Ammonia Emissions from Open Lot Beef Cattle Feedyards on the Southern High Plains

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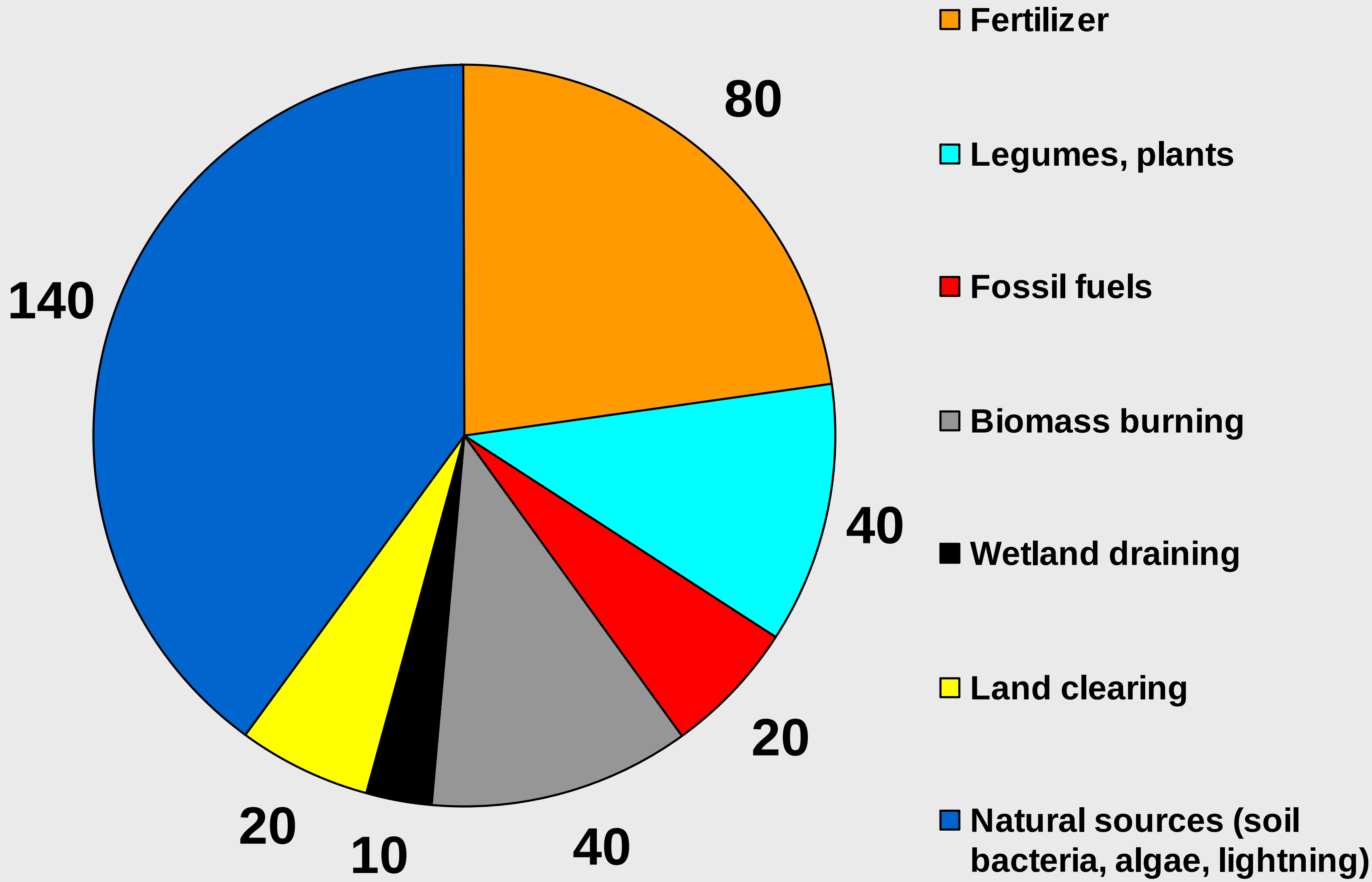
Global Sources of Reactive N
Annual release, TG of N

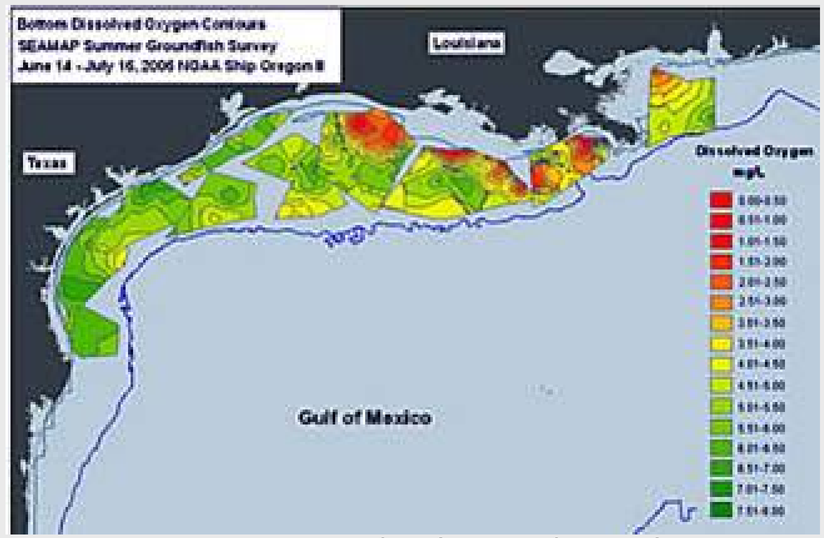


Vitousek et al. (1997)

Reactive Nitrogen Impacts Ocean Life

Hypoxic bottom zone in Gulf
caused by excessive fertilization.

www.cop.noaa.gov/stressors/extremeevents/
hab/features/hypoxiafs_report1206.html



www.noaanews.noaa.gov/stories2006/s2755.htm

Reactive Nitrogen Impacts Surface Waters

Eutrophication of fresh and coastal waters - toxic algal blooms, low oxygen, fish kills, and loss of species diversity.

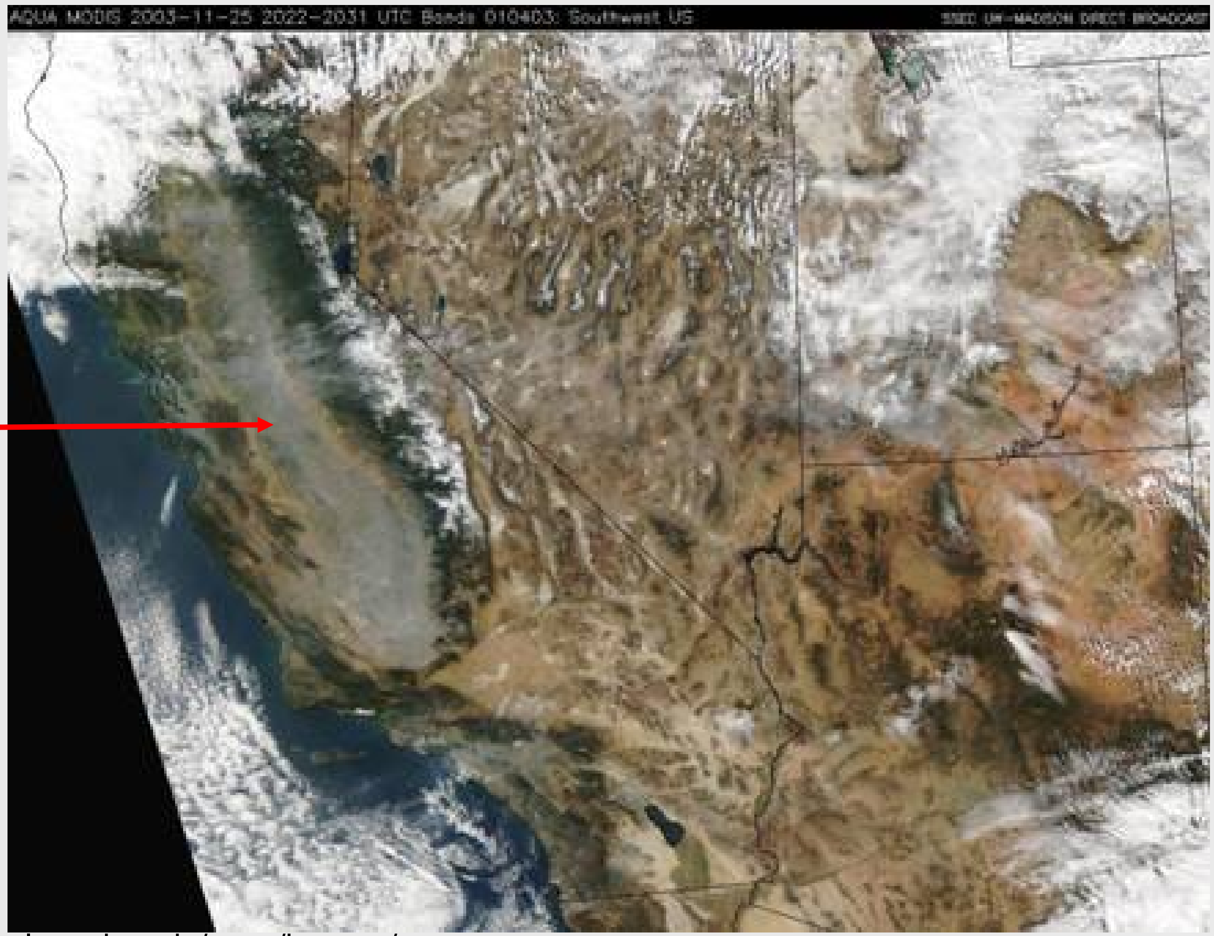
Algae bloom, Florida
www.marietta.edu/~biol/biomes/mangroves.htm

