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IMPACT OF THE INVASIVE SPECIES *ELAEAGNUS ANGUSTIFOLIA* L. ON VEGETATION IN PONTIC DESERT STEPPE ZONE (SOUTHERN UKRAINE)

ABSTRACT: The Irano-Turanian species – Russian olive (*Elaeagnus angustifolia* L.) – is one of most commonly planted tree in the shelterbelts in southern Ukraine. The consequences of introduction of the species from windbreaks, into areas of different land use in west and central Pontic desert steppe zone are evaluated. The above steppe is unique on a European scale and exists only in some parts of the Black and Azovian Sea coasts. In recent years, the socio-economical crisis in Ukraine (less intensively cultivation, as well as limited grazing) has been responsible for the intensification of the spread of alien tree species outside the windbreaks. Studies were conducted in Kherson Region, in the immediate vicinity of the Black Sea Biosphere Reserve, where the presence of aliens is undesirable. The analysis of phytosociological material (48 relevés with and without Russian olive) collected from areas of different land use type and limited human pressure (as abandoned field, former intensively grazed *solonetz* and extensively grazed desert steppe vegetation) show that *E. angustifolia* can impede the regeneration of the desert steppe. The species creates favourable conditions for the growth of geographically and ecologically alien nithrophilous weeds.

KEY WORDS: invasive species, *Elaeagnus angustifolia*, windbreaks, shelterbelts, abandoned fields, *solonetz*, Pontic desert steppe

1. INTRODUCTION

Ukrainian part of the desert steppe zone (west and central Pontic desert steppe zone after Bohn *et al.* 2000–2004) includes a type of vegetation that is unique in Europe. It is limited to a thin strip in the south of Ukraine, in some parts of the Black and Azovian Sea coasts. Only a small part of the area is placed under protection within the Black Sea Biosphere Reserve and Azovo-Sivash National Park. The remaining part of the zone is used for agriculture and grazing purposes. In the past local grazing pressure was very high (large herds of sheep).

Changes in Ukrainian agriculture over the last 20 years and the collapse of the prevailing socio-economic system in the early 1990s have led to less intensive cultivation and pasturage in the Pontic desert steppe zone and resulted locally in the abandonment of agricultural fields. In some areas the process of natural regeneration of the desert steppe has already started. Therefore, the encroachment of alien species – Russian olive (*Elaeagnus angustifolia* L.) into the steppe communities has aroused some concern.

Russian olive or Trebizon date is a small tree or shrub. The exact site of origin of the

