Biodiv. Res. Conserv. 1-2: 77-81, 2006

BRC
www.brc.amu.edu.pl

Dynamics of the flora of windbreaks in the agricultural landscape of steppes in southern Ukraine

Barbara Sudnik-Wójcikowska[1], Ivan Moysiyenko[2] & Pieter A. Slim[3]

[1]Department of Environmental Botany, Warsaw University, Al. Ujazdowskie 4, 00-478 Warszawa, Poland, e-mail: barbara.sudnik@uw.edu.pl
[2]Department of Botany, Kherson State University, 40 let Oktryabrya 27, 73000 Kherson, Ukraine
[3]Alterra, Wageningen University and Research Centre, P.O. Box 47, 6700 AA Wageningen, The Netherlands

Abstract: Floristic studies were conducted in selected fragments of forest belts and adjacent abandoned fields in the fescue/feather-grass and wormwood/sod-grass steppe zones in Kherson and Mykolayiv provinces (southern Ukraine). Protective forest belts (windbreaks) have been planted in Ukraine since the 19th century. They constitute a conspicuous anthropogenic element of the woodless area in the present agricultural landscape of southern Ukraine (in Kherson Province their total length is estimated at 30 000 km). Windbreaks play not only an economic but also an ecological role (e.g. as ecological corridors). At present some of the forest belts are in poor condition and some of the trees have been cut or died. As a result, steppe species colonize some of the gaps in neglected forest stands. These species migrate from areas where anthropogenic influences are minimal, e. g. verges of river valleys, ravines, canyons, 'balkas', kurgans. It is estimated that the dendroflora of windbreaks includes about 80 species. In the fescue/feather-grass steppe zone, tree species like *Elaeagnus angustifolia, Ulmus pumila, Gleditsia triacanthos* and *Cotinus coggygria*, are the most expansive and frequently escape into the wild. Among the self-sown trees, *Elaeagnus angustifolia* is the dominant species in the wormwood/sod-grass steppe zone. In recent years the increasing area of abandoned and less intensively managed cultivated fields as well as limited grazing have been responsible for the intensification of the spread of alien tree species outside the windbreaks. Moreover, the anthropogenic transformation of the soil cover and perhaps the tendency for the climate to become more humid (which has been registered by climatologists for the last 25 years), facilitate the expansion of trees.

Key words: expansive tree species, *Elaeagnus angustifolia,* windbreaks, abandoned fields, steppe zone, Ukraine

1. Introduction

Protective forest belts (windbreaks) have been planted in various woodless areas around the world, e.g. in southern Europe, Africa, North America, Australia. However, they are most widely distributed in the steppe zone of Eurasia, particularly within the borders of the former USSR (Matyakin 1952; Mitryushkina & Pavlovskii 1979).

The establishment of windbreaks (Russian: 'lesopolosy', Ukrainian: 'lisosmugi') in the steppes of southern Ukraine is closely associated with the history of "taming of the steppe". On a large scale the steppe area was converted into fields about 200 years ago. At present agricultural lands occupy over 80% of the area of southern Ukraine. The landscape of the fescue/feather grass steppe zone is largely dominated by cultivated fields, whereas intensively managed pastures and farmlands were a dominant part of the wormwood/sod-grass steppe landscape until recently. Today forest belts are a characteristic anthropogenic element of the woodless landscape of southern Ukraine. They play an important economic role: windbreaks reduce the speed of the wind that blows in the steppe all year round, and thus they prevent wind erosion and dust storms, help to stabilize the snow cover, and improve soil moisture conditions (Matyakin 1952; Ryzhikov 1963; Mitryushkina & Pavlovskii 1979; Skorodumov 1959; Visotskii 1983). They act as barriers to the tumbleweeds ('perekatipole', Fig. 2). Their role as ecological corridors should also be emphasized.

The aims of our investigations were: (*i*) to determine the trends and causes of changes in the present-day flora of windbreaks and adjacent areas; and (*ii*) to draw attention to the problem of tree species that escape from windbreaks into the wild in the steppe zone. This

phenomenon seems to have been overlooked by Ukrainian naturalists so far, although the steppe zone trees are so highly valued by people.

