Chapter 8

The Living Roof

Earth-Sheltered Houses discusses techniques for building homes or outbuildings of low to moderate cost, which precludes massive earth roofs in excess of a foot thick. All of the techniques of the previous chapter are appropriate for earth roofs of 4 to 12 inches in thickness, although my personal view is that an 8-inch-thick earth roof is more than adequate to maintain a green cover, while providing the other advantages of earth roofs discussed in Chapter 1. With care in soil and plant selection, a 4-inch earth roof can be beautiful, ecological, and thermally effective. In fact, we'll open the chapter with a step-by-step photo essay showing the installation of just such a roof. This section also serves as a concise review of the roof layers described in Chapter 7.

Stoneview Roof: A Step-by-Step Photo Essay

The 5-by-10 and 6-by-10 rafters at Earthwood, on relatively short spans, carry a load of about 150 pounds per square foot, as per Chapter 1. The radial rafters at Earthwood's Stoneview guesthouse are only four-by-eights and the clear span is greater than at Earthwood itself. To make up the engineering shortfall, I needed to go with a lighter-weight living roof of about 115 pounds per square foot. This was accomplished by using 4 inches of topsoil instead of 6 inches (saving 18 PSF), and substituting Enkadrain® for the 2-inch crushed stone drainage layer, saving another 17 PSF. These pictures of installing Stoneview's roof (on pages 166–169) show clearly the steps taken to install a living roof in such a way that it won't leak.

The Earth Roof

Once the drainage layer is on, you are free to install the earth. With composite drainage matting, it is good to do this as soon as possible, before it is lifted by the wind.

The thickness of the earth has been decided long ago at the design stage. Even a small shallow living roof like the one at Stoneview involves hauling a lot of soil by hand. There is an alternative, but you need to be careful. The boom of a backhoe can deliver 6 or 8 cubic feet of earth

Fig. 8.1 (right): You can't see the clear "surface conditioner" which Grace provides with the Bituthene® 4000 membrane, but it's there and has dried to a tacky feel. Large trapezoidal sheets were installed first at the perimeter, lapping 2.5" onto the aluminum drip edge. Bruce Kilgore (left) and Darin Roy set a small trapezoid of Bituthene® 4000 close to the center of the building. Darin smoothens it down while Bruce pulls the backing paper off. We lap 3" onto the previous sheet and 3" onto the exposed planking. Therefore, there is always a 6" lap on the cut ends of the sheet.

Fig. 8.2 (right): The author caulks the cut edge with Bituthene® Mastic.

Fig. 8.3 (above): Jaki and Darin Roy feather the edge of the mastic with pointing knives, to approximate the factory edge of the Bituthene® membrane. The mastic stops the cut edge from raising up or "fish-mouthing."

Fig. 8.4 (left): Jaki installs the first layer of 1" Dow Styrofoam® extruded polystyrene over the membrane. Taping the joints simply holds them together until they are covered. We installed a second one-inch layer on top of the first. Using 2" thick sheets would have been quicker, but we bought these 1" sheets at a very low price and saved a lot of money.

Fig. 8.5 (above): A layer of 6-mil black polyethylene serves as the base of the drainage layer and is installed over the insulation. This is tricky to do on an octagon roof, as the sheet needs to be folded over the saddles between facets, but it is an easy job on a Cave-type roof. We were careful to give plenty of overlap from sheet to sheet (at least 18") and paid attention to the shingle principal when making our overlaps.

Fig. 8.6 (below): Trapezoidal sheets of Enkadrain® 3615R composite drainage are placed over the plastic, with the filtration mat uppermost. No, we haven't forgotten the plastic sheet. You can see it poking out here and there. A large centerpiece of plastic will be tucked under the Enkadrain® before it is covered with earth. Heavy wooden blocks keep everything in place until the earth goes on.

Fig. 8.7 (left): Installing a woodstove chimney. Any projection cut through the membrane has to be treated very carefully, with both waterproofing and drainage. As our Metalbestos® stovepipe has an 8" outside diameter, we made a hole of 12" in diameter through the Bituthene®-covered planking. A reciprocating saw works well for cutting the hole. This way, the chimney has the required 2" clearance from combustible material. The Roof Support Package (Metalbestos® part RSP) unit shown has two adjustable metal flanges which can be screwed to the planking, allowing the installer to plumb the stovepipe itself to a true vertical.

Fig. 8.8: After the stovepipe is plumbed, the aluminum Metalbestos® flashing cone for shallow-pitched roofs is nailed in place. Using 5" strips of Bituthene®, we covered the roofing nails and the join where the aluminum overlaps the roofing membrane. Bituthene® mastic around the edges completes the waterproofing. The storm collar (Metalbestos® part SC) keeps water from dripping down the stovepipe and into the flashing cone area.

