

4. Carbon Sequestration

Background

Carbon sequestration plays an important role in the global carbon cycle. Green plants absorb carbon dioxide from the air, separating the carbon atom from the oxygen atoms, returning oxygen to the atmosphere, and incorporating the carbon into biomass in the form of roots, stems, and foliage. The carbon is thus sequestered in the biomass of vegetation.

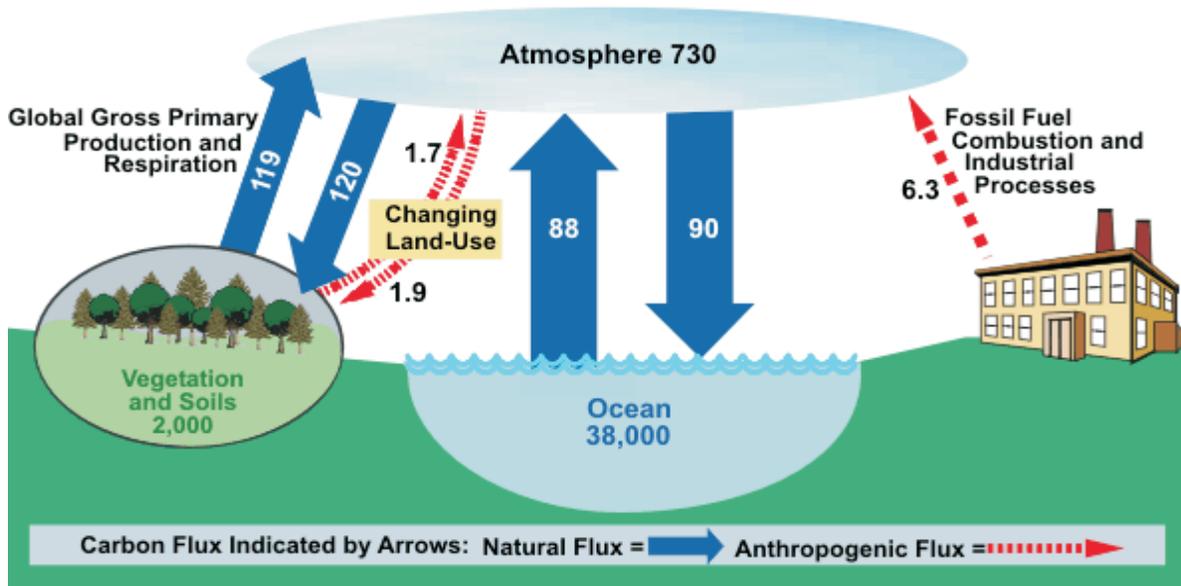
Globally, a very large amount of carbon dioxide—on the order of 120 billion metric tons of carbon—is absorbed annually during photosynthesis.²⁸ At the same time, vegetative respiration, combustion of wood as fuel, degradation of manufactured wood products, consumption of biomass for food by animals, and the natural decay of expired vegetation all release carbon to the atmosphere.

The net numerical difference, or flux, between carbon absorption during photosynthesis and release can be viewed as a measure of the relative contribution of terrestrial biomass to the carbon cycle.²⁹ For the period from 1989 to 1998, average annual net terrestrial uptake has been estimated at between 0.4 and 4.8 billion metric tons.³⁰ Figure 12 illustrates the global carbon cycle.

Forests can play an important role in offsetting human-produced carbon dioxide emissions. On average, trees are approximately 50 percent carbon by weight (oven-dry basis, excluding water).³¹ The amount of carbon a plant can sequester depends on a number of variables, including species, health of vegetation, and age, but can be quite large.

Carbon sequestration on a national scale is substantial. The EPA, relying heavily on the work of the U.S.

Figure 12. The Global Carbon Cycle



Source: Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001).

²⁸Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), p. 191.

²⁹The “carbon cycle” includes all carbon pools and exchanges of carbon from one pool to another by various chemical, physical, geological, and biological processes. The four carbon pools, which are regions of the Earth within which carbon behaves in a systematic manner, are the atmosphere, terrestrial biosphere (usually including biomass, soils and freshwater systems), oceans, and sediments (including fossil fuels).

