B1

Giant hogweed

Scientific name:
Heracleum mantegazzianum
Biennial plant (herb) in the Carrot family (Apiaceae)

B1.1 What is Giant hogweed?

- Monocarpic (i.e., it flowers once and then dies) biennial/perennial plant i.e., it does not die following the first (and only) year of growth like annual plants such as Himalayan balsam.
- In the first year of immature growth, seeds germinate, grow rapidly above ground and accumulate resources below ground in a deep tap root. If site conditions (i.e., light, nutrients and/or water) are favourable, and sufficient resources to support flowering are accumulated, established second year (mature) plants may flower. However, where conditions are less favourable flowering may be delayed for 3-5 years, though 12 years has been reported.
- Persian hogweed, a plant closely related to Giant hogweed (which is also an invasive plant in the UK) is a little bit different, as it is a long-lived (perennial), polycarpic (flowers many times) plant.
- One of the tallest perennial herbs in Europe reaching up to 5.5m tall in full growth.
- Dense seedling, first year (immature) and second year (mature) plants growth early in the growing season forms a dense, competitive groundcover restricting native plant access to space and light.
- Giant hogweed produces phytotoxins (plant poisons) including furanocoumarins and related compounds which are contained in all parts of the plant to deter insect predators in the native range. When these phytotoxins come into direct contact with the skin of people (and some herbivores) and are exposed to light they cause phytophotodermatitis, which results in extensive blistering and scarring if exposure is significant (and particularly if treated incorrectly). It is important to note that initial contact is painless. In certain circumstances phytophotodermatitis may recur for several years following exposure.

B1.2 Where do invasive hogweeds come from?

- Two species of invasive hogweeds (Giant and Persian) present in the UK and Ireland and both were introduced from southwest Asia.
- Where Giant hogweed and native hogweed grow in close proximity, hybrids have occasionally been reported.
- Sosnowsky's hogweed which also originated in southwest Asia has not been reported in the UK and Ireland to date, but is widespread in continental Europe and may become a problem in the future.

Common name	Scientific name	Origin	Brought to UK	Found growing in the wild
Giant hogweed	*Heracleum mantegazzianum*	Western Caucasus	1817	1828
Persian hogweed	*H. persicum*	Turkey, Iran, Iraq	1819	Unclear (c.1830-1850 likely)
Hybrid hogweed	*H. spondylium* × *H. mantegazzianum*	UK	N/A	1975
Sosnowsky's hogweed	*H. sosnowskyi*	Central and eastern Caucasus; western, central, eastern, southwest Transcaucasia; northeast Turkey	N/A	N/A

B1.3 What impacts do these plants have?

Competitive growth of Giant hogweed growth has significant health implications, in addition to negative ecological and socioeconomic impacts which include:

- **Human health and agriculture** – plant poisons are toxic to humans and some livestock. Consequently, there is a future risk of civil litigation in circumstances where the plant has not been reported clearly, and subsequently controlled effectively and safely.
- **Reduced habitat availability and quality** – reduction of native plant diversity.
- **Habitat alteration and degradation** – direct negative impacts upon terrestrial and freshwater food webs, particularly via siltation of watercourses.
- **High management costs** – estimated at approximately £2.4 million per annum UK-wide.
- **Limited soil binding capacity** – following dormancy/death in late autumn, few native plants remain to protect the soil surface from heavy rainfall in the winter and spring months, increasing erosion risk.
- **Access restriction** – amenity areas such as riverbanks may become inaccessible due to uncontrolled growth and safety concerns.

B1.4

What does Giant hogweed look like throughout the year?

Giant hogweed is the most common of the invasive hogweeds found in the UK and Ireland. Depending on the time of the year when it is found, it can look quite different. Images below show above ground parts of the Giant hogweed plant throughout the year and Persian hogweed is also shown in summer. Note that all parts of Giant and Persian hogweed plants (including the seeds) have a strong resinous smell.

Himalayan balsam

A Giant hogweed seedlings and immature (first year) plants in spring.

B Mature (second year onwards) Giant hogweed leaf growth in summer.

C Hollow Giant hogweed stem showing red/purple/brown blotches (blotches may rarely be continuous) and sharp bristles (5-10cm diameter at maturity).

D Mature Giant hogweed basal leaf growth with developing flower stems in summer (plant height c.1m).

