LANGUAGE OF ARCHITECTURAL WOOD: WASTE TO ECOLOGICAL ABUNDANCE

Leonard Yui[1]

[1]Roger Williams University, Bristol, Rhode Island

ABSTRACT: The sustainable paradigm in architecture emphasizes concepts of conservation like limitation and efficiency, yet the ecological processes reveals a world founded upon abundance and functional complexities. Why are materials like urban wood waste treated so differently from those in the forest? This paper investigates the terms and narratives that have come to shape the language of wood used by the architectural profession (architectural wood) and forest scientists (ecological wood) and proposes a synthesis based on the concept that ecological benefits depend on an abundance of materials. The two perspectives about wood arise from distinct but related historical and contextual variables that reveal an opposition to one another. This raises questions about whether a designer can realize deeper ecological solutions while maintaining current constructs of architecture. The research in architectural wood looks to contemporary construction methods as well as the historical evolution from the forest to human product. The investigation shows how architectural thinking favors the structural language of "strength" and "efficiency," as well as the avoidance of key ecological functions prevalent through terms such as "pests" and "decay." Materials are favored for their linear and human functions, and once exhausted, are discarded and removed from the architectural process. Ecological wood is defined by forest science research in coarse woody debris. The research in ecological wood revealed concepts of redundancy and terms associated with decomposition, disturbance and legacies. These processes are favored by a multitude of species for their complex latent properties and serve various ecological roles simultaneously. The fundamental differences in language reveals deep barriers that may discourage ecological collaborations. The conclusion proposes to elevate the concept of ecological abundance by responding to architectural design gaps revealed through ecological research. The response aims to construct and prepare a more collaborative design language between designers and scientists.

KEYWORDS: Ecology, Wood, Sustainability, Disturbance, Language

INTRODUCTION

The current discussion about material and ecology is largely about its conservation – to limit use, to offset resources, and to reuse. The importance to conserve and even preserve forest lands overshadows the truth about resource availability – we seem unable to purge it fast enough from our urban places. A Forest Service analysis reveals that about a quarter of the timber residues in the U.S. amounted to waste in the urban setting (about 62.5 million metric tons). As it relates to the architectural field, "construction and demolition" totals about 52% of the urban waste, and if one accounts for all the related wood products such as furniture, cabinets, etc. then it rises to 76% (47.7 million metric tons) (Bratkovich, 2014). About half of this wood is turned into biofuel, mulch and engineered woods, while roughly half is sent to the landfill. In one sense, there is too much wood in the environment.

In response, organizations such as USGBC LEED and the Mass Timber movement promote long-established sustainable views on material conservation and emphasize issues like embodied energy, renewable sourcing and reducing waste. Additionally, there is an ambiguous implication that offsetting human use will provide more resources for other ecological beings and processes. What is evident is that wood in the urban setting is largely limited to human use and there is little clarity about how it could be used otherwise. The existing abundance of wood in urban places seems to suggest an opportunity if designers could open their material up to a world beyond people. If sustainability represents a kind of transformation from a linear method to a "Cradle to Cradle" loop, then perhaps there exists a construct that encompasses the multitude of ways non-humans and their processes might inspire an abundance of new "loops" (Fig 1).