³⁰Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), p. 208. The two values express the statistical uncertainty of the net terrestrial uptake as being 0.7 ± 0.6 (at 67-percent confidence intervals) billion metric tons carbon per year. The carbon is expressed as carbon dioxide.

³¹R.A. Birdsey, *Carbon Storage and Accumulation in United States Forest Ecosystems* (Washington, DC: USDA Forest Service, 1992), p. 12.

Department of Agriculture's U.S. Forest Service, estimates annual U.S. carbon sequestration (generally defined according to the guidelines of the Intergovernmental Panel on Climate Change) at 828 million MTCO₂e in 2003,³² which offsets approximately 12 percent of annual U.S. anthropogenic emissions of greenhouse gases.³³

Projects Reported

For the 2004 reporting year, 54 entities reported projects on Form EIA-1605 involving forestry or natural resources that sequestered carbon or reduced emissions (Table 14). The reporters included 50 electric, gas, or sanitary service companies, 2 forestry companies, 1 petroleum refining or related industry, and 1 company specializing in the manufacture of stone, clay, glass, and concrete products. A total of 478 carbon sequestration projects were reported for 2004, an increase of 7 percent from 2003.

Carbon sequestration projects were the most numerous type reported on the long form, representing 25 percent of the projects reported for 2004 and outnumbering both electricity generation (469) and methane reduction (443) projects. The reported carbon sequestration projects were dispersed over a wide geographic area, including

39 States and 9 foreign countries. A total of 419 domestic and 59 international forestry projects were reported. Among the foreign projects, 52 represent individual equity shares in 2 projects: a forest preservation project, the Rio Bravo Carbon Sequestration Pilot Project, in Belize (28 project reports); and a modified forest management project in Malaysia (24 project reports).

Carbon sequestration reported on Form EIA-1605 for 2004, at 7.2 million MTCO₂e, was slightly lower than that reported for 2003 (Table 14). Of the 478 sequestration projects reported for 2004, most (395 or 83 percent) involved some kind of tree planting, which included afforestation, reforestation, urban forestry, and woody biomass production or agroforestry (Table 15).³⁴ These projects accounted for 17 percent (1.2 million MTCO₂e) of the sequestration and related direct emission reductions reported for 2004. Although only 33 forest preservation projects were reported, they accounted for 82 percent (5.9 million MTCO₂e) of the sequestration reported for 2004 (Table 16). Of the total sequestration for 2004, 87 percent was reported on behalf of foreign projects, including some very large forest preservation initiatives.

Urban forestry projects, involving the planting of trees in urban and suburban areas, accounted for 7 percent (32 projects) of the sequestration projects reported for 2004.

Table 14. Number of Projects, Carbon Sequestered, and Net Reductions Reported on Form EIA-1605 for Sequestration Projects, Data Years 1994-2004

Data Year	Number of Reporters	Number of Projects	Sequestration (Metric Tons Carbon Dioxide Equivalent)	Net Emission Reductions (Metric Tons Carbon Dioxide Equivalent)	
				Direct	Indirect
1994	23	58	746,545	189	23,127
1995	44	175	1,190,754	378	48,730
1996	51	175	8,676,591	1,291	32,215
1997	56	279	9,849,807	6,160	—
1998	57	321	12,490,927	716	—
1999	53	401	9,623,599	3,406	—
2000	53	468	9,011,117	1,041	—
2001	51	369	7,956,823	1,114	—
2002	51	413	7,296,516	1,875	—
2003 ^(R)	53	448	7,731,329	1,932	—
2004	54	478	7,236,120	3,982	41

^(R) Revised data.

Note: Excludes projects reported on Form EIA-1605EZ.

Source: Energy Information Administration, Form EIA-1605.

³²U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2003*, EPA-430-R-05-003 (Washington, DC, April 2005), p. 230, web site <http://yosemite.epa.gov/OAR/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2005.html>.

