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The Role of Planted Forests in a "Green Certified" Century

Robert F. Powers[1]

Introduction

Forest use has fostered human progress for 10 thousand years. Exploitation (removal without deliberate replacement) characterized much of this period and continues to the present in some parts of the world. Of the forested landscape thought to exist at the start of the Holocene, perhaps a third has been lost from exploitive practices, including conversion to other uses. Wood is our most versatile natural resource and we all have an interest in protecting and sustaining productive forests. This is not a recent concept. Forest conservation has been practiced intermittently for more than 3 millennia. Today, world population swells beyond 6 billion. Demand for wood is unprecedented and continues to rise at a predictable rate. Yet, pressures mount to preserve the diversity and extent of our remaining natural forests. How do we deal with this paradox? Can we avert a crisis?

After the Ice Age

Impacts of Forest Use. Human impacts were low 10 thousand years ago at the start of the Holocene. Global population was sparse (only about 5 million), and the social order consisted of hunter-gatherers depending wholly on plants and animals from local forests. But the invention of agriculture led to more stable village-farming communities. With this came a gradual rise in forest clearing to provide materials for subsistence and to make room for crops. The concept of producing food, rather than searching for it daily, was a turning point. As existence began to lose some of its hazards, life expectancy crept upwards from its normal level of 25 to 30 years. Populations began to rise, doubling in about 1,500 years (Ehrlich and Ehrlich 1972). But primitive technology kept impacts in check until 3500 BC and the advent of the Bronze Age—a turning point where small-scale exploitation began shifting to large-scale deforestation (permanent loss of forests). Metallurgy required unprecedented supplies of fuelwood. By 3000 BC, forests of Cyprus were cleared to produce fuel for the smelting of tin, copper and silver (Hermann 1976). In China, extensive forest clearing began about 2700 BC and continued unabated for 1,500 years. As a consequence, the Chou Dynasty (1127-255 BC) established the world's first forest service to slow forest exploitation and begin forest renewal (Hermann 1976). But with the demise of the dynasty, deforestation resumed. Floods plaguing northern China in modern times are legacies of past deforestation.

Much of Europe remained forested through Roman occupation, but major clearing began with the fall of the Roman Empire in the 4th century AD and continued to the reign of Charlemagne about 800 AD. Following the Norman Conquest in 1066, vast areas of forest were protected by Anglo-Saxon kings as royal game preserves (Hoskins 1955), but peasants continued clearing the best lands for fields and homesteads despite severe penalties for doing so. Deliberate reforestation was practiced in Central Europe some 7 centuries ago when feudal lords and communal forest managers sought to reverse the loss of wood supply and game habitat (Barrett 1949). The first European records of artificial reforestation date to 1368, when the city of Nuremberg seeded several hundred ha of burned lands to pine, spruce and fir (Toumey and Korstian 1942).

The second great wave of European clearing began in the 11th and 12th centuries as wilderness was converted to arable land and wood provided the charcoal for the surging iron industry (Nef 1952). By the 16th century, fuelwood shortages caused a decline in European iron production and much of Europe faced a wood crisis for the next 200 years (Cramer 1984). The pressure of general wood shortages and the advent of systematic botany led to dramatic improvements in reforestation procedures in the 18th century. By 1789, shelterbelt plantings were introduced to the Russian steppes to control wind erosion and protect farmlands. History is compressed and far more recent in the United States. Exploitive practices ruled the Lake States and South during the nation's first century. Public outrage over such "cut-and-get-out" practices led to the Forest Reserve Act of 1891. Establishing broad areas of public forests for serving society in perpetuity (currently about 115 million ha), this and the Organic Act of 1897 formed the foundation for the National Forest System. Of the 292 million ha of forestland in the United States, 19.5% is National Forest and another 20% is managed by other federal agencies. Of the remainder, non-federal governments control 8%, forest industry owns 18%, and non-industrial private landowners or corporations hold the rest (Council on Environmental Quality 1989).

[1] Science Team Leader, USDA Forest Service PSW Research Station, 2400 Washington Avenue, Redding, CA 96001.

Many current issues of forest management and forest sustainability clearly have a long past. Today, depending on definition, forests occupy between 3.6 and 4.8 billion ha, or 27 to 32% of the world's terrestrial surface (Post *et al.* 1982, Waring and Running 1998). Of the 6.2 billion forested ha thought to exist at the start of the Holocene, between one-fifth and one-third have been lost to soil erosion, desertification, conversion to other uses, or otherwise degraded through overgrazing or excessive fuelwood gathering (Postel and Heise 1988, Waring and Running 1998). It hasn't ended. Despite reforestation advances and a broad awareness of conservation, deforestation continues at an estimated 16 million ha annually—an annual reduction of about 0.4% of the global forest base (FAO 1997). California is the most populous state in the Nation and its numbers continue to rise. In 1945 it established the nation's first Forest Practices Act, and it has been strengthened in fits and starts over the years. But even for the 1953-1975 period covering early stages of the Act, the total area of forest shrank by only 4.7% during that 23 years, or 0.2% yr^{-1} (Bolsinger 1980). For comparison, the rate of deforestation has been 1.3% *annually* in tropical Latin America and as much as 4.7% yr^{-1} in Paraguay (Gladstone and Ledig 1990). While nations such as the United States have achieved a high level of technological sophistication and have stable forest areas, much of the world still views forests as a primary means of subsistence. Lost to many is the fact that nearly all the world's population growth is in the poorer countries where premiums are placed on fuelwood production and timber mining (Sutton 1999). Conservation is a hard sell where one's very survival depends on exploitive forestry.

Recent Trends. Society values forests for their products and functions. Products include traditional commodities such as lumber, pulp and fuelwood, and lesser-known commodities such as greenery, mushrooms, and medicinals. Forests also provide such important societal functions as watershed protection, runoff moderation, fish and wildlife habitat, refuge for endangered species, recreation, and aesthetic experience. With rising affluence comes less direct reliance on the forest for daily survival. Populations center in cities, and the connections between people and forests become diffuse, more conceptual, less practical. Freedom from basic want frees us to view forests with more detachment and to question the correctness of long-standing practices. Such is the basis for much of the modern environmental movement that began with the political action years of the 1960s and '70s. Bolstered by heady successes in this period, ecologists have moved from their historical realm of observing natural phenomena to arenas where they have scant expertise (Peters 1995). One of these arenas is forest management. Questions also were raised within the profession (Bolle 1970, Franklin 1992). Theses merged into concerns about losses in natural forest diversity and the "sustainability of ecosystem values" (Committee of Scientists 1999, Drengson and Taylor 1997).

