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European Innovation Partnership (EIP) Wales

Establishing trees in dense bracken

Final report

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Cronfa Amaethyddol Ewrop ar gyfer Datblygu Gwledig:
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European Agricultural Fund for Rural Development:
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Llywodraeth Cymru
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1. Introduction

The main purpose of this project was to examine whether mechanical cultivation could provide a method of reducing bracken growth enough to allow the successful establishment of trees.

The Welsh Government has proposed the planting of 40,000 ha of woodland as part of its climate-change strategy. Bracken land provides an obvious location for much of this woodland as it has a low agricultural value and is generally not considered to be of great conservation value. Moreover, soils in which bracken grows well are good for tree growth.

The main method of controlling bracken on steep slopes is by aerial spraying of herbicide by helicopter. This can be very effective in the short-term but it is also a problematic method. There are sufficient safety concerns that the product (Azulox) has been officially withdrawn, although it continues to be available through temporary derogations. Several instances of pollution of water courses and contamination of water supplies have been recorded. There is also the threat of collateral damage to vegetation of adjacent land. Spraying is not an available option in several circumstances: on organic land, near watercourses or water supplies, and near sites for nature conservation.

Ploughing breaks up the bracken rhizomes and can vastly reduce the vigour of the plant. The purpose of this project was to examine the potential to use ground cultivation as a control method before planting. The project looked at ploughing/ cultivating strips using various pieces of equipment and planting a variety of tree species. The subsequent growth and mortality were then monitored over three seasons. Post-planting cutting or trampling of the bracken was also assessed.

Measures to combat the Covid epidemic were in force for much of the project and this had an impact on the range of experiments that it was possible to carry out and on some of the monitoring. The winter of 2020 was exceptionally wet with February 2020 was the wettest February on record in Wales (and the UK). This also had a negative impact on the experiments.

2 Methodology

2.1 Sites

There were two experimental sites

Nannerth Fawr, Rhayader:

Altitude: 280-300m

Slope: 35-40%

Aspect: SSE

Bracken height: 1.7m

Area planted: 1 ha

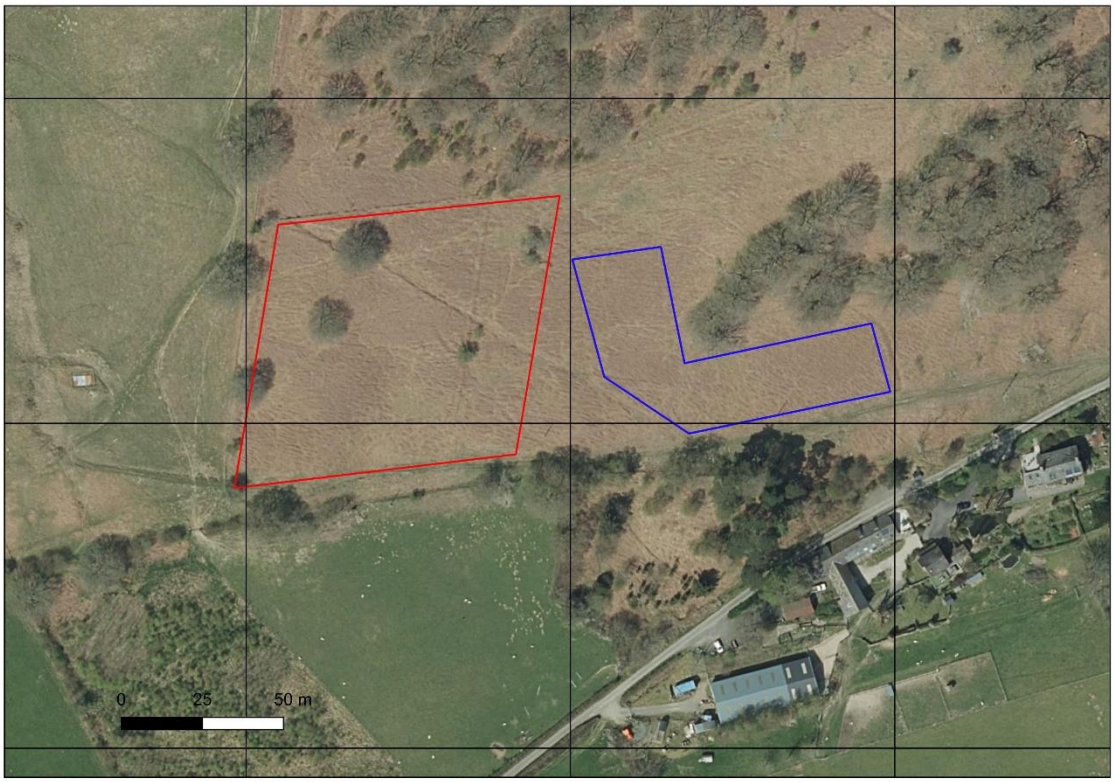

Figure 1: Aerial photograph of Nannerth site. Red polygon is the area planted in 2020: blue polygon is 2021 planting.

