Appendixes 1–6

Appendix 1. The Erosion Deposition Carbon Model

The Erosion Deposition Carbon Model (EDCM; Liu and others, 2003) is an ecosystem biogeochemical model developed from the well-established ecosystem model Century version 4.0 (Parton and others, 1987, 1994). Although the EDCM retains the basic input and output file structures of Century, major changes have been made on model structure and underlying biogeochemical processes.

A new algorithm has been implemented in EDCM for this national assessment to account for the effects of cropping improvement on the carbon cycle of an ecosystem. Crop biomass production, crop yield, and residue return to the soil greatly affect the carbon cycle in cropland systems. Crop yield has experienced continuous improvement over the past century and continuing into the future due to genetic engineering and improved management practices.

We analyzed the temporal trends of yield from 1866 through 2009 for 23 major crops in the United States based on the census data of the U.S. Department of Agriculture at the State and county levels (U.S. Department of Agriculture, Economic Research Service, 2011). To quantify the overall temporal change of each crop, the reported yield for a given crop was averaged across the country and normalized to the yield in 2000. In addition, the projected yield changes from Integrated Model to Assess the Greenhouse Effect (IMAGE) for various crops (Alcamo and others, 1998) were used to constrain the future paths and potentials of these crops for the next 50 years. These normalized yields of any given crop were then fitted to the following logistic growth curve:

$$Y_n(t) = c + \frac{k}{1 + a \times \exp\left(b \times (t - d)\right)}, \qquad \text{(A1–1)}$$

where

c, k, a, b, and d are fitted coefficients (table A1–1), and

$Y_n(t)$ is the yield in year t normalized to 2000.

After examining the normalized temporal yield curves of the all the crops, these changes were grouped into seven major categories (table A1–1). It should be noted that the curves (fig. A1–1) were developed for applications across the country, and some crops (for example, sugarcane and rice) might not exist in all ecoregions across the country. These curves are embedded in the General Ensemble Biogeochemical Modeling System (GEMS; Liu, 2009; Liu and others, 2012).

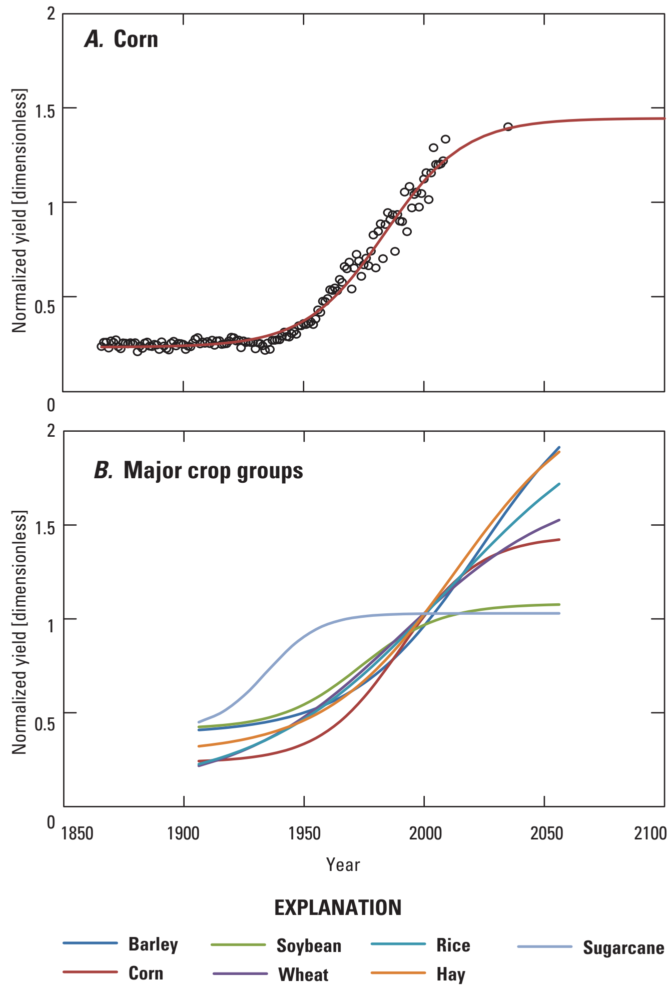

Figure A1–1. Normalized curves of grain yield in the United States for *A*, corn and *B*, major crop groups.

Table A1–1. Coefficients of the logistic curves describing the grain yield change for major crops in the United States.

[Values of c, k, a, b, and d are fitted coefficients of the logistic growth curves; see text for the equation]

Group	c	k	a	b	d	Crops in the group
Barley	0.3853	1.9614	8.6459	−0.038	1960	Barley, oats
Corn	0.235	1.2095	4.2095	−0.0602	1960	Corn, corn silage, sugar beets, sweet corn, potatoes, tomatoes, cotton
Soybean	0.413	0.6681	1.5526	−0.06	1960	Soybeans, peanuts
Wheat	0.0852	1.6525	2.3209	−0.0291	1955	Winter wheat, spring wheat, durum wheat, sunflowers
Rice	0.0846	2.1279	3.4339	−0.0256	1955	Rice, sorghum
Hay	0.2832	1.939	6.6342	−0.0365	1955	Hay, rye, tobacco, beans
Sugarcane	0.4044	0.6252	0.0575	–0.09	1960	Sugarcane, sorghum silage

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Appendix 2. The Land Greenhouse-Gas Accounting Tool

Spreadsheet-based or bookkeeping models have been used to simulate various biogeochemical processes (for example, Houghton and Hackler, 2000; Verburg and Johnson, 2001). The Land Greenhouse-Gas Accounting Tool (LGAT) is developed based on a set of rules and implemented using C++ to calculate carbon budgets and greenhouse gas (GHG) emissions, similar to a spreadsheet model in algorithms but different in form. Instead of performing calculations according to tables in a spreadsheet environment, the LGAT generates spatial data layers of carbon stocks and GHG emissions on a pixel basis according to the rules and conditions of each pixel. Changes in pixel conditions can lead to changes in carbon stocks and GHG emissions over time.

The LGAT requires the following input data:

- land cover map
- forest age distribution map
- soil carbon map
- potential aboveground and belowground biomass maps for grassland and shrubland
- forest carbon density by age and forest type
- lookup tables for methane (CH_4) and nitrous oxide (N_2O) emission factors by region and land cover

The LGAT generates maps of 12 variables on an annual basis (table A2–1). Additional data layers, such as temporal changes of total carbon, can be calculated handily at the pixel level by looking at the differences between years. The LGAT calculates carbon stocks and GHG fluxes of all pixels in a region using the following rules:

- *Soil organic carbon (SOC) stocks.*—Assign SOC stocks according to static map (no SOC change is tracked because lack of data at present).
- *Biomass carbon stocks.*—
  - If the land cover is forest—
    - If there is no disturbance, assign carbon stock values according to region (for example, the U.S. Forest Service Forest Inventory and Analysis (FIA) unit), forest type, and age.
    - If forest harvesting occurs—
      - Calculate carbon removal (as $\beta \times C_{AGLB}$, where β is the mass transfer coefficient from aboveground live carbon to harvested wood and C_{AGLB} is the aboveground live biomass carbon).
      - Assign carbon stock values according to region (for example, FIA unit), forest type, and age (=0).
    - No procedure has been implemented for other disturbances.
  - If the land cover is cropland—
    - If cover is corn, assign corn-specific constant carbon stock values.
    - If cover is not corn, assign specific constant carbon stock values.
  - If the land cover is grassland, assign carbon stock values according to a potential grassland biomass carbon stock map.
  - If land cover is shrubland, assign carbon stock values according to a potential shrubland biomass carbon stock map.
- *CH_4 flux.*—Assign CH_4 emission factor according to region and land cover.
- *N_2O flux.*—Assign N_2O emission factor according to region and land cover.