Society and the Certified Forest

Historical Basis. Concerned about loss of natural forests and diminished biological diversity, environmentalists and some professionals in many of the world's developed nations call for more conservative forest management practices that preserve or restore other ecological values. Environmental arguments carry clout that registers viscerally, affecting the voting public and the political systems serving them. Consequently, a "green advocacy" has gained broad momentum to influence how forests are managed both privately and publicly. Green advocacy has gelled into a growing industry to certify what is, and what is not, "sustainable forestry" (Anonymous 1995, Hammond and Hammond 1997). "Green certification of sustainable forest management" centers on the premise that third-party reviews are needed because managers have too great a vested interest to develop or apply objective criteria for forest sustainability (McMahon 1999). Not surprisingly, many in America's private sector are skeptical of third-party green certification, fearing that criteria may be based more on speculation or particular agendas than on science (Berg and Olszewski 1996). Yet, ignoring green certification could limit markets for industrial wood.

The central international body for green certification is the Forest Stewardship Council with two major affiliates in the United States—Smartwood and Scientific Certification Systems (Mater 1999). These and other certification groups have posted websites providing on-line product guides and lists of certified forests, manufacturers, retailers and distributors (Teisl and Roe 2000). Green certification hinges on the strategy that consumers will favor certified products—a strategy finding broad consumer acceptance in Europe but a more tepid reaction here, where most consumers are far-removed from the woods and largely are ignorant of forest practices. U.S. consumers do discriminate against labels that are tedious, confusing, or contradictory and may dismiss even useful, truthful labels if they sense these simply are marketing ploys (Teisl and Roe 2000). As educational approaches and marketing practices become more sophisticated, the consumer is more apt to make a sophisticated choice.

Ramifications. Green certification is not aimed directly at public land management agencies, but pressure has mounted on the USDA Forest Service to de-emphasize wood production on National Forests and to manage for other ecosystem values (Barnette 1999. Committee of Scientists 1999). While harvesting continues on National Forests, it has fallen steadily to roughly one-third of its historical high (Fig. 1), and current harvests from National Forests are well-below annual rates of growth. The net effect is *de facto* certification in respect to timber harvest. National Forests, particularly those of the coastal and interior west—have been a major source of domestic softwood timber supply. Consequently, forest industry has increased cutting rates on private lands. This is particularly obvious in the southern pine region where most land is privately owned. A decade ago that region accounted for only one-third of domestic lumber production (Table 1). But harvesting in the southern region has increased by more than one-third, so that today it produces nearly one-half of the nation's softwood lumber. This suggests that harvests on some private holdings may exceed annual rates of growth for the first time in decades.

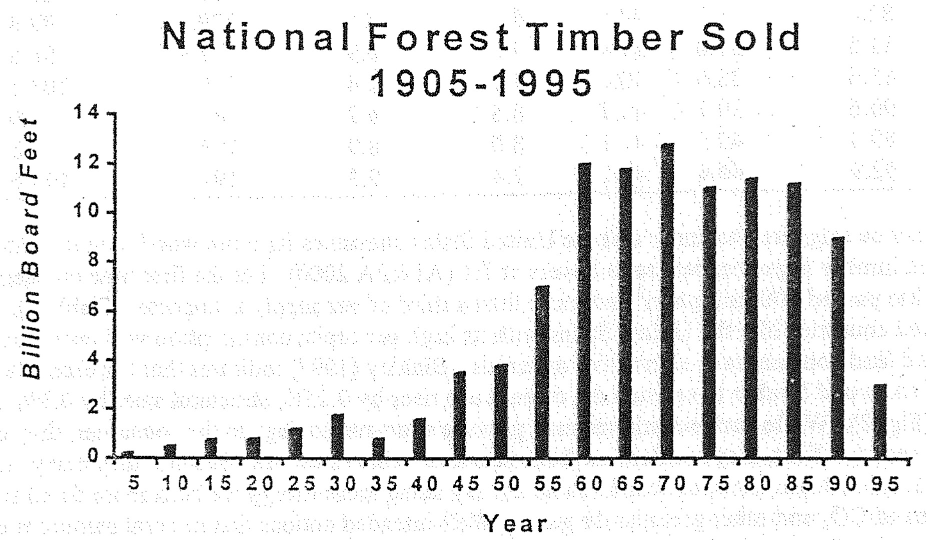

Figure 1. *Timber volume sold from National Forests in the United States by 5-year periods, 1905-1995 (from Fedkiw 1998).*

Under the best circumstances, green certification is an evolving process with feedback and improvement, and progress has been made toward developing more uniform and objective certification standards. Unfortunately, its advocates seem naïve and myopic. Currently, less than 1% of the world's forests are certified. But consider for the sake of argument that all global forests were managed at current Forest Stewardship Council standards. Harvests would average 0.7 m^3 of wood ha^{-1} annually—only one-third the current average global rate of forest growth and about the rate of mortality in over-mature stands (Binkley 1997). This leads to the unfortunate fact that global forest area *would need to expand by one-third* merely to meet current global wood demand, an obvious impossibility.

Admirably, green certification is meant to correct past wrongs and to restore ecological values. But it comes at a time when world population and demand for wood products are rising at similar rates (FAO 1997). Philosophies that wood harvests should center only on trees facing imminent mortality (Camp 1997) are either irresponsible or foolhardy. Wood demand permeates all societies and increases by 70 to 80 million m^3 annually—an increment equivalent to British Columbia's entire allowable cut in 1993 (Kimmins 1996). Reduced wood production from green-certified nations creates a strong incentive for other countries to raise forest harvesting beyond sustainable levels to reap the rewards of global demand. Native woods are being depleted in some tropical countries as global markets develop, and projections show that industrial supplies from Indonesia and Malaysia may fall by half or more by 2020 (Nambiar 1999).

