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Buttenschøn, Rita M.; Waldispühl, Stephanie; Bohren, Christian

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Guidelines
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Project partners are:
Aarhus University (Denmark), Agricultural Institute of Slovenia (Slovenia), Agroscope ACW (Switzerland), Julius Kühn Institute (Germany) and Copenhagen University (Denmark).

Project team/editors:
Niels Holst, niels.holst@agrsci.dk, Aarhus Universitet
Preben K. Hansen, prebenk.hansen@agrsci.dk, Aarhus Universitet
Per Kudsk, per.kudsk@agrsci.dk, Aarhus Universitet
Solvej K. Mathiassen, solvejg.mathiassen@agrsci.dk, Aarhus Universitet

Andrej Simoncic, andrej.simoncic@kis.si, Agricultural Institute of Slovenia
Mario Lesnik, mario.lesnik@uni-mb.si, University of Maribor, Slovenia

Christian Bohren, christian.bohren@acw.admin.ch, Agroscope ACW
Stephanie Waldispühl, stefwald@hotmail.com, Agroscope ACW

Arnd Verschwele, arnd.verschwele@jki.bund.de, Julius Kühn Instituttet
Birte Wassmuth, birte.wassmuth@jki.bund.de, Julius Kühn Instituttet
Uwe Starfinger, uwe.starfinger@jki.bund.de, Julius Kühn Instituttet

Hans Peter Ravn, hpr@life.ku.dk, University of Copenhagen
Rita Merete Buttenschøn, rmb@life.ku.dk, University of Copenhagen

Authors:
Rita Merete Buttenschøn, Stephanie Waldispühl and
Christian Bohren (Chapter 9: Best-bet control strategies)

Layout:
Karin Kristensen, University of Copenhagen

Front page photo:
Preben K. Hansen

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1. Introduction

Ambrosia artemisiifolia (common ragweed) has spread from its native range in North America into the temperate zones of Europe and in parts of Asia and Australia where it is one of the major causes of pollen-induced allergy. The ongoing spread of *Ambrosia artemisiifolia* in Europe is an increasing problem for human health and as an agricultural and non-agricultural weed. *Ambrosia artemisiifolia* is causing expenses of several hundreds of millions of Euros.

Other species of Ambrosia have been spreading to Europe together with common ragweed, e.g. *A. trifida* (giant ragweed) and A*. coronopifolia* (perennial ragweed). These species are also allergenic and grow as a troublesome weed in part of their native range in America, but they are rare in most parts of Europe.

The invasion rate of common ragweed has increased since the 1990'ies and the rate of invasion is expected to increase. Large populations of ragweed in Central Europe (Hungary, France, Italy and Croatia) may facilitate further spreading. Extensive and increasing, worldwide and intra-Community trade increases the risk of ragweed spreading. Changes in agricultural land-use with large-scale set-aside and abandonment practices along with an increasing area of construction sites and wasteland provide new areas of suitable ragweed habitats. Changing climate and perhaps adaptation to local climate in Europe has expanded ragweed's potential distribution range.

The impact of common ragweed on human health is not restricted to areas invaded by the plant. Due to wind-borne spreading of the very large production of light pollen ragweed may cause allergy in distances over 200 km off the site where it is growing.

An integrated approach based on the best-bet control strategies is needed to prevent further dispersal of common ragweed. A successful control must be made at all levels, i.e. the individual landowner, local, regional, national and international level, and appropriate measures must be taken.

Awareness of the problem is present in the afflicted European countries, but control measures vary from country to country. In Switzerland, where common ragweed is at the beginning of its invasion, mandatory control is declared in the ordinance of plant protection[1]. Similarly, in Hungary the landowners are legally obliged to prevent common ragweed in flowering[2], whereas in other European countries e.g. Germany and Austria control is based on recommen-

Ambrosia artemisiifolia. Mario Lešnik

A. artemisiifolia. Mario Lešnik

dations and is, thus, voluntary. In Italy and France, where common ragweed is widespread regionally, no effective legal mandates can help to control common ragweed.

The project *Strategies for Ambrosia control* has generated new knowledge on common ragweed's ecology and on the effect of different control measures. This has been elaborated to formulate best-bet strategies for control (see chapter 9).

The objective of "Guidelines for management of Ambrosia" is to provide European authorities, private landowners, gardeners, constructors, birdseed producers, trade companies dealing with agricultural products with scientifically based, but simple and operative practical management methods to prevent further invasion and reduce the abundance of common ragweed.

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2. Native range and distribution in Europe

The genus *Ambrosia* consists of about 40 species, most of which are native to North America. Only one of the species *A. maritima* (Sea ragweed) is believed to be native to Europe with the Mediterranean area as its native range. Common ragweed*, A. artemisiifolia*, was introduced to Europe together with other *Ambrosia* species in the 19th century.

Common ragweed

Common ragweed is the most widespread ragweed species worldwide and in Europe. According to botanical records common ragweed was recorded in many countries in Europe in the 1860s, but the main invasion within Europe, subsequent naturalisation and spreading of common ragweed as an invasive plant started about 20 to 25 years ago.

Agricultural products contaminated with seeds of *A. artemisiifolia* imported from the USA and Canada are believed to be the most important pathway of common ragweed into Europe.

Up till the 1970s, common ragweed was just one among several weed species present in cultivated fields in part of Europe, but it is now a widely distributed noxious weed in several countries. The reason for this is complex. Changes have occurred in the overall agricultural structure. Expansion of the cropped area of certain crops (e.g. sunflower), intensified and selective weed control management and shift from manure to slurry in animal manure management have led to a situation with more disturbed soils. Similarly the agriculture policies, i.e. large-scale set-aside and abandonment practices, appear to stimulate the spreading of common ragweed. Bird seeds contaminated with seeds of common ragweed have recently been an important pathway into residential areas of Europe. Finally, the recently rising temperature and climate changes optimise the growth conditions for ragweed.

The present distribution in Europe

Common ragweed is in particular widespread in Eastern and Central Europe. In Hungary almost 80 % of the arable land is infested and ragweed has become the most important agricultural weed during the latest 20 years[2]. In Croatia ragweed is especially abundant in the region of Slavonia, where it is considered a noxious weed[3]. Ragweed has spread from South Hungary and East Croatia into Serbia where it is now the dominant weed species in soya-bean and sunflower fields. In France ragweed is expanding towards the north-western regions of the country from

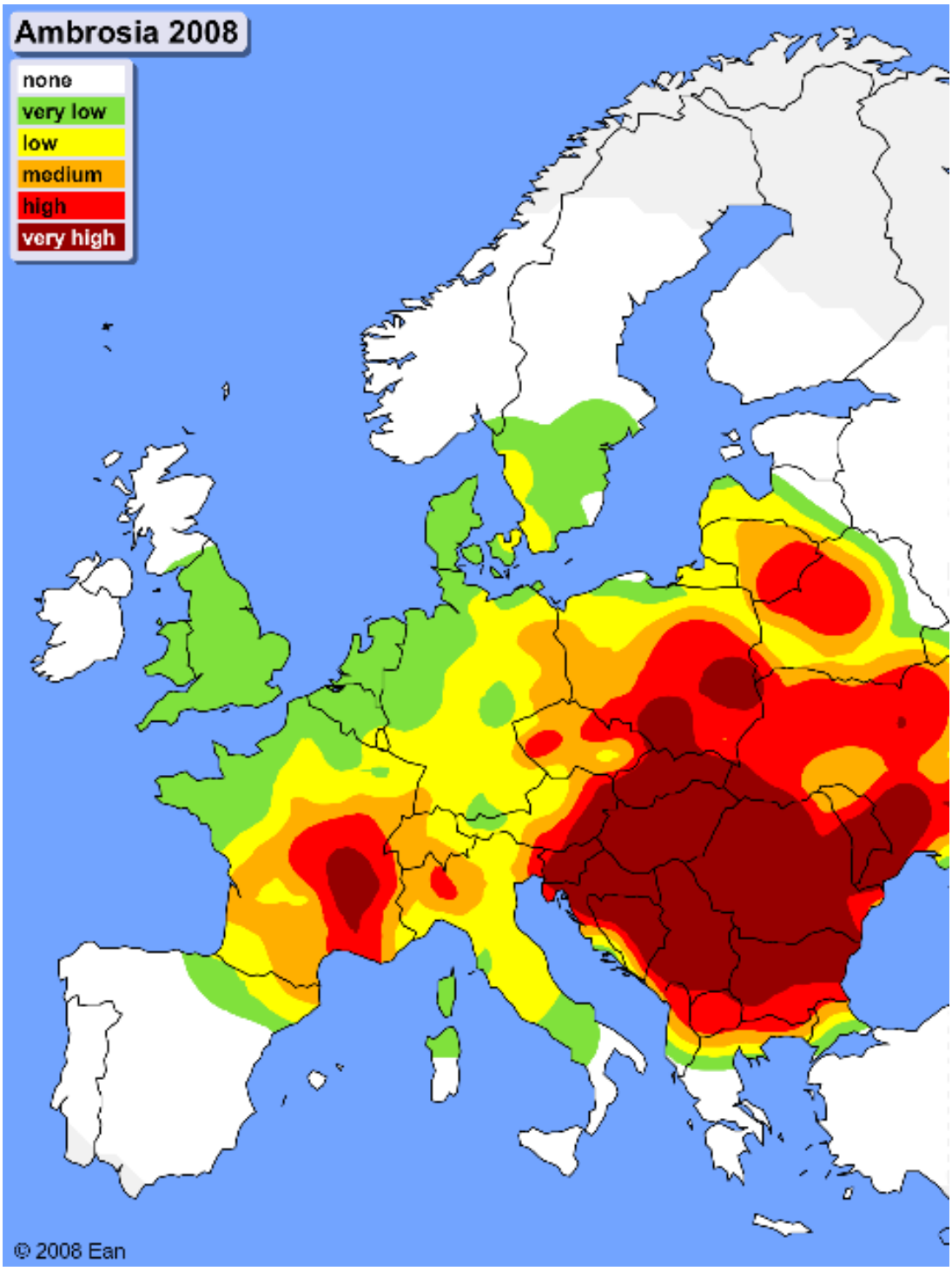
Invasion of common ragweed in France

A survey carried out by the INRA team in Dijon has established the history of the spread of ragweed in France, based on data from French herbaria[1].

