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Analysis Concerning the Disaster of the Forest:
A Theoretical and Practical Approach

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INTRODUCTION

The explosion of serious forest fires in the Rocky Mountain West in recent years has opened the public eye to the unhealthy condition of forests. The extended drought has combined with dense forest conditions to make many residents of rural Arizona quite fearful of the possibility of additional fires. The public interest has even resulted in federal policy changes known as the Healthy Forests Initiative, which has, of course, stimulated increased public discussion.

The discussions concerning the solutions or lack thereof have been primarily based on ecosystem science and political rhetoric based on the duality of extraction and preservation. This article addresses the issues concerning the health of our forests from a social and economic perspective based on the engineering capabilities of the wood and wood fiber in question. Laying a theoretical foundation of social and economic change based on Norgaard (1994), Jacobs (1984 and 2000) and Smith (1994a, 1994b and 2000) we first put the issues of forest health into a current perspective. The practical steps of forest restoration based on Covington (2003), Covington *et al.* ((1997), Pyne (1982) and others are discussed, then we explore the specific requirements of renewing forest health. Using the engineering and business analysis of Larson (2001), Dramm (1999), Polzin (1994) and Irland Group (1991), we investigate the practical realities of returning our forests to healthy and safe conditions. Finally, we make reasonable recommendations concerning policy and practices that will eventually lead to successful restoration within a reasonable amount of time. In order to set the stage for our discussions, we first provide a primer of the current status of our forests.[2]

A PRIMER ON FOREST HEALTH IN THE SOUTHWEST

Consider the forests surrounding Flagstaff, Arizona – the home of the authors. In the typical pre Euro-American settlement situation, a stand would encounter fire approximately every 2 to 8 years (Moore *et al.* 1999). These low intensity fires limited trees seedling establishment resulting in open, park-like forests across much of the landscape. As a result, stands on the nearby Coconino National Forest were dominated by large pines (an average of about 20/acre) and interspersed with small to large grassy openings (Woolsey 1911, White 1985, Covington *et al.* 1997, Mast 2003). However, early research on southwestern ponderosa pine often focused on large trees, leaving open the question as to how many seedlings, saplings and small trees accompanied the larger 'blackjack' and old growth 'yellow' pines. Pollock and Suckling (1997) speculate that many stands would have been recorded at 100 to 200 trees per acre if small trees had been tallied. Despite these caveats, there is broad recognition that tree densities have increased dramatically over the past 100 years and that most stands are now comprised of medium to small trees. Some stands in the Flagstaff area now contain well over 1,000 trees/acre (Covington *et al.* 1997), and large, old yellow pines are beginning to die because of increased competition (Mast *et al.* 1999) and bark beetle outbreaks.

[2] Readers familiar with the current problems facing our forests may easily skip the next section and go straight to the section of the theoretical background.

The causes of these changes include selective logging, which removed large trees, introduction of domestic cattle that removed fire-carrying grasses, and suppression of natural fire (Covington 2003). These changes allowed exuberant growth of tree seedlings that would have been otherwise thinned out by cleansing ground fires, but have now reached heights that serve as ladders for ground fires to reach into the overstory canopy of the forest. Furthermore, patches of dense forest, once a rarity, are now the norm, forming a continuous blanket of fuel across the landscape. When fire inevitably returns to this new forest it often burns as an intense ground fire, destroying the soil structure, killing the old growth trees with 100 years of needles accumulated around their bases, or it climbs into the canopy of the forest and kills nearly every tree in its path, threatening human lives and communities.

The economic costs associated with large, high-intensity fires are staggering. An example comes from the 2002 Rodeo-Chediski fire in eastern Arizona. More than four hundred homes and buildings were lost. This has caused Navajo County a loss of roughly $20 million in real property value and the corresponding tax losses. Businesses in Show Low and surrounding communities lost many days of patronage. And the value of the lost timber is estimated to be hundreds of millions of dollars.

The financial cost of fires such as these is not the only concern. In 2000, over 8.4 million acres of forests burned, mostly in the Rocky Mountain west, and often as large, high-intensity, uncontrollable fires. Like the ponderosa pine forests of the southwestern U. S. , many western forest ecosystems are not adapted to these types of stand-replacing fires, so the environmental consequences can be enormous, and include landslides, floods, denudation of soil, loss of endangered-species habitat, and degradation of air and water quality, among others. Often entire ecosystems are destroyed and the prospects of recovery within two or even three human generations are bleak. Air quality is severely affected across great distances for days or weeks during the fires as huge amounts of unhealthy particulates enter the atmosphere.

Clearly, the forest problem is immense, the potential adverse impacts are serious for our communities, and the costs are enormous. The unintended consequences of 100 years of human activities has set these ecosystems on an unprecedented trajectory that cannot merely be reset by letting “nature take its course.” The restoration of forests to healthy conditions while reducing fire risks requires a combined approach of thinning small-diameter trees from unnaturally-dense forests and the reintroduction of low-intensity surface fires. (Covington 2003).

