Forestry England

Forest Research

Monitoring Rewilding:

Maximising the effectiveness of ecological monitoring

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Monitoring Rewilding

Structure

1. Ecological Monitoring
2. Forest Wilding
3. Monitoring Forest Wilding
4. Improving Monitoring
5. Conclusion

Learning outcomes

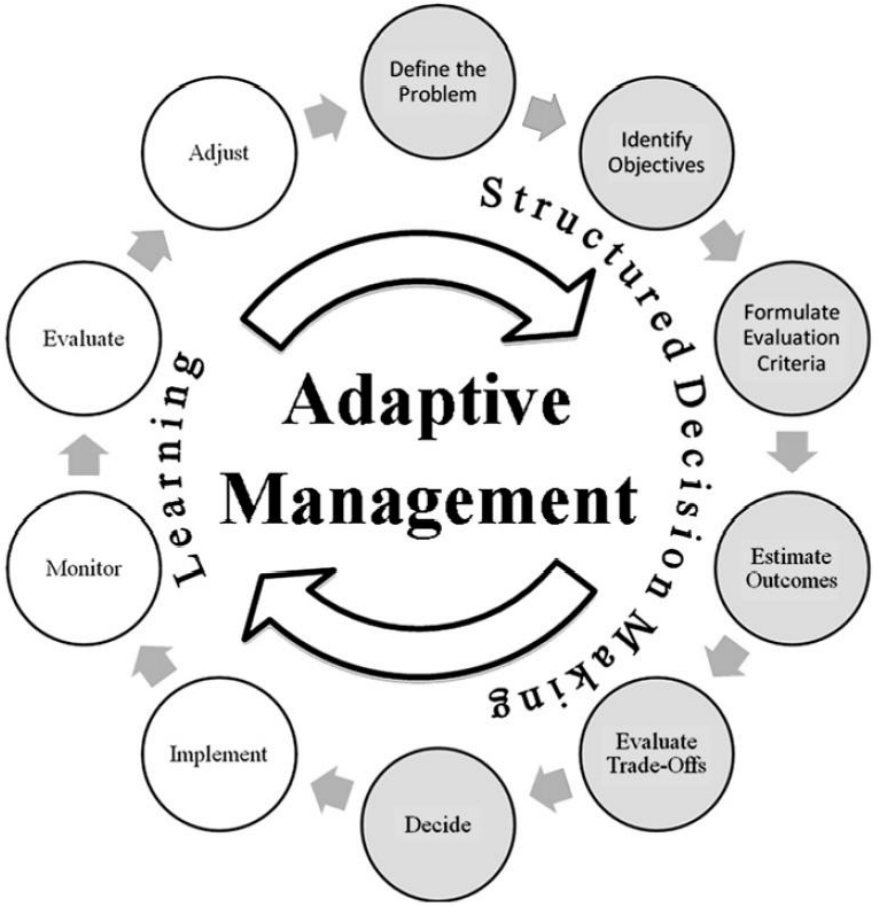
- Understand monitoring needs and challenges
- Understand Forest Wilding
- Understand benefits of modular BACI experimental approach
- Consider areas for improvement

1.1 What is Ecological Monitoring?

- The regular and systematic collection of information about ecosystems (such as species, habitats, or environmental conditions)
- To track changes over time
- The aim is to understand whether ecosystems are staying healthy, recovering, or declining, and to provide evidence that guides conservation and management decisions.

1.2 Why Monitor?

- Answer ecological questions E.g. how does a reintroduced species affect an ecosystem?
- Report outcome of conservation – e.g. reporting to funders
- To shape and improve management over time – Adaptive Management

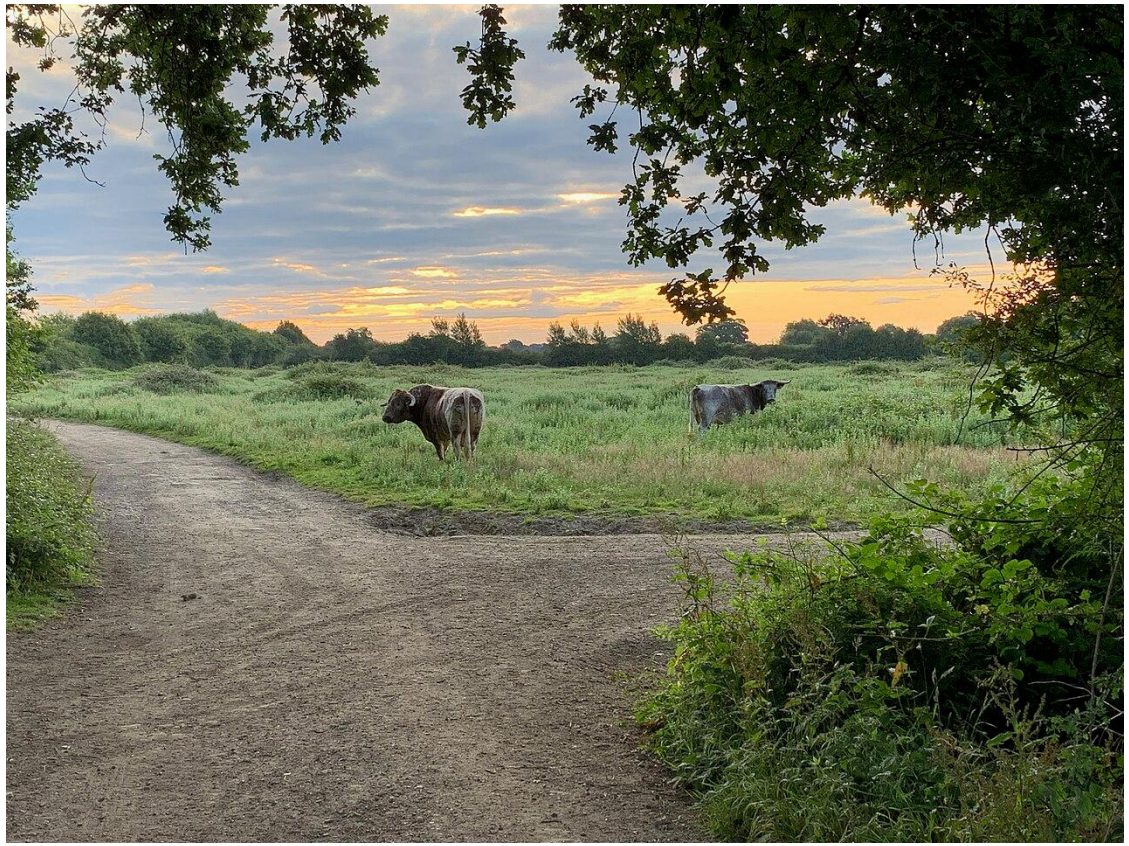


Adaptive management is a formal iterative process of resource management that achieves management objectives by increasing system knowledge through a structured feedback process. Structured decision making (grey circles), higher order learning (white circles)[1].

