The Weed Control Handbook

Guidance on the use of herbicides on nature conservation sites

August 2025

Natural England Research Report NERR158

www.gov.uk/natural-england

NATURAL ENGLAND

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Catalogue code: NERR158

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Based on a report by ADAS in 2003 under a contract from English Nature, Contract No. EIT 31-04-003, with information on individual herbicides updated by ADAS in 2020-21.

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Acknowledgements

The writing and refresh of this Handbook has been a substantial task, and a large number of people have provided invaluable assistance. Natural England would like to thank everyone involved, in particular HSE/CRD who assisted with the updates to the document between 2021 - 2024, and the experts, user testers and conservation practitioners listed below.

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Thanks also to Zoe Russell and John Gordon (Natural England),Andy House (Environment Agency), Jane Lakey (Defra) and Jonathan Newman (Environment Agency) for supporting the 2021 refresh of the Weed Control Handbook, and a special thanks to the Health and Safety Executive (HSE) Chemical Regulation Division (CRD) colleagues Ingrid Den Hoed, Rebecca Mabbett, Grant Stark, and Mark Hawkins.

Citation

Sarah Cook, Chris Britt, Alison Mole, Francis Kirkham and Adrian Terry assisted by other ADAS colleagues including Dave Arnold, James Clarke, Rossy McLaren, Anna Gundrey and Simon McMillan. 2024. *Natural England Research Report* NERR158. Natural England. **The Weed Control Handbook:** Guidance on the use of herbicides on nature conservation sites

Originally published by:
English Nature 2003 in association with FACT.

Republished by:
Natural England 2025 as a Natural England Research Report, NERR158.

Contents

Disclaimer

Natural England and ADAS cannot accept any responsibility or liability for any damage to the environment or human health, or economic losses that might be alleged to have resulted from any explicit or implied recommendations in this Handbook.

All those who use pesticides and those who advise others on pesticide use, have a clear legal responsibility to read and understand the product label (or Notice of Approval for an off-label use) and to fully comply with all the statutory conditions.

This Handbook contains details of relevant authorised pesticide products. Readers should note that the status of pesticide authorisations can change at short notice. There are a number of ways that authorisations can change. For example, listed uses (crops or situations) of a product can be withdrawn and/or changes can be made in relation to particular uses (dose rate, timing of application and/or adoption of other appropriate mitigation measures, etc.). New products and uses can also become authorised.

The information contained in this section is correct as of January 2025. Readers should therefore consult HSE's website to confirm the current authorisation status of pesticide products before deciding on appropriate control options (authorised products/uses will generally be found in the Pesticides Register of Great Britain and Northern Ireland Authorised Products and Extension of Authorisation for minor use in Great Britain and Northern Ireland (formerly known as 'SOLAs') (Both accessed 29/8/2024)

The efficacy/safety information contained within the Herbicide Information Sheets (Section 4.1.3) is intended only as an **indication** of relative species' sensitivities to various herbicides. This information and other elsewhere in the Handbook, is based on a combination of scientific data, best practice and experience. Do not assume that a non-target species will be safe from damage just because the relevant herbicide sheet lists it as 'resistant' (or vice versa).

For several of the herbicide active substances described in this Handbook there are many approved products that could potentially be used by nature conservation site managers. Not all of these products have been named, named products are given as examples only. The omission of any product does not imply that it is in any way inferior to those that are named.

Readers must bear in mind that the technical complexity of the subject area, the effects of commercial pressures and constantly evolving legislation mean that much of the detail can soon become out-of-date. The herbicides listed in this Handbook are those which are approved for use in conservation situations at the time of writing. The information is expected to be reviewed, and advice will be updated periodically. It is the responsibility of all pesticide users to ensure that the products used, and the methods of storage, preparation, application and disposal are fully compliant with current regulations and codes of practice. This cannot and should not be assumed from information in this Handbook alone, or any web version.

How to use this Handbook: a few tips for you when considering using herbicides – and this Handbook

The Weed Control Handbook is a general guidance document on the use of herbicides for managing vegetation for nature conservation. It provides useful evidence for applying an integrated pest management (IPM) type decision-making approach when using herbicides on sites of conservation value, such as Special Sites of Scientific Interest (SSSI)s, Natura 2000 sites and Wildlife Trust nature reserves.

A few points to consider when using herbicides:

- Herbicide use on SSSI's requires Natural England consent. Some uses on land with an agri-environment agreement may need consent from the Rural Payments Agency, (RPA).
- If you have a weed problem, take time to consider **why** you have a problem? Are there management practises, such as overgrazing, which may be leading to the infestation(s)?
- Take steps to ameliorate the cause(s). Without such action, it is likely you will be returning time and time again to re-treat future re-infestations. Most herbicides are not a cure for more than a few months, or a year or two, if conditions are favourable for re-infestation.
- Re-assess whether you do need to use a herbicide or if there are alternative techniques that would provide effective treatment. (This is relevant to the Sustainable Usage Directive (SUD), the 2012 pesticides National Action Plan (being revised in 2025) and the Environment Improvement Plan goals of 'Managing exposure to chemicals', Thriving plants and wildlife', and 'Clean and plentiful water'.
- Assess the various options against environmental and resource issues. Look ahead to the knock-on effects and the need for continuing or future action after you have done the current management.
- Preventing a problem is always better than trying to cure it later!
- If you get a weed problem, tackle it **early**:

  early in the infestation when its population is small, if untreated it is likely to develop into a serious problem.
  early in the day - applications in the morning are often more effective than in the evening (in terms of reducing weed numbers and weight) due mainly to higher relative humidity in the morning, (but do not spray frosted plants). Check the product label.

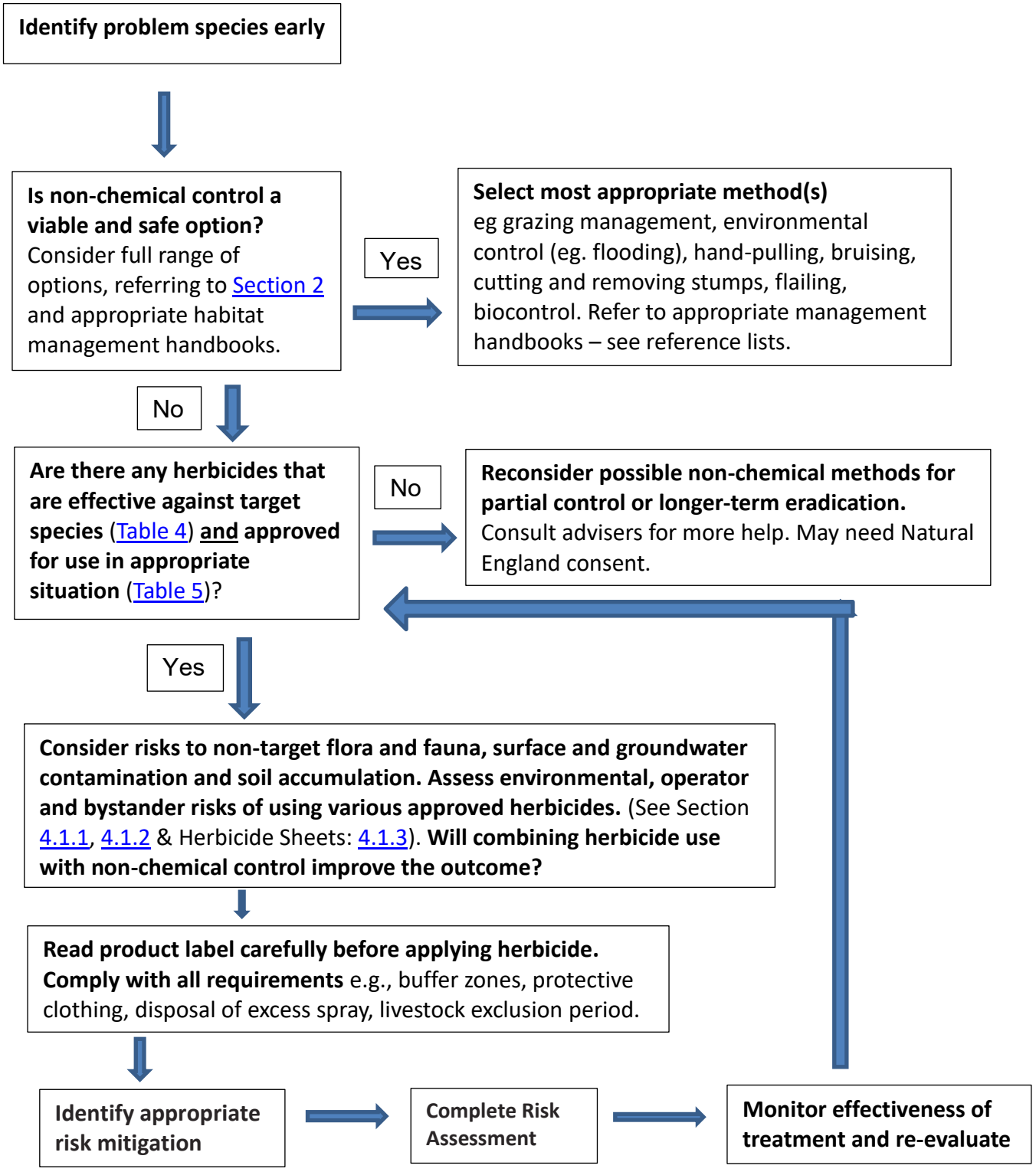
A few suggestions to help you get the best out of this handbook:

The following suggestions are made to ensure you refer to important legal information and then to guide you to the information you may require in order for you to make informed decisions as to the most suitable technique and effective herbicide choice for your situation:

- Note the 'decision tree' provided as Figure 1. This leads you through a decision-making process you should find helpful.
- Look at the **Contents** to get an overview of the information provided in the Handbook.
- Scan through the Handbook to get an overview of the information in each Section.
- Note that **Table 4** is the main source of **summary** information if you are wanting to assess the range of herbicides available which are appropriate to a **specific 'weed'**.
- Note that **Table 5** is the main source of information if you are wanting to find out **summary** information appropriate to how **specific herbicides** may be used.
- Get used to using the chemical/active substance (a.s..) name as well as the product name. The listing in Table 5 is by 'a.s..' (e.g. glyphosate) not the commercial 'approved product' or Plant Protection Product (PPP) name (e.g. Roundup ProActive).
- For more **information on a chosen herbicide** turn to **Section 4.1.3** where herbicides approved, at the time of writing, for use in conservation are described, with relevant **details**, appropriate to conservation managers.
- The list of active substances and products with approval for use is changing constantly. Information in Section 4.1.3 will inevitably become out-of-date and must be checked against HSE/CRD's Pesticides Register of Great Britain and Northern Ireland Authorised Products or Extension of Authorisation for minor use in Great Britain and Northern Ireland (formerly known as 'SOLAs'), (both accessed 29/8/24). Additional information on products, uses and restrictions is contained in the annually produced The UK Pesticide Guide (BCPC, 2021).
- Finally, before using any pesticide, **ALWAYS READ THE LABEL**.

The production team wishes you success in managing your vegetation**.**

Decision Tree



Executive summary

1. **Competitive weed species**. Vegetation management is an essential part of the overall habitat management strategy on most nature conservation sites. Species of conservation importance are frequently threatened by competitive species that are unwanted. These commonly include native species such as birch, hawthorn, bracken, docks, ragwort, common nettle, bramble and common cordgrass, as well as invasive alien species like rhododendron, Japanese knotweed, Himalayan balsam, giant hogweed and New Zealand pigmyweed (Australian swamp stonecrop). Appendix 1 provides a listing of identified target species.
2. **Early detection**. Site managers should be vigilant, watching out for early signs of possible weed problems. A problem detected in the early stages is likely to be more easily, safely and cheaply dealt with.
3. **Non-chemical control methods.** These should be considered first (see also 8 below) and herbicides used only after all other weed control measures have been carefully considered. The government's 25 Year Environment Plan (2018) states, "We should put Integrated Pest Management (IPM) at the heart of an in-the-round approach, using pesticides more judiciously". It is accepted that herbicides may frequently form a key component of the selected management programme, in combination with other measures. This is a basic principle of IPM.
4. **Purpose of the Handbook**. The primary aim of this Handbook is to summarise information on the use of herbicides to control problem species or weeds on nature conservation sites. It updates and replaces the Nature Conservancy Council publication, "The use of herbicides on nature reserves," (Cooke 1986). It includes an expanded list of potential herbicides and takes account of several important pieces of legislation that have come into force since its publication.
5. **Uses for the Handbook**. The Handbook is intended as a general guide to herbicide use for nature conservation site managers. It should also provide valuable information for other landowners, managers and contractors responsible for weed control in other semi-natural habitats (such as woodlands, forests, hedgerows, riverbanks, stream sides and aquatic areas); field margins and other areas of uncropped farmland; amenity areas; canals; road verges; and railways.

Use of herbicides – general guidance

6. **Risk assessment**. The use of herbicides should always be preceded by a risk assessment that must include consideration of any potential effects on the environment and on human health. Risk assessments should also consider the likely ecological impacts of taking no action.
7. **The Control of Substances Hazardous to Health (COSHH) Regulations 1989**. These require that pesticides (which includes herbicides) should only be used where necessary and where the benefits significantly outweigh the risks to human health and the environment. Non-chemical control options must, therefore, be considered and herbicides should only be used in situations where alternatives do not exist or are impractical or likely to be inadequate.

8. **Non-chemical techniques**. The Handbook includes a short summary of non-chemical control methods – including grazing and methods of environmental, mechanical and biological control. References to other publications that deal with this subject in much greater depth are provided.
9. **Factors affecting choice**. If a decision is made to use a herbicide, either as the sole method of control or as part of an integrated programme, then the most appropriate active substance and product must be selected. The choice will depend on a number of factors, but will be particularly influenced by:
    - Approval status. Which herbicide products (if any) can legally be used against the target species in that particular situation?
    - Efficacy. Which approved herbicides are likely to be effective against the target species? Which is the most effective option?
    - Environmental safety. What are the likely direct and indirect effects on non-target species? How do the possible alternative herbicides compare?
10. **Approvals**. Only authorised pesticides can legally be sold, supplied, stored, advertised or used. Current lists of authorised products can be found on the HSE/CRD website at Pesticides Register of Great Britain and Northern Ireland Authorised Product (accessed 29/8/24). The approval must also be for use in a relevant situation.
11. **Offences**. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use (including where the crop or situation is the subject of an off-label extension of use). ALWAYS READ THE PRODUCT LABEL BEFORE USING A PESTICIDE AND COMPLY WITH ALL STATUTORY CONDITIONS.
12. **Off-label use**. Some products may legally be used in accordance with an Extension of Authorisation for Minor Use, (EAMU). EAMU's are uses for which individuals or organisations other than the manufacturers have sought approval. Where a pesticide is to be applied under the terms of an off-label approval, users must obtain and read the relevant Notice of Approval. Lists of specific off-label approvals and the relevant notices of Approval can be found on the HSE website Extension of Authorisation for minor use in Great Britain and Northern Ireland (formerly known as 'SOLAs') (accessed 24/8/2024). Users should be aware that there is a risk that pesticides used under an 'off-label' approval may not be as effective as they are for on-label uses. Users must comply with all on-label statutory conditions for approved uses of that product, described on the product label.
13. **Adjuvants**. Adjuvants are substances that enhance the effectiveness of a pesticide, e.g. extenders and wetting agents. Although adjuvants are not classed as pesticides, pesticide legislation still stipulates that only authorised adjuvants may be used with pesticides.
14. **Tank mixes**. Users must comply with the individual conditions of approval for all pesticides concerned when making up tank mixes of two or more pesticide products.
15. **Protection of water**. FEPA places a special obligation on all pesticide users to prevent pollution of water. No pesticides may be used in or near water, unless the

approval specifically allows such use. The Environment Agency (EA) in England, SEPA in Scotland or Natural Resources Wales, (NRW) must always be consulted before any application of herbicides in the vicinity of an area of water, water courses and areas of water abstraction.

16. **Herbicides approved for use in or near water**. The control of aquatic weeds is difficult, only certain glyphosate products are approved in these situations. EA, SEPA or NRW must be consulted beforehand.
17. **Buffer zones**. Herbicides considered to have the greatest potential to harm aquatic species have a legally binding requirement for an unsprayed buffer strip between the sprayed area and any watercourse (or the top of a river or streambank). In some cases, buffer zone widths may be reduced if a properly documented Local Environment Risk Assessment for Pesticides (LERAP) concludes that the risks of water pollution can be lowered, e.g. by of the use of reduced doses, low drift spray nozzles or weed wiper.
18. **Methods of application**. Efficacy and environmental safety are directly affected by the method of application, which must comply with statutory requirements.
19. **Effective targeting of herbicides**. This is important, particularly when non-selective herbicides are used. Non-selective herbicides such as glyphosate present the highest risk to non-target plants. The method used to apply a herbicide will be influenced by:
    - approved conditions of use, as described on the label,
    - the extent and distribution of target species,
    - height and structure of target species,
    - height, structure and sensitivity of surrounding/ adjacent non-target species,
    - the nature of the local terrain, e.g. presence of streams, hillsides.
20. **Applicators**. The most widely used type of hand-held sprayer is the knapsack sprayer, which is suitable for spot-treatment of weeds, spray applications on very rough or steep terrain, basal bark sprays and cut stump treatments. Sprayers mounted on tractors or ATVs are more suitable for larger areas of relatively even ground, in areas of low vegetation, e.g. grassland.

    Granular herbicides can be applied using either hand-held ‘pepper pot’ or larger tractor- or ATV-mounted applicators.

    Weed wipers provide a method for the targeted treatment of weeds that are taller (at least 10 cm taller) than the associated non-target vegetation; for example, bracken, thistles or common ragwort in grassland (marsh ragwort in damp meadows can be at the same height as other vegetation or even below it). Weed-wipers are also available for different scales of operation – from small hand-held wipers to large tractor-mounted equipment.

    Injection of some translocated (systemic) herbicides may be made directly into the stems of target trees or shrubs, virtually eliminating any risk to non-target plants. ‘Injection’ might simply involve spraying small quantities of herbicide into a ‘frill’ cut with a hatchet.

Paintbrush application to cut stems of woody plants with a concentrated solution of a translocated herbicide may be acceptable, unless the product label precludes it.

21. **Timing of application**. The time of year that a herbicide is applied might be constrained by legal requirements stipulated in the authorisation or described on the product label. Users should take this into account as well as whether the herbicide will be effective against the target species (many herbicides are more effective when applied to actively growing weeds) and any probable impacts of different timings on other non-target species on that site.
22. **Training and certification of advisers and spray operators.** Anyone who gives advice when selling or supplying agricultural pesticides must have an appropriate BASIS Certificate in Crop Protection.

    Anyone applying a professional pesticide must also hold a recognised Certificate of Competence (unless working under the direct supervision of a certificate holder).
23. **Health and safety**. All herbicides are potentially dangerous. A risk assessment must be carried out before herbicide applications, to assess any risks to operators and the general public. A COSHH form should be filled out for all chemicals used. Any Personal Protective Equipment (PPE, which includes protective clothing and face protection) that is required for the handling and use of the pesticide will be stipulated on the product label and must be used. Information relating to first aid and medical treatment in the event of accidental exposure to the chemical is also given on the product label.
24. **Environmental safety**. An evaluation of environmental risks – essential wherever pesticides are used – is particularly important on nature conservation sites. This evaluation should always consider both short and long-term effects, remote as well as local effects, impacts on animals as well as plants and possible indirect effects, e.g. through destruction of nesting sites, deoxygenation of ponds caused by organisms decomposing, dead vegetation, or loss of seed-bearing weeds. A detailed assessment of the possible impacts on species of local conservation interest will be essential.

    To minimise the effects of herbicides on non-target species:

    - Use a selective herbicide (if available) that is less damaging to non-target species.
    - Leave an unsprayed buffer zone between treated area and vulnerable species/habitats.
    - Avoid spraying in unsuitable weather conditions, e.g. when wind speed is greater than force 2 (7-11 km per hour) on the Beaufort Scale or on very calm, warm days when volatisation can occur. Avoid wet conditions, if there is a risk of run-off from the soil surface to surface water.
    - Avoid fine sprays - use medium-coarse droplet nozzles, to reduce the risk of drift.
    - For applications using a lance not a boom, keep spray the nozzle as close as possible to target plants (taking account of minimum nozzle height).

- Spot-treat, if possible, and use a guard on the sprayer lance to more effectively target sprays and reduce drift.
- Ensure that any unused pesticide and any empty containers are disposed of safely (see Code of Practice for the Safe Use of Pesticides on Farms and Holdings).

Approved herbicides

25. **Pesticide approvals system**. Only approved herbicides may legally be used. A herbicide must also have a full or off-label authorisation for use in the situation in which it is to be applied.

    All new product approvals are authorised for use in one or more categories within the CRD 'Crop Definitions List'. The 'primary groups' most relevant to nature conservation sites are agricultural herbage and fodder crops, green cover, forestry, aquatic area, industrial and amenity areas, plant free areas and other situations. The most relevant 'basic crops or situations' within these seven primary groups are:

• Agricultural herbage and fodder crops	Grassland
• Aquatic area	Enclosed waters Intertidal zones of estuary Land immediately adjacent to aquatic area Open waters Saltmarsh
• Forestry	Cut log Farm forestry Forest
• Green cover	Green cover on land not being used for crop production
• Industrial and amenity areas	Amenity grassland Amenity vegetation Natural vegetation
• Other situations	Hedgerow

    Areas of unimproved or semi-natural grassland may be classed either as grassland (if grazed) or amenity grassland (if not grazed). The position regarding heathland habitats is less well defined. Heathland or moorland that can be grazed could be classed as grassland. Grass-dominated heathland that is not grazed might be considered amenity grassland, whilst areas with a smaller grass component would be amenity vegetation. Amenity vegetation is defined as "Any areas of semi-natural or ornamental vegetation, including trees... predominantly covered in vegetation other than grass". Hedgerows are a separate category.

26. **Target species and possible herbicides for their control**. Table 4 (Section 4.1.3) of this Handbook includes a listing including only those herbicides with approvals for use in situations considered relevant to nature conservation sites.

This table includes short notes on relevant situations, application methods and timings for each listed herbicide.

27. **Key herbicides for use in nature conservation sites**. Table 5 (Section 4.1.3) of this Handbook also includes a total of 46 single herbicides and herbicide mixtures listed with notes on the target plants/plant groups for which they are recommended, the relevant approved uses and the stock withholding periods.

28. **Herbicide Information Sheets**. In Section 4.1.3 detailed information is provided on 20 herbicides. These include information on application scenarios, fate in soil and water, effects on terrestrial and aquatic fauna, and effects on non-target plants. The herbicides covered are:

    - 2,4-D
    - amidosulfuron
    - aminopyralid
    - citronella oil
    - clopyralid
    - cycloxydim
    - dicamba
    - florasulam
    - fluazifop-P-butyl
    - fluroxypyr
    - glyphosate*
    - maleic hydrazide
    - MCPA
    - mecoprop-P
    - metsulfuron-methyl
    - pelargonic acid*
    - propaquizafop
    - propyzamide
    - triclopyr

    *These herbicides are **non-selective**, post emergent (i.e. foliar-applied) herbicides – active against most plant species. Consequently, care must be taken to avoid (or minimise) any contact with non-target species (e.g. via spray or vapour drift).

    Herbicides with **more selectivity** include clopyralid (daisy and pea families), cycloxydim (most grasses), 2,4-D (dicotyledons), dicamba (dicotyledons), MCPA (most dicotyledons), MCPB (most dicotyledons), mecoprop-P (most dicotyledons), propyzamide (grasses and some dicotyledons), triclopyr (woody plants and most other dicotyledons). The level of damage to non-target species from selective herbicides will be variable and, in many cases, species will recover, given time.

29. **Plant growth inhibitors.** Maleic hydrazide is a plant growth inhibitor used to retard the growth of grass.

Effects on non-target species

30. **Direct effects on non-target species.** Direct effects of herbicides are mainly restricted to plants, with most posing little or no direct risk to invertebrates or other animal groups.
31. **Indirect effects on non-target species.** More significant are the indirect effects of herbicides on animals, which must also be considered as part of the necessary risk assessment process. Invertebrates can be affected by the removal of food plants or destruction of vegetative cover (particularly important for over-winter survival). Birds and mammals can be affected by reduced availability of food plants (foliage, seeds, and fruits) and animal prey, and loss of nesting habitat.
32. **Knock-on effects on flora and fauna.** The selective removal of certain plant species will also result in changes to the floral composition, over and above those resulting directly from the effects of the herbicide. Eliminating, inhibiting or reducing the population of one (or a group of) species will indirectly result in enhanced competitive ability in other species. The species that subsequently do well, as a result of removal of competitors or an altered microclimate, will not always be desirable species – so the likely ecological consequences of herbicide use (or other vegetation management operations) must be carefully thought through by the nature conservation site manager before treatment commences.

1. Introduction

1.1. Vegetation management on conservation sites

Vegetation management generally forms part of the overall habitat management strategy on most nature conservation sites. Frequently, the protected species on these sites may be threatened by other, less desirable, species that must be controlled. Problem plants may include native species such as birch *Betula* spp., hawthorn, bracken, common ragwort, creeping thistle, bramble and common nettle, or invasive aliens such as *Rhododendron ponticum*, Japanese knotweed, Himalayan balsam, giant hogweed, Sitka spruce, sycamore, water fern, Canadian waterweed and New Zealand pigmyweed (Australian swamp stonecrop). Initial consultations with nature conservation site managers, conservation advisers, ecologists, researchers and weed control specialists produced a list of 85 plant species that present problems as 'weeds' on conservation sites. This list is shown in Appendix 1. Although extensive and representative of many different habitats, it is not comprehensive. There will undoubtedly be other species that occasionally require control.

Control of problem species should first be addressed by improved habitat management to remove the cause of infestation. For example, this may require changes to pasture management through changes to the grazing regime to minimise establishment opportunities. Thereafter various techniques including pulling, levering, bruising, cutting or mowing may remove or weaken plants and prevent them seeding.

However, herbicides may offer an alternative and it is accepted that herbicides may frequently form a key component of the selected management programme. There may be situations in which the use of herbicides is considered essential – either alone, or as part of an integrated approach, involving both chemical and non-chemical methods.

One important rule for nature conservation site managers is to remain vigilant for 'problem' plant species. A problem that is identified early, be it the first seedlings of an invasive exotic species or a rapid increase in a highly competitive native species, can often be solved quickly, safely and at low cost. Problems that are not spotted, or are ignored, may quite rapidly develop into major management issues that carry high environmental and economic costs.

Consultations with nature conservation site managers revealed that a small number of chemicals were predominant among the herbicides currently used. In particular, the use of glyphosate (used on almost all sites), triclopyr, clopyralid, and MCPA appears to be common – usually through carefully targeted applications, using spot-spraying, weed-wiping or stump application techniques, as appropriate.

1.2. Content of the Handbook

This Handbook summarises published research, advisory publications, legislation and codes of practice relevant to habitat management on nature conservation sites. All options are considered, but the most detailed information included is on the various herbicides that can be legally and effectively employed against the major problem species.

The Handbook is primarily intended for use by nature conservation site managers and advisers who require general guidance on the technical merits, environmental

risks and legal aspects of various herbicides that might be useful for the management of SSSI's and other nature reserves. However, it should also have a wider applicability, providing relevant information for farmers and land managers responsible for areas of land on which conservation management is an objective.

1.3. Key definitions

For the purposes of this Handbook, the following definitions are used:

Pesticide - any chemical or product approved for the purpose of killing or controlling the growth of any weed, disease or pest species. Includes plant growth regulators, insecticides, fungicides and herbicides. Is sometimes applied to wood preservatives, although these should be classed as biocides.

Herbicide - any chemical or product approved specifically for the purpose of killing or controlling the growth of any weed or other target plant species.

A full glossary of terms used is included at the end of the Handbook.

1.4. Environmental issues

The decision tree in the 'How to use this Handbook' section provides a simple summary of the main steps that should be followed by nature conservation site managers, when determining the most appropriate method to control a problem plant species. **The use of any herbicide will present some risk to non-target species – either directly or indirectly see section 6.** All pesticide users have a duty to ensure that these risks do not exceed the benefits of herbicide use, and that every reasonable action is taken to minimise risk. The environmental risks must, therefore, be properly assessed before pesticides are applied. This Handbook provides objective information that will aid the selection of a herbicide that presents the lowest possible risk to key species of conservation concern. However, available information on the impacts of herbicides on non-target species in semi-natural habitats is often scarce.

Even where 'high risk' herbicides (e.g. glyphosate, or triclopyr), with activity against a broad spectrum of plant species, are considered necessary, nature conservation site managers must have readily accessible information on how risks to non-target organisms can be minimised, by applying the chemical in the most appropriate way. Guidance is given on the method and timing of applications.

Although most herbicides have a relatively low toxicity to animal species (compared with insecticides), many can have significant indirect effects, e.g. by destroying food resources or nesting sites, or by depositing thick mulches of dead vegetation. These indirect effects are also considered.

Many herbicides pose a high risk to aquatic habitats. The Handbook clearly identifies those that can legally, and most safely, be used in or near water. It also outlines precautions that must be taken to ensure that pesticides do not contaminate watercourses.

1.5. Key references/Further reading

Environmental Improvement Plan 2023, available at Environmental Improvement Plan 2023 - GOV.UK

2. Non-chemical Methods for Weed Control

Areas of nature conservation interest are managed for ecological gain. This includes controlling undesirable species. The use of herbicides should always be seen as the last resort and where non-chemical methods are not a viable option. Where relatively small numbers of plants are involved, removal by hand or machine can be carried out. If there are large quantities of vegetation to remove, regular cutting, grazing or burning is more effective. On SSSI's and European sites, many of these treatments will need Natural England consent and Natural England should always be consulted beforehand. Treatments will usually need to be applied over a number of seasons. Herbicide use may be necessary if these methods are ineffective or impractical.

Even where a decision is made to use herbicides, non-chemical methods may also have a role. For example, the risks to non-target species, or the effectiveness of a herbicide against the target species, might be improved by firstly cutting tall plants and then treating the re-growth; the introduction of grazing livestock might be used to prevent re-occurrence of the problem. In many cases, a combination of different methods will be most effective, or to graze non-target species leaving the target weeds clear of other vegetation and accessible.

2.1. Grazing and browsing

Grazing is often the preferred option for control and prevention of encroachment of certain scrub and weed species. It allows continual removal of seedling trees and bushes and is useful for containing scrub species. It can, however, in certain circumstances, allow species such as thistles (*Cirsium* spp.), docks (*Rumex* spp.) and nettles (*Urtica* spp.) to thrive. For example, low stocking rates can encourage creeping thistle (*Cirsium arvense*), and over-grazing early in the season can also allow it to spread. Any grazing regime should, therefore, be properly balanced (Soil Assoc., 2002a & 2002b).

2.1.1. Bracken

Cattle grazing and trampling, in late winter and early spring, can be a useful component of a long-term control strategy for bracken (*Pteridium aquilinum*) (Crofts & Jefferson, 1999; Soil Assoc., 2002a). Plenty of palatable herbage must be available as bracken is toxic to grazing animals (Southern Uplands grazing partnership, 2001) and can lead to a shortage of thiamine (vitamin B) in non-ruminants. Rooting by pigs can afford effective control of bracken but will also result in the destruction of almost all vegetation on the site, leaving the site disturbed and potentially vulnerable to erosion and further weed infestation.

2.1.2. Creeping thistle

Creeping thistle (*Cirsium arvense*) is a particular problem in permanent pastures grazed by sheep. Prevention is best effected by maintaining dense productive swards and avoiding overgrazing and production of bare ground. When established, the increase in creeping thistle shoot numbers is predominantly through increases in vegetative shoots rather than from seed. Defra research (BD1437 accessed

18/10/2024) has shown that tight autumn and overwinter grazing by sheep significantly increases creeping thistle density the following spring when compared to lenient grazing. It was also found that cattle grazing reduced thistle numbers more than sheep grazing. Horses and sheep will eat young fresh thistle shoots but not the older mature stems. Goats, donkeys and llamas will eat creeping thistle. The most effective means of controlling thistles is a combination of lenient grazing together with cutting regimes or weed wiping. Sward heights for lenient grazing were 8-10cm for cattle and 6-8cm for sheep. Stocking rates of approximately 0.75 Livestock Units (LSU)/ha/year (equivalent to 5 ewes/ha/year or 0.75 cattle over 24 months of age/ha per year) (Defra, BD1449).

2.1.3. Docks

Docks (*Rumex* spp) are a particular problem in productive fertile swards where animal slurry is applied and not in lower nutrient grassland. Dock seeds can pass through animals and remain viable in manures. To prevent spreading, avoid conserving grassland with dock infestations. Maintain dense swards and prevent overgrazing. Dock infestations can be reduced using pigs to consume rhizomes, but this is likely to be very damaging on many conservation sites. Subsequent grassland management should focus on maintaining a dense sward as dock seeds can remain viable in soils for many decades.

2.1.4. Mat Grass

Overgrazing of upland heaths and moorland can result in an encroachment of Mat grass (*Nardus stricta*). The grass becomes unpalatable to grazing animals as the season progresses and is best controlled by cattle grazing in early summer. Prevent overgrazing natural upland swards to avoid mat grass becoming dominant.

2.1.5. Non-native invasive species

Sheep and cattle can be useful in the suppressing of giant hogweed (*Heracleum mantegazzianum*) and Hottentot-fig (*Carpobrotus edulis*). Japanese knotweed (*Fallopia japonica*) is palatable to sheep, goats, cattle, horses and donkeys. Grazing can suppress growth, and may reduce spread, but will not eradicate the plant. However, grazing animals can spread plant fragments.

Pony and deer grazing can be used to control shallon (*Gaultheria shallon*), though shallon foliage has low palatability and is not favoured by livestock, so control is unlikely to be possible unless other food sources are limited (Boateng & Comeau (2002), cited in Willoughby *et al*., 2017). Pigs can also be effective against shallon, uprooting plants rather than grazing them, with surviving plants needing to be pulled out by hand or sprayed. However, pigs can be very destructive of the whole site. Livestock appears to be generally less effective in controlling *Cotoneaster spp.*

2.1.6. Purple Moor-grass

Purple moor-grass (*Molinia caerulea)* is a tussock forming, invasive grass found in wet acid grasslands and moorlands. Cattle selectively graze purple moor-grass reducing its vigour. Two months of summer grazing with cattle at 0.75 cows/ha can suppress purple moor-grass sufficiently to allow dwarf shrubs such as heather (*Calluna vulgaris*) to compete (Defra report, BD1228). Cattle should only be used on

blanket bog if there is a dense mat of purple moor-grass and bog species, especially Sphagnum mosses, have already disappeared.

Grazing sheep at up to 1.0 ewes/ha (with 25% reduced stocking rate during November to February, or complete removal of sheep) will enhance the vigour of dwarf shrubs, but other measures will also be needed to reduce the competitiveness of purple moor-grass. Where purple moor-grass is present in small amounts (i.e. less than 10% of sward), summer grazing with sheep at low densities will keep it under control.

2.1.7. Ragwort

The control of common ragwort (*Jacobaea vulgaris*) is best achieved by maintaining a dense sward and avoiding overgrazing. Ragwort seedlings cannot establish in closed swards but require bare patches in which to germinate. Control of pests such as moles and rabbits in grassland will also help prevent bare patches. In very light infestations, spring and autumn grazing of young plants (at the rosette stage) by sheep and goats can be effective in reducing density and preventing seed production. All grazing animals are susceptible to the toxic effects of ragwort and the deliberate control of ragwort by grazing should not be undertaken on welfare grounds. (Defra have produced a Code of Practice on How to Prevent the Spread of Ragwort accessed 29/8/2024).

2.1.8. Rushes

Rushes are moderately tolerant of grazing. Control of rushes (*Juncus* spp.) by grazing with cattle or ponies after cutting can be an effective control method (Soil Assoc., 2002a). Grazing can also be used to create a height differential to allow subsequent control of rushes by weed-wiper application of glyphosate (Crofts & Jefferson, 1999). A combination of grazing and cutting can then be used to maintain this level of control. Avoid under or over grazing and poaching as this can lead to bare ground and seed germination.

2.1.9. Scrub

Goats are the most effective browsers of scrub, as they eat stems and leaves of woody plant species (Soil Assoc., 2002b). Native ponies can also be effective in controlling woody shrubs by browsing and bark stripping. Some breeds of sheep, for example Hebridean, browse a wide range of shrub species. Grazing, in combination with other control methods, such as cutting, burning or coppicing, can also effectively control some shrub species e.g. willow (*Salix* spp.), gorse (*Ulex europaeus*) and hawthorn (*Crataegus monogyna*).

2.1.10. Willowherbs

Summer grazing can control great willowherb (*Epilobium hirsutum*) and other tall herb species, and halt development of woody scrub. Rosebay willowherb (*Chamerion angustifolium*) is susceptible to trampling and is palatable to cattle, sheep, goats and horses. Autumn grazing has less effect on plant species which have already flowered and seeded (Crofts & Jefferson, 1999).

2.2. Environmental Control

Environmental and cultural control measures tend to be used as part of an integrated control programme, rather than in isolation. Cultural methods might include use of mulches or competitive plant species.

2.2.1. Shading and mulching

Trees planted along narrow riverbanks can shade undesirable aquatic plants and contribute to their control. The addition of mulch mats can reduce additional competition from weeds when planting standards. Black plastic sheeting, thick hessian matting, weed control fabric or other materials to exclude light, are neither selective nor good aesthetically – although the use of such artificial shade materials may provide the only effective alternative to chemical control in certain situations e.g. New Zealand pigmyweed (*Crassula helmsii*) infestations in aquatic areas (CEH, 2004e). Mulching can be used to suppress creeping thistle and common nettle (*Urtica dioica*) in meadow grassland, but it needs to be applied at least twice per annum; one application can actually increase some tall dicotyledonous species (Gaisler *et al*., 2008).

The use of a non-toxic dye (Aquashade) has been recommended for *Elodea* spp. as a means of in-water shading. Light must be reduced by 1-4% of the surface irradiance to prevent plant growth. Regular top-ups are required during the growing season to account for dilution by rainfall. Dyes are non-selective and will affect non-target species including phytoplankton, algae and other macrophytes (Hussner *et al*., 2017). The application of dyes is limited, particularly in larger water bodies.