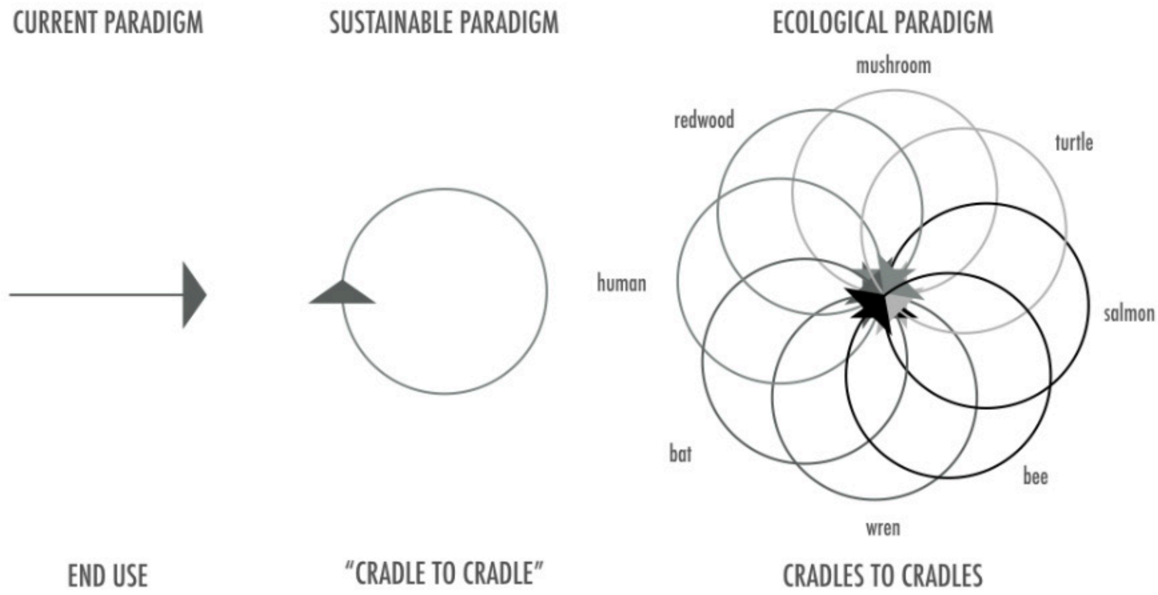

Figure 1: An Ecological Paradigm Diagram, by author

Wood is a unique object to study amongst building materials. Lumber is not a mixture or recipe like concrete or steel, but a borrowed object from a particular and existing place. The arborist and writer, William Logan, recounts how the early foresters/shipbuilders began their process in the woods where "imagination had to find the ship's' actual materials" (Logan, 2005). Wood is found, and its physical properties are discovered, which represent only parts of the object's possible characteristics. Concrete is invented with a purpose to take on particular forms, cures quickly and embodies great compressive forces. These engineered properties favor the language of specialization and linear application. Compare this to wood, which also allows for the emphasis of structural properties, but due to its organic quality also offers itself as food, energy and shelter for other organisms and ecological benefits. All materials return to the earth, but few so readily to reengage with the ecological system like wood.

The following analysis reveals the evolution and reasons as to why architects and ecologists have developed two directly opposing perspectives about the nature of wood (Fig 2). First, the investigation draws from historical origins and the cultural accretions that has come define wood for the architect. Next a comparative inspection about wood in the forest will similarly focus on use and waste and will draw from forest science research to establish language and values. The two narratives aim to define broad but distinct trajectories, rather than acute or specific one-to-one comparisons. The conclusion will suggest new applications that arise from gaps and opportunities in each narrative.

Architectural Wood ←   → Ecological Wood

Figure 2: Trajectories Diagram

1.0 ARCHITECTURAL WOOD

1.2 Value and Design Language of Architectural Wood

A narrative sharing the modern values about architectural wood begins in the North American forests at a time when the western settlers, particularly in the mid-nineteenth century, were first conquering the unknown "wilderness," while the world was transformed by industrialization. The timber historian Ralph Andrews emphasizes the "lament and hunger" the pioneers experienced, which contrasts the rhetoric from transcendentalist and environmentalist thinkers like Thoreau, Muir, and Leopold that would come later to pine the disappearing wilderness and build the modern sustainable stage (Andrews, 1968).