Table 1. Regional sources of softwood production and consumption of softwood lumber (million m^3) by year in the United States (from AF&PA 2000).

Year	Domestic production by region						Total imports	Total domestic consumption
	Southern pine	West Coast	Inland region	Coastal redwood	Other	Total production		
1989	68.7	45.0	63.0	11.8	5.9	194.5	77.2	271.7
1990	70.2	40.7	58.8	11.0	5.4	186.1	68.8	254.9
1991	68.8	36.6	52.7	9.6	5.0	172.6	66.5	239.1
1992	78.7	38.0	51.6	8.8	6.2	183.2	75.8	259.0
1993	79.4	34.2	46.0	7.7	5.7	173.0	86.4	259.4
1994	82.8	38.7	44.5	8.2	5.5	179.6	92.8	272.4
1995	81.5	37.0	39.4	7.2	6.9	171.9	98.5	270.4
1996	85.6	38.6	40.0	7.7	7.4	179.3	103.1	277.8
1997	90.6	39.7	40.7	8.5	6.7	186.1	102.0	288.1
1998	89.4	42.5	41.1	8.0	8.9	189.8	105.8	294.9
1999	92.9	46.4	43.1	7.4	9.3	199.0	108.6	307.6

Some may be staggered to know that the United States consumes far more wood than it produces. Our softwood lumber import:export ratio hovers at 7:1 (AF&PA 2000). For the first time our demand for softwood lumber has passed 300 million m^3 and more than a third of our supply is imported (Table 1). Wood scarcity in developed countries like the United States with its high per capita consumption will raise domestic prices for wood and lead consumers to alternative materials. Binkley (1997) indicates that for each 1% increase in the price of softwood lumber to consumers, cement use rises by 0.15%, structural steel by 0.3%, and brick by 0.65% (Fig. 2). While such substitutes may provide short-run savings to the consumer, they carry long-run costs to society. First, they are derived from non-renewable resources. Second, they carry energy and pollution costs at least 10-times those of wood (Table 2). By using more energy we burn more fossil fuels, raising emissions of CO_2 and other greenhouse gases. Well-intended notions that mineral resources can "save forests" by substituting for wood when such conversions are powered by fossil fuels make ecological *nonsense* as long as people are part of the ecosystem (Smith *et al.* 1997).

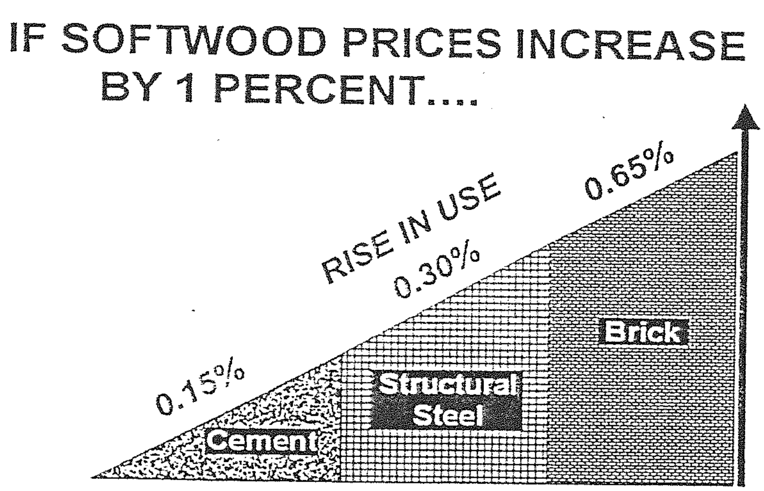

Figure 2. *Relative change in consumer preference for alternative materials per unit price increase in softwood (from Binkley 1997).*

Table 2. Comparison of world per capita daily consumption and relative energy costs of manufacture for wood and substitute products (Sutton 1999).

Consumer product	Daily consumption (g)	Relative energy cost
Wood	900	--
Steel	330	9
Concrete	710	21
Brick	n.a.	30

Meeting Modern Needs

Facing Reality. Global population is rising dramatically (Ehrlich and Ehrlich 1972). More than 9,000 years passed for populations to increase to about 500 million at the first reliable census in 1650 AD—a doubling each 1,500 years. In 200 years population doubled again, redoubling in another 80. By 1975, world population reached 4 billion, a doubling in only 45 years. Today, 6 billion people inhabit the earth, and as many as 10 billion are projected by mid-century. Paralleling this is the demand for wood. Since 1960 the world per capita consumption rate of wood has varied between 0.65 and 0.58 m^3 annually, with U.S. consumption being several times greater (Sutton 1999). Making a conservative guess that per capita consumption will stabilize at about 0.5 m^3 by 2050, this projects to an annual demand of 2 billion m^3 of wood beyond that produced today. At a harvestable mean annual volume increment (MAI) of 2 m^3 ha^{-1} (the world average for natural stands), this requires an area of new production equal in size to Europe. Everyone uses wood. Where will it come from?

Plantation Possibilities. Currently, about 80% of the world's wood consumption comes from natural forests. But natural forests often are comprised of stands under stress with high rates of mortality and low net rates of growth. Given current political tendencies, we can't rely on natural forests for long. The desire in wealthy, developed nations to conserve natural forests by reducing timber harvests or eliminating them entirely is a political fact (Nambiar 1999). On the other hand, forests planted specifically for wood production can achieve very high rates of growth. In the tropics, merchantable growth may be 4- to 10-times greater than that in natural forests (Gladstone and Ledig 1990). Pine plantations on average and better sites in temperate to tropical regions are capable of MAI between 6 and 35 m^3 ha^{-1}—rates well-above those in natural stands of softwoods including coastal Douglas-fir and Sierra Nevada mixed conifers (Table 3). In California, ponderosa pine plantations commonly produce between 6 and 15 m^3 ha^{-1} yr^{-1} over the first 50 years without unusual silvicultural investment (Oliver and Powers 1978). And with appropriate treatment, high site quality plantations can average more than 7 m^3 ha^{-1} yr^{-1} through the first decade (Powers and Reynolds 1999) with rates projecting to at least 20 m^3 ha^{-1} yr^{-1} through age 50. These rates should be silviculturally sustainable (Nambiar 1999, Powers 1999). Sedjo and Botkin (1997) argued that if plantation MAI's averaged a comparatively modest 10 m^3 ha^{-1} today's global demand for roundwood could be met merely by increasing the area of plantations from its current 3% of global forest area to about 5%. Assuming a global population of 10 billion by 2050, the world's wood needs would be met if 13% of forest area was in plantations averaging 10 m^3 ha^{-1} yr^{-1}. This, without *any* harvesting from natural forests. Intensively managed plantation forests are the world's main hope for meeting projected global shortfalls (Nambiar 1999).

