

Biodiversity impacts of common ragweed

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Introduction

Ambrosia artemisiifolia causes agricultural losses and severe health problems. Whether the species also has a negative influence on plant species richness and the composition of the vegetation is a matter of ongoing debate. The question whether common ragweed impacts biodiversity or not is of great importance as this impact may be an additional motive for the prevention of import and control. It would also have an influence as to which administrative sector is competent and responsible for these measures. In Germany, for example, where the species is not yet wide spread, the Federal Nature Protection Act provides a legal framework the management of invasive alien species. Only if ragweed would have proven negative effects on other species, communities, or habitats, could this be applied in the fight against the species.

In which way could common ragweed impact biodiversity? On the one hand the species could directly suppress other plant species, and on the other hand control measures directed against common ragweed could have negative effects on flora and fauna. A negative effect on biodiversity would be relevant if rare species or species important for the function of the ecosystem were affected. Relevant effects include the reduction of fitness of affected plants (e.g., vegetative development, flowering and seed set). or indirect effects on other trophic levels such as associated animals depending on these plants or the alteration of abiotic habitat conditions.

In the last decades *A. artemisiifolia* became the best recognised weed species in East-European countries (Kazinczi et al. 2008), and also in European countries with relatively low infestations such as in Germany. Common ragweed became well known due to various reports in the media during the last five years. In some countries this may lead, or already led to intensified control measures against common ragweed in order to protect the human population against the ragweed pollen. Control measures may have side effects on biodiversity since an intensified use of herbicides, intensified mowing, or early ploughing of stubble fields may harm accompanying species (Pal 2004, Pinke 2007, Pinke et al. 2008, Pinke et al. 2010, Pinke et al. 2011). Common ragweed is present not only on arable fields where herbicides are normally used, but also in various habitats such as field margins, abandoned fields, forest edges, field paths that could be affected by measures such as more frequent herbicide use or intensified mowing.

Against this background, this chapter is about the impact of common ragweed on biodiversity and non-target species, and the following questions are of major interest:

- Does common ragweed have biologic features that helps it to spread und suppress accompanying plant species?
- In which habitats does common ragweed occur and which are important according to nature protection issues? Which habitats could be affected in future?
- Are direct impacts of common ragweed on biodiversity currently known?
- Are indirect impacts of control measures against common ragweed on biodiversity known?

In order to find answers to these questions, a literature review was conducted. Additionally, scientists from different countries working on the topic “common ragweed” were asked for their estima-

tion regarding direct and indirect impacts of common ragweed on other species and habitats by using a questionnaire. Furthermore field studies were conducted in the East German Niederlausitz, which is the most ragweed infested area in Germany.

Methods

Literature review and inquiry via questionnaire

In January and February 2012 a literature review was conducted. Also a questionnaire (see appendix) with six questions on direct impacts of common ragweed as well as indirect effects of control measures on biodiversity was sent to 118 experts currently working on the topic “common ragweed” in 38 countries (Australia, Austria, Belgium, Bosnia-Herzegovina, Bulgaria, Canada, China, Croatia, Czech Republic, Denmark, Finland, France, Georgia, Germany, Greece, Hungary, Iran, Israel, Italy, Lithuania, Luxembourg, Macedonia, Netherlands, Norway, Poland, Romania, Russia, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, USA). It asked for information on the following questions:

1. In which habitats does *A. artemisiifolia* occur in your country (apart from gardens)?
2. Does common ragweed occur in habitats with high value for nature protection (not only legally protected areas)? Does common ragweed suppress rare and/or endangered species?
3. Do you have own investigations and/or relevées on the invaded vegetation which we could use? (e. g. relevées of affected nature reserves but also of field-vegetation, road sides etc.?)
4. How often is common ragweed controlled in your country?
If common ragweed is controlled: How do you estimate the impacts of control measures against *A. artemisiifolia* on biodiversity in your country?
5. Do you expect future negative impacts for biodiversity due to intensified control measures against common ragweed (if common ragweed spreads and/or if more action is taken)? Which habitats and species could be affected?
6. Please list other information that might be useful for this study (e.g. names of other experts to contact, published or unpublished information, vegetation relevées, etc.

We thankfully received 12 answers on the questionnaire from Norbert Bauer (Hungary), Maira Bonini (Italy), Dragana Bozic (Serbia), Bruno Chauvel (France), Anikó Csecserits (Hungary), Natalija Galzina (Croatia), Gerhard Karrer (Austria), Peter Kotanen (Canada), Robert Pál (Hungary), Sergey Reznik (Russia), Hana Skálova (Czech Republic), and Nicola Schoenenberger and Marta Rossinelli (Switzerland), and added our own estimation for Germany (Alberternst & Nawrath).

Additionally we gratefully received hints from Bernard Clot (Switzerland), Chantal Dechamp (France), Gabriella Kazinczi (Hungary), Heinz Müller-Schärer (Switzerland), Ljiljana Nikolic (Serbia), Hans Peter Ravn (Norway) and Ingrida Sauliene (Lithuania).

The information given by the experts in the questionnaire is described below.

Field work

In order to find answers on the question whether common ragweed might be a threat for biodiversity, field work was conducted in the Niederlausitz near the city Cottbus located in Eastern Germany. *Ambrosia artemisiifolia* is distributed unequally in Germany: while the species currently is rare in the northern part and relatively rare in the south-western part of the country, it occurs very often in the region south-west of Cottbus. Thus the following investigations were conducted in that region from 5th to 11th July 2011:

- Review of data from that region from literature
- Interview and field trips with two local experts
- Investigations of the vegetation with occurrences of common ragweed with special regard to rare and endangered species.

Results

Interaction between common ragweed and surrounding vegetation

In the following chapters biological features of common ragweed explaining its growing and spreading strategy, the habitats where the species occurs, and the accompanying flora and vegetation are described from the literature. Where results from the literature review and from the inquiry via questionnaire complement each other, the results are presented together in the appropriate chapter. The results from the field work are presented in an additional chapter.

Distribution and spreading capacity in the new growing range

Distribution

In its native range in North America, *A. artemisiifolia* is a very common weed (Mitich 1996) and it is assumed to be native in the Canadian Prairies (Bassett & Crompton 1975). From North America, *A. artemisiifolia* was introduced to many countries in different parts of the world such as Australia (Bass et al. 2000), Japan (Miyawaki & Washitani 2004), China (Chen et al. 2007), and Russia (Reznik 2009). It was also introduced to many European countries such as Hungary (Makra et al. 2005, Kacinczi et al. 2008), France (Dechamp & Meon 2002, Chauvel et al. 2006), Italy (Pizzulin Sauli et al. 1992, Mandrioli et al. 1998), Switzerland (Taramarcz et al. 2005, Bohren 2005), Germany (Alberternst et al. 2006), Austria (Dullinger et al. 2009), Croatia (Galzina et al. 2009, 2010), Serbia (Kostantinovic´ et al. 2011), Ukraine (Burda & Tokhtar 1992), Poland (Tokarska-Guzik et al. 2010, 2011), Lithuania (Sauliene et al. 2012), Romania (Hodisan & Morar 2008, Hodisan et al. 2008), Czech Republic (Rybnicek et al. 2000) and even Sweden (Dahl et al. 1999, Möller et al. 2002) and Britain (Richi 1994). Currently *A. artemisiifolia* is most abundant in three main European regions: in the valley of the Rhône in France, in the northern part of Italy and in an extensive area in the south-eastern part of Europe, mainly in Hungary and surrounding countries (Rybnicek & Jäger 2001).

Spreading capacity

In Hungary, common ragweed became very common on agricultural fields and moved from the 21th place of the most important weeds in 1950 to the “number one” weed in Hungary in 1997 (Tóth et al. 2004 in Novák 2009). War and political shifts in Southeast-European countries have forced the spread of common ragweed since 1989/90 which is demonstrated by the example of Hungary where the agricultural co-operatives were closed and their land was redistributed to the former owners. In many cases these persons did not continue the cultivation of the fields for years and abandoned fields were quickly colonised by *A. artemisiifolia* (Kiss & Beres 2006, Balogh et al. 2007, Kazinczi et al. 2008). Similarly, the war in former Yugoslavia led to an increase of fallow land and waste places that favoured ragweed colonisation (Taramarcz et al. 2005). According to Tóth et

al. (2004 in Kazinczi et al. 2008) *A. artemisiifolia* infested 5.4 million hectares in Hungary. In Russia, where common ragweed was considered the most noxious invasive weed since the 1940s, the area heavily infested increased up to 6 million hectares by the end of the 1980s (Reznik 2009). In the Ukrainian Carpathian mountains and the Transcarpathian plain, common ragweed spread within a 55-year period (1942-1997) with a speed of 67.6 km²/year (Song & Prots 1998).

Competitive ability

These examples demonstrate that *A. artemisiifolia* has a strong spreading capacity. In addition, the species builds up dense stands and is able to suppress accompanying plant species by competition for light, nutrients, and water and may influence them by its allelopathic capacity (Beres et al. 2002). Common ragweed is an "exceptionally good competitor" and can have a strong negative effect on species which are moderately good competitors such as *Agropyron repens* and *Plantago lanceolata* (Miller & Werner 1987, Callaway & Walker 1997, Callaway 2007). On arable fields common ragweed can cause substantial yield losses e.g. in maize, sunflower, soybean, beans, peanuts, which also demonstrates that common ragweed can act as a strong competitor (Chollet et al. 1999, Chikoye et al. 1995, Clewis et al. 2001, Zwerger & Eggers 2008, Kukorelli et al. 2011).

Reproductivity

A. artemisiifolia is an erect annual herb with unbranched to bushy branched stems. The plant is very variable regarding its size and leaf shape and it normally reaches a height of 5 cm to 100 cm. In poor sandy soil the species stays small and mostly unbranched, while in nutrient-rich growing conditions with sufficient water supply it can grow up and built branchy stems up to 2 m high. *A. artemisiifolia* is monoecious and has flower heads with either male or female flowers. Male heads contain 10-15 male flowers (Hegi 1979) and are posed in spikes terminating the stems and branchlets. Sauliene et al. (2012) found in an experiment that cultivated ragweed plants produce approximately 36.000 male flower heads per plant. The inconspicuous female heads are one-flowered and located in small clusters or single in the axils of the upper leaves (Bassett & Crompton 1975). Common ragweed plants produce one seed per flowering head. With regard to Dickerson & Sweet (1971) small plants produce about 3000 seeds while large individuals generate up to 62,000 seeds. In Russia even 88,000 seeds per plant were observed (Fisjunov 1984 in Kazinczi et al. 2008) and according to Szigetvári & Benkő (2008) 150.000 seeds were found on a plant from Ukraine. For a branchy common ragweed plant of a height of approximately 1.3 m 44,211 seeds were found in Germany (Alberternst & Nawrath unpubl. data). The germination rate of the seeds is high (Kazinczi et al. 2008).

Seed bank and meaning of soil disturbances

In Hungary first seedlings emerge between March 15 and April 12 (Kazinczi et al. 2008). This is a period when first seedlings also occur in Germany (e.g., on March 23 in 2007, and March 20 in 2010, in Friedberg). The seeds germinate at or near the soil surface (Bazzaz 1974). An investigation carried out in Hungary demonstrates that the most seeds germinated from the upper 2.6-3 cm layers (Kazinczi et al. 2008). In a burial experiment Willemsen (1975) tested the germination rate of ragweed seeds on the soil surface and 5 cm and 15 cm below the soil surface. He also found the most ragweed seeds germinating at the soil surface.

According to Kazinczi et al. (2008) seeds of *A. artemisiifolia* on the soil surface or from the upper soil layer as well as those which were stored at room temperature can lose their viability after four years. However, seeds from deeper soil layers (35-45 cm) can keep their viability for a longer time (30-40 years). Toole & Brown (1946) showed that ragweed seeds buried in the soil remained viable for 39 year or more. Similarly the result of Dr. Beal's seed viability experiment demonstrates that *A. artemisiifolia* stayed viable after storing 40 years in the soil (Tewelski & Zeevart 2002).