2.2.2. Inter-specific competition

Planting bracken rhizomes within mats of Hottentot-fig (*Carpobrotus edulis*) has proved effective in controlling this South African species (Bacon *et al*., 2001), perhaps due to a number of competitive factors e.g. allelopathic effects and competition for light, water and nutrients. Creeping thistle can be suppressed by interspecific competition from companion plants in pasture if a grazing regime is applied that delays defoliation of the grassland until late summer (De Bruijn *et al*., 2010).

A nurse crop can be used to prevent weed invasion in newly sown perennial species, for example sowing cornfield annuals with perennial wildflowers. Nurse crops have been used in Calluna establishment on restoration of heathland on ex-arable land. (Walker et al., 2007). Westerwolds ryegrass (*Lolium multiflorum*) has been used in the restoration of species rich grassland (Pywell et al., 2002).

2.2.3. Water levels and flow rates

Environmental control in aquatic and wetland environments involves altering conditions to make it less suitable for plant growth and survival. Water depth and velocity can be altered to reduce nutrient levels, which can control vegetation growth and draining lakes, for example, can also help reduce siltation and prevent immediate re-growth (Seagrave, 1988). Roworth (2000) found that by raising levels of water on a cut-over peat bog, significant areas of invasive birch died through waterlogging. Raising water levels after cutting rushes can also be an effective method of control for these species. Where common reed (*Phragmites australis*) needs to be suppressed, cutting followed by inundation with moderately saline water

for at least four weeks can be effective (Russell & Kraaji, 2008). This type of control can be important in many wildlife habitats, but dams can be difficult to install and have a limited lifespan. There are, however, alternatives to traditional dams (Bacon *et al.*, 2001).

Modifying water quality may provide a method of control of *Elodea* species (Vernon & Lilley, 2011). This could involve removing the point source of nutrients such as outputs from sewage works, farm effluent or the use of Lanthanum modified bentonite clay - a lake remediation tool designed to strip dissolved phosphorus (P) from the water column and increase the sediment P-sorption capacity. (Meis et al., 2012 cited by Cook *et al*., 2014).

2.3. Mechanical Control

Mechanical control can include removal by hand (e.g. pulling, cutting or raking) or by machine (e.g. ploughing, harrowing, pulling, pulverising, crushing, strimming or mowing). The advantage of mechanical weed control, certainly if done by hand, is that it allows selective removal of vegetation. It can however be slow and expensive.

For aquatic weed control, digging, pulling, cutting and hoeing can be effective in removing vegetation; but these procedures are very labour intensive, so are generally unsuitable for larger water bodies (Seagrave, 1988).

2.3.1. Weed pulling

Hand pulling is often the best option for small weed infestations. This method has proven successful for species such as ragwort, spear thistle (*Cirsium vulgare*) and docks (Soil Assoc., 2002a). It is important that all root fragments are removed to prevent regrowth and soil disturbance is minimised. Repeating this over a number of years can reduce the requirement for herbicide use (Defra, 2004). Regular pulling of bracken fronds and removal of litter almost eliminated bracken within 4-5 years in a pasture in Sweden and restored the original hay meadow flora (Swenson & Martinsson, 2005). Grubbing is also an effective method for reducing rhododendron (*Rhododendron ponticum*) (Edwards, 2006).

Hand pulling is an effective method for controlling small infestations of Himalayan balsam (*Impatiens glandulifera*), a shallow-rooted annual plant. Although not particularly effective against Japanese knotweed (Beerling *et al.*, 1994), individual mature stems and roots can be pulled manually to give other vegetation a competitive advantage. This technique would generally be most useful in particularly sensitive areas (Child & Wade, 2000).

Weed extraction hand tools can be used to extract weeds such as docks, thistles, ragwort, small tree saplings and nettles (Bacon, 2000).

2.3.2. Cutting, mowing and crushing

Note: Cutting, mowing and crushing should not be carried out if nesting birds are present (they have protection under the Wildlife & Countryside Act 1981). Control would have to be delayed until the risk of harm to protected species has passed.

Mechanical crushing in combination with herbicide application can be more effective than herbicide application alone and can reduce the number of applications required for successful weed control (Wiese *et al*., 2006).

2.3.2.1. Trees and shrubs

Dense areas of birch or gorse can be cleared using high horse-power machines operating flails. Costs can be very high, but the method has value in some situations especially where grazing can follow, without which re-growth from remaining stumps can be vigorous and require repeat operations at frequent intervals.

Cutting or flailing is recommended for the control of medium height bushes or broad groups of rhododendrons, with woody material then burnt or chipped. Stumps can be treated with herbicide after cutting (Edwards, 2006)

2.3.2.2. Bracken

To control bracken, cutting or crushing the fronds twice a year can be effective (Crofts & Jefferson, 1999). Cutting twice annually is at least as (Måren *et al.*, 2008) or more effective than (Cox *et al*., 2008) herbicide application in controlling bracken, with an increasing effect over time with continuous cutting (Cox *et al*., 2007). However, the effectiveness of different control methods varies among sites and, although cutting twice annually (June and July) is generally the best method, cutting once and/or herbicide application can be equally effective at some sites (Stewart *et al*., 2005; Stewart *et al*., 2008). Bracken 'bruising' is another technique that is used to damage the stems of bracken, reducing the vigour and number of stems in the next year (Lewis *et al.*, 1997; Bacon *et al.*, 2001; Soil Assoc., 2002a). There are various 'bracken bruiser' machines designed specifically for wildlife sites (Bacon *et al.*, 2001). Timing can be critical – the optimal time being just after bracken fronds have fully expanded – although care must be taken to minimise risks to reptiles and ground-nesting birds. A second treatment would be required in the same year, usually August and continued use over a number of years, to manage the problem effectively.

Short term high densities of livestock can be used to manage bracken. During the winter period they can break up litter and expose rhizomes to frost damage. This must be carefully managed to prevent damage to soils and other vegetation (Sears Scotland, 2008)

2.3.2.3. Ragwort

Cutting is not a suitable option for ragwort control, as growth is stimulated and plants may become perennialised, subsequently re-flowering later in the season or next year (Soil Association, 2002a). Cutting can be used as a last resort to prevent ragwort from flowering and producing seed. All cuttings should be removed and disposed of off-site (by burning etc.). If cuttings are left to rot down in situ, livestock should be excluded from the area until the foliage has fully decomposed and no longer presents a poisoning risk to livestock.

2.3.2.4. Thistles

Repeated cutting can reduce seeding of creeping thistles and over several years can exhaust the food supply in the roots (Soil Assoc., 2002a); but treatment should be repeated more than once a season, because stands of creeping thistle are usually unevenly matured (Simpson, 1993). The first cut should be with an elevated cutting deck/topper and then further cuts done progressively lower, as secondary growth will be below the height of the last cut.

However, twice-yearly cutting was found to be less effective in reducing creeping thistle than either lenient grazing or herbicide application and did not provide long-term control in upland or lowland grazing systems (Pywell *et al*., 2010). Cutting for a conservation crop in July will be more effective than topping treatments. Best effects are obtained using a combination of cutting and lenient autumn grazing (Defra BD1437).

2.3.2.5. Docks

Cutting can prevent seeding of docks but does not actually kill plants – in some cases; they can grow new shoots following defoliation (Simpson, 1993). Repeated cutting of docks will, however, 'exhaust' nutrient reserves in the root system (particularly starch) and is often recommended as an important component of an integrated control strategy. However, a high frequency of cutting (at least three times per annum) is required to reduce the vigour of broad-leaved dock (*Rumex obtusifolius*) (Stilmant *et al*., 2010). Cutting has also been shown to be less effective than sheep grazing, if a breed that feeds explicitly on dock can be used (Zaller, 2006). Alternatively, the cessation of grazing followed by a late cut can reduce broad-leaved dock in grassland (Pavlů *et al*., 2008).

2.3.2.6. Willowherbs

Cutting over a number of years can also reduce vigour and cover of rosebay willowherb, though at least two cuts per year would normally be required (Jefferson & Robinson, 2002).

2.3.2.7. Nettles

Cutting is not a particularly effective method of controlling common nettle, although cutting small infestations and re-seeding the exposed ground is sometimes recommended. Regular cutting and trampling can also provide some control (Fryer & Makepeace, 1978).

2.3.2.8. Rushes

Cutting (followed, if possible, by grazing or flooding) is a key component of non-chemical programmes for the control of rushes (Soil Association 2002a).

Cutting can be an effective method of preventing rushes from spreading. Two cuts per season, 4-8 weeks apart is most effective. If a single cut is done it should be timed in August just after flowering. Cutting needs to be close to the ground without disturbing the soil as this will stimulate further germination. Sites with dense stands of rush would favour being grazed, flooded or the cut material being removed to favour grass regrowth over rushes.

2.3.2.9. Non-native invasive species

Although a useful pre-treatment to herbicide application, cutting treatments alone have not been effective in the control of giant hogweed (Tiley & Philp, 1994 & 2000). Chopping roots below ground level can be effective, especially if carried out at the flowering stage, but is labour intensive. Frequent cutting of plants can lead to reduced growth, but non-flowering vegetative plants can take several years to kill, due to sizeable root reserves. If cutting is delayed until after flowering, mature fruits can develop from plant reserves in the severed stem (Dodd *et al.*, 1994).

For Japanese knotweed, repeated cutting is labour intensive, and its long-term success is uncertain, due to the longevity of its rhizome system – although it can reduce vigour. In addition, cut material has to be removed to prevent further spread (Soil Assoc., 2002a). Cutting can be used to reduce plant height, to prepare a site before application of herbicides, or to remove dead stems. Flail mowing is not a recommended practice for this species, as it can spread fragments of stem material into previously non-infested areas (Child & Wade, 2000).

Small stands of Himalayan balsam can be controlled by cutting below the lowest node or pulling. These methods tend to be ineffective for larger stands. Frequent mowing is another option, but both cutting and mowing have to be carried out before the seed pods are formed, to prevent re-growth from seed (CEH, 2004a).

Cutting combined with smothering (e.g. black plastic sheeting) has been shown to result in 98% control of non-native cordgrass (*Spartina*) species in coastal habitats (Roberts & Pullin, 2006).

Cutting appears ineffective in controlling *Cotoneaster* unless repeated frequently.

2.3.2.10. Aquatic weeds

Cutting of many aquatic weeds provides instant short-term control. There is a loss of invertebrates, with estimates of 10^6-10^9 organisms lost per tonne of weed removed in southern UK chalk streams (Dawson *et al*., 1991) and up to 50 vertebrates, including fish and amphibians from lakes in the USA (Brooms, 1999). Cutting is effective against emergent and rooted weeds, but not against free-floating weeds, filamentous algae or unicellular algae. Cutting can also be used for vegetation on riverbanks as long as the vegetation is removed and does not enter the water.

Weed cutting boats are effective for cutting large quantities of submerged and emergent weeds and are suitable for larger waterbodies. However, they are expensive and can stimulate re-growth. Tractor-mounted cutters are useful for cutting weeds along rivers if the bankside is accessible, but there are again problems with re-growth and the cutting distance is restricted by the length of the cutting arm (Seagrave, 1988).

Where weed cutting has taken place in static water, all cut vegetation has to be removed from the water otherwise, it will rot and cause a depletion of dissolved oxygen. Dredging and raking can also be effective control methods. Dredging provides long-term control but is not selective and affects the whole water body. Raking can be an effective control method for windblown weed but is not suitable for large waterbodies.

Dawson & Warman (1987) investigated the removal of New Zealand pigmyweed (*Crassula helmsii*), manually and by machine, but these methods proved unsuccessful on many occasions because of the re-growth potential of the plant. Small fragments broken off during mechanical control can re-grow and spread the infestation downstream.

Turion (winter bud) removal from sediment in early winter using a weed harvester could be a potential option for the control of *Elodea* species. It has been shown to give effective control of whorled watermilfoil (*Myriophyllum verticillatum*) in the following year and reduced growth in the subsequent growing season (Vernon & Hamilton, 2011, cited by Cook *et al.,* 2014)).

2.3.3. Digging and stump excavation

Re-growth from cut stumps will occur in most broadleaved tree and shrub species (exceptions include broom and beech) and can be very vigorous in species such as horse chestnut, rhododendron, sycamore and willow. Mattocks and equivalent tools can be used to cut out tree and shrub saplings and stumps below ground level, to prevent re-growth. Although these tools limit ground disturbance, they are labour intensive and some species still send up shoots from remaining roots (e.g. blackthorn, dogwood, privet, snowberry, wild cherry and willow).

Sapling roots can be cut below ground level using an adapted chainsaw causing minimal ground disturbance. It has been particularly recommended for use on species such as alders, beech, birch, broom, elder, hawthorn, hazel, horse chestnut, maples, oaks, sycamore, sweet chestnut and whitebeam (Day *et al*., 2003). However, the saw is only suitable for use on small and medium sized sapling roots and cannot be used on sites with an abundance of hard stones or rocks (Day *et al*., 2003). Mechanical stump grinders can be used to prevent or minimise re-growth from larger trees and shrubs after they have been felled and removed.

Digging has been suggested as a potential control method for non-native cord-grass species but evidence for its efficacy and for any detrimental effects on the environment is unclear (Tan, 2007). Digging Japanese knotweed plants and rhizomes is labour intensive and, on its own, not particularly effective, as even very small rhizome pieces can readily grow (Palmer, 1994). It can also encourage spread, as parts of rhizomes can break off and re-grow around the site of the original stand. Similarly, digging broad-leaved dock plants out to a depth of 5cm is ineffective for reducing their density in fertile grassland, even when done as often as eight times in three seasons (Strnad *et al*., 2010).

Mechanical extraction of tree or shrub stumps is expensive and can cause unacceptable disturbance of soils and vegetation across a site. In certain circumstances, however, it might be considered necessary and employed effectively. For example, a tracked excavator, fitted with a rake attachment, proved effective in clearing sea buckthorn from dune slopes and hollows on a coastal nature reserve (Rooney, 1998).

All ground disturbance can encourage other weeds to colonise from seeds in the seedbank, such as nettles and land managers need to be mindful of this.

2.3.4. Other mechanical methods

2.3.4.1. Lasers

A potential weed control method, which is not yet commercially available, is based on the use of CO2 lasers. Recent studies have shown the positive potential of using lasers as a method for weed control, but further research is needed. A BBSRC-funded iCASE studentship at Harper Adams University was investigating the use of low energy lasers to manage weeds, both alone and in conjunction with low doses of herbicide (Harper Adams, 2018, cited by Cook *et al*., 2019)

2.3.4.2. Electric weeding

Professional electric weeding devices have been developed for the amenity sector. These devices could be used on a wide range of plants and have been shown to control nettle, broad-leaved dock and creeping thistle (ADAS, 2014a)

Electric weeding can be used to spot treat specific plants, is non-toxic to micro-organisms in the surrounding soil and creates no soil disturbance – therefore bringing no new weeds seeds to the surface area. It also has the advantage that it could be used in windy conditions and the target area can be accessed immediately after use. The costs of an electrical weeding treatment are comparable to herbicide application with a handheld knapsack sprayer, but the outlay for the equipment has to be factored in (ADAS, 2014b).

2.3.4.3. Flame weeding

Flame weeding could be used for pathways and spot treating. Perennial weeds would need to be treated before the two-leaf growth stage to give effective control. Hand-held applicators are available giving ease of use in a wide range of areas. However, the contribution of burning fossil fuels to global warming and climate change must be considered.

2.3.4.4. Hot water / foam weeding

Hot water and hot foam are types of thermal weed control that use heat to kill the plant, with the foam insulating the heat to increase the efficacy. Technology has been developed to fit on to utility terrain vehicles (UTV's), pick-up trucks and trailers that enables the foam/water to be applied to surfaces such as roads and pathways

Research has shown the foam method to control a wide spectrum of weeds, including perennials, however multiple applications were required. (ADAS, 2013b). The hot water technique can control recently emerged annual and perennial weeds but struggles to kill established perennials.

Hot water and foam may not be suitable for spot treating single plants but could be used to treat specific areas such as pathways and hardstanding. Access to water would be required on site.

2.4. Biological Control

Biological control is often aimed at controlling naturalised weeds and frequently uses the plant's natural enemies to lower its density (Bovey, 2001). It is generally intended to suppress weed populations, thus allowing native species to re-establish (Charudattan, 2001).

There are two main types practised:

introduction of non-native species ("classical biocontrol"), and

manipulation of indigenous populations, either through conservation of existing predator or parasite populations or "augmentation" (e.g. through regular releases of biocontrol agents).

In both of these situations, the objective is to use organisms that can restrict the growth and development of target weeds, without disturbing non-target organisms.

A disadvantage of biological control is that is can be slow and often involves a reduction in spread of weeds rather than complete eradication (CABI, 2020). Control tends to be specific to one or a few weed species, so is generally unsuitable for areas where rapid control is required of many different weed species. It also carries serious risks, as it can potentially damage native species.

In its favour, once the biological control agent has been released it remains indefinitely and is consequently very cost-effective in the longer-term (Ani, 2018). It is also suitable for use in areas where mechanical or chemical control is unachievable, due to the terrain.

Shaw *et al*. (2018) reviewed the use of biological methods for the control of weeds in Europe. They found that despite the widespread use of biological control in glasshouses and release of at least 176 species of exotic arthropods against agricultural pests across Europe, the biological control of weeds is currently a rare occurrence.

A psyllid (*Aphalara itadori)* was identified as an effective control agent for Japanese knotweed (*Fallopia japonica*) in a research project that began in 2000. This agent did not perform well during a 5 year restricted release programme (2010-2015) and the failure has been attributed to i) the founder population having been reared under continual Japanese summer conditions in a growth room for almost 90 generations, ii) abnormal and unseasonal weather experienced in the UK in each of those years and iii) the fact that releases took place on just one occasion each season on small isolated patches of knotweed. Since then, further psyllids have been collected from Japan and these are undergoing further field assessment in the UK (Shaw *et al*, 2018).

A rust fungus, *Puccinia komarovii* var. *glanduliferae* was identified for the control of Himalayan balsam (*Impatiens glandulifera*) in a project started in 2006 and has since been released at 25 sites across England and southern Wales. Observations showed variability of control between different populations of Himalayan balsam which indicated that the rust would be only effective against a subset of populations. A further strain of rust has been tested and was released in early 2017. The programme is progressing, and further strains are being tested (Shaw *et al*., 2018).

2.4.1. Aquatic weeds

A weevil - *Stenopelmus rufinasus* probably came to Europe on plants of water fern *(Azolla filiculoides*), the weed which it is used to control. In the UK control can be less consistent than in warmer parts of the world due to fewer generations per year and increased mortality. Due to this less consistent control this weevil is being mass-reared by the Centre for Agriculture and Biosciences International (CABI) and can be purchased to target infestations (www.azollacontrol.com accessed 29/8/2024).

A mite (*Aculus* spp) is being tested for control of *Crassula helmsii*. Field testing is ongoing, and the mite was released at several sites in 2018 (CABI, 2020a). A weevil, *Listronotus elongatus* has been identified as a potential biological control agent against floating pennywort. Knowledge gaps have been identified and tests are ongoing (CABI, 2020b).

2.5. Key References/Further Reading

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3. Using Herbicides – General Guidance

3.1. Regulation (EC) No 1107/2009

Regulation (EC) No 1107/2009 concerning the placing of plant protection products (PPP's) on the market, defines PPPs to include all herbicides, fungicides, insecticides, plant growth regulators, soil sterilants and, where used to protect plants, rodenticides.

Regulation (EC) No 1107/2009 provides statutory powers to control PPP's (essentially pesticides used to control plants and plant pests). Article 1 states that its purpose is to:

> …ensure a high level of protection of both human and animal health and the environment and to improve the functioning of the internal market through harmonisation of the rules on the placing on the market of plant protection products, while improving agricultural production.

3.1.1. Pesticide authorisations

Regulation (EC) No 1107/2009 is underpinned by the Plant Protection Products Regulations 2011 (as amended). Together these regulations mean that only authorised products can be sold, supplied, stored, advertised or used. More specifically, PPP's can only be used in situations for which their use is currently authorised by Health & Safety Executive (HSE). Lists of currently authorised PPP's are available from the HSE databases (Accessed 29/08/2024) – which are regularly updated.

It is an offence to use non-authorised products or to use authorised products in a manner that does not comply with the statutory conditions of use.

Chemicals that are derived from natural sources (biopesticides) are subject to the authorisation process, in the same way that synthetic pesticides are.

Biological control agents may also be classified as pesticides, although only micro-organisms used for this purpose are subject to the PPP authorisation process, i.e. biological control agents that are not micro-organisms do not require authorisation.

It is important to note that authorisations for herbicides, as for all PPP's, are based on products, - not the active substances and a PPP might contain two or more herbicide active substances.

There are two types of product authorisation applicable, to use in nature conservation sites:

- 'On-label' these are issued for an individual product and relate to specific uses detailed on the product label.
- 'Extension of authorisation for a minor use' (EAMU) these cover "off-label" uses which are additional to those shown on the manufacturer's product label, (see 3.1.2 below).

There are also Emergency Authorisations. Under certain circumstances it is possible to grant an emergency use of a plant protection product to place on the market for a period not exceeding 120 days, for a limited and controlled use, where such a

measure is necessary because of a danger which cannot be contained by any other reasonable means.

Users of PPP's must strictly comply with the Conditions of Authorisation relating to use. Consequently, all PPP users must carefully read the product label before use. In the case of a product being applied under the terms of an EAMU, it is the user's responsibility to obtain, read and retain the appropriate Extension of Authorisation, published by HSE.

Products granted only an experimental permit cannot be advertised or sold – and do not appear in the list of authorised products.

3.1.2. Extension of authorisation for a minor use' (EAMU)

Plant Protection Products may also, in some circumstances, be used in a way or on a crop that is not specified on the product label.

Products may have an Extension of Authorisation for minor use (EAMU) in the UK (formerly known as 'Specific Off-Label Approval') for an alternative 'minor use'. Any authorised use of a PPP under an EAMU is undertaken entirely at the risk of the user, as it is not endorsed by the product manufacturer. All statutory conditions relating to normal, or "on-label" authorised uses of the PPP concerned, and any conditions specified on the EAMU, must be complied with. The application method must also be as stated on the product label.

Under certain conditions, the use of reduced spray volumes may also be legal.

3.1.3. Adjuvants

Adjuvants are substances, other than water, added to enhance the effectiveness of a PPP e.g. extenders, wetting agents or sticking agents. They are not classed as PPP's. However, **the adjuvant must be authorised for use with an authorised PPP**. The product label for an adjuvant, which must be consulted, will stipulate the circumstances in which it may be used. The label will also include details of the PPP('s) that the adjuvant can be mixed with. The current list of adjuvants authorised for use with an authorised PPP can be viewed on the CRD website(Accessed 29/08/2024)

3.1.4. Tank mixes

The regulations forbid the preparation of tank mixes of two or more PPPs, unless all of the conditions of authorisation relating to the use of all the products use can be complied with.

3.1.5. Protection of water

The Food and Environmental Protection Act 1985 (FEPA) places a special obligation on all pesticide users to safeguard the environment and to prevent pollution of water. No pesticides may be used in or near water, unless the authorisation specifically allows such use and permission has been granted by the Environment Agency, SEPA in Scotland and NRW in Wales). Guidelines for the use of herbicides in or near water can be found here and in the Code of Practice for Using Plant Protection Products and Protecting our Water, Soil and Air*:* the Code of Good Agricultural Practice for farmers, growers and land managers. (All Accessed 29/08/2024)

The Environmental Permitting (England and Wales) Regulations were introduced in 2010. These regulations control discharges or disposal of certain substances, including all pesticides. Normal use of pesticides is not affected, except for some disposal practices, such as applying pesticide washings to the ground.

The Environment Agency (or SEPA in Scotland and NRW in Wales) should always be consulted before any application of herbicides in or near water.

3.1.6. Buffer zones

Cross compliance regulations (Defra, 2020b) state that pesticides should not be applied to land within 2 metres of the centre of a watercourse or field ditch, or to land from the edge of the watercourse or field ditch to 1 metre on the landward side of the top of the bank. This does not apply for spot application of pesticides to control the spread of any of the following weeds:

- broad-leaved dock (*Rumex obtusifolius*)
- creeping or field thistle (*Cirsium arvense*)
- curled dock (*Rumex crispus*)
- giant hogweed (*Heracleum mantegazzianum*)
- Himalayan balsam (*Impatiens glandulifera*)
- Japanese knotweed (*Reynoutria japonica*)
- ragwort (*Jacobea vulgaris*)
- rhododendron (*Rhododendron ponticum*)
- spear thistle (*Cirsium vulgare*)

Some products that are potentially most damaging to aquatic species have a legally binding requirement to leave an unsprayed ‘buffer zone’, of a minimum specified width, adjacent to any waterbody (measured from the top of the bank). Buffer zone restrictions do not always apply to all products containing the same active substance.

The width of a buffer zone, where required, varies according to the PPP being used and it is important to ensure that the correct approach is followed. For buffer zones up to 5 metres, it may be possible to reduce the distance by conducting a Local Environment Risk Assessments for Pesticides (LERAPs), if a documented assessment concludes that water pollution risks are low (e.g. because of use of reduced pesticide dose or low drift spray nozzles, or if a drainage ditch is dry at the time of spraying). Some PPPs may specify larger zones, and these must not be reduced. More information can be found here (Accessed 29/08/2024)

Some products are specifically authorised for use in or near water. These products can be found in the HSE authorised products database (Accessed 29/08/2024). To restrict a search to products specifically authorised for use in or near water, select 'Aquatic use ' in the drop-down box.

Buffer zones to protect specific plants, based on experimental results, were recommended by Cooke (1993) and are listed **Error! Reference source not found.** below.

Table 1. Recommended buffer zones for the protection of selected plant groups.

Application from ground or air	Species at risk	Buffer zone (m)
Ground	Heathland lichens	0
Ground	Pasture woodland lichens	0, but avoid direct spraying
Ground	Established higher plants	10, except for glyphosate with some species
Ground	Seedling higher plants	Up to 20

3.1.7. Certification of operators and advisers

Under the law everyone who uses PPPs authorised for professional use must hold a specified certificate or work under supervision (under the 'direct and personal supervision and in the presence of a person who holds a specified certificate, where such supervision is being provided for the purposes of training). A list of recognised specified certificates is available on HSEs website. List of UK designated bodies and recognised specified certificates (hse.gov.uk) (Accessed 29/08/2024)

The Official Control (Plant Protection Products) Regulations 2020 require businesses, organisations or sole traders that use professional PPPs in Great Britain to register if:

- Work involves use of professional PPPs and any adjuvants
- Have professional PPPs and any adjuvants applied by a third party
- Applies to businesses, organisations or sole traders involved in agriculture, horticulture, amenities (e.g. local authorities), or forestry.

The 2020 Regulations will enable Defra, the Scottish Government and the Welsh Government, working with the regulatory authorities, to understand how PPPs are being sold and used in Great Britain, to support businesses and organisations to be compliant with their legal obligations and to ensure PPPs are used sustainably and in accordance with the conditions of use.

3.1.7.1. Advisors

Anyone who gives advice on the use of PPP's should hold the BASIS certificate for crop protection. A BASIS qualification provides an assurance that the advisor has demonstrated competence in advising on safe and sustainable pesticide use.

The BASIS Scheme is a system of self-regulation by the agrochemical industry, run by BASIS (Registration) Ltd – an independent organisation, working with the UK Government to establish and maintain high standards for pesticide storage, distribution and use.

BASIS-qualified pesticide advisers can join the BASIS Professional Register. The register requires members to:

- Hold a recognised qualification
- Agree to a written code of professional ethics
- Commit to a programme of continuing professional development (CPD) so that they stay up to date with all recent developments.

Members of the Professional Register are entitled to use the letters MBPR (Member of the BASIS Professional Register) after their name, followed by the category of membership shown in brackets. Members also carry an ID card and are issued with an annual certificate for display.

BASIS certification courses for field sales and technical staff are run by various training agencies across the country. Courses cover specific areas of crop protection with IPM, including agriculture, commercial horticulture, amenity horticulture (including aquatics and forestry) and grassland and forage crops.

Further details and a full list of BASIS training agencies can be found here (Accessed 29/08/2024).

3.1.7.2. Spray operators

All persons applying professional pesticides must hold the appropriate certificate of competence from City & Guilds or other designated body

List of UK designated bodies and recognised specified certificates (hse.gov.uk) (Accessed 29/08/2024) for the equipment they are using or be under the direct supervision of someone who does.

- City and Guilds NPTC pesticide award (users):
  - PA2 Boom sprayer, mounted, trailed or self-propelled
  - PA3 Broadcast, boom sprayer mounted or trailed
  - PA4 Pesticide granule applicator, mounted or trailed
  - PA5 Boat mounted applicators (amended April 2014)
  - PA6 Handheld applicators
  - PA7 Aerial application
  - PA8 Mixer/Loader
  - PA9 Fogging, misting and smokes
  - PA10 Batch dipping
  - PA11 Seed treatment equipment
  - PA12 Application of pesticides to material as a continuous process via conveyor,roller tables and other moving equipment
  - PA13 Sub surface liquid pesticide applicators

A Foundation Module, PA1, must be completed, before the appropriate certificate(s). Further information on City & Guilds NPTC courses and qualifications can be obtained from their website (accessed 29/8/2024).

3.1.8. Aerial applications of pesticides

The law requires that the aerial application of pesticides can only be undertaken if the operator is in possession of an aerial spraying permit, issued by HSE. HSE can only grant a permit when a number of conditions have been fulfilled. Key amongst these: that there is a specific PPP authorisation for the aerial use; and that where spraying takes place in or close to a conservation area that the relevant nature conservation authority (for example, Natural England) has been consulted. Operators must comply with the condition stipulated in the permit. An explanation (accessed 29/8/2024) of the permitting arrangement is available on HSE's website

3.2. Legal requirements

The distribution, sale, storage, use and disposal of any pesticide is regulated by various pieces of UK and European legislation and related codes of practice. These are summarised on the HSE website (accessed 29/8/2024) and in the latest edition of *The UK Pesticide Guide,* published annually by BCPC (accessed 29/8/2024). In the context of herbicide applications on nature conservation sites, the most important among these are:

- The Control of Substances Hazardous to Health Regulations 2002 (COSHH)
- Plant Protection Products (PPP) Regulation (EC) No 1107/2009 (implemented by the Plant Protection Products Regulations, 2011)
- Sustainable Use Directive 2009/128/EC (the way in which this Directive is implemented is explained in the UK National Action Plan for the Sustainable Use of Pesticides – a number of legislative and other mechanisms are used, key amongst these is the Plant Protection Products (Sustainable Use) Regulations 2012)
- Drinking Water Directive (98/83/EC) and Water Framework Directive (2000/60/EC)
- Codes of practice for use of plant protection products

General guidance concerning Maximum Residue Levels (MRL's): Since September 2008 all statutory MRL's are set on an EU-wide basis, under EU Regulation 396/2005(EC) (accessed 29/8/2024). Although important for agricultural and horticultural pesticide users, they are not relevant to herbicide use in nature conservation sites.

The requirements of the Weeds Act 1959, relating to the control of five specified 'injurious weeds', plus provisions under the Wildlife and Countryside Act 1981 for the control of Japanese knotweed and giant hogweed, are also relevant – and are discussed at the end of this section.

3.2.1. COSHH

The Control of Substances Hazardous to Health (COSHH) Regulations 2002. They require that pesticides should only be used where necessary and where the benefits significantly outweigh the risks to human health and the environment. A pesticide

selected for use in any particular situation should be that which poses least risk to people, livestock and the environment, whilst still being effective against the target species. Employers and self-employed spray operators are required to perform risk assessments, to validate their choice of chemical.

The COSHH Regulations also lay down the basic requirements for the assessment and control of exposure to pesticides and other hazardous substances. Substances deemed to be 'hazardous to health' include those labelled as 'toxic', 'very toxic', 'harmful', 'irritant' or 'corrosive'. Exposure of employees to these chemicals must be prevented or adequately controlled.

3.2.2. Drinking Water Directive (98/83/EC) and Water Framework Directive (2000/60/EC)

The Drinking Water Directive sets a maximum of 0.1mg/l for each individual pesticide in drinking water and 0.5mg/l for total pesticides. The Water Framework Directive, which became law in December 2003, establishes a framework for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater.

3.2.3. Codes of Practice

The Code of Practice for Using Plant Protection Products (Defra 2006 accessed 29/8/2024) explains how PPP's can be used safely and meet the legal conditions which cover their use. It also includes specific guidance on issues such as dealing with spillages, applying pesticides near water, minimising waste pesticide and disposal of pesticide concentrate, washings and containers.

The 'Code of practice for Suppliers of Pesticides to Agriculture, Horticulture and Forestry code) (Defra, 1998; accessed 29/8/2024) provides practical guidance for those involved in the sale, supply storage and transport of pesticides, on how to comply with the legal requirements.

Protecting our Water, Soil and Air: a Code of Good Agricultural Practice for farmers, growers and land managers (the 'CoGAP') (CoGAP accessed 29/8/2024) brings together and updates the former three separate codes for water, soil and air. It provides practical interpretation of legislation and provides good advice on best practice for those who handle, store, use, spread or dispose of any substances that could pollute water, soil or air.

3.2.4. Pesticide storage

Pesticides must be securely stored under appropriate conditions. For small quantities this may be a suitable, lockable chest, bin, vault or cabinet – clearly marked with a hazard warning sign. The container used must be resistant to impact and fire. To ensure that any leakage from pesticide packs and bottles is safely contained, storage facilities must have a built-in sump big enough to contain 110% the total amount of pesticide stored (185% if in an environmentally sensitive area).

For more detailed information on pesticide storage, refer to Code of practice for using plant protection products , Code of practice for Suppliers of Pesticides to Agriculture, Horticulture and Forestry and HSE Agricultural Information Sheet **16** Guidance on storing pesticides for farmers and other professional users. (HSE, 2012. accessed 29/8/2024).

3.2.5. Pesticide handling and dealing with spillages

Pesticides should be transported safely. If you collect pesticides from a supplier or move pesticides from the store to the place where they are being applied, you should check your legal obligations for the safe transport of dangerous goods. Consult the Code of Practice for Using Plant Protection Products (accessed 29/8/2024).

PPP application equipment should be filled and washed in a designated area from which spillages cannot escape, well away from drains, ditches or surface water.

Care must be taken to avoid spillages, but if they do occur then prompt action must be taken to limit the effects and, if appropriate, warn others (e.g. the Environment Agency). Small spills should be soaked up with an absorbent material e.g. act litter or sand. The contaminated absorbent must subsequently be disposed of through a licensed waste disposal operator. Major spills must be contained and the Environment Agency (SEPA in Scotland and NRW in Wales) promptly alerted (EA emergency hotline: **0800 807060**).

Never hose down a spillage or simply leave it to dry – these actions will increase the risk of water pollution.

3.2.6. Disposal of pesticides and tank washings

The waste management (England and Wales) Regulations 2006 regulates the disposal of PPP waste. It is illegal to store PPP@s that are no longer authorised. Unwanted PPP's which cannot be returned to the supplier must be disposed of using a registered waste disposal operator.

Minimise or eliminate sprayer tank washings by careful planning. Tank washings (after spraying has been completed) could be stored for use in the next batch of diluted pesticide: consult the label for guidelines. If this is not feasible, the Code of Practice for Using Plant Protection Products (accessed 29/8/2024) recommends that the washings should be either:

- sprayed onto a previously treated area of crop – as long as this is within the terms of the product authorisation and does not exceed any stated maximum dose, or
- sprayed onto an untreated crop area – if this is within the terms of the product authorisation and there are no watercourses nearby, or
- stored in a suitable container until a registered waste disposal operator collects it.

If sprayer filling or washdown are carried out in the yard, these should be conducted on a dedicated, bunded filling/washdown area which allows all liquids to be contained and collected. There are alternatives for the disposal of the collected liquids that require prior notification or approval from the Environment Agency (England). These include:

- using equipment designed to treat dilute liquid waste that contains pesticides, such as bio beds and biofilters. These require prior EA notification via an on-line T32 (accessed 29/8/2024) or
- apply washings to *land* under conditions set out in a permit from the Environment Agency under the Environmental Permitting Regulations 2016 (accessed 29/8/2024)

3.2.7. The Weeds Act, 1959

The *Weeds Act* 1959 specifies five 'injurious weeds' that are considered potentially serious threats to agricultural production. The weed species covered by the Act are:

- spear thistle (*Cirsium vulgare*)
- creeping thistle (*Cirsium arvense*)
- curled dock (*Rumex crispus*)
- broad-leaved dock (*Rumex obtusifolius*)
- common ragwort (*Jacobaea vulgaris*)

Landowners have a responsibility to control these weeds. In circumstances where control is thought to be inadequate, initial complaints should (ideally) be made to the occupier or owner of the land concerned. If this is not successful, complainants should approach Natural England (who manage the process on behalf of Defra), further details on the procedure can be found on **GOV.UK** (accessed 18/10/2024). The Department for Environment, Food and Rural Affairs (Defra) does not have the resources to investigate every weed complaint it receives, so cases are prioritised (as explained on GOV.UK). If an investigation is undertaken, it may subsequently lead to the issue of an official notice requiring the occupier/owner to take prompt action to control the spread of the weed(s) concerned. Natural England's responsibilities are for agricultural land and livestock, rather than animals kept for non-agricultural businesses or recreational purposes. Consequently, priority is given to cases where weeds are threatening land used for keeping or grazing horses and other livestock, or farmland used to produce conserved forage or other agricultural activities.

Reports of injurious weeds growing on National Nature Reserves (NNR's) or SSSI's will be taken up with Natural England.