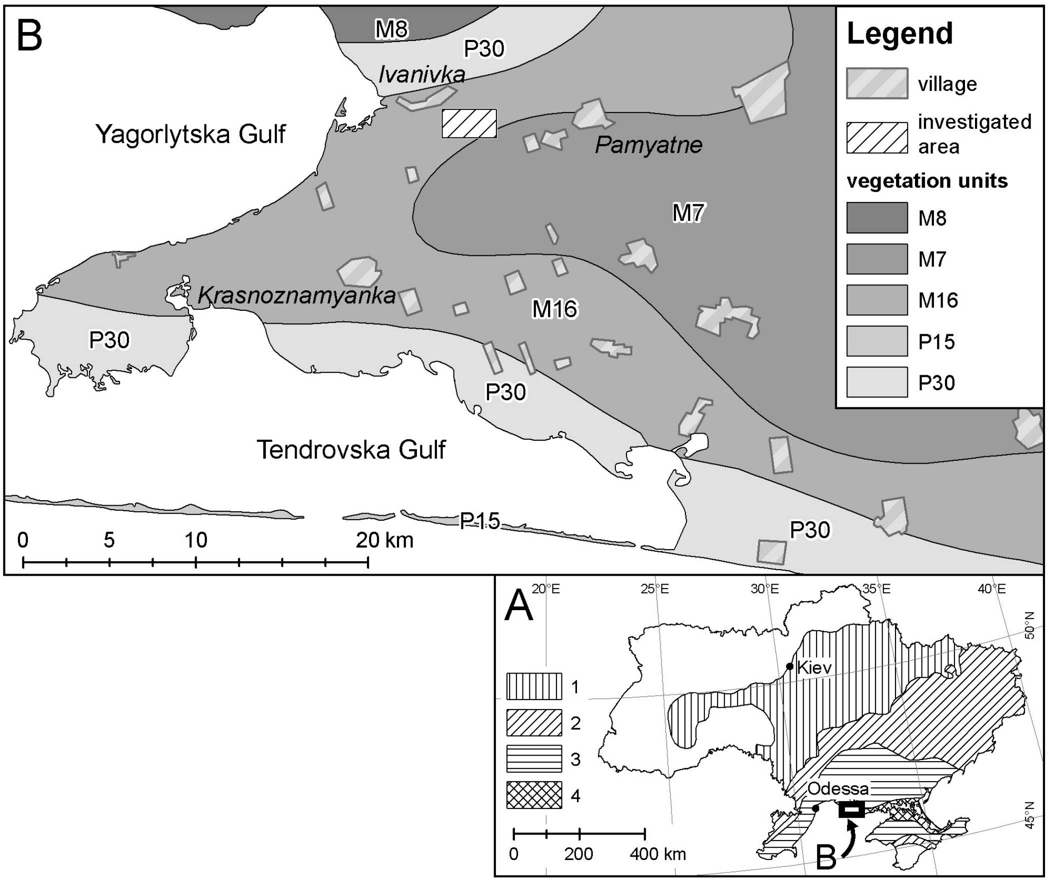

Fig. 1. A) Location of the investigated area and the main types of steppes in Ukraine: 1 – forest-steppe; 2 – fescue/feather-grass, rich forbs steppe; 3 – fescue/feather-grass, poor forbs steppe; 4 – desert steppe. B) The location of the investigated area on the *Map of the Natural Vegetation of Europe* (Bohn *et al*., 2000-2004): M7 – Pontic hemi-psammophytic herb-grass steppes; M8 - Pontic psammophytic herb-grass steppes; M16 – west and central Pontic desert steppes; P15 - west and central Pontic sand dune vegetation; P30 – west Pontic halophytic vegetation.

species has been subject to debate and still remains unclear. Some authors considered the Mediterranean area as its place of origin (e.g. Kozlovskaya 1958, Protopopova *et al*. 2006a). Tzvelev (2002) did not reject the hypothesis that the species emerged as a result of ancient cultivation and selection of closely related species (e.g. *E. oxycarpa* Schlecht.). Most authors suggest that *E. angustifolia* originated from the Irano-Turanian region. The species is widely distributed in south-west Asia. In the East its range extends from Kashmir and north-west India to eastern Kazakhstan. The western limit of the species distribution is unclear; the natural character of the tree stands in the lower Volga region (Golub *et al*. 2002) and Anatolia (Browicz 1996) is questioned. Russian olive was cultivated as an ornamental and melliferous plant. *Elaeagnus angustifolia* var. *orientalis*, sometimes recognized as a separate species *E. orientalis* L., produces edible fruit.

In the Ukrainian gardens and parks Russian olive was cultivated as early as the end of the 17th century (Kokhno 1986). In the south of Ukraine it has been planted since the 19th century (Protopopova *et al*. 2006a, b).

The shelterbelts (windbreaks, forest belts) and tree plantings in the immediate vicinity of settlements are the main source of diaspores of Russian olive. The establishment of protective shelterbelts of southern Ukraine is closely associated with the history of "the

Fig. 2 *Elaeagnus angustifolia* escaping from the windbreaks into the abandoned fields (A) and extensively used pastures (B) in the Pontic desert steppe zone, near the Black Sea Biosphere Reserve (Kherson Region).

taming of the steppe". The first windbreaks or small tree stands were planted at the beginning of the 19th century. It should be noted that at this time shelterbelts were also planted outside the steppe zone, e.g. in Western Poland by Napoleon's general D. Chłapowski on his estate in the village of Turew. At present windbreaks and its impact on some systematic groups and ecological processes are the valuable objects of study (e.g. also Boudry 1988, Burrel, Boudry 1990, Ryszkowski *et al*. 2003, Wojewoda, Russel 2003, Bernacki 2004). In Ukraine until the 1930s, however, the general value of windbreaks was not acknowledged. The situation changed when Soviet state-party leaders implemented the idea of planting windbreaks in their "*Plan to Transform Nature*". Protective forest belts were more widely planted after 1930 and on a massive scale in the 1950s and 60s (Matyakin 1952, Skorodumov 1959) which in fact paralleled the F.D. Roosevelt tree belt plan of 1935–1942 to prevent "dust bowling" in American prairies. At present forest belts are a characteristic man-made element of the woodless landscape of southern Ukraine, e.g. in the Kherson region the total length of protective forest belts exceeds 30 000 km. Windbreaks play an important economic role in the agricultural landscape: they reduce the speed of the wind which blows in the steppe all year round, prevent wind erosion and dust storms, help stabilize the snow cover, and improve soil moisture conditions (Visotskii 1983). In addition, they act as barriers to the tumbleweed ('*perekatipole*'). Their importance as ecological corridors should also be emphasized. However, their negative role as "starting points" in the process of introduction of alien tree species is much less widely recognized.

Today the legal status of windbreaks in Ukraine remains unclear. Until recently they were the property of the *kolkhozes*. As a result of privatization in the agriculture sector in Ukraine forest belts came into no one's possession. As most forest belts were planted in the 1950s–70s, many of the trees have already reached maturity; others show signs of ageing. As a consequence, the process of natural elimination of windbreak trees has started. At the same time young trees are found in the vicinity of the forest belts.

