The development of ecological restoration and the role of soils and vegetation science: where next?

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Ecological Restoration

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed

(Society for Ecological Restoration definition).

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- Since the Aberfan disaster focused the need to stabilise colliery waste with a green cover, the methods of land reclamation and restoration have greatly changed.
- This talk will provide some historical context as well as present applications of vegetation science in ecological restoration.

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Introduction

- It is fitting tribute to CIEEM's first president Tony Bradshaw's work that this annual conference's theme is restoration ecology.
- The pioneer of ecological restoration, the significance of Tony's work was creating soil on restoration sites rather than using the traditional method of importing topsoil.
- Tony's work on china clay and colliery waste recognised the importance of the functional components of ecosystems, and understanding vegetation systems so they could be emulated.
- Ecological restoration as a science is still developing but uses the foundations of Tony's pioneering work.

Tony Bradshaw
1926-2008

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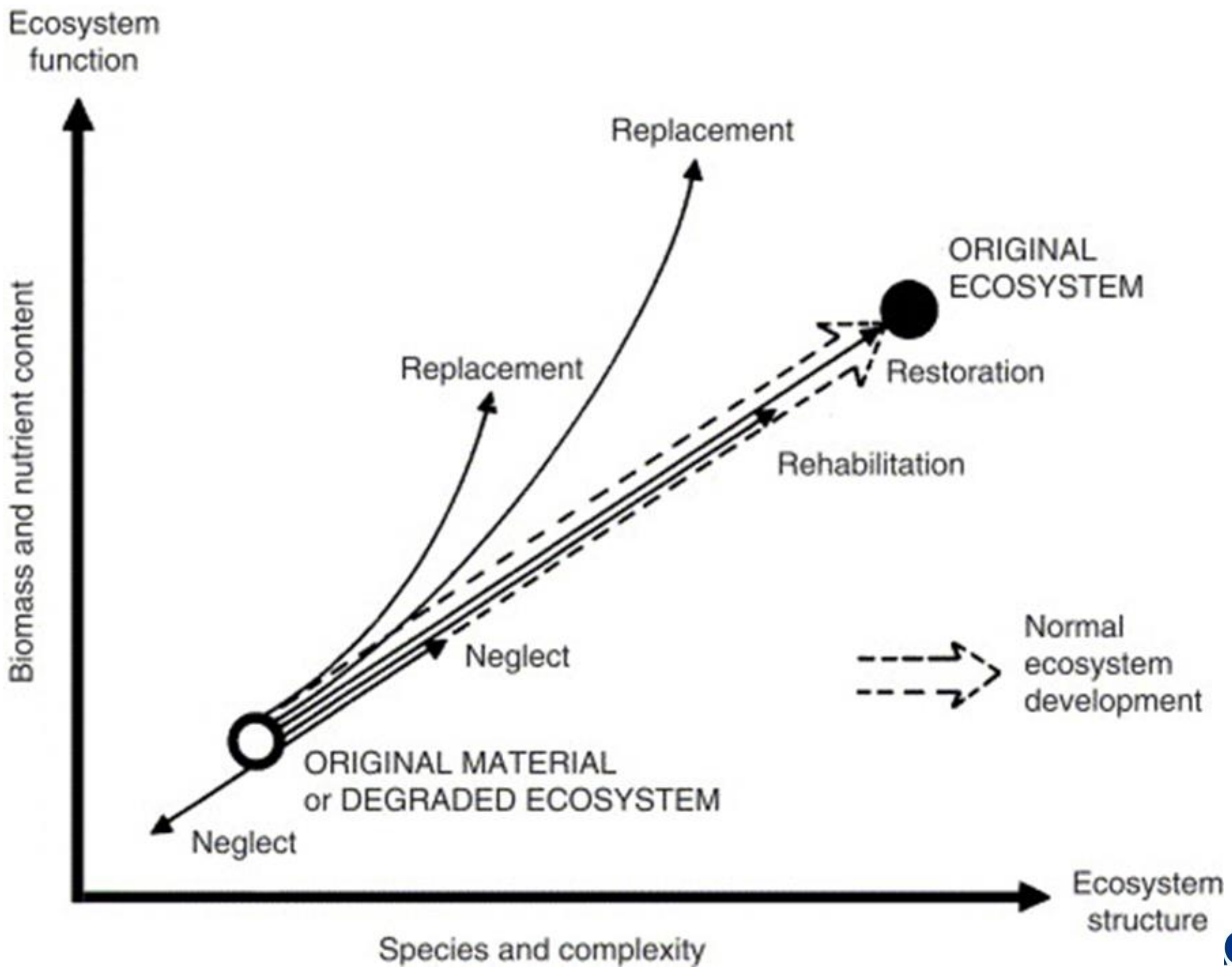
A.D. Bradshaw Reclamation of Ecosystems and Ecology of Ecosystems



Restoration Ecology: a balance between function and structure?