³³U.S. anthropogenic greenhouse gases emissions were 6983.2 MMTCO₂e in 2003. Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2004*, DOE/EIA-0573(2004) (Washington, DC, December 2005), p. x, web site www.eia.doe.gov/oiaf/1605/ggrpt.

³⁴Afforestation is the planting of new forests on lands that have not been recently forested. Reforestation is the replanting of forests on lands that have recently been harvested or otherwise cleared of trees. Urban forestry is the planting of trees individually or in small groups in urban or suburban settings. Agroforestry is the cultivation of trees in plantations for fuel or fiber.

Urban forestry projects typically are much smaller than forestry projects undertaken in rural or wilderness areas. The average carbon dioxide sequestration reported per urban forestry project for 2004 was just 600 MTCO₂e. In contrast, tree planting projects in rural or wilderness areas accounted for 16 of the 34 projects that sequestered more than 10,000 MTCO₂e each in 2004

(Figure 13). For the 478 projects for which data were reported, average sequestration in 2004 was 15,100 MTCO₂e per project.

Project developers implemented almost all (441 or 92 percent) of the reported sequestration projects in part to fulfill commitments made under DOE's Climate

Table 15. Number of Sequestration Projects Reported on Form EIA-1605 by Project Type, Data Years 1994-2004

Data Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003 ^(R)	2004
Forest Preservation	2	22	29	38	43	38	42	37	38	39	33
Tree Planting											
Afforestation and Reforestation . . .	36	113	111	175	205	288	344	251	289	321	363
Urban Forestry	8	17	21	23	28	28	31	33	33	35	32
Woody Biomass Production and Other Agroforestry	8	14	2	3	3	3	3	3	3	2	2
Unspecified	—	2	1	—	1	—	—	—	—	—	—
Subtotal	44	131	133	199	235	318	376	285	323	356	395
Modified Forest Management	12	20	10	33	41	42	44	41	47	48	45
Conservation Tillage	1	1	1	2	2	2	2	2	1	1	1
Other Projects	3	4	5	10	4	5	5	5	5	5	5
Total	58	175	175	279	321	401	468	369	413	448	478

^(R) Revised data.

Notes: Excludes projects reported on Form EIA-1605EZ. Project totals do not equal sum of components, because some projects are counted in more than one category. In previous reports, "Unspecified" tree planting projects were included in the "Other Projects" category.

Source: Energy Information Administration, Form EIA-1605.

Table 16. Carbon Sequestration Reported on Form EIA-1605 by Project Type, Data Years 1994-2004 (Thousand Metric Tons Carbon Dioxide Equivalent)

Data Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003 ^(R)	2004
Forest Preservation	73.0	615.8	6,546.5	7,545.5	10,073.4	8,523.4	7,879.6	6,804.3	6,055.9	6,469.6	5,917.0
Tree Planting											
Afforestation and Reforestation	726.8	620.4	237.3	322.4	449.0	590.6	628.0	637.9	676.1	711.9	768.4
Urban Forestry	0.2	1.1	1.3	1.9	5.3	5.8	10.5	11.2	14.4	17.7	20.3
Woody Biomass Production and Other Agroforestry	356.6	213.9	1,964.6	1,962.3	1,962.3	503.2	392.5	425.7	428.0	425.4	425.4
Unspecified	—	7.0	*	—	0.1	—	—	—	—	—	—
Subtotal	727.0	627.7	2,188.1	2,263.6	2,393.6	1,077.3	1,006.4	1,056.4	1,097.6	1,136.1	1,194.9
Modified Forest Management	363.9	366.2	93.6	148.3	167.9	164.6	74.0	51.9	98.9	81.5	80.0
Conservation Tillage	4.3	4.3	3.3	8.5	8.5	8.5	11.9	4.4	4.4	4.4	4.4
Other Projects	2.8	3.1	4.1	44.9	58.9	59.1	59.1	59.8	59.7	59.8	59.8
Total	746.5	1,190.8	8,676.6	9,849.8	12,490.9	9,623.6	9,011.1	7,956.8	7,296.5	7,731.3	7,236.1

^(R) Revised data.

