US EPA Cattle Enteric Fermentation Model (CEFM)

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April 30, 2003

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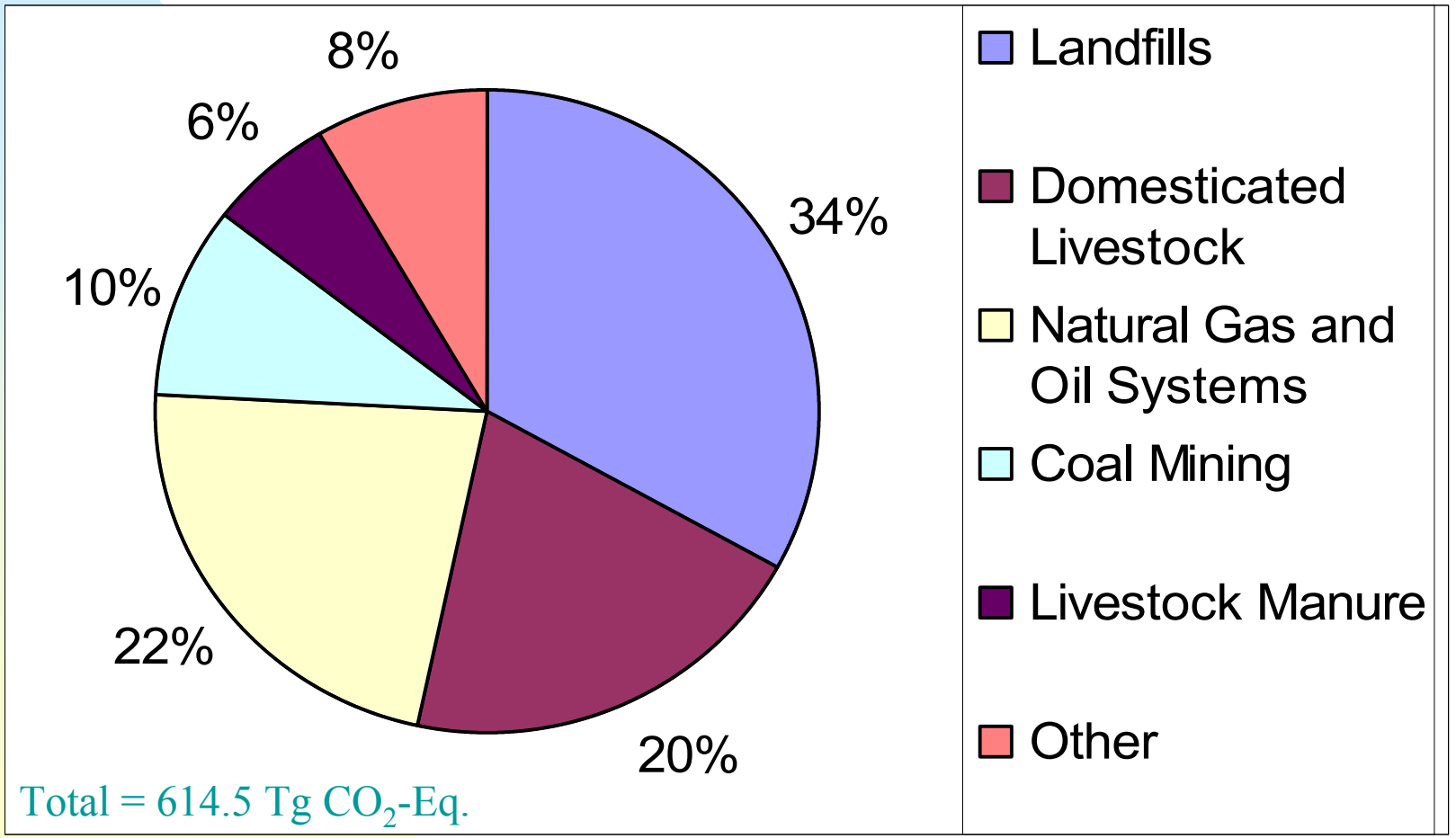
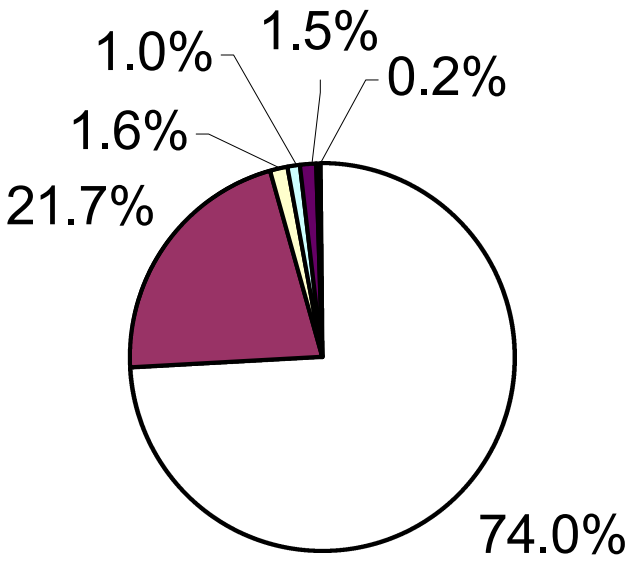
2000 US Methane Emissions (Tg CO_2-Equiv.)



