

## POPULATION DYNAMICS OF *EPILOBIUM CILIATUM* IN FIRE PLACES IN KAMANOS RAISED BOG: 5-YEAR STUDY (2004–2008)

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The populations of *Epilobium ciliatum* Raf. and plant communities were studied in eight fire places remaining in the Kamanos raised bog after management works. The survey was carried out for five years (2004–2008). The dynamics of plant number, reproduction ability, dispersal of seeds, relation between time of setting and plant abundance and period of survival was investigated.

Key words: *Epilobium ciliatum*, alien plant species, fire places in a raised bog, survival, Lithuania

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### Introduction

Fringed willowherb *Epilobium ciliatum* Raf. is an alien species in Europe originating in North America (Raven 1968). The first sample of this species in Europe was collected in Great Britain in 1889 (Doogue et Kelly 1985). Since then, *E. ciliatum* has spread in many European countries (Preston 1988, Strgulc Krajšek et Jogan 2004). In Lithuania the first herbarium specimen of *E. ciliatum* was collected in 1926. Presently *E. ciliatum* is distributed throughout the country (Gudžinskas 1998 Matulevičiūtė 2007).

In Lithuania it is a widespread species in many natural as well as anthropogenic habitats. The conditions of habitats can be very different: the light conditions vary from shaded to well-lit, the hydrological conditions – from averagely moist to wet, the soil reaction – from acid to alkaline,

the trophic conditions – from oligomesotrophic to eutrophic. But generally *E. ciliatum* prefers well-lit, moist, mesotrophic or eutrophic habitats with low acid to neutral soil reaction. So most frequently and abundantly *E. ciliatum* occurs on the banks of water bodies, in floodplains of the rivers and in ditches (Matulevičiūtė 2007).

In 2004 *E. ciliatum* was found in Kamanos raised bog in the fire places remaining after management works in the winter of 2002–2003. Occurrence of *E. ciliatum* in this habitat is determined by input of ash. It goes without saying that such habitats are temporary for *E. ciliatum*. The aim of this study was to assess:

1. How long will *E. ciliatum* survive in the fire places of a raised bog?
2. How will *E. ciliatum* plants develop in such untypical habitat?
3. What is the influence of this *E. ciliatum* population upon natural habitats?

## Methods

The survey was carried out in 2004–2008 in the Kamanos raised bog belonging to Kamanos State Strict Nature Reserve, situated in the northern part of Lithuania (Fig. 1). The vegetation was studied in eight fire places, located in the northern part of the raised bog (Fig. 2).

The size of fire places were measured. The pH values of water in the fire places were measured in 2004 and in 2008 using ISFET pH meter, model IQ120. In 2004, due to low water table, the pH measurement was possible only in four fire places, and in 2008 the water close to plant cover surface was found only in one fire place (Fig. 3).

All *Epilobium* plants were registered. The number of generative organs on *E. ciliatum* in

2004 was evaluated counting 30 accidentally chosen fertile plants and extrapolated to all fertile plants. In the period of 2005–2008, generative organs were counted on every fertile plant. For counting of seeds 30 fruits were collected in the fire place No 5 in 2004 taking three well developed fruits from ten plants.

The distance between the fire places and potential habitats of *E. ciliatum* was estimated using the orthophoto map made in 2006 and ArcGIS program package.

The number of habitats of Lithuanian *Epilobium* species was assessed using personal unpublished taxonomic data of genus *Epilobium* collected in period 2003–2008, herbarium data from the herbaria of the Institute of Botany (BILAS), Vilnius University (WI) and the Station