It is estimated that the number of tree species planted in windbreaks reaches 80 in the west Pontic grass steppe zone. The Pontic desert steppe zone is further south, therefore the protective forest belts are much poorer in species due to more severe habitat conditions (Sudnik-Wójcikowska *et al.* 2006). Factors such as low annual rainfall and local soil salinity limit the range of trees. Species native to the forest-steppe zone are almost entirely absent and *E. angustifolia* is the dominating species. In addition, American species, such as: *Acer negundo* L., *Gleditsia triacanthos* L. and *Robinia pseudoacacia* L. are planted frequently.

The object of our investigations was *E. angustifolia* which escaped from windbreaks to grow wild in Pontic desert steppe zone. The aim of the study was to evaluate the consequences of encroachment of this invasive species into abandoned fields and extensively used pastures where vegetation similar to that of the natural Pontic desert steppe is now regenerating. The rate of this process was assessed based on analysis of phytosociological relevés (species composition and degree of cover); the proportion of alien species was also considered.

2. STUDY AREA

The studied area (Figs 1, 2a, b) is situated within the desert steppe zone (the west and central Pontic desert steppe zone), which stretches as a thin strip in the south of Ukraine, along the coast of the Black Sea (from the mouth of the Dnieper River to the western part of the Azovian Sea coast) and in the north part of the Crimea (Marynych 1985, Bohn *et al.* 2000-2004). The climate in this area is characterized by hot summers and mild winters. The average annual precipitation is as much as 350 mm; most of the rain falls in June and July (Logvinov, Shcherban 1984, Boiko *et al.* 1998).

The investigations were carried in the Gola Pristan district (the south-west part of the Kherson Region), 4–5 km south of the border of the Black Sea Biosphere Reserve, between the villages of Ivanivka and Pamyatne (46°21′N, 32°07′E, Fig. 1b). The weakly structured shallow depression, which is located 1–3 m below the surrounding area, extends from west to east (length ca. 15 km, width 4 km). It seems to be the continuation (eastern part) of the Yagorlycka Gulf. In fact, it is the part of the old riverbed of the Dnieper River. Transgression of the Black Sea on the north coast, which has occurred over geological time, is noticeable (Pravotorov 1970). At present it is especially marked at lower elevations, where the area was investigated. Salted chestnut-brown soils, which occur together with *solonchak* and *solonetz* soils, prevail here (Vernander

1986); *solonchak* is a type of soil found in arid to subhumid, poorly drained conditions, which contains high level of soluble salts in its upper layers; *solonetz* is a type of soil containing within the upper 100 cm of the soil profile and is so-called "natric horizon". From the south and east side, the surveyed area is surrounded by arable (partly irrigated) fields. This part is much more populated. The depression extends north to the alluvial sand massif (which covers about 200 000 ha) occupying the second 'forest' terrace of the Dnieper River.

In the investigated area the natural plant cover consists of Pontic desert steppe vegetation which is found in slightly elevated places and on *kurgans* (barrows, funerary mounds) mostly of Scythian origin; their number exceeds 130 in the old river-bed of the Dnieper River. The Pontic desert steppe vegetation occurs in combination with halophytic and subhalophytic communities on *solonetz* and *solonchak* soils, and halophyte meadows. The desert steppe was mainly used for pasturage and only in some parts as arable fields, some of which have been gradually abandoned since 1960s–70s. The increase of salt in the soil seems to be a result of the contemporary transgression of the Black Sea and the consequence of the previous artificial watering of the fields. After the agricultural fields had been abandoned the area was intensively used as pasture for sheep. There were thousands of sheep at the end of the 1980s. At this time the crisis in Ukrainian agriculture led to changes in the structure of breeding. Herds of sheep were replaced by a much smaller number of cows.

3. MATERIAL AND METHODS

The investigations were conducted in 2004–2005 growing seasons. In the area described, *Elaeagnus angustifolia* spread spontaneously from the windbreaks and plantations, and occurred abundantly in abandoned fields and pastures, growing singly or in small groups (2–3 trees). Within this area 3 homogenous sample plots (A, B, C) were laid out. They were situated in the vicinity of the windbreaks established by *E. angustifolia* (with a very small proportion of *Gleditsia triacanthos* and *Robinia pseudoacacia*). The windbreaks accompanied local roads and field paths. The sampled areas A, B, C (0.5–1 km^2 each) differed from each other with respect to the history of land use. We used old maps and interviewed the habitants in order to reconstruct this history.

Sample area A (Fig. 3) – former agricultural fields, located close to a sheep farm, abandoned in about 1960 due to increased soil salinity and then intensively grazed by sheep up to the time of crisis and later used only extensively (pasture for cows). The vegetation is similar to that of *solonetz*. The dominating species are: *Limonium meyeri* (Boiss.) O.Kuntze, *Artemisia santonica* L., and *A. austriaca* Jacq. The absence of tuft grasses and the presence of a large number of weed species is still noticeable.