Fig. 8.9: Over the Enkadrain®, we installed 4-by-4 pressure-treated timbers to retain the earth. (An alternative method of retaining earth, involving cut sods, is discussed elsewhere.) Inexpensive galvanized truss plates tie the eight retaining timbers together to create a ring beam with good tensile strength. At Stoneview, the Enkadrain® tended to slide down the plastic, even with the relatively shallow 1:12 pitch roof. As described in the text, we stitched the bottom ring of trapezoidal sheets together with 24" pieces of 1-by-2 wooden scrap. The picture shows a couple of large plastic washers under the nail heads, holding two adjacent pieces of Enkadrain® lapped and firmly attached to the wooden piece, out of sight below the lower sheet. Once this ring of Enkadrain® was stitched together all around the building, it stayed in place and further sheets were simply laid down over each other, covering previous sheets with the 3" filtration mat factory-installed on one edge of the roll.

Fig. 8.10: The author hauled three quarters of the roof's topsoil up the stairway in 5-gallon buckets. Bruce Kilgore helped with the other quarter of the estimated 400 bucketloads.

Fig. 8.11: The author uses the back of a rake to spread the soil to a consistent loose depth of 5½". Twenty-four 6-by-6-by-8-inch blocks (actually 5½" thick) served as depth gauges. The soil slumps down to the 3½" deep retaining timber. After a winter's snowload, the loose soil compressed to a compacted depth of about four inches.

Fig. 8.12: Drainage is the better part of waterproofing! Any projection through the membrane is a potential leak. I boxed around the stovepipe with pressure-treated 1-by-6 material and placed crushed stone over the Enkadrain®. Water is quickly carried away to the edge of the building.

Fig, 8.13: Jaki plants a couple of dozen clumps of chives between 100 sedum plants (protected by mulch) on the Stoneview roof. Sedum is a succulent plant with the ability to survive prolonged drought conditions. Chives also do well in dry conditions.

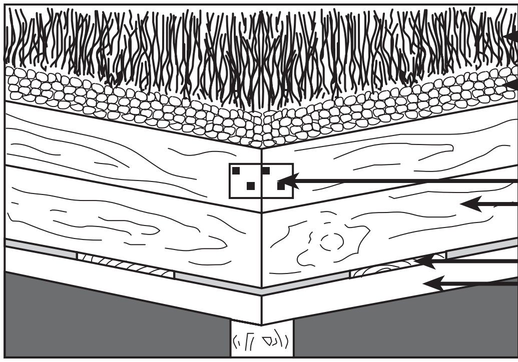

Fig. 8.14: Construction details when using rail ties or landscaping timbers at the roof's edge.

at a time. That's a lot of 5-gallon buckets. But it needs to be placed carefully on a part of the roof where the load is transferred directly by compression to the foundation. Had I used a backhoe at Stoneview, for example (and it crossed my mind), I would have had the operator place the soil right over the very center of the building, which is heavily overbuilt. (Sixteen rafters come together over the capital, supported in turn by a 15-inch-diameter post capable of taking over 40 tons on compression.) Have two or three people on the roof, armed with shovels, rakes, and buckets, to distribute the soil as it is placed on the roof. An earth roof can go on quite quickly with some organization and strong willing bodies.

With earth roofs, in the 4- to 8-inch range (settled thickness), use soils that will retain moisture. Sandy soils will transmit water to the edge of the building quite quickly, making it difficult to maintain a green cover without constant watering. Earth roofs should be low maintenance and should not require watering, which is why we are using sedum and other drought-hardy plants at Stoneview.

Retaining Earth at the Edge with Timbers

With a Cave-type situation, the earth roof meets seamlessly with the earth berm. But on the north and south parts of the roof, or with freestanding earth roofs like those at Earthwood and Stoneview, you need some sort of retaining edge to keep soil on the roof. At Earthwood, we got a great deal on railroad ties in excellent condition, just $100 for twenty … delivered! They came from a local rail yard where a section of track was being removed. You could use 6-by-6, 6-by-8, or even 8-by-8 pressure treated landscaping timbers for the purpose, but these can be quite expensive. Four-by-fours are a lot cheaper and were thick enough for the lightweight living roof at Stoneview.

Figure 8-14 shows how we join two rail ties (or landscaping timbers) on an 8-sided or 16-sided roof. (See also Figure 8.9.) A critical detail is to keep these timbers off of the roof substrate, so that an ice dam does not form behind them. Initially, we made the mistake of placing the rail ties right down on the inch of Styrofoam® that we used as a protection board for the Bituthene®. Two or three years later, about 1984, we had our first leak, which was also our last until December 2004, already mentioned. It rained for two days in a row, but air temperatures were below freezing. It can happen. Water went through the crushed stone drainage layer to the overhang, where it would freeze because it was dammed behind the rail ties, the classic "ice dam" situation.

