Ammonia Fluxes from Animal Housing at California Free Stall Dairies

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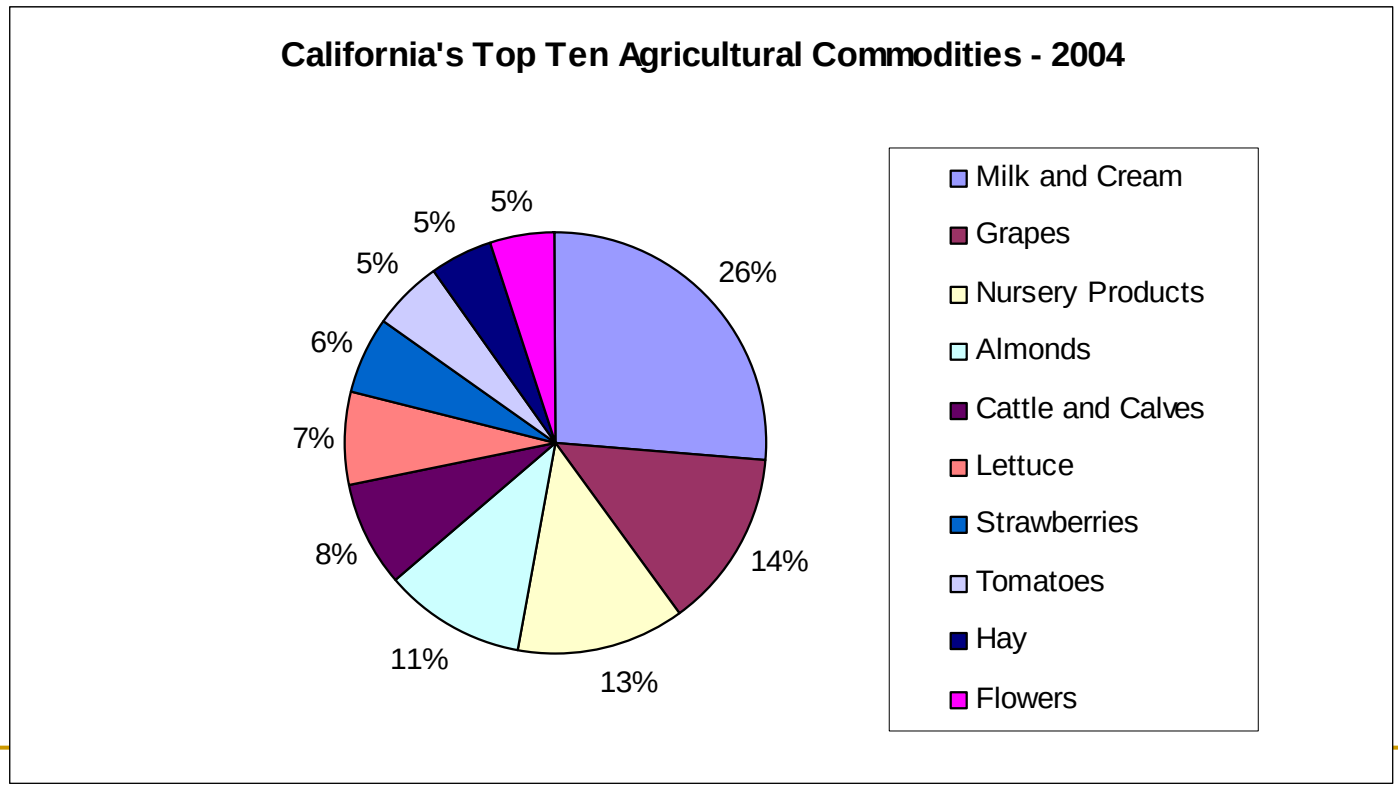
Dairy Industry in California

- Over 5 Billion Dollar Industry
- Over ¼ of Total Agricultural Value



Milk Production Process

- Forage to Milk

- Not a Closed system

Milk Production Process

- Other products of Process
  - Manure – Ammonia Source
  - Urine – Ammonia Source
  - Digestive Gasses
  - More Cows

Lactating Cow Production Characteristics

Inputs (lbs./day/animal)			
Dry Matter	Crude Protein	P	K
47	8	0.21	0.62

Outputs (lbs./day/animal)					
Dry Matter	N	P	K	Total Manure	Milk
20	0.99	0.17	0.23	150	88