E Mature flowering Giant hogweed plant in summer showing flower stem (height c.3.5m) and large flower head (umbel; 0.8m diameter) containing thousands of small white (occasionally pinkish) flowers.

F Mature flowering Persian hogweed plant in summer.

G Giant hogweed dead flower stems and seed heads (umbels) in summer surrounded by immature seedlings and mature plants that have developed from seed produced in previous growing seasons.

H Bank of watercourse in spring showing dead stems, emergent hogweed growth and limited native plant cover.

Please see the end of this section for full image acknowledgements and copyright information.

Key differences between Giant and Persian hogweeds and native hogweed are shown in the identification guide below.

Invasive hogweed identification guide

Character	Giant hogweed	Persian hogweed	Hogweed (native)
Habit	Up to 3.5(5.5)m in height	1.5-3.0m in height	Up to 2.0(3.0)m in height
Leaf shape and size	 Pinnate to ternate leaves with deep incisions (sharply divided lobes), serrations and spiked ends; 2.5(3)m long; dark green at maturity	 Pinnate to ternate leaves with deep incisions (sharply divided lobes), serrations and spiked ends (less pronounced than Giant hogweed leaves); up to 2m long; dark green at maturity	 Pinnate lobed leaves; <0.6m long; grey-green at full maturity
Stem diameter	5-10cm	1-2cm	1-2cm
Flower head (umbel) diameter	>40cm	>40cm Note that flower head is more 'domed' than that of Giant hogweed	Up to 15(30)cm

B1.5

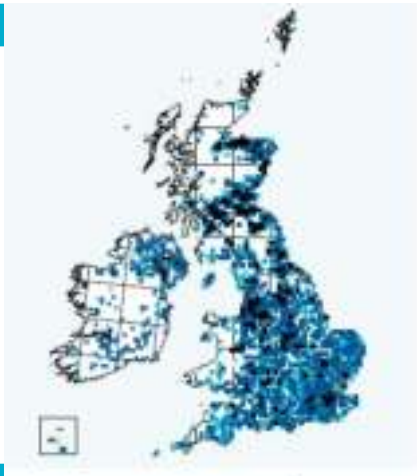
How do invasive hogweeds spread?

Invasive hogweeds spread rapidly by seed. Rapid spread is the result of exceptionally high seed production and germination rates: each Giant hogweed plant can produce 20,000-100,000 seeds, >90% of which may germinate. Seed production is significantly greater where growing conditions (light, nutrients and/or water) are ideal.

Most seeds (60-90 %) are shed directly around the mature plant (up to 5m away) though a significant proportion of seed is spread indirectly for much greater distances by people (e.g. roadside slipstreams, movement of contaminated soil, attached to clothing) and natural processes (e.g. wind, river flow, attached to animals).

B1.6

A



B

- Pre 1930
- 1930 - 1949
- 1950 - 1969
- 1970 - 1986
- 1987 - 1999
- 2000 - 2009
- 2010 - 2019
- 2020 onwards

Where do invasive hogweeds grow?

Invasive hogweeds are able to grow in many different habitats in the native and introduced (non-native) range, though there is a preference for wet/damp ground. Common habitats where invasive hogweeds are found include:

- **Rivers and other watercourses**
- **Waste ground**
- **Roadsides**
- **Railway embankments and cuttings**
- **Amenity areas**
- **Field margins**

The maps show where Giant (A) and Persian (B) hogweeds are found in the UK and Ireland

B1.7

Control and management

It is important to understand the lifecycle of Giant hogweed in order that individuals and populations can be managed effectively. Most of the time, when Giant hogweed is located and scheduled for treatment a population will already have established, containing individuals at a range of growth stages (seedling, immature and mature) with an associated seedbank in situ. Consequently, initial management recommendations should account for this population structure, though as management progresses and the invasive plant population and seed bank are depleted, management will increasingly focus on isolated individuals.