Hafodwen, Talerddig

Altitude: 300-340m

Slope: 50-80%

Aspect: SSE

Bracken height: 1.8 m

Area planted: 0.75 ha.

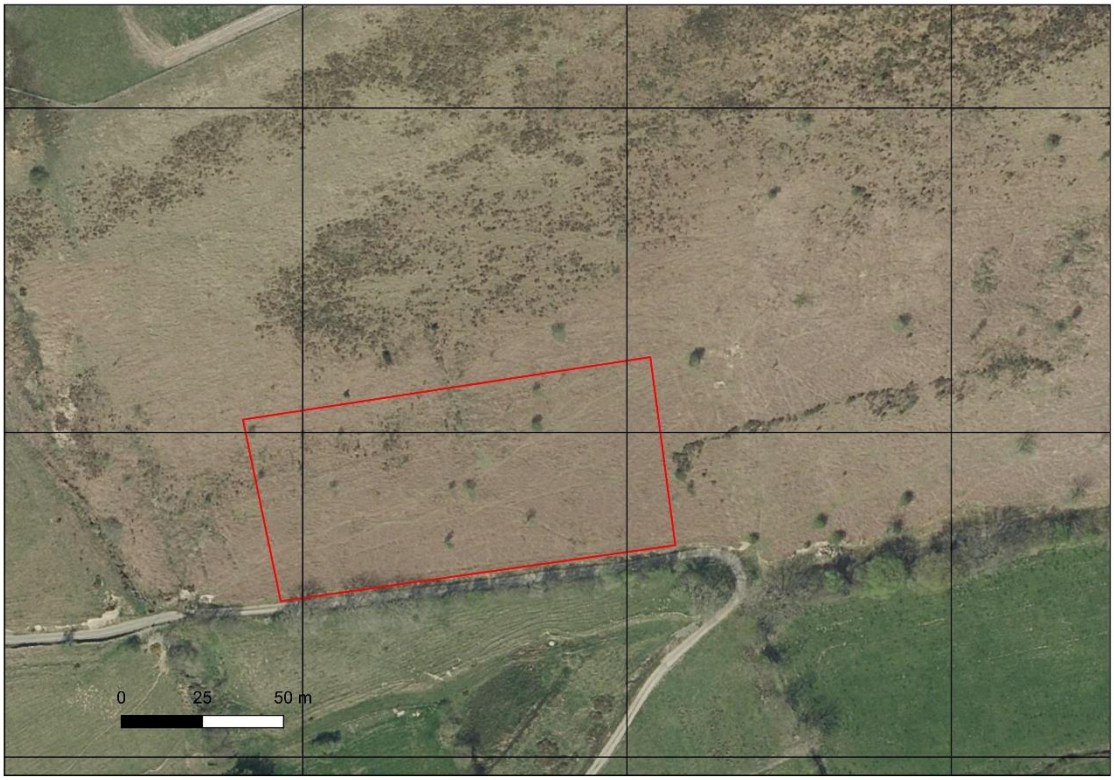

Figure 2: Aerial photograph of Hafodwen site. Red polygon shows the area planted in 2020

2.2 Cultivation experiments

The variety of cultivation techniques was reduced from the original plan. The ploughing by tractor did not happen largely due to Covid. The contractor with the forestry scarifier considered the ground at Hafodwen to be too steep to operate safely.

The cultivation experiments were carried out at Nannerth.

2.2.1 Robocut rotavator

The McConnell Robocut is a remote-controlled tracked 40hp power unit. This was equipped with a front mounted rotary tiller with a 1450mm working width and a cultivation depth 15 cm.

Figure 3: Robocut with rotavator attachment

2.2.2 Rotavator head on mini digger

Kubota 6T mini digger equipped with an Exac-1 Minitilla rotavator attachment consisting of 3 hydraulically driven vertical axis rotavator heads with an effective penetration depth of up to 25cm. The width of the cultivated strip was approximately 100cm.