The critical component of thinning, however, is expensive and generates large volumes of wood fiber that cannot be left in the forests due to risks of high intensity fire, insects, and disease. In the Flagstaff metro area alone, nearly 180,000 acres of wildland-urban interface are at risk of high severity fire. Mitigating this problem by thinning these forests will cost an estimated $150 to $1,200 per acre, representing a total cost of $90 million for restoration of the Flagstaff area alone.

In the interior western states are over 120 million acres of national forests, of which an estimated 39 million acres need some kind of restoration treatment to reduce severe fire possibilities; these figures do not include private, state or tribal lands. The projected cost for the restoration work is $51 billion. In a 1999 report, the General Accounting Office estimated that it would cost up to $12 billion to reduce fuels on high-risk forest acreage by the end of 2015, an annual average of $725 million, yet the federal budget for hazardous fuels reduction in 2001 was less than $400 million. At this level of funding, the effort will likely never reach a reasonable level of success. Net costs of treatments necessary to remove excess biomass (i.e., plant material usable as a resource) from the forests can be as high as $1,200 per acre, depending on the availability of suitable biomass markets. In contrast, in 2000 federal agencies spent more than $1.3 billion on fire suppression.

It is clear from this introductory discussion of the problems facing our forests that the costs of remediation are well beyond the willingness of taxpayers to pay. The solution, therefore, must lie with the private sector. Some would argue that past logging practices helped produce the unhealthy state of our forests and the private sector can therefore not be part of the solution. This argument is analogous to refusing medical treatment because doctors once prescribed medical treatments that later proved to be harmful. Opportunities do exist for creating healthy and safe forests through public-private partnerships that will yield profitable results for entrepreneurs and the forest. A new forest-based industry founded on the concepts of science-based forest management and ecological sustainability is the logical solution in a market-based economy.

The questions then becomes, what can this small diameter wood, the by-products of ecological restoration, be used for and can profitable markets be found and developed to encourage the private sector to engage in forest

thinning at minimal public expense? The answer is a qualified yes-qualified, because the supporting forest products industry infrastructure has mostly disappeared from vulnerable forested regions such as northern Arizona.

THE SOCIAL AND ECONOMIC THEORETICAL BACKGROUND

The previous section detailed the basics concerning the health of our forests in the southern Rocky Mountain West.[3] However, that language implies a separation between the forests and human society. The reality is that human society and the forests are intricately intertwined and the problems and possible solutions must be based on this reality. Jacobs bases her latest book on this very idea:

> The theme running throughout this exposition – indeed, the basic premise on which the book is constructed – is that human beings exist wholly within nature as part of the natural order in every respect. (Jacobs, 2000, Page ix)

> Norgaard echoes Jacobs' idea by invoking what he calls the co-evolutionary theory. He understands that: (I)n the coevolutionary paradigm, the environment determines the fitness of how people behave as guided by alternative ways of knowing, forms of social organization, and types of technologies. Yet at the same time, how people know, organize and use tools determine the fitness characteristics of an evolving environment. At any point in time, each determines the other. (Norgaard, 1994, 46)

Norgaard describes his theory using the issue of the pesticide DDT. Herein, we will apply his theory to the forestry practices of the last century. The U.S. federal forest policy became one of fire suppression in the first decades of the 20th Century. This policy may have been stimulated by a series of monumental fires such as the one in Cloquet, Minnesota on October 12, 1918. (Weatherford, 1991, p 42-47) This firestorm killed more than 500 people, burned a million acres and completely leveled the town and surrounding communities. Similar fires occurred in the Great Lakes region. Thus society's "way of knowing" was radically changed by these fires.

The form of social organization became one of reformulating forest practices to include fire suppression on a massive scale. As technology changed, the tools of fire suppression improved and the success (based on the goal of suppression) of the policies improved.

Following decades of calamitous management practices based on a faulty goal, the fitness characteristics of our forests changed. Instead of regular cleansing fires, the refuse of the forest accumulated and accumulated. For example, when researchers implemented experimental prescribed fires in the Flagstaff area, large, valuable yellow pines were inadvertently killed because of intense heating from the 100 years of needle accumulation around their bases (Covington and Sackett 1984). The increase in tree density resulting from fire suppression began reaching heights that could carry fire into the crown of old growth forests like a ladder, and they began to fill in the spaces between larger trees creating a blanket of fuel across the landscape. And foresters began to worry about the new fitness characteristics of the environment.

Due to the changes in the environment, a new way of organizing and a new set of tools were tried. National fire policy changes in the 1970s supported attempts to use fire as a management tool. "Let burn" and other prescribed fire policies recognized the potential wildlife, societal, and economic benefits of natural fire (Pyne 1982). Around this time various research groups concerned with forest health began searching for new strategies. Perhaps the national leader in forest restoration has become the Ecosystem Restoration Institute (ERI) at Northern Arizona University. Led by Wallace Covington, ERI has been exploring new ways of knowing and new tools for forest management by studying the natural history of fire-dependent ecosystems and experimenting with methods for creating sustainable forest structures that are compatible with natural processes. Using the principles of ecological restoration, the scientists at ERI have provided substantial new ways of knowing concerning the methods necessary to return our forests to healthy and safe ecosystems. However, since the sheer magnitude of the number of acres involved and the costs of restoration are overwhelming, it will also be necessary to develop new ways of organizing the efforts of restoration.