1. Allen, et al., (2018) Adaptive management for a turbulent future. *Journal of Environmental Management, 92.*.

1.3 Why Monitor Rewilding?

- Novel and experimental – opportunity to answer fundamental ecological questions e.g. How do degraded ecosystems reassemble?
- Meet controversy with transparency – Demonstrate success to the public
- Inform policy – current policy not fit-for-purpose requires change, change requires evidence.



Grazing Longhorn cattle at Knepp Wildland, UK. Pete Eastern, CC BY-SA 4.0

1.4 Monitoring Challenges

- Identifying what to monitor – Balancing variable coverage with cost
- Replication – Balancing statistical reliability with cost
- Interpretation – translating results into action

Cost = #variables measured * #replicates * time

2. Forest Wilding - Putting the wild back into the nation's forests

2.1 Who we are…

Forestry Commission

- Non-ministerial government department
- "Increases the value of woodlands to society and the environment"

Forestry England

- Landowner and manager
- England's largest land manager (0.25 million ha)
- "To grow and care for the nation's forests for this generation and the next"

Forest Research

- Research agency
- "Provider of expertise, data, products and services for government and the tree, wood, forest and natural resources sectors"

2.2 What is Forest Wilding?

https://youtu.be/Lv0jOI_DJ5k

2.2 What is Forest Wilding?

- Biodiversity Plan – Aims for the nation's forests to provide the most valuable places for wildlife to thrive and expand in England[1]
- Forest Wilding – Involves devoting areas to the restoration of natural processes.
- Natural Processes – Self-regulating physical, chemical and biological processes that shape ecosystems, and the communities of organisms in them without direct human intervention (e.g. nutrient cycling, pollination, predation, scavenging).

1.Forestry England. (2021). *Growing the future: 2021-26.*

2.2 What is Forest Wilding?

- Biodiversity Plan – Aims for the nation's forests to provide the most valuable places for wildlife to thrive and expand in England[1]
- Forest Wilding – Involves devoting areas to the restoration of natural processes by:

A. Reinstating natural processes by active reintroductions or passive land use change.

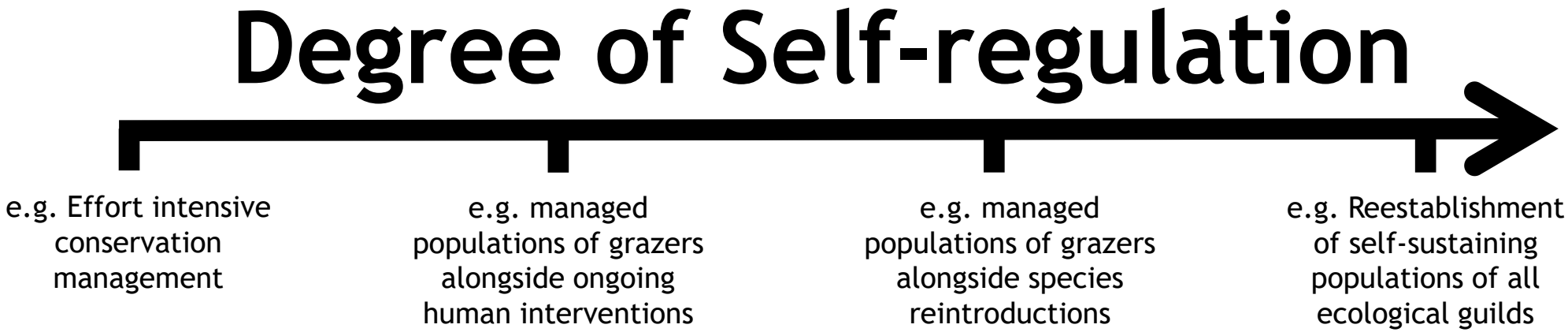
B. Accelerating the rates of recovery by translocations and other land management techniques.

C. Replicating natural processes that cannot be reinstated through active human interventions.

1.Forestry England. (2021). *Growing the future: 2021-26.*

2.3 Forest Wilding and Rewilding

- Rewilding: "The reorganisation of biota and ecosystem processes to set an identified social-ecological system on a preferred trajectory, leading to the self-sustaining provision of ecosystem services with minimal ongoing management"[1].
- Rewilding is a subset of ecological restoration, the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed[2].
- Rewilding exists on a spectrum of degree of self-regulation in the ecosystem.

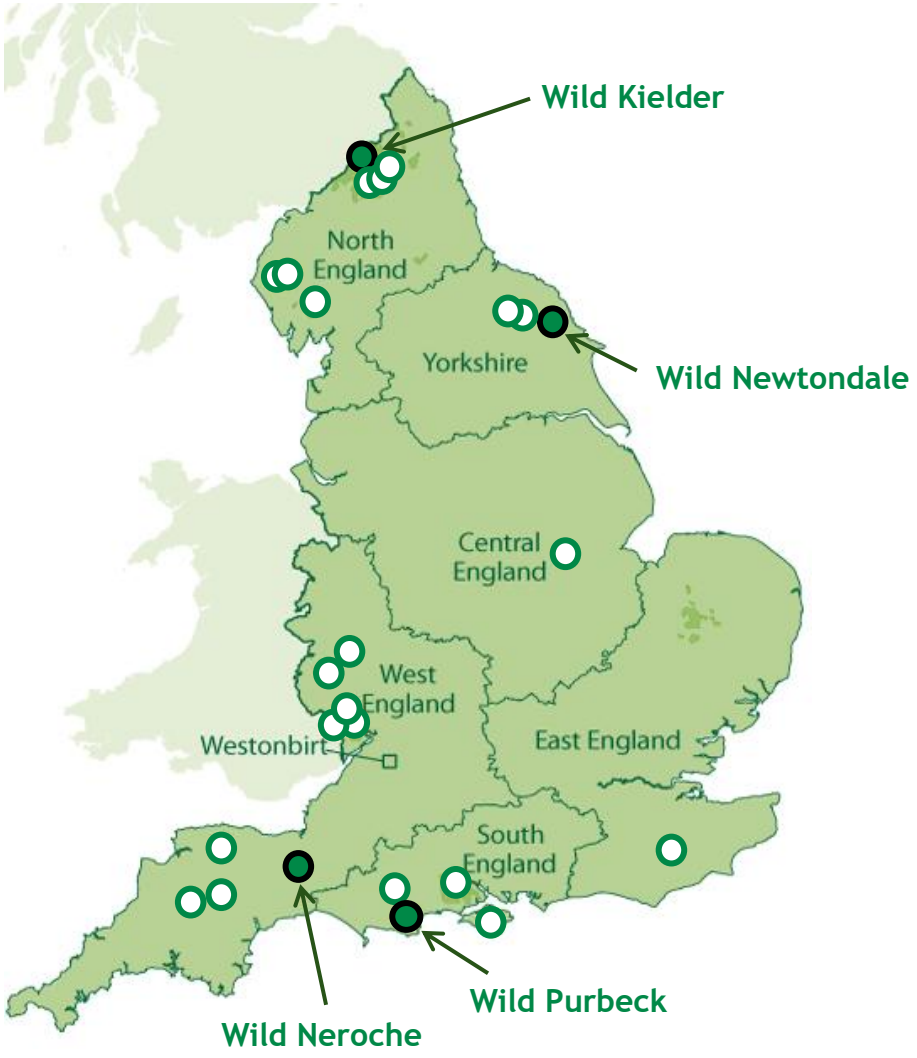


1. Pettorelli, et al., (2018) Making rewilding fit for policy. *Journal of Applied Ecology, 55*.
2. Gann, et al. (2019). International principles and standards for the practice of ecological restoration. Second edition. *Restoration Ecology, 27.*