Ambrosia artemisiifolia is adapted to soil disturbances, which is clearly shown by its feature to germinate from the soil surface and the upper soil layers (Willemsen 1975). To protect the seed bank of common ragweed in the event that the site is disturbed again when the environmental conditions may be not suitable for seedling growth, *A. artemisiifolia* has developed an induced secondary dormancy (Willemsen 1975, Bazzaz 1979, Baskin & Baskin 1980). Referring to Bazzaz (1979) this is a typical strategy for early successional plants.

The biological features described above explain why common ragweed grows only on sites where disturbances resulting in open soil patches regularly occur. Due to the species' ability to build up a persistent seed bank, common ragweed seeds can stay viable in the soil for some decades. In case of newly occurring disturbances resulting in the exposure of seeds on the top soil connected with suitable climatic conditions common ragweed can grow up quickly, flower and fill up the seed bank again.

Adaptability to habitat conditions

Ambrosia artemisiifolia has a distinct phenotypic plasticity, which allows it to tolerate a wide range of ecological conditions (Bazzaz 1974, Raynal & Bazzaz 1975). An examination of Leiblein (2008) demonstrates that common ragweed can grow and produce seeds in dry, moist and even under waterlogged soil conditions. According to Berés & Hunyadi (1991 in Kazinczi et al. 2008 a) it grows on every soil type in Hungary. It also sporadically occurs on saline soil types. In Slovakia *A. artemisiifolia* grows in saline grassland and is mentioned as a "diagnostic species" for that grassland among other species like *Artemisia santonicum*, *Cynodon dactylon*, *Plantago maritima* and *Podospermum canum*. Saline grassland is a NATURA 2000 habitat (1340* Inland salt meadows) (Seffer et al. 2002). *A. artemisiifolia* also exists in the coastal coenoflora of Ukraine (Dubyna et al. 2010). However, on strongly acid soils plants are less vigorous (Bassett & Crompton 1975).

In Hungary, where common ragweed is widely distributed, it is dominant on haplic cambisols, sandy soils and on fluvisols. Most favourable for its growing are slightly acidic, sandy adobe and muddy loam soils (Kazinczi et al. 2008). The species has a good drought tolerance and its sub-lethal water saturation deficit is high compared to other species (Kazinczi et al. 2008). Common ragweed seedlings tolerate water stress and their photosynthesis remains relatively high even at water potentials as low as -20 bars (Bazzaz 1974). Although common ragweed is a plant of open sunny habitats with a high photosynthetic rate (Bazzaz 1974), its photosynthetic light compensation is reached at a radiation intensity as low as $7 \mu\text{mol m}^{-2} \text{s}^{-1}$ detected for common ragweed plants from Germany, which enables the plant to grow even under shady conditions (Leiblein 2008). However, in closed plant associations, shading is found to be clearly inhibiting both the germination and the vegetative development of *A. artemisiifolia* (Szigetvári & Benkő 2008).

common ragweed plants are very variable concerning their growth. Currently common ragweed ecotypes are already present, as Dickerson and Sweet (1971) describe. Song & Prots (1998) describe a late-autumn variety called *A. artemisiifolia* var. *atropurpurea* which was found growing 730 m above sea level. In East Germany, common ragweed plants were found that flower as early as in June.

Compilation of data according biological features of common ragweed

In tab. 1 biological features of common ragweed respectively habitat conditions of suitable growing sites are compiled. Some features might promote the spread, others could be limiting factors.

Tab 1: Biological features and habitat conditions that could promote or limit the spread of common ragweed in a new range.

Biological feature/ habitat conditions	Feature could promote spread	Feature could limit spread
Spreading capacity	High spreading capacity especially at anthropogenic sites, spread mostly due to human activities (e.g. within soil, mowing machines, agricultural machines), Limited number of predators compared to natural habitat	Relatively big seeds, seeds not transported by wind (no flying capacity) Low spreading capacity without human assistance, probably except for spread in floating water
Competitive ability	Able to built high and dense stands especially in nitrogen-rich habitats, some competitive ability (e.g. can cause notable yield losses), relatively high drought tolerance	Plants usually remain small in nitrogen-poor habitats and often build light stands, but influence on water und nutrient supply not known, only sparse information about allelopathic ability. Easily displaced by perennial species
Regeneration capacity	High regeneration capacity after injuries (e.g. mowing, grazing), even small plants can produce seeds	-
Reproductivity and germination rate	Big plants mainly on nutrient rich soils can produce high amounts of seeds, high germination rate of seeds in upper soil layers in open regularly disturbed areas (by anthropogenic or natural means)	Small plants usually have little seeds, Low/no germination of seeds buried in the soil at undisturbed sites
Seed bank	Long living seed bank in seeds buried in deeper layers	Seeds in upper soil layers loose their viability earlier
Habitats grown by the species	Wide range of habitats, predominantly at sunny sites, disturbances necessary for germination	Less vigorous at shady sites, no/low germination in undisturbed habitats
Adaptability to habitat conditions	Large phenotypic plasticity and genetic diversity, ecotypes present	-

Habitats with occurrences of common ragweed

Ambrosia artemisiifolia occurs in a wide range of open disturbed areas, as well in its native as in its anthropogenic range. It is widespread on arable land and on ruderal sites such as waste lands, railway areas, construction sites, parks, road sides, river banks, orchards and vineyards, meadows, pastures, afforestations, glades in forests, and fields located inside of forests cultivated by hunters for shelter and feeding of wild animals (Bazzaz 1974, Bassett & Crompton 1975, Galzina et al. 2009, Kazinczi et al. 2008b, Týr et al. 2009, Pinke et al. 2011, Bauer 2006, Alberternst et al. 2006). According to Szigetvári & Benkö (2008) *A. artemisiifolia* appears in Hungary in any places apart from extreme conditions or with very low isolation.

Results from the inquiry via questionnaire (question 1)

According to the answers from the questionnaire the most extended area colonized by common ragweed in many countries such as Hungary, Croatia, Canada, France, Italy and Germany are agricultural fields (Pál, Bauer, Csecserits, Galzina, Kotanen, Chauvel, Bonini). However, this habitat type does

not provide the most extended area grown by the species in countries such as Switzerland, Russia, Czech Republic, and Serbia (Schoenenberger & Rossinelli, Reznik, Skalova, Bozic) where other habitats are mostly infested. Also in Austria the agricultural fields range on the second place for the most extended growing area after the road sides (Karrer).

Ambrosia artemisiifolia often grows on stubble fields of cereal crops as it is for example described from the Lombardy region by M. Bonini. In Serbia and in Russia the area most occupied by common ragweed is on fallow agricultural fields (Bozic, Reznik), whereas in East of France, Germany, Austria and Czech Republic the growing area on abandoned fields is not very extended (Chauvel, Skálová, Karrer). Common ragweed often occurs at field margins in East-France (where the species is considered to be still rare), Germany, Austria, Italy, Croatia, Hungary, Canada, and Russia whereas common ragweed was scarcely found in agricultural regions but it mostly grows in railway areas in Czech Republic (Skálová).

Road sides are often colonized by common ragweed and range on the first or second place for the most extended growing area in France (Chauvel), Austria (Karrer), Switzerland (Schoenenberger & Rossinelli), Germany (Nawrath & Alberternst), Italy (Bonini), Croatia (Galzina) and Canada (Kotanen).

Road margins play an important role in the spreading process of *A. artemisiifolia*. In rural settings of southern Québec, the species was clearly more abundant along rural roadsides than in fields or field margins in 2007 and 2008 (Simard & Benoit 2010). In southern Québec the expansion of the road network during the 20th century was probably the main factor that favoured the rapid dispersal of common ragweed (Lavoie et al. 2007). Road sides provide conditions appropriate for germination and growth of common ragweed because they receive considerable sunlight and are frequently disturbed (e.g. by the road maintenance) (Vitalos & Karrer 2009). The seeds are easily dispersed along the roads by vehicles or by water in drainage ditches (Bassett & Crompton 1975). However, the type of the road is important for the occurrence of the species, which could be demonstrated by Joly et al. (2011) for Québec: at verges of paved roads the species was much more frequent than at unpaved roads. Also in Germany numerous common ragweed stands were detected along the verges of Bavarian highways since 2009. Due to the fact that ragweed stands at highways in Bavaria were nearly unknown until a few years ago, the spread of the species along roads is a new phenomenon in Germany (Nawrath & Alberternst 2010, 2011). In Austria the number of records of common ragweed stands increased most strongly on road sides between 1995 and 2005 compared to other habitats such as railways, other ruderal habitats, or fields (Essl et al. 2009). From road sides, common ragweed may spread into the surrounding vegetation and also into agricultural fields.

Based on the answers from the questionnaire, common ragweed often or relatively often grows in urban-industrial sites, and it is documented from numerous construction areas in different countries. It sometimes grows in managed grassland such as meadows and pastures e.g. in Canada, Croatia, Czech Republic, Germany, Hungary, and Russia. In Russia in some cases it is found along the borders of forests (Reznik) and it occurs in Hungary in *Robinia pseudoacacia* and *Populus x euramericana* forests (Bauer, Csecserits). According to the information given by A. Csecserits, common ragweed sometimes occurs in Hungary in oak forests at deer yards or in game fields and along the roads.

Sometimes common ragweed grows in nutrient poor grassland (inclusive sand biotopes and steppe vegetation) in Hungary (Bauer, Pál, Csecserits). In Russia, the Czech Republic, Croatia, Canada, and Germany, common ragweed is found in this habitat, but compared to the other habitats it only rarely occurs here.

According to Szigetvári & Benkő (2008) in Hungary *A. artemisiifolia* is absent from undisturbed, near-natural habitats and secondary habitats that have been in the process of regeneration for a longer time, although the species is very common in that country.

Vegetation co-occurring with *A. artemisiifolia*

Ambrosia artemisiifolia is present in various plant communities which are described below.

Segetal and ruderal plant societies

In the following segetal and ruderal plant societies described from various countries that contain *A. artemisiifolia* are presented. In some cases the phytocoenoses from arable fields and ruderal sites occur in both habitat types. Segetal plant communities have been investigated intensively in Hungary by Pinke (2000, 2007) and Pál (2004). The synoptic tables of relevés (Pinke 2000, 2007) demonstrate that common ragweed is present with high frequency (more than 50 %) in various weed communities of extensively cultivated arable fields in Hungary. The following list gives an overview of these plant communities from Hungary and also of plant communities including common ragweed described from other European countries:

Stellarietea: Segetal and short living ruderal plant societies

- Camelino microcarpae-Anthemidetum austriacae
- Aphano arvensis-Matricarietum chamomillae
- Spergulo arvensis-Anthemidetum ruthenicae
- Sisymbrio orientalis-Anthemidetum ruthenicae
- Stachyo annua-Setarietum pumilae
- Chenopodio-Oxalidetum fontanae
- Echinochloo-Setarietum pumilae
- Digitario-Setarietum pumilae
- Trifolium arvense-Ambrosia artemisiifolia-Gesellschaft
- Capsello-Descurainietum papaveretosum
- Panico-Galinsogetum
- Odontito-Ambrosietum
- Ambrosietum artemisiifoliae
- Ambrosio artemisiifoliae
- Ambrosio artemisiifoliae-Xanthem strumariae
- Ambrosio-Setarietum viridis
- Ambrosia artemisiifolia-Datura stramonium community
- Sisymbrium
- Societies of Eragrostietalia
- Polygono-Chenopodietalia

Artemisietea: Perennial ruderal vegetation

- Artemisio-Tanacetum
- Arctio-Artemisietum vulgaris
- Onopordion
- Arction, Convolvulion
- Alliarion