2. The history and present state of windbreaks

The first forest belts or small forest stands were planted in Ukraine at the beginning of the 19th century, at the time when the land started to be cultivated, in order to protect the settlements, hamlets, and eventually the cultivated fields themselves. The area devoid of any trees was subject to continuous winds, which were cold and gusty in winter and dry during hot summers. It is documented that protective forest belts were planted as early as in 1809 in the woodless part of Poltavska Guberniya by the landowner W. J. Lomikowski and they "would catch and hold back the snow, contributing to increased yield of agricultural crops" (Ryzhikov 1963). At the same time, forest belts were established in other country estates in the steppe zone of the Black Sea region. The expedition organized by W.W. Dokuchaev, who launched the campaign against famine caused by severe droughts in Russia in 1891-1892, played an important role in the development of the idea of planting windbreaks. Until the 1930s, however, the general value of windbreaks was not acknowledged. The situation changed when J. V. Stalin implemented the idea of planting windbreaks in his "Plan to Transform Nature". Protective forest belts were more widely planted after 1930 and on a massive scale in the 1950s and 60s. Severe dust storms, which struck the Kherson Province in 1967 and 1969, gave an additional impulse for the establishment of windbreaks. As a result, the total length of protective forest belts exceeds 30 000 km (31 019 ha; ca. 1% of total area) in the Kherson Province, which is situated in the fescue/feather-grass and wormwood/sod-grass steppe zones.

Fig. 1. Windbreaks (protective forest belts) in the agricultural landscape of the fescue/feather-grass steppe zone (near Nova Kakhovka, Kherson Province)

In the fescue/feather-grass steppe zone, windbreaks form a characteristic grid pattern, consisting of rows of trees, which intersect each other at right angles (Fig. 1). The nodes of the grid are spaced fairly regularly (about 1-3 km apart). In the wormwood/sod-grass steppe zone there are fewer forest belts, which are usually planted along major roads.

As most forest belts were planted in the 1950s-1970s, many of the trees have already reached maturity, while others show signs of ageing. As a consequence, the process of natural elimination of trees has started. Foresters postulate that the trees planted in the steppe zone should be replenished every 50 years (pers. comm.). The legal status of windbreaks remains unclear. Until recently they were owned by the kolkhozes. As a result of the privatization in the agricultural sector in Ukraine, forest belts have became no one's possession. In addition, tree management activities have ceased.

3. Material and methods

Floristic observations were carried out in the Kherson and Mykolayiv provinces (southern Ukraine) in 2004-2005 during the growing season. The study focused on forest belts (their total length exceeded 30 km) containing a diversity of tree species, which occurred along the right bank of the Dnieper near Nova Kakhovka (fescue/feather-grass steppe zone) and within close vicinity of the Black Sea Biosphere Reserve (wormwood/sod-grass steppe zone). Special attention was paid to tree species used for windbreaks and those that occurred most frequently on abandoned arable fields and pastures in the immediate vicinity of the forest belts. The relationship between tree species composition (recorded along transects) and floristic richness of the windbreaks will be discussed in a separate work.

On the basis of archival material, interviews with residents and estimation of the age of self-sown tree specimens, we attempted to determine the main causes of changes in the present-day flora of windbreaks and adjacent areas.

The nomenclature of species follows that of Mosyakin & Fedoronchuk (1999).

4. Results and discussion

4.1. Tree flora of windbreaks

It is estimated that the dendroflora of forest belts comprises some 80 species (Moysiyenko & Sudnik-Wójcikowska unpubl.).

In the fescue/feather-grass steppe zone, the flora of windbreaks includes different groups of species. The planted native species, associated with forest-steppes, include e.g. *Acer tataricum, A. campestre, A. platanoides*,

A. pseudoplatanus, Fraxinus excelsior, Lonicera tatarica, Populus nigra, Quercus robur, Ulmus minor and *U. laevis*. In addition to tree taxa, a number of shrubs, which could have been introduced spontaneously, are recorded in windbreaks. Among them, zoochorous (mainly ornithochorous) species dominate. Their seeds and fruit were probably dispersed by animals from river terraces, ravines, 'balkas' (dry erosional depressions), where the human influences are minimal and patches of natural vegetation have survived (as opposed to cultivated fields). The following species belong to this group: *Amygdalus nana, Berberis vulgaris, Crataegus monogyna, Ligustrum vulgare, Padus avium, Prunus stepposa, Rhamnus cathartica, Sambucus nigra* and various *Rosa* species.

Among the alien plants, the following tree species dominate:

- North American: *Acer negundo, Amorpha fruticosa, Celtis occidentalis, Fraxinus pennsylvanica*, *Gleditsia triacanthos, Maclura pomifera* (= *M. aurantiaca*), *Padus serotina, Populus deltoides* and *Ribes aureum*;
- Eurasian or Asian: *Elaeagnus angustifolia*, *Cotinus coggygria, Syringa vulgaris, Ailanthus altissima, Caragana arborescens, Morus alba, Sophora japonica, Ulmus pumila* and *Pinus pallasiana*.

