Exploring the use of Ecoplugs for Woody Weed Control

Ian Willoughby, **Katherine Tubby**, **Colin Saunders** and **Suzanne Peace** ask are there more cost effective methods for controlling woody weeds than felling to recycle?

The technique of thinning or felling to recycle, which used to be called thinning or felling to waste, is sometimes necessary where conventional timber harvesting and extraction is impractical or not economic. It is also used to remove conifers that may be shading out native broadleaves, referred to as 'halo thinning'. In addition, where larch needs to be removed because it is infected with *Phytophthora ramorum*, then felling to recycle of entire stands of trees can take place.

For several years Forest Research have been investigating whether there might be a more cost effective method of killing standing trees than felling to recycle. Ecoplugs (formulated as Ecoplug Max® (680g kg^{-1} glyphosate); Monsanto, 2009; or as Ecoplug Max® (720g kg^{-1} glyphosate); Monsanto, 2016), are a novel formulation of crystalline glyphosate encapsulated in a plastic plug (see Figure 1). They are widely used to prevent resprouting from cut stumps after tree felling, particularly on railway embankments or under utility lines, but until our research there were few reports of them being tested for killing standing trees.

Ecoplugs are applied by using a battery powered hand drill with a 13mm bit to drill holes of between 30-35mm depth at regular spacing around the circumference of the stump, or in the case of our work on standing trees around the trunk (see Figures 2 and 3). The number of holes, and hence Ecoplugs, required for each tree is based on stump / trunk diameter. One Ecoplug is then inserted into each hole, with the thicker end facing outward, and then driven in with a hammer so that the head of the 13mm diameter plug seals the hole. As each Ecoplug is slightly longer than the depth of the hole, when it is hammered in the tip is forced back into the body of the cylinder which cracks the outer shell. This releases 0.283g of 720g kg^{-1} water-soluble crystalline glyphosate (giving 0.204g $plug^{-1}$ a.i. glyphosate) (see Figure 1), which should then be contained entirely within the sealed hole (see Figure 2). Because of the Ecoplug's design, there is practically no risk of drift or operator contamination, and

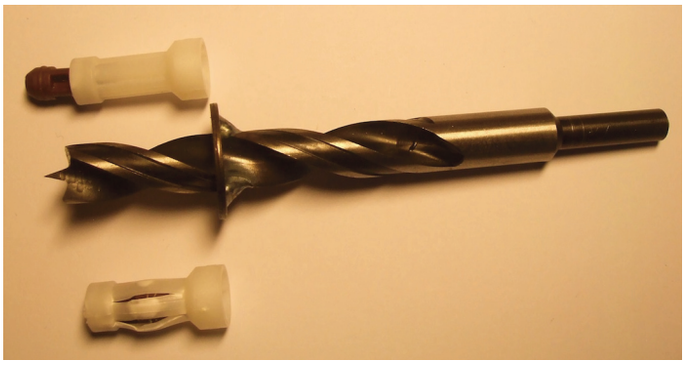

Figure 1. Ecoplug before insertion (top), 13mm drill bit used to create holes (middle), Ecoplug after insertion into hole drilled in tree stump showing cracked case which allows release of crystalline glyphosate (bottom).

Figure 2. Ecoplugs inserted into holes drilled in a cut tree stump.

the manufacturers Monsanto claim they can be used in all weathers and at any time of year.

This article reports on the findings from four research projects that investigated the efficacy of using Ecoplugs for woody weed control in comparison with conventional chemical thinning (spraying herbicide into cuts made in the tree trunk, see Figure 4) and with the traditional technique of physical ring barking (see Figure 5).

What did we research?

Our research consisted of:

1. An experiment comparing the efficacy of Ecoplugs, conventional herbicide application and manual ring barking, for the killing of standing Douglas fir; carried out at different times of year and with and without simulated rainfall.

2. A study of the relative cost and efficiency of the different chemical thinning and ring barking techniques.

3. An experiment investigating the impact of Ecoplugs, conventional herbicide application and manual ring barking on subsequent infection from the wood rotting pathogen *Heterobasidion annosum*, and also the efficacy of the treatments for killing standing Japanese larch and Scots pine.