Ammonia from Ag Sources

- Animal Ag major source of ammonia emissions with dairy ammonia emissions accounting for ? % of the inventory
  - Air Resources Board currently working on that
- Ammonia not directly regulated in CA. but there is pressure to do so
- Ammonia participates in formation of secondary particulate matter ($PM_{2.5}$)

California Dairy Systems

- Classified by manure handling method
- Three systems used
  - Free Stall / Flush – Most Common
  - Open Lot / Scrape – Roughly 20% of dairies
  - Vacuum System – Newly adopted

Free Stall / Flush

- Free Stall
  - Free Stall – location where animals housed
  - “Free” – Free choice to:
    - Feed
    - Lay down
    - Exit to exercise pen

Free Stall/Flush System

- Manure flushed out of barns 1 to 4 times a day with a large volume of water from manure storage system (
- Flush wa

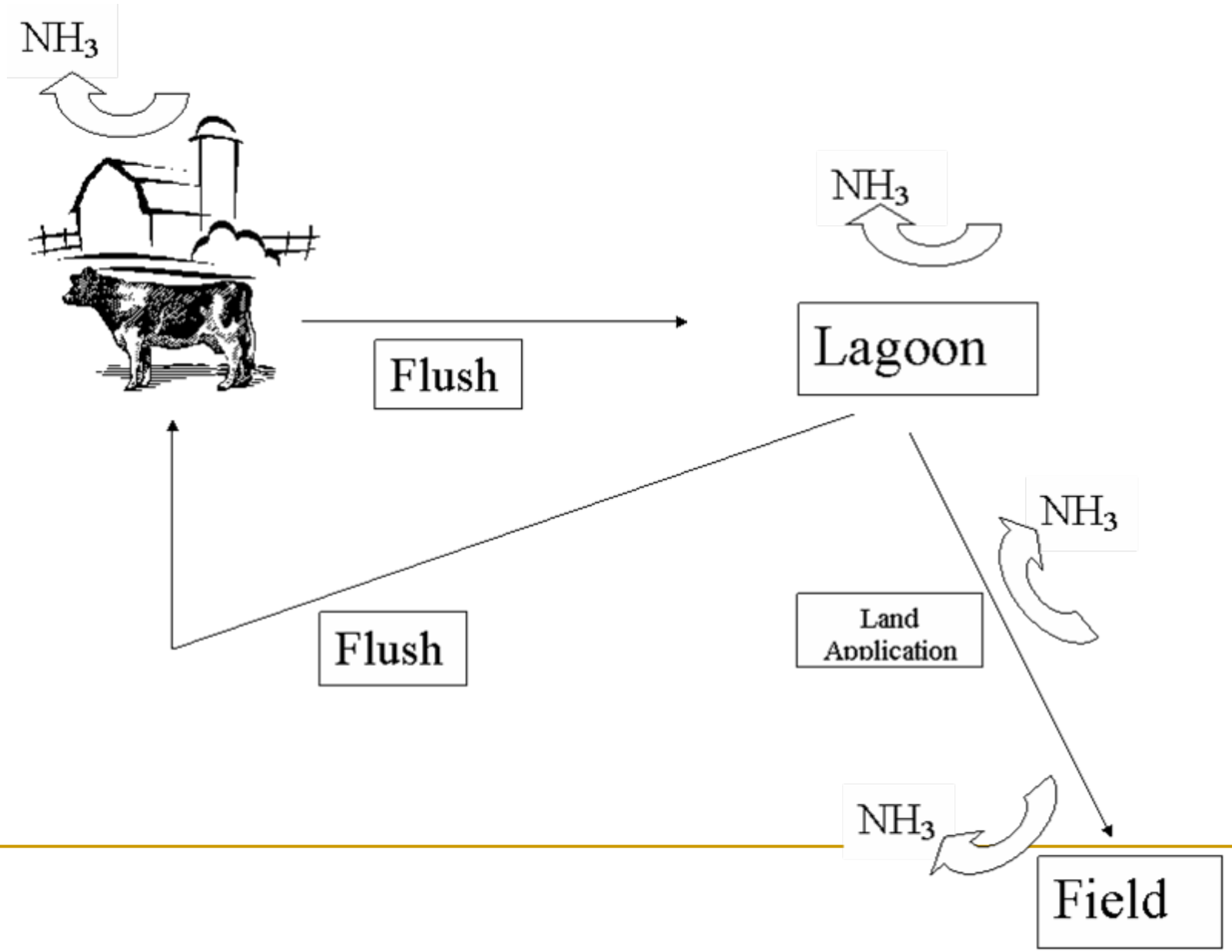
Open Lot / Scrape

- Animals housed in open lots continuously
  - No stalls but rather shades
- Manure scraped up and hauled off to be applied to fields
- Some dairies flush feeding area where most manure deposited

