

Edwards' Central Theory of *Rhododendron* Control

$$I = (S + P) * k$$

Where: S = safe sites

P = a seed source

k = (density dependant) mortality

I = invasion



$$I = (S + P) * k$$

1. If you have plants growing (I) – the site is suitable (S) and seeds source is present (P).
2. Balanced equation = reaches point where no new invasion can occur (k).
3. Rate of 'I' is influenced by 'strength' of 'S' 'P' & 'k'.
4. 'Control' without consideration to both sides of equation will only shift it temporarily.



1. Plant dispersal and growth model – to aid control planning and management operations

2. Strategic planning a management control /eradication programme



Objective :- To design and build a Decision Support Tool for stakeholders to maximise the control or eradication of *Rhododendron ponticum* (L) in the UK.

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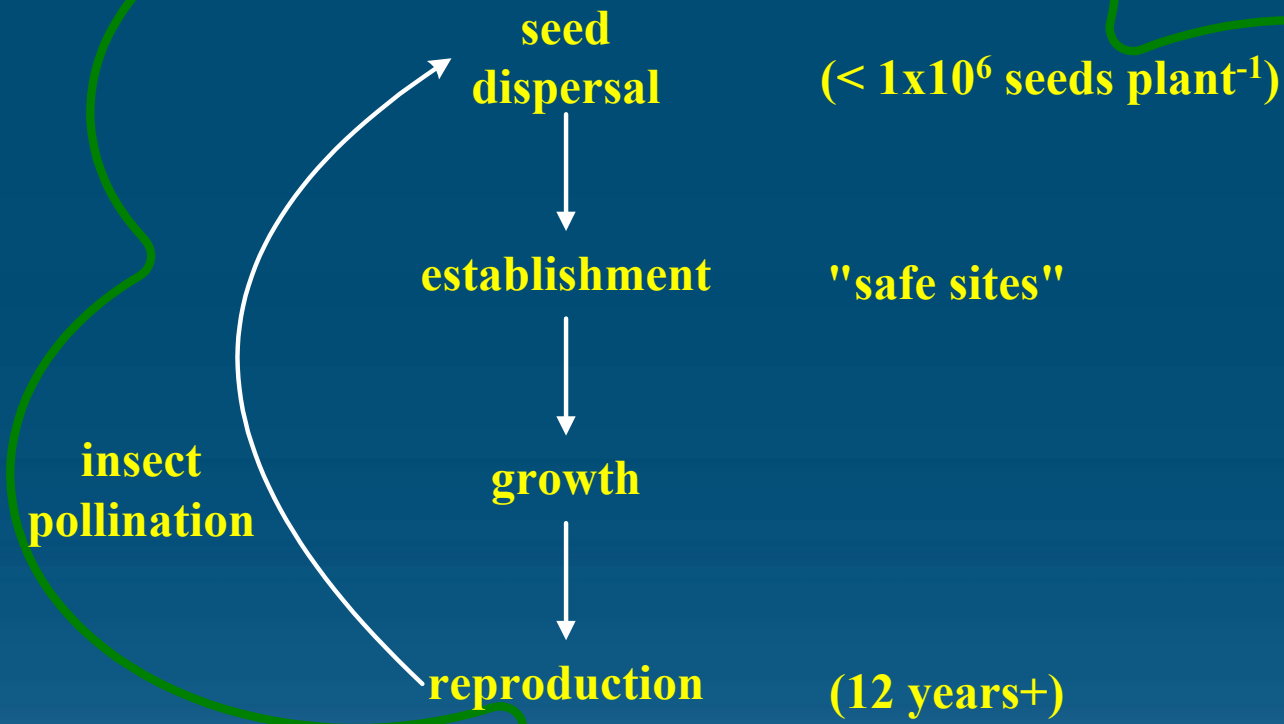
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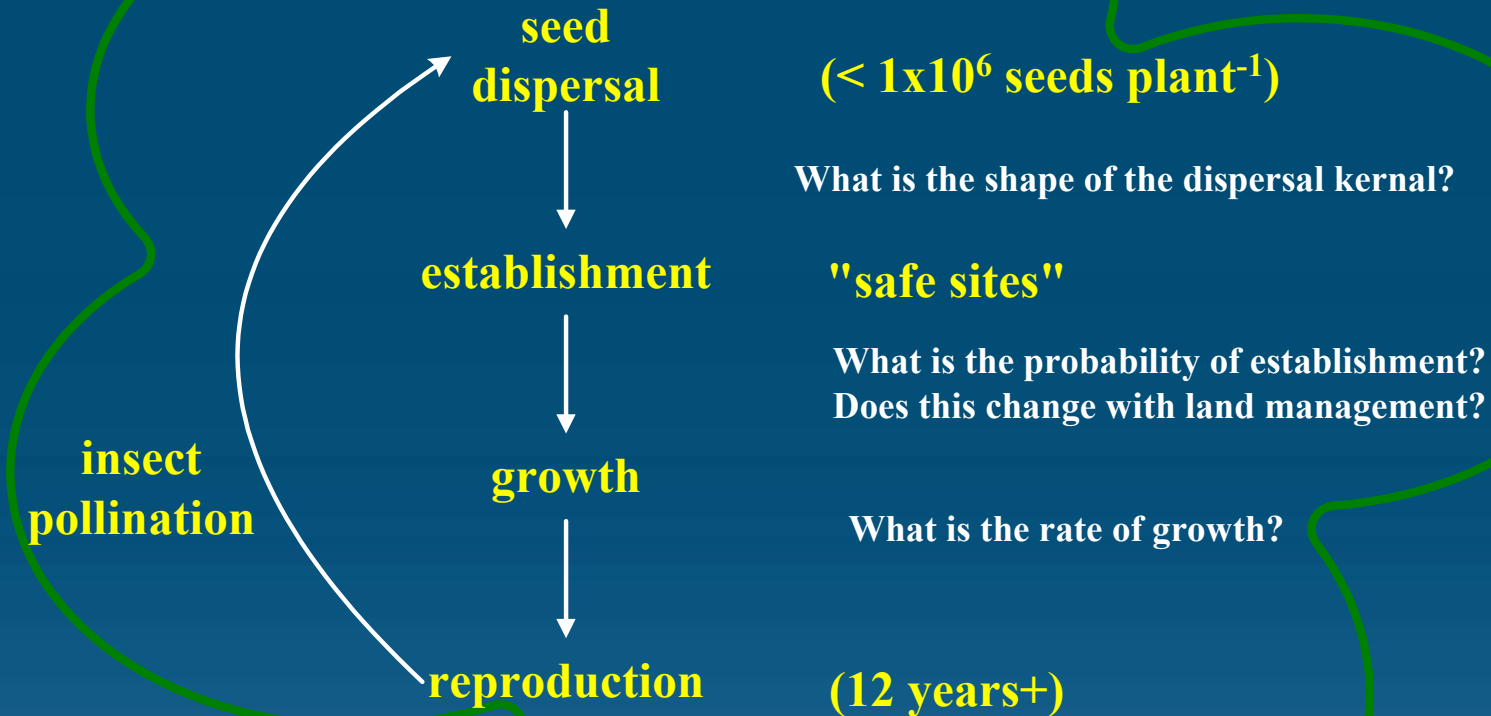
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environmental parameters



environmental parameters



Where are the points of ecological vulnerability?



