FAST-GROWN PLANTATIONS, FOREST CERTIFICATION, AND THE U.S. SOUTH: ENVIRONMENTAL BENEFITS AND ECONOMIC SUSTAINABILITY*

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ABSTRACT

The Food and Agriculture Organisation of the United Nations reports that planted forests comprise 187 million ha, or 5%, of the 3.9 billion ha of forests in the world. We estimate that about 72 million ha of these plantations are fast-grown forests with short-rotation industrial wood production as their primary objective. The U.S. South has the world's largest area of such fast-grown industrial plantation forests, with about 15.3 million ha of intensively managed pine plantations, comprising about one-fifth of the world fast-grown total. Forest certification schemes have been introduced throughout the world to ensure that natural, and especially plantation, forests achieve sustainable forest management economic, social, and environmental goals. Certified forests now include about 272 million ha of forests, or 7% of the total area. Debates over industrial plantations and forest certification are pervasive in the U.S. South, as in the rest of the world. Fast-grown industrial plantations will continue to increase in area and in the share of industrial wood they provide, based on economic returns and wood fibre needs. Forest

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certification systems are likely to improve the scientific discourse and the opportunities to practise intensive plantation forestry, but not completely quell public debate.

Keywords: forest certification; plantations; environment; economics; sustainable forestry.

INTRODUCTION

Forest plantations provide an increasing amount of the world's industrial wood fibre supply. Forestry investors have placed increasing amounts of capital into plantation investments, which have rapid growth, generally assured demand and markets, and high rates of return. In addition, forest plantations are advocated as being a means to conserve natural forest through substitution of intensive management (Sedjo & Botkin 1997; Pandey & Ball 1998; Sedjo 2001; Tomberlin & Buongiorno 2001; World Wildlife Fund 2003).

On the other hand, critics of forest plantations abound, stating that they are biological deserts, destructive of communities and the environment, and not really forests at all (Carrera & Lohmann 1996; Cossalter & Pye-Smith 2003; Forest Certification Watch 2005). This debate has been central in the forest certification arena as well, with the Forest Stewardship Council currently undergoing a 2-year review of certification of plantations (Forest Stewardship Council 2006), and other systems carefully considering the science and application of plantation forestry in their schemes.

Forest certification is the most promising method to bridge this divide between the purported benefits and costs of forest plantations. Certification, which began in 1993 with the creation of the Forest Stewardship Council and has expanded rapidly since, can assure that plantations meet all three principal criteria of Sustainable Forest Management (SFM)—economic, social, and environmental. It is a method of ensuring that forests and plantations can be managed sustainably for the present, and that they will continue to provide benefits for future generations, commensurate with the classical definition of sustainable development (Brundtland 1987). This paper examines forest plantations and forest certification, with a focus on the U.S. South, in order to assess how well certification helps meet sustainable forest management standards and satisfies proponents and critics of plantation management.

FOREST PLANTATION EXTENT

Definitions and Area

World forest and plantation data from the Food and Agriculture Organisation of the United Nations were drawn on here for summary purposes and supplemented by our research on fast-grown plantations. The world's forest cover amounts to nearly 3.9 billion ha (FAO 2003). Another report from FAO (2001) defines a forest

plantation as "A forest established by planting and/or seeding in the process of afforestation or reforestation. It consists of introduced species, or in some cases, indigenous species". It also must meet the FAO forest definitions of a minimum area of at least 0.5 ha, tree crown cover of at least 10% of the land cover, and total height of adult trees of more than 5 m (Carle *et al*. 2002).

The Food and Agriculture Organisation (2003) estimated that there were 3. 9 billion ha of forests and 187 million ha (5%) in forest plantations in the world in 2000 (Table 1). As is evident in the table, there do not appear to be clear relationships among population, forest area, and plantation forests at the broad continental scale.

Definitions of fast-grown or industrial forests are less universal. In their review, Cossalter & Pye-Smith (2003) defined fast-wood plantations as those that produce large volumes of small-diameter logs at competitive prices as quickly as possible, yielding at least 15 m^3 of wood/ha annually. They examined typical plantations such as single-species blocks of eucalypts, poplars, acacias, and pines. Using this narrow criterion, they estimated that there were approximately 10 million ha of fast-grown plantations in the world. Carle *et al*. (2002) divided the FAO 187 million ha of forests into classes of 89 million ha of industrial purpose forests, 48 million ha of non-industrial purpose forests, and 49 million ha of plantations with unspecified purposes.

We developed a definition of fast-grown plantations that includes all plantations grown primarily to produce industrial wood products in short rotations. These would include all of those grown in monocultures on short rotations for industrial products with growth rates exceeding natural stands. This excluded a large share of

TABLE 1–Land, forest, plantation, and population statistics by region, 2000

Region	Land area (000 ha)	Total forests (000 ha)	Natural forests (000 ha)	Planted forests (000 ha)	Fast-grown industrial planted (000 ha)	Population (million)
Africa	2 978 394	649 866	645 829	8 036	2.0	767
Asia	3 084 746	547 793	489 836	115 847	36.4	3 364
Oceania	849 096	197 623	194 775	2 848	2.1	30
Europe	2 259 957	1 039 251	943 160	32 015	5.4	729
N America	1 837 992	470 564	445 812	16 505	17.6	307
Central America	298 974	78 740	70 621	1 028	0.6	171
S America	1 754 741	885 618	875 163	10 455	7.8	341
World	13 063 900	3 869 455	3 665 195	186 733	71.9	5 978

Sources: All but fast-grown area - FAO (2003)
Fast-grown forest area - Roise *et al*. (2000), Siry *et al*. (2005), authors' research

plantations that are planted for fuelwood or conservation purposes, especially in Asia and Africa.