Common ragweed was initially cultivated in a few botanical gardens as early as the 18th century. But the first reports of its presence in a natural environment date from 1863, in a field in the Allier departement in France, where the plant seems to have been introduced in batches of red clover seed from North America. Its spread then continued elsewhere in France and via different vectors, notably in forage imported for American army horses during the First World War. Populations of Ambrosia artemisiifolia were described in various Atlantic harbours and in the various locations where troops remained.

heavily infested areas in the Rhône Valley and Bourgogne[1]. In Italy mainly the Lombardy province in the Po Valley is heavily infested.

Many small foci have been reported from Belgium, the Czech Republic, Austria, Slovenia, Germany, Switzerland and other European countries. They are mainly



Distribution of Ambrosia pollen 2008. EAN (European Aeroallergen Network https://ean.polleninfo.eu/Ean) and epi (European Pollen Information http://www.polleninfo.org).

situated in urban areas and apparently ragweed is not yet fully established in these countries. Further to the north common ragweed occurs only locally as an occasional introduction resulting from seed or fodder contamination – here it appears not yet to have established self-sustainable populations.

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Links

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http://www.ambroisie.info/pages/envahi.htm

http://www.austroclim.at/fileadmin/user_upload/reports/StCl05C5.pdf

http://www.ambrosia.ch/index.php?&idpage=64

http://www.international.inra.fr/press/the_common_ragweed_1

https://ean.polleninfo.eu/Ean

http://www.polleninfo.org

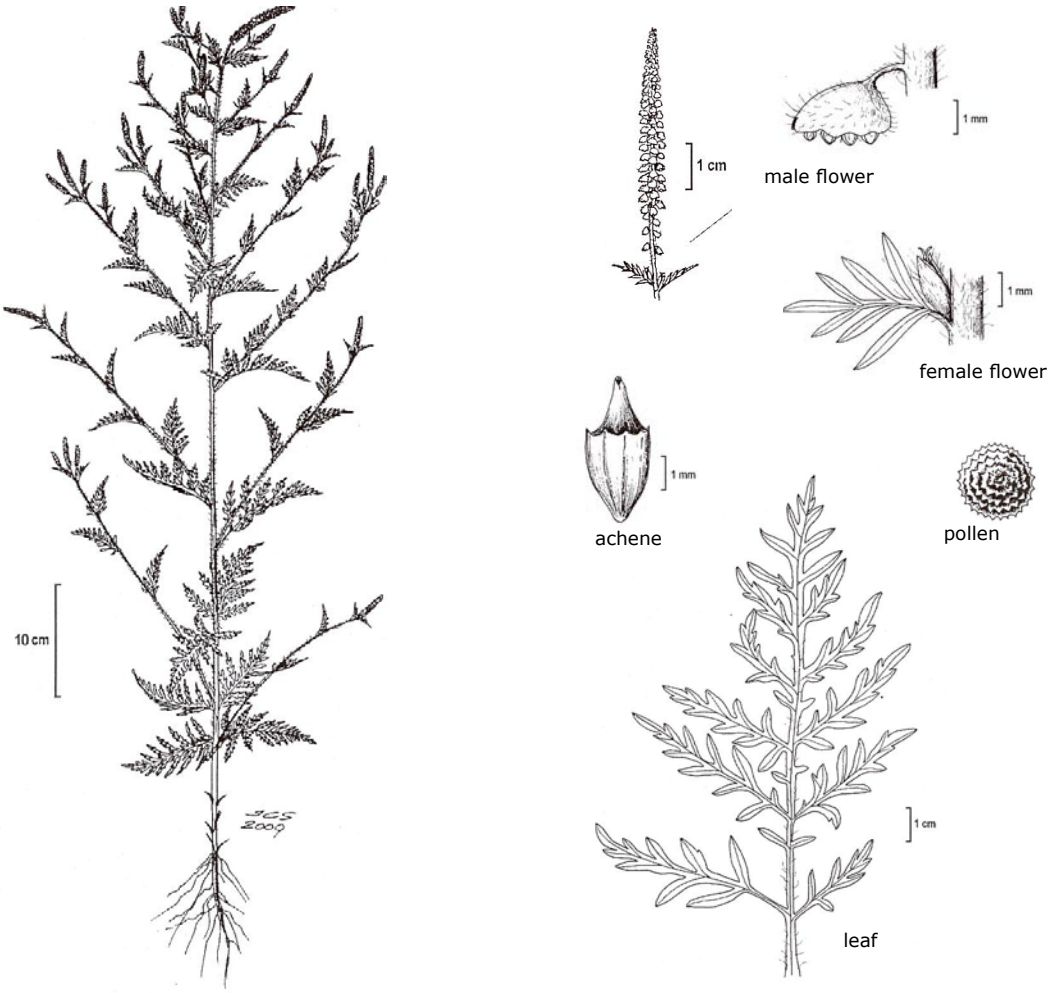
3. Identification

The genus *Ambrosia* belongs to the aster family (*Asteracea*) with their characteristic flower head composed of numerous individual sessile flowers. In *Ambrosia* the flower head only consists of male flowers, while female flowers are located solitarily or in small groups with male and female flowers in the same plant[1].

Ambrosia artemisiifolia

Common ragweed (*A. artemisiifolia*) is a summer annual herbaceous plant, a thero-phyte (i.e. annual plant characterised by long-term survival in seed bank). It is an erect and rather tall plant reaching a maximum height of 2 metres usually with many branches. Ramification starts about 2-4 cm above the ground and may include numerous side-branches. Solitary growing individuals are often shorter, but more densely ramified.

The leaves are compound and fernlike-toothed reaching lengths of 4-10 cm. They are bright green on both sides with whitish nerves. The lower leaves are arranged oppositely, the upper leaves are often arranged alternately on the stem of older plants. The stem is reddish and hairy with a stem diameter of up to 2-4 cm at the base.



Ambrosia artemisiifolia. Jens Christian Schou

A. artemisiifolia seedling.
Mario Lešnik

Young plant of *A. artemisiifolia*.
Hans Peter Ravn

Female flowers are inconspicuous located solitarily or in small groups at the base of upper leaves. Male flowers are green and small (2-4 mm) grouped in spike-like flower heads (racemes) at the end of the upper branches. Flowering takes place in the period from end of July till November (onset of frost) depending on regional and local climate. It produces a woody, reddish-brown indehiscent fruit (achenes), 3-4 mm long with one seed per fruit. The plant dies away with the onset of frost.

The seedling stem and seed leaves (cotyledons) are green and often splotched with purple. Seed leaves are about 6 mm long, spoon-shaped or nearly round, somewhat thickened and without visible nerves. The first pair of true leaves has the distinct ragweed shape.

Hairy, reddish stem.
Rita Merete Buttenschøn

Female flowers at the leaf axils.
Mario Lešnik

Key for determining common ragweed[2]

Stem
Answer "yes" or "no" to the following questions:
Is the cross section of the stem round?
The stem is hairy?
The stem is filled (not hollow)?

Continue to the next set of questions if all the answers are "yes".
If one or more answers are "no", then it is probably not a common ragweed. Have a look at the list of species that may be mistaken for common ragweed.

Leaf
Answer "yes" or "no" to the following questions:
Has the top- and underside of the leaf about the same colour?
Are the leaf nerves whitish?
Is the leaf divided into several lobes, which in turn often are split up almost to the rib?
Has the lobe-tip a fine spike?

Continue to the next set of questions if all the answers are "yes".
If one or more answers are "no", then it is probably not a common ragweed. Have a look at the species that may be mistaken for common ragweed.

Flower
Answer "yes" or "no" to the following questions:
Are there small green bell-shaped flowers in spike-like flower heads at the end of the upper branches?
Are there pale spots or yellow pollen dust at the flowers?
Are there other small flowerlike organs sitting at the axils of some of the upper leaves?

If the answer is "yes" to at least two of the questions and to all the questions about stem and leaf then the plant probably is a common ragweed.
If two or more of the questions are "no" then it is probably not a common ragweed. Have a look at the species that may be mistaken for common ragweed.

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4. Species that can be mistaken for *Ambrosia artemisiifolia*

Flowering plants of common ragweed have characteristic features that help to distinguish them from other species, while seedlings and small vegetative plants are more difficult to recognise. Especially species belonging to other genus of the Aster family e.g. Artemisia, Tagetes, Senecio and Tanacetum are often mistaken for Ambrosia. But also plants belonging to other families, especially plants with pinnately lobed leaves may be mistaken for Ambrosia.

Species of Artemisia are growing in the same type of habitats as common ragweed; they are very alike and often mistaken. The coloration and leaf structure of Artemisia spp. is very similar to leaf of common ragweed. However, Artemisia spp. has flower clusters with both male and female flowers, while common ragweed has separate clusters for male and female flowers with males in spikes and females in leaf axils (see description of Artemisia species in Appendix).

Ambrosia artemisiifolia.
Agroscope ACW

Artemisia vulgaris.
Frede Scheye

Examples of species that have been mistaken for Ambrosia are listed below in reference to their preferred habitat (Table 1).

Table 1. Examples of species, which have been mistaken for Ambrosia distributed to the habitats where they are most commonly found. Most of the species are found at two or more of the habitats. A description of the listed species is found in appendix.