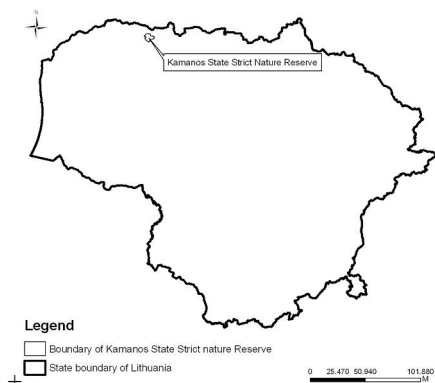


Fig. 1. Location of Kamanos State Strict Nature Reserve

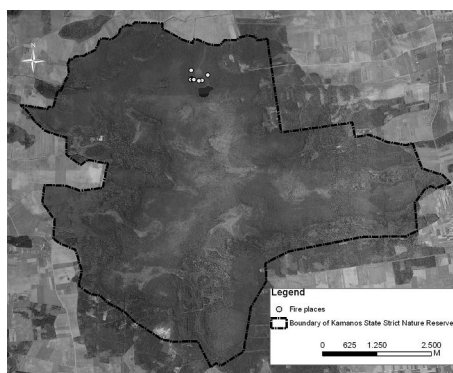


Fig. 2. Distribution of investigated fire places in Kamanos raised bog

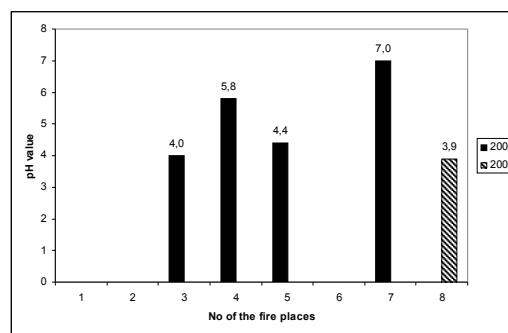


Fig. 3. The pH values of water in fire places

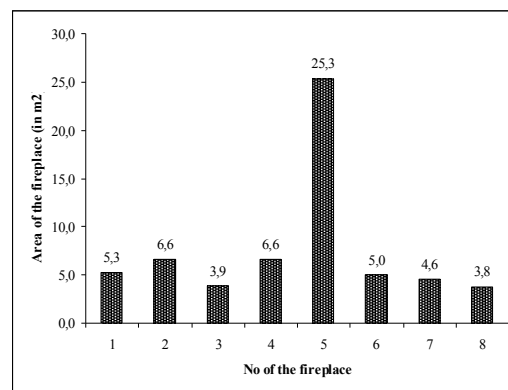


Fig. 4. The size of fire places

of Nature Investigations and Ecological Education of Marijampolė. The total number of the investigated herbarium specimens was 868. Statistical functions, such as average values and standard deviation were employed in the data processing using *Microsoft® Excel 2003* software.

## Results and discussion

### Establishment and survival of *E. ciliatum* in fire places

The size of the investigated fire places was very diverse (3.8–25.3 m<sup>2</sup>) (Fig. 4) as well as the pH values (Fig. 3), indicating very different water reaction – from acid to neutral. Such variable conditions in the fire places were determined by different input of ash.

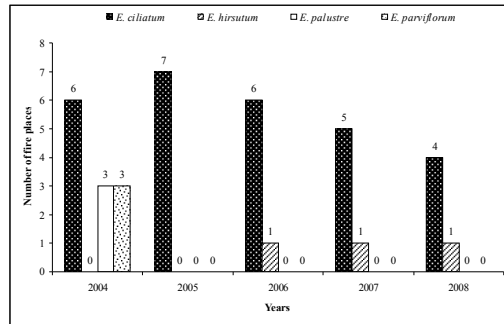


Fig. 5. Survival of plants of different *Epilobium* species in fire places during the investigation period

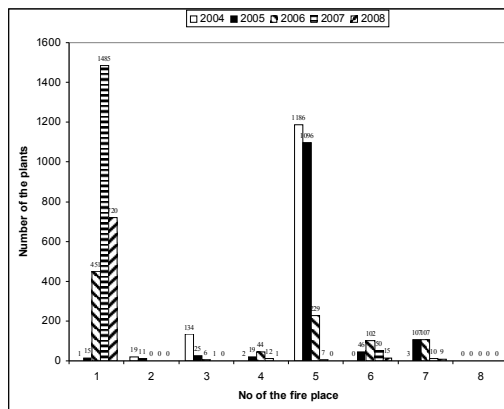


Fig. 6. The abundance of *E. ciliatum* plants in different fire places over the survey period

Although the investigation of plants started in 2004, the time of settling of *E. ciliatum* plants in the fire places could be defined in line with peculiarities of biology of this species. Plants of this species overwinter as leafy rosettes (Hausknecht 1884, Raven 1968, Stace 1997). One plant of total 30 samples collected in the fire place No 5 in 2004 had a leafy rosette. This fact indicates occurrence at least of one *E. ciliatum* plant in the fire place in 2003.

