

Introduction

Project Summary

We implemented four ecoroofs on our residence at 4510 NE Going St, covering a total of 1000 square feet with ecoroof soil mixes sourced from Philips Soil Products in depths ranging from 3.5" to 8". We implemented and planted two in October 2010, and two in June 2011. We have another 660 square feet of house roof we deemed too difficult to beef up adequately to support an ecoroof. We roofed this area in metal, and it all drains onto the sunspace, front porch, and carport roofs.

About Us

Tulsey Latoski and Norris Thomlinson have experimented at this site since 2006 practicing sustainable, low-work food production via a food forest, perennial vegetable garden, and chickens and bees.

Read more about our projects in general at <http://farmerscrub.blogspot.com>

Read ecoroof-specific blog posts at <http://farmerscrub.blogspot.com/search/label/Ecoroof>

View food harvest logs from our ecoroofs at <http://discountpermaculture.com/cgi-bin/harvest.py?ecoroof=1>

Email us at norristh@gmail.com

Design Goals

- Food production - We planned the ecoroofs for production of food crops either naturally adapted to our seasonal rains, or drought tolerant to make it through the summer.
- Reasonably low maintenance - We hope for minimum irrigation requirements, no more often than once every week or two. Once the perennial plants have fully established they shouldn't require much weeding.
- Human hang-out areas - We included space for humans to spend time eating, reading, or watching the ecoroof or the rest of the neighborhood below.
- Bird & insect habitat - Our food producing, perennial plants provide a diversity of flowers for insects through several seasons, and various seeds for birds to eat.
- Potential rabbit or chicken fodder - We envision rabbits potentially grazing on the roofs with human supervision. We planted a few plants which can either serve as human food or be cut and dropped to the chickens below.

Four Roofs - Details

Sunspace

392 ft² (13' 3" x 29' 7"): A newly expanded room whose roof we rebuilt from scratch. This roof slopes south with 1/12 pitch, and we constructed it with an ecoroof in mind. The west end receives full sun year round; the east end receives dappled morning shade from black locust trees from late spring through mid fall. It holds 5.5" of intensive B-4 soil mix.

~290 ft² of metal roof drains into this roof, evenly distributed along a ~28' line, depositing into the upper end of the ecoroof.



Since we have the quickest and easiest access from our kitchen to this roof, we planned it as our zone of most frequent harvest, concentrating leaf and flower crops here for frequent picking. The central 2' wide path extending the length of the roof doubles as a sitting area. The south, lower end of the roof overlooks the back yard, where our chickens free range, allowing for possible harvest and dropping of fodder to the chickens below. Rabbits may eventually range here, but they would require a ramp to get to it from their likely dwelling area on the garage roof.

Front Porch



136.5 ft² (7' 3" x 18' 10"): The front porch roof slopes north with about 1/12 pitch. It receives full sun year round. It holds 8" of intensive B-4 soil mix.

To access this roof, we have to walk from the sunspace roof up and over 20' of metal roof, so we planned this roof for less frequently harvested crops such as root crops, seeds, and berries.

~265 ft² of metal roof drains into this roof, with about 2/3 of that evenly distributed along a ~19' line dropping water from above into the upper end of the ecoroof. The other 1/3 coming into the ecoroof meets the soil perpendicular to the slope, allowing very little infiltration; this water mostly runs straight down the side of the soil to a drainage pipe directing it to the gutter.

Garage

245.3 ft² (11' 6" x 21' 4"): The garage roof slopes south with about 1.5/12 pitch. It receives afternoon shade from the house and from late spring through mid fall much of the roof receives dappled to heavy shade the rest of the day from black locust trees. It holds an average of 1.5" of extensive-E soil mix, but we created mounds of soil 3 - 3.5" high in between paths and areas of no soil.

We have a hang-out area for three or four people to gather and sit together in the sun, plus the path lower in the roof in the shade of the locusts allows one person to sit. As with the sunspace, the south end of this roof overlooks the chickens and could be used to grow fodder plants, though the thin soil depth limits the possibilities.