Agricultural fields	Construction sites	Road verges
Artemisia annua *Artemisia vulgaris* *Artemisia verlotiorum* *Bidens tripartita* *Fumaria officinalis* *Senecio jacobaea* *Senecio erucifolius*	*Artemisia absinthium* *Artemisia annua* *Fumaria officinalis*	*Artemisia absinthium* *Artemisia vulgaris* *Artemisia verlotiorum* *Solidago canadensis* *Solidago gigantean* *Tanacetum vulgare*
Gardens and parks	**Natural habitats**	
Amaranthus powellii *Amaranthus retroflexus* *Artemisia absinthium* *Tagetes tenuifolia* *Tagetes erecta* *Tanacetum coccineum*	*Achillea millefolium* *Artemisia absinthium* *Bidens tripartita* *Senecio erucifolius* *Senecio jacobaea*	

Ambrosia species that can be mistaken for common ragweed

Other Ambrosia species are found in Europe and may be mistaken for common ragweed. *Ambrosia trifida* (giant ragweed) and *A. coronopifolia* (perennial ragweed) have been spread into Europe together with common ragweed. They are also allergenic and are growing as weed in parts of their native range in America. They are rare in most parts of Europe though listed as invasive in Russia[1]. A few other non-native Ambrosia species, e.g. *A. bidentata*, *A. aptera*, *A. polystachia* and *A. tenuifolia* are found in Europe, but only in a very small number. One species, *A. maritima* (sea ragweed), is native to Europe.

Ambrosia maritima

Sea ragweed is an annual herb or short-lived perennial, native to and now widely distributed in the Mediterranean. It is richly branched, grey-hairy with finely dissected, fragrant leaves. Sea ragweed is cultivated in parts of Africa for medical purposes. It is up to 1 metre tall, growing in open waste spaces and riparian grassland, and sometimes forming mono-species stands.

Ambrosia maritima. Mario Lešnik

Ambrosia maritima. Mario Lešnik

Ambrosia trifida

Ambrosia trifida (giant ragweed) is a tall annual herbaceous plant, 2-6 metres tall with a native range rather similar to common ragweed. It is mainly found at disturbed places on moist fertile soils. Giant ragweed resembles common ragweed, but the two species differ in size and leaf shape. The seed leaves are more than 2.5 cm long, about four times the length of the seed leaves at common ragweed. The first true leaves are not deeply indented and the subsequent leaves are large and coarsely 3-lobed, arranged oppositely. Giant ragweed is rare in most of Europe, but is reported to be invasive in Russia[1].

Ambrosia trifida. Mario Lešnik

Ambrosia trifida. Mario Lešnik

Ambrosia coronopifolia

Ambrosia coronopifolia also named *A. psylostachya* (perennial or western ragweed) is an erect, perennial herbaceous plant up to 2.5 metres tall. It is native to North America with a distribution similar to giant and common ragweed, but prefers more dry habitats. Unlike common and giant ragweed, western ragweed can reproduce vegetatively from creeping roots. It is characterised by its bushy, dense growth habit. The leaves are mostly 1-pinnatem divided, with irregularly toothed margins. Western ragweed commonly inhabits roadsides and dry fields. It is rare in most of Europe, but is reported as invasive in Russia[1].

Ambrosia coronopifolia. Mario Lešnik

References

1. http://www.nobanis.org.

5. Biology and ecology of *Ambrosia artemisiifolia*

Common ragweed germinates in the spring (April) and grows rapidly during the juvenile phase under optimum condition promoting the competitive ability of the plant. The growth rate and final height of the plant, which can be in the range of 30 cm up to 2 m, is strongly influenced by the habitat, e.g. temperature, nutrient, water supply and competition from other plants. Ragweed germinating in cereal fields may remain in the juvenile stage until the crop is harvested and then start to grow when exposed to light[1]. It prefers full sun and nutrient rich and slightly acidic soils and can tolerate dry soil conditions[2].

Common ragweed is a pioneer that establishes easily in habitats with bare mineral soils or sparse vegetation. The texture of the soil does not seem to play an important role in establishment, but the thickness of the organic layer is inversely related to its presence. It is commonly found in ruderal or waste sites associated with frequent and extensive disturbance regimes resulting from human activities, e.g. roadsides, railways, gravel pits, construction sites, agricultural fields, waterways, urban areas, and private gardens.

Common ragweed is a short-day plant,

Yellow dust of pollen. Hans Peter Ravn

Ambrosia seed. Steve Hurst @ USDA-NRCS PLANTS Database

whose flowering is induced by a dark period of ca. 8 hours. In central Europe plants usually flower in the period July to October and seeds are produced from mid August. The rather late flowering and maturation of the seeds limits the distribution of the plant to climate zones with a long growing season. During the latest 30 years a change in temperatures has prolonged the growing season in e.g. Germany with 8-10 days allowing ragweed to grow further north and at higher altitudes.

The flowers are wind pollinated and can produce viable seeds by self-fertilisation. This means that even a single isolated plant is capable of starting a new population.

Seeds are shed directly from the parent plant and most seeds land, due to their size, within proximity of the parent plant. The seeds – or achenes (i.e. a hard coat wrapper protecting the soft seed) are about 2.5 mm broad and 3.5 mm long but very variable in size. Mean achene mass was found to be in the range from about 1.7–3.7 mg in samples from different sites in France[3]. The variation in the size of achenes is seen as an ability to cope with a wide range of conditions and an ability to establish itself in disturbed habitats. The quantities of seeds vary with plant size, density of plant and habitat. A low density of ragweed gives a much higher seed number per plant than a dense stand. In a study of several different populations in France the annual seed production per plant ranged from 346 to 6,114 with about 2,500 seeds per year as a mean[3].

The stem of common ragweed breaks easily, but it tolerates damage like removal of the stem apex and leaves and has a very large re-growth capacity, which allows it to produce flowers and viable seeds after mowing or other disturbances.

Seed bank and germination

The seeds of common ragweed enter a dormancy period that requires a period of cold to germinate. Germination starts in

the spring with only a portion of the seeds. It has broad amplitude in regard to germination temperature, between 7°C to 28°C with an optimum at about 15°C. Germination is probably light induced as seeds rarely germinate if buried deeper than 4-5 cm and most germination takes place in open sites. The seeds can stay in a secondary dormancy for years[4]. Common ragweed is thereby well adapted to survive at sites that are periodically disturbed. Though it is an annual plant it does not have to be able to produce seeds every year to survive. Seeds have been known to remain viable after 20 years of burial with 85 % germination rate[5]. In another experiment viable seeds were found after 40 years of burial, but here the germination rate was only 4 %[6].

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6. Seed dispersal

Several modes of seed dispersal are known in ragweed; some are natural, but most of the dispersal is human assisted. Most of the fruits drop to the ground close to or beneath the parent plant. Some dispersal of the fruits may occur by birds, melting snow and waterways as achenes are able to float.

Introduction pathways to new locations
Translocation of contaminated clover seeds, cereals and other agricultural crops has been an important introduction pathway from Canada and USA into Europe. Contaminated seed of sunflower and other crops are still a pathway to new localities. Besides that there are many more possible dispersal pathways.

Spreading of ragweed often takes place along linear structures, such as highways, railways and watercourses.

Introduction pathways
- Sunflower seed
- Birdseed mixtures
- Translocation on machinery/equipment
- Translocation in soil/gravel
- Compost
- Watercourses

Birdseed mixtures
Birdseed, especially those containing sunflower seeds, is one of the main sources of new long-distance introduction of common ragweed into new locations. In a survey of birdseed in Germany fruits of common

Seeds of Ambrosia and sunflower. Agroscope ACW

Table 2. Number of samples contaminated with seeds of common ragweed in Danish surveys from 2007 and 2008[2].

	Total number of samples	Number of sunflower samples	Sunflower with ragweed	Number of mixture samples	Mixture with ragweed	Total number with ragweed seeds	%
2007	16	5	2	11	6	8	50
2008	20	9	6	11	8	14	70

ragweed were found in about 70 % of the samples. From 14 of 23 samples (61 %) containing ragweed seeds the seeds germinated when cultivated in the spring[1]. Earlier surveys in Switzerland and Denmark from 2007 and 2008 (Table 2) had similar findings of contaminated birdseed. A range between 38 and 975 mg Ambrosia seed/kg bird seed grain was found in 2007; findings in 2008 maximum of 3.556 mg/kg = ~3.6 g/kg. The highest content, 3.6 g of ragweed seeds found in one of the sunflower seed sample, equals about 700 seeds per kg birdseed.

At present no EU legislation sets maximum levels of common ragweed seed in feedstuffs. Switzerland has introduced an intervention value at 50 mg ragweed seed per kg feed, which equals approximately 10 seeds per kg feedstuff.

Transport by machinery/equipment

Seeds can be transported with machinery used for mowing ragweed infested areas or with harvesting machinery used in crops with ragweed, e.g. ragweed is reported to have been spread into the region of Geneva by combine harvesters rented in the area surrounding Lyon.

Translocation of soil and construction sites are important pathways for spreading of Ambrosia. Agroscope ACW

Translocation of soil and gravel
Transportation of soil and gravel between neighbouring countries is a common practice in parts of Europe, particularly between Switzerland, France and Italy, where building construction materials and substrates near borders are exchanged across borders leading to establishment of ragweed on new sites.

Compost
Spreading of compost with ragweed plants may allow surviving seeds to be spread with the compost. Even modern compost systems may not kill all the seeds of common ragweed as they seem to be rather heat tolerant.

Water courses
Some seeds of common ragweed can float and be spread with water currents along riparian corridors. They maintain their ability to germinate after a period in water[3].

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7. Preventive measures

Prevention of invasion is generally the most cost-effective approach to control of invasive plant species. By comparison, it is very expensive to control invasive plants once they are established and spreading. Furthermore, eradication of established alien species may prove to be extremely difficult or even impossible. Common ragweed can build up a seed bank in a couple of years with seeds, which are viable in 20 years or more years. The sooner after introduction the control measures are set in the better the chances of eradication and the lower the control expenditures will be.

Common ragweed is now so widespread in Europe that entire eradication is no longer practical or economically feasible. It is still feasible, however, to prevent or reduce it spreading into new areas.