The California Condition. California has over 9 million ha of coniferous forest, of which half is National Forest and one-third is privately owned (Table 4). Of that in private hands, slightly less than half is managed by forest industry. The actual area of California's plantations has not been determined, but it seems relatively small. Nonetheless, plantations are created every year with the earliest efforts tracing to 1905 (Landram 1996). The first successful ponderosa pine plantation was established in 1920 by S.B. Show near the community of McCloud. The Show plantation has been thinned many times, and has been the centerpiece for many field trips. Today, it exhibits qualities of a mature, natural pine forest while appearing healthier than less-tended natural stands nearby. Many of California's plantations trace not to regeneration harvests, but to reforestation in the wake of massive, stand-destroying wildfires. In his recent assessment of 3.1 million ha on 9 National Forests of the Sierra Nevada and California Cascades, Landram (1996) concluded that 4% of the land base was in plantations as of 1991, and only 2% of the land was non-stocked. If we use Landram's recent estimate of planting rates as a guide, the total area of planted forests in California probably is less than 500 thousand ha at the turn of the new century.

Table 3. Mean annual volume increments (MAI) in natural and planted forests worldwide (from Boyle et al. 1999, Sedjo 1999, and various yield tables).

Geographic region	MAI (m^3 ha^{-1})	Rotation (yr)
Softwood natural forests		
Canada	1.5-5.3	35-65
Finland	2.5	60-100
Siberia	1-1.4	70-200
United States (West, Doug-fir)	1.4-14	50-75
United States (Sierra Nevada)	3.5-18	70
Softwood plantations		
Brazil (Pine)	15-35	5-35
Great Britain (Sitka spruce)	14	40
New Zealand (pine)	18-30	0-40
South Africa (Pine)	10-25	20-35
United States (South, pine)	9-11	25-35
United States (California, pine)	6-15	50
Eucalyptus plantations		
Brazil	30-70	5-20
Chile	20-30	8-20
Portugal and Spain	10-15	8-12
South Africa	15-20	10

Table 4. Ownership of major forest and range cover types in California in thousands of ha (from Timberland Task Force 1993).

Cover type	Private industry	Private non-industry	Forest Service	Bureau of Land Mgt.	Other public	Total area by type
Conifer	1,488	1,608	5,124	543	557	9,320
Hardwood	---	2,748	738	196	184	3,866
Shrub	---	3,385	1,809	1,522	1,040	7,756
Grass	---	3,398	113	142	217	3,870
Desert	---	2,048	41	4,532	1,996	8,617
Barren	---	116	274	130	338	858
Total by Ownership	1,488	13,303	8,099	7,065	4,332	24,287

Plantations are a positive response in the aftermath of stand-replacing wildfire—a fact of life in summer-dry California. Post-fire planting will continue in pine and mixed-conifer forests until natural stands are managed in a way that substantially reduces fire risk. Many forest industry lands will be converted to plantations gradually, but there will be no net change in the area dedicated primarily to wood production. Non-industrial private lands are another matter. The area of private, non-industrial coniferous forest is slightly more than that of industrial holdings. Added to this is nearly 4-times more hardwood and shrubland under non-industrial ownership (Table 4). Perhaps only one-quarter of land supporting hardwoods and shrubs is of reasonable site quality, but non-industrial private holdings do constitute a potential source of wood production. And if only one-third of the land of reasonable site quality—8% of the privately-owned, non-coniferous base—were placed in plantations, California's area of planted forests would be doubled. Admittedly, this is only a "potential." Non-industrial holdings are fragmented and wood production carries low priority with many landowners. Plantation forestry is not for everyone.

Beyond existing forest land, new plantations of fast-growing species can only be extended into grasslands, shrublands, and agricultural regions of marginal value. A classical example is the drip-irrigated eucalyptus fiber farm on droughty valley soils near Corning. Encompassing some 4,000 ha, it is one of the world's largest contiguous eucalyptus plantations. On better soils without supplemental irrigation, eucalyptus plantations have a proven capacity for dry matter production in warm climates (Table 3). A genus of more than 500 species, *Eucalyptus* ranges from hot, humid tropical lowlands to cool, temperate highlands (Turnbull 1999). Thus, there is a species tailored to nearly any site. But regardless of where plantations are placed in California, efforts will fail without public approval.

Gaining Support for Planted Forests

Several prevailing public notions must be corrected. One is that natural forests and their diversity are threatened with extinction. Another is that artificially-regenerated forests either (a) are "corn-row" forests with minimal biological diversity, and equivalent to "genetic robbery," or (b) must mimic the structure, composition, and function of natural forests. These will be addressed with specific reference to California.

The Extinction of Natural Forests. We as a nation recognize the myriad values of natural forests. This is reflected in our wilderness allocations which now exceed the land areas of Ireland, Italy, and Israel, combined. California is a leader in terms of natural forest reserved from timber harvest. Of the State's 13.2 million ha of forest, 2 million ha are administratively reserved as parks, wilderness, or ecological preserves (Table 5). These set-asides include all the forest cover types of commercial value. Allowing for bare rock and bodies of water, this represents at least 10% of California's forests. Vast areas are in National Parks and wilderness. Both types of reserves receive increasing visitor use and managers are challenged to minimize human impacts. Mindful of this, Research Natural Areas and Natural Reserves are being established to preserve natural ecosystems and their gene pools from human intervention. To date, 75 forested ecological reserves are managed in California by the USDA Forest Service and another 10 by the University of California. Varying in size between 2 ha and 24 thousand ha, 77 exceed 100 ha. Collectively, they account for a total ecological reserve of 82 thousand ha. These, combined with California's other forest reserves, sum to an area equivalent to that of New Jersey (Table 5)—more than 4-times the area currently in plantation. Reserves can't be protected from all disturbances, but they will not be logged. The variety and wide distribution of California's reserved natural forests offers some assurance that they will endure.