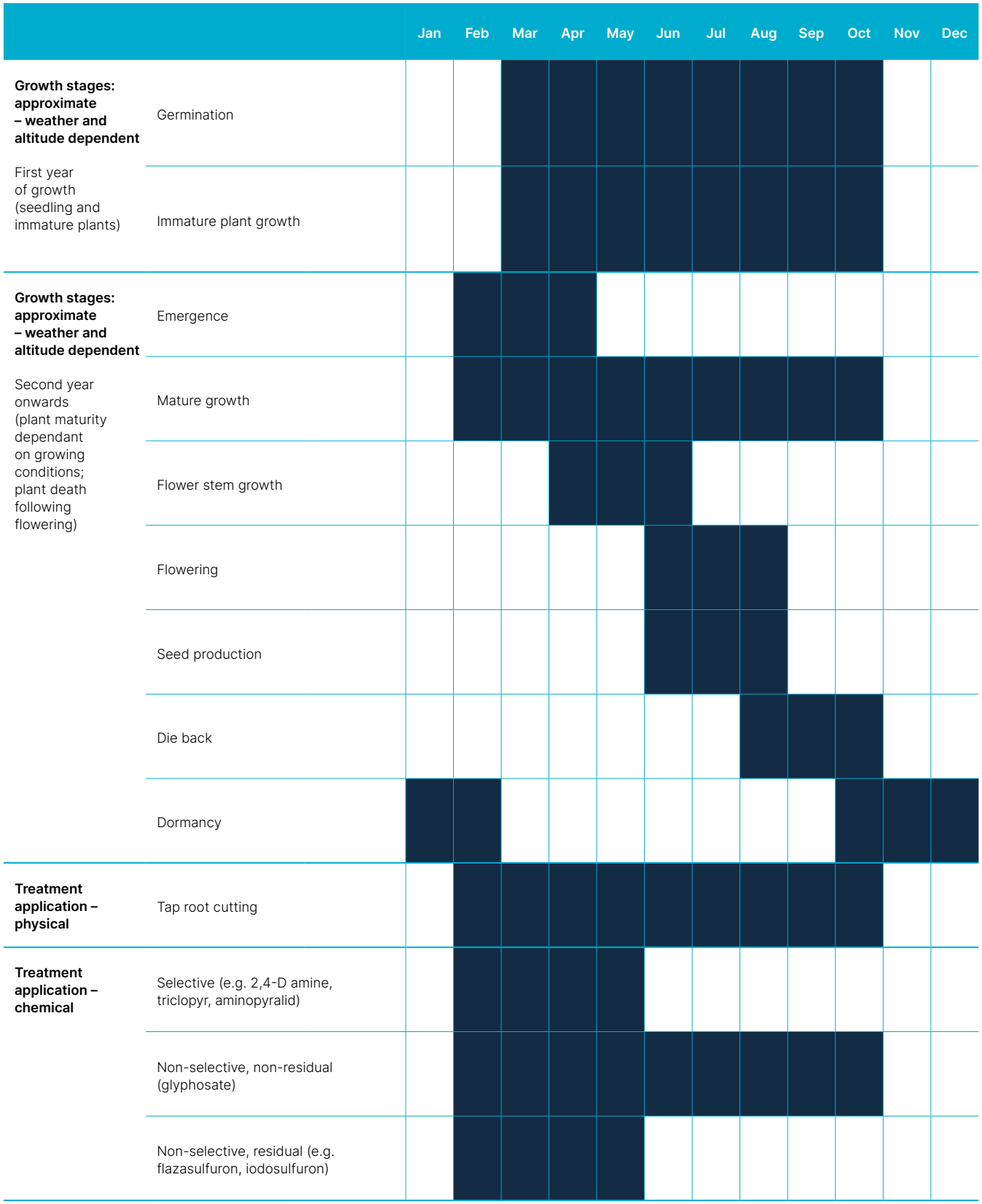
To achieve effective management of invasive plants such as Giant hogweed which spread rapidly by seed, flowering must be prevented for several years to deplete the soil seed bank. The quicker that depletion is achieved, the fewer treatments will be required in the longer-term, reducing overall project costs, herbicide use and CO_2 emissions. Control of the invaded seedbank is essential for effective, long-term management of Giant hogweed: in autumn following flowering and seed release, there may be up to 12,000 seeds per m^2. Seed is understood to be viable for 7-12 years, though there are no definitive studies of seed longevity. 95% of the seed is concentrated in the top 5 cm of the soil profile; however, as seed production is prolific (up to 100,000 seeds per plant), the remaining 5% present in lower soil layers represents a significant quantity of seed. High seed production and germination rates (more than 90%) result in early growing season seedling densities of several thousand per m^2, though only 1-2% of these establish as immature plants in the first year of growth. Given the extended viability of Giant hogweed seed, it is recommended that management programmes are planned for a minimum of 10 years. In certain settings, local eradication of Giant hogweed populations can be achieved when the seedbank is depleted, though there always remains a significant risk of reinvasion from other areas and/or upstream during flooding.

