyprinid fish through reproductive interference (Aydin et al., 2011). Invasion of *C. gibelio* was reported more than 150 freshwater body including 39 rivers, 33 lakes, 67 reservoirs, and 55 ponds (Yerli et al., 2014). In most of places *C. gibelio* became the dominant species (Balık et al., 2007)

Perch, *Perca fluviatilis* is a predatory freshwater fish species which is feeding on invertebrates. This species was originally confined to the temperate waters of the northern hemisphere, mainly Europe and North America. (Orban et al., 2007). This species has been recorded in the inland waters of Marmara, also in the west and middle parts of Black Sea region of Turkey (Geldiay and Balık, 1999) including Yesilirmak river basin (Akin et al., 2011). As a predatory fish, perch have the potential to significantly change fish communities (Closs et al., 2001). In Yesilirmak river, perch was reported as the most abundant fish species, showing predatory feeding habits.

Moreover their predatory habit suggested that perch may have an effect on local fish assemblage and itself through predation (Akin et al., 2011).

Redbelly tilapia, *Coptodon zillii,* is a native fish species to tropical and subtropical Africa and South-west Asia (Froese and Pauly, 2016). The species was intentionally introduced globally more than 50 countries for aquaculture (Chakrabarty, 2004). *Coptodon zillii* is an omnivorous species capable of altering native benthic communities through the elimination of macrophytes and outcompeting both native and non-native species for food, habitat and spawning sites through aggressive interactions (Innal and Giannetto, 2017). Redbelly tilapia has been reported from different freshwater environments in Turkey (Çelik and Gökçe, 2003; Dikel and Çelik, 1998) but their possible negative impacts are not well studied.

Nile tilapia, *Oreochromis niloticus* is native to the Nile River basin (Martin et al., 2010). This species can tolerate a wide range of environmental conditions, have flexible habitat requirements, reproduce shortly after birth and grow rapidly (Brinez et al., 2011; Costa-Pierce, 2003; Brinez et al., 2011). Also, *Oreochromis niloticus* and some of other *Tilapia sp*. has been recorded in southern Turkey, and members of *oreochromis niloticus* which were escaped from fisheries station to Seyhan River and maintained viable populations (Çelik and Gökçe, 2003; Dikel and Çelik, 1998). Possible impact on environment and native species remain unknown.

Caucasian dwarf goby, Knipowitschia caucasica, is a euryhaline species which inhabits eustaine, saline and freshwaters along cost of Black Sea, Sea of Azov, Caspian Sea and Aegean Sea. (Kovacic, 2005; Miller, 2004). This species is invaded a number of water bodies including Eğirdir, Eber, Sapanca, Beyşehir, and Büyükçemece lakes (Balık et al., 2005; Ozulug et al., 2007). Very little information is known about diet of this species in invaded freshwater (Güçlü and Erdoğan, 2017).

Common sunfish, *Lepomis gibbosus,* is a native fish species of North America (Page and Burr, 1991). The first record of the this species was reported from a small canal located in Edirne (Erk'akan, 1983). Thereafter, sunfish was reported from different freshwater environments (Baran and Ongan, 1988; Barlas and Dirican, 2004; Dirican and Barlas, 2005). The environmental impact of *L. gibbosus* in Europe remains poorly assessed. The species has been reported to prey on fish eggs (García-Berthou and Moreno-Amich, 2000).

Common whitefish, Coregonus lavaretus, is an opportunistic epibenthic omnivore fish species, but can show selective feeding behavior within the available invertebrate prey dietary range (Verliin et al. 2011)*. Invasion of C. lavaretus* was first reported from Iznik lake in 1954 (Innal and Erkakan, 2006). The environmental impact of *C. lavaretus* in Turkey remains poorly assessed

Atlantic salmon, Salmo salar, is naturally distributed in Northern Atlantic Ocean and rivers in Europe and Northeast coast of North America. Atlantic salmon eggs were exported for Aquaculture purposes to Turkey (Karataş et al., 2003). There were incidences of unintentional escapes from the cage farms. However, there is no information related with presence of any established population in Black Sea or rivers flowing to the basin.

Rainbow trout, Oncorhynchus mykiss, is another salmonid species which was introduced to Turkey for aquaculture purposed. Rainbow trout is native to North America which was probably first introduced in Turkey in 1969 into Yedigöller (Bolu) National Research Park (Uysal and Alpbaz, 2002). It is one of the most widely distributed invasive species in Turkey which can be found any inland water with fish farm where rainbow trout escapes. Natural impacts include disease transmission, predation, and competition with native species.

Brook trout *Salvelinus fontinalis,* and Arctic char, *Salvelinus alpinus,* are native salmonid species of North America (O'grady and Cowx, 2000). These two species were evaluated for their culturing potential in the eastern Black Sea region of Turkey as an alternative species to rainbow trout (Başçinar et al., 2003). Similar to rainbow trout, Natural impacts include disease transmission, predation, and competition with native species.

Clarias gariepinus is native to most of Africa, Israel, Syria, and south of Turkey. The species distributed in Asi River, Hatay, Antalya and around Eskişehir in Turkey.

Translocated individuals formed self-sustained populations within Turkey (Tarkan et al., 2014). Although, it is assessed as an invasive species, the impacts were not evaluated.

Heteropneustes fosilis is a species originally distributes from Pakistan through India to Thailand (Chandrasekhar, 2004) which was first reported in Turkey in Tigris River (Ünlü et al., 2011). The species is assumed to enter the Tigris River through introductions made by Iraqi authorities or possibly to control *Bulinus truncates* which is vector for the human parasite causing schistosomiasis (Ünlü et al., 2011). The species was not reported in other water bodies of Turkey. The studies conducted on the specimens captured in Turkey consist of morphometric characteristics of the species, thus, the impacts of the species are remaining unknown (Ünlü et al., 2011).

Pterygoplichthys disjunctivus is a herbivore endemic species in neotropical South America (Armbruster, 2001). They are benthic, sticking to streambeds with their sucker like lips. The species is an ornamental aquarium fish. Therefore, members of this genus, have been commonly imported not only into the United States and Europe, but also into tropical Asia since the middle 20th century (Innes, 1948). Probable mechanism mentioned of their introduction into Asian inland waterways have been aquarium release or escape from aquaculture farms (Page and Robins, 2006). The member of the species was likely introduced into Turkish waters in a similar way. This species is a potentially invasive species of Asi River (Özdilek, 2007).

Silurus glanis known as European catfish is native to Eastern Europe (Cucherousset et al., 2018). Turkey is one of the native distribution areas of the species. Because of its economic importance, the species has attracted interest as a potential species for fish culture (Innal and Erkakan, 2006). Thus, the species was introduced to different water bodies other than its native habitats. Introduction of the species in Turkey was firstly done by The General Directorate of State Hydraulic Works (DSI, 1988) to Kemer Dam Lake in 1969-1971 and Almus Dam Lake in same years, Yedikır Reservoir (Amasya), and Cip Dam Lake (Elazığ) (Annonymus, 1988; Annonymus, 2001). The species is a piscivorous fish, thus, it is assumed to be an invasive fish species presenting a risk to native species and ecosystems (Copp et al., 2009). However, its ecological impacts are poorly understood in the introduced habitats (Carol et al., 2009; Copp et al., 2009).

Pseudorasbora parva was described originally from Asia, however, the species can be found in many different freshwater habitats (Banarescu, 1999). It was accidentally introduced to Romania in 1961 (Banarescu, 1999), thereafter, it was recorded many freshwater habitats from European and Asian countries and even from Africa. The species was first recorded in Turkey, in Aksu River on 1996 (Wildekamp et al., 1997). Although, it is described as one of the most dangerous invasive species in Turkey (Bostancı et al., 2020) the impacts have not been extensively studied. According to Bostancı et al., (2020), *P. parva* is successfully established and became a major problem for fish biodiversity in freshwater habitats located in Ordu province.

Georgia

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9. Georgian Biodiversity Database http://biodiversity-georgia.net/

2.1.5 Impact on human activities and land use change

According to CABI (Centre for Agriculture and Bioscience International) – The global cost of invasive species is estimated at US$1.4 trillion per year – close to 5% of global gross domestic product. Invasives disproportionately affect vulnerable communities in poor rural areas, especially in developing countries which depend on natural resources, healthy ecosystems, trade and tourism for their livelihoods. By destroying livelihoods, they undermine economic growth and contribute to economic migration.

Economic impacts

Agriculture, forestry and fishing are of huge importance to the economies of developing countries. Invasive species affect the productivity of these systems, and limit the ability of producers to access export markets. This hinders sustainable economic growth and development. The impacts of invasive species include:

- Value and quality of land degraded
- Lower crop productivity
- High cost of controlling pests, weeds and diseases
- Routes to domestic and global markets blocked
- Livestock forced into marginal, sub-optimal grazing lands

Social impacts

Invasive species are a major threat to the livelihoods of the people who live in the areas they colonize. Through disrupting ecosystems, invasive plants, insects and diseases impair many of the things humans need to sustain a good quality of life – including food and shelter, health, security and social interaction. The impacts of invasive species include:

- Livelihood options narrowed
- Food security decreased
- Recreational and social opportunities limited
- Risks to human and animal health
- Increased social challenges

The threat posed by invasive species is not limited to agriculture or biodiversity – they have a significant impact on almost all Sustainable Development Goals.

Ukraine

The invaders entering new ecosystems can seriously affect their functioning, which can affect the socio-economic aspect of human life (health, fishing, aquaculture, recreation, etc.). A number of other impacts are the result of longer-term transformations affecting habitats and ecosystem functioning (nutrient cycling, trophic interactions, biodiversity loss, etc.). In addition to a negative impact, even invasive species can also have a positive impact: provide rare species with habitats and food resources, functionally replace extinct taxa, etc. (Bonanno, 2016). The introduction of new species can be extremely beneficial if the ecosystem is disturbed by anthropogenic impact, i.e. out of natural balance. Under such conditions, local species cannot cope with the flow of matter and energy. Invasive species, if their specific production turns out to be higher than the mass indigenous ones, can replace the latter and more efficiently use the excess of available matter and energy (Alersandrov, 2015). Not every invasion of exotic organisms ends with tangible environmental consequences and economic shocks.

However, as invasions intensified with the development of water transport, such cases began to recur more often, and the scale of their consequences increased more and more (Alersandrov, 2004). In November 2020, thickets of water lettuce or *Pistia stratiotes* (a plant typical of the tropical regions of our planet) literally captured the reservoirs near Kiev (Kuzemko & Pashkevych, 2020) (Fig. 2.1.5.1.) It feels good here, very actively reproduces and thus can suppress or even to displace aboriginal species - those that have lived here for hundreds and maybe thousands of years. Because all organisms in ecosystems are closely interconnected, the entire ecosystem suffers from invasive species.

Fig. 2.1.5.1. Thicket of *Pistia stratiotes* in the reservoirs near Kiev (November, 2020)

Pistia stratiotes most likely got into Ukrainian reservoirs from home aquariums or ornamental pools. It dies very quickly in cold weather, so theoretically it should not survive the winter. But if it is as warm as the previous one (which is possible given global climate change), then pistachios may continue to grow next year. This plant is especially dangerous in cooling reservoirs of hydroelectric power plants, because the water in them usually does not freeze even in the most severe winters. In other regions of Ukraine this species was introduced earlier. In 2013 there were many of them in the

Siversky Donets. But, in a few years, its population there has decreased significantly and a real environmental catastrophe, fortunately, did not happen, although there was such a danger. The problem is that when these plants die, they sink and rot, which increases the content of organic matter in the water. This can adversely affect its chemical composition and the biodiversity of water bodies.

The damage from the introduced zoobenthos species to freshwater ecosystems is often difficult to quantify, despite the fact that they are more vulnerable than marine ecosystems. The widespread *Eriocheir sinensis* and *Dreissena polymorpha* are known to be very harmful among aquatic invertebrates (Vilà et al., 2010). For Ukrainian waters, the calculation of damage caused by invasive species of benthic invertebrates in fresh waters was not carried out. Data on damage from invaders are mainly based on data on their competition with native fauna (Semenchenko et al, 2015).

The decreasing of catches of planktophagous commercial fishes after invasion of ctenophore *Mnemiopsis leidyi* is reported. After invasion of its predator ctenophore *Beroe ovata* ecosystem began gradually to recover and catches were increased (Caddy & Griffiths, 1990, Dumont at al., 2004, Polischuk & Nastenko, 2006, Shiganova & Bulgakova, 2000; Shiganova et al., 2004, 2014, 2019a,b).

All non-native fish species have both negative and positive influences on the people life. The role of alien species in fisheries activities should be noted as a positive influence (Aleksandrov et al., 2007). A significant number of intentionally introduced species have great industrial importance in both natural and freshwater reservoirs.

Thus, analyzing the catches of Ukraine in 2019 in inland waters and seas, the catch of such invasive species as so-iuy mullet – 20,211 tons, Prussian carp – 6950,156 tons of herbivores (silver carp, grass carp) – 1140,510 tons.

It should be noted the percentage of invasive fish in the total amount of fish resources caught in 2019 in fishery water bodies and on the continental shelf of Ukraine was 20.1%. That is why we should talk about the well-known importance of invasive species in fisheries.

The negative effects of invasive fish species on human activity include:

- deterioration of the fishery importance of reservoirs where invasive species significantly dominate and create competitive conditions for aboriginal fish species. In such reservoirs, the percentage of aboriginal fish species that had greater commercial value of the ranch is declining. This is effect on the profitability of the fisheries sector.
- In some reservoirs, invasive species create barriers to catching aboriginal fish species. Thus, in some waters of the Dnieper reservoirs, catching invasive pumpkinseed leads to the impossibility of conducting traditional fishing for local carp species.

Except the ecological impact, the invasive species have epidemiological influence on human activities. For example, in the Dnieper basin, Chinese sleeper (*Perccottus glenii*) is a host of the trematode *Isthmiophora melis* (Schrank, 1788), which si able to infect human (Kvach et al., 2020).

The impact of the invasive species on human activities and land use change can be olso observed in terrestrial ecosystems. Most of the terrestrial plant species (43%) were considered naturalized in human-made (anthropic) habitats. A few species (1%), mainly agriophytes, were components of both semi-natural and natural habitats. During the processes of restoration of completely or partly transformed vegetation, alien species raise the level of competition for ecotopes (Burda, 2018). In these cases, many aliens are stronger competitors than native plant species. According to their mode of immigration, most (72%) of alien species of vascular plants occurring in Ukraine are xenophytes, i.e. species introduced unintentionally; 235 species (28%) were intentionally introduced for the agricultural, horticultural, forestry, and other purposes. In the beginning of the 20th century, many unsuccessful experiments in introduction of new commercial crops "enriched" the flora of Ukraine with such species as *Asclepias syriaca* L. (*A. cornuti* Decnen) and *Iva xanthiifolia*. *Descurania sophia* (L.) Webb. ex Prantl, *Papaver rhoeas* L., *Ambrosia artemisiifolia, Sisymbrium officinale* (L.) Scop., *S. loeselii* L., *Lactuca serriola* L., *Amaranthus retroflexus* L., *A. blitoides, Galinsoga parviflora* Cav., *G. urticifolia* (Kunth) Benth., *Setaria glauca, Conium maculatum* L., *Carduus acanthoides* and many other species act in the newly formed ruderal communities as dominants or species diagnostic for syntaxa of different ranks

(Mosyakin and Yavorska, 2002; Protopopova et al., 2006; Dzhuran et al., 2007; Melnik, 2009; Zavyalova, 2010; Zvyagintseva, 2015).

Hordeum murini (Allorge, 1922) Lohm. 1950, associations of *Erigeron-Lactucetum serriolae* Ljhm., *Descurainetum sophiae* Krch 1930, *Artemisietum annuae* Fijalk, *Ambrosio artemisiifoliae-Xantheum strumariae* Kost., *Setario-Galinsogetum, Carduetum acanthoiditis*). These species are stable components in such habitats, even if these habitats are eventually transformed into fallow lands (Shelyag-Sosonko and Dubyna, 1984; Dubyna et al., 2015, 2017). A cumulative list of the highly invasive plant species threatening forest, steppe, and submediterranean zones of Ukraine in Eastern Europe is provided: *Anisantha tectorum* (L.) Nevski, *Atriplex sagittata* Borkh., *Brassica campestris* L., *Echinochloa crus-galli* (L.) P Beauv., *Galeopsis ladanum* L., *Geranium dissectum* L., *Malva neglecta* Wallr., *Malva pusilla* Smith, *Papaver rhoeas* L., *Portulaca oleracea* L., *Raphanus raphanistrum* L., *Senecio vulgaris* L., *Setaria glauca* (L.) P. Beauv., *Sinapsis arvensis* L., Mediterranean-Atlantic Epoecophyte *Sonchus arvensis* L., *Sonchus asper* (L.), *Tripleurospermum inodorum* (L.) Sch. Bip., *Acroptilon repens* (L.) DC., *Amaranthus powellii* S. Watson, *Cardaria draba* (L.) Desv., *Carthamus lanatus* L., *Cenchrus longispinus* (Hack) Fernald, *Centaurea solstitalis* L., *Chenopodium striatiforme* J. Murr., *Chenopodium suecicum* J. Murr., *Cuscuta campestris* Yunck., *Diplotaxis tenuifolia* (L.), *Geranium sibiricum* L., *Lepidotheca suaveolens* (Pursh) Nutt., *Lolium multiflorum* Lam., *Oenothera depressa* E. Greene, *Oenothera rubricaulis* Klebahn, *Oxybaphus nyctagineus* (Michx.), *Parthenocissus inserta* (A. Kern.) Fritsch, *Peganum harmala* L., *Sagittaria latifolia* Willd., *Senecio viscosus* L., *Sisymbrium loeselii* L., *Sisymbrium wolgense* M. Bieb. ex Fourn., *Setaria pycnocoma* (Steud.) Henrard ex Nakai, *Torilis arvensis* (Huds.) Link, *Xanthoxalis fontana* (Bunge) Holub, the main invasive species in Ukraine during that period were represented mostly by epoecophytes. Dispersal of *Amaranthus albus* L., *A. blitoides* S. Watson, *Lepidotheca suaveolens* (Pursh) Nutt., *Iva xanthiifolia* Nutt., and some other weedy species followed that pattern.

Most of the invasive species (35) are registered in human made habitats, these are manly *Amarathus retroflexus* L. (railways, waste dumps), *Ambrosia artemisiifolia* L.

Arrhenatherum elatius (railways), *Artemisia absinthium* (railways, waste dumps), *Asclepias syriaca* (railways).

The agriculture and transport development cause in the invasions of new invasive insects. These pests are able to damage not only agriculture crops, but also ornamental cultures in parks and garden, having economic effect (Uzhevska, 2017). For example, the horse-chestnut leaf miner (*Cameraria ohridella*) is known pest of ornamental horse-chestnut (*Aesculus hippocastanea*) everywhere in Europe, but also damaging the maple trees (*Acer* spp.) in parks and forest culture (Uzhevska and Muzyka, 2012). The box tree moth (*Cydalima perspectalis*) destroys the box trees (*Buxus sempervirens*) in different part of Ukraine. Mediterranean fruit fly (*Ceratitis capitata*) damages the fruit orchads in the Southern Ukraine, mainly in the Odessa Region.

The poikilotherm terrestrial organisms, i.e. the red-eared slider *T. scripta*, can be reservoirs or/and vectors of dangerous infections, e.g. salmonellosis *Salmonella* spp., campylobacter's *Campilobacter* spp., aeromonosis *Aeromonas* spp., mycobacteriosis *Mycobacterium* spp. and some other bacterial and viral agents with impact on human and agriculture and pet animals (Kurtyak and Kurtyak, 2013).

As mentioned before, the raccoon dog can be an agent of the rabby transmition in Ukraine, because it has highest prevalence (up to 40%) of infection among all wild mammals (Zagorodniuk, 2006). The cases of the raccoon dog rabby are registered in Zhytomyr, Luhansk, Poltava and Kherson oblasts of Ukraine. As the agent of the rabby transmition, the raccoon dog replaces the fox in Europe.

The human activities are impacted by the mammal species, such as brown rat *Rattus norvegicus* and golden jackal *Canis aureus*, both are agents of viral infection transmission. Also, they affect the agriculture and housholds.

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Turkey

Invasive species have a broad range of impacts. One of the negative effects of Invasive species is their colonization near to the livelihoods of the people which threatens human activities. Beside reducing biodiversity, invasive species cause large losses to key crops, reducing crop productivity, depleting the natural resources that people rely on not only for food but also medicines and fuel. Sociologically speaking, through disrupting ecosystems, invasive plants, insects, and diseases impair many of the thing's humans need to sustain a good quality of life including food and shelter, health, security and social interaction.