The mean annual increments (MAI) for the fast-grown industrial species in productive stands could range from 10 to 20 m^3/ha in temperate forests, to 20 to 50 m^3/ha for tropical and subtropical plantations of pine, and up to 60 m^3/ha for eucalypts. Country-wide forest averages for these species might be considerably less, but the new plantations with the best genetic material and intensive silvicultural practices could achieve these MAI. We assumed that fast-grown industrial plantations would be composed of forests with stand growth rates greater than 5 m^3/ha/yr and rotations of less than 30 years. We used this growth cutoff as a standard for "fast grown", since it is greater than the 1 to 4 m^3/ha/yr that is typical of most unmanaged natural stands throughout the world, in both the temperate regions and the tropics.

Based on our knowledge of individual countries and broad regions, unpublished consulting reports, European Forest Institute (EFI) reports, and U.S. Forest Inventory and Analysis (FIA) data, we classified the FAO plantation data as fast grown based on the rotation age and mean annual growth rate criteria. Based on our experience in various countries with the reliability of the data, we assumed that only one-third the reported FAO plantation data was fast-grown industrial wood in the tropical Asian countries, one-quarter in Africa, and 75% in Latin America plantations. For Europe, we used the specific plantation data reported by the European Forest Institute (Kuusela 1994), which included fast-grown plantations scattered throughout Spain, Portugal, Great Britain, Sweden, France, and other countries. In North America we relied on the USDA Forest Service Forest Inventory and Analysis data. Based on these analyses, the fast-grown industrial plantation area would comprise 72 million ha, or 1.8% of the world's forests. Brown (1998) estimated that fast-grown forests provide about 27% of the world's industrial fibre supply.

Our definition of fast-grown industrial forest plantations was close to the industrial purpose definition of Carle *et al.* (2002), but included less area as plantation in Asia (China and India), and more in Europe and North America. We estimated 36 million ha of fast-grown plantations in Asia, *vs* the 58 million ha of industrial purpose of Carle *et al.* (2002). In contrast, we estimated 5.4 million ha in Europe, *vs* only 0.6 million ha of Carle *et al.* These differences can be attributed to our fast growth and short rotation criteria for Asia, and the differing view of European Forest Institute reports (Kuusela 1994) about greater productivity and short rotations in Europe.

Southern United States

For forestry analyses, the southern United States traditionally includes the states from Virginia to Texas. For this analysis, we included Virginia, North Carolina, South Carolina, Georgia, and Florida on the southeastern coast. Mid-central

southern states included Tennessee, Alabama, Mississippi, Arkansas, Louisiana, eastern Oklahoma, and Eastern Texas (Fig. 1). As summarised in Table 2, planted forests comprised about 23 million ha in the United States, with 15.35 million ha in the South (Smith *et al*. 2004; Prestemon & Abt 2003). These plantations all exceed our criteria, and so one-fifth of the world's fast-grown forests are in the U.S. South—in fact more than any other region in the world. Based on U.S. Department of Agriculture Forest Service Forest Inventory and Analysis runs that we made (Table 3), one-third of the softwood timber harvests in the South now come from pine plantations. These consist mostly of loblolly pine (*Pinus taeda* L.) and slash pine (*P. elliottii* Engelm.), with small plantation areas of longleaf pine (*P. palustris* Mill.) and eastern white pine (*P. strobus* L.), and trivial amounts of Virginia pine (*P. virginiana* Mill.), shortleaf pine (*P. echinata* Mill.), or other species. The South also contributes about 15–20% of the world's industrial wood fibre supply—again the largest share of any region in the world (FAO 2003).

We updated the published Forest Inventory & Analysis data for the South with details on timberland area and removals as of 2002 (Table 3). This provides detailed information on areas and removals by forest management type and species group.

FIG. 1–States in the U.S. South

TABLE 2–Forest and plantation areas in the United States by region, 2002 (million ha)

Region	Total	Natural	Planted
Total U.S.A.	306	283	23
Total East	157	139	17
South	88	72	15
North	69	67	2
Total West	149	143	6

Source: Smith *et al*. (2004)

TABLE 3–Southern United States timberland area and timber removals by forest owner class, forest management type, and broad species group, 2005

	Owner			
	Industry/ corporate	Other private	Public	Total
Area (ha)				
Planted pine	9 193 243	5 525 402	561 083	15 279 728
Natural pine	3 263 170	7 059 296	1 372 357	11 694 728
Mixed pine-hardwood	2 140 142	6 648 290	810 871	9 599 303
Upland hardwood	4 244 370	18 531 287	1 630 207	24 405 864
Bottomland hardwood	4 017 493	6 845 791	946 131	11 809 415
Total	22 858 418	44 610 066	5 320 649	71 789 133
Pine removals (000 m^3)				
Planted pine	39 115	14 509	774	54 398
Natural pine	28 658	46 302	4 114	79 074
Mixed pine-hardwood	6 945	15 549	832	23 325
Upland hardwood	1 901	5 651	359	7 911
Bottomland hardwood	838	1 203	17	2 058
Total	77 456	83 214	6 095	166 766
Hardwood removals (000 m^3)				
Planted pine	1 294	814	25	2 133
Natural pine	2 886	5 218	385	8 489
Mixed pine-hardwood	3 897	9 547	408	13 853
Upland hardwood	7 577	31 865	1 405	40 847
Bottomland hardwood	9 367	14 641	795	24 803
Total	25 021	62 086	3 018	90 125
Total removals (000 m^3)				
Planted pine	40 409	15 324	798	56 531
Natural pine	31 545	51 250	4 498	87 563
Mixed pine-hardwood	10 842	25 096	1 240	37 178
Upland hardwood	9 478	37 516	1 764	48 758
Bottomland hardwood	10 204	15 844	812	26 861
Total	102 478	145 299	9 113	256 890

Source: USDA Forest Service Forest Inventory and Analysis database

The five forest management types are planted pine, natural pine, mixed pine-hardwood, upland hardwood, and bottomland hardwood. The two principal species groups are softwoods and hardwoods. Note that some softwood volume and removals do occur from the hardwood forest management types, and vice versa, since these are not pure stand classifications.