Table A2–1. List of output variables from the Land Greenhouse-Gas Accounting Tool.

[CH_4, methane; gC/ha/yr, grams of nitrogen per hectare per year; MgC/ha, megagrams of carbon per hectare; MgC/ha/yr, megagrams of carbon per hectare per year; N_2O, nitrous oxide]

Index	Variable	Definition	Unit	Pool/flux	Scale
1	Aglc_tr	Aboveground live carbon	MgC/ha	Pool	Pixel
2	Bglc_tr	Belowground live carbon	MgC/ha	Pool	Pixel
3	Aglc_ntr	Understory aboveground carbon	MgC/ha	Pool	Pixel
4	Bglc_ntr	Understory belowground carbon	MgC/ha	Pool	Pixel
5	CWD_st	Standing dead carbon	MgC/ha	Pool	Pixel
6	CWD_dn	Down wood carbon	MgC/ha	Pool	Pixel
7	Litter	Litter carbon	MgC/ha	Pool	Pixel
8	roots_dead	Dead roots	MgC/ha	Pool	Pixel
9	soc	Soil organic carbon	MgC/ha	Pool	Pixel
10	systemc	Total system carbon	MgC/ha	Pool	Pixel
11	N_2O	N_2O emissions	gN/ha/yr	Flux	Pixel
12	CH_4	CH_4 flux	MgC/ha/yr	Flux	Pixel

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Appendix 3. Coefficients of Forest Partial Cutting and Biomass Mortality

The U.S. Forest Service Forest Inventory and Analysis (FIA) Program is known to provide forest inventory data for the United States. The FIA database for each individual State can be downloaded from the FIA DataMart (*http://fia.fs.fed.us/tools-data/*) as a Microsoft Access database. We downloaded the forest inventory information for the period that reported the annualized data (from 2002 through 2010) to estimate the coefficients related to partial cutting and biomass mortality in the Eastern United States at FIA plot level. These coefficients were then averaged by FIA unit, defined as a group of counties by State, and delineated by forest type (tables A3–1 to A3–4). This work was primarily done by Decheng Zhou from Beijing University and Jennifer Oeding of Stinger Ghaffarian Technolgoes Inc. under contract for the U.S. Geological Survey, in consultation with FIA staff.

Table A3–1. Forest partial cutting and biomass mortality in the Eastern United States.

[Forest partial cutting is the percent of forestland area being partially cut per year, and biomass mortality is the percentage of live biomass becoming dead each year, averaged from Forest Inventory and Analysis (FIA) observations from 2002 through 2010. FIPS ID, Federal Information Processing Standard identification number]

State FIPS ID	FIA unit	Partial cutting, in percent			Mortality, in percent		
		Softwood forest	Hardwood forest	Mixed forest	Softwood forest	Hardwood forest	Mixed forest
1	1	3.82	2.76	2.79	0.91	1.19	0.85
1	2	4.65	3.07	4.35	1.44	1.35	0.85
1	3	3.80	2.84	3.15	1.15	0.91	0.75
1	4	3.56	2.75	2.73	1.41	1.14	1.56
1	5	2.36	2.33	1.53	1.56	1.48	1.36
1	6	1.78	1.83	1.55	1.03	1.54	2.00
2	0	NA	NA	NA	NA	NA	NA
2	1	NA	NA	NA	NA	NA	NA
5	1	2.92	1.73	4.24	1.04	0.11	0.37
5	2	2.98	1.76	3.36	1.36	0.32	NA
5	3	4.61	3.62	4.67	0.97	0.61	0.45
5	4	2.83	2.57	1.90	1.09	0.74	0.64
5	5	1.86	1.65	1.25	0.85	0.56	0.74
9	1	NA	1.80	1.41	0.70	0.09	0.39
10	1	0.67	0.80	3.78	0.63	0.30	0.79
11	1	NA	NA	NA	NA	NA	NA
12	1	3.80	2.39	2.99	0.77	0.77	0.85
12	2	2.98	2.76	2.80	0.71	0.80	0.39
12	3	0.97	1.45	0.83	1.06	1.23	0.82
12	4	1.02	0.79	0.55	0.27	0.26	2.00
13	1	2.69	2.69	2.21	1.43	0.71	0.51
13	2	3.57	3.11	2.41	1.44	0.84	0.78
13	3	2.86	3.31	2.30	0.92	0.94	0.66
13	4	2.25	2.37	1.86	0.91	0.77	0.95
13	5	1.92	1.17	1.24	0.62	1.39	1.67
15	1	NA	NA	NA	NA	NA	NA
17	1	0.89	1.24	NA	1.52	0.35	1.09
17	2	NA	1.45	NA	1.17	NA	NA
17	3	0.62	1.14	6.35	1.41	0.39	1.82
18	1	NA	2.44	NA	0.64	0.64	2.00
18	2	2.41	1.59	2.82	0.97	0.21	0.66
18	3	NA	0.76	1.44	0.84	0.54	1.42
18	4	4.79	1.79	NA	1.10	0.09	1.22
19	1	NA	3.00	NA	1.12	0.15	NA
19	2	NA	1.37	NA	1.20	0.58	NA
19	3	NA	1.77	NA	1.46	0.39	2.00

Table A3–1. Forest partial cutting and biomass mortality in the Eastern United States.—Continued

[Forest partial cutting is the percent of forestland area being partially cut per year, and biomass mortality is the percentage of live biomass becoming dead each year, averaged from Forest Inventory and Analysis (FIA) observations from 2002 through 2010. FIPS ID, Federal Information Processing Standard identification number]

State FIPS ID	FIA unit	Partial cutting, in percent			Mortality, in percent		
		Softwood forest	Hardwood forest	Mixed forest	Softwood forest	Hardwood forest	Mixed forest
19	4	NA	0.68	NA	2.00	NA	NA
20	1	2.26	1.29	NA	1.30	1.12	2.00
20	2	1.11	1.00	2.49	1.00	NA	0.78
20	3	NA	0.59	NA	2.00	1.06	NA
21	1	NA	1.50	2.09	1.10	0.56	1.37
21	2	1.82	1.35	NA	1.28	0.97	0.99
21	3	NA	1.46	0.90	0.77	1.72	2.00
21	4	1.18	0.86	0.81	0.80	0.54	1.75
21	5	2.71	1.32	1.19	0.72	0.77	1.40
21	6	0.65	1.07	1.80	0.50	1.08	0.73
21	7	NA	0.79	7.00	0.87	0.21	0.74
22	1	4.41	1.34	2.07	1.16	0.64	0.45
22	2	3.45	1.24	5.68	1.57	NA	2.00
22	3	4.33	2.79	3.86	1.55	1.56	1.54
22	4	3.42	2.25	4.80	2.00	1.49	0.49
22	5	4.94	3.97	4.77	0.68	0.08	0.43
23	1	3.60	2.52	10.00	0.89	2.00	0.76
23	2	2.22	3.27	NA	1.28	NA	0.99
23	3	3.09	3.04	6.78	0.99	0.12	0.87
23	4	1.94	3.02	NA	1.37	0.05	1.15
23	5	2.54	3.07	NA	1.32	1.89	1.02
23	6	2.67	2.03	2.01	1.00	0.63	1.33
23	7	1.87	4.05	3.64	1.48	1.19	0.99
23	8	3.64	2.99	3.40	0.52	0.98	0.74
23	9	2.77	3.09	3.80	1.06	0.33	0.85
24	2	1.47	1.98	2.82	1.00	0.62	0.49
24	3	2.50	1.73	4.26	0.51	1.84	1.02
24	4	3.81	1.86	4.66	0.95	0.67	0.67
24	5	NA	1.94	11.35	0.99	1.03	0.19
25	1	1.29	1.71	1.65	0.76	0.68	0.52
26	1	0.74	2.03	1.51	0.99	0.43	0.95
26	2	0.87	1.97	1.59	0.85	0.59	1.18
26	3	1.12	1.66	1.29	0.75	0.66	0.71
26	4	0.57	1.46	1.76	1.24	1.15	2.00
27	1	0.65	1.99	1.34	2.00	2.00	1.61
27	2	1.09	2.43	1.86	1.41	1.22	1.23
27	3	1.26	1.95	3.44	1.25	1.46	1.28
27	4	NA	1.32	NA	1.31	0.27	0.75
28	1	1.60	2.29	3.87	0.95	1.30	0.08
28	2	3.56	2.40	2.10	0.83	1.38	0.34
28	3	3.98	3.17	3.26	1.27	0.88	0.95
28	4	3.47	2.87	3.60	2.00	2.00	1.56
28	5	3.63	2.59	3.57	2.00	0.41	0.46
29	1	1.58	2.39	2.39	0.94	0.68	0.33
29	2	2.98	3.19	1.78	0.92	0.51	0.50
29	3	2.04	2.36	1.72	1.43	0.37	0.06
29	4	NA	1.96	2.01	1.16	1.47	0.92