*Less than 50 metric tons.

Notes: Excludes projects reported on Form EIA-1605EZ. Project totals do not equal sum of components, because some projects are counted in more than one category. In last year's report, "Unspecified" tree planting projects were included in the "Other Projects" category.

Source: Energy Information Administration, Form EIA-1605.

Challenge program.³⁵ Of the 39 investors in the UtiliTree Carbon Company,³⁶ 24 submitted individual reports on the 10 projects that were operational in 2004. Similarly, 24 investors in the PowerTree Carbon Company, the successor to UtiliTree, submitted individual reports on 3 new projects.³⁷ In addition, 31 sequestration projects reported on Form EIA-1605 for 2004 were originally part of the U.S. Initiative on Joint Implementation (USIJI). Established under the Climate Change Action Plan (CCAP),³⁸ the USIJI was a pilot program that sought to encourage foreign-based emission reduction and carbon sequestration projects conducted by U.S. and non-U.S. partners. The USIJI program terminated its activity in 2000. The projects reported include individual partner shares in two USIJI-approved forestry projects: the Rio Bravo Carbon Sequestration Pilot Project (Belize) and the Noel Kempff Mercado Climate Change Action Project (Bolivia). The third USIJI project reported is a Russian afforestation project (RUSAFOR-SAP) reported by Sustainable Development Technology Corporation. The same project was previously reported by Oregon State University (State of Oregon).

Forest Preservation

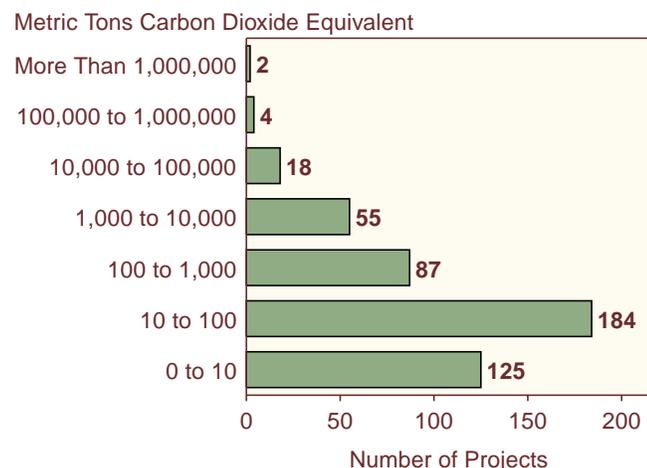
Forest preservation projects sequester carbon by avoiding the harvesting of timber or clearing of land and, thus, preventing the release of stored carbon. In 2004, 27 reporters submitted 33 forest preservation projects; however, the vast majority (28) of the projects were individual electricity generator shares—held directly or through the UtiliTree Carbon Company—in the Rio Bravo Carbon Sequestration Pilot Project in Belize. Also, 2 reporters provided information on their shares in the Noel Kempff Mercado Climate Action Project in Bolivia. No new forest preservation projects were reported for 2004.

AES Hawaii and AES Shady Point, subsidiaries of the AES Corporation, reported on the two largest forest preservation projects. AES Hawaii reported the Mbaracayu Conservation project in Paraguay, and AES Shady Point reported the OXFAM America Amazon project in Bolivia. Together, the two projects sequestered a reported 5.7 million MTCO₂e in 2004, representing 96 percent of the total sequestration reported for forest preservation projects (5.9 million MTCO₂e).

The intent of the Mbaracayu Conservation project is to offset carbon dioxide emissions from the AES Hawaii plant, a 180-megawatt circulating fluidized-bed coal-fired cogeneration plant on the island of Oahu. The project sequesters carbon by planting fruit trees and cash-producing indigenous trees in the 143,000-acre Mbaracayu forest tract, which, according to AES, would have otherwise been sold to a timber company.