2.2.3 Mini digger bucket

The 50cm bucket of a 6T mini digger was used to dig a strip around 1.2m wide down to a depth of around 30cm. Both continuous strips and individual planting positions were tried. The latter being similar to the standard “dolloping” technique.

Figure 4: Minitilla rotavator attachment

2.3 Planting

Four tree species were chosen: downy birch, rowan, sessile oak, and Sitka spruce. The transplants were 45-60cm in height. They were planted in rows perpendicular to the contour with a strict alternation of species. The deciduous species were planted with a cane and protective spiral. The spacing between the trees was approximately 2.5 m between rows and within the row. Around 1200 trees were planted at Hafodwen and around 2000 at Nannerth.

2.4 Bracken cutting and flattening

This part of the experiment was added in the light of the absence of some of the cultivation techniques. The bracken was either strimmed or trampled. Approximately 1m wide path was strimmed or trampled. Untreated controls were several rows in width to reduce any edge effect.

3. Results

3.1 Machinery suitability

The sites chosen proved challenging for most of the equipment used. Although ploughing by tractor was not carried out, it was apparent while trying to organise the work, that there would be practical difficulties at some sites. An access track of at least 3m width would be needed and there were also potential issues concerning turning at the base of the slope due to the steepness.

The potential for the use of a forestry scarifier is limited to less steep slopes.

The Robocut machine was not well suited to working up and down the slope and even small irregularities of slope caused problems and in one case minor damage to the machine. More importantly, the depth of cultivation was limited to around 15cm. This was not deep enough to break up the majority of the rhizomes.

The mini digger experiments were only carried out at Nannerth. The slightly steeper slope at Hafodwen being too great for the machine to maintain traction safely. It should be noted that the attempt was made after an exceptionally wet winter.

3.2 Impact of treatments on height

Treatment can provide a clear benefit in terms of growth. The difference is apparent in the first year of treatment and is subsequently maintained. Figure 5 illustrates the height distribution of each of the four species under the various treatments at the end of the first year. The clearest effects in Year 1 were for the birch and rowan. This was maintained in subsequent years for the trees planted in 2020. However, the impact of strimming on the growth of the 2021 planting (Nannerth only) was less, as shown in Figure 6.

The greatest heights were recorded from birch where the row had undergone continuous rotavation using the mini digger rotavator. The median height for birch given any type of rotavator preparation was 275 cm versus 161 cm for the control plots. Strimming or trampling also made a significant difference with a median height of 216 cm.

Rowan responded in similar fashion, although the effect was less consistent between the two sites: Nannerth showed little difference, whereas the impact at Hafodwen was far more marked.

For sessile oak, the impact of the treatments was much less. There was only a statistical difference at Nannerth and this was only in the rotovated plots. The difference in height was relatively small.

Sitka spruce did not perform well irrespective of treatment and site.

The median heights of the surviving trees under various treatments are shown in Figure 8.