Control and management methods

Control category	Desired effect	Control method	Application method(s)	Does it work?	Downsides
Cultural (preventative) and physical (mechanical)	Destroy above ground growth	Cutting – hand	Machete; scythe; brush cutter; mower	No	Do not attempt – operator safety risk; may spread invasive plant further; labour intensive; high labour costs and CO_2 emissions compared with spraying
		Cutting – flower (umbel)	Machete; scythe	No	Do not attempt – operator safety risk; may spread invasive plant further; labour intensive; high labour costs and CO_2 emissions compared with spraying
		Cutting – whole plant	Mower; flail	No	Do not attempt – operator safety risk; may spread invasive plant further; cannot be used near water; labour intensive; high labour costs and CO_2 emissions compared with spraying
		Ploughing	Powered equipment (tractor)	No	Do not attempt – operator safety risk; may spread invasive plant further; cannot be used near water; high labour costs and CO_2 emissions compared with spraying
		Pulling	Hand	No	Do not attempt – operator safety risk; labour-intensive control method; CO_2 emissions are high as transport to site on multiple occasions over several years will be required
		Covering (ground surface)	Geotextile	Yes	High labour costs and embedded CO_2 in covering materials; once covering is removed site is more susceptible to reinvasion by Giant hogweed as all other plants shaded out during covering
		Burning	Range of options	No	Giant hogweed has high water content; high labour costs and CO_2 emissions
	Destroy above and below ground growth	Cutting – tap root	Hand	Yes	Operator safety risk; may spread invasive plant further; high labour costs; CO_2 emissions are high as transport to site on multiple occasions over several years will be required
		Excavation/digging	Hand	Yes	Operator safety risk; may spread invasive plant further; cannot be used near water; most labour-intensive control method
		Excavation/digging	Powered equipment	Yes	Operator safety risk; may spread invasive plant further; cannot be used near water; highest costs and CO_2 emissions;
Biological control	Destroy/disrupt above and below ground growth	Grazing	Livestock	Yes	Do not attempt – safety risk to some livestock; may spread invasive plant further; cannot be used near water (not suitable for many areas where invasive plants grow)
		Biocontrol	Release	No	None available
Chemical control (plant protection products; PPPs)	Destroy above and below ground growth	Selective and/or residual herbicides	Soil and/or foliar spray	Yes	Only glyphosate can be used near watercourses
			Weed wiping	Yes	Higher labour costs than foliar spray; only use on small areas
Integrated Herbicide Management (IHM) systems	Destroy above and below ground growth	Selective + glyphosate	Foliar spray	Yes	Cannot be used near water; higher labour costs and CO_2 emissions than applying glyphosate alone
		Residual + glyphosate	Soil and/or foliar spray + foliar spray	Yes	Cannot be used near water