AES Shady Point describes the OXFAM America Amazon Project as an innovative effort to protect the tropical forest in the Amazon regions of Peru, Ecuador, and Bolivia. The project, which AES conducts in cooperation with national indigenous groups, OXFAM America, and the World Resources Institute (WRI), is intended to offset carbon dioxide emissions from the AES Shady Point plant in Oklahoma. The project will support efforts by indigenous groups to gain control over their lands, develop sustainable resource extraction plans for the forest, and help avoid tropical deforestation. WRI

Figure 13. Carbon Sequestration Projects Reported on Form EIA-1605 by Amount of Carbon Sequestered, Data Year 2004



Source: Energy Information Administration, Form EIA-1605.

³⁵The Climate Challenge program, established in 1994, focused on commitments by electricity generators to reduce, avoid, or sequester greenhouse gases by the year 2000. Because its focus was on the year 2000, the Climate Challenge program is no longer active. Power PartnersSM, which has replaced the Climate Challenge Program, is the electric power industry's vehicle for participating in President Bush's Climate VISION initiative.

³⁶The UtiliTree Carbon Company, a consortium of 39 North American electric utility companies investing in forestry projects that sequester carbon, was established under the Climate Challenge Program. The Edison Electric Institute's (EEI's) Forest Carbon Management Program administers the Climate Challenge Program, and has identified and sponsored 10 ongoing domestic and international forestry projects.

³⁷PowerTree Carbon Company is a consortium of 25 North American electric utility and other energy companies investing in forestry projects that sequester carbon. Like UtiliTree, it is administered by the Edison Electric Institute (EEI) and coordinates electric power industry sponsorship of forestry projects through Power PartnersSM for Climate VISION. Fourteen reporters are members of both UtiliTree and PowerTree.

³⁸President William J. Clinton and Vice President Albert Gore, Jr., *The Climate Change Action Plan* (Washington, DC, October 1993), Appendix II, web site www.gcrio.org/USCCAP/toc.html.

estimates that over 10 years the project would prevent the deforestation of 1.2 million hectares and avoid emissions of at least 233 million MTCO₂e.

American Electric Power and BP America individually reported their shares in the Noel Kempff Mercado Climate Action Project in Bolivia, which the USIJI accepted in November 1996. The project, which involves the preservation of 634,286 hectares of land on the southern and western boundary of the Noel Kempff Mercado National Park by incorporating it into the park, includes the following components: (1) reduction of carbon dioxide emissions through the cessation of logging activities and protection of forest land from conversion to agricultural use; (2) protection, regeneration, and preservation; and (3) leakage prevention.³⁹ Sequestration reported for the project for 2004 totaled 180,000 MTCO₂e.

The Rio Bravo Carbon Sequestration Pilot Project, a forest preservation project in Belize, was begun in 1995. Wisconsin Electric, Detroit Edison, Cinergy, PacifiCorp, and UtiliTree Carbon Company (which provided financial support), The Nature Conservancy, and Programme for Belize (a Belizean nongovernmental organization) are undertaking the project as a partnership. A 14,400-acre parcel of forest threatened by agricultural conversion was secured, linking two forested Rio Bravo properties. The project implemented a sustainable forestry management program on the entire Rio Bravo Conservation and Management Area, with a goal of increasing carbon sequestration through improved forest and timber management.

The entire Rio Bravo Carbon Sequestration Pilot Project sequestered an estimated 20,000 MTCO₂e in 2004, of which 24 project participants reported 14,000 MTCO₂e to the Voluntary Reporting Program.⁴⁰ Project partners determined the reported carbon sequestration by defining a reference case that assumes a profile of conversion from forested land to agriculture that would have occurred from 1995 through 1999 in the absence of the land preservation project. According to the UtiliTree Carbon Company, the project has sequestered an estimated 4.4 million MTCO₂e to date, with most (91 percent) being sequestered during the 5-year preservation phase of the project. The smaller annual sequestration totals reported for years after 2000 represent the accumulation of carbon in the forest that has occurred since the preservation phase.

