IS THE DEFINITION OF SCALE KEY TO OUR UNDERSTANDING AND DELIVERY OF THE RESTORATION OF ECOSYSTEMS?

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Blakemere

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Topic & Purpose

Re-establishment of semi-natural **ecosystems** and **ecosystem services** on mined land in the UK

Practical **measurable** and **workable criteria** for better **design** & **evaluation** to meet the restoration challenges posed by pending implementation of legislation and policies arising from the implementation of the *Convention Biological Diversity*

Context – surface coal mine

Context – aggregate quarry

Context – sand quarry

Ecosystems

- Comprising **biotic** (living individuals & populations) & **abiotic** (non-living environmental) components
- Sheer complexity makes it seemingly impossible to grasp and apply in mine reclamation
- Defining the **scale** of complexity the key?
- Tansley (1930s) used plant vegetation communities as the **scale** to form a rational system describing ecosystem development and succession

Restoration of Ecosystems

Likened to the repair of a damaged watch, the repairer needs –

“ *… a kit of parts and the knowledge of how to fit together … and … if done properly the watch will acquire the emergent property of the whole …*”

J L Harper (1987)

Abiotic & Biotic Restoration?

Thompson (2010) commenting on the achievements of ecological restoration considered that for the **abiotic** environment had largely been perfected in contrast to the **biotic**

What are the **essential biotic elements** in

- 1) design & implementation of mine reclamation schemes?
- 2) assessment of restoration achievement?

Biotic Elements

Three Temperate Ecosystems Considered:

- Woodland
- Dwarf Shrub (Heathland)
- Grassland

Sessile Oak woodland

Birch woodland

Calluna dry heath (dwarf shrub)

Bent-Fescue acid upland grassland

Monitoring & Assessment Standards already exist !! ?

Common Standards Monitoring (CSM) –

UK Government's JNCC criteria for assessing the functioning of nationally important and 'pristine' ecosystems.

SIX – structural elements * –

Canopy–**A**ge–**R**egeneration–**G**enetic–**I**ndicator–**E**xotic

*based on Tansley's ecosystem approach

C-A-R-G-I-E for Woodland

1. **C**anopy Cover – *tree layer 30-90% + 20% understory + 10% open space*
2. **A**ge Class – *at least 3 age-classes (**all in first cycle**) + min 3no. fallen & 4no. standing dead trees*
3. **R**egeneration Potential – *production of seed and maturation of recruits to at least sapling stage*
4. **G**enetic Pool – *min 95% native species & provenance*
5. **I**ndicators of Local Distributions – *can be distinctive species or habitats*
6. **E**xotic / Alien & Weed Species – *eradication*

C-A-R-G-I-E for Dwarf Shrub (Heath)

1. **C**anopy Cover – *tree layer 25-90% + 25-30% groundcover + 10% bare ground space*
2. **A**ge Class – Pioneer 10-40% + Building/Mature 20-80% + Degenerate <30% + Dead <10%
3. **R**egeneration Potential – *production of seed*
4. **G**enetic Pool – *min 95% native species & provenance*
5. **I**ndicators of Local Distributions – *can be distinctive species or habitats*
6. **E**xotic / Alien & Weed Species – *<1% alien/weedy species + <5% Bracken + <10% trees/scrub*

C-A-R-G-I-E for Upland Grassland

1. **C**anopy Cover – *70-80% groundcover + tree/Bracken layer <10% +<10% bare ground space*
2. **A**ge Class – > 25% mature flowering + >5cm height & >25% mature non-flowering + <5cm height + Dead <10%
3. **R**egeneration Potential – *production of seed*
4. **G**enetic Pool – *min 95% native species & provenance*
5. **I**ndicators of Local Distributions – *can be distinctive species or habitats*
6. **E**xotic / Alien & Weed Species – *<1% alien species + + <25% weedy species +<5% Bracken + <10% soft rush <10% trees/scrub*

CARGIE – Implications

Coincidence of mandatory structural C-A-R elements to meet functioning ecosystem criteria

