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Deliberate and unintentional introduction of invasive weeds: A case study of the alien flora of Ukraine

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Summary

Based on the analysis of invasions of alien plants in Ukraine, the impact of non-native plant species upon the native flora and adverse consequences of their spread are assessed. A case study gives examples of the role of alien plants in fragmentation of populations of native species; contamination of genetic resources of rare and endangered native species, formation of new ecotypes and hybridization with native taxa, disruption of the structure of natural plant communities as a result of introduction of alien species and formation of specific plant communities with domination of aliens. Arguments are provided against uncontrolled casual introductions and subsequent escape from cultivation as a result of ill-judged deliberate introduction of plants for ornamental, agricultural, technical, forestry, and other uses without any preliminary assessment of their invasion potential in the region concerned. Invasions of alien plants promote dramatic changes in the taxonomic, geographical, and ecological patterns of local floras, disruptions in the phytosociological spectrum, spectra of biomorphs, deterioration of zonal peculiarities of the flora, and finally lead to the decline of the vegetation productivity. A list of highly invasive plant species threatening forest, steppe, and submediterranean zones of East Europe is provided.

Introduction

By the end of the 20th century, the invasions of non-native (alien, introduced, adventive) organisms, including plants, were widely realized as one of the major global threats to biodiversity (Baldacchino & Pizzuto, 1996; Chornesky & Randall, 2003; Cronn & Wendel, 2003; Davis, 2003; Ellstrand & Schierenbeck, 2000; Garnatje et al., 2002; Goodwin et al., 1999; Kowarik, 2002; Mooney & Cleland, 2001; Pemberton, 2000; Protopopova et al., 2002; Pyšék, 2001; Pyšék et al., 1999, 2004; Reichard & White, 2001, 2003; Sakai et al., 2001; Sax & Gaines, 2003). Scientists from various countries accumulated much data proving the negative economic and ecological consequences of invasions of some of the most aggressive species, and also the cumulative influence of alien plants on the stability and viability of ecosystems that once consisted mostly of native species. It has been revealed that at present the basic sources of the influx of alien plants are (1) their deliberate introduction, which is frequently ill-judged and spontaneous and (2) socioeconomic development and growing connections through world trade and globalization, promoting a large-scale and chiefly uncontrolled transfer of diaspores (basic migration and dissemination units) of plants. It has been also proved that in many cases the quantitative and qualitative diversity of ecosystems (especially islands and fragmented ones) is unable to resist invasions (cf. Fritts & Rodda, 1998; Sax et al., 2002; Sax & Gaines, 2003). The areas profoundly transformed by human activities are constantly growing; trade, transportation, communications, and migrations of human populations in various countries and regions have also achieved the greatest scope known in human history. Now, with further development of agriculture, forestry and horticulture, various plants and their propagules are becoming increasingly available through global, regional and local trading networks.

International trade in plants and seeds of species used for agricultural, horticultural, ornamental, and forestry purposes is rapidly expanding, involving more and more countries, using the opportunities provided by the Internet and booming globalization. This process, which reflects the natural desire to improve human nutrition and health and to satisfy both basic vital needs and aesthetic feelings, is deeply rooted in human nature, and thus the trend cannot be reversed. Deliberately or unintentionally, new species will be introduced to new areas, often quite distant from their original ranges. One task of scientists is to provide extensive and precise data on those species which can be dangerous for native taxa and their habitats, local biological and ecosystemic processes, and sustainable economic activities (Brock et al., 1997; McKnight, 1993; Pyšék et al., 1995; Sandlund et al., 1996; Yano et al., 1997). Scientists should also provide reasonable forecast scenarios and assessments of possibilities of expansions of alien plants in their secondary (synanthropic) ranges to determine the regions favorable for their survival and subsequent spread. Consequently, we need reliable approaches to prediction of plant invasions (Goodwin et al., 1999; Higgins & Richardson, 1999; Müller-Schärer & Steinger, 2004). Through such scientific studies, it will be possible to develop uniform strict measures of, and approaches to, the control of introduction of the most dangerous non-native species, and to develop a system for constant monitoring of invasions of unintentionally introduced species. Prime examples and the discussion of the problem of intentional introduction of species, with many relevant references, are provided in recent literature (Ewel et al., 1999; Sakai et al., 2001).

The location of Ukraine in the center of Europe, the presence in the country of several natural physiographic zones (Forest, Forest-steppe, Steppe, and submediterranean zones) and diverse landscapes, complex historical conditions and the present economic situation, and other factors make Ukraine a good model for studying invasions of non-native plants and for estimating their influence on natural ecosystems. Published data on the alien flora of Ukraine expand considerably the opportunities for a comparative analysis of plant invasions in Europe. The problem of "floristic pollution" is extremely important and topical in Ukraine. The flora and vegetation of the country has been profoundly changed by humans, which exposes it to further invasions of alien plants.

Position of Ukraine

The area of Ukraine is 603.7 thousand km^2 with a population of ~49 million people. In most of the country the climate is temperate-continental, becoming more continental to the east of the Dnipro (Dnieper) River. Only on the South Coast of Crimea do subtropical features appear. The anthropically transformed territories constitute 80% of the total area of the country.

The 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. Kenophytes, or plants that arrived to the territory after the 16th century (82%), and archaeophytes that presumably immigrated before the 16th century (18%) represent a modern structure of the alien flora of Ukraine. The majority of alien species, according to their predominant life form and ecological characteristics, are annuals, therophytes, heliophytes, and xeromesophytes. Mediterranean (in a broad sense) and American species prevail among the groups selected by the area of origin, and epoecophytes are the dominant group by the degree of naturalization. The overwhelming majority of species (72%) represent unintentional introduction, one-third of species (28%) have been intentionally introduced as ornamental, medicinal, agricultural, forestry and other plants, and then escaped and naturalized.

Results

The cumulative influence of the whole set of alien species of plants, especially invasive species, and the consequences of their expansions and invasions, have caused adverse changes at population, specific, coenotic (community) and ecosystem levels. Changes caused by plant invasions in Ukraine are much deeper than the simple quantitative accumulation of additional species. Invasions promote changes in basic floristic proportions, especially taxonomic, geographical, ecological and other spectra originally typical for the local flora; they also affect the phytocoenotic spectrum, the spectra of biogroups and life forms. Thus, the zonal features of a flora are usually weakened, and the productivity of the vegetation is lowered (Burda, 1991; Protopopova, 1991). At the same time, xeric features of the flora are usually strengthened, not only because of an increase in the number of the species that originated in arid areas of the globe, but also because these species are one of the causes promoting the suppression of many native species and preventing their restoration.

