How to Build a Greenroof Using Native Vegetation

By Steven Campbell and Robert Franco

One way to enhance and restore ecological functions to the urban landscape is to build a 'greenroof', a living, vegetative landscape sitting atop a roof. Other names for the greenroof include 'living roof', 'eco-roof', 'rooftop green', 'floral crown', 'fuzzy-top', 'soft-loft', and 'shingle-tingle'. Shingle-tingles can reduce the total volume of storm water runoff from a roof by 50-60 percent. According to the Pomegranate Society, "the soil retains 90-100% of the critical first hour of heavy rainfall that can overwhelm storm water management systems." Fuzzy-tops can also improve the water quality going into water channels by filtering sediment and other pollutants that enter the watershed from unmitigated storm water. Soft-lofts also have the added benefit of reducing the heat retention that contributes to the heat island effect. Greenroofs can maintain temperatures 20-60 degrees cooler than barren, lifeless roofs in the dog-days of summer. Floral crows also have the added advantage of creating wildlife habitat, appealing to the human appetite for aesthetic surroundings, reducing noise and air pollution, and buffering building temperatures. Now let's explore how to greenroofs can be built with low-budgets and native vegetation!

How to Build a native Greenroof

Before building your green roof there are some considerations you must address such as:

Objectives	Site	Maintenance	Costs
Nature	Space available	Access to roof	Substrate and plant materials
Amenity	Conditions	Management of vegetation and facilities	Hard landscaping

Informal recreation	Aspect	Irrigation system	Maintenance and irrigation systems
Energy conservation	Height above ground		Strengthening of structure
Improvement of microclimate	Slope of roof		Equipment for erecting green roof materials (cranes etc.)
Gaining of planning permission	Strength of roof (load bearing)		Professional fees
Integration within green development	Shelter		
Protection of roof	Distance from other greenspace		
	Wind speed and direction at roof height		

Worthy of Note

Slope- roofs with pitches greater then 30% will often run into problems of slippage and slumping of materials. Flat roofs can be a problem as well. Too flat of a roof can lead to difficulties of drainage which can then lead to roof damage, root rot and damage plants. The steeper the slope the more care should be taken to make sure the plants near the top are the most drought-tolerant because they will get less water.

Climate- plants can struggle in extreme climates or in windy areas and green roofs have not been overly successful in sub-tropical or tropical environments. Tropical conditions support plant growth immediately and on any type of substrate, therefore weeds become a big problem.

Insurance- check with your insurance company before building to make sure that your policy will cover it your greenroof.

Zoning- ask city officials if zoning laws will allow you to build a greenroof on your house. Sometimes there are incentives for these sort of things. They recommend you trying to plant a greenroof on a shed or garage before your house to ensure success and minimize loss.

Structure- you may want to consult with an architect to make sure that your roof will support the weight of the design you have in mind. (The weight of a roof with a thin layer of soil and sedums is approximately the same as a roof of clay tiles).

Conditions, Covenants, and Restrictions (CC and Rs)- many subdivisions have C,C, and Rs that restrict the homeowner from changing the look of the neighborhood. It is a

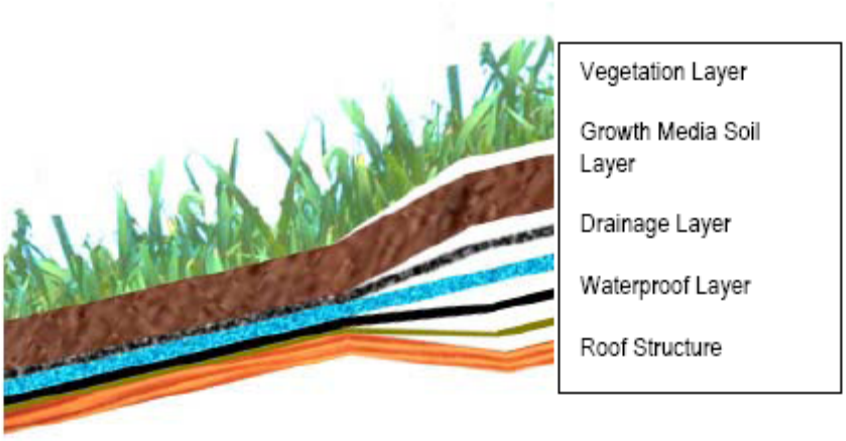
good idea to check with your neighborhood association for any C,C, and Rs regarding green roofs.

