

**THE FORESTRY IMPLICATIONS OF GLOBAL WARMING**

Submitted to the School of Journalism  
and the Robert D. Clark Honors College of the  
University of Oregon in partial fulfillment of the requirements  
for the degree of Bachelor of Arts

by  
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This thesis is a study of the forestry implications of global warming. It examines the impact of climate change on forest ecosystems, including changes in species composition, growth rates, and fire regimes. The study also discusses the potential for forest management to mitigate the effects of global warming and the role of forests in carbon sequestration.


**A THESIS**

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June, 1990

An Abstract of the Thesis of  
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in the School of Journalism to be taken June, 1990  
Title: THE FORESTRY IMPLICATIONS OF GLOBAL WARMING

Approved:

  
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Global warming threatens to change the face of the world, including its ecosystems. The consequences of this warming would be dire for forestland, and the welfare of the plants and animals--including humans--that depend on it. However, given the opportunity, forests can mitigate the impact of global warming. Timber management should reflect this.

## ACKNOWLEDGEMENTS

I thank all of those who gave me their help and encouragement: This is as much a reflection of their assistance as my own labor. The lessons inherent in an undertaking of this sort transcend the creation of sixty intelligible sheets of text, which, I guess, is the point.

In particulars, I thank my advisors (Steve Ponder, Dennis Todd and Ed Whitelaw), my parents (James and Karen), and all of those who distracted me along the way.

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## INTRODUCTION

The Northwest timber industry is currently occupied with northern spotted owl litigation and interpreting draft reports out of Washington, D.C. The future of timber management is being formed on the basis of established notions of sustained yield, as filtered past popular support for a more environmental agenda. Unheeded, and virtually unaccounted for in policy-making, global warming might be galloping softly in our direction.

If warming is a reality, it will eclipse all other forestry issues. The thesis question is: "What policy implications does global warming pose for the Northwest timber industry." In order to address this question it is necessary to explain the relationships involved.

Global warming is an uncertainty, of course, and therein lies the difficulty with fitting it into the timber harvesting equation. "Given global warming, such and such will occur..."--the "given" construction, in its many and varied forms, is one of the building blocks of the argument presented here.

The likelihood of global warming is established in the first chapter. It is hardly a seamless argument--nor should it appear to be. However, the potential threat of

global warming--to the world as we know it, and to forests as we know them--should qualify it as a player in determining forestry strategy, seams and all.

The second chapter examines the unique relationship between forests and the climate. The role of forestland in staving off warming is explained, as are the implications to forests if warming is not halted.

That established, the reasons behind forest manager's slow response to the warming threat is discussed in chapter three. This provides a framework for outlining the policy implications warming raises.

The fourth chapter addresses policy implications. The policy alternatives included are each explained on their own merit and their merit as regards global warming.

The purpose of this thesis has been to establish the validity of the global warming argument, and, having done that, to suggest ways the timber industry might want to adapt its policy. These conclusions are intended to reflect the political and economic realities of the Northwest.

There is haziness concerning global warming predictions, but this thesis demonstrates that careful consideration, if not outright action, on behalf of forests is warranted. Scientists can debate warming well into famine and desertification before agreeing it has arrived, but forests do not have the luxury of time.

CHAPTER ONE  
THE CONTROVERSY SURROUNDING GLOBAL WARMING

Before addressing the thesis question it is necessary to establish the global warming framework at its heart. This thesis is predicated on our current understanding of how our climate will behave in the coming years. Even if the probability of global warming were low, the losses it would inflict are serious enough to influence our behavior. In fact, the probability of global warming seems to be high--all the more reason for taking steps now to curb it. Global warming poses one of the most frightening and complicated dilemmas humans face, and its potential gravity cannot be overemphasized.

Wallace Broecker, writing for Nature magazine, put the global warming question in the proper perspective. Simply, He said simply, a "gigantic environmental experiment" is underway (Broecker, July 1987). An experiment on the grandest scale, surely. It comes complete with grand hypotheses, intellectual excitement, HAL 2000-type computer programs and deeply divided schools of thought. It has everything, that is, but a control: therein lies the concern.

### How Will We Know?

The preponderance of evidence to date suggests global warming looms ahead. The anticipated change, 2 to 5 degrees Celsius, is unprecedented in recorded history. Some studies indicate that within 100 years the mean year round temperature will be driven higher than it has been in one million years (Roberts, Feb. 1989).

The magnitude of such a change is dramatic: The average temperatures of Eugene, Oregon, and San Diego, California, differ by 4 degrees (Weather of U.S. Cities, 1987). New York City was buried beneath a glacier when the Earth was 4 degrees cooler (EPA Journal, Jan./Feb. 1989). The temperature rise is expected to be most pronounced at the poles, resulting in glacial melting that would increase sea level several feet and cause massive flooding (EPA Journal, Jan./Feb. 1989). Animal and human populations will shift inland and away from the equator on a huge scale (an elaborate scenario based on a 3 degree warming predicts that in 2050 Duluth will have a population of 1.3 million, Toronto 11 million (Oppenheimer, in: People, April 1990)).

How this change will begin to manifest itself is uncertain. According to James Hansen, the director of NASA's Goddard Institute for Space Studies, the warming is upon us. The 1980s had the seven hottest years on record, and during the summer of the hottest year, 1988, Hansen declared that he had "99 percent confidence the

Greenhouse Effect has been detected and is changing our climate now" (Russell, 1989) (Houghton, 1989) (Science, Feb. 1990).

Hansen's congressional testimony was widely publicized, but few scientists have followed Hansen out onto the speculative limb. Their reticence is understandable: A single decade peppered with abnormally high temperatures does not necessarily constitute a trend in a system whose natural fluctuations can last the better part of a century.

Most scientists on both sides have taken a "wait-and-see" approach, but even this position is fraught with uncertainties because what we see will not necessarily be what we get. According to Charles Keeling, after whom the "Keeling Curve" of ambient carbon dioxide is named, global warming will not present itself in a gradual fashion (Rogers, 1989). Atmospheric carbon dioxide levels, one of the most important contributors to the "greenhouse effect," have a history of dynamic 30-year cycles.

The overall trend is up, but according to Keeling's statistics we are entering a trough (Rogers, 1989). The 1980's marked a peak in carbon dioxide concentrations, with a concomitant rise in global temperature--the 1980's were the warmest decade on record. Keeling suspects the world will cool off (and the global warming theory will lose some credibility) until 2010, when new record high

temperatures will wrack the world. When the 2040 cycle arrives, Keeling warns, "the greenhouse effect will be upon us again--in spades" (Rogers, 1989).

Despite Keeling's suspicions about the nature of the warming, many scientists expect relatively immediate answers. Global warming skeptic Richard Lindzen, professor of meteorology at MIT, expects the puzzle will resolve itself considerably in the next decade (CNN, April 12, 1989).