These processes do not develop chaotically, but instead follow a certain pattern. Alien species become parts of processes in ecosystems, as it is evident from the peculiarities of their dispersal and naturalization. For example, the number of species of alien plants usually increases in the northern direction, and the number of local weeds (apophytes) grows in the southern direction, at least in temperate latitudes. The ratio of archaeophytes and kenophytes in the zonal synanthropic floras of Ukraine is also characterized by certain regularities (Table 1); the ratio between stable (completely naturalized) and unstable groups of alien species in all regions are characterized by the constant value (Protopopova, 1984, 1991).

Based on the analysis of formation and development of the alien flora in Ukraine and its influence upon the native flora for the last 150 years, we estimate the spread of alien plants as an important threat to Ukraine's biological diversity, national economy and human health (Protopopova et al., 2002, 2003). This opinion is supported by the following considerations.

Data from studies of alien plants during this period testify that the process of adventization of Ukraine's flora was constantly progressing. Tendencies of an increase in the number of alien species are clearly demonstrated, as well as the growth of both the stable component of the alien flora (i.e. species with high degrees of naturalization, agriophytes and epoecophytes), and the unstable component (ergasiophytes and ephemerophytes) (Figure 1). In addition, immigration and dispersal rates, the number and scope of invasions of certain invasive species also occur (Figure 1). Species composition, especially that of the unstable component (ergasiophytes and ephemerophytes) becomes more and more diverse in terms of the origin patterns. This probably means that conditions for naturalization of alien plants become increasingly favorable due to various factors, such as continuing deterioration of natural habitats, increased international trade and exchange, and even global climate changes. For the last twenty years, immigration of East Asian species to Ukraine considerably increased; for the first time alien species native to Sub-Saharan Africa (*Eleusine indica* (L.) Gaerth, *Sorghum sudanense* (Piper) Stapf) and Australia (*Chenopodium pumilio* R. Br.) were observed (Protopopova, 1991; Mosyakin & Fedoronchuk, 1999). Most likely such tendencies will also be evident in the future.

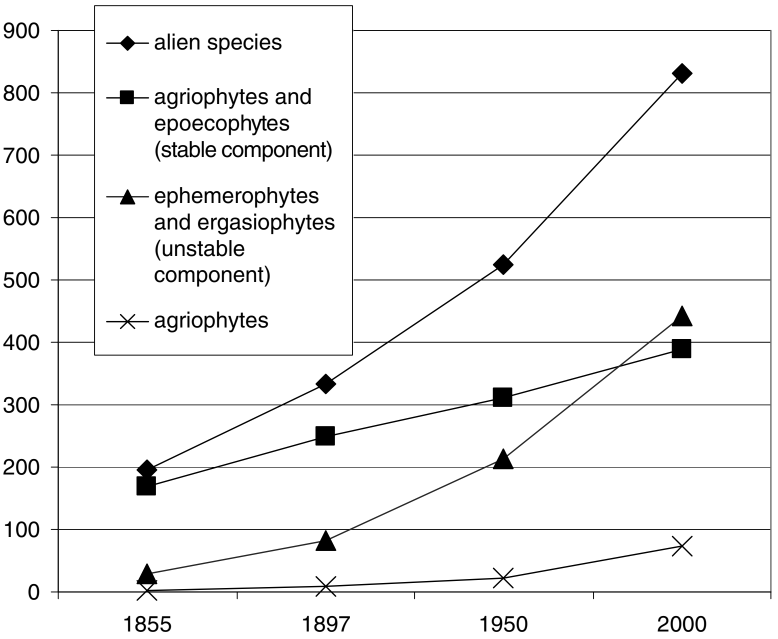
Table 1. Distribution and flora percentages of archaeophytes and kenophytes in different physiographic regions of the Ukraine

Physiographic regions of Ukraine	Archaeophytes (%)	Kenophytes (%)
Carpathians	42.5	57.5
Flatland forest regions	38.5	61.5
Forest-steppe	35.5	65.0
Steppe	31.8	68.2
Crimea	23.0	77.0

Among the alien species of plants, one of the most important groups is species of American origin. According to Protopopova (1986), there are ca. 14.2% of plants of American origin among 646 aliens listed in her work. However, at present these figures are much higher. According to our current estimation, there are at least 160 species of American plants represented in the Ukrainian wild flora (Protopopova, unpublished data). Of course, not all of them can be regarded as completely naturalized. Some of these plants are casual aliens (waifs) that may disappear in the future.

Invasions of American plants in Europe (and in Ukraine in particular) are often accompanied by significant microevolutionary changes (especially in such genera as *Epilobium* L., *Oenothera* L., *Xanthium* L., etc.) and/or dramatic coenotic adaptations (Protopopova, 1991; Rostański et al., 2004; Skvortsov, 1995).

Many American alien plants are now very common components of man-made, semi-natural and natural habitats. In many cases they are also firmly incorporated into the local floras and plant communities. Among the most invasive and successful American aliens, the following taxa should be mentioned: *Acer negundo* L., *Amaranthus powellii* S. Wats., *Ambrosia artemisiifolia* L. (Figure 2), *Amorpha fruticosa* L., *Bidens frondosa* L., *Cenchrus longispinus* (Hack.) Fernald, *Grindelia squarrosa* (Pursh) Dunal., *Quercus*



Note. X-axis – years; Y-axis – number of species.

Figure 1. Dynamics of the number of alien (non-native) species in the flora of Ukraine (1), the species of stable (agriophytes and epoecophytes), (2) and unstable (ephemerophytes and ergasiophytes), (3) components, and agriophytes (4).