In order to create a successful green roof you must have a strong link of communication between all members of the building team to ensure a high-quality job. Aims and objectives must be clear to everyone early on in order to avoid any confusion at the beginning of each stage:

- The amount of weight the roof will sustain
- The design of waterproofing and the irrigation system
- Ways in which all materials (soil, plants, tools etc.) will get onto the roof

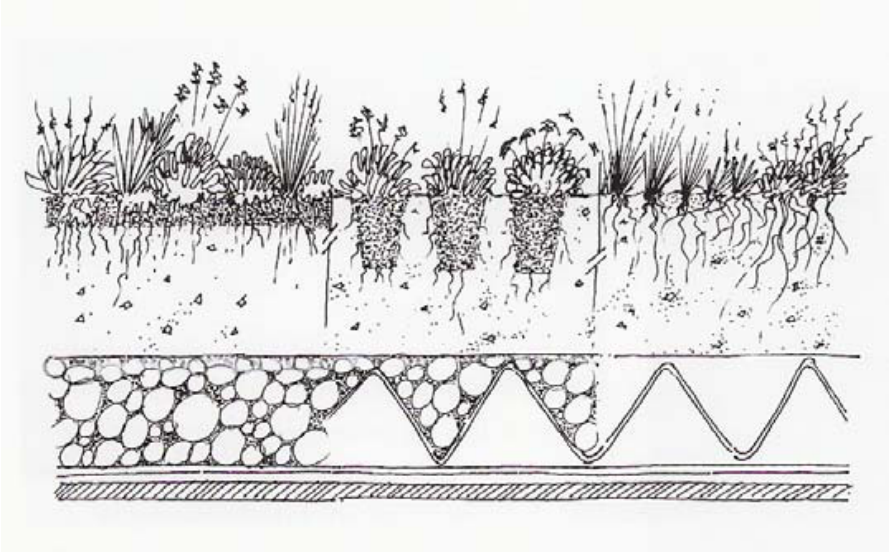
For all these reasons it is important to have the designer of the rooftop involved in all the different stages of development.

It would be much more convenient if all the houses today were built with the same structural design but this in not the case. There are lots variations in roof designs that will require specific changes but for the most part there is a basic layout that is used on all roofs as pictured below:



Waterproof layer- This is the most expensive part of all the layers but the most important as well. There are a variety of waterproof layers available ranging from single-ply, heavy duty rubber sheets to roll-on liquid layers.

Drainage layer- There is lots of variation in this as well ranging from simple fabrics to systems that channel water through v-shaped troughs. Roofs with less then 5 percent pitch must have a drainage layer. The picture below shows the variety of drainage layers available.



Growth Media- Each soil mix should retain moisture, drain out the excess water, provide and absorb nutrients and keep plants anchored. The soil mix can vary greatly depending on what type of plants and proposed method of irrigation. Soil depth can be as little as 10mm to 2000mm all depending on the root requirements of your plants.

	Depth/mm
Grass	200 - 250
Herbaceous plants and shrubs	500 - 600
trees	800 - 1300

Native Roof Vegetation- Most of the greenroofs today are being planted with hardy, drought-tolerant, low-maintenance species such as Sedum, Delosperma, and Sempervivum. In the northwest, studies are being done to see what native plants can be used. So far, native mosses have been successful as greenroof material covers. Mosses grow naturally on northwest roofs with moist wood shingles because they are adapted to damp, low nutrient environments. Roofs also provide mosses with large areas of little to

no competition. Some mosses have also adapted to drought conditions by using the process of poikilohydry, drying up and going dormant in the absence of water. The ability to withstand moderate drought and thrive in damp, low-sunlight, low-nutrient conditions adds to the light-weight, low-density properties that make mosses the leading candidates for native roof vegetation in the northwest.

