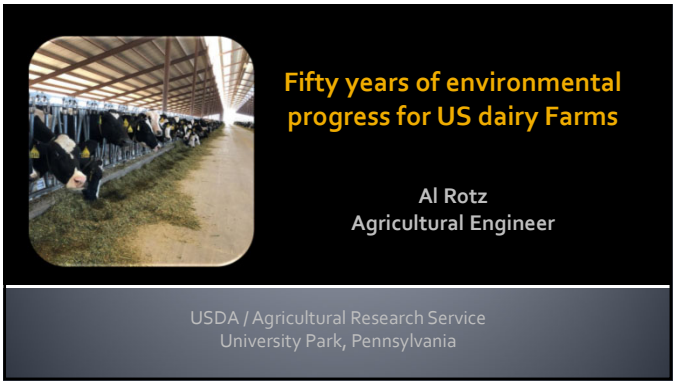
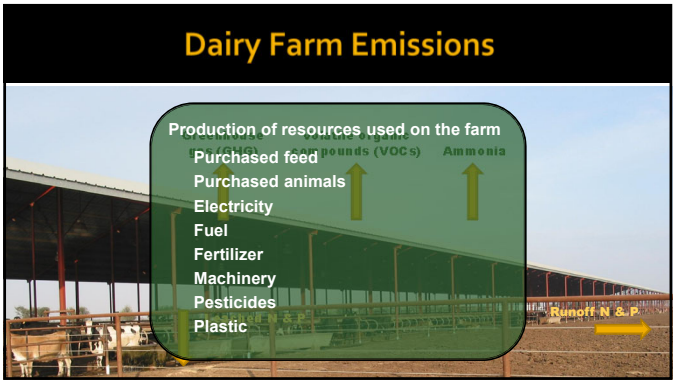

Fifty years of environmental progress for US dairy Farms
Al Rotz
Agricultural Engineer
USDA / Agricultural Research Service
University Park, Pennsylvania

1


Environmental Sustainability

2

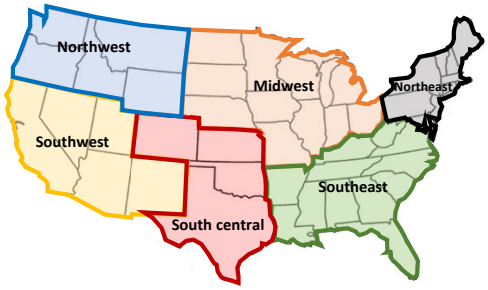

Dairy Farm Emissions
Production of resources used on the farm
Purchased feed
Purchased animals
Electricity
Fuel
Fertilizer
Machinery
Pesticides
Plastic
Ammonia
Runoff N & P

3

Current Dairy Farms

4

Regions of the US



5

General Procedure

- Learn the production practices used in each region through National Agricultural Statistic Service (NASS) data, survey data, interviews, farm visits and other information sources
- Model 20 representative operations in each region of various types and sizes using weather and soil data for the location
- Assess the environmental impacts of each farm including a cradle to farm gate life cycle assessment

6

National Analysis

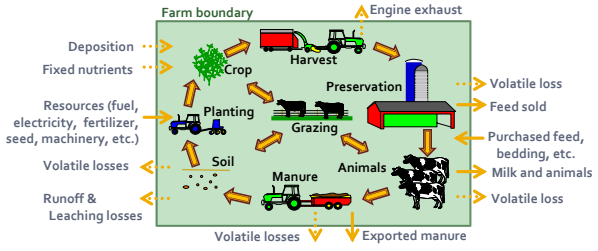
- From NASS data, milk production was determined for each state of each region
- State level impacts were determined as the sum of the "footprints" for each farm times the portion of the milk produced by that farm type
- Regional and national totals were determined as the total of state impacts times the milk produced in each state

7

Integrated Farm System Model

8

Process-Level Simulation



9

Emissions and Nutrient Losses

- Methane
- Nitrous oxide
- Carbon dioxide
- Non-methane VOC emissions
- Ammonia
- Nitrate leaching
- Nitrogen runoff
- Soluble P runoff
- Sediment P runoff

