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RESEARCH ARTICLE

# Plant communities with naturalized *Elaeagnus angustifolia* L. as a new vegetation element in Altai Krai (Southwestern Siberia, Russia)

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## Abstract

*Elaeagnus angustifolia* L. (Russian olive) is a deciduous small tree or large multi-stemmed shrub that becomes invader in different countries all other the world. It is potentially invasive in some regions of Russia. In the beginning of 20$^{th}$ century, it was introduced to the steppe region of Altai Krai (Russia, southwestern Siberia) to prevent wind erosion. During last 20 years, Russian olive starts to create its own natural stands and to influence on native vegetation. This article presents the results of ecocoenotic survey of natural plant communities dominated by *Elaeagnus angustifolia* L. first described for Siberia and the analysis of their possible syntaxonomic position. The investigation conducted during summer season 2012 in the steppe region of Altai Krai allows revealing one new for Siberia association ***Elytrigio repentis–Elaeagnetum angustifoliae*** and no-ranged community ***Bromopsis inermis–Elaeagnus angustifolia*** which were included to the Class ***Nerio–Tamaricetea***, to the Order ***Tamaricetalia ramosissimae***. During the study, the following special features of communities have been described: polydominance of herbal layer, anthropogenic and grazing load, variation of the species richness, plant cover and vertical stratification into layers. These peculiarities mostly prove unestablished character of communities, all of them are relatively young (25–30 years). Russian olive shrubberies varies in moisture and saline regime, which connected with their existence in different landforms (lake alluvial plains, gentle slopes of lakes, low lake terraces).

## Keywords

Geobotanical relevés, invasion, Kulunda steppe, naturalized plants, ordination, Russian olive, syntaxonomy

## Introduction

*Elaeagnus angustifolia* L. (Russian olive) is a deciduous summer green tree (shrub) in the Oleaster family (Elaeagnaceae Juss.), has large and brunched root system located in upper soil horizons (Ovchinnikov and Zaprjagaeva 1981). It has a rapid growth rate when young becoming moderate with age (Gilman and Watson 1993). In Altai Krai it is a shrub 2–2.5 m in height when growing in depraved overwetting conditions and can reach 5–6 m on a good aerated soils. *E. angustifolia* is an actinhorizal species, participating in a nitrogen-fixing symbiosis with actinomycetes (Katz and Shafrot 2003). It helps to adapt to a very poor soil conditions.

*E. angustifolia* is native to Europe and western Asia but it largely spreads in USA (mostly in the north-west) and in Canada because it has been planted as horticulture, for windbreaks and shelterbelts and now classifying as an invader (Tu 2003, Center for Invasive Species and Ecosystem Health https://www.invasive.org/browse/subinfo.cfm?sub=3022). Russian Olive reproduces mostly vegetatively – numerous root suckers are produced at the root crown very fast and it can occupy a vast territories in a short time. In addition, it use animals (frequently birds) for seeds dispersal and sometimes water.

Russian olive is potentially invasive in some regions of Russia (Ebel et al. 2014; Starodubtseva et al. 2014). However, other investigations highlighted that *E. angustifolia* stands have a positive impact on development of pasture vegetation. In recent years, several studies on pasture and forest-pasture ecosystems dominated by Russian olive in Volga-Akhtuba floodplain and semi-desert regions (Russia) have been made. They showed that comfortable conditions for grasses occurs under the canopy of *E. angustifolia* stands. Separate groups of trees create a special microclimate. Thus, in the middle of the day temperature under the canopy decreases on 3 °C, humidity increases on 3.8 % and wind speed falls on 37–62 % (Vdovenko et al. 2018). Such conditions looks better for grasses and productivity of herbal layer increases.

The history of Russian olive appearance in Altai Krai starts from 1920$^{th}$ when steppe regions were under the influence of the strong drought. From specialized tree nurseries *E. angustifolia* was planted to the regions of Western Kulunda for windbreaks and also to Talmensk forestry and to the city of Barnaul (Luchnik 1970; Paramonov at al. 1997). However, only in 1990$^{th}$ first naturalized trees have been matched in Kulunda steppe. Nowadays *E. angustifolia* is included in Black Book of the Siberian Flora (Silantjeva and Kirina 2016) as a "transformer" species for Altai Krai. Communities with Russian olive are still not enough studied in steppe regions and the influence of its stands on the vegetation is not obvious. The aim of our study was goebotanical survey of relatively new and insufficiently researched communities with *E. ungustifolia* on the territory of Altai Krai.

This survey aimed to provide a comprehensive characteristic of communities with *Elaeagnus angustifolia*, first described for Siberia, and the analysis of their possible syntaxonomic position.