Moss Propagation- Most mosses must be collected, since they are not widely grown by nurseries. Moss can be lifted from substrate by hand and placed into a paper receptacle. It may be necessary to make note of the conditions under which the moss grows, such as moisture, substrate, exposure, associated vegetation, and elevation.

To grow moss in flats for transplanting, it is best to use an equal mix of builder's sand and weed-free compost. If transplanting moss sods, use a mix of 1/3 acidic loam, 1/3 builder's sand, and 1/3 humus with a dash of water absorbent polymer crystals. Mix the crystals into the soil and layer the bottom of the container with ½" of hydrated crystals. This increases the drought tolerance of the moss.

There are several additives that could be used to stimulate moss growth, such as fertilizer, egg whites mixed with water, plain milk, unsalted buttermilk, or beer (2). Do not add any traces of calcium. Calcium kills moss.

Most mosses prefer soil pH to be around 5.5. Soil preparation for moss inhabitation also includes thorough weeding, raking, and removal of debris.

Plant moss in hand-sized sods at intervals of 1'. It may help to fix the moss into place with bent toothpicks or bobby-pins. Moss needs to be watered daily until acclamation occurs.

Moss spores can be propagated by rubbing dried collections of moss across a mesh screen with ¼" – 3/8" openings.

Shrubs and Perennials Associated with Moss

Shrub genera and species: Euonymus occidentalis, Kalmia microphylla ssp. occidentalis, Mahonia, Rhododendron, Vaccinium, and Viburnum

Perennial genera and species: Asarum caudatum, Camassia, Carex, Cimicifuga elata, Cornus canadensis, Dicentra, Disporum, Dodecatheon, Erythronium, Fragaria vesca, Galium, Linnaea borealis, Luzula, Oxalis, Smilacina, Streptopus, Thalictrum, Tiarella, Tolmiea menziesii, Trillium, and Viola

Moss Species suited for Greenroofs.

Genus:	Species:	Geographically native to:	Native habitat:	Notes on propagation:	Additional comments:	Source:
Atrichum	selwynii	W. WA and W. OR's coniferous forests	Acidic soils in mesic areas		Found with *Dicranella*	Vitt, Marsh and Bovey 60
Aulacomnium	palustre	All WA and all OR's artic-alpine tundras, subartic-subalpine forests-tundras, coniferous forests, and peatlands		Likes water's edges; keep moist		Vitt, Marsh and Bovey 78; Schenk 179
Barbula	convoluta	All WA and all OR's dry coniferous forests, deciduous forests, and grasslands-savannas		Grows best on sunny ground		Vitt, Marsh and Bovey 122; Schenk 179
Brachytheciu m	rivulare	W. and far E. WA and W. OR's subartic-subalpine forests-tundras, and coniferous forests		Grows best on shady ground	Found with *Philonotis fontana*	Vitt, Marsh and Bovey 97; Schenk 180
Brachytheciu m	salebrosum	All WA, except SE corner, and NW OR's subartic-subalpine forests-tundras, dry coniferous forests, and deciduous forests		Grows best on shady ground		Vitt, Marsh and Bovey 98; Schenk 180
Brachytheciu m	asperrimum	W. WA and NW OR's subartic-subalpine forests-tundras, and	Wet grounds in lowland coastal forests	Grows best on shady ground		Vitt, Marsh and Bovey 99; Schenk