Microcystis bloom in Matilda Bay, Australia
www.ga.gov.au/ozestuaries/indicators/freq_alagal_blooms.jsp

Reactive Nitrogen Impacts Air Quality

Respirable particulates that degrade visibility and can cause respiratory problems form when ammonia emitted from animal agriculture reacts with urban pollution.

Particulate haze over California's Central Valley



alg.umbc.edu/usaq/images/
2003-11-25_2022-2031_USSW_010403_HKM.jpg

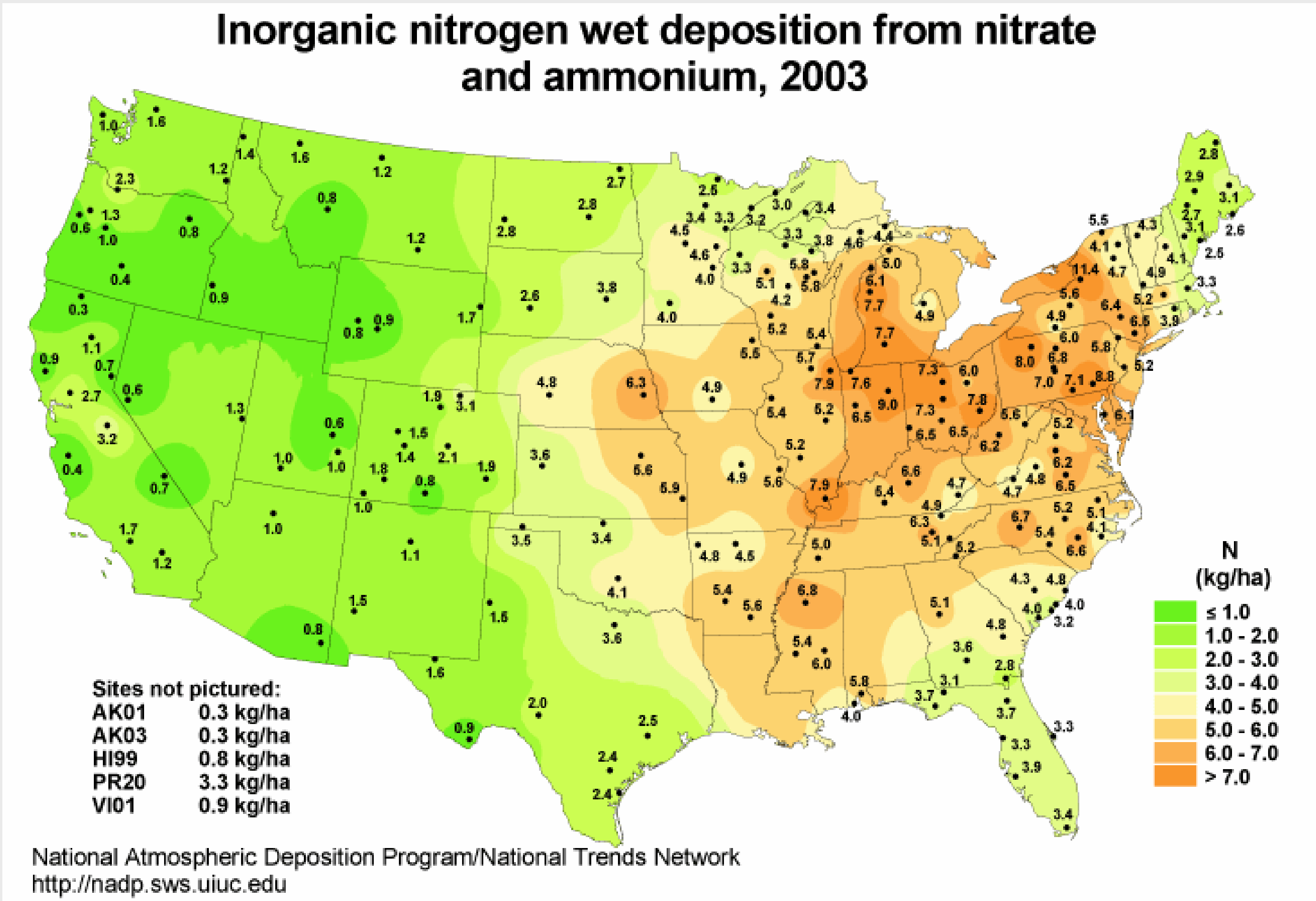
Reactive Nitrogen Impacts Terrestrial Ecosystems

www.scienceclarified.com/images/uesc_01_img0005.jpg

Loss of species diversity in N-sensitive ecosystems from overfertilization or acid rain.

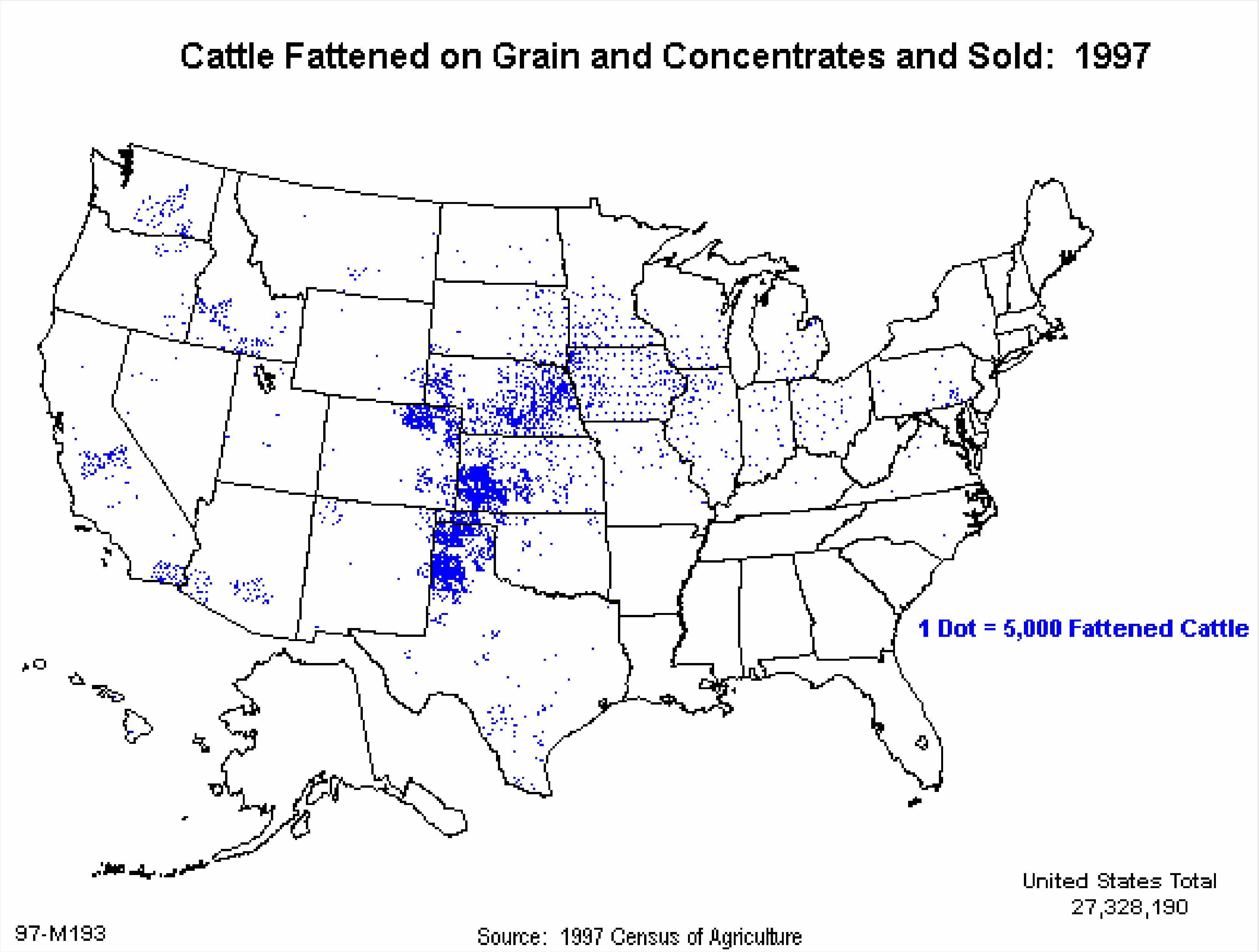
Trees killed by acid rain in the Great Smoky Mountains.

