Repairing the Damage

Species Conservation - HT 2013 - Lecture 7/16

Species Recovery Programmes

CONSERVATION BIOLOGY

RESTORATION BIOLOGY

1. Habitat restoration
2. Reproduction biology & pollination
3. Seed testing
4. Soil seed-banks
5. Smoke enhanced germination

CONSERVATION GENETICS

1. Fidelity of genetic stock
2. Breeding systems
3. Provenance
4. Sampling methods
5. Infra & inter-population variation
6. Clonality

PROPAGATION SCIENCE

1. Seed propagation
2. Smoke and other dormancy breakers
3. Shoot culture
4. Micropropagation
5. Somatic embryogenesis

GERMPLASM STORAGE

1. Seed storage
2. Cryostorage
3. Slow-growth micro-plants
4. Living collections

EDUCATION & AWARENESS

1. Politicians (local & national)
2. Banks & other funding bodies
3. Industry
4. Land owners
5. Electorate
6. School children

SPECIES RECOVERY PROGRAMMES

The goal is to establish a self propagating population

Three species recovery programmes from the USA

Cirsium pitcheri

Asclepias meadii

Platanthera leucophaea

The **cost** of saving *P. leucophaea* has been estimated at **$5,315,000**

For more information about these species go to these websites

http://www.centerforplantconservation.org/collection/cpc_viewprofile.asp?CPCNum=962
http://www.centerforplantconservation.org/collection/cpc_viewprofile.asp?CPCNum=308
http://www.bgci.org/ourwork/Platanthera_leucophaea/

Three species recovery programmes from the USA

CONTRASTING BIOLOGICAL CHARACTERISTICS & RESTORATION STRATEGIES

Species	***Cirsium pitcheri***	***Asclepias meadii***	***Platanthera leucophaea***
Habitat	Early-successional species endemic to Lake Michigan foredunes	Virgin dry-mesic Midwest prairies and glades	Mid- to late-successional prairies, sedge meadows & fens
Life history	Monocarpic after 3-5 years requiring cohort replacement	Long-lived perennial; infrequent seedling establishment	Short-lived perennial, flowering cohort half-life of 3 years; seedlings require mycorrhizae
Breeding system	Self-compatible, mixed crossing by insects	Self-incompatible; requires different genotypes for successful insect pollination	Facultative out-crossing by hawkmoths; vulnerable to inbreeding in small populations
Genetics	Low allozyme diversity; population differentiation with RAPDs	High genetic diversity with little differentiation within larger populations	Moderate genetic diversity partitioned among populations with RAPDs
Restoration strategy	Enhance cohort establishment through out-planting; restore meta-population	Increase genetic diversity within populations; implement fire management	Hand pollination & seed dispersal used to restore populations
Research needs	Assess performance differences among seed sources; monitoring to assess out-planting needs	Assess potential effects of out-breeding	Assess effects of excessive pollination & pollen transfer; Develop mycotrophic propagation methods

Choosing species for a recovery programme

CONSERVATION APPRAISAL

Proposed by Naomi Kingston & Steve Waldren (Trinity College, Dublin)

This system was designed to draw up conservation priorities on Pitcairn Island. It is therefore a model that can be adapted to different habitats and vegetations but the criteria will remain essentially the same with only the scores changing

Population size	0	>1000 individuals	The scoring is weighted in favour of smaller populations
	1	501 –1000	
	2	101 – 500	
	3	51 – 100	
	4	11 – 50	
	5	5 – 10	
	6	1 – 4	
Distribution	Score = $[2(1-p)]^3/2$		The number of grid squares (from a 250m^2 grid overlay) in which a taxon was recorded as a proportion (p) of the 75 squares possible, and converting this by a cubic function standardised to give a maximum score of 4. The cubic function weights the score in favour of the taxa that occurred in few grid squares.
Attractiveness	0	Not obviously attractive	*Sadly, experience has shown that populations of ornamentals are at threat from collectors*
	1	Attractive leaves or flowers	
Usefulness	0	No known or potential uses locally	*This is a controversial scoring since it can be argued that the more useful a species the more likely it is that people will value & conserve it.*
	1	Some potential or minor use	
	2	An important local resource	
Remoteness	0	Populations remote from tracks or settlements	*Remoteness can make field work more difficult*
	1	Some populations moderately close to tracks	
	2	Most populations close to tracks or settlements	
Accessibility	0	Access to all populations very difficult	*Remoteness can make field work more difficult*
	1	Easy access to all populations	
Habitat specificity	0	Occurs in a variety of habitats	
	1	Found in a moderate range of habitats	
	2	Restricted to a narrow range of habitats	
Habitat vulnerability	0	At least some of the habitats of the taxon are stable	
	1	Habitats may become unstable or threatened	
	2	Habitats unstable or threatened	
	3	Habitats unlikely to persist in present form (including vulnerability to invasive species)	
Dispersability	0	No factor limiting dispersal	
	1	Some factors limiting dispersal	
	2	Serious limitation or cessation in dispersal (such as the absence of a frugivorous bird)	

Recovering
Euphorbia stygiana

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- This is an oceanic island **endemic** and thus inherently **vulnerable**. The oldest island is 8.12Myr old and the youngest 0.27Myr old.
- This species is declining due to low recruitment of seedlings. Its habitat is extinct volcanic craters
- Restoration programme underway on the Azores

Cultivating
Euphorbia stygiana

- The first stage in an *ex situ* species recovery programme is to acquire seeds and **raise plants.** This was achieved in 1990.
- Seedlings were raised and planted out to test hardiness in the UK.
- This species is hardy down to at least -14ºC which is odd given that the average minimum night time temperature in the Azores is 10ºC
- ***The degree of adaptation of species to the climates under which they grow is often over-rated. We may infer this from our frequent inability to predict whether or not an imported plant will endure our climate*** (Darwin 1859)

Propagating
Euphorbia stygiana

- Having raised the first plants more were needed to hit the first target to get the plant growing in **200 gardens** in Britain & Ireland.

- **Claire Kelly**, propagator at the Botanic Garden, eventually rooted cutting using hormone rooting gel and by placing the cuttings in pure horticultural sand with bottom heat of 20ºC

- An assessment was carried out to determine if this species might become **invasive?** Mature plants are easy to up root. They do not propagate vegetatively and did not reproduce from seed in Oxford Botanic Garden.

Distributing
Euphorbia stygiana

- Distributed through the *Friends of Oxford Botanic Garden* & Plant Network and established in >200 gardens.

- Listed by at least 15 **commercial nurseries**

Propagating
Euphorbia stygiana

- Undergraduate project carried out by **Susan McBurney** to draw-up a protocol for propagating this species from seed.
- Seeds collected in August from the plants in the Garden and sown in February.
- Sowing was individually into 7cm pots with either peat-based seed compost or loam-based JI seed compost.
- Germination rates 95% in both composts
- The seedlings in the peat-based grew faster

Propagating
Euphorbia stygiana

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- Seedlings from both treatments were potted on into peat-based and loam-based composts

- After two years there was no discernible difference between the treatments but the **loam-raised plants grew away better** after planting in the Garden