## Material and methods

The investigation was conducted in the steppe and forest–steppe zones on the left bank of the Ob River in eight districts of Altai Krai (Blagoveshchensky, Burlinsky, Kalmansky, Klyuchevskoj, Kulundinsky, Romanovsky, Rubtsovsky, Tabunsky). Twelve complete geobotanical relevés, i.e. plots performed by a standard procedure at the 20x20 m have been used in analysis of vegetation. Each sample area was described in terms of position within landform and position in the Kulunda steppe structure. In addition, GPS coordinates have been recorded. The relevés were stored in the TURBOVEG database (Hennekens 1996). Two-dimensional analysis of indicator species was implemented during the work (package TWINSPAN) based on cluster analysis (Hill 1979). The quantitative processing of data was based on the screening of relevés and obtaining groups (clusters) of floristically homogeneous vegetation samples for subsequent syntaxonomic analysis. In addition, detrended correspondence analysis (DCA) ordination was carried out using package CANOCO 4.5 (ter Braak, Smilauer 2002).

While performing the classification, we took into account not only the species composition of communities, but also such characteristics as plant cover and constancy. Plant cover was assessed on a one to five scale: (+) – less than 1 %; 1 – less than 5 %; 2 – 6–15 %; 3 – 16–25 %; 4 – 26–50 %; 5 – more than 50 %. Geobotanical relevés were summarized in phytocenological tables and a constancy class was established for each species: I – less than 20 %; II – 21–40 %; III – 41–60 %; IV – 61–80 %; V – 81–100 %. The classification of plant communities was carried out using the Braun-Blanquet approach (Braun-Blanquet 1964; Westhoff and van der Maarel, 1978), furthermore "deductive method" according Kopečky and Hejny (1974) has been applied. To determine and characterize syntaxa, we used diagnostic species, which include a combination of differential and constant species (Westhoff and van der Maarel 1973).

Species names follow the list of vascular plants of the former USSR (Cherepanov 1995). Nomenclature of syntaxa follows the rules of the International Code of Phytosociological nomenclature (Weber et al. 2000).

## Results

Plant communities with naturalized *Elaeagnus angustifolia* being revealed during our investigation occupy lake gentle slopes, low flat lake terraces and flat-lowlands with saline meadows in complex with grasses-cerial marsh meadows. Sometimes communities are common for lake lowlands with halophyte grass-cerial often shrubby steppe meadows and high wavy and flat ancient lake terraces.

Distinguishing ecological feature of communities is allocation on alluvial soils characterized by chloride-sulfate and sulfate–chloride–type salinization, which can vary from horizon to horizon. Shrubby communities under research appear and

spread on the banks of steppe lakes and rivers (including Kulunda channel). Soil salinization on the high flood plains and terraces is developed in the same way as in Dauria characterized by changes in hydrological regime due to the lack of spring flooding but shallow groundwater. Lateral flooding from surface and underground water that concentrate in lowlands influence on high elements. Dry climate lead to transpiration of shallow ground water and soil salinization increases due to weak water inflow from outside and weak washing of soil with fresh flood water (Belikovich 2017). In such conditions, Russian olive appears and starts to create shrubby communities instead of meadow (steppe-meadow).

Floristic survey of communities dominated by naturalized *Elaeagnus angustifolia* recorded 99 vascular plant species (88 native and 11 adventive) belonging to 77 genera and 25 families. The most conspicuous families are Asteraceae (24 species), Poaceae (18), Fabaceae (10), Brassicaceae (6), Lamiaceae (6), Rosaceae (5). A significant role in communities play halotolerant plants (halophytes and glycophytes): *Artemisia glauca*, *A. schrenkiana*, *A. scoparia*, *Hordeum brevisubulatum*, *Inula britannica*, *Phragmites australis*, *Plantago salsa*, *Salicornia perennans*, *Potentilla anserina* etc. that include 12 % from all floristic composition. It is necessary to note that dominant of communities *Elaeagnus angustifolia* is also a glycohalophyte.

In general, the communities under study are identified by a group of mesophytes (35 %) and mesoxerophytes (31 %) with less participation of xerophytes (14 %). The percentage of hygrophytes is rather small (7 %). Ecological analysis showed prevalence of drought-tolerant plants (mesoxerophytes and euxerophytes), containing 45 % from species composition. This sharing underline ecological peculiarities of steppe communities.