N Deposition in the US, 2003

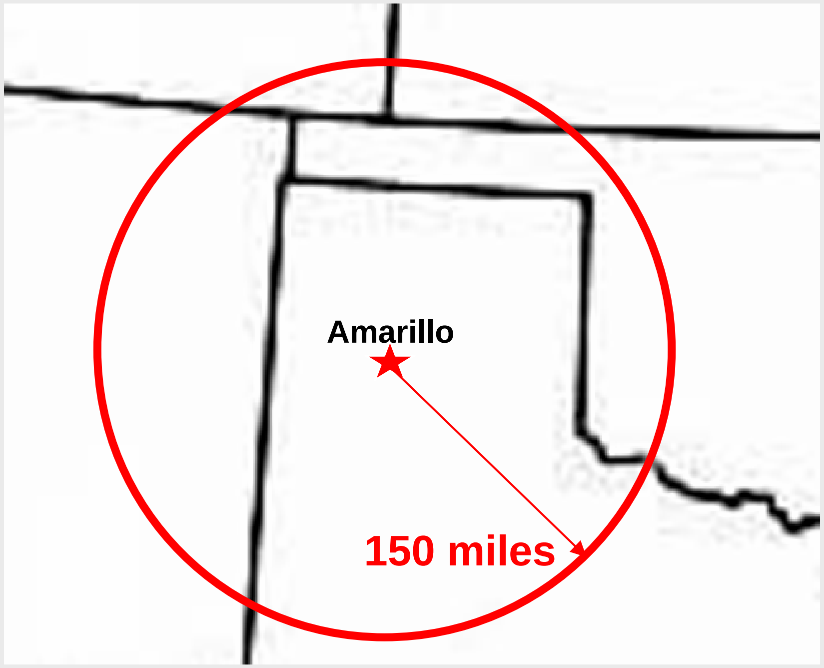


National Atmospheric Deposition Program:
http://nadp.sws.uiuc.edu/isopleths/maps2003/ndep.gif