Vacuum Systems

- Animals housed in barn similar to free stall barn
- Manure vacuumed up out of barn daily
  - Used in digester systems
  - Applied directly to field - injection

Ammonia Volatilization

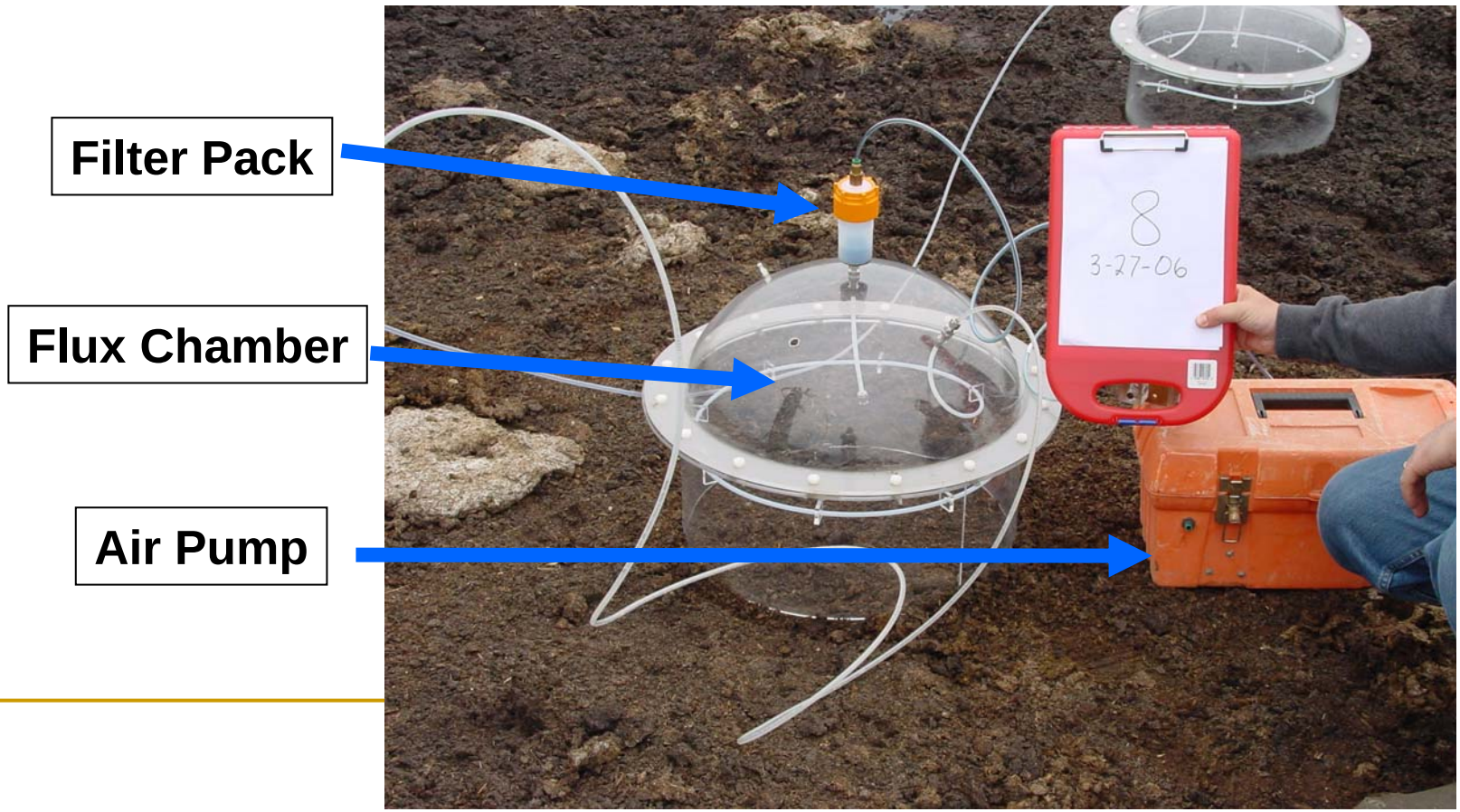


Ammonia Volatilization

- Seasonal emissions characteristics
  - Winter emissions approximately ½ of summer emissions – may be lower
  - Important to sample year round to accurately characterize emissions
- Management factors
  - Some dairymen scrape their open lots more often removing manure that would emit ammonia
  - Frequency of flushing

