

2016 Dairy Outreach Program Area Workshop  
Stephenville, TX

# Air Emissions from Open-Lot Dairies: Recent Developments

Brent W. Auvermann



# Ammonia Losses and Nitrogen Balance



Rick Todd and Andy Cole  
ARS-Bushland

Robert Hagevoort  
NMSU-Clovis

Ken Casey and Brent Auvermann  
Texas A&M AgriLife-Amarillo

Partially funded by USDA-CSREES Special Research Grants AG09-4288 and 2010-02674



# Regulatory Pressures

The screenshot shows the EPA Newsroom website. The main article is titled "EPA Announces Air Quality Compliance Agreement for Animal Feeding Operations". The release date is 01/21/2005. The contact information is Cynthia Bergman, 202-564-9828, bergman.cynthia@epa.gov. A note states that several dates in the initial news release have changed. The article text includes a quote from Thomas V. Skinner, EPA's Acting Assistant Administrator for Enforcement and Compliance Assurance, stating that the agreement is a huge step forward. It also mentions that the purpose of the agreement is to ensure that AFOs comply with applicable environmental requirements and to gather scientific data. A 2002 report by the National Academy of Sciences is cited as a key step in mitigating air pollution from these operations. Finally, it notes that AFO operators participating in the agreement will pay a civil penalty of between \$200 and \$100,000, based on the size and number of farms in their operation.

**(KEEP THIS WORKSHEET FOR FEEDYARD RECORDS)**  
**Calculation Worksheet – Ammonia and Hydrogen Sulfide**  
**Beef Cattle Feedyards**  
**January 2009**

The following emissions estimates for ammonia and hydrogen sulfide are based on research data collected by Texas AgriLife Research, Texas AgriLife Extension Service, Texas A&M University, USDA-Agricultural Research Service, and West Texas A&M University. Data has been collected as part of the USDA-CSREES-funded project, "Air Quality: Reducing Emissions from Cattle Feedlots and Dairies," between the years of 2003-2008. Field measurements are on-going and as such these values are a good faith estimate of air emissions based on currently available scientific information.

The final rule on EPCRA reporting issued by EPA on Dec. 18, 2008 and effective Jan. 20, 2009 requires reporting of ammonia or hydrogen sulfide if (1) the feedyard is 1,000 head or larger and (2) the ammonia exceeds 100 lbs/day or the hydrogen sulfide exceeds 100 lbs/day. **DO NOT report ammonia or hydrogen sulfide values if the "upper bound" is LESS THAN 100 lbs/day.**

Feedyard Name: \_\_\_\_\_

**AMMONIA (NH<sub>3</sub>) EMISSIONS ESTIMATE**

The emissions estimates provided below are inclusive of ammonia emissions from the feedyard pen surfaces and the runoff holding pond(s). Ammonia emission rates are generally lower in the winter and higher in the summer.

Ammonia (NH <sub>3</sub> ) Emissions Estimate					
	Lowest Head Count	x	NH <sub>3</sub> Emission Rate (pounds/hd/day)	=	NH <sub>3</sub> Lower Bound (pounds/day)
NH <sub>3</sub> Lower Bound =		x	0.16 <sup>a</sup>	=	
<sup>a</sup> winter emission rate from research data					
	Permitted Head Count	x	NH <sub>3</sub> Emission Rate (pounds/hd/day)	=	NH <sub>3</sub> Upper Bound (pounds/day)
NH <sub>3</sub> Upper Bound =		x	0.48 <sup>b</sup>	=	
<sup>b</sup> summer emission rate from research data					

Case 1:15-cv-00141-TSC Document 1 Filed 01/28/15 Page 1 of 30

UNITED STATES DISTRICT COURT  
 FOR THE DISTRICT OF COLUMBIA

THE HUMANE SOCIETY )  
 OF THE UNITED STATES )  
 2100 I. Street NW )  
 Washington, DC 20037, )  
 ASSOCIATION OF IRRITIATED RESIDENTS )  
 29289 Trestle Ave )  
 Shafter, CA 95263, )  
 ENVIRONMENTAL INTEGRITY PROJECT ) Civil Action No. 15-cv-0141  
 1000 Vermont Avenue NW, Suite 1100 )  
 Washington, DC 20005, ) COMPLAINT FOR DECLARATORY  
 AND INJUNCTIVE RELIEF  
 FRIENDS OF THE EARTH )  
 1100 15th Street NW, 11th Floor )  
 Washington, DC 20005, ) Administrative Procedure Act, 5 U.S.C. § 551  
 SIERRA CLUB )  
 85 Second Street, 2nd Floor )  
 San Francisco, CA 94105, )  
 Plaintiffs, )  
 v. )  
 REGINA MCCARTHY, in her official capacity, )  
 ADMINISTRATOR, UNITED STATES )  
 ENVIRONMENTAL PROTECTION AGENCY, )  
 and UNITED STATES ENVIRONMENTAL )  
 PROTECTION AGENCY )  
 1200 Pennsylvania Ave. N.W. )  
 Washington, D.C. 20460, )  
 Defendants. )