Plantaginetea: Plant communities resulting from trampling

- Plantaginetea (incl. Agropyro-Rumicion *crispi*)
- Rumici acetosellae-Spergularietum *rubrae*

others

- Quercion
- Sambuco-Salicion,
- Festuco-Brometea
- Sedo-Scleranthetea
- Rununculo sardoii-Alopecuretum *geniculati*

Description of the communities

The association **Camelino microcarpae-Anthemidetum austriacae** is common in cereal winter crops but it also occurs in spring crops and is physiognomically characterized by *Anthemis austriaca* which usually is present in large quantities. Seedlings of *A. artemisiifolia* often occur in this community. Dominant and constant accompanying species are *Papaver rhoeas*, *Consolida regalis*, *Apera spica-venti*, *Galium aparine*, *Elymus repens*, and *Cirsium arvense*. The **Aphano arvensis-Matricarietum chamomillae** is the most common association of winter crops and occurs on acid, loamy and clayey soils. In the relevés of Pinke (2007) common ragweed occurs in this association with a frequency of 70 % but is often present only with low densities (mostly “+” and 1). The **Spergulo arvensis-Anthemidetum ruthenicae** is widespread on acid nutrient-poor sandy soils in the Trans-Danubian mountains as well as in the West Hungarian area where the investigations were conducted. Characteristic species are *Papaver argemone*, *Herniaria hirsuta*, *Veronica triphyllos*, *Vicia villosa*, and *Trifolium arvense*. *A. artemisiifolia* often occurs in the lower herb layer of this community which has an optimum from middle of May to middle of June. The **Sisymbrio orientalis-Anthemidetum ruthenicae** (former name Camelino-Anthemidetum *sisymbrietosum*) evolves on basic, sandy soils in extensive cereal crops. Here besides *Anthemis ruthenica*, *Veronica triphyllos*, *Vicia villosa* and *Trifolium arvense*, species like *Bromus tectorum*, *Cerastium semidecandrum*, and *Silene conica* occur. *A. artemisiifolia* often is present in the lower herb layer. The community also has an optimum from middle of May to middle of June. The **Stachyo annuae-Setarietum pumilae** is a species-rich stubble plant community which has a symphenological optimum in late summer/early autumn. The community develops best in stubble of cereal spring crops. *Stachys annua*, *Anagallis foemina*, *Silene noctiflora*, *Euphorbia exigua*, *Kickxia elatine* et *spuria* are characteristic species of this community. *Ambrosia artemisiifolia* often occurs in this plant community, and according to the relevés of Pinke (2007) it has a constancy of 76 % in the typical variant respectively 92 % in the variant with *Oxalis stricta*.

Ambrosia artemisiifolia is also among the dominant constantly occurring accompanying species in the community **Chenopodio-Oxalidetum fontanae** and it occurs in the **Echinochloo-Setarietum pumilae** which is a typical association of root crops. The community develops in a relatively short time scale after the last hoe. Diagnostic species besides of *A. artemisiifolia* are *Echinochloa crus-galli*, *Amaranthus chlorostachys*, *A. retroflexus*, *Galinsoga parviflora*, *Chenopodium album* et *hybridum*, *Mercurialis annua*, *Persicaria lapathifolia*, *Convolvulus arvensis*, *Cirsium arvense*, *Stellaria media*, *Setaria pumila* et *viridis*, *Solanum nigrum* (Pinke 2000, 2007).

Another community on stubble fields is the **Trifolium arvense-Ambrosia artemisiifolia community**. This fragmentary community often occurs on stubble fields instead of the Camelino-Anthemidetum *scleranthetosum* on sandy-loamy soil. *Ambrosia artemisiifolia* dominates the upper vegetation layer, whereas *Trifolium arvense* grows in the medium layer. *Polygonum aviculare*, *Setaria pumila*, *Conyza canadensis*, *Elymus repens*, *Anthemis ruhtenica* (seedlings), *Fallopia convolvulus* occur (Pinke 2000).

The **Trifolium arvense-Ambrosia artemisiifolia** community presents a stage of succession into the association *Odontito-Ambrosietum* (Silc 2002) described later.

common ragweed is found in the **Capsello-Descurainietum papaveretosum** which is often present on first year abandoned fields, at the edges of winter crops and at the margins of fields. In the relevés demonstrating the floristic composition, common ragweed has only low densities (Pinke 2000, Pál 2004).

Referring to Pál et al. (2006) *A. artemisiifolia* also occurs in waterlogged patches on agricultural fields in Hungary. The plant association that is present in these wet patches matches the **Rununculo sardoii-Alopecuretum geniculati** Bodrogközy 1962. *Ambrosia artemisiifolia* is included in the relevés which show the floristic composition of these wet patches but is only mentioned to be an indifferent species. Common ragweed occurs here with high consistency (value V = 75-100% of the relevés) but only with low cover at the time the relevé was taken (in June 2005, usually “+” or “1”, Scale of Braun-Blanquet 1964). During an investigation in September, common ragweed was also registered in this association with a high consistency of V. The cover was higher than in spring and often achieved the values “2” (5-25 %) and “3” (25-50 %).

From the Crimea region in Ukraine another segetal weed association called **Ambrosio artemisiifoliae-Cirsietum setosi** Marjuschkina et B. Sl. 1985 is described (Bargrikova 2005). The association belongs to the order *Polygono-Chenopodion* W. Koch 1926 em Siss. 1946 and belongs to the class *Stellarietea mediae* R. Tx., Lohmeyer & Preising in R. TX. Ex von Rochow 1951. The class *Stellarietea mediae* comprises the associations of communities with annual species that characterize the initial stages of restoration successions that follow after disturbances (Bargrikova 2005).

In Serbia, *A. artemisiifolia* occurs in the association **Panico-Galinsogetum** Tx. et Beck 1942 in potatoes crops (Ilic & Nikolic 2011). The association is built up by 29 species and it belongs to the order **Chenopodietalia albi** in the class **Stellarietea mediae**. *Ambrosia artemisiifolia* is present in this association but according to the relevés presented, only occurs with low constancy (value II) and low densities (value “+”) (Ilic & Nikolic 2011).

In the Czech Republic *A. artemisiifolia* occurs in communities of the **Eragrostietalia**, which is a phytosociological order that includes thermophilous communities of therophytes on loose substrata mainly in south and southeast Europe. The communities occur on light-textured soils that dry and warm up rapidly and mostly consist of therophytes with C4 assimilation. Several species growing in these habitats have a clumped spatial distribution, a prostrate habitus, and a rich system of fine roots. Also, species with creeping rhizomes occur and others possess xeromorphic characters. The communities of this alliance became rare or even extinct in the northwest of Europe. In the Czech Republic the communities belonging to the orders *Eragrostion* and *Salsolion ruthenicarum* may be relevant. In the Czech Republic the communities are on the northwest border of their distribution (Kropáč 2006).

Silc (2002) and Silc & Kosir (2006) report from Slovenia that *A. artemisiifolia* is found in the association **Odontito-Ambrosietum** Jarolímek et al. 1997 that belongs to the alliance *Dauco-Melilotion* Görö 66. The association belongs to the coenological class **Artemisietea vulgaris** Lohm., Prsg. Et Tx. In Tx. 50. The class **Artemisietea vulgaris** describes plant communities of two-year to perennial ruderal communities, usually occurring at dump places, pathways, forest edges and river sides (Oberdorfer (2001). Referring to Silc (2002) the plant community of **Odontito-Ambrosietum** is found on recently deposited rubble, recently levelled terrain, along roads, on gravel sites and more rarely in fields or stubble in Slovenia. The stands are dominated by *A. artemisiifolia*, which constitutes the upper herb layer. Accompanying species are *Chenopodium album*, *Artemisia vulgaris*, *Amaranthus retroflexus*, *Atriplex patula*, *Coryza canadensis*, and *Lactuca serriola*. *Plantago lanceolata*, *P. major*, *Polygonum aviculare* agg., and *Potentilla reptans* are more or less common in the lower herb layer. Differential species of the association are *Setaria pumila*, *Amaranthus retroflexus*, *Chenopodium strictum* and *Odontites vernus*. Well represented in the association are species of the alliance **Dauco-Melilotion** and of the

class **Stellarietea mediae**. Among the accompanying species there are a lot of species of the class **Molinio-Arrhenatheretea**. The syntaxonomic classification is difficult due to a similar number of species of the classes **Stellarietea mediae** and **Artemisietea vulgaris**. The author decided to classify the stands from Slovenia into the class **Artemisietea** (Silc 2002). Similarly, Brandes (2005) reports from Slovenia that *A. artemisiifolia* is present in the class **Stellarietea** or in the **Dauco-Melilotion**, depending on the location. According to this author, common ragweed often grows with species of the class **Molinio-Arrhenatheretea**, and thus it is not possible to assign the species to the **Odontito-Ambrosietum** Jarolimek et al. 1997 in every case. The **Odontito-Ambrosietum** was also found in a harbour in Czech Republic (Jehlik 2008). Jehlik et al. (2005) point out that common ragweed was growing in an association probably belonging to the association **Odontito-Ambrosietum** on sandy deposit of the Danube River in Slovakia.

In Romania *A. artemisiifolia* dominates ruderal phytocoenoses and is integrated in the association **Ambrosietum artemisiifoliae** Vitalariu 1973. According to Coste & Arsene (2003) the association belongs to the order **Onopordetalia acanthi** in the class **Artemisietea vulgaris**. The association is found on railway embankments, at ruderal places around the railway stations, which usually have a skeletal substratum, and it entered the fields from the vicinity of the railway embankments in Romania. In the plant community described, *A. artemisiifolia* has a foliar cover of 70 to 100 %. It often occurs with *Conyza canadensis*, *Hordeum murinum*, *Bromus tectorum*, *Bassia scoparia*, *Lactuca serriola*, *Voila arvensis*, *Capsella bursa-pastoris*, *Crepis foetida* subsp. *rhoeadifolia*. The association has characteristic species from the order **Sisymbrietalia**, and the classes **Stellarietea** and **Artemisietea** (Sirbu 2008).

From Serbia Jarić et al. (2011) describes a new association **Chenopodio-Ambrosietum artemisiifoliae** ass. nova that was recorded along the edge of roads and in abandoned fields. It is a ruderal community which is dominated by species of the segetal weed communities of cultivated areas. It is floristically rich in species. Besides common ragweed, *Erigeron canadensis*, *Lactuca serriola*, *Cirsium arvense*, *Galega officinalis*, *Daucus carota*, *Stenactis annua*, *Calystegia sepium*, *Cichorium intybus*, *Medicago lupulina*, *Convolvulus arvensis* occur in this association. These species are characterized by high levels of abundance and cover. The association belongs to the (former) class **Chenopodietea albae** Br.-Bl. 1951 em. Lohm., R. et J. Tx. 1961 (Order: **Sisymbrietalia**, Alliance: **Bromo-Hordeion murini**), which currently is united with the class **Stellarietea**. It has a high level of non-native plant species. Due to the fact that weeds from these ruderal habitats may invade cultivated areas, this association is important regarding plant protection in arable fields (Jarić et al. 2011).

Brandes & Nitsche (2006) describe occurrences of *A. artemisiifolia* in the **Rumici acetosellae-Spergularietum rubrae** at road sides in Brandenburg, Germany. Common ragweed occurs with species such as *Polygonum aviculare*, *Digitaria ischaemum*, *Spergularia rubra*, *Rumex thyrsiflorus*, *Artemisia vulgaris*, *Tanacetum vulgare*. The community typically is present on open gravel and hard sandy soils in settlements and in railway areas. It belongs to the sociological class **Polygono arenastri-Poetea annuae** (annual trampling communities) (Schubert et al. 1995). According to Brandes & Nitsche (2006) common ragweed was also found along a pathway in the **Artemisio-Tanacetum**. At road sides most of the ragweed stands have a phytocoenological position between the **Sisymbrietalia**, **Dauco-Melilotion** and **Arrhenatheretalia**.