2.4 Where is Forest Wilding?

Wild Core Areas (WCA):

- "Places of innovation to rebuild biodiversity through restoring natural processes[1]".
- 8,000 ha across 4 sites:
  - Wild Kielder, Northumberland.
  - Wild Newtondale, Yorkshire.
  - Wild Neroche, Somerset.
  - Wild Purbeck, Dorset

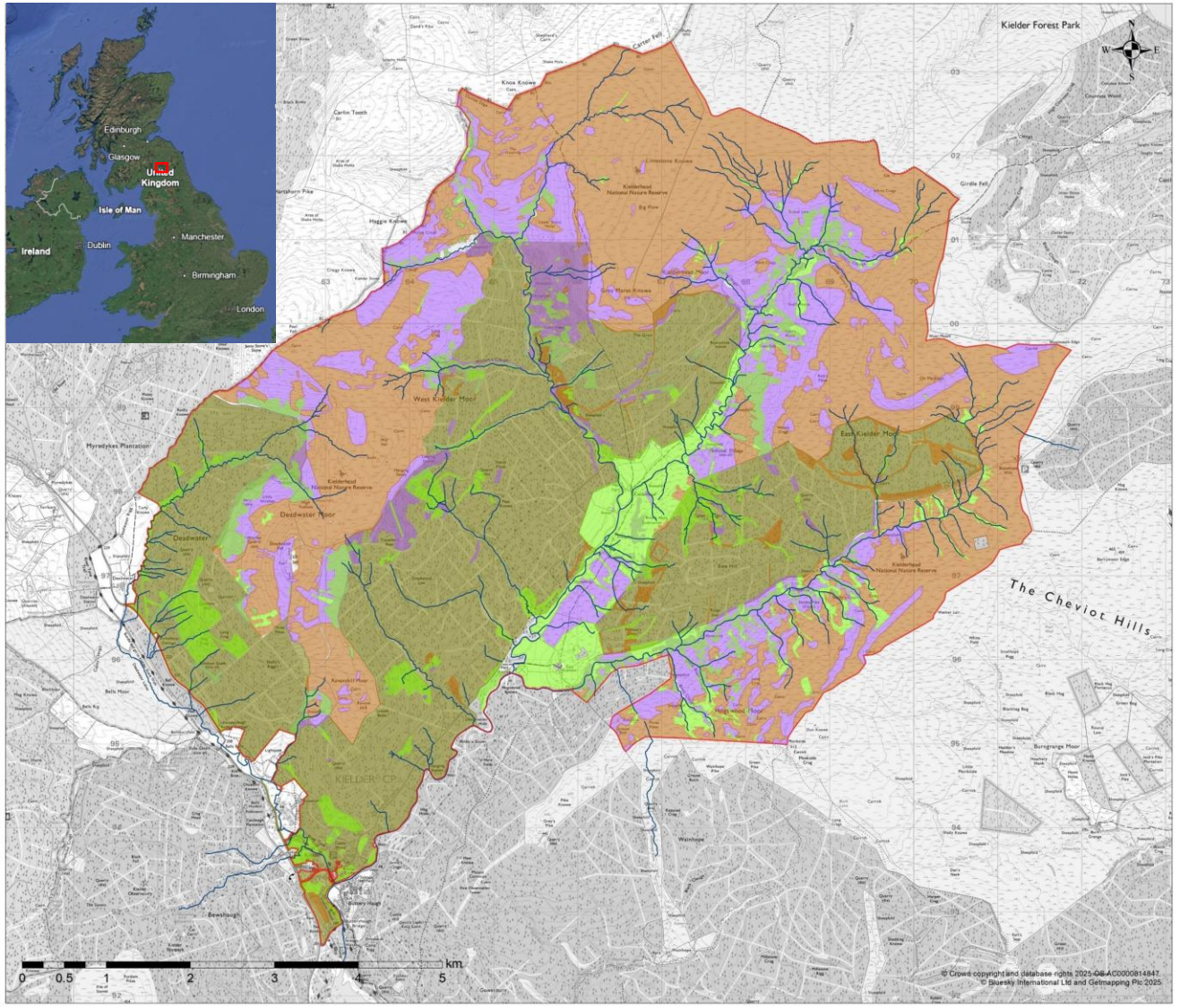


Locality map of WCAs.

1.Forestry England. (2021). *Biodiversity Plan: Forest Wilding*.

2.5 Wild Kielder

- 6,336 ha.
- North end of Kielder Forest.
- 5 broad land-use categories:
  - Blanket bog
  - Upland mosaic
  - Riparian mosaic
  - Watercourses
  - Plantation



Broad land-use map of Wild Kielder.

2.5 Wild Kielder

Vision: "Together, we are reshaping the uplands on a vast scale for nature and people - creating a dynamic, resilient landscape **rich in biodiversity**, where **sustainable, productive forests** stand as its thriving heart."

By Reinstating, Accelerating, and Replicating natural processes.

View over Wild Kielder.