Methods

- USEPA Emission Isolation Flux Chamber
- Active Chemical Filter Packs
  - (filters treated with citric acid)



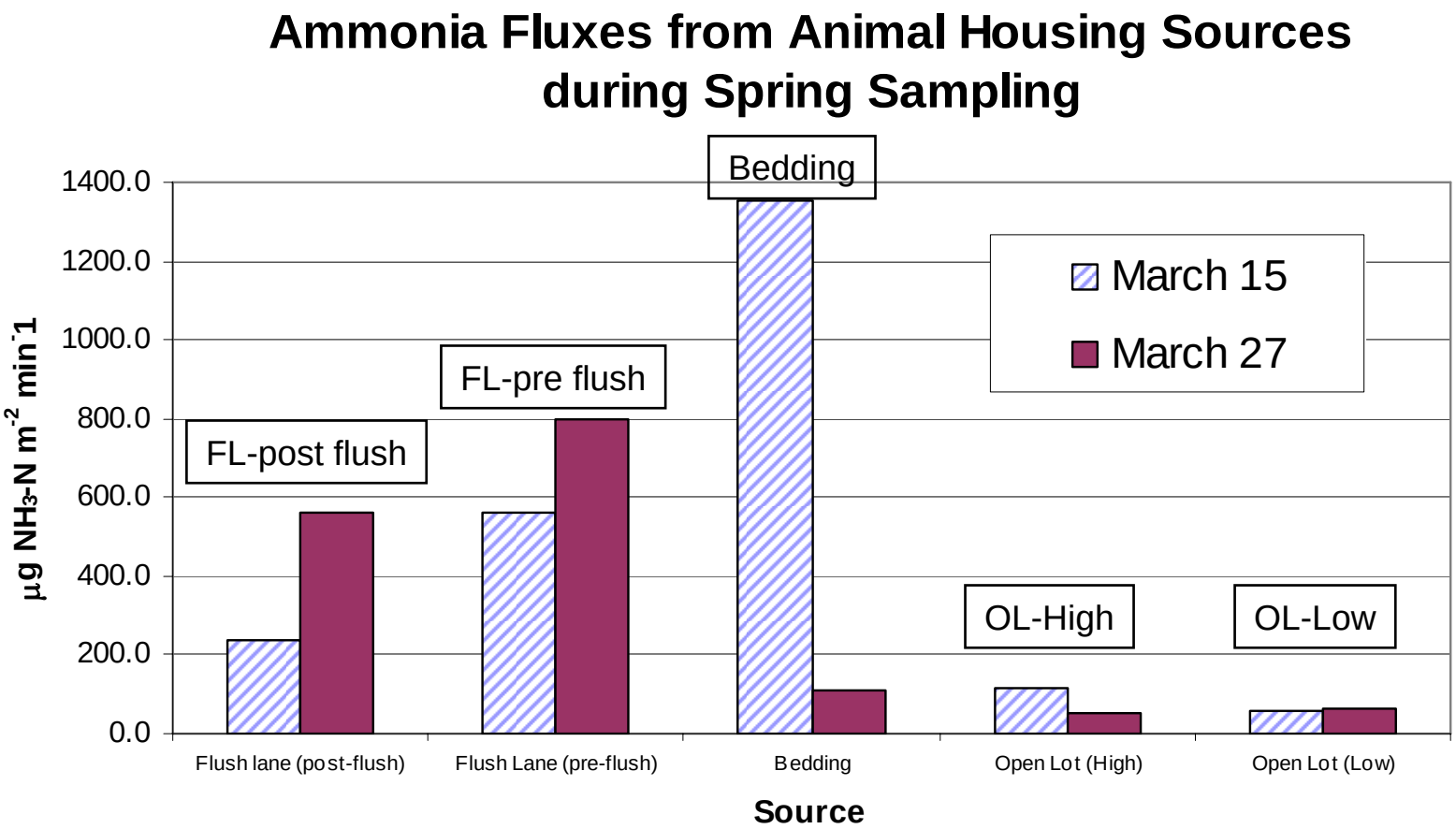
Animal Housing Sources

- Flush Lane
  - Pre Flush
  - Post Flush
- Bedding
- Open Lot
  - Deep/Shallow Manure
- Feed