Smith (1994a, 1994b and 2000) attempts to explain a social evolution framework by which social systems adapt to exogenous change. Although Norgaard views the changes in forest health as endogenous, Smith's theoretic

[3] Our focus herein is the ponderosa pine forests of northern Arizona and southern Utah. The specific treatment practices described are not appropriate for all forest types. Furthermore, the engineering study by Larson (2001) focused on the wood characteristics of this wood type.

would view them as exogenous. Since both authors were working at the same time, they do not contradict each other, rather, Norgaard was looking at the relationship between society and the environment and Smith was simply looking at the components of society. Smith, based on Parsons (1957) and others, explains how society is made up of various subsystems co-evolving to find new levels of compatibility. Examples of these subsystems, appropriate for current discussions, are the economy, the polity and the environmental movement.

Within the Smith framework, the exogenous change of severe and catastrophic forest fires has resulted in changes with the polity. By which we mean that the social awareness has led to new pieces of legislation and concern at the political level. There have also been changes within the environmental movement since many, but certainly not all, people involved with environmental concerns have realized that something *must* be done to improve the health and safety of our forests. But, as discussed above, the simple changes are unlikely to solve the problem. The economic system must also adapt.

> Arizona Governor Napolitano's January 12, 2003 State of the State speech points to this very problem: In addition, I directed that prison inmate crews work alongside local contractors to build fuel breaks and clear evacuation corridors around communities like Pine, Strawberry and Flagstaff. And the State Land Department devoted its resources to reduce excess fuels on forested trust lands throughout Arizona.
>
> In just one month, our prison inmates treated more forest lands in the Tonto National Forest than the U.S. Forest Service did all last year. We must continue to do our part on state-owned lands. Our mountain communities are depending (on) us, and we cannot disappoint them. For next year, my budget will include funding to double the number of inmate crews assisting in tree thinning near forest communities.
>
> Arizona is doing all it can to protect against the silent disaster of drought and beetle infestations, but the hard truth of the matter is that most of the forests that need treating are on federal land. And while Congress recently passed a forest health bill, it did so with inadequate funding and therefore no real promise of action. (Napolitano, 2004, p 10)

So the question becomes one of how shall the economic subsystem, one of our ways of organizing, change in the light of the forest issues facing the Rocky Mountain West? It is unlikely that our prison population will be sufficient. Prison crews working with hand tools are only able to thin the very smallest of trees, a task usually insufficient to significantly reduce the risk of high intensity fire let alone restore natural fire. In part we can develop an answer using the framework of Jacobs (1984 and 2000).

Beginning with her 1960 tome, Jacobs has repeatedly addressed the question of: what causes economic development? Roughly once a decade since then, she has reinvestigated the same question. Smith (1994b and 2000) depends heavily on her 1984 work. The following relies heavily on her expanded understanding from her most recent work (2000), where, like Norgaard, she includes the environment as an endogenous component of societal evolution.

Clearly, the polity will be unable to absorb the immense costs of restoration. Furthermore, the current practices of thinning, slash pile burning, and prescribed burning include a middle step that results in a substantial waste of potential resource. Namely the thinned wood – potentially useful wood fiber - is simply burnt. Not only is this possible resource being destroyed, it also causes serious air quality problems (GCVTC, 1996) across the region and releases large pulses of carbon dioxide into the atmosphere. Larson, Smith and Smith (2002) addressed some of the issues concerning the potential economically valuable uses of this resource.

Jacobs' (2000, Chapter 2) development paradigm is constructed from three fundamental development principles. The first is "differentiation emerging from generality" (page 16, emphasis in original) in terms of products and services being produced. As discussed below, Larson (2001) examined the multitude of products (differentiations) that might be produced using the small roundwood (generalization) thinned during the restoration process.

Jacobs' second so-called universal principle is: "*Differentiations become generalities from which further differentiations emerge.*" (page 17) As new product lines are developed using the thinned wood and wood fiber, new and different uses will develop. Thus is the entrepreneurial spirit.

The third principle is: "*development depends on co-developments.*" (page 19) An example of this, expanded on below, is the need to have co-developments with regard to transportation and processing of the resource. This is the web of development necessary for sustained progress.