Sample area B (Fig. 3) – it seems that these *solonetz* soils have never been used as arable land because of the increased salt level in the soil. Perhaps this area was intensively used as pasture for many years, at least up to the 1990s. Both sample areas A and B are located at lower elevations. Therefore, they are more exposed to salinization. Since the 1990s area B has been used only extensively. The proportion of tuft grasses is much smaller here than in the typical desert steppe.

Sample area C (Fig. 3) is covered by Pontic desert steppe vegetation and is quite a distance away from farms, therefore the impact of human activities is weaker. It is located further from the sea and at slightly higher elevations than sample areas A and B, and contains lower levels of salt. The effects of transgression seem to be less marked and the role of halophytes is limited in this area. Due to lower salinity values (compared with areas A and B) the steppe flora is also represented by several species of tuft grasses (*Festuca valesiaca* Schleich. ex Gaudin, *Stipa capillata* L.). The area was used as pasture in the past, but less intensively due to its distant location. Nowadays the impact of herbivores is similar to natural grazing pressure. The vegetation of the area is similar to the natural plant cover.

Our study focused on the impact of *E. angustifolia* on vegetation of the 3 sample areas. Only trees spreading spontaneously from the windbreaks and the understorey were included in the vegetation relevés. Eight pairs of relevés (covering an area of 6–25 m^2)

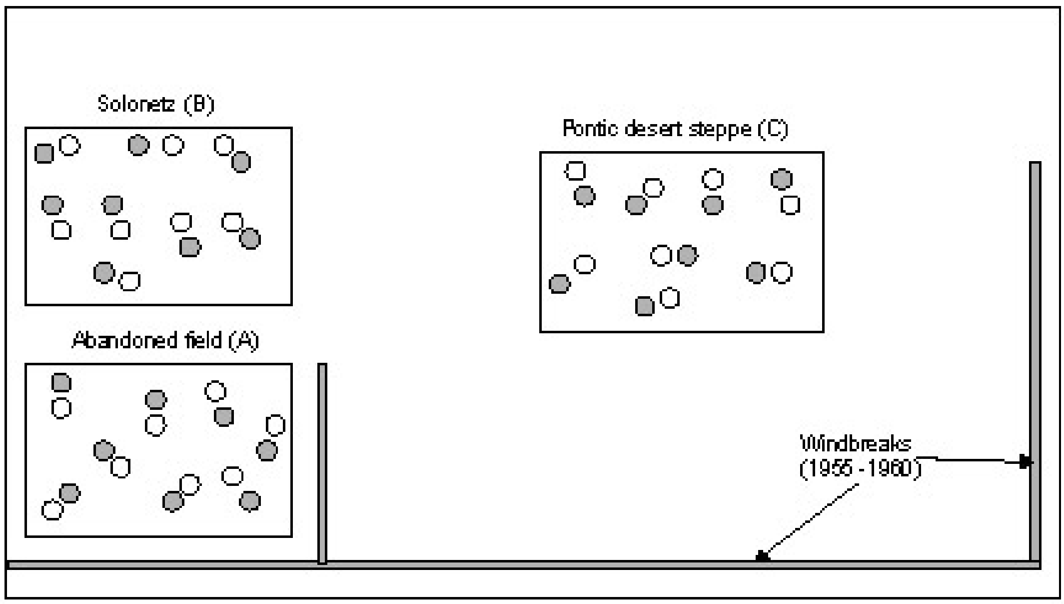

Fig. 3. Distribution of the different sample areas: A, B and C (schema; approx. distans A-B: 0.3 km, B-C: 1.7 km, A-C: km: 1.75 km); location of the successive pairs of relevés: ● – with and ○ – without *Elaeagnus angustifolia.*

were made in each of the sampled areas: A, B, C (Fig. 3). One relevé from each pair was recorded near *E. angustifolia* within the reach of the tree crown, and the other relevé – at a distance of about 10–20 m beyond the influence of the tree. The relevés in each pair were of comparable size. A total of 24 relevés with, and 24 without *Elaeagnus* were recorded. The nomenclature of species follows that of Mosyakin and Fedoronchuk (1999).

Field observations enabled us to assess man's impact on the plant cover in the areas studied.

The percentage of alien species in relevés with and without *E. angustifolia* in each of the sampled areas could be an indicator of man's impact on the flora.

Basic data processing was executed with TURBOVEG (Hennekens and Schaminée 2001). Dendrograms were calculated for the whole floristic composition based on the Czekanowski-Sørensen coefficient of similarity (also known as percentage similarity). The UPGMA clustering method was applied (Batko and Moraczewski 1993). When coverage data were taken into account, the original degrees of cover were converted to "*average percentage of coverage*" (Braun-Blanquet 1964, see also Szafer, Zarzycki 1972) as follows: the degree 5 (cover 75–100%) → 87.5, the degree 4 (cover 50–75%) → 62.5, the degree 3 (cover 25–50%) → 37.5, the degree 2 (10–25%) → 17.5, the degree 1 (1–10%) → 5, the degree + (1%) → 0.1. An analysis of the floristic similarity made it possible to assess the impact of *Elaeagnus* in different habitats (sample plots).