We Energies reported its independent sponsorship of an expansion to the Rio Bravo Conservation and Management Area, adding 20,630 acres to the preserve. We

Energies reported that its preservation initiative sequestered an estimated 30,000 MTCO₂e in 2004.

For 2004, Alliant Energy reported the only domestic forest preservation project, which sequestered 1,600 MTCO₂e. The project involves the management of more than 10,000 acres along the Wisconsin River Valley and ensures that buffer lands around its power plants in the Wisconsin River Valley will remain forested. Included in the land management plan are access restrictions that ensure the preservation of osprey and eagle habitats in the forest.

Tree Planting

Afforestation and Reforestation

Of the sequestration projects reported for 2004, 363 (76 percent) involved either afforestation or reforestation. The carbon sequestration and emission reductions reported for these projects totaled 0.8 million MTCO₂e, representing 11 percent of the total sequestration reported for 2004. All the afforestation and reforestation projects reported for 2004 were domestic.

American Electric Power, Inc. (AEP), a large investor-owned utility, accounted for the largest number of afforestation and reforestation projects, submitting 66 (18 percent) of the projects in this category for 2004. The AEP projects, all of which were afforestation projects, sequestered a reported 114,000 MTCO₂e in 2004. AEP reported 6 new domestic afforestation projects initiated in 2004 (including 3 PowerTree projects), which sequestered a reported 1,000 MTCO₂e during the year.

A total of 8 afforestation projects, including the Western Oregon Carbon Sequestration Project and 7 bottomland hardwood restoration initiatives in Louisiana, Arkansas, and Mississippi, were reported by 24 members of UtiliTree Carbon Company. The 7 restoration projects, which involve the conversion of marginal agricultural land to forest, are Mississippi River Valley Bottomland Hardwood Restoration, Upper Ouachita River Valley Bottomland Hardwood Restoration, Overflow Bottomland Hardwood Forest Restoration Project, St. Catherine-NFWF, Bayou Cocardie Bottomland Hardwood Forest Restoration, St. Catherine-ESI, and St. Francis River Carbon Offset Project.

Urban Forestry

A total of 19 reporters, 18 of which were electric utilities, reported 32 urban forestry projects for 2004. For the 32 projects, reported sequestration totaled 20,000 MTCO₂e (Table 16). Urban forestry projects are unique in that,

³⁹“Leakage” refers to the migration of logging and land-clearing activities that would have occurred in the preserve to areas outside the preserve, which would offset the sequestration achievements of the project.

⁴⁰Fifteen UtiliTree participants did not submit reports to the Voluntary Reporting Program for data year 2004, including one Canadian utility that is ineligible to report.

under some circumstances, they can reduce energy consumption as well as sequester carbon. Shade trees planted near buildings reduce summer air conditioning requirements; in addition, trees can act as windbreaks, reducing heating needs in the winter. Although the emission reductions associated with energy effects of urban forestry can be several times the sequestration benefits on a carbon dioxide equivalent basis, they are difficult to estimate. Chapter 3 discusses energy-related emission reductions attributed to the urban forestry projects submitted for 2004.

One new urban forestry project was reported for 2004. Exelon Corporation reported its average annual planting of 150 trees since 2002, including maple, dogwood, cherry, crabapple, and lilac. Exelon reported that this project sequestered 1.6 MTCO₂e in 2004.

Woody Biomass Production and Agroforestry

Woody biomass production is the cultivation of trees in intensively managed plantations to produce fuel or fiber. Agroforestry involves mixing trees with annual crops to provide wind shelter, stabilize soil, sequester carbon, and produce fuel wood and fruit crops.

One of the two agroforestry projects reported for 2004 was Minnesota Power's Short Rotation Woody Crop Establishment project. For this project, Minnesota Power established contracts to plant hybrid poplars with landowners enrolled in the Conservation Reserve Program. Following pre-planting site preparation, which began in 1994, Minnesota Power planted 2,800 acres in phases over 1995, 1996, and 1997. The project area was reduced to 2,550 acres in 2003 after consideration of adverse conditions, such as seasonal flooding of low spots, insect damage, and poor growth rates. The project sequestered a reported total of 15,400 MTCO₂e in 2004.