INTRODUCTION

I. The Humane Society of the United States (HSUS), Association of Irrigated Residents (AIR), Environmental Integrity Project (EIP), Friends of the Earth (FoE), and Sierra Club (collectively Plaintiffs) bring this action for declaratory and injunctive relief pursuant to the Administrative Procedure Act (APA), 5 U.S.C. § 551 *et seq.* The action seeks to compel the United States Environmental Protection





Dairy #1

56 acres

- 3,500 cows
- 80% lactating – consumed 90% of N fed
- CP averaged 16.7%
- Milk production 64 lb/d/hd

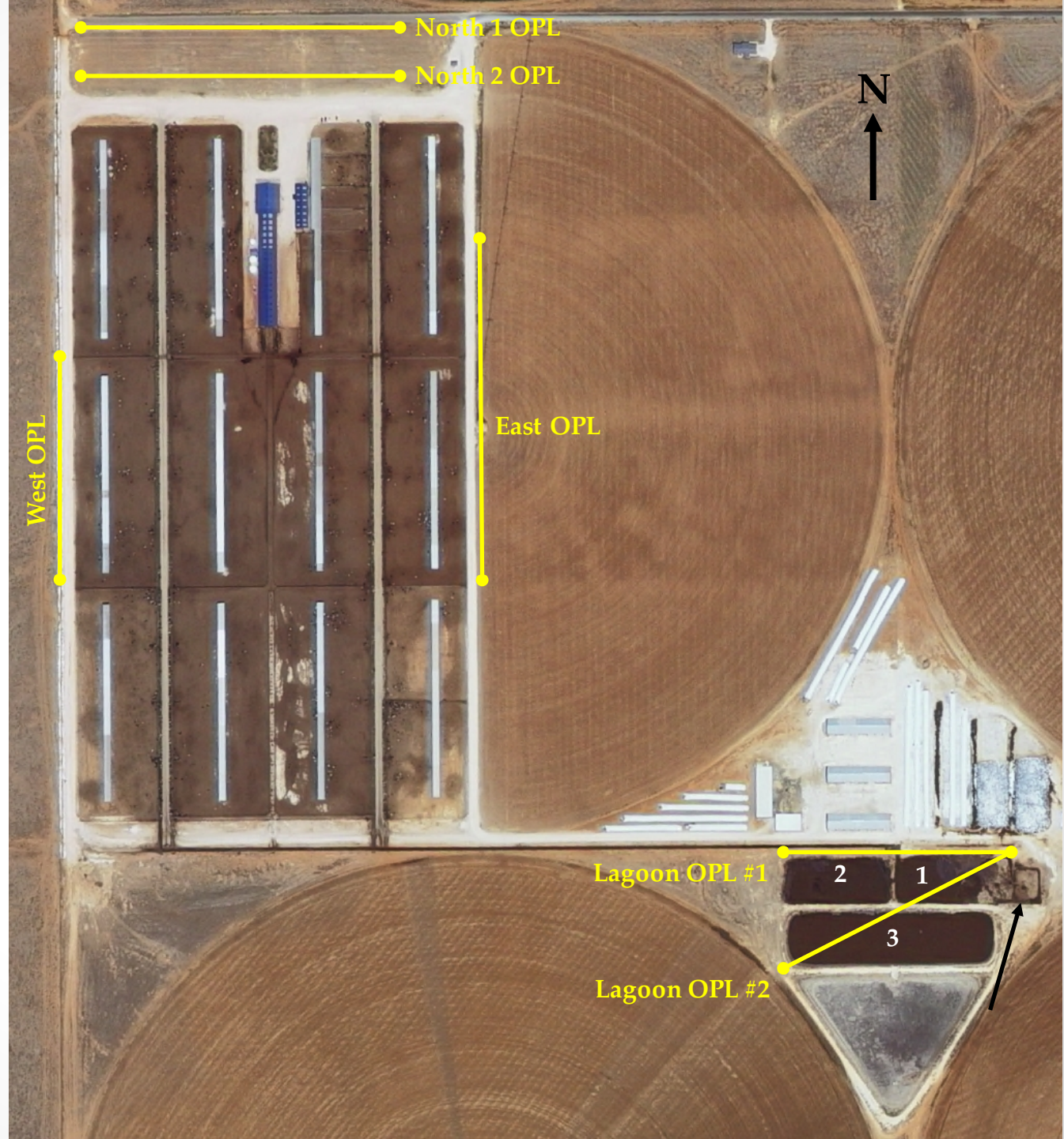
1.8 ha

352 m

Image © 2009 DigitalGlobe  
© 2009 Tele Atlas

©2009 Google





North 1 OPL

North 2 OPL



West OPL

East OPL

Lagoon OPL #1

2

1

3

Lagoon OPL #2























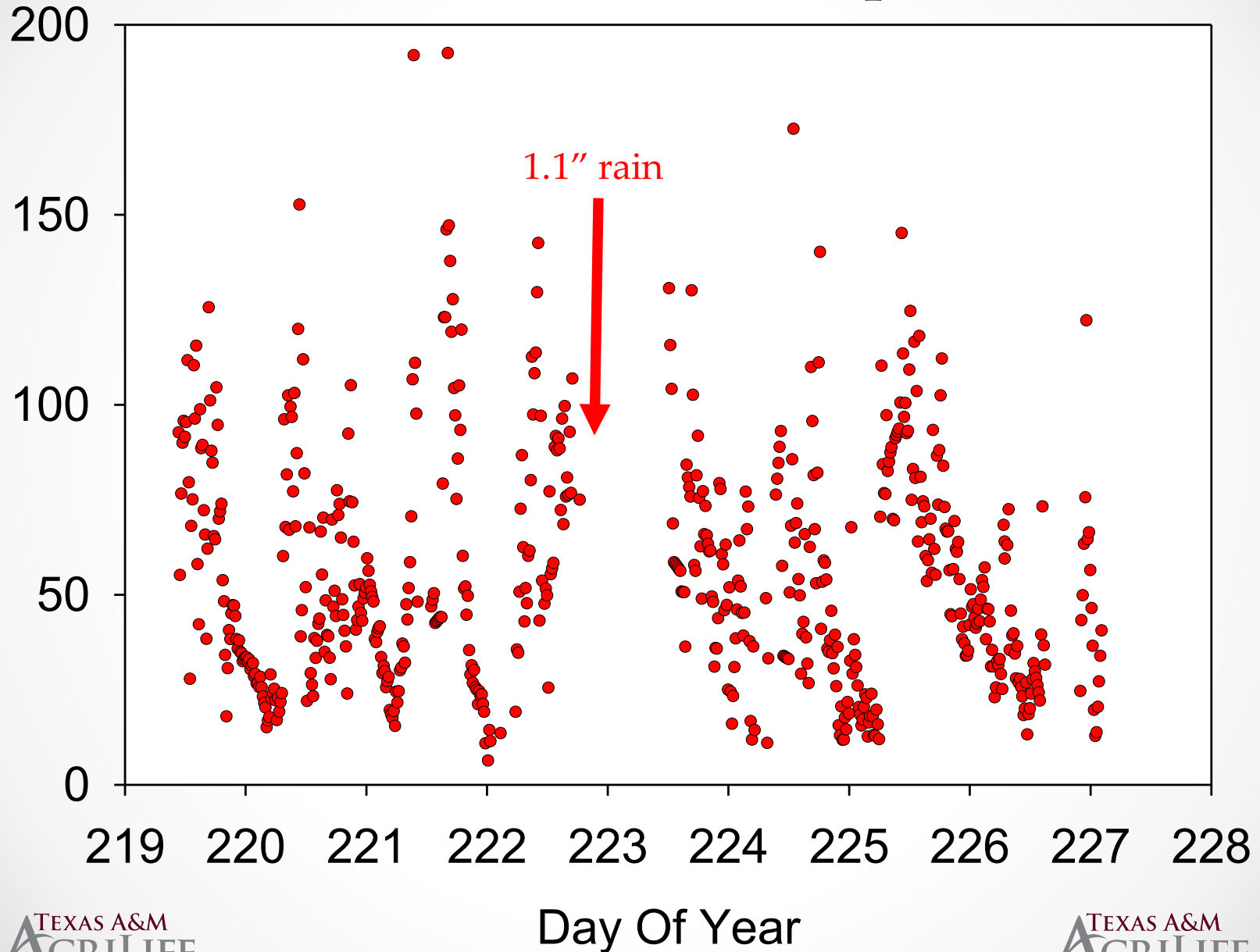