Growth model data collection -

- *R. ponticum* was planted around Mamore Lodge Hotel in 1907.
- Gardeners controlled the plants within the garden until 1935 when the Lodge then fell into disuse.
- Sheep were grazed on the surrounding hillsides until c1975 when they were removed from land to the west of the lodge, but kept on at high densities until 1999 outside of the estate and to the east of the lodge (there has always been a low level of grazing throughout the estate).
- The hillsides above the estate have been burned regularly to maintain young heather for deer and grouse.

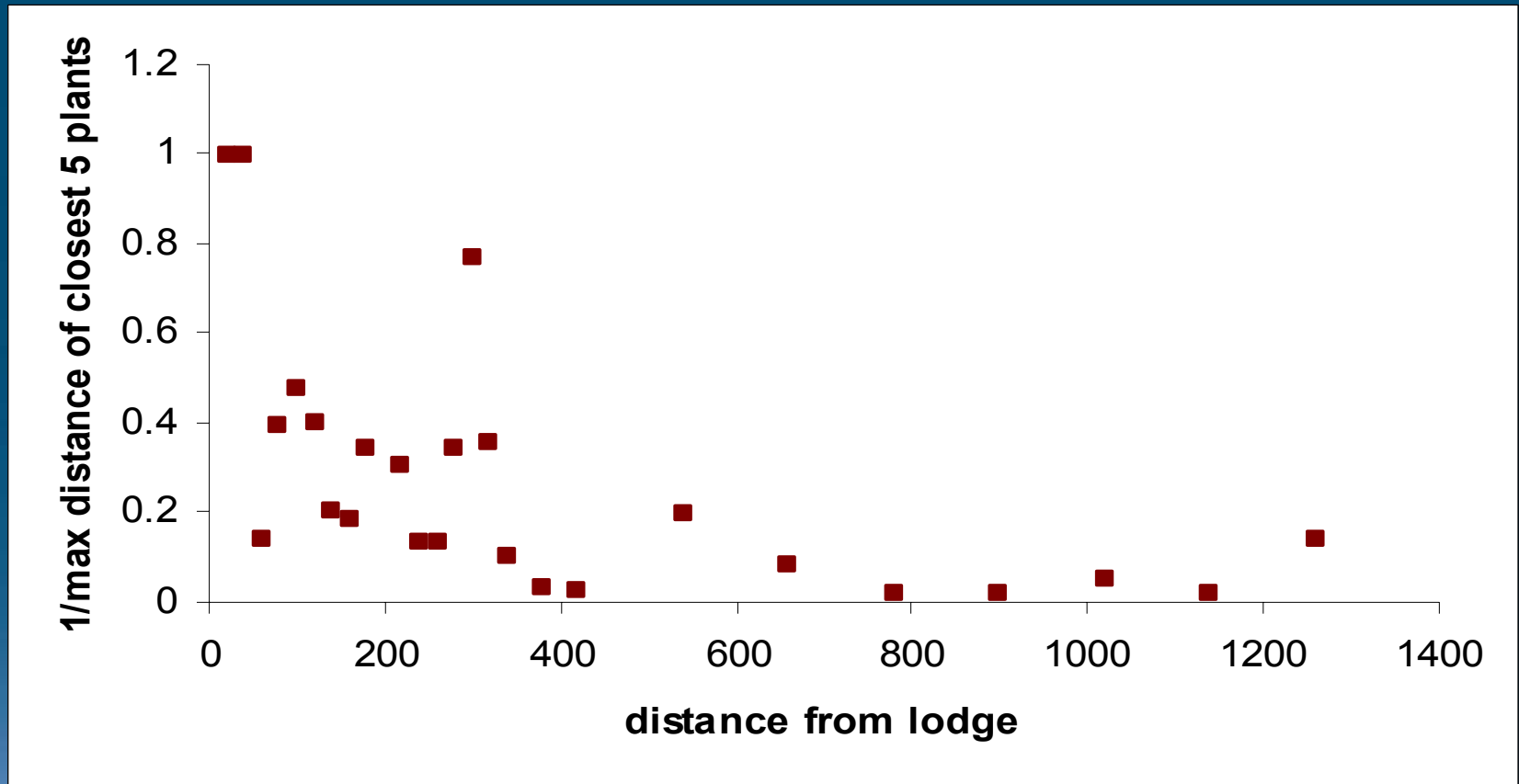