3.2.8. Wildlife and Countryside Act, 1981

Under Section 14 of the Wildlife and Countryside Act 1981, it is an offence to "plant or otherwise cause to grow in the wild" certain specified plants, listed in Schedule 9, Part II of the Act. See table 2:

Table 2: Plants listed under Schedule 9, Part II of Section 14 of the Wildlife and Countryside Act 1981

Common name	Scientific name	Type of plant*
Alexanders, Perfoliate	*Smyrnium perfoliatum*	T
Archangel, Variegated Yellow	*Lamiastrum galeobdolon subsp. argentatum*	T
Azalea, Yellow	*Rhododendron luteum*	T
Balsam, Himalayan	*Impatiens glandulifera*	T
Cotoneaster	*Cotoneaster horizontalis*	T
Cotoneaster, Entire-leaved	*Cotoneaster integrifolius*	T

Common name	Scientific name	Type of plant*
Cotoneaster, Himalayan	*Cotoneaster simonsii*	T
Cotoneaster, Hollyberry	*Cotoneaster bullatus*	T
Cotoneaster, Small-leaved	*Cotneaster microphyllus*	T
Creeper, False Virginia	*Parthenocissus inserta*	T
Creeper, Virginia	*Parthenocissus quinquefolia*	T
Dewplant, Purple	*Disphyma crassifolium*	T
Fanwort (otherwise known as Carolina Water-shield).	*Cabomba caroliniana*	F
Fern, Water	*Azolla filiculoides*	F
Fig, Hottentot	*Carpobrotus edulis*	T
Garlic, Three-cornered	*Allium triquetrum*	T
Hogweed, Giant	*Heracleum mantegazzianum*	T
Hyacinth, Water	*Eichhornia crassipes*	F
Kelp, Giant	*Macrocyctis pyrifera*	M
Kelp, Giant	*Macrocystis angustifolia*	M
Kelp, Giant	*Macrocystis integrifolia*	M
Kelp Giant	*Macrocystis laevis*	M
Kelp, Japanese	*Laminaria japonica*	M
Knotweed, Giant	*Fallopia sachalinensis*	T
Knotweed, Hybrid	*Fallopia japonica x Fallopia sachalinensis*	T
Knotweed, Japanese	*Fallopia japonica*	T
Leek, Few-flowered	*Allium paradoxum*	T
Lettuce, Water	*Pistia stratiotes*	F
Montbretia	*Crocosmia x crocosmiiflora*	T
Parrot's-feather	*Myriophyllum aquaticum*	F
Pennywort, Floating	*Hydrocotyle ranunculoides*	F
Potato, Duck	*Sagittaria latifolia*	F
Primrose, Floating Water	*Ludwigia peploides*	F
Primrose, Water	*Ludwigia grandiflora*	F
Primrose, Water	*Ludwigia uruguayensis*	F
Rhododendron	*Rhododendron ponticum*	T

Common name	Scientific name	Type of plant*
Rhododendron	*Rhododendron ponticum x Rhododendron maximum*	T
Rhubarb, Giant	*Gunnera tinctoria*	T
Rose, Japanese	*Rosa rugosa*	T
Salvinia, Giant	*Salvinia molesta*	F
Seafingers, Green	*Codium fragile*	M
Seaweed, Californian Red	*Pikea californica*	M
Seaweed, Hooked Asparagus	*Asparagopsis armata*	M
Seaweed, Japanese	*Sargassum muticum*	M
Seaweeds, Laver (except native species)	*Porphyra spp* ***except****; p.amethystea, p.leucosticta, p.linearis, p.miniata, p.purpurea, p. umbilicalis*	M
Stonecrop, Australian swamp (otherwise known as New Zealand Pygmyweed).	*Crassula helmsii*	F

*T = terrestrial, M = Maritime, F = Freshwater

The plants contained in Schedule 9 may be relevant to nature conservation site managers who use mechanical methods to control these species. This is because inappropriate disposal of plant material may cause new infestations, if new plants arise from seeds or buried stem, root or rhizome fragments. More information can be found here (accessed 29/8/2024)

The requirements of the Wildlife and Countryside Act and related requirements of the Environmental Protection Act, 1990 are particularly pertinent to nature conservation site managers taking measures to control Japanese knotweed. This species can be easily spread through the distribution of stem, rhizome or crown fragments. For this reason, the Environment Agency recommend that any cutting of Japanese knotweed is done by hand, using sharp hooks or slashers – rather than by mechanical flails or mowers, which can cause the plant to spread.

Cut stems, excavated crowns or rhizomes of Japanese knotweed, and soil contaminated with rhizomes are classified as controlled waste and must be disposed of on site or safely transferred to a licensed landfill operator. Plant material to be disposed of on site, the preferred (and much less expensive) option, should be thoroughly dried and, if local bylaws permit it, burnt. At least 1 week prior to burning contact the Environmental Health Office of the local council and the Environment Agency (0370 850 6506).

Cut vegetation, or soil contaminated with Japanese knotweed rhizomes, is regarded as controlled waste under Section 34 of the Environmental Protection Act and there is a consequent ‘duty of care’ placed upon landowners, managers and contractors to ensure safe disposal in accordance with the provisions of the Act. Any Japanese knotweed waste that leaves the site of origin must be securely transported to a licensed landfill site, where it must be buried to a depth of at least five metres.

Extra resources on Japanese Knotweed

- Defra 2020a, Prevent Japanese knotweed from spreading How to identify, prevent spread and dispose of Japanese knotweed. https://www.gov.uk/guidance/prevent-japanese-knotweed-from-spreading accessed 29/8/2024
- INNSA 2017, Code of practice managing Japanese knotweed https://www.innsa.org/wp-content/uploads/2019/06/INNSA-Code-of-Practice.pdf accessed 29/8/2024
- PCA 2018, Code of Practice for the Management of Japanese Knotweed Code of Practice Management of Japanese Knotweed - Property Care Association (property-care.org) accessed 29/8/2024

3.2.9. Licensing of non-native biological control agents

Section 16 of the Wildlife and Countryside Act allows Defra to grant licences for releases so that section 14 does not apply. Releases of non-native animals (including nematodes, mites, insects and all vertebrates) may be licensed under the act for specific purposes, such as to authorise their use for the control of pests on commercial crops.

3.3. Methods and timing of application

3.3.1. Covers Application methods

The method used to apply a herbicide will depend on several factors. These include:

- extent and distribution of target species
- height and structure of target species
- height, structure and sensitivity of surrounding/adjacent crop or other non-target species
- environmental and meteorological conditions
- label requirements, which take into account factors such as mode of uptake, efficacy and operator safety.

Pesticides must be applied by means which satisfy the conditions of the product authorisation. However, unless the label places a legal requirement on the user to use a specific type of equipment, or specifically prohibits an alternative method, an alternative method of application may be used, provided:

a) the equipment chosen is suitable for the intended application of pesticides
b) a suitable and sufficient COSHH assessment has shown that the alternative method of application does not involve an increased risk to health and safety
c) an assessment of the environmental effects of using the pesticide by that application method has been made
d) the necessary control measures to reduce the risks, so far as is reasonably practical, are in place.

Unusual or uncommon methods of application might not have been considered in any risk assessments and therefore the absence from the label of any restrictions

relating to such methods should not be taken as indicating that those methods are acceptable. In such cases, the user should contact the HSE (accessed 29/8/2024) and/or the authorisation holders for the product to discuss the proposed method.

The Sustainable Use Directive (SUD) requires that pesticide application equipment (PAE) is tested on a regular basis and further information can be found here (accessed 29/8/2024). Application equipment that does not require an NSTS test includes knapsacks, handheld and pedestrian equipment. These should be regularly inspected by a competent person, repairs made as required, and a record kept. For knapsack sprayers a checklist is available here (accessed 29/8/2024) to use and record the results

Herbicides may be applied: pre- or post-emergence of the target weeds or plant species being protected; as sprays or granules; to soil or foliage. Applications can be to selected patches or spots of target weeds (*spot treatment*), to bands (e.g. along tree rows) (*band application*) or uniformly across a larger block of land or whole field (*overall spray*).

The types of sprayer or other herbicide application equipment most likely to be used in nature conservation sites are listed below, and their main uses and features described.

Stem injection

Translocated (systemic) herbicide, such as glyphosate, can be applied directly into the stems of unwanted trees and large shrubs. The herbicide is applied into the xylem of the target trees and shrubs through spaced cuts, made around the trunk of the tree using an axe or hatchet, as a spray, by brushing or purpose-made tree injector. Herbicide can be injected directly into hollow stems, such as Japanese knotweed and Giant Hogweed

One technique (Frill girdling) involves using a hatchet to make a series of horizontal, angled, downward cuts into the bark of the tree, making a discontinuous ‘frill’ around the lower trunk. A small amount of translocated herbicide (e.g. glyphosate) is then sprayed into each cut. This may be done using a small hand-sprayer, spraying down the inside edge of the hatchet blade. This is, generally, a more effective method for killing unwanted trees than simply ‘girdling’ the trunk with an axe. The hatchet blade requires careful cleaning afterwards. Glyphosate does not normally penetrate thick, mature bark, (glyphosate). However, it can penetrate green stems, immature bark and damaged bark. This must be born in mind when applying near valued trees.

Another method of stem injection involves the use of small plastic plugs, containing crystallised glyphosate (Ecoplug® Max). A hole is drilled into the stump and the plug hammered in.

These methods pose little or no risk to non-target plants, as herbicide enter directly into the inner tissues of the undesirable tree or shrub, with almost no risk of soil and water contamination.

Paint brushes

Freshly cut stumps of unwanted trees, shrubs or woody climbers can be treated with a herbicide, carefully applied using a paintbrush. For this purpose, the herbicide is diluted and applied as detailed in the product label. As for cut stump sprays, better

results are likely if treatment follows almost immediately after cutting the stems. The risks to non-target plants should be negligible if this method is used properly.

Weed-wipers

Weed-wipers (or wick applicators) allow the safer treatment of taller target vegetation, minimising the effect of contact or translocated herbicides on shorter, non-target species. They involve a herbicide-soaked wick that continually draws chemical from an integral reservoir. The wick is drawn over, or wiped against, target weed plants – directly applying herbicide to stems and foliage, and thus avoiding any drift onto non-target plants.

Small hand-held wick applicators, of various types, suitable for small-scale spot-treatment of scattered weeds, can be purchased. These are usually lightweight, nylon or rope-wick applicators, with plastic handles which also function as the reservoir for the herbicide. Various widths of wick (e.g. 5-50 cm) and lengths of handle (e.g. 80-120 cm) are available for different purposes.

Medium-sized applicators include compact tractor/All-Terrain Vehicle (ATV) mounted or drawn weed-wipers, typically of 2-3m widths. Coupled with all-terrain vehicles, this size of applicator can offer effective solutions to weed control on difficult terrain and hard-to-access areas.

Tractor-mounted weed-wipers can be used, for example, for the larger-scale treatment of relatively tall weeds such as bracken, thistles or ragwort in grassland, or birch or gorse scrub on grassland or heathland. For large acreages, self-propelled weed-wipers with booms up to 12m are available.

To be effective, and to minimise risks to non-target species, most weed plants should be at least 10 cm taller than other vegetation. However, even in these circumstances, there will usually be several equally tall plants of non-target species that may be vulnerable - a factor that must be considered. Another frequent problem is that several plants of the target species are, almost inevitably, below the level of the applicator and, consequently, remain after treatment. The greater the heterogeneity in height of the target species, the greater this problem becomes. Attempts to overcome this, by setting the applicator at a lower level, will increase the risks to non-target species and may (especially if woody plants are being treated) result in damage to application equipment. Cutting or grazing prior to treatment can establish a more effective height difference between the target and non-target species. Care should be taken to avoid contact with suckers or low branches of susceptible tree and shrub species.

The travel speed for weed-wiper applications should be 4-10 km h^{-1}. Two passes in opposite directions may be necessary, for heavy weed infestations.

Hand-held sprayers

The most widely used type of hand-held sprayer is the knapsack sprayer, with a tank capacity of 15-20 litres. Usually, these plastic tank sprayers are carried on the operator’s back. They are pressurised by a hand, battery-operated or motorised pump, and the spray deposited via a hand-held lance, which may be fitted with a hood or cone-shaped guard to minimise unintentional drift onto non-target species. Small booms of up to 2m width, held by the operator, are also available for attachment to knapsack sprayers. One alternative is the hand-held compression

sprayer, which uses a supply of compressed air to maintain the required pressure during spraying.

Sprayers can be fitted to hand pushed or pulled trolleys, or to a mechanised vehicle such as an ATV, a wide range of tractors or small vehicles such as ride-on mowers. Mounting the sprayer on wheels increases the tank capacity that can be carried.

These types of sprayers are best suited to the application of herbicide spot-treatments around trees and shrubs, or to relatively small patches of weeds, to smaller-scale band spraying operations and to larger-scale overall sprays on very rough or steep terrain, which are not readily accessible to machine-mounted sprayers. In areas where vehicle access is difficult, mounted or trailed sprayers can be used in conjunction with hand lances on long hoses rather than booms.

Herbicides can be applied by hand-held sprayer unless it is stated otherwise on the label. Always check the label, because some products may be applied by hand-held sprayer and others not. Users of professional PPP hand-held sprayers must hold a specified certificate of competence or work under the direct supervision of someone who holds the certificate.

CDA sprayers

Hand applications of herbicides to slightly larger areas might be feasible using controlled droplet application (CDA) sprayers, which use much smaller quantities of water (10-30 l ha^{-1} instead of 100-200 l ha^{-} in field sprayers). CDA sprayers are designed for low volume (LV) and ultra-low volume (ULV) pesticide applications – increasing both pesticide and operator-efficiency. These sprayers incorporate a spinning disc, which produces a more even droplet size than traditional knapsack or tractor-mounted sprayers. CDA sprayers produced for herbicide applications produce large droplets e.g. in the 200–300-micron range. The relatively large, even-sized droplets produced by CDA sprayers reduce the risks of inadvertent drift onto adjacent non-target plants. Larger droplets and large quantities of water may increase the losses to soil and water systems, as droplets ‘bounce off’ the foliage of target plants. Very small droplets, on the other hand, are more liable to drift away from target plants.

Check the label as some PPPs have minimum water volumes that must be used, and some are not approved for application through CDA applicators.

The Nomix system (accessed 10/9/2024) incorporates CDA technology with a system of ready-to-use herbicides.

Addition of a dye marker to the herbicide solution can allow better targeting of sprays.

Tractor-mounted sprayers

Some smaller capacity agricultural sprayers are mounted onto the three-point linkage of farm tractors, typically with tanks of 500-1500 litres capacity and a boom width of 12-36 m. Some specialised ATVs also have a three-point linkage facility to which small sprayers can be attached. Small tank sprayers may be mounted on the load rack of the ATV with a spray boom or lance attached for applications such as spot-spraying nettle and thistle patches in grassland.

Trailed sprayers allow larger volumes of spray to be carried as the weight is not all on the tractor as in mounted sprayers. These sprayers have boom widths of 18-42m and

tank volumes up to 12,000 litres requiring up to 300hp and having electronically controlled double axel steering.

Agricultural contractors and many larger farms have self-propelled sprayers with even larger capacities and outputs of up to five hundred hectares per day.

These types of sprayer are best suited to large-scale, overall sprays across areas of low vegetation, such as arable fields and agricultural grassland. They are not suited to the application of spot treatments, or for use among taller vegetation (especially woody vegetation) or across very steep or rough ground.

Granule applicators

Herbicide granules (e.g. some products containing propyzamide) can be applied, on a small scale, using hand-held 'pepper-pot' type applicators: check the label to make sure this is permitted. If larger areas require treatment, then various ATV or tractor-mounted granule applicators are available. Suitable types of tractor-mounted equipment include combined fertiliser/granule spreaders. For ease of application, it is important that granules are dry. It is, therefore, vital that granular herbicides are stored in dry conditions. Although granular herbicides can be safely applied in slightly windier conditions than herbicide sprays, it is important that vegetation is dry at the time of treatment.

Aerial applicators

The least targeted spray application equipment is aerial application. The accuracy of application clearly depends on the skill of the pilot to allow for turbulence effects of the aircraft through the air, along with the weather conditions.

Timing of application

The timing of application is also a critical consideration. For example, foliar-acting herbicides may be most effective if applied to target species during a period of vigorous growth, in late spring or early summer; but this may also be the period when non-target species are most vulnerable to damage. The need to protect non-target species may require alternative, and often less effective and/or more expensive options to be considered e.g. winter-time herbicide applications to woody weed species, by stem-injection or cutting and treating stumps.

3.4. Health and safety

All herbicides are potentially dangerous to spray operators and others that might be exposed to the concentrated chemical, diluted sprays or chemical residues.

All users of professional products should be certified before they use pesticides, see section 3.1.7. They must assess the risks of pesticide applications, before proceeding with treatment. A key part of this risk assessment is to ascertain the potential dangers to operators and other people, including members of the public using nature conservation sites during or after herbicide treatments. A risk assessment should be done and more information on how to do this can be found here (accessed 10/9/2024). The product label and the MSDS (Materials Safety Data Sheet) should always be read as they give clear instructions on the appropriate protective clothing to be worn and any recommended use of mechanical means to minimise exposure. They also provide information about requirements for first aid or

medical treatment in the event of accidental inhalation, ingestion or contamination of skin or eyes. More information on COSHH assessments can be found here and a COSHH e-tool here (both accessed 10/9/2024)

IMPORTANT: Product labels must always be read carefully and all statutory requirements complied with. This is a legal obligation.

Further information about safety equipment and clothing for spray operators, including a selection chart and practical advice on maintaining and using personal protective equipment, can be found in the ***Safety Equipment Handbook***, published in 2002 by the British Crop Production Council (BCPC). Available here (PDF) Safety equipment handbook: a practical guide to pesticide safety requirements (researchgate.net)accessed 10/9/2024

3.5. Environmental Safety

Before any herbicide applications are made, landowners or managers should consider non-chemical alternatives.

To minimise the effects of herbicides on non-target species, it is important to minimise the possibility of spray drift away from the targeted area into vulnerable adjacent habitats. There are four main ways of achieving this:

1. Leave a suitably wide, unsprayed 'buffer zone'. Often herbicides have a LERAP requirement if used adjacent to surface water - see section 3.1.6.
2. Does the pesticide need to be applied as a spray, or can it be applied topically e.g. by stem injection, paintbrush or weed wiper, see section 3.3.1
3. Avoid spraying in unsuitable weather conditions. Do not spray on days when the wind speed exceeds Beaufort Force 2 (light breeze) or on very calm, warm days, when lift and movement of vapour may occur. Ideally, herbicide sprays should be applied when there is a light breeze (3.2-6.5 km h^{-1} or 2-4 mph; leaves rustle, wind felt on face), blowing away from any vulnerable areas.
4. Use nozzles that produce a medium-coarse droplet size – avoid fine sprays, to minimise drift.
5. Keep spray nozzles as close as possible to the target plants (or area of soil), taking account of the minimum recommended nozzle height.

Such precautions are particularly important to protect water bodies from herbicide contamination.

Inadvertent, direct contact and spray drift represent greater threats to non-target plants than other forms of herbicide movement, although vapour drift can also occasionally have serious consequences (Breeze *et al.*, 1999).

As well as herbicide drift and the potential dangers that this may pose to non-target species, anyone applying herbicides in semi-natural habitats must also take into account the possible consequences of vegetation destruction for the animal species that may feed, shelter, roost or nest there. Total destruction of an area of vegetation, or even the selective removal of certain plant species (which might alter the habitat structure or result in greatly increased growth rates of other species) may render that area unsuitable for some or all of its resident or foraging animal population. Nature conservation site managers need to consider the significance of this for the local

fauna – in particular for any rare species – and weigh any potential losses against the benefits of weed control.

Aquatic weeds

The treatment of aquatic weeds requires special consideration.

Only products specifically approved for this purpose may be used. The Environment Agency (SEPA in Scotland and NRW in Wales) must be notified in advance of any proposed application of pesticides to or near water.

The application of herbicides to control submerged weeds and algae is normally recommended when weeds are growing most actively, in spring or early summer. However, this is when fish and aquatic fauna are breeding within the aquatic vegetation. On the other hand, delaying herbicide applications until late summer or autumn may lead to severe problems of de-oxygenation, resulting from the microbial decomposition of large quantities of weed present in the water at this time.

For more detailed guidance on the use of herbicides for the control of aquatic weeds contact the Centre for Ecology and Hydrology Aquatic Plant Management Group (accessed 10/9/2024)

The Environment Agency have produced guidelines on applications in or near water and these can be found here, along with an agreement form (accessed 10/9/2024)

For Scotland see here (accessed 10/9/2024)

The HSE Chemicals Regulation Directorate provide guidance notes for aerial applications of herbicides and these can be found here (accessed 10/9/2024)

3.6. Key References/Further Reading

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BCPC 2020. The UK Pesticide Guide. The British Crop Protection Council (BCPC) and CABI Publishing, Wallingford, UK.
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Defra 1998. Pesticides: Code of Practice for Suppliers of Pesticides to Agriculture, Horticulture and Forestry. Part II of the Food and Environment Protection Act 1985 (Yellow Code). MAFF Defra Publications, London. 60 pp. https://www.hse.gov.uk/pesticides/resources/Y/yellow_code.pdf
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Naylor, R.E.L 2002. Weed management handbook. 9th edition. Wiley-Blackwell , Oxford, UK.
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4. Herbicide Options – Efficacy And Effects On Non-Target Species

4.1. Approved Herbicides

Only herbicides officially authorised for use by the HSE can be legally used. Furthermore, a herbicide must have either a full, label authorisation, an appropriate extension of authorisation for a minor use covering any specific situation, or an Emergency Authorisation. See section 3.3.1. Every site manager and spray operator have certain responsibilities that should be met before herbicides are applied. These responsibilities include:

- To consider any possible alternatives to herbicide use.
- If a herbicide is considered necessary, to ensure that environmental risks are fully considered, and the necessary actions are taken to eliminate or minimise those risks. If there is more than one authorised herbicide product for the task in hand, select the one that is likely to pose the lowest risk to people and non-target flora and fauna.
- To ensure that the product label (or the relevant Notice of Approval for Extension of authorisation for minor use) has been carefully read and understood. All safety instructions, restrictions and information on the label must be complied with.

Safety Data Sheet

The Safety Data Sheet (SDS) provides information on the pesticide that helps users carry out a risk assessment. It describes the hazards associated with the chemical, and gives information on handling, storage and emergency measures in case of accident.

4.2. Pesticide Authorisation System

HSE Crop Definitions List

HSE's Crop Definitions List replaces the Crop Hierarchy. It provides consistent terminology for the uses of PPP's. It also further describes the specific crops and situations covered by each term.

The Crop Definitions List is arranged in four levels:

a) Level 1

This divides all possible uses of PPPs into 3 categories: **All Edible Crops**, **All Non-Edible Crops** and **Non-Crop Production.** The Notice of Authorisation may list one or more of these as an authorised use if the PPP can be used on the full range of crops/situations covered by any of these categories.

b) Levels 2 and 3

Each of the 3 categories above is then divided into **Primary groups,** which may in turn then be sub- divided into **Parent groups.**

e.g. Under **All Edible Crops,** one of the **Primary groups** is **'**Fruit and Nuts,' which is sub-divided into the 8 **Parent groups** 'Tree Nuts, Pome Fruit, Stone Fruit, Table and

Wine Grapes, Strawberries, Cane Fruit, Bush/Small Fruit and Miscellaneous Fruit'. However, these terms will not be used on Notices of Authorisation to describe authorised uses, but they are there to help with search functions in the PPP databases.

c) Level 4

The above are finally divided into the **Basic Crop/Situation** descriptors which are the uses that will usually be specified on Notices of Authorisation and PPP labels. Each descriptor is accompanied by a **Definition** to fully describe the specific crops and situations that may be treated with a product authorised for that **Basic Crop/Situation**

Authorisations are not generally given at the parent group or primary group levels. So, for example, approvals would not be given for **agricultural herbage** or **industrial** and **amenity areas**.

A full list can be found on the HSE website Crop Definitions List _NOV_20_for PDF (hse.gov.uk) (accessed 10/09/24)

Authorisations also frequently include a list of qualifiers, to modify these basic crops or situations to cover more restrictive situations.

Table 3. The HSE Crop Definitions: top level categories and primary groups

Primary groups of greatest relevance to nature conservation sites are shown in **bold**.

All Edible Crops	All Non-Edible Crops	Non-Crop Production
Fruit & nuts	**Green cover**	Indoors
Vegetables	**Forestry**	Amateur products
Pulses (Dry)	Industrial crops	**Aquatic area**
Oilseeds and Oil fruits	Ornamentals	**Industrial and amenity areas**
Cereals		**Plant free areas**
Tea, Herbal infusions		**Other situations**
Hops		
Spices		
Sugar Plants		
Agricultural Herbage and Fodder crops		
Stored products		

Definition of Industrial and amenity areas

These areas may be open to public access and used for leisure, recreational and sports activities. This includes

- All kinds of non-agricultural land (including sports and recreational turf of all kinds; road, path and railway verges and embankments; and airfields)
- Public gardens and parks including for example National Trust properties
- Amenity woodland
- Amenity glasshouse, nursery and retail areas

- Non-cropped land such as roads, pavements, railway tracks and the surrounds of industrial installations.
- Any other similar area, whether or not used exclusively for amenity purposes.

Industrial and amenity areas do not include any areas that are grazed by livestock or that are harvested for human or animal consumption.

Table 4. Basic crops and situations, and associated definitions, most relevant to nature conservation sites.

Primary Group/ Parent Group	Basic Crop or Situation	Definition
Agricultural herbage and fodder crops	Grassland	Land grown for grass production includes short and long-term grass leys and permanent pasture, which may be grazed and /or cut for subsequent animal consumption. Includes use on newly sown leys and moorland for grazing (unless specifically excluded on the label/authorisation). **Excludes** use on amenity grass (see 'Amenity grassland')
Aquatic area	Enclosed waters	Any natural or artificial body of water that does not drain to a water course.
	Intertidal zones of estuary	The area between the low and high watermarks of a river estuary. Includes beaches.
	Land immediately adjacent to aquatic area	The bank of any water course or body of water. Includes sand dunes.
	Open waters	Any natural or artificial body of water that drains to a water course or is used as a reservoir for domestic water supplies.
	Saltmarsh	Area of vegetated salt-water marsh adjacent to the sea or saline river estuary
Forestry	Cut log	Any felled timber.
	Farm forestry	Groups of trees established on arable land or improved grassland, including those planted for short rotation coppicing.
	Forest	Groups of trees being grown in their final positions e.g. after planting out from a forest nursery. Trees grown primarily for commercial production, including ancient traditional coppice and farm forestry or from natural regeneration, colonisation or coppicing. Covers all woodland grown for whatever objective, including commercial timber production, amenity and recreation, conservation or landscaping, ancient traditional coppice and farm forestry. This includes restocking of established woodland and

Primary Group/ Parent Group	Basic Crop or Situation	Definition
		new planting on both improved and unimproved land.
Green cover	Green cover on land not being used for crop production	Areas of land with a vegetation cover that have been removed (temporarily or otherwise) from production. For example, some types of set aside. Includes fields or non-crop field margins covered by natural regeneration or by a planted green cover crop that will not be harvested. Includes conservation crops such as wild bird and pollen/nectar mixes and crops grown for game cover. Crops must not be harvested for human or livestock consumption or used for livestock grazing. **Does NOT include** use in industrial crops or inter-row use within a crop (edible or non-edible). *Since this definition covers a wide range of situations, the commercial risk is entirely the grower's if the product label does not specifically refer to the crop/species mix you are treating*
Industrial and amenity areas	Amenity grassland	Areas of semi-natural or planted grassland subject to minimal or non-intensive management. Includes areas that may be accessed by the public, such as golf roughs. May include airfields and predominantly grassed railway embankments and roadside verges. May be floristically rich and irregularly managed so that plants may flower and set seed.
	Amenity vegetation	Any areas of semi natural or ornamental vegetation, including trees. May include parks, railway embankments and roadside verges which are predominantly covered in vegetation other than grass. Also includes areas of bare soil around ornamental plants or intended for ornamental planting. **Does NOT include** hedgerows around arable fields.
	Natural vegetation	Areas of natural vegetation not covered by a situation stated separately in this Definitions List.
Other situations	Hedgerow	Linearly planted trees and/or shrubs maintained to form a boundary, including those surrounding arable fields.

Any terms used in older authorisations will be clearly explained on the product label; but the HSE website has a useful ‘Crop/Situation Conversion Form’ which indicates which old crops/situations relate to which new crop hierarchy crops/situations. This can be found at here (Accessed 10/09/24).

4.3. Relevant Authorisations

For the purposes of this manual, herbicides considered to have relevant authorisations for use in nature conservation sites include **those currently authorised for use in any of the 16 basic crops and situations listed in**

Table 4 (within the 'crop hierarchy' categories agricultural herbage and fodder crops, forestry, aquatic areas, industrial and amenity areas and other situations).

Information on herbicides that might be valuable for nature conservation site managers is summarised in Tables 5 and 6.

Table 5 lists possible herbicides for use against some of the most frequently encountered weed species requiring control in nature conservation sites. It includes only those herbicides with approvals for use in situations considered relevant to nature conservation sites (in the broader sense). Table 5 also includes short notes on relevant situations, application methods and timings for each listed herbicide.

Table 5. Target species and possible herbicides for their control. Note, some cells have been left deliberately blank.

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
Alga *Enteromorpha* spp.	Amenity grassland, Amenity vegetation	Pelargonic acid	Foliar spray via hand-held equipment. This product must **not** be applied via tractor-mounted horizontal boom sprayers for these situations	Applications must only be made between 1st May and 1st September

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
Aquatic weeds	land immediately adjacent to aquatic area, open waters	Glyphosate – certain products only	Foliar spray via vehicle mounted or hand-held equipment or a weed wiper Always consult EA or SEPA before use.	Emergent: Spray from mid-August to mid-September when weed has emerged and actively growing. Addition of an adjuvant will improve control. Submerged: no chemical control options Floating: Spray when there is a maximum emergence of floating leaves. For the control of Water Lilies, the best results are obtained from applications made from mid-July to mid-August.
Ash *Fraxinus excelsior*	See WOODY WEEDS			
Aspen *Populus tremula*	See WOODY WEEDS			
Birches *Betula* spp.	See WOODY WEEDS			
Blackthorn *Prunus spinosa*	See WOODY WEEDS			
Bracken *Pteridium aquilinum*	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Weed wiper.	Apply at full frond expansion, usually July-August.

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	on land not being used for crop production			
Bramble *Rubus* subg. *Rubus*	Grassland, Amenity grassland	Aminopyralid + fluroxypyr	hand-held equipment (Synero only)	Apply when actively growing
	Grassland, Amenity grassland	Clopyralid + triclopyr	Foliar spray via vehicle mounted or hand-held equipment.	Spray in June-August when actively growing but before plants begin to senesce in the autumn. With large bushes, all foliage should be thoroughly wetted or incomplete kill may result
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Broadcast: When actively growing but is less than 50cm high Spot: up to 1m high
	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production,	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Weed wiper	Apply when sufficient leaf growth is present between early May and late September
Broom *Cytisus scoparius*	Grassland, Amenity grassland	Clopyralid + triclopyr	Foliar spray via vehicle mounted or hand-held equipment.	Spray in June-August when actively growing but before plants begin to senesce in the autumn. With large bushes, all foliage should be thoroughly

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
				wetted or incomplete kill may result
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted or hand-held equipment (Icade).	Spot spray up to 1m high
	Grassland, amenity grassland	Fluroxypyr + triclopyr	Foliar spray via vehicle mounted equipment.	Spray in June-August when actively growing but before plants begin to senesce in the autumn.
	See chemical thinning			
Buckthorn, sea *Hippophae rhamnoides*	See WOODY WEEDS			
Buttercups *Ranunculus* spp	Amenity grassland	2,4-D + dicamba + fluroxypyr	Foliar spray via vehicle mounted or hand-held equipment	Apply to seedlings/young plants, when growing actively.
	Grassland	2,4-DB + MCPA	Foliar spray via vehicle mounted equipment. Some products can be applied using hand-held equipment.	Creeping - Treat in the autumn, on new leaf and in the spring. Bulbous – Treat in the spring or early summer
	Grassland	2,4 DB	Foliar spray via vehicle mounted equipment	Susceptible to the 2-leaf stage. Later control depends on species. Check label
	Grassland, Amenity grassland	Aminopyralid + fluroxypyr	hand-held equipment (Synero only)	Treat when actively growing, before flowering

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Treat when actively growing before flowering
	Grassland, Amenity grassland	clopyralid + florasulam + fluroxypyr	Foliar spray via vehicle mounted or hand-held equipment.	Apply at rosette stage to actively growing weeds Only apply from 1st February to 30th September
	Amenity vegetation, amenity grassland	Pelargonic acid	Foliar spray via vehicle mounted or hand-held equipment.	Non-selective. Treat when actively growing
	Amenity grassland, Grassland	Florasulam + fluroxypyr	Foliar spray via vehicle mounted or hand-held equipment	Apply when actively growing between March and October
Butterfly-bush *Buddleia davidii*	See WOODY WEEDS			
Cord-grass, common *Spartina anglica*	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Weed wiper	Spring/summer, when grass actively growing. June/July Grass with at least 4-5 new leaves & at least 10 cm tall. Two applications are more effective
Cow parsley *Anthriscus sylvestris*	Grassland, Green cover on land not being	thifensulfuron	Foliar spray via vehicle mounted equipment	2- 6 leaves

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	used for crop production			
Docks *Rumex* spp.	Amenity grassland, Grassland, Farm forestry (EAMU)	2,4-D	Foliar spray via vehicle mounted or hand-held equipment	Best results if applied to seedlings/young plants, when growing actively. Established plants in grassland will not be controlled.
	Grassland, Amenity grassland	clopyralid + florasulam + fluroxypyr	Foliar spray via vehicle mounted or hand-held equipment.	Apply at rosette stage to actively growing weeds Only apply from 1st February to 30th September
	Grassland, farm forestry (EAMU)	Amidosulfuron	Foliar spray via vehicle mounted equipment.	Apply between 1 February and 15 October on permanent grassland and 1 February and 30 June in rotational grassland when docks are actively growing.
	Amenity grassland, grassland	2,4-D + dicamba	Foliar spray via vehicle mounted or hand-held equipment	Rosettes when growing actively. Top growth of older plants will be killed but repeat application will be necessary.
	Grassland, Amenity grassland	Aminopyralid + fluroxypyr	hand-held equipment (Synero only)	Actively growing in the rosette stage up to 25cm high or wide
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Actively growing in the rosette stage up to 25cm high or wide
	Grassland, Amenity grassland	Clopyralid + triclopyr	Foliar spray via vehicle mounted or hand-held equipment.	Treat in the spring when at the rosette stage up to 25cm high. Repeat treatment may be

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
				needed on large docks and where the seedbank is high.
	Grassland, amenity grassland	Fluroxypyr + triclopyr	Foliar spray via vehicle mounted equipment.	Apply during spring or autumn when at rosette stage, up to 20 cm high or across. Allow 2-3 weeks after cutting or grazing before spraying.
	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Weed wiper	At or near flowering, but before seeds are set or the onset of senescence.
Dogwood *Cornus sanguinea*	See WOODY WEEDS			
Elder *Sambucus nigra*	See WOODY WEEDS			
Foxglove *Digitalis purpurea*	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Weed wiper	Apply during the rosette stage up to flowering, but before seed set and the onset of senescence.

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	for crop production, land immediately adjacent to aquatic area, open waters,			
Gorse *Ulex* spp.	See WOODY WEEDS			
Grasses - annual & perennial	Forest, farm forestry, hedgerow, amenity vegetation, amenity grassland	Propyzamide	Foliar spray via vehicle mounted or hand-held equipment.	Apply between 1st October and 31st December or 31st January, soil type restrictions also apply. Check label. Rain required after application, if soil is dry. Maximum of one application per year. Repeat application may be necessary in following winter for heavy couch infestations.
	Green cover on land not being used for crop production, forest	Cycloxydim	Foliar spray via vehicle mounted or hand-held equipment.	Optimum growth stage depends on species. Generally, from 2 leaves to stem erect. Check label. Do not apply to Forest between 1 July and 31 March, and green cover on land not being used for crop production between 1 September and 1 January
	Farm forestry, green cover on land not being used for crop production	Fluazifop-P-butyl	Foliar spray via vehicle mounted or hand-held equipment.	Optimum growth stage depends on species. Generally, from 2 leaves to stem erect. Check label.

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
Hawthorn *Crataegus monogyna*	See WOODY WEEDS			
Hazel *Corylus avellana*	See WOODY WEEDS			
Himalayan balsam *Impatiens glandulifera*	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Weed wiper	Spray when good foliage has developed to a height of at least 50cm in late spring, before the end of June. A second treatment may be necessary if more seedlings germinate.
Hogweed, giant *Heracleum mantegazzianum*	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment.	Spray when foliage has reached 20-50cm high in late spring, continue through the summer. Flowering plants may be sprayed with expanding lances. A second treatment will be necessary if more seedlings germinate. Monitor every 4-6 weeks
			Weed wiper	Timing as for sprays, useful in mixed populations. More information can be found here (accessed 24/3/2021)

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	Grassland, Amenity grassland	Clopyralid + triclopyr	Foliar spray via vehicle mounted or hand-held equipment.	Treat when hogweed is actively growing and less than 70cm high
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Treat when hogweed is actively growing and less than 70cm high
Japanese knotweed *Fallopia japonica*	Grassland, Amenity grassland	Aminopyralid + fluroxypyr	hand-held equipment (Synero only)	Treat when actively growing. Control is improved with spot treatment
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Spot spray up to 1m high with good foliage cover
	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment.	For a single spray the optimum timing is flowering. Spray the underside as well as the upper surface of the leaves. Two sprays -Spray plants at 1-1.5m tall, in late May and repeat on any re-growth once they reach 1.5m again. This technique can be used where stands are particularly thick, as part of an integrated control programme or where long lances are not available.
Nettle, common *Urtica dioica*	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest,	Glyphosate 2,4-D + MCPA	Weed wiper	Useful where treatment of nearby vegetation is to be avoided, spot treatment of small re-growth or stems <8mm. High

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters, Grassland			success rates, but labour intensive. Treat when1-3 m high in late summer
			Stem treatment. Spot gun or stem injection	<u>Stem Filling</u> Suitable for situations where the knotweed is growing in close proximity to valuable plants. Stems (>8mm) are cut and glyphosate in solution is placed in the top of cut stems. Treat before senescence from September through October. <u>Stem injection</u> Suitable for treating small stands, particularly by water, new invasions and to tidy up escapes from eradication control programmes. Glyphosate is injected directly into the stem (>8mm). Apply to flowering stems from late summer through October. Details of the method can be found here (accessed 24/3/2021)
			Foliar spray via vehicle mounted equipment.	Seedlings and shoots are susceptible but established plants will not be controlled.