- There is often a need to compromise between the ecosystem function and ecosystem structure in restoration projects
- The simplification of providing function is easier to achieve than complexity.
- There is often a pragmatic compromise to ensuring a timely provision of habitat for species or environmental remediation.

Don’t forget the soil

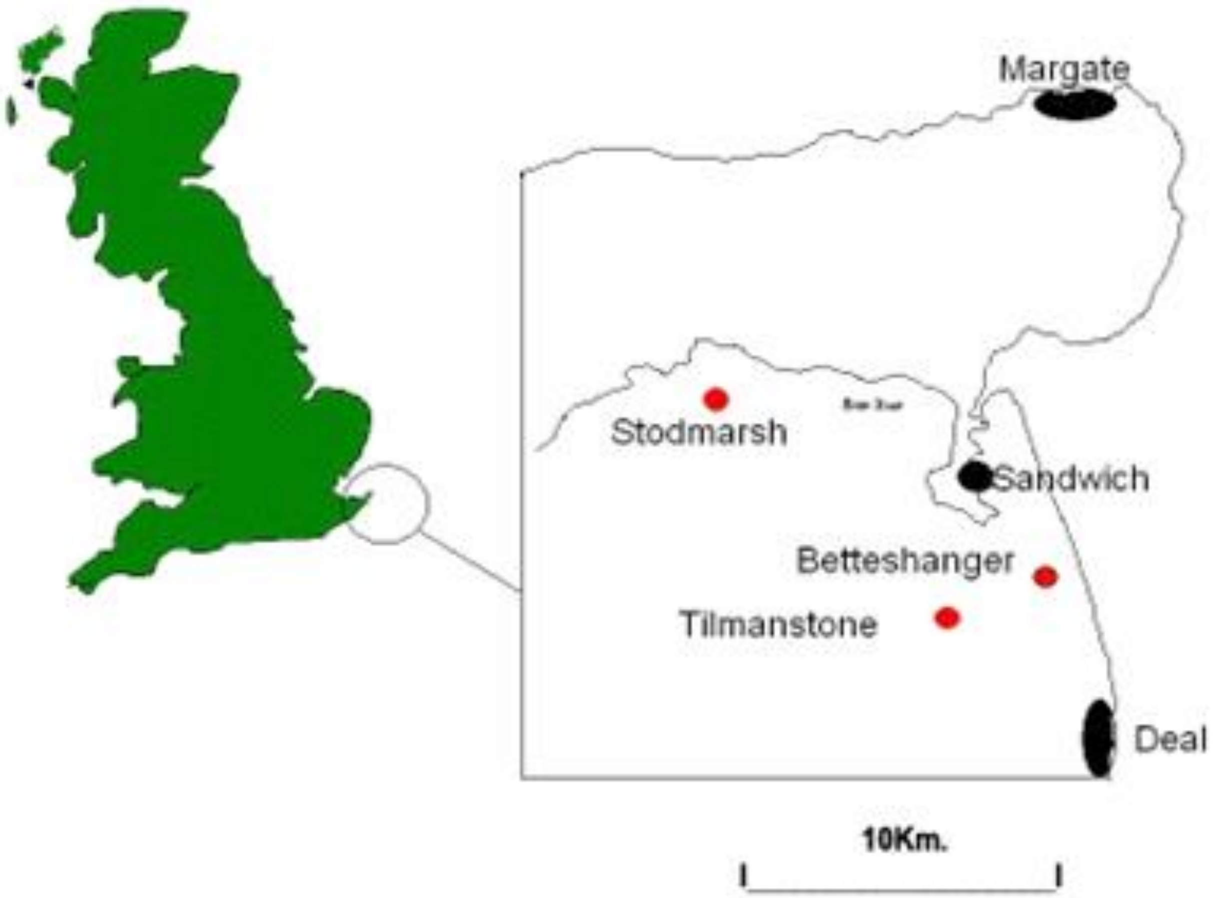
- In restoration projects getting the planting medium right is the challenge
- Different nutrient ratios and limiting factors contribute to directing vegetation establishment and the community development
- Get these wrong and the desired end ecosystem will never establish.

The approximate percentage of the total soil nitrogen pool taken up each year by different ecosystems (adapted from Killham 1994).

Ecosystem	Approx. % total soil N removed by vegetation annually[a].	Approx. total soil N (Kg N ha^{-1})
Tundra	0.4%	10 000
Temperate, upland moorland	0.5%	10 000
Temperate, coniferous forest	0.75%	20 000
Temperate, deciduous forest	0.7%	7500
Tropical rain forest	1-2%	9000
Temperate (high-yield cereal)	5%*	1000

*Total off take is greater because off take is from fertiliser N + soil + litter.

The location of the research sites.



