

# The SWITCH brown roof project, Birmingham UK: rationale and experimental design

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# Presentation Outline

## 1 & 2 Introduction & rationale

- What are green roofs?
- Advantages of green roofs
  - General benefits
  - Ecological benefits
  - Urban water management benefits
- Caveats & necessary research

## 3 Experimental design - Brown roof laboratory study

### 3.1 Ecological monitoring

### 3.2 Hydrological & meteorological monitoring

### 3.3 Water quality monitoring

## 4 Experimental design - Variation in coloniser ability study

### 4.1 Invertebrate study

### 4.2 Seed study



# What are green roofs?

Biodiversity roofs, eco-roofs, living roofs, brown roofs, rooftop gardens → all types of **green roof**

**Green roofs are any type of roof with plants growing over them (not pot plants)**

- Intensive

- Like parks (lawns, trees & water features), accessible but expensive (reinforcement & maintenance) → not applicable for use over wide areas

- Extensive

- Thin substrate, very low maintenance, widely applicable
- Less expensive → investment recuperated over life-cycle



# Intensive green roofs



Cannon Street Station, London

Photograph [livingroofs.org](http://livingroofs.org)



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# Extensive green roofs



Ford Dearborn Plant, Michigan



*Sedum album*



*Sedum acre*



Photographs [greenroofs.org](http://greenroofs.org)



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SWITCH



# Extensive green roofs



Photograph [livingroof.org](http://livingroof.org)



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# Extensive green roofs



Zürich railway station

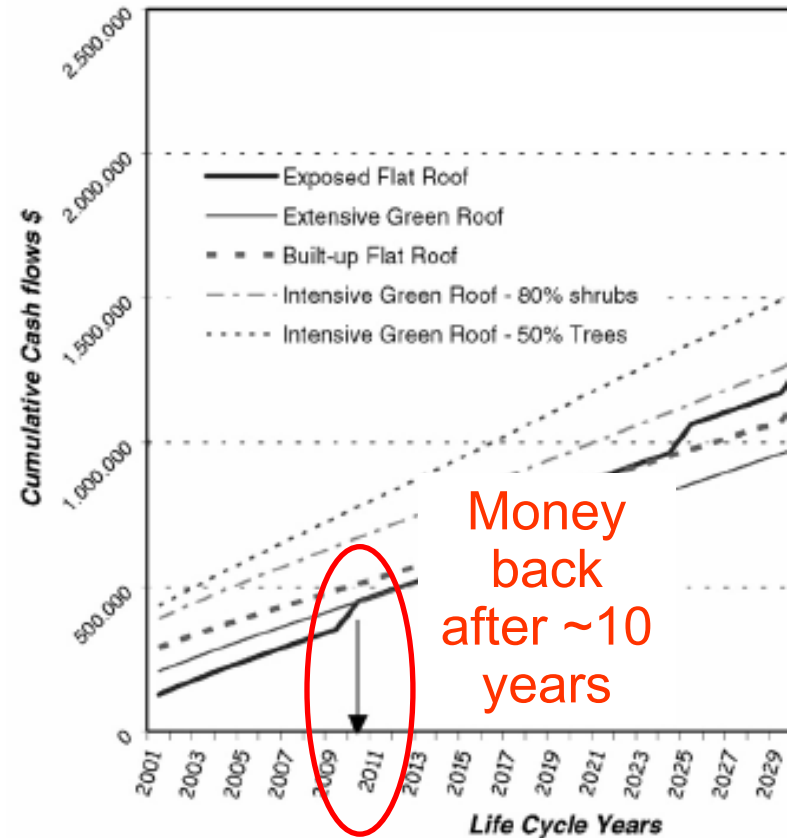
Photograph [livingroof.org](http://livingroof.org)