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
Nettle, common (cont)	Amenity grassland, grassland	2,4-D + dicamba + fluroxypyr	Foliar spray via vehicle mounted or hand-held equipment	30cm high pre-flower or regrowth
	Grassland, Amenity grassland	Aminopyralid + fluroxypyr	Hand-held equipment (Synero only)	Actively growing up to 30cm high
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Treat when actively growing
	Grassland, Amenity grassland	Clopyralid + triclopyr	Foliar spray via vehicle mounted or hand-held equipment.	Spray when actively growing but preferably before flowering (normally up to mid-June)
Oaks *Quercus* spp.	See WOODY WEEDS			
Purple moor-grass *Molinia caerulea*	Green cover on land not being used for crop production, forest	Cycloxydim	Foliar spray via vehicle mounted or hand-held equipment.	Before first node detectable Do not apply to Forest between 1 July and 31 March and Green cover on land not being used for crop production between 1 September and 1 January
	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Weed wiper	Spring/summer, when grass actively growing. Grass with at least 4-5 new leaves & at least 10 cm tall.

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	adjacent to aquatic area, open waters,			
	Forest, farm forestry, hedgerow, amenity vegetation, amenity grassland	Propyzamide	Foliar spray via vehicle mounted or hand-held equipment.	Apply between 1st October and 31st December or 31st January, soil type restrictions also apply. Check label. Rain required after application, if soil is dry. Maximum of one application per year. Repeat application may be necessary in following winter for heavy couch infestations.
Ragwort, common *Senecio jacobea*	Amenity grassland, Grassland, Farm forestry (EAMU)	2,4-D	Foliar spray via vehicle mounted or hand-held equipment	Apply from cotyledon to before flower buds are formed. Ragwort is moderately susceptible. Only aerial growth is controlled, and repeat applications will be necessary in future years. Control is improved by mixing with MCPA
	Amenity grassland, grassland	2,4-D + dicamba	Foliar spray via vehicle mounted or hand-held equipment	Spray when the majority of plants are in the rosette stage and growing vigorously in the autumn or spring but before the flower spines start to grow. Treat over 2 years for complete control.

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
Ragwort, common (cont)	Grassland	2,4-D + MCPA	Foliar spray via vehicle mounted equipment.	Good control if timed correctly. Treat in the autumn followed by a sequential application in the spring at rosette stage, before flower spikes start to grow
	Grassland, Amenity grassland	Aminopyralid + fluroxypyr	hand-held equipment (Synero only)	Actively growing in the rosette stage up to 20cm high
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Treat when actively growing in rosette stage or up to 20 cm high
	Amenity grassland, grassland, green cover on land not being used for crop production	Citronella oil	Spot spray	Rosette stage, repeat after 28 days if necessary.
	Grassland	MCPA	Foliar spray via vehicle mounted equipment.	Do not apply before the end of February in the year of harvest. Spray in spring when at rosette stage before flower spike starts to extend.
Ragwort, marsh *Senecio aquaticus*	Amenity grassland, Grassland, Farm forestry (EAMU)	2,4-D	Foliar spray via vehicle mounted or hand-held equipment	Apply at the rosette stage
	Grassland	MCPA	Foliar spray via vehicle mounted equipment.	Apply at the rosette stage
Rhododendron *Rhododendron ponticum*	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Stump and chemical thinning	An overall spray applied to the foliage will provide effective control of young bushes up to 1.3m high or as re-growth 2-3 years after cutting back. The

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	for crop production, land immediately adjacent to aquatic area, open waters,			best time for application is from early May to late September
Rosebay willowherb	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Treat when Willowherb is actively growing and less than 15cm high
	Grassland, amenity grassland	Fluroxypyr + triclopyr	Foliar spray via vehicle mounted equipment.	Treat when actively growing
Roses *Rosa* spp.	See WOODY WEEDS			
Rushes *Juncus* spp.	Amenity grassland, Grassland, Farm forestry (EAMU)	2,4-D	Foliar spray via vehicle mounted or hand-held equipment	April to June when actively growing. Treat before flowering and cut 4 weeks after (or before) treatment to improve control. Top growth killed and weeds suppressed, repeat treatment will be necessary. Control is improved in mixture with MCPA
	Grassland	2,4-D + MCPA	Foliar spray via vehicle mounted equipment.	Treat in April-June. Stems should be cut and removed either 4 weeks before or after treatment. Top growth killed and weeds suppressed, repeat treatment will be necessary.
	Amenity vegetation, amenity grassland, enclosed waters, farm	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment.	Apply when actively growing from May to early June.

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,		Weed wiper	Contact EA before use in or near water.
Sedges	Forest, farm forestry, hedgerow, amenity vegetation, amenity grassland	Propyzamide	Foliar spray via vehicle mounted or hand-held equipment.	Apply between 1st October and 31st December or 31st January, soil type restrictions also apply. Check label. Rain required after application, if soil is dry. Maximum of one application per year. Repeat application may be necessary in following winter for heavy couch infestations.
Sow thistles *Sonchus* spp.	Amenity grassland, Grassland, Farm forestry (EAMU)	2,4-D	Foliar spray via vehicle mounted or hand-held equipment	Moderately susceptible to applications made from cotyledon to 2 leaf stage.
	Grassland, farm forestry (EAMU)	Clopyralid	Foliar spray via vehicle mounted or hand-held equipment	Do not apply between 31st August and 1st March, when weeds actively growing, maximum size 15-30 cm
Spruce, Sitka *Picea sitchensis*	See WOODY WEEDS			
Sycamore *Acer pseudoplatanus*	See WOODY WEEDS			

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
Thistles *Cirsium* and *Carduus* spp.	Amenity grassland, Grassland, Farm forestry (EAMU)	2,4-D	Foliar spray via vehicle mounted or hand-held equipment	Apply from cotyledon to early flower bud stage. Only aerial growth is controlled, and repeat applications will be necessary in future years.
	Amenity grassland, grassland	2,4-D + dicamba	Foliar spray via vehicle mounted or hand-held equipment	Apply when the seedlings/young plants are up to 50cm high or regrowth post cutting. Only aerial growth is controlled, and repeat applications will be necessary in future years.
	Grassland, Amenity grassland	Aminopyralid + fluroxypyr	hand-held equipment (Synero only)	Actively growing in the rosette stage up to 25cm high
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Treat when actively growing and less than 70cm high
	Grassland, Farm forestry (EAMU)	Clopyralid	Foliar spray via vehicle mounted or hand-held equipment	Do not apply before 1st March in year of harvest. Apply to young, actively growing seedlings. Treat at rosette stage, when 15-30 cm across. Repeat 3-4 weeks later.
	Grassland, Amenity grassland	clopyralid + florasulam + fluroxypyr	Foliar spray via vehicle mounted or hand-held equipment.	Apply at rosette stage to actively growing weeds Only apply from 1st February to 30th September
	Grassland, Amenity grassland	Clopyralid + triclopyr	Foliar spray via vehicle mounted or hand-held equipment.	Spray when actively growing from the rosette stage up to 20cm tall or wide but before

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
				flowering. Increase rate for larger plants.
	Amenity grassland	Dicamba + mecoprop-P	Foliar spray via vehicle mounted or hand-held equipment	Apply at early flowering, shoots will be killed but repeat treatments will be necessary
	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Weed wiper	The optimum time for treatment is from buds are visible to before seed set or senescence, late June to early September. Spraying during flowering will prevent seed set. Topping in April/May can even up thistles for weed wiping in August. 95% control can be achieved in 1 year.
Traveller's-joy (Old man's beard) *Clematis vitalba*	Grassland, Farm forestry (EAMU)	Clopyralid	Foliar spray via vehicle mounted or hand-held equipment	Spray when actively growing between Spring and autumn
	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	When actively growing
	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment.	Cut stems and apply glyphosate to cut ends

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	adjacent to aquatic area, open waters,			
Tor-grass *Brachypodium pinnatum*	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,	Glyphosate	Foliar spray via vehicle mounted or hand-held equipment. Weed wiper	Apply when actively growing, repeat applications may be necessary in dense stands
Willows *Salix* spp.	See woody weeds			
Woody weeds				
Stumps	amenity vegetation (stump), enclosed waters (stump), forest (stump), land immediately adjacent to aquatic areas (stump), open waters (stump)	Glyphosate	Ecoplugs, drill hole and hammer in	Any time of year up to 2 days after felling
Stumps	Forest (stump)	Glyphosate	Knapsack sprayer, spot gun or paint brush.	Between November and April when trees are dormant, apply at the time of cutting with a suitably adapted clearance saw such as the Enso attachment to rotary

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
				saws, apply as soon as possible after cutting using a
Stumps	unwanted vegetation, unwanted vegetation (stump)	Triclopyr	Paint or knapsack sprayer	Autumn and winter
Chemical thinning	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,	glyphosate	Glyphosate is introduced straight into the phloem through a hatchet cut into the bark of the standing trunk or stump. The cut can be made using a small axe - make a second cut under the first to catch any surplus herbicide. Make cuts every 10cm. Alternatively, a small hole can be drilled at an angle downwards towards the centre of the trunk. Use a spot gun with a solid stream nozzle.	Late summer
Woody weeds	Grassland, Amenity grassland	Aminopyralid + triclopyr	Foliar spray via vehicle mounted and hand-held equipment (Icade).	Bramble, spot spray up to 1m high
	Grassland, Amenity grassland	Clopyralid + triclopyr	Foliar spray via vehicle mounted or hand-held equipment.	Apply to actively growing weeds. Spray broom, gorse, hawthorn between June and August before plants senesce. Wet all foliage of large bushes

Target spp.	Relevant situation(s)	Herbicide(s)	Application method(s)	Timing(s)
	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters	Glyphosate	Seedlings/young saplings controlled using weed-wiper or with hand-held sprayer (spot-treatment). Some products suitable for CDA sprayers.	Late spring/summer (leaves expanded, not senescent), trees actively growing. Tolerant conifers are not tolerant at this time of year.

Table 6 lists herbicides and mixtures, which have relevant current approvals. Table 6 also includes notes on the target plants/plant groups for which it is recommended, the relevant approved uses and, where relevant, the stock withholding period (i.e. the minimum period for which livestock must be removed after herbicide treatment). Also, areas of water/aquatic situations/weeds in or near water.

Table 6. Key herbicides for use in nature conservation sites·

Herbicide	Plants Controlled	Relevant approved uses	Stock with-holding period
2,4-D	Annual dicots., Perennial dicots	Grassland, farm forestry, amenity grassland	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
2,4-D + dicamba	Annual and perennial weeds Thistle, buttercup, ragwort, docks	Grassland, amenity grassland	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
2,4-D + dicamba + fluroxypyr	Annual dicots, Buttercups, Clover, Daisies, Dandelions, Yarrow	Grassland, amenity grassland	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
2,4-D + florasulam	Clover, Daisies, Dandelions, Plantains, Sticky mouse-ear	Amenity grassland	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
2,4-D + glyphosate	Annual meadow grass, Groundsel, Black bindweed, Knotgrass, Field bindweed, Mayweed spp, Broad-leaved dock Black medick, Cleavers, Ryegrass, Common couch, Shepherd's purse, Dandelion Speedwell spp, Red deadnettle, Creeping thistle, Fat hen,	Amenity grassland, amenity vegetation, green cover on land not being used for crop production	Livestock should be kept out of treated areas. Where ragwort is present users should consult the 'Code of Practice on How to Prevent the Spread of Ragwort'. Ragwort plants sprayed with this herbicide are more palatable and contain higher levels of toxins. Animals should be excluded from treated areas until any ragwort has completely recovered or died

Herbicide	Plants Controlled	Relevant approved uses	Stock with-holding period
	Volunteer cereals, Field forget-me-not, Volunteer oilseed rape		and there is no visible sign of the dead weed.
2,4-D + MCPA	Annual dicots, Perennial dicots.	Grassland	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
amidosulfuron	Cleavers, charlock, shepherd's purse, field forget-me-not, Docks. Safe to white clover.	Grassland, farm forestry (EAMU)	Dangerous to livestock. Keep livestock out of treated areas/away from treated water for at least 1 week and until foliage of any poisonous weeds, such as ragwort, has died and become unpalatable
aminopyralid + fluroxypyr	Buttercups, Chickweed, Dandelions, Docks, Stinging nettle, Thistles	Grassland, Amenity grassland	Keep livestock out of treated areas for up to two weeks following treatment and until poisonous weeds, such as ragwort, have died down and become unpalatable. Do not use on grassland that will be grazed by animals other than cattle or sheep. Do not use on land where the vegetation will be cut for animal feed, fodder or bedding not for composting or mulching within 1 year of treatment
aminopyralid + triclopyr	Annual dicotyledons, Brambles, Broom, Buddleia, Common mug wort, Common nettle, Creeping thistle, Gorse, Hogweed, Japanese knotweed, Perennial dicotyledons, Rosebay willowherb	Grassland, Amenity grassland	Keep livestock out of treated areas for up to two weeks following treatment and until poisonous weeds, such as ragwort, have died down and become unpalatable. Do not use on grassland that will be grazed by animals other than cattle or sheep
Carfentrazone-ethyl + mecoprop-P	Susceptible: White clover, Bristly ox tongue, Buck's horn plantain,	Amenity grassland	Keep livestock out of treated areas for up to two weeks following treatment and until

Herbicide	Plants Controlled	Relevant approved uses	Stock with-holding period
	Greater plantain, Cinquefoil spp. Moderately susceptible: Creeping buttercup, Daisy, Speedwell spp, Birds foot trefoil, Moss.		poisonous weeds, such as ragwort, have died down and become unpalatable
Citronella oil	Ragwort	Amenity grassland, grassland, green cover on land not being used for crop production	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
clopyralid	Annual dicots., Clovers, Corn marigold, Creeping thistle, Groundsel, Mayweeds, Sow thistle, Thistles	Grassland, farm forestry (EAMU)	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
clopyralid + florasulam + fluroxypyr	Annual dicots, Black medick, Bristly oxtongue, Buttercups, Common mouse-ear, Daisies, Dandelions, Plantains, Self-heal, Slender speedwell, Chickweed, Cleavers, Creeping thistle, Mayweeds	Grassland, amenity grassland	Stock grazing can resume 7 days after application. This may need to be longer if foliage of poisonous weeds is present.
clopyralid + triclopyr	Brambles, Broom, Docks, Gorse, Perennial dicotyledons, Stinging nettle, Thistles	Grassland, amenity grassland	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
cycloxydim	Annual grasses, Black bent, Black-grass, Couch, Creeping bent, green cover, Onion couch,	Green cover on land not being used for crop	none

Herbicide	Plants Controlled	Relevant approved uses	Stock with-holding period
	Perennial grasses, Volunteer cereals, Wild oats	production, forest	
dicamba + MCPA + mecoprop-P	Annual dicots. Docks, Perennial dicots.	Grassland, amenity grassland	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
dicamba + mecoprop-P	Annual dicots., Chickweed, Cleavers, Mayweeds, Perennial dicots., Polygonum	Amenity grassland	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
flazasulfuron	**NO CONTROL OF** fat hen, horsetail, black nightshade, common field speedwell, smooth hawksbeard, common sow thistle, ribwort plantain, narrow-leaved ragwort, annual meadow grass	Amenity vegetation (around)	No information
florasulam	Annual dicots., Chickweed, Cleavers, Mayweeds, Volunteer oilseed rape	Farm forestry (EAMU)	none
florasulam + fluroxypyr	Annual and perennial weeds, Buttercups, Clover, Daisies, Dandelions, Plantains	Grassland, amenity grassland	none
fluazifop-P-butyl	Annual grasses, Black-grass, green cover, Perennial grasses, Volunteer cereals, Wild oats	Farm forestry, green cover on land not being used for crop production	Treated vegetation in field margins, land temporarily removed from production etc., must not be grazed or harvested for human or animal consumption and unprotected persons must be kept out of treated areas for at least 24 h
Flumioxazine	Annual meadow grass, Loose silky bent, Chickweed, Cleavers, Common field speedwell, Dove's-	Farm forestry (EAMU)	This approval applies only to farm forestry/coppices grown on land previously

Herbicide	Plants Controlled	Relevant approved uses	Stock with-holding period
	foot Cranesbill, Ivy leaved speedwell, Red deadnettle, Mayweed, Shepherds purse, Field pansy, Volunteer oilseed rape		under arable cultivation, improved grassland or reclaimed brownfield sites.
fluroxypyr	Annual dicots., Black bindweed, Chickweed, Cleavers, Docks, Forget-me-not, Hemp-nettle, Volunteer potatoes	Grassland, farm forestry (EAMU)	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
fluroxypyr + triclopyr	Chickweed, Docks	Grassland, amenity grassland	14 days and until poisonous weeds, such as ragwort, have died down and become unpalatable
glyphosate	Annual and perennial weeds	Amenity vegetation, amenity grassland, enclosed waters, farm forestry, forest, grassland, green cover on land not being used for crop production, land immediately adjacent to aquatic area, open waters,	Some products require livestock to be excluded from treated areas and do not permit treated forage to be used for hay, silage or bedding. Check label for details

Herbicide	Plants Controlled	Relevant approved uses	Stock with-holding period
		Forest (stumps)	
glyphosate + pyraflufen-ethyl	Annual and perennial weeds	Amenity grassland, Amenity vegetation	
glyphosate + sulfosulfuron	Annual and perennial weeds	Amenity grassland, Amenity vegetation	Some products require livestock to be excluded from treated areas and do not permit treated forage to be used for hay, silage or bedding. Check label for details
Isoxaben	Annual dicots	Amenity vegetation, forest	Keep livestock out of treated areas for 50 days following treatment.
Lenacil	Black bindweed, Brassica spp, Polygonum	Farm woodland (EAMU)	Treated plants must not be used for animal consumption
maleic hydrazide	Annual grasses	Amenity grassland	Only apply to grass not to be used for grazing
maleic hydrazide + pelargonic acid	Algae, Annual and perennial weeds, Moss	Amenity vegetation	none
MCPA	Annual and perennial weeds, Annual dicots., Charlock, Fat hen, Hemp-nettle, Perennial dicots., Wild radish	Grassland, farm forestry (EAMU)	Do not roll, harrow or graze for a few days before or after spraying; check label
mecoprop-P	Annual dicots, Chickweed, Cleavers, Perennial dicots.	Amenity grassland, grassland	Keep livestock out of treated areas for at least 2 weeks and until foliage of any poisonous weeds, such as ragwort, has died and become unpalatable

Herbicide	Plants Controlled	Relevant approved uses	Stock with-holding period
metsulfuron-methyl	Docks	Green cover on land not being used for crop production	Keep livestock out of treated areas for up to two weeks following treatment and until poisonous weeds, such as ragwort, have died down and become unpalatable
Pelargonic acid	Common dandelion, Greater plantain, Annual meadow grass, Deadnettle, Common chickweed, Creeping thistle, Knotgrass, Mosses and algae. Scarlet pimpernel, Parsley piert, Willowherb, Cut leaved Cranesbill, Mayweeds, Common groundsel, Field speedwell, Fescues	Amenity vegetation, amenity grassland,	
Pelargonic acid + maleic hydrazide	Annual dicots., Annual grasses, Perennial grasses	Amenity vegetation, amenity grassland	Not currently available
Pendimethalin	Annual dicots., Annual grasses	Farm forestry (EAMU)	
Propaquizafop	Annual and perennial grasses	Forest (EAMU)	
propyzamide	Annual dicots., Annual grasses, Perennial grasses	Forest, farm forestry, hedgerow, amenity vegetation, amenity grassland	none

Herbicide	Plants Controlled	Relevant approved uses	Stock with-holding period
thifensulfuron-methyl	Docks, Green cover	Grassland, Green cover on land not being used for crop production	Keep livestock out of treated areas for at least 7 days after treatment
Tribenuron-methyl	Annual dicots	farm forestry (EAMU) Grassland (EAMU)	Only applies to farm forestry/coppices grown on land previously under arable cultivation, improved grassland or reclaimed brownfield sites. Grassland -Livestock must be kept out of treated areas for at least 21 days following treatment.
Triclopyr	stumps	unwanted vegetation, unwanted vegetation (stump)	stumps

Where EAMU is stated, this is specific to a product. Extensions of Authorisations for Minor Use conditions will not be given on the product label provided by pesticide manufacturers. It is essential that anyone who needs to use a pesticide product in accordance with an Extension of Authorisation must read the text of the Extension of Authorisation before commencing any spraying operation. Data sourced from The Plant Protection database (BCPC and NIAB, accessed 10/09/24) and HSE/CRD databases (accessed 10/09/24).

5. Herbicide Information summary sheets

5.1. Introduction

The sheets are focussed on the active ingredient rather than the formulated product (which may contain more than one active ingredient). Data are presented so as to inform and orientate the user with respect to the properties of the active ingredient. **The sheets do not replace the product labels, or the authorisation, which remains the final authoritative legal instrument for the provision of usage instructions**. The information in the summary sheets helps the user to arrive at an informed decision as to the likely risks to the environment of using the compound under the actual local use conditions. The data allow a qualitative, rather than quantitative, risk assessment, although all the compounds (and authorised products) have been assessed by HSE/CRD and deemed to be safe for the approved use.

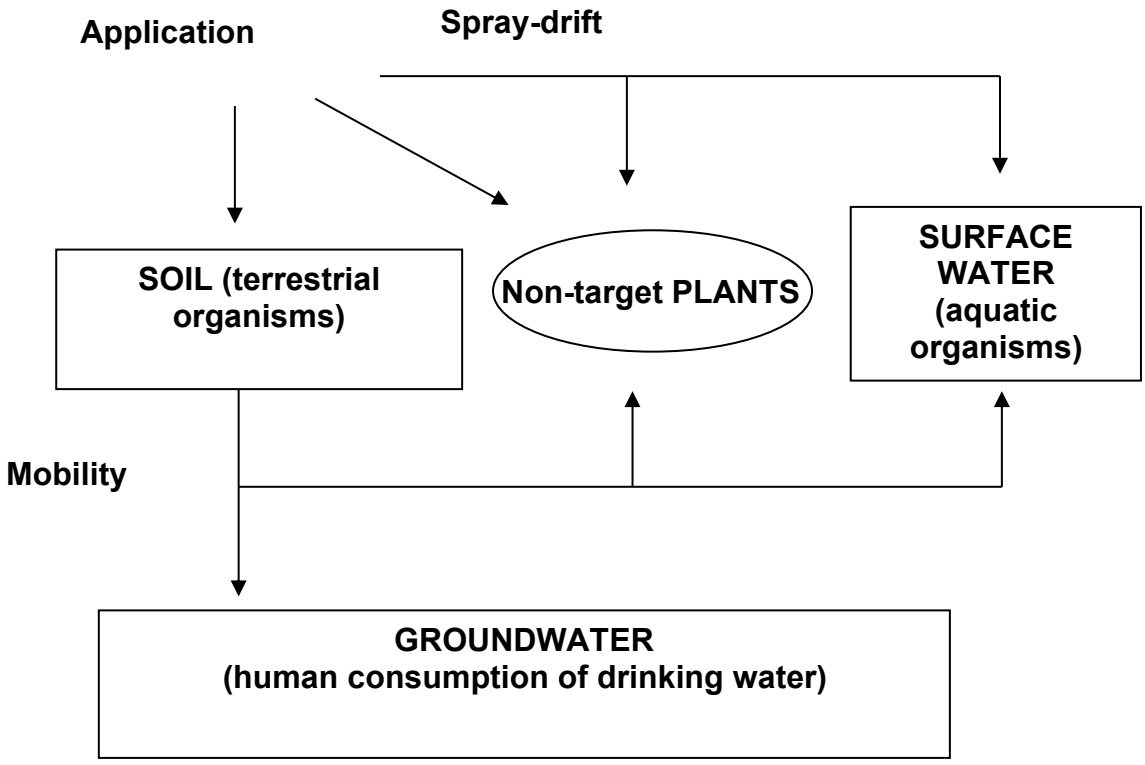
In this section, an attempt has been made to inform the user about the type of data included, as well as the limitations of those data. An outline of how the data could be used to aid in the risk assessment process is also given.

5.1.1. Non-target organisms at risk

Clearly, non-target species (plants, mammals, birds, invertebrates, etc.) within the targeted treatment area will be exposed, unless a very precise application method is employed (such as a weed-wiper). Non-target species outside of the target area (both terrestrial and aquatic, including plants) could be exposed through spray drift, or *via* the movement of residues in water either downward through the soil (leaching), or sideways over the soil surface (run-off). Plants could also be exposed *via* root uptake of a mobile compound moving through the soil water. Some compounds can exert effects after application *via* vapour drift. Downward movement of the compound through the soil could also contaminate groundwater or (via field drains) surface water. The pesticide regulatory process is designed to be protective of groundwater by ensuring the authorised conditions of use do not result in concentrations in such water bodies exceeding the drinking water standard (for water supplied at the tap of 0.1 µg/litre for individual pesticides and 0.5 µg/litre for total pesticides).

However, even authorised use of pesticide products in catchments may result in pesticides in surface waters exceeding the drinking water standard (treatment of raw waters brings the vast majority of supply into compliance). Additional care should be taken when applying pesticides in situations that facilitate the movement of pesticides to surface waters (sloping ground, rainfall close to application, under-drained soils, use of products with high soil mobility and persistence, etc.).

The following diagram summarises the non-target organisms at risk following application of a herbicide.



5.1.2. Sources and limitations of the data

Unfortunately, the data included cannot be regarded as exhaustive, for two reasons. Firstly, the PPP's will not have been tested under many of the local environmental conditions faced in the field. Secondly, data generated by authorisation holders is not available in its entirety. Only publicly available sources have been used to obtain data (and all sources are referenced). This means that the data cannot be regarded as definitive for any given local circumstance but can be used as indicative of the issues likely to be most pertinent for consideration. The main sources used for each section are summarised below.

5.1.3. Data sections included

- **Heading and Summary**

The name and chemical structure of the active substance is given, together with an example product name and formulation type. Many other equivalent products are often also available, and inclusion of a specific example should not be regarded as an endorsement. The summary seeks to encapsulate the key points, from an environmental point of view, but also includes information on the compound type and mode of transport into the plant.

- **Application Scenarios**

Authorised uses (as given by HSE) are summarised, including only those categories pertinent to use on conservation sites. Most of the active substances are also approved for use on agricultural crops. General application timings, application

methods and special warnings/instructions are also included (this information is derived from product labels/technical leaflets).

- **Fate in Soil, Fate in Water**

Where available, quantitative data are given for the various parameters that have a bearing on the fate of the herbicide in soil and water. The compound's water solubility is given and data relating to how fast it degrades (time required for 50% to dissipate: DT_{50}). The strength of binding of the compound to soil is also indicated, either through the K_d value (a measure of the partitioning of the compound between soil and water) or more normally *via* the K_{OC} value (the partitioning between soil and water normalised to the soil organic carbon content, which gives less variation between different soils). The log K_{OW} value is also given, which is an indication of how tightly the compound will associate with fat and hence a measure of its propensity to bioaccumulate. Data included in this section have been derived from various sources (e.g. EU Review documents, The Pesticide Manual (BCPC), HSE evaluation documents, product labels and various Internet sources).

- **Effects on terrestrial/aquatic fauna**

These two sections give information on the nature of the hazard for non-plant organisms of being exposed to the compound, either in the soil or in water. The data take the form of toxicity parameters, measured for various organisms. LD_{50} value is the dose of the herbicide found to be lethal to 50% of individuals; LC_{50} value is the concentration of the herbicide found to be lethal to 50% of individuals. EC_{50} value is the concentration of the herbicide found to have an adverse effect on 50% of individuals. The species tested are regarded as indicators for the organism type. Although broadly similar susceptibilities may be assumed for related organisms, susceptibility of even closely related species can sometimes vary by several orders of magnitude, so a degree of uncertainty should be assumed. Data included in this section has been derived from various sources (e.g. EU Review documents, *The Pesticide Manual* (BCPC), HSE evaluation documents, product labels, and various Internet sources).

- **Effects on non-target plants; Efficacy/safety**

These two sections cover the herbicidal activity of the compound. The product label and general environmental profile of the herbicide has been used to generate general advice regarding the threat to non-target plants posed by exposure to the herbicide. Specific data on weed susceptibility are presented in the form of tables.

Weed susceptibility data have been derived from product labels, research papers and a few Internet sources. It must be emphasised that these data have usually been generated in cropping situations very different to those encountered on nature conservation sites and it should not be assumed that a non-target species would be safe from danger because it is listed as 'resistant' in the tables. The tables should be used as an indication of likely susceptibilities, but experience and caution should inform the user's interpretation and use of the data. The absence of a species from the tables does not indicate safety. It should also be remembered that the summary sheets are active substance focussed and that a particular product may contain more than one active substance.

5.2. Using the herbicide information summary sheets

General

First, consider whether a herbicide is needed at all – investigate the underlying issues behind the weed problem and other non-herbicide options should be used where possible. (See section 2). Consider, too, whether the problem is likely to be dealt with by a single treatment, or may need several, or even ongoing, treatments. This should influence the strategy adopted for dealing with the problem.

Identify the weed problem. Think about the specific location in terms of non-target species (plants, invertebrates, birds, animals), nearby water, and soil type. What, in the location, especially needs protecting from undesirable effects of any herbicide treatment? What are the risks if the weed is NOT controlled? Seek advice from specialists over the control option that has been considered and its risks, if there is any doubt. **Always consult someone holding the BASIS Certificate in Crop Protection IPM – and preferably who is also a Member of the BASIS Professional Register – on the final choice of herbicide.**

The weed susceptibility tables in the summary sheets can provide an indication of appropriate actives. However, any candidate herbicide must be authorised for use in the target circumstances and any product label restrictions must be adhered to.

Application method

The method of application will have a significant effect on the exposure of non-target species to the herbicide. The application should be as targeted as possible, and it is worth remembering that contamination by spray drift is likely to be the largest source of non-target exposure in most cases. Consider if the application methods available and the weed susceptibility data, suggest that an acceptable treatment can be carried out. Some of the herbicides can move considerable distances in soil water and exert adverse effects following uptake by plant roots. The herbicide summary sheets indicate where this is a concern, based on the physical properties of the compound and its mode of transport into the plant.

Non-target plants

Within the target area, consider the non-target plants and review the candidate substances for activity against these (remembering that the tables are not exhaustive). Where there are especially rare or important non-target species within the target area reconsider the option of not using chemical control unless experience or specific advice clearly indicates that a candidate herbicide will not have adverse effects. Review non-target plants **close** to the target area in the same way.

Non-target soil organisms

Assess the presence of particularly rare/important soil organisms within the target area and very close by. There is little information available with respect to adverse effects on soil organisms for the herbicides but consider what is available.

Non-target aquatic organisms

Where the target area is water (for the control of aquatic weeds), ensure that the product label instructions are **very** carefully followed. For terrestrial applications, ensure that the intended herbicide application will not result in any over-spray of neighbouring watercourses.

Water bodies can also become contaminated *via* spray drift. Avoid this by appropriate choice of application method/equipment and appropriate consideration of local weather conditions at the proposed time of treatment.

Movement of herbicide away from the target area into surface waters can occur by run-off and also following downward flow through the soil coupled with lateral water flow. Assess this risk by consideration of both the properties of the compound and the local soil/topography. For example, compacted soils and heavier-textured, more clayey soils on slopes may be prone to run-off events. Also, similar-textured soils often show preferential flow, in which drainage water, possibly carrying pesticides, moves rapidly down the soil profile in cracks and fissures following a rainfall event and may reach field drains within a few hours of pesticide application. Similarly, sandy soils with underlying impermeable soil layers may be prone to downward leaching followed by lateral movement of water.

Some herbicides have very high K_{OC} (or K_d) values, which would imply less of a risk of mobility *via* water flow. However, these can move with water-borne soil particles or suspended sediment. Others may have very fast degradation rates in soil (i.e. short soil DT_{50} values), again indicative of less of a risk of movement away from the target area, but rapid drainage through the soil profile and flash surface run-off events can still carry these to water.

Relatively persistent herbicides (either in the soil or in water) represent an increased risk of water contamination. When this is coupled with a higher risk of bioaccumulation (higher log K_{OW} value), then the possibility of long-term effects on wildlife should be considered (and avoided).

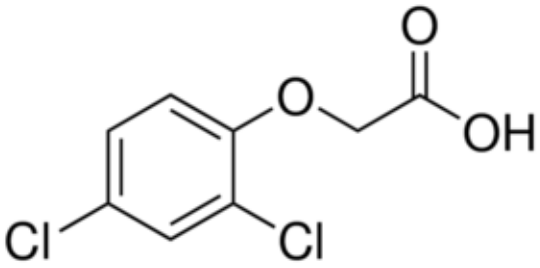
Groundwater

As indicated above, the protection of groundwater from contamination by herbicides has a special status in the UK and the EU. Generally, downward movement of herbicides is to be avoided. This leaching depends upon the soil type and the properties of the compound (soil DT_{50}, K_{OC}), but approval of the herbicide by HSE indicates that HSE do not consider contamination of groundwater to be a significant risk under normal circumstances. Nevertheless, where the treatment site is considered to be particularly vulnerable to downward movement of pesticides, for example because the soil is light or sandy or there is groundwater at a shallow depth, then specific consideration is required of the risk of using the candidate herbicide, as indicated in the summary sheets.

2,4-D

(e.g. **Depitox,** soluble concentrate)

HRAC group 4



2,4-D is a selective, post-emergent, systemic, phenoxyacetic acid herbicide, available as a straight product or in mixtures. In products it can be present as the acid, as a salt, ester or amine. Salts are readily absorbed by the roots, whereas esters are readily absorbed by foliage, followed by translocation. The solubility and aquatic toxicity of the active ingredient in the product can vary significantly, depending on the form of 2,4-D present. 2,4-D degrades rapidly in most matrices. When applying certain forms of 2,4-D, care should be exercised to minimise effects in non-target aquatic areas.

Application Scenarios

2,4-D is used for the control of annual and perennial broadleaved weeds, in amenity grassland, amenity vegetation and grassland[1]. Weeds should be actively growing at application. Annual weeds are most susceptible at the seedling stage and established perennial weeds up to the early flower bud stage[2]. Application is as a foliar spray, using tractor-mounted spraying equipment or hand-held sprayer.

Fate in Soil

2,4-D is known to degrade rapidly in soil with a DT_{50} value of 28.8 days in the field. When present as an acid-derivative, the active form is rapidly degraded to the acid in soil. 2,4-D is very soluble in water (24 g/l at pH7 buffered)[1]. Strength of soil binding is low (mean K_{OC} value of 39.3)[1]. Although 2,4-D is regarded as potentially mobile, its fast degradation and application timing reduces the likelihood of contamination of groundwater.

Fate in Water

2,4-D is degraded in natural water/sediment systems, via biotic processes (DT_{50} value of 18.2 days)[1]. 2,4-D has a low BCF[1] (10) indicating a low bioaccumulation potential.

Effects on Terrestrial Fauna

Generally, 2,4-D is regarded as moderately toxic, with an acute oral LD_{50} in the rat of >300 mg/kg bw[1], dermal LD_{50} in the rat of >2000 mg/kg[1] and acute inhalation LC_{50} in the rat of >1.79 mg/l[1]. It is classified as a neurotoxicant, respiratory tract irritant, and a severe eye irritant[1]. 2,4-D is moderately toxic to birds (oral LD_{50} for *Colinus virginianus* >500 mg/kg)[1] and is of moderate toxicity to bees (oral LD_{50} 94 □g/bee)[1]. 2,4-D is of moderate toxicity to earthworms (LD_{50} 350 mg/kg)[1].

Effects on Aquatic Fauna

2,4-D has been found to be of moderate toxicity to aquatic fauna, with fish LC_{50} values of 100 mg/l[3], and low toxicity to *Daphnia* 21-day NOEC of 46.2 mg/l[3].

Effects on Non-Target Plants

Application of 2,4-D will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to minimise such drift. Likewise, drift into natural watercourses close to the application area could also result in damage to non-target aquatic plants. 2,4-D has been found to be of moderate toxicity to aquatic plants (EC_{50} of 2.7 mg/l)[3].

Efficacy/safety[3,6]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. *ALWAYS READ THE PRODUCT LABEL*.

Susceptible:

Daisy family (Asteraceae): Argentine fleabane, Canadian fleabane, cocklebur, dandelion (seedling stage), groundsel, prickly lettuce, smooth sow-thistle, sunflower, yellow star-thistle.

Cabbage family (Brassicaceae): Cabbage/rape, London-rocket, shepherd's purse, wild radish.

Other dicotyledons: Annual morning glory, black nightshade, thornapples, common poppy, common purslane, corn buttercup, fat-hen, hairy nightshade, Japanese-lantern, nettle-leaved goosefoot, purslane, small nettle, stork's-bills, summer-cypress, velvetleaf.

Moderately susceptible:

Daisy family (Asteraceae): Autumn hawkbit, creeping thistle, cudweed, dandelion, pineapple weed, prickly sow-thistle.

Cabbage family (Brassicaceae): Swinecress.

Other dicotyledons: Amaranths, black bindweed, black nightshade, common fumitory, common orache, common nettle, creeping buttercup, field bindweed, fiddleneck, field forget-me-not, henbit deadnettle, knotgrasses, knotweeds, mallows, medicks, melilots, pale persicaria, plantains, procumbent yellow-sorrel, redshank, ribwort plantain, scarlet pimpernel, shepherd's needle.

Moderately resistant:

Daisy family (Asteraceae): Common knapweed, colt's-foot, corn chamomile, creeping thistle, daisy, dandelion, dwarf thistle, perennial sow-thistle, scentless mayweed, spear thistle, yarrow.

Other dicotyledons: Bulbous buttercup, common chickweed, common nettle, common sorrel, corn spurrey, docks, meadow buttercup, meadow sorrel, meadowsweet, self-heal, sheep's sorrel.

Resistant:

Pteridophytes: Horsetails.

Grasses: Annual meadowgrass, autumn millet, Bermuda-grass, beetle-grass sp., drooping brome, canary-grass, cockspur, fingergrasses, Italian ryegrass, Johnson-grass, rescue brome, ripgut brome, sandburs, stink-grass, volunteer cereals, wild oat, yard-grass, yellow bristlegrass.

Other monocotyledons: Galingales.

Cabbage family (Brassicaceae): Dittander, swine-cresses.

Other dicotyledons: Dodder, swinecress.

Livestock withholding period

Normally – at least 14 days and until foliage of poisonous weeds such as ragwort has died and become unpalatable[2]. Check the label.