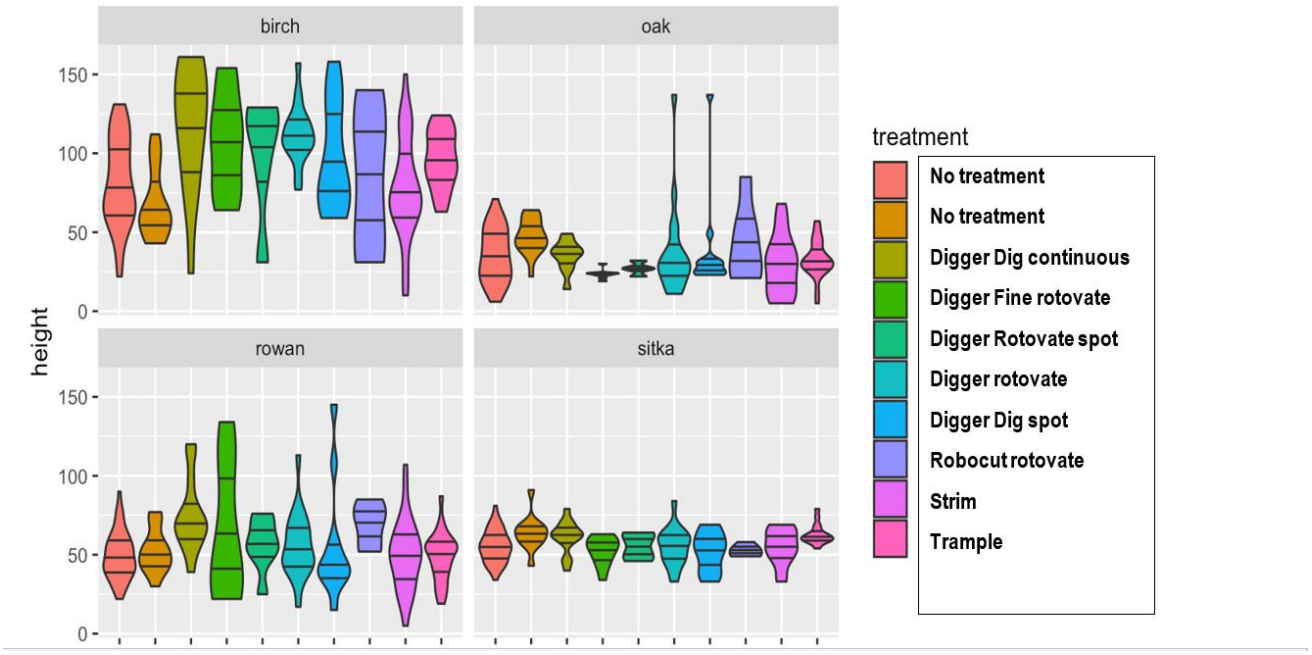

Figure 5: Height (cm) of trees recorded in November 2020 (data from Hafod wen and Nannerth combined). The width of the violin plot represents the number of trees at that height increment. The black horizontal lines show the quartile boundaries.

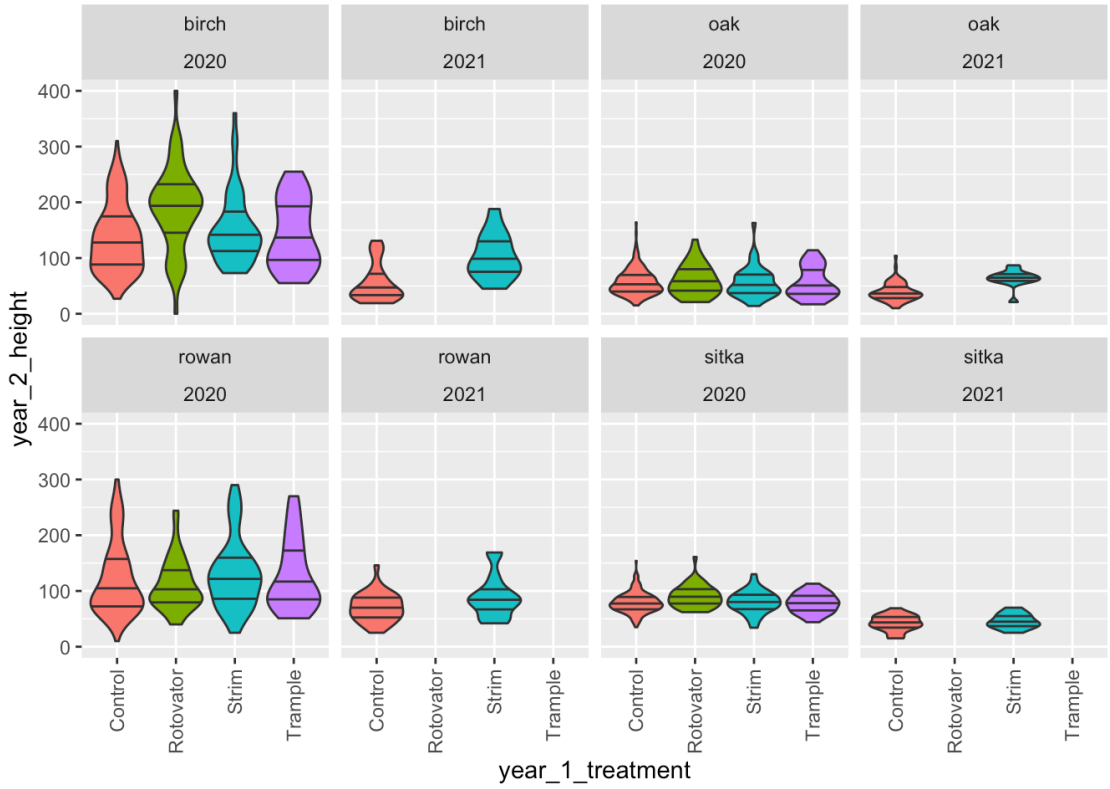

Figure 6: Height (cm) of trees planted in 2020 and 2021 by the end of their second season of growth. The width of the violin plot represents the number of trees at that height increment. The black horizontal lines show the quartile boundaries.