There are more than 90 reported invasive plant pests in Turkey (Öztemiz and Doğanlar, 2015). Invasive pest brown marmorated stink bug, Halyomorpha halys (Stal, 1855 in Çerçi and Koçak, 2017), which was recorded for the first time in Turkey in 2017 (Çerçi and Koçak, 2017) is growing in numbers and begin to cause damage in corn, beans, oranges, kiwi and hazelnut in the Black Sea region (Ak et al., 2019). Fake butterfly, Ricania japonica cause damage, especially during nymph stage, in beans, cucumbers, and also decreased the quality of kiwi fruits by causing fumagine in Eastern Black Sea Region of Turkey (Altaş and Ak, 2019). Ak et al., (2015) stated Ricania simulans, another species belonging to Ricania genus, as the most important plant pest in the Black Sea Region of Turkey. Starting from 2009, R. simulans population begin to increase dramatically and started to cause harm to many wild and cultivated plant species. Extensive host range of the species include elderberry, bean, kiwi fruit, blackberry, hydrangea, fig tree, alder, cherry laurel, tea tree, and grapevine. Anoplophora chinensis which is one of the most destructive pests for fruit trees was reported in the southern Black Sea region of the Turkey (Hızal et al., 2015). Although, the invasions were reported in recent years, very little is known about the potential economic and ecological damage.

Aedes spp. are invasive mosquito species widely or locally established in the Black Sea region of Turkey. Both the Asian tiger mosquito (Aedes albopictus) and the yellow fever mosquito (Aedes aegypti) have become a significant concern due to their seemingly uncontrollable expansion and their many risks to public health. Four significant infections transmitted by A. albopictus and A. aegypti: dengue, yellow fever, chikungunya, and Zika virus, lead to observable consequences, such as morbidity, mortality, and healthcare expenditure, in low and middle-income countries (Weeratunga et al., 2017). In addition to the diseases mentioned above, these Aedes mosquito species can be a vector of endemic viral infections such as West Nile Virus infection (WNV), Mayoro virus infection, and Eastern Equine Encephalitis virus infection (Daep et al.,2014; Romero and Newland, 2003). Due to high disease risk, there is an urgent need of control against the established Aedes spp. although control operations success was 60% for larvae and 45% for adults (Akıner et al., 2018). The success of control with pesticides is highly dependent on the precipitation regime. Extensive usage of the pesticides may cause economic and ecological impacts.

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2.2 Invasive Alien Species presence and distribution at national level (Romania, Ukraine, Greece, Turkey, Georgia)

Romania

Invasive species affect the economy and quality of environmental components globally (being harmful to agriculture mainly), but also the state of human health, being widespread [17, 18]. To address these issues, decision-makers at various institutions have established the need to develop a set of policies to prevent the spread of invasive species, with a focus on transcontinental transport and trade [19], as trade globalization and of modes of transport facilitated the spread of these species on the surface of the globe [17].

Globally, the emphasis is on the identification and analysis of ways to introduce invasive alien species, being a very important step for the management of invasive species and biosecurity, based on the precautionary principle [20]. The main routes of introduction of invasive alien species are directly or indirectly associated with trade between states. The intensification and diversification of commercial activities, as well as the intensification of transports, increase the possibility of introducing invasive alien species on the territory of certain states. They can be brought as goods subject to trade or can be transported by chance on a certain type of goods, involuntarily. [21]

The main routes of introduction and transport of invasive alien species are directly or indirectly associated with anthropogenic activities, the species being introduced in different ways by humans, voluntarily (deliberately) or unintentionally (accidentally). Studies in this area have highlighted three main mechanisms for introducing invasive species [17, 20, 22]:

a) the import of goods from different countries;

b) arrival and spread in certain areas by mean of transport vectors;

c) spreading naturally through different own dispersal modes in areas around the areas where the alien species is already present.

These mechanisms are associated with a number of six routes of introduction, four of which are recognized as a priority for alien plant species. The other two routes of introduction identified in the literature are not relevant for invasive alien plant species, being characteristic of animal species (birds, mammals, amphibians, etc.): introduction through different corridors and individually (without assistance), such as , for example, natural dispersion, etc.

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Ukraine

Ukraine is one example of a country, for which the issue of non-native species is of high importance. Therefore, summaries about the distribution of native and non-native fish over time are strongly demanded, particularly, due to the introductions of many species from this country to other parts of the World.

Aqiatic habitats. The macrophyte invaders are currently the best studied in the fresh waters in the Middle Dnieper Region (Prokopuk, 2018). The inventory of alien species of higher aquatic plants (macrophytes) of the Middle Dnieper of Ukraine, it has been established that there are spreader 11 alien species of macrophytes, that made near 15% of the lists of hydrophilic flora in the region. They prefer the reservoirs with high trophic status (from mesoeutrophic to eutrophic). The current changes of secondary area of *Acorus calamus*, *Elodea canadensis* and *Vallisneria spiralis* are not being observed, invasion on these plants took place more than many years ago and they have completely been naturalized. Eight species, invasion of which are not older than 20-50 years (*Azolla caroliniana*, *Egeria densa, Elodea nuttallii, Lemna turionifera*, *Phragmites altissimus, Pistia stratiotes*, *Zizania latifolia, Typha laxmannii*) can be considered as capable to penetrate into new habitats. It has been established that alien macrophytes in the Middle Dnieper sector form monodominants, with with a small number of species communities; some of them (that have tropical origin) have ephemeral character and develop only with the onset of the corresponding water temperatures. All alien free-floating plants show C-competitors and R-Hruderals H strategy (CR-strategy). Submerged alien plants are characterized like C-competitors, which can not only naturalized, but become transformers. Alien emergent plants usually behave like C and RS-strategy that able to transform natural ecosystems. *Azolla caroliniana, Lemna turionifera* show themselves as ephemerophytes, *Pistia stratiotes* and *Egeria densa* as colonophyte (population of *Egeria densa* has not gone beyond the place of introduction yet, but it is renewing and showing certain features of ephemerality); the other species (*Elodea canadensis*, *Elodea nuttalli*, *Phragmite saltissimus*, *Typha laxmannii*) we can be considered as those that have penetrated into natural and anthropogenically transformed phytocenoses, rarely – semi-natural areas (agriophytes and epecophytes). For the spread of ephemerophytes, they are needed biotopes, where water exchange is difficult; there are protected shallow waters that are well heated and rich in water nutrients. Contamination of phosphate of water bodies can be a limiting factor for the development of *Azolla caroliniana*. The native species of free-floating plants, that can resist an increase of phosphates, cannot grow in waterbodies with significant nitrogenation that are caused by the development of population of *Azolla.* The limiting factor for the development of *Pistia stratiotes* is both shortage and the excess of compounds of mineral nitrogen in water. Ecological preferences of the species relative to this indicator are within the meso-eutrophic waters. *Elodea canadensis (a)*, *Elodea nuttallii (b)*, *Azolla caroliniana (c)* and *Pistia stratiotes (d)* – these are species that can have a high invasive potential. Other species can be considered as alarming alien species (Fig. 2.1.1.).

Fig. 2.1.1. Species with high invasive potential: *Elodea canadensis (a)*, *Elodea nuttallii (b)*, *Azolla caroliniana (c)* **and** *Pistia stratiotes (d)*

One of the most common and well-studied rheophilic species of freshwater Rhodophyta is *Thorea hispida* (= *Th. ramosissima* Bory) (Fig 2.1.2.). Currently, the species is known from most European countries (Great Britain, Hungary, Germany, Spain, Netherlands, Poland, Russia, Romania, Finland, France, Sweden), was found in Asia (Iran, Kazakhstan, China, Pakistan, Japan), in Northern (Grenada, Mexico, USA, Jamaica) and South (Argentina, Brazil) America. In Ukraine, *Th. hispida* was first found in the Dnieper near Kiev (Borshchov, 1870); later, it was repeatedly noted in the Dnieper and its right-bank tributaries, in the Southern Bug (Moshkova, 1970). The data on the first finding of this species in the River Siversky Donets are published in 2009 (Dogadina et al., 2009).

Fig. 2.1.2. Freshwater red algae *Thorea hispida* (= *Th. ramosissima* Bory)

In ecological terms, *Th. hispida* is a typical rheophil, preferring fast flowing areas. It settles on various substrates of natural and artificial origin, up to nylon cables at locks and bridges. When the river flow is regulated, the algae disappear along with other rheophilic forms (Tsymbalyuk, 1955).

Th. hispida on the territory of Ukraine is known within the three-meridional eco-corridors – Southern Bug, Dnieper, and Siversky Donets, which coincide with the valleys of the largest rivers. For Kharkiv Oblast, taking into account previous finds (Gorbulin et al., 2005), at present 6 representatives of freshwater Rhodophyta are known: *Porphyridium purpureum* (Bory) Drew et Ross, *Compsopogon chalybeus* Kütz., *Chantransia chalybea* (Roth) Fries, *Batrachospermum* sp., *B. moniliforme* Roth f. *densum* (Sirodot) Israelson, *Th. hispida* (Thore) Desvaux.

The total number of the zoobenthic alien species in Ukraine consists of 21 species of distant invaders and about 40 species of nearby invaders (Aleksandrov et al., 2007, Semenchenko et al., 2015, 2016; Son, 2016; Son et al., 2013, 2020). The largest number of distant species of freshwater benthic organisms were introduced and dispersed in the Ponto-Caspian basin, the other part was introduced to the north-west of Ukraine and the Crimea.

In recent decades, a number of distant invaders of macrozoobenthos have been recorded in the ecosystems of the Ukrainian Danube delta, such as *Sinanodonta woodiana* (Lea, 1834), *Corbicula fluminea* (Müller 1774), *Corbicula fluminalis* (Muller, 1774), *Dreissena bugensis* Andrusov, 1897, *Potamopyrgus jenkinsi* (Smith, 1889), *Physa skinneri* (Taylor, 1954), *Physa acuta* (Draparnaud, 1805), crabs *Rhithropanopeus harrisi tridentata* Maitland and *Eriocheir sinensis* H. Milnectinwards, 1853 1851). *S. woodiana* was first detected in the Danube basin in Ukraine in quality samples from the Danube-Sasyk canal in August 1999 (Lashenko et al., 2005; Son, 2007). The bryozoan *P. magnifca* was recorded for the first time in the Ukrainian part of the Danube delta in 2005. The maximum number of colonies was recorded on reed stems in the delta branches at a distance of 1.5–2.0 km from the Black Sea. The zooid tubes of bryozoans serve as a refuge for insect larvae, which can feed on the soft tissue of colonies, as well as statoblasts. Some turbellaria, oligochaetes and molluscs may also prey on colonies of *P. magnifca* bryozoans and may contribute to the increase in the abundance of some native species (Aleksanrov et al., 2014). The coasts of the Northwestern Black Sea region and the Northern Azov region are characterized by the presence of a large number of lagoons, estuaries, riverine deltas, fresh and brackishwater lakes, connected in many areas by channels. These reservoirs form an important invasion corridor for species adapted to living in both fresh and brackish waters (*Potamopyrgus antipodarum* (Gray, 1843) and *Ferrissia fragilis* (Tryon, 1863)) (Panov et al, 2009; Son, 2010). The changes in the hydrology of the Black Sea estuaries caused by hydrotechnical construction and other anthropogenic influences have led to total changes in the fauna of many estuaries or their individual sections.

There is known one invasive alien zooplankton species in continental waters of Ukraine – *Craspedacus tasowerbii* Lankester, 1880 (Protasov & Babariga, 2009; Yakovenko & Fedorenko, 2012).

Excluding the cases of unsuccessful introductions and occasional findings, the list of established non-indigenous fish species in Ukraine contains 27 species (Aleksandrov et al., 2007; Karabanov et al., 2010; Slynko et al., 2011; Kolomytsev & Kutsokon, 2012; Demchenko & Demchenko, 2015). Nine of these species have been deliberately introduced and are commercially stocked, though natural spawning has not yet been confirmed. The list of successfully naturalized introductions includes 19 fish species, eight of which can be considered as invasive due to their continued range expansion with probable negative influences on aboriginal fauna (Kvach & Kutsokon, 2017).

Current estimates of the number of alien fish species in the Danube River Basin vary significantly. These figures are also different for the basin regions (Upper, Middle and Lower Danube). Thus, a number of Ponto-Caspian species, which are considered aliens for the Upper and Middle Danube, are indigenous to the Lower Danube. In addition, different authors may interpret random finds of new species in different ways, take into account finds in artificial reservoirs, etc.

Paunovic et al. (2015) for the entire river basin give a figure of 18 species (for the Lower Danube - 9 species), Zoric et al. (2014) – 20 species. Nalbant (2003) reports 28 species of aliens (10 of which are biologically naturalized) only within Romania (the Lower Danube region). Within the Danube Biosphere Reserve, the most studied water area of the Ukrainian part of the Danube, 8 species of freshwater fish aliens have been identified (Chronicle DBZ).

The main sources of invasion into the Danube basin are aquaculture, shipping (ballast water), unintentional release of fish into the natural environment from fish-breeding reservoirs (escape), intentional stocking, expansion of species into new water areas (Zoric et al., 2014). Zoric et al. (2014) believe that out of 20 species of aliens, 9 were introduced into the Danube basin intentionally, and 11 more were introduced unintentionally.

Terrestrial habitats. The terrestrial flora of Ukraine (including native, introduced, escaped, and most commonly cultivated taxa) is represented by more than 6,000 species of vascular plants (Mosyakin & Fedoronchuk, 1999). More detailed data on floristic diversity of the country will be available after completing the ongoing project aimed at a new edition of the "Flora of Ukraine" (coordinated by the M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine). The alien fraction of the flora, according to our data (Protopopova et al., 2002, 2003), was represented by the end of 2001 by 830 species, 14% of the total number of species in the flora. At the present time, the datadase of the alien species consists of 889 species in terrestrial plants, related to 423 genera and 89 families (Pashkevich et al., 2019).

Most of the invasive plants are originated from the Mediterranean Region (328 species; 36,9%), Asia (166; 18,7%), North America (162; 18,2%), complex of Mediterranean and Irano-Turanian Region (142; 16,0%), South America (39; 4,4%), Irano-Turanian Region (32; 3,6%) and Balkan (20, 2,3%).

Most numerous are representatives of families Asteraceae (15,4%, 58 genera and 132 species), Poaceae (13,2%, 43/113), Brassicaceae (9,4%, 41/80), Fabaceae (5,6%, 26/50), Chenopodiaceae (5,17%, 8/46), Apiaceae (3,5%, 26 /31), Lamiaceae (3,8%, 20/34) Caryophyllaceae (2,3%, 12/20), Amaranthaceae (2,1%, 3/19) and Solanaceae (2,1%, 6/19). The total species number of the 10 main families comprised of 61,2% (544 species). Most numerous is the family Asteraceae. 71 family comprised less then 1% of the alien species by numer. Main genera are *Chenopodium* L. (27 species), *Amaranthus* L. (17), *Artemisia* L. (14), *Xanthium* L. and *Echinochloa* P. Beauv. (10 species each), *Hordeum* L. and *Sisymbrium* L. (9 species each), *Bromus* L., Setaria P. Beauv (8 species each), *Panicum* L., *Vicia* L., *Helianthus* L. (7 species each), *Avena* L., *Eragrostis* Wolf, *Lepidium* L., *Mentha* L.(6 species each), *Lolium* L., *Sorghum* Moench, *Centaurea* L., *Lupinus* L., *Pyrethrum* Zinn, *Salvia* L., *Silene* L. (5 species each).

The list of invasive terrestrial invertabrates consists of 12 nematode species (Nematoda), 2 mite species (Acarina) and 98 insects (Insecta), all included into the list «Regilates pests in Ukraine» (Klechkovkyi and Chernei, 2010; Uzhevska, 2017).

Recently, several of this insect species actively spread the range, especially in the Southern Ukraine, e.g. *Metcalfa pruinosa*, *Corythucha ciliate, Hyphantria cunea, Diabrotica virgifera, Phthorimaea operculella, Tuta abcoluta, Spodoptera littoralis, Cameraria ohridella, Phyllonorycter robiniella, Phyllonorycter robiniella, Obolodiplosis robiniae, Nematus tibialis, Phyllonorycter issikii, Cydalima perspectalis, Halyomorpha halys* (Muzyka and Uzhevka, 2009; Uzhevska and Muzyka, 2012; Uzhevska et al., 2012; Uzhevska 2017; Popova et al., 2018).

Among the terrestrial vertebrates from the List of Invasive Alien Species of Union concern, four species might be recorded: red-eared slider *Trachemys scripta*, nutria *Myocastor coypus*, raccoon dog Nyctereutes procyonoides and muskrat *Ondatra zibethicus*. Except of these, several non-native species had negative impact on the local species populations, e.g. brown rat *Rattus norvegicus*, American mink *Mustela vison* and golden jackal *Canis aureus*.

In the herpethofauna of Ukraine one species, red-eared slider *T. scripta*, actively spreads and can affect the populations of the local European pond terrapin *Emys orbicularis*. The introductions of the other reptile species were not successful. Most of reptiles were registered in the Crimea and some steppe localities of the southern Ukraine, e.g. Asian tortoise *Agrionemys horsfieldii*, steppe agama *Trapelus sanguinolentus*, Kotschy's gecko *Mediodactylus kotschyi*. The findings of the non-native reptiles are known from the big cities, i.e. the thin-toed gecko *Tenuidactylus bogdanovi*, is recorded in the City of Odessa, but do not provide threat to the local ecosystem (Kukushkin, et al., 2017; Krasylenko & Kukushkin, 2017).

Among the non-native birds the species with the threat to the local ecosystem are not registered. The list of the alien bird species consist of only two species: common pheasant *Phasianus colchicus* and chukar partridge *Alectoris chukar* (Beskaravainy, 2018).

The mammal fauna of Ukraine consists of 10 introduced species, originated from different regions, e.g. Mediterranean, Eastern Siberia, Northern and Southern America, for example guinea pig *Cavia porcellus*, sika deer *Cervus nippon*, fallow deer *Dama dama*, American mink *Mustela vison*, nutria *Myocastor coypus*, raccoon dog

Nyctereutes procyonoides, rodent *Ondatra zibethicus*, European rabbit *Oryctolagus cuniculus*, red sheep *Ovis orientalis*, common raccoon *Procyon lotor* (Dulitskiy and Kormilitsina, 1975; Shvarts et al., 1993; Pavlov et al., 1993; Dulitsky, 2001; Zagorodniuk, 2003, 2005, 2006, 2010; Alimov and Bogutskaya, 2004; Koshelev, 2011). But, most of successful invaders are of Palearctic origin. Most of intentional introductions were not successful.

The distances invaders are also known in the mammal fauna of Ukraine. This group consists of only three species, spread by natural way, but due to human influence, e.g. house mouse *Mus musculus*, brown rat *Rattus norvegicus*, golden jackal *Canis aureus*. Most of them are synantropic. Invasion to Ukraine is possible for the most of cryptic species basing of the biogeographic reconstructions (Zagorodniuk, 2005).

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Greece

Greece is situated on the crossroad between different continents and from ancient times it has been invaded by a variety of species. The geographical position of Greece, combined with the ability of species to adapt into new territories, led to the enrichment of the local biota with a number of non-native species. Although historically, species' natural movement affected, primarily, neighbouring areas, the last few decades species movements have been dramatically increased via a large number of vectors and human driven pathways of introduction (Hulme 2006). As a consequence, until now, a variety of organisms (either plants or animals) and a large number of species have been characterized as alien in Greece.

The study of the alien vascular flora of Greece started in the early 1970's (Yannitsaros 1982). Although it became more intense and systematic, during the last three decades and many new records were added is still largely incomplete. Some of the Greek regions for which, however, there is sufficient knowledge of the alien flora are: Attica (Yannitsaros 1982), the island of Crete (Yannitsaros 1991; Turland et al. 1995), the urban areas of Thessaloniki (Krigas and Kokkini 2004) and Patras (Chronopoulos and Christodoulakis 2000) and some Aegean Islands, e.g. Lesvos (Bazos 2005), Chios (Snogerup et al. 2001), Kalymnos (Zervou and Yannitsaros 2009). Apart from the above-mentioned scattered information, the first checklist of the alien flora of Greece was published in 2010 (Arianoutsou et al. 2010). Based on this checklist, currently 343 alien plant taxa have been recorded for Greece so far. However, this number is relatively low compared to the number of the alien plants recorded in other Mediterranean and Southern European countries (Italy: 1023; Spain: 933; Portugal: 547). This smaller number and density of alien plant species observed in Greece might be owed to (a) the lower levels of industrialization and of transportation network development, (b) the higher proportion of underpopulated or cultivated mountainous areas, and (c) the highly fragmented physiography with many high and often inaccessible mountain ranges spreading across the mainland.

Although research on alien plant species of Greece are relatively few, the alien animals are the subject of research of several and distinct research groups (focused on e.g. marine taxa, mammals, birds, insects). Thus, the most advanced work has been performed on the marine taxa and has been undertaken by the Hellenic Center of Marine Research. The recorded numbers of alien mammals and birds are not as high, as compared to those of the other animal groups, but it is thought that their effects to local fauna cause serious problems (Assoc. Prof. Liordos Vasilios: pers. comm.). So far, a variety of birds (mainly parrots) have been recorded as alien in Greece which are mainly found in cities or in nearby areas. These birds, although were mainly brought as pets, they were released or escaped, and have established well-adopted wild populations in several areas.