Jacobs also includes an additional point relevant to our current discussion. The development process relies on testing adaptations. Not all new differentiations will be successful, but differentiations must be attempted, and the

social system must allow and even encourage these tests. Her theory is not the "Thing Theory" where we simply produce more of what we have. Rather, it is a theory of change and adaptation. "'Well, it requires economically creative people.'" (page 32)

Cornell and Kalt (1990, 1991, 1992a and 1992b) and Smith (1994b and 2000) argue that economic development must be founded and constrained by the culture of the developing social structure. Although these authors were writing in the context of developing Native American reservation lands, the idea holds true for the communities of northern Arizona. Those of us who live among the majesty of the mountains and forests tend to have a very emotional attachment to the land. In other words, the social system of our communities has evolved to include cultural components related to the land. Our concerns are not simply the danger of forest fires or the quality of our air when either uncontrolled or controlled fires occur.

Certainly, on intellectual and financial bases, we understand the potential costs, but our concerns with the forest include an emotional understanding that – to use Jacobs' language – "human beings exist wholly within nature as part of the natural order in every respect." Thus, for many of us, we need to develop new strategies that go beyond simply making our homes and businesses safe from fire hazard. For example, the authors of this paper would be far more horrified if the magnificent San Francisco Peaks were ablaze than if 50 or 100 houses in Flagstaff were lost.[4]

A few environmental groups who vehemently protest any timber harvesting have acceded to allow limited thinning programs within the wildland-urban interface. Although these programs may increase the safety of our communities, they do nothing for vast majority of at-risk acreage. However, many of the representatives of these groups do not live within the affected communities.

An example recently occurred following the Rodeo-Chediski. In order to harvest salvageable wood, efforts were made to let contracts to cut down the burned and *dead* trees. Almost immediately an environmental group *from New Mexico* filed suit to stop the process. The following is quoted from a news article at the time.

A Forest Conservation Council spokesman said the Forest Service is using the "C.E." (categorical exclusion, i.e., hazardous) designation to justify "widespread commercial logging" in the burned area…

Chairman of the Navajo County Board of Supervisors and ECO (Eastern Arizona Counties Organization) board member Pete Shumway said, "This lawsuit can only harm our local forests and communities . . . These trees must be removed because we face a continual fire hazard. Dense vegetation still exists throughout the forest, and the potential this year for another Rodeo-Chediski-type fire in our area is very real…"

Ron Christensen, Chairman of the ECO Board of Directors, said, "We are in an emergency situation throughout Arizona that demands immediate action, and this lawsuit would block months of recovery efforts. We need solutions, not obstacles." (Baeza, 2003a)

> The legal battle continued throughout 2003, and:
> Although the plaintiffs did not get what they wanted from the District Court, they are winning the battle of time. If the legal process is spread out over a long enough time period, the dead timber will be unsalvageable. (Baeza, 2003b)

Summarizing this discussion, it is clear that we need to find new ways of knowing, organizing and doing following the change in the fitness characteristics of the forests following nearly a century of improper human interaction.[5] Only when sufficient amounts of wood and wood fiber are removed from the forests will the communities of the southwest be safe and healthy. However, it is clear that federal and state tax dollars will be insufficient to restore the forests to healthy and safe status – even if we emptied the prisons to work on chain gangs. Therefore alternative methods need to be developed. Namely, economic development opportunities exist to utilize the wood and wood fiber that must be removed from the forests. These opportunities need to involve co-developments in terms of production methods and final goods.

In the next section, we present practical approaches to successful thinning programs. These approaches are based on engineering, economic and political realities.

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[4] A real –though anecdotal -example of this hypothetical was shared with one of the authors. A representative from Idaho National Engineering and Environmental Laboratory explained how one tribal member was angry with the federal fire fighters: "Why did you waste so much time trying to save those houses? It took HUD 4 months to build them, but it took centuries for the forest to grow." Private conversation with Steve Jordon of INEEL at the Modern Native America conference, Flagstaff, AZ., August, 2001.

[5] See Weatherford (1991, Chapter 4) for a discussion of Indian Fires.

CLEANING UP THE MESS: SOME PRACTICAL SOLUTIONS

The challenges facing the southern Rocky Mountain West are new in terms of our understanding the human relationship with the forests. These challenges are *unrelated* to those of the past concerning industrial logging on public lands and poor forestry practices. David Suzuki and others beautifully educated us concerning the need to change our ways of knowing, organizing and doing with regards to mining timber. In order to find solutions to the new family of issues, it is necessary for all concerned to appreciate the need for a new paradigm and to move away from the "complete or no harvest" dogma.

Perhaps the greatest difference between the existing need and that of the past is the imagined structure of what is left behind after restoration. Early harvesting practices in the U.S. focused on producing wood products, with little regard for what was left behind. Early U.S. Forest Service regulations helped ensure the perpetuation of forests by requiring that seed trees be left during harvesting or that trees be replanted where natural seeds were unavailable. Later, wildlife biologists came to realize the importance of leaving some large dead trees behind for wildlife habitat, maintaining some areas as in certain structural stages (such as old growth) to benefit certain species (such as the northern spotted owl). Yet, these actions were largely mitigation for the Forest Service's mandate to produce wood for society. Over the past two decades that mandate has become much less clear with priorities such as recreation, scenic beauty, and other societal values increasing in importance. Today, the de facto mandate of the U.S. Forest Service in the western U.S. is to provide multiple services to society, and timber production is clearly no longer the most important of these in the Rocky Mountain West. Ecological restoration, which is being pursued throughout many of the National Forests of the Rocky Mountain West, focuses on what is being left behind, not what is being removed. Harvesting projects are now referred to as 'treatments' and are prescribed to make beneficial changes to unhealthy forests--a doctor-patient relationship. The recent increase in fire size and intensity simply increases the prominence of non-timber priorities.