How to minimise common ragweed invasion of new areas
In order to efficiently prevent the spread preventive measures should be targeted at those areas that present suitable habitats and are most likely to be reached by seeds of common ragweed. There are several components to this prevention, early detection and rapid response approach:

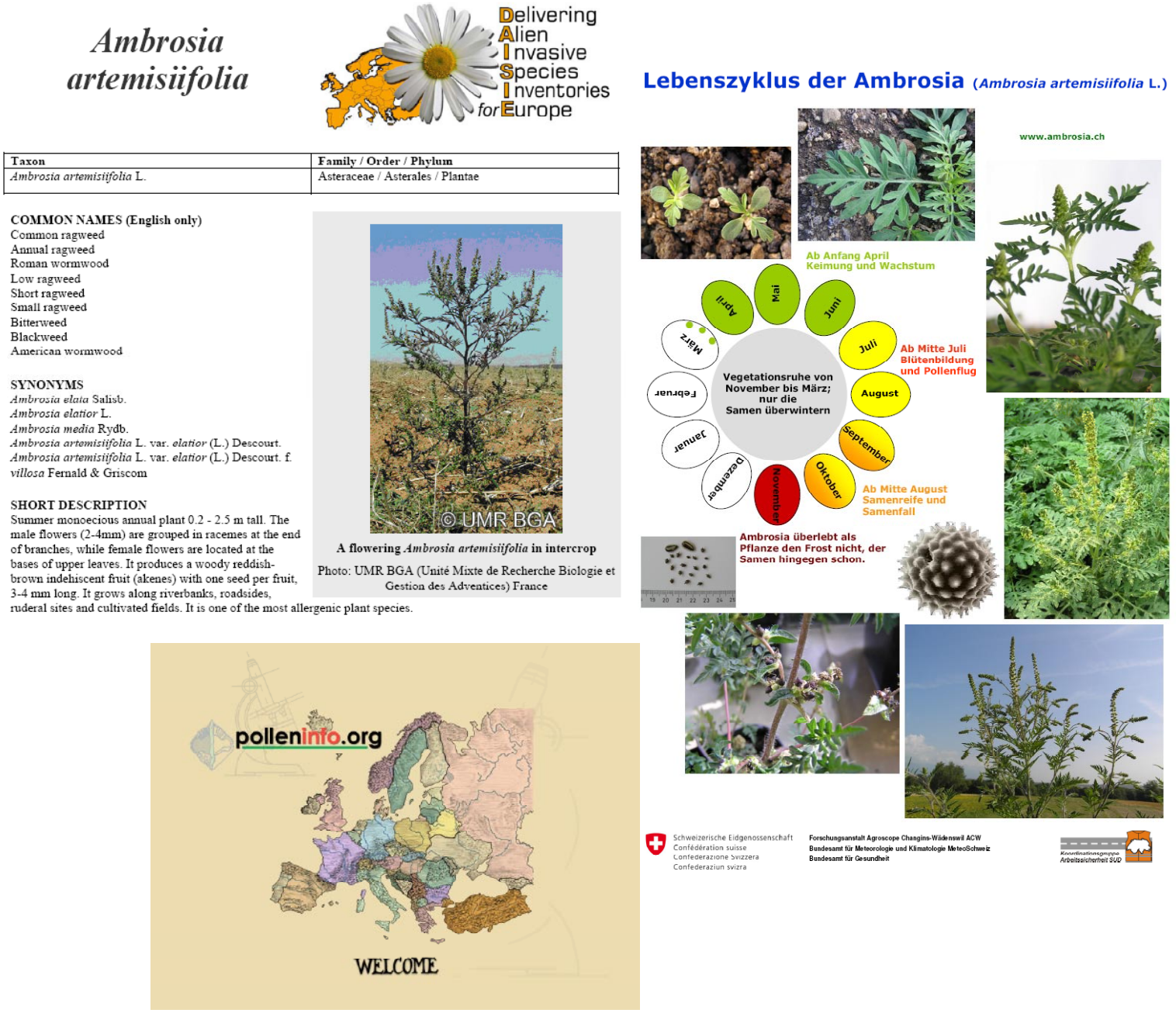
- Establishment of national/local policies and guidelines for best practice
- Prevention practices
- An awareness raising programme
- Surveys and monitor programmes
- Eradication campaigns, where preventive measures fail
- Follow-up monitoring

Establishment of national/local policies and guidelines for best practice
To be efficient a control programme must engage the authorities at all relevant levels and NGOs representing agriculture, trade, landowners and nature. At the local level programmes should also address the public by hearings, informative meetings etc.

Planning should aim at integrating the programme for control of common ragweed with broader land management programmes – designed to improve pasture vigour, use of crops not favourable for common ragweed, increase ground cover and avoid overgrazing – in areas at risk of invasion.

Prevention practices
Preventive counter measures should include initiatives to limit unintentional spreading of ragweed seeds by developing and implementing hygiene and prevention practices together with regulation of habitat quality in areas prone to common ragweed invasion. Extant stands along transport corridors (watercourses, railways, highways) should be managed to prevent dispersal of seeds.

An awareness-raising programme
Raise awareness of the impact of common ragweed on human health as a cause of hay fever and asthma and as a potential pest weed, so that the general public are familiar with the plant and are willing to help prevent its spread by e.g. reporting observations making early detection possible. Target awareness campaigns at key groups.



There are good examples to be found of websites, leaflets and other information activities addressing the public, see links.

Surveys and monitor programmes

If preventive methods fail and common ragweed colonise a new area, early detection of the new invaders is essential to facilitate a rapid eradication response. Establishment of surveys and other mechanisms to monitor spreading of common ragweed to new locations is a very important part of the preventive measures together with the creation of public awareness.

Priority areas to survey are private gardens, along roads and railway lines, sunflower crops, maize and soya bean fields, wheat stubble, construction areas,

field and forest edges, river banks, wastelands, lawns, surroundings of grain and fodder warehouses, oil mills and grain processing factories, and fodder industry factories.

Most introductions occur in private gardens and farming land. Accordingly, it is important that the general public is aware of the invasive status of the plant and takes part in the surveying and reporting of observations. The public needs to know (or must easily be able to find out) where their observations should be reported.

In Switzerland a legal obligation adopted in 2006 to control common ragweed includes an obligation for the public general to report any common ragweed observations to the authorities[1].

Eradication campaigns

When prevention has failed, eradication should be the course of action. New invaded ragweed plants should be eradicated as soon as detected and preferably before the flowering season starts. Eradication must be consequent and continuous – without a single year missing.

Collate and distribute best practice information to public and private bodies, companies, landowners and other groups involved in management of habitats suitable for introduction of ragweed.

Follow-up monitoring

It is important to establish a follow-up control as some of the plants may have escaped the control or more seeds may have germinated. The monitoring should continue the following years to be sure that complete eradication has succeeded.

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1. http://www.Ambrosia.ch

Links

http://www.Ambrosia.ch
http://www.ambrosiainfo.de
http://www.ambrosiainfo.

8. Control methods

Different methods are used in the control of Ambrosia. The individual method may be used by itself or in combination with other methods to limit seed germination. The choice of method depends on number of plants, their phenological state, presence or absence of Ambrosia seeds in the seed bank, habitat and land use (see Best-bet control strategies).

Mechanical control
Mechanical control include uprooting, cutting, ploughing etc.

Uprooting
All plants at the site should be uprooted systematically preferably before flowering to avoid spread of pollen. Uprooting of plants before seed ripening is efficient for small to medium sized populations. Non-blooming and non-fruiting plants shall be dried effectively and composted. To prevent re-growth uprooted plants should be stored without contact to soil. Alternately, uprooted plants should be put in plastic bags with soil around the roots and rendered by waste collection or incineration[1].

Uprooting of Ambrosia growing in habitats with undisturbed soil should be done slowly and carefully to minimize soil disturbance. Trampled and disturbed areas are excellent seedbeds for many weed species.

Safety instructions
Sensitised persons should not be uprooting Ambrosia plants. Gloves and fully covering clothing should be used for protection against skin irritation – and if the uprooting takes place during the flowering season mask and goggles should be used for protection from pollen.

Control of blooming stands should preferably be done in the afternoon as the pollen is mainly released in the morning.

Uprooting of ragweed. Agroscope ACW

Hoeing
Hoeing at the 2-leaf stage is efficient in control of Ambrosia in sunflower and maize crops. Hoeing can also be used manually on small plots used for growing vegetables and gives good results under dry conditions without rain[1].

Mowing/cutting
Mowing is used to prevent seed production and exhaust plants in large populations of Ambrosia in areas, where chemical control is forbidden or not possible for other reasons.

The cutting should be as close to the ground as possible, but without disturbance of the soil surface to minimize re-growth. In areas where there is a dense population of Ambrosia cutting height should be 2–6 cm. Where Ambrosia is growing in vegetation with dense cover of grass mowing height of 10 cm will prevent erosion and re-growth[1].

Time of cut is crucial as it greatly influences the plant's possibility for re-growth and flowering. Successive cuts can prevent flowering and fructification, but after cutting the plant can develop horizontal flower carrying side sprouts growing along soil surface. These branches are difficult – or impossible to cut in the following cutting.

Mowing while seeds are mature should not be made, because it increases the risk of seed dispersal. For greater efficiency, mowing should be combined with other control measures. Mowing before the blossom in combination with an herbicide

Ambrosia artemisiifolia. Rita Merete Buttenschøn

treatment on re-sprouted plants guarantees a highly efficient control.

Mechanical mowing techniques, for example a flail mower, are useful for large infested areas on plane ground. If the population is small or situated in a location unsuitable for mechanical mowing, e.g. on steep slopes, manually cutting with scythe or a trimmer is recommended.

Mowing should be replaced by uprooting where possible.

Ploughing
Deep ploughing that buries the ragweed seeds in 10 cm's depths prevents the seeds in germinating, whereas 2 cm seed burial does not[2].