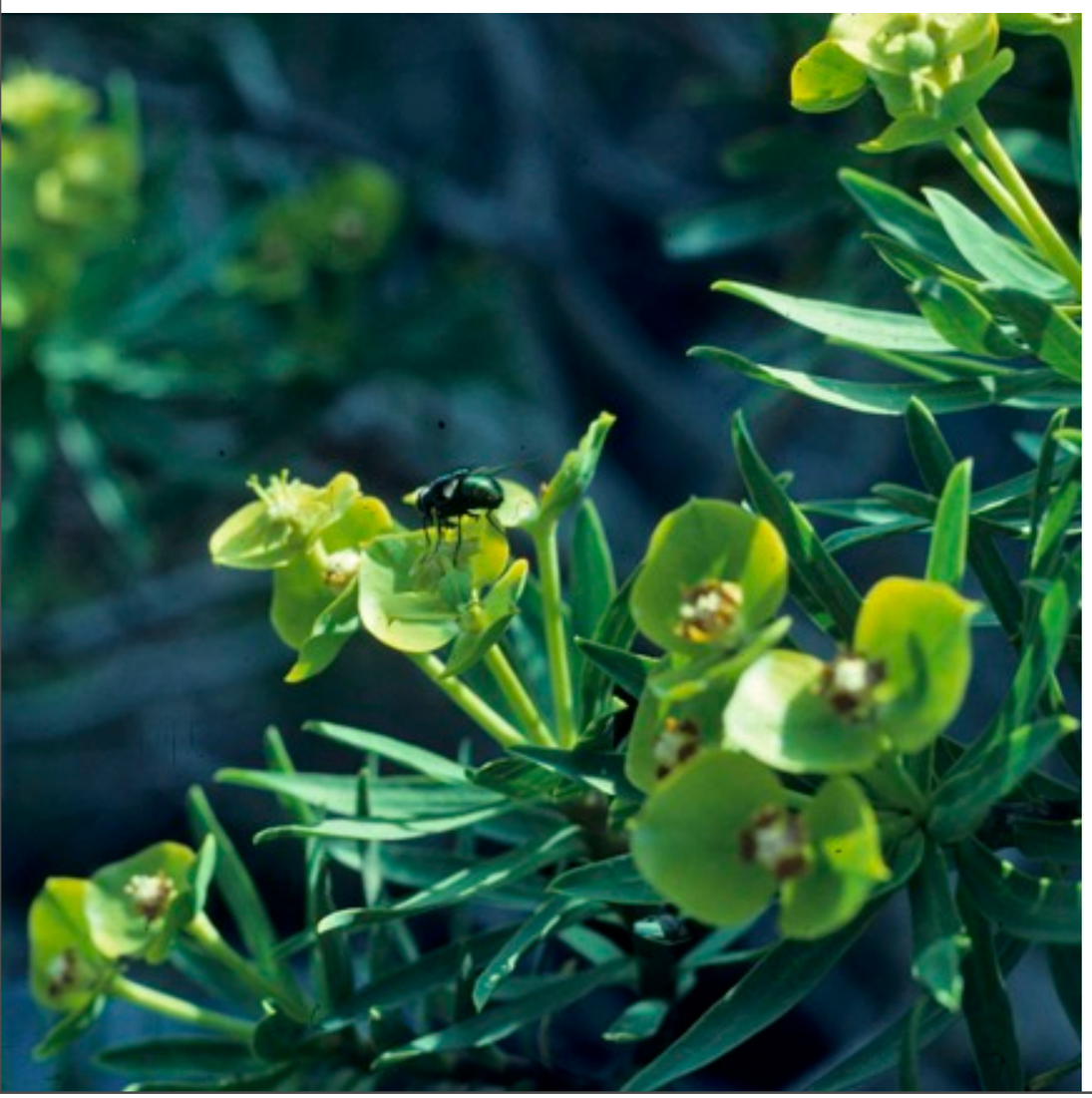
Propagating
Euphorbia stygiana

- While in the cold frame plants suffered from **thrip** damage. This was controlled using a predatory mite

Pollinating
Euphorbia stygiana

- Hardy European euphorbias do **not** appear to have developed complex relationships with specific pollinators, Ants, flies, wasps, bees, and snails visit the flowers

- Many euphorbias are **self-compatible** including *E. stygiana*



Seeds of *Euphorbia stygiana*

- Hardy European euphorbias have **orthodox seeds** that can be dried and frozen. If stored in an envelope in a drawer at ambient temperature the seed is dead within 2 years
- Seeds are dormant for 7 months following production.
- **Julia Jeans**' project showed this clearly.
- It is assumed that this is a consequence of their Mediterranean origin where inborn summer dormancy is an important survival strategy waiting for the mild wet winter.

Seeds of
Euphorbia stygiana

- Seeds of euphorbias have an **elaiosome**, a fat body. **Ants** take the whole seed back to their nests where the fat is eaten by the larvae. The undamaged seeds are then removed to the nest waste heap
- Seeds are palatable to **mice**

A population of *Euphorbia stygiana*

- The plants raised by Susan McBurney planted out in Oxford Botanic Garden and it was hoped that seedlings would emerge. They did not.
- **Helen Humphries** carried out a project to find the reason or reasons.

Predation of *Euphorbia stygiana*

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- Seeds were sown in cellular trays filled with soil from under the parent plants. Some trays were buried below the plants and some taken to the greenhouses.
- Those in the greenhouse germinated. Those outside under the parents resulted in no seedlings so soil not the problem
- **Predation** of the seeds suspected

Predation of *Euphorbia stygiana*

- Possible predators thought to be ants, mice/vole, and/or birds.
- Perpetrator discovered to be **wrens** who are usually insectivorous. They selectively ate *E. stygiana* in preference to other euphorbia species.

The future of *Euphorbia stygiana*

- Shooting 8 million wrens probably not an option
- The seeds may have to be harvested manually and **sown *ex situ in perpetua***
- A loose mulch on the soil surface might enable the seeds to fall beyond the reach of the wrens
- This species in now fixed *ex situ* and is **safe for now and it took four people and ten years**
- Saving 100,000 threatened species needs 400,000 people worldwide each to give eight months of their lives to a threatened species.

The problem of *Euphorbia x pasteurii*

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- Four spontaneous **hybrid** plants appeared at the garden in 1998. At first they were thought to be *E. stygiana*.
- Very large seedlings appeared in Susan McBurney's seedlings. Hybrid vigour was suspected.

The problem of
Euphorbia x pasteurii

- Undergraduate **George Pasteur** showed that the hybrid (centre below) is a hybrid between *Euphorbia mellifera* (right below) and *Euphorbia stygiana* *(left below)*. *E. mellifera*, from the Canary Islands is the pollen parent.
- The hybrid is self-fertile and fertile with both its parents
- Is *Euphorbia* x *pasteurii* a new species or are *Euphorbia mellifera* (right below) and *Euphorbia stygiana* *(left below)* sub-species of the same species?
- Could/should *E. mellifera* be used to **increase the gene pool** of *E. stygiana* on the Azores?
- Do oceanic island endemics matter?

The recovery of *Encephalartos ferox*

- *Encephalartos ferox* is a cycad from south west Africa.
- It is listed as rare by the IUCN and it is listed in Appendix I of **CITES** banning all trade
- It is common in cultivation in botanic gardens

The pollination of *Encephalartos ferox*

- All cycads are dioecious and many are **pollinated by beetles** (weevils)

- Pollinator species often live for less time that the plants that they pollinate with the result that many species have more than one pollinator during their life time

The recovery of *Encephalartos ferox*

- *Encephalartos ferox* **pollination *ex situ*** is now carried out using a turkey baster
- Pollen was brought from RBG Kew (below left) to Oxford where it was used successfully to pollinate the female cones of our plant

The recovery of *Encephalartos ferox*

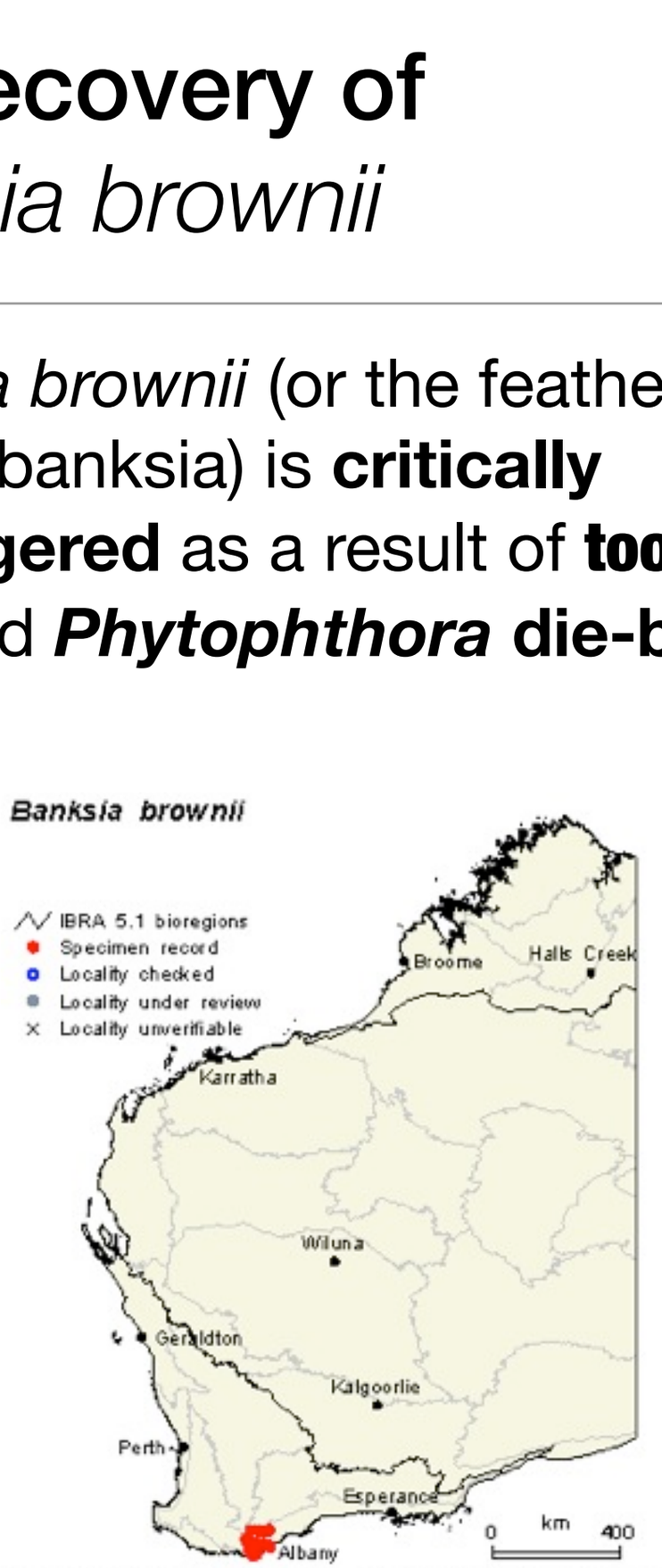
- *Encephalartos ferox* seedlings have now been **distributed** to many other gardens in Britain & Europe
- It has recently been suggested (Nagalingum 2011 & Renner 2011) that although cycads are a very ancient clade and now depauperate, they have undergone rapid speciation in the past 10 Myrs. Conserving cycads may help us to understand why plants evolve down specific routes.