Science magazine also notes the possibility of relatively immediate confirmation: "Models that predict the largest warming call for the upward trend to become obvious by the early 1990's" (Science, June 2, 1989). However, with relation to temperature trends, any opinion must be based largely on faith--short-run temperature trends can neither prove nor disprove the Greenhouse Theory.

### Greenhouse Pollutants

"The longer we wait before action, the larger the amount of warming we will have to live with," says the Environmental Protection Agency's Lee M. Thomas (EPA Journal, Jan./Feb. 1989). This is one of the most alarming aspects of the global warming phenomenon--while we await hard evidence of warming, greenhouse pollutants continue to be pumped into the atmosphere.

At the turn of the century, Swedish scientist Svante

Arrhenius predicted that pollutants associated with the industrial revolution would take their toll on the environment (McKibben, 1988). His conclusions were remarkably similar to those being made today: pollutants hang in the atmosphere, insulate the earth, and drive up temperatures.

There are skeptics of global warming, but none of the greenhouse effect. The greenhouse effect is one of the few points on which there is a firm consensus. Atmospheric gases trap solar heat and increase the temperature on planet surfaces. The greenhouse effect is believed to keep the Earth's surface some 33 degrees warmer than it would be if solar energy was not trapped (The Bulletin, April 1990).

Although other factors help determine surface temperature, none are thought to be as powerful as ambient--or atmospheric--gas. The temperature variations from planet to planet powerfully illustrate the significance of the atmosphere.

Carbon dioxide has proven to have a particularly strong correlation to surface temperature. Mars, a planet with only trace amounts of carbon dioxide, has a mean temperature of -53 degrees. Earth has an atmospheric carbon count of .03 percent, and its mean temperature is 15 degrees. On Venus, where carbon dioxide levels approach 97 percent, the mean temperature is 427 degrees (McKibben, 1988).

The 412 degree gap between Earth and Venus is more than a function of Earth's relative distance from the sun. Mercury, whose orbit takes it nearest the sun, has only traces of carbon dioxide and a corresponding mean temperature between -63 and 57 degrees (Wood, 1970).

Ambient carbon dioxide has increased some 25 percent since the mid-1800's. That increase has hardly changed its .03 percent concentration, yet carbon dioxide is believed to be the most significant contributor to global warming (Oregon Task Force, 1990). Considerable carbon dioxide is absorbed by oceans and plants, but as much as one half is ambient.

Methane, nitrous oxide and chlorofluorocarbons are the other major greenhouse gases. Together with carbon dioxide, these gases constitute 87 percent of the suspected man-made contributions to the greenhouse effect (EPA Journal, Jan./Feb. 1989).

Methane is present in much smaller concentrations than carbon dioxide, but each molecule has 3.7 times the greenhouse potential of carbon dioxide (Oregon Task Force, 1990). Ambient methane concentrations are increasing at twice the rate of carbon dioxide. It primarily results from rice cultivation, animal husbandry, fossil fuel production and forest fires (Oregon Task Force, 1990).

Nitrous oxide began increasing significantly only in the last 50 years. Clearing land, burning forest biomass

and burning fossil fuels are all thought to contribute to its increase in the environment. Molecule for molecule, it has 180 times the global warming potential of carbon dioxide (Oregon Task Force, 1990).

Chlorofluorocarbons, or CFCs, are more commonly known for their role in ozone depletion (indeed, ozone has a peripheral role in warming, also). However they are also critical greenhouse gases, with warming potentials of between 4,000 and 10,000 times that of carbon dioxide. Different types of CFCs serve different functions, but they are primarily used for refrigeration, foam production and in aerosol cans (Oregon Task Force, 1990).

Water vapor, the result of evaporation, is responsible for approximately 75 percent of total greenhouse warming. However, water vapor serves to amplify the effects of the other ambient gases. Thus, water vapor is not typically reckoned among the greenhouse gases, as its effects are shared with them (Oregon Task Force, 1990).

The insulating power of the greenhouse gases is a result of their relative transparency to sunlight. Although atmospheric gases filter out considerable radiation, they permit some 50 percent to penetrate to the Earth's surface. Five percent of the initial radiation rebounds off the planet's surface as long-wavelength, infrared radiation and returns to space.

Approximately 45 percent of the sun's radiation is absorbed on the Earth's surface (Scientific American, May 1987).

Many of the greenhouse pollutants are associated with progress, and will continue to be introduced into the atmosphere. A curious, and alarming, suspicion is that there is a time lag between our pollution and its impact on the atmosphere (EPA Journal, Jan./Feb. 1989). Even were we to halt the introduction of pollutants into the atmosphere today, pollutants would not only remain, they would probably accumulate for the next 40 years. Thus future generations are being left to bear our burden. But what will that burden be?

#### Computer Modeling

One of the tools climatologists use to simulate the environment is the General Circulation Model, or GCM. GCMs log thousands of hours on some of the most powerful computers in the world. However, for all their sophistication, GCMs cannot analyze all of variables associated with the climate. Even at thousands of calculations per second they cannot reliably predict reality.

GCMs have been developed by NASA, the University of Chicago and several other organizations. They are wildly complicated, but William Booth of the Washington Post illustrates the theory behind one model's design. The

model Booth describes divides the world into 1,920 boxes, each one 300 square miles at sea level. These boxes layer the world 21 deep--12 below sea level--in order to account for the different responses bound to occur at different altitudes (The Washington Post, June 1989). Each of the more than 30,000 boxed layers is associated with several formulas giving it a climatological character reflecting its geographic location. The model is then set in motion and cycled through the calculations thousands of times to yield a "solution."

The grid size is what most frustrates modellers. Assigning discrete variables to blocks of water, land and atmosphere hundreds, even thousands, of miles square results in reduced detail. This parameterization is frustrating to modelers, but it represents the state of the art in modelling.

The alternative to parameterization, focusing the model on a single region, only reduces confidence. Simply, "confidence drops as spatial resolution increases" (Bolin, 1986). Michael Schlesinger, formerly with Oregon State University and now with the University of Illinois, illustrates another problem. Increasing the resolution of a 300 square mile model by a factor of ten multiplies the program's running time by 1000 (Hill, 1989). Modeling a century of climate change on the 300 mile scale requires more than three weeks on the world's fastest supercomputer, making further resolution

prohibitive.

The validity of climate modeling has been a serious question among scientists on both sides of the greenhouse debate. Reid Bryson of the University of Wisconsin delivers one telling blow:

A statement of what the climate is going to be like in the year A.D. 2050 is a 63 year forecast. Do the models have a demonstrated capability of making a 63-year forecast? No. A 6.3 year forecast? No. Have they successfully simulated the climatic variation of the past century-and-a-half? No. They are marvels of mathematics and computer science, but rather crude imitators of reality. (Brookes, 1989)

Richard Somerville, head of the Scripps Climate Research Group, points out another serious flaw: "If we don't understand how the climate works in the first place, the fastest computer in the world will just be solving erroneous equations more quickly" (Rogers, May 89).

