

A tale of three extensive greenroofs: developing resilient local substrates and plants



Introduction

- NZ greenroofs – drivers and barriers
- Research programme
 - client briefs
 - plant identification & testing
 - substrate identification & testing (FLL& local criteria)
 - scaling up from lab to field
- Revisiting client briefs



NZ extensive greenroofs

- Often 'one-offs' on 'alternative' dwellings

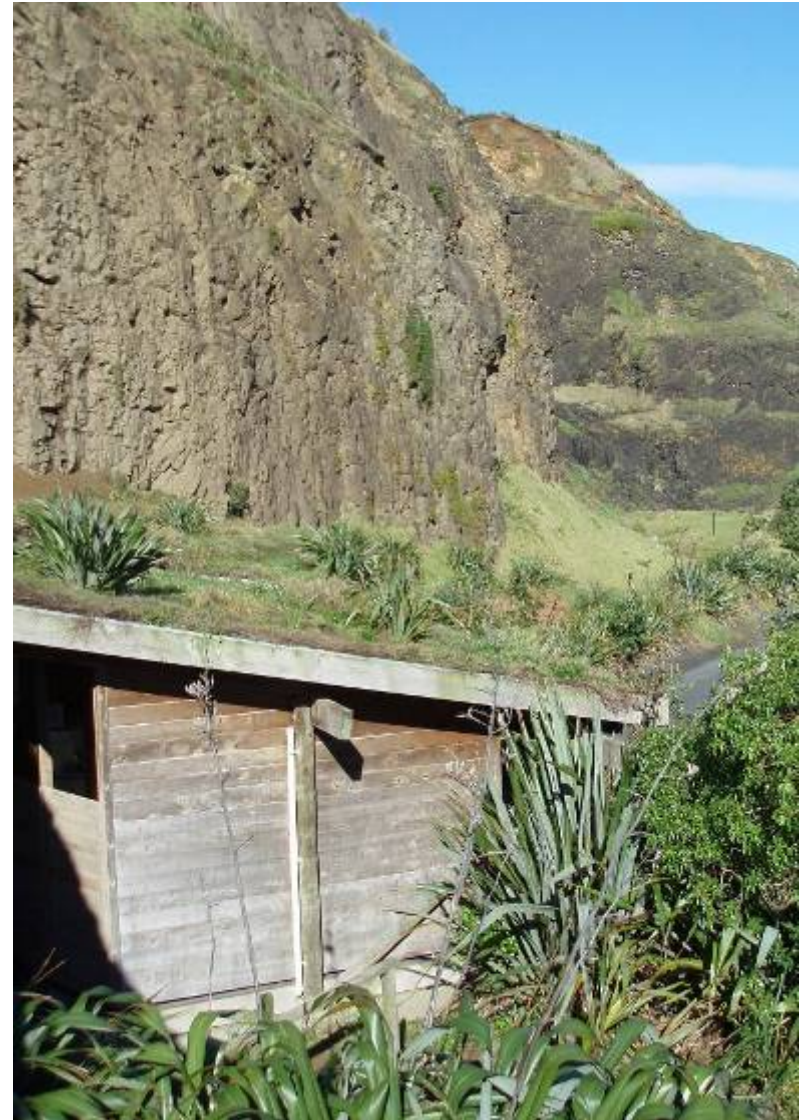
Key NZ drivers:

- Landscape mitigation (often semi-extensive roofs)
- Mitigation of impervious surfaces by reducing peak & total stormwater volumes (...Zinc runoff reduction, noise reduction, insulation, biodiversity, urban heat island...)



Barriers to extensive greenroofs

- Sparse technical knowledge and incomplete guidelines (re substrates & native plants)
- No local field data to quantify benefits, espec. stormwater
- Tiny local industry (increased cost, risk, insurance)
- No local incentives, often increased consent costs
- Few viewable examples on 'mainstream' structures



A solution...