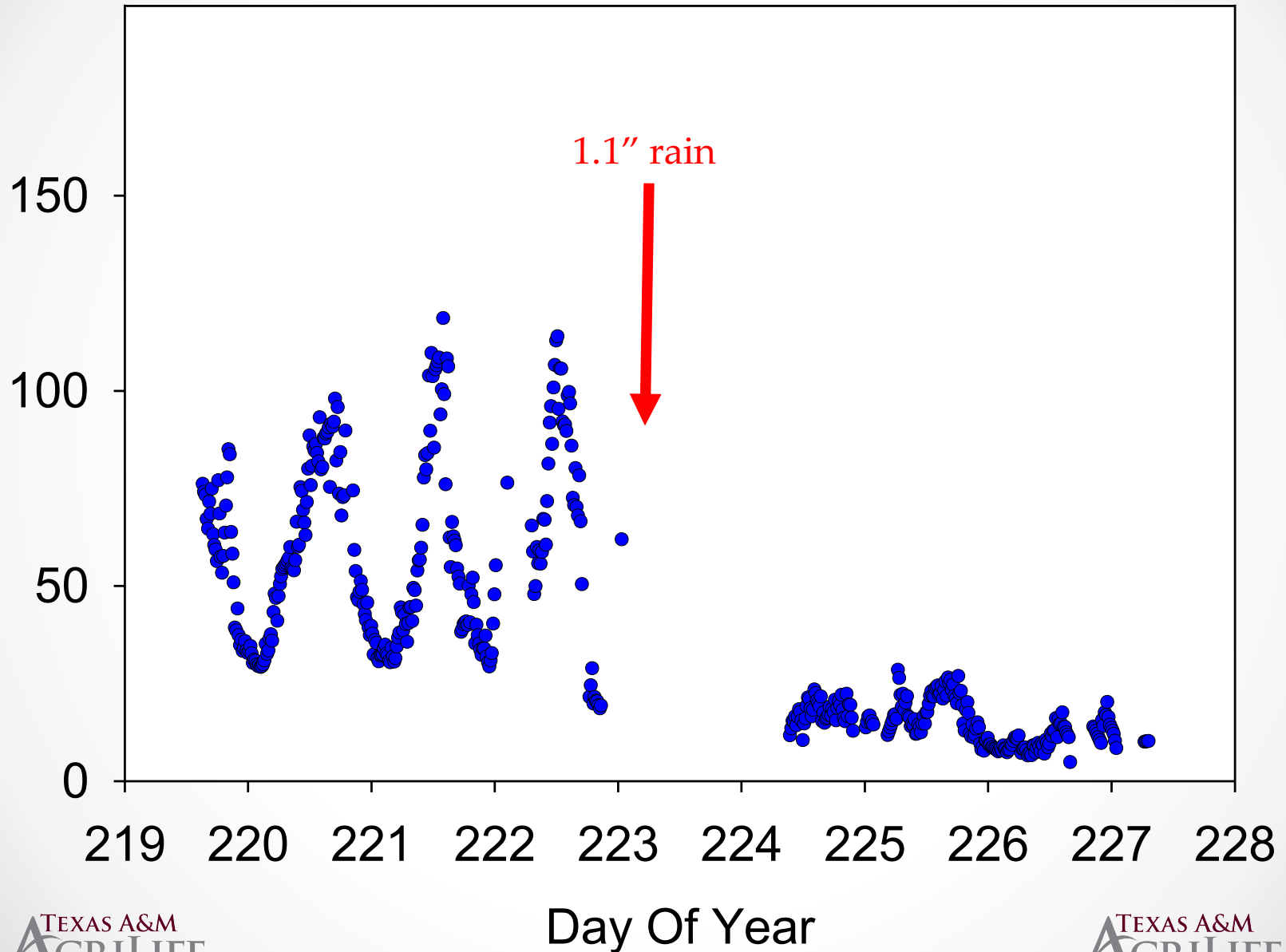


# Ammonia Flux from Open Lots



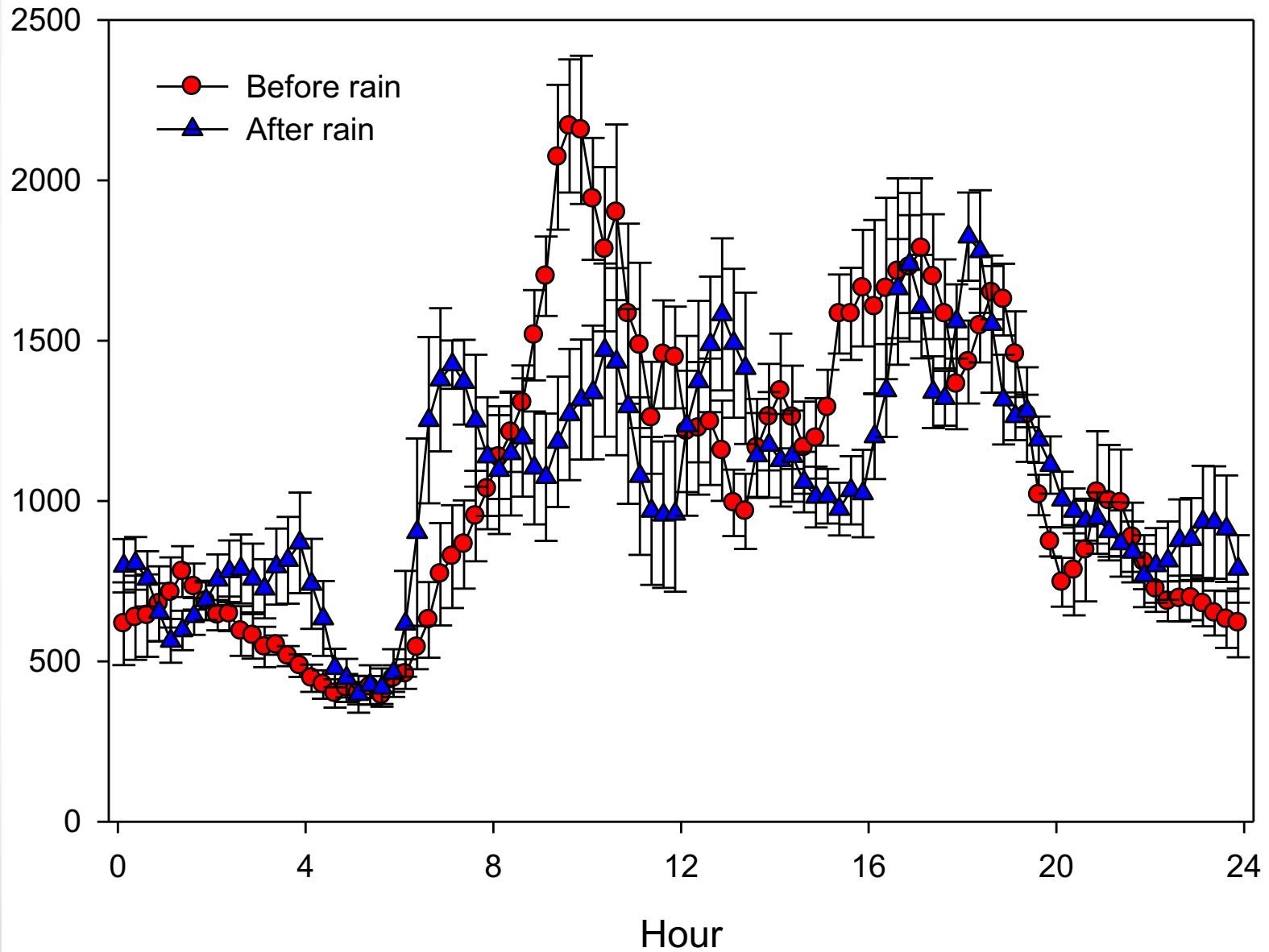


# Ammonia Flux from Lagoons



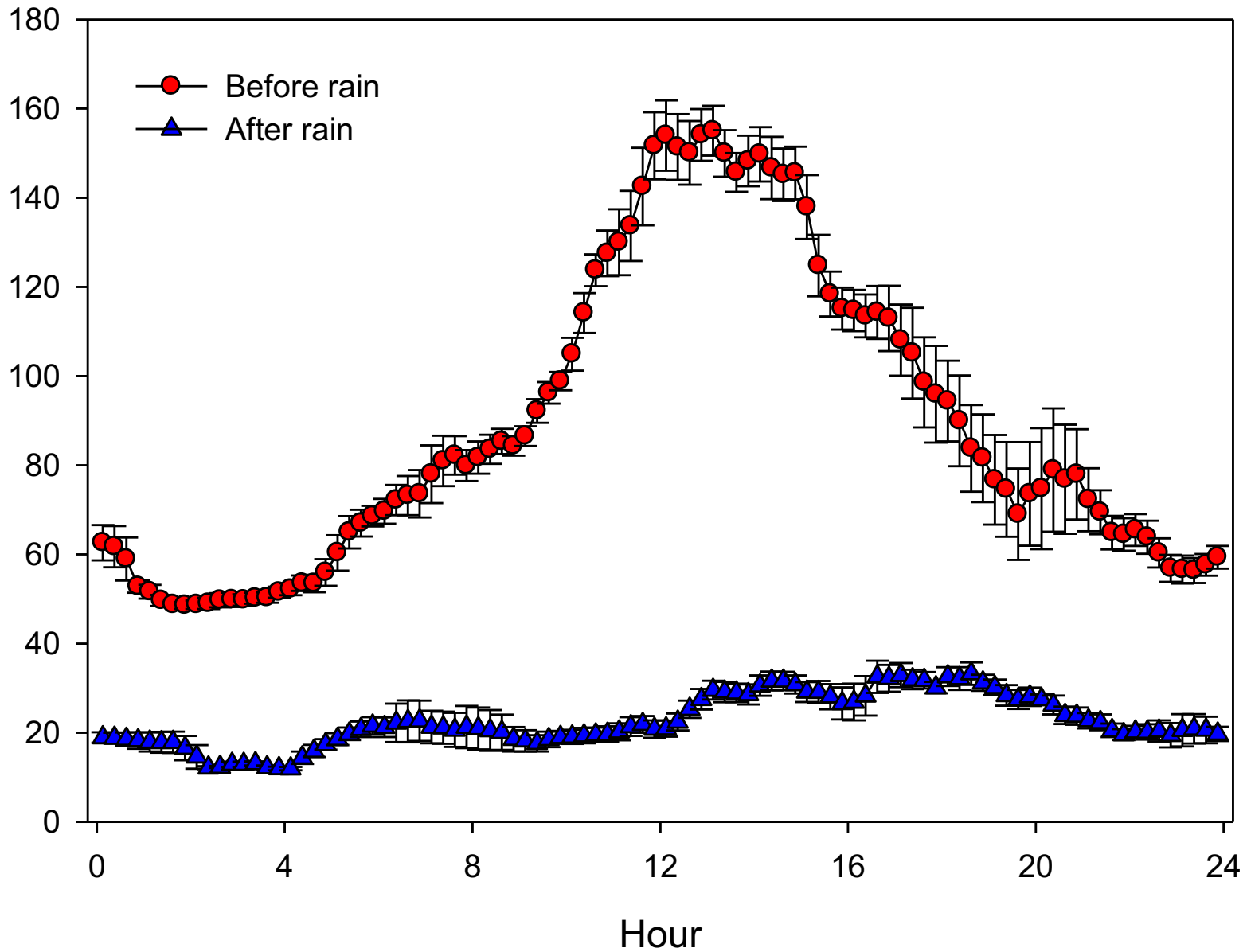


# Ammonia Emissions from Open Lots





# Ammonia Emissions from Lagoons





# Ammonia