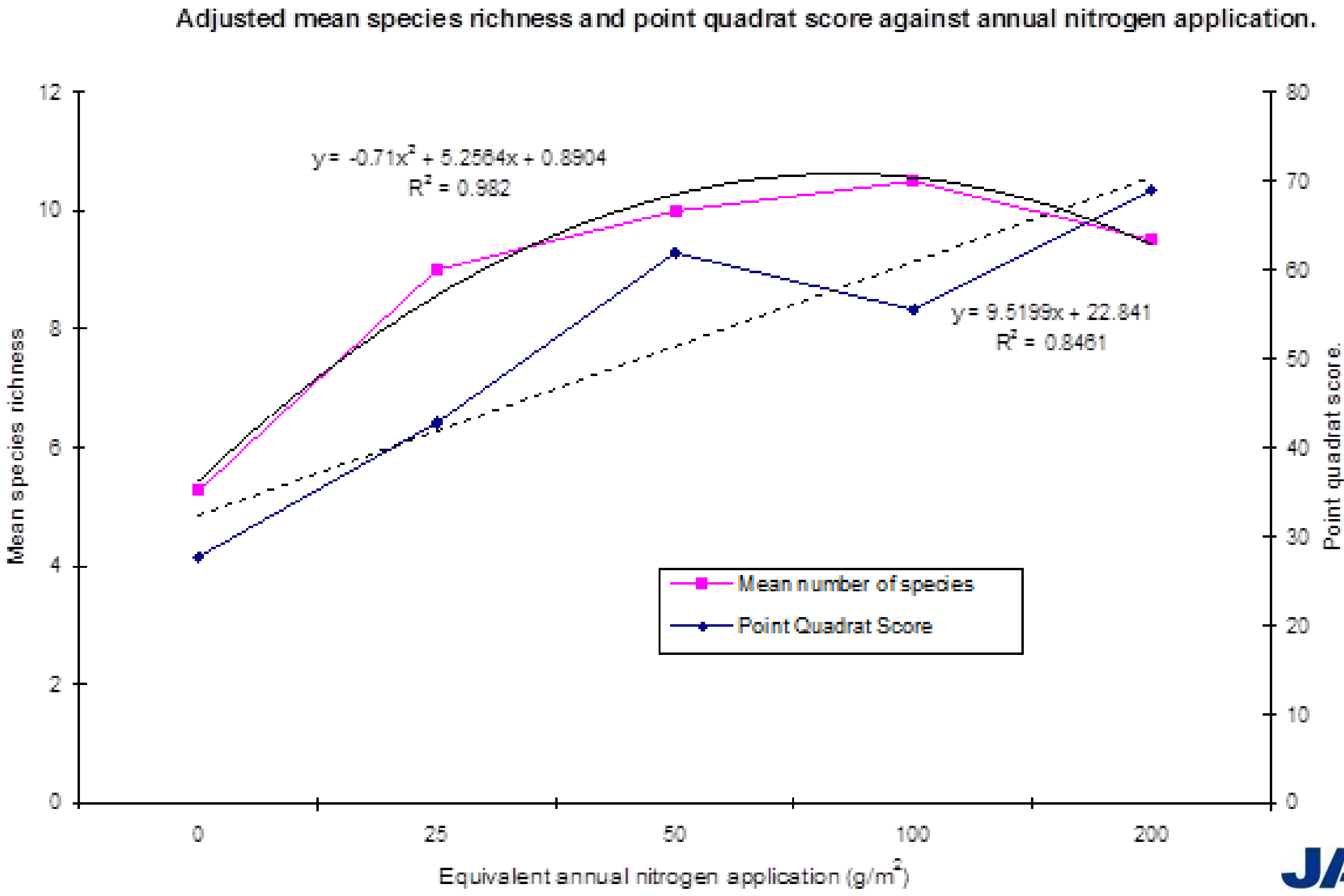
A little NPK can help…

Tilmanstone colliery waste experimental plot March 1997 with NPK added.

Six months later…not only productivity increased as expected but also species diversity.

Soil nutrients and restoration

- Eutrophic systems are often seen as problematic due to the persistent effect of elevated nutrients on community composition.
- An early seral stage is often a restoration target community which is not represented by the soil nutrient characteristics.