Following the discussion above, there is *no intention* to remove all, or even most, of the large trees from the forest. Nor is there any intention to leave behind a tree farm structure. One result stemming from this goal is the type and quality of trees that require removal. A healthy restored forest will contain trees with a robust distribution of size and maturity across the landscape. Since the current overgrowth is primarily – but not completely – due to far too many small trees, the nature of the harvesting process is substantially different from past harvesting practices aimed at large and mature trees. This change results in several new questions: transportation, processing, and wood characteristics. Although these are interdependent issues, we will treat them individually and then summarize.

Transportation

The current restoration practice for ponderosa pine forests focuses on a three-stage process: thinning, slash pile burning, and prescribed burns. Since very few markets exist for the wood, it is burned in place. One of the main difficulties with developing markets for the wood is transportation. The vast majority of the thinned timber is small in diameter and therefore requires different transportation strategies than the traditional large trees.

A second difficulty with transporting the wood out of the forest is the structure of the remaining growth. Since the goal is a healthy and safe forest ecosystem, it is not conceived that multitudinous roads – even temporary ones – be cut into the forests. Thus the path from stump to collection site is necessarily of a zigzag nature prohibiting large scale removal. Initially, the distances would be small since the wildland-urban interface is, by definition, near to available roads.

As the thinning programs move from the wildland-urban interface into the interior of the forests, the high per mile transportation costs will be multiplied by increased mileage and further exacerbate the problem. In the context of Jacobs' co-developments, the development of improved transportation methods and equipment will occur if the markets develop.

Processing

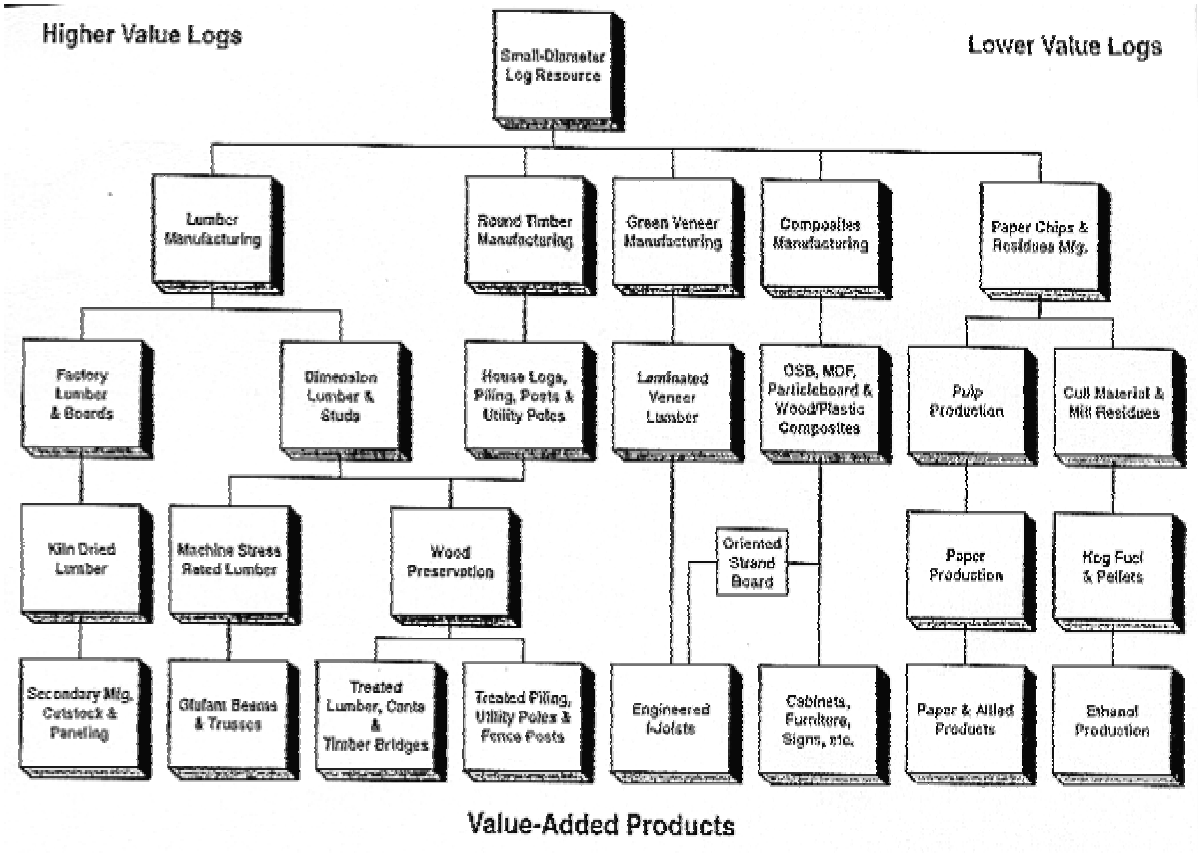
Historically, timber processing focused on large diameter trees off-site. The new puzzle of thinning small diameter trees will require new and smaller equipment to cut and process the trees on-site. Depending on the final use of the wood and wood fiber, much of the processing *could be* completed at the harvest site. This could include chipping either prior to debarking or after debarking.[6] Alternatively, small portable sawmills could be used on site to process the trees to portable sizes. As the processing industry grows, smaller and more portable equipment should become available in the sense of Jacobs' co-developments.