Of the 15.3 million ha of planted pine in the South, 60% are owned by forest industry or other corporate owners (forest products and other companies); 36% by nonindustrial private forest (NIPF) owners (individuals, farmers, professionals, etc.); and 4% by public owners (state, federal, local). Planted pine comprises 21%

of the timberland area in the South, natural pine 16%, mixed pine-hardwood 13%, upland hardwood 33%, and lowland hardwood 16%.

The Forest Inventory & Analysis regions are divided into forest survey units for each state. We computed the share of pine plantations by forest survey unit as well (Fig. 2). Southeast Georgia and North Florida have the largest share and area of planted pine in the South, with more than 40% of the total forest land, or 1 million ha each. Other major Coastal Plain forest survey units have 31–40% of their areas in pine plantations, including Northwest Florida, West Central Alabama, Western Louisiana, and East Texas. Moderate levels of plantations are scattered throughout the rest of the Coastal Plain survey units. Plantations comprise an increasingly smaller share of the forests as one progresses from the Coastal Plain units to the Piedmont, and much less in the Mountains and Mississippi Delta survey units in the South.

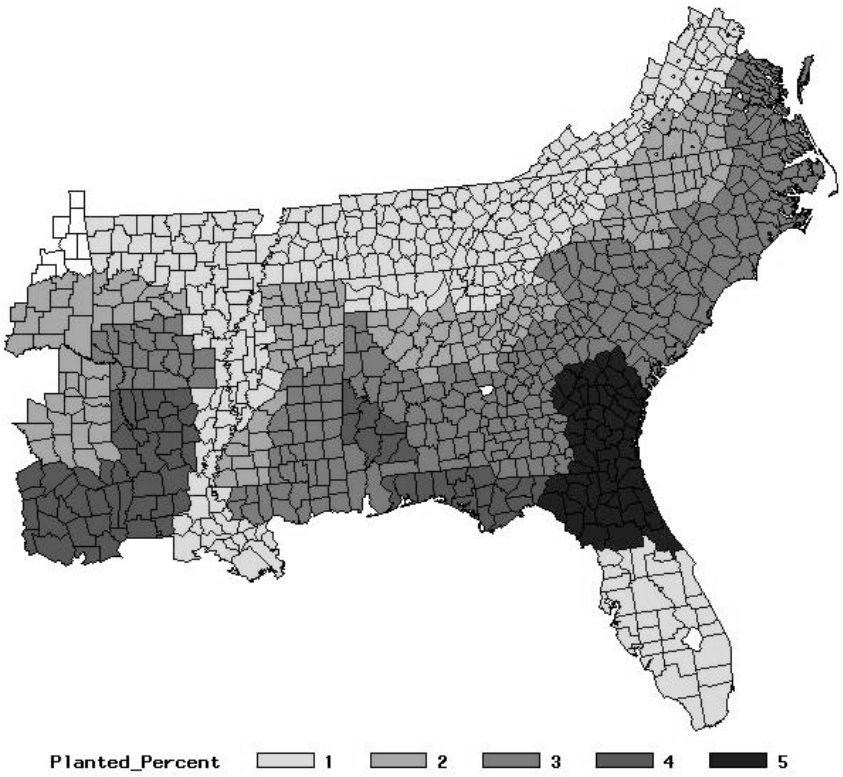

FIG. 2–Percentage of plantation pine in the U.S. South, by FIA Forest Survey Units

Key: 1: ≤10%
2: >10–20%
3: >20–30%
4: >30–40%
5: >40%

As of 2005, forest industry owns 31% of the timberland area, other private owners 61%, and public owners 7%. Pine timber removals in the South consist of 33% from pine plantations, 47% from natural pines, 14% from mixed pine hardwoods, 5% from upland hardwoods, and 1% from lowland hardwoods. Forest industry and other corporate owners harvest 46% of the pine timber harvests, nonindustrial private forests 50%, and public lands 4%.

Hardwood timber removals occur predominantly on nonindustrial private forest lands (69%), and smaller shares on industry (28%) and public lands (3%). Even planted pine contributes a small amount to total hardwood timber removals, at 2.3%. This indicates that southern U.S. pine plantations are not uniform monocultures, since they have a minor merchantable hardwood component. There surely is an even larger non-merchantable hardwood component.

Total timber removals by forest owner class are 40% for industry, 57% for nonindustrial private forests, and 4% for public lands. By forest management type, total harvests are 22% for planted pine, 34% for natural pine, 15% for mixed pine hardwood, 19% for upland hardwood, and 10% for bottomland hardwood.

Average growth rates by forest management type also indicate the importance of planted pine. Based on current forestry practices, Siry *et al.* (2001) found that growth rates for fast-grown pine plantation in the South ranged from 7.6 to 12.9 m^3/ha/yr, including bark, depending on management intensity class. Based on the Forest Inventory & Analysis, mean annual growth rates for natural pine throughout the South were 5.1 m^3/ha, mixed-pine hardwood 3.6 m^3/ha, and for upland and bottomland hardwood 2.9 m^3/ha (Siry 2004).

These data indicate the importance of forest plantations, but also indicate that natural pine harvests are still the largest total volume in the U.S. South. Pines comprise 65% of the total timber harvests in the South. Planted pine is projected to increase its share of the southern timber harvest, up to about 50% by 2040 (Prestemon & Abt 2003). Pine plantations will become increasingly important as young plantations mature, and as natural pine stands decrease significantly in area in the South in the future.