4. Three experiments comparing the efficacy of Ecoplugs with conventional herbicide application for killing rhododendron when applied to cut stumps; with different delays after cutting, and with and without simulated rainfall.

Figure 3. Standing tree after being treated with Ecoplugs.

What did the research find?

1. Efficacy of Ecoplugs

Our research found that applying one Ecoplug (formulated as Ecoplug Max® (680g kg^{-1} glyphosate); Monsanto, 2009; or as Ecoplug Max® (720g kg^{-1} glyphosate); Monsanto, 2016) per 3cm of stem diameter, an equivalent of 0.068g a.i. glyphosate per cm of stem diameter, can give effective control of around 90% of standing Douglas fir within 18 months of treatment. Ecoplugs appeared to be a more

Figure 4. Tree trunk showing axe cuts used to create reservoirs for conventional liquid herbicide application.

Figure 5. Manually ring barked tree.

effective method of applying glyphosate to kill standing Douglas fir trees than the traditional method of chemical thinning, which involves spraying neat liquid glyphosate into cuts made in the tree stem. Both traditional chemical thinning and the use of non-chemical ring barking also gave some control of standing Douglas fir trees in our work, but the speed of kill was slower and overall efficacy lower than when using Ecoplugs. The artificial rainfall applied had no effect on the treatments.

Full details of this research can be found in the scientific paper Willoughby et al. (2017a), which is freely available at: www.forestry.gov.uk/research/the-use-of-ecoplugs-for-woody-weed-control/.

2. Cost and efficiency of different control techniques

The application costs of the different methods of killing standing trees, assuming 2,000 treated stems per hectare, including the costs of tools, safety equipment, chemicals etc, were found to be as follows:

- £5,700 per hectare for chainsaw felling to recycle. However, if it were practical to extract and sell the timber, for the study site used this figure would change to a potential net revenue of around £15,000 per hectare.
- £2,860 per hectare for the Ecoplug method.
- £2,140 per hectare for manual ring barking.
- £940 per hectare for the traditional cut and spray method.

Full details of this research can be found in Saunders (2014), which is freely available at: www.forestry.gov.uk /research/the-use-of-ecoplugs-for-woody-weed-control/.

3. Impacts on Japanese larch, Scots pine and Heterobasidion annosum infection

The results from this study also suggested that applying one Ecoplug (formulated as Ecoplug Max® (680g kg^{-1} glyphosate); Monsanto, 2009; or as Ecoplug Max® (720g kg^{-1} glyphosate); Monsanto, 2016) per 3cm diameter of stem, an equivalent of 0.068g a.i. glyphosate per cm of stem diameter, can give effective control of around 100% of standing Japanese larch and 90% of standing Scots pine within 17 months of treatment in the early spring. Ecoplugs appeared to be a more effective method of applying glyphosate to kill standing Japanese larch trees than the traditional method of spraying neat liquid glyphosate into cuts in the stem, but were no more effective in Scots pine, suggesting that final efficacy of the two treatments may turn out to be similar, but that Ecoplugs may provide more rapid control.

Ecoplugs, conventional herbicide application to stem cuts and manual ring barking all allowed infection to some extent of *Heterobasidion annosum*, a pathogen that can cause serious and long term damage to current and future conifer crops. However, although it was not possible to make a direct comparison in our work, the *Heterobasidion annosum* infection that results from using Ecoplugs is unlikely to be significantly higher than the infection that typically occurs after conventional harvesting operations due to accidental stem damage. On Japanese larch the risk of infection is likely to be less than traditional chemical thinning using axe cuts and liquid herbicide. If an entire stand is going to be killed, then felling and treating stumps with the prophylactic fungicides urea or PG Suspension® (0.5% w/v *Phlebiopsis gigantea*; Forestry Commission, 2015), will present a lower risk of infection from *Heterobasidion annosum* than any method of chemically killing standing trees.