Water has no choice but to back up onto the roof. When drainage can't work, the membrane is severely taxed. We had a leak in our bedroom. In the spring, we tore up a section of the roof and found a neat little hole in the Bituthene®, created by carpenter ants from below. We repaired the leak, but then levered up every one of the 200-pound rail ties, and slipped three or four 1-inch pieces of pressure-treated boards as shims. This was not a big enough gap to allow the crushed stone through, but was sufficient to allow the water to get to the drip edge. At Stoneview, the four-by-four retaining timbers actually sit on the Enkadrain®, so that the water can find its way under the timbers and to the drip edge.

In 2002, we added an upstairs sunroom to Earthwood, which broke the continuous tensile ring of 16 rail ties, fastened together with galvanized truss plates. At that time, I found another use for the rail ties, and replaced them with moss sods, as described below.

Retaining Earth with Sods

Taking a leaf from Mac Wells' well-worn book, we used moss sods to retain the earth on the freestanding earth roofs on the Earthwood library and office buildings, which can be seen in the color section. We have also used grass sods successfully. We prefer the natural appearance of the moss (or grass) sods on the edge, and they save

Fig. 8.15: Sods are cut with a sharp square spade.

Fig. 8.16: The author installs a moss sod on the edge of the office roof.

a lot of money over wooden edging methods. We are fortunate to have a good source of moss sods growing in sandy soils at Earthwood, although any well-knitted grass sods will work as well. In Figure 8.15, I am cutting sods with my sharp square spade. I like to cut them about 5 inches wide, 5 inches high, and 10 or 12 inches long.

In Figure 8.16, I am installing a sod on the office roof.

On a shallow roof, the sods stay put and knit together nicely. It is a very rare occasion, usually during drought, when a small bit of earth falls off the edge of the roof, rarely anything larger than a baseball. Moss goes dormant during a drought, but bursts back into beautiful life with a good soaking rain. We have three or four different varieties growing on our roofs.

Figure 8.17 shows the detailing with moss or grass sods as a retaining edge. The sods go right down on the 6-mil black plastic which covers the Styrofoam® protection board.

Another successful detail, not seen in the diagram but evident in Figure 8.16, and in 8.18 below, is to install a 10-inch long piece of half-pipe every three or four feet around the edge of the building. This drainage aid, ripped from a piece of 3-inch ABS or PVC pipe, extends under the sods and meets with the crushed stone drainage layer. During the winter, we often see little icicles forming all along the drip edge around the office, but large icicles form where the half-pipes are located, showing that they provide a positive relief to hydrostatic build-up behind the sods.

With composite drainage matting, like Enkadrain®, I take the drainage sheets right to the edge and put the sods – or retaining timbers – right on top of it. The half-pipes are not needed in this case.

Log End Cave: The Earth Roof

We wanted an "instant grass roof" at the Cave in the fall, one that wouldn't erode over the winter. In June, we tilled, de-stoned, and planted a section of the front field to timothy and rye. In October, we cut a few sods from the sod field and found that 2 or 3 inches of soil came up with each piece. To get our desired 6-inch thickness, we spread 4 inches of topsoil over the entire roof, and covered it with plenty of hay mulch and pine boughs for erosion protection. Finally, long heavy sticks kept the pine boughs from blowing away. A friend experienced in golf course maintenance advised me that it was too late in the year to install the sod on the roof, but I did do 20 square feet of sod in one spot as a test. My friend was right. We sodded the rest of the roof in early June of the following year, and it was flourishing and in need of a second mowing by July 1, while the test patch was still in bad shape.

Speaking of mowing, the earth roof at Log End was really an extension of our lawn, and mowing seemed appropriate for esthetics. At Earthwood, we mowed for a couple of years, but then my environmentally-minded son, Rohan, pointed out that every hour that we run the heavily polluting two-stroke lawnmower puts as