Dairies Monitored

- Three in Central California
- Ranging from 2,000 to 3,500 lactating cows
- All free stall / flush systems
- Six sampling events from March 15 to May 1
- All samples taken in daytime hours

Results



- March 15 bedding flux 12 times higher than March 27

Bedding

March 15

March 27

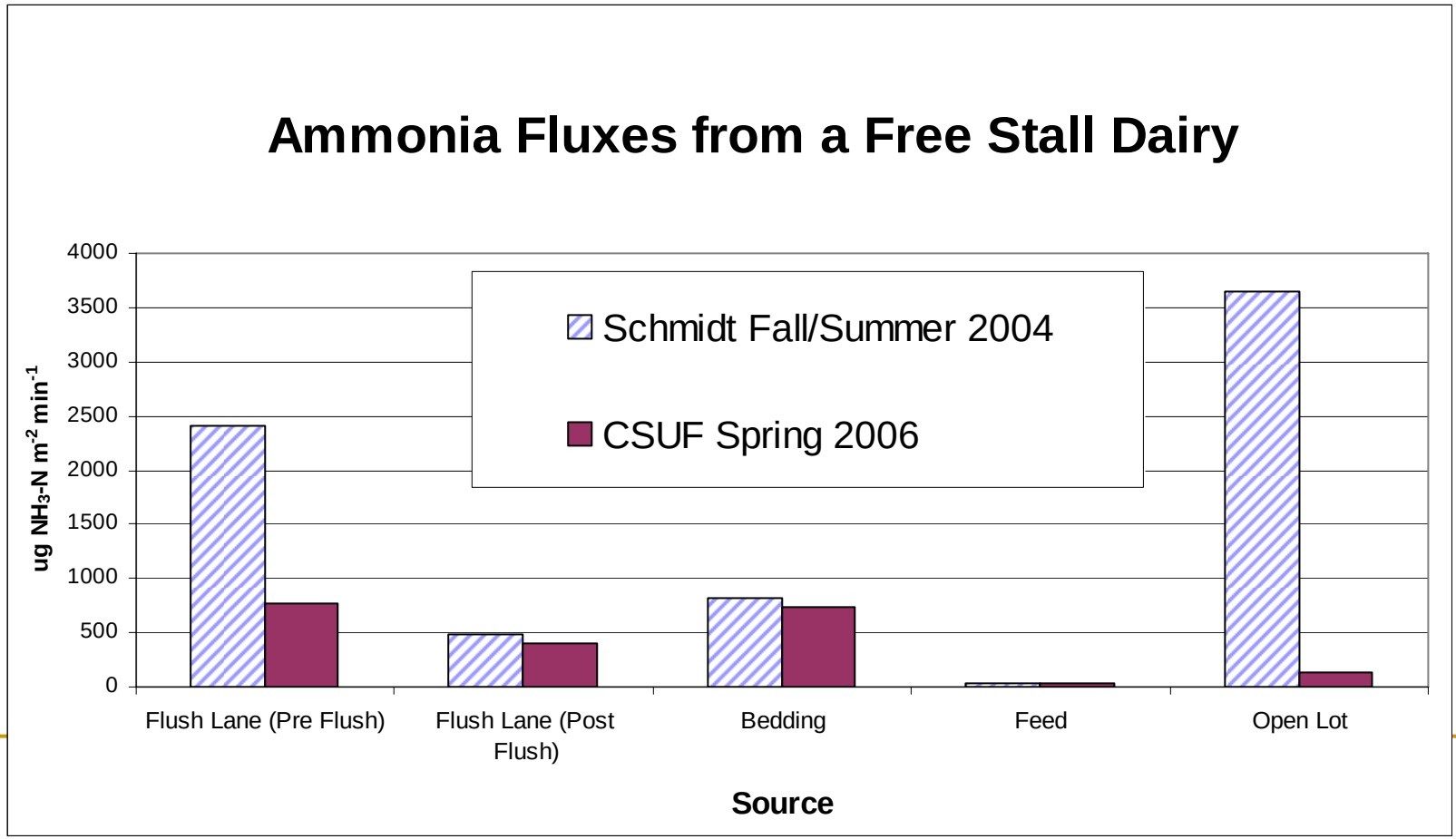
- March 15 amount of bedding was greater than March 27

Results - (Spring 2006 vs. Fall 2004)