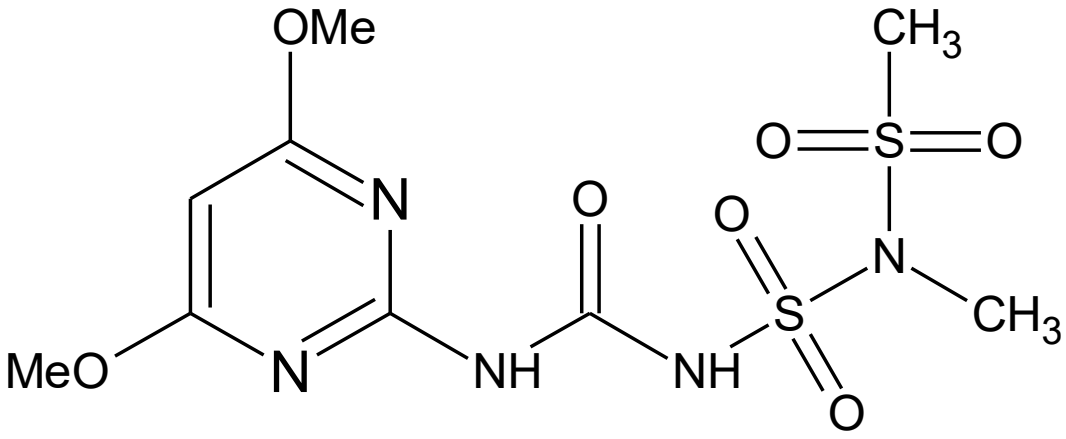
References

(1) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm). Accessed 13/09/2024
(2) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(3) Nufarm. Depitox product label Accessed 13/09/2024
(4) Conclusion on the peer review of the pesticide risk assessment of the active substance 2,4-D EFSA journal volume 12 Issue 9
(5) *The e-Pesticide Manual*, 14th Edition (2008).
(6) Weed Susceptibility Chart, University of California, Co-operative Extension program, D Cudney (2000).

AMIDOSULFURON

(e.g. **Squire Ultra,** water dispersible granule)

HRAC group 2



Summary

Amidosulfuron is a selective, post-emergent, systemic herbicide, absorbed by the leaves and roots and translocated throughout the plant. Amidosulfuron degrades rapidly in soil and has a low toxicity to terrestrial fauna but can be toxic to non-target plants. Amidosulfuron and its metabolites are mobile and may leach to surface waters where they can be toxic to aquatic invertebrates and plants. Therefore, extra-care should be exercised when applying close to natural waterbodies.

Application scenarios

Amidosulfuron is registered for the control of docks and some annual broad-leaved weeds in permanent grassland, winter and spring cereals[1,2]. Amidosulfuron must be applied only between February and June on rotational grass, and between February and 15 October on permanent grassland[2]. On cereals Amidosulfuron can be applied from February until the crop reaches GS51. Hay or silage must not be cut from treated crops for at least 21 days after treatment. Amidosulfuron is a slow-acting chemical; activity is further slowed under dry and cold conditions[2]. Application can be by tractor-mounted equipment.

Fate in Soil

Amidosulfuron is regarded as non-persistent in soil, where it degrades through microbial action in aerobic soil systems ($DT_{50\ lab}$ values ranging from 3 to 27 days[3]). However, some metabolites have a moderate to high persistency in soil. Amidosulfuron is fairly water soluble (5.6 g/l at 20°C) and is mobile (K_{oc} ranging from 3.4 to 84.7)[3]. The metabolites generally display a similar range of mobility in soil.

Fate in Water

Amidosulfuron is stable to photolysis. It is essentially stable to hydrolysis, except under acidic conditions (DT_{50} of 34 days at pH5). Amidosulfuron degrades moderately fast in water-sediment system, with $DT_{50\ whole\ system}$ values of 50.1 and 56.9 days. Its log K_{OW} is less than 3, which indicates a low potential for bioaccumulation in aquatic species (e.g. fish).

Effects on Terrestrial Fauna

Amidosulfuron is regarded as of low toxicity to mammals, with an acute oral LD_{50} in the rat of > 5000 mg/kg bw, a dermal LD_{50} in the rat of > 5000 mg/kg bw and an inhalation LC_{50} in the rat of >1.8 mg/l[3]. It is not irritating nor sensitizing to the skin and only slightly irritating to the eye[3]. The risk to birds is considered low (acute oral LD_{50} of > 2000 mg/kg bw)[4] and amidosulfuron is non-toxic to bees (LD_{50} of > 100 µg/bee)[3]. There are no adverse effects reported for worms (LC_{50} of > 1000 mg a.s./kg dw soil)[3] nor for soil microbial processes. An LD_{50} of 60g/ha for arthropods (*Aphidius* rhopalosiphi) was reported[3].

Effects on Aquatic Fauna

Amidosulfuron has been found to be of low toxicity to fish (LC_{50} of > 100 mg a.s./l)[3] and of moderate toxicity to *Daphnia magna* (EC_{50} of 36 mg a.s./l)[3]. A main metabolite has been found to be more toxic to *Daphnia*, with an EC_{50} of 3.6 mg a.s./l[3]. Amidosulfuron is of low toxicity to algae, with an EC_{50} of 47 mg a.s./l for *Scenedesmus subspicatus*, when in formulation[3]. Given its potential for mobility in soil, care should be exercised when applying near to water courses.

Effects on Non-Target Plants

Application of amidosulfuron will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to avoid such non-target plants. Likewise, drift into natural watercourses close to the application area could also result in damage to non-target aquatic plants (EC_{50} for *Lemna gibba* 0.0092 mg a.s./l[3]).

Efficacy/safety[2,5]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. *ALWAYS READ THE PRODUCT LABEL*.

Susceptible:
Other dicotyledons: Charlock, Cleavers, docks (all species), Field forget-me-not
Cabbage family (Brassicaceae): Oilseed rape, Shepherd's-purse, Wild radish
Moderately susceptible: **Daisy family (Asteraceae):** Scentless mayweed, Pineapple weed, **Cabbage family (Brassicaceae):** Shepherd's-needle,
Other dicotyledons: Black bindweed, Field bindweed, Cut-leaved crane's-bill, Corn marigold, Pale persicaria, Common poppy, Redshank, Corn spurrey

Livestock withholding period

Normally – at least 7 days and until foliage of poisonous weeds such as ragwort has died and become unpalatable. Check the label.

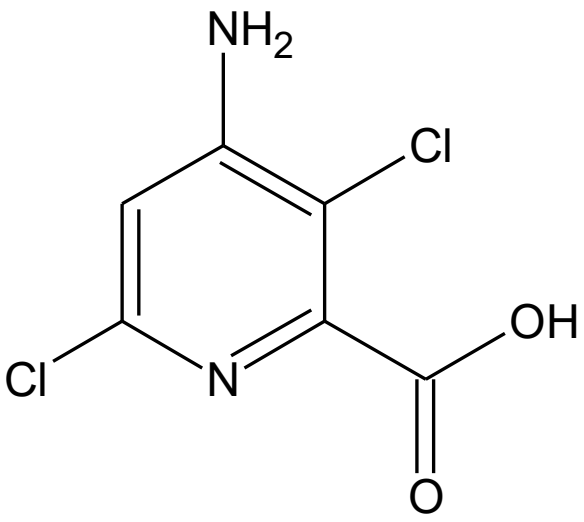
References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) Interfarm UK Ltd., ***Squire Ultra*** product label.
(3) Conclusion regarding the peer review of the pesticide risk assessment of the active substance amidosulfuron (2008) EFSA Journal Volume 6, Issue 1
(4) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) Accessed 13/09/2024
(5)Interfarm UK Ltd., ***Eagle*** product label.

AMINOPYRALID

(e.g. **Forefront T,** water in oil emulsion in combination with triclopyr)

HRAC group 4



SUMMARY

Aminopyralid is a selective, foliar herbicide, which is rapidly absorbed by leaves and roots. It causes epinasty, followed by necrosis. Aminopyralid is used in combination with fluroxypyr or triclopyr for the control of broad-leaved weeds. Aminopyralid is generally considered as being non-persistent in soil, however, it is water soluble and weakly bound to soil. Therefore, the substance may leach to nearby watercourses and to groundwater. Aminopyralid is of low toxicity to aquatic organisms and the terrestrial fauna. Aminopyralid may affect non-target plants, and therefore, every effort should be made to avoid exposure *via* drift and run-off.

Application scenarios

Aminopyralid is used for the control of annual and perennial broad-leaved weeds in grassland intended for grazing by sheep and cattle only[1,2,3]. Treated plants should not be used for composting or mulching. Drift onto susceptible crops and non-target plants should be avoided[2,3]. In mixture with fluroxypyr and triclopyr, optimum control is achieved when weeds are actively growing and before flowering[2,3]. Rain shortly after application may reduce activity. To protect groundwater, the product should not be applied to grass leys less than 1-year old[2,3] to comply with LERAP B. Application can be by tractor-mounted sprayer or hand-operated knapsack.

Fate in Soil

The degradation of aminopyralid in soil under laboratory conditions is slow with DT_{50} lab values from 26.4 to 146.9 days at 20°C[4]. Aminopyralid has been observed to degrade faster under field conditions, with a mean half-life of 12.1 days[4]. Aminopyralid is very soluble in water (2.48 g/l at pH7) and very mobile in soil, with a K_{oc} of 8.3[4]. Therefore, contamination of groundwater and watercourses is possible as aminopyralid has a high (>2.8) calculated leaching potential of 4.08.

Fate in Water

Aminopyralid is hydrolytically stable but is very susceptible to direct photo transformation in water (DT_{50} of 0.6 days in summer). However, aminopyralid can be persistent in water in absence of light, with a DT_{50} in water-sediment systems of 250 to 712 days[4]. Aminopyralid has a low log K_{OW} value (-2.87 at pH7[4]) which indicates a low potential for bioaccumulation.

Effects on Terrestrial Fauna

Aminopyralid is of low toxicity to mammals, with an acute oral LD_{50} and dermal LD_{50} of > 5000 mg/kg bw in the rat[4]. The inhalation LC_{50} was > 5.5 mg/l in the rat[4]. It is not a skin irritant but is an eye irritant. Aminopyralid is also of low toxicity to birds (acute LD_{50} of > 2250 mg/kg bw)[4]. The risk to bees is low (acute oral LD_{50} of > 3.13 µg/bee)[4]. Aminopyralid is non-toxic to earthworms (LC_{50} > 1000 mg/kg dry soil) and causes no significant impacts on non-target arthropods[4].

Effects on Aquatic Fauna

Aminopyralid has low toxicity to fish (LC_{50} *Oncorhynchus mykiss* >100 mg/l) and to *daphnia* (EC_{50} *Daphnia magna* of >100 mg/l)[4]. The toxicity to algae is low (EC_{50} of 30 mg/l for *Pseudokirchneriella subcapitata*[5]). However, the formulated product can be more toxic than the active substance alone. A formulation of 30 g/l of aminopyralid and 100 g/l of fluroxypyr presented moderate toxicity to fish and *daphnia* (LC_{50} *O. mykiss* of 6.42 mg/l, EC_{50} *D. magna* of 28.7 mg/l)[4].

Effects on Non-Target Plants

Clover is sensitive to aminopyralid. Application of aminopyralid will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to avoid such non-target plants. Likewise, drift into natural watercourses close to the application area could also result in damage to non-target aquatic plants (*Lemna gibba,* LC_{50} of > 88 mg/l[4]).

Efficacy/safety[2,3,6]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. *ALWAYS READ THE PRODUCT LABEL*.

Susceptible:
Other dicotyledons: Broad-leaved dock, bulbous buttercup, curled dock, common nettle, creeping buttercup, dandelion, prickly lettuce, henbit dead nettle
Daisy family (Asteraceae): creeping thistle, ragwort, spear thistle, musk thistle, ox-eye daisy, scentless mayweed
With fluroxypyr
As above plus, creeping buttercup, dandelion, mug wort, Japanese knotweed, bramble

Livestock withholding period

Normally – at least 7 days and until foliage of poisonous weeds such as ragwort has died and become unpalatable. Check the label.

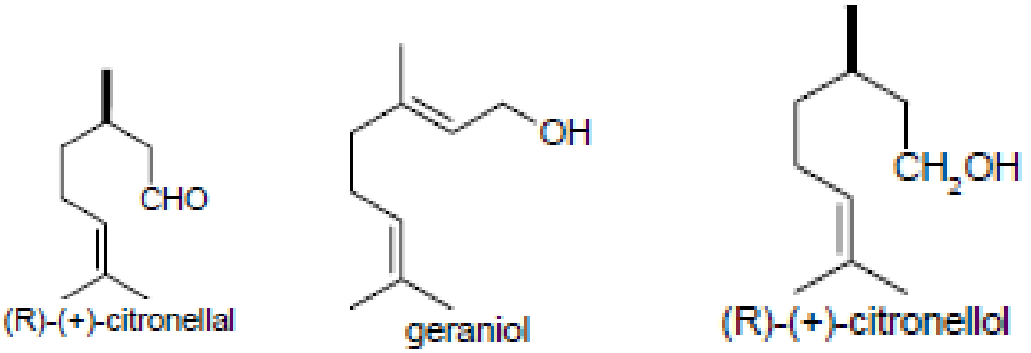
References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) Dow AgroSciences UK Ltd., ***Forefront*** product label.
(3) Dow AgroSciences UK Ltd., ***Halcyon*** product label.
(4) Conclusion on the peer review of the pesticide risk assessment of the active substance aminopyralid (2013) EFSA Journal Volume 11, Issue 9.
(5) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm). Accessed 13/09/2024
(6) *The e-Pesticide Manual,* v4.2 (BCPC 2008)

CITRONELLA OIL

(e.g. **Barrier H,** emulsion, oil in water)

HRAC not classified



SUMMARY

Citronella oil is a natural plant extract which exhibits fungicidal, insecticidal and herbicidal activity; available as a straight product for use in amenity grassland, green cover on land temporarily removed from production, permanent grassland, rotational grass. It is a non-selective, systemic, contact action that works by inhibiting photosynthesis. No information is available for the fate of Citronella oil in soil but the actual exposure in the field is likely to be localised due to its application as spot treatment. Citronella oils is of low mammalian toxicity, and not expected to adversely impact soil fauna. However, citronella oil has moderate toxicity to aquatic organisms and, therefore, every effort should be made to avoid contamination of watercourses.

Application scenarios

Citronella oil is registered for treatment of ragwort (*Senecio jacobaea*) in amenity grassland, green cover on land temporarily removed from production and grassland.[1].

Applications should be made as a spot treatment through hand-held equipment to the weed at the rosette stage. Apply 5 squirts per plant until the foliage is well covered. Check for regrowth after 28 days and reapply if necessary[2].

Fate in Soil

No information is available on the route and degradation in soil[4]. Actual exposure in the field is likely to be localised due to the application method used.

Fate in Water

Treatment of ragwort is likely to be localised in nature and drift to surface water is also likely to be localised. Whatever drift is received by the water body is likely to be diluted significantly[4]. Localised treatment to target weeds should reduce exposure of surface waters via drainage and surface runoff[4].

Effects on Terrestrial Fauna

Generally, citronella oil is regarded as being of low mammalian toxicity[3]. It has an acute oral LD_{50} in the rat of >4380 mg/kg bw[3]. It is an eye and skin irritant[3].

Citronella oil is also of low toxicity to birds (acute LD_{50} of > 2250 mg/kg bw)[3]. The risk to bees is low (acute oral LD_{50} of > 100 µg/bee)[3]. It is non-toxic to earthworms (LC_{50} > 1000 mg/kg dry soil).

Effects on Aquatic Fauna

Citronella oil has been found to be of moderate toxicity to fish ($LC_{50\ 96hours}$ carp 17.3 mg/l)[3], *Daphnia* ($EC_{50\ 48hours}$ 26.4 mg/l)[3] and algae (EC_{50} 3.65 mg/l)[3]. Contamination of ground water and risk to aquatic organisms is negligible using the approved application method[4].

Effects on Non-Target Plants

Due to the application method, there should be minimal drift and contamination of adjacent vegetation. Grasses have been shown to be less susceptible than other species[4].

Efficacy/safety[2]

Important note:

The table below is intended only as an indication of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. ALWAYS READ THE PRODUCT LABEL.

Susceptible:
Ragwort.

Livestock withholding period

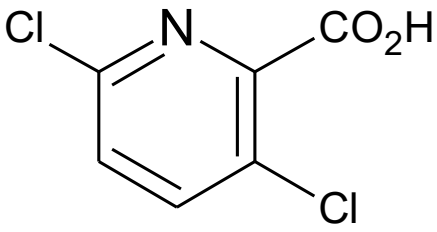
Livestock should be kept away from treated pasture for 14 days or until the ragwort is completely dead.

References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) Barrier Biotech Ltd, ***Barrier H*** product label.
(3) The Bio-pesticides database (BPDB) http://sitem.herts.ac.uk/aeru/bpdb/index.htm Accessed 13/09/2024
(4) Conclusion on the peer review of the pesticide risk assessment of the active substance plant oils /citronella oil (2012) EFSA Journal Volume 10, Issue 2

CLOPYRALID

(e.g. **Dow Shield 400**, soluble concentrate)
HRAC group 4



Summary

Clopyralid is a selective, post-emergent, systemic, pyridine herbicide, available as a straight product or as a mixture with other actives. It is absorbed by leaves and roots, with translocation both acropetally and basipetally. Clopyralid (and its salts) is very water soluble and may leach in the field. It is not toxic to mammals and other wildlife, and not expected to adversely impact soil and aquatic fauna.

Application scenarios

Clopyralid is registered for the control of a variety of annual and perennial dicotyledons, including corn marigold and creeping thistle, in grassland, amenity grassland, and a wide range of both edible & non-edible crops[1]. A label restriction is that no applications are to be made between 31st August and 1st March. Treatments are only effective when the weeds are actively growing, and most uses require application prior to flowering (June-August)[2]. Application should not take place when rainfall is expected within 6 hours. Application can be by tractor-mounted sprayer or hand-operated, knapsack sprayer.

Fate in Soil

Clopyralid is known to degrade moderately quickly in soil, through microbial action - in aerobic soil systems ($DT_{50\ field}$ values ranging from 2–13.5 days)[3]. Clopyralid is very water soluble (7.85 g/l)[3] and is not bound tightly to soil (K_{OC} range of 3.43-7.34)[3].

Fate in Water

Clopyralid is stable to hydrolysis and photolysis (DT_{50} > 1 year and 271 days respectively)[3]. In the natural environment, clopyralid slowly partitions from the water to the sediment ($DT_{50\ water}$ range 148 days)[3] and persist in the water sediment system (extrapolated DT_{50} > 500 days). Its low log K_{OW} value (-2.63 at pH7)[3] indicates that there will be a low bioaccumulation potential in aquatic species (e.g. fish).

Effects on Terrestrial Fauna

Generally, clopyralid is regarded as moderately toxic, with an oral LD_{50} in the rat of >5000 mg/kg, dermal LD_{50} in the rabbit of >2000 mg/kg and inhalation LC_{50} in the rat of >1 mg/l[3]. It is mildly irritating to the skin and severely irritating to the eyes[3]. The risk to birds is considered low (oral LD_{50} for ducks 1,465 mg/kg bw)[3], and clopyralid is

non-toxic to bees (LD_{50} >98.1 µg/bee)[3]. There are no adverse effects reported for worms ($LC_{50\ (14days)}$ >1000 mg/kg soil)[3], nor for soil microbial processes[3].

Effects on Aquatic Fauna

Clopyralid has been found to be moderately toxic to fish (LC_{50} >99.9 mg/l)[3], and slightly toxic to daphnia (acute EC_{50} >99 mg/l)[3]. Clopyralid is moderately toxic to algae (e.g. *Selenastrum capricornutum* EC_{50} 30.5 mg/l)[3]. Given its high potential for mobility in soil, care should be exercised when applying near to water courses.

Effects on Non-Target Plants

Clover is sensitive to clopyralid, and application should not be made within the root zone of species of the families *Asteraceae* (e.g. *Achillea, Carduus, Centaurea, Cirsium, Crepis, Hieracium, Hypochoeris, Picris, Pilocella*, *Senecio* spp.) or *Fabaceae* (e.g. *Cytisus, Genista, Lathyrus, Medicago, Ulex, Vicia* spp.).

Aquatic plants have been shown to have low susceptibility to clopyralid (e.g. *Lemna gibba* $EC_{50\ (7\ days)}$ 89 mg/l)[3].

Efficacy/safety[2,4,5]

<u>Important note</u>:

The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. ALWAYS READ THE PRODUCT LABEL.

Susceptible:

Daisy family (Asteraceae): Autumn hawkbit, cat's-ears, cocklebur, corn marigold, hawk's-beards, cudweed, dandelion, goat's-beard, greater knapweed, groundsel, hawkweeds, knapweeds, mouse-ear-hawkweeds, ox-eye daisy, oxtongues, pineapple weed, ragworts, scented mayweed, scentless mayweed, smooth sow-thistle, sunflower, yellow star-thistle, thistles, yarrows.

Pea family (Fabaceae): Brooms, gorses, green weeds, medicks, melilots, peas, vetches, white clover.

Other dicotyledons: Docks (seedlings), ribwort plantain, summer-cypress.

Moderately susceptible:

Daisy family (Asteraceae): Canadian fleabane, colt's-foot, perennial sow-thistle, prickly lettuce.

Cabbage family (Brassicaceae): London-rocket, shepherd's purse.

Other dicotyledons: Amphibious bistort (young plants), black bindweed, black nightshade, chickweed, docks, Japanese-lantern, knotweeds, leafy-fruited nightshade, stork's-bills, thornapples, white clover.

Moderately resistant:

Grasses: Cock's-foot, upright brome.

Dicotyledons: Black horehound, common dog-violet, common mallow, common toadflax, creeping cinquefoil, dog's mercury, early dog-violet, field bindweed, foxglove, lady's bedstraw, pale persicaria, redshank, primrose, wood avens.

Resistant:

Pteridophytes: Horsetails.

Grasses: Annual meadowgrass, autumn millet, beetle-grass, Bermuda-grass, canary-grass, cockspur, drooping brome, fingergrasses, Italian ryegrass, Johnson-grass, rescue brome, ripgut brome, sandburs, stink-grass, volunteer cereals, wild oat, yard-grass, yellow bristlegrass.

Other monocotyledons: Galingales.

Cabbage family (Brassicaceae): Cabbage/rape, dittander, swine-cresses, wild radish.

Other dicotyledons: Amaranths, annual morning-glory, common fiddleneck, fat-hen, henbit deadnettle, knotgrasses, mallows, morning glory, nettle-leaved goosefoot, pigweed, procumbent yellow-sorrel, ribwort plantain, velvetleaf.

Livestock withholding period

Normally - at least 7 days and until foliage of poisonous weeds such as ragwort has died and become unpalatable[2]. Check the label.

References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024

(2) Corteva Agriscience. **Dow Shield** 400 product label. (Dow Shield 400--) Accessed 13/09/2024

(3) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) Accessed 13/09/2024

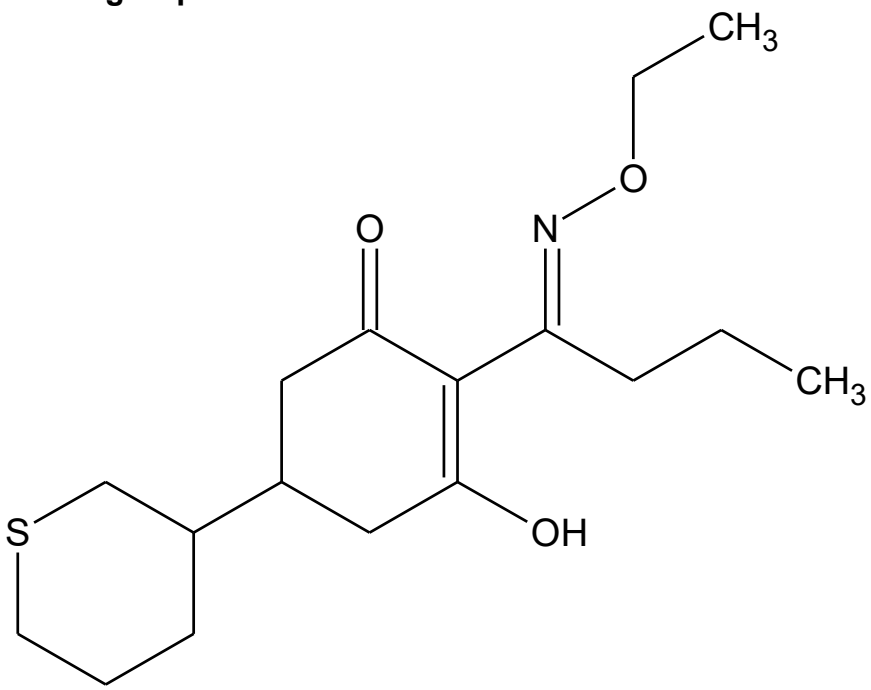
(4) Weed Susceptibility Chart, University of California, Co-operative Extension program, D Cudney (2000).

(5) Marshall, E J P & Craine, Y – previously unpublished data cited in Breeze *et al.* (1999), *Assessing Pesticide Risks to Non-target Terrestrial Plants*.

(6) Peer review of the pesticide risk assessment of the active substance Clopyralid (2018) EFSA Journal Volume 16, Issue 8

CYCLOXYDIM

(e.g. **Laser**; emulsifiable concentrate)
HRAC group 1



SUMMARY

Cycloxydim is a selective, systemic, post-emergent, cyclohexanedione herbicide, available as a straight product. It is rapidly absorbed by foliage, with translocation both acropetally and basipetally. The active component is water-soluble and only weakly bound to soil, however, it is rapidly degraded in soil and not expected to leach. Cycloxydim is of low toxicity, generally (but the formulated product is an eye and skin irritant), and not expected to adversely impact soil and aquatic fauna. Nevertheless, every effort should be made to avoid direct contamination of watercourses.

Application scenarios

Cycloxydim is registered for the control of annual and perennial grass weeds in many crops, forest and forest nursery (not between 1 July and 31 March), and green cover on land temporarily removed from production[1](not between 1 September and 1 January) Optimum control is achieved when weeds are still small and are actively growing[2]. Application can be at any time except for forests. In forestry uses trees should be established before treatment with cycloxydim. Application can be by tractor-mounted sprayer or hand-operated knapsack[2].

Fate in Soil

Cycloxydim is known to degrade fast, in aerobic soil systems (DT_{50} values ranging from 0.2 to 2.6 days in the laboratory)[3]. It is fairly water soluble (53 mg/l)[3] and is not bound tightly to soil (K_{OC} values range from 5–183)[3]. Therefore, there is a risk of leaching and movement to surface water via runoff and drainage (especially immediately following application), but this risk is expected to be low, and to

decrease rapidly with time after application, due to the fast degradation in soil. Cycloxydim is also expected to degrade in soil through the action of sunlight[3].

Fate in Water

Cycloxydim is hydrolysed faster at lower pH values (DT_{50} 1.7-8.3 days at pH3-5) than at higher pH values (DT_{50} 172-206 days at pH7-9)[3] and is expected to be hydrolysed faster in the presence of sunlight. It has a low log K_{OW} value (1.36 at pH 7)[3], and as such has a low potential to bioaccumulate.

Effects on Terrestrial Fauna

Generally, cycloxydim is regarded as being of low mammalian toxicity[4], with an acute oral LD_{50} in the rat of 3940 mg/kg bw[3]. It does not cause skin sensitisation, but the formulation is irritating to the eye and the skin[4]. The risk to birds is considered low (oral LD_{50} for quail >2000 mg/kg bw)[3], and cycloxydim is non-toxic to bees (LD_{50} >100 µg/bee)[3]. The formulated product is more toxic to earthworms (LC_{50} of 395 mg/kg corresponding to 36 mg a.s./kg) than cycloxydim itself (LC_{50} >500 mg/kg)[3]. Little or no effect is expected on soil microbial processes[3].

Effects on Aquatic Fauna

Cycloxydim has been found to be of low toxicity to fish ($LC_{50\ 96h}$ >220 mg/l)[3], and of low toxicity to *Daphnia* (acute LC_{50} >70.8 mg/l)[3]. Cycloxydim has similar toxicity to algae (e.g. *Chlorella fusca* EC_{50} >74.9 mg/L)[3]. However, the formulated product was more toxic for all species (e.g. Daphnia EC_{50} 19.8 mg/l).

Effects on Non-Target Plants

Application of cycloxydim will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to avoid such non-target plants. Likewise, drift into natural watercourses close to the application area could also result in damage to non-target aquatic plants (*Lemna gibba* E_bC_{50} of >100 mg/l[3]). Treatment to very young tree species could result in adverse effects where the plants are not fully established[2].

Efficacy/safety[2]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. *ALWAYS READ THE PRODUCT LABEL*.

Susceptible:

Grasses: Oats (cultivated & wild) (susceptible at 150 g/ha); barren brome, black-grass, canary-grass, Italian ryegrass, loose silky-bent, perennial ryegrass, soft brome (at 200 g/ha); volunteer wheat (at 250 g/ha).

Moderately susceptible:

Grasses: Black bent (susceptible at 400 g/ha); common couch, creeping bent, onion couch (at 450 g/ha).

Moderately resistant:

Grasses: Rough meadowgrass.

Resistant:

Grasses: Annual meadowgrass, red fescue.

Trees & shrubs: Ash, beech, oak, poplar, sweet chestnut, sycamore, wild cherry, willow.

Conifers: Corsican pine, Douglas fir, Japanese larch, lodgepole pine, noble fir, Scots pine, Sitka spruce, western red cedar.

Livestock withholding period

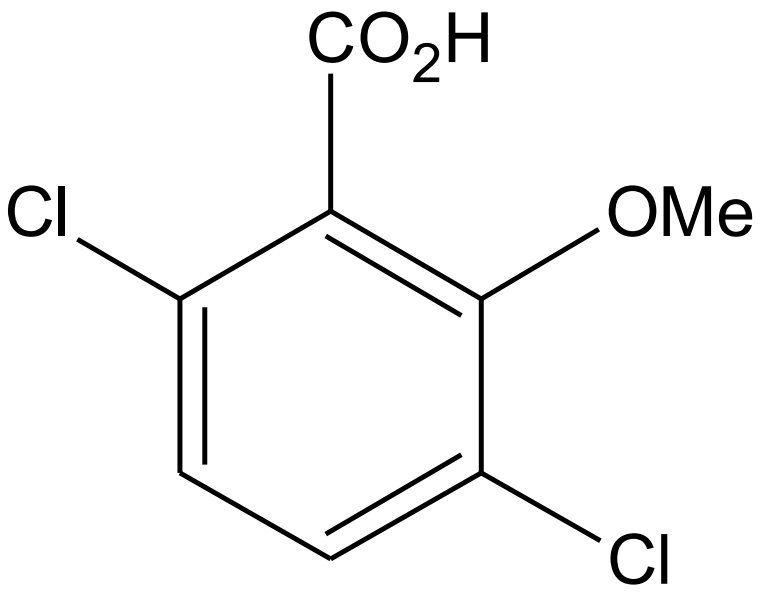
Normally – Treated plants must not be grazed by livestock or harvested for animal consumption[2]. Check the label.

References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) BASF plc. ***Laser*** product label. Laser (Accessed 13/09/2024)
(3) Conclusion on the peer review of the pesticide risk assessment of the active substance cycloxydim (2010) EFSA Journal Volume 8, Issue 7
(4) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm)

DICAMBA

(e.g. **Mircam Plus**; soluble aqueous concentrate)
HRAC group 4



Summary

Dicamba is a selective, post-emergent, benzoic acid herbicide, available as a straight product or as a mixture with mecoprop, 2,4-D, and fluroxypyr. It is readily absorbed by the leaves and roots and translocated throughout the plant via both the symplastic and apoplastic systems. Dicamba (and its salts) is very water soluble and may constitute a risk to groundwater under some circumstances. It is not toxic to mammals and other wildlife, and not expected to adversely impact soil and aquatic fauna.

Application Scenarios

Dicamba is registered for the control of a variety of annual and perennial broad-leaved weeds in mixtures with other actives, in amenity grassland and grassland. Treatments are only effective when the weeds are actively growing at time of application[2,3]. Application can be from early spring to mid-October by tractor-mounted or hand-held sprayer.

Fate in Soil

Dicamba is known to degrade moderately quickly in soil, through microbial action. When soil conditions are optimal (i.e. moist), DT_{50} values range from 2.1 to 10.5 days[4]. Dicamba is water-soluble (>250 g/l)[4] and is not bound tightly to soil (K_{OC} value of 12.36)[4]. Consequently, under some circumstances (for late applications with very wet conditions following application), leaching of dicamba into groundwater may occur.

Fate in Water

Dicamba is not susceptible to chemical hydrolysis, volatilisation, or adsorption to sediments, but is degraded microbially in natural water systems[4]. Its low log K_{OW}

value (-1.8 at pH6.8)[4] indicates that there will be no significant binding to sediments, and low bioaccumulation potential in aquatic species (e.g. fish).

Effects on Terrestrial Fauna

Generally, dicamba is regarded as of moderate mammalian toxicity, with an oral LD_{50} in the rat of 1581 mg/kg bw, dermal LD_{50} in the rat of >2000 mg/kg bw and inhalation LC_{50} in the rat of 4.46 mg/l[4]. It may cause skin irritation and is irritating and corrosive to the eye[4]. Dicamba is non-carcinogenic, non-genotoxic and not a teratogen[4]. The risk to birds is moderate (oral LD_{50} for quail 216 mg/kg bw and oral LD_{50} for ducks 1373 mg/kg bw)[4]. Dicamba is considered non-toxic to bees LD_{50} >100 µg/bee[4].

Effects on Aquatic Fauna

Dicamba has been found to be of moderate toxicity to fish (LC_{50} *ca* >28 mg/l)[4], and low toxicity to *Daphnia* ($LC_{50\ 48\ hours}$ >96.8 mg/l)[4]. Dicamba is more toxic to algae, with a lowest EC_{50} of 1.8 mg/l.

Effects on Non-Target Plants

Clover is sensitive to dicamba, as are broadleaved plants generally. When applying around trees, drift onto foliage should be avoided[3].

Care should be exercised when applying close to natural watercourses due to the toxicity to aquatic plants (*Lemna gibba* EC_{50} > 0.45 mg/l).

Efficacy/safety[2,5]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. *ALWAYS READ THE PRODUCT LABEL*.

Susceptible:

Daisy family (Asteraceae): Argentine fleabane, Canadian fleabane, cocklebur, dandelion (seedlings), daisy, groundsel, prickly lettuce, smooth sow-thistle, sunflower, thistles, yellow star-thistle.

Cabbage family (Brassicaceae): Cabbage/rape, garden radish, London-rocket, shepherd's purse.

Pea family (Fabaceae): Clover, medicks, melilots.

Other dicotyledons: Amaranths, annual morning glory, black nightshade, buckwheat, common chickweed, common purslane, docks (seedlings), fat-hen, fiddleneck, Japanese-lantern, knotgrasses, knotweeds, leafy-fruited nightshade, nettle-leaved goosefoot, pigweed, ribwort plantain (seedlings), stork's-bills, summer-cypress, thornapples, velvetleaf.

Moderately susceptible:

Daisy family (Asteraceae): Cudweed, dandelion, pineapple weed.

Cabbage family (Brassicaceae): Dittander, swine-cresses.

Other dicotyledons: Common nettle, docks, field bindweed, henbit deadnettle, mallows, procumbent yellow-sorrel, ribwort plantain.

Resistant:

Pteridophytes: Horsetails.

Grasses: Annual meadowgrass, autumn millet, cockspur, beetle-grass sp., Bermuda-grass, canary-grass, drooping brome, fingergrasses, Italian ryegrass, Johnson-grass, rescue brome, ripgut brome, sandburs, stink-grass, volunteer cereals, wild oat, yard-grass, yellow bristlegrass.

Other monocotyledons: Galingales.

Dicotyledons: Dodder.

Livestock withholding period

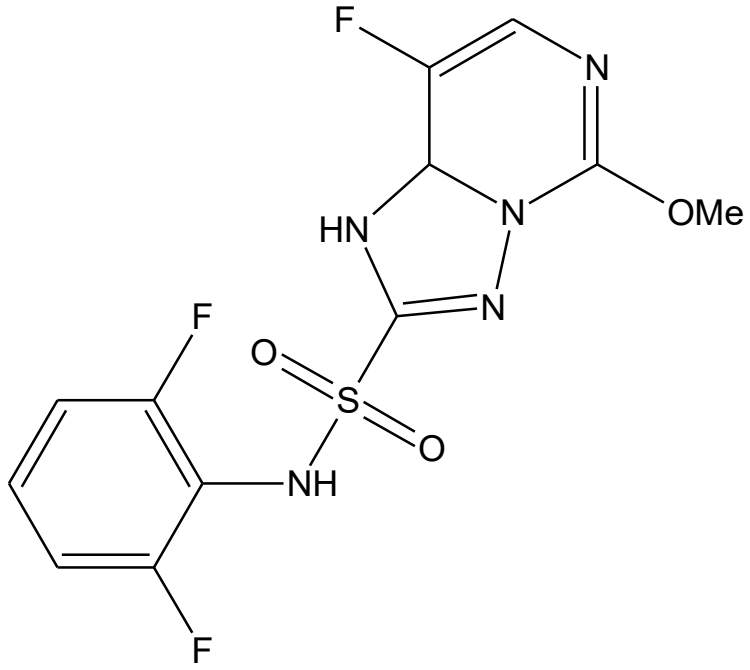
Normally – at least 14 days and until foliage of poisonous weeds such as ragwort has died and become unpalatable[3]. Check the label.

References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) Nufarm UK Ltd. **Thrust** product label https://nufarm.com/uk/product/thrust/ Accessed 13/09/2024
(3) Nufarm UK Ltd. ***Mircam Plus*** product label https://nufarm.com/uk/product/mircam-plus/ Accessed 13/09/2024
(4) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) Accessed 13/09/2024
(5) Weed Susceptibility Chart, University of California, Co-operative Extension program, D Cudney (2000).
(6) Conclusion on the peer review of the pesticide risk assessment of the active substance dicamba (2011) EFSA journal Volume 9 Issue 1

FLORASULAM

(e.g. **Cabadex*;*** suspension emulsion)
HRAC group 2



SUMMARY

Florasulam is a post emergence herbicide. It is taken up by the roots and shoots of the plant and translocated in the phloem and xylem throughout the plant. The use of florasulam constitutes a low risk to terrestrial and aquatic fauna. The active substance is water soluble and is only weakly bound to the soil; therefore, there is a possibility of leaching to watercourses where florasulam can be harmful to aquatic plants. However, florasulam degrades fairly rapidly in the soil and in water sediment systems, which limits the risks to the aquatic environment. Its main metabolite may persist in the water system but causes fewer risks to the aquatic environment than its parent compound. Nevertheless, care should be applied to avoid drift onto crops, non-target plants outside the target area and to avoid direct contamination of watercourses.