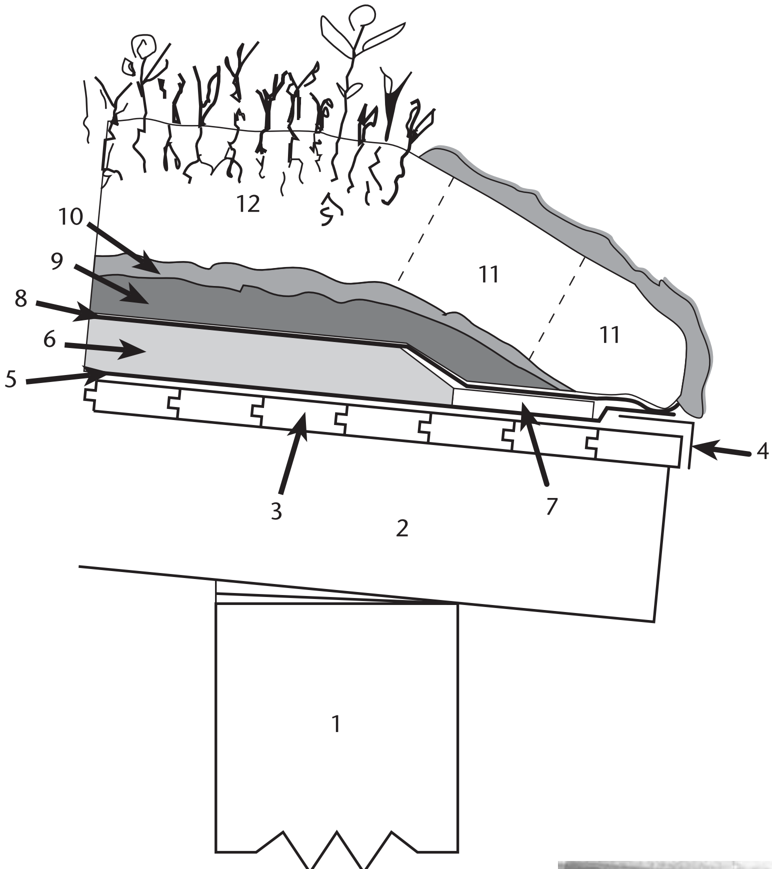

Fig. 8.17:
Roofing detail for a free-standing earth roof using moss sods to retain the earth.

Key:

1. *Above-grade wall.*
2. *Heavy wooden rafter.*
3. *2" × 6" T & G planking.*
4. *Aluminum flashing as drip edge.*
5. *W.R.Grace Bituthene® 4000 or equal membrane.*
6. *4" to 5" rigid-foam insulation*
7. *1" rigid foam or half-inch fibre board to protect membrane.*
8. *6-mil black polyethylene.*
9. *2" of #2 crushed stone drainage layer.*
10. *Hay or straw filtration mat.*
11. *Moss or grass sods cut from sandy soil, retain the earth at the edges.*
12. *7" to 8" topsoil, planted.*

much pollution into the atmosphere as driving 300 miles in a car. We have not mowed an earth roof since, and prefer the natural look. Grasses left long also withstand drought much better than mowed roofs.

Sodding was a lot of hard work. Three of us – one cutting and two hauling and laying – applied the sod onto the topsoil in two days. As we also covered the east and west berms, this amounted to about 1,600 square feet. We found that sods larger

Fig. 8.18: Moss sods drain well, retain the earth and look natural. Note "half-pipe" for drainage.

than ten inches square would break up in transport. Sods should be cut damp, not soaking, so that they hold together. It doesn't take sods long to knit together and form an instant green roof in their new location.

At Log End Cave, we accidentally discovered an easy way to start a green roof. Our mulching hay from the previous October was full of seeds, and the roof was becoming quite green on its own before we transferred the sods. Had we known, we could have applied the whole six inches of soil in the fall and let nature take its course in the spring.

We only cut sods now for instant edge retention.

Earthwood: The Earth Roof

We let the Earthwood roof sit over the winter with just the 2-inch crushed stone drainage layer on top, sufficient ballast against the wind. We installed the earth in August of 1982, at a time when the backhoe had returned to the site to finish landscaping.

First, we covered the crushed stone with three inches of loose hay, which forms a natural filtration mat under the earth, keeping the crushed stone drainage layer clean.

The "topsoil" was actually silty material that came from a stream's floodplain on a local farm. The soil is free of stones and has rather poor percolation, perfect for retaining moisture. Ed Garrow carefully used the loader end of the backhoe to place the soil on the roof. Several of us spread the soil with shovels, 5-gallon buckets and rakes.

Learning from Log End, we planted rye in early September, and, thanks to an idyllic autumn, had grass coming through a thin mulch layer in weeks. By November 1st, the grass was thick, green, and lush.