Chemical control (herbicides)
The chemicals available for common ragweed control are constrained by country, regional and local regulations. In addition the type of habitat infested sets the conditions for control in terms of biology, economy and practicality.

Herbicides are recommended in connection with large infested areas and in non-organic crops. Common ragweed has developed resistance to different groups of herbicides. In North America common ragweed was found to be resistant to 10 times the normal rate of glyphosate[3].

Safety instructions and precautions
Sensitised persons should not work with Ambrosia control. Gloves and fully covering clothing should be used for protection against skin irritation – and if the mowing takes place during the flowering season dust mask and goggles should be used for protection against pollen.

Machinery and tools used for control in the flowering season should be cleaned to avoid spread of seeds.

Re-vegetation
Re-vegetation of native perennials and winter annuals can out-compete and suppress annual ragweed growth[4]. It is important to maintain or re-establish a dense cover of relative tall and fast-growing native plants to prevent ragweed re-growth.

Mulching
Mulching can be used to limit seed germination on small areas for example on construction sites. Cover the ground and/or seedlings with mulch (hay, grass clippings, wood chips, etc.) or other type of ground cover. Mulch cover can prevent seed grains from germinating and can prevent germinated seeds (seedlings) from growing.

Safety instructions and precautions
Follow all national and local regulations regarding herbicide use.

Develop safety protocols for storing, mixing, transportation, handling spills, and disposing of unused herbicides and containers before obtaining herbicides.
Only persons with all certificates and licenses required by the state may apply herbicides.

Applicators MUST wear all protective gear required on the label of the herbicide they are using when mixing or applying herbicides:
- Rubber boots and gloves and protective aprons or suits or sturdy overalls that are not used for other activities,
- Safety glasses or goggles,
- Dust mask if the application takes place in the flowering season.

Plastic cover
Cover of (black) plastic can be used instead of mulch at construction sites to reduce light at the soil surface and raise the soil temperature to levels that kill small plants and prevent seeds in germination.

Biological control
At present, no effective biological control agent is currently available for *A. artemisiifolia* in Europe[1]. Classical biological control has been attempted in Russia, Ukraine and former Yugoslavia, and several insect agents were introduced between 1969 and 1990, but the most promising agent, *Zygogramma suturalis* (Coleoptera, Chrysomelidae*)* has failed to give successful control so far[5]. Further work is needed in this area.

Animal grazing
Animal grazing is not considered a feasible control method although common ragweed has a rather high content of crude protein and a high digestibility during spring as the plant in large amount may be poisonous to the animals. Dairy products from cows feeding on common ragweed have been reported to have an objectionable odor and taste[6]. A high grazing pressure, necessary for control of Ambrosia plants stimulates seedling emergence due to an increased light influx.

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9. Best-bet control strategies

Different control measures were evaluated in the EUPHRESCO project including cutting and herbicide application in different habitats and at three different locations in Denmark, Switzerland and Germany together with studies of the biology of Ambrosia[1]. "Best-bet control strategies" have been elaborated based on current knowledge and project results by Waldispühl and Bohren 2009[2].

General remarks

Ambrosia is an annual dicotyledonous plant, which propagates with seeds exclusively. In agriculture it becomes quickly the status of an annual noxious weed because its control is not as easy as it seems to be. Incomplete controlled plants are able to re-sprout and to produce seeds even though in smaller number.

The number of seeds produced per plant per year or per invaded surface respectively allows Ambrosia to behave like an invasive plant. Ambrosia has an enormous potential to multiply; this is given by the great number of seeds produced and by their high fertility rate.

Production of seeds, which aren't displaced by wind, is the weak point of Ambrosia. All control strategies must therefore be based on the prevention of the production of fertile Ambrosia seeds.

Control strategies must respect the actual situation in the place where Ambrosia has to be controlled: i) regions or localities where the invasion is starting and ii) regions or localities where the invasion of Ambrosia is already advanced. In a newly invaded locality no or a very small soil seed bank of Ambrosia seeds is found, while in a locality with an advanced invasion many fertile Ambrosia seeds can be found in the soil seed bank.

The prevention of the production of fertile ambrosia seeds is in the long term more important than the reduction of pollen production in one vegetation period. It is the only way to reduce soil seed bank. The best strategy is to prevent seed grain production and in parallel pollen production.

Herbicide treatments

All herbicide treatments used in this trial series (glyphosate, mesotrione, clopyralid, MCPP and florasulam) reduced biomass of Ambrosia. When controlling Ambrosia with herbicides, treatment timing had an influence on biomass reduction. The best efficacy was obtained when treatment was done as one application in the 4-leaf stage. ED_{50} was calculated for all herbicides. Glyphosate was the only herbicide where efficacy was independent of growth stage. Three growth stages from 4 leafs to inflorescence where investigated. The other herbicides had also good efficacy on Ambrosia biomass, but doses had to be increased when treatment was done later to obtain the same efficacy level.

Sequential treatments – application of herbicides in two passes, the so-called split application – showed synergistic effects. Most split applications were more effective than one application (florasulam, MCPP and mesotrione). Dose requirement was highly dependent on growth stage at application. Low doses should only be applied at early growth stages. Potential negative effects of low doses at the first application was not fully investigated. In this one-year experiment low doses at the first treatment did not reduce the effect of the second treatment.

In practical agriculture sequential treatments is common in row crops such as sugar beet and maize. If conditions were perfect for the first treatment, a second treatment could possibly be adjusted according to the efficacy level of first treatment. On the other hand, if weather conditions were not perfect at the first treatment, good knowledge about sequential treatment allows farmers to achieve high efficacy with the second treatment. Sequential treatment increases the machine and labour costs.

Mechanical treatments

It was observed in our trials, that Ambrosia was able to re-grow after a cut. A second cut can hardly reach the horizontal side sprouts growing along soil surface, which are able to produce fertile seeds although at a reduced number.

Efficacy of control measures

In agricultural fields where Ambrosia occurs as an agricultural weed, standard herbicide treatments in the crops may be sufficient to control the weed species and avoid yield losses. In some crops such as sunflower that are botanically related to Ambrosia no effective herbicides are presently available, hence crop rotation must be adapted in order to reduce soil seed bank of Ambrosia seeds.

In natural habitats, in disturbed soils and along roadsides or in other non-agricultural habitats, eradication of Ambrosia populations within a well defined time frame must be the goal of a successful Ambrosia control.

Competition of Ambrosia

Single plants of Ambrosia plant were highly susceptible to competition. In a pot trial it was shown that the competitive ability of 340 barley plants per m^2 was equivalent to the efficacy of 225 g/ha of the herbicide MCPP when plant development was simultaneous, while 51 barley plants had the same effect if they emerged 10 days before ambrosia. A combination of herbicidal effect and crop competition showed a

A. artemisiifolia. Mario Lešnik

cumulative effect. Our results suggest that the invasiveness of Ambrosia primarily can be attributed to the high number of produced seeds per plant.

Surrounding vegetation has a great influence on the invasiveness of Ambrosia. Ambrosia plants exposed to competition do show a certain delay in their phenological development. This weakness in competition can be used for control strategies in various situations where herbicide use is not allowed. High crop or plant density can effectively reduce Ambrosia plant growth, but it cannot fully prevent the Ambrosia seed production.

Best-bet strategies

General: prevention of fertile seeds production

Agricultural fields: Herbicides with good efficacy on Ambrosia must be applied according to their label. Sequential treatments may improve herbicide activity. Competitive crops can improve herbicidal performance. Organic farmers should explore the low competitiveness of Ambrosia for better control.

Building sites: Disturbed soil in building sites is a good habitat for Ambrosia. High density of a cover crop can significantly reduce growth – and therefore production of fertile seeds – of Ambrosia plants.

Roadsides: Green cover along road sides must be cut in early summer because for security reasons. In case of Ambrosia abundance, infested zones should be treated additionally with an herbicide for achieving best control effects on re-growing plants.

Gardens and parks: Dense soil-cover by plants slows down Ambrosia infestation effectively. Single plant stands should be uprooted and destroyed completely before flowering.

Natural habitats: Disturbed soil should immediately be covered by a dense population of endemic plants in case of advanced infestation. Single plant stands in areas where infestation is beginning, should be uprooted and completely destroyed.

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Christian Bohren demonstrating the effect of early grass cutting on germination rate of common ragweed. Hans Peter Ravn.

10. Negative impact on human health and economy

Public health hazards

Common ragweed represents a very serious health risk for humans as pollen-allergenic plant. Pollen of ragweed is among the most potent triggers of hay fever and allergic rhinitis. In addition to allergic rhinitis, ragweed allergy often causes severe asthma-like symptoms. In European countries with large ragweed populations 10-20 % of patients with pollen allergy symptoms suffer from ragweed-allergy. In the United States ragweed pollen represents the major source of allergenic protein. About half of the cases of pollinosis here are related to Ambrosia pollen[1].

There is evidence for large-scale (80 %) cross-reactivity between the allergens of ragweed species and mugwort species (*Artemisia spp*). Cross-reactivity to other species of the sub-family *Asteraceae* and grasses has been reported. This implies that there is a high possibility of developing multi-hypersensitivity once pollen hypersensitivity has been developed. Consequently, multi-hypersensitivity persons have a prolonged period of exposure to allergens. Common ragweed also contains volatile oils that may cause skin irritation. The annual costs of human ragweed allergy in France and Italy have been calculated to amounting to 2 million Euros.

Health risk of *Ambrosia artemisiifolia* is due to:

- Very allergenic pollen, a small concentration can provoke allergic reactions.
- Many people are hypersensitive to the pollen.
- A part of the allergic people develops asthma.
- It produces pollen in large quantities.
- Pollen can be transported by wind over long distances.
- Long pollination period from late summer through autumn.

Pollen allergy

Ambrosia pollen is very allergenic. At least six groups of allergenic agents have been identified in ragweed pollen[2]. Some of these are called 'major' for their predominant role in causing allergy in humans.