Enteric Fermentation Methane Emissions (2000)



Total Enteric = 123.9 Tg CO_2-Eq

Basic IPCC Tier 2 Enteric Calculation

- Emissions = EF X population
- EF = (GE x Y_m) / (55.65 MJ/Kg CH4)
- population: subcategorized by species
- GE = gross energy intake, derived from net energy equations in IPCC Guidelines
- Y_m = methane conversion rate as % of GE, affected by feed type and animal

Steps in Tier 2 Enteric Inventory

- Subcategorize national livestock population
- Develop gross energy estimate (MJ/day) for each animal subcategory
- Gross energy calculation requires performance data on each animal subcategory and feed data
- Agriculture experts needed to develop many of the inputs

Cattle Population Subcategories

Calves < 500 lbs.
Replacement Beef Heifers (7-23 months)
Replacement dairy Heifers (7-23months)
Other Heifers (7-23 months)
Steers (7-23 months)
On Feed (Heifers + Steers)
Dairy Cows
Beef Cows

Inputs for Animal and Feed Modeling in Tier 2

- Live-weight
- Average weight gain per day
- Mature weight
- Average number of hours worked per day
- Feeding situation
- Average milk production per day
- Fat content of milk
- Percent of females that give birth/year
- Feed digestibility
- Methane conversion rates

EPA Refinement of IPCC Tier 2 Calculation

- Cohorts of cattle subspecies are tracked through the year
- Livestock performance data (e.g., weight gain) are linked to growth stage of animal
- Emissions calculated on a monthly-basis
- Country-specific digestible energy and methane conversion rates

Key Processing Steps in the CEFM

- Build the cattle population matrix
- Diet Characterizations
  - Digestible energy values
  - Methane conversion rates (Y_m)
- Calculate emissions based on IPCC energy equations

Attachment 1 - List of all Worksheets in Model	
Worksheet	**Purpose**
Summary	Summary sheets that pull key information for use in the US Greenhouse Gas Inventory
Summary2	
Summary3-other livestock	
Initial Conditions	Extracts annual input sheet for the year being run
Beef Rep Heif Wgt	Tracks weight and weight gain by month for each subcategory
Dairy Rep Heif Wgt	
Other Steer Wgt	
Other Heif Wgt	
Calf Supply	Tracks calf supply accounting for death and slaughter
Repl Beef Heif D_S	Replacement heifer demand this year
Repl Dairy Heif D_S	
Other Heif D_S	Calculates the feedlot placement supply
Other Steer D_S	
Steer Stockers	Available supply of stockers for backgrounding and feedlot placement after subtracting all replacements and those for stock at beginning of next year
Heifer Stockers	
Combined Stockers	
Steer Feedlot	Tracks animal weight and weight gain while on step up and finishing diets
Heifer Feedlot	
Cow Pop	Used to back calculate beef and dairy death loss
1999	Annual input sheets
DressedSlaughterWeight	Average dressed slaughter weight for all years is calculated for use in 1989-1992 where data is not available
Cattle Marketed	Average of the number of cattle marketed at <1000 and 1000+ head feedlots for each year available
Placements	Feedlot placement statistics for each year available
Slaughter	Calculates scaling factors of number placed in feedlots and number slaughtered
BeefBirths	Calculates beef births by month based on available data
Assumptions	Summarizes death loss, cattle weights, and weight class definitions used in model
Livestock Summary	Summarizes emissions by subcategory and year
Compare New-Old	Compares output from current model with old methodology from 1990-1998
Emissions Summary	Summarizes the output from each year by subcategorey and region
Emissions Engine	Drives the model to run specified years and outputs
Pop Summary	Summarizes the cattle population by sub-category and year
DEandYm	Shows the DE and Ym for the year being run
Pregnant	Estimates the percentage of cows pregnant by month
Beef Lactation	Calculates the weighted average of beef milk production