Analysis of life forms according to I. G. Serebryakov (1964) shows the predominance of herbs (86 %) among which the most numerous ones are perennial plants (58 %). Long-rhizome plants have the leading position among perennial herbs (18 %) (e.g. *Elytrigia repens*, *Inula salicina*, *Poa pratensis*), the second place – taproot herbs (15 %) (e.g. *Taraxacum officinale*, *Medicago falcata*, *Lepidium crassifolium*), followed by loose cespitose plants (10 %) – *Poa angustifolia*. Annual plants are represented by 8 species three of which are adventive: *Atriplex sagittata*, *Cannabis sativa*, *Lepidium ruderale*. The predominance of rhizome herbs under cespitose plants is considered as specific feature of shrubbery with naturalized *Elaeagnus angustifolia* that we investigated. This peculiarity differs our communities from steppe ones. The llatter are characterized by prevailing of narrow-leaf (rarely broad-leaf) cespitose plants (Mordokovich 2014). The structure of life forms according to C. Raunkiær (1934) shows that the leading position in plant communities is held by hemicryptophytes (65 species), less presented: geophytes (11 species), therophytes (10), phanerophytes (6), chamephytes (5), hydrophytes (2).

The dominant of communities *Elaeagnus angustifolia* is alien plant for the territory of Altai Krai, which start to create natural shrubberies only ten-twenty years ago. So communities under study are nowadays only on the stage of development. That fact could be the explanation for a significant amount of weed plants, which appear their and feel good in new comfortable conditions. Some of them are *Achil-*

*lea millefolium*, *Linaria vulgaris*, *Equisetum arvense*, *Sonchus arvensis*, *Convolvulus arvensis* etc. In addition, the amount of adventive species is considerable (more than 10 %) some of which also belongs to the group of weeds: *Lepidium ruderale*, *Sisymbrium loeselii*, *Hordeum jubatum*, *Cannabis sativa*.

Chorological analysis shows that the Eurasian element is clearly the predominant (65 %) followed by Holarctic group (16 %). This distribution is generally common for Holarctic boreal flora of Eurasia. Cosmopolite group include 10 % of species.

## Discussion

As a result of Braun-Blanquet classification and comparative syntaxonomic analysis it was revealed that vegetation communities with *E. angustifolia* could be included in one class, order and alliance, one rankless unit – "community" and new for Siberia association.

### Prodromus of communities including *Elaeagnus angustifolia*:

**Class *Nerio–Tamaricetea* Br.-Bl. et Bolos 1958**
**Order *Tamaricetalia ramosissimae* Golub 2001**
**Suborder *Tamaricetalia ramosissimae* Golub et Kuzm. 1996**
**Alliance *Galio humifusi–Tamaricetum ramosissimae* Golub et Kuzm. 1996**
**Association *Elytrigio repentis–Elaeagnetum angustifoliae* ass. nov. hoc loco**
**Community *Bromopsis inermis–Elaeagnus angustifolia***

Class ***Nerio–Tamaricetea*** Br.-Bl. et Bolos 1958

Shrub and wood-shrub communities occurred in arid and sub-arid regions of Mediterranean and Eurasia are included into this class. Habitats of these phytocenosis are characterized by high level of ground water and usually saline soils.

For Russia, this class has not been established primary, however groups belonging to it have been revealed in the valley of the Lower Volga River according to literature. Thus, Golub and Kuzmin (2004) perform three associations, in which *E. angustifolia* dominants. These stands occupy areas where hydrological and hydrogeological regimes have been anthropogenically disturbed.

We use eco-floristic approach to describe communities with *E. angustifolia* for the first time for Altai Krai.

#### Order *Tamaricetalia ramosissimae* Golub 2001

Communities belonging to these order and class usually inhabit valleys of temporary and constant watercourses as well as irrigational systems and oases where the high level of ground water directly related with anthropogenic pressure. Plant commu-

nities included in the Order *Tamaricetalia ramosissimae* show dominance of small trees and shrubs–phreatophytes (representatives of genera *Tamarix* and *Elaeagnus*). They are distributed in the south-west of Europe and in Middle Asia (Barmin 2001). Some of cenosis in Altai Krai are under grazing load and very ruderalized.

Diagnostic species: *Elaeagnus angustifolia*, *Calamagrostis epigeios*.

**Suborder *Tamaricetalia ramosissimae* Golub et Kuzm. 1996**

Diagnostic species of the suborder = diagnostic species of the order. It is communities with dominance of small trees and shrubs–phreatophytes in the southeastern part of Europe.

**Alliance *Galio humifusi–Tamaricetum ramosissimae* Golub et Kuzm. 1996**

Diagnostic species: *Solanum kitagawae*, *Taraxacum officinale*.

Xeromesophytic communities dominanted by *E. angustifolia* are used as pastoral land.

In the frame of alliance, we revealed: association *Elytrigio repentis–Elaeagnetum angustifoliae*, community *Bromopsis inermis–Elaeagnus angustifolia* (Table 1).

