Nature rising from the rubble

Gravel and recycled aggregate gardens in Essex and London

RHS Bursary Study Tour - 13 October to 16 October 2021



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Contents

Introduction

Overview

As a kid I loved reading Asterix and Obelix. At the end of one of my favourite stories, 'The Mansions of the Gods', the heroes return the demolished mansion back to woodland by throwing magical acorns onto the rubble. If only it could be that simple! For a while I've been interested in how we can do things differently when creating and looking after the landscapes we live in. Standard specifications and preconceived ideas can sometimes hold us back. My study tour sought to understand different horticultural approaches, alternatives to using topsoil, creative approaches to using recycled demolition materials and building places which inherently support wildlife - finding the right magic acorn for the right rubble.

One approach is to grow plants in gravel and recycled mineral aggregates, as an alternative to topsoil, which creates schemes which don't need irrigation or as much maintenance for tasks like weeding. This approach has been used very successfully for ornamental herbaceous planting schemes (by seed sowing or planting - Professor James Hitchmough and Professor Nigel Dunnett, Beth Chatto, Cassian Schmidt and others in Germany, Olivier Filippi in France, Peter Korn in Sweden, and finally Ben O'Brien in Canada) and for wildflower planting schemes (mainly seeded - John Little in Essex and Richard Scott, National Wildflower Centre).

Phase 2 of Green to Grey project in Sheffield city centre; planting designed by Professor Nigel Dunnett and Zac Tudor. The herbaceous perennials are planted into deep mineral mulch (100mm depth of 20mm crushed sandstone quarry waste). (Photograph taken in Aug 2021).

A deep mineral mulch creates a sterile aggregate-based substrate which has the benefit of being a permanent surface which is weed seed free. In addition, using recycled aggregates (such as crushed concrete, brick, or ceramic waste) is very sustainable (Little, 2021). By selecting the right plants for the environment, the planting can also be long lived and does not require irrigation. The stressful conditions of the low fertile environment provide the potential for a diverse mosaic of plant communities which can be very beneficial for wildlife. These factors make this planting approach considerably easier to maintain and manage long term. There seems to me to be enormous scope for this approach to be used at all scales to create climate change adaptable planting schemes for people and wildlife.

There is literature for each individual's approach, but there is a lot less written on the innovative use of recycled materials (although John Little's social media platform and regular talks go some way to make up for this). Equally there is less which takes an overview of all the different methods. I partly wanted to undertake my tour as a project to help me to fill that gap. Whilst I had read around and been to several webinar presentations on these approaches, I had not had the opportunity to see them first-hand (apart from wildflower meadows created in Liverpool), or to discuss in detail the positive and negative issues which arise in their creation. There is a vast array of different aggregate substrates and associated depths which can be used. Ideally, I would like to be able to experiment in my own garden – but it's not that big! The next best thing was to visit some exemplar projects and, where possible, talk with their creators. I selected five projects in the southeast of England to visit. Three of these were gravel gardens – two long established ones in Essex (Beth Chatto's Gravel Garden and RHS Hyde Hall Dry Garden) and James Hitchmough's more recent Grasslands Garden at the Horniman Museum in London. Visiting Beth Chatto's garden was timed so I could attend a workshop they were running on their Gravel Garden. It is interesting to explore why each of these successful gardens works. As I am interested in exploring waste aggregates, I complemented this with a visit to John Little's own experimental 'brownfield' garden of many years standing at Hilldrop in Essex; and the car park John has created in 2021 for the Essex Wildlife Trust, Langdon Nature Discovery Park. Supporting my trip, I continued my desk top studies (literature and webinars) and communication with experts in the field.

Map of London and Essex showing location of gardens visited

In addition to understanding growing plants in mineral aggregates, I was also keen to gain insight into John Little's approach of creating wildlife habitat within structure (such as planters and bin shelters). John has been inspired by places like Canvey Wick in Essex, a brownfield site, which is now designated as an SSSI and described as "a little brownfield rainforest" by Natural England.

Aims and objectives

- Visit gardens which use gravel and mineral aggregate mulches to further understand their creation and management from preparation, planting, establishment to long term management.
- Compare the different horticultural approaches to understand why each garden visited is successful.
- Gain greater understanding of the potential of recycled construction waste as a material to use in horticultural.
- Understand the potential of structural elements to provide habitats for wildlife.
- Knowledge sharing my study tour, including exploring publishing part of my report, as suggested by the RHS committee on awarding my Bursary.

Itinerary summary

- Wednesday 13 October – travel from Liverpool to Essex – visit RHS Hyde Hall Dry Garden (meet Ian Bull and Susie Curtis)
- Thursday 14 October – visit Beth Chatto's Gravel Garden – attend course 'The Autumn Gravel Garden' (led by David Ward); also visit and study rest of garden
- Friday 15 October – visit John Little's garden at Hilldrop, Horndon-on-the-Hill, Essex and car park at Langdon Nature Discovery Park, Basildon Essex Wildlife Trust (meet John Little, Sophie Cook and Benny Hawksbee)
- Saturday 16 October – visit Horniman Museum Grasslands Garden (with a post-trip communication with Wes Shaw) and then return home to Liverpool

Author

For over two decades, I have been a chartered landscape architect, working mainly in the north west of England. Initially, I worked in a large practice on substantial commercial projects. For the last eight years, I have run my own practice. At the turn of the century, I trained at Sheffield University's Landscape Department. Prior to retraining as a landscape architect, I studied mathematics and then carried out postgraduate research in mathematical modelling of volcanic eruptions.

As a practising landscape architect, I often feel it is easy for me to become detached from the practical physical aspects of the environments I am creating. Yet I believe, when designing, it is as important to understand the sense of place, its history and people as it is the ecology / habitat and wildlife of a place.

I leapt at the chance to go on a study tour to get direct experience. Ultimately I hoped this would give me more confidence to specify and work with recycled mineral mulches and build structure which supports wildlife, as well as share the knowledge I have gained. In recent years I have also started volunteering at a newly created nature reserve at Calderstones Park in South Liverpool. The nature reserve is on an existing brownfield site adjacent to the main park. I would like to help the volunteers to take full advantage of the existing waste products on site to create a biodiverse and attractive environment for wildlife and visitors.

RHS Hyde Hall Dry Garden

RHS Hyde Hall Dry Garden, Essex

Day 1 – Wednesday 13 October 2021

I started my study tour at RHS Hyde Hall to see their Dry Garden. Whilst I was there I also looked at the recent Sky Meadow designed by James Hitchmough. I had the pleasure of meeting both Ian Bull, head gardener and horticulturalist Susie Curtis, who is responsible for looking after the Dry Garden. It was useful and interesting to hear the garden's history and its evolution and management. After my trip, I really valued dialogue with Susie on the Dry Garden. She provided helpful insight into its management as well as identifying some of the Dry Garden plants.

Dry Garden

RHS Hyde Hall Dry Garden is well-known. This Mediterranean-style garden was created 20 years ago, expanded in a lower area 8 years ago, and again a year ago to tie into the new buildings. Once the plants are established the garden has no irrigation, showcasing drought tolerant plants suited to the very low rainfall of Essex. Drought tolerant plants, from regions such as around the Mediterranean, typically suit free-draining soils. Consequently the preparation of the native heavy clay soil focused on improving drainage (see key facts). A thin pebble layer is used ornamentally as a top dressing.

Drought tolerant plants have been selected from different geographical regions with similar climatic conditions

Berkheya purpurea native to Africa

Eryngium planum native to central and south eastern Europe and central Asia

Stipa tenuissima native to south-western United States, northern Mexico and Argentina

It was a wonderful garden to explore, with undulating paths weaving in and out of planting beds, making it an immersive experience. The planting is a rich intermix of informally grouped plants. Large Scottish gabbro boulders create structure as do many of the mature Mediterranean shrubs and trees. The planting beds have soft edges to the paths of self-binding gravel, which has a similar colour to the pebble mulch and boulders, creating a cohesive whole.

Gabbro boulders create structure and contrast to the dynamic movement of Stipa tenuissima, shown adjacent to pink flowers of Nerine bowdenii

Autumnal skeleton spikes from Digitalis ferruginea 'Gigantea' intermixed with Gaura lindheimeri; both plants are short lived and self-seed everywhere

Key facts of RHS Hyde Hall Dry Garden

Topography - South facing sloped undulating landform.

Climate – very low rainfall, exposed to SW winds.

Native topsoil – heavy clay; oldest area loamy clay; alkaline.