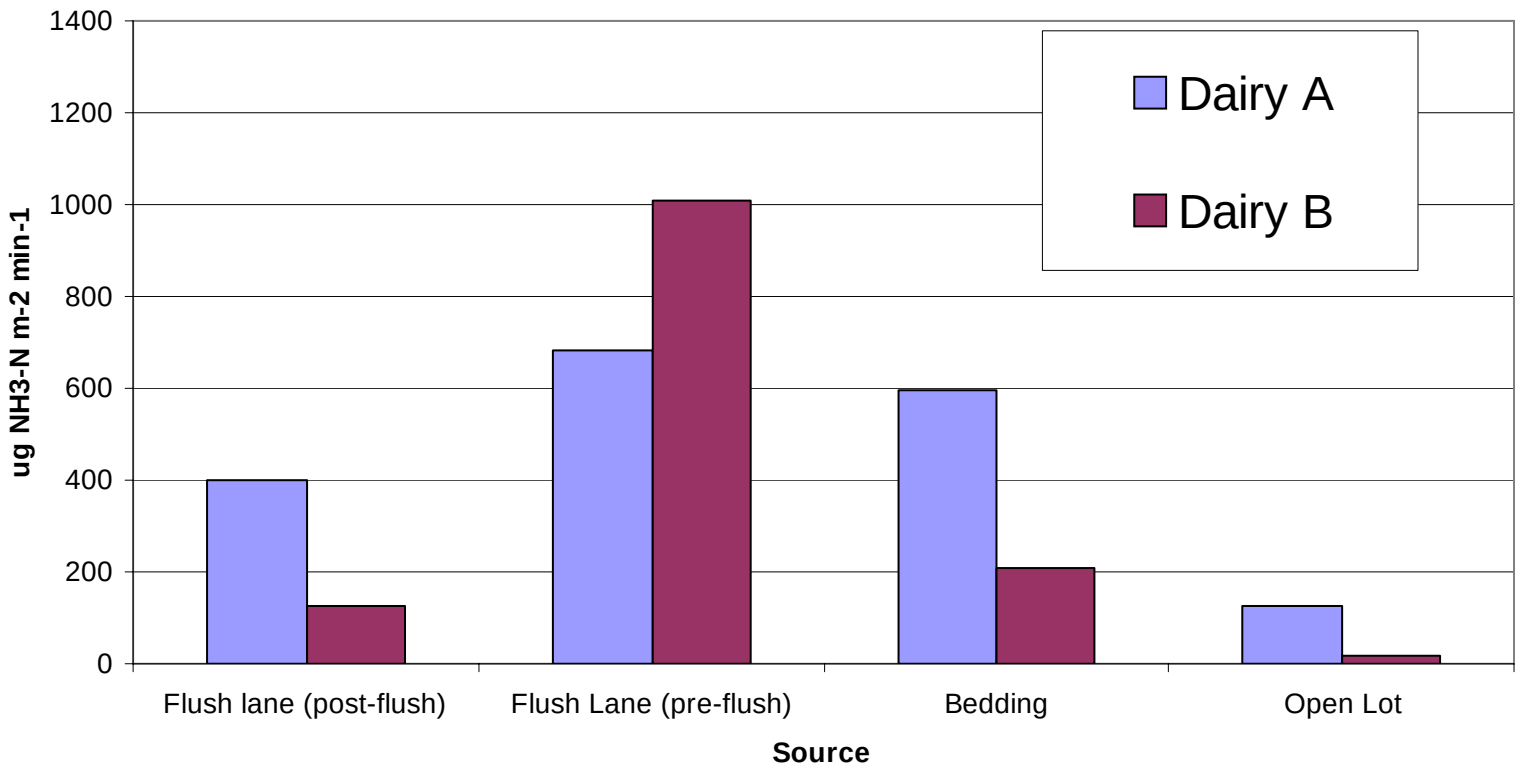
Ambient Temperatures

Schmidt Fall Sampling(18 to 38 C)

CSUF Spring Sampling (9 to 18 C)