Application scenarios

Florasulam is used for the control of broad-leaved weeds in grassland and amenity turf[1,2]. There are also off-label authorisations in crops grown for game cover, farm forestry and outdoor forest nursery. Weeds should be small and actively growing at application[2]. Application is as a foliar spray, using tractor mounted equipment.

Fate in Soil

Florasulam is known to degrade rapidly in soil under experimental conditions ($DT_{50\ lab}$ of 0.58 to 4.29 days at 20°C) with similar values in the field ($DT_{50\ field}$ from 2 to 18 days under European field conditions)[3]. Florasulam has a high solubility in water (6.36 g/l at pH7) and is not bound tightly to soil (K_{oc} value of 4 to 54)[3]. Under some

circumstances (application followed by very wet conditions), leaching of florasulam may occur.

Fate in Water

Florasulam is only susceptible to hydrolysis at high pH (half-life of 99 days at pH9) and only slightly affected by photolysis[3]. Florasulam is rapidly degraded microbially in water sediment systems (DT_{50} whole system values of 13.3 to 18 days)[3]. Florasulam has a low log K_{OW} value (-1.22 at pH7)[3], which indicates a low bioaccumulation potential in aquatic species.

Effects on Terrestrial Fauna

Florasulam is regarded as of low mammalian toxicity, with an oral LD_{50} of 5000 mg/kg bw in the rat, dermal LD_{50} of > 2000 mg/kg bw in the rat and an inhalation LC_{50} in the rat of > 5 mg/l[3]. The risk to birds is considered to be moderate, with an acute LD_{50} of 1046 mg a.s../kg bw, and the risk to bees is low (acute oral and contact LD_{50} of >100 µg a.s./bee). It is not an eye irritant nor a skin irritant nor a skin sensitizer[3]. Florasulam is moderately toxic to arthropods and of low toxicity to earthworms (acute LC_{50} > 1320 mg a.s../kg soil)[3].

Effects on Aquatic Fauna

Florasulam has been found to be of low toxicity to fish (LC_{50} > 100 mg a.s./l) and to *daphnia* (LC_{50} > 292 mg a.s./l)[3]. However, Florasulam is of high toxicity to algae (EC_{50} of 0.00894 mg a.s./l)[3].

Effects on Non-Target Plants

Application of florasulam will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to avoid such non-target plants. Likewise, drift into natural watercourses close to the application area would also result in damage to non-target aquatic plants, as florasulam has been found to be highly toxic to duckweed (*Lemna gibba* EC_{50} of 0.00118mg a.s./l)[3].

Efficacy/safety[2]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. *ALWAYS READ THE PRODUCT LABEL*.

Depends on mixture
Susceptible:
Daisy family (Asteraceae): Perennial sow-thistle, Scented mayweed, Scentless mayweed, Smooth sow-thistle
Cabbage family (Brassicaceae): Black mustard, Charlock, Hedge mustard, Oilseed rape, Shepherd's-purse, Thale cress, White mustard
Other dicotyledons: Black bindweed, Black nightshade, Broad-leaved dock, Cleavers, Common Hemp-nettle, Common chickweed, Corn buttercup, Corn chamomile, Corn marigold, Cornflower, Curled Dock, Field forget-me-not, Groundsel, Meadow buttercup, Parsley-piert, Pea, Pineapple weed, Prickly sow-

thistle, Red clover, Rough poppy, Shepherd's-needle, Small nettle, Stinking chamomile, Sugar beet, Wild carrot, Wild radish, Wild turnip

Moderately susceptible:

Other dicotyledons:

Babington's poppy, Bulbous buttercup, Common poppy, Corn spurrey, Creeping buttercup, Field bean, Fool's parsley, Knotgrass, Long-headed poppy, Meadow buttercup, Potatoes, Prickly poppy, Redshank, Rough poppy.

Livestock withholding period

Normally – none quoted. Check the label.

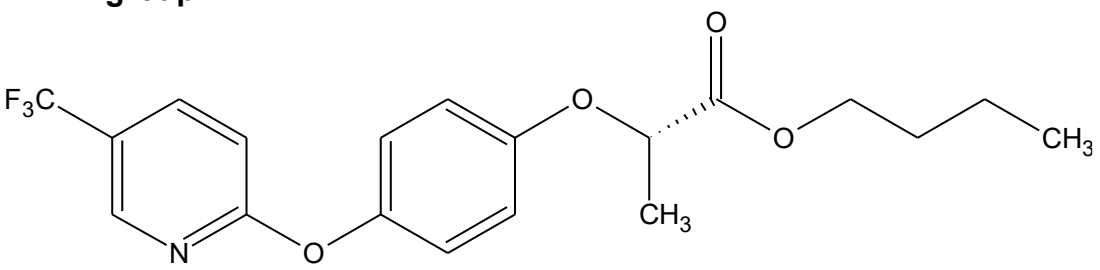
References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) Headland Amenity Products, Cabadex label. https://www.headlandamenity.com/cabadex-pesticide-3l Accessed 13/09/2024
(3) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm Accessed 13/09/2024
(4) *The e-Pesticide Manual*, 14th Edition (2008)
(5) Conclusion on the peer review of the pesticide risk assessment of the active substance florasulam (2015) EFSA journal Volume 13 Issue 1

FLUAZIFOP-P-BUTYL

(e.g., **Fusilade Max**; emulsifiable concentrate)

HRAC group 1



SUMMARY

Fluazifop-p-butyl is a selective, post-emergent, phenoxy-acid (single enantiomer) herbicide, available only as a straight product. Once absorbed by the leaves it is hydrolysed to the acid which is translocated in the xylem and phloem. It degrades rapidly in most matrices to give the acid, which is more persistent than the parent. It has low toxicity to mammals and most other wildlife but may adversely impact aquatic flora and fauna. Therefore, extra care should be exercised when applying close to natural waterbodies.

Application scenarios

Fluazifop-p-butyl is used for the control of annual & perennial grasses in Farm forestry and green cover on land not being used for crop production[1,2]. Application should be before weeds become competitive[2]. Speed of kill is more rapid when weeds are growing actively under warm conditions and with adequate soil moisture. Application is as a foliar spray using tractor-mounted sprayer or band treatment in forestry.

Fate in Soil

Fluazifop-p-butyl is known to degrade very rapidly in soil with DT_{50} values of 0.3 to 3.3 days[3], to give the acid which itself degrades with a $DT_{50\ field}$ value of 22 days[3]. Fluazifop-p-butyl is sparingly soluble in water (0.93 mg/l at pH5)[3] and is relatively strongly bound to soil (K_{OC} value of 3394)[4]. However, the acid metabolite is much more likely to leach into groundwater (K_{OC} values ranging from 106 to 304)[3].

Fate in Water

Fluazifop-p-butyl is degraded in natural water systems very rapidly (apparent $DT_{50}$of less than one day), and/or rapidly adsorbed by sediment, where it degrades to its acid. The acid degrades in the water phase with moderate persistence[3]. Fluazifop-p-butyl itself has a log K_{OW} of 4.5, indicating a potential to bioaccumulate, but is degraded too rapidly to do so[3]. The acid metabolite would not be expected to bioaccumulate due to having a log K_{OW} value of 3.18.

Effects on Terrestrial Fauna

Generally, fluazifop-p-butyl is regarded as relatively non-toxic to mammals[4], with an oral LD_{50} in the rat of 2451 mg/kg bw and dermal LD_{50} of >2110 mg/kg bw[3]. It is not considered as being a skin and eye irritant[3]. Fluazifop-p-butyl is non-toxic to birds

(oral LD_{50} for ducks >3960 mg/kg bw)[3] and is non-toxic to bees (LD_{50} >200 □g/bee)[3]. Fluazifop-p-butyl is moderately toxic to worms (LC_{50} >500 mg/kg dw)[3].

Effects on Aquatic Fauna

Fluazifop-p-butyl has been found to be of moderate toxicity to aquatic fauna[4], with a fish LC_{50} value of >1.41 mg/l[3], and Daphnia $EC_{50\ 48hours}$ of >0.62 mg/l[3]. Algae are relatively sensitive with an EC_{50} value of >0.18 mg/l[3].

Effects on Non-Target Plants

Application of fluazifop-p-butyl will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to avoid such non-target plants. Likewise, drift into natural watercourses close to the application area could also result in damage to non-target aquatic plants (EC_{50} for Lemna gibba > 1.4 mg/l[3]).

Trees are generally not very sensitive, but damage can occur if applications are made during bud burst/flushing.

Efficacy/safety[2,5]

<u>Important note</u>:
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Susceptible:

Grasses: Barley, barren brome, black bent, black-grass, canary-grass, common couch, creeping bent, Italian ryegrass, perennial ryegrass, volunteer cereals, wild oat.

Resistant:

Annual and perennial dicotyledonous species.

Grasses: Crested Dogstail (*Cynosurus cristatus*), Sheeps Fescue (*Festuca ovina*), Hard Fescue (*Festuca longifolia*), Chewings Fescue (*Festuca rubra spp commutata*), Red Fescue (*Festuca rubra spp purinsoa*), Fine-leaved Sheeps Fescue (*Festuca tenuifolia*), Annual Meadow-grass (*Poa annua*)

Conifers: Japanese Larch, Silver Fir, Douglas Fir, Cypress, Blue Spruce, Norway Spruce, Sitka Spruce, Pine, Thuja, Noble Fir

Other trees and shrubs: Alder, ash, beech, elm, common oak, maple, sycamore, willow.

Livestock withholding period

Normally – Treated vegetation must not be grazed or harvested for livestock consumption[2]. Check the label.

References

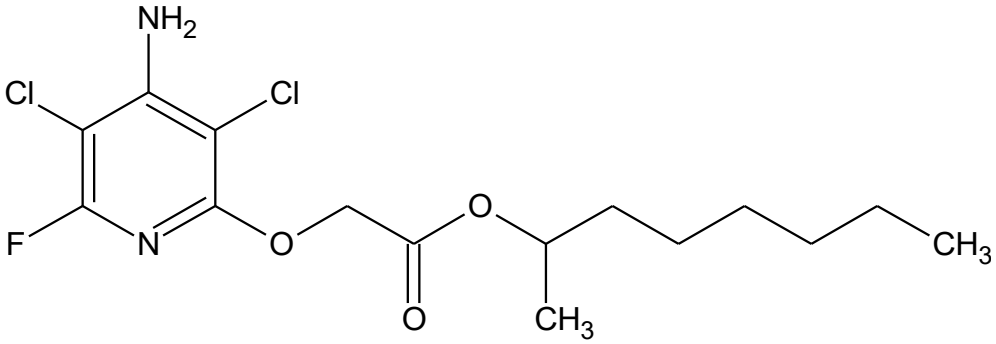
(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024

(2) Nufarm UK Ltd., Fusilade Max product label. https://nufarm.com/uk/product/fusilade-max/ Accessed 13/09/2024
(3) Conclusion on the peer review of the pesticide risk assessment of the active substance fluazifop-P (evaluated variant fluazifop-P-butyl) (2012) EFSA journal Volume 10 Issue 11
(4) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) Accessed 13/09/2024

FLUROXYPYR (meptyl)

(e.g. **Starane Hi-Load HL,** emulsifiable concentrate)

HRAC group 4



SUMMARY

Fluroxypyr, available as its meptyl-derivative (1-methylheptyl), is a selective, post-emergent, pyridine herbicide, available as a straight product or in mixtures. It is absorbed by foliage and once in the plant the meptyl ester is cleaved to give the active acid parent, which is translocated to other parts of the plant. The parent acid is weakly bound to soil, however, despite moderate degradation rates in soil, field studies indicate a low risk of leaching, but movement to surface water is a possibility. Fluroxypyr is of low mammalian toxicity, and not expected to adversely impact soil fauna. However, the parent acid is slightly toxic to aquatic organisms (and moderately toxic to aquatic plants). Therefore, every effort should be made to avoid contamination of watercourses.

Application scenarios

Fluroxypyr is registered for the post emergent control of certain broad-leaved weeds in grassland and amenity grassland[1]. Applications in established grassland is normally in the spring, up to mid-June[2]. Applications in newly established leys is in early autumn when the grasses are firmly established. Weeds should be small and actively growing[2]. Application can be by tractor-mounted sprayer[2] or knapsack sprayer (specific products only).

Fate in Soil

Fluroxypyr acid is moderately persistent in soil under laboratory conditions (DT_{50lab} values of 2.7-39.6 days[3]) with the meptyl-ester possibly more persistent[3], but the meptyl-ester is much more rapidly degraded in the field (parent acid $DT_{50field}$ values of 34-68 days, and meptyl-ester degraded to the acid with $DT_{50field}$ <3 days)[3], Fluroxypyr is not susceptible to degradation in soil through the action of sunlight[3]. The meptyl-ester has low water solubility (0.136 mg/l)[3], whereas the parent acid is very water soluble (6.5 g/l)[3]. The meptyl-ester is immobile in soil (K_{OC} values 6200-43000) whereas the parent acid is weakly bound to soil (K_{OC} value of 51-81)[3]. Therefore, there is a risk of the acid leaching, which has been investigated in the field and found to be low[3]. However, movement to surface water via runoff and drainage (especially immediately following application) is a possibility.

Fate in Water

Fluroxypyr-ester hydrolyses to the parent acid at a pH above 7 with a DT_{50} of 3.2 days at pH9 [3], the acid is hydrolytically stable but is microbially degraded in the water phase with a DT_{50} value of 24 days[3]. The meptyl-ester is rapidly absorbed to sediment, and rapidly degraded to the acid, has a whole system DT_{50} of 10.5 to 34.7 days. The meptyl-ester has a high log P_{ow} value (5.04)[3], but its rapid degradation implies a low bioaccumulation risk. The parent acid also has a low bioaccumulation risk as its log K_{OW} is low (0.04)[3].

Effects on Terrestrial Fauna

Both the parent acid and meptyl-ester are regarded as being of low mammalian toxicity[4]. They have an acute oral LD_{50} in the rat of >2000 mg/kg bw[3], neither the meptyl-ester nor the acid are an eye or skin irritant[3]. The risk to birds from both acid and meptyl-ester is low (LD_{50} >5000 mg/kg bw)[3], and meptyl-ester is non-toxic to bees (LC_{50} >100 µg/bee)[3]. The acid is moderately toxic to bees with an oral acute LD_{50} of 37.1 µg/bee. The acid and the meptyl-ester are considered to be moderately toxic to earthworms with an LC_{50} of >64.8 mg/kg dw for the acid and an LC_{50} of >500 mg/kg dw for the meptyl-ester[4].Both the acid and meptyl-ester are not toxic to a range of beneficial insects[3] and soil microbial processes[4].

Effects on Aquatic Fauna

Fluroxypyr acid has been found to be of moderate toxicity to fish (L. macrochirus $LC_{50\ 96hours}$ 14.3 mg/l)[3], Daphnia ($EC_{50\ 48hours}$ >100 mg/l)[3] and slightly toxic to algae (S. capricornutum LC_{50} 49.8 mg/l)[3]. The formulated product has a higher toxicity to aquatic organisms (O. mykiss LC_{50} 0.2 mg/l[3], daphnia EC_{50} >0.183 mg/L[3], S. subspicatus LC_{50} >0.5 mg/l[3]) than the acid. Given fluroxypyr acid's moderate soil persistence and mobility in soil, care should be exercised when applying near to watercourses.

Effects on Non-Target Plants

Application of fluroxypyr will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to avoid such non-target plants. Likewise, drift into natural watercourses close to the application area could also result in damage to non-target aquatic plants (L. gibba LC_{50} of 12.3 mg/l for parent acid)[3].

Efficacy/safety (fluroxypyr alone)[2]

<u>Important note</u>:
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Susceptible:
Daisy family (Asteraceae): Dandelion, groundsel, mayweed.
Other dicotyledons: Black-bindweed, black nightshade, broad-leaved dock, bramble, broom, cleavers, common chickweed, common fumitory, common nettle,

corn spurrey, curled dock, field forget-me-not, Henbit deadnettle, knotgrass, pale persicaria, red deadnettle, speedwell,

Resistant:

Cabbage family (Brassicaceae): Charlock, common orache, field pennycress, shepherd's purse, Wild radish, Volunteer rap

Other dicotyledons: Bugloss, common poppy, corn marigold, fat-hen, scarlet pimpernel, small nettle

Livestock withholding period

Normally – keep livestock out for at 14 days and until foliage of poisonous weeds such as ragwort has died and become unpalatable[2]. Check the label.

References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024

(2) Corteva Agriscience Starane Hi-load product label. https://www.corteva.co.uk/products-and-solutions/crop-protection/starane-hi-load.html Accessed 13/09/2024

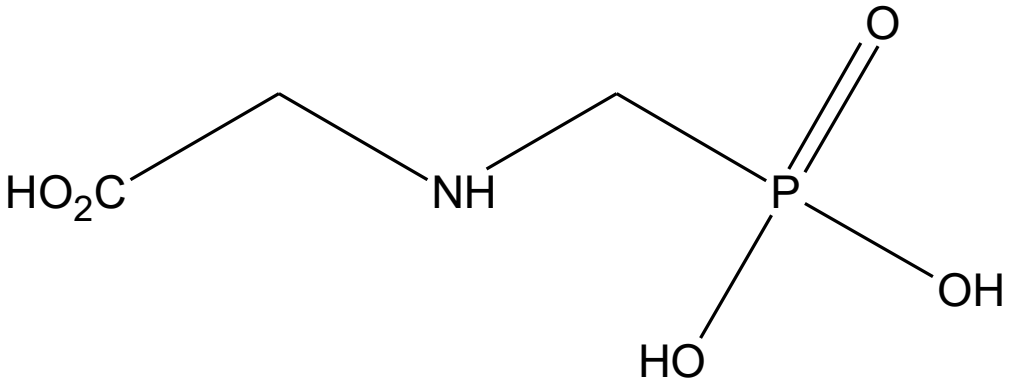
(3) Conclusion on the peer review of the pesticide risk assessment of the active substance fluroxypyr (evaluated variant fluroxypyr-meptyl) (2011) EFSA journal Volume 9 Issue 3

(4) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) Accessed 13/09/2024

GLYPHOSATE

(e.g. **Roundup Biactive GL**; soluble concentrate)

HRAC group 9



SUMMARY

Glyphosate is a non-selective, post-emergent, contact, organophosphorus herbicide, absorbed by the foliage with rapid translocation throughout the plant. It is as a straight product, from a large number of different sources, and as in mixture with pyraflufen-ethyl, sulfosulfuron or 2,4-D. In products it is usually present as a salt; and, in general, the formulated product is more toxic than the active ingredient. Glyphosate degrades very rapidly in most matrices. When applying, care should be exercised to minimise effects in non-target areas, due to spray drift.

Application Scenarios

Glyphosate is used for the control of annual and perennial broadleaved weeds and grasses, and a wide range of other unwanted plant material (e.g. bracken, rushes, weed beet, watercress and water lilies) in amenity grass and vegetation, sward destruction in grassland, hard surfaces, forest, forest nursery, farm forestry, land temporarily removed from production, non-crop farm areas, and aquatic situations[1,2]. Application should not take place if vegetation or soil are very wet, or if rain is expected within 6 hours of application (and preferably not within 24 hours of application[2]). Weeds should be actively growing at application, which can take place from June to October. Application is as a foliar spray using tractor-mounted equipment, with knapsack and other hand-held sprayers, or by weed-wipe.

Fate in Soil

Glyphosate is known to degrade rapidly in soil with DT_{50} values ranging from 5.7 to 40.9 days in the field[3]. Glyphosate is very soluble in water (10.5 g/l)[3], with glyphosate-salts even more soluble. Strength of soil binding depends on the soil but is generally moderate to tight (K_{OC} values between 884 and 50660)[3]. Although glyphosate is regarded as potentially mobile, its fast degradation, relatively tight binding to soils and application timing reduces the likelihood of contamination of groundwater.

Fate in Water

Glyphosate dissipates moderately fast in natural water/sediment systems, via adsorption (Dissipation half-life from water 9.9 -74.5 days)[3]. Glyphosate has a very low log K_{OW} (-3.2)[3] - indicating a very low potential to bioaccumulate.

Effects on Terrestrial Fauna

Glyphosate acts on metabolic pathways present in plants and some micro-organisms[3]. Generally, glyphosate is regarded as having moderate mammalian toxicity[4], with an acute oral LD_{50} in the rat of > 2000 mg/kg bw[3], a dermal LD_{50} in the rat of > 2000 mg/kg bw[3] and an acute inhalation LC_{50} in the rat of > 5 mg/l[3]. It does not cause skin irritation but can be irritating to the eye[3]. Glyphosate is non-toxic to birds (acute LD_{50} > 4640 mg/kg feed)[4]. Glyphosate is not harmful to worms (LC_{50} > 5600 mg/kg dw)[3].

Regulatory studies have shown that glyphosate is non-toxic to bees (oral LD_{50} 100 µg/bee)[3]. There are indications from the literature, however, that glyphosate may perturb the honeybee gut microbiome, and may potentially leave bees more susceptible to pathogens, but effects on overall colony health are unclear[10]. Therefore, it may be wise to exercise caution while applying glyphosate to, or close to, flowering plants.

While regulatory studies indicate negligible effects of glyphosate on micro-organism mediated soil nitrogen and carbon transformation[3] (i.e. functional endpoints), there is some evidence for changes in beneficial soil microbe abundance and community structure following repeated applications of products containing glyphosate (note, however, that this study was conducted in Argentina, and consisted of repeated annual field-rate applications of glyphosate-containing products with unknown co-formulants. Further, effects on soil microbial processes are unknown. Therefore, relevance to likely effects on soil function in UK is unclear)[11].

A study of the effects of glyphosate (and propyzamide) on non-target insects in farm forestry[5], found no significant effects on mortality of chafer larvae or adult ground beetles – leading the researchers to the conclusion that glyphosate is non-toxic, at least to the various herbivorous and predatory species tested. Laboratory studies[6], investigating the direct effects of glyphosate on non-target spiders (*Lepthyphantes tenuis*), found that spider mortality was less than 10% after 48 hours and under still 15% after 72 hours - suggesting that glyphosate was harmless to these arthropods. Indirect effects were also studied, in field margins which had been sprayed with varying levels of glyphosate[6]. The abundance of spiders was significantly lower in the sprayed plots compared to an unsprayed control plot. The reasons for this decline seemed to be increased amounts of dead vegetation and decreasing height of the remaining vegetation. The glyphosate applications only had a within-season indirect effect on the spider.

Effects on Aquatic Fauna

Glyphosate has been found to be of low to moderate toxicity to aquatic fauna, with fish LC_{50} value of 38 mg/L[4], and Daphnia $LC_{50\ 48hours}$ of 40 mg/L[4]. However, the formulated product may be more toxic in the aquatic environment than the active ingredient alone. Glyphosate is of low to moderate toxicity to amphibians which are generally considered to be less sensitive than fish to the active substance[3]. An acute 96-hour LC_{50} for larvae of the common frog *Rana temporaria* of 10.4 mg a.s../L was

reported in the literature, from a study conducted with formulated product (which did not contain polyethoxylated tallow amine (POEA))[12].

Effects on Non-Target Plants

Glyphosate is toxic to most plant species. Consequently, application of glyphosate will pose a risk to all plants outside of the target area, where spray drift is possible. Care should be taken to minimise such drift.

A review concluded that limiting glyphosate spray drift to <5 g a.s./ha would protect 95% of plants against minor effects, and that reducing spray drift to 1-2 g a.s./ha would almost completely protect plants in non-target areas against adverse and hermetic effects[13].

Likewise, drift into watercourses close to the application area could also result in damage to non-target aquatic plants. Where glyphosate is used for control of aquatic species then very careful adherence to good agricultural practice is required (aquatic plants, EC_{50} 12 mg/L)[3].

Efficacy/safety[2,7,8]

Most plant species are damaged by glyphosate, so great care must be taken to avoid contact with non-target species. However, there are differences in the relative sensitivities of plants – and the table below gives an indication of those species that are likely to be killed by relatively low rates and those which are killed only by high rates. Species listed as 'moderately resistant' are those showing resistance to glyphosate at rates of 3.0 kg a.s. per hectare, or higher[9].

Glyphosate can persist in treated plant remains. For example, treated straw should not be used as a mulch or growing medium for horticultural crops, (UK Pesticide Guide 2020)

Important note:
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Terrestrial species

Susceptible:

Ferns: Bracken.

Grasses: African love-grass, annual meadow-grass, autumn millet, barley, barren brome, beetle-grass sp., bents, Bermuda-grass, black bent, black-grass, bristle bent, bristle-grasses, canary-grass, cat's-tails, cock's-foot, cockspur, common couch, common reed, confused canary-grass, creeping bent, creeping soft-grass, crested-dog's tail, darnel, drooping brome, European bur-grass, false oat-grass, fescues, finger-grasses, foxtail brome, great brome, green bristle-grass, hairy finger-grass, Highland bent, Italian rye-grass, Johnson-grass, loose silky-bent, oats, meadow fescue, onion couch, perennial rye-grass, purple moor-grass, reed canary-grass, reed sweet grass, rescue brome, ripgut brome, rough meadow-grass, sandburs, slender oat, soft-brome, smooth meadow-grass, sharp-flowered

signal-grass, stink-grass, sweet vernal grass, Timothy, volunteer cereals, wall barley, wild oat, winter wild-oat, wood millet, wood small-reed, yard-grass, yellow bristle-grass, yellow oat-grass, Yorkshire fog.

Other monocotyledons: Bulrush, sedges, white water lily, wood-rushes yellow water lily.

Other trees & shrubs: Alders, alder buckthorn, ash, aspen, beech, black wattle, blackthorn, dog rose, elder, goat willow, oaks, privet, raspberry, rowan, silver birch, sweet chestnut, hawthorns, sycamore, western gorse.

Daisy family Asteraceae): Argentine fleabane, black-jack, bristly oxtongue, burdocks, butterbur, Canadian fleabane, chamomile sp., cockleburs, coltsfoot, common fleabane, common ragwort, corn chamomile, corn marigold, creeping thistle, crown daisies, cudweed, dandelion, dwarf marigold, field marigold. floss flower, gallant soldier, golden thistle, groundsel, hawk's-beards, hemp agrimony, Jersey cudweed, mayweeds, milk thistle, Michaelmas daisies, mug wort, oxeye daisy, perennial sow-thistle, pineapple weed, plain treasure flower, prickly lettuce, prickly sow-thistle, rough star-thistle, scented mayweed, scentless mayweed, smooth sow-thistle, southern marigold, spear thistle, stinking chamomile, sunflower, tansy, yellow star-thistle, wood ragwort.

Cabbage family (Brassicaceae): Bitter-cresses, black mustard, cabbage/rape, charlock, creeping yellow-cress, garden radish, hairy bitter-cress, London-rocket, perennial rocket, rockets, shepherd's purse, swine-cresses, thale cress, wall-rocket spp., water cress, white mustard, white wall-rocket, wild radish.

Pea family (Fabaceae): Black medick, liquorices, vetches, white clover (seedlings), yellow restharrow.

Carrot family (Apiaceae): Cow parsley, shepherd's-needle, fennels, fool's parsley, hogweed.

Other dicotyledons: African pepperwort, amaranths, amphibious bistort, annual morning glory, annual mercury, Bermuda buttercup, bistort, bittersweet, black bindweed, black nightshade, bramble, broad-leaved dock, cleavers, common amaranth, common chickweed, common field-speedwell, common fumitory, common hemp-nettle, common mouse-ear, common nettle, common orache, common poppy, common purslane, common stork's-bill, common toadflax, corn buttercup, corn mint, corncockle, corn spurrey, cranesbills, creeping buttercup, creeping cinquefoil, curled dock (seedlings), cut-leaved crane's bill, dodder, dog's mercury, dwarf mallow, fat-hen, fiddleneck, field bindweed (seedlings), field forget-me-not, field gromwell, field pansy, foxglove, fumitories, germander speedwell, gold-of-pleasures spp., great willowherb, greater plantain, green amaranth, green field-speedwell, grey field-speedwell, ground-ivy, henbit dead-nettle, hound's-tongues, ivy-leaved speedwell, Japanese-lantern, knotweeds, leafy-fruited nightshade, least mallow, mints, mouse-ears, nettles, nettle leaved goosefoot, pale persicaria, parsley-piert, perforate St John's-wort, petty spurge, procumbent yellow-sorrel, prostrate pigweed, red dead-nettle, redshank, ribwort plantain (seedlings), rosebay willowherb, scarlet pimpernel, sheep's sorrel, small nettle, soft stork's-bill, speedwells, spurges, summer-cypress, sun spurge, thorn-apples, vervain, wall speedwell, white dead-nettle, wild pansy, woundworts

Moderately susceptible:

Pteridophytes: Horsetails.

Grasses: Common bent, giant reed, meadow foxtail, red fescue, sheep's-fescue, tufted hairgrass, water fingergrass, wavy hairgrass.

Other monocotyledons: Galingales, Italian lords-and-ladies, rosy garlic, tassel hyacinth, wild onion.

Conifers: Corsican pine, Douglas fir, lodgepole pine, Norway spruce, Sitka spruce, Scots pine.

Other trees & shrubs: Alder, blackthorn, broom, common gum cistus, dog rose, green alder, green weeds, downy birch, field maple, French lavender, gorse, guelder-rose, hazel, hornbeam, Montpellier rockrose, raspberry, Spanish gorse, tree heath, willows.

Daisy family (Asteraceae): Canadian goldenrod, daisies, goldenrod, greater burdock, oxtongues, tansy, yarrow.

Pea family (Fabaceae): Common bird's-foot-trefoil, lucerne, medicks, melilots, tufted vetch, white clover.

Carrot family (Apiaceae): Ground-elder, hoary cress, wild carrot.

Other dicotyledons: Buck's-horn plantain, common hemp-nettle, common purslane, corn buttercup, cowbane, curled dock, field bindweed, garden pink-sorrel, ground-ivy, heather, hedge bindweed, Japanese knotweed, knotgrasses, mallows, perfoliate honeysuckle, ribwort plantain, rosebay willowherb, stork's-bills, velvetleaf, wood sorrel.

Moderately resistant:

Ferns: Hard fern, male fern.

Other monocotyledons: Field garlic.

Trees & shrubs: rhododendron, Spanish heath.

Daisy family Asteraceae): Chinese mug wort, welted thistle.

Pea family (Apiaceae): Clovers.

Other dicotyledons: Birthwort, cinquefoils, comfreys, stonecrops, traveller's-joy.

Aquatic species

Susceptible: Grasses: Common reed, floating sweet-grass, reed canary-grass, reed sweet-grass, whorl-grass.

Other monocotyledons: Arrowhead, beak-sedges, branched bur-reed, bulrush, duckweeds, greater pond-sedge, hard rush, sea club-rush, sedges, sharp-flowered rush, soft rush, water-plantain,

Daisy family (Asteraceae): hemp-agrimonies, marsh thistle, marsh sow-thistle.

Other dicotyledons: Watercress, water-violet, white waterlily, yellow waterlily.

Moderately susceptible:

Algae: Cladophora spp., Enteromorpha intestinalis, Rhizoclonium spp. Spirogyra spp. Vaucheria dichotoma.

Grasses: Common reed.

Other monocotyledons: Branched bur-reed, Canadian waterweed, common club-rush, curled pondweed, horned pondweed, ivy-leaved duckweed, lesser bulrush, lords-and ladies, rushes, sedges, soft rush, yellow iris.

Dicotyledons: Amphibious bistort, rigid hornwort, spiked watermilfoil, water hyacinth, water mint, whorled watermilfoil, waterpepper, woundworts.

Moderately resistant:
Grasses: Giant reed.
Other monocotyledons: Fennel pondweed.
Dicotyledons: Creeping yellow cress.
Resistant:
Monocotyledons: Broad-leaved pondweed.

Livestock withholding period

Normally – at least 5 days[2] and until foliage of poisonous weeds such as ragwort has died and become unpalatable or have been removed. Check the label.

Safety concerns

The Environment Agency has produced the following briefing on glyphosate and its safety to users, which Natural England supports. The briefing was produced before the UK left the EU, but it remains valid:

“Following an EU routine review, the approval of glyphosate was renewed on 16 December 2017 for five years, until 15 December 2022*. As part of that review, concerns were raised over the safety of the original Roundup type product formulations containing tallow amine; all such products no longer have authorisation in the UK. The UK, along with other member States, are now in the process of re-examining product formulations containing glyphosate for renewal under Article 43 of 1107/2009.”

(*Since the briefing was written, a decision has been made that active substance approvals due to expire before December 2023 have been extended for three years, to allow time to plan and implement the GB review programme.)

“All pesticide approvals are subject to periodic review and the approval of glyphosate has recently gone through this process. On 28 November 2017, the EU re-approved the continuing use of glyphosate from 16 December 2017. Reviews of the scientific data by the European Food Safety Authority (EFSA) and the European Chemicals Agency’s Committee for Risk Assessment have found no safety concerns that would prevent continuing approval, and UK scientists agree with this assessment. The new approval lasts until 15 December 2022; use beyond that date would be subject to a further decision.”

The UK Government’s priority is the protection of people and the environment. Decisions on the use of pesticides should be based on a careful scientific assessment of the risks. The UK government supported the continued approval because glyphosate meets our high standards for the protection of health and the environment. Although the period of the approval (five years) is less than we considered appropriate, the decision does provide UK farmers with the certainty that they need.

All products which contain glyphosate have to be authorised for use and applications for use must be approved by The Health and Safety Executive’s Chemicals Regulation Division. Where pesticides can be used safely, the regulatory system

should allow continued use of glyphosate. Glyphosate is important for the control of weeds in agriculture and in other sectors such as transport.

The Environment Agency approves the use of glyphosate products for control of aquatic weeds and weeds growing near water. Their approval process ensures that only the safest products are used in these special areas. They do this by only permitting the use of products that have no label hazard warning phrases, meaning that they are safe for both operators and the environment when used correctly.

Q&As:

Will you support a ban on glyphosate, which may cause cancer?

> The Government follows the scientific evidence. UK specialists support the conclusions of the EU and global science advisory bodies which have concluded that glyphosate meets the safety requirements for approval. The European Chemicals Agency has concluded (March 2017) that glyphosate should not be classified as a carcinogen.

How can you trust EFSA on glyphosate?

> EFSA works to high standards, and we regard it as independent of vested interests. We do not, in any case, automatically follow EFSA's lead. Our own specialist assessors and independent advisers look at the evidence on these important decisions. All products which contain glyphosate have to be authorised for use, and applications for use must be approved by The Health and Safety Executive's Chemicals Regulation Division. The UK, along with other Member States, is now in the process of re-examining product formulations containing glyphosate for renewal under Article 43 of Regulation 1107/2009.

What will happen to approval of glyphosate once we leave the EU?

> Once outside the EU, we will continue to make decisions on pesticides based on the best available science.

How safe are the crops and food which have been sprayed with glyphosate?

> We do not expect glyphosate residues to pose any adverse health effects to consumers. An examination of recent monitoring data has shown that the residues of glyphosate found in UK food are not present at levels that would be expected to have an effect on health.
>
> Maximum residue levels (MRL's) for glyphosate are set, and subject to regular review, under an associated EU work programme. The EU would review these MRLs if there were evidence to show that exposure to glyphosate poses a sufficiently greater degree of risk to human health than previously assessed.

Is glyphosate safe to use in my garden?

> The same level of scrutiny and high standards of risk assessment are applied to products for use by amateurs as those for professional users.

Is glyphosate safe to use our parks and public spaces?

> The risk associated with the use of pesticides in amenity areas, such as parks, is specifically considered as part of the authorisation process. Legally enforceable conditions of use are imposed on the way products can be

applied to ensure the public are not exposed to levels of pesticides that would harm health or have unacceptable effects on the environment.

The responsible use of pesticides in amenity areas as part of an integrated programme of control can help deliver substantial benefits for society. These include management of conservation areas, invasive species and flood risks; access to high quality sporting facilities; and a safe public space (for example, by preventing weed growth on hard surfaces creating trip hazards), industrial sites and transport infrastructure. The government is working with industry bodies and others to promote best practice in vegetation and weed management in the amenity sector.

EFSA reviews

A review of the substance, led by EFSA, was completed in late 2015 and found no concerns that would prevent a new approval being issued. This is consistent with the conclusions of other major regulators, such as the US EPA.

Since that review was completed, EFSA has further advised (September 2017) that glyphosate is not an endocrine disruptor. The European Chemicals Agency has concluded (March 2017) that glyphosate should not be classified as a carcinogen.

In summary, therefore, the relevant EU advisory bodies have not found any reason to withhold approval of glyphosate. UK experts have been involved in this work and agree with the conclusions. The UK therefore supported approval.

Formulations containing tallow amines

No such formulations have authorisation in the UK since 30 June 2018. The ongoing legal challenge in the USA concerns only the original tallow amine formulations and no such formulations are in use in Europe today. This product type use has declined in the last 15 years since the introduction of safer and more effective formulations.

As published on the HSE website on 17 March 2017, Regulation (EU) 2016/1313 amended the conditions for the EU approval of glyphosate. It included a requirement that Member States ensure that glyphosate products do not contain the co-formulant POE-tallow amine.

All plant protection products which contain glyphosate and POE-tallow amine authorised in the UK were therefore withdrawn with the following expiry dates:

- For sale and distribution: on or before 30 June 2017
- For disposal, storage and use: on or before 30 June 2018

Renewal of approval

Voting on active substance approvals takes place in the Standing Committee on Plants, Animals, Food and Feed (Phytopharmaceuticals Legislation Section). If no opinion is delivered, the proposal is referred to the Appeal Committee for consideration. Both Committees vote by qualified majority.

HSE agrees the UK's position on each proposal for voting with Defra beforehand. Defra agreed with HSE's recommendation to support the proposal for renewal of approval of glyphosate.

Standing Committee did not deliver an opinion on the proposal on 9 November 2017, so it was referred to the Appeal Committee. After some amendments to the text, the

Appeal Committee voted by qualified majority in favour the proposal on 27 November 2017. Eighteen member States voted in favour (65.71% of the population), with nine against and one abstention.

The UK voted in favour of the proposal, in accordance with the position agreed with Defra.