Example DE & Ym values

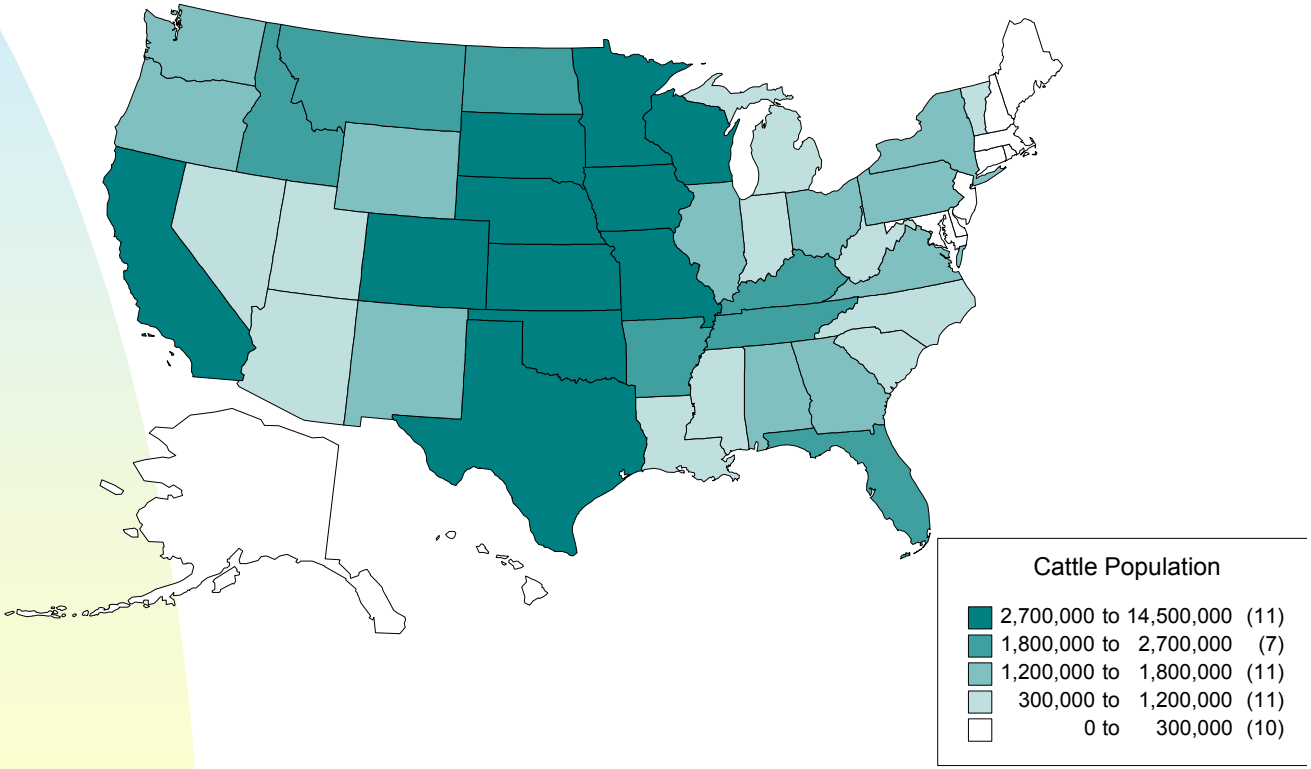
- Grazing cattle
  - DE = 62%
  - Y_m = 6.5%

  ⟹ Primarily pasture with some supplements
- Dairy cows
  - DE = 69%
  - Y_m = 5.7%

  ⟹ Pasture, concentrates, and mixed diets
- Feedlot Cattle
  - DE = 85%
  - Y_m = 3.0%