2.6 Managing Wild Kielder

- Herbivory

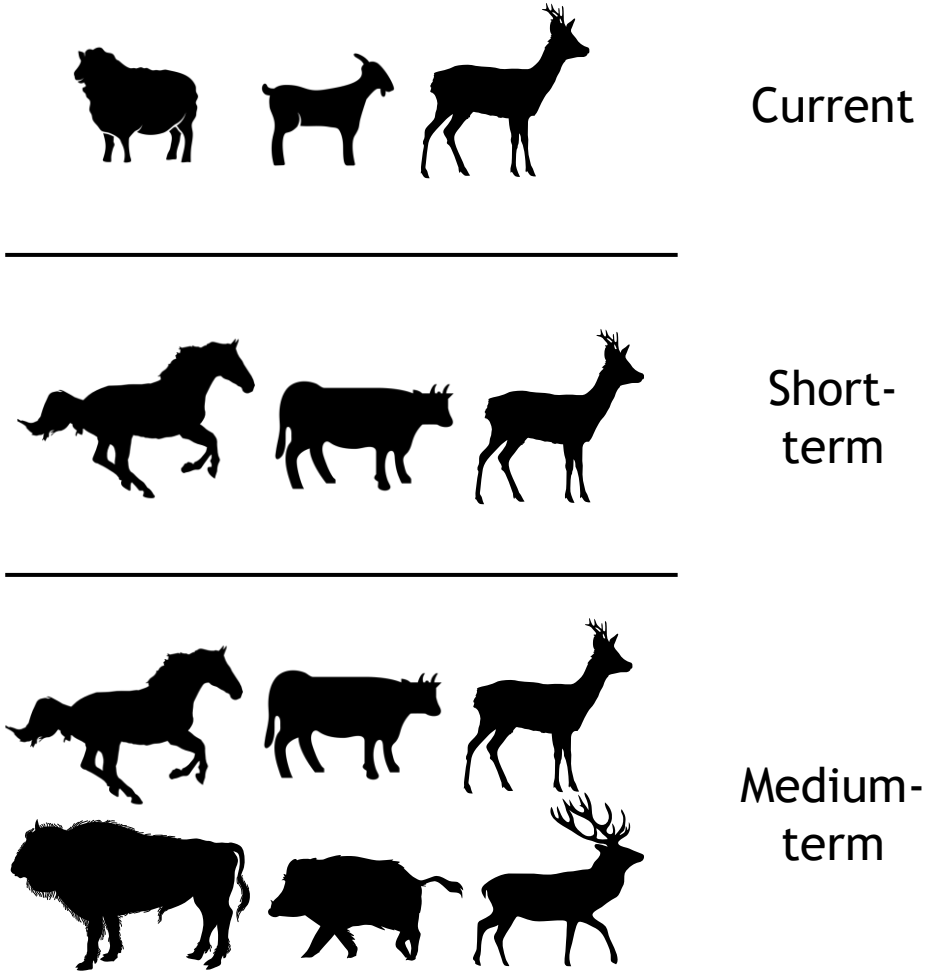
- Rewetting

- Woodland Management

- Reintroduction and Reinforcement

2.6 Managing Wild Kielder

- Herbivory
  - Aim: Establish an appropriate naturalistic disturbance regime.
  - Short-term (1-5 years):
    - Reduce sheep and goat pressure.
    - Introduce cattle and horses.
    - Allow natural colonisation by red deer and boar.
  - Medium-term (6-20 years):
    - Establish wild species – e.g. elk, boar, roe deer, and red deer
    - Taxon replacement – cattle, horse, bison (?)



Planned changes to herbivore community at Wild Kielder.

2.6 Managing Wild Kielder

- Rewetting
  - Restoring natural hydrology.
  - Removing artificial drainage from agriculture and plantations.
  - Be beaver ready.

Example of riparian zone at Wild Kielder.

2.6 Managing Wild Kielder

- Woodland Management
  - Diversify plantations – species, age, density, and distribution.
  - Remove woodland from deep peat areas.
  - Potential for forest to bog and bog woodland restoration.
  - Natural colonisation and planting of native trees in upland mosaic.

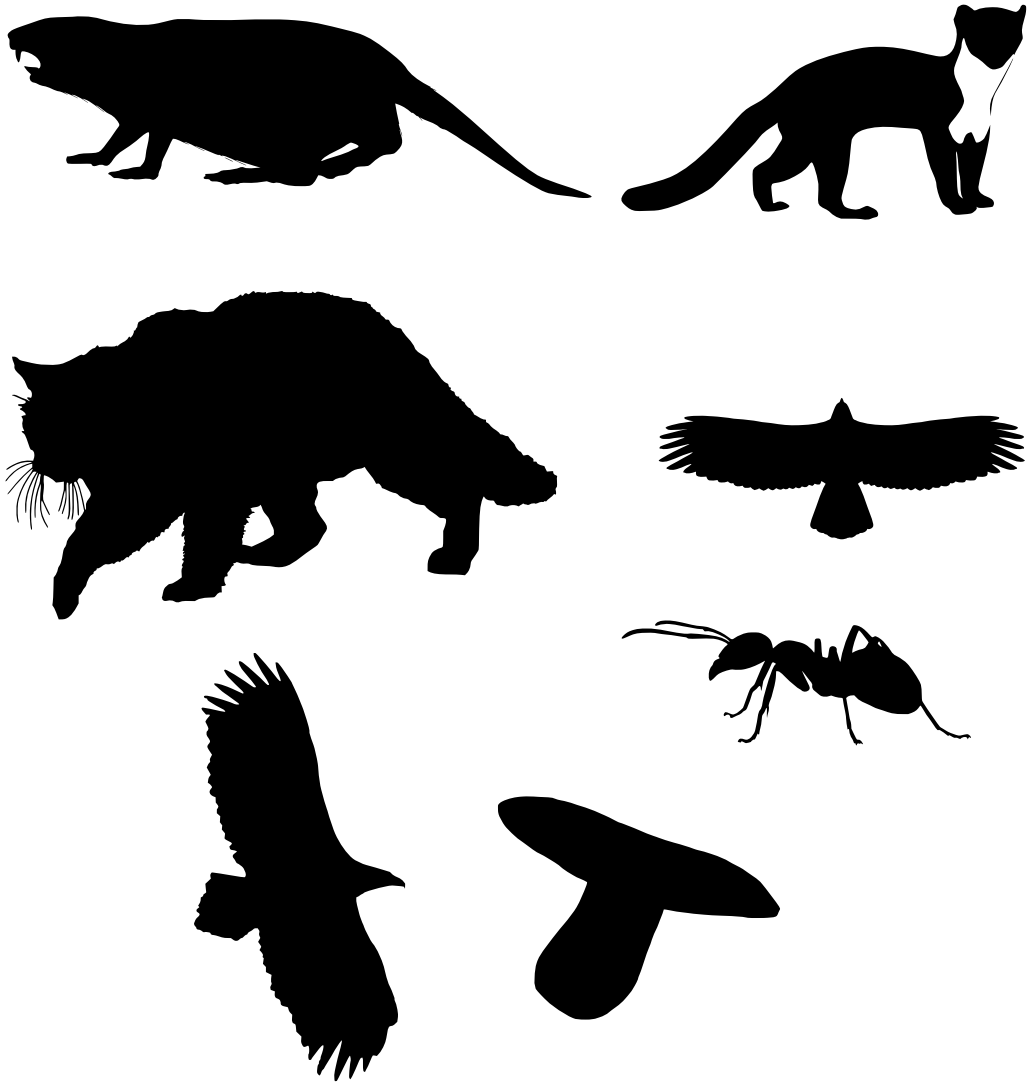
Current

Future

Planned changes to woodlands at Wild Kielder.