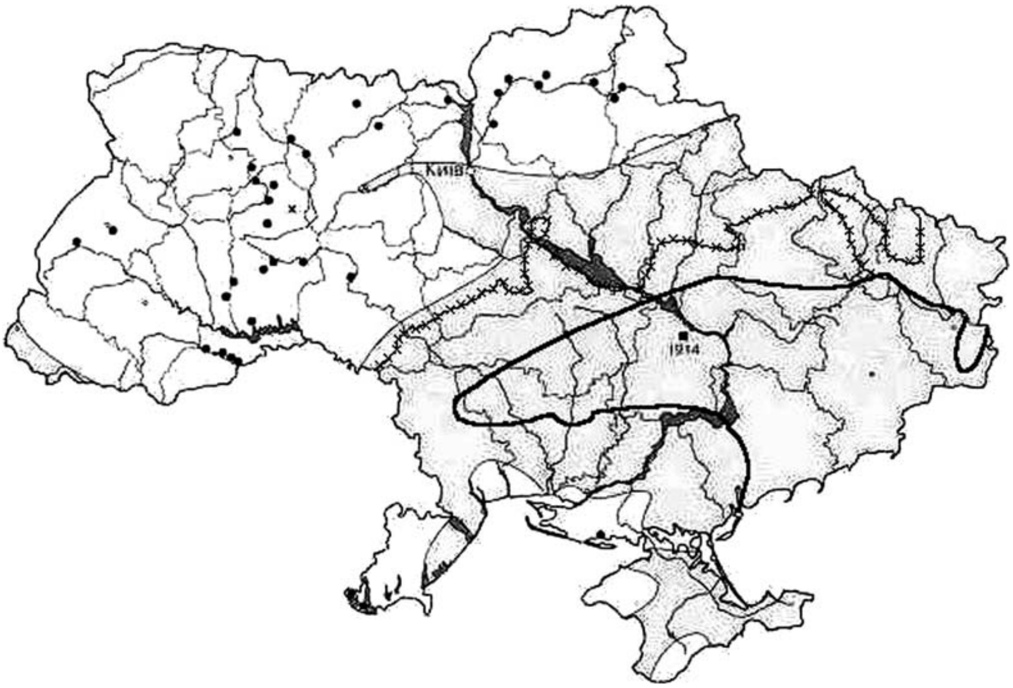


Figure 2. Distribution map of *Ambrosia artemisiifolia* in the Ukraine.

rubra L. (=*Q. borealis* Michx.), *Robinia pseudoacacia* L., etc. As case studies (including those described below) show, these and some other American species should be regarded as invasive taxa threatening native plant communities and species.

Let us consider several case studies involving invasive trees and shrubs, and some herbaceous plants. According to our estimation, ca. 40 species of alien American (almost exclusively North American) plants can be regarded as agriophytes (plants well-established in natural and semi-natural habitats). The group of epoecophytes (plants firmly established mostly in man-made or disturbed habitats) is represented by ca. 50 species. These naturalization categories are approximate, because they could be different for the same species in different regions of Ukraine.

Practically all invasive American trees and shrubs were originally cultivated in Ukraine for ornamental, forestry and other purposes. First introduced into Ukraine in 1804 by V. Karazin, a famous horticulturist, black locust (*Robinia pseudacacia*), a native of eastern North America, has been extensively cultivated in the country as an excellent ornamental and honey plant. It was also much praised for its ability to prevent land erosion. However, it has only recently become recognized as an invasive plant. Black locust is especially dangerous for remnant, vulnerable tiny patches of steppe and meadow-steppe vegetation in the central and southern parts of Ukraine (Forest-Steppe and Steppe physiographic zones). For example, our observations and studies demonstrated that in Kaniv Nature Reserve (Cherkassy Region, central Ukraine) black locust actively penetrates into protected steppe communities on loess slopes, transforming these habitats into dense *Robinia* thickets and dramatically decimating the native biological diversity (plants, fungi, insects, other invertebrates, etc.). Similar situations occur at many other sites and areas in Ukraine.

Another American alien, *Amorpha fruticosa* (known in cultivation in Ukraine since the first half of the 19th century), is extremely invasive in riparian and alluvial habitats of the valleys of large rivers, especially the Dnipro. In such habitats *A. fruticosa* outcompetes local shrubs (especially native species of *Salix* L.). It also often occurs along forest margins, in forest shelter belts, along railroads, etc.

Cultivated in Ukraine as an ornamental and forestry tree since the 1850s, northern red oak (*Quercus rubra*, [=*Q. borealis*]) is quite common in many regions of Ukraine. In some areas it is known as escaped and/or completely naturalized, penetrating into the natural forest plant communities. It is especially aggressive in the broad-leaved and mixed forests and parks of the "Green Belt" of Kyiv, strongly outcompeting native tree species (such as the native pedunculate oak, maples, and even hornbeam) and completely changing the structure of native plant communities. Other North American taxa of *Quercus* L. (ca. 15 species) are cultivated mostly in botanical gardens and parks and are not known to be invasive. However, *Q. palustris* Moench has also occasionally escaped.

The threat posed by these and some other (*Acer negundo*, *Fraxinus pennsylvanica* March., *Padus serotina* (Ehrh.) Agardh [=*Prunus serotina* Ehrh.]) quite common cultivated non-native plants was underestimated, and has been realized only recently. Unfortunately, at present we do not have any programs aimed at effective control of these invasives in natural and semi-natural habitats of Ukraine.

Extensive invasions of trees and shrubs (especially *Elaeagnus angustifolia* L., *Amorpha fruticosa*, *Ailanthus altissima* (Mill.) Swingle and some other taxa) are registered and monitored in the Black Sea area. Such species are especially noxious in alluvial habitats along large rivers of the southern part of Ukraine. *Bupleurum fruticosum* L. is an important invader of submediterranean habitats in Crimea, especially along its South Coast on rocky slopes and along roads. The species is completely naturalized and aggressive, especially in juniper and juniper-pistachio forests previously dominated by *Juniperus* spp., *Arbutus andrachne* L., *Quercus pubescens* Willd., and *Pistacia mutica* Fisch. et Mey.

Expansions of alien plants (*Helianthus* spp., *Echinocystis lobata* [Mixch.] Torr. et A. Gray, *Impatiens glandulifera* Royle, *Heracleum mantegazzianum* Sommier et Levier (Figure 3), *Reynoutria japonica* Houtt.) are observed in the Transcarpathian river basins and in riparian habitats of western Ukraine. The degree of spread of these species in Transcarpathia seems to be narrower than in West Europe, but the increase in the rate of spontaneous distribution, numerous and stable populations testify to the start of expansion of these species in Transcarpathia. The tendency of expansion of these neophyte species eastward has been observed (Protopopova & Shevera, 1998, 2005).

Sandbur (*Cenchrus longispinus*) is a good example of a large-scale invasion of an alien North American herbaceous species in Ukraine (Mosyakin, 1995). It was accidentally introduced into Ukraine in the first half of the 20th century. It was first reported for Ukraine in 1951 (as "*C. tribuloides* L.") by D. Larionov, from

A

B

C

Table 2. Rates of synanthropization, modernization, and instability of the alien flora of the Ukraine

Time period	Percent of adventhization of flora (%)	Index S[a]	Index M[b]	Index I[c]
Second half of the 19th century	6	249	0.5	85
First half of the 20th century	10	312	1.0	213
Second half of the 20th century	14	389	1.5	412

[a]S (index of synanthropization) = archaeophytes + agriophytes.
[b]M (index of modernization of flora) = (number of agriophytes + number of epoecophytes which immigrated aft er the 15th century)/number of archaeophytes.
[c]I (index of instability of synanthropized flora) = (number of non-naturalized, unstable aliens, ephemerophytes + ergasiophytes).