Andrews describes how there was no need for forest "management" because nature was something to be tamed and even naturalists at that time, "only saw beauty in the forest… (and) at first considered them inexhaustible" (Andrews, 1968). The advent of the circular saw, machined nails, sawmills and platform framing along with an exploding population were all instrumental in highlighting woods use as a building material (Sturges, 1992). Wood's rapid commodification created greater distances between wild places and the places they were marketed and sold. These three key qualities:

inexhaustibility, technology and commodification remain embodied in the essence of today's architectural wood. Technology and commodification seem self-evident, but inexhaustibility is less so, but remains important to design. Although old-growth forest resources have dwindled greatly enough to expose quality-loss, formally protected forests continue to be extracted, engineered woods offer less dependence on high quality woods from old forests, and silviculture as a method to maintain "renewable resources" has only protracted the idea of the "inexhaustible."

Standardization happened early in this process to support the commodification of wood. For example, US forest service cites that dimensional lumber arose from the need for a "common understanding between the mill and markets" created by the increasing distances of rail or water transportation (Smith and Wood, 1964). Efficient delivery and mass production sustained the perception that resources were inexhaustible, even though forests were diminishing. Technology helped the industry to stay ahead of production by extracting more lumber efficiently. Consider that a "2x4" today still remains as a ubiquitous element both in form and in quantity. The succeeding World Wars accelerated the need for standards and engineered variants that could be stronger and lighter. This desire and dwindling forest resources propelled the creation of engineered woods. The population explosion from post WWII housing would systematize most of the modern language of architectural wood (Ore, 2011). So what does that language share about today's perception and how does it echo the history of post industrial efficiency and inexhaustibility?

"Good architecture starts always with efficient construction," echoes a familiar Meisian proverb as an embodiment of modern architecture (Konstantinidis, 1964). For wood this means structures and constructions are safe, strong and predictable - so there is no need to use more than needed. Words such as cantilever, load factor, gravity, strength, maximum forces, allowable stresses, strong, stiff, efficient, bend, capacity, deflect, directional, etc. are typical of textbook architectural descriptions associated with the human benefits of wood (Iano, 1999). These descriptions satisfy, in more definite terms, a basic professional creed in architecture to ensure the "health, safety and welfare" of the public.

Such doctrines are achieved by a slurry of words that neatly categorize wood into its most significant structural elements. Wood construction seems to be overshadowed by ingenuity of steel and concrete, but ironically, wood seems to be the root metaphor for both elements and construction methods. Wood offers a more plentiful vocabulary that pertains to the location in an assembly; one thinks of terms such as purlins, rafters, girders, beams, sills, plates, and so on. These are then augmented with connection words such as mortise and tenon, pegged, bolted, spline, laminate, tongue and groove, notched, drilled, nailed, hangers, straps, anchors, wedged, braced, and the thousands of variations of existing joints that provides a safe and predictable product. It is the malleability of wood that ensures the potential for more words, even as new tools such as CNC machines help to define new ways of engaging it.

One of the most important qualities of the architectural language is its propensity to reject the ecological processes of decay. A fundamental architectural textbook on construction methods points to the avoidance of wood products that have "discontinuities" and "distortions," with obvious prudence (Allen, 1999). These concepts shape negative sentiments about wood by defining them as "peppered with defects… (it) can split…warp… give splinters… decay and harbor destructive insects" (Allen, 1999) These dismissive qualities of wood are sensible conceptual barriers to reinforce safety. However, their presentation as apriori truths also implies that using "poor" qualities of wood might also suggest poor, amateurish designs, which sets up professional barriers for creative exploration.

The modern architectural wood language sustains the tension between humans and environment. Forests are still conceived as inexhaustible because so much is hidden and materials are extracted and discarded without regard to its other non-human benefits. The construction language favors those qualities that extract out the "wild" parts of wood for the benefit of structural efficiency. Such language originated from the a particular relationship with the natural world and it continues a trajectory away – an "anti-" sentiment – from the environmental processes (Fig 3).