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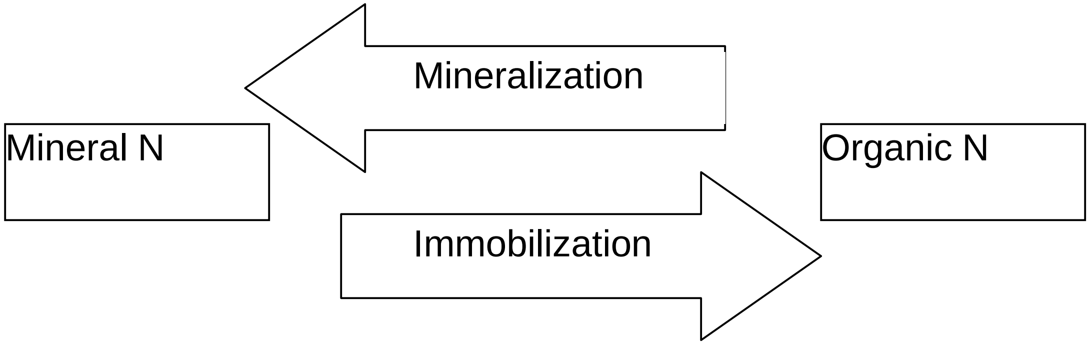

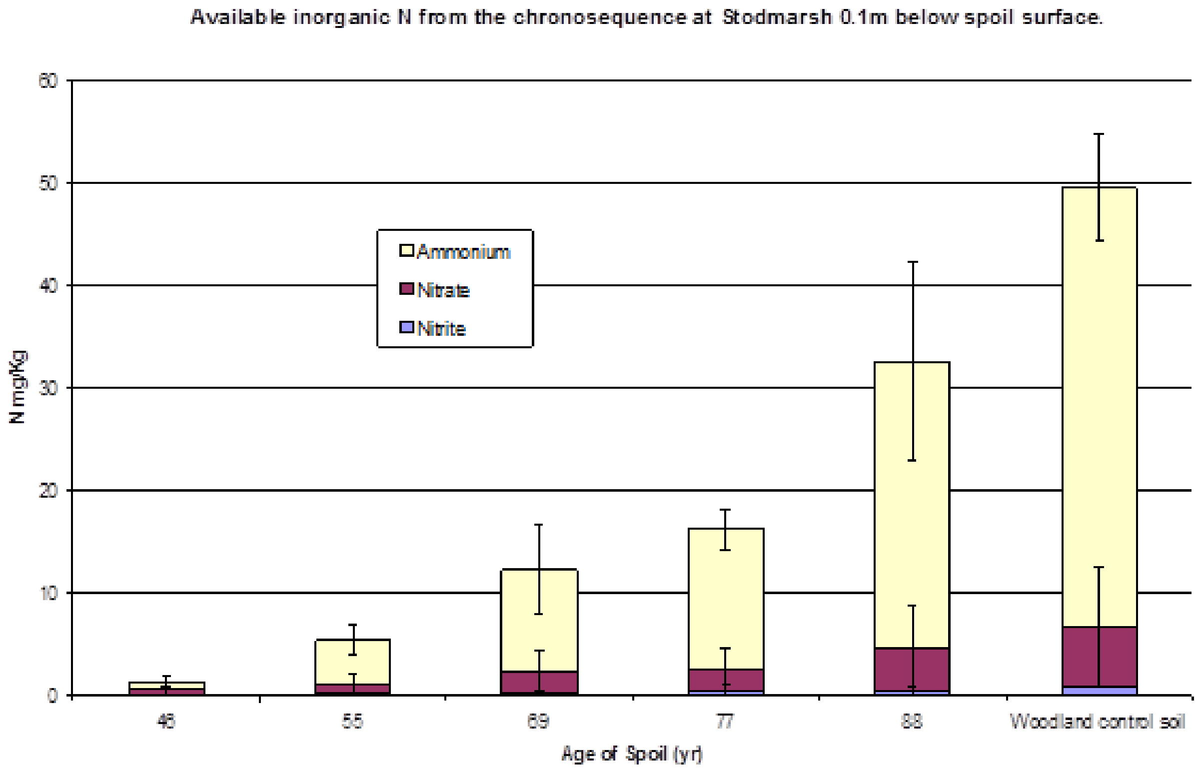

Available inorganic N from different aged colliery waste 0.1m below spoil surface at Stodmarsh in Kent.

Niche assembly

- The niche-assembly model for community structure suggests that the species observable in a community are dependent on the functional roles and ecological niches of individual species.
- Retention of limiting resources within the community, and higher levels of diversity decrease the susceptibility of an ecosystem to invasion.
- Also the more complete utilisation of limiting resources at higher diversity, increases resource retention, further increasing productivity….and stability.