It is noteworthy that windbreaks also include fruit tree species, such as: *Amygdalus vulgaris, Armeniaca vulgaris, Juglans regia, Prunus divaricata, Cerasus vulgaris, C. mahaleb, Malus domestica, Prunus domestica* and *Pyrus communis*.

In the wormwood/sod-grass steppe zone the dendroflora of windbreaks is much poorer in species due to more difficult environmental conditions. The low annual rainfall of about 350 mm and locally increasing soil salinity have limited the range of trees that were planted in protective forest belts. Species native to the forest-steppe zone are almost entirely absent and *Elaeagnus angustifolia* is the dominant species. *Acer negundo, Gleditsia triacanthos* and *Robinia pseudacacia* have been planted less frequently.

4.2. Dynamics of the flora of windbreaks

Changes in the species composition of trees and herbaceous plants have been observed in the forest belts and adjacent areas during the last 2 decades or so. The following trends in the flora of windbreaks are observed in the fescue/feather-grass steppe zone:

(*i*) Impoverishment of the dendroflora: the loss of some tree species, especially those associated with the forest-steppe (e.g. species from the genera *Acer, Ulmus, Populus* and locally *Quercus robur*).

(*ii*) Local colonization of the bigger gaps in forest stands by steppe species. Some of the species are classified as hemi-apophytes (found in habitats slightly transformed by man). These include the following xero-

Fig. 2. Windbreaks as barriers to the tumbleweeds (near Nova Kakhovka, Kherson Province)

mesophyte species: *Achillea setacea, A. pannonica, A. nobilis, Artemisia austriaca, Carex praecox, Coronilla varia, Eryngium campestre, Euphorbia agraria, Falcaria vulgaris, Hypericum elegans, Linaria biebersteinii, Marrubium praecox, Medicago falcata, Poa bulbosa, Seseli campestre, Veronica verna*. In some cases the 'microrestitution' of steppe grassland fragments occurs in places where big gaps in forest stands have existed for a sufficient time period, in treaded places and in close proximity to the source of diaspores of steppe species (refuges, which are not agriculturally managed, such as: river valley sides, ravines, canyons, 'balkas' and even kurgans). As a result, communities with tufted steppe grass species (e.g. *Festuca valesiaca, Koeleria cristata, Stipa capillata*) and xerophytes (*Lavatera thuringiaca, Linum austriacum, Phlomis pungens, Potentilla recta, Ranunculus oxyspermus, Salvia nemorosa, Veronica steppacea*), resembling fragments of natural steppe formations, develop in gaps in the forest stands. Species associated with thermophilous brushwood are noted as well, e.g. *Asparagus verticillatus*.

(*iii*) Expansion of alien tree species out of the windbreaks into the adjacent abandoned fields. The fact that the conditions prevailing in the immediate vicinity of forest belts are less extreme than in the open steppe, facilitates the expansion of trees. The most frequently encountered species that escape from the windbreaks are: *Ulmus pumila* (Fig. 3a), *Elaeagnus angustifolia, Gleditsia triacanthos, Acer negundo, Fraxinus pennsylvanica* and *Cotinus coggygria* (Fig. 3b). The above species can locally threaten open areas and (together with *Ailanthus altissima*) the natural flora of 'balkas'.

In the wormwood/sod-grass steppe zone:

(*i*) None of the tree species planted in windbreaks in this zone shows such a tendency to expand as *Elaeagnus angustifolia* does (Fig. 4). This species

a b

Fig. 3. The "escape" of trees from the windbreaks into abandoned fields in the fescue/feather-grass steppe ("Jelanetzkii Steppe", Mykolayiv Province): (a) *Ulmus pumila*; (b) *Cotinus coggygria*

occurs as a weed on fallow fields and extensively used pastures, especially those gradually transformed into 'solonetz'. This species reproduces both sexually and vegetatively. It is dispersed by birds over long distances. The trees occur singly or in small groups (1-2 individuals), often at a considerable distance from each other and from the forest belts. It is easy to notice that the flora recorded around self-sown trees, within the root zone, is very different from the flora of the wormwood/sod-grass steppe and 'solonetz'. This attests to the role of symbiotic actinomycetes.