# General benefits - the individual

- Reduced building, heating and cooling costs
  - Insulation properties of green roofs
- Protection of roof membrane
  - Much lower temperature range  
→ less cracking due to expansion & contraction
  - Protection from UV radiation
  - Protection from mechanical damage e.g. hail, walking



Wong et al. (2003)  
for Singapore



# General benefits - wider community

- Reduction in the urban heat island effect
  - Reflects much more short-wave radiation back into the atmosphere
  - Increased evaporative cooling
- Aesthetic & amenity value
  - Amenity value if roof access, but also if overlook the roofs
- Re-use of 'waste' demolition aggregates
  - Rising transport & landfill costs → over-availability of materials
- Improvement in air quality
  - Filtering out & taking up air pollutants, raising humidity, etc



Photograph Rossa Donovan



Photograph Adam Bates



# Ecological benefits

- Can design for biodiversity
  - Many possibilities e.g. meadow, heath, open riparian habitats
  - Research focus on brownfield type habitats → brown roofs
    - Threatened urban habitat
    - Like for like mitigation for habitat lost during construction in urban areas
- Use as stepping stone linking habitats → Habitat networks
  - Re-colonisation after local extinction
  - Allow species to respond to climate change



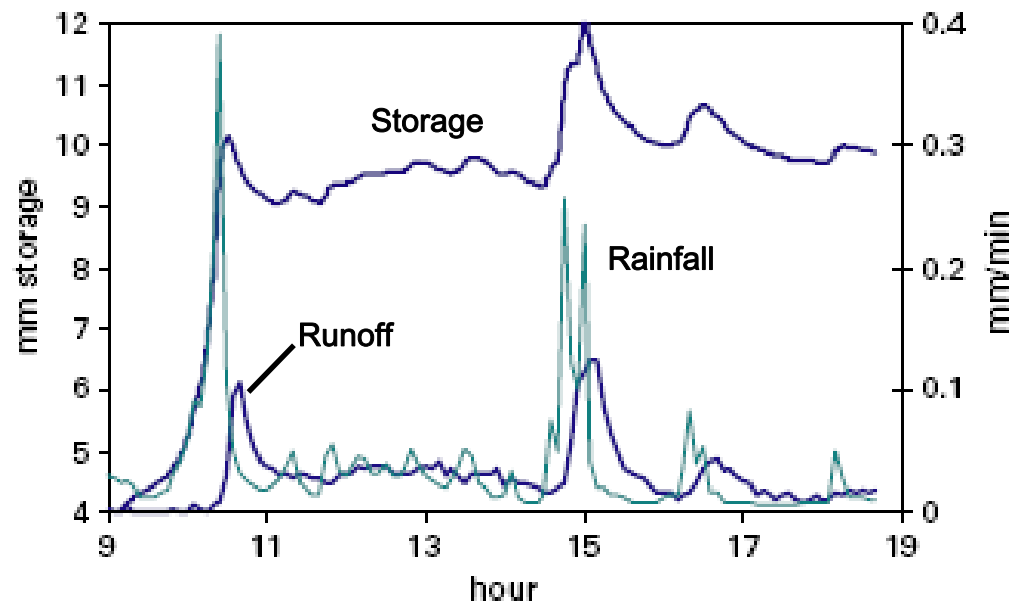
Photograph Craig Churchill

Black redstart (*Phoenicurus ochruros*) – schedule 1, fully protected species

# Urban water management benefits

Green roofs can potentially:

1. Reduce roof runoff intensity → reducing flooding & pressure on drainage infrastructure
2. Improve ecological conditions in streams
  - Lower hydrological disturbance
  - Lower influx and re-suspension of pollutants
  - Remove pollutants from precipitation in the roof substrate
3. Provide water for non-potable uses such as toilet flushing & garden watering