GCMs, for all their uncertainties, maintain a mystique. This was illustrated in a television exchange that occurred between a global warming proponent, the Environmental Defense Fund's Michael Oppenheimer, and a skeptic, MIT's Lindzen. Oppenheimer, criticising Lindzen's arguments, asked Lindzen "Where are your models?" Not satisfied with Lindzen's answer Oppenheimer grinned wryly: "You're not on the cutting edge" (CNN, April 1990).

To wit: Lest it be overlooked, GCMs are frequently given priority to log on at some of the most powerful

computers in the world. Computer time on these machines is usually booked solid by organizations that include aerospace research and military groups. They are used for various other purposes, but rarely frivolous ones.

Computer models are not accepted as gospel, but they do serve a purpose. "Mathematical climate models cannot simulate the full complexity of reality," says one of the most outspoken advocates of the Greenhouse Theory, Stephen H. Schnieder (Scientific American, 87). "They can, however, reveal the logical consequences of plausible assumptions about the climate."

### Holes In The Warming Theory

There are large holes in the fabric of the global warming analysis. It is the different ways these holes are filled that results in the different scenarios currently forwarded. Three of the factors that cloud the most sophisticated models and confound the most prescient climatologist are the oceans, cloud cover and human behavior.

### Oceans

A worldwide study of ocean temperatures conducted by MIT scientists found there had been no appreciable warming since 1850. Drawing on their ocean study, climatologists Reginald Newell, Jane Hsuing and Wu Zhongiang said "there appears to have been little or no global warming over the past century"(Brookes, 1989).

At least one model that supported an overall warming also predicted cooling in the south. The scientists that had designed the model were unsure of the reason for this, but suspected deep ocean currents from Antarctica had welled up and cooled the air (Booth, 1989)

The ocean's effect on climate is poorly understood, but there is no question its behavior can dramatically affect global weather patterns--after all, oceans cover more than three-quarters of the Earth's surface. Syukuro Manabe, a climatologist with Princeton's Geophysical Fluid Dynamics Laboratory admits: "we really don't understand how the ocean behaves" (The Bulletin, April 1990).

### Clouds

Clouds present a similar problem. While it is clear they have a tremendous impact on our climate, their reaction to global warming cannot be predicted.

If global warming occurs, there is expected to be a melting of polar ice caps and alpine snow packs. The worldwide increase of water circulating through the system--melting and being evaporated more quickly in the increased heat--would suggest a concomitant increase in cloud cover. Whether this feedback would brake or accelerate the anticipated warming has not been determined.

Sulfur dioxide is one source of the problem. Sulfur dioxide contributes to the formation of clouds (it is

commonly used to "seed" areas hit by drought). Low-lying stratocumulous clouds reflect sunlight away from the planet's surface, which results in net cooling. The University of Virginia's Duane Michaels sums up one school of thought on the matter: "If you only perturb the model with carbon dioxide, it will predict the greenhouse warming effect. If you only perturb it with sulfur dioxide, you get an ice age" (Brookes, 1989).

However there are flaws with the sulfur dioxide argument. It is suspected that, unlike low-lying clouds, high level cirrus clouds will further insulate the earth. They allow direct sunlight to filter through, but contain long wave, infrared radiation that attempts to return to space (Monastersky, 1989).

One of the men most closely associated with the cloud-cooling argument punched one of the largest holes in it with a 1989 paper. The University of Chicago's Veerabhadran Ramanathan concluded in a 1988 study that "clouds appear to cool Earth's climate" (Brookes, 1989). However, late in 1989 he co-authored a study published in Nature demonstrating that water vapor accumulation would amplify global warming (Nature, Dec. 1989).

The study supported the most extreme greenhouse theories, suggesting that once warming began it would snowball, so to speak, severely disturbing the atmosphere. Specifically, "The coupling between surface temperatures and the greenhouse effect will lead to a

strong positive feedback on any perturbations to the present climate" (Nature, Dec. 1989). Ramanathan was left grasping for other information that might mitigate the feedback. "Frankly, I didn't expect that our work would support the [greenhouse] theories so strongly," Ramanathan said in an interview later (Register Guard, Dec. 17, 1989).

Although the effects of cloud cover can certainly not be ignored, they are often only marginally accounted for in GCMs. This omission provides excellent ammunition for those who disagree with the model's conclusions, but cannot be avoided. Our present understanding of clouds and their impact--subtle and dramatic--is poor.

#### Human Behavior

Finally, global warming scenarios fail to account for human behavior. This variable may be the most difficult to predict, but stands to have considerable impact on the environment of the 21st century and beyond.

On the one hand there are the *ceteris paribus*--or all other things remaining the same--arguments. These arguments suggest that the population will continue to grow, energy needs will grow (and be addressed), the effect of pollution control will be negligible and the sources of energy will remain the same. With the Earth's population expected to grow to eight billion by 2030, these assumptions steer the world toward the darkest global warming scenarios.

The University of California, Davis', Kenneth E.F. Watt does not agree with such assumptions. Watt, a professor of ecology, cites the diminishing supply of fossil fuel resources and downward shifts in the population as reasons global warming should not be expected. "There is no earthly way demographic trends can continue because of AIDS," he says (Watt, 1990). And the result of this change in human behavior? No global warming. In Watt's opinion--and he is not alone--global warming is little more than a "propaganda blitzkrieg" (Watt, 1990). There is a solid front of respected scientists that express skepticism (remember, even global warming's staunchest advocates are mildly skeptical--even NASA's Hansen put the chances at 99 percent), but they are constantly bombarded with new models and newer statistics that support warming.

Jerry D. Mahlman, director of the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory, blasted MIT's Lindzen for his skeptical evaluation of the global warming argument. According to Mahlman, Lindzen's paper "came across as a whiny complaint without scientific justification. Dick Lindzen is a friend of mine so I do not say that lightly. I was disappointed" (Science, Dec. 1989)

#### Acceptance of the Warming Theory

In an arguably positive development, global warming

has drawn enough attention to constitute a campaign issue. The Union of Concerned Scientists found in a 1989 poll that 79 percent of American voters were aware of global warming, up from 58 percent in 1988 (Union of Concerned Scientists, 1989). Of those surveyed, 72 percent said "the U.S. must take the lead in fighting global warming--even in the absence of an international agreement" (Union of Concerned Scientists, 1989).

Grass roots opinion has had impact on politicians (in a campaign speech, President George Bush assured he would counter the Greenhouse Effect with the "White House Effect" (Register Guard, Apr. 23, 1990)), but federal response to date has been limited to further study. The changes suggested to stave off global warming are viewed as too drastic to undertake without total confidence in the dire warnings. In a position he has since reasserted President Bush explained "You can't take a policy and drive it to the extreme and say to every country around the world, 'You aren't going to grow at all'" (Brookes, 1989).