Other Living Roofs

All earth roofs should wind up as living roofs, but all living roofs do not necessarily require a layer of earth. During the 1990s, we built three small outbuildings, all in the woods, with roof areas of 100 square feet up to 320 square feet. Influenced by work which others had done in the natural building field, we experimented with hay bale roofs. On the first one, a guest house called La Casita, we put up all the layers of waterproofing membrane, insulation, and drainage, as described in Chapter 7, but, instead of sods or topsoil, we finished the roof surface with full bales of hay, packed tight against one another and tied together around the perimeter with baling twine. We never cast any seeds, but, within a year, all sorts of green things were growing up there. No doubt there were lots of grass (and other) seeds in the bales, and birds and wind probably brought other seeds. After a couple of years, the bales had compressed to a third of their original thickness and the roof was positively lush. Moss took a foothold and poplar trees got established. After six years, I pulled all of the poplar trees, fearing that their roots might create havoc with the membrane. Now, in the spring of 2005, ten years after the hay bales were installed, the roof is still alive, with mosses and wild blackberries mostly, and the bales have compressed and composted with years of leaves to form a three-inch layer of rich, black, lightweight humus. A white birch tree has established itself. I hate to pull it out.

The Straw Bale guesthouse and the composting toilet were done at about the same time, around 1997. Again, we covered the buildings with hay bales, straw being uncommon in our area, but we also placed a good inch of topsoil on top of the bales, and seeded the roofs to grass. These roofs established themselves even faster than at La Casita, and became green and lush within weeks. One year, the Straw Bale guesthouse was covered with "pigweed," also called "Lamb's Quarters," an edible plant, good in salads or cooked like spinach. These roofs seem to have maintained the hay thickness better than the roof on La Casita. They are not as old, it is true, but I expect that the topsoil has something to do with it as well.

All three living hay-based roofs have shown great resiliency against drought conditions over the years, probably because they are in very shady areas, and protected from the worst of the wind. There seems to be an irregular turnover of vegetation, but that's okay. I reckon that whatever is growing up there is the right thing. These are wild roofs, not a great deal different in appearance from the forest floor, and so they fit in well with the habitat.

I wish we had ready access to straw. I had to go 150 miles to get bales to build the Straw Bale guesthouse. My thinking is that bales of straw, topped with an inch of topsoil for seed starting, would make an excellent living roof, particularly in a shady or partially shaded area. The straw bales would not decompose as fast as hay bales, but would provide a good medium for root growth.

What to Grow on the Roof …

… is a function of roof thickness, the growing medium, climate, and whether the site is sunny, partly sunny, or mostly shady. We've been happy with our living roofs, so, in the spirit of writing about our own experience, and not what we have heard second-hand from others, here it is:

Our major earth roofs at Log End and Earthwood had compacted earth layers of 6 to 7 inches. Various grasses (timothy, rye, even tough local "Johnson" grass) and clover have provided most of the vegetation on these roofs. I have described how we sodded the Cave roof and planted grass on the Earthwood house.

The 350 square-foot office roof, with a similar thickness of earth, presented a slightly different situation. In the fall, we planted what was supposed to have been "annual rye;" that is, it was supposed to survive as a green cover until spring, and then die off. Well, there must have been a percentage of perennial grasses mixed in with the seed. Most, but not all, of the nice green grass cover did die off. Our intent was to plant a temporary green cover until we could grow a wildflower roof in the spring. Well, we did have great success with the seeded wildflowers … for about a year. We broadcast the contents of a can of wildflower seeds onto the almost (but not quite) barren roof in the spring. The label on the can claimed "26 varieties" of wildflower seed. And the results were glorious, as you can see in the color section. But, of the 20-odd species that grew the first year, only three or four returned the second year because the "annual rye" took over the roof. By the third year, only a few odd wildflowers popped up here and there, and now they are rare. Grasses seem to trump wildflowers, except, perhaps, in the wild. If you want wildflowers, plant them without grass. Eventually, though, grasses will probably arrive spontaneously on the roof and choke out the flowers.

We were sorry that the office roof didn't look like that wonderful first summer in subsequent years, but, you know, it still looks pretty darned good, with its moss edge and the variety of grasses and other wild plants, some of which flower, most of which don't. There is no such thing as a weed in the wild, at least not insofar as they don't belong there. (The exceptions to this idealistic comment, I suppose, are the "invasive species" which choke out native plants, vegetative varmints like kudzu in the South, and purple loosestrife in the North.) The office roof does change character with the seasons and the amount of rain. We do not mow it and it almost always looks good.

The library roof has never been a great success, except that it is at least alive and not dead. But (until recently) it was never a vibrant roof, except for mosses, which seemed to be happy up there. We suspected the soil was sandier and lacking in nutrient. Combined with its smaller roof area, the net effect is that the library roof was more prone to damage from drought. In early May of 2005, we attempted to rejuvenate the roof by planting some sedum and other plants here and there, and I have added considerable nutrient by raking in some well-composted "humanure" from the composting toilet. A month later, the roof was looking better than it had in years.

It is important to note, however, that while not quite as pretty as the other roofs, the library roof was never ugly, either, and, esthetics aside, still accomplished the other earth roof goals and purposes.