Results

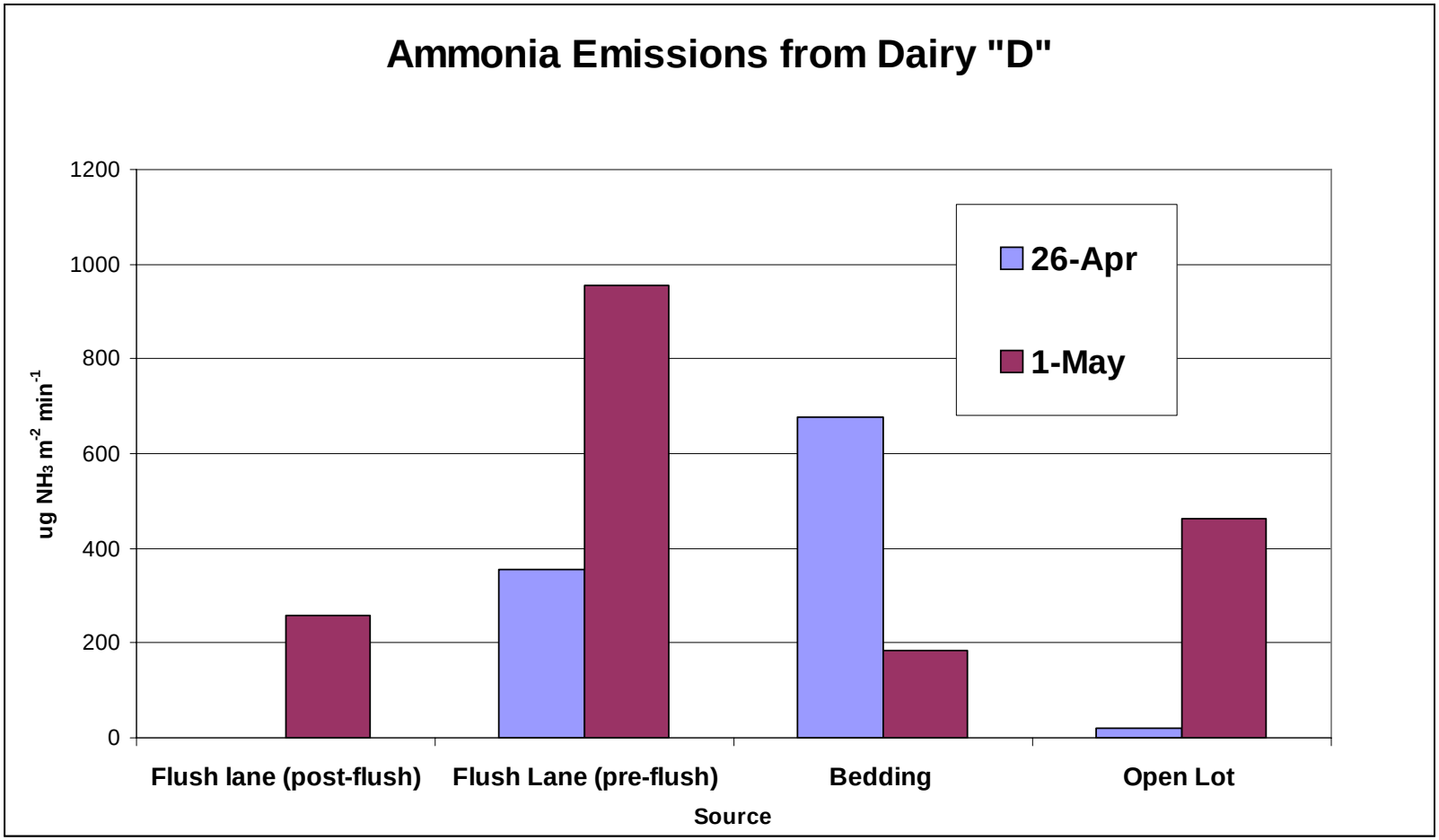


- Dairy A's Bedding emitted 3 times Dairy B's Bedding

Results

- Bedding from Dairy “A” emitted 3 times the amount of ammonia than bedding from Dairy “B”
- Bedding Source
  - Dairy “A” Scraped Manure from Open Lot
  - Dairy “B” Separated Solids