The Loss of Biological Diversity. Genes are the basis for all biological diversity. In forest regeneration, the ceiling on genetic diversity is set by the variability in the makeup of seedings, regardless of regeneration method. The important factor is not the *number* of genetically different individuals, but rather the *degree* and *frequency* of genetic differences (Libby and Rauter 1984). Arguments sometimes are made that replacing natural forests with plantations will diminish the genetic base by favoring strains of closely-related individuals, often exotics, chosen only for wood production. These are the facts that the public should know.

Fact 1. First, and in strong contrast with planting policies in many other nations (Nambiar 1999), California's native forests are not routinely replaced by exotic species. Rather, planted trees reflect the same species present in the original natural stand. And in fact, mixed plantings are increasingly common in California. Even where mixed-species sites are planted to one species, they rarely remain monocultures for long. In 1960 the Volcano Fire destroyed 18 thousand ha of mixed conifers on the Tahoe National Forest. In the aftermath, ponderosa pine was planted extensively and exclusively. Today, the plantation has a diverse understory of naturally-regenerated species. Studies in an adjacent, slightly older plantation confirmed that all five Sierra Nevada mixed-conifer species were abundant at 25 years, regardless of the stand density of planted ponderosa pine (Oliver and Dolph 1992). In the Douglas-fir region, Miller and Anderson (1995) compared six matched plantations and natural stands establishing following wildfire. Although the former were planted purely with Douglas-fir, more than half the trees present after 65 years were of other species.

Table 5. Approximate area (and average size) of California forests reserved from timber harvest (from multiple sources, including web sites). Thousands of ha.

Ownership	Parks	Wilderness	Ecological preserves[1]	Total by ownership
Federal	735 (147)	1,159 (55)	41 (0.6)	1,935
State	35 (3)	---	--	35
Univ. California	---	---	41 (6)	41
Total by reserve	770	1,159	82	2,011

[1]Areas less than 100 ha not included.

Fact 2. Few if any forests are pristine. California's long history of selective logging of the largest and most valuable trees removed "the best and the brightest" from many natural stands, often leaving them in a structurally (and probably genetically) degraded condition. In principle such cutting practices lead to dysgenic selection because the rare, best-formed individuals are removed (Smith *et al.* 1997). In other cases, poor stocking control in natural stands has created stress conditions triggering explosive outbreaks of insects that kill groups of trees in the Sierras and Cascades (Oliver 1995). Can anyone argue rationally that replacing such stands with genetic material selected for adaptation is a mistake? Further, the largest share of California's plantations were and are established following wildfire (Landram 1996). Often, entire watersheds of genetic diversity have literally vanished in smoke. Planted forests are a way of restoring conifer diversity promptly, before soil erodes and the site is degraded physically and permanently.

Advantages of prompt artificial regeneration should be obvious. Not only can managers regenerate with species genetically adapted to each particular site, but they also can vary genotypes in advance of projected shifts in climate. California has been an international leader in identifying and managing the diversity of forest trees, and this is reflected in the seed orchard strategy and planting policy of the USDA Forest Service (Kitzmiller 1990). Such advantages hold even with clonal material because managers can pick among clones that are genetically dissimilar. In principle, genetic discontinuities possible with cloning add flexibility and "insurance" to plantation management. By choosing clones with distinct genetic differences (rather than seedlings with closely related, sometimes overlapping traits from seed orchard programs), it may be possible to introduce substantive genetic barriers to widespread damage from insects, disease or climate (Libby and Rauter 1984).

Historically, genetic attention has centered on adaptation (Kitzmiller 1990). In fact, programs have been so successful that the most important questions have been answered for California, and new attention should turn to how dry matter might be apportioned within trees to reduce slash production and maximize usable fiber (Libby 1987). Selection and tree breeding strategies may also produce plantations targeted at specific ecological or sociological needs on degraded or unstable lands. Through modern techniques, new genetic variation is created by recombining variation already present in a specific population. This holds promise for developing genotypes that use water and nutrients more efficiently (Boyle *et al.* 1997).

False Expectations. Problems arise if the public and some professionals perceive plantations as necessarily mimicking natural forests in structure, composition and function. Such perceptions lead to impractical demands that create distrust. Planted forests are even-aged and are designed for specific purposes (wood production, soil stabilization and watershed protection, land rehabilitation). Thus, they are not meant to mimic the structural diversity present in older natural forests. Compared with plantations, the character of natural forests changes slowly. So slowly that to many they seem static. Every few centuries natural forests are disturbed sufficiently by fire, pests, or wind that they enter an extended period of recovery, a prolonged period of maturation, then a gradual slide into senescence. Each period is marked by specific kinds of structure producing specific biotic habitats. Structural conditions characterizing older natural forests arise from long periods of competitive stress, pockets of mortality, and gap openings occupied by shade-tolerant vegetation--conditions clearly at odds with most management strategies for plantations. Some habitats can only be provided by old-growth forests. Both the general public and forest managers must understand that there are tradeoffs between wood production and habitat conservation.

Although plantations may not provide all the amenities of natural forests, they are not the "tree deserts" pictured by their adversaries. In the tropics, particularly on degraded lands, production plantations have stablilized the landscape and modified the ground environment enough that native flora reestablish beneath them (Harrington and Ewel 1997, Lugo 1997, Nambiar 1999). Halpern and Spies (1995), studying forest chronosequences in the Oregon Cascades and Coast Ranges, found that changes in understory diversity were fairly short-lived after harvesting and that relatively few taxa were eliminated by site preparation. By crown closure, species richness in regenerated clearcuts can recover to preharvest levels. At the stand or watershed level, flora typical of old-growth understories were maintained. In a California chronosequence study, DiTomaso *et al.* (1997) found far greater richness of understory species where herbicides had been applied in plantations and that biological diversity was equivalent to that in matched, old-growth pine forests. This "herbicide paradox" can be explained by the fact that early vegetation control in summer-dry plantations prevents understory domination by a small variety of aggressive, perennial shrubs such as manzanita or ceanothus.