FOREST CERTIFICATION

Forest certification aims to measure, monitor, audit, and improve forest practices at the forest level (Ramesteiner & Simula 2002)**.** Data on the area certified by the major forest certification organisations in the world and in the U.S. were collected from their programme web sites in January 2006. At the close of 2005, about 272 million ha of forests were certified worldwide (Table 4). This area amounts to about 7% of global forest area, but the influence of these systems on setting standards for forest management is much greater than the modest area might suggest. In the

TABLE 4–Forest certification systems in the world and the United States, December 2005

System	World (million ha)	U.S.A. (million ha)	South (est.) (million ha)
Sustainable Forestry Initiative (SFI) (2004 data)	50.2	18.5	9.3
Forest Stewardship Council (FSC)	68.1	5.6	0.6
American Tree Farm System (ATFS)	12.1	12.1	6.9
Green Tag	0.03	0.03	0.004
Canadian Standards Association (CSA)	47.4	0	0
Programme for Endorsement of Forest Certification (PEFC)	186.8*	0	0
Malaysian Timber Certification Council	4.7	0	0
Certificación Forestal (Chile)	1.6	0	0
Certificaçao Florestal (Brazil)	0.4	0	0
Total	272.1	36.2	16.6

* Includes 69.2 million ha of CSA in Canada, 54.4 million ha of SFI in U.S.A. and Canada, 1.6 million ha of CertFor in Chile, 5.2 million ha in Australia, 56.5 million ha in Europe

Sources: www.aboutsfb.org; www.fsc.org; www.pefc.org; www.mtcc.com.my; www.greentag.org; E.Chan, ATFS (pers. comm.); J.Metnick, SFI (pers. comm.); authors' research.

United States, the major forest certification systems were the Sustainable Forestry Initiative (SFI, 18.5 million ha), American Tree Farm System (ATFS, 12.1 million ha), Forest Stewardship Council (FSC, 5.6 million ha), and Green Tag System (27 055 ha), for a total area of 36.2 million ha.

The programmes do not report areas by region of the country per se, but estimates can be made for the Forest Stewardship Council based on the reports that summarise individual forest certifications granted. We obtained data on Sustainable Forestry Initiative and American Tree Farm System areas in the South from programme representatives. Green Tag reports areas by state, but the total is small. Based on the programme data and our division of area into regions, there are 16 million ha of certified forests in the South. Thus the U.S. South contains about 29% of the nation's forests and 46% of its certified forests. Forest industry owns about 9 million ha of pine plantations as of 2005, and almost all of these would be certified. However, perhaps up to one-third of this land is currently for sale, mostly to large Timber Investment Management Organisations (TIMOs), which will reduce the amount of industrial forest land and probably certified forest land in the South.

Forest certification has many components that explicitly or implicitly address forest plantations. In the United States, the Sustainable Forestry Initiative, which was created by the forest industry, is the dominant certification system. The Forest Stewardship Council, which was initiated by environmental non-government

organisations, is less prevalent in the U.S., but remains a benchmark for "green" certification. Relevant components for each programme are paraphrased below, and an introduction is given to their terminologies of principles, criteria, and objectives.

Sustainable Forestry Initiative

The Sustainable Forestry Initiative has a hierarchy of 5 Principles, 13 Objectives, 34 Performance Measures within those Objectives, and 103 required Indicators. Sustainable Forestry Initiative Objectives 1 through 7 provide means of evaluating the compliance of Programme Participants with the SFI standards on forest lands they own or control through long-term leases. Objective 8 deals with wood procurement systems. Objectives 9 through 11 deal with research, training, legal compliance, public and landowner involvement, management review, and continual improvement (Table 5).

Programme participants must follow all standards and sub-standards relevant to their land-owning or wood-using status. They must have a written policy for the

TABLE 5–Paraphrased Sustainable Forestry Initiative Objectives, 2005–2009

Number	Objective
1	Broaden the implementation of sustainable forestry by ensuring the long-term harvest levels based on the use of the best scientific information available
2	Ensure long-term forest productivity and conservation of forest resources through prompt reforestation, soil conservation, afforestation
3	Protect water quality in streams, lakes, and other water bodies
4	Manage quality and distribution of wildlife habitats and contribute to the conservation of biological diversity
5	Manage visual impact of harvesting and other forest operations
6	Manage Programme Participant lands that are ecologically, geologically, historically, or culturally important in a manner that recognises their special qualities
7	Promote the efficient use of forest resources
8	Broaden the practice of sustainable forestry through procurement systems
9	Improve forestry research, science, and technology
10	Improve the practice of sustainable forest management by resource professionals, logging professionals, and contractors through training
11	Comply with federal, provincial, state, or other local laws and regulations
12	Broaden the practice of sustainable forestry by the public and the forestry community, and publicly report progress
13	Promote continual improvement in the practice of sustainable forestry and monitor, measure, and report performance

Source: Sustainable Forestry Initiative (2004)

principles on sustainable forestry, responsible practices, reforestation and productive capacity, forest health and productivity, long-term forest and soil productivity, protection of water resources, protection of special sites and biological diversity, legal compliance, and continual improvement. They must demonstrate their compliance with these objectives and indicators through third person certification audits of their written documentation and field practices (Sustainable Forestry Initiative 2004).

Selected 2005–2009 SFI Objectives and Indicators relevant to forest plantations include the following (Sustainable Forestry Initiative 2004). Objective 2 explicitly covers reforestation and afforestation, stating "Performance Measure 2.1. *Program Participants* shall reforest after final harvest, unless delayed for site-specific environmental or forest health considerations, through *artificial regeneration* within two years or two planting seasons, or by planned *natural regeneration* methods within five years". Five specific indicators cover the (1) designation of management units, (2) criteria to judge adequate stocking and respond to problems, (3) minimised planting of exotic species, and doing so based only on research documentation, (4) protection of advanced natural regeneration during harvest, and (5) artificial regeneration programmes that consider the potential ecological impacts of a different species or mix from that which was harvested. Performance measure 2.5, indicator 1, requires a "*Program* for appropriate research, testing, evaluation, and deployment of *improved planting stock*, including trees derived through *biotechnology*".