← Architectural Wood | Ecological Wood |

Figure 3: Architectural Wood Post-industrial Trajectory

2.0 ECOLOGICAL WOOD

2.1 Value and scientific language of ecological wood

The field of forestry and ecology offer a description of wood in natural systems through the science of coarse woody debris (CWD). A biodiversity guidebook defines CWD as, "sound and rotting logs and stumps that provide habitat for plants, animals and insects in the source of nutrients for soul development of material generally greater than 8 to 10 cm in diameter" (Stevens, 1997).

Colloquial descriptors for CWD include "dead-wood" or "waste" and as their negative connotations might suggest, they are both ecologically and culturally misunderstood as useless objects. However, since the late seventies, CWD research supports emerging new theories about the benefits of disturbance and waste. The more recent acceptance in science to redefine wood from a thing of disease to an object of benefit is due to a shift in perceptions about ecological health and complexity. World Wildlife Fund (WWF) notes:

> For generations people have looked on deadwood as something to be removed from forest, either to use as fuel, or simply as necessary part of 'correct' forest management...breaking up these myths will be essential to preserve healthy forest ecosystems and the environmental services they provide (Dudley, 2004).

The changing values in the forest are in line with the shifting paradigmatic values about ecological systems in the last century – from static to a more dynamic, "chaotic," "complex" way to understand the world (Worster, 1994). Most notable is the dialog between ecologist like Eugene Odum and Henry Gleason who challenged different models of ecological systems. Odum advocated a world of balance and equilibrium which long dominated twentieth century thinking about forest ecosystems, while Gleason's more controversial "individualistic concept" favored the organism autonomy and a world in less balance (Clements, 2000). As work like Gleason's became more validated, a growing number of researchers began to study processes like deadwood in the forest differently, from one that disrupted balanced systems in negative way, to one that offered benefits through those disturbances. Embodied in the language of CWD research are distinct terms that contrast the concepts of "balance" and "equilibrium."

Some CWD term include: death, disturbance, decomposition, mortality, uprooting, disruption, decadence, legacies, old-growth, complexity, exclusions, diversification, fragmentation, leaching, collapse, settling, seasoning, disease, failure, distribution, regeneration, debris, catastrophe, habitat, nutrients, dynamic, accumulate, etc.[1] The terms focus around the concepts of entropy and death. All waste is utilized and cycled, which present a different kind of efficiency. It is achieved through structural diversity and the ability to connect generations in order to maintain historical continuities. These transitional states also reemphasize the simultaneous, multi-uses of CWD and are crucial background agents in important ecological concepts such as "biological legacy." The Dictionary of Forestry defines the term as:

> a biologically derived structure or pattern inherited from a previous ecosystem – note biological legacies often include large trees, snags, and down logs left after harvesting to provide refugia and to structurally enrich the new stand (Society of American Foresters).

A key structural quality of CWD is its role as a complicated background figure. It is functional scaffolding for the many interacting species, but more importantly its contribution is to link ecological time and place (Fig 4).

Figure 4: CWD complicating a old growth forest riverine system in H.J. Andrews Experimental Forest, photo by author

In terms of management of these systems, a set of prominent research ecologists explains that "structural attributes of forest stands are increasingly recognized as being of theoretical and practical importance in understanding and managing forest ecosystems" (Franklin, 2002). Significant reasons for this development include structure providing a clearer way to identify difficult to measure "surrogate functions," such as productivity. The inclusion of CWD research (i.e. dead trees) with "live trees" is significantly providing a more dynamic understanding of forest structure and therefore ecosystems.

Much like the architectural world, CWD research also identifies many terms through structural and spatial qualities and applications. Some examples include limbs, trunk, elevated areas, loose bark, food source and sites, root wad, perches, cavities, hallow, protected areas, nesting cover, thermal cover, lookouts, low soft areas, resting areas, storage, burrows, humus, etc. (Maser, 1979). And it is likely that continued observation will generate even more. Many of these terms embody simultaneously functional and formal qualities, i.e. lookouts, thermal cover, etc. Each term also describes objects with multiple intermixed functions - with ephemeral uses. A "perch" can also be a "cavity" as well as "nutrients" and even "humus" for the forest floor. Organisms like the woodpecker, a keystone specie, can intercede the process, as a "primary cavity excavator" by creating spaces in CWD that "are critical for life history needs of other species of birds and mammals." The resultant occupants, who depend on these places are described as "secondary cavity users" (Bevis and Martin, 2002).