Table A3–1. Forest partial cutting and biomass mortality in the Eastern United States.—Continued

[Forest partial cutting is the percent of forestland area being partially cut per year, and biomass mortality is the percentage of live biomass becoming dead each year, averaged from Forest Inventory and Analysis (FIA) observations from 2002 through 2010. FIPS ID, Federal Information Processing Standard identification number]

State FIPS ID	FIA unit	Partial cutting, in percent			Mortality, in percent		
		Softwood forest	Hardwood forest	Mixed forest	Softwood forest	Hardwood forest	Mixed forest
29	5	4.00	1.85	1.50	1.11	0.64	0.34
31	1	1.18	0.84	2.57	1.35	1.44	0.41
31	2	0.29	0.58	NA	2.00	0.83	0.86
33	2	2.10	2.24	2.87	1.05	1.15	2.00
33	3	2.93	2.12	3.74	0.75	0.48	0.72
34	1	0.19	1.01	1.43	0.81	0.61	0.59
36	1	0.99	1.76	2.21	1.26	1.17	1.16
36	2	0.57	1.64	3.77	0.70	0.30	1.22
36	3	1.46	1.53	NA	0.95	0.95	0.84
36	4	0.46	0.92	2.52	1.12	0.90	0.88
36	5	3.44	2.17	NA	0.47	0.90	1.68
36	6	1.19	2.33	3.22	0.60	0.79	0.67
36	7	1.37	2.05	1.51	0.58	0.50	0.52
36	8	0.98	1.00	NA	0.84	0.22	0.78
37	1	4.61	3.14	3.24	1.76	1.00	0.69
37	2	3.31	2.93	3.58	1.24	1.68	1.14
37	3	1.69	2.10	2.50	0.95	1.49	1.53
37	4	0.98	1.12	1.83	0.64	1.28	1.41
38	1	NA	0.59	NA	2.00	NA	0.74
39	1	0.37	1.23	2.79	1.00	1.14	0.41
39	2	NA	1.15	2.12	0.90	2.00	0.48
39	3	NA	1.01	NA	1.11	2.00	0.81
39	4	2.84	1.22	NA	1.08	NA	0.31
39	5	NA	0.48	NA	0.86	0.65	NA
39	6	2.73	1.10	NA	0.95	1.89	1.70
40	1	4.57	1.89	2.97	0.83	0.23	0.71
40	2	2.31	0.98	1.52	2.00	2.00	NA
40	3	NA	NA	NA	1.07	0.87	0.92
40	4	NA	NA	NA	1.07	0.87	0.92
40	5	NA	NA	NA	1.07	0.87	0.92
40	6	NA	NA	NA	1.07	0.87	0.92
40	7	NA	NA	NA	1.07	0.87	0.92
42	0	NA	1.97	NA	1.14	1.66	0.33
42	5	2.68	2.24	NA	0.86	2.00	1.00
42	6	0.66	1.65	1.02	0.70	0.50	0.71
42	7	NA	2.13	4.87	0.69	0.42	2.00
42	8	3.28	1.41	1.86	0.79	2.00	1.34
42	9	NA	1.90	NA	0.76	0.07	0.89
44	1	0.49	0.96	NA	0.51	0.08	0.72
45	1	3.24	1.92	1.91	0.82	0.79	0.61
45	2	2.85	2.37	2.37	0.75	0.60	0.59
45	3	3.01	1.95	2.02	0.88	1.12	0.96
46	1	NA	0.59	NA	2.00	NA	0.22
46	2	2.08	3.40	NA	1.18	NA	1.14
47	1	1.67	2.09	2.25	1.15	0.70	0.82
47	2	3.44	2.03	2.29	0.88	0.96	0.28
47	3	0.56	1.87	1.20	0.82	0.56	0.40

Table A3–1. Forest partial cutting and biomass mortality in the Eastern United States.—Continued

[Forest partial cutting is the percent of forestland area being partially cut per year, and biomass mortality is the percentage of live biomass becoming dead each year, averaged from Forest Inventory and Analysis (FIA) observations from 2002 through 2010. FIPS ID, Federal Information Processing Standard identification number]

State FIPS ID	FIA unit	Partial cutting, in percent			Mortality, in percent		
		Softwood forest	Hardwood forest	Mixed forest	Softwood forest	Hardwood forest	Mixed forest
47	4	2.34	2.13	1.96	0.85	2.00	2.00
47	5	0.98	1.23	1.13	0.96	2.00	2.00
48	1	3.84	2.75	4.52	1.43	1.05	0.76
48	2	4.52	3.12	3.64	0.94	0.65	0.98
48	3	NA	NA	NA	1.07	0.87	0.92
48	4	NA	NA	NA	1.07	0.87	0.92
48	5	NA	NA	NA	1.07	0.87	0.92
48	6	NA	NA	NA	1.07	0.87	0.92
48	7	NA	NA	NA	1.07	0.87	0.92
50	2	3.83	3.02	2.68	0.88	0.63	1.15
50	3	2.88	2.33	NA	1.06	0.35	0.45
51	1	2.21	1.59	1.84	1.34	1.00	0.81
51	2	1.92	2.10	1.99	0.61	1.03	0.74
51	3	2.64	1.32	1.86	0.87	1.34	0.77
51	4	0.63	0.81	0.67	0.64	0.49	1.85
51	5	1.07	1.17	1.15	0.51	0.53	2.00
54	2	0.11	2.30	3.52	0.77	0.65	0.51
54	3	NA	2.85	2.45	0.66	0.40	0.96
54	4	0.77	2.18	3.02	0.90	0.56	1.41
55	1	1.42	2.39	2.43	0.79	0.51	0.60
55	2	1.23	2.08	1.49	1.11	1.26	0.60
55	3	3.19	2.80	2.45	1.16	1.16	0.75
55	4	1.75	2.41	2.75	1.43	1.57	0.48
55	5	0.58	1.92	3.47	1.26	2.00	0.87

Table A3–2. Age distribution of forest mortality in the Eastern United States.