E.g. from Bengtsson *et al.*  
(2005) thin (30mm) *Sedum*  
roof





# A solution to multiple problems?

- **Green roofs are not a panacea**
- There are likely to be trade-offs between the various advantages
  - E.g. 100% vegetation cover (*Sedum*) good for water retention, bad for biodiversity
  - E.g. 100% vegetation cover often requires fertiliser, bad for runoff quality
- **Our research focuses on brown roofs designed for biodiversity & examines their propensity for use in sustainable urban water management**



# Can brown roofs replicate brownfield habitat?

## Controlled design issues

- Aggregate depth & size distribution
- Effect of drainage layer
- Seeding mix & density
- Additional biodiversity measures (e.g. dead wood, sand piles)
- **Aggregate material used → research focus**



Photograph Rossa Donovan

# Can brown roofs replicate brownfield habitat?

## Un-controlled issues

- Different microclimate on roofs
  - Much stronger winds → high evapotranspiration, plant damage, etc
  - Lower max. & higher min. temperature → fewer frosts, longer growth period
- **Height effects on dispersal & habitat utilisation → research focus**
  - **Can species colonise?**
  - **Can species move between habitats?**
    - Genetic isolation
    - Local extinctions
    - Use in habitat networks





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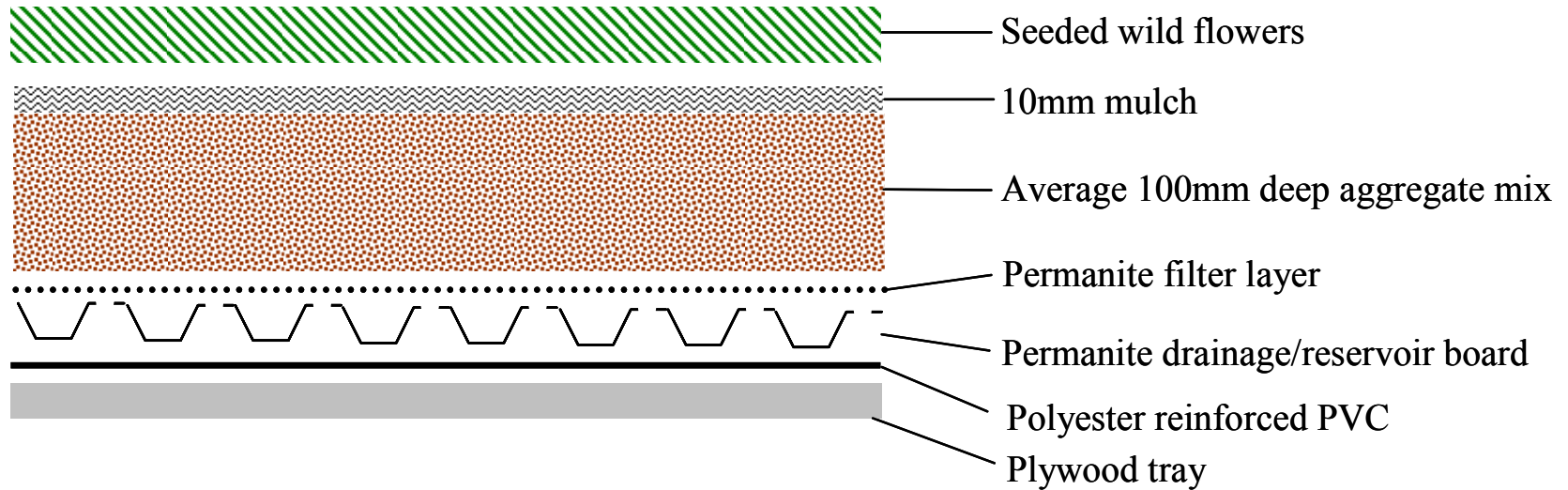
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# Experimental design



- 35 experimental (8' x 4') trays on 5-floor campus roof
- 7 different mixtures of recycled aggregate and mulch used (crushed demolition waste, crushed brick & incinerator bottom ash)