The recovery of *Nymphaea thermarum*

- *Nymphaea thermarum* is thought to be extinct in the wild. It is endemic to Rwanda, where it lives in the mud around hot springs. This habitat has been **destroyed by people sinking wells for water**
- 30 seeds were germinated in 2009 by **Carlos Magdalena** at Kew and he grew the seedlings on to maturity.

The recovery of *Banksia brownii*

- *Banksia brownii* (or the feathered-leaved banksia) is **critically endangered** as a result of **too frequent fires** and ***Phytophthora* die-back**



Map by Paul Gioia, WA Herbarium. Current at November 24, 2009

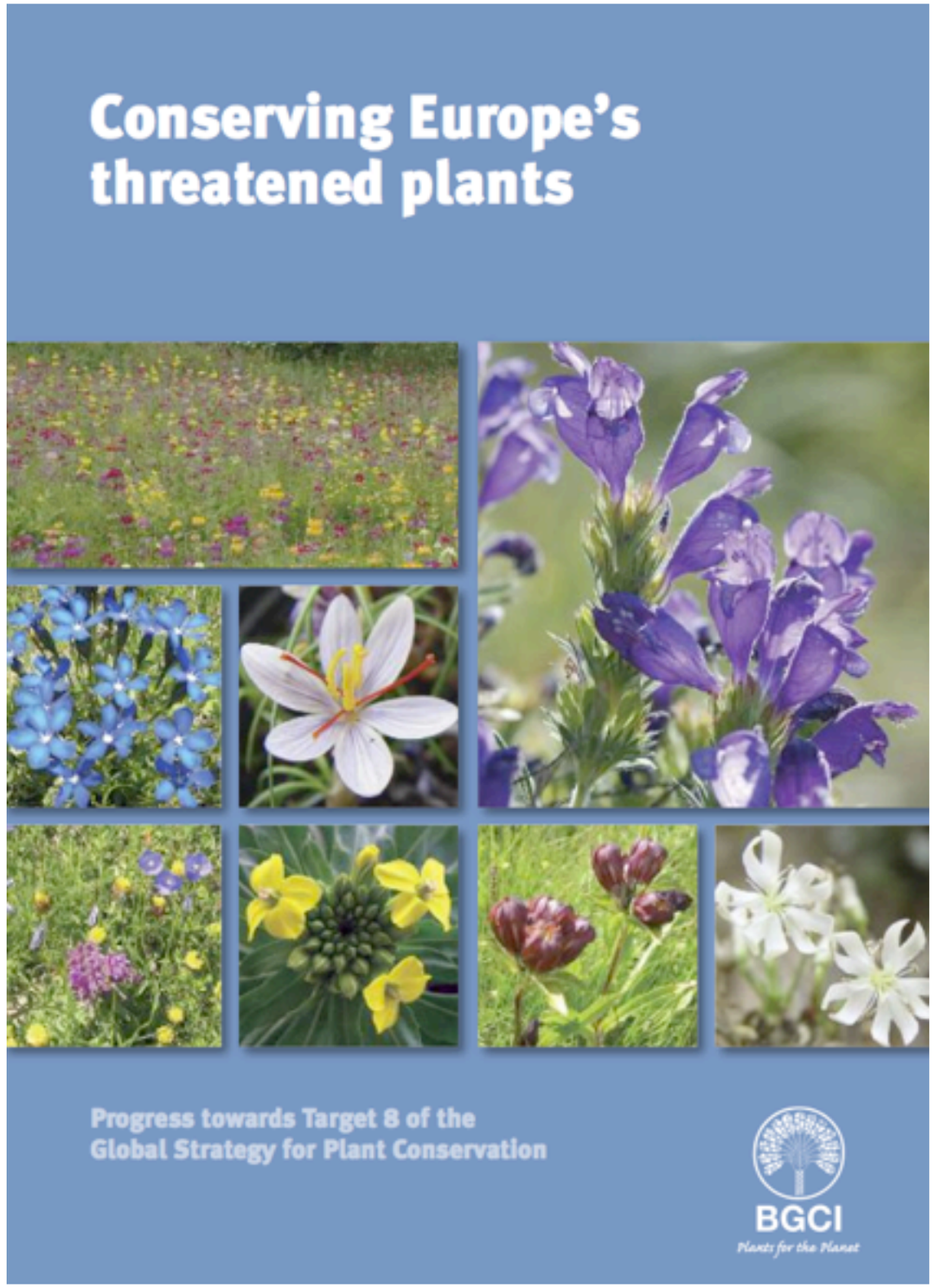
The recovery of
Banksia brownii

- April 2007 - seeds sent to MSBP at Kew by Kings Park & Botanic Garden
- September 2007 - 165 seedlings “returned” to Perth
- May 2008 - plants planted out at 2 disease-free sites near Albany, WA.
- The project succeeded due to a better understanding of germination requirements as a result of research at MSBP
- It was the **first-ever repatriation of live material from Kew**. There were huge quarantine implications

The recovery of
Europe's threatened plants

BGCI
Plants for the Planet

- European Botanic Gardens and plant species conservation
- **bgci.org**
- Go to the *resource centre* and there you will find many examples of *ex situ* conservation projects



The recovery of
Cypripedium calceolus

Sainsbury's Try something new today

Kew ROYAL BOTANIC GARDENS

- *Cypripedium calceolus* (the lady's slipper orchid) is a **UK Biodiversity Action Plan (BAP) species**
- The UK population was reduced to one plant in Yorkshire as a result of over collection by orchid collectors
- There are now 11 populations of flowering size plants in Britain thanks to the pioneering work of **Margaret Ramsay** at Kew whose work was funded by **Lady Sainsbury**
- The only threat to this species was **over-collection by humans** and this has been removed through legislation and making plants available to collectors through nurseries.

Conservation of rare Oxfordshire native species

- Oxfordshire is home to a number of nationally rare species including *Apium repens* which is a species listed in the **Wildlife & Countryside Act 1981**
- The only UK site for ***Apium repens*** in the UK is Port Meadow where its survival is a due to a mixture of winter water levels and trampling

Conservation of rare Oxfordshire native species

- Following changes in the management of the River Thames in the 1990s plants were propagated at the Botanic Garden prior to being established at a **new site** at North Hinksey in1996. There are now more than 100m^2 of *Apium repens* at this site.

Reversion of pasture & arable land to British NVC community **MG5**

- This is a **Biodiversity Action Plan Habitat**
- In the past 50 years this habitat has declined by 96.5% (since 1958)
- Since 1963 the Botanic Garden has increased its **MG5** from 12 acres to 67 acres
- This habitat is uncommon on southern England. There is good example of this community at Chimney Meadows in West Oxfordshire