Data collection

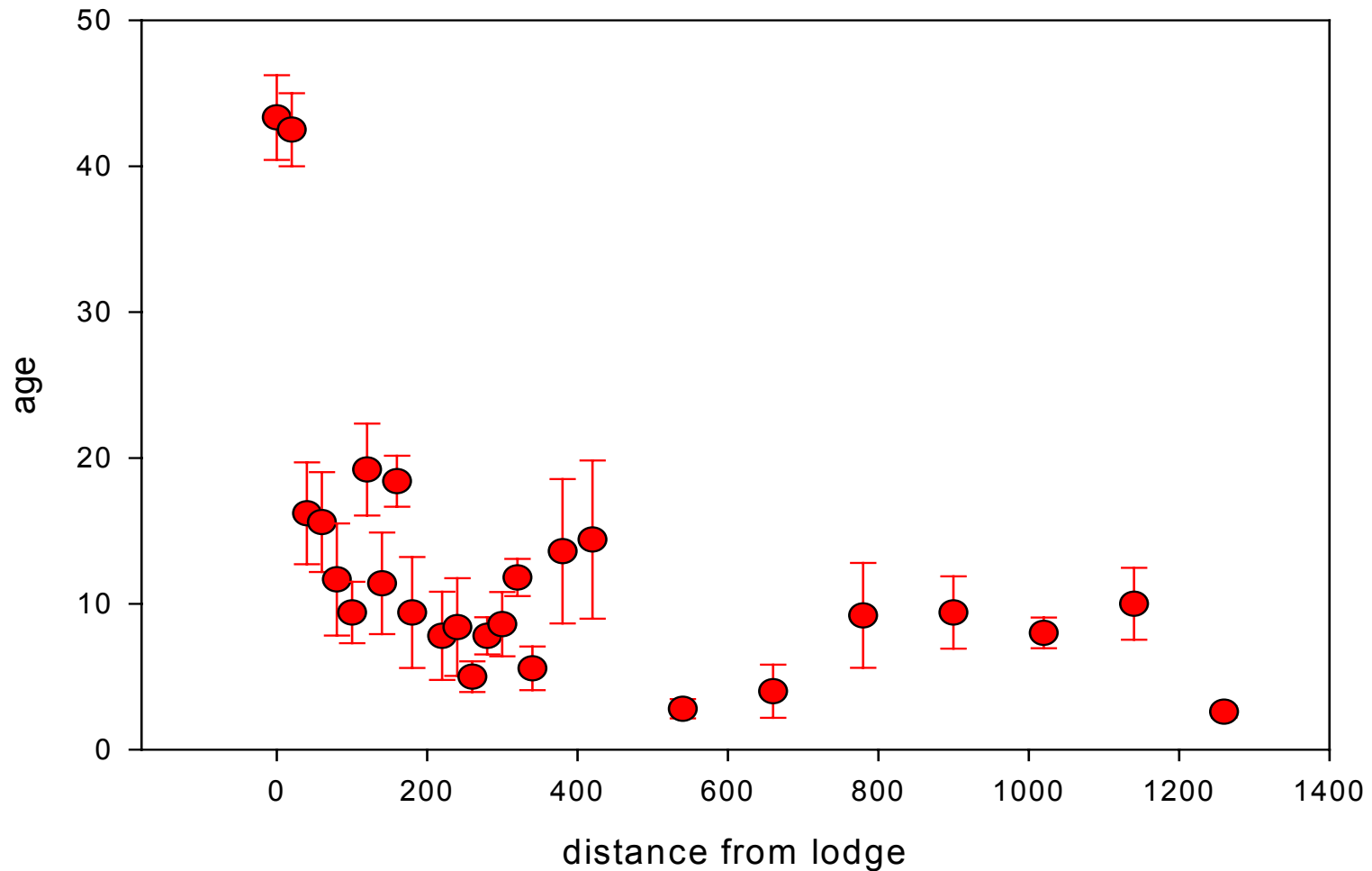
- **1260m transect east from Mamore lodge**
- **Point data every 20m for the first 340m (0-340m)**
- **then every 40m for the next 80m (380-420m)**
- **then every 120m for the last 720m (540-1260m)**
- **At each point for 5 plants closest to the point :**
 - the distance of each plant from the transect**
 - plant height (m)**
 - plant radius (m)**
 - age**
 - the presence of flower buds**
- **Percentage cover of *R. ponticum* in a 5m radius.**



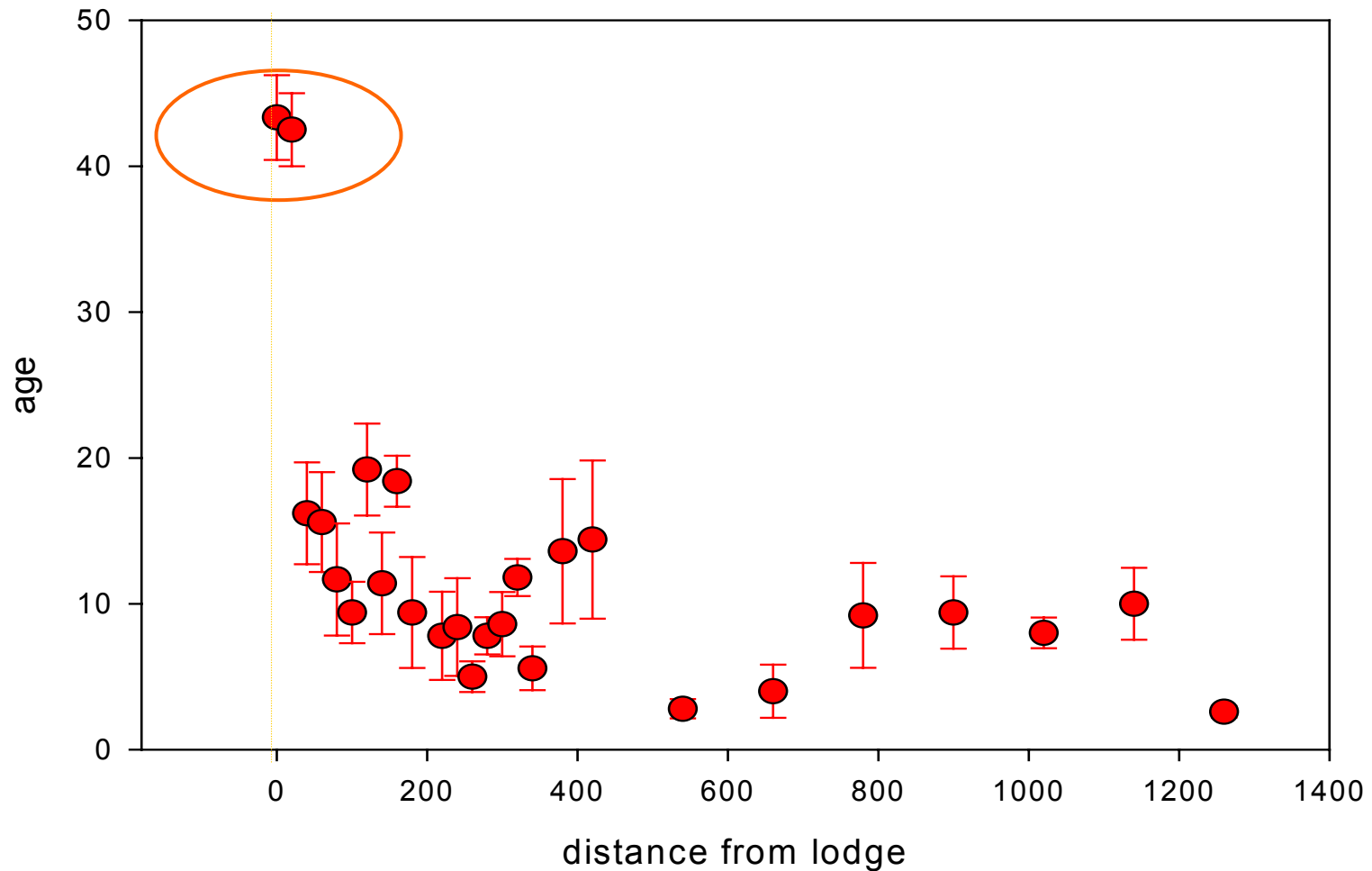
Density of established bushes along study transect