The recorded number of invasive alien mammals that occur in Greece is low (American Mink: *Neovison vison*; Coypu: *Myocastor coypus;* Muskrat: *Ondatra zibethicus*; Raccoon dog: *Nyctereutes procyonoides*) but is expected that their effects in local fauna are or might be very serious. Adamopoulou & Legakis (2016), provided information and data on the distribution of 7 selected invasive alien vertebrates in Greece [*Lithobates catesbeianus, Trachemys scripta* (*T. s. elegans* and *T. s. scripta*), *Neovison vison, Myocastor coypus, Nyctereutes procyonoides* and *Ondatra zibethicus*]. Based on their results, the coypu (*Myocastor coypus*) appeared to be the most widely distributed of all species, having conquered practically all wetlands of Western and Central Greece, whereas the raccoon dog (*Nyctereutes procyonoides*) was recorded just once in Lake Prespa area (NW Greece). Coypu has been classified among the top-100 worst invasive alien species of Europe. Similarly, the American Mink is also considered a major threat to biodiversity especially in the Special Protected Areas of the NATURA 2000 network GR1320003 (LIFE ATIAS project; http://lifeatias.gr/description/). Their increased recorded number is due to the fact that approximately 50,000 American minks were deliberately released from fur farms by animal rights activists in 2010. Muskrat is also listed by DAISIE (Inventory of alien invasive species in Europe) as one of the 100 worst invasive species in Europe, but in Greece only scattered sightings of it have been recorded up to now. However, the threat is evaluated as serious as its control is difficult because of its high reproduction rate.

Regarding the species that can be found in the Greek Seas, until now 214 alien species and 62 cryptogenic species have been recorded (Zenetos et al. 2018). Approximately, 80% of the introduced species in Greek Seas consists of the taxa classified in Mollusca, Polychaeta, Crustacea, Fishes, and Macroalgae. The rather high number of Non Indigenous Species (NIS) recorded so far in Greece, could be owned to the geographical position of the country. Specifically, Greece and in general the Eastern Mediterranean Sea, lay along the natural spread route of many of the Indo-Pacific taxa entering from the Red Sea, according to the prevailing Mediterranean currents (Bergamasco & Malanotte-Rizzoli 2010). Moreover, apart from this “natural” way of species introduction, a number of NIS recorded in Greece were introduced via other vectors (aquaculture, escapes from aquarium trade, accidental introductions etc) (Zenetos et al. 2018).

Moreover, a rather large number of non-native insect species have been recorded so far in Greece (Avtzis et al. 2017). Specifically, the non-native insect fauna of Greece includes 266 species, classified in 78 families and 10 orders, and most of these species (more than 75%) originate from Asia, Australasia and North America. A study, focusing exclusively in ants (Salata et al. 2019), showed that 15 invasive ant species have been recorded so far in Greece. These species are strongly associated with anthropogenic environments, whereas 4 of them can also be found in semi-natural or even natural habitats.

Despite the rather large number of alien species that have been recorded in Greece, not all of these are invasive. Although detailed information on the behavior of fishes and insects are missing, we do have information about the invasive character of the alien plant species. Specifically, out of the 343 alien species recorded in Greece, 50 are naturalized and present an invasive behavior (Table 1), having established in a variety of habitats (Arianoutsou et al. 2010). Among them, *Ailanthus altissima, Amaranthus albus, Chenopodium ambrosioides, Datura stramonium, Eleusine indica,* *Erigeron bonariensis, Nicotiana glauca, Opuntia ficus-barbarica, Oxalis pes-caprae, Paspalum distichum, Solanum elaeagnifolium, Symphyotrichum squamatum* and *Xanthium spinosum* are typical cases of plants characterized as invasive (Arianoutsou et al. 2010).

However, apart from the species mentioned in Table 1 (Arianoutsou et al. 2010), it has been noticed that another one alien species, namely *Amorpha fruticosa*, presents a serious invasive behavior. This species has also been identified as an Invasive Alien Species in several countries (e.g. Romania: Kucsicsa et al. 2018), whereas it has been classified among the most invasive alien plant species in Europe by CABI (https://www.cabi.org/isc/datasheet/5001#tosummaryOfInvasiveness).

Although the list of the potentially invasive plants in Greece contains 51 taxa (including *Amorpha fruticosa* as well), their effects in natural or semi-natural ecosystems were not studied so far. Specific information exists only for the tree species *Ailanthus altissima* which was introduced in Greece as an ornamental tree in the late 18th century. *Ailanthus altissima* has the ability to spread widely due to its aggressive nature and this is why it has been characterized as an invasive species. The ability to invade and to spread can be attributed to its allelopathic properties, which in turn are owned to the presence of ailathine which is a quassinoid (Sazeides 2016).

Table 1. Alien plant species with an invasive behavior (Arianoutsou et al. 2010)

Taxon	Family	Chorology
Acer negundo L.	Sapindaceae	N American
Aeonium arboreum (L.) Webb & Berth.	Crassulaceae	Macaronesian
Agave americana L.	Agavaceae	N American
Ailanthus altissima (Mill.) Swingle	Simaroubaceae	E Asiatic
Amaranthus albus L.	Amaranthaceae	N American
Amaranthus blitoides S. Watson	Amaranthaceae	N American
Amaranthus deflexus L.	Amaranthaceae	S American
Amaranthus hybridus L.	Amaranthaceae	N American
Amaranthus quitensis Kunth	Amaranthaceae	S American
Amaranthus retroflexus L.	Amaranthaceae	N American
Amaranthus viridis L.	Amaranthaceae	S American
Aptenia cordifolia (L. f.) Schwantes	Aizoaceae	S African

Taxon	Family	Chorology
Arundo donax L.	Poaceae	C Asiatic
Asclepias fruticosa L.	Apocynaceae	S African
Azolla filiculoides Lam.	Azollaceae	Neotropical
Carpobrotus edulis (L.) N. E. Br.	Aizoaceae	S African
Cenchrus incertus M. A. Curtis	Poaceae	Neotropical
Chenopodium ambrosioides L.	Amaranthaceae	Neotropical
Chenopodium multifidum L.	Amaranthaceae	S American
Coronopus didymus (L.) Sm.	Brassicaceae	S American
Cotula coronopifolia L.	Asteraceae	S African
Cuscuta campestris Yuncker	Convolvulaceae	N American
Cymbalaria muralis P. Gaertn., B. Mey. & Scherb	Plantaginaceae	S European
Datura stramonium L.	Solanaceae	Cosmopolitan
Elaeagnus angustifolia L.	Elaeagnaceae	Temperate Asiatic
Eleusine indica (L.) Gaertn.	Poaceae	Cosmopolitan
Erigeron bonariensis L.	Asteraceae	Neotropical
Erigeron canadensis L.	Asteraceae	N American
Erigeron sumatrensis Retz.	Asteraceae	Neotropical
Euphorbia maculata L.	Euphorbiaceae	N American
Euphorbia prostrata Aiton	Euphorbiaceae	N American
Halophila stipulacea (Forssk.) Ascherson	Hydrocharitaceae	W Indian Ocean, Red Sea
Heliotropium curassavicum L.	Boraginaceae	Neotropical
Malephora purpuro-crocea (Haw.) Schwantes	Aizoaceae	S African
Medicago sativa L. subsp. *sativa*	Fabaceae	Paleotemperate
Nicotiana glauca R. C. Graham	Solanaceae	S American
Opuntia ficus-barbarica A. Berger	Cactaceae	Neotropical
Opuntia vulgaris Mill.	Cactaceae	N American
Oxalis debilis Kunth var. *corymbosa* (DC.) Lourteig	Oxalidaceae	S American
Oxalis pes-caprae L.	Oxalidaceae	S African
Paspalum dilatatum Poiret	Poaceae	S American
Paspalum distichum L.	Poaceae	Neotropical
Phytolacca americana L.	Phytolaccaceae	N American
Ricinus communis L.	Euphorbiaceae	Paleotropical
Robinia pseudoacacia L.	Fabaceae	N American
Setaria adhaerens (Forssk.) Chiov.	Poaceae	Sub-cosmopolitan
Solanum elaeagnifolium Cav.	Solanaceae	S American
Symphyotrichum squamatum (Spreng.) G. L. Nesom	Asteraceae	Neotropical
Veronica persica Poiret	Plantaginaceae	W Asiatic
Xanthium orientale L. subsp. *italicum* (Moretti) Greuter	Asteraceae	S European
Xanthium spinosum L.	Asteraceae	S American
Zantedeschia aethiopica (L.) Spreng.	Araceae	S African

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Turkey

Invasive species can out complete native species in any habitat and can severely threated the long-term health of the ecosystem. The existence of the invasive species in different ecosystems of Turkey and Turkish Black Sea Region were given in this section. Reported and potential impacts on the biodiversity were assessed by reviewing the literature.

Georgia

Research studies on the bio-ecology and impacts of alien species brackish and estuarine ecosystem (Impact on wetland ecosystems) and Impact on freshwater ecosystems are very limited in the Georgia, we have only several scientific works and articles about aquatic alien species of Georgia.

The main invaders establishing and having the most dramatic impacts on species diversity are: Prussian carp - *Carassius gibelio*, Stone moroko - *Pseudorasbora parva*, Pacific mullet - *Liza haematocheila*. All kinds of impacts due to invasive species had a big effect on the reduction of total fish populations in the wetlands and fresh water ecosystems as predation, food competition and major destruction in the food web. There are many other species introduced to the wetlands and fresh water ecosystems.

Prussian carp - Carassius gibelio

Carassius carps have been a popular freshwater fish from ancient times as a valuable food source and as the basis of sport fisheries. The goldfish, Carassius auratus (Linnaeus, 1758) is also likely the most popular aquarium fish species in the world. Because of its popularity and ability to deal with a wide range of aquatic conditions, species of the genus Carassius have also become one of the most successful invader fish species of the last century, which makes it a group for ecological concern as well. In Georgia, crucian carp Carassius carassius (Linnaeus, 1758) was known from only one locality after Kessler's record (1877–1878) with no new findings until 1985. Since then C. carassius rapidly and simultaneously invaded almost all water bodies of Georgia. In 2004, it was for the first time noted that this invasive Carassius sp. could not be a C. Carassius, but was a form of Carassius gibelio (Bloch, 1792). However no further data is available about this invasive species in Georgia. Prussian carp

Carassius gibelio (Bloch,1782), by its high reproduction capacity by means of gynogenesis and tolerance to environmental changes, considered as asuccessfull invasive. It can become the dominant species in new habitat in a short time with the help of these attributes. After the first spread report of Carassius gibelio from Thrace in 80's, Carassius gibelio became to be a problem in inland waters of Geporgia as it is in some countries of Europe.

Stone moroko - *Pseudorasbora parva*

The topmouth gudgeon (stone moroko), Pseudorasbora parva (Temminck et Schlegel, 1846) is an inva-sive species that has expanded its natural range due to accidental introduction. Whereas the native range of the species is situated in the East of Asia, from Amur basin to Northern Vietnam, the invasive one oc-cupies broad areas both in Europe and Central Asia. Expansion of stone moroko in the Caucasus is tightly correlated with the work on acclimatization of eastern commercial fish. Expansion of the stone moroko is facilitated by man's impact on watercourses and high ecological plasticity of this fish. The stone moroko is an undesirable invasive animal that often generates numerous populations, has no commercial value, and reduces nutritional re-serve of native species.

Pacific mullet - *Liza haematocheila*

The pacific mullet, Liza haematocheila (Temminck & Schlegal 1845) (=Mugil so-iuy Basilewsky, 1855) native to the Armur river estuary and Japan Sea. Pacific mullet is one of the new introduced species in the eastern Black Sea. It was intentionally introduced in the Black Sea in the period 1972-1980 (Zaitsev 1991). Another view about the introduction is it had been escaped from the rearing cages in the Azov Sea. The Pacific mullet well adapted to the Black Sea since 1980 - has established a self-sustaining multiple-age population in the Black Sea. Spawning and fishing both take place from May to August. There are five native mullet species in the Black Sea, namely; Mugil cephalus, Liza ramada, L. saliens, L. aurata and Chelon labrosus. Its growth rate is considerably higher than the native mullet species (Okumus & Bascinar 1997). After the introduction of pacific mullet the population of native mullet declined to high level food competition (Turan et al., 2009). Fishermen also were obliged to change their gill nets to catch bigger sized Pacific mullet. Pacific mullet is a euryhaline species, which regularly enter the brackish and fresh waters of the black sea basin - therefore spread a negative effect on these waters.

Invasive Alien Species of Flora

The alien flora of Georgia is still insufficiently studied. Current knowledge clearly indicates that invasive plants will deteriorate some of the unique natural ecosystems of the country and pose threats to the indigenous species diversity, agriculture and human health.

The Georgian flora comprises 3884 native species belonging to 176 families (Table 1; excluding subspecies and lower taxa). From the 460 taxa of alien origin recorded in Georgia (archeophytes and neophytes combined), about 80 species are cultivated species that are not, or rarely, found in the wild, or there is no valid data on their current occurrence in Georgia. The 380 remaining alien species have become subspontaneous, adventive, naturalized and invasive. These alien species, which represent about 8.9 % of the Flora of Georgia. This percentage is similar to what has been observed in other European countries, e.g. 9.1 % in Austria, 10.2 % in France, 12.6% in Switzerland, but much less than for total Europe (22%; DAISIE, 2009), North America, e.g. 28 % in Canada, or islands, e.g. 47 % in New Zealand (Heywood, 1989). The density of alien species in Georgia (i.e. the number of alien species per log country size in km2) is 78.7 and slightly higher than in several other European countries. This may be due to the topography and diversity of climates encountered in Georgia which allows both xerophyte and mesophyte species to become naturalized. Almost one third of all alien species recorded in Georgia have been introduced from Asia (33%). Of these, approximately 90% originate from East Asia, and the remaining species were introduced from other parts of Asia. An equally high number of alien species are of Mediterranean origin (22%); over the recent years, an increasing number of plant invaders, primarily in the westernmost parts of Georgia, have been recorded from

North America (17%) and from south America (8%). Plant invaders from Europe (13%) are mainly from Atlantic Europe. 7% of inviders are from others parts of earth.

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3. Invasive Alien Species in Black Sea Basin

3.1 Romania

The issue of "invasive species" is a very topical one, given that they pose a major threat to global biodiversity, can cause extinction of native species, can change the functions of ecosystems (Vitousek, P.M., 1994).

Knowledge of these invasive species thus becomes very important especially when we are dealing with an internationally protected area, such as the Danube Delta. It has a quadruple status: Biosphere Reserve, Ramsar site (wetland of international importance), UNESCO World Natural Heritage site, Natura 2000 site (ROSCI0065 and ROSPA0031).

The biodiversity of the Danube Delta is high compared to other deltas in Europe and even the Earth. Thus, so far 1642 plant species, 3768 animal species and 23 natural ecosystems have been inventoried (according to the Standard Natura 2000 Form for ROSCI0065). In accordance with the annexes of GEO 57/2007, on the territory of the Danube Delta Biosphere Reserve (RBDD) were identified 29 Natura 2000 habitats and 37 species of flora and fauna of community interest (5 mammal species, 5 amphibian and reptile species, 14 fish species, 8 invertebrate species, 5 plant species) (Anastasiu, P., et al. 2013).

The oldest reports of non-native plants in the Danube Delta belong to and refer to the following three species: *Calibrachoa parviflora* (syn. *Petunia parviflora*), *Heliotropium curassavicum*, *Diplotaxis erucoides*. (Ciocârlan, V., 1994) lists 73 non-native plants, and later (Schneider, E. and M. Tudor, 2006) indicate the presence in the Danube Delta of only 33 taxa "from other continents". (Doroftei, M. and S. Covaliov, 2009) lists 128 non-native plants, of which 116 are identified by the author in the field. (Anastasiu, P., et al., 2011), following the research undertaken on the territory of R.B.D.D. between 2009-2011, it reports 168 non-native plants, of which 35 are considered invasive.

Possible sources and vectors for plant invasions in the Danube Delta

Among the factors that have favored and continue to favor the presence and spread of non-native plants in the Danube Delta we mention: geographical location; the presence of numerous anthropogenic ecosystems including agricultural, fisheries and forestry arrangements, complex arrangements, small-scale isolated crops, poplar plantations on river banks, human settlements; the numerous landscaping works carried out between 1960-1989 which led to important imbalances, including experiments aimed at fixing sand dunes with exotic plants (*Ailanthus altissima, Elaeagnus angustifolia*, etc.) (Anastasiu, P., et al., 2013).

The ports of Sulina and Tulcea, but also Reni, Ismail and Chilia (Ukraine), the last two on the Chilia arm, can be gateways for non-native species in the Danube Delta, along with goods transported by water. Ships entering the Danube Delta, either from the Black Sea or from the mainland, may bring with them seeds or parts of the vegetative organs of non-native plants both in ballast water and in the goods they carry. A relatively recent study shows that in Sulina more than a quarter of the total inventoried plants are non-native (Anastasiu, P., et al., 2011).

Tourists can become, sometimes even involuntarily, vectors for some non-native plants. How many times, after a trip in nature, did we not find that we have the fruits or seeds of some plants hanging from us? Here is one of the easiest ways for a plant to get from one place to another. Along with humans, animals can also be an important vector for invasive plants. In the Danube Delta we often see how horses and cattle carry with them, clinging to tails and manes, the fruits of *Holera* and *Cornuți*. Birds can carry long distances fragments of plants, seeds, spores that are caught on claws, beak or plumage (Anastasiu, P., et al., 2013).

As the Danube Delta is an inhabited area, with houses and even cities, some non-native plants are brought here intentionally, for decorative, food, medicinal purposes. An example of this can be *Gaillardia pulchella*, a beautiful relative of the Sunflower (Helianthus annuus), which is grown in gardens for ornamental purposes, but which can escape the culture and can grow without any help from us on sands in the vicinity of the localities. And if some ornamental or food plants accidentally escape from the gardens, others are taken even by the locals near some natural or semi-natural habitats. Thus, although there are clear rules regarding the storage of garbage, near the localities of Sulina and Sf. Gheorghe, through salt, garbage dumps can be seen on which plants such as Cucumbers, Castor, Morning glory, Red tomatoes and others grow, a sign that that garbage also contained remains of plant materials from the gardens (Anastasiu, P., et al., 2013).

On the other hand, it should be noted that wetlands have an increased vulnerability compared to other ecosystems and are susceptible to invasion both due to disturbances (Pino, J., J.M. Seguí, and N. Alvarez, 2006) and the easy mode of dispersal favored by water (Pyšek, P. and K. Prach, 1993).

According to (Zedler, J.B. and S. Kercher, 2004), invasive plants in wetlands have substantial and persistent effects on habitat structure, floristic and faunal diversity, food chains.

The current situation of alien plant species in the Danube Delta

The alien flora of the Danube Delta is largely represented by species of American origin (83 taxa), mainly from North America (52 taxa). These include a number of invasive species: *Acer negundo, Amaranthus albus, Amaranthus retroflexus, Ambrosia artemisiifolia, Amorpha fruticosa, Elodea nuttallii, Euphorbia maculata, Iva xanthiifolia, Symphyotrichum ciliatum*. Regarding the biological form, 90 species are therophytes, 26 are phanerophytes, 8 helohydrophytes, and the rest hemicryptophytes, hemiterophytes, geophytes, chamephites. We specify that 28 non-native (alien) species are reported for Romania only from the Danube Delta territory, but some of them are not confirmed by our field research: *Aegilops crassa, Ammophila* *arenaria subsp. arundinacea, Bidens connata, Cuscuta approximata, Cyperus esculentus, Diplotaxis erucoides, Euphorbia leptocaula, Fimbristylis bisumbellata, Hordeum marinum, Matthiola longipetala, Saccharum ravennae, Sagittaria lancifolia, Salsola acutifolia, Salsola collina, Silene chalcedonica, Suaeda splendens, Xanthium orientale subsp. orientale*. For some of them there are explanations, for others not yet. There are situations of uncertain determined taxa or confusion by the authors that signaled the species in the field. For example, *Aegilops crassa* may have been confused with *Aegilops cylindrica*, a native species that can be found in the Chilia agricultural area. *Elodea canadensis*, according to bibliographic sources [13], was replaced by Elodea nuttallii. In the case of species of the genus Xanthium, things can be more complicated given the difficulties of separating some species based on morphological characteristics.