Additionally, *A. artemisiifolia* was reported to exist in the following phytosociological communities:

- **Arctio-Artemisietum vulgaris** (Tx. 1942) Oberd. et al. 1967, in Serbia, growing with *Artemisia vulgaris*, *Arctium lappa*, *Carduus acanthoides*, *Cirsium arvense*, *Lactuca serriola* (Stanković-Kalezić et al. 2009)
- **Ambrosio-Setarietum viridis** in Slovakia (Mochňák 2005).
- **Ambrosio artemisiifoliae-Xanthemum strumariae** Kost. 1991 in Ukraine (Protopopova et al. 2006).

- **Ambrosia artemisiifolia-Datura stramonium community**, in Germany. The association belongs to the alliance **Sisymbriion** and was found in a harbour at the Elbe-Müritz water way (Dömitzer Hafen). Besides common ragweed and *Datura stramonium* other species such as *Amaranthus retroflexus*, *Setaria pumila*, *Galinsoga parviflora*, *Sonchus oleraceus*, *Chenopodium album*, *Oenothera biennis*, *Berteroa incana*, *Cichorium intybus* and *Artemisia vulgaris* occur in this plant community (Brandes 2003).

Song & Prots (1998) give an overview of the frequency of occurrence of *A. artemisiifolia* in the most important plant communities for the Ukrainian Carpathian Mountains and the Transcarpathian plain (tab. 2). According to these authors common ragweed predominantly grows in segetal and ruderal plant communities. Much more rarely the species is found in nutrient-poor, dry grasslands (**Sedo-Scleranthetea** and **Festuco-Brometea**) and it rarely occurs in nitrophilous shrub vegetation (**Sambuco-Salicion**, **Alliarion**) and oak forests (**Quercion**).

Tab 2: Frequency of occurrence of *A. artemisiifolia* in the most important syntaxa by sociologic-ecological classification in the Ukrainian Carpathians Mountains and the Transcarpathian plain (Song & Prots 1998).

Syntaxa	Frequency of occurrence in %	
	Transcarpathian plain	Ukrainian Carpathians Mountains
Quercion	1.7	-
Sambuco-Salicion, Alliarion	1.7	-
Festuco-Brometea	5.4	10.2
Sedo-Scleranthetea	3.4	2.5
Plantaginetea (incl. Agropyro-Rumicion crispi)	12.9	18.7
Arction, Convolvulion	13.7	15.1
Onopordion	14.5	9.5
Onopordion	15.7	13.6
Sisymbriion	22.4	21.2
Polygono-Chenopodietalia	8.6	9.2
Naturalized adventive species (anthropophytes) with undefined phytosociological attachment and ephemero-phytes		

Sandy grassland

According to Bauer (2006), *A. artemisiifolia* grows in open sandy grasslands of the Bakony region in Hungary, where the *Festucetum vaginatae* is the dominant plant community. *Ambrosia artemisiifolia* is found growing together with *Calamagrostis epigeios* and *Euphorbia cyparissias* in the association **Festuco vaginatae-Corynephorum**. This association mainly occurs on disturbed patches, in glades in forests, at forest edges, on road slopes of regenerating vegetation adjoining forest and on sandy surfaces on a recultivated area. *Ambrosia artemisiifolia* also occurs in *Corynephorus* grasslands that can be classified as **Thymo angustifolio-Corynephorum**. In the relevés of Bauer (2006) common ragweed occurs with a frequency of III (25-50 %) and with low levels of folia cover ("+" or "2"). The association can be found on limeless sandy surfaces, where usually calciphobe sandy grassland is characteristic. *Corynephorus canescens*, *Jasione montana* and *Rumex acetosella* are frequent in that association in the Bakony region, whereas *Potentilla argentea*, *Hypochoeris radicata*, *Scleranthus annus* and *Thymus serpyllum* occur infrequently. The association is poor in species and may therefore easily be taken over by weeds. The high frequency of several weeds such as *A. artemisiifolia* and *Coryza canadensis* is the result of severe disturbance (Bauer 2006).

In Germany, common ragweed also grows in open, disturbed pioneer vegetation on sandy soils in the **Corynephorum** and in the **Bromo-Corispermetum leptopteri** (alliance Salsolion, order Sisymbrietalia; Brandes & Nitsche 2006).

Plant communities in wet habitats or/and along river sides

Ambrosia artemisiifolia has a wide ecological range and is able to grow in habitats with wet soil conditions. In the relevés of Szirmai et al. (2009) the occurrence of *A. artemisiifolia* is mentioned in the plant community **Glycerietum maximae** in the Bodrogeköz in Hungary. Additionally common ragweed was found in the herb layer of a stand in the Bodrogeköz in Hungary dominated by the sedge *Carex riparia* and the willow *Salix cinerea*.

In South Ukraine, *A. artemisiifolia* is part of a floodplain plant community **Phragmito australis-Amorphetum fruticosae** which occupies the ridges near beds of rivers and periodically flooded territories on boggy, meadow-bog clayey and sandy soils. While the shrub layer is mainly formed by *Amorpha fruticosa*, *Eleagnus angustifolia*, *Salix alba* and *Populus nigra*, the herb layer consists of species such as *Phragmites australis* (5-25%), *Conyza canadensis*, *Poa angustifolia*, *Xanthium strumarium* and even *A. artemisiifolia* (each up to 10% foliar cover, Dziuba et al. 2010).

Jehlik et al. (2005) found *A. artemisiifolia* growing in the association **Bidenti-Polygonetum hydro-piperis** Lohmeyer in R. Tx. 1950 on a gravel bank at the Danube River at Hamuliakovo in Slovakia. The association belongs to the alliance Bidention tripartiti. Common ragweed occurs in this plant society with species such as *Persicaria hydropiper*, *Bidens frondosa*, *Ranunculus repens*, *Carex acuta*, *Galium palustre*, and *Iris pseudacorus*.

common ragweed was found in the floodplain on the Croatian side of the Drava River (Csiky & Purgger 2008) in amphibious plant communities. It occurs in the association **Polygono-Eleocharitetum ovatae** Egger 1933 which belongs to the class Isoeto-Nanojuncetea (incl. Nanocyperion) and is present on bare surfaces of river gravel and sand banks. In the relevé presented, common ragweed co-occurs with species such as *Carex bohémica*, *Phalaris arundinacea*, *Polygonum hydropiper*, *Agrostis stolonifera*, *Cyperus glomeratus*, *Juncus articulatus*, *Rorippa palustris*, *Salix pupurea*, *Solidago gigantea*, *Cyperus fuscus*, *Conyza canadensis*, *Poa compressa*. In the floodplain of the Drava River many rare plant species listed in the Croatian red list are present, e.g. *Cyperus fuscus*, *Chenopodium ficifolium*, *Limosella aquatica*, *Scrophularia umbrosa*, *Leersia oryzoides*, and *Cyperus glomeratus*. *Carex bohémica* is also rare in Hungary. *Ambrosia artemisiifolia* occurs in the floodplain besides other invasive plant species such as *Solidago canadensis*, *Robinia pseudoacacia*, *Amorpha fruticosa*, *Ailanthus altissima*, *Lindera dubia* which are a potential danger for the valuable stands of the natural vegetation in the flood plain (Csiky & Purgger 2007).

Influence of common ragweed on the vegetation

In the following the interference of common ragweed and the surrounding vegetation is described from the literature. Results from own investigations and the information given by the experts in the questionnaire are added.

a) Succession on abandoned fields in the native range

Ambrosia artemisiifolia is a pioneer species of open disturbed habitats where it builds up dense and extensive stands. It is able to grow in various habitats with disturbances regularly occurring, and it spreads from its growing sites predominantly by human activities. If the vegetation develops without further disturbance, in its native range common ragweed is suppressed by other plant species within a few years (Bazzaz 1968). In his study aiming in a determination of trends and rate of secondary succession, Bazzaz (1968) found *A. artemisiifolia* dominating an abandoned corn field in the first year after harvest. In the second year common ragweed was also abundant with a frequency of 97%, but only few individuals were more than 15 cm tall. In the third year common ragweed still had

a high frequency (80 %), but the plants were rather small and inconspicuous and were suppressed by other plant species. Bazzaz (1968) concluded that dominant and subdominant species on abandoned fields become established in a definite sequence. In this study winter-annual plants, especially *Erigeron annuus* and *Erigeron canadensis*, suppressed the growth of common ragweed-seedlings in undisturbed sites in the second year after abandonment. The winter annuals germinated in late summer and fall of the year following the abandonment. They developed into rosettes during fall and winter and in the following spring and summer these plants had a competitive advantage over the summer annuals that geminate in spring. This leads to progressive suppression of summer annuals such as common ragweed (Raynal & Bazzaz 1975). The population regulation of a common ragweed-stand occurs through phenotypic plasticity rather than by density-dependent mortality. This results in the survival of many stunted plants which produce only a few seeds. By this way there still remains a diversity of genotypes which can further adapt to environmental conditions (Raynal & Bazzaz 1975).

Armesto & Pickett (1985) who investigated changes in species richness and abundance following experimental disturbance in a 7th-yr old field dominated by *Solidago canadensis* and a 2nd-yr old field dominated by *A. artemisiifolia* in the species' native range, state that common ragweed did not suppress the growth of other species early in summer, perhaps due to its slower growth rate and thinner cover compared to *Solidago*.

b) Succession on abandoned fields in the non-native range

Also investigations from Hungary demonstrate that common ragweed predominantly occurs in recently abandoned fields while it rarely grows in fields where closed secondary grassland established: Csecserits et al. (2011) investigated the vegetation of abandoned fields where the fields were categorized in fields that were abandoned 1-7, 8-20, and 21-57 years ago. *Ambrosia artemisiifolia* was found to be the most important non-native species in "young old fields" (abandoned 1-7 years ago), but its cover decreased significantly during the succession. Similarly Csecserits et al. (2009) found *A. artemisiifolia* occurring primarily on "young old-fields" in the Danube-Tisza-Interface in Hungary. On fields with a longer time of abandonment, where closed secondary grassland could establish, the abundance of common ragweed was lower than for example on plough-lands, and in semi-natural habitats (e.g. grasslands, forests). Here ragweed occurred only rarely and with low abundance (Csecserits et al. 2009).

In contrast to the situation described above, Maryushkina (1991) found that common ragweed inhibits the restoration of both annual and perennial native species, decreases the diversity of communities and delays the succession process in its new range in Ukraine. The author investigated the effect of common ragweed on species diversity on an abandoned field in Ukraine in order to analyse the influence of common ragweed on native species. Species composition and phytomass was compared on plots where common ragweed was manually removed with plots without removal of the plant. On a freshly ploughed plot on an abandoned field common ragweed significantly decreased the number of annual species, especially at the beginning of the succession process. From the results the author states that *A. artemisiifolia* inhibits the restoration of both annual and perennial native species, decreases the diversity of communities and delays the succession process in its new range. Common ragweed might profit from the fact that the number of herbivores is limited in the new range, while in the native range over 300 species of phytophagous insects feed on plants of the genus common ragweed (Kovalev 1971 a, b in Maryushkina 1991).

c) Suppression of common ragweed by perennial plants

Milanova et al. (2010) report that the plants *Lolium perenne*, *Dactylis glomerata* and *Medicago sativa* are able to suppress *A. artemisiifolia*. The turf of *Lolium perenne* was found to inhibit strongly (98 %) the production of biomass of common ragweed. *Medicago sativa* and a mixture of *M. sativa* and *Dactylis glomerata* are reliable means to suppress the growth, development and seed production

of common ragweed under suitable conditions (Valkova et al. 2009). In Brandenburg (Germany) an extensive stand of *A. artemisiifolia* on an arable field was reduced nearly completely until 2011 after cultivation of a mixture of grasses and lucerne in 2009 (Jentsch 2011, pers. communication).

d) Investigations in dry grassland areas

In open grassland common ragweed is often suppressed by the closing grassland vegetation after a short time. For example in grassland which developed on an abandoned field on sandy soil in the Niederlausitz in 2007, millions of common ragweed plants were found and about 800 common ragweed plants were counted on an area of 1 square meter. Four years later common ragweed was still present in the grassland, but it occurred only to a minor extent, mainly at disturbed open patches (Fig. 1, 2). This was probably due to missing disturbance and the competition of the accompanying vegetation.