In addition to forest plantation standards, implicitly related Sustainable Forestry Initiative Objectives address water quality and environmental protection (Objective 3), biological diversity (4), unique sites (6), wood procurement systems (8), forestry research (9), and public input (12). Relevant standards related to reforestation include Performance measure 8.4, indicator 1.a, which requires a verifiable monitoring system to evaluate the results of promoting reforestation across the wood and fibre supply area; Performance Measure 9.2, Indicator 1, which requires participation in the development or use of regeneration assessments and growth-and-drain assessments; and Performance Measure 11.1, Indicator 4, which requires adherence to all applicable regulations and international protocols for research and deployment of trees derived from improved planting stock and biotechnology.

Forest Stewardship Council

The Forest Stewardship Council has 10 Principles and 56 Criteria, and 138 national indicators in the United States guidelines (Forest Stewardship Council 2001). They focus more on social issues in the first few components, and then address ecological issues (Table 6).

TABLE 6–Forest Stewardship Council principles

Number	Objective
1	Compliance with laws, international agreements, and FSC principles
2	Tenure and use rights and responsibilities
3	Indigenous people's rights
4	Community relations and workers' rights
5	Multiple benefits from the forest
6	Environmental impact and biodiversity conservation
7	Management plans
8	Monitoring and assessment
9	Maintenance of high conservation value forests
10	Plantations

Source: Forest Stewardship Council (2001)

The Southeastern U.S. Forest Stewardship Council standards were developed by a group of non-government organisations, government officials, academics, and consulting foresters, but forest industry purposely declined to attend any formative meetings, probably due to the perceived environmental bias of the system. Subsequent explicit FSC standards for the Southeastern United States for forest plantations are described below (Forest Stewardship Council 2004). Standard 5.6 states that the rate of harvest of forest products shall not exceed levels that can be permanently sustained. Standard 6.3.a. covers forest regeneration and succession. Subcomponent 6.3.a.2 requires certified owners to maintain or restore forests to natural conditions to the extent possible. Other components of Section 6.3.a address means to retain and manage natural forests.

The Forest Stewardship Council-U.S. Southeastern certification standard defines a commercial plantation as "A stand established through artificial regeneration for the commercial production of forest products, usually at the shortest practical rotation, with a single species, and at a regular spacing in rows. Although commercial plantations may assume characteristics of a semi-natural forest, these plantations should continue to fall under the guidelines set for Principle 10". Restoration plantations are defined as those planted for the primary purpose of returning a site to natural forest conditions.

Key Forest Stewardship Council standards related to commercial forest plantations include Section 6.3.b. genetic, species, and ecosystem diversity. This includes 6.3.b.1, forest management to maintain site productivity as well as genetic, species, and community diversity of the stand. Standard 6.8 requires that use of biological control agents shall be documented, minimised, monitored, and strictly controlled. Furthermore, it states "Use of genetically modified organisms shall be prohibited". This includes the statement: "Applicability Note: Genetically improved mechanisms

(e.g., …Mendelian crossed) are not considered to be GMOs and may be used. The prohibition of GMOs applies to all organisms including trees".

The FSC Southeastern U.S. standards explicitly limit plantations, especially of exotic species. They state: 6.9 The use of exotic species shall be carefully controlled and actively monitored to avoid adverse ecological impacts; 6.9.a. that exotic species are not planted or otherwise introduced, and that 6.9.b, planted exotic species are monitored to ensure they do not spread beyond their originally planted site, and controlled if they do spread. To date, exotics are a minor issue in the U.S., since none is widely planted on a commercial scale. Old experimental plantings of Chinese tallow tree have escaped and are a nuisance in much of the Southeast, and have required elimination in Forest Stewardship Council certification audits. Some paulownia plantings have been established, but none are certified yet.

More importantly for the southern U.S., the Forest Stewardship Council standards mandate that: 6.10 Forest conversion to plantations or non-forest uses shall not occur, except for (a) when it occurs as a limited portion of forest management unit, (b) does not occur in high conservation value forests, and (c) provides clear, substantial, additional, secure, long-term conservation benefits across the forest management unit. Standard 6.11 requires the elimination of invasive exotic species from the property if biologically possible and economically feasible.

The Southeastern U.S. standards state that owners must manage their forest plantations per Principles and Criteria 1 through 9; that plantations must complement management of, and reduce pressures on, and promote restoration and conservation of natural forests; that plantation management objectives be clearly stated; that wildlife corridors, streamside zones, different ages and rotations must be employed; and that diversity in the composition of plantations is preferred. Exotic species shall be used only when their performance is greater than that of native species, and a portion of the overall forest management area shall be managed to restore the site to a natural forest cover. Managers must protect soil resources, minimise pests, diseases, fire, and pesticides, and assess on- and off-site ecological and social impacts and local access and use. Plantations converted from natural forests after November 1994 normally shall not qualify for certification, unless the manager/ owner is not responsible directly or indirectly for conversion.

However, typical southern forests regenerated from old farm fields are not considered "natural", so this may not be daunting as it appears. In addition, plantations converted between 1994 and 2001 may be considered for certification if a restoration plan covering all such stands is being implemented. Thus in practice, plantations may still be planted in most areas of the Southeast where farming occurred. But the plantation limits may still prevent certification of forests where they are converting truly natural or virgin timber. Such areas might include deep

pocosins, alluvial wetlands, or very rare mountain ecosystems. This concern would need to be addressed in gap assessments before full certification audits were conducted, in order to prevent problems.