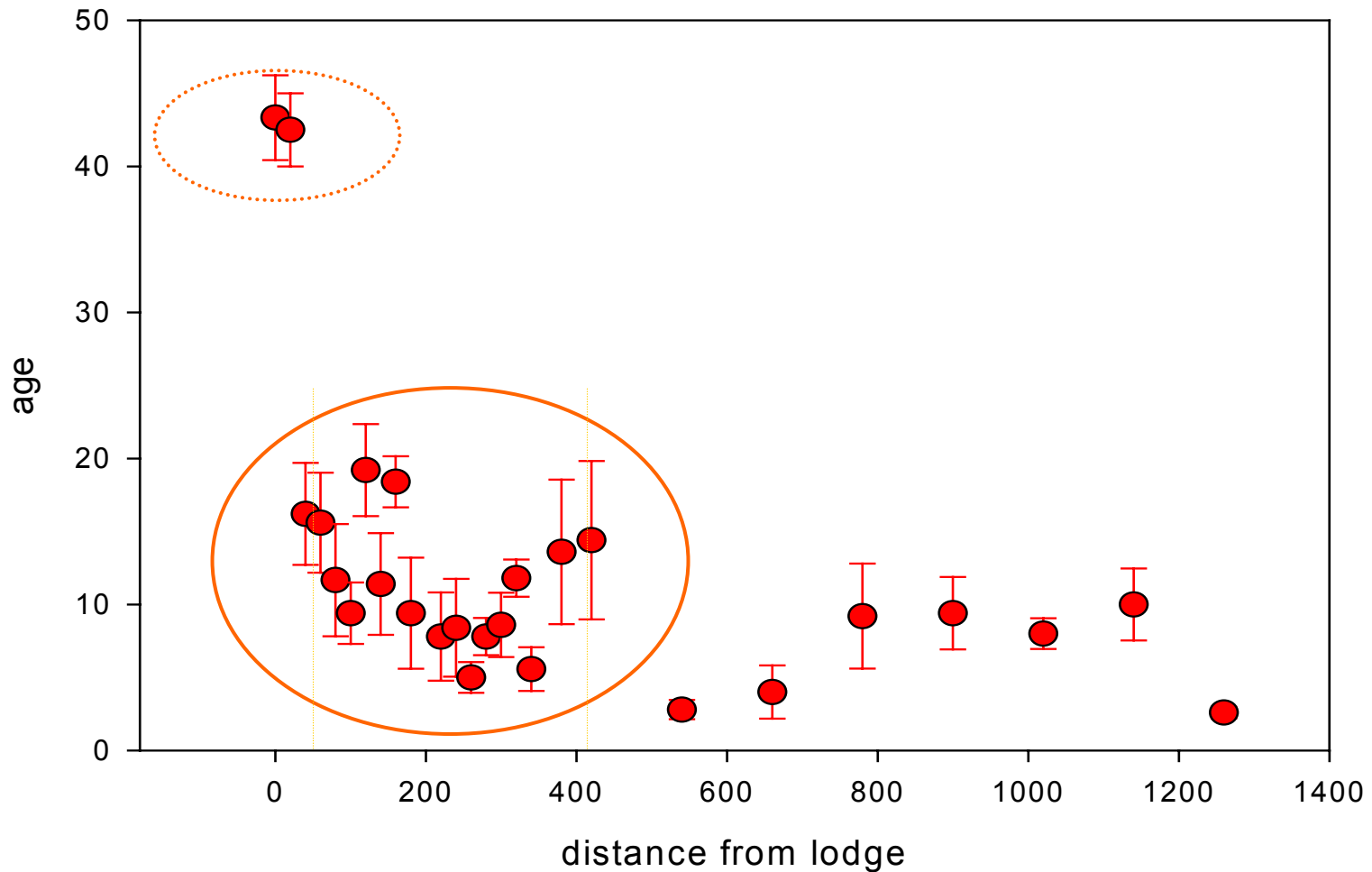
Distribution of ages along transect



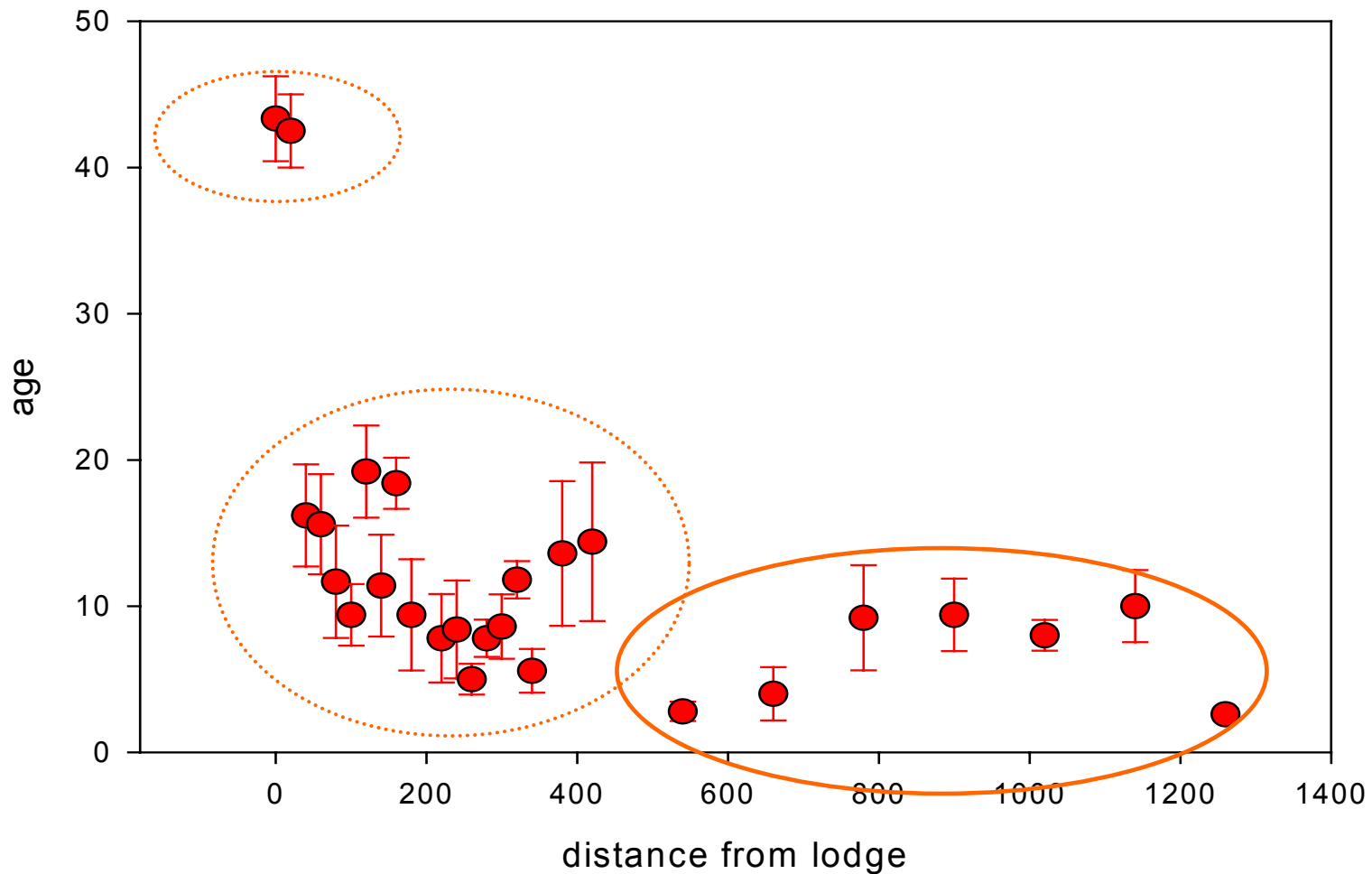
Distribution of ages along transect



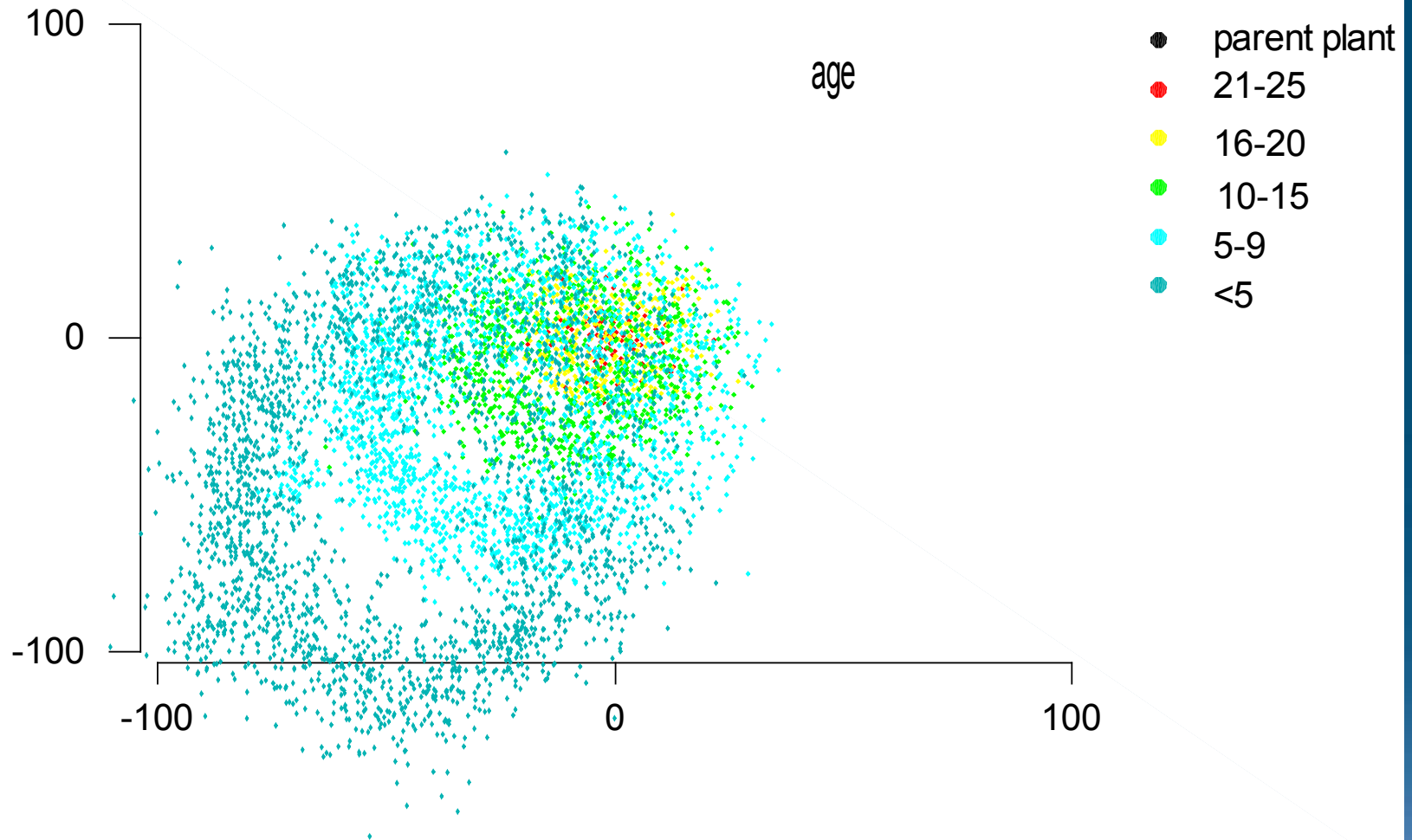
Distribution of ages along transect



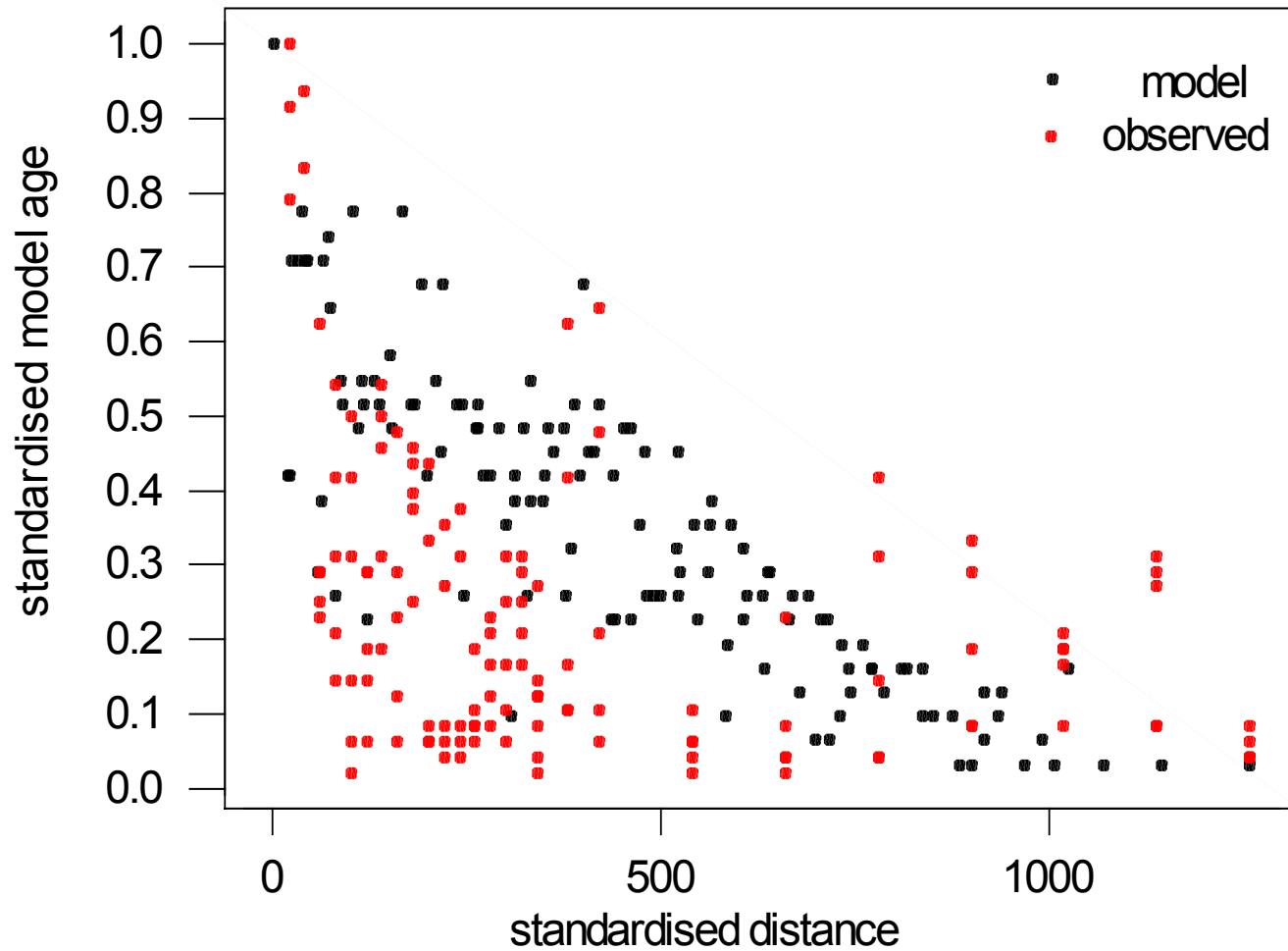
Distribution of ages along transect



Model output colour coded by age



Transect through model