[6] See sample equipment descriptions at Morbark, Inc., www.morbark.com and Wallingford's, Inc., www.wallingfords.com,.

Wood Characteristics and Possible Markets

Larson (2001)[7] investigated the potential uses for small diameter ponderosa pine trees. She began by using Dramm's (1999) flow chart of possible uses for small diameter log resources. Two dimensions were evaluated for possible uses. The horizontal dimension, left to right shows decreasing log value. The vertical dimension, top to bottom, shows increasing levels of processing.

Figure 1. Potential Products for Small-Diameter Utilization (Dramm, 1999)



Larson evaluated eight dimensions to create a decision matrix for possible uses of the fiber. These criteria reflect the requirements and constraints that possible solutions must meet. Evaluation criteria at this stage of decision making are at a relatively high level of abstraction, but are distinct enough to differentiate between fiber uses. The criteria include the following: initial costs and flexibility, discharge, water usage, wood material properties, size suitability (four categories), revenue potential, jobs, and market outlook. The results of Larson's work are summarized below.

Ways of Organizing

The above quote from Governor Napolitano mentions how the state contracts current thinning projects. In other words, the state *pays* contractors to thin sections of the forest. Historically, harvesting contracts on state and federal lands have worked the other way – the timber company *pays* a royalty to the government. These ways of organizing need to be reconsidered given the current fitness characteristics of the forests and the goals of the thinning program. As such, two guiding principles were used to screen the various uses; yielding a smaller number of truly viable alternatives.

The two guiding principles were (Larson, 2001, p4-5):

[7] This unpublished work is available for interested readers at the Sustainable Energy Solutions website in the Engineering Reports subheading. Inclusion of the complete report herein would unnecessarily lengthen and confuse the current focus on policy initiatives.

1. The projected size of a northern Arizona based forest health and fire-risk reduction program is large[8]. Given this, it was felt that only those industries that could convert, on a sustained basis, large volumes of wood from small diameter trees should be considered. Small-volume, independent users were not considered, because they would not be able to sustain, on the basis of input volume, a restoration program of any significant level.

2. Those uses that represented primary manufacturing approaches were considered over secondary products. Secondary products are manufactured from one or more primary products. Examples include wood boxes, kitchen cabinets, wood I-joists composed of structural panels, or laminated veneer lumber. Secondary products are not feasible if the primary materials are not readily available. In addition, the location of secondary products manufacturing is a key factor in determining market success. Proximity to market is more important than proximity to raw material (Polzin, 1994). Market research shows limited opportunities for "value-added" wood products in rural areas (Irland Group, 1991) like that of northern Arizona.

Upon application of these two guiding principles to the criteria listed above, seven products, listed in Table 1, were deemed suitable for further analysis.

Table 1. Possible Uses for Small Diameter Ponderosa Pine in Northern Arizona (Larson, 2001, p 5)

Label	Product
A	Oriented Strand Board (OSB)
B	Plywood
C	Particleboard (Part'b'd) and Medium Density Fiberboard (MDF)
D	Lumber and Boards
E	Mechanical Pulp
F	Ethanol
G	Roundwood use cluster

Table 2. Completed Decision Matrix Comparing the Suitability of Uses (Larson, 2001, p 30)

			A	B	C	D	E	F	G
	Criteria	Wts. (%)	OSB	Plyw'd	Part'bd	Lumber & Boards	Mech. Pulp	Ethanol	Round Wood
1	**Initial Cost/Flexibility**	12.5	3	4	3	4	4	2	5
2	**Discharge**	6.25	3	3	3	4	2	3	4
3	**Water Usage**	6.25	3	3	3	3	2	1	5
4	**Wood Properties**	12.5	3	1	3	2	3	3	3
Size Suitability:									
5	**Slash, B&N**	6.25	3	3	3	3	3	4	3
6	**3" ≤ dbh < 5"**	6.25	3	3	4	3	4	4	3
7	**5" ≤ dbh < 9"**	12.5	3	1	3	2	3	3	3
8	**9" ≤ dbh < 12"**	6.25	3	2	3	4	3	3	4
9	**Revenue Potential**	12.5	3	1	2	2	4	1	2
10	**Jobs**	6.25	3	3	3	3	3	3	1
11	**Market Outlook**	12.5	3	1	3	3	4	2	1
	Total Raw Score		33	25	33	33	35	29	34
	Rank*		3	5	3	3	1	4	2
	Total Weighted Score		30.00	20.63	29.38	28.75	33.13	25.00	30.00
	Weighted Rank*		2	6	3	4	1	5	2

*Ranking ranges from 1 to 7, with 1 being best.

