APROVECHO'S SUSTAINABLE RESEARCH AND EDUCATION: A FOCUS ON NATURAL BUILDING

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FIGURE 1. Aprovecho's 40 acre campus in the foothills of Oregon's Coast range.

INTRODUCTION

Aprovecho is a non-profit research and education center dedicated to living, learning, organizing and educating to inspire a sustainable culture. Located on a forty acre land trust in the Coast Range outside of Cottage Grove, Oregon, Aprovecho's campus features a living demonstration of sustainable human settlement, organized around five core areas: food, shelter, water, forests, and energy. Aprovecho offers educational opportunities in all five of its core areas, including shelter through the Natural Building program. The Aprovecho Natural Building program trains students in the use of locally-sourced, non-toxic building materials for the construction of energy-efficient, affordable, healthy homes that work within natural communities and that enrich local economies.

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KEYWORDS:
natural building, locally sourced materials, sustainable shelter, code approval of natural building materials and techniques, non-toxic lifestyle

Energy and Technology

Internationally, Aprovecho is best known for developing the Rocket Stove. This simple technology has helped people throughout the world burn biomass more efficiently and reduce the amount of indoor air pollution and forest dependency. It is a great window into how Aprovecho has approached sustainability over the past thirty-five years. By asking simple questions on important but often overlooked topics related to sustainability, Aprovecho has used simple science to find solutions that work with local materials, cultures, and the ecosystems in which they live. As of 2014, over half the world's population depends on biomass as a primary source of energy either for cooking or heating. In the early 1990's under the guidance of Oregon State University combustion scientist Larry Winiarski, Aprovecho developed a set of design principles for wood-burning stoves.

Agroecology and Livelihood

The desire for farm fresh foods and the accompanying health, social and environmental benefits is not just a current trend with consumers. Evidenced by the growing number of small farms and local food options, increasing numbers of young people are seeking small-scale farming as a viable career path. The aim of Aprovecho's Agroecology program is to demonstrate sustainable food production models while teaching students not just the practical skills associated with agriculture but also the basics of business that will allow them to use their training to develop a livelihood for themselves into the future.

The "back-to-the-land" movement provided an important critique of industrial human's separation from nature and key contributions are present within the sustainability movement today. One of the important evolutions that Aprovecho has undergone over the last thirty-five years is a shift in the focus of our education programs. Previously serving a majority of students with dreams of the "sustainable homestead" and the accompanying utopian ideal,

FIGURE 2. Aprovecho's greenhouse in production.

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we now recognize that the majority of our students are looking primarily, not for an isolated future, but for a livelihood pathway in-line with their values. By empowering students with small-business skills, Aprovecho hopes to enrich the movement towards sustainable, local economies.

Aprovecho's Agroecology program teaches a combination of different agricultural philosophies including but not limited to Permaculture, Organic, and BioDynamic. These practices are visible throughout the campus in places like the two acre garden where pockets of food forest are intermingled with annual production beds, berry patches, and an aquaculture system growing tilapia and catfish. This hybrid of perennial and annual production is a key characteristic to a food production model that aims to produce a good product while not producing an overworked farmer.

NATURAL BUILDING

Before any natural building program begins at Aprovecho, we start with a classroom session intended to characterize and debate the type of building practice that we mean when we say "natural building." This is particularly important because the word "natural" comes with all sorts of problematic and vague connotations. The line between what is natural and what is non-natural is far less important than the specific personality of the shelter we are shaping. The following is a product of countless conversations between students, practitioners, and the spaces we create.

FIGURE 3. Classroom session in Aprovecho's earthen plastered classroom.

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Locally Sourced and Minimally Processed Materials

The local food movement is one of the fastest growing sectors of the food economy. The basic premise behind this movement is that by sourcing your nutrition needs locally, you receive fresher, healthier food, while directly supporting the local social fabric by establishing relationships with farmers, the local economy by keeping your dollars within the community, and the reduction of global environmental degradation by reducing the embedded energy and chemical fertilizers used to grow your food. One of the important questions the natural building movement proposes to green architecture is why the obsession with concrete, steel and glass? Can we not have high-performance buildings made with the clever use of locally sourced, minimally processed materials? As the local food movement grows, where is the accompanying local home movement?