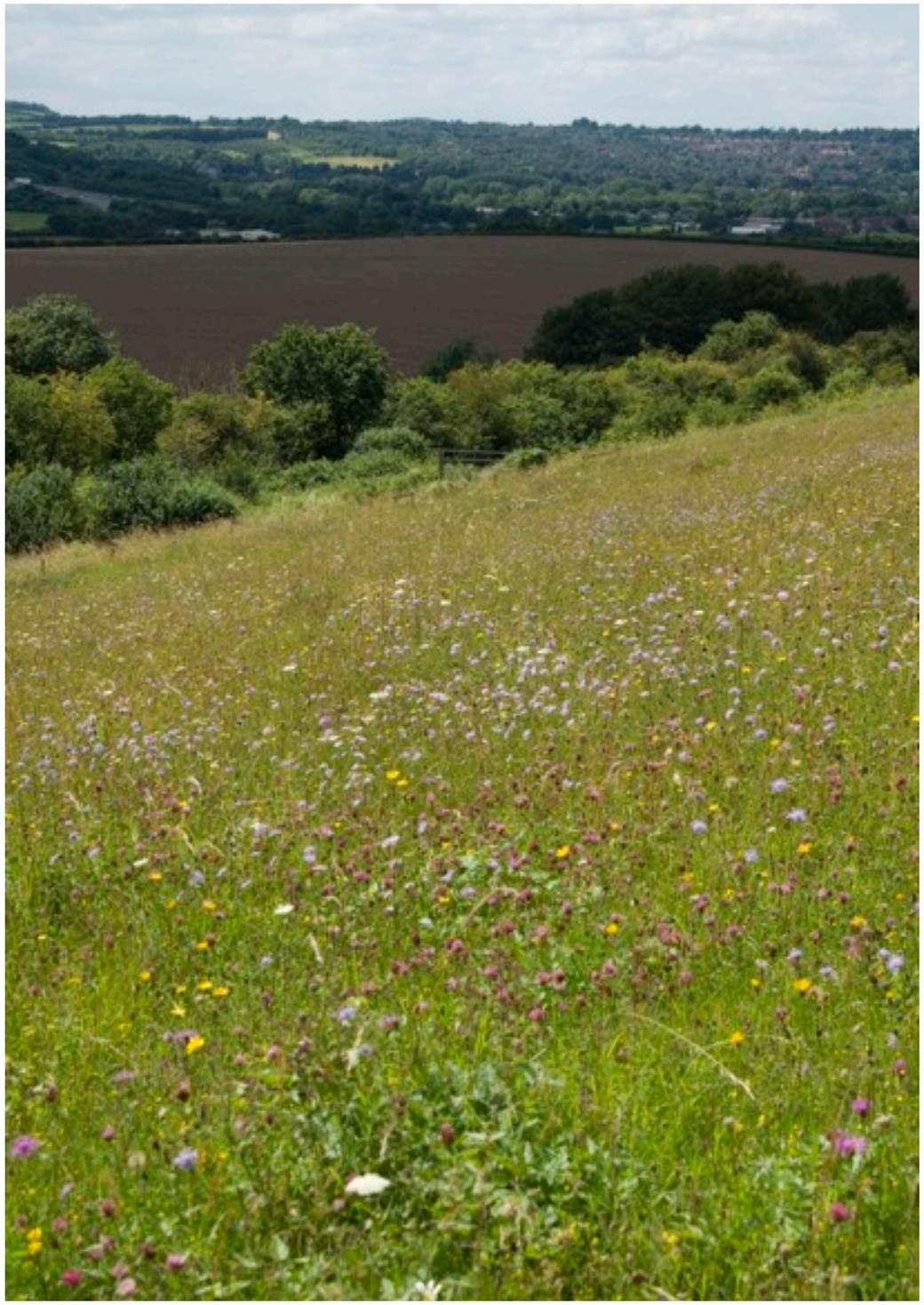
Reversion of pasture & arable land to British NVC community MG5

- **Traditional hay meadows** common before the Black Death (1348/50). Hay was essential for survival of cattle & sheep.

- Post Black Death there was field abandonment and enclosures.

- 1970s & 1980s UK farmers told to specialize (arable or livestock) but **no mixed farming**.

- Morden Hill (*right*) has been reverted from arable to hay meadow in 12 years; every species can be put back.



Reversion of pasture & arable land to British NVC community MG5

The following constant species are found in this community:

- **Common Bent** (*Agrostis capillaris*)
- **Sweet Vernal-grass** (*Anthoxanthum odoratum*)
- **Black Knapweed** (*Centaurea nigra*)
- **Crested Dog's-tail** (*Cynosurus cristatus*)
- **Cock's-foot** (*Dactylis glomerata*)
- **Red Fescue** (*Festuca rubra*)
- **Yorkshire-fog** (*Holcus lanatus*)
- **Common Bird's-foot Trefoil** (*Lotus corniculatus*)
- **Ribwort Plantain** (*Plantago lanceolata*)
- **Red Clover** (*Trifolium pratense*)
- **White Clover** (*Trifolium repens*)

One rare species, Tuberous Thistle (*Cirsium tuberosum*), is associated with this community.

British NVC community MG5

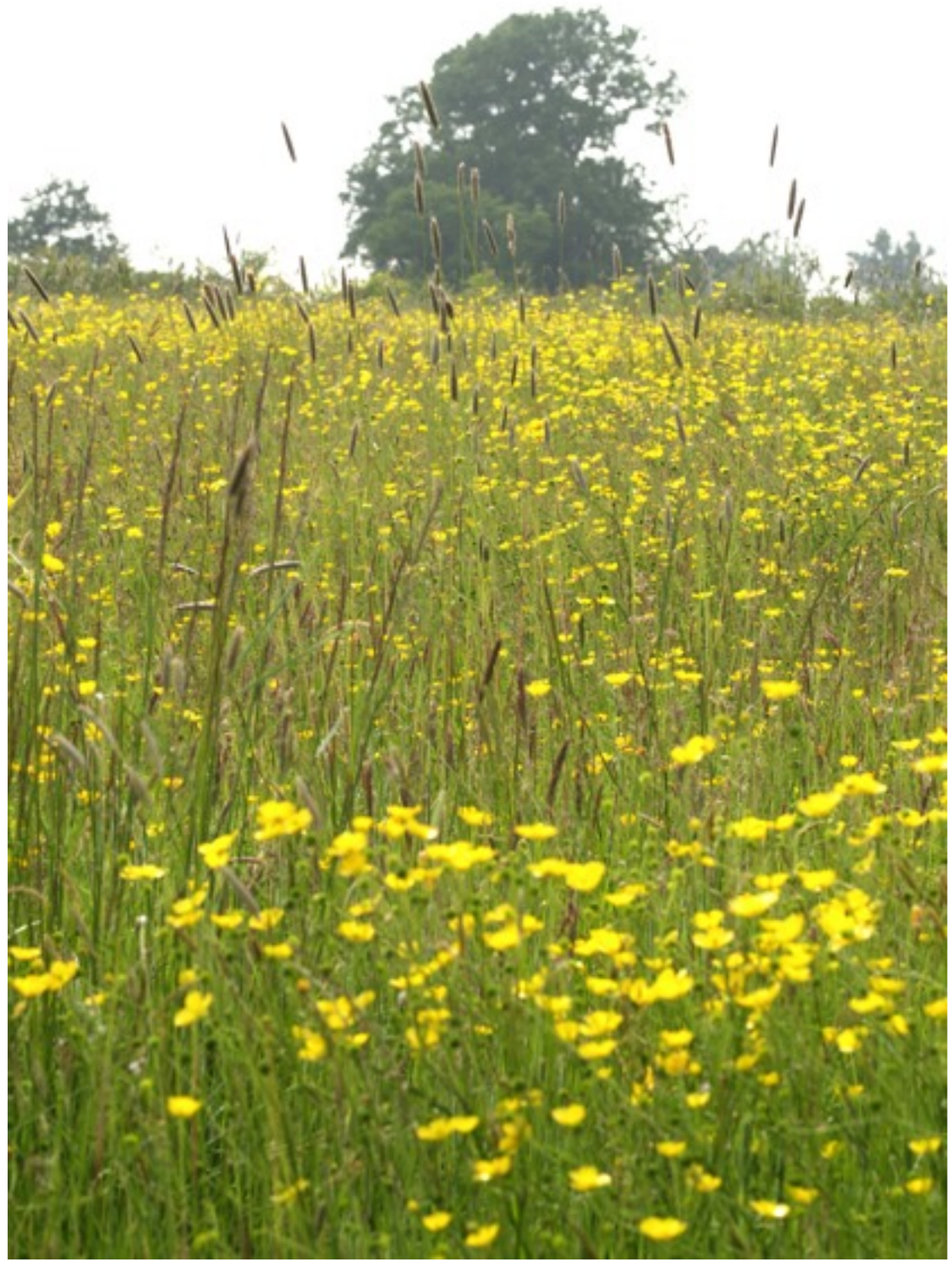
Meadow thistle, pignut & bird's foot trefoil & their pollinators in MG5