2.6 Managing Wild Kielder

- Reintroduction and Reinforcement
  - Seven priority Forestry England keystone taxa: Beaver, pine marten, wildcat, golden eagle, white-tailed eagle, wood ants, fungi.
  - Local habitat specific reintroductions: e.g. early successional *Sphagnum* to peatlands.
  - Support continued recovery of existing native species: pine marten, red squirrel, water vole.



Forestry England priority keystone taxa for reintroduction to WCAs.

Adaptive management

Policy impact

3. Monitoring Forest Wilding

Reporting

Answer ecological questions

3.1 Monitoring Goals

Primary monitoring question:

Do prescribed management interventions successfully restore nature?

Successful restoration of nature assessed by changes **3 key ecosystem features (based on WCA Evidence Framework):**

A. Increasing **structural heterogeneity**

B. Increasing **biological diversity** and abundance

C. **Ecosystem processes** enhanced relative to baseline conditions with increases in integrity and resilience

3.2 Monitoring Questions

Primary monitoring question:

Do prescribed management interventions successfully restore nature?

Monitoring of the WCAs should answer the following questions:

1. **Do interventions increase habitat heterogeneity?**
2. **Do interventions increase biological diversity and abundance?**
3. **Do interventions enhance integrity and resilience of ecosystem processes relative to baseline conditions?**

3.3 Monitoring Principles

Robust monitoring at WCAs site is essential to:

(i) Understand whether planned management interventions are having significant and long-lasting effects on nature recovery.

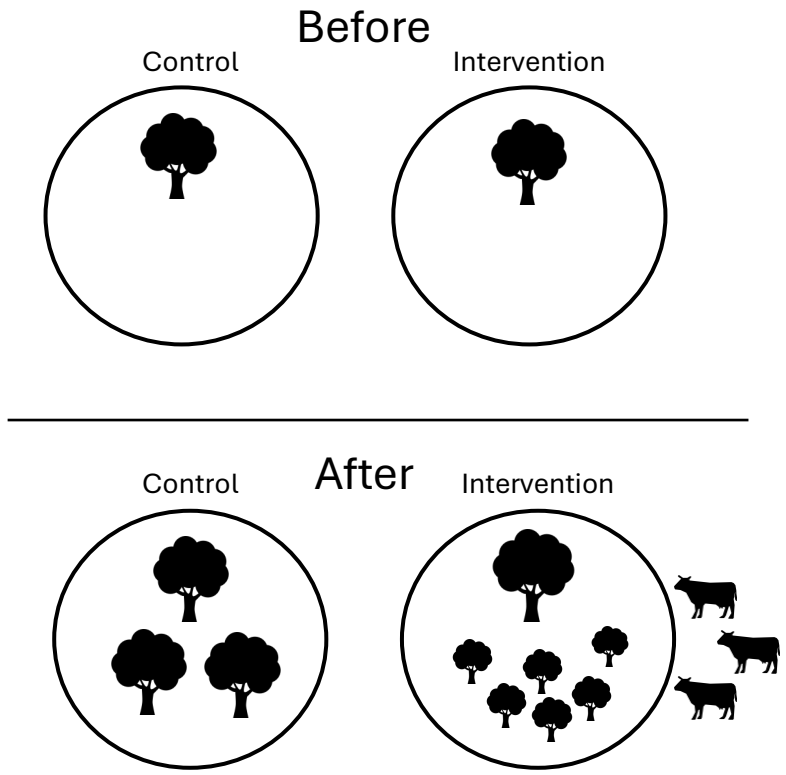
(ii) Inform adaptive management.

(iii) Provide a pilot case ‘working example’ of forest wilding and associated monitoring approaches in WCAs that can potentially be applied elsewhere if found to be successful.

Monitoring should be **question-led**, **intervention-focused**, and **scientifically robust**.

3.4 BACI Experimental Design

- Before-After Control-Intervention (BACI)
- Monitoring of one or more areas where an intervention is applied (intervention plots) and one or more areas where no intervention occurs (control plots).
- Data is collected before and (at intervals) after the intervention at both types of plot.
- “Gold standard” of ecological monitoring.

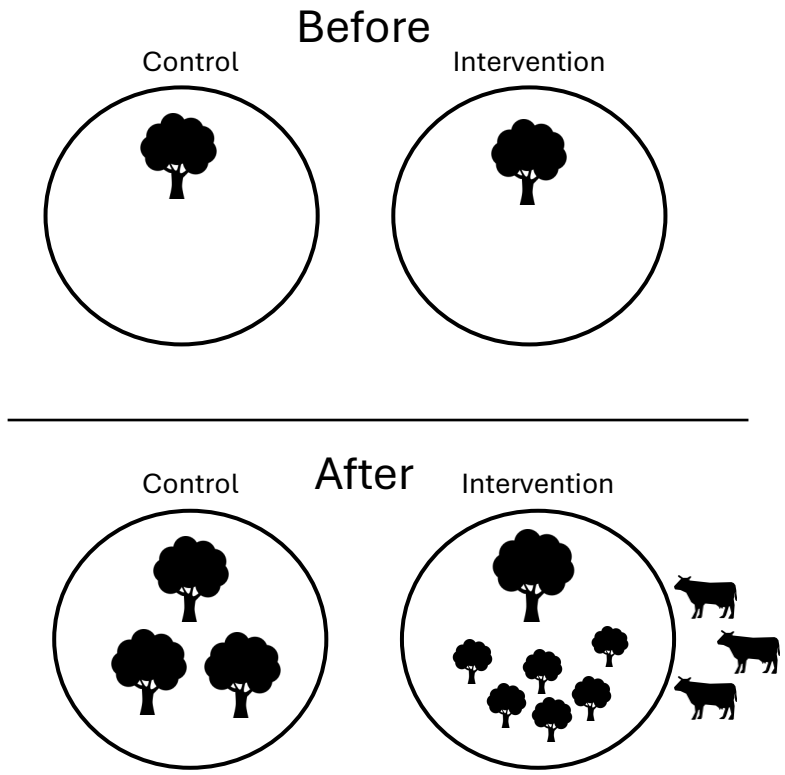


Schematic of hypothetical BACI experiment testing impact of grazer introduction on forest structure.