AES Thames reported the only other agroforestry initiative, which involved a fruit, pulp, and fuelwood tree plantation in Guatemala. For 2004, AES Thames reported that the project sequestered 410,000 MTCO₂e.

Modified Forest Management

Modified forest management involves modifying the management regimes of existing forests to increase their carbon capture rates. Of the 45 modified forest management projects reported for 2004, 24 were associated with member shares in a reduced-impact logging initiative in Malaysia, sponsored by the UtiliTree Carbon Company, which introduced reduced-impact logging practices to 2,422 acres of forest beginning in 1997. The participating utilities reported total sequestration of 7,000 MTCO₂e in 2004.

⁴¹Conservation tillage includes practices (such as reduced till or no till) that, compared to conventional tillage methods, increase carbon storage on cropland.

American Electric Power reported two new modified forest management projects for 2004. The utility implemented the projects in predominantly upland central hardwood stands ranging from 10 to 70 years in age. The stands were selectively harvested to remove over-mature, mature, cull, and diseased trees, as well as other stems as necessary to improve growing relationships and maximize growth rates. The two efforts have sequestered a reported 1,000 MTCO₂e to date.

Sequestration exceeding 10,000 MTCO₂e in 2004 was reported for the following three previously reported modified forest management projects:

- Southern California Edison Co. reported sequestration of 24,000 MTCO₂e by its Net Growth of Timber at Shaver Lake project.
- Alliant Energy's afforestation project also had a modified forest management component. The entire project sequestered a reported 20,000 MTCO₂e in 2004; however, Alliant Energy did not report the sequestration quantity attributable to modified forest management alone.
- American Electric Power's Guaraquecaba Climate Action Project, located in Brazil, sequestered a reported 11,000 MTCO₂e in 2004.

On a smaller scale, DTE Energy/Detroit Edison conducted selective harvesting operations in previously unmanaged wood lots in southeastern Michigan and reported increasing sequestration by 1,400 MTCO₂e in 2004.

Conservation Tillage and Other Sequestration Projects

Not all the carbon sequestration projects reported for 2004 involved conventional forestry. Other projects reported involved conservation tillage,⁴¹ reuse of utility poles, and restoration of terrestrial, wetland, and marine habitats. Six such projects were reported for 2004.

Exelon (formerly Commonwealth Edison and PECO) reported on its Illinois Prairie Grass Plantings project, which involves the planting of native prairie grasses on various properties in the utility's Illinois operations. In contrast to conventional turf grass, the deep root system of native Illinois prairie grasses affords environmental benefits that include reducing soil erosion and downstream flooding and eliminating the need for irrigation, fertilizers, pesticides, and herbicides. In addition, the deeper root systems sequester more carbon dioxide. For this project, Exelon reported sequestering 700 MTCO₂e in 2004. In another project, Exelon reused structurally sound wood utility poles to avoid the harvesting of trees

for the manufacture of new utility poles. The utility pole reuse project was reported to have sequestered 600 MTCO₂e in 2004.

Alliant Energy reported on a conservation tillage project in south central Wisconsin that involved the conversion of 956 acres of former corn and soybean row cropland to a variety of other uses, including tall grass prairie, wetlands, conservation tillage, and oak savanna. This project reportedly sequestered 4,300 MTCO₂e in 2004.

Alliant Energy also reported on a habitat restoration project in Wisconsin, which sequestered 3,500 MTCO₂e in 2004.

Other carbon sequestration projects include the reclamation of 5,500 acres of wetlands in Texas and Louisiana by Entergy Services, Inc., and the reclamation of six acres of wetlands by Pepco Holdings Inc. The two projects sequestered a reported 54,900 and 14 MTCO₂e in 2004, respectively.