# Designed primarily for biodiversity

- Low nutrient substrates  
→ higher diversity  
because the harsh  
environment prevents  
competitive exclusion by  
species that can use  
nutrients efficiently
- Seed mix based on  
species of local  
brownfields & species  
known to thrive on  
brown roofs



Corn cockle  
*Agrostemma githago*  
Photograph Josef  
Hlasek

Great mullein  
*Verbascum thapsus*  
Photograph Jarmo  
Holopainen





# Ecological monitoring

- Fortnightly sampling in summer months (less frequent in winter)
- Vegetation surveys, pitfall trapping, bird surveys & sweep netting
- Flowering plants, beetles, butterflies, birds, spiders, bees & wasps target groups
- Aims to identify which substrate most favourable
  - Biodiversity, number of rare species & their similarity to brownfield communities



Little ringed plover  
*Charadrius dubius*  
Photograph Jarmo  
Holopainen



Wall butterfly  
*Lasiommata megera*  
Photograph Paul Opler



# Hydrological & meteorological monitoring

Measuring local weather conditions including rainfall with a weather station sited on the roof

Measuring hydrology with v-notch weirs

- How much is the through-flow delayed?
- How much is lost through evapotranspiration?
- Can it be modelled e.g. using soil characteristics & % vegetation cover?



# Water quality monitoring

- Water quality compared to that of precipitation
- Variety of measurements
  - pH, suspended sediments, nitrate, sulphate, phosphate, aluminium, arsenic, copper, lead, iron, presence of coliform bacteria, *E. coli* etc
  - Photometry, enzyme substrate tests & ICPMS
- Change over time (first-flush, vegetation development)?
- How is water quality affected by the aggregate mixture used?

BedZED (Beddington  
zero energy  
development)  
Photograph Bill Dunster





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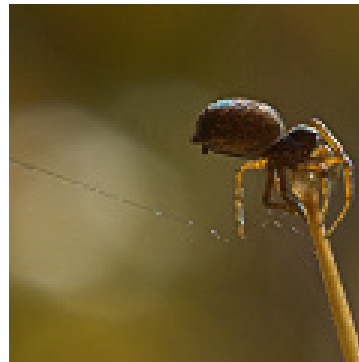
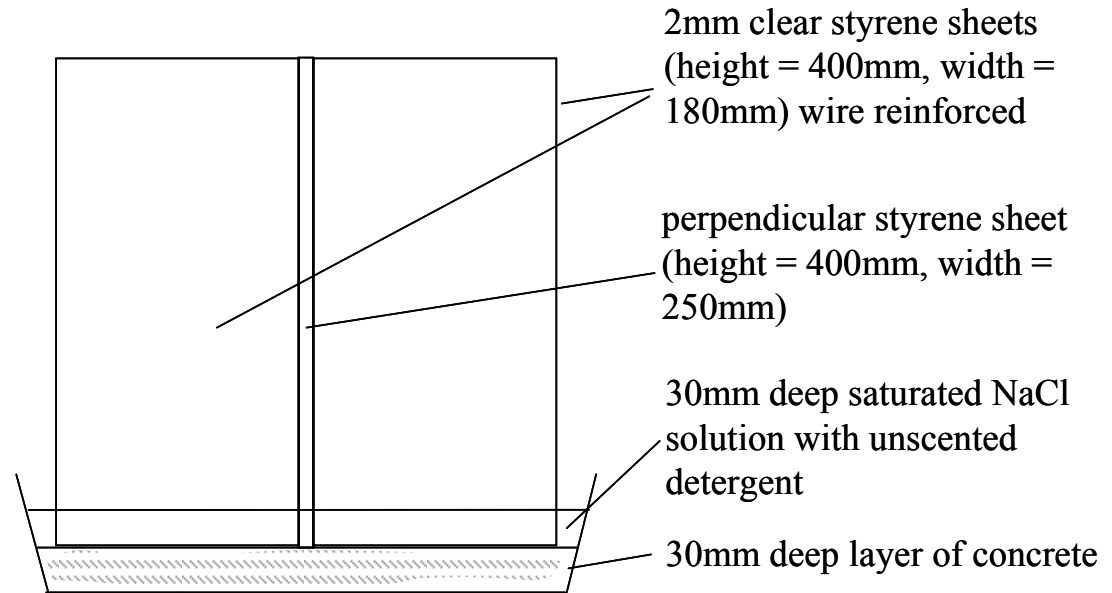
# Experimental design