Kherson Region (southern Ukraine). Now it is a quite common and aggressive weed in sandy habitats in southern Ukraine, where it is known from Kherson, Mykolayiv, Odesa (Odessa), and Donetsk regions, and from Crimea. It is also rapidly spreading in the Kyiv (Kiev) area (northern central Ukraine), along the sands of the Dnipro, and in ruderal habitats within the city. Sandbur is officially recognized in Ukraine as a noxious quarantine weed extremely dangerous for agriculture, livestock, and native plant communities. In particular, sandbur replaces local plants and alters native vegetation patterns in vast sandy areas of the Lower Dnipro, including unique sand steppes and alluvial habitats of Black Sea (Chornomorsky) Nature Reserve. All attempts of the state phytoquarantine officials to control the species have been unsuccessful so far.

Other examples of invasive American grasses now actively spreading in Ukraine are *Echinochloa microstachya* (Wieg.) Rydb. (= *E. muricata* [P.Beauv.] Fern. var. *microstachya* Wieg.), *Eragrostis pectinacea* [Michx.] Nees (which seems to out-compete the native species *E. pilosa*), *Hordeum jubatum* L. (spreading mostly along railroads), *Panicum capillare* L. and *P. dichotomiflorum* Michx. (Bortnyak et al., 1992; Mosyakin, 1991, 1996). Such adverse consequences of flora's adventization are predominantly evident in changes of the structure of the flora, its floristic complexes and plant communities, in the influence of some species on ecosystems.

The analysis of plant invasions (phytoinvasions) in Ukraine during the period of 1855–2000 allowed us to calculate the indexes describing a degree of synanthropization (S, the total number of naturalized aliens, archaeophytes + agriophytes), modernization (M, the number of agriophytes + epoecophytes that immigrated after the 15th century divided by the number of archaeophytes) and instability (I, the number of non-naturalized, unstable aliens, ephemerophytes + ergasiophytes) of floras. These indexes were proposed by J. Kornaś (1968); they show dynamics of the process of adventization of floras during different periods (Table 2). Their application provides reliable means for comparison of alien components of floras in various regions, cities and towns, etc. Our analysis of plant invasions in Ukraine from 1850 to 2001 demonstrated the increase of the number of alien species participating in plant invasions. The percentage of alien species in the total flora for 150 years changed from 3% in 1855 to 6% in 1900, 10% in 1950, and 14% in 2002. Other indexes changed in the following mode: in 1855 – S = 168, M = 0.29, I = 28; in 1900 – S = 249, M = 1,6, I = 85; in 1950 – S = 312, M = 2,0, I = 213; and in 2001 – S = 389, M = 2,6, I = 429 (Protopopova & Shevera, 1999; Protopopova et al., 2002). During the period analyzed, the naturalization parameters for most species remained stable. Most of the species (43%) were considered naturalized in man-made (anthropic) habitats. A few species (1%), mainly agriophytes, were components of both semi-natural and natural habitats. A cumulative list of the highly invasive plant species threatening forest, steppe, and submediterranean zones of Ukraine in Eastern Europe is provided (Table 3).

Our analysis (Table 4) of the above indexes showed that the synanthropization level (S) was highest in Crimea and the Forest-Steppe zone and lowest in the

Figure 3. (A) A monodominant community of *Xanthium albinum* in riverbank habitats in Mykolayiv Region. (Photo credit: O. Korniyenko); (B) *Elaeagnus angustifolia* penetrating steppe habitats in Kherson Region. Photo by M. Shevera, and (C) *Echinocystis lobata* in ruderal habitat in Male Polissya (Khmelnytsky Region). Photo by L. Gubar'

Table 3. A list of the highly invasive plant species threatening forest, steppe, and submediterranean zones of the Ukraine

Species	Origin	Category
Archaeophytes: (29 species)		
Acorus calamus L.	South and South-Eastern Asian	Agriophyte
Anisantha tectorum (L.) Nevski	Mediterranean-East Asian	Epoecophyte
Artemisia absinthium L.	Irano-Turanian	Epoecophyte
Atriplex sagittata Borkh.	Irano-Turanian	Epoecophyte
Ballota nigra L. s.l.	Mediterranean-Irano-Turanian	Epoecophyte
Brassica campestris L.	Central Asian	Epoecophyte
Capsella bursa-pastoris (L.) Medic.	Unknown	Epoecophyte
Carduus acanthoides L.	Mediterranean	Epoecophyte
Conium maculatum L.	Mediterranean-Irano-Turanian	Epoecophyte
Descurania sophia (L.) Webb. ex Prantl.	Irano-Turanian	Epoecophyte
Echinochloa crus-galli (L.) P Beauv.	Asian	Epoecophyte
Galeopsis ladanum L.	Mediterranean	Epoecophyte
Geranium dissectum L.	Mediterranean	Epoecophyte
Hordeum murinum L.	Mediterranean-Irano-Turanian	Epoecophyte
Lepidium ruderale L.	Irano-Turanian	Epoecophyte
Lycium barbaratum L.	East Asian	Epoecophyte
Malva neglecta Wallr.	Irano-Turanian	Epoecophyte
Malva pusilla Smith	Resistant species	Epoecophyte
Papaver rhoeas L.	Mediterranean-Irano-Turanian	Epoecophyte
Portulaca oleracea L.	Irano-Turanian	Epoecophyte
Raphanus raphanistrum L.	Mediterranean	Epoecophyte
Senecio vulgaris L.	Asian	Epoecophyte
Setaria glauca (L.) P. Beauv.	Indo-Malaysian	Epoecophyte
Sinapsis arvensis L.	Mediterranean-Atlantic	Epoecophyte
Sonchus arvensis L.	Mediterranean	Epoecophyte
Sonchus asper (L.) Hill	Mediterranean	Epoecophyte
Sonchus oleraceus L.	Mediterranean	Epoecophyte
Tripleurospermum inodorum (L.) Sch. Bip.	West Asian	Epoecophyte
Vicia villosa Roth	Mediterranean	Hemiepoecophyte
Kenophytes (65 sp.):		
Acer negundo L.	North American	Agriophyte
Acroptilon repens (L.) DC.	West Asian	Epoecophyte
Ailanthus altissima (Mill.) Swingle	Mediterranean	Epoecophyte
Amaranthus albus L.	North American	Epoecophyte
Amaranthus blitoides S. Watson	North American	Epoecophyte
Amaranthus powellii S. Watson	North America	Epoecophyte
Amaranthus retroflexus L.	North American	Epoecophyte
Ambrosia artemisiifolia L.	North American	Epoecophyte
Amorpha fruticosa L.	North American	Ergasiophytes
Artemisia annua L.	East Asian	Epoecophyte
Asclepias syriaca L.	North American	Epoecophyte
Azolla caroliniana Willd.	North American	Agriophyte
Azolla filiculoides Lam.	South American	Agriophyte
Bidens frondosa L.	North American	Epoecophyte
Bupleurum fruticosum L.	Mediterranean	Epoecophyte
Cannabis ruderalis Janisch.	Middle Asian	Epoecophyte