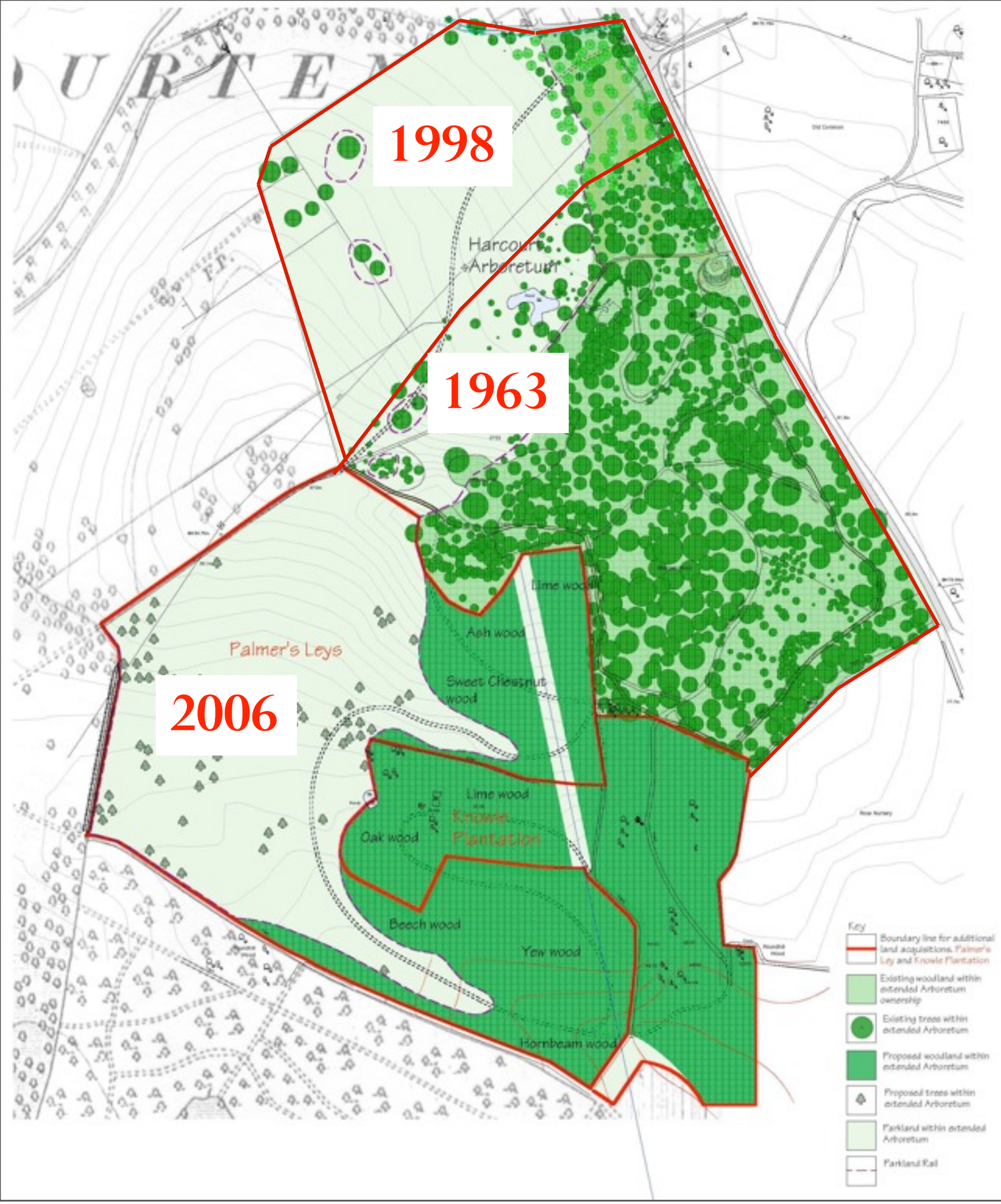
Reversion of pasture & arable land to British NVC community MG5

- Should abandoned fields be left to regenerate serendipitously or put back to species-rich grassland?

- *Restoration purists regard this as* **reversing the wrong way** *down a successional gradient,* ***away*** *from a climax endpoint of mature forest in temperate ecosystems*

- Science (2009) **325** 573





Acquisition of meadowland in the Harcourt Arboretum at Nuneham Courtenay for the Botanic Garden

Reversion of pasture & arable land to British NVC community MG5

- in 1963 the Botanic Garden acquired the Harcourt Arboretum that included 12-acres of former parkland on Windmill Hill that was used for grazing sheep, cattle & deer. Common spotted orchids, ragged robin & cowslips thrived

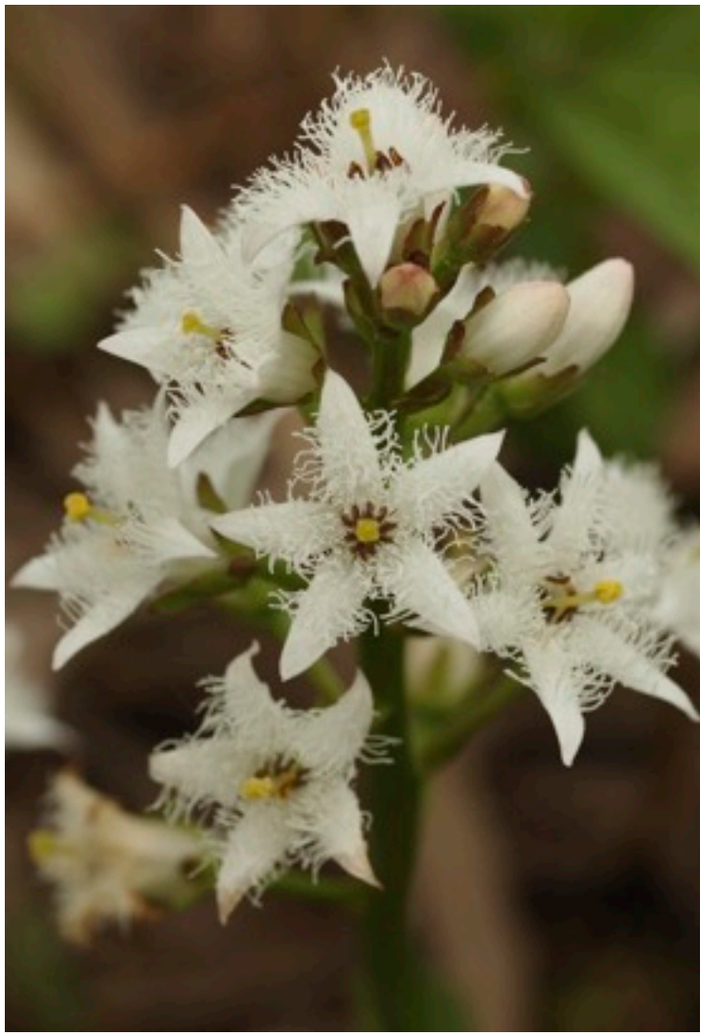
The presence of **pignut** (*Conopodium majus*) is a classic indicator of **ancient grassland**

Reversion of pasture & arable land to British NVC community MG5

- From 1963 neither pesticides, nor lime, nor fertilizers were applied to Windmill Hill. Each year, in early August, the meadow was **cut for hay** and the crop was removed. This cut was late enough to give the plants long enough to set seed. After **40 years** of this simple regime a diverse community of British native species had been established.

Reversion of pasture & arable land to British NVC community MG5

- In 1971 a pond was created on the site of a seasonal dew-pond at the bottom of Windmill Hill. This is now home to the nationally rare bog-bean (*Menyanthes trifoliata*) *(below)* and the parasitic toothwort (*Lathraea squamaria*)



Wednesday, 13 February 2013

Reversion of pasture & arable land to British NVC community MG5

- In 1998, the tenancy of 25-acre Pylon Meadow next to the existing meadow became vacant because the land was **over-grazed and not "improved"** by the farmer who was therefore unable to make a living.

- The Garden made a successful bid for the tenancy because any proper farmer would lime and fertilize the land and probably spray with selective herbicides. There was a danger that these chemical might leach into the pond and drift onto the original 12-acres.

Reversion of pasture & arable land to British NVC community MG5

- The “poor” farming was a good because the soil was already **nutrient poor**
- From 1998 management of Pylon Meadow followed that of Windmill Hill with a hay cut in early August each year.
- However, after the cut and the hay had been removed a tractor drawn chain harrow was employed to drag the aftermath from Windmill Hill over Pylon Meadow and vice-versa.

Reversion of pasture & arable land to British NVC community MG5

- There are two **management regimes**. The first is better for high quality sites with high species diversity such as the Harcourt Arboretum. The second is more appropriate for amenity sites with full public access.

- **Regime 1** - Allow plants to grow, flower, & set seed until the end of July. Remove cut material and then graze or mow the regrowth in October/November. This is very good for cowslips & lady's smock (*Cardamine pratense (below)*). Late grazing essential if yellow rattle being used

- **Regime 2** - Cut or graze until end of May. Allow plants to grow, flower, & set seed until the end of September. Remove cut material and then graze or mow the regrowth in October/ November. Some piles of cut material should be left for the grass snakes

