Annex G

Methodology for Estimating Methane Emissions from Enteric Fermentation

Step 1: Collect Livestock Population Data

All livestock population data, except for horses, was taken from U.S. Department of Agriculture (USDA) statistical reports. For each animal category, the USDA publishes monthly, annual, and multi-year livestock population and production estimates. Multi-year reports include revision to earlier published data. Recent reports were obtained from the USDA Economics and Statistics System website, at <http://www.mannlib.cornell.edu/usda/>, while historical data were downloaded from the USDA-National Agricultural Statistics Service (NASS) website at <http://www.usda.gov/nass/pubs/dataprd1.htm>.

The Food and Agriculture Organization (FAO) publish horse population data. These data were accessed from the FAOSTAT database at <http://apps.fao.org/>. Table G-1 summarizes the published population data by animal type.

Step 2: Estimate Emission Factors for Dairy Cows

Regional dairy cow emission factors from the 1993 Report to Congress (EPA 1993) were used as the starting point for the analysis. These emission factors were used to calibrate a model of methane emissions from dairy cows. The model applies revised regional emission factors that reflect changes in milk production per cow over time. Increases in milk production per cow, in theory, require increases in feed intake, which lead to higher methane emissions per cow. Table G-2 presents the emission factors per head by region used for dairy cows and milk production. The regional definitions are from EPA (1993).

Step 3: Estimate Methane Emissions from Dairy Cattle

Dairy cow emissions for each state were estimated by multiplying the published state populations by the regional emission factors, as calculated in Step 2. Dairy replacement emissions were estimated by multiplying national replacement populations by a national emission factor. The USDA reported the number of replacements 12 to 24 months old as "milk heifers." It is assumed that the number of dairy cow replacements 0 to 12 months old was equivalent to the number 12 to 24 months old replacements.

Step 4: Estimate Methane Emissions from Beef Cattle

Beef cattle methane emissions were estimated by multiplying published cattle populations by emission factors. Emissions from beef cows and replacements were estimated using state population data and regional emission developed in EPA (1993), as shown in Table G-3. Emissions from slaughter cattle and bulls were estimated using national data and emission factors. The emission factors for slaughter animals represent their entire life, from birth to slaughter. Consequently, the emission factors were multiplied by the national data on total steer and heifer slaughters rather than live populations of calves, heifers, and steers grown for slaughter. Slaughter population numbers were taken from and USDA datasets. The Weanling and Yearling mix was unchanged from earlier estimates derived from discussions with industry representatives.

Step 5: Estimate Methane Emissions from Other Livestock

Methane emissions from sheep, goats, swine, and horses were estimated by multiplying published national population estimates by the national emission factor for each year.

A summary of emissions is provided in Table G-4. Emission factors, national average or regional, are shown by animal type in Table G-5.

Table G-1: Livestock Population (thousand head)

Animal Type	1990	1991	1992	1993	1994	1995	1996
Dairy							
Cows	10,007	9,883	9,714	9,679	9,514	9,494	9,409
Replacements 0-12	4,135	4,097	4,116	4,088	4,072	4,021	3,902
Replacements 12-24	4,135	4,097	4,116	4,088	4,072	4,021	3,902
Beef							
Cows	32,677	32,960	33,453	34,132	35,325	35,628	35,414
Replacements 0-12	5,141	5,321	5,621	5,896	6,133	6,087	5,839
Replacements 12-24	5,141	5,321	5,621	5,896	6,133	6,087	5,839
Slaughter-Weanlings	5,199	5,160	5,150	5,198	5,408	5,612	5,580
Slaughter-Yearlings	20,794	20,639	20,600	20,794	21,632	22,450	22,322
Bulls	2,180	2,198	2,220	2,239	2,304	2,395	2,346
Other							
Sheep	11,356	11,174	10,797	10,201	9,742	8,886	8,454
Goats	2,545	2,475	2,645	2,605	2,595	2,495	2,495
Horses	5215	5650	5650	5850	5900	6000	6,000
Hogs	54,014	56,478	58,532	57,999	60,018	59,792	56,716

Table G-2: Dairy Cow Emission Factors and Milk Production Per Cow

Region	1990	1991	1992	1993	1994	1995	1996
Dairy Cow Emission Factors (kg/head)							
North Atlantic	116.2	118.8	121.3	121.0	122.3	124.7	124.8
South Atlantic	127.7	128.7	132.3	132.2	134.5	134.4	132.9
North Central	105.0	105.7	107.8	107.6	109.8	111.2	110.0
South Central	116.2	116.1	117.9	119.2	121.1	122.2	120.9
West	130.4	129.4	132.7	132.3	135.6	134.8	137.3
Milk Production (kg/year)							
North Atlantic	6,574	6,811	7,090	7,055	7,185	7,424	7,440
South Atlantic	6,214	6,300	6,622	6,608	6,813	6,792	6,673
North Central	6,334	6,413	6,640	6,627	6,862	6,987	6,881
South Central	5,696	5,687	5,849	5,971	6,148	6,248	6,128
West	8,339	8,255	8,573	8,530	8,874	8,789	9,047

Table G-3: Emission factors Beef Cows and Replacements (kg/head/yr)

Region	Replacements (0-12)	Replacements (12-24)	Mature Cows
North Atlantic	19.2	63.8	61.5
South Atlantic	22.7	67.5	70.0
North Central	20.4	60.8	59.5
South Central	23.6	67.7	70.9
West	22.7	64.8	69.1

Table G-4: Emissions from Livestock Enteric Fermentation (Tg)

Animal Type	1990	1991	1992	1993	1994	1995	1996
Dairy	1.47	1.46	1.47	1.47	1.47	1.47	1.46
Cows	1.15	1.14	1.15	1.15	1.15	1.16	1.15
Replacements 0-12	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Replacements 12-24	0.24	0.24	0.24	0.24	0.24	0.24	0.23
Beef	3.95	3.98	4.04	4.12	4.27	4.34	4.29
Cows	2.18	2.20	2.23	2.28	2.36	2.38	2.36
Replacements 0-12	0.11	0.12	0.13	0.13	0.14	0.14	0.13
Replacements 12-24	0.33	0.35	0.37	0.38	0.40	0.40	0.38
Slaughter-Weanlings	0.12	0.12	0.12	0.12	0.12	0.13	0.13
Slaughter-Yearlings	0.98	0.98	0.97	0.98	1.02	1.06	1.06
Bulls	0.22	0.22	0.22	0.22	0.23	0.24	0.23
Other	0.28	0.29	0.29	0.29	0.29	0.28	0.27
Sheep	0.09	0.09	0.09	0.08	0.08	0.07	0.07
Goats	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Horses	0.09	0.10	0.10	0.11	0.11	0.11	0.11
Hogs	0.08	0.08	0.09	0.09	0.09	0.09	0.09
Total	**5.70**	**5.73**	**5.80**	**5.88**	**6.03**	**6.10**	**6.02**

Table G-5: Enteric Fermentation Emission Factors

Animal Type	kg/head/year
Dairy	
Cows	regional
Replacements 0-12	19.6
Replacements 12-24	58.8
Beef	
Cows	regional
Replacements 0-12	regional
Replacements 12-24	regional
Slaughter-Weanlings	23.1
Slaughter-Yearlings	47.3
Bulls	100.0
Other	
Sheep	8.0
Goats	5.0
Horses	18.0
Hogs	1.5