When we decide to source materials locally, we reduce the amount of embedded energy in the home by reducing the travel distance from source to factory to wholesaler to store to home. Our reasons for reducing the embedded energies in our buildings is our desire to reduce greenhouse gas emissions and the pollution associated with our current energy.

FIGURE 4. Sand, clay and fiber are locally available ingredients useful in walls and plasters

Locally sourced materials also help to enrich our local economy by purchasing as directly as possible from local producers. By keeping our dollars local we put money into the pockets of our local businesses contributing to increased local economic activity and growth. This scaled economy of material supply creates a more resilient economy better able to mitigate the fluctuations of building material supply and cost. Fluctuations in supply and cost are the result of events often out of the hands of the average person, such as diminishing global oil supplies, international conflict, and financial speculation. When our homes are made from materials close at hand, we are more empowered and less dependent on forces outside of our control

The resilience of a community is facilitated by the relationships between the people in the community. By having a more direct relationship with both the people and the ecosystems

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responsible for the production of our building materials, we strengthen the social fabric of our communities – a welcome relief to the social trend towards isolation. This is also true with our relationship to local ecosystems. By having a more direct relationship to the forests, fields, and quarries that create the contents of our home, we have an increased incentive to responsibly steward these natural systems.

Non-Toxic Life-Cycle

Natural Building is keenly interested not just in the source of building materials, but in the fate of those building materials. Many of the materials used in conventional construction will one day find their way to the dump ending their life as a once-used material toxic to human and environmental health. This is not only an inefficient use of the energy necessary for creating materials, like fiberglass, foam, asphalt, latex, and drywall, but it is also an increased burden on the costly waste disposal systems necessary for processing these materials. By using agricultural fibers such as straw, bamboo, hemp, and wood—in combination with binders such as clay and lime—we can create buildings that sequester carbon during their active lives, and whose eventual fate is soil-enriching compost.

FIGURE 5. The materials in a natural home facilitate a non-toxic worksite appropriate for all ages.

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The same reason it is necessary to specially process conventional building materials at the end of their life is often the same reason why many conventional materials are problematic during their life: toxicity to human health. One of the best examples of this can be found in conventional paints whose ingredients contain chemicals present on the EPA's list of Hazardous Air Pollutants. One such class of chemicals, Volatile Organic Compounds (VOCs), can reach levels 1000 times the amount of outdoor levels after a fresh application of paint. In contrast, the use of clay and lime based finishes in the home not only removes the threat of indoor toxicity but in fact enhances indoor air quality by stabilizing indoor air humidity. By using non-toxic alternatives to conventional building materials, we ensure a healthy environmental and human contribution throughout the material's entire life cycle.

Building Vernacular

Vernacular is a linguistic term that refers to the language or dialect spoken by the people of a particular region or country. This language "of the people" and "of the place," perhaps captures best one of the most important elements of Aprovecho's building practice: the aim to create a building culture that is accessible to the average person and is an expression of a particular place. Based upon the materials available, the local climatic conditions, and the local culture and custom, each region should have a unique expression of shelter.

The United States has a strong history of the owner/builder. From native building practices to the early European homesteads, common people of the continent have been engaged

FIGURE 6. This farm office was built by students out of materials sourced mostly from within 100 miles.

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in the construction and maintenance of their homes throughout their history. The intent of the Aprovecho building program is to give people the opportunity to re-engage with shaping the space they will spend the majority of their life. Therefore, built into most elements of the Aprovecho building practice is the ability to apply various building techniques using simple, low-cost methods. The very specific intent is to not only increase the joy present when we have a direct relationship with our interior space but to resist the trend of debt associated with home ownership today. Not that everyone will want to build their own "natural home" in the woods, but the advantages of a building practice accessible to the non-professional can still be realized even if one decides only to apply their own clay paint on one wall in one room.