**Association *Elytrigio repentis–Elaeagnetum angustifoliae* ass. nov. hoc loco**

Association Elytrigio repentis–Elaeagnetum angustifoliae ass. nov. hoc loco (Table 1., nomenclature type (holotypus) – relevé 2 (author number 4–12–III): Altai Krai, Kalmansky district, vicinity of Kalmanka village, left bank of the Marushka river, 52.91035°N, 83.50911°E, 17.06.2012. Author – A.A. Shibanova).

Diagnostic species: *Elytrigia repens*, *Medicago falcata*, *M. lupulina*, *Festuca valesiaca*, *Hordeum jubatum*, *Juncus compressus*, *Lepidium crassifolium*, P*oa angustifolia*, *Taraxacum officinale*.

This community occurs in Blagoveshchensky, Burlinsky, Kalmansky, Klyuchevskoj, Kulundinsky, Rubtsovsky, Tabunsky districts of Altai Krai (Fig.1). It occupies high wavy and flat ancient lake terraces with meadow–boggy solonchakous soils and chestnut–meadow solonetz. Soils under most communities are characterized by chloride-sulfate and sulfate–chloride–type salinization, which can vary from horizon to horizon.

Canopy density varies from 0.4 to 0.9. The herb and shrub layers cover is 30–80 % and species richness 14–28 species per plot. Significant part of herb layer is occupied by graminoid (*Elytrigia repens*, *Festuca valesiaca*, *Poa angustifolia*) with cover up to 40 %. Sometimes *E. angustifolia* forms single species thickets with canopy density up to 90 %. Herb layer is poorly developed with the average cover 55 %.

Grazing digression was performed for most communities, providing abundant appearance of the following species: *Taraxacum officinale*, *Lepidium crassifolium*, *Hordeum jubatum*, *Elytrigia repens*, *Berteroa incana*, *Sonchus arvensis*. The lack of frozen brunches proves that Russian olive shrubs feel good in these communities

**Table 1.** Association ***Elytrigio repentis–Elaeagnetum angustifoliae***, community ***Bromopsis inermis–Elaeagnus angustifolia.***

| Number of relevé | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Constancy | 11 | 12 | Constancy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field number | 8 - 12 - III | 4 - 12 - III | 10 - 12 - III | 9 - 12 - III | 1 - 12 - III | 6 - 12 - III | 7 - 12 - III | 5 - 12 - III | 3 - 12 - III | 2 - 12 - III | | 11 - 12 - III | 12 - 12 - III | |
| Canopy density | 0.5 | 0.6 | 0.4 | 0.4 | 0.9 | 0.4 | 0.6 | 0.5 | 0.5 | 0.6 | | 0.3 | 0.4 | |
| Cover grass and shrub layer, % | 80 | 60 | 70 | 70 | 50 | 60 | 30 | 40 | 50 | 60 | | 40 | 40 | |
| Total number of species | 14 | 22 | 26 | 15 | 15 | 21 | 24 | 27 | 24 | 28 | | 17 | 29 | |
| Dominant of upper layer | | | | | | | | | | | | | | |
| *Elaeagnus angustifolia* | 3 | 5 | 3 | 1 | 2 | 4 | 2 | 2 | 4 | 5 | **V** | 4 | 4 | **2** |
| D. s. of association ***Elytrigio repentis–Elaeagnetum angustifoliae*** | | | | | | | | | | | | | | |
| *Elytrigia repens* | 1 | 2 | - | 1 | - | 2 | 2 | 2 | + | + | **IV** | - | - | **.** |
| *Medicago falcata* | - | + | + | + | + | - | 1 | + | + | + | **V** | + | - | **1** |
| *M. lupulina* | - | 2 | 1 | + | 2 | + | + | + | + | + | **V** | - | - | **.** |
| *Festuca valesiaca* | - | + | 2 | 2 | - | - | + | - | 1 | 1 | **IV** | - | - | **.** |
| *Hordeum jubatum* | + | + | - | - | + | + | - | + | + | 1 | **IV** | - | - | **.** |
| *Juncus compressus* | 2 | 2 | - | - | + | 1 | + | + | 2 | + | **IV** | - | - | **.** |
| *Lepidium crassifolium* | 2 | 2 | - | - | + | - | 1 | - | + | + | **IV** | - | - | **.** |
| *Poa angustifolia* | - | 2 | 1 | 1 | 2 | - | - | - | 1 | 2 | **IV** | 2 | - | **1** |
| *Taraxacum officinale* | - | 1 | + | - | + | 2 | - | + | 2 | + | **IV** | - | - | **.** |
| D. s. of community ***Bromopsis inermis–Elaeagnus angustifolia*** | | | | | | | | | | | | | | |
| *Bromopsis inermis* | - | - | + | - | - | - | 2 | 2 | 1 | 1 | **III** | 2 | 2 | **2** |
| *Poa pratensis* | - | - | - | - | - | + | 3 | 2 | - | - | **II** | - | 2 | **1** |
| *Atriplex sagittata* | + | - | - | - | - | + | - | - | - | + | **II** | - | + | **1** |
| *Carduus crispus* | - | - | - | - | - | - | - | - | - | - | **.** | + | + | **2** |
| *Equisetum arvense* | - | - | - | - | - | - | - | - | - | - | **.** | + | + | **2** |
| *Eryngium planum* | - | - | - | - | - | + | - | - | + | + | **II** | - | + | **1** |
| *Inula salicina* | - | - | - | - | - | - | - | - | - | - | **.** | + | + | **2** |
| *Serratula coronata* | - | - | - | - | - | - | - | - | - | - | **.** | + | + | **2** |
| *Potentilla anserina* | - | + | - | - | + | + | - | + | - | - | **II** | - | + | **1** |
| D. s. of suborder ***Tamaricetalia ramosissimae*** | | | | | | | | | | | | | | |
| *Calamagrostis epigeios* | - | + | - | - | 3 | + | + | - | - | - | II | - | - | **.** |
| *D. s.* of class *Nerio-Tamaricetea* and order *Tamaricetalia* | | | | | | | | | | | | | | |
| *Phragmites australis* | 2 | - | - | - | - | + | - | - | - | - | I | 1 | 2 | **2** |
| **Other species** | | | | | | | | | | | | | | |
| *Centaurea scabiosa* | - | - | + | - | - | - | - | - | - | - | I | - | - | **.** |
| *Artemisia scoparia* | - | 1 | + | + | - | - | + | - | + | - | III | - | + | **1** |
| *Plantago salsa* | - | + | 1 | 2 | - | - | - | - | + | - | III | - | - | **.** |
| *Acer negundo* | - | - | - | - | - | - | + | + | - | - | II | - | - | **.** |
| *Achillea millefolium* | - | - | - | - | - | - | + | + | - | + | **II** | - | + | **1** |