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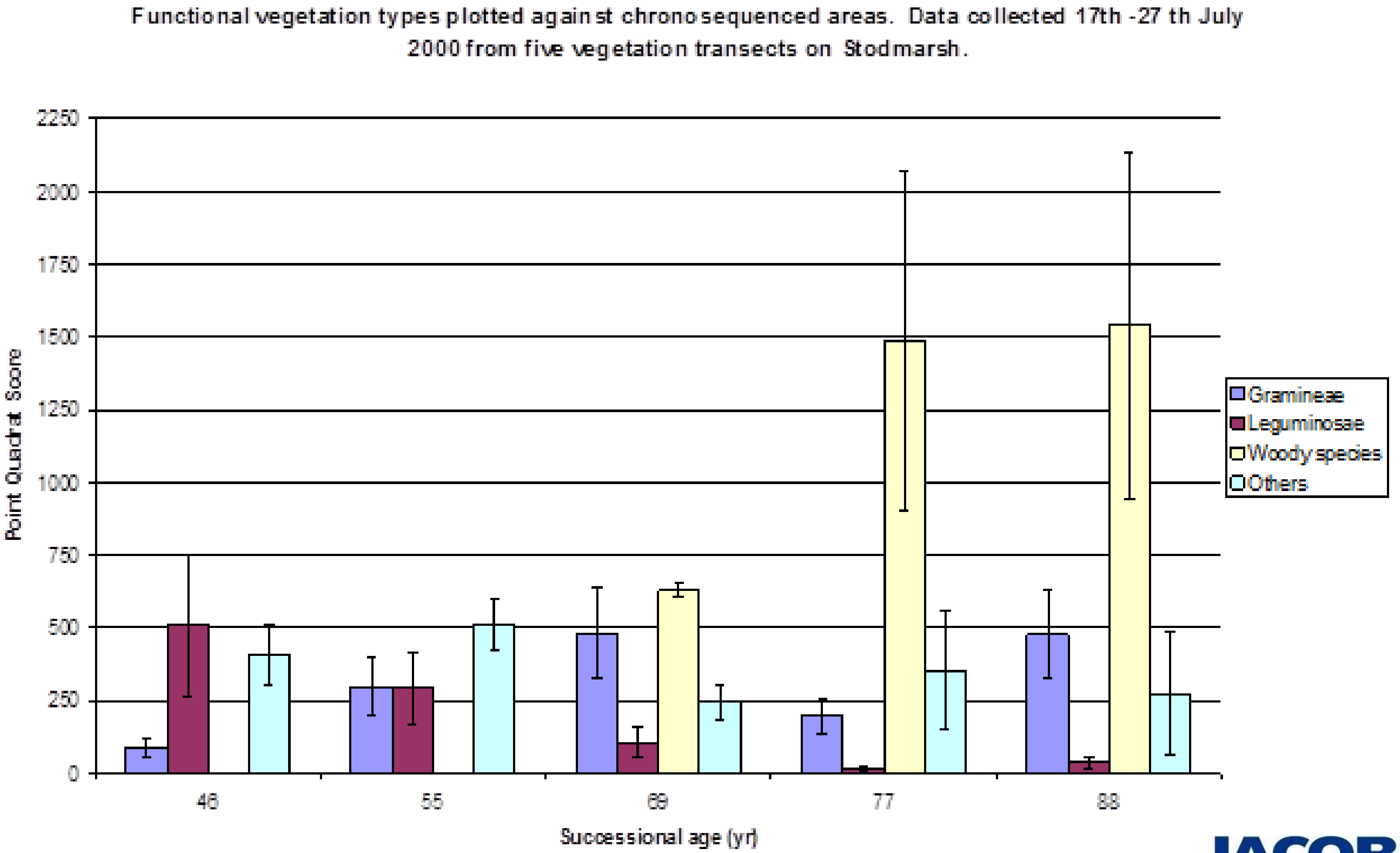
Functional vegetation types plotted against chronosequenced areas. Data collected 17th-27th July 2000 from five vegetation transects on Stodmarsh.