Emission Averages

Source	kg/d	g/hd-d	% of N intake
Open lot	1,061	304	41
Lagoons	59	17	2.3

## *Caveats*

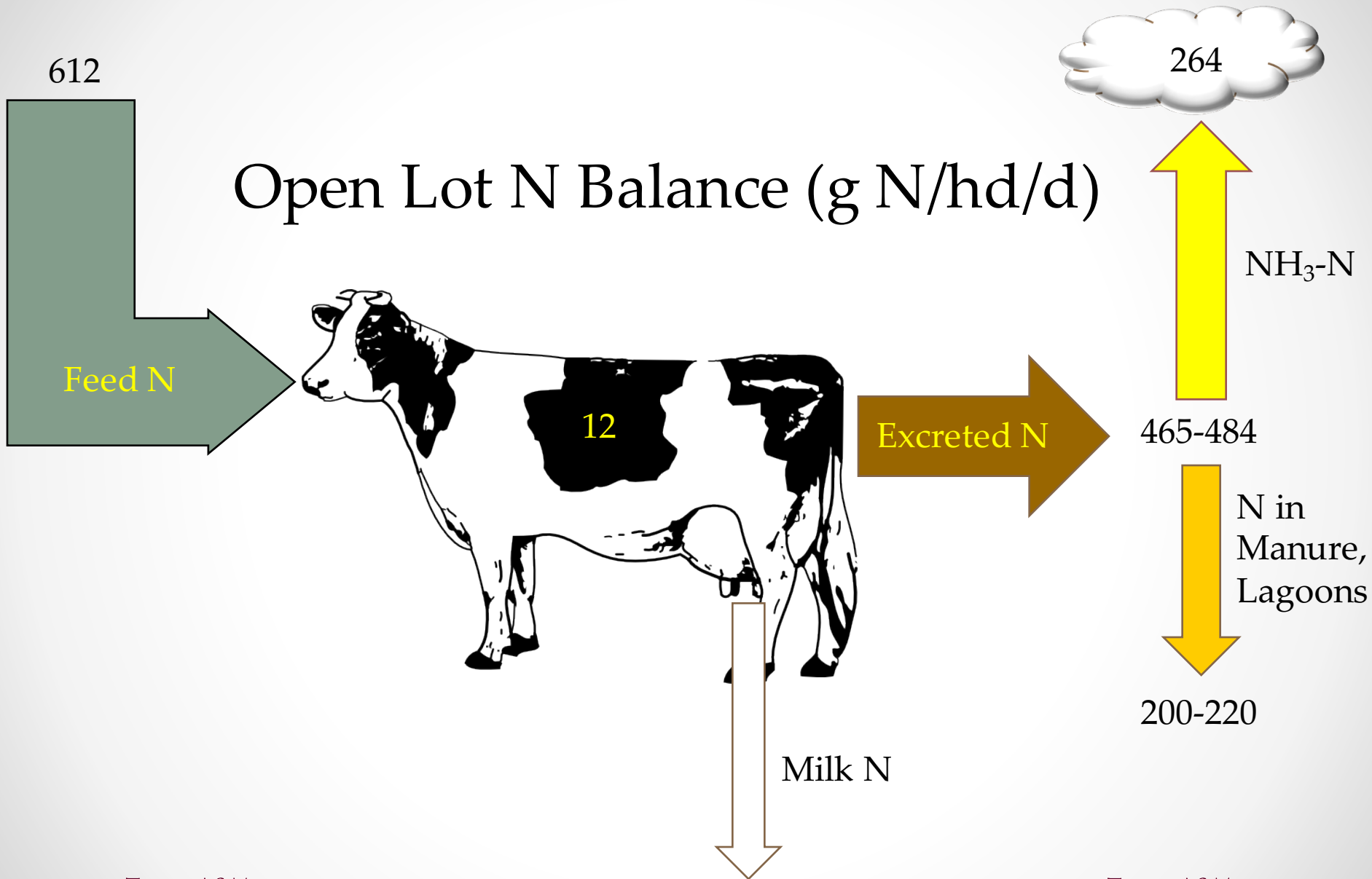
- Late summer – expected peak annual emissions
- Adult cows – lactating or pregnant dry cows
- Most manure deposited on open lot