Non-native plants that we consider invasive in the Danube Delta, based on definitions and The terminology presented above are: *Acer negundo* - American Maple (North America); *Ailanthus altissima* - Tree of heaven (Asia); *Amaranthus albus* - Tumble pigweed (North America); *Amaranthus blitoides* - Prostrate pigweed, *Procumbent pigweed* (North America); *Amaranthus blitum* var. *blitum* – Guernsey pigweed (Mediterranean area); *Amaranthus blitum* subsp. *emarginatus* - Purple amaranth (tropical areas); Redroot pigweed (North America); *Ambrosia artemisiifolia* - Common ragweed (North America); *Amorpha fruticosa* - False indigo-bush (North America); Artemisia annua - Sweet sagewort (Asia); *Azolla filiculoides* - Water fern (North America); *Bassia scoparia* – Burning bush (Eurasia); *Bidens frondosa* - Devil's beggartick (North America); *Conyza canadensis* - Canadian horseweed (North America); *Cuscuta campestris* - Field dodder (North America); *Cyperus odoratus* - Fragrant flatsedge (tropical areas); *Dysphania ambrosioides* - Mexican tea (Tropical America); *Echinocystis lobata* - Wild cucumber (North America); *Eclipta prostrata* - False daisy (Tropical America); *Elaeagnus angustifolia* - Russian Olive, Willow (Asia); *Elodea nuttallii* - Water Plague (North America); *Euphorbia maculata* - Spotted spurge (North America); *Fraxinus pennsylvanica* - Green ash (North America); *Galinsoga parviflora* – Gallant soldier (South America); *Iva xanthifolia* - Giant Sumpweed (North

America); *Lindernia dubia* - Yellowseed false pimpernel (North America); *Lycium barbarum* - Matrimony vine (Asia); *Morus alba* - White mulberry (China); *Oxalis corniculata* - Creeping woodsorrel (America); *Oxalis europaea* - (America); *Paspalum paspalodes* - knotgrass, ditch-grass, jointgrass, water couch (Africa and tropical America); *Phytolacca americana* - American pokeweed (North America); *Solanum retroflexum* - Wonderberry or sunberry (North America); *Symphyotrichum ciliatum* - Rayless alkali (Asia); Veronica persica - Birdeye speedwell (Asia); Xanthium italicum - Italian cocklebur (Mediterranean area); *Xanthium spinosum* - Spiny cocklebur (South America).

The question is: do these species have any impact on the natural and semi-natural plants and habitats in the Danube Delta? The research undertaken during 2009-2011 by a group of researchers from the University of Bucharest [9] shows that, at least in the case of some of them, the impact is obviously negative. Thus, of the approximately 180 plant associations in the Danube Delta, some are built of non-native plants: *Acoretum calami* Eggler 1933, *Amarantho - Chenopodietum albi* Morariu 1943, *Amorpha fruticosa* comm., *Artemisietum annuae* Morariu 1943 em. Dihoru 1970, *Artemisio annuae-Heliotropietum curassavicae* Dihoru et Negrean 1975, *Cladietum marisci* (Allorge 1922) Zobrist 1935, *Elaeagnus angustifolia* comm., *Elodeetum canadensis* Eggler 1933, *Elodeetum nuttallii* Ciocârlan et al. 1997, *Heliotropio currasavicae- Petunietum parviflorae* Sanda et al. 2001, *Hippophae-Salicetum eleagni* Br.-Bl. et Volk 1940, *Ivaetum xanthifoliae* Fijalk. 1967, *Lemno-Azolletum carolinianae* Nedelcu 1967, *Lemno-Azolletum filiculoides* Br.-Bl. 1952, *Potentillo supinae-Petunietum parviflorae* Dihoru et Negrean 1975, *Riccio-Azolletum carolinianae*, *Salsolo ruthenicae-Xanthietum strumarii* Oberd. et Tx. 1950, *Xanthio strumarii-Chenopodietum* Pop 1968, *Xanthietum italici* Timar 1950, *Xanthietum spinosi* Felf. 1942, *Xanthietum strumarii* A. Paucă 1941.

Among the non-native species mentioned in the various plant associations are: *Acer negundo, Amaranthus albus, Amaranthus blitoides, Amaranthus crispus, Amaranthus hybridus, Amaranthus retroflexus, Ambrosia artemisiifolia, Amorpha fruticosa, Apium graveolens, Artemisia annua, Azolla filiculoides, Bidens frondosa, Dysphania* *ambrosioides, Conyza canadensis, Coronopus didymus, Datura stramonium, Elaeagnus angustifolia, Elodea canadensis, Elodea nuttallii, Galinsoga parviflora, Heliotropium curassavicum, Petunia parviflora, Solanum retroflexum, Vallisneria spiralis, Xanthium strumarium, Xanthium italicum, Xanthium spinosum, Veronica persica*.

To these are added the following: *Ailanthus altissima* (dunes at the eastern edge of the Letea Forest reservation), *Dysphania pumilio* (alluvium = fresh fluvial soil deposits at Caraorman), *Commelina communis* (alluvium at St. George), *Cyperus difformis* (alluvium at Chilia Veche), *Cyperus odoratus* (alluvium at Sf. Gheorghe, Sacalin, Chilia Veche, Tătaru forest), *Eclipta prostrata* (alluvium at Sf. Gheorghe and Chilia Veche, salts on Sacalin), *Elaeagnus angustifolia* (in salt soils, not only on dunes, especially at Sulina and Cardon), *Euphorbia maculata* (slightly salted sands at Sulina), *Fraxinus pennsylvanica* (in willow and poplar galleries, especially on the Chilia Veche arm, Babina, Cernovca islands), *Helianthus annuus* (dunes at Sulina, alluvium at Sf. Vilia, on the arm Gheorghe etc.), *Lemna minuta* (on Lake Nebunu and St. George, along with native species of *Lemna, Hydrocharis morsus-ranae*), *Monochoria korsakowii* (alluvium on the Chilia Veche arm, near Chilia Veche), *Morus alba* (dunes south of Periprava), *Oenothera glazioviana* (dunes with Euphorbia seguieriana, especially at Sulina), *Perilla frutescens* (alluvium at St. George), *Sagittaria trifolia* (Sacalin and St. George), *Solanum retroflexum* (ruderal sands at St. George, Caraorman, C.A. Rosetti), *Symphyotrichum ciliatum* (dunes and interdune depressions at St. George, saltines on Sacalin) (Anastasiu, P., et al., 2013).

Most alien plants in the Danube Delta are present in ruderal plant communities, heavily anthropized, and fewer in natural and semi-natural communities. Thus, *Amaranthus blitoides* was found in the Chilia agricultural area, in the association *Artemisietum maritimae*.

Amaranthus blitum subsp. emarginatus enters the structure of the association *Eleocharidetum acicularis*, although the most common is ruderal.

Ambrosia artemisiifolia, recently installed in the Danube Delta, was noted in *Hordeo murini-Cynodontetum* at Sulina and Juncetum maritimi on Sahalin Island.

Amorpha fruticosa forms monodominant communities, but it was also noted from the following plant associations as well: *Atripliceto hastatae - Cakiletum euxinae, Salicetum albae, Salicetum albo-fragilis, Salicetum cinereae, Salicetum triandrae, Calamagrostio epigei- Hippophaetum rhamnoides, Argusio-Petasitetum spuriae, Elymetum gigantei*.

Azolla filiculoides is frequently present in the association *Lemno-Hydrocharitetum morsus-ranae*, but also in *Lemno-Salvinietum natantis* and *Lemno-Azolletum carolinianae* reaching a coverage of up to 85%.

Conyza canadensis is present in *Elymetum gigantei*, *Convolvuletum persici*, *Plantaginetum coronopi*, *Argusio-Petasitetum spuriae*.

Elaeagnus angustifolia has been noted in the plant associations *Elymetum gigantei, Plantaginetum coronopi, Juncetum maritimi, Calamagrostio epigei- Hippophaetum rhamnoides*.

Elodea nuttallii builds the association *Elodeetum nuttallii*, that is frecquently replacing *Ceratophylletum demersi association*.

Lindernia dubia was found in Chilia Veche, in *Dichostylido michellianae-Gnaphalietum uliginosi*.

Symphyotrichum ciliatum was identified in *Argusietum sibiricae* and *Acorelletum pannonici*.

Xanthium italicum associates in the structure *Argusietum sibiricae*, *Atripliceto hastatae-Cakiletum euxinae, Convolvuletum persici, Acorelletum pannonici, Elymetum gigantei, Suaedeto-Kochietum hirsutae, Calamagrostio epigei-Hippophaetum rhamnoides, Suaedeto maritimae*.

Xanthium spinosum is quite rare, in *Trifolio fragifero-Cynodontetum* (Anastasiu, P., et al., 2011).

From the national proposed list of alien invasive plant species available online (http://invazive.ccmesi.ro) we have selected a number of 44 taxon that have been found in the available sources as being present in Danube Delta Biosphere Reserve Territory.

The publications/books that sustain the alien invasive species selection for the above-mentioned table are the following:

1. *Abutilon theophrasti* Medik. - Szabo 1841: pe malul Bahluiului (Malva tomentosa!) [Gurău 2012]; Guebhard 18421848: pe lângă Iași și Galați (Sida abutilon L.) [Brândză 18791883]
2. *Acer negundo* L. - Fătu 1871: Iași (IS) (cult.); Prodan 1946: Cluj-Napoca (CJ)
3. *Ailanthus altissima* (Mill.) Swingle - Fuss 1866: Transilvania (cult.); Grecescu 1898: România
4. *Amaranthus albus* L.   Moesz 1905: Reci (CV) [Morariu 1952]
5. *Amaranthus blitoides* S. Watson var. blitoides - Nyârâdy 1931: Ismail (TL) (var. blitoides); Morariu 1948: Tulcea (var. reverchoni) [Costea 1998]
6. *Amaranthus blitoides* S. Watson var. reverchoni Uline et Bray - Morariu, in Săvulescu 1952; Costea 1998: Tulcea (leg. Morariu 1948)
7. *Amaranthus emarginatus* Moq. ex Uline et Bray - Danciu & Parascan 1968: Moldova Veche (MH) [Costea 1998] (var. emarginatus); Costea 1998: Delta Dunării (var. pseudogracilis)
8. *Amaranthus retroflexus* L. - Baumgarten 1816: Transilvania (comuna)
9. *Ambrosia artemisiifolia* L. - Javorka 1910: Orșova (MH) (leg. 1908) [Javorka 1925]
10. *Ambrosia psilostachya* DC. - Ciocârlan & Constantin 1992: Delta Dunarii-C.A.Rosetti (TL)
11. *Ambrosia trifida* L. - Fătu 1871: Iași (cult.); Vițalariu et al. 1977: Medea, Palas-Constanța (leg. 1976)
12. *Chenopodium ambrosioides* L. - Sigerus 1791: Zlatna (AB), Axente Sever
13. *Conyza canadensis* (L.) Cronq. - Baumgarten 1816: Transilvania (leg. in 1814 ?) (în Carpați -frecventă încă din 1814) [Nyârâdy 1964-FL. IX]; f pusillus Schur: studiată încă de J. Lerchenfeld la sfârșitul secolului al XVIII-lea [Schur 1866]
14. *Cuscuta campestris* Yunck. - Degen 1911: jud. Alba (leg. 1886), jud. Satu Mare (leg. 1898 și 1909) și Dej (CJ) (leg. 1902) (eronat sub C. suaveolens Ser.) [Buia 1938/1939]

15. *Datura stramonium* L. - Benko 1778 (sub numele de maszlag): Transilvania [Pop 1930b], Baumgarten 1816: Transilvania
16. *Eclipta prostrata* (L.) L. - Sârbu A 1994-1996: Insula Mică a Brăilei (BR) [Dihoru & Sârbu A. 1998].
17. *Elaeagnus angustifolia* L. - ***** 1792: Gornești (cult.) (MS) [Marcus 1958]; Baumgarten 1816: Dobra, Deva
18. *Elodea canadensis* Michx. - Macovei & Scriban 1906; Lacul Crapina (TL) (sub Helodea canadensis) [Prodan 1935].
19. *Elodea nuttallii* (Planch.) H.St John - Ciocârlan et al. 1993: Delta Dunării [Ciocârlan et al. 1997],
20. *Euphorbia maculata* L. (Chamaesyce maculata (L.) - Nyarady 1931: Sulina (TL) (sub Euphorbia chamaesyce subsp.
21. *Fraxinus pennsylvanica* Marshall - ***** 1910-1915: Bazoș (TM) (cult.) [Marcus 1958]; Borza 1947: Transilvania
22. *Galinsoga parviflora* Cav. - Schur 1866: Sibiu (SB), Brașov (BV)
23. *Gleditsia triacanthos* L. - Schur 1866: Transilvania (cult.); Grecescu 1898: România (naturaliz.) (fără localiz.)
24. *Helianthus tuberosus* L. - Benko 1778: Transilvania (cult.) [Pop 1930b]; Heuffel 1858: Banat (fără localiz.)
25. *Iva xanthifolia* Nutt. - Borza & Arvat 1935; Cluj-Napoca (cult. în Grăd. Bot.); Răvăruț 1945; Iași (leg. 1942-IASI)
26. *Lemna minuta* Kunth. - Ciocârlan & Sârbu 1998: Delta Dunării, în bălțile de pe lângă Lacul Nebunu (TL)
27. *Lindernia dubia* (L.) Pennell - Ciocârlan & Costea 1994: Delta Dunării
28. *Lonicera japonica* Thunb. - Nagodă 2015: Țigănești (leg. Rădulescu 1948, BUC 286088; BUC 286089; BUC 286073; BUC 286074) [(Strat 2013)]
29. *Lycium barbarum* L. - Kladni cca. 1840: Transilvania (leg. fără localiz.) (cult. ?) [Drăgulescu 2009b]; Guebhard 1842-1848: Moldova [Brândză
30. *Morus alba* L. - ****sec. XVI (cult.) [Bordeianu et al. 1963]; **** sf. sec. al XVIII-lea (subspont.) [Giurea 1929, citat de Călinescu 1941]

31. Oxalis corniculata L. - Schur 1866: Transilvania: (fără localiz.)
32. *Parthenocissus inserta* (A. Kerner) Fritsch - Neugeboren cca. 1850: Sibiu (Herb. Soc. Şti. Nat. Sibiu) [Drăgulescu 2009b] [Anastasiu, P., et al. (2013)]
33. *Paspalum paspalodes* (Michx.) Scribn. - Roman 1992: Drumul Turcului ("La Tablă") în Pădurea Letea (Delta Dunării) (TL)
34. *Phytolacca americana* L. - Sestini 1780 /1815: Floreşti (cult. ?) (CJ) [Pop 1930; 1942]; Rochel 1828: Banat [Borza 1942]
35. *Populus x canadensis* Moench - Fătu 1871: Iaşi (IS) (cult.)
36. *Robinia pseudoacacia* L. - **** 1750: România (cult.) [Haralamb 1968]; Benko 1778: Transilvania (cult.) [Pop 1942]; Sestini 1780/1815: Cluj-Napoca (cult.) [Pop 1930]; Baumgarten 1816: Transilvania (cult. şi subspont.).
37. *Solidago canadensis* L. - Schur 1866: Avrig, Bradu (SB)
38. *Sorghum halepense* (L.) Pers. - Heuffel 1858: Banat
39. *Symphyotrichum ciliatum* (Ledeb.) Nesom (syn.: Erigeron ciliatus Ledeb., *Brachyactis ciliata* (Ledeb.) Ledeb., B. angusta (Lindl.), *Aster brachyactis* S. F. Blake, *A. angustus* (Lindl.) Torr. et A. Gray) - Pop & Viţalariu 1971: Socola (IS), Tanacu (VS) (leg. 1967)
40. *Vallisneria spiralis* L. - Heuffel 1858: Banat
41. *Verbesina encelioides* (Cav.) Bentham et Hooker fil. ex A. Gray - Anastasiu et al. 2009: Sarighiol de Deal (TL); Râmnicul de Jos, Grădina şi Cheia (CT)
42. *Veronica persica* Poir. Baumgarten 1816: Sibiu (SB), Bahnea, Sighişoara (MS), Turda, Cluj-Napoca (CJ) (sub V. filiformis DC.)
43. *Xanthium orientale* L. subsp. italicum (Moretti) Greuter Borbas 1884 - Grigore 1987: cp. Timişului
44. *Xanthium spinosum* L. **** 1819; Czihack 1836: Moldova [Brândză 18791883]

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***LEGE nr. 58 din 13 iulie 1994 pentru ratificarea Convenţiei privind diversitatea biologică, semnată la Rio de Janeiro la 5 iunie 1992 EMITENT: PARLAMENTUL ROMANIEI apărută în MONITORUL OFICIAL nr. 199 din 2 august 1994

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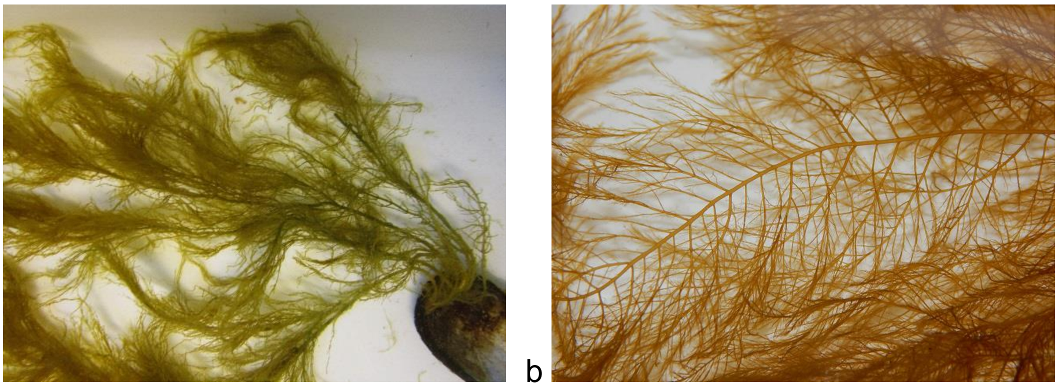
3.2 Ukraine

The Black Sea is a semi-isolated brackish water basin characterized by a high diversity of alien species that have a significant impact on the marine ecosystem (Gomoiu et al. 2002; Aleksandrov 2004). The risk of penetration of alien organisms into the Black Sea was facilitated, among other things, by the development of shipping and deepening of the shipping canals. **The main vectors of alien species introduction to the Black Sea are:**

- **expansion of the range of Mediterranean species,**
- **purposeful or random introduction,**
- **the introduction of species with ballast water,**
- **underwater parts of ship hulls.**

Over the past thirty years (since the 90s of the last century) the most significant events associated with the invasion of macrophytes into the ecosystem of the Ukrainian sector of the north-western part of the Black Sea, which influenced the change in the structure of community macrophytobenthos, is the invasion of two cold-loving arctic algae *Desmarestia viridis* (Mull.) (Lamour.) (Minicheva, Eremenko, 1993) and *Chorda tomentosa* Lyngb. (= *Halosiphon tomentosum* (Lyngbye) Jaasund) (Minicheva, 2015a,b).

Against the background of the depletion of the floristic composition of benthic algae in the North-Western Black Sea (NWBS), associated with the process of anthropogenic eutrophication, in 1990-93. the appearance of a number of new species was noted. Brown alga *Punctaria latifolia* f. *angustifolia* (Kütz.) has become a common element of vegetation. In May 1992, the brown alga *Desmarestia viridis* (Müll) was found in large quantities (Fig. 3.1.), subarctic species. In the spring-summer period of 1992, outbreaks of the development of a number of benthic algae, rare for the NWBS, were recorded.



a b

Fig. 3.1. *Desmarestia viridis* (Müll) J.V. Lam., Invader to the North-Western Black Sea in the 90s of the last century: a) general view of the thallus; b) thallus structure

Currently, *Desmarestia viridis* become mass in the north western region of Black Sea during the cold period of the year. This macrophyte was found at the area of the Zernov's *Phyllophora* Field (north-western shelf of the Black sea) in 2017 and 2019.

At the present time, *Desmarestia viridis* is a dominant in the phytocenoses of benthic vegetation along the entire coastal part to a depth of 10 m of the Danube-Dnieper inter-riverine.

Development of sporophytic phase of brown algae *Chorda tomentosa* was found on April 30, 2015 in the Cape Velykyi Fontan (NWBS, Ukraine, Odessa Bay: 46° 22.469 N, 30° 45.249 E) during underwater survey on the sandy and shell substrate at the depth of 5–8 m and temperature of 9°C (Fig. 3.2.).