| Number of relevé | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Constancy | 11 | 12 | Constancy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field number | 8 - 12 - III | 4 - 12 - III | 10 - 12 - III | 9 - 12 - III | 1 - 12 - III | 6 - 12 - III | 7 - 12 - III | 5 - 12 - III | 3 - 12 - III | 2 - 12 - III | | 11 - 12 - III | 12 - 12 - III | |
| Canopy density | 0.5 | 0.6 | 0.4 | 0.4 | 0.9 | 0.4 | 0.6 | 0.5 | 0.5 | 0.6 | | 0.3 | 0.4 | |
| Cover grass and shrub layer, % | 80 | 60 | 70 | 70 | 50 | 60 | 30 | 40 | 50 | 60 | | 40 | 40 | |
| Total number of species | 14 | 22 | 26 | 15 | 15 | 21 | 24 | 27 | 24 | 28 | | 17 | 29 | |
| *Achillea nobilis* | - | - | 1 | 1 | - | - | - | - | - | - | **II** | - | - | **.** |
| *Arctium tomentosum* | - | - | - | - | - | - | - | 1 | - | - | **I** | - | + | **1** |
| *Artemisia frigida* | - | - | 1 | 2 | - | - | - | - | - | + | **II** | - | - | **.** |
| *Artemisia glauca* | - | - | + | + | - | - | - | - | - | - | **II** | - | - | **.** |
| *Artemisia nitrosa* | 1 | - | - | - | - | 2 | - | - | - | - | **II** | - | - | **.** |
| *Berteroa incana* | - | - | 1 | + | - | - | + | + | - | + | **III** | - | - | **.** |
| *Cannabis ruderalis* | - | - | - | - | - | - | - | + | - | + | **II** | - | - | **.** |
| *Cichorium intybus* | - | - | - | - | - | - | - | - | 1 | - | **I** | 1 | - | **1** |
| *Convolvulus arvensis* | - | - | - | - | - | - | + | + | - | + | **II** | - | - | **.** |
| *Euphorbia virgata* | - | - | - | - | - | - | + | + | - | - | **II** | 2 | - | **1** |
| *Glycyrrhiza uralensis* | + | 1 | - | - | + | - | - | - | - | - | **II** | - | - | **.** |
| *Hordeum brevisubulatum* | - | + | + | - | - | - | - | - | - | 1 | **II** | - | + | **1** |
| *Inula britannica* | - | - | - | - | - | - | - | - | + | 1 | **II** | - | - | **.** |
| *Leymus ramosus* | - | - | 2 | 1 | - | - | - | - | - | - | **II** | - | - | **.** |
| *Lotus sergievskiae* | - | 1 | - | - | + | - | - | - | - | - | **II** | - | - | **.** |
| *Melilotus dentatus* | + | + | - | - | - | + | - | - | + | - | **II** | - | - | **.** |
| *Odontites vulgaris* | - | + | - | - | + | - | - | - | - | - | **II** | - | - | **.** |
| *Phlomoides tuberosa* | - | - | + | - | - | - | - | - | - | - | **I** | - | + | **1** |
| *Plantago major* | - | - | - | - | - | - | - | - | + | - | **I** | - | + | **1** |
| *Potentilla argentea* | - | - | + | + | - | - | - | - | + | 1 | **III** | - | - | **.** |
| *Potentilla bifurca* | - | - | - | - | - | - | - | - | + | - | **I** | - | + | **1** |
| *Puccinellia distans* | + | + | - | - | - | + | - | - | - | + | **II** | - | - | **.** |
| *Sisymbrium loeselii* | - | - | - | - | - | - | + | + | - | + | **II** | - | - | **.** |
| *Solanum kitagawae* | - | - | - | - | - | + | - | + | - | - | **II** | - | - | **.** |
| *Sonchus arvensis* | - | - | - | - | - | - | 1 | 1 | - | - | **II** | + | - | **1** |
| *Tripleurospermum perforatum* | - | - | - | - | - | + | - | - | - | + | **II** | - | - | **.** |
| *Carex acuta* | - | - | - | - | - | - | - | 1 | - | - | **I** | - | 2 | **1** |