Waitakere City and Auckland Regional Councils funded:

- Two greenroofs
- Development of a technical design standard (substrate & plants)
- Collection of performance data

This leveraged funds from:

- Landcare Research (sheds, staff)
- Government PGSF: Low Impact Urban Design (biodiversity)
- University of Auckland School of Engineering (staff & equipment)



The Waitakere Brief

Design & monitor a green roof with native plants:

- ≤ 150 mm deep and < 300 kg/m² saturated* weight
- low maintenance (no watering after establishment)
- provides habitats/food for insects, birds
- aesthetically attractive (texture, seasonal colour, form)



The Auckland Brief

Produce a design standard for extensive greenroofs suitable for retrofits that maximises stormwater mitigation

We interpreted this as:

- Design greenroofs $<100 \text{ kg/m}^2$ saturated* weight using local materials that store 'every day' rain events & $>80\%$ plant cover
- Develop a hydrological model with sub-daily time step



Plant selection

- Native plants identified by ecologists, growers
- Also surveyed walls, roofs, cliffs, exposed habitats with thin substrates (exotics & natives)
- Pot plants into greenroof substrate & ‘challenge’



Spontaneous greenroofs

Often have afternoon shade,

Often inputs of leaf litter

Often receive runoff

Plants include canopy epiphytes



Plant lessons (natives)

- Ensure nursery weed hygiene
- Specify height & form for variable species (prostrate, low-branched)
- Include prolific seeders and stolon spreaders to speed cover and recovery
- Visibility is important for 'public' roofs: upright growth form (tussocks), contrasting colours
- Shady, deeper refugia critical for very thin roofs



Plant outcomes (exotics)

- Plug shape, length influence stability
- Instant mats well received
- Sedums outperform natives at ≤ 70 mm depth
- Main weeds cosmopolitan
- Woody & bird-dispersed weeds influenced by local seed sources – control prior to greenroofing



Substrate: standards and tests

FLL 'Property reference value'	Rationale and target value (TV)	FLL method (NZ equivalent)
Water permeability*	Avoid ponding of water TV \geq 0.01 cm/sec (360 mm/hr)	Rate of water flow thru saturated media using falling head (=Ksat with specified base plate)
Maximum water capacity *	Indicates plant water supply 'Normal' winter operating weight (dead weight) for structural support calcs TV \geq 20% v/v	Water content 2 hours after draining from saturation (= Field capacity, c.0.5 kPa tension)
Air volume at maximum water capacity *	Confirm adequate air volume for plant growth. TV \geq 10% v/v	Difference between total pore volume and water content at maximum water capacity (= Field Air Capacity)
Granulometric distribution*	TV \leq 7%w/w 63 microns TV \geq 25% gravels (\leq 4mm) 0% > 10–12 mm (flat roofs <100 mm deep)	Mesh of screens specified (<63 microns = clay+silt) (No dispersion or oxidation of OM)

Best substrates are light with high permeability & supply air and water for plants

Substrate testing

Components (% v/v)			OM type	Max water capacity (75 mm depth)	Max. Water Capacity	Water Permeability
Pumice 4–8 mm	Zeolite 0.5–2mm	OM		TV <100 kg/m ²	TV >50%	TV ≥ 0.10 cm/sec
80	10	10	B+Peat	96.7	55.0	0.07
70	10	20	B+Peat	100.5	57.1	0.04
80	10	10	B	94.2	47.3	0.10
70	10	20	B	102.9	47.4	0.04
80	10	10	B+Coir	95.1	45.9	0.10
70	10	20	B+Coir	99.0	50.2	0.00

-> hard to meet permeability & dead load targets without compromising water supply