Carport



227.2 ft² (11' 9" x 19' 4"):

The carport roof slopes east with about 1/12 pitch. It adjoins the garage roof. It receives afternoon shade from the house. ~85 square feet of metal roof drops its water into the upper edge of this roof, with about 75% dropping into a single spot.

Two paths run the length of the roof, allowing for sitting in the sun or during the afternoon in the shade of the house. It holds an average of 1.5" of extensive-E soil mix, but we created mounds of soil 3 - 3.5" high in between paths and areas of no soil. The thin soil depth and mostly full sun exposure doesn't allow for much more than succulents and Alliums.

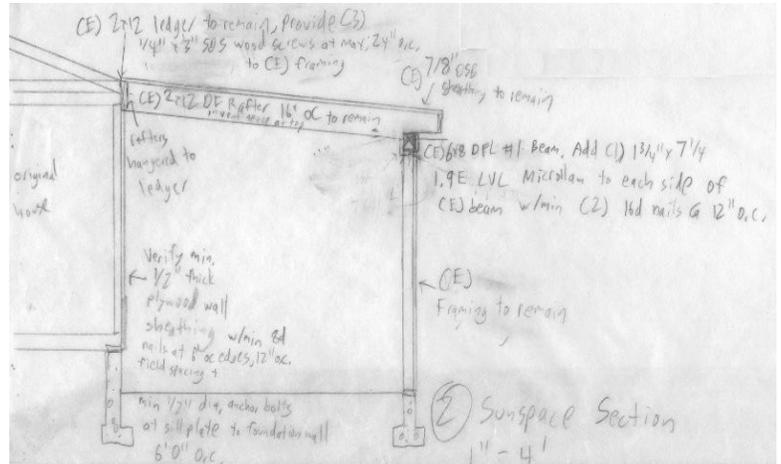
Structure & Layers

Structural Engineering

We worked with Ken Safe and Jeff Hartman at Miller Consulting Engineers to determine the necessary structural modifications to support a minimum additional ecoroof weight of 35 pounds per square foot (psf), allowing 5.5" of intensive soil mix:

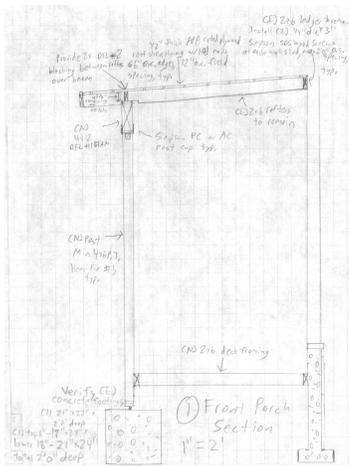
Sunspace

We had already built the sunspace with 2x12 joists on 16" centers, spanning ~12', sheathed with 7/8" tongue & groove OSB. The north wall of the sunspace is a standard 2x4 stud wall, with a 2x12 ledger attached with lag bolts to carry the joists. The south wall is a window wall, with multiple windows 34" wide with 2x6 studs between them on 3' centers. A 6x8 header spans the windows and rests on 6x6 posts (one 9' and one 12' span between posts).



Miller determined that the 2x6 studs between the windows were too weak to handle the load from the 6x8 header, and the header couldn't make the full 9' and 12' spans on its own. They recommended the retrofit of adding a 2x6 LVL to both the inside and outside face of the header to stiffen it up. They also had us add SDS screws to attach the 2x12 ledger to the house wall, as the existing lag screws weren't strong enough. Because the window wall had too few areas of plywood sheathing to provide adequate shear strength, they had us add plywood to the interior north wall of the room, calculating that the shear load could be transferred via the OSB roof sheathing to that interior wall.

Front porch



Our porch roof had existing 2x6 joists on 16" centers, spanning 67", sheathed with 1/2" plywood. One end of the joists hung from a 2x6 ledger nailed to the house studs; the other end rested on a 4x6 beam supported by 4x4 posts. Miller determined that we needed to use a 4x12 beam instead of the 4x6, and 4x6 posts set in poured concrete pads instead of the 4x4s on pre-cast pier blocks. They also had us add SDS screws to attach the 2x6 ledger to the house wall. These changes permitted 50 psf. (Zoom in within your PDF viewer to see details of the picture.)