The following is an extract from the HSE website:

'Glyphosate was considered by the Appeals Committee on 27 November 2017 and renewal of its approval agreed for five years from 16 December 2018. Authorisations for products containing this substance will need to be renewed in accordance with Article 43 of Regulation (EC) 1107/2009, with applications required by 15 March 2018.' "

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(5) Whitehouse & Brown (1993). Herbicides in farm forestry: effects on non-target insects. *BCPC Weeds 1993* **1**. 121-126.
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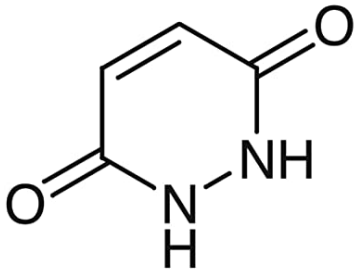
MALEIC HYDRAZIDE

(e.g. **Fazor,** water soluble granule**)**

HRAC not classified



SUMMARY

Maleic Hydrazide is a plant growth inhibitor, uracil antimetabolite, with limited herbicidal activity. It is absorbed by leaves and roots and translocated in the xylem and phloem. Maleci hydrazide is available as a single active product as a growth regulator and as a mixture with pelargonic acid as a herbicide. It degrades very rapidly in soil and so, despite being very mobile is not expected to constitute a risk to groundwater. It is not expected to have an adverse effect on terrestrial or aquatic environments.

Application scenarios

Maleic hydrazide is used to retard sprout growth in potatoes and onions and as a growth regulator in amenity grassland (EAMU) to reduce growth and prevent seed head production (motorway verges). In a mixture with pelargonic acid it is used as a herbicide in amenity vegetation.

Fate in Soil

Maleic hydrazide degrades rapidly in soil with DT_{50} values 0.2-3.9 days in the laboratory under aerobic conditions[3]. Degradation under anaerobic conditions is somewhat slower DT50 values of 30 days[4]. Maleic hydrazide is very soluble in water (around 156g/l)[4]. And binding to soil is also weak with K_d value of 0.73[4]. Although Maleic hydrazide is regarded as potentially mobile, its fast degradation and application timing reduced the likelihood of contamination of groundwater.

Fate in Water

Maleic hydrazide is reported as being rapidly degraded in water via the action of sunlight[5]. It has a very low log K_{OW} (-1.96) indicating a very low bioaccumulation potential.

Effects on Terrestrial Fauna

Generally, Maleic hydrazide is regarded as low toxicity[4] to mammals with an acute oral in the rat of > 2000 mg/kg , a dermal LD_{50} in the rabbit of > 2000 mg/kg and an inhalation LC_{50} in the rat of >3.2 mg/l. It is a skin, eye and respiratory tract irritant[4]. The risk to birds is considered low (acute oral LD_{50} of > 4640 mg/kg)[4] and maleic hydrazide is non-toxic to bees (LD_{50} of > 100 µg/bee)[3]. There are no adverse effects reported for worms (LC_{50} of > 1000 mg/kg)[3].

Effects on Aquatic Fauna

Maleic hydrazide has low toxicity to fish (LC_{50} > 1000 mg/l)[3] and of moderate toxicity to *Daphnia magna* (Acute 48-hour EC_{50} 107.7 mg/l)[3]. Maleic hydrazide is of low toxicity to algae, with an EC_{50} >100 mg/l for chlorella vulgaris.

Effects on Non-Target Plants

No significant risks to non-target plants have been reported. Due to maleic hydrazides mode of action (growth inhibition) it is unlikely that any effects would be long lasting. Toxicity to aquatic plants is low EC_{50} for *Lemna gibba* >110 mg/l.

Livestock withholding period

Check the label.

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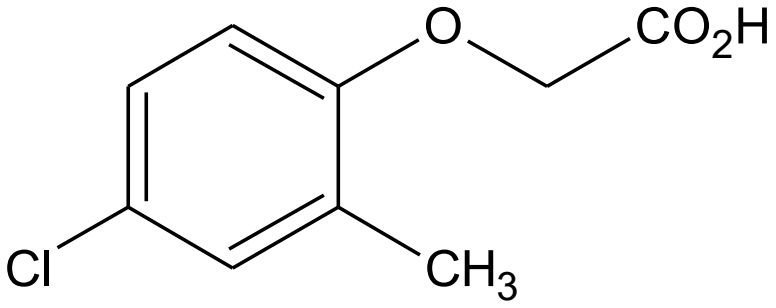
MCPA

(**e.g. Easel;** soluble concentrate)

HRAC group 4



SUMMARY

MCPA is a selective, post-emergent, systemic, phenoxyacetic acid herbicide available as a straight product or in mixtures. It is absorbed by the leaves and roots and translocated. In products it can be present as the acid, as a salt, ester or amine. The solubility of the active in the product can vary significantly, depending on the form of MCPA present. MCPA degrades rapidly in most matrices, and apart from effects on non-target plants is not expected to adversely impact terrestrial or aquatic environments.

Application scenarios

MCPA is approved for the control of annual and perennial broadleaved weeds in established grassland and farm (EAMU)[1]. Weeds should be actively growing at application, which should optimally take place when annual weeds are at the seedling stage and when the flower buds are forming in perennial weeds[2]. Application is as a foliar spray, using tractor-mounted spraying equipment. Keep livestock away from the treated area until targeted weeds have died and become unpalatable.

Fate in Soil

MCPA degrades rapidly in soil, with a DT_{50} that varies according to organic carbon content (DT_{50} range from 7 to 41 days at 20°C under aerobic conditions)[3]. MCPA, and its salts, are soluble in water (293.9 g/l for the acid)[3], but although MCPA is regarded as potentially mobile (calculated GUS of 2.98), its fast degradation and application timing reduces the likelihood of contamination of groundwater.

Fate in Water

MCPA is stable to hydrolysis but degrades rapidly by photolysis in aqueous environments (DT_{50} 69 min at pH7 under test conditions and 25.4 days at pH5 under natural sunlight)[3,]. It has a low Log K_{OW} (-0.81 at pH7)[4], indicating a very low bioaccumulation potential.

Effects on Terrestrial Fauna

Generally, MCPA is regarded as moderately toxic to mammals, with an acute oral LD_{50} in the rat of 962 mg/kg bw[3], dermal LD_{50} in the rat of >4000 mg/kg bw[3] and acute inhalation LC_{50} in the rat of >6.36 mg/l[3]. It is classified as a severe eye irritant[3]

but is not a skin irritant. MCPA is moderately toxic to birds (oral LD_{50} for quail 234 mg/kg bw[3]) and is non-toxic to bees (oral LD_{50} >200 µg/bee)[3]. MCPA is not harmful to worms ($LC_{50\ 14days}$ 325 mg/kg dw)[3]. MCPA-derivatives appear to have similar toxicities to the acid.

Effects on Aquatic Fauna

MCPA has been found to be of low toxicity to aquatic fauna, with fish LC_{50} values of >72 mg/l[3], and *Daphnia* LC_{50} of >190 mg/l[3]. MCPA is of low toxicity to algae (EC_{50} for *Pseudokirchneriella subcapitata*>79.8 mg/l)[3].

Effects on Non-Target Plants

Application of MCPA will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to minimise such drift. Likewise, drift into natural watercourses close to the application area could also result in damage to non-target aquatic plants (aquatic plants LC_{50} 152 µg/l).

Efficacy/safety[2,5]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. ALWAYS READ THE PRODUCT LABEL.

Susceptible:

Daisy family (Asteraceae): Argentine fleabane, Canadian fleabane, cocklebur, dandelion (seedlings), prickly lettuce, smooth sow-thistle, sunflower.

Cabbage family (Brassicaceae): Black mustard, cabbage/rape, charlock, field pennycress, garden radish, London-rocket, runch, shepherd's purse, white mustard.

Other dicotyledons: Amaranths, black nightshade, corn buttercup, creeping buttercup, curled dock (seedlings), fat-hen, greater plantain, hoary plantain, Japanese-lantern, leafy-fruited nightshade, nettle-leaved goosefoot, pigweed, ribwort plantain.

Moderately susceptible:

Monocotyledons: Common rush, soft rush.

Daisy family (Asteraceae): Annual sow-thistle, autumn hawkbit, cats-ear, common knapweed, common ragwort, creeping thistle, cudweed, daisy, dandelion, pineapple weed, smooth hawksbeard, smooth sow-thistle, spear thistle, yellow star-thistle.

Cabbage family (Brassicaceae): Hoary cress.

Other dicotyledons: Annual morning glory, black nightshade, common chickweed, common fumitory, common hemp-nettle, common mouse-ear, common nettle, common orache, common poppy, common purslane, curled dock, fiddleneck, field gromwell, forget-me-nots, knotweeds, mallows, procumbent yellow-sorrel, ribwort plantain, scarlet pimpernel, self-heal, small nettle, stork's-bills.

Moderately resistant:

Pteridophytes: Horsetails.

Daisy family (Asteraceae): Corn chamomile, field pansy, perennial sow thistle, ragwort, scentless mayweed, yarrow.

Other dicotyledons: Corn spurrey, dove's-foot crane's bill, knotgrasses, pale persicaria, procumbent pearlwort, redshank, silverweed, sorrel, speedwells.

Resistant:

Pteridophytes: Horsetails.

Grasses: Annual meadowgrass, autumn millet, barley, beetle-grass sp., Bermuda-grass, canary-grass, drooping brome, fingergrasses, Italian ryegrass, Johnson-grass, rescue brome, ripgut brome, sandburs, stink-grass, volunteer cereals, wild oat, yard-grass, yellow bristlegrass.

Other monocotyledons: Galingales.

Daisy family (Asteraceae): Corn marigold, groundsel, mayweeds.

Cabbage family (Brassicaceae): Dittander, swine-cresses.

Pea family (Fabaceae): Medicks, melilots.

Other dicotyledons: Black bindweed, broad-leaved dock, cleavers, corn spurrey, deadnettle, dodder, henbit deadnettle, ivy-leaved speedwell, parsley-piert, red deadnettle.

Livestock withholding period

Normally – at least 14 days and until foliage of poisonous weeds such as ragwort has died and become unpalatable[2]. Check the label.

References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) Nufarm UK Ltd. ***Easel*** product label. https://nufarm.com/uk/product/easel/ Accessed 13/09/2024
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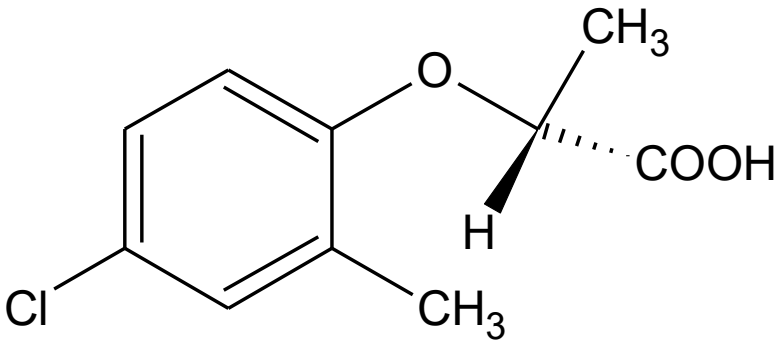
MECOPROP-P

(e.g. **Duplosan KV** soluble concentrate)

HRAC group 4



SUMMARY

Mecoprop-P, available as its potassium (or dimethylamine) salt, is a selective, post-emergent, phenoxy acid herbicide, available as a straight product, or in mixtures. It is absorbed by foliage and translocated to the roots. Mecoprop-P degrades very rapidly in soil, and so, despite being very mobile is not expected to constitute a risk to groundwater. Movement to surface water is, though, possible. Mecoprop-P has slight mammalian toxicity and is not expected to adversely impact soil fauna. Every effort should be made to avoid contamination of watercourses.

Application scenarios

Mecoprop-P is registered for the post emergent control of certain broad-leaved weeds in amenity grassland. Applications should be when the weeds are actively growing (and the soil moist and warm) and not shielded by the sward[2]. Generally, applications can be made from spring to autumn[2]. Application can be by tractor-mounted sprayer or knapsack sprayer[2].

Fate in Soil

Mecoprop-P is rapidly degraded in soil under laboratory conditions (DT_{50lab} values of 4-8.2 days[3]) and in the field ($DT_{50field}$ values of 5-17 days)[4]. Degradation under anaerobic conditions, however, was slow (DT_{50lab} >31 days)[3]. Mecoprop-P is soluble in water (250 g/l[3]) and its salts are very soluble (e.g. 920 g/l for the potassium salt[5]). Mecoprop-P and its salts are weakly bound to soil with increasing affinity at lower pH for mecoprop-P (K_{OC} values of 5.6-7.6 for pH 5.6-7.6 and 135-167 for pH 4.3-44)[3]. Therefore, there is a risk of leaching, which has been investigated in the field and found to be low in practice[3]. However, movement to surface water via runoff and drainage (especially immediately following application) is known to occur[4].

Fate in Water

Mecoprop-P is hydrolytically stable but is microbially degraded in the water phase with an overall DT_{50} value of 92-141 days in natural water/sediment systems[3]. Mecoprop-P has a very low log K_{OW} value (-0.19) at pH7 and, therefore, has a low potential to bioaccumulate[3].

Effects on Terrestrial Fauna

Mecoprop-P (and its salts) has only moderate mammalian toxicity[3]. It has an acute oral LD_{50} in the rat of 431 mg/kg bw[3,] and a dermal LD_{50} in the rat of >2000 mg/kg bw[3]. The inhalation LC_{50} was >2.13 mg/l[3] in the rat. It is a severe eye irritant, but it is not a skin irritant[3]. Mecoprop-P is moderately toxic to birds (LD_{50} for quail 500 mg/kg bw)[3], and of low toxicity to bees (LC_{50} >83µg/bee)[4]. Mecoprop-P is not toxic to earthworms ($LC_{50\ 14days}$ 988 mg/kg dw)[3], and is not toxic to a range of beneficial insects[3] and soil microbial processes[3].

Effects on Aquatic Fauna

Mecoprop-P has been found to be of moderate toxicity to fish ($LC_{50\ 96h}$ trout >93 mg/l)[3], Daphnia ($EC_{50\ 48hours}$ >91 mg/l)[3] and low toxicity to algae (EC_{50} 16.2 mg/l)[4]. However, given mecoprop-P's moderate persistence in water/sediment systems care should be exercised when applying near to watercourses.

Effects on Non-Target Plants

Application of mecoprop-P will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to avoid such non-target plants. Likewise, contamination of natural watercourses close to the application area could also result in damage to non-target aquatic plants (EC_{50} of 1.6 mg/l based on biomass)[3].

Efficacy/safety[2,5]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. ALWAYS READ THE PRODUCT LABEL

Susceptible:
Daisy family (Asteraceae): Argentine fleabane, Canadian fleabane, cocklebur, prickly lettuce, smooth sow-thistle, sunflower.
Cabbage family (Brassicaceae): Cabbage/rape, black mustard, charlock, field pennycress, garden radish, London-rocket, shepherd's purse, treacle mustard, white mustard.
Other dicotyledons: Amaranths, black nightshade, cleavers, common chickweed, common mouse-ear, common nettle, curled dock (seedlings), dandelion (seedlings), fat-hen, greater plantain, Japanese-lantern, leafy-fruited nightshade, nettle-leaved goosefoot, ribwort plantain, small nettle.
Moderately susceptible:
Daisy family (Asteraceae): Cudweed, dandelion, prickly sow-thistle, yellow star-thistle.
Cabbage family (Brassicaceae): Wild turnip.
Pea family (Fabaceae): Medicks, melilots.
Other dicotyledons: Annual morning glory, common field speedwell, common fumitory, common orache, common purslane, corn buttercup, curled dock, dove's-

foot crane's bill, fiddleneck, ivy-leaved speedwell, knotgrass, knotweeds, mallows, procumbent yellow-sorrel, red deadnettle, ribwort plantain.

Moderately resistant:

Daisy family (Asteraceae): Groundsel, smooth sow-thistle, scentless mayweed.

Other dicotyledons: Black-bindweed, black nightshade, common poppy, cut-leaved crane's bill, common hemp-nettle, knotgrass, pale persicaria, redshank, scarlet pimpernel, viper's-bugloss.

Resistant:

Pteridophytes: Horsetail.

Grasses: Annual meadowgrass, autumn millet, barley, beetle-grass sp., Bermuda-grass, canary-grass, cockspur, drooping brome, fingergrasses, Italian ryegrass, Johnson-grass, rescue brome, ripgut brome, sandburs, stink-grass, volunteer cereals, wild oat, yellow bristlegrass.

Monocotyledons: Galingales.

Daisy family (Asteraceae): Corn marigold, groundsel, pineapple weed, scented mayweed.

Cabbage family (Brassicaceae): Dittander, swine-cresses.

Other dicotyledons: Dodder, field bindweed, field forget-me-not, field pansy, henbit deadnettle.

Livestock withholding period

Treated grass seed crops must not be grazed or cut for fodder. Check the label.

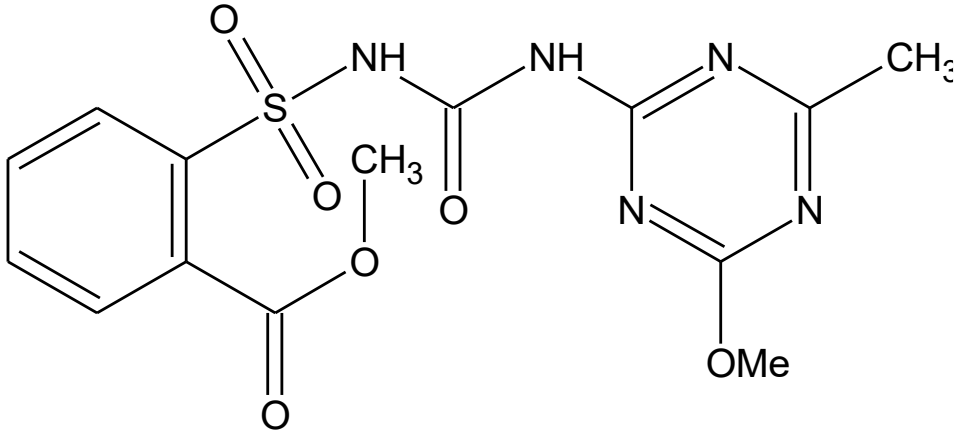
References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) Nufarm UK Ltd, Duplosan KV https://nufarm.com/uk/product/duplosan-kv/ Accessed 13/09/2024
(3) Peer review of the pesticide risk assessment of the active substance mecoprop-P (2017) EFSA journal Volume 15 Issue 5
(4) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm)
(5) Weed Susceptibility Chart, University of California, Co-operative Extension program, D Cudney (2000).

METSULFURON-METHYL

(e.g. ***Jubilee SX,*** soluble granule)

HRAC group 2



SUMMARY

Metsulfuron-methyl is a selective, post emergence, systemic herbicide, available as a straight product or as a mixture with other actives (e.g. thifensulfuron-methyl). It is absorbed by the leaves and roots and translocated to the apex of the plants. Metsulfuron-methyl is water soluble, mobile and only slowly degrades in water sediment systems. Therefore, leaching to watercourses and groundwater is a possibility. Toxicity to fauna is low, but metsulfuron-methyl could be harmful to non-target plants in both terrestrial and aquatic environments. Care should be applied when spraying in the proximity of water bodies, and the spray should be directed to fall at least 5 metres away from the top of the bank.

Application scenarios

Metsulfuron-methyl is registered for the control of broad-leaved weeds on cereal crops and land removed from production. It should be applied to small actively growing weeds. Activity is enhanced when soil is moist; appropriate soil moisture may also improve the control of susceptible plants germinating soon after application[2]. For land temporarily removed from production, application can be made once per year anytime from until the end of July. Application can be by tractor-mounted sprayer.

Fate in Soil

Metsulfuron-methyl is known to be moderately persistent in soil ($DT_{50\ lab}$ from 6.4 to 48.8 days)[3]. Metsulfuron-methyl is water soluble (2.79 g/l at pH7, 25°C)[3] with an increasing solubility as pH values increase. Metsulfuron-methyl is not bound tightly to soil, with Koc values ranging from 4 to 207[3]. Some metabolites, such as triazine amine and saccharin, are persistent in soil. Triazine amine is moderately mobile, while saccharin is very mobile in soil. Consequently, under some circumstances (for applications followed by very wet weather conditions), leaching into groundwater of metsulfuron-methyl and its metabolites may occur.

Fate in Water

Metsulfuron-methyl is susceptible to hydrolysis under acidic conditions (DT_{50} of 22 days at pH5 and 25°C), but stable otherwise[3]. Metsulfuron-methyl is stable to photolysis and non-volatile. Degradation in water-sediment systems is slow ($DT_{50\ whole\ system}$ from 115 to 224.3 days)[3]. Its low log K_{OW} value (-1.87 at pH7)[3] indicates that there is a low bioaccumulation potential in aquatic species.

Effects on Terrestrial Fauna

Generally, Metsulfuron-methyl is regarded as of low mammalian toxicity, with an acute oral LD_{50} in the rat of > 5000 mg/kg bw, dermal LD_{50} in the rat of > 2000 mg/kg bw and an inhalation LC_{50} in the rat of > 6.2 mg/l[3]. It is not an eye irritant, nor a skin irritant nor a sensitizer[3]. Metsulfuron-methyl is non-carcinogenic, non-genotoxic and not a teratogen[3]. The risk to birds is low, with a LD_{50} to mallard duck of > 2510 mg/kg bw. Metsulfuron-methyl is not considered to be dangerous to bees (acute oral LD_{50} > 44.3 µg a.s./bee and contact LD_{50} > 50 µg a.s./bee) and to arthropods[3]. Metsulfuron-methyl is of low toxicity to earthworms (LC_{50} > 1000 mg a.s./kg dry soil)[3].

Effects on Aquatic Fauna

Metsulfuron-methyl has been found to be of low toxicity to fish (LC_{50} of > 110 mg/l). The toxicity to *daphnia* (EC_{50} of > 43.1 mg/l) and algae is moderate, with an E_bC_{50} of 0.113 mg/l to *S. capricornutum*[3].

Effects on Non-Target Plants

Metsulfuron-methyl controls a wide range of broad-leaved weeds. Drift onto broad-leaved plants outside the target area or land intended for cropping should be avoided. Care should be exercised when applying close to natural watercourses or ditches, due to the toxicity to aquatic plants (*Lemna gibba* EC_{50} of 0.36 µg/l[3]).

Efficacy/safety[2]

<u>Important note</u>:

The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. ALWAYS READ THE PRODUCT LABEL.

Target size: Up to 2 expanded true leaves

Susceptible:

Daisy family (Asteraceae): Daisy, Dandelion, Prickly sow-thistle, Scented mayweed, Scentless mayweed, Smooth sow-thistle, Stinking chamomile, Sunflower

Cabbage family (Brassicaceae):

Charlock, Nipplewort, Oilseed rape

Other dicotyledons: Broad-leaved dock, Bugloss, Colt's-foot, Common fiddleneck, Common field speedwell, Common hemp-nettle, Common mouse-ear, Common vetch, Common chickweed, Common poppy, Corn buttercup, Corn chamomile, Corn cockle, Corn marigold, Corn mint, Corn spurrey, Cornflower, Cow parsley, Creeping buttercup, Curled dock, Cut-leaved crane's-bill, Dove's-foot

crane's-bill, Fat hen, Field bean, Field forget-me-not, Field gromwell, Field pansy, Field penny-cress, Flixweed, Fool's parsley, Gallant soldier, Greater plantain, Groundsel, Henbit dead-nettle, Hogweed, Knot-grass, Large-flowered hemp-nettle, Pale persicaria, Parsley-piert, Pea, Pineapple weed, Potatoes, Red dead-nettle, Redshank, Rosebay willow herb, Scarlet pimpernel, Shepherd's-needle, Shepherd's-purse, Silverweed, Small nettle, Spring beauty, Sugar beet, Sun spurge, Venus's-looking-glass, White campion, Wild carrot, Wild mignonette, Wild radish, Yarrow

Moderately susceptible:

Other dicotyledons: Alkanet, black Bindweed, common Orache, field Bindweed

Moderately resistant:

Other dicotyledons: Common fumitory, Field horsetail, Black nightshade, Field scabious, Ivy-leaved speedwell

Livestock withholding period

Normally – treated green cover must not be grazed by livestock. Check the label.

References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024

(2) FMC Agro Jubilee SX, JUBILEE-20SX-GB-240G-BKL-F-01863-23Nov18.pdf (fmc-agro.co.uk) Accessed 13/09/2024

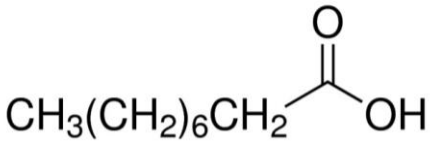
(3) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) Accessed 13/09/2024

(4) Conclusion on the peer review of the pesticide risk assessment of the active substance metsulfuron-methyl (2015) EFSA journal Volume 13 Issue 1

PELARGONIC ACID

(e.g. **Finalsan,** Emulsifiable concentrate**)**

HRAC not classified



Summary

Pelargonic acid is a non-selective, post-emergent, contact herbicide, absorbed by the leaves.

Pelargonic acid is not expected to have adverse effects on non-target organisms or the environment. It is of low to moderate toxicity on non-target organisms, such as birds, fish, and honeybees, revealed little or no toxicity. The chemical decomposes rapidly in both land and water environments, so it does not accumulate. Because pelargonic acid is an herbicide, it could harm non-target plants if pesticide spray drifted beyond the intended target area.

Application scenarios

Pelargonic acid is registered for the control annual and perennial weeds, mosses and algae in amenity grassland and amenity vegetation[1,2]. Pelargonic acid destroys all green plant parts, it is highly toxic to aquatic organisms, do not apply until weeds have established and groundcover has reached 25%[2]. At temperatures below 15°C the herbicide is less effective. Rainfall within less than 12 hours after treatment may impair the effect of the product. Avoid spraying/application within 5 m of important areas to reduce effects on non-target insects or other arthropods. Only apply between 1 May and 1 September.

Grass must not be cut from treated crops for 1 day after treatment. Application can be by tractor-mounted or handheld equipment.

Fate in Soil

No information is available on the route and degradation in soil[4].

Fate in Water

Pelargonic acid readily degrades in water

Effects on Terrestrial Fauna

Pelargonic acid is of low toxicity to mammals, with an acute oral LD_{50} in the rat of > 5000 mg/kg bw, a dermal LD_{50} in the rat of > 2000 mg/kg bw and an inhalation LC_{50} in the rat of >5.29 mg/l[3]. It is a skin and eye irritant[3] and is moderately toxic to bees (LD_{50} of > 25 µg/bee)[3]. It is of low risk to birds and mammals[4].A risk was identified for earthworms and in-field populations of non-target arthropods[4].

Effects on Aquatic Fauna

Pelargonic acid has been found to be of moderate toxicity to fish (LC_{50} of > 59.2 mg a.s../l)[3] and of low toxicity to *Daphnia similis* (EC_{50} of >100 mg a.s../l)[3].

There is no information on its effects on algae. There is a data gap to address the risk to higher aquatic plants[4].

Effects on Non-Target Plants

Application of pelargonic acid will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to avoid such non-target plants. Likewise, drift into natural watercourses close to the application area could also be avoided.

Efficacy/safety[2]

Important note:
The table below is intended only as an indication of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. *ALWAYS READ THE PRODUCT LABEL*.

Susceptible:

Grasses: Echinochloa crus –galli, Poa annua

Other dicotyledons: Chenopodium album, Matricaria chamomilla, Lamium purpurem, Spergula arvensis, Senecio vulgaris, Stellaria media, Galinsoga parviflora

Cabbage family (Brassicaceae): Thlaspi arvense

Livestock withholding period

Normally – at least 7 days and until foliage of poisonous weeds such as ragwort has died and become unpalatable. Check the label.

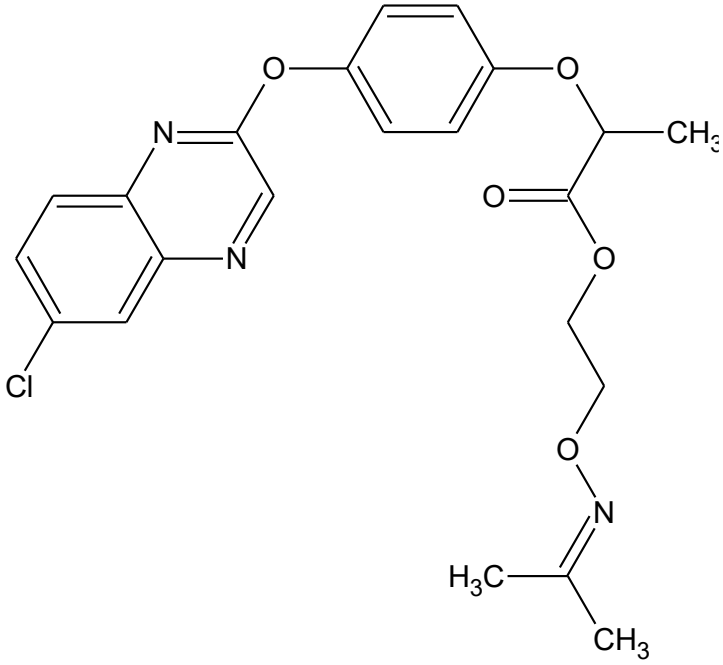
References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) Certis Europe Finalsan label. Untitled-5 (certisbelchim.co.uk) Accessed 13/09/2024
(3) Bio-Pesticide properties database (BPDB) (https://sitem.herts.ac.uk/aeru/bpdb/index.htm) Accessed 13/09/2024
(4) Conclusion on the peer review of the pesticide risk assessment of the active substance Fatty acids C7 to C181 (approved under Regulation (EC) No 1107/2009 as Fatty acids C7 to C20) (2013) EFSA Journal Volume 11, Issue 12

PROPAQUIZAFOP

(e.g. ***Falcon,*** emulsifiable concentrate)

HRAC group 1



SUMMARY

Propaquizafop is a systemic foliar applied herbicide for post-emergence control. Propaquizafop is absorbed by the foliage and roots and translocated throughout the plant. In general, the formulated product is more toxic than the active ingredient. When applied to the soil, propaquizafop is rapidly degraded. Propaquizafop is generally of low toxicity to terrestrial fauna (but not all) but is toxic to aquatic organisms and has a potential to bioaccumulate. Care should be exercised to minimise contamination of the aquatic environment, and to minimise drift into non-target terrestrial areas.

Application scenarios

Propaquizafop is used for the post-emergence control of annual and perennial grass weeds in forest (EAMU)[1,2]. Broad-leaved weeds will not be controlled. Best results are obtained under warm conditions with adequate moisture[2]. Application is as a foliar spray using tractor-mounted equipment, knapsack sprayer or as an overall or band treatment in forestry situations[2].

Fate in Soil

Propaquizafop is rapidly degraded in soil, with DT_{50} lab values less than 3 days, while its main metabolite (quizalofop) is of low to high persistency, having DT_{50} values ranging from 7 to 182 days, with a median of 24.3 days[3]. Degradation of the metabolite is enhanced under light conditions. Propaquizafop has a low water solubility (0.63 mg/l) and is probably not mobile in soil with a calculated K_{OC} of 2220[3].

Considering the low mobility and fast degradation, there is a low risk of contamination of groundwater.

Fate in Water

Propaquizafop is degraded by hydrolysis, with a half-life of 32 days at pH7[3]. The degradation rate increases under acidic and alkaline conditions (10.5 days and 12.9 hours at pH5 and pH9, respectively). The log K_{OW} of 4.78 for propaquizafop suggests possibility of bioaccumulation. The degradation of the active substance is very rapid in water sediment systems (DT50 whole system < 1day).

Effects on Terrestrial Fauna

Propaquizafop is regarded as having low mammalian toxicity, with an acute oral LD_{50} of 5000 mg/kg bw in the rat, a dermal LD_{50} of 2000 mg/kg bw in the rat and an acute LC_{50} inhalation in the rat of > 2500mg/m^3[3]. The toxicity to birds is moderate, with a LC_{50} to mallard duck of > 827 mg/kg bw/day[3]. Propaquizafop is non-irritating to the skin and to the eye but is a skin sensitizer. Propaquizafop has a low toxicity to earthworms (acute LC_{50} >1000 mg a.s../kg[3] but the formulated product is more acutely toxic (LC_{50} of 54.6 mg a.s../kg soil). Propaquizafop is moderately toxic to arthropods, with a low risk to most species, but a potentially high risk to *Aphidius .*

rhopalosiphi. Risk to honeybees is considered to be low (acute oral LD_{50} of > 20 µg/l and acute contact LD_{50} of > 200 µg/l)[3]

Effects on Aquatic Fauna

Propaquizafop has been found to be of moderate toxicity to aquatic species, with fish LC_{50} values of 0.11 mg a.s../l and daphnia LC_{50} of 0.24 mg a.s../l[3]. The EC_{50} of propaquizafop to algae was 0.15 mg a.s../l[3].

The toxicity of the soil metabolites to aquatic organisms was assessed as being generally lower than the active substance, though potentially harmful in some instances[3].

Effects on Non-Target Plants

Propaquizafop is toxic to a wide range of annual and perennial grass and will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Care should be taken to minimise such drift. Likewise, drift into watercourses close to the application area could also result in damage to non-target aquatic plants. Propaquizafop is of moderate toxicity to some aquatic species (EC_{50} *Lemna gibba* of > 1.4 mg a.s../l[3]).

Efficacy/safety[2]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. *ALWAYS READ THE PRODUCT LABEL*.

Susceptible:

Grasses:

0.7 or 1.0 l/ha: Volunteer wheat and barley, black-grass, wild oats, sterile brome
1.0 or 1.2 l/ha: Barley cover crops
1.2 l/ha: Rye grass (from seed)
1.5 l/ha: Common crouch

Livestock withholding period

Normally – none quoted. Check the label.

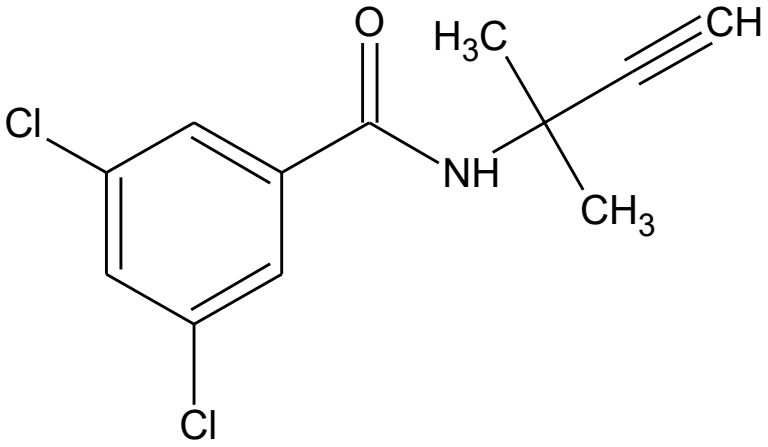
References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) ADAMA, ADAMA Falcon 5L Label Accessed 13/09/2024
(3) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) Accessed 13/09/2024
(4) Conclusion regarding the peer review of the pesticide risk assessment of the active substance propaquizafop (an ester variant of quizalofop-P) (2009) EFSA journal volume 7 Issue 3

PROPYZAMIDE

(e.g. ***Levada*****,** suspension concentrate)

HRAC group 3



SUMMARY

Propyzamide is a selective, systemic, pre- or post-emergent amide herbicide. It is absorbed through the roots and translocated. Propyzamide is of low mammalian toxicity and is expected to constitute a low risk to non-target flora and fauna but is known to be persistent in soil and water. Care should be taken to avoid contamination of water courses.

Application scenarios

Propyzamide is registered for the control of grasses and broad-leaved weeds in amenity vegetation, forest, farm forestry and hedgerow. Applications can be made at any time between the beginning of October and the end of January[2]. Best residual activity is obtained in moist soils of fine tilth and can be applied under frosty conditions[2]. Application can be by tractor-mounted sprayer or knapsack sprayer[2]. It is also available as granules.

Fate in Soil

The mean half-life of propyzamide is 50.5 days in the laboratory[3], but residual herbicide activity is claimed for up to 6 months after application DT_{50} range of 13.9-271.3 days[3]. Propyzamide may be susceptible to degradation in soil through the action of sunlight[3]. Propyzamide is sparingly soluble in water (9.0 mg/L[3]) and tightly bound to soil (K_{OC} values of 548-1340[3]) and is not expected to contaminate groundwater despite its potential soil persistency. However, one of its major soil metabolites is possibly mobile (K_{OC} range of 96-210)[3].

Fate in Water

Propyzamide is hydrolytically stable but may be susceptible to degradation in water through the action of sunlight (DT_{50} of 41 days)[3]. However, propyzamide may be persistent in water (DT_{50} in river water-sediment system of 94 days[3]). Propyzamide has a relatively high log K_{OW} value (3.27[3]) and, therefore, has a slight potential to bioaccumulate.

Effects on Terrestrial Fauna

Propyzamide has only slight mammalian toxicity[3]. It has an acute oral LD_{50} in the rat of >5000 mg/kg bw[3,] and a dermal LD_{50} of >2000mg/kg. The inhalation LC_{50} was >2.1 mg/l[4] in the rat. It is a mild skin irritant but is not irritating to the eye[3]. Propyzamide is of low toxicity to birds (LD_{50} for quail >6578 mg/kg bw)[3], and non-toxic to bees (LD_{50} >136 µg/bee[4]). Toxicity to earthworms is low (LC_{50} >173 mg/kg)[3].

Effects on Aquatic Fauna

Propyzamide may be moderately toxic to fish ($LC_{50\ 96hour}$ trout >4.7 mg/l)[3] and to daphnia (LC_{50} >5.6 mg/l[4]) but the low water solubility made testing difficult. Propyzamide is moderately toxic to algae (EC_{50} of 2.8 mg/l for *Selenastrum capricornutum*[3]). Care should be taken not to contaminate water courses.

Effects on Non-Target Plants

Application of propyzamide will pose a risk to susceptible plants outside of the target area, where spray drift is possible. Likewise, contamination of natural watercourses close to the application area could also result in damage to non-target aquatic plants (EC_{50} for *Lemna sp.* of 1.4 mg/l[3]).

Efficacy/safety[2,5]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. ALWAYS READ THE PRODUCT LABEL.

Susceptible:

Grasses: Annual meadow-grass, autumn millet, barren brome, beetle-grass, black-grass (seedlings), canary-grass, cockspur, common bent, common couch, creeping soft-grass (seedlings), downy brome, hairy finger-grass, rescue grass, great brome, volunteer cereals, yard-grass, yellow bristle-grass, love-grass, rye-grass, sweet vernal, grass, tufted hair-grass, wild oat, Yorkshire fog.

Daisy family (Asteraceae): Tansy.