[Values are as a percentage of the total forest type. Columns represent age class: age10, 0 to 10 years old; age20, 11 to 20 years old; age30, 21 to 30 years old; age40 =31 to 40 years old; age50, 41 to 50 years old; age60, 51 to 60 years old; age70, 61 to 70 years old; age80, 71 to 80 years old; age90, 81 to 90 years old; age 100, 91 to 100 years old; age 110, > 100 years old]

Forest type	age10	age20	age30	age40	age50	age60	age70	age80	age90	age100	age110
Hardwood	0.69	1.42	2.74	6.82	13.61	17.24	20.29	15.39	10.74	5.77	5.29
Mixed	1.19	3.25	5.08	8.87	18.29	23.47	15.71	13.29	8.10	1.71	1.03
Softwood	1.45	6.78	15.57	10.94	16.59	15.52	12.25	9.24	4.74	2.45	4.48

Table A3–3. Age distribution of partial forest cutting in the Eastern United States.

[Values are as a percentage of the total forest type. Columns represent age class: age10, 0 to 10 years old; age20, 11 to 20 years old; age30, 21 to 30 years old; age40 =31 to 40 years old; age50, 41 to 50 years old; age60, 51 to 60 years old; age70, 61 to 70 years old; age80, 71 to 80 years old; age90, 81 to 90 years old; age 100, 91 to 100 years old; age 110, more than 100 years old]

Forest type	age10	age20	age30	age40	age50	age60	age70	age80	age90	age100	age110
Hardwood	1.23	1.29	3.05	7.22	12.50	19.43	20.93	15.48	8.94	4.39	5.56
Mixed	0.92	3.30	11.19	16.93	16.35	24.84	10.33	8.23	3.06	2.47	2.39
Softwood	0.51	15.66	28.53	17.71	15.68	10.24	5.56	2.96	1.52	0.60	1.03

Table A3–4. Frequency distribution of forest cutting in the Eastern United States.

[Values are as a percentage of the total forest type. Columns represent removal rate of aboveground biomass: ci0, 0 to 10 percent removal; ci20, 11 to 20 percent removal; ci30, 21 to 30 percent removal; ci40 =31 to 40 percent removal; ci50, 41 to 50 percent removal; ci60, 51 to 60 percent removal; ci70, 61 to 70 percent removal; ci80, 71 to 80 percent removal; ci90, 81 to 90 percent removal; ci100, 91 to 100 percent removal (that is, clearcut).

Forest Type	ci10	ci20	ci30	ci40	ci50	ci60	ci70	ci80	ci90	ci100
Hardwood	3.741	7.489	9.647	9.486	10.44	11.15	9.335	7.911	13.1	17.7
Mixed	3.286	5.521	4.801	6.879	10.25	6.89	15.08	11.35	16.53	19.41
Softwood	1.018	2.897	5.83	7.527	9.354	9.768	8.314	9.152	9.948	36.19

Appendix 4. Optimized Maximum Monthly Gross Primary Production

The maximum gross primary production rates (PRDX) for all land cover types within each county in the Eastern United States were calibrated using county-based grain-yield-survey data by crop type and 250-meter resolution net primary production data from the moderate resolution imaging spectroradiometer (MODIS) for other land-use and land-cover types such as forests and grasslands from 2001 through 2005. Figure A4–1 shows the distribution of PRDX for the major land cover types across more than 1,990 counties in the Eastern United States.

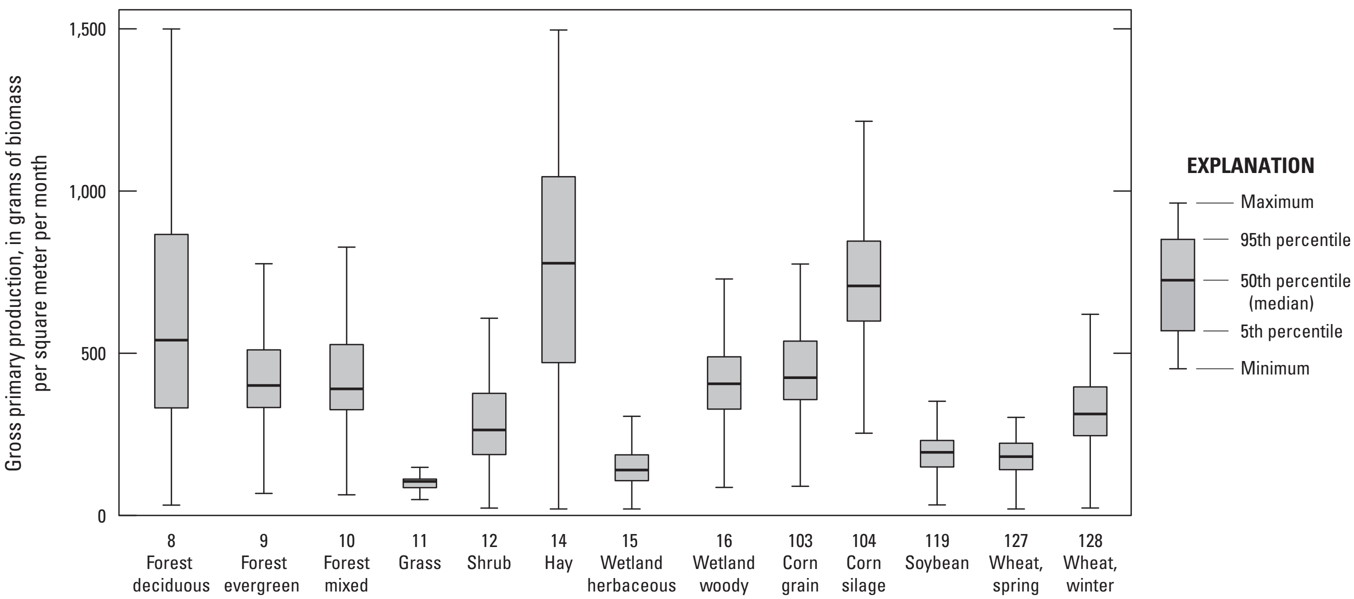

Figure A4–1. Graph showing the distribution of the optimized parameter potential monthly gross primary production (PRDX), in grams of biomass per square meter per month, in the Erosion Deposition Carbon Model (EDCM) for each major land cover across 1,990 counties in the Eastern United States. Each box-and-whisker represents the distribution of the PRDX values derived for 1,990 counties. The line inside the box shows the median, the upper and lower ends of the box are the 75th and 25th percentiles, respectively, and the whiskers show the maximum and minimum values.

Appendix 5. Comparison of Sampling-Based and Per-Pixel Model Runs

Biogeochemical modeling over large areas is computationally intensive. In order to accelerate turnover time of modeling results for repeated analysis and debugging, sampling-based model simulations are implemented in the General Ensemble Biogeochemical Modeling System (GEMS; Liu, 2009; Liu and others, 2012). Not all pixels will be simulated using the sampling approach. Instead, GEMS systematically selects the pixels to simulate according to user input. For example, simulating every fifth pixel in both x and y directions would result in a sampling rate of 1:25, every tenth pixel would result in a rate of 1:100, and so on. Users can select sampling rates according to situation (for example, the size of study area and the running time they can afford). The running time for the Century version 4.0 model (Parton and others, 1987, 1994; Metherell and others, 1993) and the Erosion Deposition Carbon Model (EDCM; appendix 1; Liu and others, 2003) can be shortened by more than 98 percent with a sampling rate of 1:100.