3.4 BACI Experimental Design

WCA BACI:

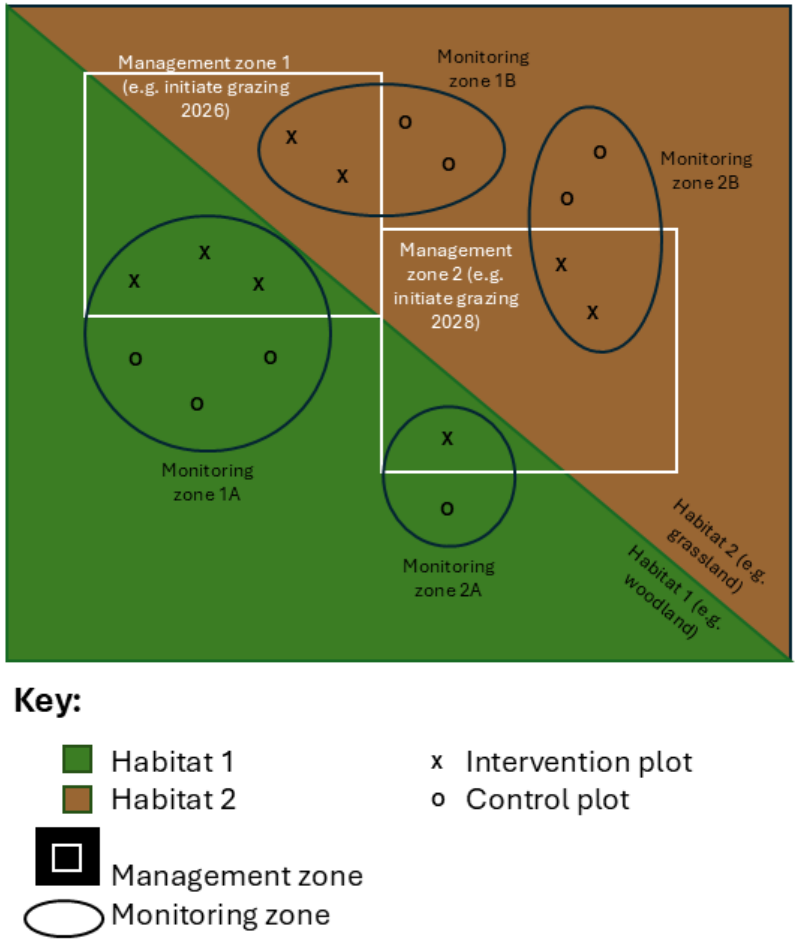
- One BACI per intervention
- **Monitoring Plots**: 10 x 10 m permanently marked quadrats
- Monitoring plots as **ecological weather stations**: Assume measurements within plots representative of wider ecosystem.
- **Multiple replicate** paired test and control plots across each site.
- Measure range of ecological variables within each plot.
- Measure baseline ecological variables before intervention and then regular monitoring across subsequent years.



Schematic of hypothetical BACI experiment testing impact of grazer introduction on forest structure.

3.5 Modular Layout

- Complex management landscape with different interventions applied in different areas at different times with overlap.
- Plots deployed in modules, grouped by initiation time and habitat type.
- Allows gradual roll out of experiment with management roll-out and accounts for different underlying habitats.



Schematics of experimental layout and relative placement of management zones, monitoring zones, and intervention and control plots.

3.5 Modular Layout

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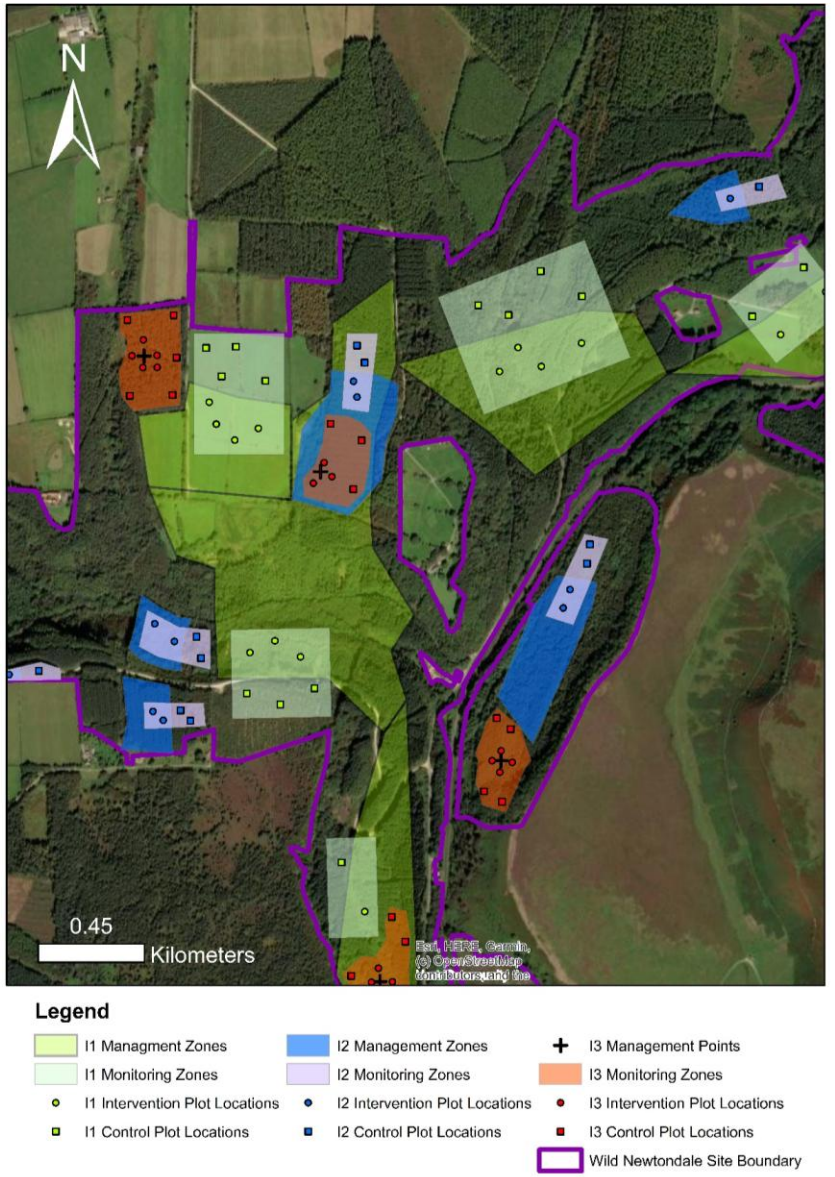


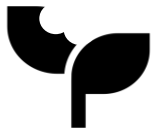
Hypothetical map of example layout of management zones, monitoring zones, and monitoring plots for three different management interventions applied to the Wild Newtondale site.

3.6 Monitoring Techniques

- Monitoring plots as **ecological weather stations**: Assume measurements within plots representative of wider ecosystem.
- Monitor variables representative of key **ecosystem features**:
  A. Habitat structure
  B. Biodiversity
  C. Ecosystem processes
- Prioritise **high-impact low-cost** techniques.
- Align with **preestablished standardised** protocols so data is **comparable with national datasets**.
- Surveys between every 1 and 5 years.

Tree surveys:
- Diversity
- Recruitment
- Density
- Biomass

Dead wood surveys:
- Habitat creation.
- Nutrient cycling.



Herbivory surveys:
- Disturbance.
- Grazing intensity.