Therefore, although for Phytophthora infected larch sanitation felling is always by far the best approach, if for some reason it cannot be practised, as a last resort, or on sites at low risk of infection from *Heterobasidion annosum*, or where conifers will never be grown again in the future, Ecoplugs are the next best method of killing standing trees. Applications should take place before the end of October to maximise the chances of reducing sporulation in the following year.

Full details of this research can be found in the scientific paper Tubby et al. (2017), which is freely available at: www.forestry.gov.uk/research/the-use-of-ecoplugs-for-woody-weed-control/.

4. Efficacy of Ecoplugs on rhododendron

Our research found that applying one Ecoplug (formulated as Ecoplug Max® (680g kg^{-1} glyphosate); Monsanto, 2009; or as Ecoplug Max® (720g kg^{-1} glyphosate); Monsanto, 2016) per 3cm of stump diameter, an equivalent of 0.068g a.i. glyphosate per cm of stump diameter, can give around 80-90% control of cut rhododendron stumps. Control is likely to be as good as, but no better than, conventional sprays of liquid glyphosate, and in both cases, repeat visits to control regrowth will almost certainly still be required. Although it is

recommended that Ecoplugs should always be applied to stumps within two days of cutting, if a delay is unavoidable, our work suggests that they may still be effective if applied up to eight weeks after cutting. The artificial rainfall applied had no effect on the treatments.

Full details of this research can be found in the scientific paper Willoughby et al. (2017b), which is available at: www.forestry.gov.uk/esearch/the-use-of-ecoplugs-for-woody-weed-control/.

Conclusions

What can we conclude about the efficacy and cost effectiveness of Ecoplugs compared to other methods used to control woody weeds?

- Ecoplugs appear to be at least as good as conventional herbicide sprays containing glyphosate at preventing regrowth from cut rhododendron stumps, and to be equally or more effective for killing standing conifers.

- Ecoplugs may also offer other advantages such as effectively eliminating the risk of drift and operator contamination, and providing the potential for year round application in wet and windy weather conditions that would preclude conventional spraying. The risk that effectiveness will be reduced if follow up herbicide applications to cut stumps are delayed is also lessened. However, because applying Ecoplugs is likely to cost at least three times as much as conventional herbicide treatment, their use will not be appropriate in all situations.

- For the removal of non-native trees around native species ('halo thinning'), or thinning of crop trees to favour diameter growth in those that remain, if conventional timber harvesting and extraction including stump treatment with prophylactic fungicides is economic and practical, this is always the best option.

- Where conventional harvesting is not possible, if the time taken for the tree to die is not the most important consideration, the use of the traditional method of chemical thinning of spraying neat glyphosate into cuts made into the standing tree stem will be the cheapest effective option. However this method should only be used if there is also either a low risk of infection by *Heterobasidion annosum*, or if sites will never be used to grow conifers again in the future.

- If there is a desire to avoid pesticide use entirely then manual ring barking may be an option, but it may take a considerable time for treated trees to die. There are also some other caveats that should be taken into consideration – the final levels of efficacy are not yet known, long term implications for infection by *Heterobasidion annosum* are not clear, the technique is more expensive than traditional chemical thinning, and its effectiveness and practicality on a wider range of tree species and ages is not yet known.

- On difficult to access sites where managers wish to reduce the need for follow up operations, if the risk of *Heterobasidion annosum* infection on that site is low or conifers will never be grown again in the future, then the use of Ecoplugs may be the best option. This could also be the case where the risk is high but managers are prepared to accept a similar level of infection as would result from conventional thinning if harvesting damage occurred, and providing the increased cost is acceptable. The use of Ecoplugs may also be the best option where rapid kill of standing trees is required, or where prevailing weather conditions or lack of skilled labour make conventional herbicide treatment problematic. But again the above mentioned caveats apply.