To illustrate the effects of sampling on model simulations, figures A5–1 and A5–2 compare model-simulated carbon stocks and fluxes using sampling-based and per-pixel simulation approaches in the Mixed Wood Shield ecoregion (other ecoregions showed similar results). The sampling rate of 1:100 used for this assessment was sufficient to represent the overall dynamics of carbon stocks and fluxes compared with the per-pixel simulation approach.

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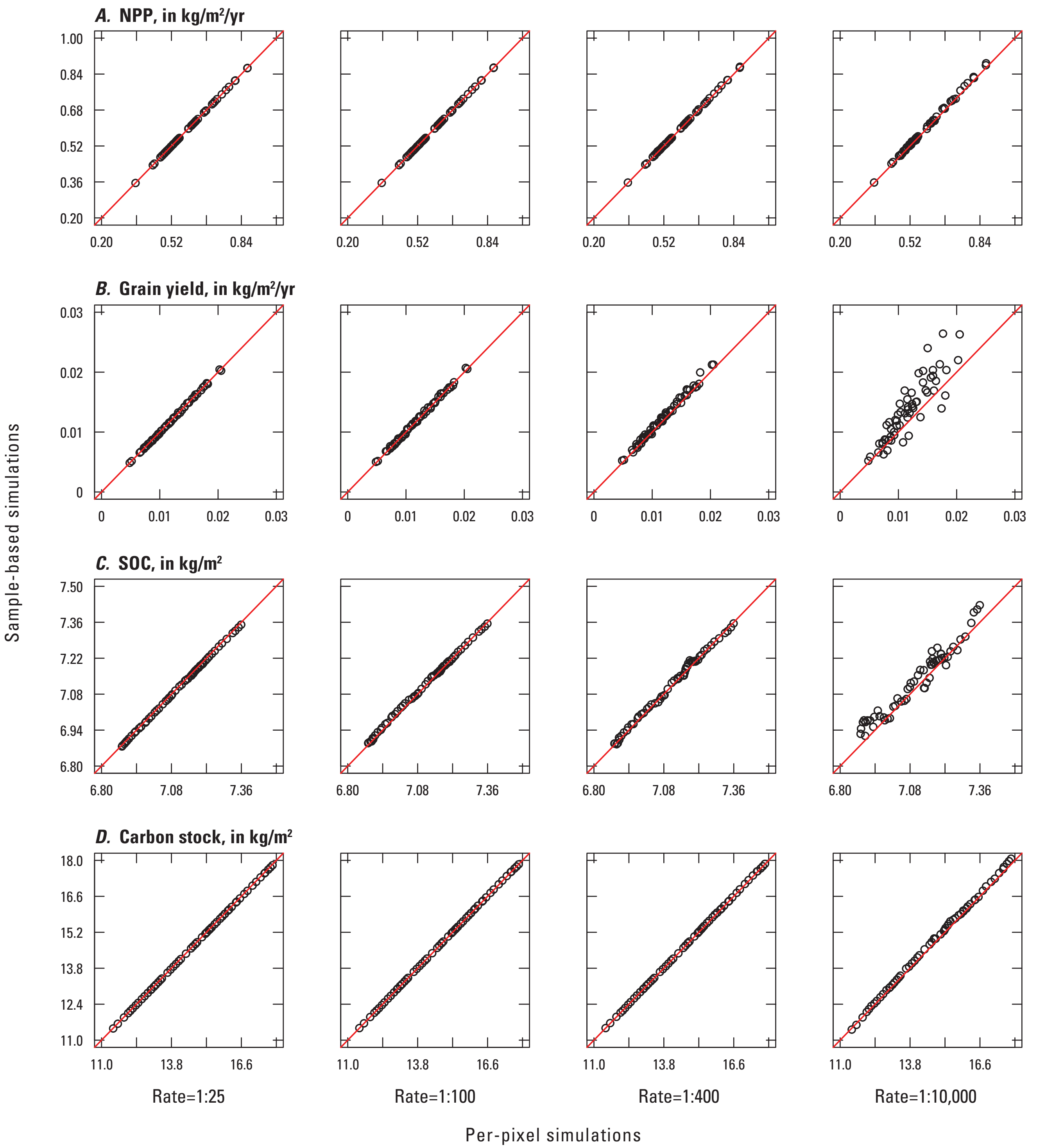

Figure A5–1. Comparison of simulations in the Century version 4.0 model (Parton and others, 1987, 1994; Metherell and others, 1993) of net primary production (NPP), grain yield, soil organic carbon (SOC), and total ecoregion carbon storage in the Mixed Wood Shield ecoregion using per-pixel and sampling-based approaches. Each circle represents the carbon stock or flux for a given year between 1992 and 1950; the circles on or near the per-pixel simulation trend (red line) show the deviation of results of the sampling-based simulations compared with results from the per-pixel simulation. kg/m²/yr, kilograms per square meter per year.