**Notes. Species with low frequencies:** *Agrostis gigantea* 8: 2; *Vicia sativa* 7: +; *Bolboschoenus planiculmis* 8: 2; *Alisma plantago-aquatica* 8: +; *Vicia cracca* 5: +; *Lepidium ruderale* 7: +; *Kochia prostrata* 7: +; *Herniaria polygama* 9: +; *Bassia sedoides* 6: +; *Lycopus exaltatus* 6: +; *Rumex crispus* 6: +; *Acroptilon repens* 7: +; *Myosotis cespitosa* 5: +; *Agropyron pectinatum* 7: +; *Salicornia perennans* 6: +; *Calystegia sepium* 12: +; *Agrimonia pilosa* 12: +; *Dactylis glomerata* 12: 1; *Salix alba* 11: 1; *Astragalus testiculatus* 10: +; *Salvia stepposa* 12: 2; *Scutellaria scordiifolia* 12: +; *Salix caprea* 11: 1; *Cirsium setosum* 12: +; *Glechoma hederacea* 12: +; *Senecio*

(Shibanova et al. 2013). Sometimes *E. angustifolia* has a form of multi-stemmed tree with the height 4.5 m.

It must be admitted that syntaxonomic position of the association *Elytrigio repentis–Elaeagnetum angustifoliae* in the class ***Nerio–Tamaricetea*** is still discussible. For the following deep clarification, we need geographically wider investigations. Association *Elytrigio repentis–Elaeagnetum angustifoliae* described for the first time for Siberia cannot be classified as natural herbaceous and synanthropic classes, as it forms woody vegetation dominated by *E. angustifolia*.

**Community *Bromopsis inermis–Elaeagnus angustifolia***

Diagnostic species: *Bromopsis inermis*, *Poa pratensis*, *Atriplex sagittata*, *Carduus crispus*, *Equisetum arvense*, *Inula salicina*, *Serratula coronata*, *Potentilla anserina*.

This community was described from Klyuchevskoj and Romanovsky districts where it occupies lake gentle slopes on the chestnut soils, low flat lake terraces and flat-lowlands with saline meadows in complex with grasses–cerial marsh meadows on meadow–chernozemics solonchakous and meadow–boggy solonetzic and solonchakous soils. Sometimes communities are common for lake lowlands with halophyte grass–cerial often shrubby steppe meadows on meadow solonetz and solonchak and meadow-solonchakous soils.

*jacobaea* 10: +; *Phleum phleoides* 10: +; *Linaria vulgaris* 12: +; *Medicago sativa* 12: +; *Plantago lanceolata* 10: +; *Carex praecox* 10: 1; *Geranium pratense* 12: +; *Crepis tectorum* 10: +; *Galium ruthenicum* 10: +; *Thymus marschallianus* 10: +; *Odontites vulgaris* 11: 1; *Alopecurus arundinaceus* 11: +; *Achillea asiatica* 11: +; *Astragalus danicus* 1: 1; *Lactuca sibirica* 2: +; *Malus baccata* 2: +; *Galatella angustissima* 1: +; *Lactuca tatarica* 4: +; *Cacalia hastata* 5: +; *Puccinellia tenuissima* 3: 2; *Melilotus officinalis* 2: +; *Poa palustris* 5: 1; *Alopecurus pratensis* 4: +; *Descurainia sophia* 5: +; *Oberna behen* 5: +; *Ribes nigrum* 2: +; *Polygonum aviculare* 3: +; *Erysimum hieracifolium* 3: +; *Euphorbia uralensis* 3: 1.