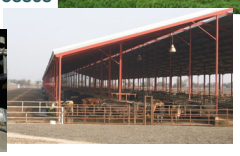
10

Life Cycle Assessment

11

Environmental Footprints

- Greenhouse gas (CH_4, N_2O, CO_2) emissions
- Fossil energy use
- Blue (non-precipitation) water use
- Reactive nitrogen (NH_3, NO_3, N_2O, NOx) losses



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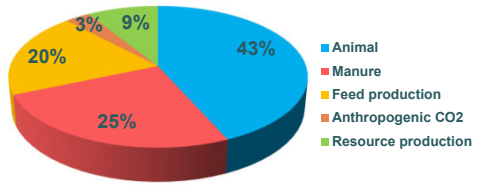
Greenhouse Gas Emission

1.01 ± 0.09 lb CO_2e / lb FPCM



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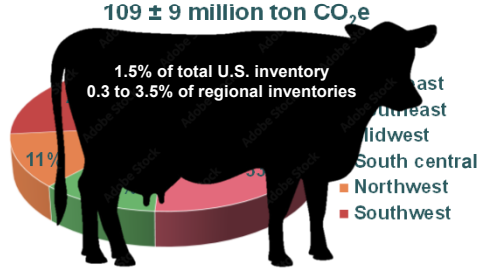
Greenhouse Gas Emission

109 ± 9 million ton CO_2e



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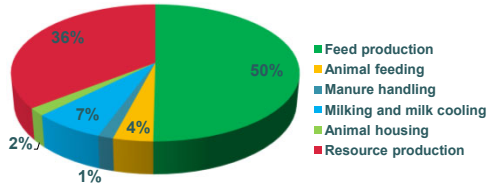
Fossil Energy Use

0.3 ± 0.05 kWh / lb FPCM



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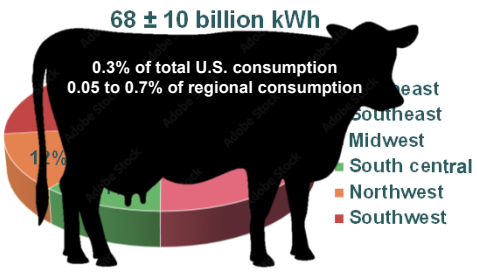
Fossil Energy Use



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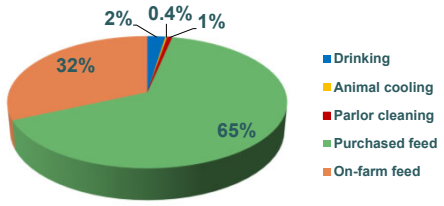
Blue Water Consumption

9.6 ± 2 gallons H_2O / lb FPCM



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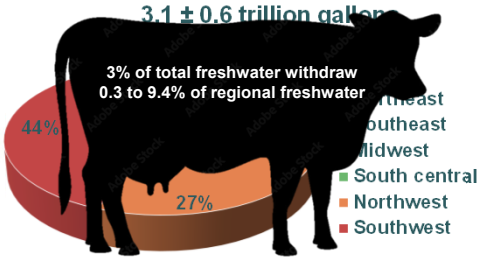
Blue Water Consumption



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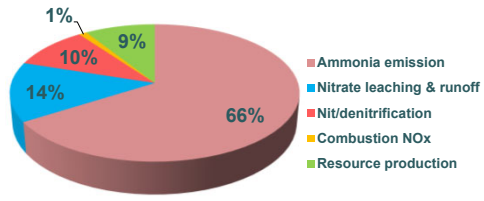
Reactive N Footprint

20 ± 2.8 lb N / ton FPCM



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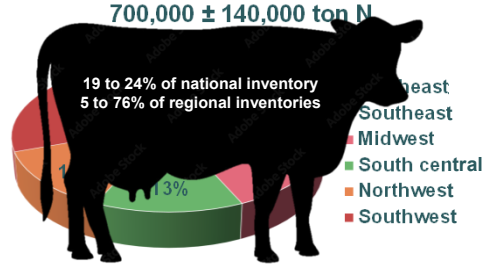
Ammonia Emission