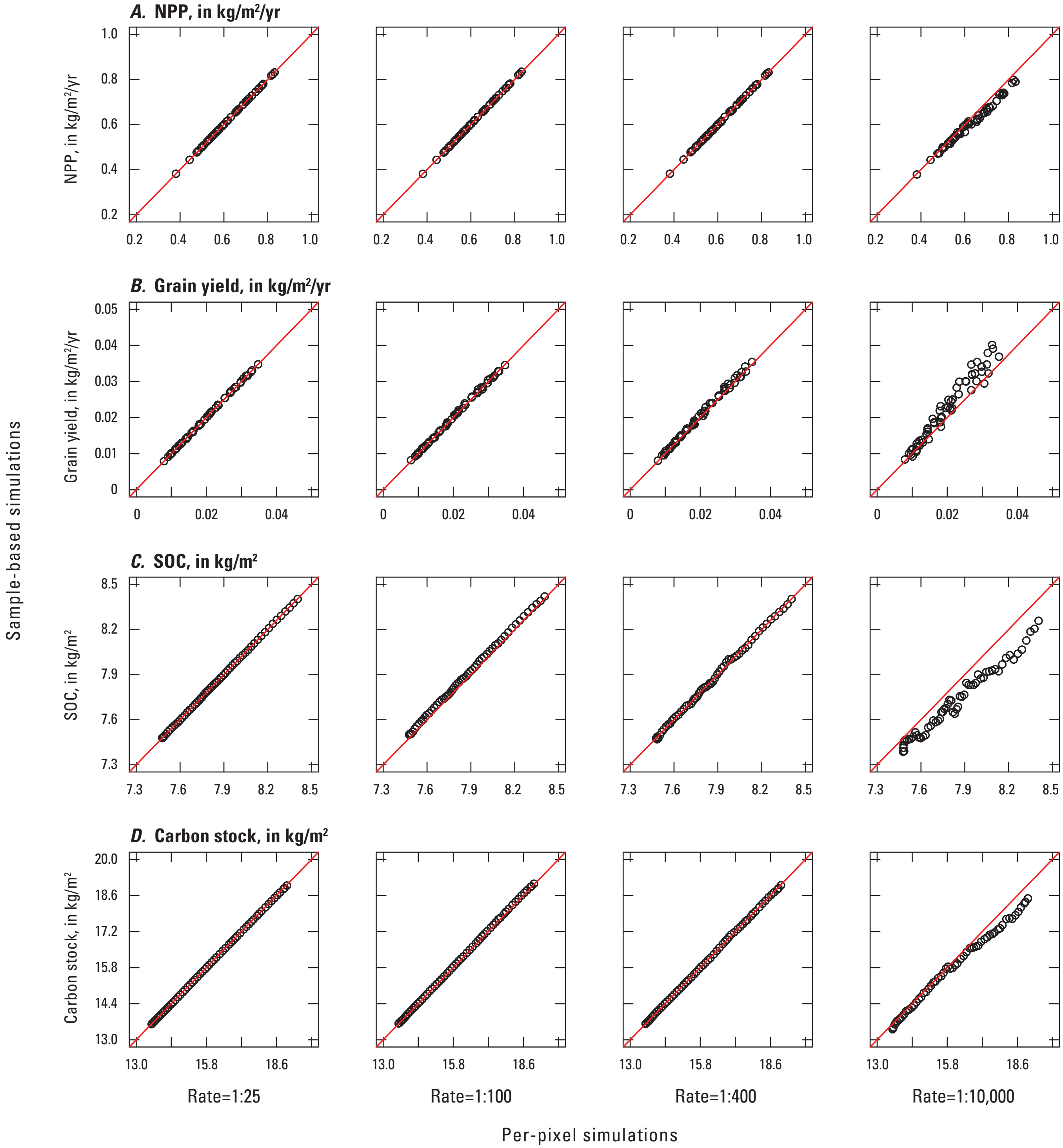

Figure A5–2. Comparison of simulations from the Erosion Deposition Carbon Model (EDCM; appendix 1; Liu and others, 2003) of net primary production (NPP), grain yield, soil organic carbon (SOC), and total ecoregion carbon storage in the Mixed Wood Shield ecoregion using per-pixel and sampling-based approaches. Each circle represents the carbon stock or flux for a given year between 1992 and 1950; the circles on or near the per-pixel simulation trend (red line) show the deviation of results of the sampling-based simulations compared with results from the per-pixel simulation. kg/m^2/yr, kilograms per square meter per year.

Appendix 6. Emission Factors of Nitrous Oxide and Methane in the Eastern United States

Nitrous oxide (N_2O) and methane (CH_4) are major greenhouse gases; in terms of global warming potentials (GWP), N_2O and CH_4 have 310 and 21 times, respectively, more of an effect than carbon dioxide (CO_2; U.S. Environmental Protection Agency, 2012). Atmospheric concentrations of these gases are increasing in exponential rate (Corre and others, 1999); human activities are the only reason for these increases. Agricultural activities are major emitter of anthropogenic CH_4 (27 percent) and N_2O (70 percent) to the global atmosphere, although natural systems, such as wetlands and forests, emit a significant amount of these gases (Smith and others, 2007).

N_2O flux is highly dependent on nitrogen input and precipitation and only slightly on temperature. However, soil parameters, including pH, organic carbon content, and nitrogen content, have a significant effect (Mosier and others, 1997b; Gleason and others, 2009; Anderson and others, 2010). CH_4 is produced when organic materials decompose in oxygen-deprived conditions, notably from fermentative digestion by ruminant livestock, from stored manures, and from rice grown under flooded conditions (Mosier and others, 1998).

The compilation of the emission factors was conducted using an Intergovernmental Panel on Climate Change data collection approach (Goodwin and others, 2006). For this approach, published emission factors of various land use and land cover types in the United States were collected, and type of land use (types of crop, forest, wetland, or grassland), management practice, annual mean flux (if multiple years were reported, we took average annual flux), and location were recorded. Collected values were averaged when there were multiple values for any ecoregion and ecosystem. If no published value was found for any particular region, the value for a nearby similar region was used. Tables A6–1 and A6–2 list the compiled results of N_2O and CH_4 emission factors by ecoregion and ecosystem type with data source flag.

Table A6–1. N_2O emission factors by ecosystem and level II ecoregion.

[LC ID, land cover name and identification (U.S. Geological Survey Land Carbon Project designation for the purposes of the assessment). Values are in kilograms of nitrous oxide as nitrogen per hectare per year. Values in flag columns explain if mean is measured or surrogated: 0, measured, 1, assumed, 2, average of all measured value for the land cover type. Data are from the sources listed in the References Cited section of this appendix]

LC name	LC ID	ER_52	Flag_52	ER_53	Flag_53	ER_62	Flag_62	ER_71	Flag_71	ER_81	Flag_81	ER_82	Flag_82	ER_83	Flag_83
Water	1	0.080	0	0.825	2	0.825	2	1.581	0	0.880	0	0.880	0	3.430	0
Developed	2	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Mechanically disturbed, national forest	3	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Mechanically disturbed, other public lands	4	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Mechanically disturbed, private lands	5	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Mining	6	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Barren	7	0.484	2	0.484	2	0.484	2	0.484	2	0.484	2	0.484	2	0.484	2
Deciduous forest	8	0.020	0	0.253	0	0.649	2	0.649	2	0.110	0	0.649	2	0.420	0
Evergreen forest	9	0.170	0	0.180	0	0.572	2	0.572	2	0.050	0	2.430	0	6.200	0
Mixed forest	10	0.253	0	0.230	0	0.492	2	0.492	2	0.555	0	0.492	2	1.350	0
Grassland	11	1.999	0	1.027	2	1.921	0	1.027	2	0.185	0	0.250	0	1.027	2
Shrubland	12	0.150	0	0.928	2	0.150	0	0.928	2	0.630	0	0.928	2	0.928	2
Agriculture	13	1.300	2	1.300	2	1.300	2	1.300	2	1.300	2	1.300	2	1.300	2
Hay pasture	14	0.813	2	0.813	2	0.813	2	0.813	2	0.813	2	0.813	2	0.813	2
Herbaceous wetland	15	0.010	0	0.846	2	0.846	2	0.846	2	1.450	0	1.450	0	0.846	2
Woody wetland	16	1.222	2	1.222	2	1.222	2	1.222	2	1.222	2	1.222	2	1.222	2
Perennial ice/snow	17	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Barley	100	2.459	2	2.459	2	2.459	2	2.459	2	2.800	0	0.900	0	2.459	2
Beans	101	1.310	2	1.310	2	1.310	2	1.310	2	1.310	2	1.310	2	1.310	2
Canola	102	2.400	2	2.400	2	2.400	2	2.400	2	2.500	0	2.400	2	2.400	2
Corn grain	103	2.680	2	2.680	2	2.680	2	2.680	2	1.873	0	5.111	0	2.680	2
Corn silage	104	2.680	2	2.680	2	2.680	2	2.680	2	1.873	0	5.111	0	2.680	2
Cotton	105	0.489	2	0.489	2	0.489	2	0.489	2	0.489	2	0.489	2	0.543	0
Flaxseed	106	0.500	1	0.500	1	0.500	1	0.500	1	0.500	1	0.500	1	0.500	1
Forage	107	2.572	2	2.572	2	2.572	2	2.572	2	3.470	0	2.572	2	2.572	2
Hay	108	0.320	2	0.320	2	0.320	2	0.320	2	0.320	2	0.320	2	0.320	2
Lentils	109	0.510	2	0.510	2	0.510	2	0.510	2	0.510	2	0.510	2	0.510	2
Sorghum silage	110	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2
Oats	111	0.160	2	0.160	2	0.160	2	0.160	2	0.160	2	0.160	2	0.160	2
Peanuts	112	6.200	1	6.200	1	6.200	1	6.200	1	6.200	1	6.200	1	6.200	1
Peas	113	0.510	2	0.510	2	0.510	2	0.510	2	0.510	2	0.510	2	0.510	2
Potatoes	114	3.095	2	3.095	2	3.095	2	3.095	2	3.095	2	3.095	2	3.095	2
Rice	115	0.117	2	0.117	2	0.117	2	0.117	2	0.117	2	0.117	2	0.117	2
Rye	116	0.038	2	0.038	2	0.038	2	0.038	2	0.038	2	0.038	2	0.038	2
Safflower	117	1.200	2	1.200	2	1.200	2	1.200	2	1.200	2	1.200	2	1.200	2
Sorghum	118	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2
Soybeans	119	1.981	2	1.981	2	1.981	2	1.981	2	1.070	0	1.981	2	1.981	2
Sugarbeets	120	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
Sugarcane	121	0.280	2	0.280	2	0.280	2	0.280	2	0.280	2	0.280	2	0.280	2
Sunflowers	122	2.000	1	2.000	1	2.000	1	2.000	1	2.000	1	2.000	1	2.000	1
Sweet corn	123	3.790	2	3.790	2	3.790	2	3.790	2	3.790	2	3.790	2	3.790	2
Tobacco	124	2.258	2	2.258	2	2.258	2	2.258	2	2.258	2	2.258	0	2.258	2
Tomatoes	125	7.375	2	7.375	2	7.375	2	7.375	2	7.375	2	0.750	0	7.375	2
Wheat durum	126	2.011	2	2.011	2	2.011	2	2.011	2	2.265	0	2.011	2	2.011	2
Wheat, spring	127	2.011	2	2.011	2	2.011	2	2.011	2	2.265	0	2.011	2	2.011	2
Wheat, winter	128	2.011	2	2.011	2	2.011	2	2.011	2	2.265	0	2.011	2	2.011	2