Results



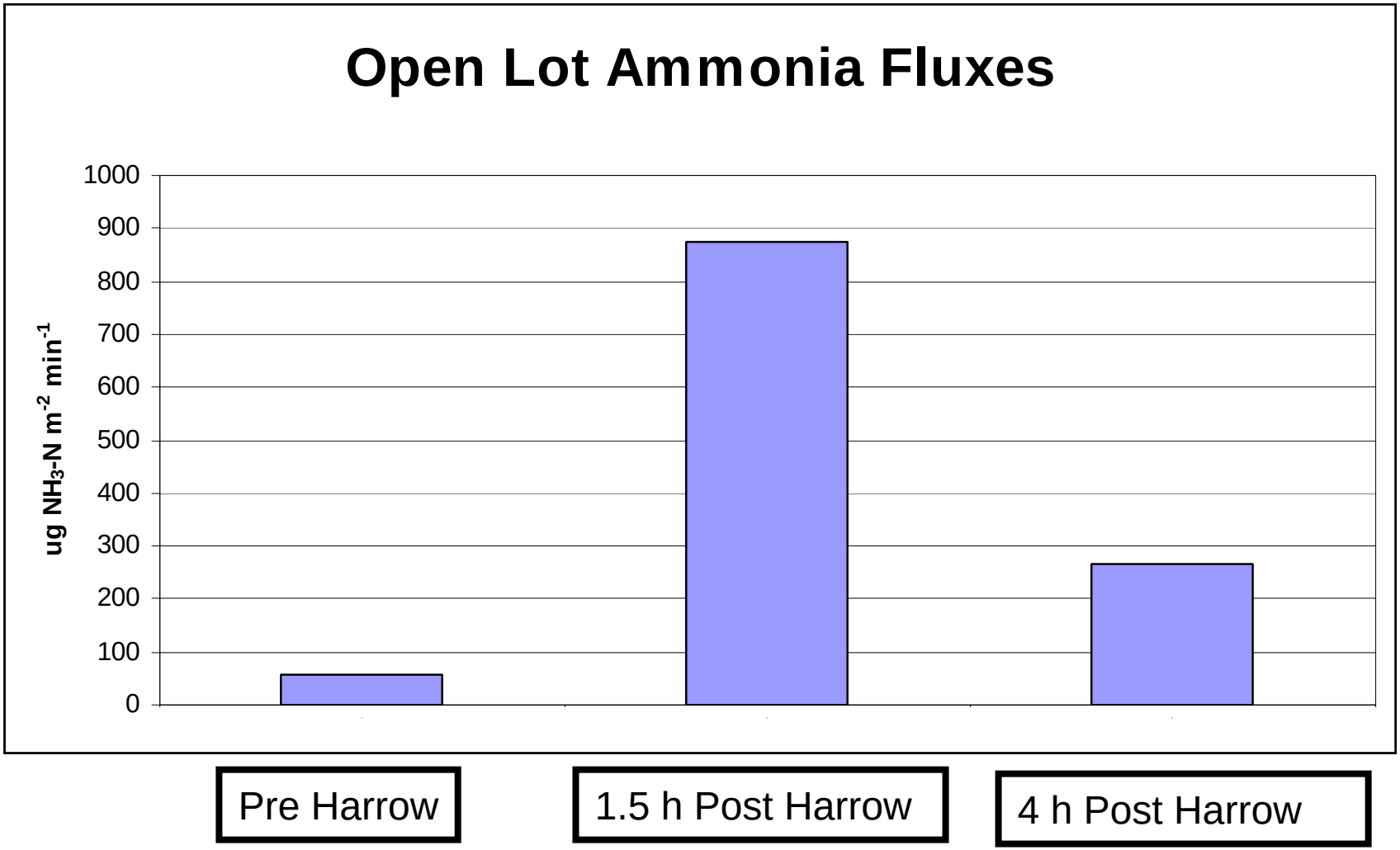
- Sampled after disturbance of open lot on May 1

Open Lot Management

- Open lot used to dry down separated solids in preparation for use as bedding
- Harrowed frequently to enhance drying, fly control
- Scraped up, stockpiled, and covered, once dry

Results – Open Lot Post Harrowing

Results – Open Lot Harrowing



Conclusions

- Emissions of ammonia greater during warmer conditions
- Bedding source significant in ammonia emissions
- Open lot management may be significant in mitigating ammonia emissions

Future Work

- Summer Sampling (May and June)
- Land Application of dairy effluent
  - Spring
  - Fall
- Use of data in computer simulation model (DNDC)
- Lagoon emissions

Land Application

- Occur in spring and fall months
  - Between crops
- Liquid - from lagoons and storage ponds
- Solid - from corrals and solids separators

Land Application Sampling

- Field Gas Analyzer
  - NH_3, N_2O, CO_2, Ethanol, and Methanol
  - Portable, field rugged
- Liquid Manure
  - NH_3 – emitted immediately
  - N_2O – occurs sometime after application
    - Dependent on denitrification by microbes
- Solid Manure
  - Incorporated into soil shortly after application

Questions?

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