Fig 1: Grassland on an abandoned field near Leuthen, 11th August 2007. Common ragweed dominated the field. Approx. 800 common ragweed plants per m² were counted.



Fig 2: The same area four years later: Only a small amount of common ragweed plants was present in the meadow (9th July 2011).

According to investigations of Maryushkina (1991), common ragweed is a typical r-strategist (Grime 1979), which only is able to suppress other plants with r-properties. *Ambrosia artemisiifolia* itself is inhibited by species with K-properties. Thus, in Ukraine common ragweed usually does not penetrate into pastures which are normally dominated by species with K-properties.

Szigetvári (2004) studied the role of invasive alien plants in open sandy grassland in Hungary. The general aim of the study was to give a general description of the interaction between the most important non-woody invasive plants and the open sand grassland vegetation in the Kiskunság region in Hungary. The study took place in an area which was dominated by different types of the Pannonian open perennial sand-grassland (*Festucetum vaginatae*). In some patches the perennial grassland was linked to open annual grassland (*Brometum tectorum*), and agricultural fields as well as old fields are located between the sand-grassland areas. The area was of high conservation value. Szigetvári (2004) studied the role of invasive alien plants in the grassland and found *A. artemisiifolia* which was present in this area almost exclusively growing on the dirt roads (Szigetvári 2002, 2004). According to the author, common ragweed did not seem to have a substantial transformer impact on the essential dynamic processes and structural relations of the open sand grasslands. It was strongly related to recent disturbances and does not threaten undisturbed vegetation (Szigetvári 2004). According to Szigetvári & Benkö (2008) common ragweed occurs in near-natural sites mostly in the more frequented and thus more disturbed visitor zones, and in the buffer zones where often many newly abandoned fields providing suitable growing conditions for the species are present.

However in Bavaria (Germany) common ragweed spread on a dry inland sand dune protected for

nature conservation reasons, where it was introduced unintentionally with an illegal soil deposition. The species spread in the disturbed area but was also dispersed into areas which were untouched by the soil deposition. In 2004 ca. 10,000 plants were removed by hand pulling. The ragweed population decreased to 11 plants in 2011, after regularly removal. Although the plants were displaced and thus were hindered to fill in the seed bank, the species is still present and single plants grow up till now. Possibly trampling of wild deer leads to natural disturbances and stimulates growing of common ragweed from the seed bank (pers. comm. S. Nawrath 2012/03/01). This case gives a hint that common ragweed might be able to grow in dry grassland valuable for nature protection, in case it reaches the area and natural disturbances by animals occur.

e) Impact on segetal communities

In the lowlands of Croatia the species is so frequent that it displaces all autochthonous weed species, which cannot compete with common ragweed (Pandza et al. 2001). Also in Hungary, where common ragweed is observed to build up very dense stands, it directly suppresses other weed species on arable fields (R. Pál, personal communication 2012/20/02) and thus can have severe negative impact on segetal plant communities. In Romania, a negative influence on the biodiversity of the segetal flora is expected in case of an uncontrolled expansion of *A. artemisiifolia* (Farcasescu & Lauer 2007).

Plant communities of extensive arable fields in Hungary, especially the Camelino-Anthemidetum caucalidetosum and scleranthesosum, represent refuges for many threatened weed species (Pinke 2000). Also, wet patches on arable fields have a high value for agrobiodiversity and provide a growing habitat for many endangered species such as *Elatine alsinastrum*, *Limosella aquatica*, *Lindera procumbens*, *Montia fontana*, *Peplis portula* (Pál et al. 2006). Weed species are valuable sources of food for animals and habitats for several insect and bird species (Pinke & Pal 2009, Pinke et al. 2011). Pinke et al. (2011) state that the biggest threat to the conservation of endangered weed species in Hungary is the increasing spread of *A. artemisiifolia*. According to the authors this is not only so because the species is invading more and more habitats of rare weed species but also because of eradication campaigns against common ragweed leading to a total weed control (see below).

f) Results from the inquiry via questionnaire (question 2)

According to the answers given by the experts on the questionnaire, in countries or regions with low common ragweed infestations such as Eastern France/Burgundy/Côte d'Or (invasion front; Chauvel), Czech Republic, Switzerland, and Germany it currently is not known and/or documented that common ragweed directly suppresses rare/and or endangered species. Also in Russia where common ragweed occurs in natural habitats in a few cases, no effects on biodiversity are known. However, also in countries where the species occurs more frequently data on biodiversity impacts are not or only sparsely available. A main reason for this might be that common ragweed predominantly grows in disturbed anthropogenic habitats such as road sides, construction sites, fields that are regarded as areas with relatively low nature protection value (Schoenenberger & Rossinelli, Reznik).

Field work

The field work was conducted from 5th to 11th July 2011 in the Niederlausitz in Eastern Germany. This area was chosen because it is the most common ragweed-infested area in Germany. *Ambrosia artemisiifolia* is present in this area since many decades (Hegi 1974), but the rapid spread of the species is a new phenomenon (Jentsch 2007). The study area, bordered by the villages Calau, Cottbus, Spremberg and Senftenberg, is characterized by the surface mining of brown coal, which took place during the last 100 years and is still practiced up today. Sandy soils dominate the region, and due to the mining the groundwater is lowered. On the sandy soils, often pine forests grow, and in the plains arable fields occur (BfN 2012). It was the aim of the field work to find out whether habitats or species are affected by the species.

Consultation of local experts

Due to the intensive surface mining large parts of the landscape were destroyed and are now in a recultivation process. In these areas bare soil is often present and the vegetation often shows gaps. These open areas provide good growing conditions for common ragweed. Thus, local experts were contacted to find out whether common ragweed is already spreading in the recultivation areas. The "Lausitzer Seenland Gemeinnützige GmbH" that conducts a nature conservation project in a 5760 ha big area near the city Hoyerswerda was contacted. Common ragweed occurs in that region (personal communication Dr. Alexander Harter), and during a field trip on 7th July 2011 Mr. Noak from the working group thankfully presented the plants in the field. Mostly *A. psilostachya* was present, forming extensive populations with thousands of sprouts (fig 3), but at the margin of a sandy road also a small population of *A. artemisiifolia* was detected. Occurrences of *A. artemisiifolia* were found only at the side of the dirt road. It was not known how long the species was present here, and thus it was not possible to estimate whether it enters and spreads in the open mining areas or not.

Additionally a local expert, Helmuth Jentsch, who studies the flora and vegetation including the spread of common ragweed since the 1950s (e.g. Jentsch 2007), thankfully provided a field trip at the 6th of July and demonstrated various habitats with occurrences of the species and gave an overview of the vegetation that contains common ragweed.



Fig 3a, b: Extensive stand of *A. psilostachya* growing in a recultivation area in the "Lausitzer Seenland" (demonstrated by Mr. Noak 2011/7/7). *A. psilostachya* often grows here with *Helichrysum arenarium*, *Jasione montana*, *Trifolium arvense*.

Vegetation units with occurrences of *A. artemisiifolia*

During the field work 56 relevés were conducted at sites, where *A. artemisiifolia* was found to a remarkable amount in the following habitats:

- Arable fields
- Fallow arable fields
- Field margins
- Field paths
- Forest paths and forest edges
- Road sides and food paths
- Ruderal areas
- grassland

a) Arable fields

In the investigated area *A. artemisiifolia* was often found growing on arable fields. Sometimes common ragweed occurred only at the edges of agricultural fields, in other cases the species was dispersed over the whole field (figs 4, 5). Twelve relevés were conducted on fields highly infested with the species (2 x peas, 2 x lupine, 4 x rye, 1 x sunflower, 1 x barley, 1 x maize, 1 wet patch on an arable field). 78 plant species in addition to common ragweed were found in the relevés and the mean species number was 14.5. Common ragweed was found with a cover from 3 (25-50 %) to 5 (75-100%), on average nearly 75 %. The species mostly growing with common ragweed in the fields were *Che-nopodium album* and *Apera spica-venti*. Besides, *Artemisia vulgaris*, *Centaurea cyanus*, *Polygonum aviculare* agg., *Viola arvensis*, and *Lolium perenne* often occurred. Common ragweed was also found growing at a wet patch in an arable field. Here it grew with species such as *Glyceria fluitans*, *Rumex maritimus*, *Rorippa palustris*, *Gnaphalium uliginosum*, *Polygonum hydropiper*, and *P. persicaria*. Common ragweed was present in this vegetation type only with a relatively low cover of 16-25 % (value 2b).

No endangered species were detected in the sites investigated. Similarly, Nitzsche (2010) who conducted relevés in arable fields in the same region some years earlier (in 2006), did not find endangered species on these sites too, whereas Jentsch (2007) reported of *Filago arvensis* growing in arable fields together with common ragweed. *Filago arvensis* is recorded in the German Red List of endangered plant species. It is critically endangered in the Federal State Brandenburg (Ludwig & Schnittler 1996).



Fig 4: Sunflower field highly infested with common ragweed near Auras (2011/11/07).



Fig 5: Lupinus field completely infested with common ragweed near Koschendorf (2011/10/07).

Common ragweed was found predominantly at places where disturbances regularly took place. In dense vegetation with a large proportion of turf it was not present, or only rare. For example *A. artemisiifolia* was found growing with high densities in a rye field (fig 7) near Domsdorf. The field bordered on a light pine forest which had a dense grass-dominated understory. Common ragweed was not found in this vegetation unit and was also absent from the pine forest. It only occurred in the arable field which was regularly ploughed (fig 6, 7).



Fig 6: common ragweed occurs in high densities in the understory of a rye field near Domsdorf (2011/7/8).



Fig 7: common ragweed only occurs in the field regularly ploughed. It was not found in the grass dominated edge of a light pine forest that borders on the field (2011/07/08).

b) Field margins and field paths

In some cases, *A. artemisiifolia* occurs at the margins of the arable field only. In relevés of the margins of two wheat and four maize fields, 73 plant species were found apart from common ragweed. The medium plant number per relevé was 20.5, which is much higher compared with the situation inside of the field, where only 14.5 species per relevé were detected. The most common plant species growing at the field margins are *Echinochloa crus-galli*, *Elymus repens* and *Chenopodium album*. Once the endangered *Filago arvensis*, was found, and also *Jasione montana*, *Galium verum*, *Anchusa arvensis*, *Daucus carota*, *Lotus corniculatus* and *Vicia angustifolia* occurred at the field margins of the area investigated.

In some cases common ragweed was also present on field paths where the species usually remained small due to frequent disturbances (e.g. trampling) and occurred only in small amounts. In a relevé from a field path near Löschen, 17 plant species were found. Common ragweed grew here with species typical for trampled vegetation such as *Plantago major*, *Lolium perenne*, *Poa annua*, and *Polygonum aviculare* agg. Next to the field path investigated, dry extensive grassland with species such as *Helichrysum arenarium*, *Jasione montana*, *Artemisia campestre*, *Sedum acre* and *Festuca ovina* was present. Although this vegetation was full of gaps, common ragweed was not found here.

c) Fallow arable fields

Ambrosia artemisiifolia is able to built up extensive populations on fallow arable fields in the area investigated (fig 9). The species was recorded with cover values of 3 (25-50 %), 4 (50-75 %) and 5 (> 75%) and the plants grew up to a height of ca. 60 cm. 30 plant species were found on three fallows growing with common ragweed, and the mean species number was 23.3. *Conyza canadensis* and *Apera spica-venti* often occurred in this habitat type. During the investigation no endangered species were detected on the three fallow fields. Nitzsche (2010) also found the two species mentioned above most frequently growing with common ragweed in fallow lands and at ruderal sites. Jentsch (2007) reported from these habitats the endangered species *Filago arvensis* growing here with com-

mon ragweed. In the relevés containing *Filago*, common ragweed only had a cover of 2a (cover 5-15 %) or 2b (cover 16-25 %).