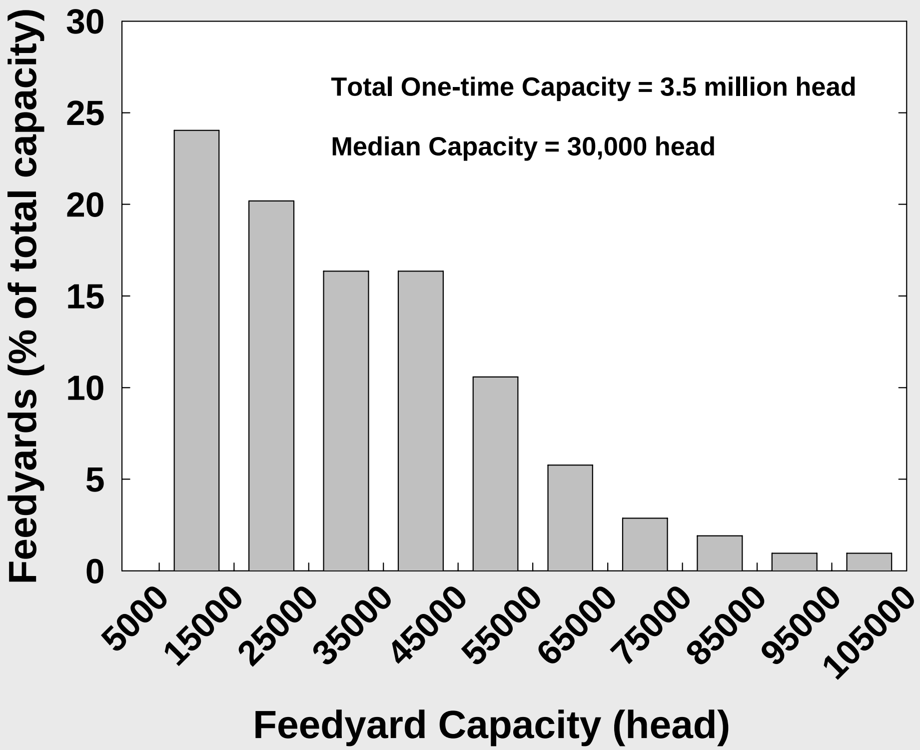
Distribution of fed cattle in the US



Texas Panhandle –
Center of the fed cattle industry



- More than 7 million fed annually
- 1/3 of U.S. fed cattle

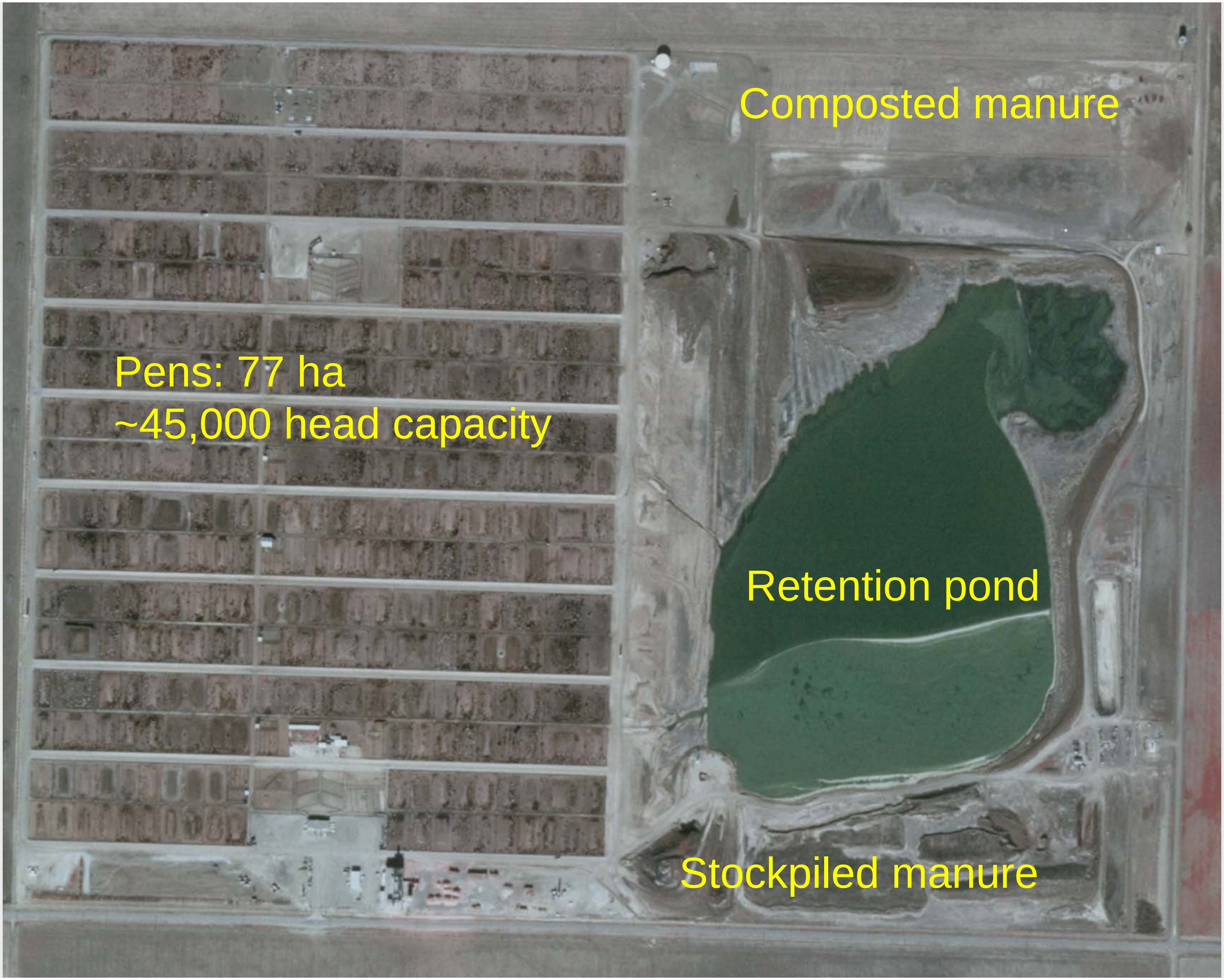


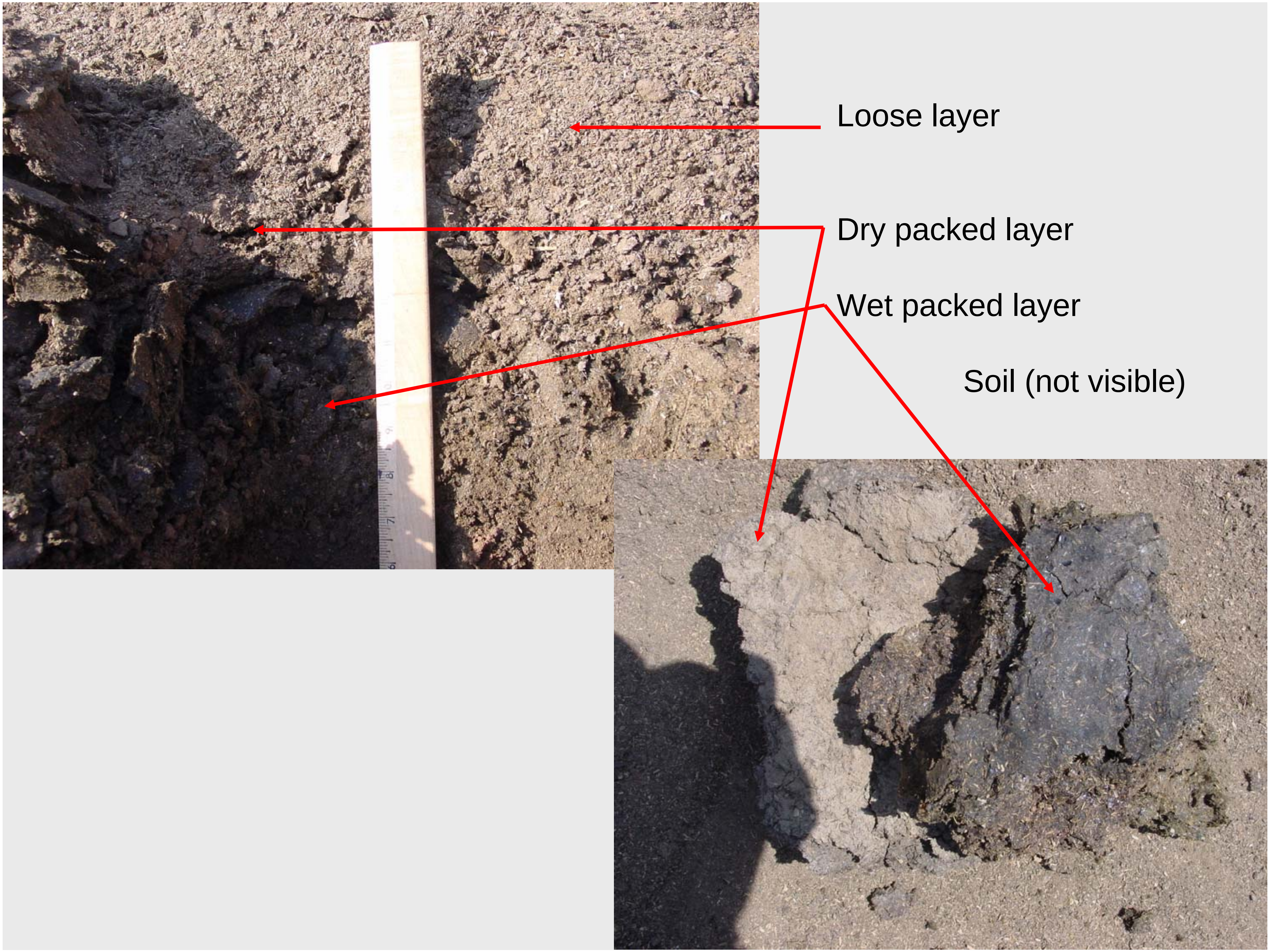
Objectives

Quantify ammonia emissions from a beef cattle feedyard using Windtrax[†], a Backward Lagrangian Stochastic (BLS) dispersion model.

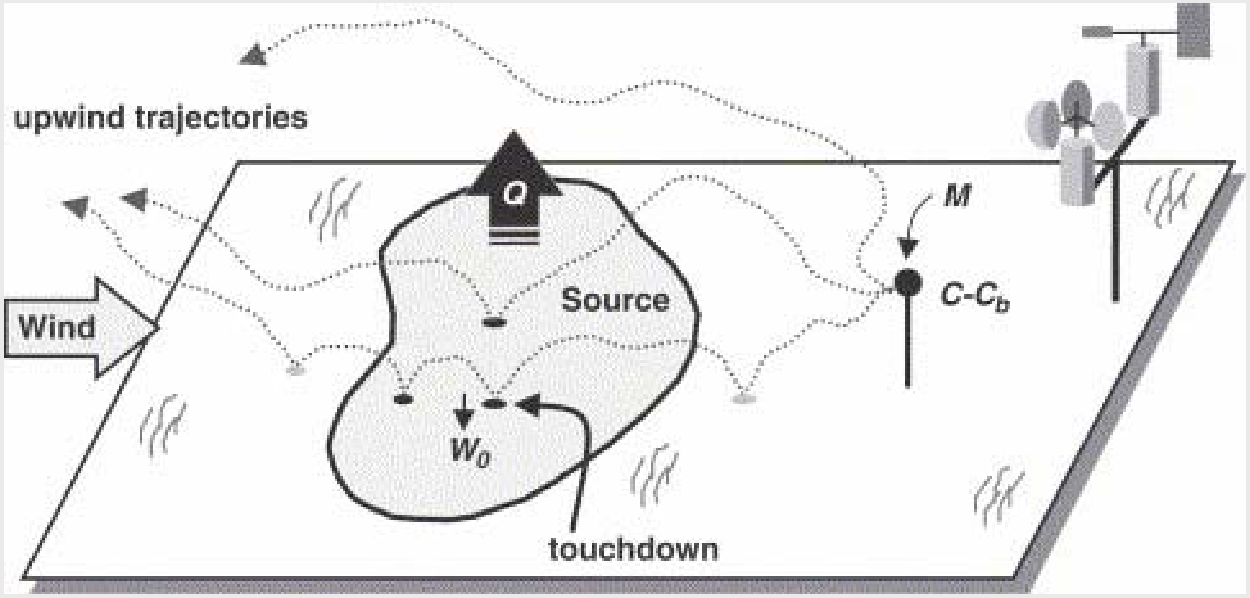
Determine ammonia emission factors for the feedyard.

[†] Mention of trade or manufacturer manes is made for information only and does not imply endorsement, recommendation, or exclusion by USDA-ARS.