Garage

Our garage roof has 2x6 joists on 24" centers spanning 10' 1", sheathed with 1/2" plywood. One end of each joist hangs from a 2x6 ledger lag bolted to the house; the other end rests on a 2x4 wall. Miller determined we would need one extra joist between each existing set for a final spacing of 12" on center, and we would need to strengthen the 2x4 wall.

Carpport

Our carport roof has 2x6 joists on 24" centers spanning 11' 2", sheathed with 1/2" plywood. One end of each joist hangs from a 2x6 ledger lag bolted to the house; the other end rests on a 4x6 beam support by 4x4 posts. Miller determined that we needed to add two joists between each existing set for a final spacing of 8" on center, and do something to strengthen the 4x6 beam, such as adding metal C-beams. The 2x6 ledger against the house

should have SDS screws added to attach to the house studs.

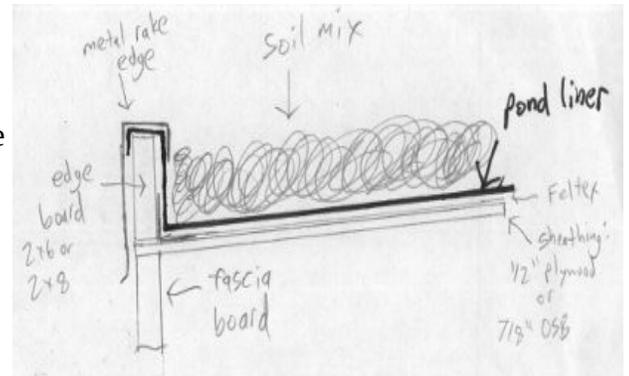
Scale-Down of Garage & Carport

We originally planned to implement the garage and carport roofs similar to the sunspace and front porch, with at least 5.5" of intensive soil mix to support food crops. However, these two roofs were built right up to the property line in the past, so to put ecoroofs requiring permits on these structures would have triggered requirements to bring various aspects up to code. We didn't want to deal with that, so we decided instead to implement very light ecoroofs of 30% of the allowed dead load value. Therefore, we did not add any joists or strengthen the beams for these roofs.

Layers

From bottom to top, the ecoroof layers consist of:

- Sheathing (1/2" plywood on all roofs except the sunspace with its 7/8" OSB)
- Feltex (light-weight substitute for tar paper)
- EPDM pond liner (45 mil Firestone Pondgard. We purchased sheets large enough to fit onto each roof without having to join multiple pieces together, so as to avoid potential leak spots.)
- Rotting wood (on sunspace and front porch roofs, to act as a physical dam slowing water down as it works down the roof, and to hold and store water and nutrients. Though the wood was already rotting and soft, we placed a thin layer of soil mix under the wood as an extra precaution to protect the pond liner.)
- Soil mix (Intensive on sunspace & front porch; extensive on garage & carport)



We figured that the roofs had sufficient slope (1 or 1.5 in 12) to move water via gravity through the soil mix, so we didn't include a separate drainage layer.

We created "raised beds" by using 2x6 and 2x8 boards around the edges of the roofs, running the pond liner up and over before capping the boards with metal rake edge protecting the edge boards and the sheathing, extending down at least 2" into the fascia boards attached under the sheathing. We secured the edge boards with 4"x4" right angle brackets, and placed scrap pond liner pieces or foam padding over the exposed metal to prevent the main pond liner layer from being damaged by the brackets.



Overflow

The front porch roof already had a gutter attached, so we worked with that for our overflow drainage. We lifted the lower "raised bed" edge board an inch off the surface of the decking, then cut slits in the pond liner to allow water to run under the board and into the gutter. We placed filter fabric all along the slit with a layer of river rock to retain soil.