700,000 ± 140,000 ton N



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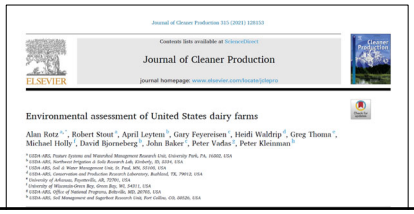
Take Home

Dairy farms have a relatively small impact on national inventories of greenhouse gas emission, fossil energy use, and water consumption; ammonia emission may be of greater concern to long-term sustainability


Journal of Cleaner Production

Environmental assessment of United States dairy farms

21

1970 vs. 2020 Dairy Farms

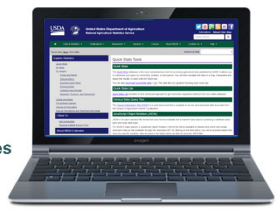
22

50 Years of Change

23

Available Information

- Milk production
- Milk yield per cow
- Cow numbers
- Primary dairy counties
- Farm size distribution
- Primary crops grown in the dairy counties
- Crop yields
- Animal mortality and replacement rates
- Weather and soils information for the predominate dairy counties



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Interview Information

- Housing facilities used
- Associated manure handling practices
- Percentage of non-Holstein cattle used
- Grazing practices
- Common tillage practices
- Feed crops commonly grown on farms
- Inorganic fertilizer and lime use
- Irrigation use (type and amount)

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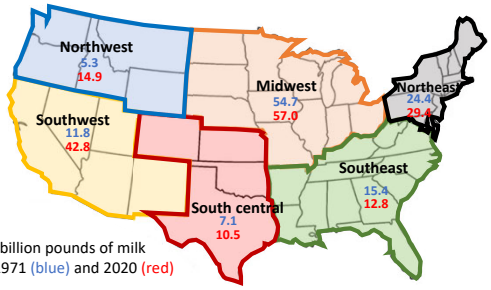
National Assessment



Numbers are billion pounds of milk produced in 1971 (blue) and 2020 (red)

26

50 Year Change, %

	Eastern regions	Western regions	National
Cows	-49	103	-21
Milk yield	139	121	138
FPCM yield	150	132	149
FPCM	27	372	97

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50 Year Change, %

	Eastern regions	Western regions	National
Cows	-49	103	-21
Milk yield	139	121	138
FPCM yield	150	132	149
FPCM	27	372	97
Forage consumed	-32	133	-3
Concentrate feed	-9	293	50
Total feed consumed	-25	187	14

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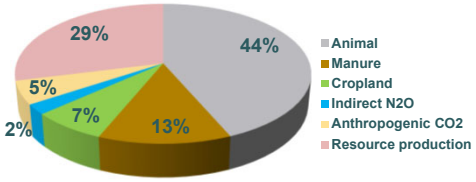
Milk Carbon Footprint

1.7 lb CO_2e / lb FPCM
Regions: 1.6 to 2.0
Production systems: 1.3 to 2.3



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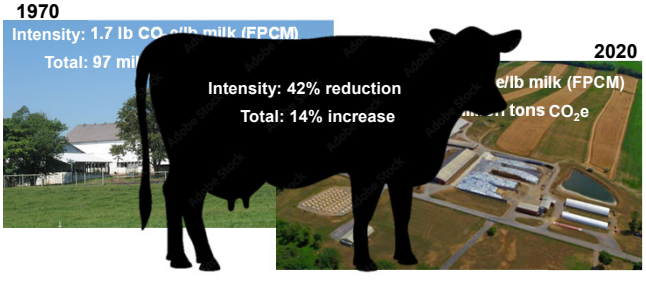
Greenhouse Gas Emissions



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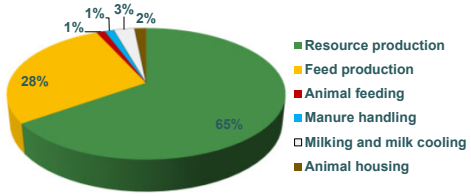
Fossil Energy Use