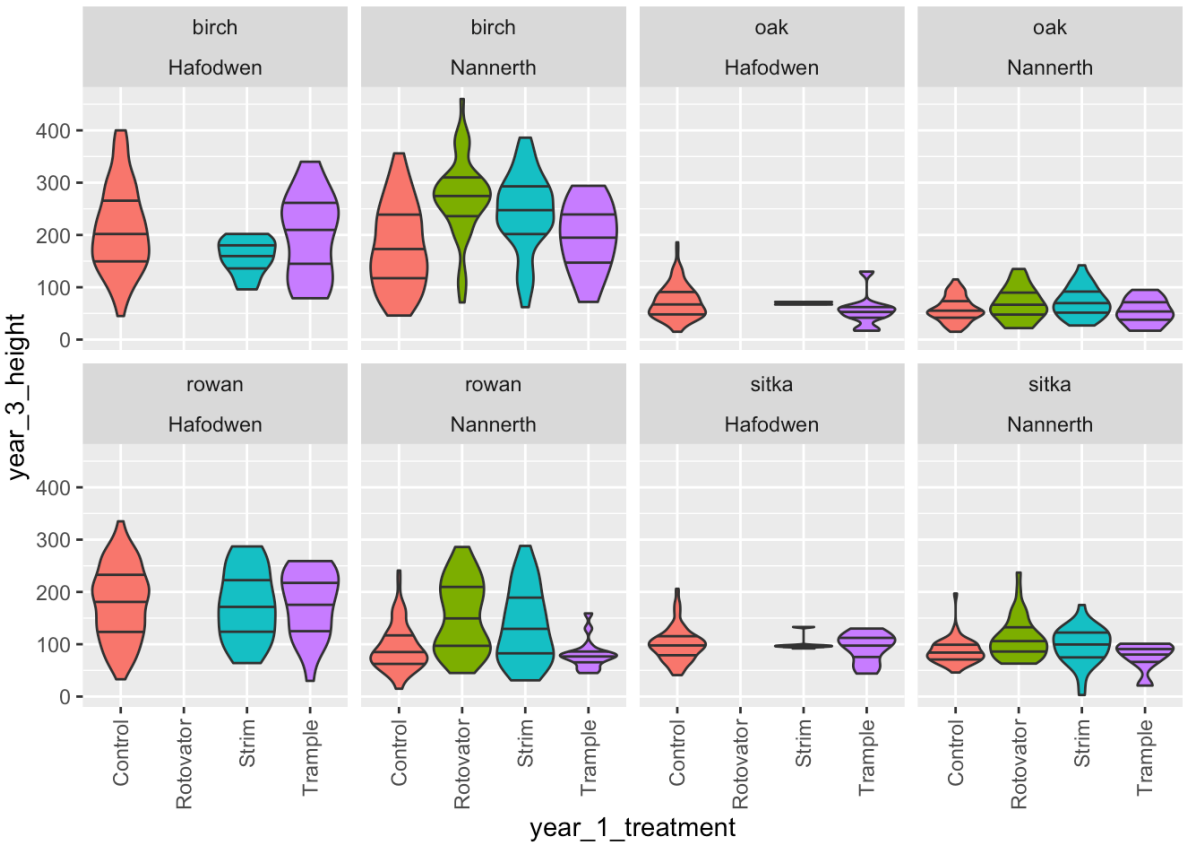

Figure 7: Height (cm) of trees planted in 2020 by the end of 2022. The width of the violin plot represents the number of trees at that height increment. The black horizontal lines show the quartile boundaries.