Modern understanding of ecological wood embraces the concepts of excess and decay and depends upon the concept of inexhaustibility. These material elements seem to be stored in a form of beneficial purgatory between resource and waste – as an ecological storage bin. Abundance and redundancy help to ensure biological diversity and successional legacies when disaster strikes. Although large pieces of wood have influence, more often, smaller pieces scattered, working collectively, can have more significant impact on landscape processes. CWD presents a more complete picture of wood and also reveals the gaps that architectural wood embodies. These contemporary understandings about wood offers to draw architects toward a more ecologically collaborative synthesis (Fig 5).

Architectural Wood → | Ecological Wood |

Figure 5: Architectural Wood Trajectory toward Ecological Processes

3.0 BRAIDED WOOD

It was the inexhaustibility or abundance of resources that fueled the invention of the architectural wood through technology and commodification. Abundance is also the key bridge back to ecological processes, and therefore the notion to conserve materials, as emphasized by the sustainable paradigm, may further remove this connection. Landfills are proof that abundance can be unsustainable, however, the process of creating abundance may be the ironic foundation for an ecological transformation. Such insatiable consumption of materials has the potential to also sustain unlimited ecological – non-human – habitats. However, sustaining ecological abundance depends on designers integrating and elevating complex ecological processes like decay as an acceptable material aesthetic.

Table 1: Sample of Opposing Languages of Wood

Element	Architectural Wood	Ecological Wood
People	Architects + Urban Designers	Ecologists + Scientists
Example	(Lumber)	(Coarse Woody Debris)
Terms Used	Life, new, strong, durable, light, thin, powerful, sleek, easy, simple, balanced, hard, lasting, harmony, grace, stable, static, indestructible, clean, uniform, flawless, beautiful, load factor, gravity, strength, max forces, allowable stress, stiff, efficient, bend, capacity, deflect, directional, etc.	Death, disturbance, decomposition, mortality, uprooting, disruption, decadence, legacies, old-growth, complexity, exclusions, diversification, fragmentation, leaching, collapse, settling, seasoning, disease, failure, distribution, regeneration, debris, catastrophe, habitat, nutrients, dynamic, accumulate, salvage, heterogeneity, etc.

One way to breach this topic for the profession and collaboration is to have awareness of these embedded differences (Table 1). A recognition of these conflicts should better prepare and identify the ecological insufficiencies of design or approach. It may inspire unique design questions and barriers that help to disrupt standard practice toward ecological thinking. For example, how does one use lumber to create places for food to accumulate or to provide shelter from predators? Where and how can I site the building in order to enhance soil biology?