		coniferous forests				180
Bryum	caespiticium	All WA, except SE corner, and W. OR's alpine-artic tundras, subartic-subalpine forests-tundras, dry coniferous forests, deciduous forests, and grasslands-savannas	Dry, calcareous soils, especially in weedy situations	Grows best in sandy soil in sun		Vitt, Marsh and Bovey 67; Schenk 181
Bryum	pseudotriquetrum	All WA and all OR, except SE corner, in alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, deciduous forests, and peatlands		Grows best in sandy soil in sun		Vitt, Marsh and Bovey 67; Schenk 181
Bryum	argenteum	All WA and all OR's alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, deciduous forests, and grasslands-savannas	Sandy soils	Grows best in sandy soil in sun	Silver color is unique to *B. argenteum*	Vitt, Marsh and Bovey 68; Schenk 181
Bryum	miniatum	W. WA and W. OR's coniferous forests		Grows best in sandy soil in sun	Forms golden to wine colored cushions	Vitt, Marsh and Bovey 68; Schenk 181
Calliergon	stramineum	W. WA's alpine-artic tundras, subartic-subalpine forests-tundras, and peatlands	Swamps, fens, and peaty grounds	Grows best on damp ground; quick growing		Vitt, Marsh and Bovey 88; Schenk 185

Calliergon	sarmentosum	NW WA's alpine-artic tundras, subartic-subalpine forests-tundras, and peatlands	Seepy, acidic cliff shelves and wetlands in alpine-artic tundras and subartic-subalpine forests-tundras	Grows best on damp ground; quick growing		Vitt, Marsh and Bovey 89; Schenk 185
Calliergonella	cuspidata	NW WA and NW OR's peatlands		Grows best on damp ground; quick growing	Common in urban areas as a weed	Vitt, Marsh and Bovey 87; Schenk 185
Ceratodon	purpureus	All WA and OR's alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, deciduous forests, and grasslands-savannas	Montane and boreal forests	Grows well on all soil types	Common on rooftops	Vitt, Marsh and Bovey 130; Schenk 186
Climacium	dendroides	W. WA and NW OR's alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, deciduous forests, and peatlands	Mesic organic soils	Grows best on wet soils in shade to nearly full sun		Vitt, Marsh and Bovey 113; Schenk 191
Dicranella	varia	W. WA and W. OR's subartic-subalpine forests-tundras, coniferous forests, and deciduous forests	Exposed, moist, inorganic soil			Vitt, Marsh and Bovey 126
Dicranum	scoparium	All WA and all OR, except SE corner, in alpine-artic tundras, subartic-subalpine forests-tundras, and coniferous forests	Sheltered, moist, spruce-fir forests	Propagates well using the transplant method; grows best in deep, peaty humus in full sun to 3/4 a day in full shade		Vitt, Marsh and Bovey 124; Schenk 191

Dicranum	polysetum	E. WA's subartic-subalpine forests-tundras and dry coniferous forests	Upland boreal and montane forests	Propagates well using the transplant method; grows best in deep, peaty humus in full sun to 3/4 a day in full shade		Vitt, Marsh and Bovey 124; Schenk 191
Dicranum	undalatum	W. WA's peatlands	Organic soils in muskeg habitats	Propagates well using the transplant method; grows best in deep, peaty humus in full sun to 3/4 a day in full shade		Vitt, Marsh and Bovey 125; Schenk 191
Drepanocladus	uncinatus	All WA and all OR, except SE corner, in alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, and peatlands		Easy to propagate; likes upland wood conditions with lots of sun;		Vitt, Marsh and Bovey 90; Schenk 196
Eurhynchium	pulchellum	All WA and all OR's alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, deciduous forests, and grasslands-savannas	Boreal and montane forests, especially aspen forests	Grows taller and fluffier when in shade		Vitt, Marsh and Bovey 94; Schenk 197
Hypnum	lindbergii	NW WA's alpine-artic tundras, subartic-subalpine forests-tundras, dry coniferous forests, deciduous forests, and peatlands	Wet fen habitats, especially at bases of sedge clumps	Easy to transplant; likes upland ground		Vitt, Marsh and Bovey 102; Schenk 201
Leucolepsis	menziesii	W. WA and W. OR's wet coniferous forests	Humid coastal forests, on logs,	Grows best in deep, fertile sand in part		Vitt, Marsh and Bovey