- 6 ground sites and 7 roof sites sampled on campus
  - Ground sites → ruderal to mown grass sites
  - Roofs → vary widely in height (1-6 stories) & character (e.g. type of safety parapet)
- 12 seed traps, 3 window & 3 pan traps installed at each site
- Multivariate ordinations used to assess e.g. effect of proximity to seed source, height above ground, etc.



# Invertebrate study

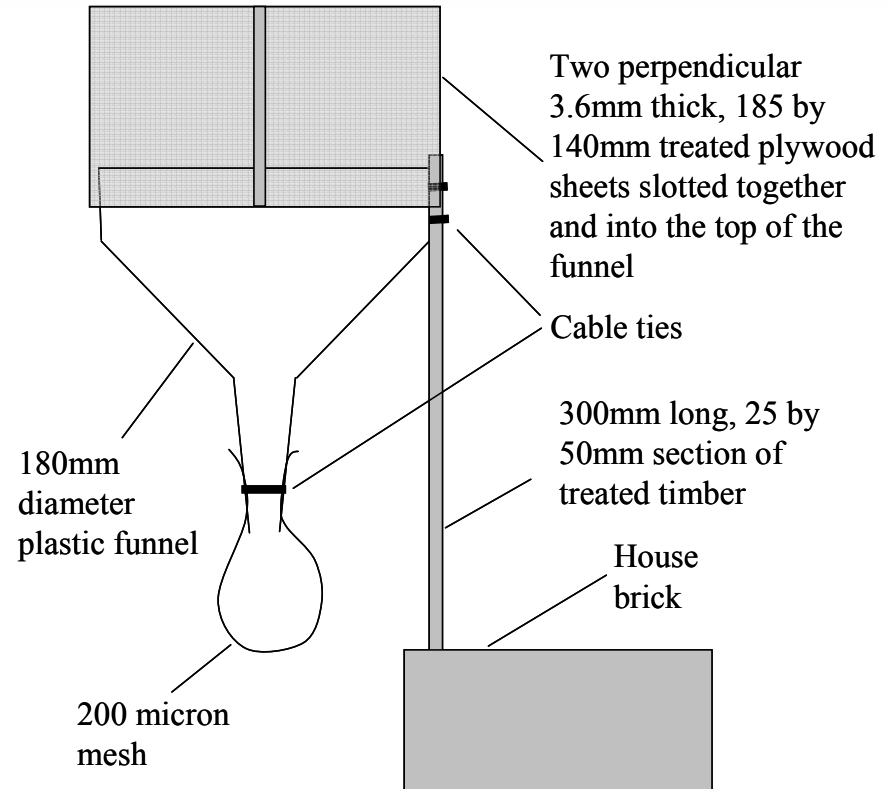
- Bulk monthly samples except for winter
- Reinforced window traps
- Multi-coloured pan traps
  - Red, yellow, white & blue → attract wide range of invertebrates



Ballooning spider

# Seed study

- Monthly samples except for winter
- Seeds grown on when necessary for identification
- Seed morphotype recorded (e.g. winged, plumed, fruited)



Cornflower  
(*Centaurea cyanus*)

Great Mullein  
(*Verbascum thapsus*)



Dandelion (*Taraxacum officinale*)



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- Dusty Gedge & [www.livingroofs.org](http://www.livingroofs.org) for permission to use some photographs and information
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