Study	Location	PCER (g/hd/d)
<b>Open lot, whole farm, summer</b>		
Todd et al. (2015)	New Mexico	321
Bjorneberg et al. (2009)	Idaho	190
Moore et al. (2014)	California	140-199
Leytem et al. (2011)	Idaho	127
<b>Freestall barn or barn+open lot, whole farm</b>		
Leytem et al. (2013)	Idaho	332 (summer)
Flesch et al. (2009)	Wisconsin	93-100 (summer)
Cassel et al. (2005a)	California	50 (winter)
Cassel et al. (2005b)	California	103 (spring)



# Open Lot N Balance (g N/hd/d)





# Estimated Annual Emission

Season	PCER g cow <sup>-1</sup> d <sup>-1</sup>	Fraction fed N %
Summer	321	43
Winter	189	22-26*
Annual	255	30-35*

\* N intake: 600 to 700 g N/hd/d



# Conclusions

- High emissions during study
  - 321 g NH<sub>3</sub> cow<sup>-1</sup> d<sup>-1</sup>
  - 43% of fed N
- Manure management is critical
  - 95% of NH<sub>3</sub> emissions from open lot
  - Where N is excreted and how handled plays important role in determining NH<sub>3</sub> emissions



# Open-Lot Particulate Matter, 2011-2015

...

A Survey of Recent Research



# Summary

- #1: BIOAEROSOLS (50%)
  - Inflammatory agents and endotoxin
  - Microbial speciation & persistence
  - Endocrine activation

# Ravva et al. (2011)

- *PLoS ONE* 6(2):1-9
- Bacterial RNA sequencing
  - Sonoma dairy vs. Modesto dairy
  - Manure bacteria vs. aerosol bacteria
- Predominant airborne bacteria are NOT predominant bacteria in manure
- Location dependent (but n=2)



# Dungan et al. (2011)

- *Journal of Animal Sci.* 89(10):3300-9
- 10,000-head open/free-stall dairy
- Endotoxin, bacteria, and fungi
- Upwind & downwind (50m, 200m)
  - 50m: elevated concentrations
  - 200m: near background concentrations

Adapted from Dungan et al. (2011)





# Summary

- #2: OCCUPATIONAL HEALTH (30%)
  - Pulmonary function of workers
  - Characterization of PM
  - Occupational exposure
  - Endotoxin
  - SYSTEMATIC REVIEW – Reynolds et al., 2013

# Reynolds et al. (2013)

- *Journal of Agromedicine* 18(3):219ff
- Lung disorders linked to endotoxin exp.
- Obstructive changes “generally mild”
- Emerging evidence beyond endotoxin
- Parlor washing has measurable effect
- Protective effect of early-life exposure