Species	Site	Control/Treated	Planting Year	Sample size	Median Ht Yr 1(cm)	Median Ht Yr2 (cm)	Median Ht Yr 3 (cm)	P value
Downy Birch	Nannerth	Control	2020	97	73	117	161	a***
	Nannerth	Treated Any	2020	130	96	168	264	a***
	Nannerth	Treated Rotovate	2020	73	109	189	275	
	Nannerth	Treated Veg	2020	57	84	152	216	
	Nannerth	Control	2021	34	38	41		
	Nannerth	Treated Veg	2021	52	61	64		
	Hafodwen	Control	2020	69	77	123	170	e***
	Hafodwen	Treated All	2020	242	88	142	210	e***
Sessile Oak	Nannerth	Control	2020	116	33	52	55	b**
	Nannerth	Treated Any	2020	124	29	48	65	b**
	Nannerth	Treated Rotovate	2020	66	28	53	67	
	Nannerth	Treated Veg	2020	59	30	45	55	
	Nannerth	Control	2021	44	32	34		
	Nannerth	Treated Veg	2021	51	43	57		
	Hafodwen	Control	2020	68	25	51	57	f
	Hafodwen	Treated Veg	2020		30	55	66	f
Rowan	Nannerth	Control	2020	100	48	76	81	c***
	Nannerth	Treated Any	2020	124	55	95	115	c***
	Nannerth	Treated Rotovate	2020	72	61	108	162	
	Nannerth	Treated Veg	2020	52	49	84	79	
	Nannerth	Control	2021	39	65	72		
	Nannerth	Treated veg	2021	59	60	73		
	Hafodwen	Control	2020	51	47	88	144	g***
	Hafodwen	Treated Veg	2020	168	74	142	200	g***
Sitka Spruce	Nannerth	Control	2020	99	56	77	82	d**
	Nannerth	Treated Any	2020	118	54	84	98	d**
	Nannerth	Treated Rotovate	2020	63	56	85	104	
	Nannerth	Treated Veg	2020	55	59	82	96	
	Nannerth	Control	2021	46	38	51		
	Nannerth	Treated Veg	2021	42	36	41		
	Hafodwen	Control	2020	86	57	76	100	
	Hafodwen	Treated Veg	2020	149	60	77	94	

*Figure 8: Median heights of surviving trees under different treatments. The rotovated plots have been combined into one category and likewise the treatments involving strimming or trampling (the category is labelled "treated veg" in the table). The final column shows statistical analysis of various pairs of results. *** indicates P <0.01, ** indicates P<0.05.*

The 2022 strimming experiments at Nannerth were carried out in early June, early May and mid-August. The date of strimming did not appear to have a significant effect on the median height of the trees at the end of the season. The amount of data collected was insufficient for a full statistical analysis. The data do suggest that, for rowan, the early strimming gives a strong boost to the height gained.

3.3 Impact of treatments on survival

Arguably, survival is a more important measure of the success of the treatment than the height, although clearly the two are related. Figure 9 below shows the cumulative mortality according to the treatment.

There were significant differences in mortality for some interventions. For example, the mortality of rowan at Nannerth was halved in the rotavated, strimmed or trampled sites. But there was little difference in the mortality rate of the treated and control plots of rowan at Hafodwen. Here the mortality rate was much lower.

The patterns of variation are quite complex and there are major differences between the sites for some species, despite the apparent similarity of the sites. The response of the trees from the two planting seasons at Nannerth was not similar.

Species	Site	Control/Treated	Planting Year	Sample size	cumulative mortality Year 1	cumulative mortality Year 2	cumulative mortality Year 3
Downy Birch	Nannerth	Control	2020	97	4%	14%	39%
	Nannerth	Treated Any	2020	130	2%	11%	26%
	Nannerth	Treated Mech	2020	73	1%	1%	16%
	Nannerth	Treated Veg	2020	57	3%	22%	27%
	Nannerth	Control	2021	34	29%	62%	
	Nannerth	Treated Any	2021	52	2%	40%	
	Hafodwen	Control	2020	69	1%	7%	30%
	Hafodwen	Treated Veg	2020	242	3%	7%	32%
Sessile Oak	Nannerth	Control	2020	116	11%	18%	33%
	Nannerth	Treated Any	2020	124	10%	23%	41%
	Nannerth	Treated Mech	2020	66	9%	23%	32%
	Nannerth	Treated Veg	2020	59	10%	45%	55%
	Nannerth	Control	2021	44	2%	13%	
	Nannerth	Treated	2021	51	0%	2%	
	Hafodwen	Control	2020	68	31%	37%	43%
	Hafodwen	Treated Veg	2020		24%	40%	62%
Rowan	Nannerth	Control	2020	100	5%	19%	31%
	Nannerth	Treated Any	2020	124	2%	8%	16%
	Nannerth	Treated Mech	2020	72	4%	8%	17%
	Nannerth	Treated Veg	2020	52	0%	8%	15%
	Nannerth	Control	2021	39	0%	5%	
	Nannerth	Treated	2021	59	0%	5%	
	Hafodwen	Control	2020	51	6%	8%	14%
	Hafodwen	Treated Veg	2020	168	2%	6%	12%
Sitka Spruce	Nannerth	Control	2020	99	10%	21%	51%
	Nannerth	Treated Any	2020	118	9%	25%	43%
	Nannerth	Treated Mech	2020	63	0%	11%	21%
	Nannerth	Treated Veg	2020	55	20%	33%	55%
	Nannerth	Control	2021	46	20%	74%	
	Nannerth	Treated	2021	42	2%	38%	
	Hafodwen	Control	2020	86	9%	15%	40%
	Hafodwen	Treated Veg	2020	149	7%	13%	33%