- **Target** of seed/seedlings/nursery stock + saplings + mature/seed bearing trees + decaying/over mature trees + dead/fallen trees
- Reclamation schemes represent in early years sequential and **incomplete** series starting with planted stock (**1element**) > saplings (**1**) > mature/seed bearing + seed/seedlings (**2**) > mature/decay + saplings (**2**) > dead + mature/seed bearing + seed/seedlings (**3**) etc

Time Implications for Woodland

Tree Layer Life Cycle	Birch Woodland	Oak Woodland
0–5 Years	Planted stock/seedling	Planted stock/seedling
5–15	Sapling	Pre-sapling
15–20	Mature	Sapling
20–30	Seed bearing + seedling	Sapling
30–50	Seed bearing + seedling	Mature
50–70	Decaying + sapling	Seed bearing + seedling
70–80	Dead + decaying + mature	Seed bearing + seedling + sapling
80–100	Dead + seed bearing + seedlings	Seed bearing + seedling + sapling
100–120	Seed bearing + seedling + sapling	Seed bearing + seedling + sapling + mature
120–150	Decaying + mature + sapling	Mature + sapling + seed bearing + seedling
150–200 = Birch Woodland	**Dead + decaying + mature + seed bearing + seedlings**	Decaying + sapling + mature + seed bearing + seedling
200–250	Dead + decaying + mature + seed bearing + seedlings	Decaying + sapling + mature + seed bearing + seedling
250–350 = Oak Woodland	Dead + decaying + mature + seed bearing + seedlings	**Dead + decaying + mature + seed bearing + seedlings**

Implications for Woodland Ecosystem Reclamation

Reliance on planting nursery stock:

- Birch >> 150-200 years**#
- Oak >> 250-350 years**#

Planting plus Intervention – providing seed/additional planting + **dead wood**:

- Birch >> 15-20 years (reduced by factor x10)#
- Oak >> 30-50 years (reduced by a factor x 8)#

** Expect reliance on natural colonisation to be longer

Does not account for slow colonising floras & faunas

Dead-wood structural component

Felled woodland a source of dead-wood in reclamation schemes

Dead-wood recovered for use in woodland reclamation scheme

Standing dead-wood placed in woodland reclamation scheme

Time Implications for Dwarf Shrub & Grassland Communities

Life Cycle	Dwarf Shrub	Upland Grassland
0–5 Years	Seedling/pioneer	Seedling + tillering + mature + seed bearing
5–10	Building/seed bearing + seedling	Seedling + tillering + mature + seed bearing + decaying
10–15 = Grassland	Building/seed bearing + seedling	**Seedling + tillering + mature + seed bearing + decaying + dead**
15–20	Mature + building/seed bearing + seedling	
20–30	Decaying + mature + building/seed bearing + seedling	
30–50 = Dwarf Shrub	**Dead + decaying + mature + building/seed bearing + seedling**	

Implications for Dwarf Shrub & Grassland Ecosystem Reclamation

Reliance on seeding:

- Dwarf Shrub >> 30-50 years**#
- Upland Grassland >> 10-15 years**#

Seeding + Intervention (**provision of dead material)**:

- Dwarf Shrub >> 15-20 years (reduced by factor x2)#
- Upland Grassland >> 5-10 years (reduced by a factor x 0.3)#

** Expect reliance on natural colonisation to be longer

Does not account for slow colonising floras & faunas

Conclusions

Question of Scale?