Site preparation – mix of topsoil to sharp sandy grit 50:50 to a depth of 300mm over subsoil and crushed concrete rubble (to create height).

Mulch / mineral aggregate layer – 20-40mm rounded / flint pebbles to depth 50mm.

Planting – container grown plants (variable pot sized), some plants also self-seed around, usually plant out in March, after planting watered only 3 times during establishment.

Maintenance – ongoing editing; note challenges in text, main ongoing task is weeding. There is main annual cutback in March, with some species cut earlier like irises in July / August.

The native clay soil has created, and continues to create, additional horticultural challenges. Even though the soil is prepared to improve drainage, over time the clay migrates and intermixes, reducing drainage. When areas are replanted / edited more grit is added. In addition, many drought tolerant plants (native and intended) have deep tap roots so weeding / editing can be more difficult especially during periods of drought when the soil dries solid. The shallow pebble mulch allows for self-seeding, the offset is that some unwelcome weeds also set seed – particularly in the lower area which has windborne grass weed seeds from the adjacent fields.

Challenges Shallow decorative gravel layer allows for self-seeding (particularly during 2021 which has been wetter). Many drought tolerant plants and weeds associated with clay soil have deep tap roots which are a challenge to weed out particularly when the clay soil is dried solid. Chunky pebbles also make weeding harder.

Multiple seedlings of Nigella damascene growing in the gravel

Silver veined leaves of Galactites tomentosa self-seeds extensively and has deep tap roots

Acanthus mollis has deep roots which spread via underground roots

The Dry Garden at Hyde Hall changes through the season – it looked excellent even in October but clearly from the plant list provided by Ian and Susie there are seasonal dramas from spring purple *Allium spps.* to orange *Eschscholzia californica* in summer, all of which would be well worth seeing. The garden has many parallels to the younger Gravel Garden at Chanticleers (Roper, 2020), which also has clay native soil and no irrigation after establishment. It is not truly low maintenance - a choice has been made to edit and care for the garden keeping it fresh and balanced, which requires intelligent horticultural commitment from Susie and the garden team.

Permanent structure with evergreen shrubs and conifers Trachycarpus fortunei and Abies spps

Sky Meadow

After exploring the Dry Garden I walked around the recent Sky Meadow created in the last couple of years. It is a direct sown planting scheme on deep (100mm) coarse sand designed by Professor James Hitchmough (Hitchmough, 2017). Ribbons of different seed mixes were designed to wrap around a mature oak tree. Each plant mix is based on a geographic region - Eurasian steppe, North American prairie and the velds of South Africa – to create long seasoned dynamic planting on a large area. Unfortunately during the Covid lockdown, with reduced volunteers and staff, weeds have significantly encroached the planting from grass paths and wind-blown seeds from adjacent scrub planting. It demonstrates that whilst the direct seeded approach, on a deep sand bed, is lower maintenance, it still requires commitment and horticulturally knowledgeable weeding at specific times to remain manageable long term. It also demonstrates, as discussed by James in his book (Hitchmough, 2017), that adjacent vegetation grass and shrubs will always pose a threat of encroaching a planting.

North American Prairie planting

Challenges weeds have encroached the planting via creeping roots and also wind borne seeds from adjacent vegetation

Creeping thistle (Cirsium arvense) and couch grass (Elymus repens)

Goat willow (Salix caprea)

Beth Chatto's Gravel Garden

Beth Chatto's Gravel Garden

Day 2 – Thursday 14 October 2021

My second day was spent at Beth Chatto's garden near Colchester in Essex. In the morning I attended a workshop on the Gravel Garden led by David Ward (Garden Director), and then in the afternoon I spent time looking around the whole garden and resisting temptations in their unusual and excellent nursery.

Beth Chatto's garden and writing is known throughout the horticultural world. During her lifetime Beth Chatto created a garden around her family home which exemplified the 'right plant right place' approach, where plants are chosen because they will suit the growing conditions. Beth's garden has very varied conditions in terms of micro-climates (shady and sunny), moisture (damp and dry) and soils (both clay and sand) to showcase this approach. Throughout my career, her ecological approach to planting design has been very formative for me.

The Gravel Garden was created 30 years ago in an area that was a heavily compacted grass car park (Chatto, 2000). The vision was for it to be an experimental garden which demonstrates drought tolerant planting. Once planted the garden is not irrigated, even during establishment. The layout is a sweeping path, a 'dry river bed' of gravel between a series of organic shaped planting beds. On my visit, it was a delight to walk through the immersive immaculate planting and unusual colours.

Repeating autumn hues from the unusual yellow-oranges in the Bupleurum fruticosum foreground and distant Amelachier x lamarckii

The autumn oranges of the Bupleurum fruticosum echoed in the narrow grass like leaves of the Libertia peregrinans

Workshop

The workshop started with a discussion on ecologically based plant selection, and then a practical demonstration looking at their approach to soil preparation, planting, establishment and mulching. Finally, we walked around the garden. With regard to ecological plant selection, David discussed, and demonstrated with nursery stock, the common characteristics of plants, and their sociability, as associated with specific ecological conditions (soil, fertility, moisture, rainfall, shade level). For example plants suited to drought conditions are often silver / grey with narrow leaves.

I appreciated the practical aspects, particularly in relation to my study tour. Whilst many of the techniques presented were very familiar, I did learn some new approaches and it was invaluable to hear their present day approach. Ground preparation used to start with applying the herbicide glyphosate. Nowadays, rather than using herbicide, weeds are suppressed for a year under light-excluding geotextile membrane covered with a mulch layer of bark chips.

Key facts of Beth Chatto's Gravel Garden

Topography – Flat landform.

Climate – very low rainfall, sheltered by tall Leylandii hedges.

Native topsoil – sedimentary gravel and sand, low fertility.

Site preparation – double dig soil and add organic matter, at a depth of 50-75cm which is forked or rotovated in (preferred choice is mushroom compost). Original garden also used garden compost and bonfire ash. For the gravel garden, a sub-soiler was also used to break up the compacted soil.

Mulch / mineral aggregate layer – shallow layer of 10-12mm grade local shingle / gravel depth at least 25mm; the back of the borders are mulched with straw biannually.

Planting – mixture of sized pots, some plants also self-seed around, usually plant in March / April (see notes in text), plants submerged, top of pot's soil is removed, roots teased and then watered only once immediately after planting.

Maintenance – constant editing and selective weeding and to some degree tidying of planting; main ongoing task is weeding. There is main annual cutback in March / April.

When refreshing or creating a new planting bed, all soil, whether it is clay or sandy, is double dug in the autumn and enriched with mainly mushroom compost. The traditional process of double digging takes quite a commitment. In the Gravel Garden, it makes sense to enrich the very low fertility gravely soil to improve fertility and also to improve water retention properties. We did not touch on how this might affect the soil structure and mycorrhiza. Interestingly, David is experimenting with deep sand beds with no enrichment (see end of this section).

Planting demonstration of Cistus x argenteus 'Peggy Sammons'

Prior to planting, the plants are submerged in water till they are fully saturated. Then the top 25-40mm of soil is rubbed off, and the roots are teased out. The plants are planted with the soil forming a shallow dip / depression and they are flooded with water several times. The dip is smoothed out retaining a 25mm gap between the soil and nursery soil plant level. The gravel mulch is spread around the planting bed bringing the level of the ground back up to the plant nursery level. Finally the plant is pruned back at least a third depending on the species – all tips are nipped.

The practical demonstration highlighted the logic to the planting sequence and how it all fits together. Similar methods are discussed by others (Hitchmough, 2017 and Fillipi, 2019). Removing the top section of soil from the plants removes a source of weed seeds, reducing maintenance burden, and could be used more universally in the landscape industry. It also allows the gravel mulch to run up to the neck of the plant, but not swamp it.

Another useful tip shared was that they plant spring flowering bulbs in pots in the autumn. The bulbs are then set out and planted at the same time as the main planting in spring. This is a really simple and appealing way of having more control over the layout of the bulb design as an integral part of the scheme. If adding into an existing scheme it allows integration with bulbs already there, which can be hard to remember in autumn when planting. David also touched on planting design, how structure plants are placed singly and that Beth's design approach was inspired by 'Ikebana' Japanese flower arranging principles. Finally plants perform better in drought if pruned in spring / early summer (similar to a Chelsea Chop): 'don't use a hosepipe use secateurs'.