But with the stakes so high, and the odds so uncertain, policy in many regions of the world is being re-evaluated. In the Netherlands, design changes are underway for an expansion of dikes, dunes and other coastal defenses (Stevens, Nov. 16, 1989). The U.S. electric power industry is planning to meet increased demand for electricity as temperatures warm and the need

for air conditioning increases (Stevens, Nov. 16, 1989). The U.S. Department of Agriculture is studying hundreds of crops to determine which of them will best cope with warmer weather and changed rainfall patterns (Stevens, Nov. 14, 1989).

And the Northwest timber industry has taken its first step toward recognition of global warming. Alarmed by modeling that shows disastrous warming impacts on forestland, Georgia Pacific Corporation has provided loblolly pine seedlings for desert experiments (Stevens, Nov. 14, 1989).

Global warming defies verification empirically because any trend of abnormal weather can be reasonably dismissed as an aberration. However, coupled with state of the art modeling and theory, documented weather changes can certainly suggest the presence of a trend. This is the case with the global warming issue: The preponderance of evidence suggests the Earth will become warmer and that regional climates will change unpredictably. This theory must be taken into account as humans move into the 21st century.

## CHAPTER TWO

## THE EFFECTS OF GLOBAL WARMING ON NORTHWEST TIMBER

Having established the possibility of global warming, this chapter addresses that warming as it relates to timber. The Pacific Northwest is the national breadbasket for timber, thus the welfare of our forestland has importance that extends beyond the Oregon and Washington borders.

"Tell me about those beautiful trees," insists wonderstruck FBI agent Cooper in ABC's prime time "Twin Peaks." The character is fictional, the trees are not-- they are Douglas fir, living in a stand 6,000 years old, according to the University of Washington's Linda Brubaker (Science, April, 1989). The Douglas fir range extends up and down the West coast, south into Northern California and north into Canada, and is part of a larger range that includes trees ranging from western red cedar to Sitka spruce in the north. This "moist temperate conifer forest" is host to massive trees and a rich understory: "the richest commercial forest in the world" (Encyclopaedia Britannica, 1982).

The Damage Being Done

As Jerry Franklin, a professor at the University of

Washington and a long-time employee of the forest service wrote in Natural Vegetation of Oregon and Washington, "few have appreciated how truly unique these forests are" (Rosemary, 1988). This appreciation is dawning on us now, but, here as elsewhere, much damage has already been done. Harvesting and cutting land for agriculture and grazing have taken their toll.

Current timber harvesting, despite being predicated on sustainable yield, is reducing the acreage and density of forestland worldwide--the Worldwatch Institute predicted a 20 percent loss of forestland between 1986 and 2000 (Bolin, 1986). More concretely, an area of forestland the size of New York state and Vermont is "lost or logged" each year, according to Worldwatch Institute's vice-president for research (EPA Journal, Jan./Feb. 1989).

Based on the shrinking forestland, the Woods Hole group made a dire prediction: "If the growth in population continues indefinitely...[forests] are expected to disappear during the first half of the 21st century" (Woodwell, 1983). This has to do with both active deforestation, such as harvesting and plowing under, and our passive contributions to deforestation in the form of pollutants.

Instances of inadvertant damage to forestland are mounting. On the other side of the globe multiple stresses have driven forests into smaller and smaller

ranges. Trees within German forests have been dying, pressured by acid rain, increasing ozone and, significantly, temperature rise (Blank, 1985). Closer to home, in South Carolina, "the death of the mountaintop spruce and fir forests might be... 'the canary in the coalmine'--an early warning that forests of low altitudes, including hardwood forests, are also in danger of being damaged by a combination of man-made and natural stresses" (Oregonian, July 1988).

These cases may indeed be a "canary in the coalmine," they may be that and much more. Back in 1983 a group with the Woods Hole Ecosystems Center concluded that "deforestation appears to be the dominant biotic effect on atmospheric carbon dioxide" (Science, Dec. 1983). It seems to be the nature of this "canary" to both signal and amplify climatic damage to forestland.

#### The Role of Forestland in Carbon Storage

Trees and the biomass, or understory, of forestland bind carbon dioxide to the earth. As forestland is reduced through cutting or burning, carbon dioxide is freed into the atmosphere. This is different than what occurs with decayed forestland and natural burns: massive carbon dioxide storage is still provided in the biomass, and is accompanied by natural regrowth. The carbon dioxide lost through cutting and burning cycles back into the atmosphere and serves to further insulate

the Earth, increasing the stress on forests.

Daniel Dudek, the Environmental Defense Fund's senior economist, writes: "It is generally agreed upon that global deforestation, particularly in the tropics, accounts for approximately 20 percent of annual carbon dioxide into the atmosphere" (Dudek, Sept. 1988). A paper published in 1989 is in agreement with Dudek's assertion, with one important exception. "The temperate rain forests of the Northwest harbor more biomass than tropical rain forests of Brazil," asserts William Booth in an article for *Science* magazine (Booth, 1989).

A 1990 study established a correlation between biomass and carbon storing. The study revealed that forest biomass could sequester significant amounts of carbon (*Science*, Feb. 1990). This alters the long-standing assumption that young trees are more effective in carbon absorption than old growth. Young trees do absorb carbon more quickly and efficiently than older trees (the distinction between young and old being made at 30 years old) (*Science*, Feb. 1990). However, older forests, because of the size of their trees and the associated understory, absorb far more carbon than young forests.

As a result, "conversion of old-growth to young plantations invariably reduces carbon storage" (*Science*, Feb. 1990). In addition, considerable nitrogen is stored in forest biomass (*Nature*, July 7, 1988). After forests

are clearcut they no longer collect the detritus associated with large trees, and the plants peculiar to the understory lose their host environment. Slashburning only compounds the problem, burning away the carbon- and nitrogen-storing biomass more quickly. The cumulative effect is limited carbon storing ability in young, replanted forests.

### Greenhouse Gases and Forest Response

The changes global warming has in store for forestland are the focus of considerable study. Forests have proven durable in the past, but the stresses threatened by global warming have no historical precedent. However, together with the the possibility of increased stress there is the potential for more rapid growth.

In a number of studies higher ambient carbon dioxide levels have been found to result in greater photosynthesis and "greater water-use efficiency" (Bolin, 1986). This suggests the possibility that forests will thrive in a carbon dioxide-rich environment. Such a positive reaction to carbon dioxide would increase the strength of forests in the face of the other, negative aspects of global warming.

Also acting as insulation against global warming, precipitation might increase. Worldwide, precipitation is expected to increase, however regions will not respond

uniformly--variations in precipitation are to be expected. The threat of forest fire would be reduced by such a change, and fire is one of the stresses most likely to take a toll on forestland. A reduction of this threat would radically change the forest dieback scenario that is often suggested. According to Weyerhaeuser's Steve Caffanata, "If it were to get warmer and wetter it could increase the productivity of our forests" (Caffanata, Feb. 1990).