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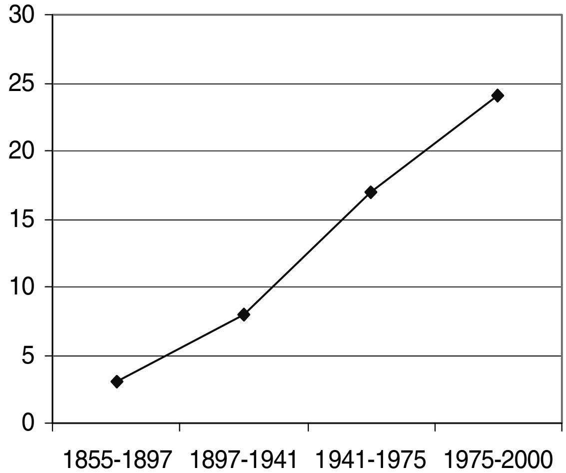
Table 3. (*Continued*)

Species	Origin	Category
Cardaria draba (L.) Desv.	South European, Asian	Epoecophyte
Carthamus lanatus L.	Mediterranean	Epoecophyte
Cenchrus longispinus (Hack) Fernald	North American	Epoecophyte
Centaurea diffusa Lam.	Mediterranean Irano-Turanian	Epoecophyte
Centaurea solstitalis L.	Mediterranean–West Asian	Epoecophyte
Chenopodium striatiforme J. Murr.	Mediterranean	Epoecophyte
Chenopodium suecicum J. Murr.	Asian	Epoecophyte
Conyza canadensis (L.) Cronq.	North American	Agriophytes
Cuscuta campestris Yunck.	North American	Epoecophyte
Diplotaxis tenuifolia (L.) DC.	Mediterranean	Epoecophyte
Echinocystis lobata (Mixch.) Torr. et A. Gray	North American	Agriophytes
Elaeagnus angustifolia L.	Mediterranean	Agriophytes
Elsholtzia ciliata (Thunb.) Hyl.	Asian	Epoecophyte
Impatiens glandulifera Royle	South Asian	Ergasiophytes
Impatiens parviflora DC.	Central Asian	Agriophytes
Foeniculum vulgare Mill.	Mediterranean	Agriophytes
Galinsoga parviflora Cav.	South American	Epoecophyte
Galinsoga urticifolia (Kunth) Benth.	South American	Epoecophyte
Geranium sibiricum L.	Asian	Epoecophyte
Grindelia squarrosa (Pursh) Dunal	North American	Epoecophyte
Helianthus x *laetiflorus* Pers.	North American	Ergasiophytes
Helianthus subcanescens (A. Gray) E.E. Wats.	North American	Ergasiophytes
Helianthus tuberosus L.	North American	Ergasiophytes
Heracleum mantegazzianum Sommier et Levier	Caucasian	Agriophytes
Hordeum leporinum Link	Mediterranean	Epoecophyte
Iva xanthiifolia Nutt.	North American	Epoecophyte
Lepidium densiflorum Schrad.	North American	Epoecophyte
Lepidotheca suaveolens (Pursh) Nutt.	North American	Epoecophyte
Lolium multiflorum Lam.	Mediterranean -Iran-Turanian	Ergasiophytes
Oenothera depressa E. Greene	North American	Epoecophyte
Oenothera rubricaulis Klebahn	North American	Epoecophyte
Oxybaphus nyctagineus (Michx.) Sweet	North American	Epoecophyte
Padus serotina (Ehrh) Ag.	North American	Agriophytes
Parthenocissus inserta (A. Kern.) Fritsch	North American	Ergasiophytes
Phalacroloma annuum (L.) Dumort	North American	Agriophytes
Phalacroloma septentrionale (Fernald et Wieg.) Tzvelev	North American	Agriophytes
Peganum harmala L.	Mediterranean -Iran-Turanian	Epoecophyte
Reynoutria japonica Houtt.	East Asian	Agriophytes
Sagittaria latifolia Willd.	North American	Agriophytes
Saponaria officinalis L.	Mediterranean	Agriophytes
Senecio viscosus L.	Middle European	Epoecophyte
Sisymbrium loeselii L.	Mediterranean and Asian	Epoecophyte
Sisymbrium wolgense M. Bieb. ex Fourn.	East Pontic	Epoecophyte
Setaria pycnocoma (Steud.) Henrard ex Nakai	East Asian	Epoecophyte
Solanum cornutum Lam.	North American	Epoecophyte
Solidago canadensis L.	North American	Epoecophyte
Torilis arvensis (Huds.) Link	Mediterranean	Epoecophyte
Xanthium albinum (Widd.) H. Scholz	Mediterranean	Agriophytes
Xanthoxalis fontana (Bunge) Holub	North American and East Asian	Epoecophyte



Note. X-axis – years; Y-axis – number of species

Figure 4. Dynamics of the number of alien species in the flora of the Ukraine, which participated or participate in expansions.

Carpathian Mountains; modernization of the flora (M) grows from north to south; the highest percentage of unstable (casual, not naturalized) species was observed in Crimea, then followed by the Steppe and Forest-Steppe zones (Protopopova, 1991).

Alongside with the increase in the number of species and rates of their dispersal, we observe some condensation of secondary ranges of species due to some expansion of an ecological spectrum of ecotopes suitable for colonization by alien plants. On the one hand, it testifies that the condition of the local vegetation worsens and the areas occupied by disturbed plant communities and ecosystems increase; on the other hand, the adaptability of invasive species is accelerated.

If we consider the expansions of alien plants in Ukraine during 150 years (Protopopova & Shevera, 1999; Protopopova et al., 2002, 2003), we notice that the pattern of fast dispersal and territorial expansions of species has changed (Figure 1, Table 5). In the middle of the 19th – the beginning of the 20th centuries, expansions severely affected only man-made (anthropic) habitats and ecotopes. Consequently, 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. Since the second half of the 20th century, the prevailing majority of species participating in expansions spread on both man-made (or severely transformed) and semi-natural habitats. Not only these species, but also those spreading more gradually, in many cases penetrated the ecological barrier of natural communities, which can be partly explained, on the one hand, by progressing deterioration of the normal structure of plant communities under the influence of anthropic pressure, and from the other hand, by the strengthened invasion ability of alien plants and their better adaptation to specific habitats and conditions of their new synanthropic range within Ukraine (Burda, 1991; Protopopova, 1991).