Composted manure
Pens: 77 ha
~45,000 head capacity
Retention pond
Stockpiled manure


Loose layer
Dry packed layer
Wet packed layer
Soil (not visible)

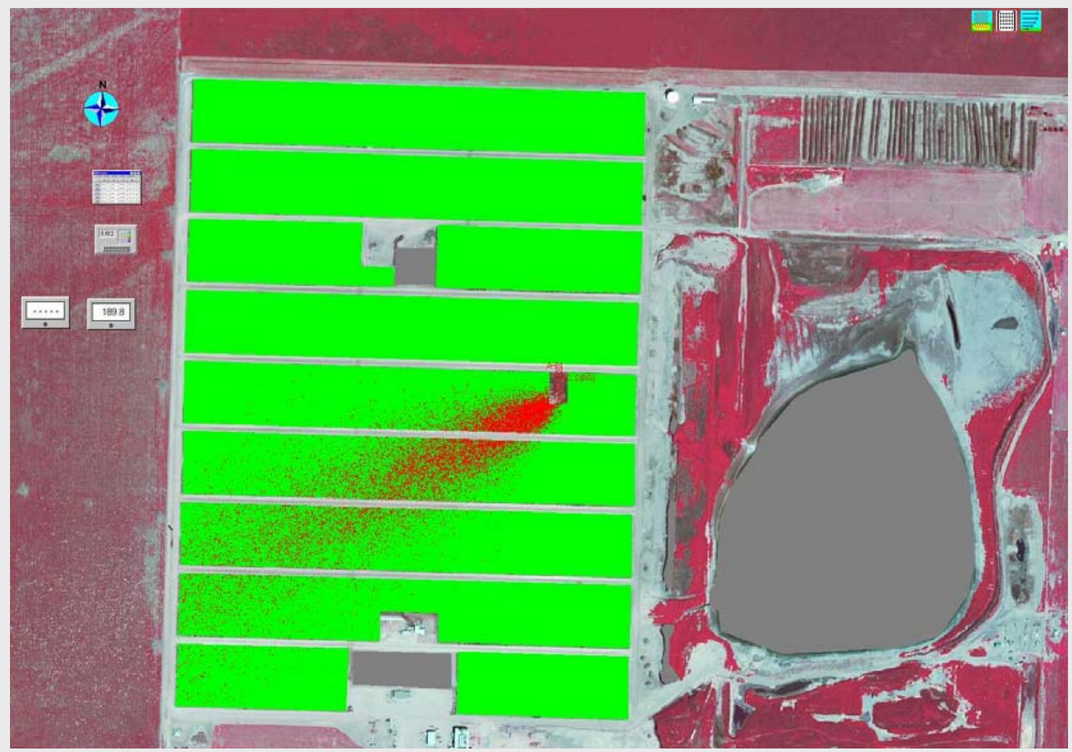

Sharpie
FINE POINT
PERMANENT MARKER



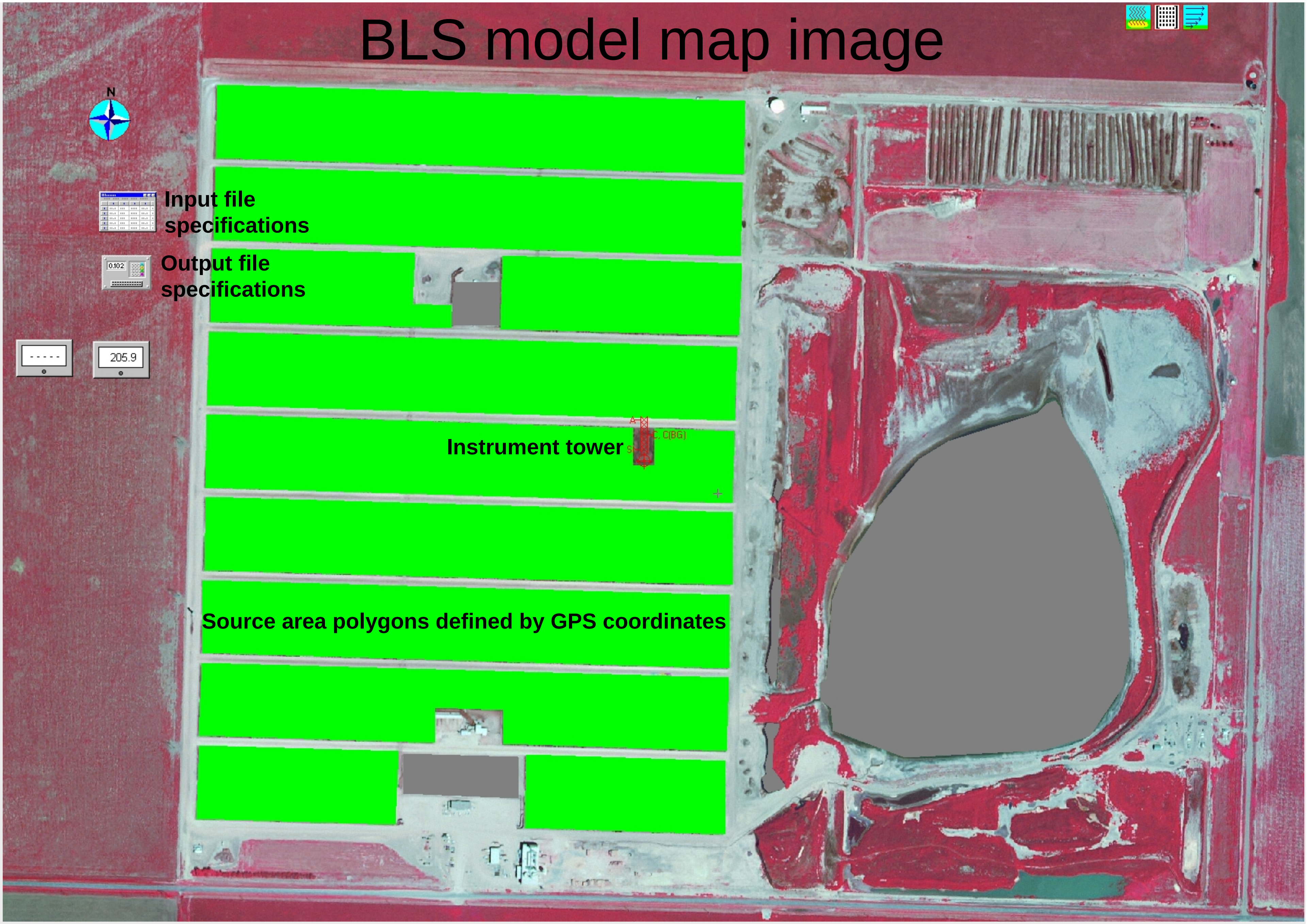
Inverse dispersion technique to estimate emission
(Flesch et al., 2005)