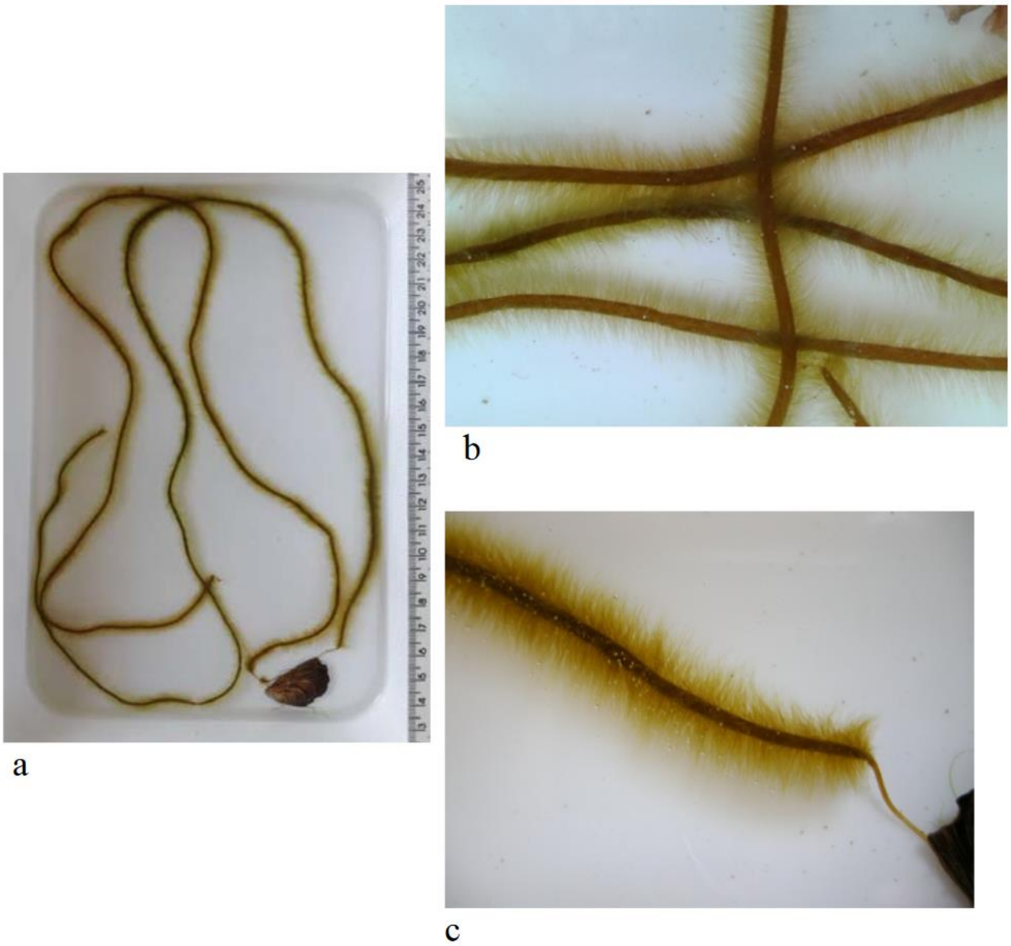


Fig. 3.2. *Chorda tomentosa* found at Cape Velykyi Fontan, North-Western Black Sea, in April 2015: **a** – general view of thalli; **b** – middle part of thallus with fibrils; **c** – thallus base with bottom.

The results of the above survey have shown that there were no single specimens, but quite a developed population of *C. tomentosa* having patchy distribution. In places the «rosettes» of the algae with 5–10 thalli develop at the distance of 1.5–3 m from each other. The height of thallus in the population is 50 to 80 cm in general (the maximum was 85 cm) and they form biomass reaching 100–150 g·m-2. This is a big macroalgae rising above the level of local phytobenthos coenoses and easy to spot visually. At present *C. tomentosa* fills the places in cold (up to 10 °C) and deep (below 5 m) phytocoenoses dominated by *Desmarestia viridis* and *Ceramium diaphanum* var. *elegans* (Roth) Roth (Fig. 3.3.).

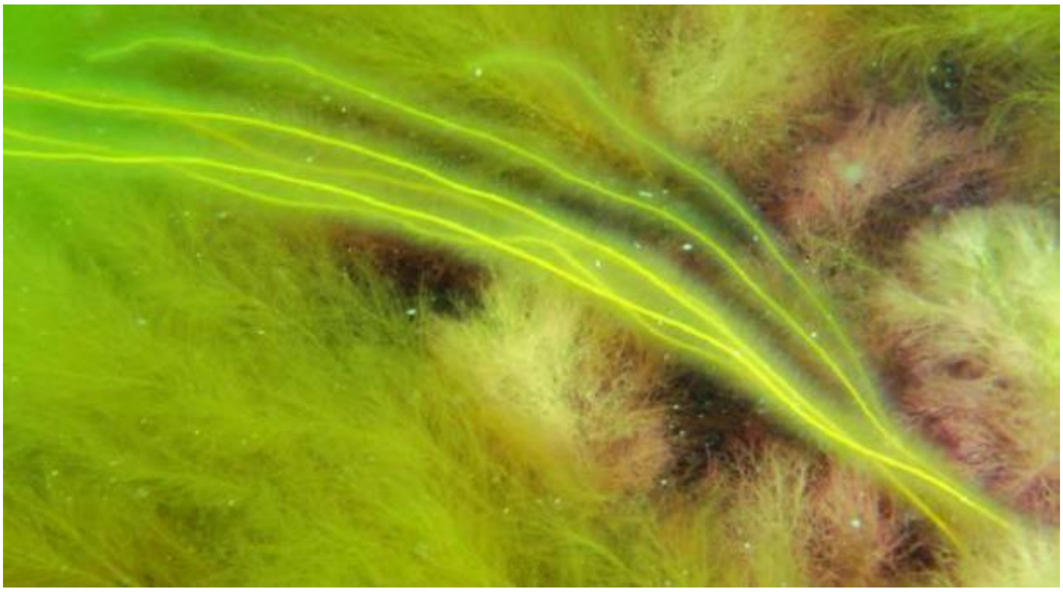


Fig. 3.3. *Chorda tomentosa* as an element of a phytocoenosis dominated by *Desmarestia viridis* and *Ceramium diaphanum* var**.** *elegans* (photo by A.P. Kurakin)

Southern boundary of its habitat is located further north than *C. filum* habitat (http://www.ecosystema.ru/08nature/vod/019.htm). At present *C. filum* has the status of alien species with high level of introduction in the Mediterranean Sea (CIESM 2009) and is entered into the list of the Marmara Sea alien species (Zeybek et al., 1986).

Calculation of specific surface of *C. tomentosa* has shown that the S/W value of tubular thallus is 5.69±0.47 m2·kg-1 and of the fibrils – 197.20±8.79 m2·kg-1. In general, the coefficient of ecological activeness of the alien species population is 82.2±4.3 m2·kg-1. At present, in the coastal zone of Odessa Bay, such development is characteristic of macroalgae with the S/W value of population equal to 25–140 m2·kg-1; the average regional value of this indicator makes ~80 $m^2 \cdot kg^{-1}$. Apparently the species feature of *C. tomentosa***,** connected with dense pubescence of quite coarse tubular thalli with thin fibrils, determines the intensity of metabolic processes and enables this species to use optimally the nutrients of its new area and conditions of the winter season with low temperatures.

An important factor simplifying the naturalization of alien species, including zoobenthos, is eutrophication, which was first observed in the northwestern part of the Black Sea since the early 1970s (Aleksandrov, 2007; Panov et al., 2010). Currently, only among benthic invertebrates of the Ukrainian part of the Black Sea of macrozoobenthos, 30 species of invaders have been recorded – representatives of different taxonomic groups (Zolotarev, 2006; Shurova, Losovska, 2003; Shurova, 2006; Aleksandrov et al., 2007; Boltachova et al., 2011; Kovtun et al., 2012; Radashevsky, Selifonova, 2013;). The introduction of *Polydora cornuta* (Bosc, 1802), *Mya arenaria* (Linne, 1758), *Anadara kagoshimensis* (Tokunaga, 1906), *Rapana venosa* (Valenciennes, 1846) had a significant impact on the state of benthic communities. The introduction and successful naturalization of *M. arenaria* in the northwestern part of the Black Sea, in its coastal and estuarine areas, as well as estuaries, led to the emergence of a new biocenosis. Already in 1970-1972. it occupied vast areas in the area from the Dniester-Bug estuary to Zhebriyanskaya bay (sandy, silty-sandy soils, depth 3–16 m). In the 1980s the biocenosis was already registered at the Odessa Bank, at the northern end of the Tendrovskaya Spit. In the modern period, the biocenosis is recorded in the coastal zones of the Dnieper-Bug region and the Danube-Dniester interfluve (North-Western part, 2006, Stadnichenko, 2015). The mollusk *R. venosa*, being very prolific, without serious competitors and endowed with a high adaptive capacity to low salinity, water pollution and hypoxic conditions, the newcomer managed to form rich populations. This largest mollusk in the Black Sea has become very common and abundant not only on rocky substrates down to a depth of 30 m, where they feed on bivalve molluscs, but also on sandy soils (Gomoiu et al. 2002; Govorin, Kyrakin, 2011; Stadnichenko, Kyrakin, 2014). *Anadara kagoshimensis* is quite widespread in the NWBM and in the southern part of the Sea of Azov, inhabiting sandy and silty soils to a depth of 40 m (Gomoiu et al. 2002; Finogenova, 2020). Polychaete *P. cornuta*was first discovered in 1962 in the Sukhyi Estuary, which at that time actually turned into the water area of the Illichivsk (now Chornomorsk)

Marine Port. In 1963, this species settled throughout the estuary, and later mastered the entire water area of the NWBS. The successful naturalization of *P. cornuta* significantly influenced the benthic fauna of the northwestern shelf and, especially, the estuaries of the Black Sea region. In the interfluve areas, this species has become a characteristic form of mussel and *Alitta succinea* biocenoses (North-Western Black Sea, 2006). The increase in the intensity of navigation and the risk of the introduction of alien species with the ballast waters of ships contributed to a detailed study of their role in the dispersal of aquatic organisms, including benthic invertebrates. In 2001, 12 invasive species of macrozoobenthos were registered in the Odessa seaport, 4 of which were first found in the Black Sea (Aleksandrov, 2004).

Among the forage zooplankton, three holoplankton species were recorded in Ukrainian waters: *Acartia tonsa* Dana, 1849, *Pseudodiaptomus marinus* Sato, 1913, *Oithona davisae* Ferrari & Orsi, 1984 and *Amphibalanus improvisus* (Darwin, 1854) (Belmonte et al, 1994; Gubanova, 2000; Polischuk & Nastenko, 2006; Alexandrov et al., 2007; Selifonova, 2009; Altukhov & Gubanova, 2008, 2014; Seregin & Popova, 2019).

Acartia tonsa and *Oithona davisae* became established in the Black Sea ecosystem since the 1970s and 2000s, respectively. *Acartia tonsa* is considered as an opportunistic species, resistant to pollution and eutrophication, and is usually confined to coastal waters with high food concentrations and relatively high temperatures (Cordell, 2008; Lawrence et al., 2004; Gubanova, 2003). *Oithona davisae* was first recorded in the Sevastopol Bay in 2000 (Zagorodnyaya, 2002), then it was found only in 2005 and after that it is expanding along the Black Sea coast since 2009 (Tamura et al., 2004; Mihneva & Stefanova, 2013; Shiganova et al., 2012). The genetic analyses supported identification of *O. davisae* (Shiganova et al., 2015). The small flagellate development in the Black Sea during last years maybe a significant driving force contributing to the proliferation of the *O. davisae* population, especially in the eutrophic inlets (Mihneva & Stefanova, 2013). *Acartia tonsa* and *O. davisae* reproduce and established self-sustaining populations in their new Black Sea environment with regular occurrence in coastal, shelf, slope and open sea. *Oithona davisae* is the most abundant in the coastal waters up to 30-50 m depth but it was recorded also in the deep waters of the open sea. It occupies own niche in the Black Sea forage zooplankton useful for planktophagous commercial fish species.

The third species, *P. marinus*, was first found near the Crimean coasts (Seregin & Popova, 2019). Seasonally, the first juvenile stages of the species appeared in the Sevastopol coastal waters in September. The maximum values were reached at different times: from the end of September to the end of November. Then, the abundance quickly dropped. The presence of nauplius and copepodites in plankton suggests that the new species of copepods successfully reproduces in the Black Sea coastal waters. The temperature is assumed to be one of the main factors in the regulation of interannual variability in the abundance of the invasive species (Seregin & Popova, 2019).

From the non-forage zooplankton, two invasive alien species of Ctenophora: *Mnemiopsis leidyi* Agassiz 1885 and its predator *Beroe ovate* Bruguière, 1789 were reported from the Black Sea. The abundance of *M. leidyi* significantly dropped after arrival of *B. ovata*. The introduction of the predator *Beroe ovate* into the Black Sea demonstrates a meaningful example of internal biological control.

Mnemiopsis leidyi was brought in 1982 and spread around the Black Sea in 1988 (Shiganova, 1998; Vinogradov et al., 1989). At that time there were no any its predators in the Black Sea and *M. leidyi* could establish under optimal temperature sand food (zooplankton) concentration in the Black Sea and reached high abundances. Its main food is zooplankton, fish eggs and small larvae. Its larvae feed on microzooplankton (Shiganova et al., 2019a). During following years were observed collapsing of planktophagous fish populations, drop of large pelagic fish and dolphins stocks. The decreasing of zooplankton species diversity and stocks; and increasing of phytoplankton biomass released from zooplankton pressure were registered. The bacterioplankton increased growing on the high production of mucus released by *M. leidyi* and its degradation fragments, heterotrophic flagellates and ciliates increase follow (Shiganova et al., 2004, 2019a). By the late 1980s, the pelagic ecosystem had become dominated by gelatinous plankton, where *M. leidyi* comprised of the most of biomass (Shiganova et al., 2004). According to the experimental data *M. leidyi* cease the reproduction when temperature reaches 27°C (Shiganova et al., 2004).

10 years later its predator *B. ovata* was introduced in the Black Sea (Konsulov & Kamburska, 1998; Shiganova & Bulgakova, 2000; Seravin et al., 2002). According to the genetic analyses both species were released with ballast waters into the Black Sea from the vicinity of the Gulf of Mexico or Caribbean areas (Shiganova et al., 2010; Reusch et al., 2010; Johansson et al., 2018). In the upper layer of the Black Sea *Beroe ovata* feeds on *M. leidyi*. After arrival of *B. ovata*, the Black Sea ecosystem began to recover progressively (Shiganova et al., 2014; 2019b). Together with de-eutrophication in the late 1990s it has led to a general improvement of the Black Sea ecosystem (Shiganova et al., 2014). Nevertheless, these two invaders are still playing a role of drivers of entire pelagic ecosystem functioning (Finenko et al., 2003; Shiganova et al., 2014).

The Black Sea pelagic ecosystem was extremely degraded from blooms of gelatinous species first native jelly fish *Aurelia aurita*, then invasive ctenophore *M. leidyi* since the end of 1980s. After invasion of its predator, *B. ovata*, ecosystem began gradually to recover (Shiganova et al., 2014, 2019b). However, this trend is not continuous; it depends on other environmental factors, first of all temperature, which is increasing due to global warming.

In general, in this paper, we do not refer to the invasive species of fish that migrate from the Mediterranean Sea (Gomoiu et al., 2002; Shiganova et al., 2012).

Thus, excluding migrants from the Mediterranean in the Black Sea fauna to invasive species, there are 9 species of fish. These records have been made since the 1960s on the basis of various publications.

It should be noted that such fish as *Lateolabrax japonicus, Tribolodon brandtii, Oncorhynchus keta, Plecoglossus altivelis* were observed singly in the middle of the last century and are not observed in the modern period (Zaitsev & Mamaev, 1997). The findings of invasive fish species in the waters of the Crimean peninsula should be noted separately. Some of the species that got into this region together with ballast waters or were accidentally universes today have created local populations. These include *Sebastes schlegelii, Millerigobius macrocephalus, Tridentiger trigonocephalus* (Boltachev et al., 2010; Boltachev & Karpova, 2014; Karpova et al., 2019).

The most widespread invasive species is *Planiliza haematocheila*. This species was deliberately introduced into the waters of the Azov-Black Sea region and has been successfully acclimatized since the end of the last century. In some years, the industrial catch of this species amounted to more than 10 thousand tons.

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3.3 Greece

The knowledge on the distribution of invasive alien species close to Nestos river area is limited. According to the floristic list presented by Vasilopoulos (2005) and personal unpublished data (Tsiftsis Sp.: unpubl. data), the species that were characterized by Arianoutsou et al. (2010) as invasive are presented in Table 2.

Table 2. Invasive Alien Species
that have been recorded close to Nestos river area.

Taxon	Family	Chorology
Acer negundo L.	Sapindaceae	N American
Amaranthus deflexus L.	Amaranthaceae	S American
Amorpha fruticosa L.	Fabaceae	N American
Datura stramonium L.	Solanaceae	Cosmopolitan
Eleusine indica (L.) Gaertn.	Poaceae	Cosmopolitan
Medicago sativa L. subsp. *sativa*	Fabaceae	Paleotemperate
Paspalum distichum L.	Poaceae	Neotropical
Phytolacca americana L.	Phytolaccaceae	N American
Robinia pseudoacacia L.	Fabaceae	N American
Solanum elaeagnifolium Cav.	Solanaceae	S American
Xanthium spinosum L.	Asteraceae	S American

The knowledge about animal species that are invasive and occur close to Nestos area are even more sparse. The only information about the occurrence of invasive alien animal species comes from the study of Adamopoulou & Legakis (2016). Specifically, according to their study only the vertebrate *Trachemys scripta* was recorded in the wider area of Nestor river. It was recorded in 1999 and 2010 and since then it was never recorded again.

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3.4 Turkey

Invasive species are really important phenomenon not only Black Sea but also all aroun the world. Because of the semi enclosed water body character effects of the non-indigenous species on Black Sea ecosystem are more nonreversible. Some of the alien species i.e. *Rapana venosa, Anadara inaequivalvis, Mnemiopsis leidyi, Beroe ovata, Mya arenaria, Balanus improvisus, Mugil soiuy, Potamopyrgus jenkinsi* caused significant impacts on the Black Sea ecosystem and fisheries. All kinds of impacts due to invasive species had a big effect on the reduction of total fish production in the Black Sea as predation, food competition and major destruction in the food web. Major alien species were identified in Black Sea Turkish coast where called as Anatolian coast are as follows. The species which are indicated with " * " will be studied during the IASON project at Kizilirmak estuary (Table 7).

Table 7. The species list indicated present species in Kızılırmak estuary (*) and Turkish Black Sea coastal area

Diatoms
Chaetoceros tortissimus Gran, 1900
Pseudo-nitzschia calliantha Lundholm, Moestrup & Hasle 2003
Pseudosolenia calcar-avis (Schultze) B.G.Sundström 1986 **(*)**
Thalassiosira nordenskioeldii Cleve 1873
Dinoflagellates
Alexandrium minutum Halim
Alexandrium tamarense Balech 1995
Gymnodinium uberrimum Kofoid & Swezy 1921
Oxyphysis oxytoksoides Kofoid 1926 **(*)**
Scrippsiella trochoidea (F.Stein) A.R.Loeblich III 1976
Cholorophyta
Cladophora flexuosa (O.F.Müller) Kützing 1843
Cladophora hutchinsiae (Dillwyn) Kützing, 1845
Codium fragile fragile (Suringar) Hariot, 1889
Enteromorpha kylinii Bliding = E. Lingulata Bliding, 1948
Ulva lactuca Linnaeus, 1753 = *Ulva fasciata* Delile, 1813
Phaophyta
Cystoseira corniculata (Turner) Zanardini, 1841
Desmarestia viridis (Müll). (Lamouroux, 1813)

Ectocarpus siliculosus (Dillwyn) Lyngbye 1819
Halothrix lumbricalis (Kützing) (Reinke, 1888)
Sargassum hornschuchii C.Agardh, 1820
Vaucheria dichotoma f. marina Hauck, 1884
Punctaria tenuissima (C.Agardh) Greville, 1830
Pilayella littoralis (Linnaeus), (Kjellman, 1872)
Rhodophyta
Acrochaetium codicolum Børgesen, 1927
Acrochaetium crassipes (Børgesen) Børgesen 1915
Acrochaetium kylinii G. Hamel, 1927 = Rhodochorton *endophyticum* Kylin
Acrochaetium leptonema (Rosenvinge) Børgesen, 1915
Acrochaetium mahumetanum G. Hamel, 1927
Acrochaetium mediterraneum (Levring) Boudouresque, 1970
Acrochaetium moniliforme (Rosenvinge) Børgesen, 1915
Acrochaetium rosulatum (Rosenvinge) Papenfuss, 1945
Acrochaetium subpinnatum Bornet ex G.Hamel, 1927
Ahnfeltiopsis furcellata (C. Agardh) P.C. Silva et DeCew, 1992
Amphiroa rigida J.V. Lamouroux, 1816
Asparagopsis armata Harvey, 1855
Bonnemaisonia asparagoides (Woodward) C. Agardth, 1822
Chondrophycus papillosus (C. Agardh) Garbary et Harper, 1998 = *Palisada perforata* (Bory de Saint–Vincent) K.W. Nam, 2007
Chrysymenia ventricosa (J.V. Lamouroux) J. Agardh, 1842
Colaconema codicola (Borgesen) H. Stegenga, J.J. Bolton et R.J. Anderson, 1997
Erythrocladia irregularis Rosenvinge, 1909
Ganonema farinosum (J.V.Lamouroux) K.C.Fan & Yung C.Wang, 1974
Gelidiella nigrescens (J. Feldmann) J. Feldmann et G. Hamel, 1934
Gelidiella pannosa (J. Feldmann) J. Feldmann et G. Hamel, 1934
Gelidiella ramellosa (Kützing) J. Feldmann et G. Hamel, 1934
Gelidiocolax christianae J. Feldman et G. Feldman
Gelidium corneum (Hudson) J.V. Lamouroux, 1813
Gelidium pulchellum (Turner) Kützing, 1868
Gelidium pusillum (Stackhouse) Le Jolis, 1863
Gelidium spathulatum (Kützing) Bornet, 1892
Gracilaria armata (C. Agardh) Greville, 1830
Hildenbrandia canariensii Børgesen, 1929
Jania longifurca Zanardini, 1841
Laurencia intermedia Yamada, 1931
Liagora viscida (Forsskål) C. Agardh, 1822
Lithophyllum orbiculatum (Foslie) Foslie, 1900 = *Pseudolithothamnion orbiculatum* (Foslie) Lemoine
Peyssonnelia rosa–marina Boudouresque et Denizot (1973)