The other part to a vernacular building practice is "of the place." Previously discussed are some of the social, economic and environmental advantages of using locally sourced building materials. Being "of the place" also means a design and use of materials appropriate for the specific climatic conditions of a region. Here in Cottage Grove, Oregon, we depend on an auxiliary heat source during the winter and, though we orient our buildings for solar gain, we also create insulated wall assemblies with high mass interiors. This may, however, not be the most appropriate building design for another location, like the Southwest of the United States, where a high mass wall system using adobe (unfired clay/sand/straw bricks) or cob (clay/sand/straw walls) is more appropriate for the high diurnal temperature fluctuations. Being "of the place" incorporates all of the important design details associated with energy efficient green buildings and applies them, where possible, within the local climatic conditions.

SUSTAINABLE SHELTER

Every summer between ten and fourteen students gather at Aprovecho to construct a tiny home from the ground up. This seven week intensive building course is taught by a team of regional professionals who guide the students through a curriculum spanning foundations, timber and round pole framing, wall systems, floors, roofs, and more. Typically, students come to the Sustainable Shelter Series either seeking the skills and confidence to construct their own

FIGURE 7. The "Boathouse" was built by students starting in 2012.

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home, to begin their career as a natural builder, or to augment their existing building skill set in order to offer clients more diverse, sustainable options. Though the first two tiny homes were constructed on Aprovecho's campus as demonstration buildings, Aprovecho has begun constructing tiny homes for local farm businesses in the hope of adding helpful infrastructure to important agricultural producers within the local economy. These tiny homes serve as our best thinking in vernacular architecture for our Pacific Northwest Region and feature a wide gamut of natural building techniques.

Foundations

What is the best way to start a building program featuring locally sourced, minimally processed, non-toxic materials? Concrete? The strength and apparent ease of a concrete foundation is seductive. The costs are hidden and distant. We teach elements of conventional concrete foundations so as to empower our students with a variety of techniques, which they can use depending on the project and available materials. Each year we find better ways to reduce Portland cement in our foundations, while retaining the strength needed for a long lasting home.

Most of our buildings have featured a rubble trench foundation topped by a four inch bond beam and a two foot stem wall made of insulated concrete forms, rebar, stone and concrete. After leveling the site, a trench is dug, 18 inches at the shallowest corner sloping at 2% to the adjacent corner and then out to daylight. The trench is filled with a layer of drain rock followed by a "burrito" of drain rock and continuous perforated pipe, which is also sloped at 2%. Finishing with drain rock two inches below grade the trench is now ready to receive 4 inch forms for a concrete perimeter bond beam. Integrated with the rebar embedded within the bond beam, a two foot stem wall is constructed using insulated concrete forms. In our case we use a two foot by one foot block made of 80% mineralized wood chips and 20% Portland cement. These "Faswall" blocks are made by a local company called ShelterWorks, and we have found them to be very easy to work with and intuitive for students. The exterior six inches of Faswall are filled with mineral wool to provide insulation. After two courses, the cavities are filled with rebar, concrete, and stone ready to receive the cedar bottom sill.

FIGURE 8. Form to receive a concrete bond beam placed on top of a rubble trench.

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Recently, Aprovecho has welcomed Alan Ash to the teaching team: a master stone mason holding a teaching certificate with the Dry Stone Walling Association of Great Britain. The goal of collaborating with Alan was to build a foundation using traditional dry stone techniques with occasional Natural Hydraulic Lime (NHL) and clay mortar reinforcement. This foundation uses local basalt. Working with the forces of gravity and friction, the stone foundation was designed to have a batter of 2" per foot with a finished width at 18" above grade of 16" (minimum stone wall standard.) This meant that two feet below grade the wall's starting width was 30". Guided by Ash, the wall was constructed using batter frames, string lines, line levels, rock hammers and the diligence from the students. At the four major load bearing points, an NHL based mortar was used for reinforcement. In order to properly integrate the timber frame into the foundation, a custom plate anchor was welded and installed two courses from the top. The all thread will receive the posts. We chose to clay/lime mortar to the above grade courses in order to keep draft and animals out. The final course was composed of capstones spanning the entire width of the wall, embedded with anchors to receive the next layer of framing. One year later this tiny home is not exhibiting any signs of stress or settling due to the stone and mortar foundation.