The 24 individuals of *E. angustifolia* recorded in the relevés were cored with drilling equipment. We estimated their age by counting the tree rings. An analogous parameter was measured for the oldest trees (*E. angustifolia* and *Robinia pseudoacacia*) in windbreaks in order to determine when they were planted. An analysis of the data enabled the assessment of the age of the trees as well as the past weather conditions. We could also confirm the time when changes occurred in the utilization of the area investigated.

4. RESULTS

Tree ring measurements enabled the estimation of the age of the protective forest belts in the immediate vicinity of the areas sampled. The oldest planted trees of *Elaeagnus*

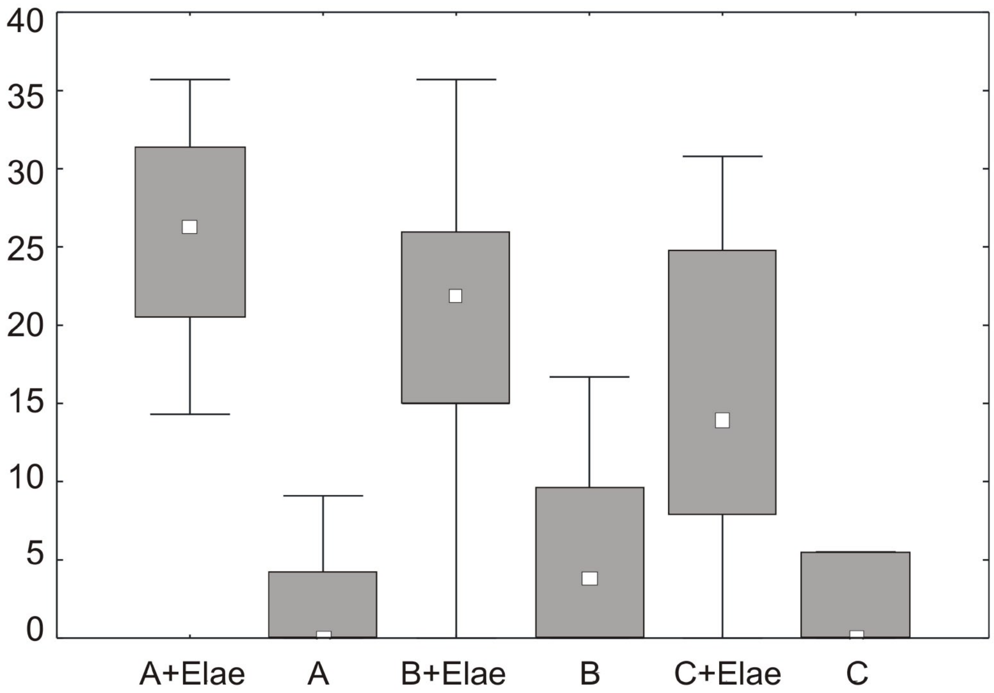

Fig. 4. The percentage (median and quartile value) of alien species occurring in relevés with and without *Elaeagnus angustifolia* for each of the three sampled areas (A, B, C).

angustifolia and *Robinia pseudoacacia* were found to be about 47 years old (windbreaks were, therefore, planted in about 1958). The individuals which had escaped from the windbreaks were much younger than their parent trees (their height did not always correlate with their age). In the case of abandoned cultivated fields (sample area A) the oldest trees were estimated to be 19–20 years old, on *solonetz* soils (sample area B) – 19–22 years old and in the desert steppe (sample area C) – 17–18 years old. This indicates that cultivation and intensive grazing ceased in the period 1983–88. A detailed analysis of the annual ring growth showed that the years 1993 and 2000 were the most unfavourable in terms of tree growth and development.

