

## A decade of habitat restoration for early successional chalk downland butterflies.

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### Ecological Engineering

In 2007 I started the first of what was to be many explorations into the restoration of habitats for early successional butterfly species associated with chalk grassland. This work was initially based on the suggestions made by Morris *et al.*<sup>(1)</sup> who described an ecological engineering approach to microclimatic manipulation at ground level, through medium scale (10's to 100's metres) modification of landscape topography. It was suggested that this could create a range of environmental resources that would satisfy the niche requirements for the different life histories of our rare downland butterflies (see **Plate 1**).



### Chalk dust is biodiversity gold dust

The application of these methods at Dorothy Stringer School, through the creation of the first experimental reserve - the Liz Williams butterfly haven<sup>(2)</sup> demonstrated that the low nutrient concentrations, the relatively high pH of chalk, its exceptional drainage capacity, plus varying aspects, provided suitable growing conditions for a wide range of local wildflower species. Many being specifically adapted to poor nutrient levels and this is especially true of Fabaceae (formally Leguminosae) species such as; Kidney Vetch *Anthyllis vulneraria*, Horseshoe Vetch *Hippocrepis comosa* and Bird's Foot Trefoil *Lotus corniculatus*. These plants are able to fix atmospheric nitrogen, consequently growing tissues relatively rich in amino acids.

**Plate 1.** Early successional downland butterfly species: Adonis Blue *Polyommatus bellargus*, Brown Argus *Plebeius agestis*, Small Copper *Lycaena phlaeas*, Green Hairstreak *Callophrys rubi*, Small Blue *Cupido minimus*, Chalkhill Blue *Polyommatus coridon*.

It is therefore of no surprise that these leguminous species tends to be the host plants on downland, for many of our rarest and most beautiful butterflies, such as the Adonis *P. bellargus*, Chalk Hill *P. coridon* & Small Blues *C. minimus*.

The low nutrient concentrations of the chalk also helped to reduce dominance in these artificially created plant communities and so after seeding with the appropriate seed mix and

planting with wildflower plugs, these habitats quickly imitated the conditions found in the ancient/established chalk grassland of the South Downs. However, it should be pointed out that no attempt was made to replicate any of those plant species assemblages described in the National Vegetation Classification<sup>(3)</sup> as semi-natural calcicolous grasslands found in the south-east lowlands of England. Rather these plant communities created surrogate habitats whose main purpose was to cater for local invertebrate faunas, of which the most notable group would comprise the butterflies.

Although this work has always been promoted as habitat restoration for butterflies, the simple fact remains that this ecosystem approach inevitably raised biodiversity for many groups of organisms. Never the less, since its creation in 2007, the Liz Williams butterfly haven has attracted 28 butterfly species to the site (see **Table 1**) representing 76% of the Brighton & Hove butterfly fauna. More than half of these species have been observed breeding (15) on the site, a success that has been widely reported<sup>(4 & 5)</sup>. To date 37 species of butterfly has been recorded as breeding within the city of Brighton & Hove.