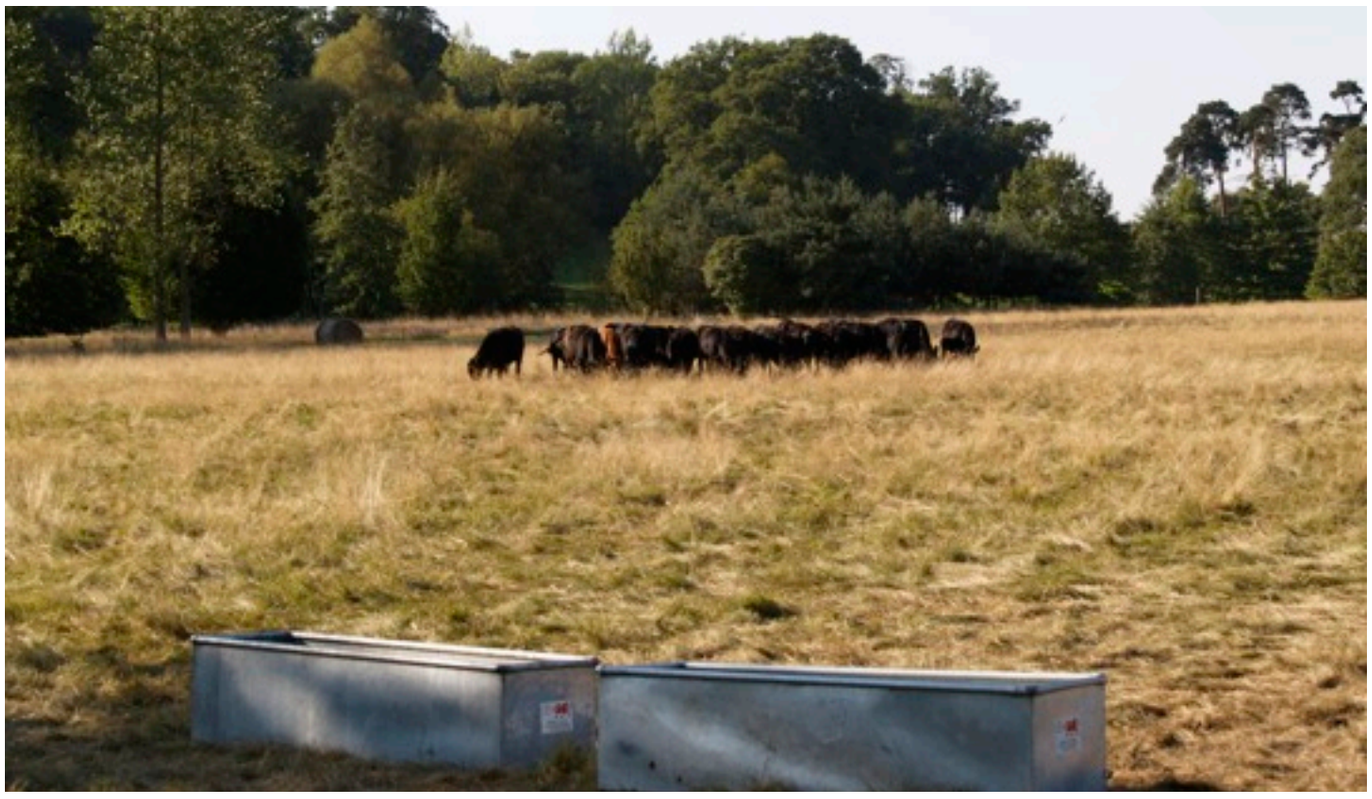
Reversion of pasture & arable land to British NVC community MG5

- **Cutting time is important.** July 25th is the best date despite the pollinators still being on some of the knapweed. If you cut later you may get a may get a monoculture of knapweed.
- Cutting on **July 25th** will result in hay with high nutrient levels.
- A cut to 150mm in May of the headland will extend the **nectar period**.

Reversion of pasture & arable land to British NVC community MG5

- In 2002 Pylon Meadow & Windmill Hill qualified for Higher Level Stewardship under the Countryside Stewardship Scheme. This resulted in the addition of **aftermath grazing** by Aberdeen Angus cattle from September to December.

- The addition of grazing animals introduces a new disturbance and a greater diversity of nutrient distribution across the meadow



The introduction of **grazing has increased the diversity** of species in the community

Reversion of pasture & arable land to British NVC community MG5

- **Countryside Stewardship** is also to do with management, public access and historically significant features in the landscape.

- Grants are awarded for management such as ragwort pulling, tree surgery on **veteran trees** such as Parish oaks, installing all-year-round, wheel chair **accessible** paths held together with netlon, and for planting **hedges**.

Reversion of pasture & arable land to British NVC community MG5

- **Conservation hedge** mix of hawthorne, hazel, blackthorn, dogwood, field maple, dog rose, spindle, & wayfaring tree

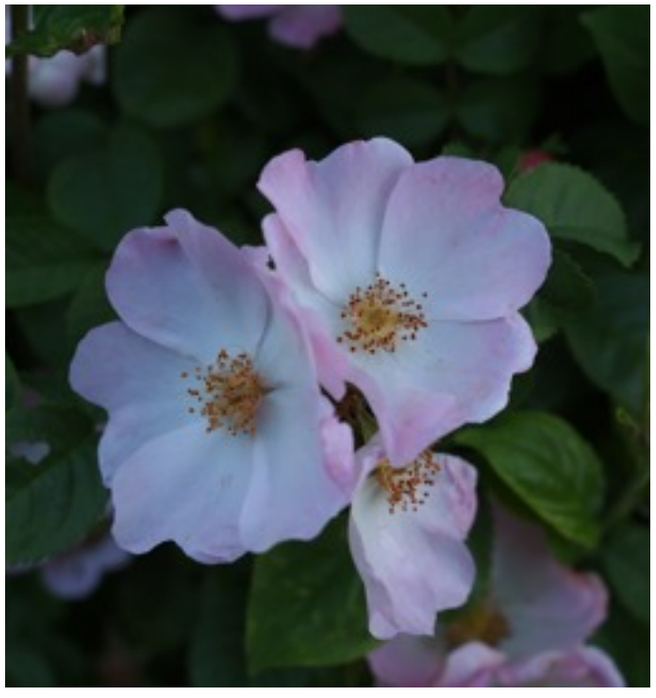
- **Local provenance** of the plants is important. Ours came from Frilford in west Oxfordshire

Reversion of pasture & arable land to British NVC community MG5

- Conservation hedge mix can be **laid**
- Hedge planted in 2002 is first laid in 2011

Reversion of pasture & arable land to British NVC community MG5

- Provides nectar for invertebrates, fruit for birds and small mammals, and **the food chain** is completed by the barn owl



Reversion of pasture & arable land to British NVC community MG5

- 2006 **Palmer's Leys** put up for sale: 50-acre field next to the Arboretum.
- This had been an arable field until 2004 but was then put into set-aside
- The Botanic Garden paid £185,000 for the field in December 2006. The **money** was donated from two trust funds and the members of The Friends of Oxford Botanic Garden & Harcourt Arboretum.

The site was **surveyed** for its historical and botanical value. The species composition was compared with that of the adjacent Pylon Meadow & Windmill Hill. It was decided that 20-acres should be planted with trees and 30-acres should be reverted to MG5 meadowland.

January & February 2008 15 staff plus two local schools planted **13,000 trees** of English yew, small-leaved lime, oak, ash, & hornbeam. In 150 years this area should look like the native woodland elsewhere in the Arboretum. (See Merryweather 2007 for an opposing view)

Reversion of pasture & arable land to British NVC community MG5

- Merryweather (2007) believes that planting trees results in **plantations not woodlands**. The Bluebell wood at the Arboretum was planted 170 years ago. (See Xu in *Nature* 21 September 2011 **477** p371 for similar view from China)

- The original oaks are declining and there is no natural regeneration due to the non-native muntjak deer and the management regime for the bracken. The next generation of oak trees are being planted with nurse trees & under story species

The plantings were funded by **grants** from the Woodland Trust and Defra via Natural England

- The provision of **nectar** is important at different times of year. Many species of invertebrate pollinators require plants from more than one habitat to complete their life-cycle. For example, brimstone butterflies need hedgerow buckthorn and meadow plants.

- February - April: woodland plants are most important

- May - July: meadow plants are most important

- August - September: pond and marginal plants are most important

- October: meadow plants are most important

- **A diverse landscape is required**

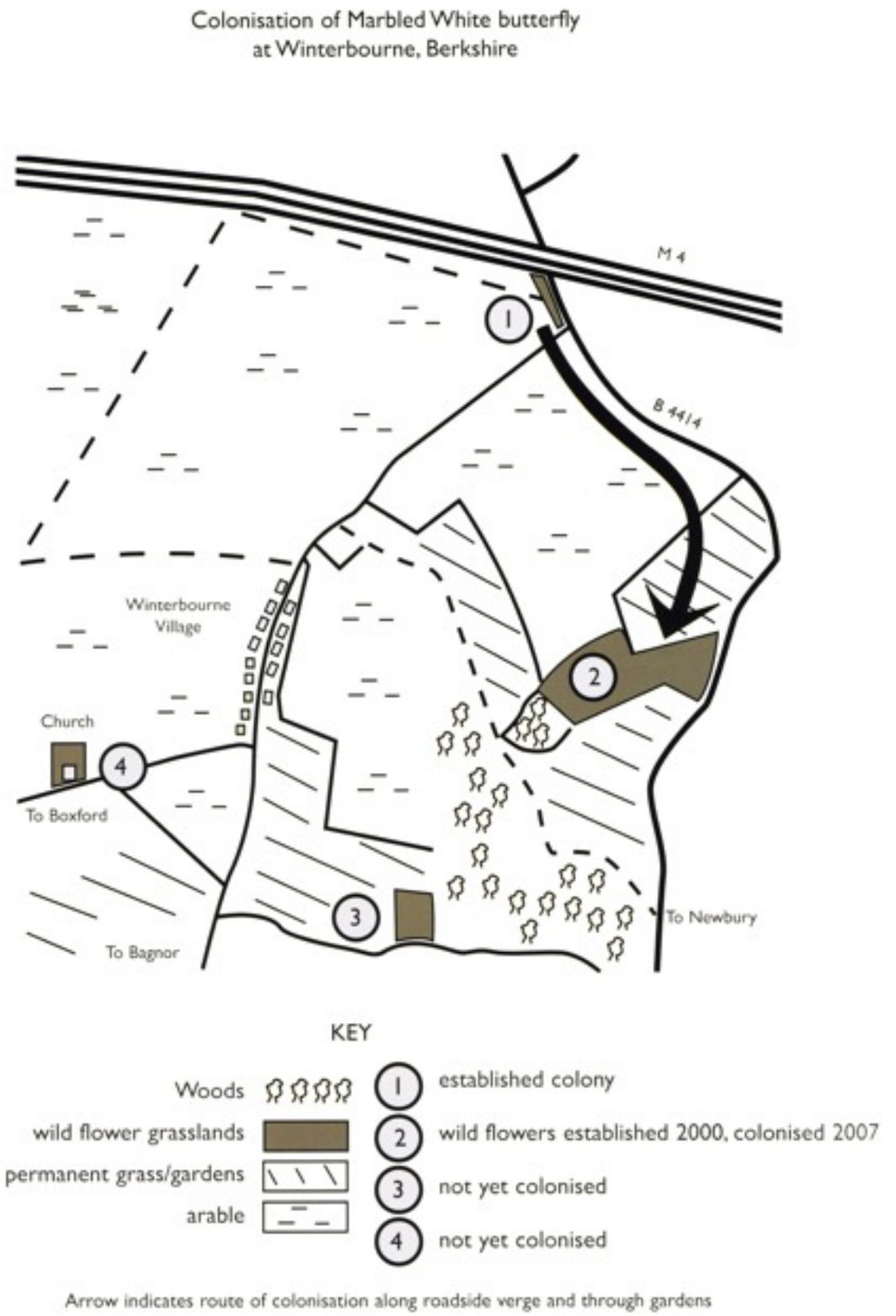
A **mosaic of habitats**, such as exist at the Harcourt Arboretum, is required for some animals.