Now alien species are registered in Ukraine as components of almost all types of natural plant communities and ecosystems (forest, steppe, aquatic vegetation, etc.). In forests we register invasions of *Acer negundo*, *Padus serotina* (=*Prunus serotina*), *Impatiens parviflora* DC., *Parthenocissus inserta* (A.Kern.) Fritsch, and species of *Rubus* L. Along river shores, *Heracleum mantegazzianum, Impatiens glandulifera*, *Bidens frondosa*, *Echinocystis lobata*,

Table 4. Rates of synanthropization, modernization and instability of the alien flora of Ukraine in the different botanical and geographical regions

Botanical and geographical regions of the Ukraine	S[a]	M[b]	I[c]
Carpathian	211	0.64	90
Flatland forest regions	214	0.72	108
Forest-Steppe	238	0.83	133
Steppe	230	1.0	132
Crimea	283	1.50	161

[a]S (index of synanthropization) = archaeophytes + agriophytes.
[b]M (index of modernization of flora) = (number of agriophytes + number of epoecophytes which immigrated aft er the 15th century) / number of archaeophytes.
[c]I (index of instability of synanthropized flora) = (number of non-naturalized, unstable aliens, ephemerophytes + ergasiophytes).

Table 5. The primary invasive alien plant species in the Ukraine, year and region of the first registration

Species, Year and region (if known) of the first registration in Ukraine	Second half of the 19th century[a]	20th century		
		Before 1940[a]	1941–1970[a]	1971–2000[a]
Amaranthus albus L., 1880, Odesa	+	+		
Lepidotheca suaveolens (Pursh) Nutt., 1868		+		
Impatiens parviflora DC., 1908		+	+	+
Galinsoga parviflora Cav., 1855	+	+	+	+
Iva xanthiifolia Nutt., 1842, Kyiv		+	+	+
Phalacroloma annuum (L.) Dumort, 1897,			+	+
Oxybaphus nyctagineus (Michx.) Sweet (1897, cultivated)				+
Acer negundo L., (19th century, cultivated)		+	+	+
Centaurea diffusa Lam., 1855	+	+	+	
Amaranthus blitoides S. Watson, 1926		+	+	
Geranium sibiricum L., 1855			+	+
Galinsoga urticifolia (Kunth) Benth., 1949			+	+
Bupleurum fruticosum L., 1895				+
Ambrosia artemisiifolia L., 1914, vill. Kudashivka, Dnipropetrovsk Region (cultivated), 1925, Kyiv			+	+
Lepidium densiflorum Schrad., 1895			+	
Solanum cornutum Lam., 1928			+	+
Xanthium albinum (Widd.) H. Scholz, 1928, near Mykolayiv			+	+
Xanthium pensylvanicum Wallr., 1964, Kakhovka, Kherson Region			+	+
Cenchrus longispinus (Hack) Fernald, 1950, vill. Luch, Kherson Region			+	+
Grindelia squarrosa (Pursh) Dun., 1949, Mykolayiv Region,			+	+
Echinocystis lobata (Michx.) Torr. et A. Gray, 1929, Transcarpathia			+	+
Amorpha fruticosa L. (1895, cultivated)				+
Bidens frondosa L., 1970, Kaniv, Cherkassy Region				+
Impatiens glandulifera Royle, 1938, Transcarpathia, Didivtsi				+
Helianthus decapetalus L., 1962, Kyiv				+
Helianthus tuberosus L. (1855, cultivated)				+
Helianthus subcanescens (A. Gray) E.E. Wats., 1972, Uzhgorod, Transcarpathia				+
Heracleum mantegazzianum Somm. & Levier, 1962, vill. Osmoloda, Cis-Carpathians, Ivano-Frankivsk Region				+
Reynoutria japonica Houtt., 1929, Rakhiv, Transcarpathia Region				+

[a]*Note.* + Indicates that the species was invasively expanding its range during the period concerned.

Reynoutria japonica, and several species of *Helianthus* form large, often monodominant, populations. Meadows, especially those used as pastures, are commonly occupied by *Xanthium albinum* (Widd.) H. Scholz and other species of this genus, as well as *Phalacroloma septentrionale* (Fernald et Wiegand) Tzvelev, *Setaria glauca* (L.) P.Beauv. and other aliens. Constant components of sandy habitats are *Conyza canadensis* (L.) Cronq., species of the genus *Oenothera* L. (especially *O. depressa* E. Greene, *O. rubricaulis* Klebahn); the quarantine weed *Cenchrus longispinus* spreads to new regions and invades new areas of sandy soil. In the 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. *Elodea canadensis* Michx., *Azolla filiculoides* Lam. and *A. caroliniana* Willd. colonize aquatic ecosystems. Even on granite outcrops plant communities include *Portulaca oleracea* L., *Setaria glauca*, *Solidago canadensis* L. and some other alien species.

These are only few examples, but the number of alien species penetrating into disturbed natural or semi-natural plant communities is much higher. For example, the level of adventization of some steppe communities reaches 12% (Protopopova et al., 2002, 2003). In many places, coastal 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.

At present, the process of adventization of vegetation in natural habitats progresses rapidly. Many species not only constantly occur in these habitats, but also form communities in which alien plants dominate. Invasive species especially greatly influence the structure of plant communities. They cause pauperization of their species structure and composition, and in extreme cases promote a replacement of regional native plant communities or florocomplexes by synanthropic variants of plant communities. 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 *Hippophaë 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., 2002, Dubyna et al., 2004). *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.

Grindelia squarrosa very aggressively colonizes steppe plant communities. 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. For example, *Ambrosia artemisiifolia* penetrates even into dense stands of *Festuca sulcata*, especially if the communities are overgrazed and trodden by cattle and other livestock (Solomakha et al., 1992).

It is typical that invasive species often have wide ecological amplitudes (Protopopova et al., 2002, 2003). The ecological flexibility of alien plants provides them some advantage in their competition with local, often ecologically stenoptopic, species for the dominant position in ecotopes. For example, *Grindelia squarrosa* is naturalized in steppe, petrophytic, coastal and riparian, xerophytic and shrubby communities, which have never been exposed to radical transformations; this species also readily colonizes pastures, abandoned arable lands, and severely degraded habitats. Another species, *Phalacroloma septentrionale*, becomes easily and extensively naturalized in meadow, coastal, marginal (forest margins and glades), and synanthropic habitats: forest shelter belts, pastures, settlements, roadsides, abandoned fields, etc. Another species, *Conyza canadensis*, is a constant component of at least nine synanthropic and three natural floristic complexes; *Xanthium albinum* occurs in ten synanthropic and three natural floristic complexes, and *Ambrosia artemisiifolia* occurs in eight and two complexes, respectively.