The 48 relevés recorded in the communities of the Pontic desert steppe zone (sample areas A, B, C) were arranged in a synoptic table: 24 relevés with *E. angustifolia* and 24 relevés without Russian olive. The relevé database included 95 species, of which 19 were species of alien origin: *Amaranthus albus* L., *Anisantha sterilis* (L.) Nevski, *Anisantha tectorum* (L.) Nevski, *Anthriscus caucalis* M. Bieb., *Atriplex micrantha* C.A. Mey, *Atriplex tatarica* L., *Bromus squarrosus* L., *Capsella bursa-pastoris* (L.) Medikus, *Centaurea diffusa* (Lam.), *Chenopodium opulifolium* Schrad., *Chenopodium strictum* Roth, *Cirsium arvense* (L.) Scop., *Cirsium vulgare* (Savi) Ten., *Conyza canadensis* (L.) Cronquist, *Fallopia convolvulus* (L.) A. Löve, *Lactuca serriola* L., *Polycnemum sp.*, *Solanum nigrum* L., *Sonchus asper* L. For each of the 6 groups of relevés – from area A, B and C – with and without *E. angustifolia*, the percentage of alien species in the flora of relevés was used as an indicator of man's impact. The median and quartile value of the percentage contribution of aliens for every of 6 groups of relevés were presented (Fig. 4). The percentage of alien species was much higher in the relevés with *Elaeagnus*. In the relevés without *E. angustifolia* the lowest representation of aliens was recorded in the case of the desert steppe (C) and abandoned field (A). The highest value and the most significant differences between the proportion of aliens in the relevés with and without *E. angustifolia* were noted in the case of abandoned field. It may be concluded, therefore, that the spread of *E. angustifolia* can contribute to the persistence of alien species.

Floristic similarities between the 48 relevés were displayed in the form of dendro-

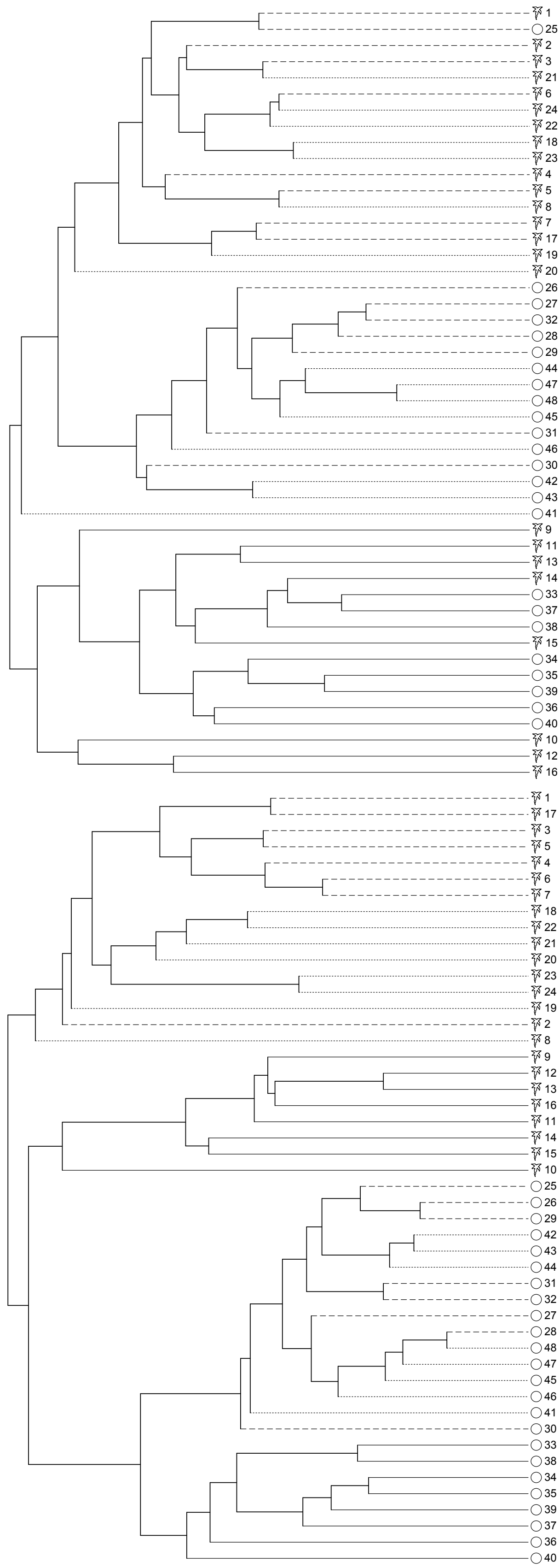

Fig. 5. Floristic similarity (Czekanowski-Sørensen coefficient of similarity and UPGMA clustering method were applied) between 48 relevés with and without *Elaeagnus angustifolia* from the sample areas A, B, C, based on: 5a) the list of species in releves; 5b) coverage data.

Symbols:

…… sample area A (abandoned field)

– – – sample area B (*solonetz*)

–––– sample area C (desert steppe)

Relevés with *E. angustifolia* are indicated by graphic symbol (flower), relevés without *Elaeagnus angustifolia* are indicated by white circle.

grams (Fig. 5). The first dendrogram (Fig. 5a) includes the species inventory. The second dendrogram (Fig. 5b) contains coverage data. Both dendrograms indicate that the relevés are clearly differentiated. However, the dendrogram based on the coverage data is more accurate.

It is easy to distinguish a group of 16 relevés made in sample area C, i.e. in the Pontic desert steppe (Fig. 5a). As stated earlier, the above area is distinguished from the other two sample areas (A and B) by lower salinity levels and better-preserved natural plant cover, which is more compact and strongly resistant to the encroachment of aliens. The proportion of aliens recorded in the relevés without *E. angustifolia* is very small.