Four *Epilobium* species were found during the 5-year period: *E. ciliatum*, *E. palustre*, *E. parviflorum* and *E. hirsutum* (Fig. 5). *E. palustre* and *E. parviflorum* have been growing in the fire places only during one year (2004), while *E. hirsutum* was found in 2006, 2007 and 2008. *E. ciliatum* occurred in the fire places throughout the whole period of investigations. Differences

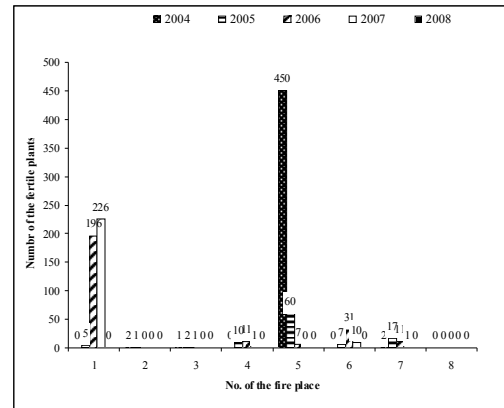


Fig. 7. The number of fertile plants in different fire places over the survey period

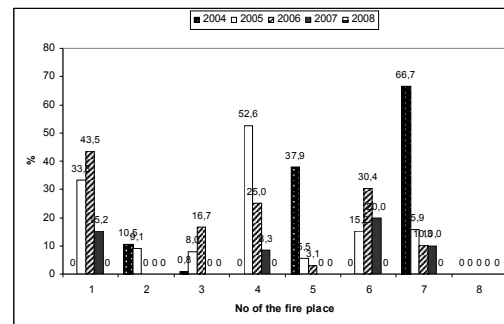


Fig 8. The ratio of fertile and general plant number

in plant abundance between species were also recorded: plants of native *Epilobium* species were sparse, while plant number of *E. ciliatum* was different in separate fire places over the survey period and varied over a very wide range – from one to 1485 individuals (Fig. 6). Such considerable differences in plant abundance and survival time of different *Epilobium* species could not be accidental. In order to establish the cause of these differences, the analysis of habitat types of all Lithuanian *Epilobium* species was made (Tab. 1). According to these data, *E. ciliatum* occupies nearly twice as many-habitat types as the ecologically plastic native *Epilobium* species, such as *E. hirsutum*, *E. montanum* and *E. parviflorum*. Eminent differences in diversity of habitat types indicate particularly high ecological plasticity of *E. ciliatum* determining its abundance and very long survival period in fire places. It can be one of the reasons for rapid spreading of *E. ciliatum* in Europe as well.

The fact that *E. ciliatum* plants were established in seven fire places from eight (Fig. 5), i.e. had been never growing in the fire place No 8, induces the analysis of placement peculiarities of fire places. Seven fire places were located on the hummocks and one in the hollow. *E. ciliatum* plants grew only in fire places situated on the hummocks and have never been growing in the fireplace No 8 situated in the hollow. It is possible that the high water table is not beneficial to this willowherb. Moreover, the ash in the hollow can be very quickly neutralised by humic acid.

Analysing the time of *E. ciliatum* plants' settling, it should be pointed out that these plants (Fig. 5) have not established in the fire places simultaneously: in 2004 they were found only in six fire places, and in one site they appeared only in 2005. The survival time of *E. ciliatum* plants was also different: it varied from two to five years (until the end of the investigation period). The time of settling was not related to plant abundance and period of survival. The dynamic tendencies of plant number in the fire places varied: three fire places showed significant decline in plant number, while considerable increase during

second or third year and following decline was observed in four fire places.

The maximum number of *E. ciliatum* plants was estimated in the fire places No 5 (in 2004 and 2005) and No 1 (in 2006 and 2007). The size of fire place had no decisive influence on the number of *E. ciliatum* plants although the fire place No 5 was the largest, and No 1 was of medium size (Fig. 3).