A certain amount of shade seems to be a plus for earth roofs, making them more proof against drought. Our small sauna roof, just 112 square feet, has a lush cover of various grasses. The soil is no thicker than other roofs, but the building is shaded by the house for three or four hours each summer day, a break from the sun not enjoyed by the library or office roofs. As I write, the lushest roof at Earthwood happens to be the little (28 square feet) roof on the former Littlewood playhouse, now a kindling storage depot. This roof gets more shade than the others, morning and evening, but also gets full sun for several hours when the sun is at its highest.

The guesthouses and outhouse in the woods, with their hay bale living roofs, we leave completely to nature, save pulling trees out every few years.

Planting a Lighter-Weight Earth Roof

Nigel Dunnett and Noël Kingsbury, in their fine *Planting Green Roofs and Living Walls* (see Bibliography), comment that: "To achieve its function, rooftop vegetation must be able to:

1. Cover and anchor the substrate surface within a reasonable time after planting;
2. Form a self-repairing mat, so that new growth will be able to fill any areas that become damaged, for example, through drought;
3. Take up and transpire the volumes of water that is planned for the water balance of the structure; and
4. Survive the climatic conditions prevailing on the rooftop, with particular attention to cold-hardiness and drought tolerance; worst-case weather scenarios should be assumed."

All the literature – and our conversations with those with more experience than ourselves – points to sedum as the plant of choice on a lightweight (4-inch or less) earth roof. In fact, sedum has done well with as little as an inch of soil. Why? What is this stuff? I'd never heard of it until one of my students told me about it in 2004. Later that year, the same student gave us a tray of various sedums – there are hundreds of varieties – to experiment with, and we have now planted them on the library roof.

Sedum is the name for a genus of plants characterized by having a moisture-retaining leaf system, like succulents or cacti. Dunnett and Kingsbury enthuse: "Sedums have … become the bedrock of shallow-substrate roof-greening systems for their drought tolerance, year-round good looks, ease of propagation, and suitability for shallow substrates."

We live in a very cold climate, but we knew from speaking with Chris Dancey, author of the case study that closes this chapter, that there are sedum varieties tolerant to severe cold. Her own beautiful living roof features sedums in Ontario, a climate similar to our own in northern New York. For the 4-inch-thick Stoneview roof, Jaki ordered from plant catalogs that she has dealt with in the past and selected two varieties: Dragon's Blood (*S. spurium*), a brilliant red-flowered sedum from Gurney's, and Improved Golden Sedum (*S. kamtschaticum*) from Spring Hill Nurseries. Both varieties were recommended for cold climates. She ordered about 100 plants in all. She also ordered 24 Vinca Minor plants, for variety. Vinca is not a sedum, but an evergreen foliage "super in sun or shade and in any soil," according to Gurney's. It will end up about 6 inches high in a tight mat. "Royal purple flowers bloom in spring."

Grasses, fescues, and sedges can be grown with a soil thickness of 4 inches or more. If you are looking for a lawn type of situation, go with the regular species for that purpose: rye, Kentucky bluegrass, fescue, etc. If you want wildflowers to coexist with your grasses, you might want to select shorter ornamental grasses. Although written from a British point of view, *Planting Green Roofs and Living Walls* does give a lot of information on grasses and other potential green covers for shallow roofs. An important consideration, however, will be suitability and hardiness for your climate, so it is a good idea to get advice from landscape gardeners and suppliers in your area. Let them know that you have shallow soils and need something that is drought-resistant as well as cold-hardy.

Jaki had a huge clump of chives growing in one of the raised beds. She read in *Planting Green Roofs and Living Walls* that chives (*Allium schoenoprasum*) "survive well on green roofs under both wet and dry conditions," so we hauled the clump up onto the Stoneview roof and she broke it into a couple of dozen small clumps, which, hopefully, will spread between the sedums. We have also planted a variety of wildflower seeds while there is little or no grass up there, to provide some vegetation and color until the sedums take hold and spread. The container lists 24 varieties, including various poppies, primroses, lupine, daisies, and baby blue eyes, a mixture of annuals and perennials.

To avoid introducing an invasive species, use only local native plants or ones that have been cultivated in your area for a long time without causing problems. Plant suppliers should know which plants are safe and should not be selling you anything which can cause environmental damage, but, as Dunnett and Kingsbury point out, "There are as yet no horticultural industry protocols on the risk assessment of introduced species."

Avoid strange and exotic species. If in doubt, don't.

Maintenance of Living Roofs

We have done very little to maintain our several earth roofs. I'm not advocating this approach, you understand. But here are some comments, for what they are worth:

I don't think that a roof that requires watering is a well-designed roof. And mowing a roof doesn't make much sense, either.