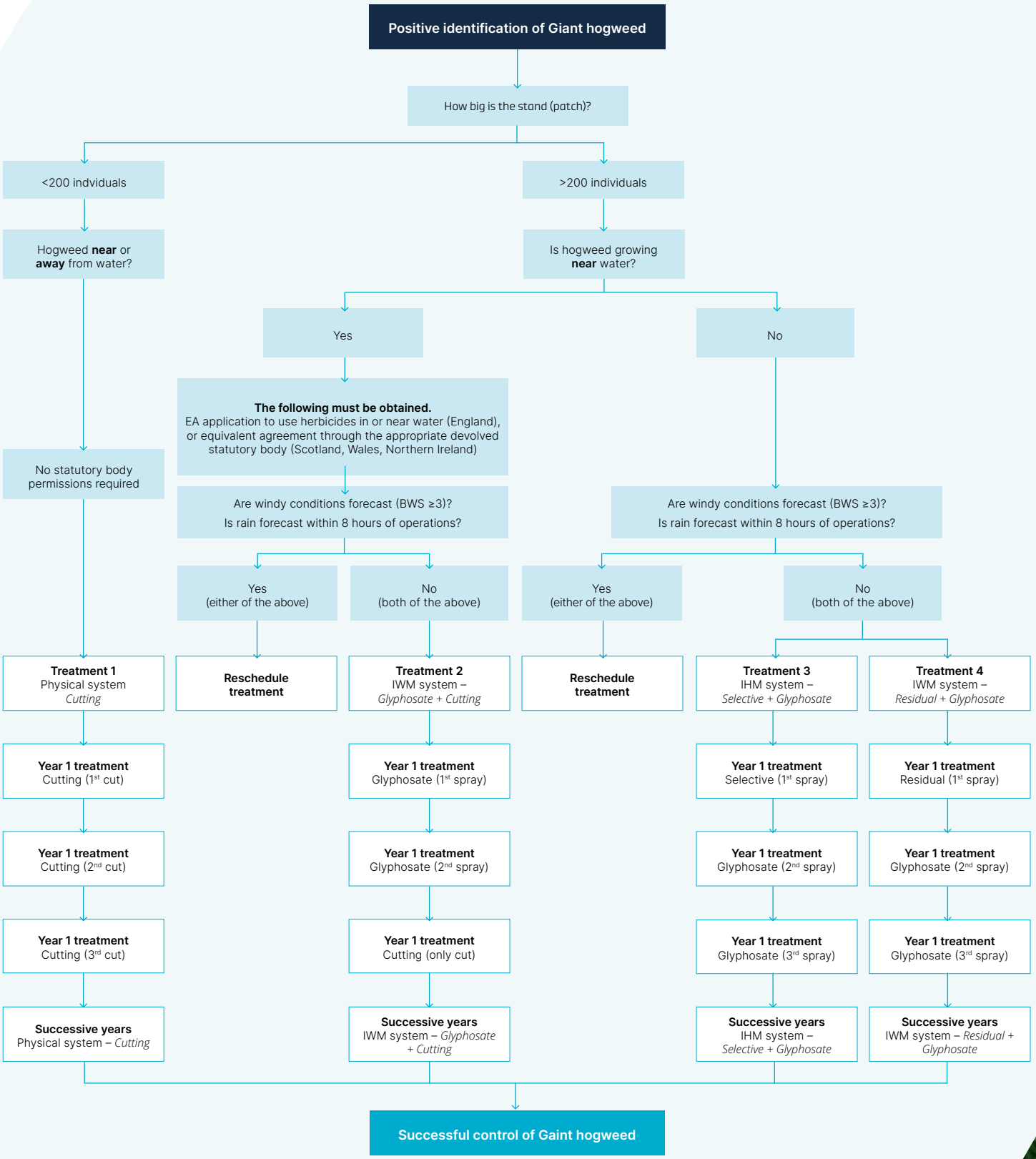
Timing of Giant hogweed growth stages and treatment application

Timings of Giant hogweed growth stages are shown below along with recommended treatment timings. It is recommended that chemical and physical control methods should be applied three times per year to ensure that no seed is set; where this is not achieved, population recovery and management failure will result.



Treatment decision tree

One physical, one Integrated Weed Management (IWM), and two Integrated Herbicide Management (IHM) systems are recommended for the sustainable control and management of Giant hogweed over 10 years (see decision tree and full treatment specifications below). Treatment specifications are suitable for the management of Giant and Persian hogweeds.



Full treatment specifications

Treatment 1	Physical management system - Tap root cutting
Frequency	Cutting three times per year, all years of treatment
Herbicide	N/A
Method	Cutting taproot using a spade or specialist equipment 10-15cm below the lowest leaves (basal rosette); plants cut above this point may continue to grow, flower and set seed.
Rate	N/A
Timing	Apply all three control methods between February and June. Undertake the first cut between February and April, the second cut between April and May and the third cut between May and June.

Control method application timings

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cutting – 1st treatment		■	■	■								
Cutting – 2nd treatment				■	■							
Cutting – 3rd treatment					■	■						

Treatment notes
Can be used near water.
Only use on individual plants and smaller stands (<200 individuals)
Aim to undertake all treatments as early as possible to minimise flowering and seed production. Note that viable seed can be produced on intact flower heads following cutting later in the growing season (plant resources permitting).
Additional equipment requirement: spades and/or specialist hand cutting equipment, rakes, forks and wheelbarrows.
Ensure good waste management processes are agreed before beginning this treatment method as waste will be generated. Create access routes and disposal areas away from water to prevent waste piles containing soil and seed from previous growing seasons being washed downstream during flooding. Do not dispose of any waste material in general compost.
Giant hogweed plant material (including soil contaminated with seeds) is a 'controlled waste' under the Environmental Protection Act 1990 which means it can only be transported by a registered waste carrier to suitably permitted or exempt sites; do not move any plant or soil waste generated by management from the area where it produced.
Check waste piles periodically for any plants re-rooting, as these may flower and seed.
Clean down equipment in a designated wash down area (away from water) prior to moving offsite.
Higher labour requirements and CO_2 emissions compared with other IWM and IHM system treatments recommended.
Giant hogweed herbicide resistance development is not relevant.