American Tree Farm System and Green Tag

The Sustainable Forestry Initiative and Forest Stewardship Council are the two principal forest certification systems with detailed, rigorous standards in the United States. The American Tree Farm System was initiated in 1941, and required periodic inspection of the forests of participating "Tree Farms." However, the rigour of the rules was modest and the inspections were sporadic. In order to become credible for forest certification, new standards and auditing procedures were developed in 2002, and implemented in 2004 (American Tree Farm System 2005). Audit inspections are now required every 5 years, and are conducted by co-operating foresters with the forest industry, private consultants, or state foresters. The programme has the same structure as the Sustainable Forestry Initiative, as one might expect since it also relied on the forest industry for development and programme support, but it had fewer standards to follow. The American Tree Farm System has 9 broad Standards, 14 Performance Measures, and 22 specific Indicators.

Standard 4 of the American Tree Farm System is Reforestation, which requires that forest owners provide timely restocking of desirable species of trees, compatible with regional ecosystems. Performance measure 4.1 requires land to be reforested with natural seedling, sprouting, direct seeding, or reforestation with tree seedlings. Indicator 4.1.1 states that harvested forest land must achieve satisfactory stocking within 5 years after harvest, or within the time required by applicable regulation.

Green Tag Forestry (2005) has 10 criteria and 46 indicators for forest certification. It is administered by the National Woodlands Association, and forestry consultants serve as the inspectors for the programme. Criterion 3 is Logging, Post-Harvest Evaluation, and Reforestation. The fourth indicator of this Criterion requires that the site is regenerated within 2 years or less of harvest.

PLANTATIONS, THE ENVIRONMENT, AND CURRENT ISSUES

A number of articles have examined the role of forest plantations in forest conservation and protecting biodiversity. In general, the premise of these articles is that fast-growing plantations can help produce industrial wood fibre at growth rates that greatly exceed rates of natural forests, and thus lessen pressure to harvest those forests. Evolving theory and practice also suggest that plantations can provide incentives to protect natural forests as part of the intensively managed landscapes, such as recommended by the Forest Stewardship Council standards. However, the merits of this premise are controversial.

Environmental Aspects

Forest plantations have been promoted for many environmental benefits. This is of course the case with forest restoration, desertification prevention, fuelwood, and watershed protection plantation projects. But many authors, including Binkley (1997), Sedjo & Botkin (1997), and Sedjo (1999, 2001) contend that fast-grown industrial plantations will indeed decrease pressure on the harvest of natural forests, noting that the high growth rates can supply an increasing proportion of the world's wood fibre needs, especially the increase in demand in the future.

In addition, plantations have been suggested as a promising way to store carbon and reduce global warming (DiNocola *et al*. 1997, cited by Tomberlin & Buongiorno 2001; Carle *et al*. 2002), although there is much scientific and popular debate about the effects (Cossalter & Pye-Smith 2003). However, Carrere & Lohman (1996), the World Rainforest Movement (2005), the Dogwood Alliance (2005b), and many other critics contend that plantations have negative impacts on indigenous people, biodiversity, and hydrological processes, especially water quantity.

Cossalter & Pye-Smith (2003) summarised much of the world literature about fast-wood forestry and environmental, social, and economic issues. They concluded that forest plantations generally have not replaced biodiversity-rich natural habitats, but warned against converting tropical forests into plantations. However, while plantations may be more diverse than agricultural fields, they are still relatively limited ecosystems unless significant corridors and natural areas are part of the forest estate. Plantations are not likely to have major impacts on water quantity in wet climates, but could reduce water yields and stream flows during dry seasons. Plantations are similar to agricultural crops in effects on soils. Intensive management causes more erosion, but much less than crops; soil nutrients are depleted somewhat, requiring small amounts of fertiliser, but again much less than with agricultural crops. And while pest infestations are often cited as potential disasters, integrated pest management and use of chemicals have prevented most problems to date (Cossalter & Pye-Smith 2003), although this has required substantial efforts using biological control, traps, and pesticides to control leaf-cutting ants in particular.

All the forest certification standards themselves obviously have environmental protection as a major focus—perhaps **the** major focus. There is a plethora of standards designed to protect the environment and biodiversity during forest operations, require the use of best forest science, and monitor impacts of forest practices. The empirical evidence of the effects of these systems is scant, since forest certification is new and estimating regional impacts is difficult.

Two recent surveys of certified forest lands in the United States found that environmental practices were better under forest certification schemes. The Texas Forest Service (Simpson *et al*. 2005) found that implementation of best management

practices was statistically higher when the timber was delivered to a Sustainable Forestry Initiative mill. A Manomet Center for Conservation Sciences (Hagan *et al.* 2005) study found that landowners who were certified sustainable under either the Sustainable Forestry Initiative or the Forest Stewardship Council had significantly stronger biodiversity practices than landowners not certified. Furthermore, they concluded that there was no difference between the Forest Stewardship Council and the Sustainable Forestry Initiative in terms of the overall biodiversity practice scores.

Economic Aspects

Sedjo (2001) calculated average investment returns for selected industrial plantation species in the world with different management regimes and intensities. He found that internal rates of return (IRR) in the Southern Hemisphere were significantly greater than those in the Northern Hemisphere (Table 7). Surprisingly, at that time, pulpwood and sawtimber rates of return were generally comparable, and in several cases pulpwood IRR were greater. Work in progress (Cubbage *et al.* in press) has calculated investment returns to exotic forest plantations in South America and the Southern United States. These financial calculations illustrate the financial benefits of industrial forest plantations. In fact, Cubbage *et al.* (in press) found that internal rates of return from fast-grown plantations in the Americas, ranging from about 10% to 22%, were much greater than those for native plantations or from natural stands.