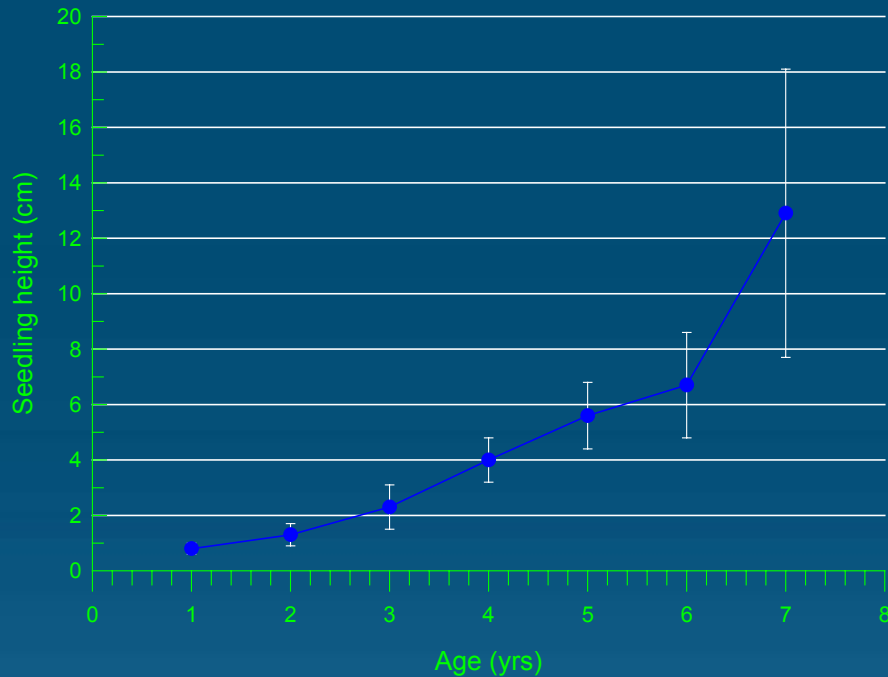
Research to improve model

- **Mechanistic approach** – Calculate terminal velocity of seeds under controlled conditions. *done*
- **Experimental approach** – ‘Controlled’ capture/release of irradiated seeds under different wind conditions. *done*
- **Monitoring approach** – Seed trapping from the edge of *R. ponticum* stands in wooded and non-wooded sites. *done*