Comparable to the situation on the arable fields, common ragweed predominantly occurred in disturbed areas. In a ruderal field next to the fallow heavily grown with common ragweed only a small amount of small (< 10 cm) common ragweed plants was detected (fig 8, 9).

In nitrogen-poor grassland next to a fallow field where many common ragweed plants occurred, no ragweed was found, although gaps were in the vegetation of the grassland (fig 11, 12). In the grassland *Helichrysum arenarium* was present. According to the Red list of endangered species *Helichrysum* is endangered in Germany (Ludwig & Schnittler 1996, value 3), but not in the federal state Brandenburg where the study area is located.



Fig 8: Extensive stand of *A. artemisiifolia* on an abandoned field at Buckwitzberg (2011/8/7; pictures: Albernerst)



Fig 9: common ragweed predominantly occurs on the fallow field (on the right). Only a small amount of little (<10 cm) ragweed plants were found in the ruderal area (on the left) beside of the fallow field.

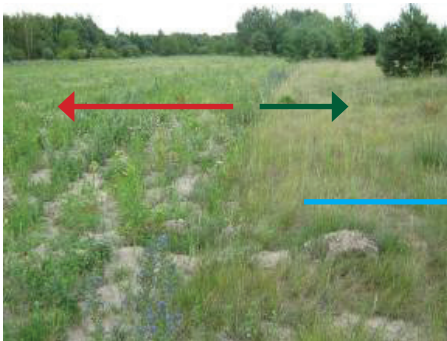


Fig 10: Fallow field with common ragweed on the left, nitrogen-poor grassland on the right side of the picture (2011/7/8). No common ragweed was found in the grassland (fig 12).



Fig 11: Nitrogen-poor grassland with gaps aside of the abandoned field with many common ragweed plants (fig 11). *Helichrysum arenarium*, which is endangered in Germany (D: 3, BB: -) grows here. No common ragweed was found in the grassland.

In own investigation of 2007, *A. artemisiifolia* is often present in stubble fields in the studied area in the Niederlausitz. At the time of the field trip in July 2011 the cereal crops had not yet been harvested, thus no relevés from stubble fields are presented.

d) Grassland

Ambrosia artemisiifolia is able to grow in grassland and pastures. In the study area it was documented from four grassland sites. In two cases common ragweed had a low cover (less than 5 %) in two other sites it reached a cover value between 50 and 75 %. In the four relevés 56 plant species were found. The medium number of plant species in the relevés was 21.5. *Achillea millefolium*, *Festuca rubra*, *Rumex thyrsiflorus*, and *Agrostis capillaris* were the most common plant species growing with common ragweed. At one site *Dianthus deltooides* was found, a species which is endangered in Brandenburg. At another site *Filago cf arvensis* occurred. In the grassland where common ragweed was found the vegetation was developed sparsely and showed gaps. The common ragweed plants were small (< 10 cm).



Fig 12: Grassland near Leuthen with occurrences of *A. artemisiifolia* (9th July 2011).

e) Ruderal sites

Thirteen ruderal sites located next to a newly built federal highway (B169), frequently disturbed sites in mining areas, ruderal sites next to agricultural fields or beside a parking area where common ragweed was present, were investigated. Similar to the situation in the abandoned fields *Apera spica-venti* and *Conyza canadensis* were the most frequent accompanying species. Also *Taraxacum* sect. *Ruderalia* and *Tripleurospermum perforatum* often occurred. In total, 104 species apart from common ragweed were found in the sites investigated and the mean species number per relevé was 21.3. Mostly common species such as *Elymus repens*, *Achillea millefolium*, *Agrostis capillaries*, and *Rumex acetosella* were detected, but in 7 of the 13 relevés the endangered species *Filago arvensis* was present.

Comparable to the situation in the arable fields, where common ragweed was found on wet patches as well as in relatively dry growing conditions, the species also has a wide ecological amplitude at the ruderal sites and occurred in wet as well as in dry growing conditions. In some dry and nutrient-poor growing places the whole vegetation was developed sparsely and common ragweed remained small (< 15 cm) (fig 13, 14), while in sites with a better nutrient supply common ragweed was taller and reached cover values up to 75-100 %.



Fig 13: common ragweed occurring with the endangered *Filago arvensis* at a dry ruderal site near Domsdorf (2011/07/10) (picture: Alberternst).



Fig 14: common ragweed at a dry nutrient-poor ruderal site next to a newly build highway near Domsdorf (2011/07/10, picture: Alberternst).

f) Roadsides

In the study area *A. artemisiifolia* often occurs at roadsides. The species usually grows in a distance up to ca. 50 cm (maximum 100 cm) from the paved surface. Common ragweed prefers this area next to the tarmac and was found in the vegetation away from road only in a few cases (fig 15, 16).

In seven relevés conducted at roadsides near Domsdorf, Senftenberg, and Luckaitz, 66 plant species were found in addition to common ragweed. The medium species number in seven relevés was 18.6. Common ragweed was often growing with species such as *Polygonum aviculare* agg., *Rumex acetosella*, *Festuca rubra* and *F. ovina*, *Trifolium arvense*, and *Lolium perenne*. No endangered species were found, but two species (*Armeria maritima* and *Leontodon saxatilis*) which populations currently are decreasing in Brandenburg (Rote Liste Gefäßpflanzen 2006, value: V) occurred at road sides.

According to Jentsch (2007) in the area investigated the strong appearance of common ragweed at roadsides is a recent phenomenon. Common ragweed was probably introduced into these sites with contaminated soil which was used for the filling of the road shoulders. The species could also have entered the road sides with agricultural machines losing soil containing ragweed seeds from the agricultural fields.

Road sides are an important spreading route for common ragweed also in the area investigated: In an extensive recultivation area near Senftenberg the species was recently introduced with the construction material for a new road (fig. 18). Common ragweed grows on the shoulder of the road at a great number of sites. Whether common ragweed reaches the open vegetation in the surrounding area, for example via water flow in the drainage tubes (fig 17), needs to be studied further.



Fig 15: *Ambrosia artemisiifolia* grows in the area up to 50 cm beside of the paved road near the village Löschen. Only in a few cases the species was found growing apart from the road side.



Fig 16: common ragweed prefers the area beside of the road near Ogrosen, although the vegetation bordering on the road often is open.



Fig 17: Extensive recultivation area near Senftenberg. Many common ragweed plants were found in the banquet of a newly build road. The species was obviously introduced with the construction material for the road. Whether common ragweed spreads into the open vegetation in the surrounding e. g. with water flow in the yellow drainage tubes (Fotos: Alberternst), needs to be studied.



g) Forest margins and forest paths

During the field work common ragweed was found at forest paths and at forest edges, especially at sites which bordered to arable fields. In six relevés from these habitats 78 plant species were found and the mean species number was 20.7. Common ragweed had a foliar cover between “+” (2-5 individuals, less than 5 % cover) and “4” (50-75 % cover) and it often grew with species such as *Bromus sterilis*, *Achillea millefolium*, *Taraxacum* Sect. *Ruderalia*, *Elymus repens*, *Geranium pusillum*, *Agrostis capillaris*, *Chenopodium album*, *Urtica dioica*, *Poa annua*. Usually common ragweed was not the dominant species in the vegetation. No endangered species were found at these sites during the investigation.



Fig 19: Light forest road and food path near Domsdorf with a stand of *A. artemisiifolia* at 8th of July 2011. At the beginning of July common ragweed was small, but it still was in the growing process (Fotos Alberternst).

Compilation of the vegetation data

During the field work, 194 plant species were found in the 56 vegetation relevés conducted in the Lower Lusatia at beginning of July. The compilation of data presented in table 3 demonstrates that the highest number of plant species was found in ruderal areas, whereas the number of relevés from these sites was relatively high compared with the number from other habitats. The mean number of plant species was highest in grassland, followed by ruderal areas and forest edges, whereas the smallest amount of plant species was present in abandoned and arable fields. In the ruderal areas, in grassland, at forest edges, field margins and at roadsides rare, respectively endangered species (*Filago arvensis*, *Dianthus deltoides*, *Armeria maritima*, *Leontodon saxatile*) were found. No such species were recorded from the arable fields or from the fallows during this study, whereas Jentsch (2007) detected *Filago arvensis* on agricultural fields some years earlier.

A suppression of other plant species was not obviously visible during the investigation, as it is for example in dense stands of *Fallopia japonica* in which nearly no other species exist. At the sites investigated where the mentioned rare species, or species with decreasing populations occurred, the vegetation often was sparsely developed and common ragweed usually remained small and did not dominate the stand.

Comparative studies of sites with and with removed ragweed plants

In the agricultural area of the study area common ragweed often builds up extensive and dense stands whereas spring crops, especially sunflower fields, are mostly affected by dense ragweed stands due to a low efficacy of herbicides, and the late sowing date of the crop. The investigations conducted by Drotkowski (2012) demonstrate that the cover and height of accompanying weed species are lowered by common ragweed in sunflower fields, whereas in winter crops this is not obvious due to the fact that common ragweed remains small and starts to grow in the stubble fields after harvest of the crop. Muranko (2012) did not find significant differences in the species composition in sites with and with removed ragweed plants in sunflower and winter rye fields, in grassland and at road sides in the Niederlausitz. However, the cover of ragweed in the sites investigated was relatively low and an impact might be more evident when the plant cover of ragweed exceeds 75 %.

Tab 3: Compilation of the number of plant species found in the habitats investigated. On arable fields no endangered species were found during this study, whereas the endangered *Filago arvensis* was found on arable fields in the same region by Jentsch (2007) some years earlier. The total number of plant species detected in the sites investigated was 194.

Habitat type	number of relevés	total number of species	mean number of species	Rare/endangered species present
Arable fields 13		68	14,5	Not found in this study
Fallow fields	3	31	13,0	-
Field margins	6	74	20,5	+
Forest edges	6	78	20,7	-
Grassland	4	56	21,5	+
Ruderal areas	13	105	21,3	+
Road sides	7	68	18,6	+

Data compilation on habitats colonized by common ragweed and assessment of possible effects on biodiversity

In the following, an overview of habitats grown with common ragweed, the nature protection value and possible impacts of common ragweed on biodiversity is given. The influence on biodiversity is described and data regarding biodiversity impacts are compiled. To estimate the biodiversity impact not only changes in the species composition should be considered, it should also be noted whether rare and/or habitat specific species that are important for associated species in these habitats (e.g. food resources) are affected.

Tab 4: Compilation of data on occurrence of *A. artemisiifolia* in different habitats and assessment regarding nature protection issues.