However, both increased photosynthesis and increased precipitation are only speculation. According to Mark Harmon, one of the scientists responsible for the old growth carbon dioxide study, the notion of carbon dioxide spurring accelerated growth is a questionable one. "It's been studied for a few plants--soybeans and cotton. It's a working hypothesis, but it hasn't been proven" (Harmon, Feb. 1990).

Punching another hole in the chances of Northwest forests, there is speculation that this region will experience reduced rainfall. In an address to a forestry conference, Jerry Franklin, professor of Ecosystem Analysis at the University of Washington, assumed the Northwest would suffer reduced rainfall (Kadera, 1989). One major model, commissioned by NASA, predicted increased rainfall, but two others supported Franklin's argument. The National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory

and Oregon State University's GCMs both predicted reduced rainfall in the Northwest. These global warming models revealed a pronounced reduction in precipitation during the summer months (Kadera, 1989).

Given similar or reduced rainfall and rising temperatures, Northwest forests would be in extreme jeopardy. The list of stresses that would grow includes disease, insect activity, fire and high winds.

Disease and insect activity are interrelated. Warmer winters would decrease the mortality of insects (Shands, 1987). "Pests and disease-causing micro-organisms will adapt to climate change faster than trees; other stresses, such as air pollution and acid precipitation would exacerbate the damage" (Tangle, 1988). Insects would exploit the longer periods between freezes to increase in number and increase the stress on their host timber.

Fire poses the most severe problems to a forest in the global warming scenario. "With continued fire suppression and the further warming, fuel build-up will result in more intense and/or more frequent fire," according to James S. Clark of the University of Minnesota's Department of Ecology (Clark, 1988). Fire suppression has resulted in abnormal buildup of understory, which, together with the replacement of old trees with young, increases fire threat. When forest fires burn today, they burn more intensely--consuming

more acreage and doing more damage--than fires did in the forest's natural state (Harmon, Feb. 1990).

"If regional drought persisted and fires increased, total forested areas in the West could be dramatically reduced and some species would go locally extinct," according to a recent Science article (Roberts, 1989).

This results in what Washington's Franklin calls "a 'double whammy' for forest ecosystems" (Rosemary, 1988). In addition to being destroyed by fire and losing the initial ecosystem, forestland will be unable to reestablish itself because of the worsening conditions. A research hydrologist for the timber industry's National Council of Air and Stream Improvement, George G. Ice, guardedly agrees: "Re-establishing new forests may present problems" (Rosemary, 1988).

#### Natural Adaptation to Increased Stress

Forests are not without recourse in the face of these threats, but natural responses may be inadequate. In the past, when climate has undergone change, forest ranges have shifted in response: Young trees begin to grow in areas made more hospitable by the climate change. This has been documented in a number of studies.

When the climate began warming some 15,000 years ago, North American trees dispersed northward at a rate of about 10 to 45 kilometers a century, the fossil record shows. Beech, which is dispersed by jays, averaged about 20 kilometers a century. Spruce holds the record, 200 kilometers a century, when it migrated into Canada about 9000 years ago.

(Roberts, 1989)

In the same article a 100- to 150-kilometer shift (or, where possible, an elevation increase) is predicted for every one degree increase in temperature. With a 2 to 5 degree global increase expected in the next century, forests are unlikely to be able to move quickly enough to keep pace with the shifting climate.

There are factors besides the potential speed at which trees can seed the territory ahead of them that limit their range shift. Trees cannot grow in new territory unless the soil chemistry is suitable. Different trees require different nutrients in their host soils, and, while nutrients do develop or leach away as climate changes, it is expected that climate change will outpace the soil change.

The information accumulated to date suggests a tragic scenario. Tree species will be under increased stress in the lower altitudes and along the southern ends of their ranges. As heat increases, assuming no appreciable increase in precipitation, fire will ravage the insect- and disease-weakened forests. Along the southern ends of their ranges, forests will be unable to re-establish themselves in the changing climate. And, as temperatures increase, there will be favorable climate to the north of their current range. However, forests will be unable to move quickly enough to exploit their new range, and will suffer severe loss in total acreage.

Upslope shifts also result in a net loss of forestland. There is less land as elevation increases--mountain peaks are smaller than their bases. The timberline acts as another barrier, limiting the upslope movement of various tree species.

To make matters worse, as forests succumb to the increasing stresses they will surrender their carbon and nitrogen, much of which will find its way into the atmosphere. In a classic case of positive feedback, the released greenhouse gases will stoke global warming, and, in turn, redouble the stress on forests.

For the Pacific Northwest, this could mean the loss of a variety of tree species, including the Douglas fir. "It is quite conceivable the southern extent of [the Douglas fir's] range could be Vancouver, British Columbia," according to Michael Fosberg, a research coordinator with the U.S. Forest Service (Rosemary, 1988). Exploiting the climate change, ponderosa pine would slowly begin shifting northward into land made unsuitable for the Douglas fir (Rosemary, 1988).

Global warming would have serious consequences worldwide, and those consequences would be particularly pronounced in Northwest forests--the "richest commercial forests in the world" (Encyclopaedia Britannica, 1982). Allowed to run its course, global warming would overtax the adaptive mechanisms of trees and their ecosystems, battering them with fire, wind, and disease. Forestland

would be dramatically reduced, with tragic implications for the timber industry, the national and world economies, and human life.

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## CHAPTER THREE

## FORESTRY ISSUES RAISED BY GLOBAL WARMING

The region's timber industry is not yet receptive to global warming arguments. At the moment, the timber industry is under attack by environmental groups, facing more layoffs and reduced harvests as trees grow back to cuttable levels. Weighed against these immediate issues, the threat of global warming seems remote and unconvincing. However, this inaction must not continue. Forests are not only prone to severe damage if warming occurs; they could serve as a check against increasing accumulations of greenhouse pollutants.

The Wall Street Journal recently ran an article on its editorial page that puts the global warming debate in perspective:

Most climate experts expect unequivocal greenhouse warming in the 21st century, and some predict the first clear signs in the 1990's. If they are right, what people are doing to the atmosphere is arguably as important as what they do to the economy, domestic politics or international relations. (The Wall Street Journal, Dec. 2, 1989)

The correlation is even stronger than this suggests, because what people do to the atmosphere will directly affect the economy, domestic politics and international relations. Because forests interact with the atmosphere in a dynamic way, concern for the atmosphere should be

incorporated into any debate about forestry.

But neither the timber industry nor any regulatory agencies have suggested global warming as a vehicle to drive policy. Dudek, the Environmental Defense Fund's senior economist, sums up the reticence on the issue: "When we consider solutions to the problem, frequently people back away. It's just too awesome, too large, and it will involve too many painful sacrifices" (Stevens, July 1989).