**Relevés's localities** (all relevés have been made in Altai Krai in 2012): 1 – 16 VI, Blagoveshchensky district, on the south-west of Blagoveshchensky village (along the road to Kulunda), 52.82564°N, 79.82161°E; 2 – 17 VI, Kalmansky district, vicinity of Kalmanka village, left bank of the Marushka river, 52.91035°N, 83.50911°E; 3 – 17 VI, Kalmansky district, vicinity of Kalmanka village, left bank of the Marushka river, 52.91021°N, 83.50878°E; 4 – 15 VI, Klyuchevskoj district, on the south from Severka village, 52.12650°N, 79.28267°E; 5 – 15 VI, Klyuchevskoj district, on the south from Severka village, 52.12532°N, 79.28344°E; 6 – 18 VI, Tabunsky district, vicinity of Lebedino village, bank of Lake Shoshkaly, 52.78891°N, 79,31348°E; 7 – 16 VI, Burlinsky district, eastern bank of Lake Bol. Topolnoe, 53.35242°N, 78.05323°E; 8 – 15 VI, Rubtsovsky district, on the west from town Rubtsovsk, on the left from the road to Novoegorjevka village, 51.56342°N, 81.12960°E; 9 – 15 VI, Romanovsky district, bank of the pound on the east of Tambovskoe village, 52.65559°N, 80.99399°E; 10 – 15 VI, Romanovsky district, bank of the pound on the east of Tambovskoe village, 52.65645°N, 80.99213°E; 11 – 15 VI, Kulundinsky district, vicinity of Kulunda village, south-western bank of Lake Schekulduk, 52.53571°N, 78.84041°E; 12 – 15 VI, Blagoveshchensky district, vicinity of Blagoveshchensky village, north bank of Lake Kuchukskoe, 52.77498°N, 79.73798°E.

**Relevés author:** A.A. Shibanova.

Canopy density is 0.3–0.4. Average height of herb layer – 60 sm. Herb and shrub layers together are characterized by cover 40–60 % and species richness 17–29 species per plot. Distinguishing feature of the association is a higher role of meadow-steppe species (*Poa angustifolia*, *P. pratensis*, *Elytrigia repens*, *Calamagrostis epigeios*, *Medicago falcata*) meanwhile xerophilous species are not significant in community (1–2 species with low abundance). *E. angustifolia* grows quite abundantly in community with the presence of mixed-age sprouts but does not create a dense shrub layer. Some crowns are damaged by freezing.

Analysis of participation of diagnostic species from other classes in the researched communities revealed many diagnostic species from herbaceous classes, but according to the totality of physiognomic and structural features, the selected association cannot be attributed there. Thus, six diagnostic species belong to the cl. *Molinio-Arrhenatheretea* (*Achillea millefolium*, *Agrostis gigantea*, *Bromopsis inermis*, *Elytrigia repens*, *Plantago lanceolata*, *Poa pratensis*, *Vicia cracca*), two species to the cl. *Trifolio-Geranietea* (*Agrimonia pilosa*, *Crepis tectorum*). To the steppe vegetation classes: six species – cl. *Festuco-Brometea* (*Astragalus danicus*, *Festuca valesiaca*, *Medicago falcata*, *Phleum phleoides*, *Phlomoides tuberosa*, *Poa angustifolia*), two species – cl. *Cleistogenetea-Squarrosa* (*Artemisia frigida*, *Potentilla bifurca*). Diagnostic species of synanthropic vegetation classes: cl. *Stellaria media* – four species (*Convolvulus arvensis*, *Descurainia sophia*, *Medicago lupulina*, *Sonchus arvensis*), cl. *Artemisietea vulgaris* – eight species (*Achillea asiatica*, *Arctium tomentosum*, *Berteroa incana*, *Carduus crispus*, *Dactylis glomerata*, *Linaria vulgaris*, *Melilotus officinalis*, *Potentilla argentea*), cl. *Polygono arenastri-Poetea annuae* – four species (*Plantago major*, *Polygonum aviculare*, *Potentilla anserine*, *Taraxacum officinale*). Diagnostic species of salina soil vegetation classes: cl. *Scorzonero-Juncetea gerardii* – three species (*Alopecurus arundinaceus*, *Hordeum brevisubulatum*, *Juncus compressus*), cl. *Festuco-Puccinellietea* – one species (*Plantago salsa*). One species *Artemisia scoparia* belongs to the class *Pyrolo-Pinetea*.