Structure plants of different form and texture are used singly to create focal points

Melianthus major

Pennisetum macrourum

Seeing the garden and discussing its care highlighted to me that it is not low maintenance. Whilst the garden is not irrigated, it is constantly very well managed by a horticulturally knowledgeable garden team. It is also worth noting that David said they were not hugely impacted by the loss of volunteers during the recent lockdowns. Many plants are encouraged to seed around, seedlings are then edited when small so the garden is allowed to evolve all the time and yet maintain its fresh original dynamism.

Careful selective weeding of seedlings such as Stipa tenuissima, Verbena bonariensis and Verbascum spps. to allow the scheme to evolve yet retain its fresh dynamic character – weeding Galactites tomentosa (a problem in the heavy clay at RHS Hyde Hall) is less of a problem in the gravelly sand

Trial planting in 2021 on deep 300mm 'as dug' gritty sand (from onsite excavation) on top of the poor gravelly native topsoil

Growing in deep beds of sand

Beth Chatto's progressive experimental legacy continues, including collaboration with John Little. Over the last year they trialled drought tolerant plants in deep beds of 'as dug' sand. The plants selected were particularly drought tolerant – a narrower subset of plants from the Gravel Garden. So far they have only had one plant loss and clearly plan to continue with the experimentation further. This counter balances double digging and compost enriching the soil with shallow gravel mulch. It has parallels both to the work of Peter Korn (Korn, 2013 and Cook, 2018) who grows drought tolerant plants on deep beds of coarse sand and to John Little's work on growing plants in pure mineral aggregates.

A13 Garden John Little's private garden at Horndon-on-the-Hill

Hilldrop, Horndon-on-the-Hill

Day 3 – Friday 15 October 2021 - morning

My penultimate day was spent at the private garden of John Little in Horndon-on-the-Hill and also viewing his recent work at the car park for Langdon Nature Discovery Park.

Over 7 years ago I heard John talk about his responsive approach to local residents in managing the public grounds of Poppy Estate, an area of social housing in Hackney. More recently, I have attended webinars in which he talks about the importance of variety and structure for wildlife in the landscapes, the use of recycled mineral aggregates as a growing media (particularly in new landscapes) and biodiverse green roofs (Little, 2019, 2021 and 2020 and Cuttle, 2021). As well as questioning horticultural assumptions, such as the default for topsoil everywhere, he challenges the systems in place which miss habitat and wildlife opportunities. One example is the A13 road widening, which could have created sand terraces that would have been similar (although not tidal) to the threatened Thames Terraces.

Green roof prototype used as a garden shed

Key facts of John's Brownfield Gardens

Topography - south facing slope.

Climate – very low rainfall, sheltered by surrounding trees.

Native topsoil – fertile heavy clay, alkaline (previously a chicken farm).

Site preparation – experimental garden with a large variety of different approaches. In some areas topsoil is stripped, in some areas a close weave biodegradable geotextile barrier has been used. Organic matter is never added.

Mulch / mineral aggregate layer – deep aggregate layers laid with variable depth from 100mm to over 500mm to create undulations 'topography'. A variety of over 20 mineral substrates have been used from locally sourced as dug sands to crushed recycled materials – see main text and appendix B.

Planting – mainly direct seeding in September or March/April (John uses native and non-native mixes designed for green roofs) but he is also experimenting with drought tolerant plants in 0.5L pots in collaboration with Beth Chatto's Gardens. No irrigation during establishment.

Maintenance – minimal weeding of tree and shrub seedling, some editing. There is main annual cutback in late autumn / winter.

During my visit, I really appreciated the welcome John gave me and all the time he took discussing his ideas and showing me around his garden and the car park (next section). It was also a pleasure to meet and share ideas with his recently employed garden team - Sophie Cook and Benny Hawksbee.

John has lived at Horndon-on-the-Hill since 1995. His garden has a huge variety of different landscape elements (horticultural and built structures) as well as brownfield gardens, 3 ponds, grass meadows, wood copses, trees and scrub; there are also structural elements such as biodiverse green roofs (prototypes for The Grass Roof Company). John's brownfield gardens take inspiration from observing biodiverse abandoned landscapes – a habitat type defined as 'Open Mosaic Habitat on Previously Developed Land'. Open Mosaic Habitats have been found to be of high value to invertebrates and are a Priority Habitat in UK Biodiversity Action Plan (see Joint Nature Conservation Committee's website). They are a patchwork of bare, early-successional habitats on previously disturbed ground where soil has been removed or severely modified. Examples range from disused quarries, former industrial works and railway sidings to urban brownfield land. It is worth adding that part of the success of Open Mosaic Habitats is that they provide a wide variety of food and also habitats for wildlife.

Experimental garden curved path of hoggin (self binding mix of sands, gravel, stones, and clay locally sourced) for ground nesting bees with undulations of different aggregates either side, ready to be direct sown

The brownfield gardens around John's house have evolved over the years, broadly they can be split into three zones based loosely on their chronology:

- Long sinuous mound of crushed concrete forming an 'inverted swale' (15 years ago) – inspired by seeing a client's green roof planting seeding into their driveway of limestone hardcore, the mound has soft edges onto mown grass. John says it is evolving into a chalk grassland plant community.

- Experimental garden (about 8 years ago but being refreshed 2021) in front of John's house - more sophisticated design and use of materials, distinctive in character with sinuous paths edged in mild steel, circular domes of different aggregate minerals seeded with native wildflowers, interweaving of aggregate materials again seeded with native wildflowers, bare sand, built elements including metal walkway over wild thyme (*Thymus spp's*), bee posts, planters and quirky elements like a half sunken Citroen van.
- A13 garden (2021, photos below and on page 16) – rectilinear garden created using different aggregate material substrates (mainly sands from A13 road widening) for native and non-native flowering plants, with variable depths and including structural elements like log piles, gabions and standing dead wood.

A13 garden; unusually biennial Daucus carota and perennial Centaurea nigra have flowered in their first year

A13 garden includes log piles, standing dead wood, grass covered chalk mound with Eschscholzia californica in the foreground

John's gardens are multi-functional, designed with invertebrates in mind. He varies both the substrates (which have fines / no fines, different pHs and fertility, although often low) and their depths (to create topography) forming a complex mosaic of different environments which in turn supports diverse plant communities. The other key element is including structure so it can provide habitats for wildlife – from elements like planters, which incorporate habitat, to those which provide a specific habitat purpose, such as bee posts. In appendix C, I have included some of the structural elements for wildlife in John's garden. Although not touched on in detail here, John has 3 ponds which are worth mentioning, as water, especially temporary, is an integral element of Open Mosaic Habitats.

Key elements of brownfield gardening

Variety of recycled mineral aggregates used as growing media with depths 100mm to 500mm

Varied topography

Structural elements with wildlife habitats – such as log piles, bee posts and gabion walls

The range of mineral substrates John has used can be summarised as follows (see appendix B for more details):

- Locally sourced 'as dug' sand, there are three types sourced from the widening of A13 road, one of which is Thanet sand.
- Crushed construction waste (with and without fines) such as ceramics, concrete, brick and often mixture of all as general demolition waste – using recycled materials created for the construction industry provides more control as aggregates have been crushed, graded and screened. They can be washed to remove fines / dust.
- Other industrial waste products like chalk, a by-product of sugar beet production, crushed asphalt and coal.

As a weed seed-free substrate, these mineral aggregates are ideal for direct sowing. Many of the aggregates have a very low nutrient levels allowing wildflowers to thrive without grasses and other plants out-competing them.

John's has found that plants initially grow slowly within the stressed substrates, until their roots reach the fertile heavy clay soil beneath, whereupon they flourish. To reduce fertility and increase the stress, so plant communities evolve more slowly, John sometimes strips the topsoil and uses it elsewhere, such as a vegetable patch. Where invasive perennial weeds are likely to be an issue he lays a biodegradable geotextile membrane between the native soil and mineral substrates. Lessons to be gained from his garden are more about approach than creating a universal specification. For example John extensively uses A13 sands, sourced locally; this sand would be an unsustainable option if specified elsewhere in the country.

Beyond tackling the fertility of the native clay soil there are two main challenges John talks about for his brownfield gardens:

- Firstly, rabbits; as well as eating the plants they also dig up bare sand, disturbing ground nesting bees. John has tried localised barriers (large pieces of crushed material and metal mesh) none of which have been totally successful. He currently has rabbit proof fencing

around much of the brownfield gardens and accepts some damage elsewhere. The disadvantage with this is it also excludes other wildlife such as hedgehogs.