Potential aggregates

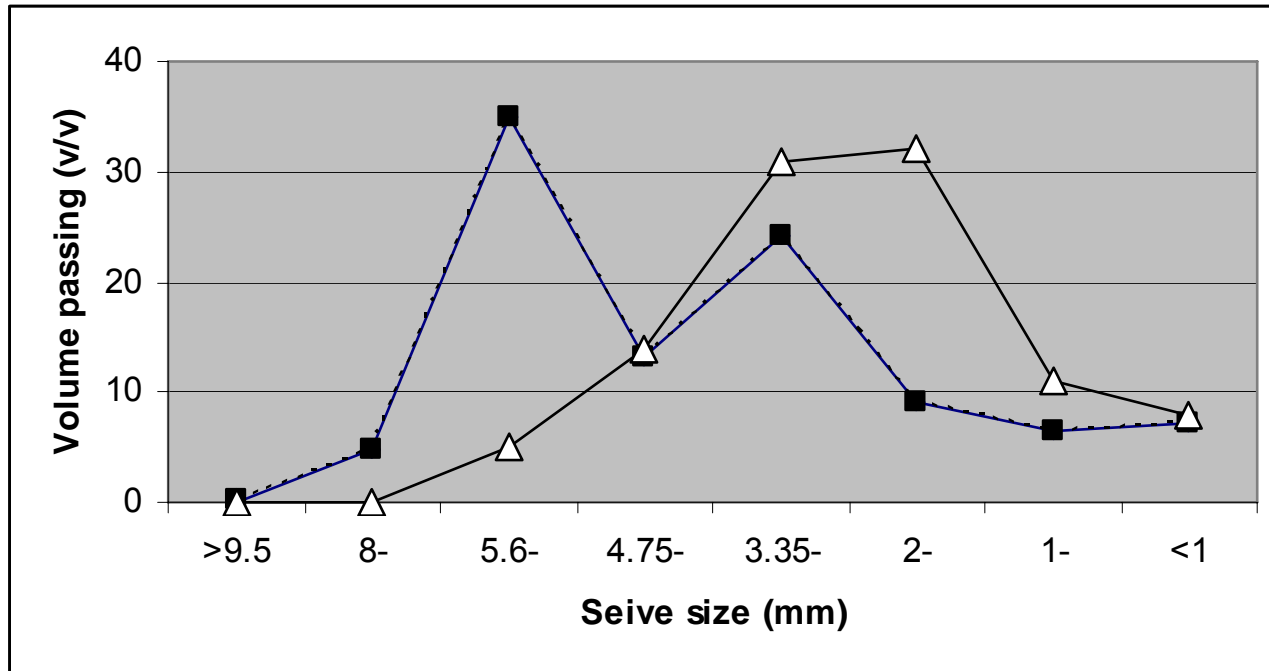
Aggregate is 80-90% v/v of substrate;

Our dry BD target <800 kg/m³ (c. 600 ideal)

- Pumice
- Perlite
- Zeolite
- Soils
- Scoria
- Vermiculite
- Crushed brick/concrete
- (no expanded clay/slate/shale)



Substrate inconsistency



- Particle size distribution specified was inconsistent with that supplied, varied when supplied in bulk, and could vary over time
- FLL particle size envelope does not link to permeability or weight

Substrate: organic sources

Key factors (\$ less important):

- Product consistency in bulk supply, no weeds*
- Contributes fines to increase moisture & nutrient storage (Cation Exchange Capacity)
- Stable over c.5 years to avoid shrinkage, N leaching, discoloured runoff (C:N ratio)
- Contribution to weight
- High P and Cu in some products (Olsen P)
- Most products met pH & salts guidelines

Substrate development: scaling up from lab to field

- field mixing after overnight rain (& weight conversion)
- ferocity of mixing increased fines
- residue in mixing tank

Substrate	Weight at MWC (kg/m ³)		Dry Bulk Density (kg/m ³)	Permeability (cm/sec)
	50 mm	70 mm		
LAB P:Zeolite:B	65	86	581	0.096
FIELD P:Zeolite:B	88	118	839	0.007
LAB P:Bark	65	86	586	0.101
FIELD P:Bark	86	116	1003	0.005

Response to scaling issues

- Changed mixing method (low impact, no residue)
- Increase substrate resilience (zeolite change from 3-7 mm to 1-3 mm)
- Mix by volume only or have undercover stockpiles (espec organic component)
- New pumice supplier



Third generation substrate

- Repeatable, consistent, product
- Resilient to changes in moisture content and compaction

BUT

- Does not use on-site sources (soil, leaf mould)



Meeting client expectations

not 'green' enough in summer



Meeting client expectations

- Requires weeding of innocuous species (public viewing window) & problems (legumes, shrubs)
- Starting biodiversity push (geckos, invertebrates)



Collaborators

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Supporters



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Blue Pacific
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