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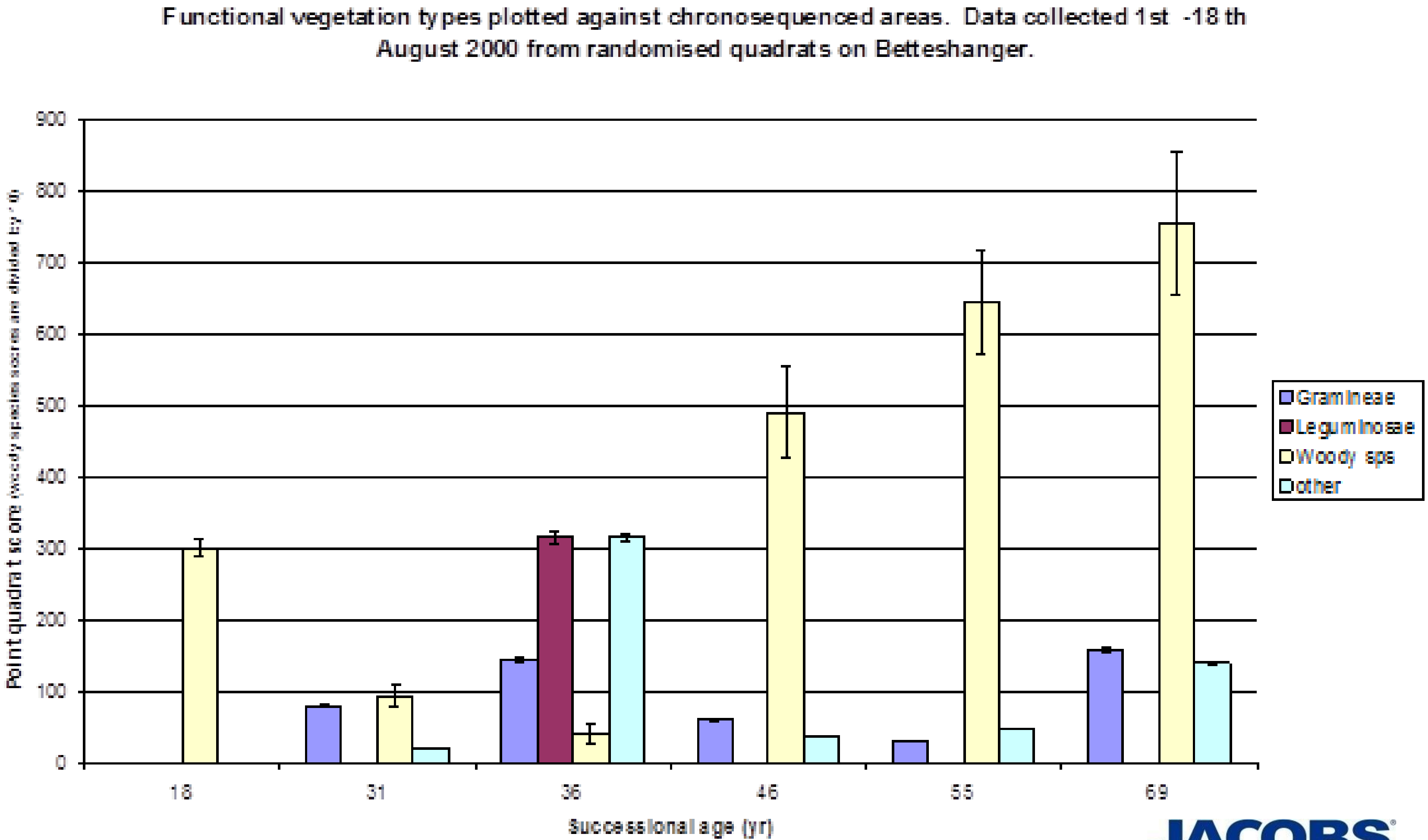
Dispersal assembly

- The dispersal-assembly model for community structure suggests, that, community structure is the result of species brought together by chance, site history and random dispersal.