FIGURE 9. "Faswall" blocks being placed on top of a 4" bond beam.

Timber and Round-Pole Framing

The advantages of using traditional timber frame joinery are an open, flexible floor plan, the reduction of costs associated with milling, aesthetic beauty, and the lack of steel hardware. Some of the disadvantages include the need for large trees and the high level of precision needed to achieve a good result. The use of round poles in construction is even better. Through the combination of traditional timber frame joinery and the introduction of a minimum of steel fasteners, one can achieve a strong, beautiful result that negates the need for the expense related to milled timber. Aprovecho uses both techniques in order to construct the roof-bearing frame for our tiny homes.

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FIGURE 10. Dry and mortared stone foundation in process for a farm office.

FIGURE 11. Stone foundation made mostly from local basalt.

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FIGURE 12. Timber frame raising during 2014 Shelter Series.

FIGURE 13. Roundpole purlins on top of timber frame.

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Wall Systems

At a seminar "Engineering for Natural Buildings" in 2012, Bruce King, structural engineer and founder of the Ecological Building Network proposed an integrated theory of concrete. The basic idea was to help planning officials see the merits of natural material assemblies by using appropriate language already familiar within the trade. Many of the most commonly used wall systems for instance operated on the same science and set of relationships that conventional Portland cement based building practices use. For instance "cob"—a combination of clay, sand, and straw—uses the same relationship between binder, aggregate, and fiber that reinforced concrete does. The important difference is what choice of binder, aggregate, and fiber is being made and the relative performance for different assemblies. Within a natural building practice we have both insulative and high-mass wall options, load-bearing and non load-bearing options, as well as code-approved and research-needed options.

Some of the high-mass wall building techniques most commonly used by natural builders include cob, adobe, and rammed earth. All ancient techniques use these building practices and combine clay, sand, and fiber to create load-bearing walls out of low-impact materials. With cob, this "clay concrete" is applied to the wall after mixing, kneading each handful into the existing wall to create a homogenous wall. Adobe is a masonry building system composed of sun-dried clay, sand, and fiber bricks laid with a clay-based mortar. As with cob, these materials are typically available on-site and this building practice has been used for thousands of years. The longest surviving rammed earth buildings date back 8000 years and can be