This map shows how marbled white butterflies are being considered at **Winterbourne**. Site 2 is a 10-acre field.

The marbled white will not fly >50m over arable crops such as wheat.

With small, isolated populations you will get inbreeding depression.

A stream is being created from the NE to SW to facilitate further spread of the butterfly



Reversion of pasture & arable land to British NVC community MG5

- **2007 Undergraduates' projects** showed that the species numbers were similar (54 Pylon Meadow:45 Palmer's Leys) but there were 11 botanical families in Pylon Meadow & only 5 families in Palmer's Leys. Also in Palmer's Leys 90% of the species were from 2 families - the Asteraceae & the Poaceae (grasses and daisies)

Reversion of pasture & arable land to British NVC community MG5

- The dominant grass in the area selected for reversion was **Yorkshire fog** (*Holcus lanatus*) While this is an MG5 species, it should not be the dominant species. It was decided that rather than trying to over-sow or plant new species, the existing sward would be sprayed off and the area re-sown

- **High soil fertility is a problem** on former arable land and on a small scale top soil can be removed. Alternatively, semi-parasitic **yellow rattle** (*Rhinanthus minor*) can be used (and was here) to subdue the Yorkshire fog.

Reversion of pasture & arable land to British NVC community MG5

- **Yellow rattle** (*Rhinanthus minor*) is an essential element in reversion of both pasture and arable land. Sow at 1kg/ha

- This is a semi-parasitic annual plant whose seeds are viable for just 2-3 years and so it is easy to loose.

- It **will halve the growth rate** of vigorous grasses such as Yorkshire fog, colt's foot and false oat grass.

- The large, flat seeds are difficult to get into the soil so **stock are important** for disturbing the soil surface and pushing the seeds into the soil.

- Yellow rattle is useful for reducing the Phosphorous index. The P-index should be <1 in order to attract grants from Defra.

Reversion of pasture & arable land to British NVC community MG5

- The reversion starts with two activities.
- **Seed** collection/acquisition
- Preparation of the **soil** for sowing.
- Advice was sought from **Charles Flower** Farms who has subsequently used the project for teaching.

Reversion of pasture & arable land to British NVC community MG5

- Seed must be of known **provenance** and as local as possible
- Seed was collected from Pylon Meadow using either a converted combine harvester or a box harvester
- The seed collected, dried & weighed. Only enough local seed to sow 10 acres each year at **20 lbs per acre (22.5 kg per ha)** so the area to be reverted was divided into Thirds

Reversion of pasture & arable land to British NVC community MG5

- Seeds can be harvested from drilled & combined populations (*right*) but the new seeds need to be harvested from a natural population every 5 years

- **Wild characters can be lost** if new seed not used every 5 years. Reverted meadows can be used for seed collection if <5% of the seed taken.

- Rarer species or small species such as dwarf thistle, need to be hand collected

The UK Native Seed Hub

at the Millennium Seed Bank Project

- Since starting the Palmer's Leys restoration project Kew's MSBP have been given £750,000 by the Esmee Fairbairn Foundation to establish a seed bank designated to the conservation of **restoration project quantities of seeds**. This project will

- Increase the **quality, quantity, & diversity** of UK native plants & seeds available to conservation organisations & others involved in habitat restoration projects to enhance UK biodiversity

- **Support** UK Native seed producers & conservation agencies through the provision of high quality seed stocks, information & advice

- **Develop research** into improved nursery & plant production techniques for UK native plants

To the Pylon Meadow mix was added:

bird's foot trefoil
common sorrel
cowslip
field scabious
lady's bedstraw
lesser knapweed
ox-eye daisy
ragged robin
ribwort plantain
self heal
tufted vetch
yarrow
yellow rattle

NATURAL ENGLAND

SCIENTIA PLANTARUM 1621 OXONIENSIS

UNIVERSITY OF OXFORD

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Rooting depths vary

grasses to 10mm
ox-eye daisy to 15mm
ribwort plantain to 20mm
cowslip, wild carrot & common sorrel to 25mm
bird's foot trefoil to 30mm
late knapweed to 35mm
agrimony to 40mm

Deeper rooting species are good to improve the nutritional value of the hay. The hay is better for the animals and (apparently) tastes better

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Reversion of pasture & arable land to British NVC community MG5

- The seed is **dried and cleaned** with a 10mm x 10mm mesh sieve
- It is stored in the dry until required in the autumn
- **no storage is best**
- It is acceptable to spread wet hay including seeds with a muck spreader in the autumn

Reversion of pasture & arable land to British NVC community MG5

- The preparation of the soil is very important. Some plants (docks, nettles & creeping thistle) must be **eliminated** before work starts because they will return form seeds or perennating organs. This may take four sprayings with glyphosate over a year and several fallow years due to their persistent seeds. These plants rarely occur in former arable land.

- There was not a big **seed bank in the soil** of Palmer's Leys but this can be a problem, particularly coarse grasses. If this is the case then the seed bed is prepared and each wave of germination is sprayed off until the number of seedlings is low.

Reversion of pasture & arable land to British NVC community MG5

- The sward was sprayed with **glyphosate** in summer 2008.
- The land was **shallow ploughed** so as not to bring up a nutrients of deeply buried seeds

Reversion of pasture & arable land to British NVC community MG5

- The **seedbed** was created using a chain harrow. A second, half-strength spray can be given if there is a flush of seedlings from the seed bed

- Third 1 was sown in October 2008 at least 2 weeks after harrowing. **Autumn sowing** is always preferable as the soil will be warmer than in the spring

Reversion of pasture & arable land to British NVC community MG5

- The germination was very good
- **Monitoring** began in April 2009 using the new vegetative key to the British Flora

Paul Wilkinson surveying in April 2009

- Third 1 (sown October 2008) compared to Third 2 (scheduled for sowing in October 2009)

- Top right picture May 5th 2009. Bottom left picture June 16th 2009

- **Diversity of the new sward and difference from what was there before is clearly visible**

- Seedlings of cowslip now visible (below left). The presence of cowslips and lady's bedstraw is a very good sign

16th June 2009 - In **year 1** the new sward should be **cut back to 150mm** to allow light to penetrate to the soil surface

In **year 2** some of the sward should be **cut back to 150mm** in May to stimulate later flowering for **nectar production**. (picture taken in August)

9th November 2009. Third 2 ready for sowing but the soil conditions were too wet for the machinery to get on the soil.

15th August 2010. The Third closest is yet to be sown. The middle third was sown in spring 2010 & not autumn 2009 as planned.

Top picture: 15th August 2010. The Third closest is yet to be sown. The middle third was sown in spring 2010 & not autumn 2009 as planned. The middle Third (**Third 2 is looking very thin due to poor germination in the following spring sowing**.)

Lower picture: 29th June 2011. The Third closest was sown as planned in autumn 2010 as planned. The **middle third** that was sown in spring 2010 & not autumn 2009 as planned has "**caught up**" the furthest Third that was sown in autumn 2008.

Top picture: 16th February 2011.
Third 3 sown in autumn 2010 as planned is on the left. The ditch between the two Thirds drains into the pond

Lower picture: 29th June 2011.
These two pictures were taken 14 weeks apart. Third 2 is now very close to Third 1 (out of shot) despite the spring sowing.