**Table 1. Butterfly species seen at the Liz Williams Butterfly Haven, initial sighting and status.**

Number	Species	Initial sighting	Status
1	Essex Skipper ( <i>Thymelicus lineola</i> )	2007	Breeding observed
2	Small Skipper ( <i>Thymelicus sylvestris</i> )	2011	Breeding observed
3	Large Skipper ( <i>Ochlodes sylvanus</i> )	2011	Breeding observed
4	Orange tip ( <i>Anthocharis cardamines</i> )	2007	Occasional visitor
5	Large White ( <i>Pieris brassicae</i> )	2007	Frequent visitor
6	Small White ( <i>Pieris rapae</i> )	2007	Frequent visitor
7	Green Veined White ( <i>Pieris napi</i> )	2007	Occasional visitor
8	Clouded Yellow ( <i>Colias croceus</i> )	2007	Occasional visitor
9	Brimstone ( <i>Gonepteryx rhamni</i> )	2008	Occasional visitor
10	Wall Brown ( <i>Lasiommata megera</i> )	2013	Occasional visitor
11	Speckled Wood ( <i>Pararge aegeria</i> )	2007	Occasional visitor
12	Meadow Brown ( <i>Maniola jurtina</i> )	2007	Breeding observed
13	Gatekeeper ( <i>Pyronia tithonus</i> )	2009	Breeding observed
14	Marbled White ( <i>Melanargis galathea</i> )	2010	Occasional visitor
15	Red Admiral ( <i>Vanessa atalanta</i> )	2007	Occasional visitor
16	Painted Lady ( <i>Vanessa cardui</i> )	2007	Breeding observed
17	Peacock ( <i>Inachis io</i> )	2007	Breeding observed
18	Small Tortoiseshell ( <i>Aglais urticae</i> )	2007	Breeding observed
19	Comma ( <i>Polygonia c-album</i> )	2009	Occasional visitor
20	Small Copper ( <i>Lycaena phlaeas</i> )	2007	Breeding observed
21	Green Hairstreak ( <i>Callophrys rubi</i> )	2010	Breeding observed
22	White-letter Hairstreak ( <i>Satyrrium w-album</i> )	2011	Occasional visitor
23	Small Blue ( <i>Cupido minimus</i> )	2009	Breeding observed
24	Holly Blue ( <i>Celastrina argiolus</i> )	2007	Breeding observed
25	Brown Argus ( <i>Aricia agestis</i> )	2009	Breeding observed
26	Common Blue ( <i>Polyommatus icarus</i> )	2007	Breeding observed
27	Adonis Blue ( <i>Polyommatus bellargus</i> )	2010	Breeding observed
28	Chalk Hill Blue ( <i>Polyommatus coridon</i> )	2010	Occasional visitor

### **Sward Structure and soil fertility**

As the Liz Williams butterfly haven developed there was a marked change in the grassland sward structure of the reserve, from one that was initially dominated by wildflowers and fine grasses i.e. *Festuca* species, to a ranker sward that over two or three years became increasingly dominated by coarse grasses. This produced lush and denser vegetation, composed of much taller plants and crucially the species diversity reduced. This process led to a loss of bare ground and areas of sparse vegetation became uncommon, making it difficult for butterflies like the Adonis Blue to find the optimal microclimatic conditions for the development of their immature stages.

It seems likely that high soil nutrient levels caused this phenomenon. The nitrogen fixing vetches, must contribute to increasing soil fertility but it may also have been caused by the substrate mix, composed of subsoil and the chalk bedrock (Seaford formation). With this in mind, the next butterfly haven created during the winter of 2011 to 2012, within the grounds of Varndean College, was one composed entirely of chalk. This was an attempt to create a habitat with reduced soil nutrient conditions and thus avoid rapid floristic successional changes.

Furthermore, the Liz Williams butterfly haven, had been originally sown with an Emorsgate seed mix for Chalk and Limestone soils - EM6, at a rate of 22 g/m<sup>2</sup>, of which 80% of the mix was different grass species. Consequently, for every metre squared sown, only 4.4g were wildflower seeds; whilst 17.6g were grass seed, which the wildflowers had to compete with, for light, water, soil nutrients and other resources. In contrast the Varndean Haven had only a gentle dusting of a locally sourced wildflower seed mix, supplied by John Gapper from the Wildflower Propagation Unit at Stanmer Nurseries, Brighton<sup>(6)</sup> (see **Plate 2**). Additionally, in December 2015, a few hundred wildflower plugs were planted into this butterfly haven.

Subsequent observations suggest that sites constructed using these methods will be able to make an extended contribution to nature conservation, perhaps in the order of 25 to 30 years. Indeed it was not until 25 July 2017 – five years after its creation, that the first colonists of the Small Blue butterflies were observed on the reserve. This is now a controversial site for there are plans to develop it for expensive urban housing (see: <https://www.greenvarndean.com>).