Association *Elytrigio repentis–Elaeagnetum angustifoliae*, community *Bromopsis inermis–Elaeagnus angustifolia*, revealed during our study significantly differs by species composition from communities dominated by *E. angustifolia* described

**Figure 1.** Flat ancient lake terrace covered with *Elaeagnus angustifolia* stands (Rubtsovsky district of Alati Krai).

from the valley of the Lower Volga (Golub and Kuzmina 2004) that does not allow us to set them to previously published associations.

The pattern of floristic differentiation of syntaxonomic units of studied shrubberies was visualised using detrended correspondence analysis (DCA) ordination (Fig.2). The first axis of DCA – ordination is interpreted as a factor of soil fertility, the second as a humidity factor. According attitude to the soil fertility shrubberies of community *Bromopsis inermis–Elaeagnus angustifolia* lay in the range 2.5, and communities of association *Elytrigio repentis–Elaeagnetum angustifoliae* occupy range 0–3.5. However, it is noteworthy that relevés of the *Bromopsis inermis–Elaeagnus angustifolia* community represent a separate group on axis 2 in the extreme left position, i.e. these communities are formed on richer soil but dryer conditions than the communities of ass. *Elytrigio repentis–Elaeagnetum angustifoliae*.

## Conclusion

Polydominance of grass layer, anthropogenic and grazing load, variation of the species richness, plant cover and vertical stratification into layers mostly prove the unestablished character of communities dominated by *E. angustifolia* in Al-

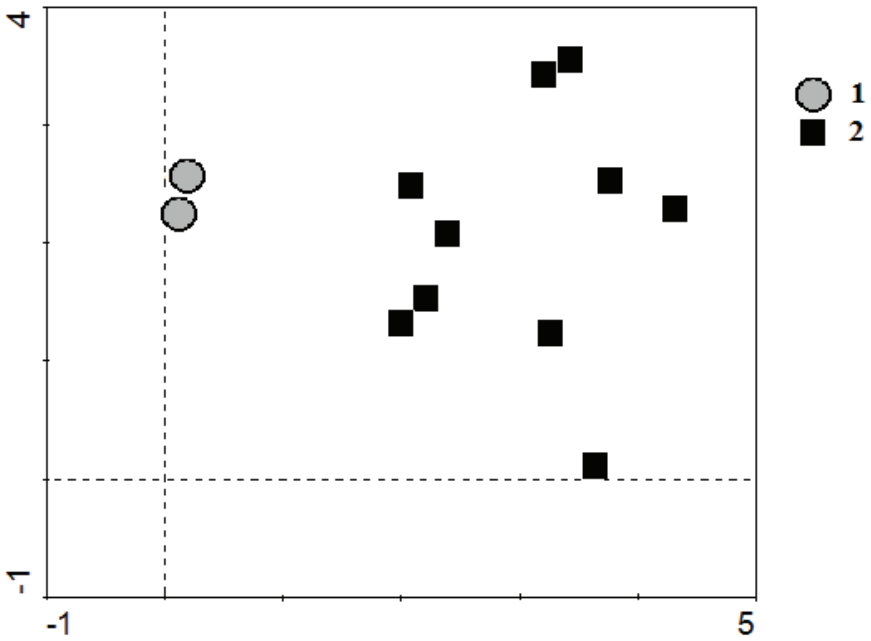


**Figure 2.** Distribution of revealed syntaxons along the axes DCA – ordination. **1** – community *Bromopsis inermis–Elaeagnus angustifolia*; **2** – association *Elytrigio repentis–Elaeagnetum angustifoliae*.

tai Krai. All communities are relatively young and does not reach the age more then 25–30 years. Communities of ass. *Elytrigio repentis–Elaeagnetum angustifoliae* described in Tabunsky district on the banks of Lake Shoshkaly grow on the meadow-boggy solonchakous and chestnut-meadow solonetz forming almost monospecies thickets with very high canopy density. Soils under communities have different particle-size distribution. In the direction from Barnaul to the south-west, the quantity of communities dominated by *E. angustifolia* increases and most of them are localized in steppe districts of Altai Krai because of drought and salt tolerance of this plant.

Russian olive shrubberies vary in moisture and saline regime, which connected with their existence in different landforms (lake alluvial plains, gentle slopes of lakes, low lake terraces). *E. angustifolia* is undemanding and has a rapid growth rate that is why it plays an environmental role and forms a new phytocenosis.

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