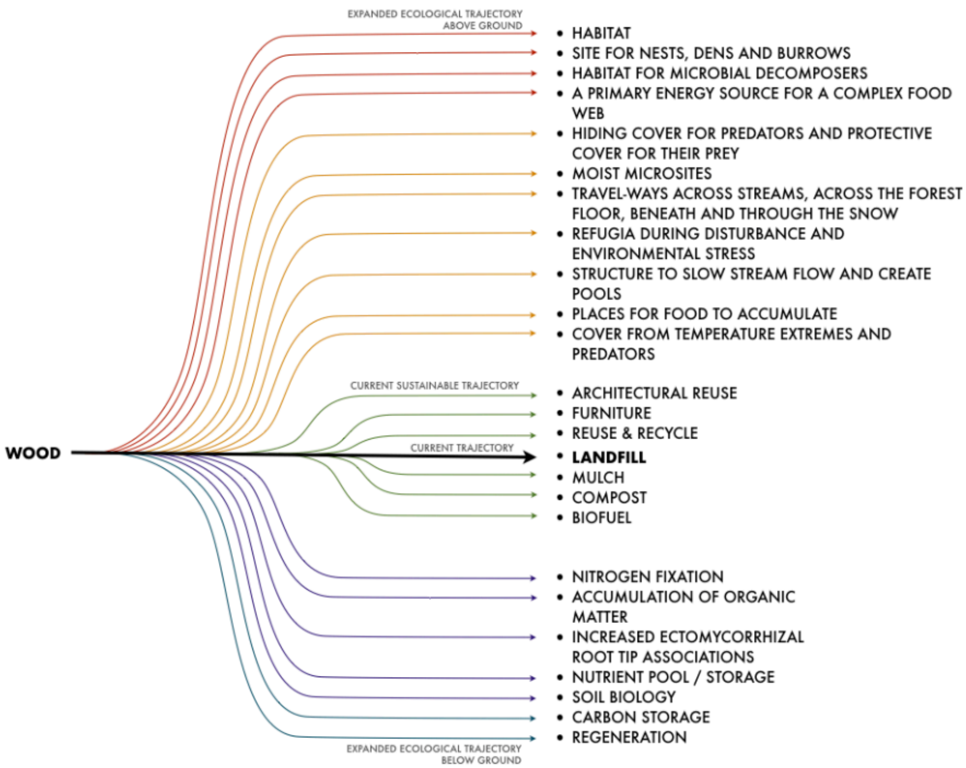

Figure 6: The Expanded Threads to an Ecological Braid

A more structured application might begin by listing the research findings about ecological wood as generated from researchers (Fig 6) (Stevens, 1997). Each potential strategy is described here as an "expanded thread," and offers a practical way to encourage ecological abundance. We can then situate the architectural design language within an array of other possible threads. The prior narration about architectural wood reveals how the current profession largely occupies one dominant thread – a linear movement from resource to landfill. The sustainable paradigm has expanded some practical "green" threads with a promise to "sustain" human benefits. The proposition here is to further expand ecological opportunities through the contribution of forest science – ecological threads. Designer working toward a more braided outcome will also naturally work within linguistic threads and frameworks familiar to ecologists. The desire is to promote a more purposeful and direct collaboration that magnifies the expertise of each discipline, rather than isolating them (Fig 7). A braided project that is able to draw from a more diverse and abundant set of threads provides resiliency through redundancy and has the potential to sustain social relevance as well as economic well being.

Architectural Wood →   ← Ecological Wood

Figure 7: Braided Mediation

The architectural theorist Brook Muller writes about the role of metaphor and ecological thinking as "extending outward to the unfamiliar leads to intimacy of shared ethos and generation of new metaphorical scaffolds" (Muller, 2014). The braided metaphor is a scaffold to make more concrete a shared ethos that environmentally conscious designers strive for, yet often times run into limitations. A dip into an authentic ecological world through the lens of our common building materials is, unfortunately, strangely unfamiliar and unrecognized. It raises many questions about what potential habitats can be brought together with such structures and how this may challenge more traditional architectural responses. What are the professional and regulatory challenges for architects to integrate "habitats" for non-human species and processes? How does architectural education reimagine a world of decay and abundance in terms of sustainability? How might the recognition of non-human ecological processes in materials change other parts of the design language, such as studio, structure and construction? What are the best methods to braid ecological threads so they promote the highest level of collaboration and benefit?

REFERENCES

Allen, Edward. *Fundamentals of Building Construction : Materials And Methods.* 3rd ed. New York: Wiley, 1999.

Andrews, Ralph. Timber. Toil and Trouble in the Big Woods. Superior Publishing Company, 1968. Hardcover.

Bevis, Kenneth R, and Sandra K Martin. "Habitat Preferences of Primary Cavity Excavators in Washington's East Cascades." *Laudenslayer, WF, Jr.; Shea, PJ; Valentine, BE* (2002): 207-20.