Polysiphonia fucoides (Hudson) Greville, 1824 *(syn. Polysiphonia violacea* (Roth) Sprengel, 1827)
Polysiphonia paniculata (Montagne, 1842)
Porphyra minor Zanardini, 1847
Porphyra umbilicalis Kützing, 1843
Pterocladiella melanoidea (Schousboe ex Bornet) Santelices et Hommersand, 1997
Spermatophytae
Cymodocea nodosa (Ucria) Ascherson, 1870
Cilliata
Eutintinnus lusus-undae (Entz, 1885) ist. strait
Cnidaria
Hydrazoa
Solmundella bitentaculata (Quoy & Gaimard, 1833)
Scyphozoa
Chrysaora hysoscella linnaeus 1766
Paraphyllina ransoni Russell, 1956 (ist. Strait)
Solmundella bitentaculata (Quoy et Gainmard 1833)(İst strait)
Ctenophora
Mnemiopsis leidyi (Agassiz, 1865) **(*)**
Beroe ovata Mayer 1912 **(*)**
Mollusca
Gastropoda
Potamopyrgus jenkinsi (E. A. Smith, 1889)
Rapana venosa (Valenciennes, 1846) **(*)**
Bivalvia
Anadara inaequivalvis (Bruguière, 1789 **(*)**
Anadara kagoshimensis (Tokunaga, 1906)
Mya arenaria (linne 1758) **(*)**
Mytilus edulis Linnaeus, 1758
Teredo navalis Linnaeus, 1758
Annelida
Polychaeta
Ficopomatus enigmaticus (Fauvel, 1923) (Sinop)
Prionospio pulchra Imajima, 1990
Arthropoda
Acartia tonsa (Dana, 1849) **(*)**
Amphibalanus eburneus (Gould, 1841) (İst strait)

Balanus improvisus Darvin 1854 **(*)**
Callinectes sapidus (Rathbun, 1896) **(*)**
Oithona davisae Ferrari F.D. & Orsi, 1984 **(*)**
Pandalus kessleri Czerniavsky, 1878
Sirpus zariquieyi Gordon, 1953
Echinodermata
Asterias rubens Linnaeus, 1758 (ist strait)
Pisces
Gambusia holbrooki (Girard, 1859)
Gobius cruentatus Gmelin, 1789
Liza haematocheila (Temminck & Schlegel, 1845) =*Mugil soiuy* Basilewsky, 1855
Parablennius incognitus (Bath, 1968)
Sardinella aurita Valenciennes, 1847
Sarpa sarpa (Linnaeus, 1758)
Sphyraena sphyraena(Linnaeus, 1758) (Istanbul Strait region)
Syngnathus acus Linnaeus, 1758 **(*)**

3.5 Georgia

Research studies on the bio-ecology and impacts of alien species to the marine ecosystem are very limited in the Georgia, we have only several scientific works and articles about aquatic alien species of Georgia.

The Black Sea, a unique fragile ecosystem, has been under the threat of pollution, climate change, invasive alien species and overfishing over many years, combined impacts of these threats caused serious problems in the Black Sea ecosystem, fisheries by reduction of the catch of commercial fish species, decrease in biodiversity, loss of habitats, increased food competition of endemic species and related problems in the food web by changes in various trophic levels.

The Black Sea biodiversity has become extremely more sensitive to immigrants' expansion than those in other seas. Rich diversity of biotopes and the poor local species diversity provide favorable conditions for some exotic invaders finding naïve ecological niches with no competitors or predators. The main invaders establishing and having the most dramatic impacts on species diversity are Rapa whelk Rapana venosa, Scapharca cornea, Comb jelly fish Mnemiopsis leidyi, Pacific Mullet Mugil soiuy. Rapana venosa, introduced during 1940s, spread all over the Black Sea due to lack of predators ie sea stars. All kinds of impacts due to invasive species had a big effect on the reduction of total fish production in the Black Sea as predation, food competition and major destruction in the food web. There are many other species introduced to the Black Sea from phytoplankton to top predators.

Ctenophores - *Mnemiopsis leidyi* and *Beroe ovata*

Mnemiopsis leidyi was unintentionally introduced into Black Sea in the early 1980s, probably with ballast water of shipping vessels from NW Atlantic (Vinogradov et al. 1989). First it was recorded in the Black Sea in 1982 and six years later (1988) in the Azov Sea. It was well adopted the Black Sea conditions and its population has increased sharply due to lack of predators and abundant preys (Shiganova et al. 2001). Their prey is the eggs and larvae of zooplankton-eating fish. Total biomass of Mnemiopsis was estimated as 100 million tons in 1994. The first out-break of the M. leidyi population in the Black Sea occurred in 1989 causing dramatic decline in anchovy and then in horse mackerel production.

Four main impacts on the ecosystem and fisheries were identified:

1. Changes in the food web which was considerably stable over years,
2. Predation on fish eggs and larvae; in shelf waters Mnemiopsis was estimated to graze up to 70% of total Ichtioplankton stock (Tsikhon-Lukanina et al. 1993);
3. feeding on the food of larvae and adult fish, thus causing starvation (Bilio & Niermann 2004);
4. Further accelerating of ongoing ecological change due to euthrophication.

After the invasion of another predacious comb jelly, Beroe ovata in 1997, the abundance of M. leidyi declined sharply and was maintained at a level more than four times lower than during the late 1980s (Kamburska et al. 2000). Introduction ways of Beroe ovata is not clear whether it was introduced with ballast waters or naturally transferred from the Mediterranean Sea. However, there are signs that the ecosystem of the Black Sea began to recover due to sharp decreases in Mnemiopsis population (Kideys & Romanova 2001; Shiganova et al. 2001; Yunev et al. 2001). Investigations in the Black Sea have shown that Beroe almost exclusively feeds on Mnemiopsis and very effective in controlling its levels (Kideys et al. 2000; Finenko et al. 2000; 2001, Shiganova et al. 2000, 2001).

Rapa whelk - *Rapana venosa*

The gastropod mollusc Rapana venosa a native of the Sea of Japan was first discovered in 1947 in Novorossiysk Bay (Drapkin, 1953) and has settled along the coast of the Black Sea. It has reached high biomass and has serious consequences on oyster and mussel beds (Zolotarev 1996). There are no major predators of adult Rapana venosa in the Black Sea and the population has become very abundant and destructive to native marine life: it has been responsible for the destruction of native bivalve populations i.e. oysters, scallops, and mussels. It was first observed in 1949 (Gudauta Bank) in the Eastern Black Sea of Georgia. Settlement in the Georgian Black Sea area was completed about 25-30 years. At present, the growth rate of rapa whelk considerably decreased due to lack of food but recruitment of the population is out of control and its impact continues at maximum level.

Blood cockle – *Anadara inaequivalvis*

A member of Arcidae, Anadara inaequivalvis (Syn. Scapharca inaequivalvis; Cunearca cornea), has been introduced into Black Sea accidentally from Indo-Pacific (Zolotarev & Zolotarev 1987; Sahin 1995; Sahin et al. 1999). The blood-cockle was transferred from Indo-Pacific region into Adriatic and Aegean and Black Sea through ballast waters during late 1970s. It was first time recorded by Russian scientists on the Bulgaria coasts in 1981 and initial data from the Black Sea and its distribution were published after several years (Zolotaryov et al. 1987). Blood-cockle prefers a substratum structure to hide itself easily and so, it increases its survival and filter feeding. Therefore, they became dense near coasts and river mounts. It is known that Anadara sp. can survive in very shallow waters and even when sea water withdraws in tide. However, they can be hardly found waters less than 3 m depths in the Black Sea. This is mainly because the substratum in shallow waters of the Black Sea is mostly consisted of gravels and coarse sand particles. The studies indicate that growth performance seems to better in the Black Sea than in other coastal waters and oceans. For example, lack of competition for space and food is among the major factors for better growth in the Black Sea. The species forms quite dense stocks in particular places where there is no any fishing activity yet. Blood-cockle is not consumed in Georgia, but many people consume it in far-east counties and future demands may trigger blood-cockle fishing in the Black Sea and it can be a new fisheries resource for coastal communities (Sahin et al. 2009). It is very important for the Black Sea ecosystem as to be a filter feeder to reduce euthrophication and played an important role instead of depleting native mussel stocks. But, in the progressive years the abundance of blood cockle decreased due to heavy predation of Rapana.

Pacific mullet - *Liza haematocheila*

The pacific mullet, Liza haematocheila (Temminck & Schlegal 1845) (=Mugil so-iuy Basilewsky, 1855) native to the Armur river estuary and Japan Sea. Pacific mullet is one of the new introduced species in the eastern Black Sea. It was intentionally introduced in the Black Sea in the period 1972-1980 (Zaitsev 1991). Another view about the introduction is it had been escaped from the rearing cages in the Azov Sea. The Pacific mullet well adapted to the Black Sea since 1980 - has established a self-sustaining multiple-age population in the Black Sea. Spawning and fishing both take place from May to August. There are five native mullet species in the Black Sea, namely; Mugil cephalus, Liza ramada, L. saliens, L. aurata and Chelon labrosus. Its growth rate is considerably higher than the native mullet species (Okumus & Bascinar 1997). After the introduction of pacific mullet the population of native mullet declined to high level food competition (Turan et al., 2009). Fishermen also were obliged to change their gill nets to catch bigger sized Pacific mullet.

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4. Legislation and guidelines concerning Invasive Alien Species, climate change and nature conservation

4.1 European framework

Invasive Alien Species (IAS) represent a major threat to native plants and animals in Europe, causing damage worth billions of Euros to the European economy every year. As invasive alien species do not respect borders, coordinated action at the European level will be more effective than individual actions at the Member State level.

According to - EC (European Commission) - **EU Regulation 1143/2014 on Invasive Alien Species** (https://ec.europa.eu/environment/nature/invasivealien/index_en.htm)
Regulation (EU) 1143/2014 on invasive alien species (the IAS Regulation) entered into force on 1 January 2015, fulfilling Action 16 of Target 5 of the EU 2020 Biodiversity Strategy, as well as Aichi Target 9 of the Strategic Plan for Biodiversity 2011-2020 under the Convention of Biological Diversity.
The core of the IAS Regulation is the list of Invasive Alien Species of Union concern (the Union list). For information about the species currently included on this list, click here.
The IAS Regulation provides for a set of measures to be taken across the EU in relation to invasive alien species included on the Union list. Three distinct types of measures are envisaged, which follow an internationally agreed hierarchical approach to combatting IAS:

- **Prevention**: a number of robust measures aimed at preventing the intentional or unintentional introduction of IAS of Union concern into the EU.
- **Early detection and rapid eradication**: Member States must put in place a surveillance system to detect the presence of IAS of Union concern as early as possible and take rapid eradication measures to prevent them from establishing.

- **Management**: some IAS of Union concern are already established in certain Member States. Concerted management action is needed to prevent them from spreading any further and to minimize the harm they cause.

Committee and expert groups on invasive alien species

The Commission is assisted by a number of bodies in the implementation of the IAS Regulation.

- The **Committee on IAS** assists the Commission in the preparation of implementing acts foreseen by the IAS Regulation, mainly the adoption and updates of the list of invasive alien species of Union concern. It consists of representatives of all Member States.
- The **Invasive Alien Species Expert Group (IASEG)** supports the implementation of the IAS Regulation beyond the Commission's implementing powers. It consists of representatives of all Member States.
- The **Scientific Forum on IAS** provides advice on scientific questions related to the implementation of the IAS Regulation. It consists of representatives of the scientific community appointed by the Member States.
- The **Working Group on IAS** assists the Commission and facilitates coordination. It consists of interested stakeholders and Member States representatives.

Relevant acts

- Commission Implementing Regulation (EU) 2019/1262 updating the list of invasive alien species of Union concern
- Commission Delegated Regulation (EU) 2018/968 with regard to risk assessments in relation to invasive alien species
- Commission Implementing Regulation (EU) 2018/1454 specifying the technical format for reporting by the Member States
- Commission Implementing Regulation (EU) 2017/1263 updating the list of invasive alien species of Union concern

- Commission Implementing Regulation (EU) 2016/1141 adopting a list of invasive alien species of Union concern
- Commission Implementing Regulation (EU) 2016/145 adopting the format of the document serving as evidence for the permit issued by the competent authorities of Member States

Support to the implementation of the Regulation

Several information documents have been developed in support of the implementation of the Regulation.

Prevention:

- Categories of pathways of introduction and spread of IAS
- Prioritising Pathways of Introduction and Pathway Action Plans
- Legal provisions on soil import

Early detection and rapid eradication:

- Surveillance of Invasive Alien Species of Union concern
- Identification guide for customs on invasive alien species of Union concern
- Identification guide for surveillance on invasive alien species of Union concern
- High resolution identification pictures

Management:

- Management of Invasive Alien Species of Union concern
- Notes on measures and costs per (potential) IAS of Union concern
- Note on lethal measures to manage IAS of Union concern
- Note on the costs of management

Other information:

- Managing invasive alien species to protect wild pollinators
- Interaction between the IAS Regulation and the Nature Directives
- Regional Sea Conventions and invasive alien species
- Invasive alien species native in a part of the Union
- Avoidable invasions

- Notice to stakeholders: withdrawal of the United Kingdom and EU rules on invasive alien species

Information support system & citizen science

The European Commission has developed an information exchange mechanism to facilitate the implementation of the EU policy on invasive alien species: the European Alien Species Information Network (EASIN). It's an online platform that aims to facilitate access to existing information on alien species from a range of sources.

EASIN includes a Species Search and Mapping tool, allowing for basic and advanced search of a database including over 14 000 alien species in Europe, and showing their distribution on a map. It includes the species currently on the Union list.

EASIN includes the notification system, NOTSYS, for Member States to inform the Commission on new observations of IAS of Union concern, and on the rapid eradication measures taken.

Financial support system

The European Commission is supporting action on invasive alien species through its existing financing instruments. **Some examples**:

- LIFE - the EU's financial instrument for environmental, nature conservation and climate action projects - supports measures on invasive alien species ranging from preventing their spread to eradicating or controlling them in places where they are already present. LIFE also provides support for trans-border cooperation and awareness-raising on invasive alien species.
- Horizon 2020 - the EU Research and Innovation programme, for example the Project DAISIE ("Delivering Alien Invasive Species Inventories for Europe") under FP 6, which brought together data about biological invasions across Europe.
- The EU Rural Development policy 2014-2020 provides opportunities to address invasive alien species through national and regional rural development programmes.

- Cohesion funding may also include action on invasive alien species, e.g. the INVEXO Interreg IV A-project which supported joint management efforts on 4 priority invasive alien species in Flanders and the South of the Netherlands.

History of the EU IAS Policy

Preparation of the Regulation

Two public consultations were held on the IAS policy in 2008 and 2012.

Preparatory studies towards Regulation (EU) 1143/2014.

- Policy options to minimise the negative impacts of IAS on biodiversity in Europe and the EU, with annexes -2008
- Recommendations on policy options to minimise the negative impacts of invasive alien species on biodiversity in Europe and the EU - 2009
- Assessment of the impacts of invasive alien species in Europe and the EU - 2009
- Analysis of the impacts of policy options/measures to address IAS, with Annexes - 2009
- Assessment to support continued development of the EU strategy to combat invasive alien species – 2010
- Assessment of existing policies on invasive alien species in EU Member States and selected OECD countries, with country assessments and background information - 2011

On 3 December 2008 the European Commission adopted a Communication "Towards an EU Strategy on Invasive Species":

- Communication
- Impact Assessment
- Impact Assessment – Executive Summary
- Press Release: Commission presents policy options for EU Strategy on Invasive Species

The EU 2020 Biodiversity Strategy adopted in May 2011 announced a dedicated legislative instrument on invasive alien species, hence the new proposal.

The Commission proposal for a regulation on Invasive Alien Species was launched on 9 September 2013.

Preparation of the Union list

Preparatory studies towards the first list of IAS of Union concern.

- Framework for the identification of invasive alien species of EU
- Ad hoc scientific workshop to complete IAS risk assessments – February 2015 This workshop provided scientific support to the development of the first list of IAS of Union concern.

Studies on ragweed.

- Assessing and controlling the spread and the effects of common ragweed in Europe, with background information, including maps - 2012
- Complex research on methods to halt the Ambrosia invasion in Europe, with background reports – 2014.

4.2 Climate Change Adaptation Strategies

The Commission's proposal for the first European Climate Law aims to write into law the goal set out in the European Green Deal – for Europe's economy and society to become climate-neutral by 2050.

The law aims to ensure that all EU policies contribute to this goal and that all sectors of the economy and society play their part.

Objectives:

- Set the long-term direction of travel for meeting the 2050 climate-neutrality objective through all policies, in a socially-fair and cost-efficient manner
- Create a system for monitoring progress and take further action if needed
- Provide predictability for investors and other economic actors

- Ensure that the transition to climate neutrality is irreversible

Key elements

With the European Climate Law the Commission proposes a legally binding target of **net zero greenhouse gas emissions by 2050**. The EU Institutions and the Member States are bound to take the necessary measures at EU and national level to meet the target, taking into account the importance of promoting fairness and solidarity among Member States.

The Climate Law includes **measures to keep track of progress and adjust our actions accordingly**, based on existing systems such as the governance process for Member States' national energy and climate plans, regular reports by the European Environment Agency, and the latest scientific evidence on climate change and its impacts.

Progress will be reviewed every five years, in line with the global stock take exercise under the Paris Agreement.

The Climate Law also addresses the **necessary steps to get to the 2050 target**:

- Based on a comprehensive impact assessment, the Commission has proposed a **new EU target for 2030** of reducing greenhouse gas emissions by at least 55% compared to levels in 1990. The Commission has proposed to include the new EU 2030 target in the Law.
- By June 2021, the Commission will review, and where necessary propose to revise, all relevant policy instruments to deliver the additional emissions reductions for 2030.
- The Commission proposes the adoption of **a 2030-2050 EU-wide trajectory** for greenhouse gas emission reductions, to measure progress and give predictability to public authorities, businesses and citizens.

- By September 2023, and every five years thereafter, the Commission will assess the consistency of EU and national measures with the climate-neutrality objective and the 2030-2050 trajectory.
- The Commission will be empowered to issue recommendations to Member States whose actions are inconsistent with the climate-neutrality objective, and Member States will be obliged to take due account of these recommendations or to explain their reasoning if they fail to do so.
- Member States will also be required to develop and implement **adaptation strategies to strengthen resilience** and reduce vulnerability to the effects of climate change.

Next steps

The legislative proposal was submitted to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions for further consideration under the ordinary legislative procedure.

Stakeholder input

The Commission conducted extensive analysis and stakeholder consultation in preparation of its strategic vision for a climate-neutral EU published in November 2018. This was followed by an EU-wide debate on the vision.

A high-level public conference on 28 January 2020 provided a further opportunity for open, public stakeholder debate on the European Climate Law before its finalization and adoption.

The public also had the possibility to provide feedback on the roadmap for the legislative proposal, with nearly 1000 contributions.

Documents

- Commission proposal for a Regulation: European Climate Law
- Commission amended proposal for a Regulation: European Climate Law

- Climate Law Factsheet

Turkey

In Turkey, it was estimated that the temperature would increase by 1.7°C in 2050 and 5.1°C in 2080. This climate estimation show also that the effects of climate change would occur severely in Turkey (Bozoglu,et al, 2019).