Plantations normally are hurried through the open, grass-shrub stage to a closed canopy forest. This means that habitat conditions for early seral-dependent wildlife will be brief. Plantations are harvested before the onset of natural decline, and then replanted. Therefore, species dependent on late seral conditions are apt to be absent. But several plantation rotations may pass in the time that a natural forest reaches maturity, so the absolute period of early habitat conditions may be somewhat comparable for plantations and natural forests. Wildlife habitat niches in conventionally managed plantations will differ from those of older, natural forests. But silvicultural know-how does exist for creating more varied structure and habitat conditions in plantations, provided that the manager has a clear vision of the goal (Curtis *et al.* 1998, Powers and Aune 1997). Multi-tiered, multi-species stands can be created through careful thinning, and needs of cavity nesting birds can be tackled by recruiting and managing large dead or dying trees. This is silviculturally possible and perhaps desirable under special circumstances, but it defeats the extraordinary value of planted forests for growing wood. A managerial alternative is to create multi-aged patchworks of even-aged plantations of irregular size and shape across a landscape. Such patchworks can enrich the biological diversity of a landscape beyond that offered by natural forests while still producing wood (Cannell 1999).

Plantations for Multiple Purposes

Sustainable Wood Production. Plantations are assets created for multiple purposes, but one outstanding trait is usable wood production—a trait unrivaled by natural forests. Recognizing this, geneticists have called for more high-yielding plantations to remove the pressure to harvest natural forests (Gladstone and Ledig 1990). Evidence that high rates of wood production can be sustained indefinitely through appropriate soil and vegetation management is quite convincing (Boyle *et al.* 1999, Nambiar 1999, Powers 1999). However, it also is possible that improved stocking and genetics can increase yields while masking possible soil degradation (Powers 1999). Accordingly, practicable soil-based indicators have been proposed for monitoring soil condition on either an intensive or extensive basis (Burger and Kelting 1998, Powers *et al.* 1998).

The public knows that plantations grow wood. But they should understand that plantations serve other purposes, such as land rehabilitation. A recent global assessment concluded that almost 2 billion ha of land have been degraded since the middle of the last century (Oldeman *et al.* 1991, in Marcar and Khanna 1997). Beyond actual deforestation, causes include soil erosion from such poor agricultural practices as overgrazing, pollution from industrial chemicals, and surface mining. Planted forests have a role in restoration ecology.

Land Stabilization. Plantations have an impressive record relative to land stabilization—particularly in respect to afforestation or reforestation of abandoned fields (Fig. 3). The fact that soil remains on former farmlands of the Coastal Plain and Appalachian Provinces of the eastern United States is due, in many cases, to tree planting (Barrett 1962). Smelter fumes have devegetated mountain slopes in many parts of the world, but nowhere nearer home than the slopes above the town of Kennett near what is now Shasta Dam. Between 1905 and 1919, fumes from the roasting of copper sulfite ore devegetated more than 250 km^2 of land. Winter mudflows often blocked the railroad line between Kennett and Keswick, the site of another smelter. By 1932 gully and sheet erosion were rampant and more than 30 million m^3 of soil had been lost (Kraebel 1955). Herculean efforts were made to stabilize gullies with check dams and metal riprap and to stabilize the remaining landscape with test plantings of a wide variety of trees. Today, the slopes are relatively stable from the gradual invasion of manzanita and oak, but the greatest stability is where pines had been planted. By 13 years, a carpet of pine needles literally had smothered the gullies (Kraebel 1955). Those early plantings are now among the oldest in the state (Oliver 1978, Oliver and Powers 1978).

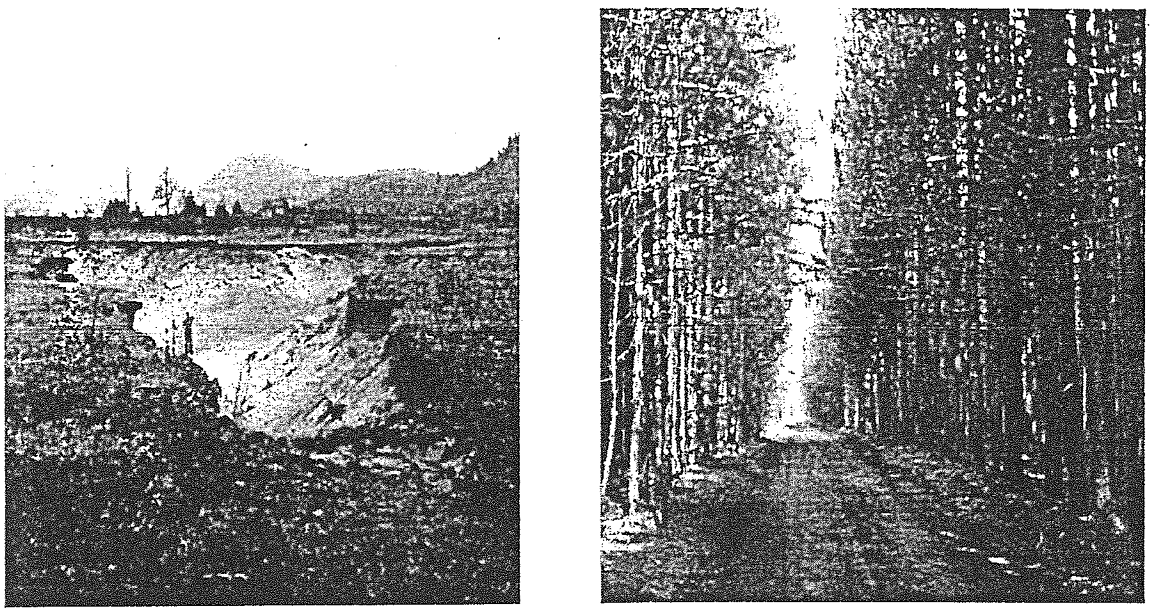

Figure 3. *Effectiveness of planted forests in arresting soil erosion, Pack Plain, New York. Left: eroded gully in a sandy soil following the abandonment of agriculture (1930 photo). Right: the general area in the 1970's following the planting of red pine. The stabilized gully is a short distance from this site. (Photos courtesy of E.H. White, State University of New York, Syracuse)*

Land Rehabilitation. Tree planting is a well-established step in reclaiming degraded sites such as those left in the aftermath of mining (Bradshaw and Chadwick 1980), as well as reclamation of salt-affected sites in regions of arid or seasonally-dry climate (Marcar and Khanna 1997). A lesser-known purpose of planted forests is their rehabilitative role in degraded riparian zones. An outstanding example is work done along Washington Creek in agricultural southern Ontario (Oelbermann and Gordon 2000). There, farming and overgrazing reduced riparian cover, eroded banks, and led to nutrient runoff. By 1985, Washington Creek was a shallow, warm, eutrophic stream (Fig. 4A). That year, banks were planted with mixtures of alder and hybrid poplar with silver maple and other species added in subsequent years. In 1993, portions of the restored riparian forest were thinned (Fig. 4B) and more species were planted. Today, Washington Creek has been restored to nearly natural conditions (Fig. 4C).