- **Population age structure** – Growth ring analysis of six *R. ponticum* stands (e.g. Duke of Argyll’s estate, Inveraray; Brodick Castle, Arran). *done*
- **Monitoring the natural ‘temporal’ release** of seeds from capsules with respect to windspeed, wind direction, air humidity. *Not completed*

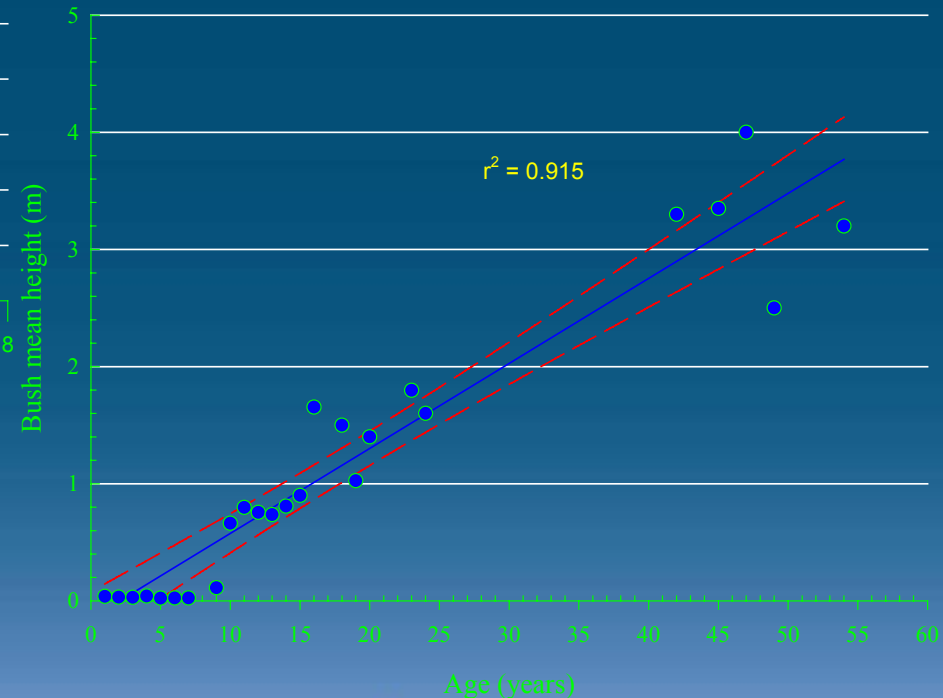


Plant growth from germination to maturity.