**Plate 2.** Pupils, students and staff from Balfour Primary, Varndean and Dorothy Stringer School, Varndean College and Downs View Link College, helping John Gapper (Stanmer Nurseries) seed the second Butterfly Haven on the Surrenden Campus, March 2012.

#### **Aspect, resilience and climate change**

Unlike the Liz Williams butterfly haven, which was constructed with linear tiers, the topography of this second haven was fashioned into curvi-linear banks. This approach exposed the substrate to multiple aspects and thus increased variation in light intensity,



temperature and humidity at ground level. It also afforded disparities in air movements around the variedly shaped mounds. This design methodology, later incorporated into all new butterfly havens, was intended to produce a wider range of microhabitats, which would thus build resilience into the new butterfly havens, so that they would be better able to buffer the effects of broader scale climate change<sup>(7)</sup>.

### Meta-population dynamics and landscape-scale conservation

The meta-population concept can be viewed as a 'population of populations', occupying islands of habitat within a 'sea' of unsuitable habitat<sup>(8)</sup>. This definition clearly described the potential for multiple - connected habitats within the city of Brighton & Hove. So, I spoke with both the Brighton & Hove Planning and Parks departments, suggesting an approach for the creation of a series of ecologically distinct sites, separated by a successional chronology (sites constructed at different times) specifically designed to maximise biodiversity gain, by dealing with butterfly conservation on a landscape scale. This ethos had two main objectives: firstly, to create sites with maximal habitat quality and secondly, improve connectivity both within and between sites, thus improving the rate of colonization. I suggested that quality and connectivity could be ensured with the construction of chalk bunds that removed barriers to dispersal because they would be planted with wildflowers that were both nectar sources and host plants for pollinators, as well as provide the appropriate microclimatic conditions for these thermally constrained insects.

### Marsh Christian Awards

To date, the Parks department has produced approximately 30 butterfly havens within the city of Brighton & Hove<sup>(9)</sup>. A baseline botanical survey was undertaken in March 2014 at eight sites adjacent to newly constructed butterfly havens, to enable comparisons of the original

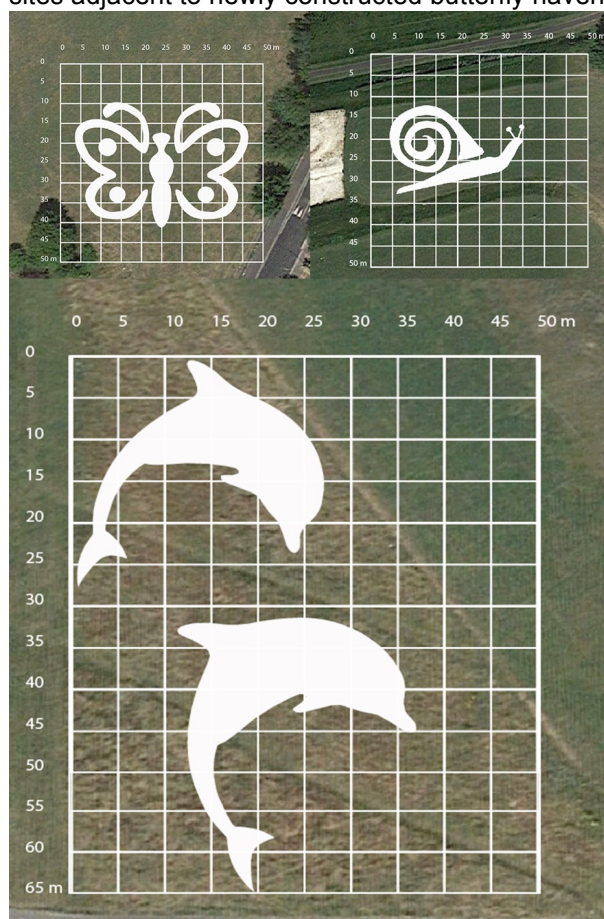
plant communities, with those that develop at a later date<sup>(10)</sup>. Some of these sites have produced exceptional conditions for butterflies, for example the Roedean butterfly haven (TQ 34696 03216) has generated 100's of Small Blues.