			boulders, and soil	shade, or boggy ground in full sun		72; Schenk 208
Philonotis	fontana	All WA and all OR's alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, and peatlands	Calcareous seepages or springs	Grows best in moist soils with good drainage		Vitt, Marsh and Bovey 81; Schenk 223
Plagiothecium	denticulatum	W. WA and W. OR's alpine-artic tundras, subartic-subalpine forests-tundras, and coniferous forests	Swampy soil, moist humus, and grassy fens	Overpowers other mosses, but doesn't hinder ferns' or flowering plants' growth; grows best in shady, humus soil; successful, but slow propagation	Makes woodland carpets	Vitt, Marsh and Bovey 101; Schenk 224
Plagiothecium	undulatum	W., SE WA and W. OR's wet coniferous forests	Shaded, low-elevation rainforests on logs, boulders, and soil	Overpowers other mosses, but does'nt hinder ferns' or flowering plants' growth; grows best in shady, humus soil; successful, but slow propagation		Vitt, Marsh and Bovey 101; Schenk 224
Pohlia	cruda	All WA and all OR's alpine-artic tundras, subartic-subalpine forests-tundras, and coniferous forests	Inorganic soils and peat banks	Easily cultivated if not allowed to become too hot and/or dry	Low, matting moss	Vitt, Marsh and Bovey 69; Schenk 226
Pohlia	filum	Far W. WA and all far W. OR's alpine-artic tundras and subartic-subalpine forests-tundras	Exposed mineral soil	Easily cultivated if not allowed to become too hot and/or dry	Low, matting moss	Vitt, Marsh and Bovey 71; Schenk 226
Pohlia	longibracteata	Far W. WA's wet coniferous forests	Sandy cliffs and banks of coastal forests	Easily cultivated if not allowed to become too hot and/or dry	Low, matting moss	Vitt, Marsh and Bovey 70; Schenk

						226
Pohlia	nutans	All WA and all OR's alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, deciduous forests, grasslands-savannas, and peatlands	Montane and boreal forests on soil and rotting logs	Easily cultivated if not allowed to become too hot and/or dry	Low, matting moss	Vitt, Marsh and Bovey 70; Schenk 226
Pohlia	wahlenbergii	All WA and W. and far E. OR's alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, and deciduous forests	Boreal forests, along river banks	Easily cultivated if not allowed to become too hot and/or dry	Low, matting moss	Vitt, Marsh and Bovey 69; Schenk 226
Polytrichum	commune	All WA and all OR's subartic-subalpine forests-tundras, coniferous forests, and deciduous forests	Moist forests	Acclimates to new surroundings with constant watering; easy to transplant; grows best in full sun to 4/5 shade in any acidic soil; do not transplant from good soil to poor soil	Forms loose mats	Vitt, Marsh and Bovey 56; Schenk 226
Polytrichum	juniperinum	All WA and all OR's alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, deciduous forests, and grasslands-savannas	Disturbed prairie soils, and boreal and montane forest floors	Acclimates to new surroundings with constant watering; easy to transplant; grows best in full sun to 4/5 shade in any acidic soil; do not transplant from good soil to poor soil		Vitt, Marsh and Bovey 57; Schenk 226
Polytrichum	piliferum	All WA and all OR's subartic-subalpine	Sandy soils	Acclimates to new surrounding		Vitt, Marsh and

		forests-tundras, dry coniferous forests, and grasslands-savannas		s with constant watering; easy to transplant; grows best in full sun to 4/5 shade in any acidic soil; do not transplant from good soil to poor soil		Bovey 58; Schenk 226
Polytrichum	strictum	All WA and all OR's peatlands	Organic soils of boreal and montane peatlands	Acclimates to new surroundings with constant watering; easy to transplant; grows best in full sun to 4/5 shade in any acidic soil; do not transplant from good soil to poor soil		Vitt, Marsh and Bovey 57; Schenk 226
Pogonatum	alpinum	W. WA and W. OR's alpine-artic tundras and subartic-subalpine forests-tundras	Mineral soils of high elevations			Vitt, Marsh and Bovey 59
Pogonatum	contortum	W. WA's wet coniferous forests	Exposed mineral soils			Vitt, Marsh and Bovey 58
Pogonatum	urnigerum	W. WA's alpine-artic tundras and subartic-subalpine forests-tundras	Disturbed acidic, gravely, sandy soil			Vitt, Marsh and Bovey 59
Racomitrim	canescens	W. WA and W. OR's alpine-artic tundras, subartic-subalpine forests-tundras, and wet coniferous forests	Gravely soil and sandy outwash areas	Grows at a "satisfying" rate; repels many small weeds; performs best on slopes open to breezes		Vitt, Marsh and Bovey 134; Schenk 229
Rhytidiadelphus	loreus	W. WA and W. OR's wet coniferous forests	Lowland and montane forests as a dominant groundcove	Sturdy groundcovers; fairly fast growing; easily transplanted		Vitt, Marsh and Bovey 108; Schenk