Because we don't mow, there is sometimes a lot of dead chaff and stubble on the roof that seems to choke off growth. I have, on three or four occasions, burned off this dead material. I choose my time carefully, late in the day, when it is cool and damp and never at a time of fire danger to the surrounding grasses or forest. Each time I have burned the roof off, it has bounced back lush and green. My neighbors think I'm nuts, but with a megalithic stone circle in the front yard since 1987, I doubt if burning off the roof has greatly altered their opinion.

The other "maintenance" I have performed is to remove poplar and birch trees, which establish themselves. A shallow roof is not the right place for trees, shrubs, or root crops. (Leafy vegetables, however, are an option for those who are otherwise short of garden space.)

Where we have been remiss is in not feeding the roofs once in a while. By not mowing, the roof achieves equilibrium similar to a natural habitat, but I am sure that a little feeding once in a while, with organic fertilizers such as bone meal, and with ash from the woodstove, will help plants to thrive. And now I've found a good safe use for our humanure.

Living Roofs on a Commercial Scale

Living roofs are big business in Europe, particularly in Germany. For the most part, the projects are commercial, municipal or industrial. But the reasons for choosing living roofs on commercial buildings are very similar to the reasons listed in Chapter 1 for homes and small projects. An additional advantage to living roofs in cities is that they can effectively change the micro-climate for the better: every black tarscape converted to a green, oxygenating surface has got to help the overheating problems prevalent in urban areas. Another reason for green roofs cited in the commercial literature is that they last much longer than conventional roofs.

The idea is catching on in the United States, too. Ford Motor Co. made the headlines in 2002 with their nearly 10-acre earth roof renovation of their Dearborn automobile plant. An American firm, Colbond (makers of Enkadrain®, already mentioned) had an involvement with the Ford project, as well as the 320,000 square-foot Millenium Park in Chicago and the 180,000 square-foot International Plaza in Atlanta. Of the Ford project, it is said that the roof cost twice as much as conventional roofing, but will last twice as long. Ford's executives figured that the positive PR of building "the world's largest ecologically inspired roof" was worth the cost.

Colbond manufactures a "root reinforcement matrix" called Enkamat® R²M 7010, made to "permanently anchor plant roofs on sloped roofs or in high wind conditions. … As the roots grow they become entwined within the Enkamat®, making an extremely stable cover. Its tough root reinforcing system anchors vegetation and provides a holding cavity for the growing medium."

Then, taking convenience a step further, Colbond provides pre-planted Enkaroof® VM, which the company describes as "an Enkamat® core with a non-woven fabric attached to the bottom side designed for pre-vegetated mat applications. The mat is filled with the growing medium and plants are grown directly in the mat structure. … The fabric holds soil medium and vegetation in place while the flexible matting is re-rolled and shipped to the installation location."

Other companies have products designed to do the same sort of thing: provide a fast, proven, lightweight living roof. Appendix B lists several of these companies, and some excellent websites that will put you in touch with what is happening in the – pardon me – fast-growing Green Roof industry.

Are these commercially oriented systems worth their cost? Depends on the size of the

Fig. 8.19: Flowering sedum makes an attractive summertime cover.

project and your budget. The techniques accented in this book are directed towards the owner-builder on a low to moderate budget, but there may be circumstances where modern-day living roof technology might be helpful, so it is good to be aware of it. For example, some of the sedum mat systems, with just 2 cm (less than an inch) of growing medium, can keep the additional weight of the living roof layer down to just 10 pounds per square foot, considerably better than the 4-inch saturated soil load of 40 pounds per square foot at our "lightweight" living roof at Stoneview guesthouse. These systems could pay for themselves on reduced structural costs, or might provide a green-roof alternative where spans greater than 12 feet are needed.

Fig. 8.20: This view of the Dancey home in Ontario was taken in January, 2004.

I thought it would be good to give the reader a break from my voice, and learn a little about green roofs from my friend Chris Dancey, who has taken the medium to a more esthetic level in Ontario. So I'll give Chris the last word in this chapter.

Chris Dancey: Our Living Roof in Ontario

Our living roof brings us joy year round, through its beauty and ever-changing nature. In five years it has progressed from small patches of succulents, mostly sedum, to a dense mat of ever-changing color. Even during winter, it is elegant in a cloak of white, with a hint of the life beneath.

Two reasons motivated us to construct and care for a living roof. The first was simply the desire to have a beautiful roof and the second was to demonstrate for others that alternative roofs are a viable choice.

In urban areas the motivation may be different, since living roofs can help control pollution and provide garden space. Whatever the motivation, remember that having this style of living roof is not as maintenance-free as most roofing systems. Now that my roof is established, I do roughly two hours of weeding and maintenance each month, for about eight months each year.