TABLE 7–Average industrial forest plantation timber investment annual internal rates of return (IRR) from Sedjo (2001) and Cubbage *et al.* (in press)

Country / Species	Sedjo (2001) pulpwood IRR (%)	Sedjo (2001) sawtimber IRR (%)	Cubbage *et al.* (in press) IRR (%)
U.S. South – *Pinus taeda*	12.0–13.9	12.4–14.1	9.5
U.S. Pacific Norhwest – *Pseudotsuga menziesii*	7.1–8.8	7.1–9.6	na
Brazil Central – *Eucalyptus* sp.	20.2	15.5	22.9
Brazil South – *P. taeda*	15.6	17.5	16.0
Chile – *P. radiata*	23.4	16.0–17.5	16.9
Argentina – *P. taeda*	na	na	10.5–12.9
Uruguay – *P. taeda*	na	na	15.1
Uruguay – *E. globulus*	na	na	12.8
Uruguay – *E. grandis*			21.9
New Zealand – *P. radiata*	11.9	11.1–13.1	na
South Africa – *P. patula*	19.3	16.2–17.7	na
Europe – *Picea abies*	4.6	5.6	na

Tomberlin & Buongiorno (2001) compared harvest projections from a timber supply model with estimates of timber production in plantations. They found that in most countries, plantation production is unlikely to increase enough to reduce harvest pressure on natural forests. Similarly, Cossalter & Pye-Smith (2003) found that plantations might contribute to industrial forestry production and profits, but they were unlikely to be able to provide all the wood supply needed in developing countries, usually provided few local community benefits, and often were not useful for forest conservation. The reverse may be true in developed countries such as Australia and New Zealand.

Cossalter & Pye-Smith (2003) concurred that growing fast wood can be a very efficient way of producing timber and pulpwood, and profitable as well. However, they concluded that the social costs of plantations, especially in terms of subsidies, were much greater than realised. Plantations may create new jobs, leading to roads, schools, and other benefits. They noted that, in developing countries, plantations are just as likely to spark conflicts with local people, especially where they have deprived them of the land on which their livelihoods are based.

A host of other social and economic issues involve forest plantations in more developed countries. They may displace small-scale agrarian commercial activities, and even lead to less population than farming. They often face other social issues regarding opposition to intensive forestry in scenic areas, especially clear-cutting and replacing natural hardwood stands with pine plantations.

Again, forest certification addresses these economic and social issues of natural forest and plantations directly, as detailed above. The Forest Stewardship Council has three chambers—environmental, economic, and social—to ensure sustainable forest management in all three dimensions. It has extensive, rigorous indicators designed to protect the environment, and to limit potential damage from plantation monocultures or from plantation operational management. The Sustainable Forestry Initiative focuses on productivity and utilisation as well, to ensure that forests are sustainable through appropriate intensive management and prevention of waste. Long-term sustained yield mandates also address these economic components. And all systems require that certified forest owners obey all social as well as environmental laws. The current Forest Stewardship Council forest plantation review is trying to explicitly integrate plantations with social and environmental concerns. These components provide a demonstrable means that forest certification can achieve sustainable forest management (Ramesteiner & Simula 2002).

Southern United States Debates

These debates over the merits of forest plantations are reflected in the forest certification standards, as noted above, and their ongoing interpretation and

implementation, in the world and in the Southeast U.S. The Sustainable Forestry Initiative explicitly approves the use of plantations and even has a standard covering genetically improved material, but expects plantations and other forest practices to be based on sound research. Furthermore, the Sustainable Forestry Initiative restricts the use of exotic tree species to careful, scientifically supported situations. This has been moot to date, since no exotics are planted commercially on a large scale in the United States.

The Southeastern U.S. Forest Stewardship Council standards for plantations clearly contain many regulations and proscriptions regarding their use and their limits, as they do world-wide. These range from using only genetically improved materials from conventional tree breeding programmes, not genetically modified organisms (GMOs), to blending plantations with part of the natural landscape. Exotic forest plantations are permitted if they are more productive than natural species, but are not encouraged. Nevertheless, the Forest Stewardship Council has approved the greatest number of exotic forest plantations in the world, particularly in the Southern Hemisphere. Furthermore, companies in Latin America are actively seeking Forest Stewardship Council certification to ensure access to international markets in Europe, Japan, Canada, and the U.S. Forest Stewardship Council certification also helps locally, by confirming that the companies are providing social benefits to local communities and to employees of the firm, as well as protecting the environmental benefits of water, native flora and fauna, and natural forests.

The debate over plantation certification in the Forest Stewardship Council continues. The Forest Stewardship Council review of their forest plantation standard is a response to criticism from environmental non-governmental organisations, and fears by certified organisations that plantations will not be certified or that the standards will become unreasonable (Forest Certification Watch 2005). The Forest Stewardship Council definition of plantations (Forest Stewardship Council 2003) is telling in this regard: "forest areas lacking most of the principal characteristics and key elements of native ecosystems, which result from the human activities of planting, sowing or intensive silvicultural treatments". Thus the Forest Stewardship Council recognises that plantations are simple forests, but believes that they have an important role to play in the conservation of biodiversity, water, and soils at the local level, and that they can contribute to social and economic benefits for local communities. Of course, plantation forests must conform to all the rigorous Forest Stewardship Council standards, not just Principle 10.

Controversy over forest certification systems has erupted in the Southeast U.S. in particular. In March 2005, the Dogwood Alliance and other environmental non-governmental organisations started a campaign against the Sustainable Forestry Initiative, calling it the "Same-old Forest Industry" programme. This included

national media releases, purchasing of ads, and a major joint protest letter against the Sustainable Forestry Initiative that was signed by 90 scientists throughout the South and posted on the Dogwood web site, along with an extensive amount of material challenging the merits and credibility of the Sustainable Forestry Initiative (Dogwood Alliance 2005a, b). The letter contended that the Sustainable Forestry Initiative does not discourage buying of wood from biologically sensitive areas; that it allows conversion of natural to planted forests; that it allows harmful logging practices; and enumerates other alleged failures of the Sustainable Forestry Initiative. Instead of supporting the forest industry-based Sustainable Forestry Initiative, they advocated the use of the Forest Stewardship Council. The Sustainable Forestry Initiative responded with a letter on their web site, supporting the independence and accomplishments of the Sustainable Forestry Initiative, pointing out flaws in the assumptions of the Dogwood Alliance letter, and noting the specific indicators in the Sustainable Forestry Initiative standard that rebut the specific Dogwood claims (Banzhaf 2005).