#### Why Policy Change is Slow In Coming

Economic considerations are important in addressing timber management. The wood products industry is an important part of the Northwest economy, it employs five percent of Oregon's labor force and constitutes six percent of the Gross State Product, according to an economist with the Wilderness Society (Kadera, Feb. 1989).

According to a 1990 report, Oregon's lumber and wood products industry employed 77,400 people in 1988, the highest total nationwide. Washington employed the third highest number in lumber and wood products, 58,400. These figures constituted 38 and 36 percent of these state's manufacturing employments, respectively. If anything, these statistics understate the significance of the industry in the Northwest. Log trucking and machine shops associated with lumber mills, for instance, are not

included in the lumber and wood products figures  
(Northwest Portrait, 1990).

In recent years, the timber industry has been engaged in ongoing legal battles over the size and nature of its harvest. According to John Beuter, a former Oregon State University School of Forestry professor, Oregon's timber harvests between 1976 and 1987 dropped by 20 percent (Stevens, Nov. 16, 1989). Regardless of environmental legislation, the timber industry is expected to suffer a further five to ten percent decline in the timber harvest over the next decade. This lull will be accompanied by the loss of 14,400 timber-related jobs, according to Beuter (Stevens, Nov. 16, 1989).

In an economic trough, and under fire from environmental groups, the timber industry is not likely to begin making concessions that will cost jobs and cut profits. "They don't buy the argument that replanting a forest with new growth contributes to global warming," says Lance Robertson, a reporter who has been following the recent timber controversies for the Eugene Register-Guard (Robertson, 1990).

Quite the contrary, until recently global warming was used as a justification for clearcutting. The relatively rapid carbon absorption rates of young trees outstripped that of older trees, thus the justification. Such arguments have been rendered obsolete by the OSU biomass study. Says co-author Mark Harmon, "not many

[timber managers] are out there now waving the banner of clearcutting as a way of stopping the greenhouse effect" (Harmon, 1990). But neither are they suggesting forestry be re-evaluated in the face of the global warming threat.

Instead, there is a general disregard for the danger of global warming, which may have been caused by some of the sweeping changes that have been proposed. In a study commissioned by, among other groups, the EPA, Margaret Davis and Catherine Zabinski called for the recreation of "entire forest ecosystems, including dominant trees, understory plants, and important animals, 'on a large scale' in northern locations" (Roberts, 1989).

The Oregon Department of Energy's Alex Sifford reflects the skepticism many feel, suggesting that such measures are as yet unrealistic and probably misguided. "To try and replant species where they don't have ranges yet is going against the natural selection of species," he said in a February interview. "Still plant what grows there and let the species evolve. Replanting other species would be economic suicide" (Sifford, 1990).

Finally, even the most extreme forestry measures geared toward the halt of global warming would be of little consequence if undertaken unilaterally. The forests of the Pacific Northwest comprise a significant portion of the United States' 737 million acres of forestland--Oregon is the nation's leading lumber producer--but there are more than seven billion acres of

forestland worldwide (EPA Journal, Jan./Feb. 1989; Kadera, Feb. 1989). For this reason, our treatment of timber "is a minor issue in terms of global carbon budgets," according to the University of Washington's Franklin (Franklin, 1990). Franklin's words are not intended to justify inaction at the regional level, but to stress the necessity of global cooperation.

Thus, although the reasons for hesitation are clear, they are not without flaws. Global warming requires a leap of faith that timber managers have refused to make, the short-term consequences of acknowledging the danger has been daunting. However, as we delay addressing global warming, the problems compound: The long-term consequences of not acknowledging the danger could prove catastrophic.

#### Why Warming Should Be Acknowledged

The richness of Northwest forestland makes it one of the most important carbon sinks in the world. Indeed, "the temperate rainforests of the Northwest harbor more biomass than tropical rain forests of Brazil" (Science, April 1989). It has been estimated that, while Northwest forests cover only .017 percent of the Earth's surface, a century of human logging and clearing here has contributed two percent of the carbon now in the atmosphere (Science, Feb. 1990).

Northwest forests, then, have tremendous impact on

the global environment, relative to their size. The driving force behind timber policy in the coming years should be concern about warming. The motive behind placing such significance on warming? Simply, global warming would cripple the timber industry. "Watershed and timber management practices have to change, because within one rotation of trees there's going to be a vastly different climate and ecosystem," says research forester David Sandberg (Rosemary, 1988).

The economic argument may be the most persuasive. The replacement of the Northwest's Douglas fir by ponderosa pine is only a single aspect of global change, but it provides a powerful illustration. Economically, loss of the Douglas fir would be disastrous--it is currently the most replanted tree in the Northwest (Caffanata, Feb. 1990). Douglas fir grows relatively quickly and is typically 30 to 50 percent again as valuable as the average for commercial trees (Warren, 1985 and 1987).

University of Oregon economics professor Ed Whitelaw has another insight that sheds light on the economic realities of policy change. In a 1989 paper he discussed the "second paycheck" citizens in the Northwest receive from the environment.

Every worker in Oregon receives, in effect, two paychecks: one denominated in dollars and the other in the state's clean air, clear streams, scenic vistas, publicly owned beaches, and forested mountains. Take away or damage this environment,

and many workers will leave, while those who remain will experience a sudden downward shift in their standard of living and will demand additional monetary wages to compensate them for this loss. (Old Oregon, Spring 1989)

Forestland, then, has value not related to its board footage.

Whitelaw provides a unique perspective, but not one intended to justify wholesale alterations in the face of global warming. Although global warming would alter the Northwest, it would also alter the rest of the world. Thus, "if Oregon's quality of life deteriorates that's not good, but it may still have its value...if the quality or value in other states deteriorates more rapidly" (Whitelaw, April 1990).

Until there is more certainty on the issue and it becomes evident that policy change is justified on economic grounds, drastic change cannot be expected. Future conditions may dictate severe measures, but the current state of greenhouse knowledge justifies only limited action. Severe steps can always be taken as confidence in global warming increases, but, realistically, they are still premature. Accepting that we cannot be certain about the validity of global warming, we can, in the words of one greenhouse skeptic, at least "ride the global warming issue to essentially encourage policies that are a good idea anyway" (Global Warming Hearing, Feb./May 1989).

Within this economic framework, the matter of policy

formation seems more appropriate. The reluctance of the timber industry to react strongly to the possibility of global warming is understandable, but it is also misguided. There is a sound rationale for the timber industry to face global warming, and not from an extremist environmentalist standpoint; from its own.

The timber industry has a long history of environmental stewardship. It has been a leader in the development of sustainable forestry practices, and it has a strong track record of environmental responsibility. The industry's commitment to sustainability is a key factor in its success, and it is a model for other industries to follow.