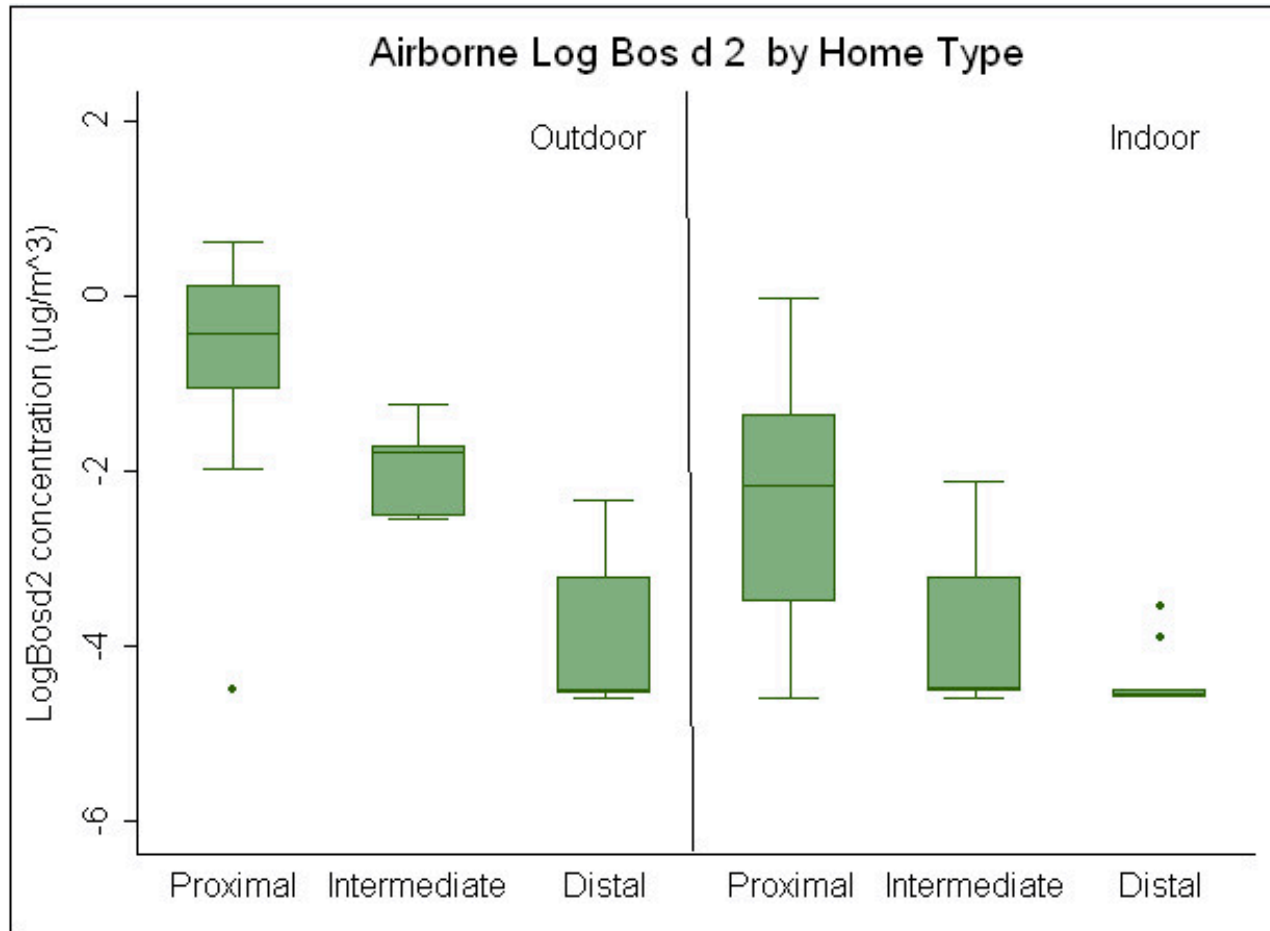
# Summary

- #3: CONCENTRATION MEASURES (24%)
  - Cow allergen and dust vs. distance (D)
  - PM concentrations (FY)
  - Elemental concentrations (D)
  - Barn concentrations vs. animal activity (D)

# Williams et al. (2011)

Figure 2.

Resolution: [standard](#) / [high](#)



Comparison of outdoor and indoor airborne concentrations of Bos d 2 between proximal, intermediate and distal homes.

Williams et al. *Environmental Health* 2011 **10**:72 doi:10.1186/1476-069X-10-72

[Download authors' original image](#)



# Joo et al. (2013)

- Free-stall dairy barn, Washington state
- Pronounced seasonality for  $PM_{10}$
- TSP (not  $PM_{2.5}$  or  $PM_{10}$ ) weakly correlated with animal activity
- Emission rates: 26-33 lb/1,000 hd-d  $PM_{10}$

# Conclusions

- Significant attention to bioaerosols, public and occupational health
  - Systematic reviews
  - Public exposure monitoring
  - In vitro bioactivity assays
  - Microbial markers of livestock
- Alternatives to IDM for flux estimation