Very low concentrations, e.g. 5-10 pollen per cubic meter of air, suffice to trigger allergic reactions in hyper-sensitised individuals[1]. Concentrations between 6 and 10 pollen grains per cubic meter air represent a moderate load of ragweed pollen. By comparison the upper limit of moderate loads of grass pollen is five times as high.

High prevalence

Ragweed allergy is presently increasing rapidly in large areas of Europe, in particularly in certain regions of France, Italy, Austria, Hungary, Croatia, and Bulgaria. A pan-European study of ragweed pollen hypersensitivity from 13 European countries showed that the prevalence of ragweed pollen hypersensitivity in people with pollen allergy symptoms was above 2.5 % in all parttaking countries except Finland. 2.5 % has previously been suggested as a cut-off for high prevalence. Unexpectedly high prevalence was found in the Netherlands, Germany and Denmark (between 14.2 % and 19.8 %)[3]. Cross-reactivity between mugwort (Artemesia spp.) and ragweed pollen is very high (at least 80 %)1. This may account for high

prevalence of ragweed pollen hypersensitivity in regions where ragweed is not yet established in appreciable amounts and do not yet have a self-sustaining population.

Hypersensitivity dermatitis
Contact with ragweed may cause hypersensitivity dermatitis, typically with symptoms of dermal congestion, hyperaemia, development of serous vesicles and itching.

Ambrosia dermatitis has an airborne pattern and is caused by lipid soluble oleoresins of pollen. Dermatitis inflicted by Ambrosia and other oleoresin containing species of the Compositae family is a world-wide disease, although often misdiagnosed[4].

The causative agent – ragweed pollen
The ragweed pollen is sized from 18 to 22 μm and has small non-sharp spikes at its surface on electron microscopy. Pollen grains can reach the upper respiratory tract and induce allergic reactions as hay fever, but are too large to penetrate in the lower airways and lead to asthma. Light rain or thunderstorm can release allergen carrying pauci-micronic (sized less than 5 μm) particles, which are responsible for asthma attacks[1]. In the ragweed-infested region, Departement Rhône-Alpes, up to 12 % of the population has ragweed pollen-allergic conditions during the pollen-shedding period.

Pollen production
Ragweed produces pollen in large quantities. An evaluation of the seasonal pollen production in several ragweed populations in France showed that the pollen production per plant ranged from a 100 million to 3 billions depending on plant size and habitat[5].

Pollination and climate
The allergenic content of the atmosphere varies according to climate, geography and vegetation. Ragweed pollen shedding begins at sunrise and continues during the morning reaching its highest count around midday. Temperature and relative humidity have minimal effect on the day-by-day ragweed pollen count while rainfall and unstable atmospheric conditions have a considerable impact on ragweed pollen counts.

The main pollination period is August and September, but it may start as early as late June and last till the end of October. Daily pollen count over a five-year period in Hungary illustrated that the starting day varied almost a month from 20th June to 13th July due to climatic conditions[6].

Changes in climate may expand the potential distribution of ragweed, thus expansion of ragweed further north in Europe seems likely. On average, the length of the growing season in Europe is

Pollen blowing in the wind. Agroscope ACW

Common ragweed (*A. artemisiifolia*) a noxious weed. Mario Lešnik

increased by 10–11 days during the last 30 years. Parallel to this, local increase in temperature late in the 20th century was associated with trends of rising pollen production. The duration of the pollen season was also extended in the mentioned period, especially in summer and in late autumn. Rising CO_2-concentration in the atmosphere may increase ragweed pollen production[7].

Long-distance transport of pollen

Ragweed pollen is transported over long distances by the wind. The distance and direction that pollen travels depends on air turbulence, wind velocity and direction. Seen in the light of longer growth season and increasing incidence of climatic extremes airborne pollen dispersal may prolong the pollen season in regions where ragweed is already present and may induce new hyper-sensitivity in regions where ragweed is not yet established. Several occurrences of long-distance transport of ragweed pollen have been reported i.e. from the South of France to Switzerland. Presence of ragweed pollen in Denmark and Sweden since 1997 is interpreted as long-distance transport from Eastern Europe[8].

Noxious weed

Common ragweed is known as a major weed in its native range and in part of Europe colonizing spring crops[10]. As a result of late emergence of *A. artemisiifolia* it can also grow during the inter-crop period in rape or cereal stubbles, as well as on fallow or set-side land. It is especial-

One gram of ambrosia pollen contains about 30-35 million pollen grains, and one well-grown plant can produce more than 45 grams of pollen in one year, depending on the quality of the habitat9.

About 10 pollen grains per cubic metre of air provoke allergic rhinitis in sensitive people – compared to 50 grass pollen grains[1].

ly a problem in crops like sunflower, maize, sugar beet, soya beans and cereal crops causing serious yield loss. In South Hungary and East Croatia common ragweed is now the dominant weed species in soya bean and sunflower fields. In crop plants with low height as beets the yield loss can be as high as 70 %. In addition herbicide resistance and other problems make control difficult.

Common ragweed in fields does contribute to the general spread and build-up of the ragweed population even in regions and countries where it has not yet established as a serious weed. Hence weed control is required and the farmers must be part of an overall strategy to combat ragweed.

Effect on biodiversity and recreation
Dense growth of common ragweed may lead to out-shading of existing vegetation and may be a threat to native species especially after a disturbance such as overgrazing which put competitive pressures on the native flora[11]. It can also cause illness in livestock that ingest it and thereby be a problem for the conservation management of pastures.
New introductions of common ragweed often happen in open areas in urban areas, as well as beaches and other areas used for leisure. As a consequence, tourism can be affected if visitors avoid areas with high Ambrosia occurrence.

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Distribution maps from the different countries

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12. Appendix

Description of the species ranked alphabetically:

***Achillea millefolium* (Common Yarrow)**
Common Yarrow belonging to the Aster family is an erect herbaceous perennial plant that has a rhizomatous growth form. It is frequently found in the mildly disturbed soil of grasslands.

Achillea millefolium[1]

Seedling: 2 sessile elliptically oblong, entire seed leaves, glabrous and tip rounded. First pair of leaves are opposite, sessile, oblong and dentated.

Achillea millefolium[2]

Stem: One to several stems 0.2–1.0 m tall with evenly distributed leaves.
Leaves: Green on the upper side and with whitish down on the underside 5-20 cm long, lance-shaped in outline and finely dissected.
Flowers: White to pink in a flat-topped cluster.
Flower season: Summer – autumn.
Scent: Leaves with a mildly aromatic scent.

***Amaranthus retroflexus* (Common Amaranth) and *A. powellii* (Green Amaranth)**
Two species of the Amaranthus family, A. retroflexus and A. powellii are common in most parts of Europe and have a general "Ambrosia-like" appearance but are differentiated by leaves and flowers. A. retroflexus and A. powellii are tall annual herbs much alike. They are native to tropical America but are now widespread as introduced species on most continents and growing in a number of habitats.

Amaranthus retroflexus[1]

Seedling: Seed leaves are elliptically lanceolate (10-12 mm long) and green to reddish in colour on the upper surface. Lower surfaces have a reddish tint. First pair of leaves alternate, ovate in shape, and are slightly notched at the tip of the leaf blade.
Stem: Erect reaching a maximum height near 3 metres, often red especially near the base, with alternately arranged leaves**.**
Leaves: Long-stalked egg-shaped or lance-shaped up to 15 centimetres long on large individuals, with wavy margins and hairs that occur along the veins of the lower leaf surfaces.
Flowers: Green in a dense cluster interspersed with spiny green bracts.
Flower season: Summer – autumn.

***Artemisia absinthium* (Absinthium)**
It is a perennial herbaceous plant belonging to the Aster family with a hard, woody rhizome. It grows naturally on uncultivated, arid ground and at the edge of footpaths and fields.

Artemisia absinthium[1]

Seedling: Seed leaves are obovate with short petiole ½-1 mm and cuneate base. First pair of leaves is opposite, petiole 1 mm, hairy, elliptically oblong and entire.
Stem: The stems are straight, growing to 0.8-1.2 m tall, grooved, branched, and silvery-green with leaves spirally arranged.
Leaves: Greenish-grey above and white below, covered with silky silvery-white trichomes, and bearing minute oil-producing glands; the basal leaves are up to 25 cm long, tri-pinnate with long petioles, stem-leaves less divided 5-10 cm long and with short petioles; the uppermost leaves can be both simple and sessile.
Flowers: Pale yellow, tubular, and clustered in spherical bent-down flower heads, which are in turn clustered in leafy and branched panicles.
Flower season: Early summer to early autumn.
Scent: The leaves and shoots are aromatic scented.

***Artemisia annua* (Sweet Wormwood)**

Artemesia annua

Sweet wormwood is an annual herb, belonging to the Aster family, with native range in Asia, but naturalised throughout the world. It prefers habitats with sandy soil and full sun.
Stem: Single stem up to about 2 m tall with alternating branches and leaves.
Leaves: Light green with a smooth or hairy underside, finely 2-3 pinnately dissected into very narrow short, blunt lobes. The lower and basal leaves are slender-petioled, the upper are sessile and less divided, but none of them entirely.
Flowers: Bright yellow. Flower heads are in dense clusters.
Flower season: Late summer – early autumn.
Scent: A camphor-like scent.

Artemisia vulgaris (*Common Mugwort*)
Common mugwort is a tall, shrubby herbaceous perennial, belonging to the Aster family. It grows on rich soils on weedy and uncultivated areas and roadsides. It is very common in Europe.

Artemisia vulgaris[3]

Seedling: Seed leaves reversely egg-shaped, toothed and sessile.

Artemesia vulgaris[2]

Stem: Brown ascending with alternate leaves, height 60-120 cm.
Leaves: Smooth and dark green on the upper side and with downy whitish hair at the underside; deeply and irregularly lobed into narrow segments.
Flowers: Green or yellowish. Flower heads are in leafy spikes or clusters with both male and female flowers.
Flower season: July – October.
Scent: The leaves are aromatic scented.