Bratkovich, Steve, Jeff Howe, Jim Bowyer, Ed Pepke, Matt Frank, and Kathryn Fernholz. "Municipal Solid Waste and Construction and Demolition Wood Waste Generation and Recovery in the United States. ." *Dovetail Partners, Inc.* (2014).

Clements, Frederic E. "Preface to Plant Succession: An Analysis of the Development of Vegetation." In *The Philosophy of Ecology: From Science to Synthesis*, edited by David R. Keller and Frank B. Golley, xiii, 366 p. Athens: University of Georgia Press, 2000, 1916.

Dudley, Nigel , Daniel Vallauri, and WWF France. "Deadwood - Living Forests." Gland, Switzerland, 2004.
Forest Products Laboratory, L. W. Smith, and L. W. Wood. *History of Yard Lumber Size Standards.* [Madison, Wis.]1964.

Frampton, Kenneth, John Cava, and Graham Foundation for Advanced Studies in the Fine Arts. *Studies in Tectonic Culture : The Poetics of Construction in Nineteenth and Twentieth Century Architecture.* Cambridge, Mass.: MIT Press, 1995.

Franklin, J.F., T.A. Spies, R.V. Pelt, A.B. Carey, D.A. Thornburgh, D.R. Berg, D.B. Lindenmayer, et al. "Disturbances and Structural Development of Natural Forest Ecosystems with Silvicultural Implications, Using Douglas-Fir Forests as an Example." *Forest Ecology and Management* 155, no. 1-3 (2002): 399-423.

Iano, Joseph. "A Naturally Grown Building Material." In Fundamentals of Building Construction : *Materials And Methods*, edited by Edward Allen, x, 852 p. New York: Wiley, 1999.

Logan, William Bryant. Oak: *The Frame of Civilization.* WW Norton & Company, 2005.

Maser, Chris, Ralph G. Anderson, Kermit Cromack Jr., Jerry T. Williams, and Robert E. Martin. "Dead and Down Woody Material." *In Wildlife Habitats in Managed Forests : The Blue Mountains of Oregon and Washington*, edited by J. Louise Parker, Jack Ward Thomas, United States. Forest Service., United States. Bureau of Land Management., Pacific Northwest Forest and Range Experiment Station (Portland Or.), Pacific Northwest Forest and Range Experiment Station (Portland Or.). Information Services. and Wildlife Management Institute., 512 p. Washington, D.C.: Wildlife Management Institute : U.S. Dept. of Interior For sale by the Supt. of Docs., U.S. G.P.O., 1979.

Muller, Brook. *Ecology and the Architectural Imagination*. Routledge, 2014.

Odum, Eugene P. "The Emergence of Ecology as a New Integrative Discipline." In *The Philosophy of Ecology: From Science to Synthesis*, edited by David R. Keller and Frank B. Golley, xiii, 366 p. Athens: University of Georgia Press, 2000, 1977.

Ore, J. "Mobile Home Syndrome: Engineered Woods and the Making of a New Domestic Ecology in the Post–World War Ii Era." *Technology and culture* 52, no. 2 (2011): 260-86.

Society of American Foresters. "The Dictionary of Forestry." http://www.dictionaryofforestry.org/.

Stevens, Victoria. *The Ecological Role of Coarse Woody Debris: An Overview of the Ecological Importance of Cwd in Bc Forests.* British Columbia, Ministry of Forests, Research Program, 1997.

Sturges, W.G. "An Exploration of the Relationships between Houses and Forests in American History." *Journal of architectural education* (1992): 66-75.

Worster, Donald. "The Ecology of Order and Chaos." In *The Wealth of Nature: Environmental History and the Ecological Imagination:* Oxford University Press, 1994.

ENDNOTES

1 Many of the CWD terms identified through out this paper can be found in the following overview article. However, other terms were all also collected from CWD papers cited throughout this paper. Stevens.