Treatment 2	Integrated Weed Management (IWM) system - Glyphosate + tap root cutting
Frequency	Glyphosate twice per year, cutting once per year, all years of treatment.
Herbicide	Glyphosate.
Method	Foliar spray using hand-held, knapsack or large volume sprayers – weed wiping may also be suitable; Cutting taproot using a spade or specialist equipment 10-15 cm below the lowest leaves (basal rosette); plants cut above this point may continue to grow, flower and set seed.
Rate	Half of maximum permitted application rate (see product label), twice per year.
Timing	Apply all three control methods between February and June. Undertake the first glyphosate application between February and April and the second glyphosate application in April/ May. Cutting of remaining Giant hogweed plants should be undertaken in May/June, one month after the final herbicide treatment and before seed production.

Control method application timings

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Glyphosate – 1st treatment		■	■	■								
Glyphosate – 2nd treatment				■	■							
Cutting					■	■						

Treatment notes	
	Can be used near water.
	Apply from February onwards when Giant hogweed seedlings and established plants are actively growing and monthly rainfall (precipitation) is declining.
	Aim to undertake all treatments as early as possible to minimise flowering and seed production. Note that viable seed can be produced on intact flower heads following cutting later in the growing season and ineffective herbicide application.
	Additional equipment requirement: spades and/or specialist hand cutting equipment, rakes, forks and wheelbarrows.
	Ensure good waste management processes are agreed before beginning this treatment method as waste will be generated. Create access routes and disposal areas away from water to prevent waste piles containing soil and seed from previous growing seasons being washed downstream during flooding. Do not dispose of any waste material in general compost.
	Giant hogweed plant material (including soil contaminated with seeds) is a 'controlled waste' under the Environmental Protection Act 1990 which means it can only be transported by a registered waste carrier to suitably permitted or exempt sites; do not move any plant or soil waste generated by management from the area where it produced.
	Check waste piles periodically for any plants re-rooting, as these may flower and seed.
	Clean down equipment in a designated wash down area (away from water) prior to moving offsite.
	Higher labour requirements and CO_2 emissions than Integrated herbicide management (IHM) systems.
	Giant hogweed herbicide resistance development should be considered, ensure total within-season control of whole population.

Treatment 3	Integrated Herbicide Management (IHM) system - Selective + glyphosate
Frequency	Selective once per year, glyphosate twice per year, all years of treatment
Herbicide	Selective (e.g. 2,4-D amine, triclopyr, aminopyralid) + glyphosate
Method	Foliar spray using hand-held, knapsack or large volume sprayers.
Rate	Selective herbicide at full (maximum permitted) application rate (see product label), once per year; glyphosate at half of maximum permitted application rate (see product label), twice per year.
Timing	Apply all three control methods between February and June. Undertake the selective application between February and April. Undertake the first glyphosate application in April/May and the second glyphosate application in May/June.

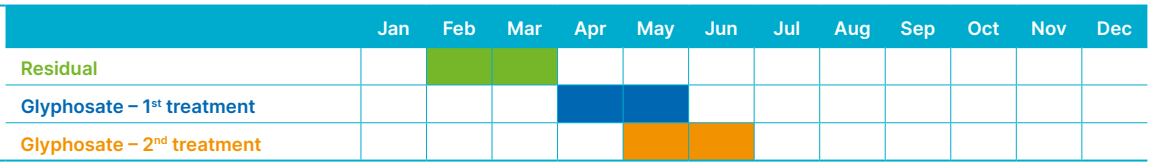
Control method application timings

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Selective		■	■	■								
Glyphosate – 1st treatment				■	■							
Glyphosate – 2nd treatment					■	■						