- The other challenge is weeds. Using weed free deep mineral substrates and topsoil stripping definitely reduces the commitment of managing weeds. However, once an area is established, woody airborne weed seeds, like goat willow (*Salix caprea*), from nearby scrub and also encroachment from grass edges, such as creeping thistle (*Cirsium arvense*), couch grass and brambles (*Rubus fruticosus*) are the main source of weeds. John manages this by hand weeding. More recent garden areas have defined edges and buffers which make it easier to manage and control encroachment.

Challenges

Rabbit proof fencing encloses the experimental garden and A13 garden

Main maintenance task is to weed seedlings of shrub and trees (Rubus fruticosus shown here)

Encroachment of grass from paths into planting (Dipsacus fullonum (teasel) and Foeniculum vulgare

The brownfield gardens are just part of the garden; there are also places to sit and grow vegetables

There is a really playful, distinctive character to John's garden. The circular mounds of aggregates, rusty steel edges, and orange painted structures give it an identity and character of its own. These designed elements complement the loose wildness of the space. To some it might appear uncared for - particularly towards the end of the year. However, John's garden is an optimistic reminder that there is always scope to create habitat for invertebrates as well as humans; to think creatively with our landscapes and to experiment through observation.

Langdon Nature Discovery Park Car Park, Basildon

Day 3 – Friday 15 October 2021 - afternoon

Langdon Nature Discovery Park is a nature reserve managed by Essex Wildlife Trust. Recently, they built a new visitor centre and car park for 150 cars. In 2020, John Little was commissioned to enhance the car park which was just an expanse of granite hard core with a single group of mature trees in the middle. During the afternoon of my tour, John took me to see what he'd created.

Insect bays- mini-brownfield gardens for wildlife occupy car parking spaces

With a limited budget, John has enhanced the car park area to create a cohesive scheme befitting a nature reserve with a number of elements:

- Insect bays – 8 mini brownfield gardens in place of parking bays delineated with orange painted metal edges. Bays were filled with a range of mineral aggregates and bee posts. The planting is a mixture of pot plants and wildflower seeding. The bee posts have a range of hole sizes for solitary bees and other insects (see appendix C).
- Gabions to form a retaining wall along the boundary to the reserve. This wall was backfilled with stretches of A13 gritty sand and chalk over felled logs and stumps left by the previous contractor. Sand was direct seeded with wildflower seed.
- Central gabion running through the middle of the car park. Gabions are staggered to create niche planting pockets for birch trees and drought tolerant plants.

- An entrance area is created near the visitor centre by larch timber planters with integral seating. There is also a shed with a biodiverse green roof and habitat panels, bee sand planters and circular gabion planters.

The gabions form a series of narrow wildlife corridors / margins, a new and different habitat within the nature reserve. The insect bays and staggered linear gabions break up the monotony of the large car park.

Central gabion - silver birch with biodegradable tree guard planted in 150mm deep crushed ceramics on car park base

Front entrance – UK larch planters with integral seating, annual seed mix is allowed to self-seed at the base

Key facts of Langdon Nature Reserve Car Park

Topography – level.

Climate very low rainfall, large expanse surrounded by scrub and trees more open to the west.

Native topsoil /Site preparation – site already had a car park base of 250mm layer of granite Type 1 DoT.

Mulch / mineral aggregate layer – deep substrate layers: A13 Thanet sand, A13 ballast (gritty sand), crushed ceramics, chalk, recycled subbase Type 1 DoT 50mm to dust – all with variable depths from 100mm to approx. 300mm to create undulations.

Planting – direct seeded native wildflower mix for green roofs and drought tolerant plants in pots. No irrigation.

Maintenance – minimal weeding / re-firming plants which have been dug out by children and rabbits, cut back in winter.

Direct sown *native and exotic mixes suitable for Green Roofs from Emorsgate and Pictorial Meadows.*

Drought tolerant plants *in pots from Bath Chatto's nursery*

Epilobium canum 'Ed Carman' Syn. Zauschneria californica 'Ed Carman'

Ballota pseudodictamnus ex Crete

Nepeta racemosa 'Little Titch'

The plants in the 'insect bays' near the visitor centre have established less well and there is a green hue to the aggregates suggesting the ground is retaining water. John plans to raise levels in these bays with more mineral aggregate. Some digging by kids and rabbits was in evidence in the sand. There was insufficient budget for information boards which would have been a positive benefit to visitors.

The car park, as a culmination of John's knowledge and experiments, is an excellent example of what can be achieved on a limited budget - a testament to his personal commitment and vision.

Bee post- timber post with different sized holes for aerial hole nesting insects

Bee sand planter – with nesting habitats for solitary bees, sand behind holes in metal planter and, to the left, holes in logs within habitat panels

South African Planting - Grasslands Garden, Horniman Museum

Horniman Museum Grasslands Garden

Day 4 – Saturday 16 October 2021

On the final day of my tour, I visited the gardens around the Horniman Museum. The Horniman Museum is located in Dulwich in south east London and opened in 1901. The grounds around the Museum are free to visit with a diverse range of different garden spaces. Innovative horticultural approaches are taken to managing these gardens, which change and evolve often reflecting concurrent exhibitions as well as redeveloping less sustainable horticultural practices (Fernandes, 2021).

The specific purpose of my visit was to see the Grasslands Garden, a relatively recent complex herbaceous planting scheme on deep gravel beds. In parallel with a new World Gallery (2015), and to celebrate endangered landscapes associated with indigenous cultures, the Grasslands Garden was designed by Professor James Hitchmough and created by the then head gardener Wes Shaw in 2016/2017 (Hitchmough and Livingstone, 2020 and Pope, 2021). After my trip I had the pleasure of talking with Wes Shaw about the planting, establishment, and initial maintenance of the garden.

North American Prairie Planting

Key facts of Horniman Museum Grasslands Garden

Topography – gently sloping south facing slope.

Climate – very low rainfall sheltered by trees.

Native topsoil – heavy fertile London clay (previously a kitchen garden enriched with organic matter) free draining beneath.

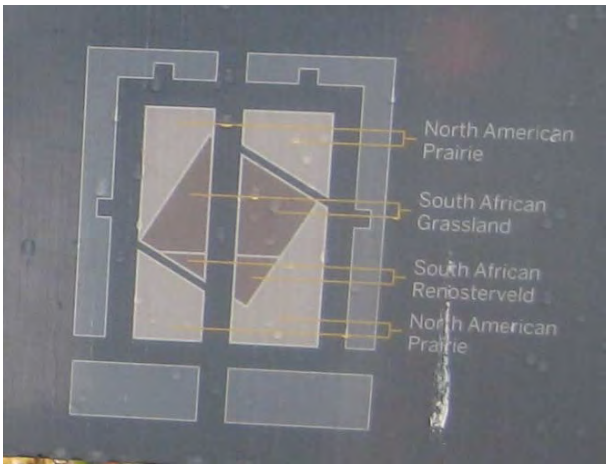
Site preparation – topsoil stripped to a depth of 100mm and then rotavated.

Mulch / mineral aggregate layer – 100mm deep 10 mm grade pea gravel.

Planting – P9 pot plants (grown in house) set out randomly at 300mm centres. Planted in November. Top of the soil from each pot is removed before planting. No irrigation.

Management – virtually no weeding, annual cutback in February. Management approach is changing to a 'slow edit' with ongoing reviews to keep the scheme looking good, tackle gaps and the balance of plants (see main text).

The Grasslands Garden was developed on the old, very high maintenance, kitchen garden. James Hitchmough's planting design created three geographically based grassland plant mixes native to North America and two regions of Southern Africa. Within two long rectangular beds, the North American Prairie planting wraps around a central twisted square bed of South African Grassland and South African Renosterveld steppe planting.



Plan of garden layout

North American Prairie *plants earlier in the season include Asclepias tuberosa, Silphium terebinthinaceum, Liatris aspera and Baptisia australis*

Cone seed heads of Echinacea paradoxa and Echinacea pallida

Schizachyrium scoparium (Little Bluestem)

Echinacea tennesseensis 'Rocky Top'

South African Grassland *plants earlier in the season include Kniphofia uvaria, Berkheya purpurea, Gladiolus papilio and Bulbinella latifolia*

Nerine bowdenii

Hesperantha coccinea (syn. Schizostylis) Kaffir lily with Dierama pulcherrimum stems behind and Eucomis spps in front

Eucomis spp possibly Eucomis autumnalis

From the 1980s / 90s Germany has led the way with planting design based on ecological principles (Hansen and Stahl, 1993). Complex, long lived and low maintenance plant communities have been created and trialled all over Germany to match different garden habitats (BdS - Association of German Perennial Gardeners). For mixes in the sun, a mineral aggregate mulch of 50-70mm is recommended. James Hitchmough's approach (sometimes referred to collectively with Nigel Dunnett as the 'Sheffield School') builds on this philosophy of horticultural ecology to create 'high impact, low input' gardens and landscapes often for prominent urban locations. The planting, often from one geographical habitat, aims for a 'wow' factor with a long seasonal display, and is drought tolerant with straightforward, low maintenance.