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## CHAPTER FOUR

POLICY SUGGESTIONS FOR NORTHWEST FORESTRY GIVEN  
THE PRESENT STATE OF KNOWLEDGE ABOUT GLOBAL WARMING

To twist Einstein's words, timber managers can simultaneously prevent and prepare for warming. This preparation manifests itself in ways that amount to hedging a bet, not gambling. Total reassessment of timber policy is not in order, only a fine tuning with the emphasis on adjustments that are a "good idea anyway."

Replanting As A Means of Carbon Storage

Several of the policy adaptations center on the role of forests as carbon sinks, but the Environmental Defense Fund's Daniel Dudek expressed misgivings about the ability of forestland to reclaim the carbon thrown up by human activity. In a 1988 interview with the Oregonian he said:

Sequestering five gigatons per year of carbon from the atmosphere, an amount roughly equal to current annual additions [other estimates are as low as two gigatons annually], would require between 1.28 and 1.65 billion acres of new plantation forests. By comparison, the total land area of the United States is 2.27 billion acres. (Oregonian, Sept. 1988)

It would be necessary to increase current forestlands worldwide by 20 percent to sequester that amount of carbon. In addition to the geographic difficulties,

Roger Sedjo, a forestry expert with Resources for the Future, suggests such an undertaking would be extremely expensive. Sedjo calculated that it would cost between \$186 billion and \$372 billion to establish new forests with the ability to absorb between two and three gigatons of carbon (Stevens, July 1989). However, as Sedjo argued, "we spend those kinds of monies on national defense every year," and forestation would be a one-time cost (Stevens, July 1989).

University of Oregon Chemistry Professor Paul Engelking puts it another way. "Even if we double the forest coverage of the Earth's surface--probably the limit of what is possible on land--we will have only taken care of a tenth of the eventual carbon dioxide problem created by burning all fossil fuels" (Engelking, 1988). Engelking says "the carbon in recoverable fossil fuels outweighs that either in living land plants or in the atmosphere by 10 to 1" (Engelking, 1988). Thus, until the oceans claim the excess carbon--as will happen over the course of several centuries--plants and atmosphere will be overtaxed as more fossil fuels burn to keep pace with population growth.

Engelking concludes his argument saying that, over a short period of time, the Earth simply cannot "gag down" the carbon dioxide we produce:

While it would be hard to justify a reforestation plan on the sole basis of the greenhouse effect, one cannot justify a scorched Earth policy on the

grounds that it would "only" double the current level of carbon dioxide in the atmosphere! (Engelking, 1988)

Aware of replanting's limitations, the Environmental Defense Fund's Dudek still supports it as "one strategy among many" (Oregonian, Sept. 26, 1989). In a proposal to Congress, Dudek argued that ten million acres of new forest would absorb all of the carbon dioxide emitted by power plants in the next decade. Replanting on that order would cost between \$1 and 2 billion, making it the "most cost effective option" for mitigating human contributions to the Greenhouse Effect, Dudek said (Oregonian, Sept. 20, 1988).

#### Replanting Options

There are different variations on the basic replanting scenario. Planting trees in urban areas would absorb carbon dioxide as well as "provide shade that would help reduce energy use in hot weather" (Stevens, July 1989). Gregg Marland, of the Department of Energy's Oak Ridge laboratory, supports the use of trees in this manner. According to some calculations, Marland says, the shading effects of trees planted on the south side of buildings are 15 times as effective at reducing carbon as the trees themselves (Marland, April 1990).

"Plantation" systems are currently being considered wherein fast-growing trees would be harvested while younger than ten years old (Stevens, July 1989). This

"short-rotation" theory has supporters within the timber industry. During a 1989 "Oregon's Forests in 2010" conference Ray Wilkeson, lobbyist for the Oregon Forest Industries Council, contended that timber might be cropped repeatedly, "like wheat" (Kadera, Feb. 1989).

Oak Ridge's Marland reports that, to date, just such a program is meeting with success. The soils of the short rotation crops must be fertilized, Marland says, but trees can be grown repeatedly in the same area (Marland, 1990). The plantation system is only now in the process of being implemented--by Connecticut's AES Thames electric utility company. The Connecticut company will mitigate the impact of a new 180 megawatt fossil fuel burning plant by planting 52 million trees--on the order of 55,000 acres-- in Guatemala (Marland, 1990; Stevens, July 1989).

Plantation forestry, however, has its detractors. Charles Philpott, director of the Forest Service Northwest Research Station, expressed doubts whether even a third timber crop could be produced in the Northwest without refertilization. Quick rotation of a timber "crop" would overtax the soil, depleting it of vital nutrients and leaving it unsuitable for later timber growth (Kadera, Feb. 1989).

The University of Washington's Franklin also harbors doubts about the effectiveness of such a policy. "We don't know how sustainable repeated croppings are. A lot

of things can happen under those kinds of regimes," Franklin says (Franklin, 1990). In addition to nutrient depletion, Franklin cited compaction and erosion as two forces that would take a toll on the short rotation system.

University of Oregon Biology Professor Dennis Todd points out another flaw in the rotation system. Although repeated croppings can be achieved by fertilizing the soil, the process of making fertilizer releases carbon into the atmosphere, effectively offsetting the net carbon storage. Although such rotation systems may have applications, their use in offsetting global warming remains uncertain.

One replanting option that the American Forestry Association suggests is "reforesting 20 percent of the United States' highway corridors." This suggestion directly addresses one of the assertions Oregon's Whitelaw has made.

Clearcuts are unsightly and their presence devalues the second paycheck. However, by some timber management sleight of hand, that value can be increased and selective clear-cutting can continue. Whitelaw explains: "If clearcuts aren't visible from the highways, maybe there's no impact" on the attitudes and appreciation of the citizens (Whitelaw, April 1990). Thus, placing a high priority on establishing and re-establishing "visual corridors" is advisable.

### The Benefits of Old Growth

Replanting is recognized as an effective means of absorbing carbon; however it is a poor substitute for allowing established forests to remain standing.

"Decadence in moderation is probably a very useful thing," says the Forest Service's Franklin (Science, April 1989). Nowhere is this clearer than in old growth stands where decadence abounds in the form of biomass. The study by Harmon, Ferrell and Franklin revealed that a 450-year old forest stores 611 to 612 megagrams of carbon, while a 60-year old forest stores between 259 and 274 megagrams (Science, Feb. 1990). There are between three and six million acres of old growth forest left in the Northwest, but they account for a considerable amount of the forest's carbon (Science, April 1989).

Between 45,800 and 60,400 acres of old growth are harvested annually in Oregon alone, according to a draft report by the biomass subcommittee of the Oregon Task Force on Global Warming (Oregon Task Force, 1990). Oak Ridge's Marland, asked the amount of acreage that would need to be replanted to mitigate the carbon loss of this old growth, replied, "huge." More specifically, Marland speculated, it would require up to 100 times the old growth acreage, or up to six million acres of new growth to mitigate the lost old growth.