The influence of invasive species upon ecosystems is extremely diverse. In particular, they cause redistribution of roles of species in communities. This redistribution disrupts the ecological balance and finally can lead to the loss of typical features of the affected floristic complexes. For example, the spread of such invasive species as *Grindelia squarrosa* and *Centaurea diffusa* on steppe slopes not exposed previously to radical transformations but used only as pastures, or invasions of *Cenchrus longispinus* in sandy habitats result in a gradual pauperization of the floristic structure and a wider spread of such steppe anthropophytes as *Galatella linosyris* (L.) Rchb.f. or *Marrubium praecox* Janka, which radically changes the typical structure of these communities. Feathergrass (*Stipa*) formations, fragments of shrubby steppes formed by *Caragana frutex* (L.) Koch, *Amygdalus nana* L., dwarf species of *Rosa* L. and *Spiraea* L., which are still preserved on slopes, disappear not only because of overgrazing, but also because of severe competition with alien species. Large stands of such invasive weeds as *Ambrosia artemisiifolia*, *Carduus acanthoides* L., *Artemisia absinthium* L., *Anisanta tectorum* and other species on pastures prevent the process of restoration of steppe communities, which are replaced by various synanthropic communities, especially under proceeding overgrazing pressure (Protopopova et al., 2002, 2003).

Consequently, the community of perennial grasses, *Caragana* L. and other shrubby communities are replaced in steppes by annuals, which greatly affects the structure of all steppe ecosystems. Under the influence of the explosive spread of *Amorpha fruticosa* in floodplains of rivers, structural and functional changes of floodplain ecosystems are observed. *Elodea canadensis* in small reservoirs suppresses development of plants and animals, creates unfavorable conditions for the living functions of the whole ecosystem. Dense thickets of *Azolla filiculoides* change the hydrology of the affected bodies of water; *A. caroliniana* promotes bogging and by that not only interferes with processes of development and life activity of free-floating species, but also adversely affects nearly all aquatic organisms (Dubyna & Protopopova, 1980; Shelyag-Sosonko & Dubyna, 1984; Dubyna et al., 2002).

During the processes of restoration of completely or partly transformed vegetation, alien species raise the level of competition for ecotopes. In these cases, many aliens are stronger competitors than native plant species. For example, *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, for example, class *Meliloto-Artemisietea absinthii* Elias 1980; order *Sisymbrietalia officinalis* J.Tx. 1966; union *Bromo-Hordeum murini* (Allorge, 1922) Lohm. 1950, associations *Erigeron-Lactucetum serriolae* Ljhm. 1950 ap. Oberd. 1957; *Descurainetum sophiaae* Krch 1930; *Artemisietum annuae* Fijalk, 1967; *Ambrosio artemisiifoliae-Xantheum strumariae* Kost. 1991; *Setario-Galinsogetum* (Krus. et Backer, 1942) R. Tx 1950; *Carduetum acanthoiditis* (Allorge, 1922) Morariu 1939, etc. (Solomakha et al., 1992). These species are stable components in such habitats, even if these habitats are eventually transformed into fallow lands (Dubyna et al., 2002; Dubyna et al., 2004; Shelyag-Sosonko & Dubyna, 1984).

On pastures, stands of *Carduus acanthoides*, *Xanthium albinum*, *Artemisia absinthium*, *Grindelia squarrosa*, *Peganum harmala* L. etc. are formed. Even in habitats where typical dominants of steppe communities (e.g., *Stipa lessingiana*, *Festuca sulcata*, *Salvia nutans*, *Phlomis pungens* Willd.) are still preserved, the introduction of such species as *Grindelia squarrosa* or *Centaurea diffusa* sharply slows down the processes of restoration of vegetation. 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. Instead of diverse herbaceous and feathergrass steppe sites on slopes, communities of alien and weedy native species are formed, often with participation of *Ballota nigra* L., *Artemisia absinthium*, *Centaurea diffusa*, *Carduus acanthoides*, *Ambrosia artemisiifolia*, *Grindelia squarrosa*, *Anisantha tectorum*, and other species.

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. Dispersal of alien plants causes fragmentation of populations of native plants to the level of unstable micropopulations, or even separate individuals. Some fragmented populations disappear. This reduction of the number and decrease of the density of populations result in some decrease in genetic diversity of populations (Fahrig, 1997; Tsaryk et al., 2001). Because of that, the exchange of the genetic material is sharply reduced, the inbreeding frequency increases, and the genetic diversity declines. All these factors have an extremely adverse effect on fertility and viability of plants (Tsaryk, 1994; Tsaryk et al., 2001). Expansions of alien plants are powerful factors of destruction of the integrity of linear populations along the rivers of the Carpathian Mountains (Protopopova & Shevera, 1998).

Formation of new morphotypes, ecotypes, mutants, and hybrids, especially in such genera as *Xanthium*, *Centaurea* L., *Helianthus* L., has been observed. These processes raise adaptive capacities and opportunities of alien plants. At the same time, these processes have evolutionary significance, thus affecting not only biodiversity units, but also the evolutionary processes that sustain it (Moritz, 2002). An example of a complex of taxonomic units of a rather debatable taxonomic status is *Carduus nutans* L., an archaeophyte of Western Mediterranean origin (Kondratyuk & Gorlacheva, 1985). Within its secondary range on the left bank of the Dnipro, closely related vicariant geographical races C. attenuatus Klokov and C. thoermeri Wein represent this genus. The latter, in its turn, is represented by two ecologically distinct forms: the steppe form *C. thoermeri* and the weedy form *C. pseudomacrocephala* Klokov. The presence of natural and intermediate forms substantially complicates their differentiation. At the same time, the marked polymorphism testifies to some divergence of the populations, which has arisen probably because some deviant forms of the peripheral populations of alien species during their colonization of the territory, under the influence of different factors could master and occupy new ecological niches. The ecologically successful forms in these populations probably have developed from mutations that have arisen in new environmental conditions. The ecological and geographical differentiation in a secondary range is characteristic also for some other species, for example, the *Ballota nigra* L. aggregate, which has within its range a rather distinct steppe race known as *B. longicalyx* Klokov, or *Lamium amplexicaule* L., which is represented in Ukraine not only by the typical form, but also by two or three deviate forms peculiar to steppe and rocky habitats (Protopopova, 1991). The genus *Xanthium* demonstrates well-expressed polymorphism patterns (Protopopova, 1964, 1991, 1994). Eventually, there often occurs a fragmentation of ranges connected with the expansion of the ecological range of a species, and with its adaptation to conditions of new bioclimatic zones (Protopopova, 1991).