In preparation for the Grasslands Garden, soil productivity was reduced by stripping a layer of topsoil and replacing it with a deep layer of pea gravel (Hitchmough and Livingston, 2021). Reducing soil productivity suits the stress tolerant grassland plants avoiding 'floppy soft vegetation' (Hitchmough, 2017). The pea gravel not only supresses the weed seed bank in the soil underneath (provided it is at least 75mm deep (Hitchmough 2017)), it also, if fines are not present, provides an inhospitable environment for windborne weed seed germination (Hitchmough and Livingston, 2021). Once established, planting in a deep gravel mulch requires no irrigation and virtually no weeding (in the first few years Wes estimated an hour per season of weeding for the garden). Whist ongoing maintenance entails significantly less commitment than a traditional herbaceous border, the initial set up and effort involved is significant.

Challenges the complex plant community is fairly stable with little seeding around. However there is some evolution in the plant communities. To keep the dynamic balance some ongoing management is needed especially if the aspiration is to keep it looking good all the time. I did note some slug damage visible (a snail is visible on the Goldenrod below) and wondered if they pose any problems for some emerging perennials (particularly North American forbs) in spring.

South African planting has more gaps where plants have not established or are short lived

Eryngium yuccifolium has flopped over, in places Silphium terebinthinaceum has also flopped

Solidago speciosa (Goldenrod) has spread extensively and is becoming dominant so in 2021 the garden team have been reducing its presence

The main maintenance task is an annual February cutback. However, Errol Fernandes, the current head gardener, explains that, as it is a high profile public garden, the ongoing maintenance is

evolving to ensure that it looks good throughout year (Fernandes, 2021). He described his approach as a 'slow edit' looking at the composition of the planting as a picture / painting and removing and adding elements which aren't contributing positively. This is a more sophisticated horticultural management than perhaps originally intended and whilst still much less maintenance than a traditional herbaceous planting bed it does require an artistic eye and sensitive regular horticultural input. Errol does also say that this balance aims to keep as much as possible standing to support local wildlife with elements like hollow stems for insects and seed heads for birds. By changing to a management approach to involve editing the pea gravel will be disturbed, this could bring the weed seed bank to the surface and also a top surface more hospitable to wind-borne weed seeds, weed problems could become slightly more of a problem - particularly where the vegetation is less dense. It would be interesting to know how the management commitment evolves in the long term.

Looking across the South African planting with the taller North American Prairie grassland both in the foreground and also creating a backdrop around to the perimeter

When I visited the garden on a rather wet, drizzly Saturday October morning the garden had a very high footfall of people both passing through and also stopping and looking. The garden definitely has a high impact, and in autumn it had a dynamic wild exuberance full of interest to look at and a sense of delight. The complex variety draws you into the planting. I wanted to step over the roped boundaries of the beds and be immersed in the detail of the planting.

Discussion of my Aims and Objectives

Below I briefly discuss my aims and objectives set out in the introduction.

Visit gardens which use gravel and mineral aggregate mulches to further understand their creation and management from preparation, planting, establishment to long term management.

The discussion over the next few paragraphs brings together what I have learnt during my study tour. To help visualise the relationships and parameters of using mineral aggregates and creating brownfield gardens, I have also created a flow chart in appendix A.

Thin mulch of mineral aggregates – drought tolerant planting

The two older established gardens I visited, Beth Chatto's Gravel Garden and RHS Hyde Hall Dry Garden, are both exemplary showcases of what is possible without irrigation, using thin (less than 50mm) gravel / pebble mulches decoratively and, to some extent, to stop the soil drying out. Their inspiration lies in using a plants adapted to drought conditions. Throughout the year the gardens are well maintained by horticultural experts. Plants are allowed to self-seed, and are edited so that the planting evolves whilst remaining fresh and dynamic.

Preparation follows traditional horticultural practices, including adding organic matter. Differences relate to their contrasting native soils: Beth Chatto's low fertility, free draining gravelly sand compared to RHS Hyde Hall's fertile heavy clay. RHS Hyde Hall's heavy clay poses additional maintenance challenges as it is harder to weed / edit and in time the clay soil needs additional gravel to maintain free-draining properties. In recent years both gardens, elsewhere on their sites, have been exploring using deep beds of coarse sand as a growing media.

Deep mineral aggregates as a growing media

The next generation of gardens I visited, John Little's brownfield gardens and James Hitchmough's Grasslands Garden at the Horniman Museum, used deep mineral substrates (over 75mm; Hitchmough, 2017) to significantly lower maintenance in terms of weed management (Hitchmough, Kendle and Paraskevopoulou, 2003; Schmithals and Kühn, 2017; Hitchmough, 2017; O'Brien 2020; and Hitchmough and Livingstone, 2020). These gardens are still not irrigated after establishment. The deep mineral substrate provides a sterile planting bed and is deep enough to suppress the weed seeds in the soil beneath the mineral substrate. When fines are not present, windborne weed seed establishment is slowest (Hitchmough and Livingstone, 2020). Schmithals and Kühn (2017) found higher mortality, during establishment, for prairie plants in 70mm of gravel when compared to topsoil.

Both gardens are heavy clay and no organic matter is added. In fact, to reduce fertility at the Horniman they stripped the upper topsoil layer before laying gravel. John Little has done the same in parts of his brownfield garden. Another successful approach taken to reduce fertility, and remove weed seed bank, is soil inversion, which buries the rich topsoil (Luscombe and Scott, 2004). Lowering the nutrient levels allows stress tolerant plants to establish and then thrive when their roots reach the soil beneath without competition (Hitchmough, 2017 and Korn, 2013). The underneath substrate, whether topsoil stripped or not, still influences the planting over the long term.

Plant palette and the way mineral aggregate is used

Significant differences between James Hitchmough's and John Little's approaches lie in the application of the mineral aggregates and the plant palette selection. At the Horniman Museum, the fines-free pea gravel is applied as a flat canvas, forming a weed-supressing backdrop to the planting scheme. The plant palette is a sophisticated plant mix based on specific geographical locations (Hitchmough, 2017 and Hitchmough and Livingstone, 2020). By contrast, John Little's brownfield gardens mimic Open Mosaic Habitats, interweaving a variety of mineral aggregates, some with fines, in an undulating topography. The mineral aggregates in a brownfield garden are an integral part of its design and style. The plant selection by John is drought tolerant native and non-native seed mixes used for green roofs and careful selection of drought tolerant plants as used by Beth Chatto's gardens. The presence of fines, in the context of brownfield gardens, may help with germination and, as the substrate is deep and infertile, can be an important factor of creating highly contrasting plant communities.

Long term management

In the short term, both gardens demonstrate the benefits of mineral aggregates in establishing planting which has a much lower maintenance commitment. It will be fascinating to see how these relatively newer gardens evolve and how much commitment they take to manage in the long term. The main weeds for the brownfield gardens are from windborne seeds of woody plants, which John Little hand weeds out. At the Horniman Museum they are starting to edit the planting balance, which, as it disturbs and potentially mixes the gravel with the clay soil beneath, could make more weeds appear in gaps. Schmithals and Kühn (2017) discuss the stability of North American prairie planting and whether they are stable when the forb to grass mix has been adjusted for aesthetics; monitoring this is ongoing.

Recycled aggregates are an integral part of Hilldrop's brownfield gardens

At the Horniman Museum, education is an important element of the Grasslands Garden

Compare the different horticultural approaches to understand why each garden visited is successful.

All the gardens I visited are exemplary in the context of their specific purposes, whether they be horticultural showcase gardens open to the public, urban parks or private experimental gardens. I

believe they drive home the importance of establishing a vision for any garden and landscape design and also the importance of knowing what the maintenance / management is long term for the garden if it is to be a success. Apart from John Little's garden, they are primarily beautiful gardens designed to educate and for people to enjoy. John Little's vision goes further as his gardens are as much for wildlife as they are for people.