Old growth forests seem to stand up well under Michaels' "good idea anyway" criterion. Old growth

forests harbor several species that are unfit for life in second growth forests, with their lower, thinner canopy and sparser understory. The northern spotted owl is an indicator species for old growth wildlife, and was recently listed as "threatened" prompting severe federal restrictions on old growth logging.

Old growth also harbors flora rarely found elsewhere. An example of this is the Pacific yew, a "shade tolerant tree very closely associated with old growth" (Science, April 1989). Jerry Rust, who has written Yew, says "they can survive clearcutting, but they don't propagate well without cover" (Rust, 1990). The problems posed to such flora are more than the idle concerns of historians and botanists; the Pacific yew is being studied by cancer researchers (Science, April 1989). The question of extinction is not an academic one; any extinction can have effects that run up and down the food chain, even in ways as apparently arbitrary as the Pacific yew.

As the debate over old growth logging continues, the old growth role in carbon storing certainly deserves a place at the table. If, in terms of total carbon storage, the removal of one hectare of old growth would need to be mitigated by on the order of 100 hectares of new growth, perhaps the carbon considerations should be at the head of the table. While we understand many of the implications of harvesting the old growth trees

themselves, "it's the other part of the ecosystem that we don't know too much about, and that's the problem," says Franklin (Franklin, 1990).

### Automation

Automation has been vilified by environmentalists and industry employees alike, but it has positive aspects in the carbon-storing argument. According to Paul Ehinger, owner of a consulting firm in Eugene, the introduction of thinner, more accurate saws and laser scanning have increased efficiency by roughly 50 percent since the late 1940s.

Oregon and Washington's timber-related industries lost 28,600 jobs between 1976 and 1986. However, during the same period, softwood lumber production increased from 20.1 to 21.4 billion board feet (Warren, 1985, 1987). The higher output from a smaller workforce is partially the result of automation. Recalling the concurrent reduction in harvest levels cited by Beuter's report in chapter two, it is fair to assume automation reduced waste; larger amounts of board footage were obtained from smaller amounts of timber.

Every 1000 board feet that entered a mill in the late 1940s yielded 1200 to 1300 board feet in product. The technology introduced since has hiked that final figure up to nearly 2000 board feet for each 1000 coming into the mill (The discrepancy--i.e. 1000 b.f. being

"rendered down" to 2000 b.f. is the result of two different log scaling systems that continue to be used) (Ehringer, 1990). The impact of this automation is such that "the main effort in all the successful mills is wood recovery" (Ehringer, 1990).

The advantages are twofold. In addition to requiring a smaller harvest than was once necessary to produce the same amount of finished product, less wood that is harvested is rendered down to sawdust or hog-fuel ("hogs" are machines that pulverize waste wood, often for use as fuel). This is important because, as OSU's Hansen says, "When you convert from old growth to young forest one of the key factors is how you can convert that old growth into something that lasts, something that will decrease the loss of carbon" (Hansen, 1990).

As is already clear, one of the negative aspects of automation is the cost to the labor force. According to the second Beuter report, 2,500 of the 7,300 jobs that are expected to be lost by 1995 will be the result of automation (Kadera, Nov. 1989). However, the economic advantages of automation dictate that it will continue regardless of the cost to the labor force.

However, employment losses can be mitigated, and domestic lumber supply needs can continue to be addressed, if the export of raw logs is discontinued. This matter is only peripherally related to the thesis and will not be dealt with here.

There are several policy alternatives available that do not appear prohibitively expensive or difficult. Oak Ridge's Marland stressed finding "no regrets options," and several appear to exist. It is up to the people of the Northwest to ensure that global warming is taken into account as timber policy continues to be discussed, and that it is not swept under the rug in favor of more immediate issues. Global warming is immediate.

## CONCLUSION

Unchecked, global warming will drastically alter the size and composition of forests. Indications are the changes would be to the detriment of the Pacific Northwest. Thus, the timber industry has a vested interest in averting climate change. Inaction in the next few years, much less failure to prepare, will be expensive and tragic if warming occurs.

Although it is beholden upon the timber industry to concern itself with the fate of forestland, public concern is also germane. The majesty of forests resonates within all humans. They have inspired writers from Tolkein to Lord Byron, and are beginning to inspire quasi-military action on their behalf by environmental organizations such as Earth First!

However, forests provide humans with wood for shelter and fuel. Wood has proven a beautiful, workable material in human development, and will continue to be. The elegance of forests can translate well into buildings, furniture--even cutting boards. There is no crime in harvesting timber, only in failing to sustain the yield by overcutting or ignoring a threat like warming.

We must strike a balance. We can neither exploit

nor sanctify the forests. We must find ways to meet the needs of the forest as we meet our own needs, because, simply, their survival is necessary. Spiritual and aesthetic concerns aside, we need forests for hard scientific reasons. The Earth's climate is balanced--not exactly delicately, but delicately enough to react under the strain of five billion humans--and one nudge might tip the scales. Once nudged, a series of positive feedbacks could send the climate careening into a completely new form.

Altering Northwest forestry practices would have a negligible impact on the global climate. However, the same measures, taken in concert with an effort worldwide, would 1) slow global warming and 2) mitigate its impact on forestland. Many nations have already exhibited a willingness to adopt policy that combats global warming.

#### Four Policy Recommendations

- \* Increase replanting efforts, concentrating on urban areas and along highway corridors.
- \* Develop new-forestry techniques that reproduce many of the carbon-storage aspects of natural forests.
- \* Allow old growth forests--today only a shadow of their former size--to go uncut, fulfilling their photosynthetically reproductive existences.
- \* Encourage automation that increases cutting

precision and reduces waste wood.

The wholesale implementation of these measures cannot be expected until global warming is established as a legitimate phenomenon, but each of them is a "no regrets" option.

Of course, timber policy is only a single battle in the massive campaign against global warming. Oak Ridge's Marland has done some calculations that put the issue in perspective. In a recent address President Bush suggested one billion trees be planted throughout the United States. The carbon stored in this manner could also be saved if every U.S. citizen turned off a single one-hundred watt bulb for 1.4 hours daily (Marland, April 1990).

Storing carbon in forests would have to be only a single aspect of a comprehensive global effort to combat global warming. Fortunately, many of the steps we can take, at both the individual and the international levels, require only concern, not daunting sacrifice. With or without global warming, there are no regrets in conserving energy, reducing fossil fuel emissions and agitating in defense of ecologically sound policies.

To rethink Marland's illustration, one billion newly planted tree stores an amount of carbon equivalent to 1.2 billion hours of burning one hundred watt light bulbs annually. Allowed to grow, these trees would eventually come to absorb 100 times the carbon they do in their



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