For the other three roofs, we cut holes at the bottom edge of the roof through the decking, large enough to allow a 1.5" diameter PVC or ABS pipe to fit through. We cut the pond liner in an "X" pattern over the drainpipe, folded the flaps down into the pipe, and secured and caulked it with P&L Roof & Flashing Sealant. (For the garage & carport roofs we inserted a plastic ring to help hold the flaps against the inner wall of the pipe.) We used one hole each for the garage and carport roofs, and two holes for the sunspace roof.

Over each drainage hole, we placed a ~10" diameter coffee can with holes drilled or cut out all around the sides of the can. We cut one hole in the bottom of the can to match the hole cut through the pond liner. We wrapped each can with filter fabric then a ring of river rock to minimize loss of soil, and caulked the bottom of each can to the pond liner to secure it and prevent soil from getting under the can. We painted each can with rustoleum.



The excess water from the roofs drains to different places:

- Sunspace: waterfalls into three bath tub ponds, which then overflow away from the house
- Front porch: waterfalls into a large pond constructed of the scrap pond liner pieces left over from the four ecoroofs
- Garage and Carport: trees and shrubs near their respective downspouts

Plants

Sunspace & Front Porch Planting Plan

The deep soil of the sunspace and front porch roofs supports a relatively broad palette of plant species, and hopefully allows for productive cropping. We designed these roof plantings for polycultures of edible plants providing nearly 100% soil coverage throughout the year. Mostly we aimed for each patch to include an evergreen ground cover with evergreen or deciduous plants rising above.

For ground covers, we planted *Arctostaphylos uva-ursi*, *Fragaria chiloensis*, *Rubus calycinoides*, *Viola odorata*, *Campanula portenschlagiana*, *C. poscharskyana*, *C. cochlearifolia*, *Gaultheria shallon*, *G. procumbens*, *Vaccinium angustifolium*, *V. vitis-idaea*, *Valerianella locusta*, and *Sedum telephium*. For taller plants, we planted many *Allium* species including garlic and elephant garlic, *Astragalus canadensis*, *Linum perenne*, *Hemerocallis* sp, *Agastache foeniculum*, *Asphodeline lutea*, *Chenopodium bonus-henricus*, *Sedum spectabile*, *Anthriscus cerefolium*, *Papaver somniferum*, *Oenothera biennis*, several ephemeral bulbs in the *Camassia*, *Triteleia*, *Brodiaea*, and *Erythronium* species, and a few miscellaneous others. See our [Ecoroof Final Planting Plan](#) blog post for full details.

Carport & Garage General Plan

We didn't design the carport & garage roofs in as much detail, since we only had about 3.5" of soil depth to work with. We obtained numerous cuttings of *Sedums* and other succulents, mostly of unknown species from similarly thin-soiled, dry conditions. We also planted several *Allium cernuum* plants, one *Fragaria chiloensis*, a large *Origanum vulgare*, and a large unknown species of *Thymus*. In areas of the garage roof which receive heavy summer shade from the black locust trees, we planted *Viola odorata* and *Campanula glomerata*, since the protection from the sun may allow a wider diversity of plants to grow in that area despite the thin soil.

Mid-summer report

For an ongoing record of harvests from the ecoroofs, visit <http://discountpermaculture.com/cgi-bin/harvest.py?ecoroof=1>

Sunspace & Front Porch

Our one plant of *Vaccinium moupinense* died within a month of being planted. Our seeds of *Lepidium peruvianum* (old seed), *Valerianella locusta*, and *Papaver somniferum* never germinated. Otherwise, the plants on the sunspace and front porch, planted in October 2010, survived the winter and now flourish to a greater or lesser extent. The wet spring and summer this year have sustained growth with no irrigation on our part except for a few recently added plants, and occasional spot watering of some of our more valued experiments (*Vaccinium angustifolium*, *V. vitis-idaea*, *Gaultheria shallon*, *G. procumbens*, *Chenopodium bonus-henricus*, *Akebia*, and *Astragalus canadensis*).