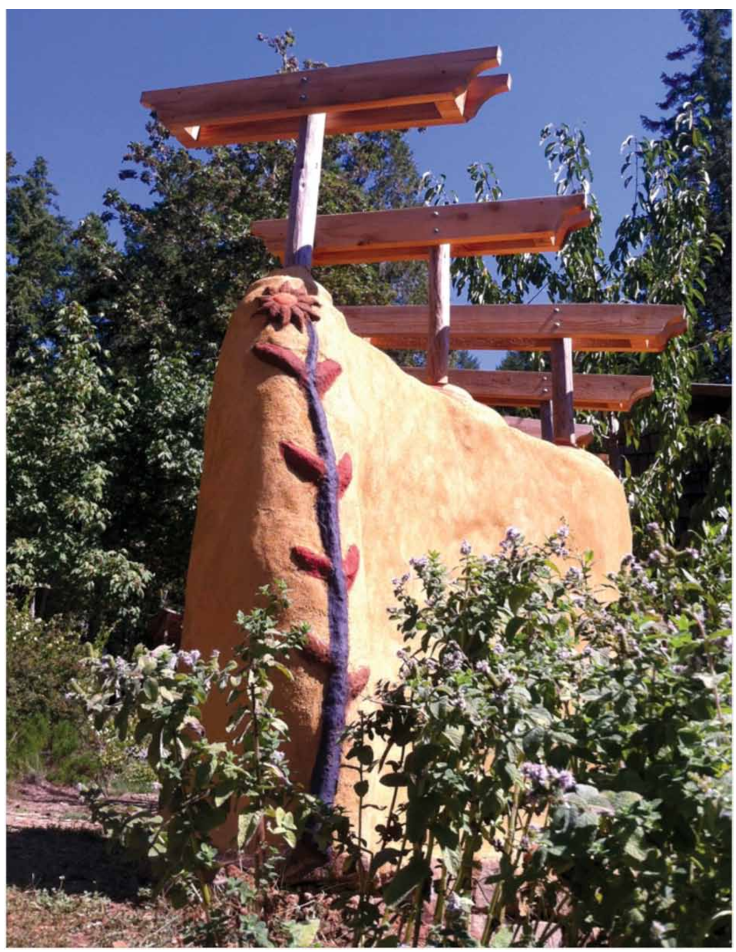

FIGURE 14. Cob garden wall on Aprovecho campus.

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found in ancient city states, like Mesopotamia, or in and the Great Wall of China. This clay and sand based building technique has featured a revival in recent decades as home builders seek greener ways to build.

Some of the challenges with these high-mass, load-bearing wall systems are their weight and rigidity, both qualities unfavorable for seismic zones. Thanks to the pioneering work of the Ecological Building Network, there is now an ASTM standard for earth buildings that has gone a long way towards making these low-impact building practices safer for all. Though more appropriate as a wall system for regions like the Southwestern United States, at Aprovecho we typically incorporate these techniques as sculptural, aesthetic features adding mass, and therefore efficiency, to our home interiors.

There are currently a growing number of insulative wall systems, many code approved, available to the vernacular builder. The most commonly known is probably the use of strawbales. By uses bales of straw as bricks one can achieve either a load or non-load bearing wall system with r-values between 2 and 2.5 per inch. This building system also depends on both horizontal and vertical pinning with either rebar, or preferably bamboo. There is a plethora of information available about straw bale construction, which has been code-approved in most U.S. states for a decade or more.

FIGURE 15. A student ensuring a strawbale wall remains plumb before pinning with bamboo stakes.

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The insulative wall system we are currently using most often at Aprovecho is a technique called light clay straw, or LCS. LCS has a section in the latest Oregon Reach Code, thanks to the efforts of architect/builders like Robert and Paula Laporte. Requiring twelve inch wide walls typically framed with ladder trusses two feet on center, this wall system mixes clay slip (watery clay) with loose straw and then packs the resultant mix into temporary wall forms. After removing the forms (same day) the result is an insulative (typically 1.5 per inch) wall system resistant to mold, fire, and rodents. We prefer LCS walls at this time for our wet PNW climate because the presence of clay in the wall, though compromising overall r-value, helps buffer the vulnerabilities of straw.

FIGURE 16. Up close photo of a LCS wall which is a mix of clay and straw packed in between larsen trusses.

There are several insulation methods we are currently experimenting with at Aprovecho. "Slip and Chip" mixes barkless wood chips approximately 2-3 inches wide with a clay slip. As with LCS, the clay protects the wood chips, creating a mixture resistant to fire, mold, and rodents. Lathe is necessary for this infill technique in order to hold the wood chips within the wall and to receive the eventual clay or lime plaster finish. Though hemp is currently illegal according to federal law in the United States, we are interested in its use as a fiber and agricultural insulation product. When the "chiv" or shredded inner bark is mixed with lime the resultant materials can achieve r-values up to 2.5 per inch. Placed within or around light wall framing, hemp/lime is also highly resistant to fire, mold and rodents and receives a natural plaster very well.