However, the division within the above group of 16 relevés is not so clear (Fig. 5a). It seems that in habitats where man-made impact is limited, *E. angustifolia* does not strongly influence the plant species composition of the area in the immediate vicinity of the tree (the potential sources of weed diaspores are quite far away). It is important to keep in mind that the trees of *Elaeagnus* are still fairly young (about 20 years old). Perhaps the impact and selection of the species will increase with the individuals' age.

The remaining relevés were recorded in an abandoned field (sample area A) and on *solonetz* soils (area B), which were subject to stronger human influence. Relevés either with or without *E. angustifolia* can be distinguished within this group. It is clear that in the case of the abandoned field and *solonetz* Russian olive had a more significant influence on the species composition of the vegetation developing under the tree crown. Nowadays limited human pressure in the two habitats is responsible for the gradual reduction of weeds (associated earlier with arable land and intensively used pasture land), which are eventually replaced by desert steppe species.

Elaeagnus trees not older than 20 years could establish themselves in places where cultivation and intensive grazing had ceased. It appears that the developing and ageing individuals of Russian olive contribute to the persistence of weeds which are displaced from the area surrounding the trees. The tree crown provides shade, and the nitrogen-fixing actinomycetes which form a symbiotic association with *Elaeagnus* (genus *Frankia* in the root nodules) seem to play an important role in this process. It is generally recognized that most weed species are nitrophilous.

The coverage data (Fig. 5b) clearly differentiate a group of relevés with *E. angustifolia* from the more strongly transformed habitats, i.e. the abandoned field (sample area A) and *solonetz* (area B). The other relevés, which formed a separate group, were recorded in the above habitats (but did not contain Russian olive) and in the desert steppe (either with or without *E. angustifolia*). A group of relevés with *Elaeagnus* recorded in the desert steppe, where the human influence was relatively low, can be distinguished within the above group. A common characteristics of all the other relevés is the absence of *Elaeagnus*. In the case of the Pontic desert steppe the differences between the relevés with and without *Elaeagnus* are less pronounced than in the communities more strongly transformed by man, although Russian olive can also alter the steppe conditions by providing shade and enriching the soil with nitrogen.

It may be concluded, therefore, that in the three sampled areas Russian olive contributes significantly to the abundance of weeds included in the relevés. Its impact is less marked in the case of communities closely resembling the natural ones. Therefore, past land use practices play an important role. *Elaeagnus* "preserves" the changes that occurred in the previously intensively managed steppe. The area under the crown of the tree provides 'refuge' for weed species which were displaced during the process of regeneration of the steppe.

A contrasting group of relevés without *E. angustifolia* recorded in the three habitats was also identified. The desert steppe can be distinguished from the other habitats by a low percentage of alien species in relevés and a relatively high proportion of tuft grasses. However, the relevés from the other two subgroups (recorded on *solonetz* soils and in the abandoned field) differ slightly from each other with respect to species composition and abundance.

5. DISCUSSION

Russian olive is resistant to drought, low temperature and tolerates elevated salinity levels. This greatly facilitates the expansion of cultivation of the tree and its establishment in the wild in the steppe zone. *Elaeagnus angustifolia* grows singly, in groups or forms bushes. It particularly prefers river valleys, riverside terraces, on the slopes and bottoms of canyons and ravines (*balkas*), on shore sand, offshore islands and sandbars. Protopopova *et al.* (2006a) identified in Ukraine at least 8 plant communities invaded by *E. angustifolia* on sands (e.g. *Saliceto rosmarinifolia-Holoschoenetum vulgaris* Mitielu *et al.* 1973, *Secaletum sylvestre* Popescu et Sanda 1973, *Secalo-Stipetum borysthenicae* Korz. 1986 Dubyna, Neuhasl et Stehl 1995, *Calamagrostio epigei-Hippophaetum rhamnoidis* Popescu, Sand, Nedelescu 1986) and 7 communities invaded by the species in riverside biotopes (e.g. *Salicetum albo-fragilis* (Issler 1926) Tx. 1955, *Populetum nigro-albae* Slavnic 1952, *Salicetum triandrae* Malcuit 1929, *Tamaricetum ramosissimae* Simon et Dihoru 1962). Russian olive can colonize disturbed areas after fires in a short period of time (propagated by means of sprouts from roots and root crowns). The tree flowers and produces fruit relatively early in life (at the age of between 4 and 5 years). The fruit remains on the branches for a considerable period of time and is dispersed by water or even by the wind. The seeds are propagated by birds, small mammals and fish. Digestion of fruits may break dormancy. Russian olive seeds stored in ordinary conditions remain viable for up to 3 years but seed longevity in the field is undocumented (Bugała 1991, Seneta 1996, Brock 1998, Zouhar 2005). It is estimated that about 60% of the seed bank population has the potential for germination (Brock 2003).