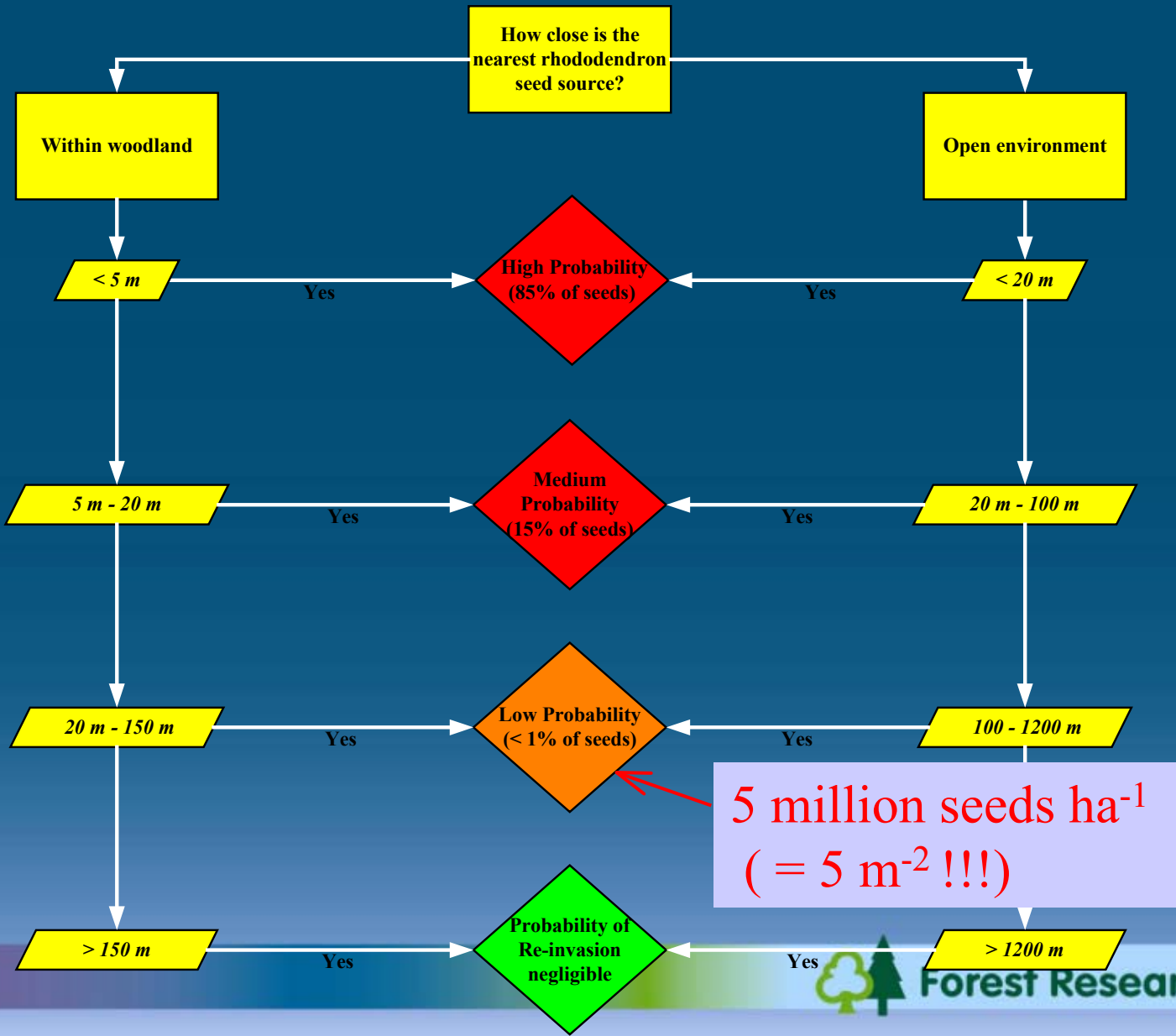
Graph of early *R. ponticum* seedling growth
adapted from Cross



Graph of bush growth from germination to full maturity



Probability of seed dispersal onto site; 'normal' wind speed, medium elevation, low receptivity.



But! High wind speeds and bushes at elevation will disperse further.

Animal and human movement of seeds may be more important than previously thought.



Model predictions clearly show that the best long-term strategy is to remove the seed source, then clear-up peripheral bushes.

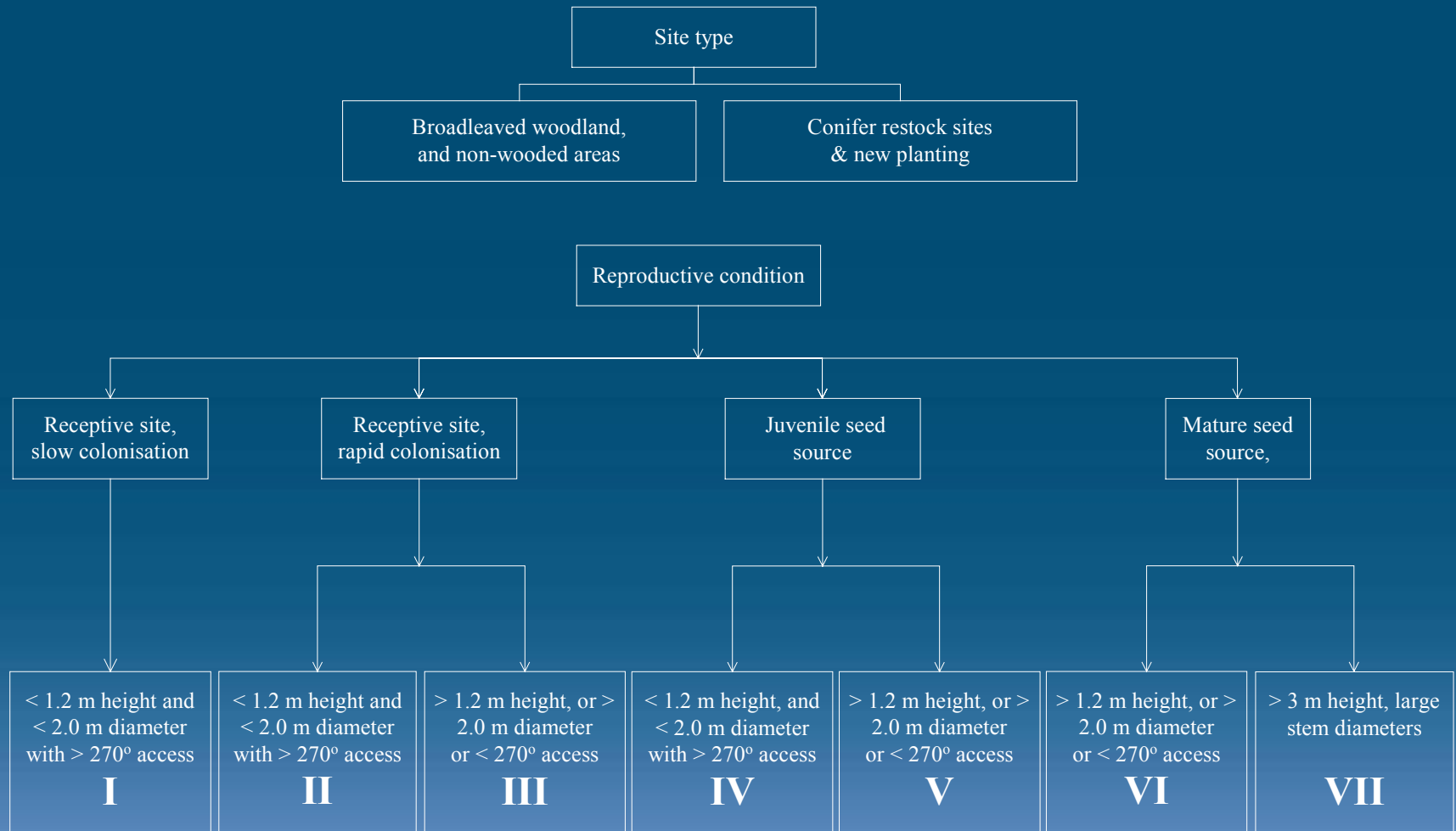


Strategic planning a management control /eradication programme

- Starts with a site survey
- Based on bottom up approach to killing *R ponticum* (from research results)
- May be modified to conditions for each site/region/effective control operations



Site survey - DSS



Rhododendron ponticum bush types used during site survey.