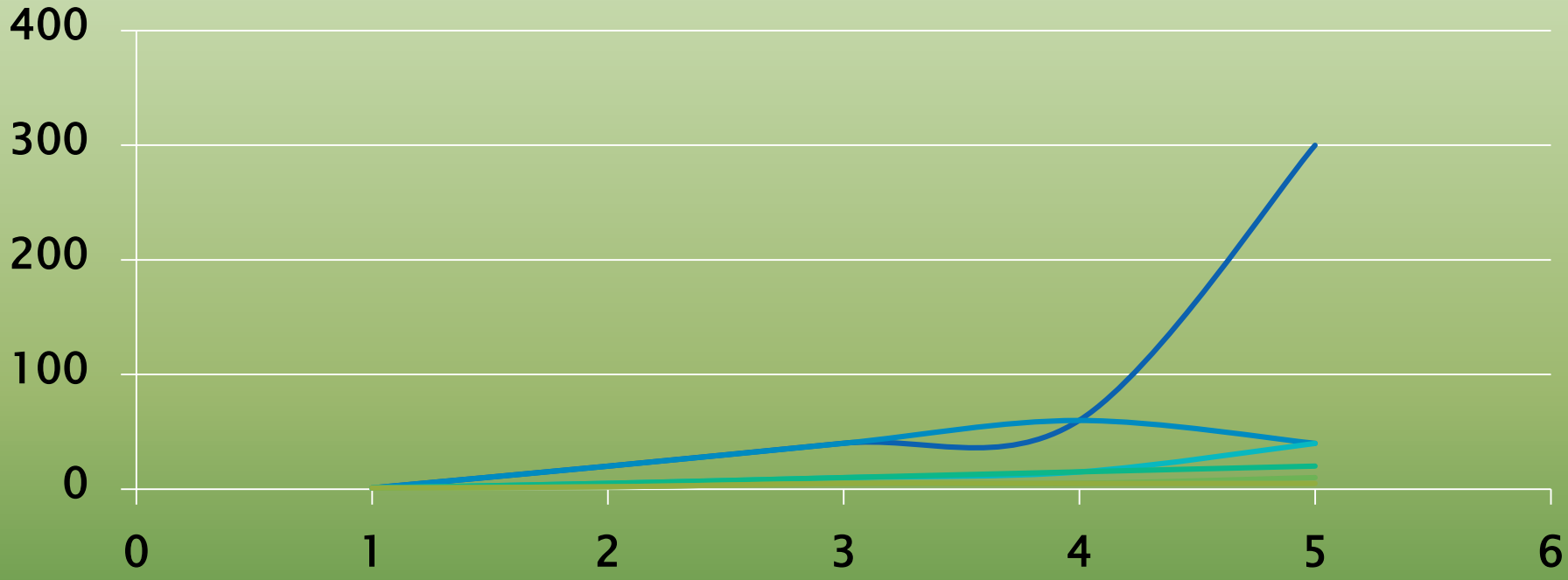
Prospect of applying Biotic component of ecosystem concept to mine reclamation might be bewildering in its complexity … however …

- Tansley's plant community provides a **structural scale** – recognisable, pragmatic and encompasses ecosystem structure & functions as represented by **CARGIE Model**
- **Time** (as life-cycle dynamics) is the key dimensional scale and ultimate determinant of reclamation success

Concluding Words (1)

- Paper introduces and examines a measurable and workable concept of **scale** for natural ecosystem reclamation on mine sites
- **CARGIE** Model helps understand what is needed – contributes to better design indicates where biotic component of ecosystem reclamation can be more certain, enhanced and speeded up
- Provision of **dead/decaying** biotic element is **principle limiting biotic factor** in woodland /dwarf shrub temperate ecosystem reclamation

Relative Effects of Introducing Dead Wood on Rate of Ecosystem Development



Age Class (X axis) vs Years (Y axis)

Oak WOODLAND: 1 = seed/transplant 2 = sapling 3 = mature 4 = seed baring 5 = dead wood

Dwarf Shrub: 1 = seed 2 = pioneer 3 = seed baring 4 = mature 5 = dead wood

Concluding Words (2)

- **Abiotic** component determining the capability of undisturbed and restored sites not considered, but acknowledged
- **Biotic** below ground and slow coloniser components ignored
- **Biotic** approach proffered seemingly simplistic but UK JNCC use **CARGIE biotic** criteria in their CBD assessments
- **CARGIE** based on standard criteria familiar and accepted by authorities & regulators (compliant with CBD expectations for natural habitats in the UK – no need to invent bespoke reclamation criteria)

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The opinions expressed are solely the author's