Contamination of the gene pool of native species may occur through their hybridization with related alien plants. Hybridization of alien plants with related native or established species is observed in genera such as *Xanthium*, *Helianthus*, *Centaurea*, *Medicago* L., *Oenothera*, and many others. Such hybridization is especially dangerous for endemic, relict, and rare species, which are usually represented by small and isolated populations. For example, such danger is posed by the ecologically active species *Centaurea diffusa*, which is widespread in the steppe zone of Ukraine, including the area where several endemic species of *Centaurea* occur. This species forms hybrids with several rare species, in particular, with *Centaurea margarita-alba* Klokov, *C. sterilis* Steven, and *C. aemulans* Klokov. Species of hybrid origin have been described, e.g. *C.* × *hypanica* Pacz. (*C. margarita-alba* Klokov × *C. diffusa)*, and *C.* × *dobroczaevae* Tzvel. In particular, this process of hybridization greatly promoted the disappearance of *C. margarita-alba* (Protopopova et al., 2002, 2003; Shelyag-Sosonko, 1996).

Dispersal of alien species poses a serious danger to native rare species and natural protected areas. In the lower reaches of the Danube, in Danube Biosphere Reserve, the spread of alien water fern species *Azolla filiculoides* and *A. caroliniana* affects conditions of populations of native protected and relict species *Salvinia natans* and *Trapa natans* L., which are listed in the Red Data Book of Ukraine (1996). Associations formed by a highly invasive species, *Amorpha fruticosa*, pose a threat for the very existence of the floristic complex of the Danube delta, which is unique for the steppe zone and is restricted to arboreal and shrubby vegetation; this complex includes at least 18 endemic and subendemic and five relict species. The total number of alien plant species in Danube Biosphere Reserve reaches 19% of the total number of vascular plant species (Dubyna et al., 2002). We do not have data on possible cases of direct extirpation of rare native species because of alien invasions in Danube Biosphere Reserve, but the dramatic changes at the level of plant communities are evident. That means that invasions of alien plants in critical natural areas first of all initiate disruptions of vegetation and only then affect the floristic composition.

In Chornomorsky (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.). In coastal habitats in the lower reaches of the Dnipro, 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 Nature Park, alien plant species represent 13.5% of the total number of species of vascular plants (Lyubinska et al., 1999). 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.

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*. 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* promoted their invasions in forest plant communities. *Ambrosia artemisiifolia* and *Grindelia squarrosa* were originally cultivated in Ukraine as medicinal plants, and that became the main reason of their occurrence as escaped and subsequent formation of powerful centers of their expansion.

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 *Hippophaë rhamnoides*.L.

With seeds of cultivated plants imported from other countries, weeds typical for these crops often find their way to our country. That was the mode of immigration to Ukraine of *Galinsoga parviflora*, *Xanthoxalis dillenii* (Jacq.) Holub (=*Oxalis stricta* L.), *Cuscuta campestris* Yunck, .*Solanum cornutum* Lam. and many other species. Some species escaped from botanical gardens, nurseries, experimental stations; however, especially unforeseen consequences were observed at spontaneous and uncontrolled introduction of plants by separate persons. Therefore, one of the most needed measures should be raising of the awareness of the local population regarding possible consequences of uncontrollable import and introduction of non-native plants. (Protopopova et al., 2002).

The State Plant Quarantine Service has been operating in Ukraine since 1931. The control over import and distribution of the already introduced alien plants is performed at a rather high level; however, the efficiency of these actions is rather low as any species subject to the control are far from being eradicated, or even limited or restricted in their distribution. Only during the last fifteen years, more than 100 new alien species have been registered in Ukraine, and only few of them have disappeared. Hence, in addition to toughening control measures on imports, it is necessary to establish an efficient system for monitoring all alien species, not just those considered economically harmful or potentially dangerous. Studies of dynamics and patterns of invasions in Ukraine show that real invasions of such highly invasive aliens as *Ambrosia artemisiifolia* and *Amorpha fruticosa* began only many years after their initial immigration, after a lag phase. In some cases the seemingly “extinguished” expansion unexpectedly gain in strength again due to development of favorable habitats as a result of transformation of local plant communities (for example, the cases of *Iva xanthiifolia* and *Solanum cornutum*).

For developing the scientific base for the control of quarantine alien plants at the modern level and developing the early warning system to predict and prevent invasions, we propose the following approaches for assessing the environmental impact of alien weeds and alien species in general (Protopopova & Shevera, 2004).

(a) Typization of localities and distribution zones of alien plants should be managed at the zonal and ecological basis rather than based on exclusively administrative territorial units, as it is practiced today;
(b) Differentiation of distribution ranges of each species should be characterized according to a potential harmfulness scale (the character of localities, abundance, status of populations, invasive potential);
(c) Biological invasive potential of each species should be studied at the populational level;
(d) Large-scale mapping of species ranges in Ukraine for monitoring purposes (to follow and prevent the invasive trends).

We believe that in planning measures to control invasive alien plants, the special attention should be paid to the agriophytes (plants completely naturalized in native plant communities), and also to potential agriophytes among epoecophytes, since these groups are especially dangerous to the native biodiversity at all levels (gene pool, species and populations, plant communities, ecosystems). In addition to that, a monitoring system should be established for risk assessment of the potential threat posed by ephemerophytes (casual aliens, non-persisting species). In order to prevent and combat invasions of alien plants in Ukraine, we need a new level of cooperation and coordination between various official bodies and sectors within the country (research institutions of the National Academy of Sciences and the Agricultural Academy, ministries and governmental agencies, such as customs, phytoquarantine structures, local administration, NGOs, etc.).

Conclusion

The experience of plant invasions in Ukraine gives reasons to conclude that in most cases the best policy would be to prevent introduction of alien plants. In this respect, it is necessary to avoid unnecessary and intentional introduction of ornamental and other species for horticulture, forestry, agriculture and other sectors without any preliminary assessment of their invasion potential in the region concerned. However, if an alien species immigrated to the country, its spread should be better stopped at the initial phases of its naturalization, before the onset of the actual or even potential invasion. Invasions of alien plants promote dramatic changes in the taxonomic, geographical, and ecological patterns of local floras, disruptions in the phytosociological spectrum, spectra of biomorphs, deterioration of zonal peculiarities of the flora, and finally lead to the decline of the vegetation productivity.

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