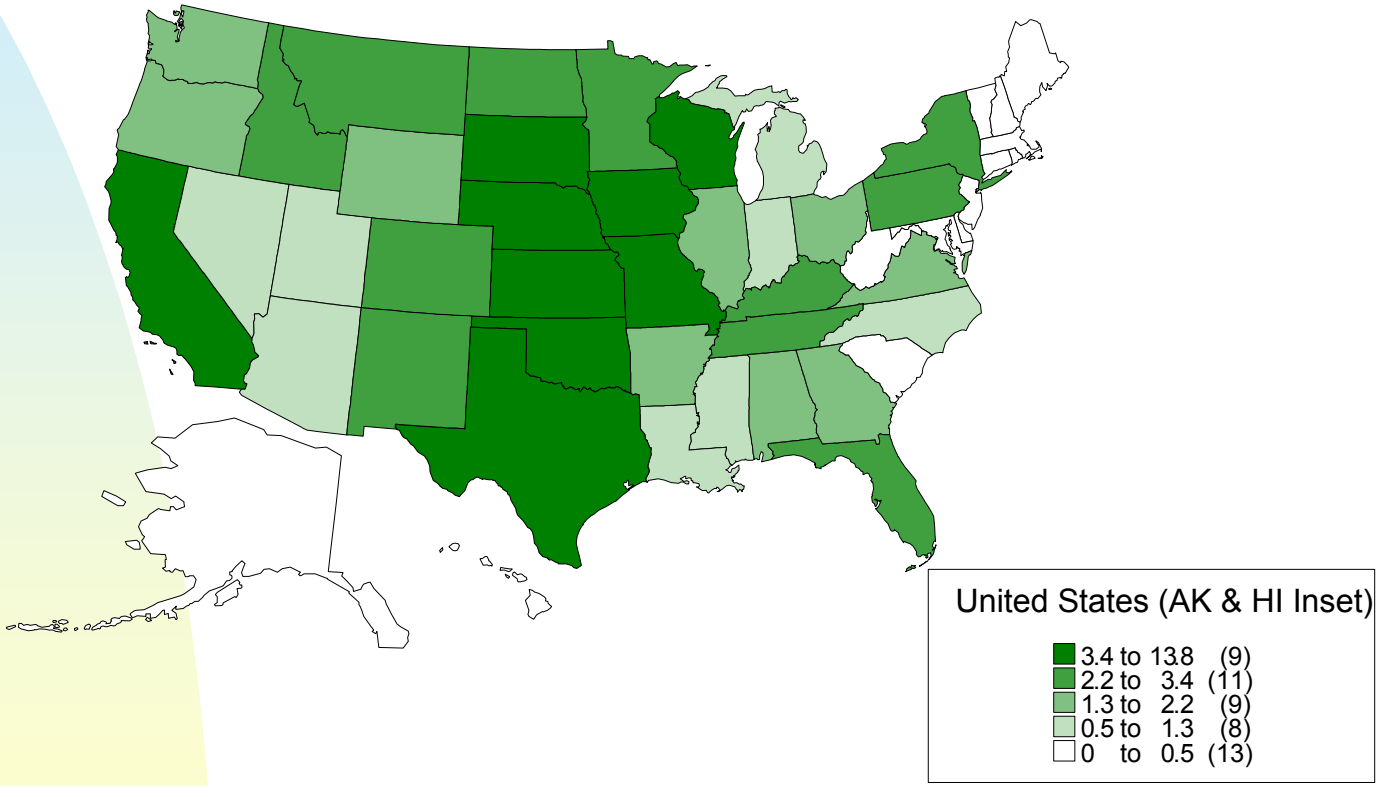
  ⟹ Step-up and finishing diets

US Cattle Populations -2001

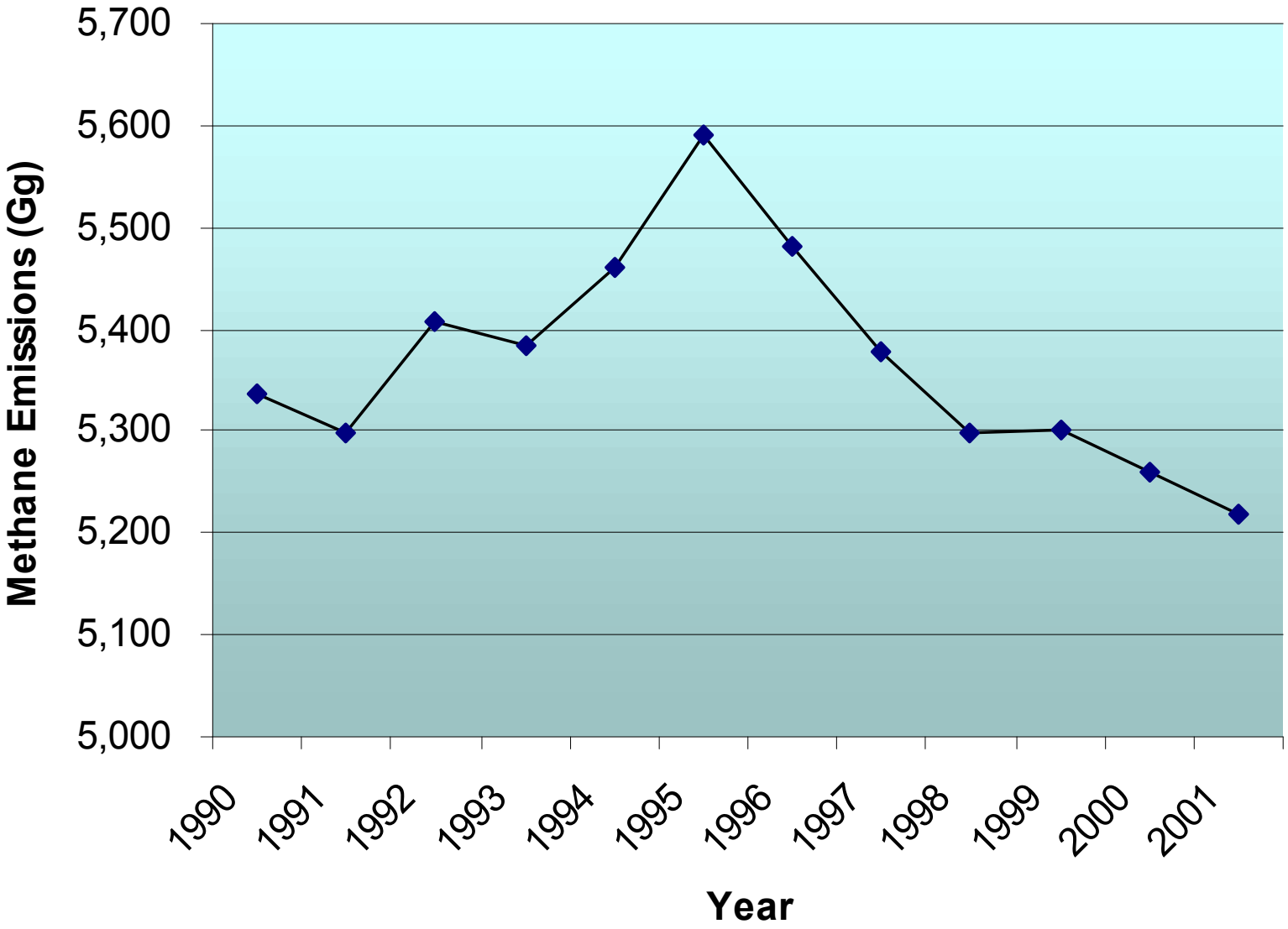


Source: USDA, 2002

Methane Emissions from Cattle Enteric Fermentation - 2001



Cattle Enteric Methane Emissions 1990 - 2001



Direct Measurement Data for Enteric Emissions

- Measurements for validation and new EF development
- Calorimeter chambers (basis for some of current default EFs)
- SF-6 Tracer gas technique
  - Field tested in US, Canada, Australia, South America
- Head-box chambers
  - ILRI research in Africa

CEFM results

- 6% increase in annual methane emissions as compared to previous method
- Current emission trends reflect decreasing populations and improved feeds/productivity
- Allows user to model changes in the cattle production industry
- Now using model output on waste energy production to estimate manure production

What's next?

- Evaluate uncertainties in Y_m
- Modeling regional and local variations in feed and feed management practices
- How to project improvements in feeds/management practices on methane impact
- Compare/validate CEFM results to direct measurement results