#### Age structure and seed production of *E. ciliatum* coenopopulation in fire places

*E. ciliatum* plants did not develop equally in different fire places over the 5-year period (Fig. 7). The highest number of fertile plants was counted in the most abundant populations, while the ratio of fertile and general plant number was the highest in fire places with lower total number of *E. ciliatum* plants (Fig. 8). Its tendency to change was also different. This may be caused by diverse conditions and individual development of each fire place during the investigation period. Different ratio of fertile plant number and their various dynamic tend to prove

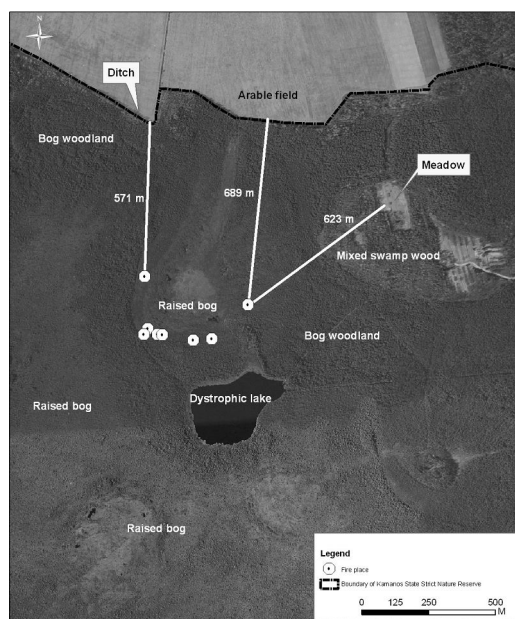


Fig. 9. The minimum distance between fire places and potential *E. ciliatum* habitats

Table 1. The number of habitat types of Lithuanian *Epilobium* species

Habitat types	<i>E. ciliatum</i>	<i>E. collinum</i>	<i>E. hirsutum</i>	<i>E. montanum</i>	<i>E. obscurum</i>	<i>E. palustre</i>	<i>E. parviflorum</i>	<i>E. roseum</i>	<i>E. tetragonum</i>
<b>Natural and semi-natural habitat types</b>									
Bank of the lake	+	.	+	+	.	+	+	+	.
Bank of the river	+	.	.	+	.	+	+	.	.
Dry grassland	.	+	.	.	.	.	.	.	.
Dry pine forest	+	.	.	+	.	.	.	.	.
Fen	+	.	.	.	.	+	+	.	.
Floodplain	+	.	.	.	.	+	.	+	.
Grassland on the peat soil	+	.	.	.	.	+	+	.	.
Gravelly bank of the river	.	.	.	.	.	.	.	.	+
Hygrophilous tall herb fringe	+	.	+	.	.	.	.	.	.
Lag of the raised bog	+	.	.	.	.	.	.	.	.
Littoral	+	.	+	.	.	+	.	.	.
Mesophilous deciduous forest	.	.	.	+	.	.	.	.	.
Mesophilous mixed forest	.	.	.	.	.	.	.	.	.
Mesophyte grassland	+	.	.	.	.	.	.	.	+
Muddy bank of the river	+	.	.	.	.	+	.	+	+
Oxbow lake	+	.	.	.	.	+	.	.	.
River valley	+	.	+	+	.	.	.	.	.
Sandy bank of the lagoon	+	.	+	.	.	+	.	.	.
Steep bank of the river	+	.	.	.	.	.	.	.	.
Shallow stream	+	.	.	.	.	+	+	+	.
Spruce forests	.	.	.	+	.	.	.	.	.
Surroundings of the spring	+	.	.	+	.	+	+	+	+
Transition mire	+	.	+	.	.	+	.	.	.
Thicket of the helophytes	+	.	+	.	.	+	+	.	.
Wet deciduous forest	+	.	+	+	.	+	+	+	+
Wet grassland	+	.	.	.	.	+	+	.	.
Wet shrubbery	+	.	+	+	.	+	+	+	.
Wet mixed forest	+	.	+	.	.	.	+	.	.
Xeric sand grassland	.	+	.	.	.	.	.	.	.
<b>Anthropogenic habitat types</b>									
Areas with destroyed soil surface	+	.	.	.	.	.	.	.	.
Banks of the ponds	+	.	.	.	.	+	+	.	.
Clay quarry	+	.	+	.	.	.	.	.	.
Dike	+	.	.	+	.	.	.	.	.
Ditch	+	.	+	.	.	.	+	+	.
Exploited peatland	+	.	+	.	.	.	.	.	.
Fire place on the mineral soil	.	.	.	+	.	.	.	.	.
Fireplaces in the raised bog	+	.	.	.	.	.	.	.	.
Forest cutting area	+	.	+	.	.	.	.	.	+
Forest quarter line	+	.	.	+	.	.	.	.	.
Garden	+	.	.	+	+	.	.	.	.
Gravel quarry	.	.	.	.	.	.	.	.	+
Holes in the alluvial meadow	+	.	.	.	.	.	.	.	.
Nutrient rich ruderal habitat	+	.	.	.	.	.	.	.	.
Pine plantation on sandy soil	.	+	.	.	.	.	.	.	.
Spruce plantation on loam soil	+	.	.	+	.	.	.	.	.
Railway	+	.	.	.	.	.	.	.	.
Road side	+	.	+	+	.	.	.	+	.
Scrapheap	+	.	.	.	.	+	.	.	.
Side of the ditch	+	.	+	+	.	.	+	+	.
Urban territory	+	.	+	+	.	.	.	+	.
Virgin soil	+	.	.	+	+	.	.	.	+
Wasteland	.	.	.	.	.	.	.	.	+
<b>Total number of the habitat types</b>	<b>42</b>	<b>3</b>	<b>17</b>	<b>18</b>	<b>2</b>	<b>18</b>	<b>14</b>	<b>11</b>	<b>19</b>