***Artemisia verlotiorum Lamotte* (Chinese Mugwort)**
Chinese mugwort is an herbaceous perennial related to and very similar to common mugwort and growing at the same type of habitats.
Seedling: Elliptical to reversely egg-shaped, with rounded tip, sessile.
Stem: Green ascending, with downy hairs, height 40–120 cm.
Leaves: Smooth and green with upper- and underside alike, lobed, not dentated, but pointed. Lower leaves in pseudo-rosette.
Flowers: Reddish**.** Flower heads are in dense clusters.
Flower season: Late autumn.

Scent: The plant is more strongly and pleasantly aromatic than A. vulgaris.

***Bidens tripartita* (Three-lobe Beggarticks)**
B. tripartita is an annual herb belonging to the Aster family. It grows in disturbed wet habitats, often temporarily flooded ponds and ditches.

Bidens tripartita[2]

Seedling: Seed-leaves smooth, entire, elliptically lanlceolate and petiolated about 10 mm long.

Bidens tripartita[2]

Stem: Erect stem 20–60 cm, nearly smooth, angular, solid and marked with small brown spots, so as to almost give it the dark purple appearance.
Leaves: Dark green smooth and sharp-pointed, with coarsely toothed margins, divided into three segments, occasionally into five, the centre lobe much larger and also often deeply three-cleft. The uppermost leaves are sometimes undivided. The underside scattered hairy.
Flowers: Flowers in terminal cymes, brownish-yellow in colour and somewhat drooping.
Flower season: Summer – autumn.
Scent: The flower heads smell like rosin or cedar when burnt.

***Fumaria officinalis* (Common Fumitory or Earth smoke)**
It is an annual herb belonging to the Fumariacea family. It is growing at waste places or near old gardens.

Fumaria officinalisl[1]

Seedling: Seed leaves entire, linear to lancet-shaped, sessile with a smooth surface, 2.5-3.5 cm long. First pair of leaves alternated, petiole 1–2 cm deeply divided into three lobes.

Fumaria officinalis[2]

Stem: Partially erect or reclaiming, angled, about 10 to 50 cm.
Leaves: Light green and finely divided into irregular narrow segments.

Flowers: Pinkish flower with a crimson tip in long racemes.
Flower season: May – September

Senecio jacobaea **(Ragwort)**
Ragwort is perennial (rarely annual) herbaceous belonging to the Aster family. It is found throughout Europe usually in dry, open places, and has also been widely distributed as a weed elsewhere.

Senecio jacobaea[3]

Seedling: Seed leaves entire and smooth, egg-shaped, petiolate about 6 mm.

Senecio jacobaea[2]

Stem: Ascending stem 40-80 cm.
Leaves: Green, the rosette-like basal leaves are pinnately lobed with a blunt end lobe. Stem leaves are deeply lobed with a toothed tip and with stem-circumvenient, toothed earlike, often hairy leaves at leaf-basis.
Flowers: Flower heads are yellow daisy-like flat-topped in umbel-like cluster.
Flower season: June – October.
Scent: Leaves with an unpleasant smell and taste.

Senecio erucifolius **(hoary ragweed)**
Hoary ragweed is an herbaceous perennial belonging to the same family and rather similar to ragwort, but less bushy and greyer, with short creeping runners. It is widespread in parts of Europe mostly growing on sandy soils but also found on clay soil.

Senecio erucifolius[1]

Seedling: Seed leaves are oblong egg-shaped, base cuneate, petiole 3–4 mm. First pair of leaves is alternate, elliptically oblong, base cuneate.
Stem: Rigid, simple or branched, purple and woolly. The stem is both angular and furrowed with alternating leaves.
Leaves: The rosette-like basal leaves are deeply lobed and toothed. Stem leaves are deeply and narrowly lobed, with the end lobe narrow and pointed. Gray–green with cottony gray down at the underside.
Flowers: Yellow in umbel-like cluster (raceme), flower heads larger than at common ragwort.
Flower season: July – October. It flowers 4 to 6 weeks after ragwort.
Scent: Leaves with an unpleasant smell.

Solidago canadensis **(Canadian Goldenrod) and** ***S. gigantea*** **(Giant Goldenrod)**

Solidago canadensis[1]

S. canadensis and S. Gigantea, belonging both to the Aster family, are native to North America. They are two of the oldest ornamental introductions from North America into Europe. They are very common and growing in many disturbed sites; along railways, on roadsides, abandoned fields, as well as in forest edges, open forests and on banks of rivers. They are very much alike, but can be distinguished by size of flower heads and presents or non-presents of hair at the stem.

Stem of S. canadensis: Main stem smooth near the base, downy above, height 0.6–1.2 m with alternating leaves.
Stem of S. gigantea: Main stem is smooth, without hair, height 0.6–2.0 m.
Leaves: Green, long, narrowly lance-shaped, sharply toothed.
Flower of S. canadensis: Yellow borne on numerous small flower heads – 3 mm in diameter - that form a broad pyramidal panicle.
Flower of S. gigantea: Like those of S. Canadensis just with bigger flower heads – 7 mm in diameter.
Flower season: July – October.

***Tagetes tenuifolia* (Lemon marigold) and *T. Erecta* (Mexican Marigold)**
Tagetes tenuifolia and T. erecta are two out of about 60 species of Tagetes native to different parts of America. They are found widespread, grown as ornamental flowers in garden and parks. Tagetes belong to the Aster family; they all have pinnate, green leaves and smaller or larger daisy like flowers, usually yellow, orange or brownish, but a lot of different cultivars have been developed. They are either annual herbs or perennial herbaceous. Most of them have strongly aromatic leaves or flowers.

Tagetes Erecta

Tagetes tenuifolia
Stem: Up to 0.8 m tall with opposite or sub-opposite leaves.
Leaves: Green, oblong 6–8 cm long, finely odd-pinnately compound, petiolated with serrate margins.
Flowers: Orange, yellow, golden or bi-coloured flower heads.
Flower season: Early summer to frost.
Scent: The flowers of some cultivars have pleasant citrus-like flavour leaves.

Tagetes Erecta
Mexican marigold is an annual herb.
Stem: Erect 0.5–1.0 m tall with opposite or sub-opposite leaves.
Leaves: Green, oblong, odd-pinnately compound petiolated with toothed (dentate) margins.
Flowers: Yellow to orange flower heads.
Scent: Flowers have a strong aroma that deters against many garden pests.
Flower season: Early summer to frost

***Tanacetum vulgare* (Tansy)**
Tansy is a perennial herbaceous belonging to the Aster family. It is common at roadsides and on formerly cultivated ground.

Tanacetum vulgare[1]

Seedling: Seed leaves sessile with cuneate base, elliptically oblong. First pair of leaves is opposite, petiole 3-5 mm, pinnatilobated pinnatifid, 5-7 mm.
Stem: Erect, stout, somewhat reddish, usually smooth, 50-150 cm tall, branching near the top. Alternating leaves.
Leaves: Green 10-15 cm long with short hair, pinnately lobed, deeply divided into about seven pairs of segments that are again divided into smaller lobes having saw-toothed edges.
Flowers: Yellow with roundish, flat-topped, buttonlike flower heads in terminal clusters.
Flower season: July – August.
Scent: Strong, persistent camphor-like scent.

***Tanacetum coccineum* (Pyrethum Daisy)**
A perennial herbaceous closely related to Tansy. It is growing at moist soils at meadows and as an ornamental in gardens and parks.

Stem. Bushy, hairless and with erect stems 40-80 cm.
Leaves: Dark green oblong, finely divided, basal leaves.
Flower: Daisy-like flower heads up to 10 cm across, with white, pink or red ray florets and yellow disk florets.
Flower season: June-July.
Scent: Aromatic scented leaves.

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12. Appendix

Description of the species ranked alphabetically:

***Achillea millefolium* (Common Yarrow)**
Common Yarrow belonging to the Aster family is an erect herbaceous perennial plant that has a rhizomatous growth form. It is frequently found in the mildly disturbed soil of grasslands.

Achillea millefolium[1]

Seedling: 2 sessile elliptically oblong, entire seed leaves, glabrous and tip rounded. First pair of leaves are opposite, sessile, oblong and dentated.

Achillea millefolium[2]

Stem: One to several stems 0.2–1.0 m tall with evenly distributed leaves.
Leaves: Green on the upper side and with whitish down on the underside 5-20 cm long, lance-shaped in outline and finely dissected.
Flowers: White to pink in a flat-topped cluster.
Flower season: Summer – autumn.
Scent: Leaves with a mildly aromatic scent.

***Amaranthus retroflexus* (Common Amaranth) and *A. powellii* (Green Amaranth)**
Two species of the Amaranthus family, A. retroflexus and A. powellii are common in most parts of Europe and have a general "Ambrosia-like" appearance but are differentiated by leaves and flowers. A. retroflexus and A. powellii are tall annual herbs much alike. They are native to tropical America but are now widespread as introduced species on most continents and growing in a number of habitats.

Amaranthus retroflexus[1]

Seedling: Seed leaves are elliptically lanceolate (10-12 mm long) and green to reddish in colour on the upper surface. Lower surfaces have a reddish tint. First pair of leaves alternate, ovate in shape, and are slightly notched at the tip of the leaf blade.
Stem: Erect reaching a maximum height near 3 metres, often red especially near the base, with alternately arranged leaves**.**
Leaves: Long-stalked egg-shaped or lance-shaped up to 15 centimetres long on large individuals, with wavy margins and hairs that occur along the veins of the lower leaf surfaces.
Flowers: Green in a dense cluster interspersed with spiny green bracts.
Flower season: Summer – autumn.

***Artemisia absinthium* (Absinthium)**
It is a perennial herbaceous plant belonging to the Aster family with a hard, woody rhizome. It grows naturally on uncultivated, arid ground and at the edge of footpaths and fields.