Clearly, planted forests are versatile, but this largely is unknown to the public. To reach the public we must establish credibility. How do we convey the importance of plantation forestry to a skeptical public in the new "green certified" century?

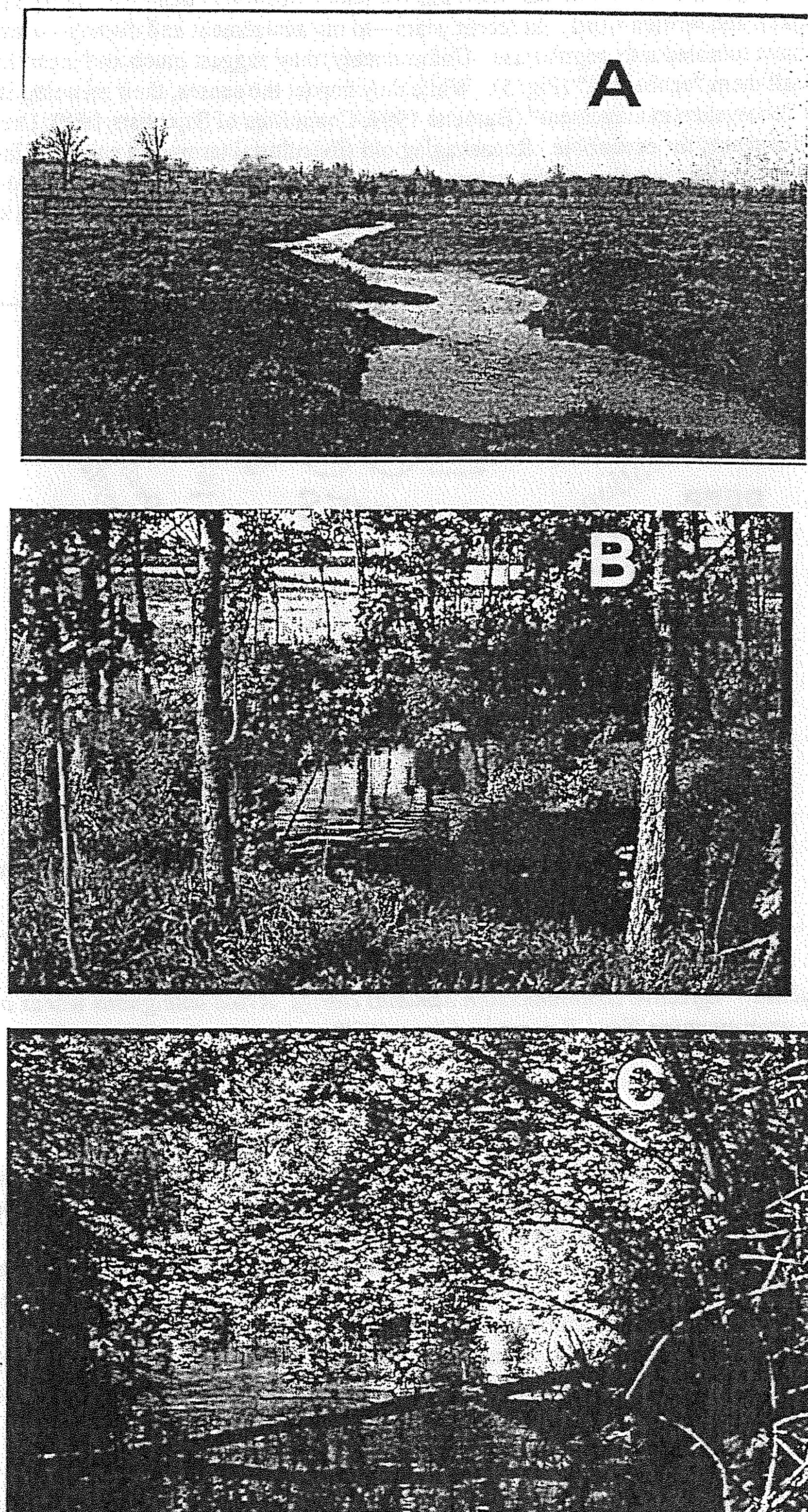

Figure 4. *Tree planting to improve riparian habitat along Washington Creek, southern Ontario. A: Washington Creek in 1985, prior to rehabilitation. B: In 1989 after planting alder, hybrid poplar, and maple. C: In 1996. Note presence of woody structures in stream. Photos courtesy of A.M. Gordon, University of Guelph, Ontario.*

Building Credibility

Plain Talk. The first step toward building trust with other professionals and the public is clarity in our message. Words used well carry power. Affecting our peers and the public positively demands clarity in transmitting our thoughts to the spoken and written word . In recent years—to my amazement and dismay—a torrent of wondrous phases have tumbled into popular use. Unfortunately, they suggest much and mean little. Powers and Aune (1997) call them "ecobabble" (Fig. 5). While they impact the senses, their meaning is obscure. "Ecoforestry" and "ecosystem management" (Barnette 1999, Committee of Scientists 1999, Drengson and Taylor 1997) seem magnets for ecobabble. Repackaging old silvicultural terms and concepts into ecobabble in the hope of adding luster does not elevate the stature of our profession. Communication is give-and-take between plain speaking and active listening. Let's say what we mean in a way that captures its significance and the interest of others.