0.7 kWh / lb FPCM
Regions: 0.6 to 0.8
Production systems: 0.3 to 1.1



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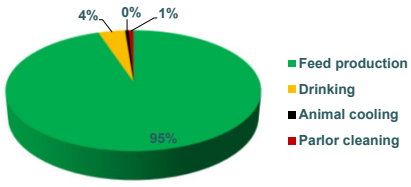
Fossil Energy Use

32

Water Consumption

13.5 gallons / lb FPCM
Regions: 4 to 69
Production systems: 3 to 96



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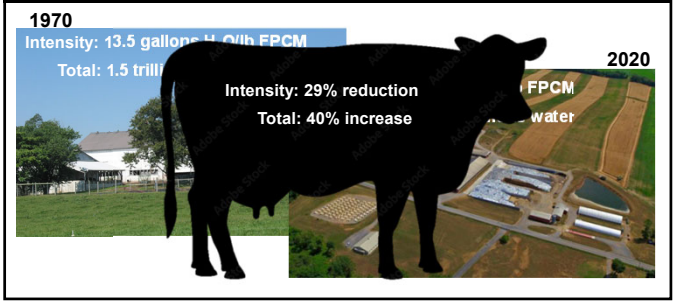
Water Consumption



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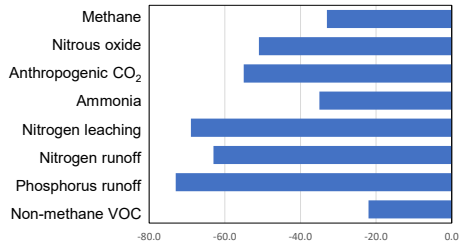
Change in Intensity, %



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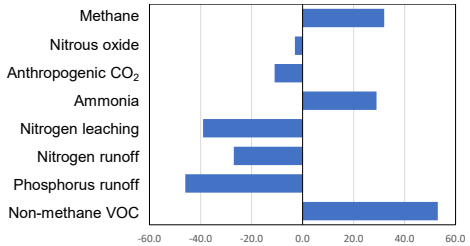
Change in Total, %



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Reduction in Intensity, %

	Eastern regions	Western regions	National
Methane	32	32	33
Nitrous oxide	55	62	51
Anthropogenic CO_2	52	50	55
Ammonia	41	43	35
Leached N	58	79	69
Runoff N	59	63	63
Non-methane VOC	1	52	22
Soluble P runoff	58	59	64
Sediment P runoff	70	68	75
Surplus P	84	88	86

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Total Reduction, %

	Eastern regions	Western regions	National
Methane	13	-220	-32
Nitrous oxide	42	-78	3
Anthropogenic CO_2	39	-136	11
Ammonia	24	-171	-29
Leached N	47	2	39
Runoff N	47	-73	27
Non-methane VOC	-26	-125	-53
Soluble P runoff	47	-95	28
Sediment P runoff	62	-53	51
Surplus P	79	42	72

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Take Home

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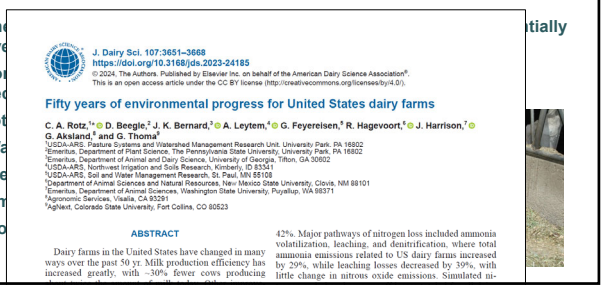

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Fifty years of environmental progress for United States dairy farms

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ABSTRACT

Dairy farms in the United States have changed in many ways over the past 50 yr. Milk production efficiency has increased greatly, with ~30% fewer cows producing

42%. Major pathways of nitrogen loss included ammonia volatilization, leaching, and denitrification, where total ammonia emissions related to US dairy farms increased by 29%, while leaching losses decreased by 39%, with little change in nitrous oxide emissions. Simulated nit-

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Mitigation Strategies

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USDA

Agricultural Research Service

Pasture Systems and Watershed Management Research Unit

University Park, Pennsylvania

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