[8] Earlier work (Larson and Mirth, 1998) suggested that there are over 600,000 acres in the Coconino National Forest alone that may need some treatment with the potential of generating 2.5 million ccf of fiber from 5" to 12" dbh tree class.

By evaluating the relative performance of six logical products to a benchmark product within eleven categories ranging from revenue potential to raw material compatibility to infrastructure flexibility, Larson found that large-scale commodity type products dominated. Mechanical pulp and its related paper and board products were judged as the most suitable product opportunities. Two of three panel products, OSB and the non-structural grouping of particleboard and MDF, followed closely behind. They are judged suitable because of their ability to convert large quantities of small diameter ponderosa pine with objectionable growth characteristics into high value product, while providing better paying employment opportunities. These types of commodity markets, however, are vulnerable to complex demand and supply problems. They typically overbuild their production capacity during times of high product demand that eventually results in oversupply and price compression.[9] This cyclic behavior reflects back into the community through production slowdowns, short or long term layoffs, and demands for cheaper raw materials.

Small-scale roundwood uses were also judged suitable. Even though this study evaluated only one mix of products (firewood, hogans, hand-peeled vigas and poles), we believe that the conclusions drawn about this mix are relevant to other small-scale product uses. It represents the type of specialty niche market that is small in scale, requires less up-front capital investment, but demands high quality and attention to customer service. Roundwood use clusters can convert only small quantities of wood fiber into value-added products. As a result, their ability to sustain large-scale forest health and fuels reduction programs within the region's national forests will be limited. Depending on the actual products, the roundwood uses may target higher quality trees – which will require either a pre or a post thinning sorting.

Although a wood-to-ethanol manufacturing facility could utilize a great deal of small diameter wood and provide potential economic benefits to the local community, the cost of the input fiber precludes further analysis

Because of the current lack of suitable wood fiber markets, the ability of the region's forest systems to fund thinning projects depends heavily on state and federal appropriations provided for fire reduction goals. Current appropriations are limited and and the promise of new money is uncertain. The need to thin, however, will grow stronger, while the ability to do so is diminished unless alternative funding mechanisms are found. Wood product industries provide that alternative funding through the purchase of thinning by-products. In effect, the manufacture of suitable wood-based products *is a necessary component for sustaining forest health and fuels reduction programs*. Their establishment, however, relies heavily on the availability of a steady supply of fiber of sufficient quantity.

In response to the catastrophic fires in recent years, Arizona Governor Napolitano created the Forest Health Oversight Council to make recommendations concerning forest management. On January 27, 2004, the council released draft recommendations for public comment. The recommendations describe new ways of organizing society to respond to the new situation facing Arizonans. Recommendation 18 (of 30) specifically addresses the need to recreate the wood utilization industry in Arizona:

> 18. The (Arizona) Department of Commerce should cultivate businesses that will contribute to an economically and ecologically sustainable wood utilization sector. (Forest Health Oversight Council, 2004, p22.)
>
> The rationale for this recommendation is given as:
> Over the last fifteen years Arizona has lost its wood-harvesting and utilization infrastructure. This has left Arizona in a situation where there are thinning and restoration projects ready for implementation, but no companies with the expertise to remove trees and nothing but a handful of commercial interests willing to use a minute portion of the material. The result is that projects are delayed and wood is disposed of in landfills or burned on site—creating smoke, releasing carbon, and wasting valuable energy. In the face of this difficulty there is opportunity for positive change. Over the last forty years we have learned that sustainable forest communities and sustainable wood-based enterprises depend on ecologically sound management of our forests. There is general acceptance that future commercial development should be based on long-term goals of community and forest health. The Economic Utilization Subcommittee will develop through open / inclusive communication and dialogue a zone of agreement surrounding the sustainable harvest of forest resources, related to the outflow of materials from forest restoration and fire-hazard reduction activities. (Forest Health Oversight Council, 2004, p23.)

[9] Although a competitive environment is typically desired, care must be taken with regard to policy design to avoid over investment in the wood utilization sector. The quantity of available wood must be balanced with the efficient size of the typical processing plant to determine the possible number of subsidized businesses.

The redevelopment of the wood utilization sector presumes that access to raw materials is readily available. This will require an alteration in the current state and federal practices of restoration: thinning, slash pile burning and prescribed burning. A new system of contracts needs to be developed that will be attractive to private businesses to complete the harvesting, transporting and processing of the fiber. At the same time systems and procedures need to be determined to ensure a healthy forest. Concerns of over harvesting and improper processing must be addressed (including penalties) prior to implementation. This new way of organizing will be an adaptation of the two existing systems.