Artemisia absinthium[1]

Seedling: Seed leaves are obovate with short petiole ½-1 mm and cuneate base. First pair of leaves is opposite, petiole 1 mm, hairy, elliptically oblong and entire.
Stem: The stems are straight, growing to 0.8-1.2 m tall, grooved, branched, and silvery-green with leaves spirally arranged.
Leaves: Greenish-grey above and white below, covered with silky silvery-white trichomes, and bearing minute oil-producing glands; the basal leaves are up to 25 cm long, tri-pinnate with long petioles, stem-leaves less divided 5-10 cm long and with short petioles; the uppermost leaves can be both simple and sessile.
Flowers: Pale yellow, tubular, and clustered in spherical bent-down flower heads, which are in turn clustered in leafy and branched panicles.
Flower season: Early summer to early autumn.
Scent: The leaves and shoots are aromatic scented.

***Artemisia annua* (Sweet Wormwood)**

Artemesia annua

Sweet wormwood is an annual herb, belonging to the Aster family, with native range in Asia, but naturalised throughout the world. It prefers habitats with sandy soil and full sun.
Stem: Single stem up to about 2 m tall with alternating branches and leaves.
Leaves: Light green with a smooth or hairy underside, finely 2-3 pinnately dissected into very narrow short, blunt lobes. The lower and basal leaves are slender-petioled, the upper are sessile and less divided, but none of them entirely.
Flowers: Bright yellow. Flower heads are in dense clusters.
Flower season: Late summer – early autumn.
Scent: A camphor-like scent.

Artemisia vulgaris (*Common Mugwort*)
Common mugwort is a tall, shrubby herbaceous perennial, belonging to the Aster family. It grows on rich soils on weedy and uncultivated areas and roadsides. It is very common in Europe.

Artemisia vulgaris[3]

Seedling: Seed leaves reversely egg-shaped, toothed and sessile.

Artemesia vulgaris[2]

Stem: Brown ascending with alternate leaves, height 60-120 cm.
Leaves: Smooth and dark green on the upper side and with downy whitish hair at the underside; deeply and irregularly lobed into narrow segments.
Flowers: Green or yellowish. Flower heads are in leafy spikes or clusters with both male and female flowers.
Flower season: July – October.
Scent: The leaves are aromatic scented.

***Artemisia verlotiorum Lamotte* (Chinese Mugwort)**
Chinese mugwort is an herbaceous perennial related to and very similar to common mugwort and growing at the same type of habitats.
Seedling: Elliptical to reversely egg-shaped, with rounded tip, sessile.
Stem: Green ascending, with downy hairs, height 40–120 cm.
Leaves: Smooth and green with upper- and underside alike, lobed, not dentated, but pointed. Lower leaves in pseudo-rosette.
Flowers: Reddish**.** Flower heads are in dense clusters.
Flower season: Late autumn.

Scent: The plant is more strongly and pleasantly aromatic than A. vulgaris.

***Bidens tripartita* (Three-lobe Beggarticks)**
B. tripartita is an annual herb belonging to the Aster family. It grows in disturbed wet habitats, often temporarily flooded ponds and ditches.

Bidens tripartita[2]

Seedling: Seed-leaves smooth, entire, elliptically lanlceolate and petiolated about 10 mm long.

Bidens tripartita[2]

Stem: Erect stem 20–60 cm, nearly smooth, angular, solid and marked with small brown spots, so as to almost give it the dark purple appearance.
Leaves: Dark green smooth and sharp-pointed, with coarsely toothed margins, divided into three segments, occasionally into five, the centre lobe much larger and also often deeply three-cleft. The uppermost leaves are sometimes undivided. The underside scattered hairy.
Flowers: Flowers in terminal cymes, brownish-yellow in colour and somewhat drooping.
Flower season: Summer – autumn.
Scent: The flower heads smell like rosin or cedar when burnt.

***Fumaria officinalis* (Common Fumitory or Earth smoke)**
It is an annual herb belonging to the Fumariacea family. It is growing at waste places or near old gardens.

Fumaria officinalisl[1]

Seedling: Seed leaves entire, linear to lancet-shaped, sessile with a smooth surface, 2.5-3.5 cm long. First pair of leaves alternated, petiole 1–2 cm deeply divided into three lobes.

Fumaria officinalis[2]

Stem: Partially erect or reclaiming, angled, about 10 to 50 cm.
Leaves: Light green and finely divided into irregular narrow segments.

Flowers: Pinkish flower with a crimson tip in long racemes.
Flower season: May – September

Senecio jacobaea **(Ragwort)**
Ragwort is perennial (rarely annual) herbaceous belonging to the Aster family. It is found throughout Europe usually in dry, open places, and has also been widely distributed as a weed elsewhere.

Senecio jacobaea[3]

Seedling: Seed leaves entire and smooth, egg-shaped, petiolate about 6 mm.

Senecio jacobaea[2]

Stem: Ascending stem 40-80 cm.
Leaves: Green, the rosette-like basal leaves are pinnately lobed with a blunt end lobe. Stem leaves are deeply lobed with a toothed tip and with stem-circumvenient, toothed earlike, often hairy leaves at leaf-basis.
Flowers: Flower heads are yellow daisy-like flat-topped in umbel-like cluster.
Flower season: June – October.
Scent: Leaves with an unpleasant smell and taste.

Senecio erucifolius **(hoary ragweed)**
Hoary ragweed is an herbaceous perennial belonging to the same family and rather similar to ragwort, but less bushy and greyer, with short creeping runners. It is widespread in parts of Europe mostly growing on sandy soils but also found on clay soil.

Senecio erucifolius[1]

Seedling: Seed leaves are oblong egg-shaped, base cuneate, petiole 3–4 mm. First pair of leaves is alternate, elliptically oblong, base cuneate.
Stem: Rigid, simple or branched, purple and woolly. The stem is both angular and furrowed with alternating leaves.
Leaves: The rosette-like basal leaves are deeply lobed and toothed. Stem leaves are deeply and narrowly lobed, with the end lobe narrow and pointed. Gray–green with cottony gray down at the underside.
Flowers: Yellow in umbel-like cluster (raceme), flower heads larger than at common ragwort.
Flower season: July – October. It flowers 4 to 6 weeks after ragwort.
Scent: Leaves with an unpleasant smell.

Solidago canadensis **(Canadian Goldenrod) and** ***S. gigantea*** **(Giant Goldenrod)**

Solidago canadensis[1]

S. canadensis and S. Gigantea, belonging both to the Aster family, are native to North America. They are two of the oldest ornamental introductions from North America into Europe. They are very common and growing in many disturbed sites; along railways, on roadsides, abandoned fields, as well as in forest edges, open forests and on banks of rivers. They are very much alike, but can be distinguished by size of flower heads and presents or non-presents of hair at the stem.

Stem of S. canadensis: Main stem smooth near the base, downy above, height 0.6–1.2 m with alternating leaves.
Stem of S. gigantea: Main stem is smooth, without hair, height 0.6–2.0 m.
Leaves: Green, long, narrowly lance-shaped, sharply toothed.
Flower of S. canadensis: Yellow borne on numerous small flower heads – 3 mm in diameter - that form a broad pyramidal panicle.
Flower of S. gigantea: Like those of S. Canadensis just with bigger flower heads – 7 mm in diameter.
Flower season: July – October.

***Tagetes tenuifolia* (Lemon marigold) and *T. Erecta* (Mexican Marigold)**
Tagetes tenuifolia and T. erecta are two out of about 60 species of Tagetes native to different parts of America. They are found widespread, grown as ornamental flowers in garden and parks. Tagetes belong to the Aster family; they all have pinnate, green leaves and smaller or larger daisy like flowers, usually yellow, orange or brownish, but a lot of different cultivars have been developed. They are either annual herbs or perennial herbaceous. Most of them have strongly aromatic leaves or flowers.

Tagetes Erecta

Tagetes tenuifolia
Stem: Up to 0.8 m tall with opposite or sub-opposite leaves.
Leaves: Green, oblong 6–8 cm long, finely odd-pinnately compound, petiolated with serrate margins.
Flowers: Orange, yellow, golden or bi-coloured flower heads.
Flower season: Early summer to frost.
Scent: The flowers of some cultivars have pleasant citrus-like flavour leaves.

Tagetes Erecta
Mexican marigold is an annual herb.
Stem: Erect 0.5–1.0 m tall with opposite or sub-opposite leaves.
Leaves: Green, oblong, odd-pinnately compound petiolated with toothed (dentate) margins.
Flowers: Yellow to orange flower heads.
Scent: Flowers have a strong aroma that deters against many garden pests.
Flower season: Early summer to frost

***Tanacetum vulgare* (Tansy)**
Tansy is a perennial herbaceous belonging to the Aster family. It is common at roadsides and on formerly cultivated ground.

Tanacetum vulgare[1]

Seedling: Seed leaves sessile with cuneate base, elliptically oblong. First pair of leaves is opposite, petiole 3-5 mm, pinnatilobated pinnatifid, 5-7 mm.
Stem: Erect, stout, somewhat reddish, usually smooth, 50-150 cm tall, branching near the top. Alternating leaves.
Leaves: Green 10-15 cm long with short hair, pinnately lobed, deeply divided into about seven pairs of segments that are again divided into smaller lobes having saw-toothed edges.
Flowers: Yellow with roundish, flat-topped, buttonlike flower heads in terminal clusters.
Flower season: July – August.
Scent: Strong, persistent camphor-like scent.

***Tanacetum coccineum* (Pyrethum Daisy)**
A perennial herbaceous closely related to Tansy. It is growing at moist soils at meadows and as an ornamental in gardens and parks.

Stem. Bushy, hairless and with erect stems 40-80 cm.
Leaves: Dark green oblong, finely divided, basal leaves.
Flower: Daisy-like flower heads up to 10 cm across, with white, pink or red ray florets and yellow disk florets.
Flower season: June-July.
Scent: Aromatic scented leaves.

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