The plant was introduced into North America and became a very serious nuisance in many of the states, e.g. Nevada, Arizona, Colorado, Nebraska, South Dakota, New Mexico, Idaho, California, Texas, Montana (Christiansen 1963, Brock 1998, Deiter 2000, Katz and Shafroth 2003, Zouhar 2005). It meets the biogeographic, spread, and impact criteria for invasive species. The threat that the escaping individuals of *E. angustifolia* pose to the steppe vegetation of Ukraine is often underestimated.

Paczoski (1915), who investigated areas within the west and central Pontic desert steppe zone nearly 100 years ago, noted that "…*Elaeagnus angustifolia is often cultivated, especially in the southern part of the Kherson region. The species is, however, never found in places at some distance from the cultivation site…*". Perhaps Russian olive was in a lag phase (*sensu* Kowarik 1995) during this time. Since the mid-20th century *E. angustifolia* has been occurring more and more frequently. It was the main tree species planted in windbreaks in the desert steppe zone. The protective forest belts created new microhabitats that could attract specific animal species, mainly birds feeding on and dispersing the fruit of Russian olive.

The oldest trees in the forest belts located in the vicinity of the sampled areas were estimated at 47 years old. However, the oldest individuals which had escaped into the wild were about 20 years old. The establishment of the species on a wider scale took place when the seedlings of the tree found a suitable habitat for their growth. Therefore, the changes that occurred in Ukrainian agriculture about 20–25 years ago were of great importance. In the investigated area the limitation of man's impact occurred in 2 stages:

- since the 1960s the area of cultivated land has been reduced and some fields converted into sheep pastures;
- since the late 1980s or early 90s sheep grazing has become less intensive.

It seems, therefore, that the elimination of large herds of sheep played the most important role in the spread of *E. angustifolia*.

The increase in soil salinity in the area investigated is noteworthy. It is the consequence of previous artificial watering of the fields. However, the ongoing transgression of the Black Sea on the north coast could be the main reason for the abandonment of the cultivated fields. The salt in the soil did not prevent the escape of *E. angustifolia* into the wild, although it could have limited, locally or temporarily, the spread of the species. However, further detailed studies are still necessary.

The role that climate changes play in the spread of the species should not be overlooked. According to climatologists (Chornyi 2004, Chornyi and Khotynenko 2005), a tendency towards a more humid climate has been observed in southern Ukraine over the last 25 years (the total annual precipitation has increased by 30–35 mm during this period). The year 1997 was very significant as meteorological stations in Kherson recorded 679 mm of total annual rainfall, which was twice the normal amount (Boiko *et al.* 1998).

The negative impact of *E. angustifolia* increases when it escapes from windbreaks into the wild and encroaches into habitats transformed by man. The tree creates a suitable habitat for weed species (which are much less abundant in the natural desert steppe) by increasing the nitrogen level in soil. When the coverage data were taken into account, a group of relevés with Russian olive from the most strongly altered habitats (abandoned fields) could be easily distinguished. It may be assumed, therefore, that *E. angustifolia* "preserves" the changes induced by man and slows down the process of regeneration of the steppe in places where human activities have ceased. It should be pointed out that only the area in the immediate vicinity of Russian olive trees, which were about 20 years old, was analyzed. It cannot be excluded that the impact of the species on its immediate neighbourhood will increase with the individuals' age (although it is not a long-living species).

Burda (2003) estimates that 84 species of alien trees and shrubs (including *E. angustifolia*) have become established in the agricultural landscape of Ukraine. Among them 9 species were given the status of agriophyte = neophyte *sensu* Thellung (Naegeli and Thellung 1905). *E. angustifolia* is not included in this group. We suggest that the above species should be regarded as one of the most invasive agriophytes, at least in southern Ukraine.

The study area is close to the Black Sea Biosphere Reserve and should be placed under protection within the reserve or designated as a scenic (landscape) park, where agricultural practices would be limited. The regenerating Pontic desert steppe, as well as fragments of the halophyte and littoral vegetation, could be preserved. Both protected and endangered species are noted in the area studied (Moysiyenko and Sudnik-Wójcikowska 2006a, b). The presence of a large number of archaeological monuments (*kurgans* or *tumuli*) is an additional argument for protecting this area. In this case the abundant presence of Russian olive, which is responsible for transformation of the landscape (Fig. 2) and "preservation" of man-made changes in the flora, is highly undesirable. Windbreaks, including those that have been neglected, are not only a regular source of diaspores of *E. angustifolia* but also create favourable microhabitats for birds, which disperse the fruit over longer distances. There is no need to maintain the existing windbreaks in the protected areas. On the other hand, the gradual replacement of *E. angustifolia* by appropriate 'safe' tree species should be considered in windbreaks located in areas which are still under agricultural use.

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