Figure 9: Cumulative mortality. The rotovated plots have been combined into one category and likewise the treatments involving strimming or trampling (the category is labelled "treated veg" in the table).

4 Discussion

4.1 Mechanical cultivation

The results of the experiments suggest that cultivation is not a promising option for preparing bracken sites for trees planting even though it clearly does improve survival. In practice, most bracken sites are likely to be too steep for the safe or efficient use of machinery. On less steep sites, there may be some potential for ploughing. There are potential issues of erosion especially if the whole site is treated.

The use of the digger to produce local mounds, even those larger than those typically used in mounding, is not likely to be effective. The adjacent rhizomes still produce dense growth.

4.2 Mortality and growth

There is good evidence that the growth rate is improved if the site is prepared by rotavation or if the bracken is subsequently cut or trampled. But the effect is only pronounced for rowan and birch. The rate of mortality for these two species is also significantly reduced following treatments

The figures for mortality are surprising. One might have expected that the rate of mortality would decrease over successive years. This was not the case. The rate of mortality even increased in the third year in some cases. At first site, this is counterintuitive. If the plant survives, and makes growth, this larger, more established plant might be supposed to better equipped to survive with each subsequent year. One explanation is that it is not the lack of light that is the crucial factor determining survival but the burying of the trees beneath the bracken litter. In the observations for Year 3 (2022) there were numerous examples of trees that had been pushed over by the bracken and subsequently died. There were also numerous examples, particularly for the birch, where the leading shoot had been snapped off.

The greater survival of rowan and birch in the treated areas may be primarily due to the fact that these conditions led to sturdier plants which were more capable of resisting flattening from the collapsing bracken.

The rather limited data from the strimming experiments at Nannerth did not show any obvious relationship between the timing of the strimming and the growth rate of the trees. The effect of the different strimming dates on mortality could not be assessed within the timescales of the project. If the surmise that the dominant impact of bracken is that of burying the young trees, then strimming (or trampling) at the end of the season could be the most effective time for an intervention. This is worthy of further investigation.

4.3 Natural regeneration

It was hoped that the ground preparation could also make the site receptive to establishment of trees from natural seeding. Birch, in particular, has a propensity for establishing on bare mineral soils. Cleared-felled sites of conifer plantations commonly have prolific natural regeneration of birch even in the absence of a large local seed source. In practice, there was little evidence of natural regeneration in the rotovated areas at Nannerth. The main regeneration present was in grass in the immediate vicinity of the birch trees at the southern edge of the site.

5. Conclusions

1. Notwithstanding the reduced amount of experimental data due to Covid, this study suggests that cultivation of bracken is not likely to be a promising option. A slope above 50% is probably the safe limit for working. Most bracken covered land is likely to be too steep for most equipment. The cultivated strips would have to be wide in order to avoid the impact of vigorous growth of adjacent bracken. Complete ploughing or rotavation of the site would be the most practicable option and this could lead to erosion and other environmental problems.

2. Planting into dense bracken (using canes and spirals) in the absence of cutting or trampling leads has a poor rate of establishment. Significant cumulative losses continue for at least three years after planting.

3. The most resilient of the four species chosen was rowan. Birch was also fairly resilient. These species should be favoured when planting difficult bracken sites.

4. The pushing over and smothering effect of the bracken appears to be a greater problem than the direct shading. Trees planted into bracken without any support are not likely to survive. Any support that helps prevents the tree from being pushed over should help reduce mortality. Any canes used should be extra sturdy.

5. The impact of the timing of strimming and/ or trampling, on tree survival is a topic of research that would be worth looking at in the future.