2.1.2011

29.5.2011

12.8.2011

Third 3 (sown autumn 2010) on left / Third 2 (sown Spring 2010) on the right

Sheep & cattle graze differently and should be used in conjunction. The Castlemilk Moorit sheep are a rare breed of sheep. The cows are Aberdeen angus. Both are borrowed from Rycote Estate near Thame

Reversion of pasture & arable land to British NVC community MG5

- This reversion has only been possible because the Friends of Oxford Botanic Garden & Harcourt Arboretum provided the **money** to make the initial purchase and subsequent work has been supported by Natural England

Reversion of pasture & arable land to British NVC community MG5

Berkshire
Buckinghamshire
Oxfordshire

- A similar reversion is taking place at **Chimney Meadows** in west Oxfordhsire

- The site is managed by the BBOWT and is a National Nature Reserve

Reversion of pasture & arable land to British NVC community MG5

Berkshire
Buckinghamshire
Oxfordshire

- The new round of **Environmental Stewardship** includes payments of educational visits and activities.

- Hay meadow restorations & reversions have been very successful, perhaps because they always have **a managed habitat**.

Reversion to prairie in USA

- This type of reversion is happening in many places
- boeufcreeknature.com/index.php gives details of a project in Missouri

The rise of Restoration Ecology

(Science (2009) **325** p555 onwards

- Restoration ecology is a growing discipline
- Well-done restoration **consistently enhances biodiversity & ecosystem services**
- It is unlikely to lead to the full recovery of the biodiversity & ecosystem services of undisturbed systems
- There is a **struggle** to balance ecosystem complexity & economic reality

Restoration Ecology **in China**

(Science (2009) **325** p556

- **Economic reasons** in southern China forests are being replaced with eucalyptus, rubber, & oil palms. Clearance of forest has been blamed for losses due to ice storms in 2008

- An **alternative** being tried is to plant *Cunninghamia lanceolata* (Chinese fir) with 20 hardwood timber species.

- There is a mixture of pioneer, through mid-, to terminal-succession trees **species with different ecological roles** including soil formation to providing food for birds. The soil is richer & better at holding water than plantations & are more resilient to pests & diseases

- **Selective logging** of the trees is more expensive than clear felling plantations but there is a premium price for these hardwoods.

- The result is "**a healthy forest ecosystem that is a reasonable facsimile of potential natural vegetation**"

Restoration Ecology **in South Africa**

(Science (2009) **325** p562

Patron in Chief:
Nelson Mandela

- **Working for Water** has more than 300 projects, costing $100M *per annum*, employing 29,000 people, aimed at controlling non-native invasive species.

- Currently **non-native species** take 7% of rainfall and this will rise to 20% if unchecked.

- In the 15 years WfW has cleared 1Mha such as pompom weed (below left)

- 75 imported insect spp have been used to control 45 invasives

Basket-weaving aliens. Villagers earn income from cleared invasives, such as using the bark of *Acacia* for baskets.

Restoration Ecology **in South Africa**

(Science (2009) **325** p562)

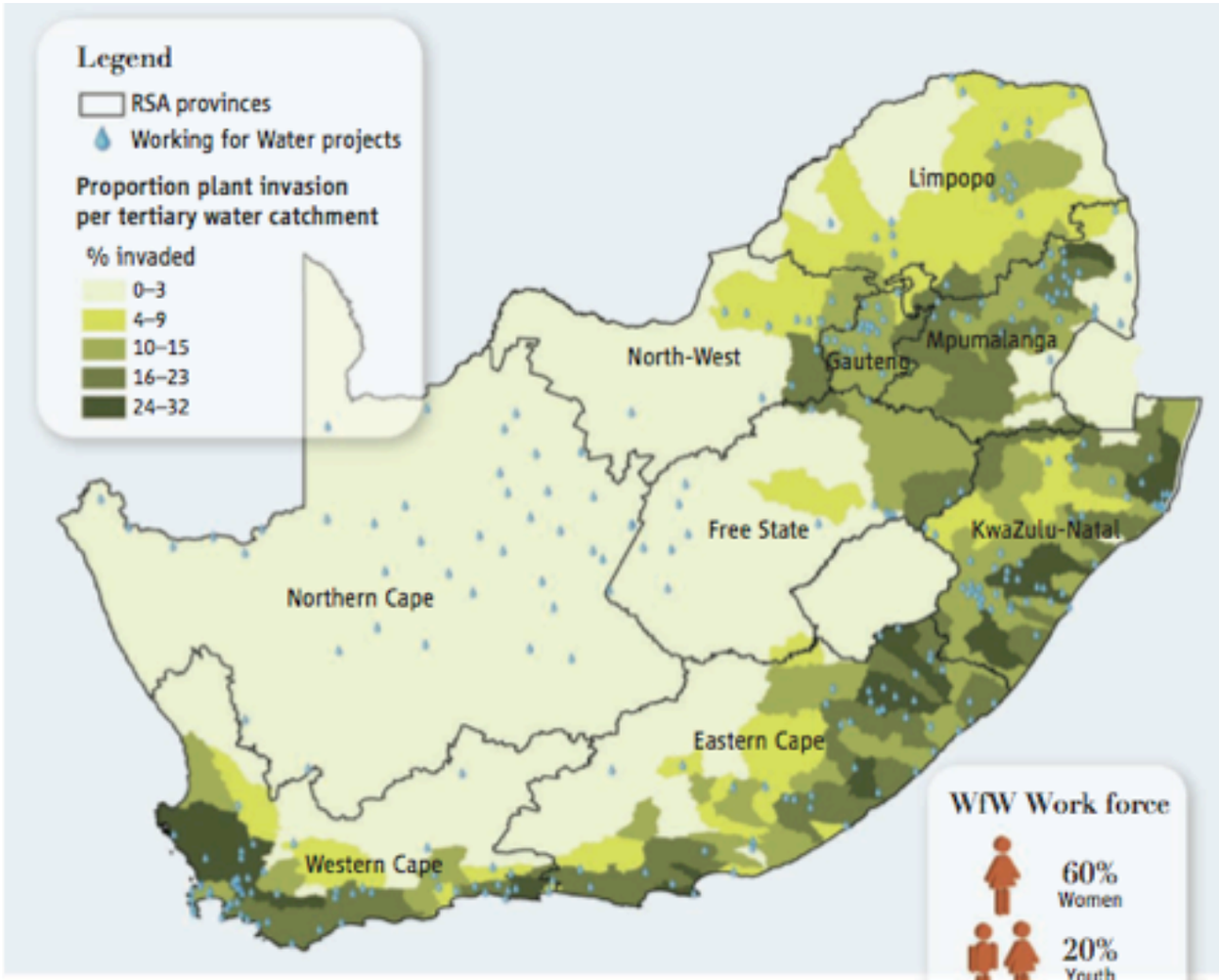
Patron in Chief:
Nelson Mandela

- 10Mha have been invaded & the plants have consumed 3.3Bm^3 water *per annum*

- **Control is cost effective compared to alternative water supply schemes**

- Restoration depends on the landscape, climate, the invasive species & the native seed bank. Re-seeding can be required.

- Ceres Stream damselfly & Cape Bluet dragonflies have been **taken off the extinct list** following invasive clearance & pond restoration



Battle lines drawn. Invasive species have dug in along South Africa's coast and in its northeastern interior; WfW has enlisted a diverse demographic profile to fight the scourge (*inset*).

Restoration Ecology
in Indonesia (Science (2010) **329** p1279)

- With an outbreak of **democracy** in Indonesia NGOs were able to work with the Ministry of Forestry to create Burung Indonesia.
- Restoring 98,000 ha of heavily logged forest
- Goal is to create **sustainable livelihoods** for local communities
- Planting 5 million trees has begun
- Sumatran tiger with cubs have been seen

Conservation and discovery. Indonesia is trying different approaches to protect and preserve natural habitat in the Heart of Borneo, Harapan Rainforest, and Foja Mountains.

Restoration Ecology
in Indonesia (Science (2010) **329** p1298)

- This & other projects are showing that **success** depends on:
- **maintaining** the managed habitat,
- **large** habitats,
- **connected** rather than isolated,
- a **hospitable** matrix,
- **local community** involvement,
- **sustainable**, commercial extraction

Fig. 1. Community tree nursery in Harapan Forest, lowland Sumatra, Indonesia, where an innovative 2007 law enabled management of logging concessions for ecosystem restoration rather than timber extraction. Harapan's is the first such license, and the concession now covers nearly 100,000 ha of biodiversity-rich habitat (**inset**) with restoration being carried out under a joint project of Burung Indonesia, the Royal Society for the Protection of Birds (UK), and BirdLife International. The Indonesian government is committed to expanding the area licensed for forest restoration to 2 million ha by 2020. [Photo: Harapan Rainforest Initiative/M. Lambertini]

Plant Species Conservation in Botanic Gardens & Arboreta

- Trends in Plant Science **2009** vol 14, No.11 special edition on plant conservation

- This is a very good summary of the ways in which **botanic gardens and arboreta** can contribute to plant species conservation.

- Topics include strategies, ecosystem management, conservation genetics, conservation economics, red lists, information technology, orchid conservation, conservation & climate change

- You should read this.

Next ...
There is no technical obstacle to the conservation of every plant species