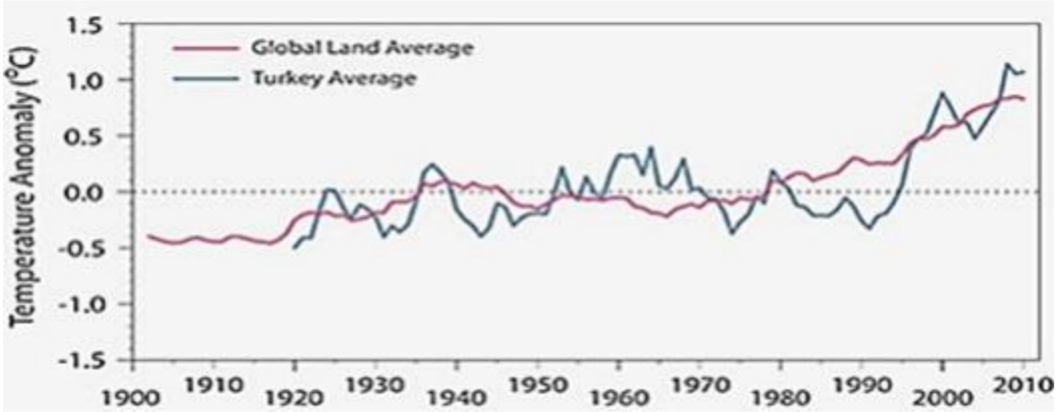

Figure 1: Developments in the average annual temperatures in Turkey (Sen, 2018)

Figure 1 shows the estimated future changes in the annual temperature of Turkey. Based on the average of 1961-1990, the estimated annual mean temperatures in Turkey for the periods of 2010-2039, 2040-2069 and 2070-2099 show that the temperature will increase in all over Turkey. The temperature increase from 1960s or 1970s to the 2000s was close to 1.5^{O}C. By 2050, it was estimated that while annual mean temperature would increase by 1.5°C and precipitation would decrease by 1.5 mm (Şen,2018)

The primary objective of Turkey within the scope of global fight against climate change is to participate global efforts for preventing climate change, which is a common concern of mankind, to determined common mind with the international parties

With Decision 26/CP.7 of the Seventh Conference of Parties (COP) in Marrakesh in 2001, Turkey was deleted from the list of Annex II countries, under the United Nations Framework Convention on Climate Change. Moreover, Decision 26/CP.7 enshrined an invitation to all Parties to recognize the special circumstances of Turkey relative to other Annex I Countries, placing it in a different situation. Following this decision, Turkey became a party to the United Nations Framework Convention on Climate Change on May 24, 2004. Before becoming a party to the UNFCCC, Turkey, in 2001 has carried out an institutional structuring and with the Prime Ministerial Circular no.2001/2 established the Coordination Board on Climate Change (CBCC). The CBCC was restructured in 2004 after Turkey became a party to the UNFCCC and in 2010 its remit was expanded with the participation of new members. The members of the CBCC are: Ministry of Science, Industry and Technology, Ministry of Environment and Urbanization (Coordinator), Ministry of Foreign Affairs, Ministry of Economy, Ministry of Energy and Natural Resources, Ministry of Food, Agriculture and Livestock, Ministry of Development, Ministry of Finance, Ministry of Forestry and Water Works, Ministry of Health, Ministry of Transportation, Maritime Affairs and Communication, Undersecretariat of Treasury, Turkish Union of Chambers and Commodity Exchanges (TOBB) and Turkish Industry and Business Association (TUSIAD). There are 11 technical working groups established under the CBCC. Law No. 5836 on the Endorsement of Turkey's Ratification of Kyoto Protocol to the United Nations Framework Convention on Climate Change was published in the Official Gazette numbered 27144 and dated February 17, 2009. Following the publication of the Council of Ministers Decree on the "Ratification Instrument" declaring Turkey's accession to the Kyoto Protocol in the Official Gazette on May 13, 2009, the ratification instrument was submitted to the UN Secretariat General on May 28, 2009, and Turkey officially became a party to the Protocol on August 26, 2009.

Turkey is tried to mitigate the impacts of climate change by participating in many national and international programs and projects. First, Turkey has participated in the Climate Change Convention of United Nation in 2004. Constitution 1982 of Turkey, 10th Development Plan (2014-2018), Medium Term Program (2014-2018), Climate Change National Action Plan (2011-220), Turkey's Climate Change Strategy Document (2010-2023) the Strategic Plan of Ministry of Food Agriculture and Livestock (2018-2022), and National Rural Development Strategy (2014-2020) has consisted of the main climate change policy documents of Turkey.

According to the article 45 of 1982 Constitution, the government is responsible to prevent unintended use and destruction of agricultural lands and pastures (TBMM, 2011). The strategic objectives of Turkey's Climate Change Adaptation Strategy and Action Plan are to integrate climate change adaptation into the agricultural sector and food security policies, to determine natural disaster risks and the effects of climate change on agriculture, to protect soil and biodiversity, to plan sustainability of agricultural water use, to develop institutional capacity and inter-institutional cooperation or coordination, to improve information, monitoring and evaluation systems for decision making processes and R&D capacity, to strengthen the management of intervention mechanisms, to organize education, information and public awareness activities and to improve mitigation and adaptation capacity of climate change (MoEU, 2012).

The Medium-Term Program has envisaged to develop tax policies for combating with climate change (OGoTR, 2018). National Rural Development Strategy (OGoTR, 2015) has objected to improve rural environment and to sustain natural resources in Turkey. This strategy has foreseen some measures such as promoting environmentally friendly agricultural practices, improving organic agriculture, preventing environmental pollution caused by agricultural activities and improving pastures in order to ensure the sustainability of soil and water resources. However, the strategy also aims to develop irrigation infrastructure and income generating activities in the protected areas, to promote land consolidation and its surroundings in order to ensure efficiency of agricultural land use (Bozoglu.2019). The determination of the impact of the climate changes in the Turkish regions is listed in Table 11.

Table 11: Impact levels of climate change on the regions and sectors in Turkey (MoEU, 2012)

Impacts	Severity	Region or Province	Sector or Theme
Declining of surface waters	Medium	West Anatolia	Agriculture, infrastructure of water distribution network
Forest fires		West Anatolia	Tourism, agriculture
Increase in shortage of usage water		Afyon, İzmir, Kayseri, Muğla, Manisa	Agriculture, industry, energy
Flood		Black Sea, Southeast Anatolia	Survival of farms, human health
Landlessness/loss of soil		Southwest Anatolia	Farms' survival, food security, shallow lakes and wetlands
Decrease in agricultural productivity		Mediterranean, Aegean	Agriculture (employment), food security
Change of river/basin regimes	Low	All	Ecosystem services and biodiversity
Soil losses/salinity		Mediterranean, Black Sea, Aegean	Tourism, ecosystem services, biodiversity, seafood
Disruption of marine ecosystem		Mediterranean, Black Sea, Aegean	Ecosystem services and biological diversity
Migration of species		Mediterranean	Tourism, agriculture, food security
Decrease in seafood production		Mediterranean	Agriculture, food security, water distribution network
Coastal erosion		Black Sea	Fishing, unemployment

Turkey prepared its Climate Change Strategy for 2010-2023 periods. With this strategy, Turkey actively participate in the negotiations carried out for the establishment of a comprehensive and functional international cooperation mechanism, within efforts to combat and adapt to global climate change.

Basic Principles of the National Climate Change Strategy are defined as follows: "Turkey's primary objective within the scope of global combat against climate change is to participate in the global efforts that are carried out to prevent climate change, which is the common concern of humanity, and that are determined with common mind in cooperation with international parties in the light of objective and scientific findings, without compromising sustainable development efforts, based on the principle of common but differentiated responsibilities and within the framework of the special circumstances of our county". In the Strategy Document, Turkey's Strategic Targets within the scope of basic principles are listed as follows (Anon, 2011);

- to integrate policies and measures for mitigating and adapting to climate change into national development plans, consistent with the UNFCCC principle of "common but differentiated responsibilities" and its special circumstances,
- to contribute to the global greenhouse gas emission mitigation policies and measures, within its own capacity, by limiting the rate of growth of national greenhouse gas emissions, without disrupting its development program aligned with sustainable development principles,
- to increase national preparedness and capacity in order to avoid the adverse impacts of global climate change and to adapt to these impacts; to share emerging experiences and knowledge from such efforts with other countries in the region; and to develop bilateral and multilateral joint research projects for mitigation and adaptation,
- to comply with the design and implementation of global strategic objectives of mitigation, adaptation, technology transfer and finance that accounts for responsibilities of the parties, and to take active role in international activities,
- to increase access to the financial resources required for undertaking mitigation and adaptation activities,
- to develop national research and development (R&D) and innovation capacities towards clean production and to establish national and international financial resources and incentive mechanisms aimed at increasing competitiveness and production in this area by taking into consideration our current technology and development levels,
- to facilitate climate change adaptation and mitigation activities by ensuring efficient and continuous coordination and decision making processes based on transparency, stakeholder participation, and a strong reliance on a science focus,

- to raise public awareness in support of changing consumption patterns in climatefriendly manner through joint efforts of all parties such as the public sector, private sector, universities and NGOs,
- to establish an integrated information management system in order to increase the flow and exchange of knowledge in national climate change efforts.

Georgia

The international treaties and agreements significantly influence national policy of climate change due to its global nature. In October of 1994, Georgia ratified the United Nations Framework Convention on Climate Change (UNFCCC) and in June of 1999, accessed to the Kyoto Protocol. In 2010, Georgia acceded to the Copenhagen Accord and declared that "Georgia will take steps to achieve a measurable, reportable and verifiable deviation from the baseline scenario (below "Business as Usual" levels) supported and enabled by finance, technology and capacity building."

The Paris Agreement on climate change entered into force for Georgia in 2017. In 2015, prior to the adoption of the Paris Agreement, Georgia submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC. According to the INDC, Georgia plans to unconditionally reduce its GHG emissions by 15% below the Business as Usual (BAU) scenario by 2030. This number will mean a 34% reduction in emission intensity per unit of GDP from 2013 to 2030. Conditional to a global agreement addressing the importance of technical cooperation, access to low-cost financial resources and technology transfer, this 15% can be increased up to 25%. At 25%, Georgia's reduction in greenhouse gas emission intensity per unit of GDP from 2013 to 2030 would be approximately 43%. The 25% reduction would also ensure that by 2030, GHG emissions in Georgia will stay 40% below 1990 levels.

In order to fulfil its obligations under the Paris Agreement, the MEPA has planned the development of a 'Climate Action Plan' (CAP) before 2020 and its implementation in the following years. As one of the first steps, a revision of the Georgian INDC is planned to be conducted based on which, the new NDC will be developed and submitted to the UNFCCC secretariat by 2019.

The EU-Georgia Association Agreement is another key document shaping the Climate Change commitments at the national level. Specifically, the AA stresses the need for cooperation on the following areas: mitigation of climate change, adaptation to climate change, carbon trade, integration into industrial policy on climate change issues and the development of clean technologies. The agreement explicitly mentions the cooperation on the preparation of the Low Emission Strategy (LEDS), as well as Nationally Appropriate Mitigation Actions (NAMA), and the measures aimed at promoting technology transfer based on the technology needs assessment.

4.3 National legislation

4.3.1 Romania

Regulatory acts governing the introduction Non-native species in Romania:

ORDER on the introduction of non-native species, interventions on invasive species, as well as the reintroduction of the native species provided in the annexes no. 4A and 4B to the Ordinance Government Emergency Department no. 57/2007 regarding the regime of protected natural areas, conservation natural habitats, wild flora and fauna, on the national territory (MO, p.I, Nr. 500/20.V11.2009) (http://legislatie.just.ro/Public/DetaliiDocument/83289)
Emergency Ordinance no. 201/2008 (M.O., P. I, no. 826 of December 9, 2008) for the amendment and completion of the Government Ordinance no. 136/2000 on protective measures against the introduction and spread of quarantine organisms harmful to plants or plant products in Romania (http://legislatie.just.ro/Public/DetaliiDocument/100075)

Government Decision no. 563/2007 (M.O., P. I, no. 468 / 12-07-2007) for the approval of the methodological norms for the application of Government Ordinance no. 136/2000 and Annex to H.G. no. 563/2007 published in M.O., P. I, no. 468 bis / 12-07-2007, with subsequent amendments and completions) (http://legislatie.just.ro/Public/DetaliiDocument/83536)
Order of the Minister of Agriculture and Rural Development no. 581/2007 (M.O., P. I no.499 / 25-07-2007) on the recognition of protected areas exposed to certain phytosanitary risks in the Community (Commission Directive 2001/32) (http://legislatie.just.ro/Public/DetaliiDocument/83856)
Order of the Minister of Agriculture and Rural Development no. 585/2007 (M.O., P. I no. 502 of July 26, 2007) on the identity control and phytosanitary control of plants, plant products or other objects, provided in part B of annex no. V to the Government Decision no. 563/2007, which may be carried out at a place other than or near the point of entry into the Community, and which specifies the conditions relating to such controls (http://legislatie.just.ro/Public/DetaliiDocument/83882)
Order of the Minister of Agriculture and Rural Development no. 685/2007 (OJ, P. I no. 620 of September 7, 2007) for establishing the conditions for the introduction or putting into circulation in Romania or in certain protected areas in Romania, for experimental or scientific papers and works for varietal selections, of certain harmful quarantine organisms, plants, plant products and other objects provided in annexes no. I-V to the Government Decision no. 563/2007 for the approval of the methodological norms for the application of the Government Ordinance no. 136/2000 on protection measures against the introduction and spread of quarantine organisms harmful to plants or plant products in Romania (http://legislatie.just.ro/Public/DetaliiDocumentAfis/85222)
Order of the Minister of Agriculture and Rural Development no. 584/2007 (OJ, P. I, no. 499/25 - 07-2007) on establishing the rules for the movement of certain plants, plant products or other objects through a protected area and for the movement of these plants, plant products or other originating objects from a protected area and circulating in such a protected area

(http://legislatie.just.ro/Public/DetaliiDocument/83837)
Law 37/2006 (M.O., P. I no. 200 / 3-03-2006) regarding the reorganization of the plant protection activity and phytosanitary quarantine, with the subsequent modifications and completions (Law no. 93/2007) (http://legislatie.just.ro/Public/DetaliiDocument/84525)
EMERGENCY ORDINANCE no. 57 of June 20, 2007 (OJ, No. 442 of June 29, 2007) on the regime of protected natural areas, conservation of natural habitats, wild flora and fauna (http://legislatie.just.ro/Public/DetaliiDocument/83289)
DECISION for the approval of the Methodological Norms for the application of the Government Ordinance no. 136/2000, regarding the protection measures against the introduction and spread of quarantine organisms harmful to plants or plant products in Romania, M.O., p. I, Nr. 721/13 November 2001 (http://legislatie.just.ro/Public/DetaliiDocument/24128)
Government Ordinance no. 136/2000 (M.O., P. I no. 431 of September 2, 2000) on protection measures against the introduction and spread of quarantine organisms harmful to plants or plant products in Romania, approved and amended by Law no. 214/2001 (http://legislatie.just.ro/Public/DetaliiDocument/24128)

4.3.2 Ukraine

Relevant Ukrainian legislation

Legal regulation
The Law of Ukraine On Environmental Protection, Date of Entry into Force: July 1, 1991https://zakon.rada.gov.ua/laws/anot/en/1264-12
The Law of Ukraine On Nature Reserve Fund of Ukraine, Date of Entry into Force: July 25, 1992 https://zakon.rada.gov.ua/laws/anot/en/2456-12
The Law of Ukraine On Plant Protection, Date of Entry into Force: November 24, 1998 https://zakon.rada.gov.ua/laws/anot/en/180-14
Law of Ukraine “On Flora”, Date of Entry into Force: May 13, 1999 https://zakon.rada.gov.ua/laws/anot/en/591-14
The Law of Ukraine On Ratification of the Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, Date of Entry into Force: July 30, 1999 https://zakon.rada.gov.ua/laws/anot/en/832-14

The Law of Ukraine On Land Reclamation, Date of Entry into Force: February 16, 2000 https://zakon.rada.gov.ua/laws/anot/en/1389-14
The Law of Ukraine On Hunting Economy andS hooting, Date of Entry into Force: March 28, 2000 https://zakon.rada.gov.ua/laws/anot/en/1478-14
Law of Ukraine"On the National Program for Creating the National Environmental Network of Ukraine for the Years 2000-2015", Date of entry into force: November 8, 2000 https://zakon.rada.gov.ua/laws/anot/en/1989-14
Law of Ukraine On Adopting the State Program for Protecting and Restoring the Black and Azov Sea Environment, Date of entry into force: May 4, 2001 https://zakon.rada.gov.ua/laws/anot/en/2333-14
The Law of Ukraine On Fauna, Date of Entry into Force: January 16, 2002https://zakon.rada.gov.ua/laws/anot/en/2894-14
The Law of Ukraine On the Red Book of Ukraine, Date of Entry into Force: March 14, 2002 https://zakon.rada.gov.ua/laws/anot/en/3055-14
The Law of Ukraine On Land Protection, Date of Entry into Force: July 29, 2003 https://zakon.rada.gov.ua/laws/anot/en/962-15
The Law of Ukraine"On Ecological Network of Ukraine", Date of Entry into force January 1, 2005 https://zakon.rada.gov.ua/laws/anot/en/1864-15
The Law of Ukraine On the State System of Biosafety at the Time of Creating, Testing, Transporting, and Using Genetically Modified Organisms, Date of entry into force: June 21, 2007 https://zakon.rada.gov.ua/laws/anot/en/1103-16
Law of Ukraine “On Fishery, Industrial Fishing and Protection of Water Bioresources", Date of entry into force: August 4, 2011https://zakon.rada.gov.ua/laws/anot/en/3677-17
Law of Ukraine On Environmental Impact Assessment, Date of Entry into Force: June 18, 2017 https://zakon.rada.gov.ua/laws/main/2059-19#Text
The Law of UkraineAbout the Basic principles (strategy) of the state environmental policy of Ukraine for the period till 2030, Date of Entry into Force: January 1, 2020https://zakon.rada.gov.ua/laws/show/2697-19#Text
The Forest Code of Ukraine, Date of entry into force: April 13, 1994https://zakon.rada.gov.ua/laws/anot/en/3852-12
The Water Code of Ukraine, Date of Entry into Force:July 20, 1995https://zakon.rada.gov.ua/laws/anot/en/213/95-%D0%B2%D1%80
The Land Code of Ukraine, Date of Entry into Force: January 1, 2002 https://zakon.rada.gov.ua/laws/anot/en/2768-14

4.3.3 **Greece**

According to Greece’s National Biodiversity Strategy and Action Plan which has been established by Decision No 40332/2014 (FEK B 2383/08.09.2014) of the Minister for the Environment, Energy and Climate Change, the spread of invasive alien species has been identified as a major threat to local biodiversity. Thus, the protection of biodiversity from the impacts of invasive species is among the main challenges of Greece's policy. The negative impacts of IAS in biodiversity makes the adoption of preventive measures a critical priority, starting from the study and detection of invasive alien species already present in Greece, as well as examining the way that they were or are introduced, so as to take the necessary steps to prevent the further invasion and spread of these species. Their invasion starts with intentional or accidental introduction and escape in the terrestrial, freshwater or marine environment. Therefore, it is absolutely necessary to raise public awareness about the threat presented by alien species invasions (Decision No 40332/2014).

Dealing with invasive species impacts on biodiversity requires early detection, continuous monitoring, measures to limit their consequences to biodiversity, and the effective implementation of the CITES Convention. In cases where biodiversity has been affected by invasive species, action is required to restore the system. The first step towards an action plan depends on the identification and mapping of species invasions in Greece.

This general target includes the following specific targets that should be achieved by 2020 (Decision No 40332/2014):

(a) Prevention, early detection and control of the introduction and spread of invasive species.

(b)Taking action to restore the impacts of invasive alien species on biodiversity.

(a) Prevention, early detection and control of the introduction and spread of invasive species

According to Greece's National Biodiversity Strategy and Action Plan, the specific target contains three actions that should be achieved in the period 2014-2018:

(1) Establishing an institutional framework for detecting, preventing entry, controlling or eradicating invasive species, for the restoration of systems affected by these and related mechanism for liability – Preparing for a management plan for invasive alien species including provisions for prevention, early detection, monitoring and remediation depending on the risk category.

(2) Recording invasive species observed in the country (compiling a list of invasive species and classifying them on the basis of their frequency and spatial distribution, the degree of risk to biodiversity, economy and health) – Exploring their mechanisms of entry and monitoring their spread and impacts – Recording potentially invasive species and exploring possible ways of preventing their entry into Greece (controls at plant nurseries and importers for possible points of introduction).

(3) Implementing national programmes for information/public awareness and training the staff of relevant agencies (per region and municipality, customs officials, etc.) on alien and invasive species.

(b) Taking action to restore the impacts of invasive alien species on biodiversity

According to Greece's National Biodiversity Strategy and Action Plan, the specific target contains three actions and these actions should be achieved in the period 2014-2018:

(1) Monitoring and securing the long-term containment of the spread of invasive species (establishing a system for detection, early warning and monitoring of invasive species, with control mechanisms at the points of entry into Greece).

(2) Achieving the restoration of native biodiversity affected by invasive species – Designing and implementing pilot actions to control populations of invasive alien species and habitat restoration.

(3) Ensuring the restoration of disturbed forest environments with native species.

4.3.4 Turkey

This section focuses on legal instrument relevant (direct or indirect) to and can be used for prevention and mitigation of invasive alien species at the national level. The legislation on nature conservation in Turkey has been set to date since the 1950s, however, the environmental policies and institutional structuring has started after the 1972 by United Nation Conference on Human Environment (Stockholm Conference).