Cabbage family (Brassicaceae): London rocket, mustard.

Other dicotyledons: Black bindweed, black nightshade, common chickweed, common nettle, creeping buttercup, fat-hen, fiddleneck, goosefoot, henbit, knotgrass, Japanese-lantern, leafy-fruited nightshade, pigweed, purslane, redshank, small nettle, speedwells, summer-cypress.

Moderately susceptible:

Pteridophytes: Field horsetail.

Grasses: Black-grass (established), creeping soft-grass, (established), **Other monocotyledons:** Sedges.

Cabbage family (Brassicaceae): Shepherd's purse (seedlings), wild radish.

Other dicotyledons: Broad-leaved dock, common, fumitory (seedlings), creeping buttercup, dodder, mallow, prostrate spurge, sheep's sorrel.

Moderately resistant:

Grasses: Cock's-foot (established).

Dicotyledons: Cleavers (seedlings).

Resistant:

Pteridophytes: Horsetails.

Monocotyledons: Purple nutsedge, yellow nutsedge.

Daisy family (Asteraceae): Argentine fleabane, Canadian fleabane, cocklebur, creeping thistle, cudweed, dandelion, gallant-soldier, groundsel, mayweed, prickly lettuce, ragwort, sow-thistle, sunflower, yellow star-thistle.

Cabbage family (Brassicaceae): Dittander, shepherd's, purse (established), swine cress.

Other dicotyledons: Bindweed, Thornapples, cleavers, (established), clover, common nettle, common fumitory, (established), common poppy, stork's bill, foxglove, hemp-nettle, plantains, red deadnettle, rosebay, willowherb, scarlet pimpernel.

Livestock withholding period

None quoted. Check the label.

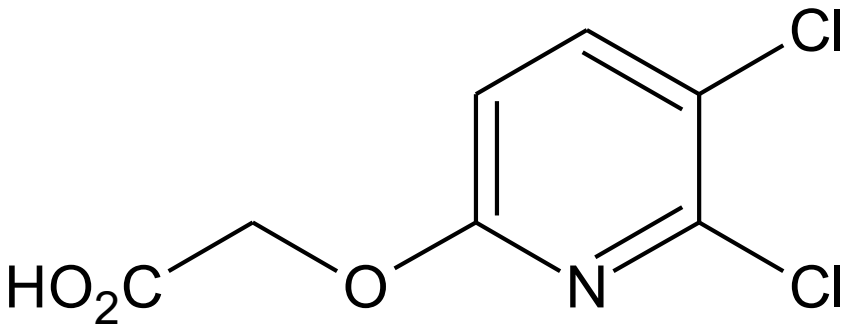
References

(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm Accessed 13/09/2024
(2) Certis, Levada_Label.pdf (certisbelchim.co.uk)Accessed 13/09/2024
(3) Peer review of the pesticide risk assessment of the active substance propyzamide (2016) EFSA journal volume 14 issue 8
(4) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) Accessed 13/09/2024
(5) Weed Susceptibility Chart, University of California, Co-operative Extension program, D Cudney (2000).

TRICLOPYR

(e.g. **Blaster Pro;** emulsifiable concentrate, mixture with clopyralid)

HRAC group 4



Summary

Triclopyr is a selective, systemic, pyridine herbicide. It is rapidly absorbed by the foliage and roots and translocated throughout the plant. Triclopyr is available as a straight product. It is present as a salt or ester in products, both of which rapidly transform to the acid, in environmental compartments. Triclopyr is water soluble and moderately persistent in soil and constitutes a slight risk to groundwater. Its main soil metabolite is more persistent, and mobile, and the risk of groundwater contamination is greater. Generally, triclopyr has low toxicity to mammals and other wildlife; but its derivatives and main metabolite are moderately toxic to aquatic fauna. Given its mobility in soil, triclopyr-derivatives should not be applied to areas from which they can move into surface waters or areas where non-target plants would be affected (e.g. on slopes, and near to watercourses).

Application Scenarios

Triclopyr is registered for the control of perennial broadleaved weeds, brambles, docks, scrub, common nettle and woody weeds, on amenity grassland, and grassland. It can also be used to control unwanted standing coppice or scrub and for the prevention of shoot growth on cut stumps. For non-crop grass areas treatment should be in the summer[2]. For the control of tree shoots, application is best in the winter[2]. Tree stem treatments (basal bark spray, frill girdling and tree injection) are best carried out in late summer[2]. Treatments can be made either by tractor-mounted spray systems or knapsack and other hand-held sprayers, and also by tree stem treatment methods. Do not allow direct spray from horizontal boom sprayers to fall within 5 metres of the top of the bank of a waterbody or within 1 metre of the top of a ditch which is dry at the time of application. Do not allow direct spray from hand-held sprayers to fall within 1 metre of the top of the bank of a waterbody[2].

Fate in Soil

Triclopyr-derivatives (salts and esters) very rapidly convert/hydrolyse to the acid, with DT_{50} values of <3 day[3]. The acid is degraded under aerobic conditions moderately quickly (DT_{50} values between 8.11-53.1 days under laboratory conditions[3]), but the main soil metabolite is more persistent. Under anaerobic conditions the acid is much more persistent (DT_{50} values >365 days[3]). The acid is water soluble (8.1 g/l at pH7) and is only moderately tightly bound to soil (K_{OC} values ranging from 35.84 to

80.22)[3]. The main soil metabolite is more mobile. Consequently, movement of the acid to groundwater must be considered as possible, and that of the metabolite as reasonably likely. Furthermore, there is also a risk of movement of triclopyr and the metabolite to surface water via runoff and drainage.

Fate in Water

Triclopyr-derivatives convert/degrade very rapidly to the acid in water environments (DT_{50} values <1 day)[3]. The acid is degraded rapidly through the action of sunlight DT_{50} 0.1 days[3]. As triclopyr acid, and its metabolite, have low Log K_{OW} values (-0.45 at pH7 for the acid)[3], there is a low risk of bioaccumulation.

Effects on Terrestrial Fauna

Generally, triclopyr and its derivatives are of low mammalian toxicity with oral LD_{50} values in the rat of 630 mg/kg bw for triclopyr[3] and inhalation LC_{50} in the rat of >4.8 mg/L for the ester[3]. However, the acid is an eye irritant, and both the acid and ester are skin sensitisers[3]. Triclopyr and derivatives are of low toxicity to birds (oral LD_{50} for ducks 1698 mg/kg bw[3]) and is non-toxic to bees (oral LD_{50} >100 µg/bee[4]).

Effects on Aquatic Fauna

Although the triclopyr acid is non-toxic to fish ($LC_{50\ 96\ hours}$ 117 mg/l)[3], and non-toxic to Daphnia (LC_{50} >132.9 mg/l)[3], the ester and metabolite are moderately toxic to both fish and Daphnia (LC_{50} for fish 0.31 mg/l, and for Daphnia 0.66 mg/l for the ester)[3]. Likewise, triclopyr acid is less toxic to algae (EC_{50} 181.1 mg/l)[3], than the derivatives (EC_{50} for the ester 0.193 mg/l)[3].

Effects on Non-Target Plants

When applying triclopyr, because of its persistence and mobility, it is important that spray drift is not permitted to contaminate crop land or irrigation water, or to drift onto or within the root zone of susceptible non-target plants. Sitka spruce, Norway pine, Douglas fir, Larch and other conifers are susceptible to damage when not completely dormant. Aquatic plants are also susceptible to triclopyr (e.g. *Lemna gibba* EC_{50} 2.2 mg/L for the ester)[3].

Efficacy/safety[2,5]

<u>Important note</u>:
The table below is intended only as an <u>indication</u> of relative species' sensitivities to this herbicide. The information used was not necessarily based upon objective, scientific data. DO NOT ASSUME THAT A NON-TARGET SPECIES WILL BE SAFE FROM DAMAGE, JUST BECAUSE THIS TABLE LISTS IT AS 'RESISTANT'. ALWAYS READ THE PRODUCT LABEL.

Susceptible:

Trees & shrubs: Alders, apple, ash, beech, birches, blackthorn, box, briar, broom, buckthorn, dogwood, elder, elms, false acacia, field maple, gorse, hawthorn, hazel, hornbeam, horse chestnut, laurel, lilac, limes, oaks, pear, poplars, privet, rhododendron, rock-roses, rosemary, rowan, St Lucie Cherry, sweet chestnut, sycamore, wild cherry, wild pear, willows.

Daisy family (Asteraceae): Canadian fleabane, dandelion, goldenrod, groundsel, mouse-ear hawkweed, prickly lettuce, smooth sow-thistle, sunflower.

Cabbage family (Brassicaceae): Cabbage/rape, garden radish, London-rocket, shepherd's purse.

Pea family (Fabaceae): Medicks, melilots.

Other dicotyledons: Amaranths, black nightshade, bramble, common chickweed, cross-leaved heath, curled dock (seedlings), fat-hen, field bindweed (seedlings), ground-elder, Japanese-lantern, heather, honeysuckle, leafy-fruited nightshade, nettles, nettle-leaved goosefoot, perforate St John's-wort, primrose, procumbent yellow-sorrel, rosebay willowherb, tormentil, violets, wild strawberry.

Moderately susceptible:

Trees & shrubs: Cornelian-cherry, ever-green oak, Midland hawthorn, wayfaring tree.

Daisy family (Asteraceae): Yellow star-thistle.

Other dicotyledons: Curled dock (established), field bindweed, old man's beard, ribwort plantain, stork's-bills.

Resistant:

Pteridophytes: Horsetails.

Grasses: Annual meadow-grass, autumn millet, beetle-grass sp., barley, Bermuda-grass, canary-grass, cockspur, common bent, drooping brome, false oat-grass, finger-grasses, Italian rye-grass, Johnson-grass, rescue brome, ripgut brome, sheep's fescue, smooth meadow-grass, sandburs, stink-grass, volunteer cereals, wild oat, yard-grass, yellow bristle-grass, Yorkshire-fog.

Other monocotyledons: Field woodrush, galingales.

Daisy family (Asteraceae): Smooth hawk's-beard.

Cabbage family (Brassicaceae): Dittander.

Other dicotyledons: Dodder, mallows, sheep's sorrel.

Livestock withholding period

Normally – at least 7 days and until foliage of poisonous weeds such as ragwort has died and become unpalatable[2]. Check the label.

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(1) Pesticide Register databases https://www.hse.gov.uk/pesticides/databases/index.htm. Accessed 13/09/2024
(2) Corteva Agrisciences Blaster Pro product label Accessed 13/09/2024
(3) Conclusion regarding the peer review of the pesticide risk assessment of the active substance triclopyr (2006) EFSA journal Volume 4 Issue 1
(4) Pesticide properties database (PPDB) (https://sitem.herts.ac.uk/aeru/ppdb/en/index.htm) Accessed 13/09/2024
(5) Weed Susceptibility Chart, University of California, Co-operative Extension program, D Cudney (2000).

6. Effects on non-target species

6.1. Direct effects

The pesticide registration process includes a requirement for detailed studies of the direct effects on non-target organisms. Published data are available on the safety of registered pesticides to a number of standard test organisms, including terrestrial vertebrates, invertebrates and aquatic species. Data for older pesticides will include evidence of their toxicity to bees, but the introduction of EC Directive 91/414 required that tests must include additional invertebrate groups. Toxicological testing now includes consideration of non-target arthropods (parasitic wasps, predatory mites, ground beetles, rove beetles, spiders, ladybirds and lacewings. Other soil dwelling arthropods such as springtails and soil mites may also be tested under certain circumstances)

6.2. Indirect effects

The use of many herbicides, such as glyphosate, will have much more significant indirect effects on invertebrate populations, through the removal of the vegetation that provides food and shelter. These indirect effects must also be considered when a risk assessment is completed in advance of any herbicide application. Breeze *et al* (1999) have summarised the ways in which herbicides can indirectly affect different animal groups:

6.2.1. Invertebrates

The removal of important nectar and pollen plants or removal of important food plants for herbivores can have an indirect adverse effect on many invertebrate populations. Breeze *et al* (1999) reviewed the importance of UK plant species and summarised:

- The carrot (Apiaceae) and daisy (Asteraceae) families attract the greatest diversity of nectar and/or pollen feeding insects. Hawthorn (and other Rosaceae), various species of the pea (Fabaceae), deadnettle (Lamiaceae) and figwort (Scrophulariaceae), are also very valuable sources.
- Species identified as being among the most important ‘direct’ food plants for invertebrates were hazel, hawthorn, cornflower, foxglove, bush vetch, welted thistle, hogweed, bird’s-foot trefoil, dandelion and white clover.
- Hazel, hawthorn, common nettle, bird’s-foot trefoil and white clover were considered to have the greatest ‘indirect’ food value.
- Alteration of the vegetation structure or destruction of vegetative cover can have particularly serious consequences for over-winter survival. For example, many predatory ground and rove beetles are strongly associated with shrubby cover or tussocky grasses (e.g. cock’s-foot).

6.2.2. Birds

The indirect effects on birds of herbicide use Breeze *et al* (1999) report can include:

- Reduced availability of invertebrate or vertebrate prey for insectivores and raptors.
- Negative impacts on thrushes and waders where herbicides have a relatively high toxicity to earthworms and other soil-dwelling invertebrates.
- Reduced availability of invertebrates for adult birds to feed to their young during spring and early summer.
- Removal of important food plants, such as species of the knotweed (Polygonaceae), goosefoot (Chenopodiaceae), pink (Caryophyllaceae), cabbage (Brassicaceae), rose (Rosaceae), pea (Fabaceae), daisy (Asteraceae) and grass (Poaceae) families. The individual species considered to have the greatest value as 'direct' food plants for birds were hawthorn, cornflower, fat-hen, corn marigold, knotgrass, garlic mustard, bush vetch, welted thistle, creeping thistle, ox-eye daisy, bird's-foot trefoil, ragged robin, dandelion, white clover, common vetch, creeping bent, false brome, cock's-foot and red fescue.
- Those species of most value as 'indirect' food plants were thought to be hazel and hawthorn. These two species were also considered to be the two most valuable providers of bird nesting sites.
- Destruction of nesting habitat, e.g. loss of shrubby cover or tussocky plant communities.

6.2.3. Mammals

The indirect effects of herbicide use on mammals Breeze *et al* (1999) report can include:

- Reduced availability of invertebrate prey for insectivores, such as shrews, hedgehogs and bats.
- Herbicides that have a relatively high toxicity to earthworms and other soil-dwelling invertebrates may have negative impacts on moles and common shrews.
- Removal of important food plants, such as hawthorn, hazel, bramble (for wood mice, bank voles and common dormice) and grasses such as cock's-foot, fescues and false brome (for field voles).
- Common nettle and ragged robin were also considered to be very important food plants for mammal species.
- Destruction of nesting habitat, e.g. loss of shrubby cover or tussocky plant communities. Hazel and cock's-foot are both very important species in this regard.

6.3. Ecological effects - additional information

6.3.1. Impacts of herbicides on non-target plants and animals

Herbicides often play a vital part in the control of invasive species such as giant hogweed, but it is important to look at the effect of herbicides on the environment and on non-target plants (Marshall 2001). Non-target plants can receive doses of herbicide through drift, vapour movement, leaching and erosion.

Marshall (2001) reviewed the effects of herbicides on non-target plants. Direct effects can include death, damage, reduced flowering or sometimes enhanced growth. Marrs *et al* (1989b) assessed the effect of herbicide spray drift on various botanically important plant species. They surmised that the risk of damage depended on the amount of herbicide used and the likelihood of drift during application. They tested five herbicides – MCPA, mecoprop, asulam, glyphosate and chlorsulfuron + metsulfuron. (Asulam is not approved for use; chlorsulfuron is not approved but herbicides in the same Herbicide Resistance Action Committee (HRAC) mode of action group (2) are still approved for use). They found that most of the severe effects (i.e. severe growth inhibition and death) were confined to a short distance from the sprayer. More damaged plants were found after the spring treatments compared to the autumn ones and, although damage effects were seen at a greater distance than severe effects, most of the affected plants recovered. These results suggested to Marrs *et al* that buffer zones around nature reserves could be quite narrow – between 5 and 10 m wide. This would, however, be heavily dependent upon the sensitivity of the vegetation within the reserve.

Boutin *et al* (2013) looked at the effect of herbicide drift from a range of herbicides from arable fields onto non-target plants. Herbicides caused delays in flowering and reduction in seed production.

Fluazifop-p-butyl used for the control of grass weeds in field margins caused reductions in seedling emergence and increased levels of phytotoxicity on wildflower and grass species. These effects were only temporary, (Blake *et al*, 2011).

McMullin *et al* (2012) noted that triclopyr and glyphosate reduced the abundance of 40% and 56% of lichen species respectively. They divided lichens into tolerance classes based on their response to the herbicides.

The impacts of herbicide drift on non-target plant species is considered in detail by Breeze *et al* (1999). Pesticide buffer zones were also reviewed by Burn (2003).

6.3.2. Moorlands

Milligan *et al*, (2003) evaluated a range of graminicides (cycloxydim, quizalafop-ethyl and propaquizafop) against glyphosate in a *Molinia* and *Calluna* dominated grassland. Propaquizafop and quizalofop-ethyl gave a short-term check to Molinia and another, cycloxydim, provided a reduction for at least 1 year, but this effect disappeared after 3 years. Damage to Calluna was less than that caused by glyphosate and the selective herbicides had little effect on other moorland species present (*D. flexuosa, Empetrum nigrum, Eriophorum vaginatum or Vaccinium myrtillus*.).

6.3.3. Woodlands

Watt *et al* (1988) examined the effects of a range of herbicides on a woodland ground flora. Of those herbicides still available, only glyphosate (at high application rates) had any significant effect on vegetation cover or height and on amount of bare ground. The number of species per square metre was not significantly affected by any of the herbicides. A reduction in flowering could have implications for a plant's seed bank and for insects that survive on it, but in this experiment, only Yorkshire fog was affected in this way. Whitehouse & Brown (1993) looked at the effects of glyphosate and propyzamide on non-target insects in farm forestry. They found no

significant effects of these two herbicides on mortality of chafer larvae or adult carabid beetles, so they concluded that they were non-toxic, at least to the various herbivorous and predatory species tested.

6.4. Herbicide choice to reduce damage to non-target species

In nature reserves, it is particularly important to consider the effects of pesticides on non-target plants, so choice of herbicide is important, as is the application method.

Carter (1990) suggested that 'selective' herbicides such as MCPA and 2,4-D can be used in situations where spray drift into neighbouring areas could otherwise cause problems. However, the drift of MCPA or 2,4-D onto sensitive plant communities is still likely to cause unacceptable damage.

Currently, there are several, much more selective, herbicides available that will greatly reduce the chances of damage to non-target plants. These include specific graminicides, such as fluazifop-p-butyl as Fusilade Max and clopyralid as (Dow Shield 400), the latter of which is principally active against plants of the daisy (Asteraceae) and pea (Fabaceae) families.

Fluazifop-p-butyl as Fusilade Max is recommended for use in farm forestry and green cover on land not being used for crop production to control barren brome, black-grass and wild-oats (Nufarm, 2019). It is safe to annual and perennial dicotyledonous species and a range of Festuca species, but it can reduce the frequency of a number of non-target grasses. The following species are known to be resistant to the herbicide at rates between 1 and 1.5 l/ha:

- Crested Dogstail (*Cynosurus cristatus*)
- Sheeps Fescue (*Festuca ovina*)
- Hard Fescue (*Festuca longifolia*)
- Chewings Fescue (*Festuca rubra spp commutata*)
- Red Fescue (*Festuca rubra spp purinsoa*)
- Fine-leaved Sheep's Fescue (*Festuca tenuifolia*)
- Annual Meadowgrass (*Poa annua*)

Propyzamide controls established grasses among dicotyledonous plants but must be applied in winter. Putwain *et al* (1991) looked at seedlings are sensitive to competition from grassland vegetation, a substantial area around their bases needs to be kept weed-free. Propyzamide applications the role of herbicides in establishing amenity woodland by direct seeding. Since tree allow some ground cover to survive (annual plants and herbaceous perennials) but suppress competitive grasses. They found that using propyzamide enhanced tree populations, allowing a smaller quantity of tree seed to be sown initially. The more diverse flora of the plots provided a more suitable habitat for many wildlife species such as butterflies.

6.5. Application methods to reduce risks to non-target species

If herbicide use is considered essential – and alternatives must always be considered first – then the method of application is very important. Weed-wipers can be used to

apply herbicides to ragwort, docks and thistles, to avoid damaging low-growing desirable plants.

For scrub control, (including rhododendron), a combination of cutting and herbicide application is frequently necessary.

The main advantages of direct application methods (e.g. weed-wiping, stump treatment, glyphosate plugs, stem injection) are that they are more precise, cause minimal crop damage, logistical problems are reduced and there is no herbicide drift (Lane, 1984). For example, direct application of glyphosate gives adequate vegetation control and is a more environmentally safe way to apply the herbicide.

Herbicide applications can also be timed to have maximum effect against target species, whilst posing minimum risk to non-target species. For example, winter sprays might safely and effectively remove a problematic, evergreen perennial whilst otherwise highly sensitive, non-target species are dormant. Sadly, such convenient options are not always available, as many herbicides are only effective when applied to actively growing target plants.

Skuterud *et al* (1998) took the question of the importance of application timing to another level. Their research found that sprays applied in the morning were more effective (in terms of reducing weed numbers and weight) than evening sprays, mainly due to relative humidity.

6.6. Key references/further reading

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No 20. Information sheet: Sparganium rectum Branched bur-Reed https://www.researchgate.net/publication/234111358_CEH_Information_Sheet_20_sparganium_erectum Accessed 18/09/2024

Information sheet . 6 Control of Fringed Waterlily (*Nymphoides peltata*) https://www.researchgate.net/publication/234111297_6_Fringed_Water_Lily Accessed 18/09/2024

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Information sheet. 10 Control of Spiked Water-milfoil (*Myriophyllum spicatum*)
https://www.researchgate.net/publication/234111300_CEH_Information_Sheet_8_Myriophyllum_spicatum Accessed 18/09/2024

Information sheet. 12 Curled Pondweed (*Potamogeton crispus*)
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Information sheet 15 Poison Hemlock (*Conium maculatum*)
https://www.researchgate.net/publication/234111343_Centre_for_Aquatic_Plant_Management_Information_Sheet_15_Poison-Hemlock Accessed 18/09/2024

Information sheet *19. Sparganium emersum* (Unbranched Bur-Reed)
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Information sheet. 27 Ragwort (*Senecio jacobea*)

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Information sheet. 18 *Berula erecta* (Water Parsnip)

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Information sheet 16. Control of Duckweeds (*Lemna* species)

https://www.researchgate.net/publication/234111348_CEH_Information_Sheet_16_Duckweeds Accessed 18/09/2024

Information sheet. 29 Control of Horsetails (*Equisetum* species)

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GLOSSARY

Acropetal translocation. Movement of materials (e.g., pesticides) within the plant towards the apex or shoot tips, usually upward from the roots.
Adjuvant. A substance other than water which enhances the effectiveness of a pesticide with which it is mixed. Although not classed as pesticides themselves, only currently authorised adjuvants may be legally used.
a.i. Active ingredient.
Alien species. Any non-native plant or animal introduced into Britain. Includes invasive species such as Japanese knotweed, Indian balsam and Rhododendron ponticum.
Allelopathic. Plant species capable of producing chemicals which inhibit the growth of one or more other species.
Amenity grassland. An area of semi-natural or planted grassland subject to minimal management.
Amenity vegetation. Any area of semi-natural or ornamental vegetation, including trees. Includes areas of grassland or turf and areas to which the public have access.
Apoplastic. Pathway of water movement from the soil solution, through the root cortex, towards the central cylinder via the free space between cells (apoplasm).
Around. When used in the context of an approval for use, in a certain specified situation, it implies that a herbicide may be used within the immediate vicinity of a crop or crop plant but excluding any direct application to the crop. Includes treatment of crop margins, around the base of trees, inter-row treatments, etc.
'**Authorisation' Directive.** European Council Directive 91/414/EEC. Introduced in July 1993, this Directive is the means by which the EC intends to ensure harmonisation of national arrangements for the authorisation of plant protection products.
Basipetal translocation. Movement of materials (eg pesticides) within the plant away from the apex or shoot tips, usually downward from shoots and leaves toward the roots.
BASIS. British Agrochemical Standards Inspection Scheme or BASIS (Registration) Ltd, who implement the officially recognised schemes for the certification of those who sell pesticides or provide technical advise to pesticide users.
Buffer strip. A legally binding strip of land of a minimum specified width adjacent to any water body (measured from the top of the bank, rather than the water's edge) which must be left unsprayed.
Carcinogen. A substance (eg pesticide) or agent producing or inciting cancer.
CDA. Controlled droplet application.
Certificate of competence. Official documentation required by those who sell pesticides and by most spray operators, to demonstrate an acceptable level of knowledge and/or practical skill in relevant areas.
Chlorosis. Blanching of the green parts of a plant.
COPR. Control of Pesticides Regulations 1986. An important part of the UK pesticides legislation made under the Food and Environment Protection Act 1985 (FEPA). These Regulations lay down the Approvals required before any pesticide may be sold, stored, supplied, advertised or used.
COSHH. Control of Substances Hazardous to Health Regulations 1988 and 1994. An important part of the UK pesticides legislation. Regulations made under the Health and Safety at Work Act 1974 apply to virtually all substances hazardous to health,

including those pesticides classed as Very toxic, Toxic, Harmful, Irritant or Corrosive. Require risk assessments and appropriate measures to reduce risks.
CRD. Chemicals Regulation Division. Executive Agency of HSE responsible for the regulation of chemicals and provision of advice to the UK Government on chemicals (including pesticides) policy.
Defra. Department for Environment, Food and Rural Affairs. Includes the former Ministry of Agriculture, Fisheries and Food. Responsibilities include pesticides policy and regulation, through PSD.
EAMU. Extension of authorisation for a minor use. Allows the legal use of particular pesticides on specified crops, and/or in specified situations, that are outside those stated on the product label. Conditions for use are given in a Notice of Approval, which must be obtained and strictly complied with. Formerly known as 'Specific Off-Label Approval.
Enantiomer. Either of a pair of chemical compounds, whose molecular structures have a mirror-image relationship to each other.
Enclosed waters. Any natural or artificial body of water that does not drain to a water course.
Epinasty. More rapid growth on the upper side of an organ (eg a leaf, resulting in downward curling of the leaf blade).
Farm forestry. Groups of trees established on arable land or improved grassland, including those planted for short rotation coppicing.
FEPA. Food and Environment Protection Act 1985. An important part of the UK pesticides legislation.
Forest. Groups of trees being grown in their final positions. Includes all woodland grown for whatever objective, including commercial timber production, amenity and recreation, conservation or landscaping, ancient traditional coppice and farm forestry. Includes restocking of established woodland and new planting on both improved and unimproved land.
Genotoxic. Damaging to cellular DNA. 7 12 Herbicide. Any chemical approved specifically for the purpose of killing or controlling the growth of any weed or other target plant species.
HSE. Health and Safety Executive.
Industrial use. Crops that will not be used directly or after processing for human or animal consumption.
kg ha. Kilograms per hectare. (One kilogram is a thousand grams).
Knapsack sprayer. Hand-held sprayer, with a plastic tank (carried on the spray operator's back) pressurised by a hand- or battery-operated pump.
LERAPs. Local Environmental Risk Assessments for Pesticides. A risk assessment procedure for pesticide users, that allows the possibility of reduced buffer zone widths. LERAPs provide a mechanism for taking into account other factors that may reduce the risks to watercourses, eg dose reduction, use of low drift spray nozzles and whether watercourse is dry or flowing.
MBPR. Member of the BASIS Professional Register.
Metabolite. Derivitive substances produced as a result of chemical processes within an organism or environment.
mg l^{-1}. Milligrams per litre. (One milligram is a thousandth of a gram).
Necrosis. Death of parts of a plant.
NPTC. National Proficiency Test Council who implement the officially recognised schemes for the certification of those who use pesticides.

Off-label approval. Legal approval for a pesticide to be used in situations other than those specified on the product label. Off-label approvals can be either under Emergency Authorisation or through a 'Extension of authorisation for a minor use EAMU'
Open waters. Any natural or artificial body of water that drains to a watercourse or is used as a reservoir for domestic water supplies.
Permanent grassland. Grazed areas that are intended to be permanent in nature. Includes permanent pasture and marginal land such as moorland that can be grazed; can be less intensively managed and floristically rich.
Pesticide. Any chemical approved for the purpose of killing or controlling the growth of any weed, disease or pest species. Includes wood preservatives, plant growth regulators, insecticides, fungicides and herbicides. Does not include adjuvants.
Phloem. Vascular tissue that conducts synthesised foods (eg sugars, proteins and some mineral ions) through the plant.
PPE. Personal Protective Equipment, eg spray suits, gloves and respirators that might be required to be worn whilst handling pesticides and during spraying operations.
PPPR. Plant Protection Products Regulations 2011. This Regulations implement Regulation (EC) No 1107/2009 into British law. It offers regulation and control of plant protection products (basically agricultural pesticides) in the same way as COPR.
PROMPT. Professional Register of Managers and Pest Technicians.
Rotational grass. Short-term grass crops (leys) grown on land that is likely to be growing different crops in future years. Normally short-term leys, intensively managed, that are under grass for one to three years (then in an arable crop in other years).
Single active product. Chemicals containing one herbicide, as opposed to mixtures of active ingredients.
Stubble. Remains of combinable crops after harvesting.
Symplastic. Pathway of water movement from the soil solution, through the root cortex, towards the central cylinder via the cell cytoplasm (apoplasm).
Systemic. Affecting the entire plant.
Teratogen. A substance (eg pesticide) that causes malformation in embryos.
True-leaves. The first leaves produced by a plant after the cotyledon (primary) leaf/leaves.
Weed-wiper. Herbicide application equipment which uses a herbicide-soaked wipe-head, that draws chemical from an integral reservoir. The wipe-head is drawn over, or wiped against, target weed plants – directly applying herbicide to stems and foliage.
Xylem. Vascular tissue that conducts water and mineral salts, taken in by roots, through the plant and provides it with mechanical support.
µg. Micrograms.

APPENDIX 1: POTENTIAL TARGET SPECIES

Species identified as posing weed problems on nature conservation sites in the UK

Common name	Species	Family	Native?	Habitat(s)
Algae, Green	*Enteromorphora* spp.	Ulvaceae	YES	Aquatic
Ash	*Fraxinus excelsior*	Oleaceae	YES	Grassland
Aspen	*Populus tremula*	Salicaceae	YES	Wet grassland, fens
Birch, Downy	*Betula pubescens*	Betulaceae	YES	Wet grassland, fens
Birch, Silver	*Betula pendula*	Betulaceae	YES	Woodland, grassland, peatland
Blackthorn	*Prunus spinosa*	Rosaceae	YES	Grassland
Bracken	*Pteridium aquilinum*	Dennstaedtiaceae	YES	Woodland, grassland, heath, peatland
Bramble	*Rubus* subg. *Rubus*	Rosaceae	YES	Woodland
Broom	*Cytisus scoparius*	Fabaceae	YES	Grassland, heathland
Burnet rose	*Rosa pimpinellifolia*	Rosaceae	YES	Grassland
Buttercups	*Ranunculus* spp.	Ranunculaceae	YES	Grassland
Butterfly-bush	*Buddleja davidii*	Buddlejaceae	NO	Grassland
butterfly-bush, Alternate-leaved	*Buddleja alternifolia*	Buddlejaceae	NO	Grassland
Cleavers	*Galium aparine*	Rubiaceae	YES	Grassland
Common cordgrass	*Spartina anglica*	Poaceae	YES	Coastal (tidal mudflats)
Common fiddleneck	*Amsinckia micrantha*	Boraginaceae	NO	Arable field margins
Cotoneaster, Himalayan	*Cotoneaster simonsii*	Rosaceae	NO	Grassland
Cotoneaster, Small-leaved	*Cotoneaster integrifolius*	Rosaceae	NO	Grassland
Cotoneaster, Wall	*Cotoneaster horizontalis*	Rosaceae	NO	Grassland
Cow parsley	*Anthriscus sylvestris*	Apiaceae	YES	Grassland
Creeping thistle	*Cirsium arvense*	Asteraceae	YES	Grassland
Dock, Broad-leaved	*Rumex obtusifolius*	Polygonaceae	YES	Grassland
Dock, Curled	*Rumex crispus*	Polygonaceae	YES	Grassland
Dogwood	*Cornus sanguinea*	Cornaceae	YES	Grassland
Duckweeds	*Lemna* spp.	Lemnaceae	YES	Aquatic
Elder	*Sambucus nigra*	Caprifoliaceae	YES	Grassland

Common name	Species	Family	Native?	Habitat(s)
Field horsetail	*Equisetum arvense*	Equisetaceae	YES	Grassland, etc.
Floating pennywort	*Hydrocotyle ranunculoides*	Apiaceae	NO	Aquatic
Foxglove	*Digitalis purpurea*	Scrophulariaceae	YES	Grassland
Giant hogweed	*Heracleum mantegazzianum*	Apiaceae	NO	Riparian
Giant salvinia, Kariba weed	*Salvinia molesta*	Salviniaceae	NO	Aquatic
Goat's rue	*Galega officinalis*	Fabaceae	NO	Grassland
Gorse	*Ulex europaeus*	Fabaceae	YES	Grassland & heaths
Ground-elder	*Aegopodium podagraria*	Apiaceae	NO	Various
Hawthorn	*Crataegus monogyna*	Rosaceae	YES	Grassland
Hazel	*Corylus avellana*	Betulaceae	YES	Grassland
Hemlock water-dropwort	*Oenanthe crocata*	Apiaceae	YES	Wet grassland, fens
Hybrid knotweed	*Fallopia japonica* x *sachalinensis*	Polygonaceae	NO	Riparian, woodland, etc
Indian (Himalayan) balsam	*Impatiens glandulifera*	Balsaminaceae	NO	Riparian
Knotweed, Giant	*Fallopia sachalinensis*	Polygonaceae	NO	Riparian, woodland, etc
Knotweed, Japanese	*Fallopia japonica*	Polygonaceae	NO	Riparian, woodland, etc
Mosquito plant	*Azolla caroliniana*	Azollaceae	NO	Aquatic
Mrs Wilson’s barberry	*Berberis wilsoniae*	Berberidaceae	NO	Grassland
Nettle, Common	*Urtica dioica*	Urticacae	YES	Woodland & grassland
New Zealand pigmyweed/ Australian swamp stonecrop	*Crassula helmsii*	Crassulaceae	NO	Aquatic
Oak, Evergreen	*Quercus ilex*	Fagaceae	NO	Grassland
Oak, Pedunculate	*Quercus robur*	Fagaceae	YES	Grassland
Oak, Sessile	*Quercus petraea*	Fagaceae	YES	Grassland
Oak, Turkey	*Quercus cerris*	Fagaceae	NO	Grassland
Parrot's-feather	*Myriophyllum aquaticum*	Haloragaceae	NO	Aquatic
Perennial ryegrass	*Lolium perenne*	Poaceae	YES	Grassland
Pondweed, Broad-leaved	*Potamogeton natans*	Potamogetonaceae	YES	Aquatic

Common name	Species	Family	Native?	Habitat(s)
Purple moor-grass	*Molinia caerulea*	Poaceae	YES	Upland moors, grassland
Ragwort, Common	*Senecio jacobea*	Asteraceae	YES	Grassland
Ragwort, Marsh	*Senecio aquaticus*	Asteraceae	YES	Marshes & wet grassland
Rhododendron	*Rhododendron ponticum*	Ericaceae	NO	Woodland, peatland
Rosebay willowherb	*Chamerion angustifolium*	Onagraceae	YES	Grassland
Roses	*Rosa* spp.	Rosaceae	YES	Grassland
Rush, Blunt-flowered	*Juncus subnodulosus*	Juncaceae	YES	Grassland
Rush, Compact	*Juncus conglomeratus*	Juncaceae	YES	Grassland
Rush, Hard	*Juncus inflexus*	Juncaceae	YES	Grassland
Rush, Jointed	*Juncus articulatus*	Juncaceae	YES	Grassland
Rush, Sharp-flowered	*Juncus acutiflorus*	Juncaceae	YES	Grassland
Rush, Soft	*Juncus effusus*	Juncaceae	YES	Grassland, peatland
Scots pine	*Pinus sylvestris*	Pinaceae	YES	Grassland
Sea buckthorn	*Hippophae rhamnoides*	Elaeagnaceae	YES	Coastal (sand dunes)
Shallon	*Gaultheria shallon*	Ericaceae	NO	Woodland
Snow-in-summer	*Cerastium tomentosum*	Caryophyllaceae	NO	Coastal shingle
Sow-thistles	*Sonchus* spp.	Asteraceae	YES	Grassland
Spruce, Sitka	*Picea sitchensis*.	Pinaceae	NO	Woodland
spruce,Norway	*Picea abies*	Pinaceae	NO	Woodland
Strawberry-tree	*Arbutus unedo*	Ericaceae	NO	Grassland (calcareous)
Sycamore	*Acer pseudoplatanus*	Aceraceae	NO	Woodland
Thistle, Musk	*Carduus nutans*	Asteraceae	YES	Grassland (calcareous)
Thistle, Spear	*Cirsium vulgare*	Asteraceae	YES	Grassland
Tor-grass	*Brachypodium pinnatum*	Poaceae	YES	Grassland
Traveller's-joy (Old man's beard)	*Clematis vitalba*	Ranunculaceae	YES	Woodland & hedgerows
Water chestnut	*Trapa natans*	Trapaceae	NO	Aquatic
Water fern	*Azolla filiculoides*	Azollaceae	NO	Aquatic
Water hyacinth	*Eichornia crassipes*	Pontederiaceae	NO	Aquatic
Water lettuce	*Pistia stratiotes*	Araceae	NO	Aquatic

Common name	Species	Family	Native?	Habitat(s)
Water primrose	*Ludwigia hexapetala*	Onagraceae	NO	Aquatic
Waterweed, Canadian	*Elodea canadensis*	Hydrocharitaceae	NO	Freshwater (ponds, lakes, slow rivers)
Waterweed, Nuttall's	*Elodea nuttallii*	Hydrocharitaceae	NO	Aquatic
Wayfaring tree	*Viburnum lantana*	Caprifoliaceae	YES	Grassland (calcareous)
Wild privet	*Ligustrum vulgare*	Oleaceae	YES	Grassland
Willows	*Salix* spp.	Salicaceae	YES	Marshes & wet grassland

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