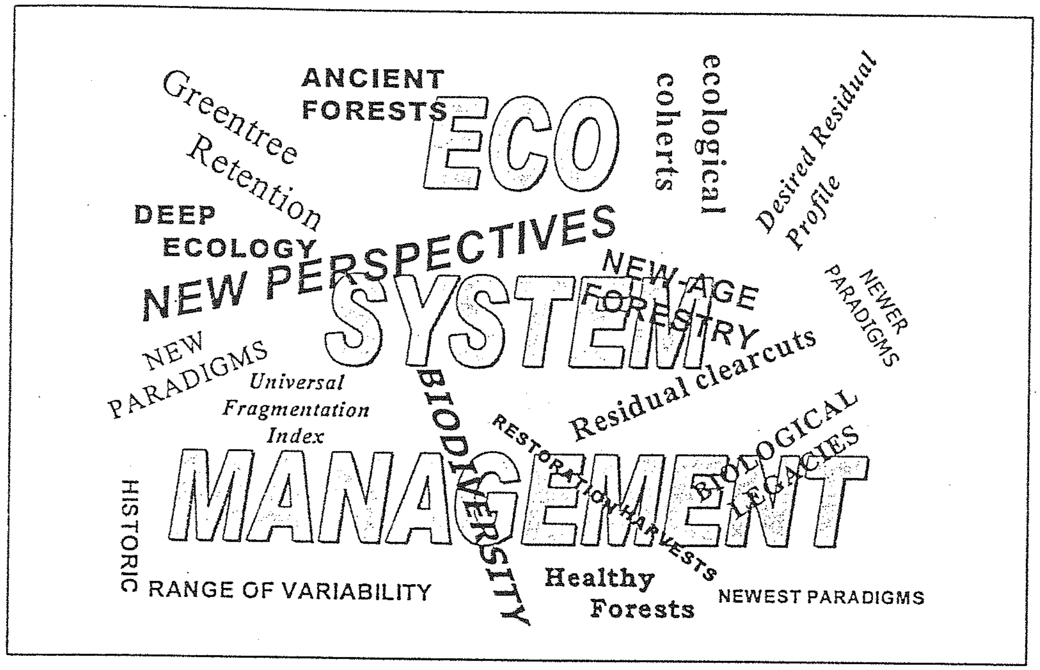

Figure 5. *"Ecobabble." Effective communication demands clarity. Avoid ambiguous words and phrases that fail to convey your meaning (from Powers and Aune 1997).*

Continuing Education. Persuading others of the value of planted forests demands that we back our message with factual, objective knowledge. And this demands continuing education. During the early seventies, the Bolle Report (1970) criticized the USDA Forest Service for timber harvesting practices. As one response, the agency launched the Forest Service Silvicultural Certification Program—a sustained continuing education effort that strikes me as a landmark achievement. The Society of American Foresters saw a similar need, and continuing education became a priority national program in 1977. Today, professional foresters in California must accumulate hours of approved training to maintain their professional standing. Despite reduced budgets, such education *must* be sustained. And those from other disciplines should participate not only as instructors, but as students. It keeps us on the leading edge of our profession and helps keep our profession relevant to others.

Professional Outreach. Making our profession relevant means higher visibility in the educational activities it sponsors. Beyond that, we must be ambassadors to other groups, raising our professional profile and broadening the understanding of how natural and planted forests relate to social issues. The challenge is to break the comfortable mold of "just talking to each other." But time is precious. Probably, little will be gained by investing time with "professional adversaries" whose *raison d' être* seems to lay in *not* building bridges. Seek others of good will and be a contributor to *their* meetings.

Teaching the Teachers. Educational investments create the widest ripples, and the sooner they're made, the better. Today's students will be tomorrow's voters affecting forestry issues. How informed will they be? The most positive program I've seen dealing with this is "FIT," the "Forestry Institute for Teachers." FIT is a grassroots concept of the Northern California Society of American Foresters (1993). It aims to arm kindergarten through 12th-grade teachers with sound, balanced knowledge of forest ecology and management. FIT's goal is to spread such objective knowledge to generations of students by "teaching the teachers." County Superintendents of Education and the University of California Cooperative Extension grasped the significance of the program and supported it from the start. FIT is offered annually at three sites in northern California. It attracts about 120 teachers each year from both urban and rural settings to a forested field classroom for one week in the summer. It is an interactive classroom involving instruction by practicing resource professionals on the physical, biological, and ecological aspects of forestry with lots of field excercises. Assisted by curriculum specialists and materials from "Project Learning Tree," "Project Wild," and other resources, enrollees develop K-12 courses covering 4 to 6 weeks in the coming school year. Participants give daily evaluations for immediate feedback. Meals, lodging, and materials are provided, as well as a stipend once a classroom course has been created. Attendees also earn 3 units of graduate credit from a local university. FIT is an ideal setting for presenting the worth of plantation forestry to a non-traditional audience. Funding for FIT has been borne mainly by forest industry, school districts, and volunteer contributions. This investment in small group training may produce large, long-term payoffs. FIT is only as effective as its volunteers. Be one promoting the many values of planted forests.

In Closing

Planted forests simply are our best hope for meeting societal demands for wood while preserving the condition of natural forests. This conclusion is inescapable and avoiding or evading it is irresponsible. Our task, then, is to convince others of the worth of planted forests in the new century. Inspiration for this paper came from a landmark conference held June 1995 in Portland, OR (Boyle *et. al.* 1999). One of the most forceful products of this conference is a planted forest website (see *www.cof.orst.edu/pubs/cof/plntdfor/index.htm*). The time is right for a conference tailored to California. If we choose to do this, I think we must reach beyond our traditional audience and plan beyond our traditional conference "product." Of course, we must publish a *Proceedings*. But if we stop there, we've failed. We need to capture the versatility of planted forests and the enthusiasm of those that manage them. One way might be a narrated film of the quality of *Nova*. The film would include many field examples showing the versatility of planted forests in landscapes of California and the world. It would be distributed broadly to schools and to public television. Public attitudes about planted forests will not be changed by a conference, but people are moved by what they see and hear. Vision leads to passion. I hope we can be the catalyst.

I'm indebted to my colleagues Phil Aune (California Forestry Association), Jim Boyle (Oregon State University), Bill Libby (University of California), and Sadanandan Nambiar (CSIRO, Australia) for providing me with ideas, facts, and encouragement.

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