			r	; competes with lawn grass		233
Rhytidiadelphus	squarrosus	W. WA and W. OR's subartic-subalpine forests-tundras, wet coniferous forests, and peatlands	Wet, grassy slopes and swampy areas	Sturdy groundcovers; fairly fast growing; easily transplanted; competes with lawn grass	Common weed of Seattle yards	Vitt, Marsh and Bovey 109; Schenk 233
Rhytidiadelphus	triquetrus	All WA, except SE corner, and W. OR's subartic-subalpine forests-tundras and coniferous forests	Forest floor vegetation	Sturdy groundcovers; fairly fast growing; easily transplanted; competes with lawn grass		Vitt, Marsh and Bovey 108; Schenk 233
Sphagnum	angustifolium	W. WA and NW OR's peatlands	Weakly ionic peatlands (poor fens)	Killed by alkaline and calciferous soil	Acidifies its soil; holds 20 times its dry weight in water	Vitt, Marsh and Bovey 54; Schenk 238
Sphagnum	fuscum	W. WA and central OR's peatlands	Ombrotrophic hummocks, either in true bogs or on isolated hummocks in ionically rich fens	Killed by alkaline and calciferous soil	Acidifies its soil; holds 20 times its dry weight in water	Vitt, Marsh and Bovey 55; Schenk 238
Sphagnum	girgensohnii	W. WA and NW OR's alpine-artic tundras, subartic-subalpine forests-tundras, coniferous forests, and peatlands	Shallow peatlands in forested habitats	Killed by alkaline and calciferous soil	Acidifies its soil; holds 20 times its dry weight in water	Vitt, Marsh and Bovey 54; Schenk 238
Sphagnum	magellanicum	W. WA's peatlands	Minerotrophic and ombrotrophic peatlands; forming moderate-size hummocks	Killed by alkaline and calciferous soil	Acidifies its soil; holds 20 times its dry weight in water	Vitt, Marsh and Bovey 53; Schenk 238
Sphagnum	papillosum	W. WA and W. OR's peatlands	Hummocks	Killed by alkaline and calciferous soil	Acidifies its soil; holds 20 times its dry weight in water	Vitt, Marsh and Bovey 53; Schenk 238

Sphagnum	warnstorfii	Far W. WA's peatlands	Calcareous habitats	Killed by alkaline and calciferous soil	Acidifies its soil; holds 20 times its dry weight in water	Vitt, Marsh and Bovey 55; Schenk 238

Conclusion

Incorporating more types of natural landscapes within our urban environments will help increase ecological functions, such as reducing runoff, increasing water quality and mitigating air pollution. Native greenroofs have a way of adding a softer touch to the hard and sterile environment that sits before many of us, while adding a place for nature to thrive. Native greenroofs offer great potential in the restoration of urban ecosystems. There will surely be many more studies done with using native vegetation and tools to increase wildlife value. The roof over the future looks green.

1. Johnston J and Newton J. 1993. Building Green: *A Guide To Using Plants On Roofs, Walls, and Pavements.* The London Ecology Unit. Pgs. 47-58.

2. Pomegranate Center. "Green Roof Manual, How to Replace your Dead Roof with a Living Landscape," 2005.
http://www.pomegranate.org/docs/greenroof.pdf

3. Richie, Megan, 2001. The Selection, Collection, and Propagation of Mosses for the Northwest Eco Building Guild's EcoRoofs.
http://www.hadj.net/green-roofs/MOSS.htm