Treatment notes
Cannot be used near water.
Apply from February onwards when Giant hogweed seedlings and established plants are actively growing and monthly rainfall (precipitation) is declining.
Aim to undertake all treatments as early as possible to minimise flowering and seed production. Note that viable seed can be produced following ineffective herbicide application.
Selective herbicides may not kill mature Giant hogweed plants later in the growing season (May/June onwards).
Glyphosate-based herbicides work more slowly and are less effective when plants reach full maturity later in the growing season (June onwards); earlier treatments are strongly recommended. Note that the 2nd glyphosate application window in June is targeted at controlling late germinating plants and plants which have escaped previous treatments.
Aim to undertake all treatments as early as possible to minimise flowering and seed production; where herbicide treatments have been delayed and seed pods have formed, supplemental tap root cutting of Giant hogweed plants can be undertaken between July and August.
Clean down equipment in a designated wash down area (away from water) prior to moving offsite.
Lower labour requirements and CO_2 emissions than Integrated Weed Management (IWM) systems.
Giant hogweed herbicide resistance development should be considered, ensure total within-season control of whole population.

Treatment 4	Integrated Herbicide Management (IHM) system - Residual + glyphosate
Frequency	Residual once per year, glyphosate twice per year, all years of treatment.
Herbicide	Residual (e.g. flazasulfuron, iodosulfuron) + glyphosate.
Method	Soil and foliar spray using hand-held, knapsack or large volume sprayers.
Rate	Residual herbicide at full (maximum permitted) application rate (see product label), once per year; glyphosate at half of maximum permitted application rate (see product label), twice per year.
Timing	Apply all three control methods between February and June. Undertake the selective application between February and March. Undertake the first glyphosate application between April and May and the second glyphosate application between May and June.

Control method application timings



Treatment notes
Cannot be used near water.
Apply from February onwards when Giant hogweed seedlings and established plants are actively growing and monthly rainfall (precipitation) is declining.
Aim to undertake all treatments as early as possible to minimise flowering and seed production. Note that viable seed can be produced following ineffective herbicide application.
This IWM system has the advantage of controlling Giant hogweed populations more quickly than other recommended treatments. Residual herbicides should only be applied over the whole control site for 2 years; once the population is under effective management, treatment using these herbicides can be targeted more precisely in areas where it is known that there is a dense seed bank remaining in situ. This approach will maximise recovery of native plants (limiting potential for control site recolonisation by invasive plants). Note that this IWM system emits less CO_2 than other treatments and uses less herbicide over the whole treatment lifecycle than other IWM and IHM systems.
Residual herbicides do not kill mature Giant hogweed plants later in the growing season (May/June onwards); early application is recommended to control a high proportion of seed germinating early in the growing season.
Glyphosate-based herbicides work more slowly and are less effective when plants reach full maturity later in the growing season (June onwards); earlier treatments are strongly recommended. Note that the 2nd glyphosate application window in June is targeted at controlling late germinating plants and plants which have escaped previous treatments.
Aim to undertake all treatments as early as possible to minimise flowering and seed production; where herbicide treatments have been delayed and seed pods have formed, supplemental tap root cutting of Giant hogweed plants can be undertaken between July and August.
Clean down equipment in a designated wash down area (away from water) prior to moving offsite.
Lower labour requirements and CO_2 emissions than Integrated Weed Management (IWM) systems.
Giant hogweed herbicide resistance development should be considered, ensure total within-season control of whole population.

General management notes – Do's and Don'ts!

Do's

Improve your Giant hogweed control results by thinking about the following:

- ✓ **Timing** – the key to controlling Giant hogweed is preventing it from seeding and depleting the seed bank; act early in the growing season to reduce labour and herbicide requirements later in the growing season when the plants are larger.
- ✓ **Coverage** – good coverage means treating every plant – when using foliar spray this means treating a few leaves per plant. Attention to detail (operator performance) is critical. Do apply residual herbicides to the soil surface in advance of germination and ensure even soil coverage.

Do's

- **Spray retention** – adjuvants help you to make each application count. Adjuvants improve control results by sticking the herbicide to the leaf – this allows the herbicide to absorb better and the adjuvant protects the herbicide from being washed off by unexpected rainfall. Protecting your herbicide from rainfall is really important in western areas of the UK, as dry periods exceeding 6-7 hours duration (i.e. enough time for glyphosate herbicide absorption) are rare even in summer! Make sure your applications are rainfast by using one of the following recommended products (always read label instructions before use):
  - Adjuvant (use near water)
  - Adjuvant (use away from water): Speedway Total

  Only apply adjuvants authorised for use in the areas being treated. Ensure the adjuvant being used is compatible with the plant protection product (herbicide) – check with the manufacturers of both products.