I was delighted to nominate the city of Brighton & Hove for the Marsh Christian Award for major contributions to the conservation of Lepidoptera and they were awarded this accolade in 2014<sup>(11)</sup>.

### Planning applications & mitigation

In 2014 Dorothy Stringer School made a planning application for the construction of an artificial football (turf) pitch (ATP) and I was asked to write a plan for the habitat restoration that would mitigate for this development<sup>(12&13)</sup>. This project was to work with all the educational institutions on the Surrenden Campus, to create new butterfly havens that would give the pupils/students at each institution the opportunity to have direct contact with local nature.

Given that chalk is a high contrast material and that we intended to work with it on a landscape scale, it seemed



**Plate 3.** The geoglyphs designs for the Balfour School Butterfly (top left) the Varndean College Snail (top right) and the Varndean School Dolphins (bottom) - as well as their marking grids (units in metres).

sensible to further enhance the cultural dynamic of this habitat restoration project by creating butterfly havens, which were also geoglyphs. For millennia human beings have been drawing large-scale images on the landscape. The most famous geoglyphs are the Nazca Lines in Peru but examples are also found nearer to home, in the form of the Long Man of Wilmington and the Cuckmere White Horse, both of which hold strong cultural resonances for local people. The design of new geoglyphs also presented the possibility to incorporate multiple aspects and varied topographies. With this in mind, work began in partnership with the other educational institutions on the Surrenden campus, to run competitions amongst their own pupil/student populations, to find designs for geoglyphs that best suited their interests. The concept was promoted as "painting on the landscape" with images that would be visible from space or if not from space Google Earth, the next time aerial photographs were updated.

If social fashions change, economics never do, by the time the ATP was constructed funding became restricted and so the geoglyphs were considered too prohibitively expensive to produce but like Morris' original work<sup>(1)</sup>, they are included here because others might utilise this concept in the future (see **Plate 3**). Never the less, the Liz Williams Butterfly haven was re-landscaped and three other new butterfly havens were created on the Surrenden campus; one at Balfour School (see **Plate 4**), another at Varndean School and the third was constructed from the bare chalk exposed on the western facing side of the new ATP. This last site was colonised by the Small Blue butterfly on 17<sup>th</sup> May 2017, two years after the site's construction. This indicated that the three sites on the Surrenden campus supporting this butterfly, were now forming a mosaic of habitats, working within a meta-population dynamic framework.



**Plate 4.** Pupils from Balfour Primary School help plant cowslips in their own butterfly haven, 6<sup>th</sup> May 2016.

### **Green Hay**

A primary emphasis in the constructions of these reserves has been to use plants of local provenance, which enables us to work with stock that has evolved to best fit in with and cope with the local ecology. One means by which this can be done is to use the green hay methodology and others have done this with considerable success<sup>(14)</sup>. This technique uses sweep nets to collect seed from the donor sites but I have found this method coincidentally harvests a range of invertebrate species, associated with established chalk grassland sites. With repeated visits to the donor sites - to collect different seeds during different parts of the spring and summer seasons - these animals are repeatedly collected and eventually the recipient sites may be able to support their establishment (see **Plate 4**).





**Plate 4.** A handful of green hay, collected from Castle Hill NNR in May 2011, in which a significant proportion of the biota is represented by invertebrates.

We made a tacit agreement with Malcolm Emery of Natural England (Sussex and Kent areas) the then reserves manager for Castle Hill NNR, to collect seed from this site to provide a source of Green Hay and a biodiversity education experience for pupils/students participating in this project. Experiments with both the annual Yellow Rattle *Rhinanthus minor* and Rough Hawkbit *Leontodon hispidus* have, in particular, shown positive results.