- For Phytophthora infected larch, sanitation felling is by far the best approach to minimise the risk of sporulation and the spread of the disease. However, if for some reason sanitation felling is not possible, then as a last resort Ecoplugs are probably the next best method of killing standing trees. However, Ecoplugs should not normally be used to kill an entire stand of trees if the risk of *Heterobasidion annosum* infection on that site is high,

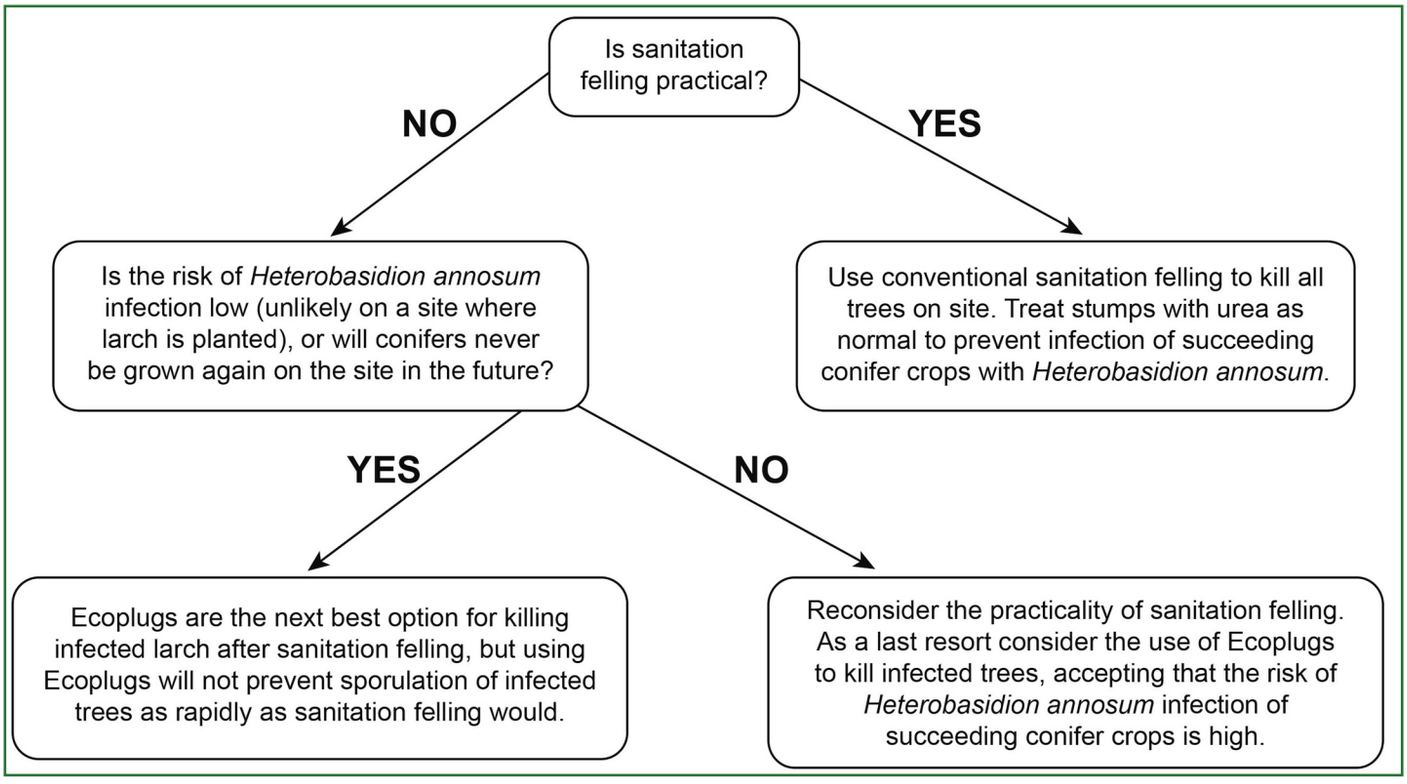

Figure 6. A possible decision process for deciding on the most suitable method of killing an entire stand of larch trees infected with Phytophthora ramorum, where the aim is to prevent infection of nearby crops.

unless conifers will never be grown again on that site in the future.

See Figures 6 and 7 for a decision process that could be used to help decide on whether or not the use of Ecoplugs might be appropriate for different scenarios, based on the results and conclusions of our research as described above.