- **Herbicide absorption** – use water conditioners to get the best performance from your glyphosate products. Glyphosate can stick to salts in water and this stops some of the herbicide working properly. Water conditioners remove salts from the water, before you mix in your glyphosate product, meaning that you get more bang for your buck. In hard water areas (e.g. south east of England) using water conditioners such as NupHix can make a big difference to control results.

- For consistency and convenience **use premixed glyphosate-based products with in-built water conditioners and surfactant systems** such as Roundup® ProVantage. Labour is your biggest cost – protect your work and get the results that you need.

- **Use the right tools for the job** – think about which of recommended treatments will work best using the least herbicide and labour.

- **Use the right glyphosate-based herbicides at the right time,** recommended products include:
  - Roundup® ProActive
  - Roundup® ProVantage
  - Amenity Glyphosate XL
  - Roundup® ProVantage

- **Use good quality selective and residual herbicides** to ensure effective control results, recommended products include:
  - Synero® (selective)
  - Icade® (selective)
  - Lockstar® (residual)

- Where spread and/or dispersal onto neighbouring land occurs as a result of misapplication of control treatments, there is potential for civil liability.

Don'ts

- ✗ Because we can kill Giant hogweed plants and where we have managed the soil seed bank for 7-15 years, we can talk about local eradication of the plant. Note that **eradication of large infestations exceeding more than 200 plants may take more than 10 years to achieve.**
- ✗ **Don't exceed the dose of herbicide specified on the product label** – aside from this being illegal, beyond a threshold (label) dose, higher doses and/or more frequent herbicide treatment does not improve control outcomes.
- ✗ **Acetic and pelargonic acid-based herbicides are ineffective** for Giant hogweed control.

B1.8

Acknowledgements

Image acknowledgements

Images A, D and H: courtesy of Brian Taylor (© The Knotweed Company 2021)

Image E: courtesy of Gethin Bowes (© Caerphilly CBC 2021)

Image F and Persian Hogweed leaf: courtesy of Jouko Lehmuskallio (© NatureGate 2021)

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References

1. **Advanced Invasives** *Caerphilly CBC* (2019)
2. **Booy et al.** *Bloomsbury* (2015)
3. **Caffrey** *Hydrobiol. J.* (1999)
4. **Caffrey** *J. Aquat. Plant Manage.* (2001)
5. **CEH** *Centre for Ecology & Hydrology* (2004)
6. **EA** *Environment Agency* (2010)
7. **Hüls et al.** *Biol. Invasions* (2007)
8. **Klima and Synowiec** *Weed Res.* (2016)
9. **Klingenstein** *NOBANIS* (2007)
10. **Krinke et al.** *Seed Sci. Res.* (2005)
11. **Meinlschmidt and Dittrich** *Freistaat Sachsen* (2007)
12. **Moravcová et al.** *Acta Oecol* (2005)
13. **Moravcová et al.** *Preslia* (2005)
14. **Nielsen et al.** *Forest and Landscape* (2005)
15. **Page et al.** *Can. J. Plant Sci.* (2005)
16. **Pergl et al.** *Am. J. Bot.* (2006)
17. **Pergl et al.** *CABI* (2007)
18. **Perglová et al.** *CABI* (2007)
19. **Pyšek and Antonín** *J. Veg. Sci.* (1995)
20. **Pyšek et al.** *Preslia* (1995)
21. **Pyšek et al.** *Biol. Invasions* (2007)
22. **Rose** *Warne* (2016)
23. **Stace** *C&M Floristics* (2019)
24. **Stuart** *BSc Thesis* (1979)
25. **Thiele and Otte** *CABI* (2007)
26. **Thiele et al.** *CABI* (2007)
27. **Tiley et al.** *J. Ecol* (1996)
28. **Tweed Invasives Project** (2020)
29. **Wildlife and Natural Environment Act** *Northern Ireland* (2011)
30. **Wildlife and Natural Environment Act** *Scotland* (2011)
31. **Williams et al.** *CABI* (2010)