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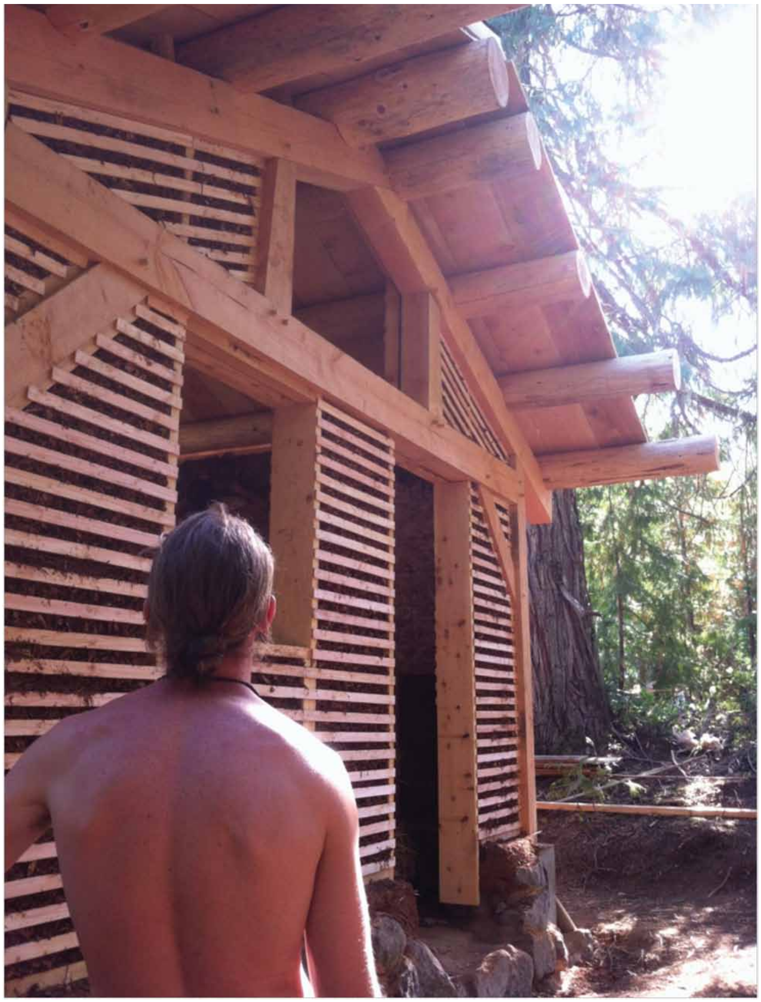

FIGURE 17. A slip and chip wall before plaster. The clay covered wood chips fill the cavities defined by the wooden lathe and provide insulation.

One of the more exciting insulation techniques we are experimenting with at Aprovecho uses fungal mycelium to grow light-weight, foam-like panels. According to Ecovative, one of the pioneers of "myco-foam," they have achieved a consistent r-value of 3.8 per inch. At Aprovecho we combine a mixture of pasteurized, chopped straw with rough cut hardwood saw dust and then inoculate this medium with the appropriate fungal species. Placed into aerated forms, the straw/wood substrate is colonized by mycelium that when dehydrated at the appropriate time creates a light-weight panel one can place in a hardened state to insulate areas such as the ceiling and floor. When using mycelial insulation, it is necessary to first bake the material at high temperatures in order to render the panels innocuous and unable to grow into future walls. It is this type of innovative approach to healthy local homes that inspires our students and teachers to find new approaches to natural insulation.

Earthen Walls and Floors

When I first heard of "earthen floors," I was highly skeptical. How do you clean a dirt floor? How does it last overtime? Aprovecho is attempting to model a sustainability that resists the idea of a dramatic reduction in standard of living in order to achieve a sustainable lifestyle. Lifestyle changes will certainly be necessary, but certainly we can still have hard, cleanable floors?

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We applied the first earthen floor under the guidance of Sukita Crimmel from Claylin LLC in a house I was living in at the time. After three days we had a smooth, level floor of clay, sand and chopped straw. After allowing the poured floor to dry we applied linseed oil and beeswax to create a hybrid material that, when fully dried, was hard, durable and puddled liquids making it easy to mop and clean. I found this high-mass floor system to be a pleasant and useful alternative to other massive floor systems based on Portland cement. Earthen floors can be used with high efficiency, in tandem with hydronic heating systems.