Perhaps need to think in advance what height plants will be when applications are to be made.

| Bush type | Description |
|-----------|-------------|
|-----------|-------------|

| | |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Type 1 | Bushes below 1.2 m height that permits safe overall total application of herbicides. Access to entire bush circumference allows all live foliage to be treated. |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|

| | |
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| Type 2 | Bushes above 1.2 m height, which then require to be cut or flailed before herbicides can be applied. -or- Access to entire circumference is prevented and foliar applications will not reach all live foliage. Partial applications of some herbicides result in incomplete bush control. Top growth removal is recommended, followed by stump treatment or foliar regrowth applications. |
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|--------|--------------------------------------------------------------------------------------------------------------------------------------|
| Type 3 | Very large bushes with access to stems that have large diameters. Stem injection with glyphosate an option that avoids bush removal. |
|--------|--------------------------------------------------------------------------------------------------------------------------------------|



Rhododendron ponticum bush Classes used during site survey.

| Class† | Description of Class and potential control options. |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Class 0</p> | <p>Bushes absent. <i>No control required.</i> Ensure sites remain clear of seedlings if adjacent to Class IV – VII sites by avoiding major disturbance events that will create suitable conditions for seedling establishment.</p> |
| <p>Class I</p> | <p>Sites that are <i>poorly receptive</i> to seed influx and potentially new germination and establishment of bushes. Bush growth very slow and age to flowering extended. Bush densities likely to be low, usually an expanding margin onto an unsuitable habitat for major <i>rhododendron ponticum</i> growth. <i>Very low priority</i> sites that are easily treated by foliar overall applications with herbicide, or if seedlings very small – hand pulling and removal from site. <i>Unlikely to develop into Class III.</i></p> |
| <p>Class II</p> | <p>Sites that are <i>highly receptive</i> to seed influx and potentially new germination and establishment of bushes. Probable recently disturbed sites, or sites with ground cover of low growing bryophytes. Bush growth rapid, but with >8 years to flowering age expected. Early in stage of bush development, many years before seed production and further expansion. Size within limits for overall foliar applications with herbicides, likely to be too large to hand pull. <i>Mid-priority</i> sites that are easy to treat but should not be left too long or they will be too large to treat without cutting down. <i>Will rapidly become Class III</i> sites which then requires bush removal before herbicide control is possible.</p> |
| <p>Class III</p> | <p>Sites that are <i>highly receptive</i> to seed influx and potentially new germination and establishment of bushes. Bush growth rapid with <4 years to flowering age likely. Late in stage of bush development with limited time before seed production. Size outwith limits for overall applications, some cutting, or flailing required before herbicides can be applied. <i>Low priority</i> sites that are too large to treat without cutting down. <i>Will rapidly become Class IV sites.</i></p> |

| | |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Class IV</p> | <p>Sites that are acting as <i>minor seed sources</i>, dispersal and potential establishment of bushes onto adjacent sites very low. Bush growth slow and mainly vegetative, although a few flowers produced annually. Likely at limits for bush survival, either on excessively dry or wet soils, high pH or exposed sites. Seed production low. Size within limits for overall applications. <i>Mid priority</i> sites that are easy to treat, but should be left until higher priority sites cleared. Unlikely to develop into Class V unless major site changes. <i>Should not be left if very close to Class II or Which are highly receptive.</i></p> |
| <p>Class V</p> | <p>Sites that are acting as <i>minor seed sources</i>, dispersal and potential new establishment of bushes onto adjacent sites low. Bush growth rapid although flowering still limited. <i>Likely to become Class VI or VII very quickly.</i> Seed production low, but potential for increase in subsequently years. Likely to be under dense shade from a tree canopy, which if reduced or completely removed will result in rapid growth and onset of flowering. Size outwith limits for overall applications, some cutting or flailing required before herbicides can be applied. High priority sites that are not easy to treat, but can be left while still producing few seeds until higher priority Class VI & VII sites cleared. <i>Should not be left if adjacent to Class II or III sites.</i></p> |
| <p>Class VI</p> | <p>Mature sites that are acting as a <i>major seed source</i>, dispersal and potential new establishment of bushes onto adjacent sites very high. Bush growth rapid, density likely to be high. <i>Likely to become Class VII very quickly.</i> <i>Seed production very high, 750k – 1.5million seeds bush-1 year-1.</i> Size outwith limits for overall applications, some cutting or flailing required before herbicide can be applied. Access to stems not possible to allow stem injection treatment. Highest priority sites that are not easy to treat but should be cleared first along with Class VII. <i>Should not be left if adjacent to Class II or III sites.</i></p> |
| <p>Class VII</p> | <p>Very mature sites that are acting as <i>major seed sources</i>, dispersal and potential new establishment of bushes onto adjacent sites very high. Bush growth into woody stage, probably associated with an overstorey of trees. Seed production high, 750k seeds bush⁻¹ year⁻¹. Size outwith limits for overall applications, some cutting or flailing required before herbicide can be applied. Stem injection application of herbicide possible on these bushes, avoiding having to cut down bushes before control. Highest priority sites that are not easy to treat unless stem injection treated, should be cleared first along with Class VI. <i>Should not be left if adjacent to Class II, III sites, or Class 0 sites that are likely to be disturbed.</i></p> |
| <p>Class VIII</p> | <p>Foliar regrowth from stumps originally classed as III, IV, V, VI or VII. Allow to grow for at least 1 full growing seasons, but before reaching 1.2 m height, before herbicide applications using overall foliar techniques.</p> |

†The suffix ‘C’ to be added to those classes that have been cut or flailed.

†The suffix ‘T’ to be added to those Classes that have been treated with herbicide.

Strategic planning – points to consider

- Don't cut & drag bushes when seed capsules liable to disperse seed onto disturbed site.
- Start up-wind so seed blows back onto the seed source
- Start with main seed source – if possible to be selective – and mop-up small material later.
- Avoid operations that generate seed beds for re-invasion.
- Don't spray small seedlings – pull or leave 'till larger!