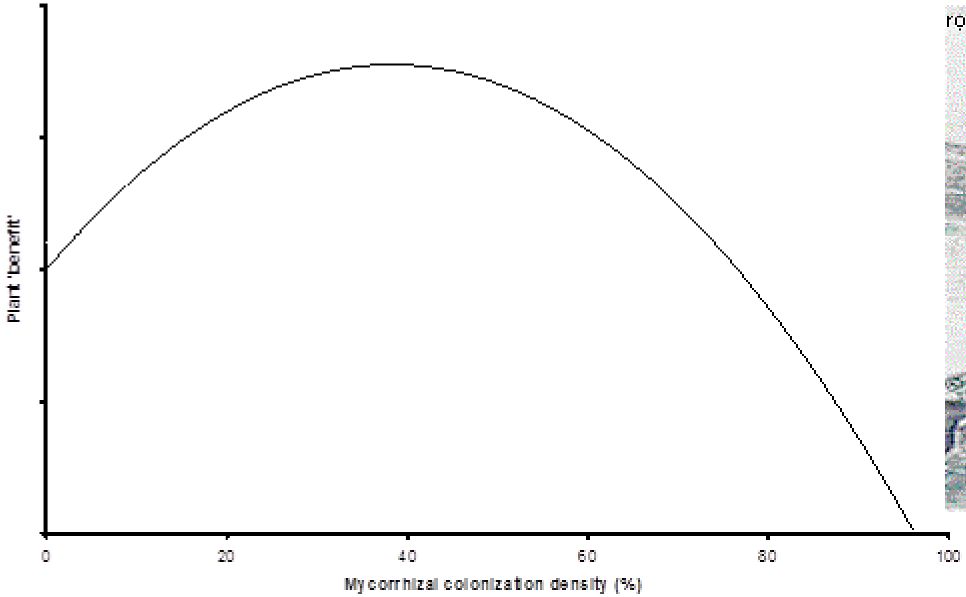
Succession

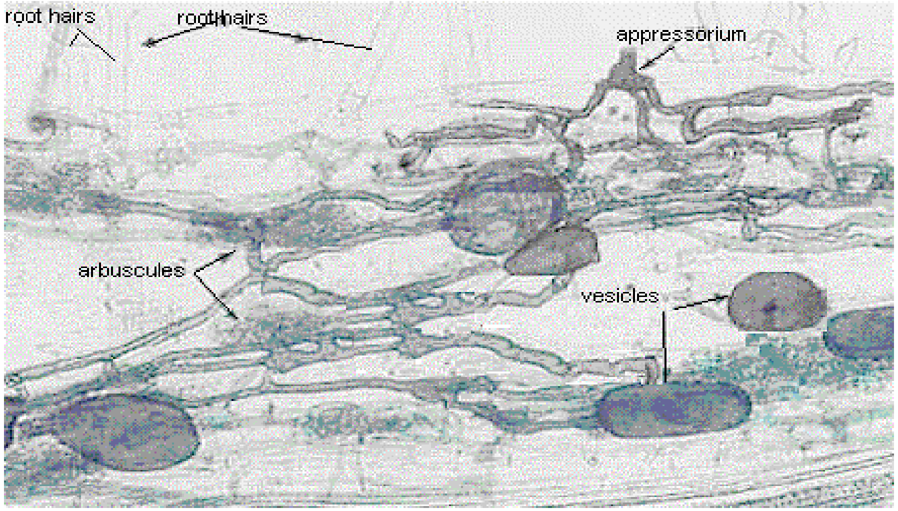
- Plant communities not at their climatic climax will trend toward their climatic climax…
- These plant communities are dynamic.
- The balance between function and complexity in restoration can follow the same path as 'spontaneous' succession…but there is more than one model of succession…which is the challenge

The challenges for restoration ecology

- Restoration communities can be essentially open and not in equilibrium,
- The presence or absence of any species in a restored community after a period of time can be potentially dictated by random dispersal and stochastic extinction.
- This is why continued adaptive management can be so important in ecological restoration success.

Soil: don't forget the mycorrhizal fungi





Mycorrhizae can play a critical role in developing plant communities.

Their ability to forage nutrients for plants can influence communities and their resilience.

Owens Lake Dust Mitigation Programme U.S.A.

- Revegetation plans for the largest dust remediation project in the United States
- Large-scale salt grass revegetation and shallow flooded habitat on a particularly inhospitable site - a dry salt lake bed.
- Functional species were selected for their halophytic properties

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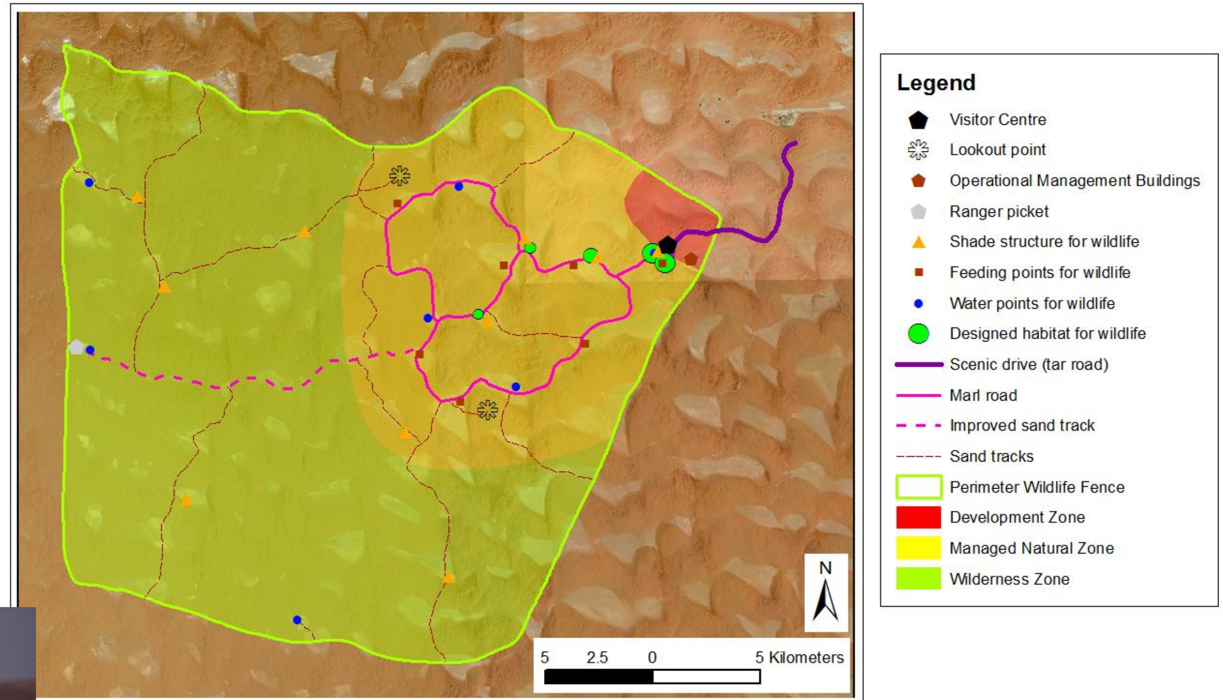
Ecological restoration for endangered species: Arabian oryx