Habitat	How often does common ragweed occur? (in countries/regions with high infestations)	Nature protection value of habitat	Influence of common ragweed on biodiversity	Influence regarding nature protection issue
Agricultural fields	Very often, occurs in various plant communities	Mostly low in intensively managed areas, partly high value in extensively used areas, and in species rich habitats	Suppression of weeds in dominant ragweed stands (e.g. Pandza et al. 2001, Pál 2004, Pinke et al. 2011, Drotkowski 2012)	Negative impact when rare/endangered species or species of high value for associated species are affected (Pál 2004, Pinke et al. 2011), On abandoned fields, succession could be delayed (Maryushkina 1991)
Ruderal sites	Often, in various plant communities	Often low (e.g. in nutrient rich habitats), Could be high in nutrient-poor places when various, and also rare species are present	common ragweed could suppress weed species in dense stands e.g. at nitrogen-rich sites, Influence mostly unknown	?, in most cases probably low impact (suppression of <i>A. a.</i> during succession)
Roadsides	often	Mostly low	? or probably low (Muranko 2012), in very dense stands species could be suppressed	?, in most cases probably low impact
Nutrient-poor grassland (incl. sand habitats)	Rarely	high	?	?, in Germany in a single case negative influence assumed In Hungary occurrence in a grassland area only at disturbed sites (e.g. dirt roads, Szigetvari 2009) or mostly (?) in disturbed plant communities (Bauer 2006)
Newly grown meadows, pastures	sometimes	Sometimes high	?	?, probably low due suppression of common ragweed during succession
Flood plains	sometimes	Sometimes high (Czisky & Purger 2008)	?	?
forests	sometimes	Sometimes high	?	?

Discussion

Common ragweed is an annual plant and a pioneer species which needs open disturbed sites for germination and it prefers open and sunny habitats where competition with other species, especially perennials, is low. The field work in the Niederlausitz showed that common ragweed is present in the most disturbed sites and usually does not grow to a remarkable amount in the undisturbed vegetation next to extended ragweed stands. Unsuitable growing conditions in the vegetation and lacking disturbance could be the reason, but it also is possible that the species did not reach the area due to its limited spreading abilities (relatively heavy seeds, no adaptation to wind dispersal) until now. This dependence of common ragweed on disturbance limits the number of habitats where the species can grow.

In spite of its relatively low spreading capacity the species profits from human activities such as the massive transportation of soil containing ragweed seeds, e.g., during construction measures, transportation of seeds with agricultural, construction or mowing machines, resulting in an efficient and quick spread of common ragweed. However, agricultural areas, road sides and ruderal sites, where common ragweed is often present in many European countries and also in the study area in the Niederlausitz, provide suitable growing conditions for the species but these areas are usually not in the main focus of nature protection. The results from the field study show that also in these habitats sometimes rare and endangered species occur that might be affected by dense ragweed stands. In Croatia, common ragweed suppresses weed species in arable fields (Pandza et al. 2001) but it is not mentioned whether this has negative effects for nature conservation. Studies from Hungary, where common ragweed spread intensively in agricultural areas since the beginning of the 1990s, demonstrate that common ragweed suppresses also rare and endangered weed species in extensive arable field and thus is assessed as having negative impacts on the agrobiodiversity (Pinke et al. 2011, Pál 2004).

On abandoned fields but also in other habitats where plant species grow and close vegetation gaps, common ragweed itself is mostly suppressed by the establishing plant species in the native and also in the non-native range during the succession. However, a study from Ukraine shows that common ragweed inhibits the restoration of both annual and perennial native species, decreases the diversity of communities and delays the succession process probably due to a less impact of predators feeding on the plants in the non-native range.

In countries with low infestations where the intensive spread of common ragweed just started such as in Germany or in East of France no direct negative impacts of common ragweed on the biodiversity are documented, indicating that due to low infestations no conflicts with aims of the nature protection are currently present. However, also in Russia where common ragweed is very wide spread and considered to be the most noxious invasive weed since the 1940s (Reznik 2009), the impact of common ragweed on natural biodiversity is regarded to be small (Reznik, information given in the questionnaire 2012).

In general, common ragweed has a wide ecological amplitude and a great morphological plasticity that allows it to exist in various growing conditions. Thus, the species could also be expected to grow in open sites where natural disturbances such as trampling by deer or disturbance due to floating water and also dispersal by these means occur, in case the species reaches the growing habitat. It is the first step in an invasion process that the species gets in suitable habitats. The more common common ragweed becomes in anthropogenic sites, e.g. in agricultural areas, the higher is the likelihood that it reaches more natural habitats where an impact is currently not foreseeable. In the study area in the Niederlausitz *A. artemisiifolia* is present since many decades (Hegi 1974) but the rapid spread of the species just started a few years ago (Jentsch 2007), common ragweed thus might not have reached areas with higher nature protection values till now and therefore possibly no negative impacts are currently known.

In some countries common ragweed is already present in more natural habitats for example in

flood plains where natural disturbances regularly take place and common ragweed spreads with the floating water. Some of the plant communities contain rare and endangered plant species (e.g. Csiky & Purger 2008). As far as we could find out currently there is only limited knowledge on the influence of common ragweed on the accompanying plant species in these, but also in many other habitats affected. Negative impacts on biodiversity are unforeseeable at the moment in countries where common ragweed spreads but has not reached all potential growing areas. Climatic changes may force the process of dispersal and thus possibly forces impacts of the species on biodiversity.

Impact of control measures against common ragweed on biodiversity

Control measures such as herbicide application and the use of mechanical control against *A. artemisiifolia* may have a negative influence on the biodiversity. Also a land use change in order to control common ragweed may cause damage to flora and fauna. In Hungary for example, since the year 2007 it has been compulsory for farmers to prevent the forming of common ragweed flower buds (Kazinczi et al. 2008). According to these authors, in crops, common ragweed must be controlled if the foliar cover of common ragweed exceeds 30 %. Specialists of "Field Offices", which exist in every large town in Hungary, conduct a survey after 30th of June. In case there is an offense against the law, a penalty can be imposed which varies between 80 and 20.000 Euros depending on the size of the infested area. This recently led to increased control activities against *A. artemisiifolia* by Hungarian farmers (Kazinczi et al. 2008). According to Beres (2004 in Kazinczi 2009) early stubble-stripping done in time prevents seed ripening of common ragweed, and after that, frequent soil cultivation triggers seed germination leading to a reduction of soil seed bank. Also Saric et al. (2011) recommend early and adequate stubble treatments in order to control common ragweed. Due to the fact that chemical and mechanical control methods are not species-specific, a wide range of species is incidentally affected (Pál 2004, Pinke et al. 2011). This definitely affects weed species diversity due to the fact that potential habitats of several native and archaeophytic weed species are destroyed (Pál, pers. comm. 2012).

To this background the common ragweed experts from the different countries where asked in the questionnaire for their estimation regarding the impacts of control measures on biodiversity.

Results of the inquiry

a) Implementation of control measures (question 4 a)

Fig. 20 shows the answers to the question how often common ragweed is controlled in different habitats, and it is demonstrated that common ragweed is controlled predominantly on agricultural fields. In some countries common ragweed is controlled at field margins, at road sides and on fallow land. In most countries common ragweed is never or only rarely controlled in ruderal habitats or in pastures and meadows, whereas in some countries common ragweed is rare (e.g. in Czech Republic) and thus no control measures are conducted. In some other countries there is an obligation to control the species, e.g. in Croatia where since 2004 a special legislation obliges all land owners to control common ragweed on their land. The obligation also includes public places and thus, common ragweed is more often controlled in Croatia than before the year 2004 (N. Galzija). Also in Hungary landowners are obliged to control common ragweed as described above.

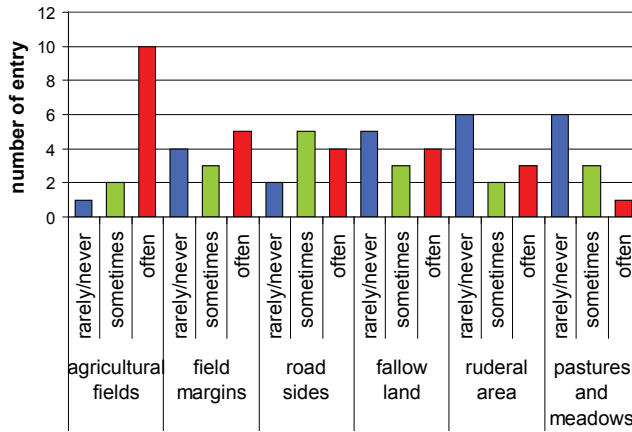


Fig 20: Answers to the question how often common ragweed is controlled depending in different growing habitats (Answers from 13 questionnaires, without answers where a question mark was put in).

b) Impact of control measures against common ragweed on biodiversity (question 4 b)

Fig 21 and fig 22 give an overview on the answers of the experts regarding the question, whether control measures against common ragweed have a negative impact on biodiversity. Additionally it was asked for available scientific studies on this question (fig 22).

In countries with low ragweed infestations no (or only little) negative impacts on biodiversity are known. Also from regions where common ragweed occurs more frequently, the impact often is regarded to be small, due to the fact that common ragweed predominantly grows in disturbed anthropogenic habitats. Some experts refer to negative impacts on biodiversity due to intensified herbicide use on arable fields as well as in non-agricultural areas such as field margins or road sides (if herbicide use is legal). Mowing of field margins or other areas to control common ragweed is thought to have a negative impact on biodiversity in some cases. Whereas early tillage in order to control common ragweed is a threat factor for rare weeds in some regions in Hungary, this is not quoted to be a problem in some other countries (sometimes due to the fact that this method is not used to control common ragweed).

However, the inquiry demonstrates that even in countries where common ragweed frequently occurs, data concerning the above mentioned question is sparse or even missing.

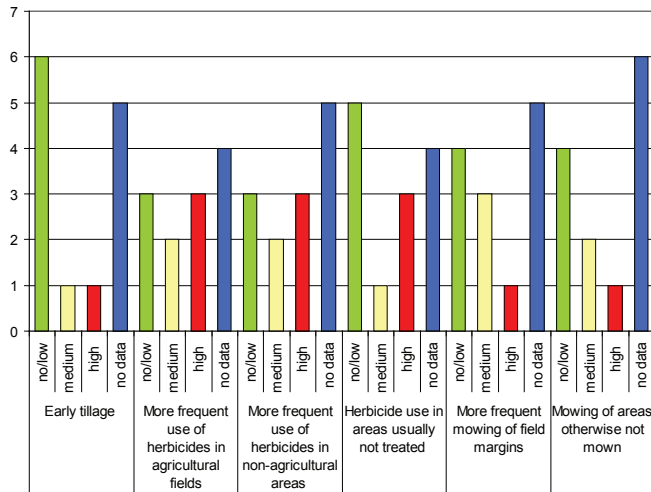


Fig 21: Estimation of the impact (no/low, medium, high impact) of control measures against common ragweed on biodiversity.

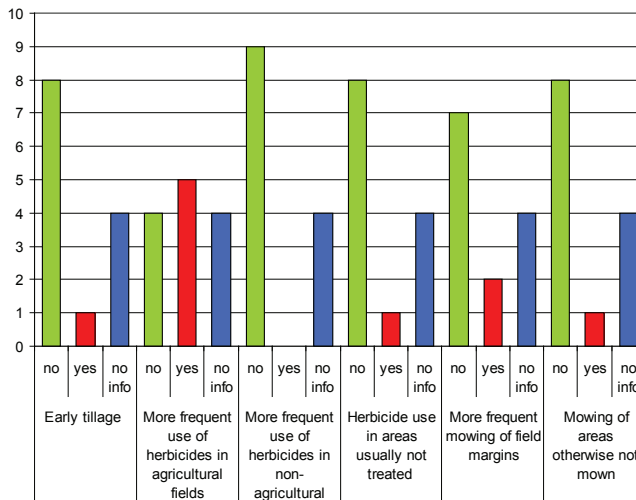


Fig 22: Availability of studies regarding the impact on biodiversity of different types of control measures against common ragweed (**no**: no studies available, **yes**: studies available, **no info**: no information given in the questionnaire).

c) Expected negative impacts in case of intensified control of common ragweed (question 5)

Some experts expect no or only minor negative impacts on biodiversity in future, even in the case of more frequent chemical or mechanical control of common ragweed, since the species predominantly grows in disturbed habitats where rare and endangered species usually are sparse or not present. Others expect adverse effects on rare and/or endangered weeds or whole vegetation units for example on extensively used arable fields or at field margins. Negative impacts due to intensified use of herbicides that could spread to other habitats (e.g. via water flow) are feared. Also rare r-strategists occurring along roadsides and railway tracks may be affected by more frequent use of herbicides. Another expert expects a negative effect for row crops. Also more frequent mowing is thought to have a negative impact on biodiversity e.g. at roadsides and forest roads. Intensified control measures in open dry grassland and xerothermic forest also could injure vegetation (information provided by N. Bauer, M. Bonini, D. Bozic, B. Chauvel, A. Csecserits, N. Galzina, G. Karrer, P. Kotanen, R. Pál, S. Reznik, H. Skálova, N. Schoenenberger, M. Rossinelli, B. Alberternst, S. Nawrath).