As a result of our research, the Forestry Commission have successfully applied for an Extension of Authorisation for Minor Use from the Chemicals Regulation Division of the UK Health and Safety Executive to allow Ecoplug Max® to be used on standing trees in forests (Chemicals Regulation Directorate, 2017).

Whatever method of killing standing trees is adopted, an appropriate inspection regime needs to be put in place by land managers to monitor the deterioration of the treated, dead and dying standing trees, and to ensure the future safety of staff and the general public who may be on site for follow up operations.

Acknowledgements

We are grateful to Forestry Commission Scotland who funded the fieldwork and provided the sites for the experiments, to Monsanto who provided the Ecoplugs via Nomix Enviro, to the Forestry Commission who funded the production this article via the Delivering Resilient Forests Research Programme of the Forestry Commission Science and Innovation Strategy, and to Trees For Life for sharing their ring barking method. We are also very grateful to all of our Forest Research colleagues who contributed to this work – for a full list please see the individual scientific papers referred to in this article. Figures 1 and 2 are reproduced courtesy of Mansanto.

Disclaimer

The Forestry Commission (and hence Forest Research) accepts no liability whatsoever for any loss or damage arising from the interpretation or use of the information in this article. All applications are made at users' own risk. The product label remains the primary source of information for the safe use of a pesticide. Reference to a particular manufacturer or product does not imply endorsement or recommendation of that product or manufacturer by the Forestry Commission.

References

Chemicals Regulation Directorate (2017). Extension of Authorisation Number 0195 of 2017. Chemicals Regulation Division, The Health and Safety Executive, York. www.hse.gov.uk/pesticides (Accessed 12/1/17).