The *Fragaria chiloensis* has impressed us with its rapid growth and precocious berry production; this species may make sense as the primary ground cover, since it stays evergreen, grows low, fills in gaps between taller plants very quickly, and tastes delicious! Large swaths of the *Arctostaphylos uva-ursi* died off following its transplantation from our yard below, but the portions that survived have made a few berries. Unfortunately, the berries of this species don't taste very exciting so it makes an inferior ground cover in our food-focused system. The *Rubus calycinoides* is establishing fairly slowly, though a few plants have produced flowers. The *Vaccinium*

angustifolium is producing a few berries.

The garlic and elephant garlic seem to have done very well, producing numerous scapes followed by reasonably sized bulbs. We haven't weighed them all yet, but it looks like a very good yield. The other Alliums are establishing fairly well, but with much less vigor so far.

The *Chenopodium bonus-henricus* has produced a tiny amount of seed; we'll need to wait until next year to assess the production potential of established, mature plants. The *Linum perenne* made numerous flowers but only a handful across all the plants set seed; we're waiting anxiously to evaluate convenience of seed harvest and their taste. We're disappointed that the *Papaver somniferum* didn't germinate, as we would have enjoyed that as a seed crop. We have one *Oenothera biennis* plant flowering profusely, which should result in a reasonable number of seeds for ourselves or for the chickens.

Hemerocallis (daylily) is proving itself very tough, already producing numerous flowers for harvest.

Many other plants have flowered over the last two months, providing an ongoing diversity of blooms and making the roofs pleasant hang-out spaces and valuable for foraging insects.

Carport & Garage

We didn't plant the carport and garage roofs until late June 2011. A month later the cuttings and plants seem to be establishing well.

Implementation

We found it fairly straight forward to implement everything. For each roof, once we had the structural supports in place as designed by our structural engineer, we removed all the old asphalt roofing, tar paper, and roofing nails. We swept up all the dirt and debris to create a clean surface. In places with more than 1/8" gap between plywood we added shims so the pond liner wouldn't get stretched down into the crevice.

Once we had the plywood surface cleaned up, we laid the feltex on the decking in the same manner as tar paper. Then we placed our pond liner, running it under the flashings of the roofs above (sunspace and front porch) or up the wall of the house (garage and carport). We worked it up and over the "raised bed" edge boards, and cut off the excess. We adjusted the liner to minimize any bubbles in the middle of the roof, and folded the extra material at the corners.

The hardest part of placing the liner was dealing with the wood stove chimney projecting through the sunspace roof. We cut an oval hole about 2/3 the size of the chimney flashing, and worked the pond liner down over the chimney, making small cuts as needed to get the pond liner down to the roof. We had to make sure the pond liner stayed 2" away from the actual chimney, so we could only bring it up the flashing to that point. It proved difficult to cut the hole in exactly the right place, so we wound up with a slit in the pond liner extending upslope from the chimney for a few inches. We protected that by adding scrap pieces of pond liner, caulked to the chimney flashing underneath the storm collar and to the main layer of pond liner. To minimize water approaching from upslope, we placed two pieces of plastic to divert water to either side of the chimney. (We also initially placed a ring of drainage pipe and river rock around the chimney, but removed them later when we suspected that rainfall was splashing off those and getting under the storm collar.)



Next we placed the rotting wood for the sunspace & front porch, then soil for all the roofs. And finally, of course, we planted the plants!

Maintenance

Irrigation

Since we planted the sunspace & front porch roofs last October, and have had a wet spring with rains extending into June, as of July 12th we've only watered a few spring-planted additions and (perhaps unnecessarily) some of our more valued experimental plants (see "Plants" section above for details.) Since we completed the carport & garage plantings at the end of June, we expect to water two or three times a week to allow establishment.

The metal roofs condense some water during humid summer nights. We don't know yet whether that will provide any meaningful moisture input, but we hope that the plants at the upper edges of the sunspace and front porch roofs will benefit.