CONCLUSIONS

We have covered a large amount of ground here, including forest areas and plantations; forest certification systems, areas, and standards; and environmental issues with plantations and certification. What can one conclude about all these factors?

The United Nations Forestry & Agriculture Organisation estimates indicate that the world has about 3.9 billion ha of forests, which cover 26% of the earth's land area. We lose about 10 to 15 million ha of forest per year, which argues the need for increased efforts at sustainable forest management for producing and protecting diverse goods and services. Planted stands can help achieve much of this sustainable forestry, although they certainly engender criticism as well as praise. We have about 187 million ha of planted stands in total (5% of world forests), and 72 million ha of fast-grown industrial plantations (1.8% of world forests). Plantations provide about one-quarter of the world's industrial wood fibre, and this share is projected to increase substantially in the next two decades. In the U.S. South, plantations comprise about 20% of the total forest area, and this area represents 21% of the total fast-grown plantation area in the world.

Forest certification, which mandates and audits standards of forestry practice at the stand or ownership level, has potential for a large impact on forest management and conservation. The Sustainable Forestry Initiative specifically requires that programme participants demonstrate that they conduct or support forestry research in health and productivity, water quality, and wildlife and biodiversity. The Sustainable Forestry Initiative clearly encourages use of plantations, tree improvement, and forest management, and infers that forest biotechnology would

be acceptable. With appropriate safeguards, exotics are legitimate under the Sustainable Forestry Initiative, although there are no exotic timber species being planted in the U.S. yet on an operational basis.

Forest certification by the Forest Stewardship Council requires that managers favour natural stands and biodiversity. The Forest Stewardship Council allows plantations and tree improvement with fairly extensive strictures to protect natural stands and ecosystems. It explicitly proscribes the use of genetically modified organisms. The Forest Stewardship Council has been very flexible in decisions, allowing a large number of forests with exotic plantations to be certified if they have a large natural stand/reserve component as well. It does require refereed science to justify the use of exotic species and ensure that they do not cause environmental harm.

In the U.S. South, forest certification by the Sustainable Forestry Initiative, the Forest Stewardship Council, and the American Tree Farm System covers 16.6 million ha, or 23% of the private land base of 73 million ha. Much of the certified area, about 8 million ha, belongs to industrial landowners or large Timber Investment Management Organisations, under the Sustainable Forestry Initiative programme. These owners hold 23 million ha of forests, and 9 million ha of forest plantations, or 60% of all the plantations in the U.S. South.

The Programme for Endorsement of Forest Certification has endorsed most of the individual country standards in the world except for the Forest Stewardship Council. The Sustainable Forestry Initiative just received endorsement at the end of 2005, and the American Tree Farm System is performing a gap analysis to determine what will be required to meet these standards.

Continued competition will occur between the Programme for Endorsement of Forest Certification and its component country systems and the Forest Stewardship Council. The latter remains a benchmark for environmental and social standards, and has unique concerns in its standards and audits with respect to plantations, genetically modified organisms, indigenous people, chemical usage, and other components. The Forest Stewardship Council continues to expand, including to many large public land holdings in the United States, and a few large industrial forestry firms. U.S. Timber Investment Management Organisations will be very important in this evolving certification practice as well, as the U.S. forest industry divests itself of many of its industrial forests. This may decrease the area certified by the Sustainable Forestry Initiative somewhat, and some Timber Investment Management Organisations are certified by the Forest Stewardship Council.

The American Tree Farm System is continuing to enhance the rigour of its inspections of its members. Both it and the Forest Stewardship Council are developing group certification procedures for small landowners, state organisations

of landowners, or consulting foresters, which will make them a most attractive choice for small landowners, who own 62% of the South's timberland. These trends in the U.S. will maintain competition among the three large systems—the Sustainable Forestry Initiative, the Forest Stewardship Council, and the American Tree Farm System—and continue to ensure scrutiny of their standards, practices, audits, and enrolment.

Forest certification helps ensure that industrial forest plantations are managed in an economically, socially, and environmentally acceptable manner. It also provides an imprimatur for intensive management that is typical in forest plantations. However, there certainly are many individuals and groups that remain unconvinced that forest certification by the Sustainable Forestry Initiative and perhaps the Forest Stewardship Council has eliminated all problems of intensive forest management. These public certification debates will continue to place scrutiny on the firms receiving certification, the firms auditing the applications, and the retailers purchasing wood and paper products.

Overall, forest plantations can enhance sustainable forestry by improving the sustained yield of timber (economic benefits); providing adequate jobs, employment, and income for workers and local communities (social benefits); and protecting the environment in plantations and during harvests, as well as decreasing harvest pressure on natural forests (environmental benefits). Sound science, excellent forest practices, good public relations, and continuous improvement all will be required to ensure that plantations continue to receive public approval, and forest certification provides a clear means to demonstrate this commitment on the part of forest landowners.

Fast-grown industrial plantations will continue to increase in area and the share of wood they provide, based on economic returns and wood fibre needs. Forest certification systems will be fundamental in acceptance of forest plantations and intensive forest management. Their standards promote forest management with sound environmental protection standards; applications of science, including explicit consideration of exotics and genetically modified organisms; development of social benefits; and recognition of economic benefits.

Certification has set the agenda for debate on how we will manage or occasionally limit forest plantations. Forest certification should help avoid outright opposition to management and harvests of forests and plantations. Debates about forestry will always continue, but the focus on acceptable management practices under forest certification should be better than rigid debates about protection, regulation, and lawsuits. Forest certification requires managers to think about social, environmental, and economic factors, and prompts critics to discuss the best means of management, not just protection.

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