At both the state and federal levels, systems exist for forest restoration and commercial timber contracting. The new system for small diameter wood harvesting will fall between these two. Based on modern ways of knowing about forest health, being developed by ERI and others, a new system of rules and regulations needs to be created to allow for contracts between the state and federal governments and private businesses. The resulting market price will be between what the state pays for current thinning and what the state receives for current harvesting.[10]

Depending on the market conditions for the final processed material, either the utilization businesses will be profitable enough to pay for access to the forests, or the government will reduce costs by paying lower per acre rates for the company to complete the thinning process. In the former case, the government will generate additional revenues to be used for forest restoration where commercial contracts are not viable. In the second case, current government expenditures can be used to restore additional acreage since the per acre rate is now lower. In either case, additional acreage will be processed and the forests will be returned to a healthy and safe status quicker than without the letting of the contracts.

However, the new ways of organizing will also require new ways of knowing. As discussed above, organizations like the Forest Conservation Council need to agree that this type of organizational structure is beneficial to ecosystems and communities alike.[11] The litany of having thinning projects commence “as an excuse to allow commercial logging” needs to be changed from a negative to a positive idea! Entrepreneurs will not invest in the recreated wood utilization sector unless they can be assured access to raw materials. With the current continuous threat of litigation, as described above, no such investments will take place. It appears that some of these organizations are beginning to agree that forest management practices need to change, but there is usually the caveat that this can only take place if no commercial value is found for the thinned trees.

This rhetoric needs to be altered. For reasons itemized above, tax dollars will never be sufficient to return the vast acreage of our forests to a healthy and safe condition. These organizations grudgingly agree that thinning can occur at the urban-wildland interface. However, the practice of slash pile burning, which is an approved practice, not only leads to diminished air quality, it also results in the release of vast amounts of carbon as carbon dioxide, and therefore contributes to global warming concerns. A concern such organizations should be aware of.

[10] From the perspective of the entrepreneur, the price will be negative if the State pays for the thinning and positive if the State receives a royalty payment.

[11] Although, in the Norgaard and Jacobs sense, there is no difference between the two.

CONCLUSIONS

In this paper we have addressed how the current condition of the forests in the southern Rocky Mountain West, particularly northern Arizona, is a co-evolution result stemming from past forest management practices. Following Norgaard (1994) it is therefore necessary for society to develop new ways of knowing, organizing and doing to return the forests to a healthy and safe status.

The Forest Health Oversight Council's recommendations included a few additional items that will stimulate the wood utilization sector. These include:

> 19. The Governor, by executive order, should require all new or renovated state facilities to consider using commercially based wood pellets or wood chips for heating purposes (schools, universities, etc.).
>
> 20. The legislature should provide a tax credit for homeowners that install and use wood pellet heat.
>
> 21. Through a collaborative process develop recommendations for achieving greater contribution to energy generation in Arizona from renewable resources focusing on utilization of biomass materials while not undermining other renewable alternatives. (Forest Health Oversight Council, 2004, p 23-24)

If enacted, these practices will further increase the profitability of the entrepreneurs entering the industry and therefore increases the acreage that will be processed. Although Larson determined the production of ethanol as an energy source to be at the low end of profitability, the use of biomass as an energy source does hold potential. The main provider of electricity in Arizona, APS, has invested in a pilot project to develop biomass as an energy source. A plant located in Eagar will produce 3 megawatts of electricity.

"APS is committed to developing clean renewable energy sources today that will fuel tomorrow's economy," said Ed Fox, vice president of Communications, Environment and Safety for APS. "Biomass is one of those future energy sources, and in Arizona, it also can be part of a solution to our forest health issues." (APS, 2003).

The opportunity to substitute biomass for fossil fuels is expected to reduce the production of greenhouse gases and result in improved air quality. The Arizona Corporation Commission currently sets the Environmental Performance Standard (EPS).[12] The EPS requires regulated utilities to generate 1.1 percent of their total retail energy sales from renewable sources by 2007. Generating energy from small wood and wood by-products will generate a market while solving a disposal problem.

Morton *et al.* (2003, p. 17-19) indicate that the full cost of damage resulting from the Cerro Grande fire near Los Alamos, New Mexico in 2000 was $26,000/acre. That figure includes lost property, rehabilitation, lost work productivity, and many other costs. Clearly, allowing access to the forests is vastly better than letting them burn in catastrophic fires.

Snider *et al.* (2003) compared the cost of restoration to no action (and a subsequent unnatural fire) to demonstrate that it is cost-effective to spend up to $505/acre to restore forests to prevent catastrophic fire and avoid associated fire suppression costs. Conservatively estimating the cost of restoration versus the cost of suppression, emergency rehabilitation, and lost timber production shows a need for allowing commercial access to the forests, as described above, since state and federal coffers do not contain such sums to restore the vast acreage in need.

[12] See Ratliff and Smith (2001) for a discussion of the EPS and other energy policies in Arizona.

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