With more time I would have been interested to look more into the sustainability and environmental cost of the different materials used. Given our collective awareness on the environmental impacts of using finite raw materials, using recycled materials must offer sustainable benefits. The carbon footprint of any new landscape can take years to become carbon positive and even start sequestering carbon (Brossart, 2021 and online tool called Pathfinder 2.0 at Climate Positive Design). A thick layer of virgin mineral aggregates used within the planting will increase the embodied carbon, so a new landscape will takes longer to become carbon positive. More optimistically, soils which contain demolition waste high in lime (like concrete dust) have been found to capture carbon rapidly; likewise, plant diversity captures carbon faster than monocultures of plants (Little, 2020). It is exciting to think that taking a brownfield garden design approach could have a more positive impact on the environment.

Gain greater understanding of the potential of recycled construction waste as a material to use in horticulture

My study tour of the work of James Hitchmough and John Little highlighted the enormous potential of mineral aggregates as a growing media (discussed above). The sustainability issues around using finite construction materials makes considering recycled mineral aggregates a viable option for the future. In appendix B I summarise what I have learnt, from a horticultural perspective, about recycled construction waste from 'as dug' sand (a by-product of highways work) to crushed demolition waste. This is at pioneer stage of horticulture, in which John Little and others are carrying out experiments exploring / testing different recycled aggregates, which I will follow with interest (Little, 2020).

Brownfield gardens at Hilldrop are juvenile soils with early successional habitats. It would be interesting to understand how these soils, their mycorrhiza and fauna (like earth worms), evolve. Gilbert (1989) shows the increasing presence over time of larger invertebrates in or on different ages of brick rubble sites in Sheffield.

One important point I am still balancing in my mind is where is it is appropriate to use recycled minerals. Rightly, John emphasises it is not for everywhere such as a vegetable garden which needs to be contaminant-free and fertile. I can see real benefit from brownfield gardening a site which was previously a brownfield site, like Jo McKerr's garden at Church Farm (McKerr, 2020) and for planting in new landscapes whose soil has been stripped or significantly disturbed from small scale domestic extensions to large scale housing developments, highways work and creation of new train routes. It could even include restoring an artificial lawn back to nature. Finally, there is scope in manufactured soil as a component of the growing media, for example trials by Ben O'Brien in Canada (O'Brien, 2020). Also, at Fidelity International, James Hitchmough's prairie-like vegetation was direct sown on sand on top of a manufactured soil which has a portion of crushed concrete and rubble waste created from the demolition of the original buildings (Hitchmough, 2017).

Understand the potential of structural elements to provide habitats for wildlife.

Dead wood – wildlife needs habitats

Before my study tour I knew both Hilldrop and the car park at Langdon Nature Discovery Park had been created with wildlife in mind. One of John Little's mantras is 'structural diversity'. As well as providing planting as a food source for wildlife, John's gardens create habitats for wildlife such as bee posts and include habitats within structural elements from planters to bike shelters (see appendix C). He provides a convincing argument that these structural elements could be designed, working with entomologists and ecologists, in a multi-functional way to also support wildlife.

There are reoccurring themes in the elements John has created which add porosity to the environment, giving form to areas of bare sand for ground nesting bees, shape to dead wood mini eco-systems and framework to loose rubble for spiders (see appendix C). Talking with him highlighted the enormous scope to build biodiversity into any landscape and garden design, something any designer from architect to garden designer could easily embrace.

Knowledge sharing

I would be happy to share the knowledge I have gained on my study tour with anyone who is interested. I will be exploring opportunities to do a presentation with groups such as my local Society of Gardens Designers Cluster Group, the North West Branch of the Landscape Institute and Friends of Calderstones Park in Liverpool. I also intend to contact the Landscape Institute to see if I can publish part of the report in their magazine, as well as exploring other journals such as *The Horticulturist* as suggested by the RHS committee on awarding my Bursary.

Concluding thoughts and future plans

It has been an enormous pleasure and privilege to undertake my study tour, read around the subject and write the report. At times the interlinked subjects of horticulture, soil science and entomology can feel dauntingly complex for me as a landscape architect. It has therefore been illuminating to see real gardens, get a more in-depth knowledge of their innovative approaches and be inspired by the people who create and look after them.

As a result of the tour and accompanying research, I understand better the role mineral aggregates and recycled waste can play in the landscape. In my own practice, topsoil will never be a default specification again, and this holds a wider lesson for landscape and horticultural professionals. Likewise, there is always scope to create landscapes and gardens to be for wildlife as well as people. It is by thinking innovatively and creatively that we can ensure critical elements like biodiversity are core to design. Taking into account all of these factors can help us make a contribution to answering the urgent environmental concerns of our time.

There are a number of future avenues for me arising from this report. I look forward to following how the gardens and experiments covered here develop, and are complemented by other initiatives. These initiatives include trials of using crushed recycled waste as a growing medium, either used pure or as a component in manufactured soils. Planting based on habitat ecology is well established. I would like to see how it might be coupled, in a climate-adaptive way, with the use of recycled waste substrates in different contexts, like shade, to create self-sustaining planting which is low maintenance and straightforward to manage. The final piece of the jigsaw is exploring further ways of including structural elements for wildlife within landscape and garden design.

Personally, I would love to visit more landscapes which explore these areas from plant habitat ecology on mineral aggregates (for example, see Michael Livingstone's PhD trials in Sheffield; Professor Cassian Schmidt's work at Hermannshof in Germany; and Olivier Filippi's dry Mediterranean garden & nursery in France). I would also like to see other brownfield gardens like Jo McKerr's, which is created on a brownfield sites; the 'rewilding' garden at Knepp by James Hitchmough and Tom Stuart-Smith; and finally explore natural Open Mosaic Habitats such as at Canvey Wicks.

Overall, the core inspiration I have taken from the study tour is that observation and creative approaches are key to realising the potential of landscape and garden design in particular for biodiversity and wildlife.

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- Boningales Nursery https://www.boningale.co.uk/floratopia/
- The Grass Roof Company https://greenroofshelters.co.uk/
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- Beth Chatto’s Gravel Garden https://www.bethchatto.co.uk/garden-nursery/gallery/gravel-garden.htm
- Hilldrop, Hornton-on-the-Hill https://www.grassroofcompany.co.uk/
- Langdon Nature Discovery Park https://www.essexwt.org.uk/nature-reserves/langdon
- Horniman Museum Grasslands Garden https://www.horniman.ac.uk/event/grasslands-garden/

Acknowledgements

A very special thank you to:

- The RHS Coke Trust Bursary Fund for assisting me with this scholarship project

- The RHS for providing travel grants – this gave me the catalyst and motivation to pursue my tour

- Ian Bull and Susie Curtis at RHS Hyde Hall, and helpful communications afterwards

- David Ward at Beth Chatto's Garden

- John Little at Hilldrop, Horndon-on-the-Hill, especially for all his time generously given

- Sophie Cook and Benny Hawksbee at Hilldrop, Horndon-on-the-Hill

- Wes Shaw for communications about the Grasslands Garden, Horniman Museum

- Ben O'Brien, Richard Scott, James Hitchmough, Angeliki Paraskevopoulou and Tom Massey for their insights

- Louise Emberson and Carolyn Willitts for their references for the application and support

- My husband Steven Shakespeare; without his support (and proof reading), my involvement in this project would not have been possible.