Drywall is the third most energy intensive building material behind concrete and steel. The often locally-available alternatives are clay based plasters and finishes. Clay based plasters and finishes are simply appropriate combinations of clay, sand, fiber, and sometimes amendments like wheat paste that add to the binding and hardness qualities of the plaster. Builders can use a traditional lathe and plaster system with clay-based finishes or, depending on the choice of insulation, apply the plaster directly onto the wall. Clay plasters have all the advantages of being a vernacular building material. As well, they add mass to interior space and when placed appropriately can act as a thermal battery within the home. Clay has a high moisture absorption capacity as well, which when applied within the home stabilizes indoor air humidity.

FIGURE 18. Installing an earthen floor during an Aprovecho workshop.

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FIGURE 19. Students applying a smooth clay finish plaster on top of a rough base plaster.

Similarly, there are locally available, non-toxic alternatives to commonly used latex paints. Latex paints are not only one of the most energy intensive (by weight) building materials to manufacture but they are often the culprit for unhealthy indoor levels of chemicals such as VOCs. Even if a home is already finished with drywall, homemade clay paints containing clay, sand, wheat paste and pigment are a great way to incorporate natural materials into the home.

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FIGURE 20. Four different clay paints drying during a retrofit of a historic downtown Cottage Grove building. The lighter colors are the finished colors.

FUTURE DIRECTIONS

There are social, economic, and environmental advantages to using natural building materials. There are an increasing number of code-approved natural building assemblies currently available to the home-builder. The materials needed, like clay, straw, sand, and wood are inexpensive. Why then are natural building assemblies not more widely adopted?

There are several probable factors contributing to the slow growth of natural building assemblies throughout the green building industry. We frequently experience during our open house tours a person's first encounter with natural building. There is often surprise when seeing and touching the clay-plastered walls in our Meeting Hall. Many visitors are also not aware that many of the techniques demonstrated at Aprovecho are available to them, believing that you have to "break code" in order to build a natural home. Aprovecho is attempting to

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offset this lack of public understanding by providing gift economy campus tours and weekend workshops where participants have the opportunity to engage the materials directly.

It is not only the public who needs more information but the builders themselves. There has been great progress over the past thirty years towards better understanding of how natural building assemblies operate from an engineering and performance perspective. This crucial, quantifiable data is essential for the wider adoption into building codes and for the safe construction of future natural homes. One of the appealing characteristics of natural building is that the materials themselves are highly decentralized and therefore resists a centralized, industrial production model. With this lack of a natural building industry also comes a lack of sufficient capital to scientifically demonstrate that natural building assemblies meet industry standards. As more and more creative new combinations of locally available materials occur, research will be needed to determine safe and appropriate application of these techniques. There are currently several organizations like the Ecological Building Network and the Development Center for Appropriate Technology whose primary objectives include wider code adoption for natural building.

FIGURE 21. Applying a cob bond beam to a stone stem wall.

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Even though the materials are comparatively inexpensive, a natural home can be just as expensive when labor is taken into account. Though we may hope more people will engage with the construction and maintenance of their own home, the reality is that the majority will depend on a professional builder. Natural building assemblies would be more widely adopted if the cost of construction for such a home was competitive with conventional building practices. One important advance necessary is the development of labor saving technologies that will allow building contractors to offer natural building assemblies at a market competitive price. One example of this technology was developed by EcoNest Company. Using an electric motor, a culvert tube, and some metal spikes, EcoNest developed a more efficient way of mixing Light Clay Straw for mass application in larger homes. These labor saving technologies will go a long way to reduce the barriers currently resisting the adoption of a building practice that's better for human and environmental health.

FIGURE 22. A promising technology for mixing straw and clay slip, saving time in an otherwise labor-intensive process.

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CLOSING

When the founders of Aprovecho set down roots in rural Oregon thirty three years ago, they intended to create a model of sustainable living that would serve as an inspiration for students and visitors far into the future. Sustainability is not a static point but a pursuit with many discoveries ahead as we continue to apply the same basic research process that lead to developments like the Rocket Stove and natural building. There is much to celebrate within the current options available to the natural builder, and there is much to look forward to as we continue to discover and apply a building practice that enriches our lives and the lives of those around us.

FIGURE 23. View from above a reciprocal roof found on top of a yurt at Aprovecho.

FIGURE 24. The "Playhouse" constructed by students in 2011.

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