Microclimate:
- Temperature
- Humidity
- light

LiDAR surveys – habitat structure

Bioacoustics surveys – vertebrate diversity

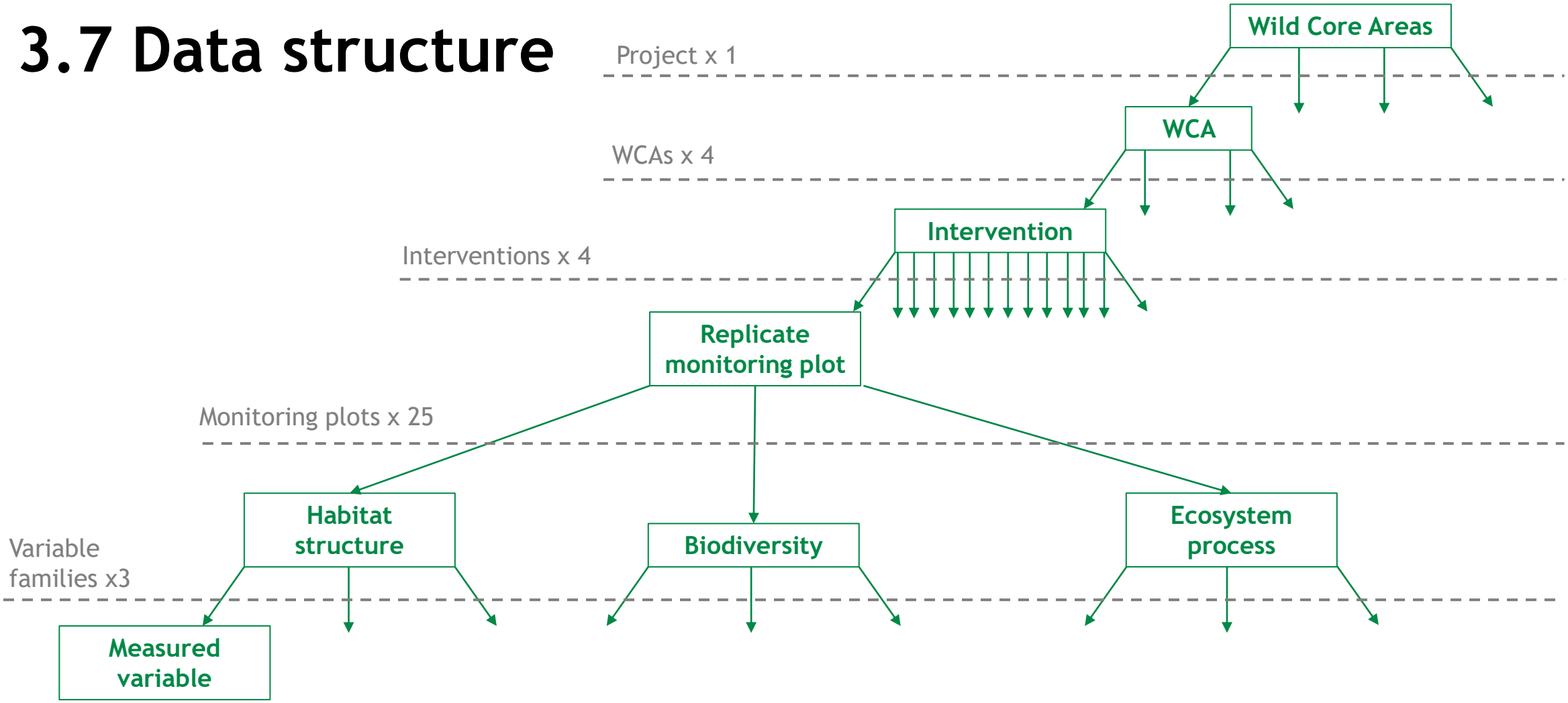
Botanical surveys – botanical diversity and abundance

Soil eDNA - biodiversity

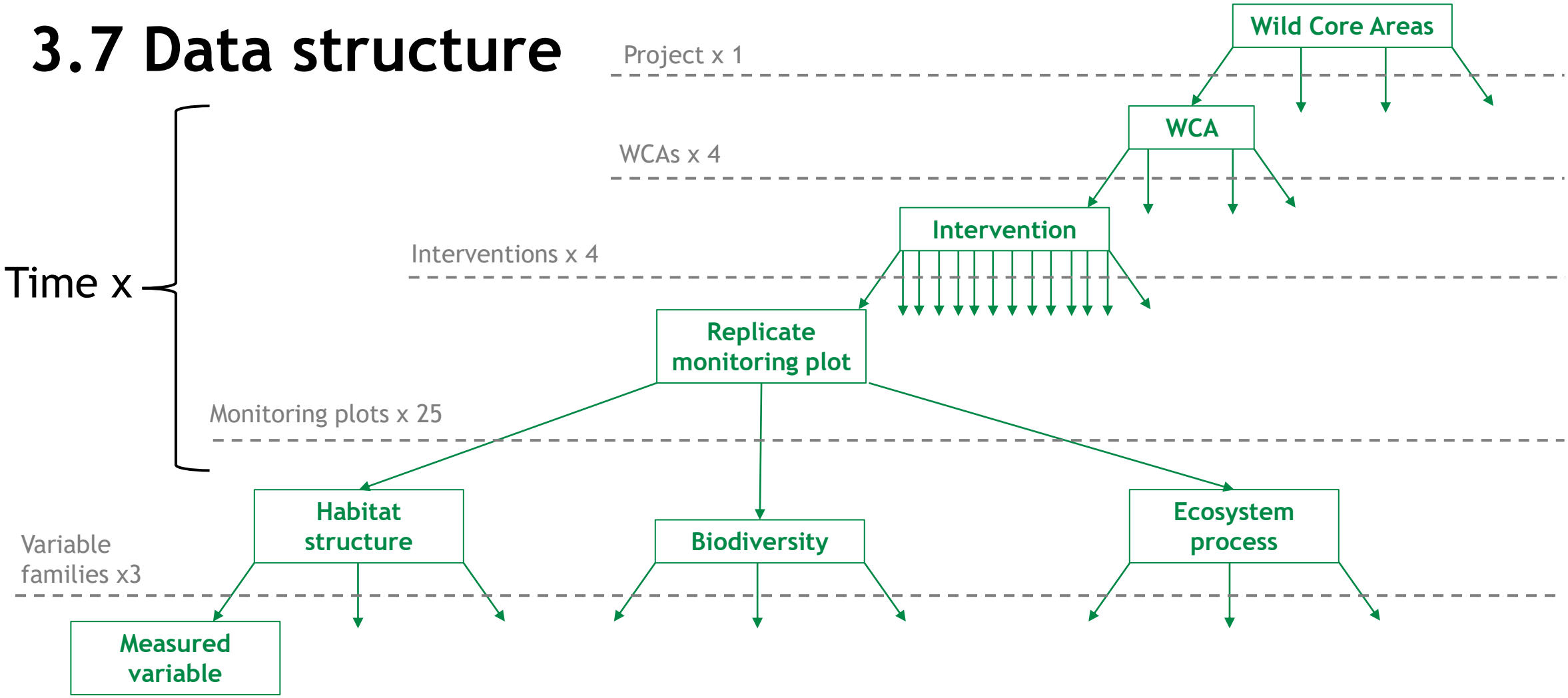
Soil chemistry:
- Nutrient cycling
- Carbon storage

Examples of suggested techniques and variables to be monitored as part of WCA monitoring.