On the positive side, a well-designed living roof can extend the life of a waterproof membrane by many years, even decades, as the soil and plants protect the membrane from ultraviolet rays and extreme temperatures. Our waterproof membrane is a two-layer product from Soprema (listed in Appendix B), which was designed for this purpose.

We live in southwest Ontario, Canada, about ten miles north of Lake Erie. Our latitude of 43 degrees is similar to Rome, Italy, and southern Oregon. The Great Lakes have a huge effect on our weather. Summer can be hot and humid, or dry with weeks of drought. Cold, snow-laden winds are common in winter, but we can also have mild winters with little snow. So far our roof has thrived in the varied conditions, mostly because of the diverse selection of plants. For me, this is part of the beauty of my roof.

The building below our living roof is heated roughly six months each year. The roof is insulated, so the living roof and snow cover are bonus insulation and would never be adequate on their own in a cold climate.

Summer is when you really notice the positive insulation value of a living roof. The roof surface doesn't heat up and the plants and soil have a cooling effect. Even with two large roof windows, the building is always comfortable inside.

Chris Dancey

Fig. 8.21: The Danceys collect excess water from the roof for use in their garden.

The composition of our soil is equal parts sand:clay:soil. The sand helps with drainage. The clay holds rainwater and then releases it slowly. The quality garden soil provides nutrient and is a good growing medium. We bought this mixture from a landscaping company that was able to create a custom blend for us.

When we put the soil on the roof, it was about 6 inches deep. Over time, we knew the soil would settle to about 4 inches in depth. Walking on the roof during planting and maintenance has also compressed some areas. In 2003, I took a bit more soil up to fill in the depressions. The original soil and this new soil carried lots of seed for plants I didn't want on my roof. Until my selected plants were able to provide an effective ground cover, I had to do a fair bit of weeding.

The slope on our roof is 18 degrees, which is a 4:12 pitch. About two days after our roof was

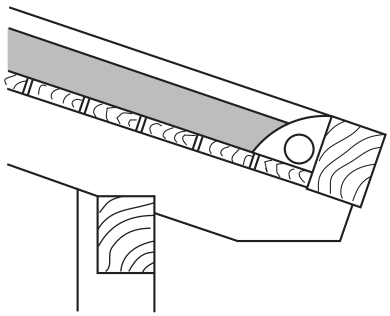

Fig. 8.22: Drainage detail at the bottom of the slope.

Fig. 8.23: Photograph of the drainage detail at the Dancey home.

Chris Dancey

planted, we experienced torrential rain for several hours. I was afraid to look, thinking that the soil and plants might now be on the ground below. When I finally got up the courage to inspect, I found that the soil had settled, but there wasn't even a sign of run-off.

The plants I chose don't need nutrient-rich soil. The majority are drought resistant, succulent varieties that are used in poor soil conditions and rock gardens. They are low growing and send out roots on their new branches, which makes them easy to establish, and they stabilize the soil. The dense, leafy growth shields the soil from the drying effects of the sun and wind. Condensation is adequate to keep them alive during a drought.

Profuse flowering begins with the self-seeding violas and violets in the spring. As the days become hotter and the soil dryer, these plants die back, but not until they have set seed for the next cool damp spell.

Before choosing the plants for our roof, I looked at several roofs in Germany and many published photos. I knew the style and plants I chose would require more maintenance than a sod or 'wild' style, but I've never regretted the choice. For me, the ratio of work to pleasure is excellent.

Some Technical Details

A 3-inch-diameter big 'O' tube that is in a fabric filter runs the length of the roof on both sides. Pea gravel, which acts as a coarse filter, surrounds the big 'O' tube. A 6-inch-by-9-inch oak timber forms the edge. The whole edge of the roof is sloped toward the drain outlet above the rain barrels. The entire wood surface of the roof is protected from moisture by the Soprema membrane. Metal flashing protects the upper surface of the timber.

When the soil is dry, it absorbs and holds the rainwater. Once the soil is saturated, the drainage system must be able to carry the excess water off the roof. A wet roof is also extremely heavy, so the structure must be engineered for the weight of the wet soil load. My husband, Wil, designed and built the pine timber-frame structure and he also did training with Soprema to enable him to do a professional installation of the membrane.

Two rain barrels catch the run-off. A garden hose hook-up allows me to use gravity to water the garden below. If the rain barrel reaches the overflow level, a second outlet channels this water into a vertical tube beside the building. Through a system of elbow and T-joints, the water is moved under the deck to the garden. The water is then distributed along the length of this garden, through a perforated tube – also known as *soaker hose* — that was buried a few inches under the soil, before I planted the garden.

During the winter, the rain barrels must be removed. We attach a big 'O' tube to the stainless steel spout and this handles any run-off from melting snow. Again, the water runs into the garden below.