Example of 15-min model run

u = 8 m s^{-1}
winddir = 240 deg
L= -61 m
z_0 = 0.1 m

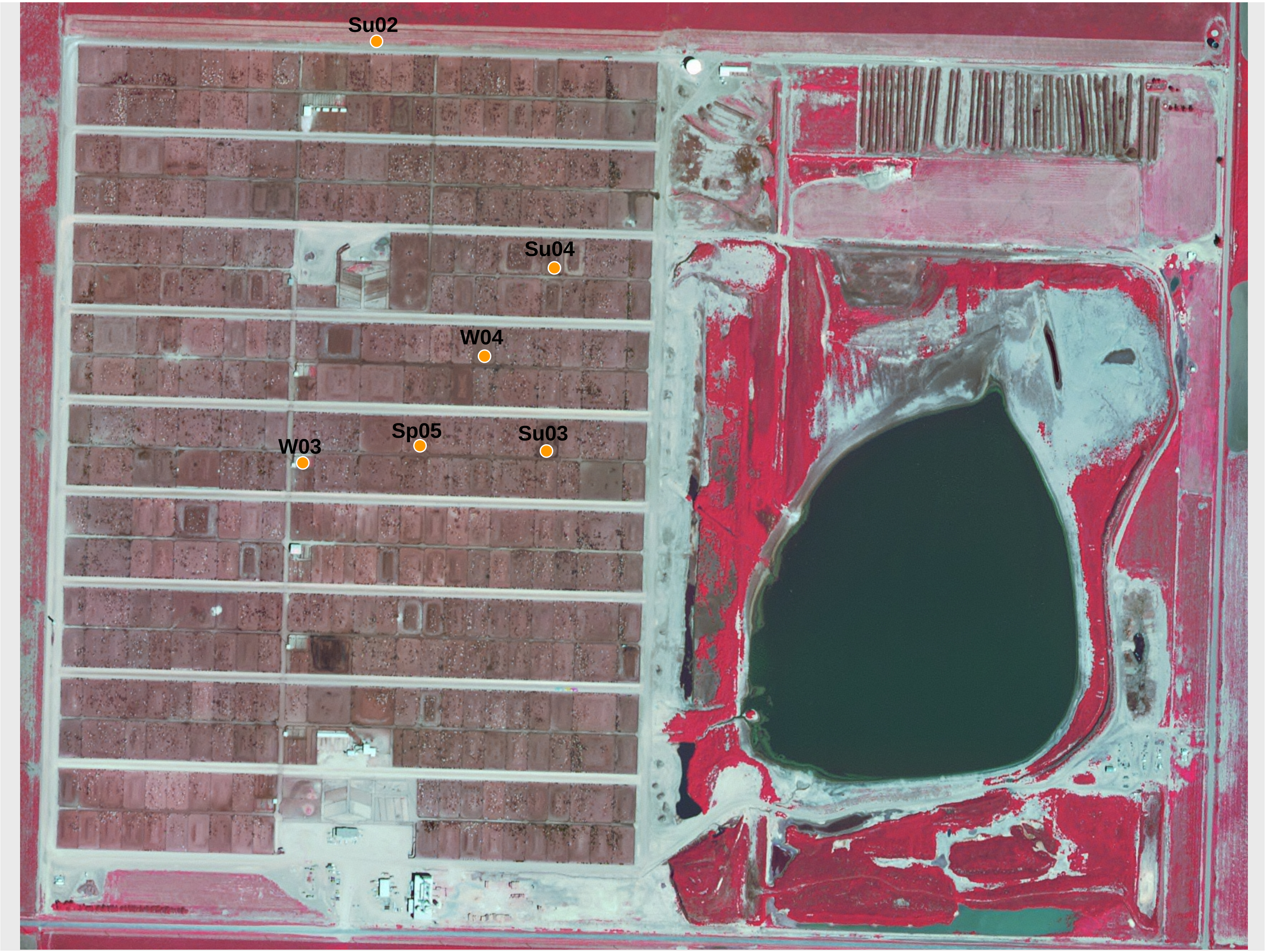


BLS model map image

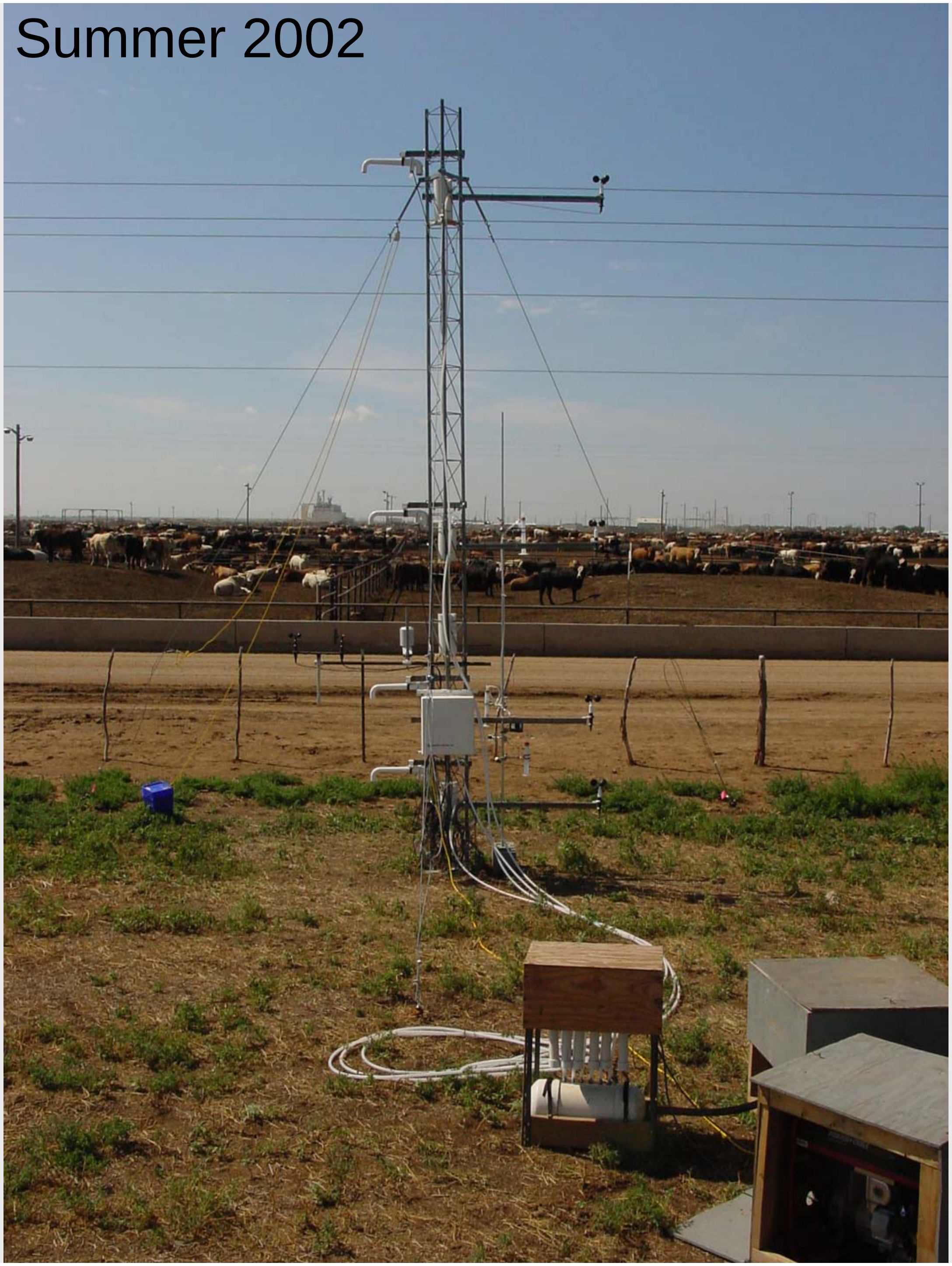


Measurements

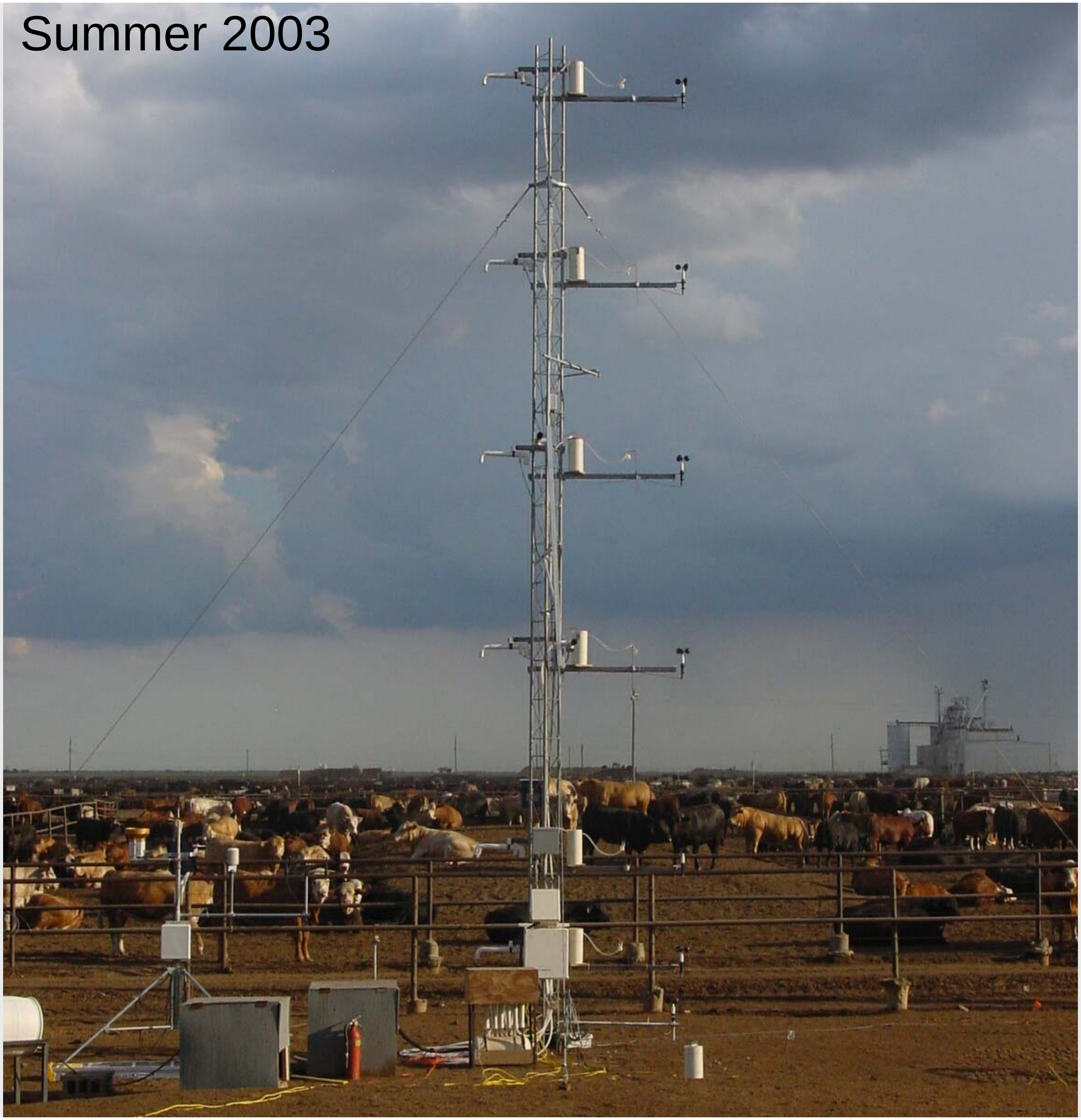
Model Inputs	Instrumentation
Ammonia concentration	Gas washing/wet chemistry or chemiluminescence (Su04)
Wind speed	Cup anemometers
Wind direction	Wind vane
Air temperature	Aspirated fine wire thermocouples
Stability	Wind speed and air temp. profiles
Roughness length	Wind speed profiles