#### **Targeting particular butterfly species with specific wildflower seed mixes.**

If ecological engineering can manipulate microclimate at ground level and provide preferred host plants as well as nectar sources, it begs the question; what other environmental parameters might be varied that would favor particular butterfly species? Numerous researchers have found that vegetation structure influences the composition of invertebrate communities<sup>(15)</sup>.

Two early successional butterfly species, the Adonis Blue *P. bellargus* and the Chalkhill Blue *P. coridon* have varying degrees of tolerance towards vegetation height - an aspect of vegetation structure. This is because the Adonis Blue is a bivoltine species, i.e it has two generations per year, whilst in contrast the Chalkhill Blue is a univoltine species, with only one generation per year. In the spring the caterpillars of the Adonis Blue can only survive on it's host plant if the host plant grows no higher than 1 to 3 cm tall<sup>(16)</sup>. This is because if the host plant is allowed to grow any taller than 3 cm it reduces exposure of the soil surface to short wave radiation (sunlight) from the sun, which the soil re-emits as long wave radiation (heat energy). This process creates a microclimate that enables the overwintering Adonis Blue caterpillar to develop earlier than the Chalkhill blue caterpillars, which hatch later. Thus, the short vegetation structure allows the Adonis Blue butterfly to be on the wing about a month and half earlier than the Chalkhill Blue butterfly, allowing it to have a second generation before the end of the breeding season. Later in the season both species, show a preference for tall vegetation, which is at that time of year is no longer thermally restrictive (too cold) and is a location in which they roost as adults at night<sup>(17, 18)</sup>.

Given that the average height of different wildflower species can vary considerably from species to species, it is possible to select wildflower species with low average heights, to produce a seed mix which would create a shorter sward. Of course the opposite is also true and a mix of seeds of wildflowers species with a taller average height could be formulated (see **Table 2**).

Species #	Species	Height (cm) *	Mean Height (cm)
1	Wild Thyme ( <i>Thymus polytrichus</i> )	5	5
3	Milkwort ( <i>Polygala vulgaris</i> )	5 to 10	7.5
4	Stemless Thistle ( <i>Cirsium acaulon</i> )	5 to 10	7.5
2	Tormentil ( <i>Potentilla erecta</i> )	10	10
5	Hairy Violet ( <i>Viola hirta</i> )	5 to 15	10
6	Primrose ( <i>Primula vulgaris</i> )	5 to 15	10
7	Cowslip ( <i>Primula veris</i> )	5 to 15	10
8	Common Dog Violet ( <i>Viola riviniana</i> )	2 to 20	11
9	Horseshoe Vetch ( <i>Hippocrepis comosa</i> )	5 to 20	12.5
10	Wild Strawberry ( <i>Fragaria vesca</i> )	5 to 30	12.5
11	Self-heal ( <i>Prunella vulgaris</i> )	10 to 20	15
12	Rock-rose ( <i>Helianthemum nummularium</i> )	5 to 30	17.5
13	Felwort ( <i>Gentianella amarella</i> )	5 to 30	17.5
14	Mouse-ear Hawkweed ( <i>Pilosella officinarum</i> )	5 to 30	17.5
15	Common Bird's-foot Trefoil ( <i>Lotus corniculatus</i> )	10 to 30	20
16	Kidney Vetch ( <i>Anthyllis vulneraria</i> )	10 to 30	20
17	Red Clover ( <i>Trifolium pratense</i> )	10 to 40	25
18	Wild Basil ( <i>Clinopodium vulgare</i> )	10 to 40	25
19	Rough Hawkbit ( <i>Leontodon hispidus</i> )	10 to 40	25
20	Autumn Hawkbit ( <i>Scorzoneroides autumnalis</i> )	10 to 40	25
21	Field Scabious ( <i>Knautia arvensis</i> )	15 to 50	32.5
22	Betony ( <i>Betonica officinalis</i> )	10 to 60	35
23	Carlina Thistle ( <i>Carlina vulgaris</i> )	10 to 60	35
24	Lady's Bedstraw ( <i>Galium verum</i> )	15 to 60	37.5
25	Devil's-bit Scabious ( <i>Succisa pratensis</i> )	15 to 60	37.5
26	Common Knapweed ( <i>Centaurea nigra</i> )	15 to 60	37.5
27	Meadow Buttercup ( <i>Ranunculus acris</i> )	20 to 60	40
28	Small Scabious ( <i>Knautia columbaria</i> )	15 to 70	42.5
29	Common Sorrel ( <i>Rumex acetosa</i> )	30 to 80	55
30	Wild Marjoram ( <i>Origanum vulgare</i> )	30 to 60	55
31	Greater Knapweed (Greater Knapweed)	30 to 80	55
32	Sheep's Fescue grass ( <i>Festuca ovina</i> )	10 to 30	20