Table A6–1. N_2O emission factors by ecosystem and level II ecoregion.—Continued

[LC ID, land cover name and identification (U.S. Geological Survey Land Carbon Project designation for the purposes of the assessment). Values are in kilograms of nitrous oxide as nitrogen per hectare per year. Values in flag columns explain if mean is measured or surrogated: 0, measured, 1, assumed, 2, average of all measured value for the land cover type. Data are from the sources listed in the References Cited section of this appendix]

ER_84	Flag_84	ER_85	Flag_85	ER_92	Flag_92	ER_93	Flag_93	ER_94	Flag_94	ER_101	Flag_101	ER_102	Flag_102	ER_111	Flag_111
3.430	2	0.022	0	2.370	0	0.850	0	0.825	2	0.825	2	0.825	2	0.825	2
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.484	2	0.484	2	0.484	2	0.400	0	0.353	0	0.103	0	0.484	2	0.484	2
0.649	2	0.030	0	0.649	2	0.649	2	0.649	2	0.649	2	0.649	2	0.649	2
0.572	2	0.030	0	0.572	2	0.572	2	0.572	2	0.572	2	0.572	2	0.572	2
0.535	0	0.492	2	0.492	2	0.030	0	0.492	2	0.492	2	0.492	2	0.492	2
1.027	2	1.027	2	0.465	0	2.040	0	0.800	0	0.245	0	1.027	2	1.027	2
0.928	2	0.928	2	0.928	2	0.928	2	0.928	2	0.230	0	0.928	2	0.928	2
1.300	2	1.300	2	1.300	2	1.300	2	1.300	2	1.300	2	1.300	2	1.300	2
0.813	2	0.813	2	0.813	2	1.410	0	0.450	0	0.813	2	0.813	2	0.813	2
0.846	2	0.790	0	1.845	0	0.740	0	0.846	2	0.846	2	0.846	2	0.846	2
1.222	2	1.222	2	3.150	0	0.495	0	1.222	2	1.222	2	1.222	2	1.222	2
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
2.459	2	2.459	2	2.459	2	2.443	0	3.692	0	2.459	2	2.459	2	2.459	2
1.310	2	1.310	2	1.310	2	1.310	2	1.310	0	1.310	2	1.310	2	1.310	2
2.400	2	2.400	2	2.400	2	2.370	0	2.400	2	2.400	2	2.400	2	2.400	2
2.050	0	1.140	0	5.684	0	0.180	0	1.786	0	2.680	2	2.680	2	1.892	0
2.050	0	1.140	0	5.684	0	0.180	0	1.786	0	2.680	2	2.680	2	1.892	0
0.489	2	0.516	0	0.489	2	0.489	2	0.624	0	0.489	2	0.489	2	0.489	0
0.500	1	0.500	1	0.500	1	0.500	1	0.500	1	0.500	1	0.500	1	0.500	1
2.572	2	2.572	2	4.207	0	0.040	0	2.572	2	2.572	2	2.572	2	2.572	2
0.320	2	0.320	2	0.320	2	0.320	2	0.320	0	0.320	2	0.320	2	0.320	2
0.510	2	0.510	2	0.510	0	0.510	2	0.510	2	0.510	2	0.510	2	0.510	2
2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2
0.160	2	0.160	2	0.160	2	0.160	0	0.160	2	0.160	2	0.160	2	0.160	2
6.200	1	6.200	1	6.200	1	6.200	1	6.200	1	6.200	1	6.200	1	6.200	1
0.510	2	0.510	2	0.510	2	0.510	0	0.510	2	0.510	2	0.510	2	0.510	2
3.095	2	3.095	2	3.095	2	3.095	2	3.095	2	3.095	0	3.095	2	3.095	2
0.117	2	0.117	0	0.117	2	0.117	2	0.117	2	0.117	2	0.117	2	0.117	2
0.040	0	0.035	0	0.038	2	0.038	2	0.038	2	0.038	2	0.038	2	0.038	2
1.200	2	1.200	2	1.200	2	1.200	0	1.200	2	1.200	2	1.200	2	1.200	2
2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2	2.200	2
1.450	0	2.235	0	3.168	0	1.981	2	1.981	2	1.981	2	1.981	2	1.981	2
1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1
0.280	2	0.280	2	0.280	2	0.280	2	0.280	2	0.280	2	0.280	2	0.280	2
2.000	1	2.000	1	2.000	1	2.000	1	2.000	1	2.000	1	2.000	1	2.000	1
3.790	2	3.790	2	3.790	2	3.790	2	3.790	2	3.790	0	3.790	2	3.790	2
2.258	2	2.258	2	2.258	2	2.258	2	2.258	2	2.258	2	2.258	2	2.258	2
7.375	2	7.375	2	7.375	2	7.375	2	7.375	2	7.375	2	7.375	2	14.000	0
1.880	0	2.011	2	4.150	0	0.863	0	0.898	0	2.011	2	2.011	2	2.011	2
1.880	0	2.011	2	4.150	0	0.863	0	0.898	0	2.011	2	2.011	2	2.011	2
1.880	0	2.011	2	4.150	0	0.863	0	0.898	0	2.011	2	2.011	2	2.011	2

Table A6–2. CH_4 emission factors by ecosystem and level II ecoregion.