- Ecological design for habitat restoration
- Main issue for the desert rangeland was over grazing by camels
- Specific endemic planting plans developed



HABITAT CATEGORIES

Habitat	Visual aspect	Irrigation	Plant species	Irrigated lawns	Water features
Visitor Centre habitat	Green landscape	Permanent	Larger Rub al Khali including ornamentals	Yes	Ornamental / hard-edged ponds & fountains
Designed habitat	Green / brown landscape	Permanent	Larger Rub al Khali excluding ornamentals	No	Natural-looking pond only
Enhanced habitat	Brown / green landscape	Intermittent	Larger Rub al Khali excluding ornamentals	No	None (except waterholes for wildlife)
Restoration habitat	Brown landscape	Temporary	Larger Rub al Khali excluding ornamentals	No	None (except waterholes for wildlife)
Natural habitat	Brown landscape	None	Shaybah species only	No	None (except waterholes for wildlife)

HABITATS FOUND IN THE DIFFERENT ZONES

Habitat	Visitor Centre Habitat	Designed Habitat	Enhanced Habitat	Restoration Habitat	Natural Habitat
Development Zone					
Managed Natural Zone					
Managed Wilderness Zone					

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Development Zone

Managed Natural Zone

Managed Wilderness Zone

Visitor Centre Habitat

Designed Habitat

Enhanced Habitat

Restoration Habitat

Natural Habitat

Managed Wilderness Zone

Managed Natural Zone

Development Zone

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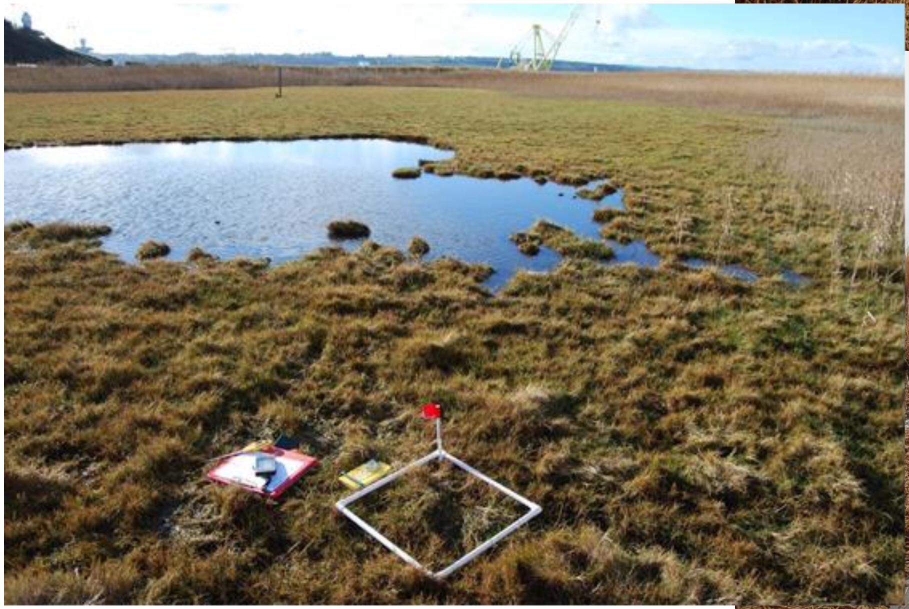
Queensferry Crossing: St Margaret’s Marsh

The challenges with restoration included getting the water balance right but also tackling the eutrophic conditions on site. More information can be found at:

https://www.cieem.net/data/files/5_Peter_Gilchrist.pdf



What next?

- Understanding vegetation dynamics and their influence on community development will continue to inform restoration ecology.
- DNA metabarcoding as a restoration monitoring tool is becoming possible.
- We've undertaken DNA meta-barcoding for identification of diversity of soil biota in ancient woodland soil translocations on large infrastructure projects.
- Monitoring will identify the success of the translocation in terms of the functional groups, which will help to inform aftercare and restoration approaches in the future.

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What next?

- Re-wilding and letting natural processes take their course can have dramatic results for restoring ecosystems e.g. the wilding project at Knepp (Isabella Tree *Wilding*).
- Policy changes and the move towards biodiversity enhancement will re-focus the importance and resources for ecological restoration.
- Using vegetation science in designing mitigation planting still needs to be driven into projects.

Conclusions

- Understanding vegetation science is important for designing successful ecological restorations.
- Clear objectives are essential for targeted end results and establishing success.
- Functional restoration is more achievable than structural restoration.
- Soil biota and it's critical role in vegetation development is often overlooked when design restoration approaches.
- The development of tools and techniques such as DNA metabarcoding are facilitating new approaches to restoration ecology.

AMF spore preparation enabling identification: in this example *Glomus geosporum* (X 100)

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Thank you for listening

Any Questions?

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