Since this institutional structuring, the process of becoming a party to international conventions related to the environment has accelerated.

Biodiversity in Turkey is protected by distinct laws and protected area statuses. Some of these protected areas statuses are based on national legislation, and some are based on international conventions. Despite Turkey has not yet enacted national laws that explicitly state control on invasive alien species, Turkey is part of international and regional conventions on environment and biodiversity protection. The environmental and biodiversity protection agreement to which Turkish is an important party will have legal force, the agreement will be immediately implemented without the obligation to enforce the implementation law and it is considered as part of the national legislation. International treaties for the protection of the environment and biodiversity to which Turkey is a party are listed below (UNEP-MAP-RAC/SPA, 2005; TBA, 2014; Aytemiz, 2015; MERA, 2016; FAO, 2019[a]).

- Paris Convention (1956). International Convention for the Protection of Birds is to protect birds in the wild state, considering that in the interest of science, the protection of nature and the economy of each nation, all birds should as matter of principle be protected (URL-4, 2020; URL-5, 2020);
- Barcelona Convention, 1981: Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its attached protocols, including the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (1976) aims to prevent, abate, combat and to the fullest possible extent eliminate pollution of the Mediterranean Sea Area and to protect and enhance the marine environment in that area so as to contribute towards its sustainable development (URL-6, 2020). The Article 10 of the Convention mandated "The Contracting Parties to take all appropriate measure individually or jointly in order to protect and preserve biological diversity, rare or fragile ecosystems, as well as species of wild fauna and flora which are rare, depleted, threatened or endangered and their habitats, in the area to which this Convention applies" (URL-7, 2020) ;

- Long Range Transboundry Air Pollution Convention (CLRTAP), 1983: The Convention on Long-Range Transboundary Air Pollution is one of the central means for protecting our enviroment It intended to protect the human environment against air pollution and gradually reduce and prevent air pollution, including long-range transboundary air pollution (URL-8, 2020);
- Bonn Convention, 1983: Convention on the Conservation of Migratory Species of Wild Animals (CMS) is an environmental treaty of the United Nations that provides a global platform for the conservation and sustainable use of terrestrial, aquatic and avian migratory animals and their habitats. The Article III of the Convention requests Parties to prevent, reduce and/or strictly control the introduction of exotic species, and to control and/or eliminate those already introduced (URL-9, 2020);
- Convention for the Protection of the World Cultural and Natural Heritage (1983): The Convention defines the kind of natural or cultural sites which can be considered for inscription on the World Heritage List. According to Decision 39 COM/7, paragraph 10 "The World Heritage Committee notes with concern the significant threat posed by invasive alien species to natural World Heritage properties, strongly encourages States Parties to develop adequately resourced strategies to eradicate invasive species in World Heritage properties and prevent their (re-)introduction and/or establishment, and also calls on the international community to support invasive species eradication campaigns in affected properties (WHC, 2015);
- Cooperation Program Cross-border Crossing of Pollutants in Europe (EMEP), 1984: The programme is an instrument for international cost-sharing of a monitoring programme which forms the backbone for review and assessment for relevant air pollution in Europe in the light of agreements on emisson reduction (URL-10, 2020);
- Bern Conservation, 1984: The Conservation of European Wildlife and Natural Habitats is an international treaty in the field of nature conservation, covering most of the natural heritage of the European continent, and extending to some

states of Africa. The treaty aims to protect both species and habitats and to bring countries together to decide how to act on nature conservation. In the period of 2016-2017, the Convention focused most of its work and adopted new standards om conservation s issues including spread of invasive alien species. In the Article 11(2) B, the Bern Convention dictates that he introduction of alien species must be strictly controlled. The definitions of alien species, invasive alien species and introduction are further clarified in a recommendation by the Standing Committee (Portegies, 2017; COE, 2018)

- Vienna Convention, 1990: The aims of the convention is to protect human health and the environment against adverse effect resulting from modification of the ozone layer (URL-11, 2020);
- The Montreal Protocol, 1990: The international agreement designed to stop the production and import of ozone depleting substance and reduce their concentration in the atmosphere to help protect the Earth's ozone layer (URL-12, 2020);
- MARPOL, 73/78; 1990: International Convention for the Prevention of Pollution from Ships adopted by International Maritime Organization (IMO) provides regulation in several technical Annexes aimed at preventing and minimizing pollution from ships also the transfer of invasive aquatic species through the discharge of ballast water (URL-13, 2020);
- Basel Convention, 1994: Convention on the Control of Transboundary Transport and Disposal of hazrdous Wastes is an international treaty aims to protect human health and th environment against the adverse effect of hazardous waste. It was designed to reduce the movements of hazardous waste from developed to less developed countries (URL-14, 2020);
- RAMSAR, 1994: The Convention on Wetlands of International Importance especially as Waterfowl Habitat is an intergovernmental treaty that provides a set of general instructions and guidelines on conservation and wise use of wetlands and their resources for national action and international cooperation. The Contracting Parties adopted two resolutions (Resolution VII.14 1999 and

Resolution VII.18 2002) both dealing with the issue of invasive alien species and calling upon the Contracting Parties to address the environmental, economic and social impact of invasive alien species in wetlands within their jurisdictions (Batanjski et al., 2015).

Ramsar Convention entered into force in Turkey on 13 November 1994. Turkey currently has 14 sites designated as Wetlands of International Importance (Ramsar Sites), with a surface area of 184,487 hectares (Table 12).

Table 12. Sites protected under Ramsar Convention

Name of the Ramsar site	Province	Designation date	Ramsar area (ha)
Kızılırmak Delta	Samsun	15.04.1998	21,700
Lake Seyfe	Kırşehir	13.07.1994	10,700
Lake Kuyucuk	Kars	28.08.2009	416
Sultan Marshes	Kayseri	13.07.1994	17,200
Meke Maar	Konya	21.07.2005	202
Nemrut Caldera	Bitlis	17.04.2013	4,589
Kızören Obrouk	Konya	02.05.2006	127
Lake Burdur	Burdur	13.07.1994	24,800
Lake Kus (Manyas)	Balıkesir	13.07.1994	15,000
Lake Uluabat	Bursa	12.06.1998	19,900
Yumurtalık Lagoons	Adana	21.07.2005	19,853
Akyatan Lagoon	Adana	15.04.1998	14,700
Gediz Delta	İzmir	15.04.1998	14,900

- Bucharest Convention, 1994: The Convention on the Protection of the Black Sea against Pollution was signed in Bucharest and ratified by all six legislative assembles of the Black Sea countries in the beginning of 1994. It is the basic legal framework for regional cooperation to protect the coastal and marine environment. More specifically the Convention focus on the control of land-based source of pollution, dumping waste and joint action in the case of accidents (such as (oil spills) (URL-15, 2020). The Strategic Action Plan was revised in April 2009 by all member states, which reconfirmed their commitment o the protection of the

Black Sea ecosystem and introduction of alien species was one of the concern issues;

- ACCOBAMS, 1996: Cetaceans of the Black Sea and Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) is a legal conservation tool based on cooperation aims to reduce threats to cetaceans notably by improving current knowledge on these animals (URL-16, 2020) ;
- CITES, 1996: Convention on International Trade in Endangered Species of Wild Fauna and Flora is an international agreement between governments. It aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. The Convention considering that alien species can pose significant threats to biodiversity, and that species of fauna and flora in commercial trade are likely to be introducing to new habitat as a result of international trade. The Conference of the Parties to the Convention adopted Decision 10.54, 10.76 and 10.86 regarding trade in alien species and directed to the Parties and to the Animal Committee (AC) respectively (CITES, 2004)
- FAO, 1996: Precautionary approach to capture fisheries and species introduction contains detailed guidelines on how to conduct fishery management and research and how to develop and transfer fishery technology in a context of uncertainty and responsibility fisheries. Guidelines are also provided on species introduction, voluntary or accidental (including through ballast water and sediment discharge), recognizing the difficulty of ensuring a precautionary approach in relation to that issue (URL-17, 2020);
- Rio de Janeiro, 1997: United Nation Convention on Biological Diversity (CBD; Rio de Janeiro, 1997) and its subsidiary program called “Jakarta Mandate on Marine and Coastal Biodiversity” (1995; work program 1998) and Cartagena Protocol on Biosafety (2004) are international legal instruments concerns on the protection, management and sustainable use of the biodiversity in general, which has been ratified by 196 nations. It is addressed relevant issues in the environment including the impact of alien species. The CBD has identified IAS as a major cross-cutting theme. Article 8(h) of the CBD states that “each

contracting Party shall, as far as possible and as appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". The CBD sets priorities, guidelines, collects information and helps to coordinate international action on invasive alien species. The CBD has adopted guidance on prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species, which can be accessed on the CBD website. The website also provides further information on invasive species and relevant decision of the Conference of the Parties to the CBD (Genovasi & Shine, 2004; URL-18, 2020).

- UN-CCD,1998: United Nation Convention to Combat Desertification (CCD; Bonn, 1998) is a legal framework to combat desertification and land management issues. The convention addressed invasive plant and animal species as potential causes of land degradation can disrupt the ecosystems, crowding out and/or destroying native and endemic species (UN, 2020);
- IUCN Guidelines, 2000: The guidelines for the prevention of biodiversity loss caused by invasive alien species (2000) is a guidelines aims to prevent further losses of biological diversity due to the deleterious effects of alien invasive species. (UN, 202);
- European Landscape Convention,2001: of the Council of Europe promotes the protection, management and panning of the landscapes and organizes international co-operation on landscape issues. (URL-19, 2020);
- Protocol for the Prevention of Pollution Arising from Cross-Border Movements and Disposal of Hazardous Wastes in the Mediterranean, İzmir 2003: The protocol objectives to set out measures to control transboundary movements of hazardous wastes in the Mediterranean with a view to the protection of its environment (URL-20, 2020);
- United Nation Framework Convention on Climate Change, 2004: The convention is one of the three Rio Conventions, the UNFCCC's ultimate objective is to achieve the stabilization of greenhouse gas concentration in the atmosphere at

a level that would prevent dangerous interference with the climate system (URL-21, 2020);

- The Black Sea Biodiversity and Landscape Conservation Protocol (2004): The aim of the protocol is to maintain the Black Sea ecosystem in the good of ecological state and its landscape in the favorable conditions, to protect, to preserve and to sustainably manage the biological and landscape diversity of the Black Sea in order to enrich the biological resources.(URL-22, 2020) ;
- (BWM; London, 2004): Ballast Water Management Convention (BWM) aims to prevent the spread of harmful aquatic organisms from one region to another and halt damage to the marine environment from ballast water discharge, by minimizing the uptake and subsequent discharge of sediment and organisms. The BWM Convention requirements entered into force in September 2017 to ship to have been required to manage their ballast water to avoid the transfer of potentially invasive aquatic species. All ships must have a-ship-specific ballast water management plan and keep a ballast water record book (URL-23, 2020).
- ICES, 2005: Code of Practice on the Introduction and Transfer of Marine Organisms sets forth recommendation procedures and practices to diminish the risks of detrimental effects from the international introduction and transfer of marine (including brackish water) organisms. The Invasive Alien Species defined as "such animals and plants that are not native to these new locations are defined as species transported intentionally or accidentally by a human-mediator vector into aquatic habitats outside their native range, including secondary introductions by human-mediated or natural vectors (ICES, 2005).
- IPPC,1951: The International Plant protection Convention in a plant health treaty signed by over 180 countries aims to protect biodiversity and the environment. IPCC, (2007) protects plant resources from pests without setting up unnecessary barriers to trade and transport;
- PGRFA 2006: International Treaty on Plant Genetic Resource for Food and Agriculture (PGRFA) aims to conserve and sustainable use of all plant genetic resources for food and agriculture and the fair and equitable sharing of the

benefits arising out of their use. Invasive alien species have also deemed a threat to PGRFA (FAO, 2012; FAO, 2019[b]);

- Kyoto Protocol to the UN Framework Convention on Climate Change,2009: It is an international treaty which extends the 1992 United Nation Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that (part one) global warming is occurring and (part two ;
- Liaison Group on Biodiversity Convention,(BLG) 2017: It is a join forces meeting on FAO Headquarters on 28-29 September 2017 of eight biodiversity-related Convention in support global biodiversity and sustainable development goals. In the period up to 2020 the Strategic Plan for Biodiversity 2011-2020, and in particular Aichi Target 9, will provide the main focus of the work of this group to support measures to prevent the introduction and mitigate the impact of invasive alien species (URL-24, 2020).

Turkey participated in the convention is explained as a substantial indicator of its great importance on environmental issues. Moreover, it is announced as Turkey showing awareness about environment and biodiversity issues and its interest in distant-geographic scientific cooperation.

In order to protect the natural environment, Turkey set up Strategic Planning as a fundamental tool for public administrations to ensure that planned service delivery, policy development based on the determined policies, action plans, programs and budgets, and effectively monitoring and evaluating the implementation. Turkish National Strategic, Plans and Programs on Environment:

- National Environmental Action Plan (1998);
- National Plan for On-Site Conservation of Plant Genetic Diversity (1998);
- National Biological Diversity Strategy and Action Plan (2001);
- National Agenda 21 Program (2001);
- National Wetland Strategy (2003);

- Turkey's National Forestry Program (2004);
- National Science and Technology Policies 2003-2023 Strategy Document (2004);
- National Action Program on Combating Desertification Turkey (2005)
- National Environmental Strategy (2006);
- Natural Rural Development (2006).

The first official nature conservation in Turkey began with the Declaration of Istanbul Belgrade Forest as "Conservation Forest" in 1951 (Teksöz et al., 2014). The first legal development took place with the 4th and the 25th Articles of the Forest law dated 31st August 1956 and numbered 6831 and the introduction of the term "National Park" into the Turkish legislation. In the 4th Article of the Law states that forest are classified as Conservation Forests, National Parks, and Industrial Forests in terms of qualification and character (Yücel, 2005). Later, National Parks were separated from the Forest Law with the implementation of the National Park Law No 2873 dated 9 August 1983 and the National Parks Regulation dated 12 December 1986 (Yeşil, 2016).

Policy on nature and biodiversity protection in Turkey are consists of Environmental Law No 2872, National Park Law No 2873, Forest law No 6831, Cultural and Natural Properties Protection Law No 2863, Land Hunting Law No 4915, and Special Environmental Protection Decree Law No 383. These Laws provide the legal basis of Natural Conservation and Biodiversity Policy in Turkey.

Laws and regulations for species and site protection in Turkey are as follows:

1. Forest Law (6831 – September 8th 1956);
2. Aquaculture Law (1380 – April 4th 1971);
3. Law on the Protection of Cultural and Natural Properties (2863 – July 23rd 1983);
4. Environmental Law (2872 – August 11th 1983);
5. National Parks Law (2873 – August 11th 1983);
6. Anti-Smuggling Law (1986);

7. Decree on the Establishment of the Special Environmental Protection Agency (383 – October 19th 1989);
8. Convention on water areas of International importance as the living environment of especially water birds (21937 – May 17th 1994);
9. Land Hunting Law (4915 – July 1st 2003);
10. Law on the Organization and Duties of the Ministry of Environment and Forestry (2003);
11. Animal Health and Police Law (2004);
12. Animal protection Law (5199 – June 24th 2004);
13. The Law Regarding the Approval of the Protocol on the Conservation of Biological Diversity and Landscape in the Black Sea to the Convention on the Protection of the Black Sea Against Pollution (2004);
14. Law Amending the Environmental law (2006);
15. Implementation of the Convention on the International Trade in Endangered Species of Wild Animals and Plants Regulations (CITES);
16. By-Law on the Protection of Wetlands;
17. Regulation on the Removal, Production and Export of Natural Flower Bulbs;
18. Beekeeping Regulation;
19. National Parks Regulation.

The protected areas of Turkey include natural ecosystems ranging from deep valleys and canyons to glaciers, from deltas to forests and highlands of Black Sea, from seas to coasts to Mount Agri, from steppes to lakes and streams (Küçükosmanoğlu et al., 2019)

While the regulations for the protection of species and areas also serve to protect genetic resources, there are also regulations made by the Ministry of Food, Agriculture and Livestock for the protection of genetic resources directly. These:

1. Regulation on the Collection, Preservation and Use of Plant;
2. Regulation on Conservation of Animal Gene Resources;

3. The Convention for the conservation of the world cultural and natural heritage (17959 – February 14th 1983);
4. Decree Law on Protection of Patent Rights (1995);
5. The Convention on International trade of wild plants and animal species that are in danger (22672 – June 20th 1996);
6. The Convention on Biological Diversity (22860 – December 27th 1996);
7. UN Convention to Combating Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly Africa (23344 – May 16th 1998);
8. Customs Law (1999);
9. Animal Breeding law (4631 – February 28th 2001);
10. Law on the Approval of the Cartagena Biosafety Protocol of the Convention on Biological Diversity (2003);
11. Law on the Protection of Breeders Right Regarding New Plant varieties (5042 – January 8th 2004);
12. Seeding Law (5553 – October 31st 2006);
13. The UN Framework Convention on Climate Change (The Kyoto Protocol) (27227 – May 13th 2009).

The laws and regulation regarding to sustainable use of biological diversity and regulation on the management of resources used are as follows:

1. Forest law (6831 – June 31st 1956);
2. Plant Protection and Agricultural Quarantine Law (1957);
3. Coastal Law (3621 / 3830 – April 4th 1990);
4. National Afforestation and Erosion Control Mobilization Law (4122 – July 23rd 1995) and Afforestation Regulation;
5. Pasture Law (4342 – February 1998) and Rangeland Regulation;
6. Organic Agriculture Law (2004);
7. Organic Agricultural Law (5262 – December 1st 2004);
8. Soil Conservation and Land Use Law (5403 – July 3rd 2005);
9. Agricultural Law (5488 – April 18th 2006);

10. Regulation on Conservation and Use of Agricultural Lands (5403 – June 29th 2009);
11. Regulation on Good Agricultural Practices (27778 – December 7th 2010);

The Draft law on conservation of nature and Biological Diversity has been prepared and aimed to be soon enacted (MERA, 2016).

4.3.5 Georgia

Legislative portal: www.matsne.gov.ge

1. The Convention on Biological Diversity (ratified by Resolution No 471 of the Parliament of Georgia, 21 April 1994);

2. United Nations Framework Convention on Climate Change (enacted in Georgia by the Cabinet of Ministers on 16 May 1996);

3. The Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1997) (ratified by Resolution No 136 of the Parliament of Georgia, 11 February 2000);

4. Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) of the Bonn Convention (ratified by Resolution No 768 of the Parliament of Georgia of 2 March 2001);

5. Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contigous Atlantic Area (ACCOBAMS), (ratified by Resolution No 769 of the Parliament of Georgia, 2 March 2001);

6. Agreement on the Conservation of Populations of European Bats of the Bonn (ratified by Resolution No 1202 of the Parliament of Georgia, 21 December 2001);

7. The Convention on Wetlands of International Importance, especially as Waterfowl Habitat (RAMSAR) (ratified by Resolution No 201 of the Parliament of Georgia, 30 April 1996);

8. The Convention on the Conservation of European Wildlife and Natural Habitats (Berne, 1979) (ratified by Resolution No 940 of the Parliament of Georgia, 30 December 2008);

9. The European Landscape Convention (2000) (Order of the President of Georgia #39, 9 June 2010);

10. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), (ratified by the Parliament of Georgia on 12 August 1996);

11. Law of Georgia “On Environmental Protection” (1996);

12. Law of Georgia “On the System of Protected Areas” (1996);

13. Law of Georgia “On Wild Fauna” (1996);

14. Law of Georgia “On Water” (1999);

15. The Forest Code of Georgia (1999);

16. Law of Georgia “On the Red List and Red Data Book of Georgia” (2003);

17. The Law of Georgia “On Fees for Natural Resource Use” (2004);

18. The Law of Georgia “On Licenses and Permits” (2004);

19. Law of Georgia “On the Basis of Spatial Organization and Urban Planning” (2005);

20. Law of Georgia “On the Permits for Impact on Environment” (2007);

21. Law of Georgia “On Ecological Expertise” (2007);

22. Law of Georgia “On the Management of the Forest Fund” (2010);

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Turkey

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For the literature survey of invasive alien species (IAS) in the Turkish Black Sea coastal area specif attention to Kızılırmak Deltaic area (if available data present) many specific titles are investigated, discussed and listed. These are;

1. The name of the Invasive alien species distribution along the Turkish Black Sea area and Kızılırmak Deltaic area
2. Although Turkey is not responsible to forest area species, such as trees, pets and other plants, literature survey was done for the background knowledge to the IASON project.
3. Strategies of Turkey for the managing IAS distribution were discussed. Turkey has no natural protected area in the sea but has some Special Protected Areas for protecting natural reserves in the coastal and sea area. The neccessities and importance of the protected areas may be explained to decision makers and folks with the IASON project.
4. Turkey is a party of many international convention and agreement and their requrements and actions are part of the national legislation. However the invasion of the IAS could not be stopped or diminished. The reason and new actions will be discussed under the IASON project.

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