[LC ID, land cover name and identification (U.S. Geological Survey Land Carbon Project designation for the purposes of the assessment). Values are in kilograms of nitrous oxide as nitrogen per hectare per year. Values in flag columns explain if mean is measured or surrogated: 0, measured, 1, assumed, 2, average of all measured value for the land cover type. Data are from the sources listed in the References Cited section of this appendix]

LC name	LC ID	ER_52	Flag_52	ER_53	Flag_53	ER_62	Flag_62	ER_71	Flag_71	ER_81	Flag_81	ER_82	Flag_82	ER_83	Flag_83
Water	1	37.308	0	37.308	2	6.570	0	42.431	0	37.698	2	37.698	2	37.698	2
Developed	2	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Mechanically disturbed, national forest	3	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Mechanically disturbed, other public lands	4	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Mechanically disturbed, private lands	5	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Mining	6	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Barren	7	–1.182	2	–1.182	2	–1.182	2	–1.182	2	–1.182	2	–1.182	2	–1.182	2
Deciduous forest	8	–6.955	2	–8.547	0	–9.230	0	–6.955	2	–2.212	0	–6.955	2	–6.955	2
Evergreen forest	9	–2.770	2	–6.993	0	–1.060	0	–2.770	2	–0.857	0	–2.770	2	–2.770	2
Mixed forest	10	–3.245	2	–4.413	0	–4.650	0	–3.245	2	–3.245	2	–3.245	2	–1.920	0
Grassland	11	–1.833	2	–1.833	2	–3.380	0	–1.833	2	–1.500	0	0.240	0	–1.833	2
Shrubland	12	–2.670	2	–2.670	2	–2.670	2	–2.670	2	–2.670	2	–2.670	2	–2.670	2
Agriculture	13	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Hay pasture	14	–0.609	2	–0.609	2	–0.609	2	–0.609	2	–0.609	2	–0.609	2	–0.609	2
Herbaceous wetland	15	373.029	0	149.450	2	167.860	0	149.450	2	306.800	0	149.450	2	19.040	0
Woody wetland	16	277.309	2	277.309	2	16.260	0	277.309	2	277.309	2	277.309	2	277.309	2
Perennial ice/snow	17	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
Barley	100	0.040	2	0.040	2	0.040	2	0.040	2	0.040	2	0.040	2	0.040	2
Beans	101	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Canola	102	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Corn grain	103	–0.813	2	–0.813	2	–0.813	2	–0.813	2	–0.360	0	0.103	0	–0.813	2
Corn silage	104	–0.813	2	–0.813	2	–0.813	2	–0.813	2	–0.360	0	0.103	0	–0.813	2
Cotton	105	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Flaxseed	106	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Forage	107	–1.557	2	–1.557	2	–1.557	2	–1.557	2	–2.045	0	–1.557	2	–1.557	2
Hay	108	–2.380	2	–2.380	2	–2.380	2	–2.380	2	–2.380	2	–2.380	2	–2.380	2
Lentils	109	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Sorghum silage	110	–1.230	2	–1.230	2	–1.230	2	–1.230	2	–1.230	2	–1.230	2	–1.230	2
Oats	111	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Peanuts	112	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Peas	113	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Potatoes	114	0.983	2	0.983	2	0.983	2	0.983	2	2.677	0	0.983	2	0.983	2
Rice	115	253.773	2	253.773	2	253.773	2	253.773	2	253.773	2	253.773	2	253.773	2
Rye	116	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Safflower	117	–0.510	2	–0.510	2	–0.510	2	–0.510	2	–0.510	2	–0.510	2	–0.510	2
Sorghum	118	–1.230	2	–1.230	2	–1.230	2	–1.230	2	–1.230	2	–1.230	2	–1.230	2
Soybeans	119	–0.538	2	–0.538	2	–0.538	2	–0.538	2	–1.750	0	–0.010	0	–0.538	2
Sugarbeets	120	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Sugarcane	121	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Sunflowers	122	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Sweet corn	123	–0.545	2	–0.545	2	–0.545	2	–0.545	2	–0.545	2	–0.545	2	–0.545	2
Tobacco	124	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Tomatoes	125	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
Wheat durum	126	–1.055	2	–1.055	2	–1.055	2	–1.055	2	–1.626	0	–1.055	2	–1.055	2
Wheat, spring	127	–1.055	2	–1.055	2	–1.055	2	–1.055	2	–1.626	0	–1.055	2	–1.055	2
Wheat, winter	128	–1.055	2	–1.055	2	–1.055	2	–1.055	2	–1.626	0	–1.055	2	–1.055	2

Table A6–2. CH_4 emission factors by ecosystem and level II ecoregion.—Continued

[LC ID, land cover name and identification (U.S. Geological Survey Land Carbon Project designation for the purposes of the assessment). Values are in kilograms of nitrous oxide as nitrogen per hectare per year. Values in flag columns explain if mean is measured or surrogated: 0, measured, 1, assumed, 2, average of all measured value for the land cover type. Data are from the sources listed in the References Cited section of this appendix]

ER_84	Flag_84	ER_85	Flag_85	ER_92	Flag_92	ER_93	Flag_93	ER_94	Flag_94	ER_101	Flag_101	ER_102	Flag_102	ER_111	Flag_111
37.698	2	37.698	2	47.180	0	37.698	2	37.698	2	37.698	2	37.698	2	37.698	2
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
–1.182	2	–1.182	2	–1.182	2	–1.182	2	–0.663	0	–1.700	0	–1.182	2	–1.182	2
–11.895	0	–6.955	2	–6.955	2	–6.955	2	–6.955	2	–6.955	2	–6.955	2	–6.955	2
–2.770	2	–1.770	0	–2.770	2	–2.770	2	–2.770	2	–4.160	0	–2.770	2	–2.770	2
–3.245	2	–1.750	0	–3.583	0	–3.245	2	–3.245	2	–3.245	2	–3.245	2	–3.245	2
–1.833	2	–1.833	2	–1.635	0	–1.530	0	–2.107	0	–1.960	0	–1.833	2	–1.833	2
–2.670	2	–2.670	2	–2.670	2	–2.670	2	–2.670	2	–3.830	0	–2.670	2	–2.670	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.609	2	–0.609	2	–0.609	2	–2.145	0	0.928	0	–0.609	2	–0.609	2	–0.609	2
106.935	0	35.238	0	185.530	0	19.170	0	149.450	2	149.450	2	149.450	2	149.450	2
277.309	2	314.406	0	277.309	2	16.260	0	277.309	2	277.309	2	277.309	2	277.309	2
0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1	0.001	1
0.040	2	0.040	2	0.040	2	0.040	2	0.040	0	0.040	2	0.040	2	0.040	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.813	2	–0.813	2	–0.343	0	–0.890	0	–2.575	0	–0.813	2	–0.813	2	–0.813	2
–0.813	2	–0.813	2	–0.343	0	–0.890	0	–2.575	0	–0.813	2	–0.813	2	–0.813	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–1.557	2	–1.557	2	–0.245	0	–1.557	2	–2.380	0	–1.557	2	–1.557	2	–1.557	2
–2.380	2	–2.380	2	–2.380	2	–2.380	2	–2.380	0	–2.380	2	–2.380	2	–2.380	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–1.230	2	–1.230	2	–1.230	2	–1.230	2	–1.230	0	–1.230	2	–1.230	2	–1.230	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
0.983	2	0.983	2	0.983	2	0.983	2	0.983	2	–0.710	0	0.983	2	0.983	2
253.773	2	321.390	0	253.773	2	253.773	2	253.773	2	253.773	2	253.773	2	186.155	0
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.510	2	–0.510	2	–0.510	2	–0.510	0	–0.510	2	–0.510	2	–0.510	2	–0.510	2
–1.230	2	–1.230	2	–1.230	2	–1.230	2	–1.230	0	–1.230	2	–1.230	2	–1.230	2
–0.538	2	–0.538	2	0.148	0	–0.538	2	–0.538	2	–0.538	2	–0.538	2	–0.538	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.545	2	–0.545	2	–0.545	2	–0.545	2	–0.545	2	–0.545	0	–0.545	2	–0.545	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2	–0.571	2
–1.055	2	–1.055	2	–0.675	0	–0.330	0	–1.588	0	–1.055	2	–1.055	2	–1.055	2
–1.055	2	–1.055	2	–0.675	0	–0.330	0	–1.588	0	–1.055	2	–1.055	2	–1.055	2
–1.055	2	–1.055	2	–0.675	0	–0.330	0	–1.588	0	–1.055	2	–1.055	2	–1.055	2

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