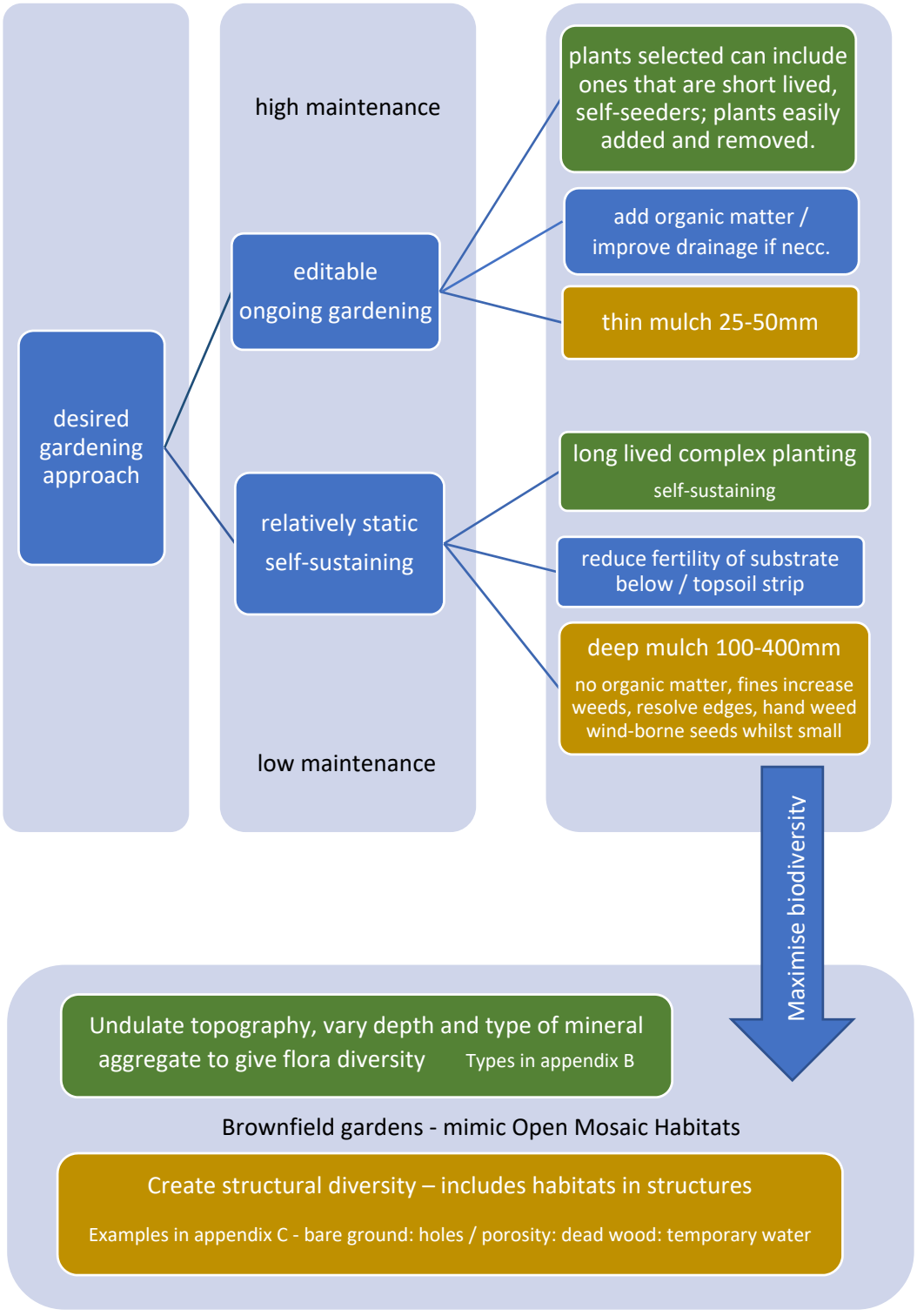
Final budget breakdown

Description	Actual Cost
Train / Tube and Bus Fares	
Return from Liverpool to London (train and bus)	£96.80
Return from London to Laindon and Travel card zones 1-6 – one day	£36.50
Car hire Charge (3 days) Enterprise Rent-a-Car (smallest car) from Basildon (near Laindon)	£271.47
Mileage: - Hire Car fuel cost	£ 25.51
Accommodation: 3 nights (The Bell Inn, Horndon-on-the-Hill)	£234.00
Food: 4 days (combined receipts)	£72.16
Other Costs	
Insurance – travel (to cover cancellations etc.)	£9.64
Garden Masterclass Webinars (and films were not available in time)	£18.21
Beth Chatto – workshop The Autumn Gravel Garden	£40.00
TOTAL	**£804.29**
RHS BURSARY AWARD (RHS Coke Trust Fund)	**£636.00**
PERSONAL CONTRIBUTION	£168.29

Appendices

A. Using mineral aggregates and creating brownfield gardens

Below is a summary flow chart of the factors I learnt about on my study tour – it's by no means all-encompassing but does show different parameters and how they relate to one another.



B. Recycled mineral substrates in horticulture

Before becoming interested in using mineral aggregates as a growing medium, I knew relatively little about soil, beyond its texture and pH, and even less about demolition products. Below I have tried to organise what I have learnt from my study tour, a bit of detective work and discussions with my local suppliers on demolition products (Sources of information John Little 2020 & 2021; Luscombe and Scott, 2004; Hitchmough, 2017; Gedge, Grant, Kadas, and Dinham, 2019; Gilbert & Anderson, 1998; Hitchmough, Kendle and Paraskevopoulou, 2003; Dunnett and Kingsbury, 2004; and Korn, 2013). Terminology seems to vary regionally in the UK and with different trades, so please use this information intelligently!

Sustainable sourcing of materials ideally should focus locally and could take advantage of local construction works, from road widenings to on-site demolition and excavation. The characteristics of recycled waste - presence of fines, pH (how it changes as the substrate settles), potential nutrients, percolation soil test, shape of grains - all inform how it could be used horticulturally. There are disadvantages with using unscreened demolition materials where these characteristics are unknown (Gedge, Grant, Kadas, and Dinham, 2019). There is more control to using standard recycled construction materials in that they are uniform, although some factors like pH and nutrient levels may vary. They are, however, not sold as growing media and are not suitable everywhere, such as for vegetables and fruit. Appropriateness and safety, as discussed in the main text, should always be considered. Finally, for small scale projects, there is always scope to hire a small crusher on site – this method allows for a variety of different grades and the ability to mix things around although the crushers are very noisy (John Little and personal communication with Tom Massey).

A reminder on the basic soil type particle sizes in the British Soil Classification System:

- Clay < 0.002mm
- Silt 0.002-0.06mm
- Sand 0.06 to 2mm (less than 4% silt)
- Grit 2 to 6mm
- Gravel 2 to 60mm (rounded (marine or fluvial) or angular (quarried or crushed))
- Cobbles 60-200mm

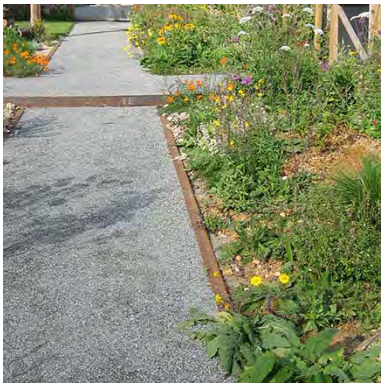
10mm pea gravel at Horniman Museum

Apart from sand, I have not covered other common aggregates already used within the horticultural industry such as the pea gravel used at the Horniman Museum Grasslands Garden.

In the tables that follow, all photographs are from John Little's brownfield gardens at Hilldrop or Langdon Nature Discovery Park car park.

Mineral aggregate (and other names)	**Notes on horticultural potential**
Natural / virgin materials dug as a result of construction or quarry waste products	
Sharp sand (Coarse angular shape; aka quarry / pit sand)	Very freely draining and variable pH. (Pure sand (mostly made from silica) has a neutral pH). Good for drought tolerant plants / direct seeding, however not moisture retentive. Favoured by: • Peter Korn bare root plants in depths 200-300mm (Korn, 2013 and Cook, 2018). • James Hitchmough in depths 75-200mm direct, seeding lowest level of weed seedlings & slug damage (includes hessian mesh and irrigation every 1/3 days during establishment) (Hitchmough, 2017).
Builder's sand (Fine Sand – smoother rounded shape contains some clay / silt; aka bricklayer's / screening sand)	Good for ground nesting bees as silt content helps it clump together. Less good for plants, rounded particles can pack together more tightly and clay can make drainage poorer.
'As dug' sand (variety of types – unwashed and may contain aggregates up to 5mm) Name often associated with the region it has been dug from.	Variable pH and texture, so the potential is specific to each type. John Little uses three types of sand dug from the widening of the A13: • Thanet sand (aka New Haven Sand) similar to builder's sand but even better for ground nesting bees. • Ballast sand – gritty sharp sand (with some 20mm gravel). • Glacial outwash / alluvial sand; a mix of ballast and clay. Richard Scott uses Merseygrit (dredged from the Mersey for shipping routes) for his direct seed sowing of wildflower as part of Scouse Flower House.
 *A13 Thanet Sand*	 *A13 Ballast sand*	 *A13 Alluvial sand*
Jointing / beach sand (rounded smoothest / washed)	Very clean, free of contaminants and expensive!
Crushed quarry waste (with and without fines, from limestone, granite sandstone quarries) (aka quarry scalpings)	Uniform product which could be aesthetically appealing for high profile projects. Regional availability will vary. PH will vary according to stone. Not used by John Little.