We expect to provide occasional (perhaps once a week) irrigation in future summers to maximize crop production, though certainly we have the option to not irrigate and just accept whatever harvests are possible.

Harvests

Most of the future maintenance should be simply harvesting greens & flowers two or three times a week, plus seasonal harvest of root crops like garlic, camassia, and yellow asphodel.

Further experimentation

We'll adjust the crops planted based on how well they perform. If new plants suggest themselves as good candidates, we'll try adding them.

Weeding

Hopefully most unwanted plants will be excluded by the establishment of a solid canopy of desired plants. After that, we just have to keep those desired plants in balance, which may mean rearranging some polycultures or selectively harvesting greens of certain plants more heavily to set them back.

Fertilization

The sunspace and front porch roofs will require ongoing fertilization to replenish nutrients taking during harvest. We can easily accomplish this by occasional application of urine during harvest trips.

Lessons Learned

Early loss of silt

The runoff water from the sunspace and front porch roofs obviously carried a lot of silt for at least two weeks after the beginning of the fall rains. Perhaps the ideal time to install soil and plant would be mid spring, so that plant roots could grow quickly while the soil was still moist, but without heavy enough rains to carry off so much silt and presumably fertility.

Excess water flows

Due to the extra water coming from our existing metal roofs, we had two problem spots. On two occasions of the heaviest rainfall last winter, the water flowing onto the sunspace roof backed up enough to get past the flashing and into the interior wall of the house. We added two drainpipes, one towards each end of the ecoroof, buried and running under the path directly down the roof. The pipes are wrapped in filter fabric with the upper ends protruding past the upper end of the soil for water to easily enter. This now allows excess water to safely drain away.



On the front porch roof, moderate rains caused a stream of water to overflow the lower edge of the "side channel" where some of the metal house roof meets the edge of the ecoroof perpendicular to the ecoroof slope. We built up a higher "dam" with metal caulked to the existing edge, which now allows excess water to enter a drainpipe running from that spot towards the gutter. The picture on the left shows eroded soil piled up against the original, shallow edge at the far right.

Gutter vs Drainhole

We found integration with the front porch gutter to be more awkward than the drainholes we created for the other roofs. We made a mistake by not caulking the pond liner down to the feltex along the slit we cut for discharge into the gutter, so water initially wicked back upwards under the pond liner and leaked through nail holes in the sheathing until we corrected the problem. The gutter will require more ongoing maintenance to keep it free of leaves than will the drainholes with their small cans.

Surprising absorption of rainfall events

We've been impressed by how much of the rainfall the roofs can hold before discharging anything into the overflow, especially the sunspace & front porch which receive so much extra water from the rest of the house. We haven't made precise measurements and observations, but it seems that if the roofs dry out a bit, they can fully absorb at least a .25" rainfall.

Difficult to buy low-cost plants

We were disappointed to find that we couldn't source low-cost sedums or other ecoroof plants. The wholesalers with good prices apparently only sell to retailers, not directly to end users, even if you can meet the minimum bulk requirements. Luckily, we found friends who allowed us to take cuttings of their sedums.

Costs

With the help of friends, we did all the labor ourselves, so we only had to pay for construction materials, soil mix, plants, structural engineering, and the permit. We located used material as much as possible via the Rebuilding Center, craigslist, etc. Our total cost was about \$5400:

- \$700 - Structural engineering
- \$94 - Permit
- \$180 - Concrete (front porch pier pads)
- \$129 - Dump fees for old roofing
- \$1023 - Lumber - structural posts & beams, sheathing, edge boards, etc. (We would have bought some of this lumber anyway for the sunspace, but it wouldn't have needed to be so beefy had we not put the ecoroof on it.)
- \$108 - Nails & fasteners
- \$157 - Brackets (to attach edge boards)
- \$403 - Rake edge to protect edge boards & match existing metal roofing theme
- \$148 - Feltex (light-weight tar paper equivalent)
- \$849 - Pond liner
- \$692 - Soil mix
- \$906 - Plants & seeds
- \$15 - Drain pipe for water overflow