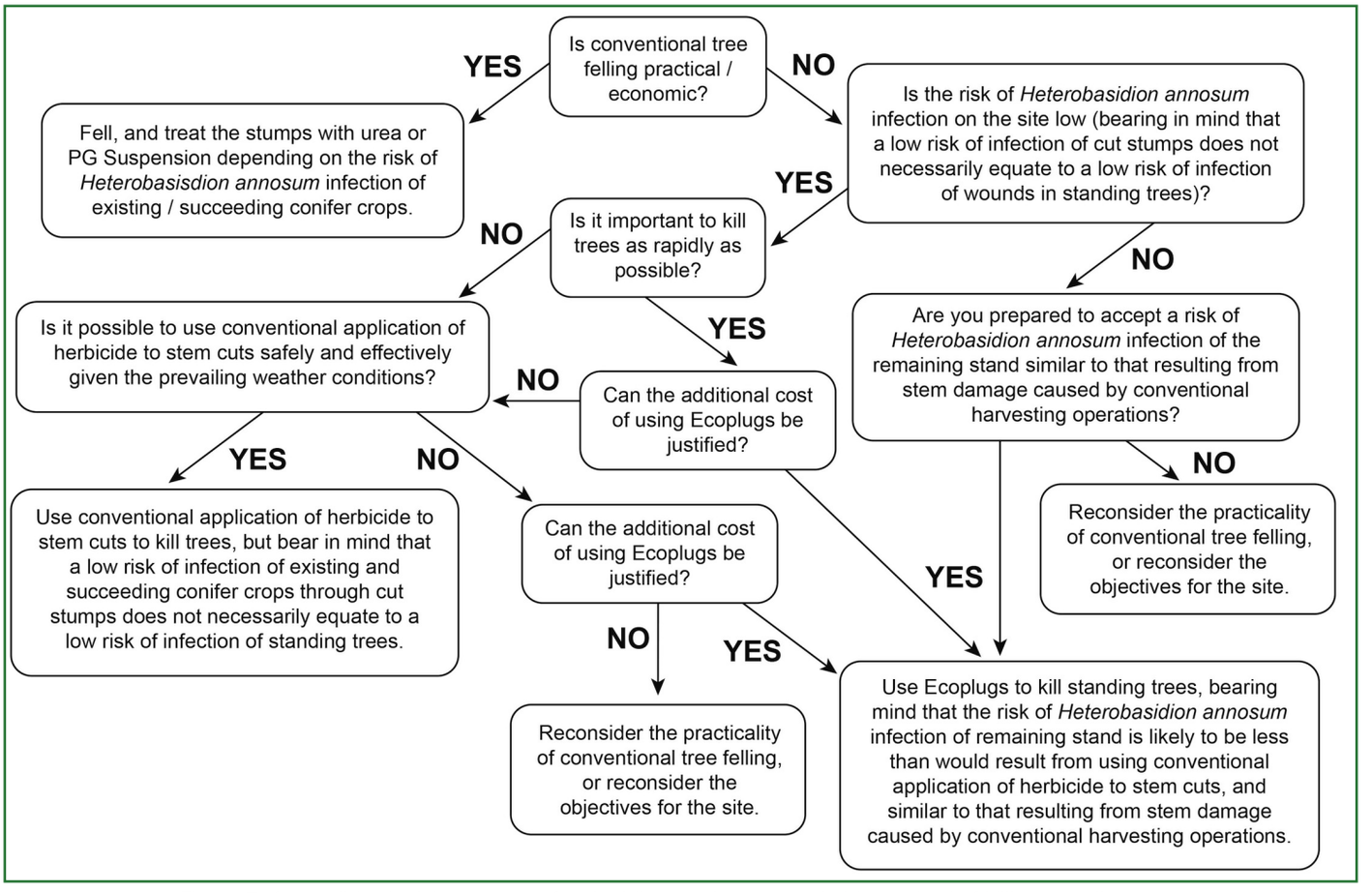

Figure 7. A possible decision process for deciding on the most suitable method of killing standing trees as part of a selective or halo thinning operation.

Forestry Commission (2015). PG Suspension® product label. www.forestry.gov.uk/fr/pgsuspension (Accessed 8/2/16).

Monsanto (2009). Ecoplug Max® product label (MAPP number 14741). www.monsanto-ag.co.uk (Accessed 8/2/16).

Monsanto (2016). Ecoplug Max® product label (MAPP number 17581). www.monsanto-ag.co.uk (Accessed 16/11/16).

Saunders, C. (2014) An Investigation into the Efficiency of Ecoplugs for Chemical Thinning. Technical Development Job Report 121. Internal report available from: Technical Development, Forest Research, Ae Village, Parkgate, Dumfries, DG1 1QB, Tel: 01387 860264.

Tubby, K.V., Willoughby, I.H. & Forster, J. (2017) The efficacy of chemical thinning treatments on *Pinus sylvestris* and *Larix kaempferi* and subsequent incidence and potential impact of *Heterobasidion annosum* infection in standing trees. *Forestry*, **90**(5):728-736. https://doi.org/10.1093/forestry/cpx038.

Willoughby, I.H., Stokes, V.J. & Connolly, T. (2017) Using Ecoplugs containing glyphosate can be an effective method of killing standing trees. *Forestry*, **90**(5):719-727.

https://doi.org/10.1093/forestry/cpx028.

Willoughby, I.H., Stokes, V.J. & Edwards, C. (2017b) Ecoplugs containing glyphosate can be effective in preventing regrowth from *Rhododendron ponticum* stumps. *Scottish Forestry*, **71**(3):33-39. http://www.rsfs.org/journal.

Dr Ian Willoughby is a silviculturist with Forest Research, part of the Forestry Commission, and is based at Alice Holt research station. He leads the Delivering Resilient Forests multidisciplinary science programme, and has a particular research interest in regeneration and integrated pest, weed and disease management.

Dr Katherine Tubby is a plant pathologist at Forest Research, Alice Holt, and is currently leading projects investigating the use of fungicides and non-chemical disease management, and on the surveillance and management of Dothistroma needle blight.

Colin Saunders is an operations manager with Forestry Commission Scotland, and was formerly a Technical Development Forester in Forest Research carrying out work and method studies, and machinery development, to improve forest management and harvesting operations.

Dr Suzanne Peace is a research liaison officer at Forest Research, Alice Holt, and is a specialist in communicating science and delivering knowledge exchange activities.