Mineral aggregate (and other names)	Notes on horticultural potential
Crushed construction waste (huge variety & variability, can be graded / screened / can be washed of fines)	
Crushed ceramics (from sinks / toilets)	Grade 10mm down to dust Favoured by John Little, creates a good substrate texture - clay content doesn't seem to clag (may be due to high firing temperatures) and the crushed glaze forms something similar to horticultural grit. Availability may vary with region.
 *Ceramics*  *Ceramics with visible dust*  *Recycled DoT Type 1*  *Screened 10mm*  *Screened 20mm*  *Screened oversized*	
Crushed general demolition waste	Can be concrete / brick / reclaimed gravel and other elements, so is very variable. However, specified standard recycled subbases, intended for hard landscape industry, have some known characteristics and uniformity (Gedge, Grant, Kadas, and Dinham, 2019 on unscreened waste). Specified types which are available: • Recycled subbase Type 1 DoT 50mm to dust, so has fines present (sometimes referred to by older name of MOT) and 6F5 Crusher Run 75mm down to dust. Good for dry lime rich soils although fines can make it 'pack together' so roots of seedling can't penetrate, better when particle maximum size is 15mm – rotovating in 50mm layer of sharp sand helps address this (Hitchmough, 2017). • Recycled subbase Type 3 DoT (40mm open graded reduced fines) and recycled shingle & gravel (where crushed waste is graded and washed to remove fines; grades are 10, 20, 40mm

Mineral aggregate (and other names)	Notes on horticultural potential
Crushed construction waste cont.	
Crushed general demolition waste cont.	or can be mixed). Could be used in a similar way to an angular gravel in horticulture or to create a mini Dungeness. • Oversized crushed waste / recycled nuggets - 125mm-50mm screened to remove fines – John uses 75-100mm in gabions.
Crushed concrete (contains fines initially very high alkaline pH, which decreases in time)	Limited moisture retention and limited nutrients, very high alkaline ph. Highly stressful for plants – John Little finds it is suited to growing Thyme (*Thymus spp's*) which copes with high pH but doesn't like any competition. Some options: • Crushed concrete can be specified as Type 1 DoT (50mm to dust) (John uses this as subbase & surface for paths). • Concrete sand / concrete fines – 6mm down to fines. Fine grades rotovated into soil can give good calcareous soil (Gilbert and Anderson, 1998). • Crushed concrete can be mixed 50:50 with subsoil which lowers alkalinity to pH of around 8 suitable for a calcareous wildflower seeding (Luscombe and Scott, 2004). • Pure concrete and 50:50 crushed concrete and sand in depths of 150mm for North American prairie planting trials; had some losses but was better than expected (O'Brien, 2020).
 *Crushed concrete with Thymus*	 *Crushed conrete used in the path*	 *Crushed brick rubble*
Crushed brick (clay bricks or tiles, brick rubble)	Some nutrient content and moisture content. If some mortar and cement is present it will raise pH of substrate (Dunnett and Kingsbury, 2004). When fines are present dust can become claggy / clay-like (John Little). • Used for some green roof substrate as a custom designed mix such as Bourne Amenity's SKY1 which is a mixture of crushed graded brick, other aggregates and organic material. • A bit too fertile for John Little, but he is currently trialling crushed brick rubble defects from a Manchester Brick Factory. • In experiments on urban waste soils, crushed brick (graded 10mm to fines) was the least successful substrate for germination, survival and satisfactory growth of North American prairie forbs and British meadow forbs and grasses (Hitchmough, Kendle and Paraskevopoulou, 2003). It is improved when mixed with subsoils or sand.

Mineral aggregate (and other names)	Notes on horticultural potential
Crushed construction waste cont.	
Crushed asphalt / road chippings (aka tarmac scalpings, road plannings)	Type 4 crushed asphalt is similar to type 1 DoT however John Little uses less as it is fertile and variable. Luscombe and Scott (2004) used bottom limey scrapings of fine motorway waste (10mm to dust) from major road works.
Crushed glass (aka recycled sand)	Similar properties to sharp sand. Dust / Health and Safety issue, best to work with it when wet and with mask (Tameside Reclamation Centre experimentation, Greater Manchester; information sourced from Paving Expert, 2021).
Colliery shale	Can give an acid soil over time (Gilbert and Anderson, 1998).
Railway track ballast	30-70mm screened granite or limestone, type of crushed quarry waste – not sure of availability.
Other industrial waste products	
Chalk (a by-product of sugar beet production, aka calcium carbonate)	• John Little is currently exploring options for waste chalk. He has found it to be a claggy / sticky, initially smelly product which solidifies when dry, so difficult to work with. However, high alkaline pH suggests it could be used / mixed to create growing media suited to chalk grassland habitat. • Jack Doyle successfully created self-sustaining chalk downland flower mix on chalk mounds over rubble in 1970s (Luscombe and Scott, 2004)
 *Chalk*	 *Mix of aggregates with ceramic and coal visible*	 *Coal*
Cockle shells	Suited to chalk grassland habitat due to the high calcium carbonate content. Availability during harvest season (March / April). Luscombe and Scott (2004) recommend using shell sand and allowing salts to leach out and odours to dissipate!

C. Wildlife habitats within structure

The focus of my study tour was looking at aggregates as a growing medium. However, as discussed in the main text, integral to John Little's brownfield gardens is including biodiversity within structure. This can be with specific features like a bee post. It is also about making structural elements which are part of any landscape - from walls, surfaces to bin shelters - multifunctional so they provide wildlife habitats too. In the next couple of pages I have collected different structures within John's brownfield gardens, to illustrate the potential. The different elements have been grouped into furniture and features, boundaries, surfaces, or large structures. By giving wildlife habitats shape, form and framework, their intention is more easily understood and accepted. Most structures could be made more receptive to wildlife taking on different styles, expressions and character so they could fit into any landscape.

The structures have repeating themes, adding porosity to the environment:

- Rubble particularly good for spiders (round planters, gabion walls, surface mounds).
- Bare sand for ground nesting solitary bees (Thanet sand mounds, acoustic barriers, bee sand post, hoggin path and bee planter).
- Holes in wood for solitary bees (bee post, drilled log sections habitat panels, dead standing wood).
- Dead wood in sun and shade for detritivore-feeding invertebrates and hibernation site for small mammals, reptiles and amphibians (standing dead trees, log piles, dead hedges, and tree stumps).

A brief note on bees: a comprehensive coverage of what bees need to thrive, from pollen, nectar and nest sites, is covered in Kirk and Howes (2012). Nesting environments vary with species, some solitary bees nest in hollow stems, in bored wood and form ground nesting species in bare soil. John uses Thanet sand or builder's sand for ground nesting bees, however recently he has observed different bees will nest in bare clay soil. Similarly, I have observed bees nesting in bare loamy soil.

Furniture and features		
Bee posts: timber post in full sun; range of hole sizes from 2mm diameter and 8cm deep to 9mm diameter and 15cm deep 	Sand bee post: metal posts with pre-drilled holes infilled with builder's sand or Thanet sand for ground nesting bees 	Planters (could be bins): metal perforated with holes to a layer of sand for ground nesting bees. Note habitat panel of dead wood on the side. 

Furniture and features cont.

Planter with a gabion skin of rubble

Shelter for reptiles: corrugated roofing felt is used by ecologists to monitor reptiles (newts, lizards, slowworms and even voles)

Boundaries and walls

Gabions filled with 75-100mm crushed graded demolition rubble, sharp ends have been filed down & spiral guard added

Acoustic barrier: 2 perforated galvanised metal sheets with builder's sand between.

Climbers: utilising existing railings and trellis for climbers.

Dead hedge (recycle twigs, brash and branches on site)

Log piles

Line of tree Stumps

Surfaces

Sand banks & mounds: bare Thanet sand or builder's sand for ground nesting bees.

Paths with hoggin for ground nesting bees, with areas of bare rubble for spiders.

Metal walkways over Thanet sand for ground nesting bees.

Large structures

Bin Shelter (could equally be bike / bus shelter): robust galvanised steel structure incorporating lots of different habitat elements including a biodiverse green roof.

Standing dead wood / trees:
John Little has experimented with ring barking and 'badly' pruned trees (Salix / willow below) to create habitats within the living trees (this should be carried out sensibly & safely).

Other elements (mentioned here but not in detail)

Ponds – open / ephemeral / closed	Living hedges	Compost bins
Woodland	Beetle mound / bump	And many more…
Scrub	Hibernicia	