the diverse and uneven conditions in the fire places. The absence of fertile plants in 2008 in all fire places and drop of total plant number indicate a decline of population vitality. It is possible that this *E. ciliatum* population in the fire places of the raised bog is going extinct.

The number of generative organs of each fertile plant varied strongly among different fire places as well as within each site and year of investigation. Over the period of research the minimum number of generative organs per plant was one and the maximum – 234. The most fecund *E. ciliatum* individuals were found in the fire places No 5, 6 and 7, although the number of fertile plant in the fire places No 6 and 7 was rather low.

All *E. ciliatum* plants have produced 12869 generative organs over a period of five years (2004–2008). Every fruit consists of 213–241 seeds (average 228.3; standard deviation 13.2). Consequently 2 937 993 *E. ciliatum* plants should develop in all fire places over a 5-year period. Seeds of *E. ciliatum*, as of other *Epilobium* species, are distributed by wind (Hausknecht 1884), but the distance of seed dispersal was unknown yet. The occurrence of *E. ciliatum* seeds in seed bank of the habitat type unsuitable for this species, such as a bog (Houplainen et al. 2000), in spite of the absence of plants of this species in vegetation cover indicates that they can be transferred from one habitat type to another. Kamanos raised bog is unsuitable habitat type for *E. ciliatum* plants as well. Seeds might have arrived -into fire places from other habitat types. The minimum distance between fire places and the nearest potential habitat of *E. ciliatum* in consideration of all habitat types of this species in Lithuania (Matulevičiūtė 2007) is 571 m (Fig. 9). So the dispersal of *E. ciliatum* seeds by wind is very likely to occur at such distance.

With a view to a huge seed production of *E. ciliatum*, fire places in a raised bog are significant seed source of this alien species. Although it has not any role for raised bog vegetation per se, fire places might be a transitional site and help the seeds of *E. ciliatum* to reach more remote

suitable natural habitats and penetrate into them. According to Crawley, Harvey & Purvis (1997), there will be always a possibility of replacement of native early successional species by alien *r*-strategists (e.g. *Epilobium ciliatum*) that disperse their seeds more widely.

## Conclusions

*E. ciliatum* plants can survive in the fire places of raised bog for 2–5 years. However, vitality of plants during the last year of survey is low: plants do not mature.

The amount of fertile *E. ciliatum* plants forms very different portion of coenopopulations in separate fire places and seasons: it varies over a range of 0.75 – 66.67 %.

The size of the fire place has no decisive influence on the number of *E. ciliatum* plants.

The dynamics of the total number and number of fertile *E. ciliatum* plants showed no tendency. The maximum distance of *E. ciliatum* seeds spreading by the wind is more than 500 meters. Fire places in a raised bog are significant seed source of this alien species. They might help the seeds of *E. ciliatum* to reach more remote potential habitats.

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