(*ii*) It is interesting that Paczoski (1915), who investigated these areas nearly 100 years ago, reported: "…*Elaeagnus angustifolia* is often cultivated, especially in the southern part of the Kherson Province. The species is, however, never found at some distance from the cultivation site".

4.3. Causes of changes in the flora of windbreaks

The observed dynamics in the flora of windbreaks can be associated with the economic crisis and political transformations which have occurred in Ukraine in the last 10-20 years or so. This in turn has led to the following activities within the forest belts:

- uncontrolled felling of trees, which increased dramatically during the 1990s;
- limited or lack of care and maintenance of trees (due to limited financial support): dead and sick trees are not removed, and new trees are not planted – as a result gaps in forest stands appear.

Fig. 4. *Elaeagnus angustifolia* on extensively used pastures in the wormwood/sod-grass steppe near the Black Sea Biosphere Reserve (Kherson Province)

The following changes that take place in adjacent areas also have an effect on the condition of the forest belts:

- in recent years, frequent burning of fields, which also destroys fragments of forest belts;
- limited watering of fields, which also has an effect on the trees;
- abandonment of some agricultural fields in the fescue/feather-grass steppe zone. It appears that trees encroach more easily on anthropogenically transformed soils. The moisture regime of cultivated soils is better suited for trees than that of steppe soils. The snow cover remains for a longer time on the fields that are surrounded by windbreaks. Evaporation rate is lower and relative humidity is higher. Consequently the microclimate is more suitable to trees on those fields (especially if they have been recently abandoned). Undoubtedly the process of trees escaping from cultivation had taken place even earlier, but regular cultivation of the soil prevented the species from spreading further;
- abandonment of cultivated fields, and even occasionally pastures in the wormwood/sod-grass steppe zone, due to increased soil salinity;
- significant changes in the animal breeding structure: large herds consisting of several thousands of sheep have disappeared and were replaced by smaller herds of cattle.

It must be mentioned here that natural factors can also contribute to the process of trees escaping into the wild. According to climatologists (Chornyi 2004; Chornyi & Khotynenko 2005), a tendency towards a more humid climate has been observed in the last 25 years (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 annual rainfall, which was twice the normal annual rainfall (Boiko 1998).

The collected data on the age of self-sown specimens confirm that the expansion of species started after ploughing, mowing and intensive grazing had ceased. It seems that the reintroduction of cultivation and grazing can to some extent impede the spread of more expansive tree species. It should be emphasized, however, that the problem of expansive tree species is poorly recognized in southern Ukraine.

References

Boiko M. F. (ed.). 1998. Pryroda Khersonskoi oblasti. 120 pp. Fitosociocentre, Kyiv.

Chornyi S. G. 2004. Klimat ta eroziini procesy na pivdni Ukrainy. Visnyk agrarnoi nauky 4: 52-55.

Chornyi S. & Khotynenko O. 2005. Suchasna zmina klimatu v stepu Ukrainy ta protydeflyatziina nebezpeka. Zbirnyk naukovykh pratz` „Regyonalni problemy Ukrainy: geografichnii analiz ta poshuk shlyakhiv vyrishennya. pp. 43-46. PP Vishemirskii, Kherson.

Matyakin G. I. 1952. Lesnye polezashchitnye polosy i mikroklimat. 144 pp. Geografgiz, Moskva.

Mitryushkina K. P. & Pavlovskii E. S. 1979. Les i pole. 279 pp. Kolos, Moskva.

Mosyakin S. L. & Fedoronchuk M. M. 1999. Vascular plants of Ukraine. A nomenclatural checklist. 346 pp. National Academy of Sciences of Ukraine, M. G. Kholodny Institute of Botany, Kiev.

Paczoski J. K. 1915. Opisanie rastitelnos'ti Khersonskoi gubernii. Vypusk 1. Lesa. 203 pp. Jestestv.-istorich. Muzei Khers. Gub. Zem., Kherson.

Ryzhikov D. T. 1963. Vliyanie polezashchitnykh polos na urozhai selskokhozyaystvennykh kultur. 208 pp. Izdat. Selskokhozyaistvennoi literatury, zhurnalov i plakatov, Moskva.

Skorodumov O. S. 1959. Vplyv lisovykh nasadzhen` na grunty v stepi. 224 pp. Vydavnyztvo Ukrainskoi Akademii Silskogospodars`kikh Nauk, Kyiv.

Visotskii G. N. 1983. Zashchitnoe lesozavedenie. 208 pp. Naukova Dumka, Kyiv.