\* Source: Rose, F. (1991) The Wild Flower Key, British Isles - N. W. Europe, Frederick Warne.

**Table 2.** The host plant and nectar source preferences of the butterflies associated with chalk grassland habitats, sorted by plant height to make two different swards, the short sward (yellow) and tall sward (green). Both swards would also have 2% *Festuca ovina* added to their mixes (red).

In 2014, an agreement was made with the Native Seed Hub, part of Kew's Millennium Seed bank at Wakehurst, to produce this seed mix. Three years later the first batch was sown on a yet again re-landscaped "Liz Williams butterfly haven" and this was filmed and broadcast by BBC South East on 18<sup>th</sup> December 2017. We wait with excitement to see the consequences of this work.

### Seed sowing patterns and flints

Recent observational evidence from sites that maintain good local colonies of Adonis Blue and Dingy Skipper *Erynnis tages* indicates that good quality habitat may best be created by sowing seeds in a clustered distribution, leaving areas of chalk substrate bare. This is probably because it allows the ground to maintain high temperatures conducive with the development of the early stages of these insects. Recent work on the Grizzled Skipper *Pyrgus malvae*<sup>(19)</sup> and the Dingy Skipper<sup>(20)</sup> have suggested that using aggregate strategically placed around the host plant can simulate these effects. This approach has been successfully used by Slater<sup>(21)</sup> who built a dry stonewall using this concept.

In chalk we found a considerable amount of flint was left in situ after the plant machinery had done its work fashioning a haven and this could present problems for brush cutters, as the vegetation on the site developed. One solution was to imbed the flint into the chalk banks, around the perimeter of the existing host plants, thus minimising the potential for conflict between the blades of the brush cutters and the flints, as well as enabling the flints to act as solar regulators, which provide critical microclimatic conditions for larval development.





**Plate 5.** *Birdsfoot trefoil surrounded by stone (after Hopkinson - date unknown).*

### Summary

It had been thought that the Liz Williams butterfly haven was the first of its kind but a school teacher in Hertfordshire, a Mr Jack Doyle, experimented in the 1960's and 70's introducing wildflower plugs and seed mixes into chalk mounds, created within his school's grounds<sup>(22)</sup>. Not only were these projects extremely successful, they also lasted for a considerable period of time...up to 25 years. More importantly, Doyle refined his management for these habitats and crucially it appears that cuts/grazing in September should be followed by more cutting/ grazing in late May and then early June. This stringent approach to management maintained his wildflower communities, significantly extending the "life-span" of these artificial communities.

However, what this does underscore is that although a decade has passed during which time we have been experimenting with the creation of surrogate habitat for early successional chalk grassland butterflies within the Brighton & Lewes Downs Biosphere, I suspect that we have only just begun to "scratch" the surface of our understanding about what makes good new habitat for these threatened butterfly species. Finding Jack Doyle's work was a happy stroke of serendipity, but it would have been all too easy for any record of his work, to have been lost. In creating this document I have tried to bring together all the references which to date, relate to this work, as well as indicate its broader significance<sup>(23)</sup>. I have also hoped to celebrate our successes by increasing our skills base whilst creating even more butterfly habitat, which seems like a particularly relevant thing to do in Butterfly Conservation's 50 birthday year.

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