Su02
Su04
W04
Sp05
Su03
W03

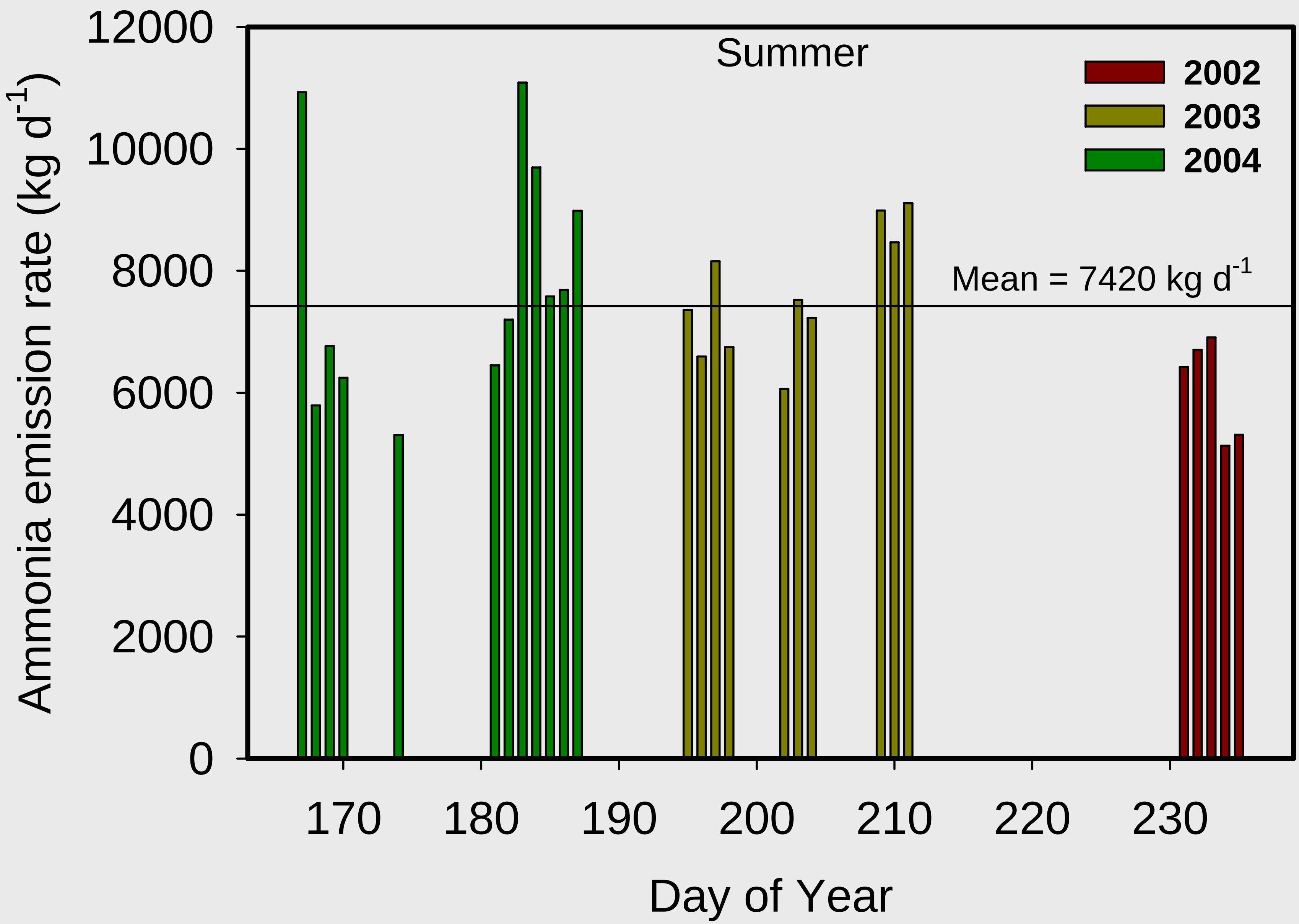

Summer 2002

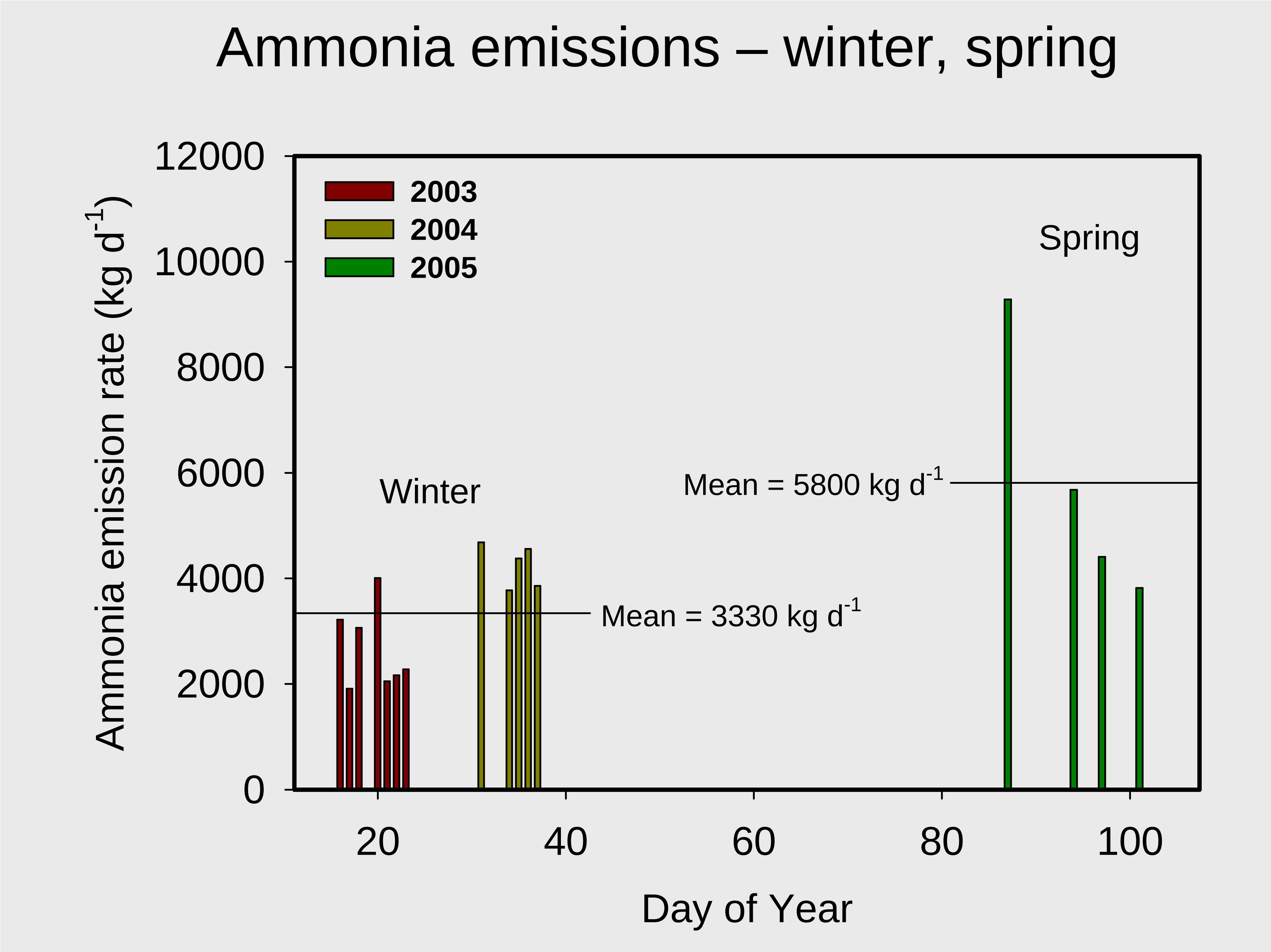
Winter 2003


Summer 2003

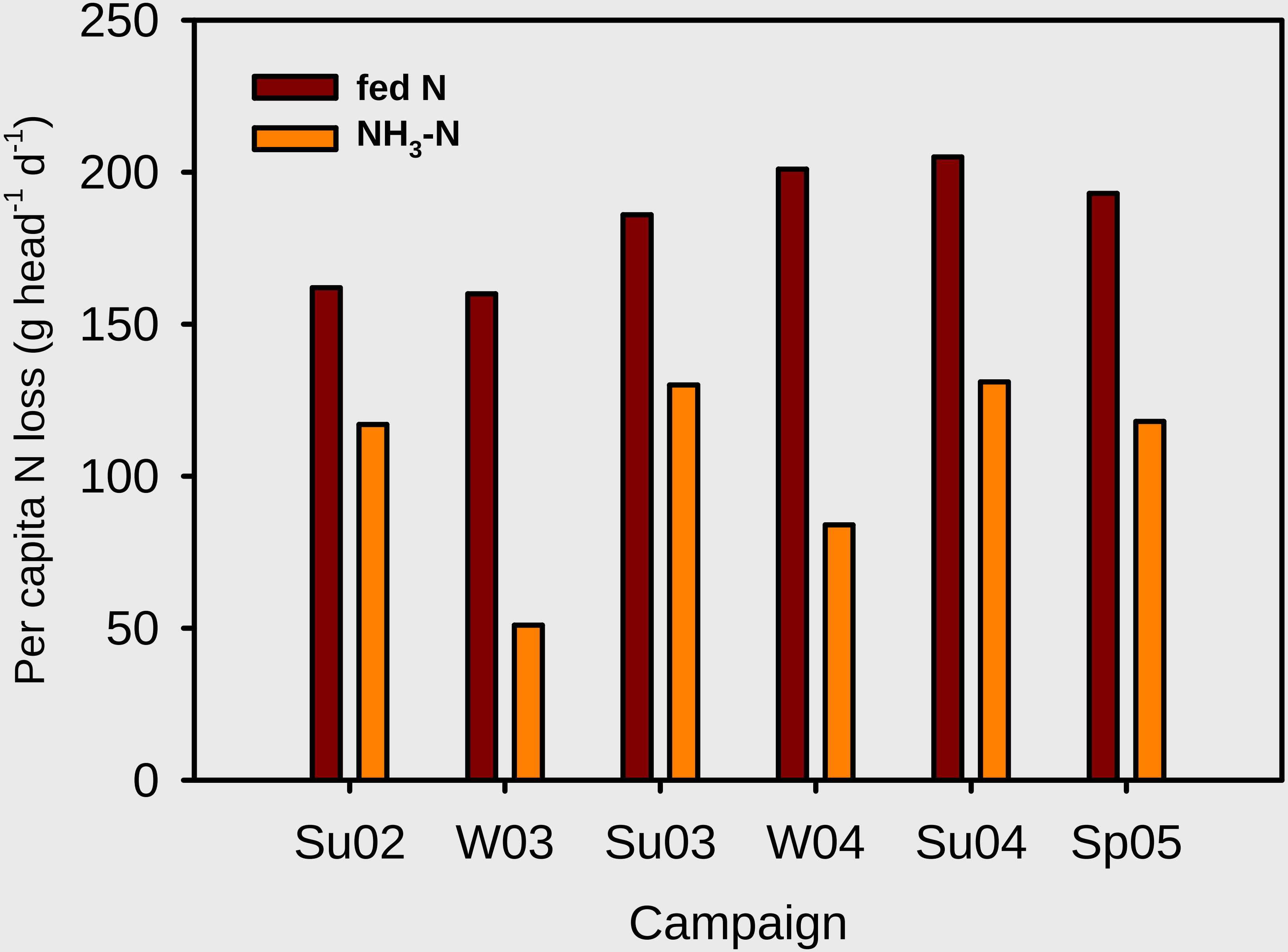
Ammonia, wind speed, and air temperature measurements

Ammonnia emissions - summer




Ammonia emissions – winter, spring
Ammonia emission rate (kg d-1)
12000
10000
8000
6000
4000
2000
0
2003
2004
2005
Spring
Winter
Mean = 5800 kg d-1
Mean = 3330 kg d-1
20
40
60
80
100
Day of Year

Per capita fed N or NH3-N loss



BLS-estimated ammonia emissions using independent inputs

Summer 2004	BLS model inputs: This study†	BLS model inputs: Flesch et al.‡
No. days§	12	12
NH_3 emission rate (kg d^{-1})	7810	7300
per capita NH_3-N loss (g $head^{-1}$ d^{-1})	131	123
NH_3-N as % of fed N	64	63

† Chemiluminescence, wind and temperature profiles.
‡ Open path laser, 3-d sonic anemometer.
§ Four days in common.

Flesch, T.K., J.D. Wilson, L.A. Harper, R.W. Todd, and N.A. Cole. 2007. Determining ammonia emissions from a cattle feedlot with an inverse dispersion technique. Agric. For. Meteorol. 144:139-155.

BLS-estimated ammonia emissions using independent inputs

	BLS model inputs	
Spring 2005	This study[†]	Flesch et al.[‡]
No. days[§]	4	10
NH_3 emission rate (kg d^{-1})	5800	6100
per capita NH_3-N loss (g $head^{-1}$ d^{-1})	118	124
NH_3-N as % of fed N	62	65

[†] Gas washing/wet chemistry, wind and temperature profiles.
[‡] Open path laser, 3-d sonic anemometer.
[§] Three days in common.