Possible impacts of control measures on biodiversity

Currently there is a gap in the knowledge on how control measures against common ragweed might influence the biodiversity. Due to the fact that investigations are only sparsely available, possibilities how control measures against ragweed can/could impact biodiversity, are listed here:

- Increased herbicide use could lead to an enhanced environmental burden and also kill accompanying plant species.
- Land use change as part of measures against common ragweed could have a negative impact on the vegetation. For example, early tillage may kill plants and can alter plant communities.
- Repeated mowing in order to reduce pollen production of common ragweed can lead to a reduced flower production of native species resulting in less seed set. Additionally the amount of pollen and/or nectar and also seed which provide food for insects is reduced.
- Hand pulling of ragweed plants could enhance disturbances and thus may influence the species composition.

In the following examples and results from literature and own investigations are given.

In many countries *A. artemisiifolia* predominantly occurs in agricultural fields and at field margins and thus, control measures against the species mostly occur in these habitats. Special control measures against common ragweed can impact the weed flora on stubble fields of cereal crops. Cereal fields are usually disturbed only at the beginning of the season and if the fields remain unploughed after harvest during the summer and autumn months these habitats provide the longest undisturbed growing conditions for annual weed species in arable systems (Pinke et al. 2010). Some weeds belong to the group of summer annual species which usually germinate during the spring. These species usually remain within the lower herb layer in the cereals and start to grow after harvest when the light conditions are more favourable. Intensive agricultural management with using of chemicals and early ploughing of stubbles thus has great impact on these agricultural weed communities (Pinke et al. 2010). Pinke et al. (2008) stress that *A. artemisiifolia* seriously threatens the existence of red list and other rare weed species in Hungary, not only because it is invading more and more habitats of them, but also due to intensified control measures including greater emphasis on the importance of total weed control and early ploughing of stubbles.

The following example from Bavaria demonstrate that control measures against common ragweed can also have a negative impact on the weed flora on a fallow field in Germany although common ragweed currently is not widely distributed: *Ambrosia artemisiifolia* was found on a fallow in

Georgensgmünd where endangered plant species such as *Arnoseris minima* (Red List Germany: 2), *Consolida regalis* (Red List Germany: 3) and *Filago cf. arvensis* (Fig. Red List Germany: 3) were present (fig 23). In 2010 this field was treated with herbicides especially to kill *A. artemisiifolia*. The control measure also killed the accompanying rare plants on this field.



Fig. 23: Fallow agricultural field with occurrences of *A. artemisiifolia*. Here are rare and endangered species: *Arnoseris minima* (on the right), *Consolida regalis* and *Filago cf. arvensis* occur (2011/07/04, pictures: Nawrath).

In Germany the composition of segetal plant communities drastically changed during the last 50 years. Intensified agricultural management as well as abandonment of agricultural fields especially on poor soils lead to profound changes in the floristic composition of the weed flora. The populations of many weed species strongly decreased and currently a great amount of these plants is recorded in the red list of endangered plant species in Germany (Meyer et al. 2008, Hofmeister & Garve 2006). Associated with this development, also the diversity of the fauna of arable fields drastically decreased (Heydemann & Meyer 1983).

Edges and margins of agricultural fields, and also stubble and fallow fields, often provide last refuges for segetal weed species and the associated fauna and thus are important for the agrobiodiversity (v. Elsen 2005). Common ragweed often occurs in these habitats. In the case intensified herbicide use, mowing or even ploughing takes place in order to reduce the pollen production and prevent the spread of the species, biodiversity could also be impacted at these sites. The measures might lead to reduced food resources for insects or birds or worsen habitat structures for animals living in these habitats (Pinke et al. 2011, Pál 2004). This is not only true for agricultural habitats but also for ruderal sites such as road margins, railway tracks, or industrial areas where accompanying species could be affected by control measures against common ragweed as well.

Due to its wide ecological amplitude *A. artemisiifolia* is able to grow in many different habitats such as ruderal areas, road margins, river plains, nutrient-poor dry grassland where also rare and endangered plant species could be present. Thus, intensified control measures carried out especially to remove common ragweed might also affect the accompanying plant species and the fauna associated with these species, in case nature conservations aspects are not taken into account.

Discussion

The number of studies dealing with indirect impacts of control measures against common ragweed on biodiversity is currently low and is, as far as we know, mainly confined to the work conducted by Pinke (2000, 2007), Pinke et al. (2011) and Pál (2004) in Hungary. In our opinion the indirect influences of control measures against common ragweed have a stronger negative effect on biodiversity than the direct effects. The authors from Hungary show that some of the control measures against common ragweed already have negative impacts on the biodiversity. In case of the spread of common ragweed not only in agricultural fields, but also in all habitat types suitable for the species, control measures could be intensified in order to prevent human health problems leading to negative impacts on flora and fauna.

In general, the efforts to reduce ragweed plants and populations and prevention of spread of the species in Europe should be intensified. However, nature protection as well as environmental aspects (e.g. in case of herbicide use) should be taken in consideration and accompanying plant species should be spared during the control, for example by hand pulling of small populations instead of complete ploughing or spraying of the whole site. The occurrence of *A. artemisiifolia* at a site should not be used for a justification to intensify weed control in general. Additionally, it also should not be an argument to renounce environmental friendly methods to run farming (e.g. non-ploughing cultivation methods).

Summary and conclusion

To find answers on the question whether *A. artemisiifolia* or control measures against the species have negative impacts on the biodiversity a literature review, an inquiry and field work was conducted. A review of the literature is given regarding biological features of common ragweed, the habitats and the vegetation where the species is present in Europe, and how it influences the accompanying species. The inquiry was conducted via questionnaire and 118 experts from 38 countries currently working on the topic "common ragweed" were asked for their estimation regarding the biodiversity impacts of common ragweed. The field work was conducted in the Niederlausitz, which is the most common ragweed-infested area in Germany. It was investigated in which habitats common ragweed currently is present and whether negative impacts on accompanying species can be detected. We thankfully received 12 answers on the questionnaire, whereas this number of answers is very low. This possibly reflects the limited amount of scientific information currently available on the topic.

common ragweed predominantly grows in areas where disturbances regularly occur, and it scarcely is present in undisturbed areas. The species predominantly occurs in agricultural areas and at rural sites and thus it mainly grows in plant communities of the phyto-sociological classes Stellarietea and Artemisietea. In general, *A. artemisiifolia* has a wide ecological amplitude, and in Europe it is present in various plant communities from wet sites, such as the Glycerietum to phytocoenoses from dry habitats, such as the Corynopheretum and it was even found in Quercion communities (Song & Prots 1998, Bauer 2006, Szirmai et al. 2009).

In agricultural fields, on stubble fields, and on fallows common ragweed can build up dense and extensive stands. Common ragweed is a good competitor and thus causes yield losses in various crops. In Hungary common ragweed suppresses accompanying plant species by competition for light, nutrients, and water and may influence them by its allelopathic capacity (Beres et al. 2002, R. Pál, personal communication 2012/20/02). This also happens in the lowlands of Croatia where *A. artemisiifolia* displaces autochthonous weed species, which cannot compete with common ragweed (Pandza et al. 2001). Not only in its alien, but also in its native range, common ragweed can have a strong negative effect even on species which are moderately good competitors such as *Agropyron repens* and *Plantago lanceolata* (Miller & Werner 1987, Callaway & Walker 1997). Studies conducted by Maryushkina (1991) on a freshly ploughed plot on an abandoned field in the Ukraine show that common ragweed significantly decreased the number of annual plant species, especially at the be-

gining of the succession process, and the author stated that *A. artemisiifolia* inhibits the restoration of both annual and perennial native species, decreases the diversity of communities and delays the succession process in its new range.

During the field work in the Niederlausitz *A. artemisiifolia* was found in different habitats, in arable fields, fallows, field margins, field paths, forest paths and forest edges, roadsides and food paths, ruderal areas, and in grassland. In 56 relevés from different habitats with occurrence of common ragweed 194 plant species were found. Extensive ragweed stands were present in agricultural fields, on fallows, at field margins and also at road sides and ruderal fields. Common ragweed was mainly found in disturbed areas and was rarely present in undisturbed vegetation. At some sites such as roadsides, in ruderal areas, in grassland, field margins and fallows, rare species such as *Filago arvensis*, *Helichrysum arenarium*, *Armeria maritima*, and *Leontodon saxatile* were recorded. A direct suppression of these species by common ragweed, however, could not be demonstrated. In case of more intensified control of common ragweed in these habitats, rare species could also be affected by the control measures.

According to the answers of the experts in the questionnaire, in countries with low ragweed infestations no (or only little) negative impacts on biodiversity are known. But also from regions where common ragweed occurs more frequently, the impact often is regarded to be small, due to the fact that common ragweed predominantly grows in disturbed anthropogenic habitats. Some experts report negative impacts on biodiversity due to intensified herbicide use on arable fields as well as in non-agricultural areas such as field margins or road sides (if herbicide use is legal). Mowing of field margins or other areas to control common ragweed is thought to have a negative impact on biodiversity in some cases. Whereas early tillage in order to control common ragweed is a threat factor for rare weeds in some regions in Hungary, this is actually not quoted to be a problem in some other countries (sometimes due to the fact that this method is not used to control common ragweed).

Some experts expect no or only minor negative impacts on biodiversity in future, even in case of more frequent chemical or mechanical control of common ragweed, since the species predominantly grows in disturbed habitats where rare and endangered species usually are sparse or not present, others expect adverse effects on rare and/or endangered weeds or whole vegetation units for example on extensively used arable fields or at field margins. Negative impacts due to intensified use of herbicides that could spread to other habitats (e.g. via water flow) are also expected. Also rare r-strategists occurring along roadsides and railway tracks might be affected by more frequent use of herbicides. Another expert worries about a negative effect on weeds in row crops. Additionally, more frequent mowing is assumed to have a negative impact on biodiversity, e.g. at roadsides and forest roads and intensified control measures in open dry grassland and xerothermic forest also could injure vegetation.

In general, there are many gaps in knowledge on biological impacts of common ragweed on biodiversity. Probably the species has minor direct impacts on the biodiversity at various anthropogenic sites, but the former mentioned studies, especially from the agrobiocoenoses in countries with high ragweed infestations, suggest that biodiversity could be directly affected by common ragweed respectively indirectly by control measures against the species. Additionally, common ragweed currently spreads in many countries and due to its wide ecological amplitude in future it may also occur in habitats where conflicts with aims of the nature protection could arise.

Conclusion: Due to the fact that control measures against common ragweed could have negative environmental effects the nature protection authorities should be involved in activities to control and prevent spread of common ragweed. Not only the agricultural and the human health sector, but also the nature protection sector should be involved in the development of strategies against the spread of common ragweed in Europe in an interdisciplinary task.

In order to reduce knowledge gaps regarding the direct and indirect influences of common ragweed on biodiversity, specific inquiries should be conducted.

Proposals for further research

- Comparison of vegetation types with high infestations of common ragweed (>75 % plant cover of common ragweed) with vegetation without infestations.
- Investigations in areas of high nature protection values where common ragweed is present and study of its growing behaviour.
- Inoculation and competition experiments in laboratories and at natural study sites.

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