3.7 Data structure



3.7 Data structure



3.8 Modelling Approaches

- Automated data management and reporting system.
- Experiments designed for analysis by Linear Mixed Models/ Generalized Linear Mixed Models.
- Models identify if management interventions have a significant effect on measured ecological variables.

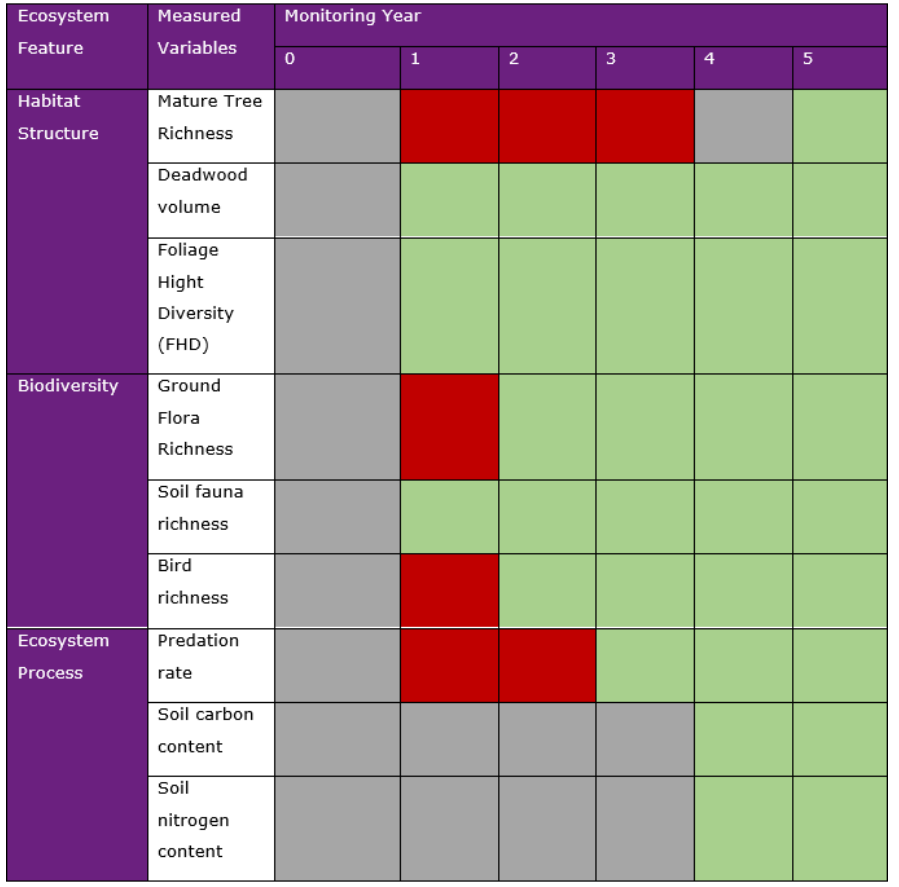
Success Measure~ Management Treatment * time + (1|site)

e.g.
Species Diversity ~ grazing treatment * time + (1|site)

Simplified model structure to analyse outcome of Forest Wilding interventions.

3.9 Measuring Success

- Automated data management and reporting system.
- Experiments designed for analysis by Linear Mixed Models/ Generalized Linear Mixed Models.
- Models identify if management interventions have a significant effect on measured ecological variables.
- An intervention can be assumed to be successful if ecological variables in intervention plots diverge from those in control plots in a desirable direction and if these differences are found to be significant by statistical treatment.



Ecosystem Feature	Measured Variables	Monitoring Year					
		0	1	2	3	4	5
Habitat Structure	Mature Tree Richness						
	Deadwood volume						
	Foliage Hight Diversity (FHD)						
Biodiversity	Ground Flora Richness						
	Soil fauna richness						
	Bird richness						
Ecosystem Process	Predation rate						
	Soil carbon content						
	Soil nitrogen content						

Example of hypothetical monitoring results summary for 5 years of monitoring of a forestry management intervention at Wild Newtondale with three ecological variables measured per ecosystem feature. Grey boxes represent no difference between results from intervention and control plots. Green boxes represent a change towards a desired state in intervention plots relative to control plots. Red boxes represent a change away from the desired state in intervention plots relative to control plots. Hypothetical example assumes every measured variable has been measured annually.

4. Improving Monitoring: Knowledge exchange with mathematicians

4.1 Improving Monitoring

- Maximising efficiency of monitoring effort in hierarchically structured monitoring:
  - Choosing the most informative variables to measure
  - Establishing appropriate number of replicates
- Better statistical approaches?
- Modelling interactions between variables and cascading effects? – structural equation modelling?
- Producing user friendly workflows and outputs to aid decision making

4.2 Priority questions

1. What are the optimal statistical approaches for analysing monitoring data?

2. How can we meaningfully integrate multiple monitored variables in analysis to produce useful outputs?

4.3 Other Forest Wilding questions

Priority themes:

1. **Climate resilience and adaptation:** e.g. Are reintroduced communities resilient to the next 100 years of climate change?
2. **Economics:** e.g. What are the economic trade-offs of moving from timber production to forest wilding?
3. **Pests & Disease:** e.g. How do reintroductions effect pest and disease risks?

5.1 Summary

- Monitoring can be used to generate evidence and inform adaptive management.
- Forest Wilding is the devotion of forest land to restoration by reinstating, accelerating, and replicating natural processes.
- Wild Core Areas are experimental sites where Forest Wilding is being trialled.
- Monitoring at WCAs takes an experimental BACI approach.
- How can monitoring approaches be improved and remain user-friendly?

5.2 Acknowledgements

Thanks to:

The **Forestry England Wilding Team**, particularly…

Neal Armour-Chelu – Wild Core Areas Ecologist
Tina Taylor – Wild Kielder Project Officer

… and the rest of the **Forest Research Wilding Monitoring Team** …

Prof Kevin Watts – Principal Landscape & Restoration Ecologist
Dr Nadia Barsoum – Senior Forest Ecologist – Biodiversity Monitoring & Assessment

5.3 Questions

Thank you for Listening!

Any questions?

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