Flesch, T.K., J.D. Wilson, L.A. Harper, R.W. Todd, and N.A. Cole. 2007. Determining ammonia emissions from a cattle feedlot with an inverse dispersion technique. Agric. For. Meteorol. 144:139-155.

Annual Ammonia Emission Factors

	kg NH_3 (head fed)$^{-1}$	kg NH_3 Mg^{-1} biomass produced
Pens	19.3	70.2
Pond	0.9	3.2

Production	100 465 head yr^{-1}
Biomass produced	27 630 Mg yr^{-1}
Ammonia emission rate, pens	1940 Mg yr^{-1}
Ammonia emission rate, pond	87 Mg yr^{-1}

NH_3-N loss as % of fed N

Study	Summer	Winter	Annual
	---------------------- % ----------------------		
This study	68	36	53
Flesch et al. (2007)	63		
Harper et al. (2004)	53	29	
Todd et al. (2004) N:P ratio method	45	44	45
Bierman et al. (1999)	51-61		
Erickson et al. (1999)	63		
Erickson and Klopfenstein (2001)	53-63	35	

Annual beef cattle emission factors

Study	Source Area	Animal type	EF
			kg NH_3 head^{-1}
This study	Open lot pens	Beef steers and heifers,	19.3
	Retention pond	275-550 kg	0.9
EPA (2004)	Drylot	Beef and heifers	11.4
	Storage pond	Beef and heifers	71% of N input
Battye et al. (1994)		Heifers>227 kg	13.04
		Steers>227 kg	8.22
Asman (1992)	Stable+storage	Fattening calves	1.6
		Young cattle for fattening	5.76
Misenheimer et al. (1987)	Beef cattle feedlots		5.9

Summary and Conclusions

	NH_3 emission	NH_3-N emission	Per capita NH_3-N loss
	kg d^{-1}	% fed N	g $head^{-1}$ d^{-1}
Summer	7420	68	128
Winter	3330	36	64

Summary and Conclusions

Annual Ammonia Emission Factors		
	kg NH_3 (head fed)$^{-1}$	kg NH_3 Mg^{-1} biomass
Pens	19.3	70.2
Pond	0.9	3.2