

# Fertilizing western rangelands for sagebrush habitat improvement: an assessment

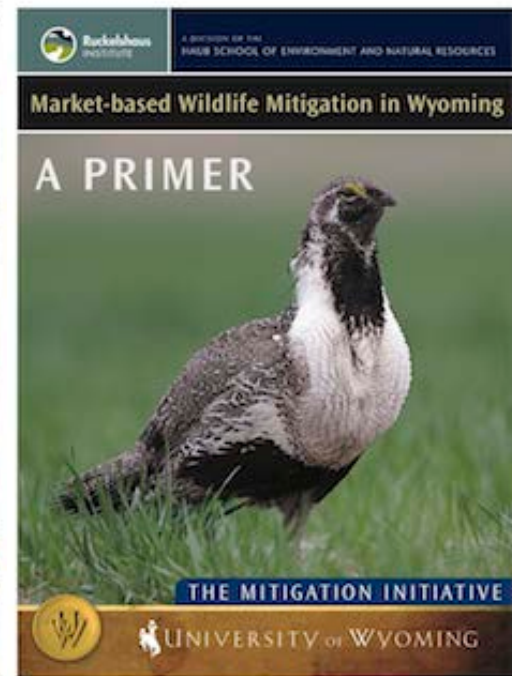
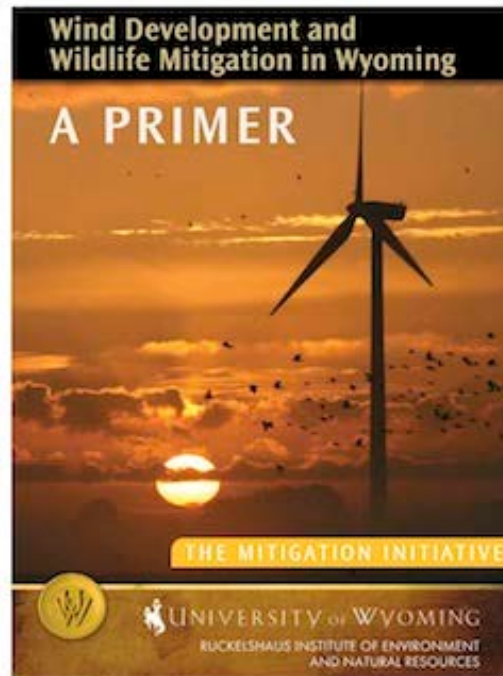
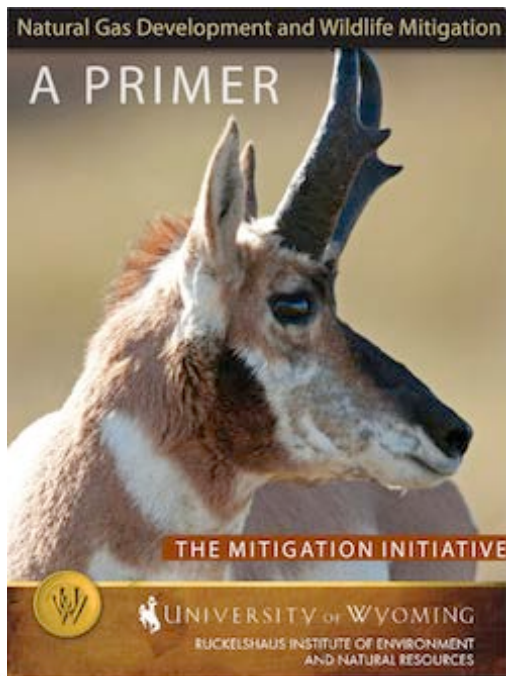


Photo by Joe Riis



N. Korfanta, M. Mobley, and I. Burke

# Ruckelshaus Institute Energy Mitigation and Outreach Initiative

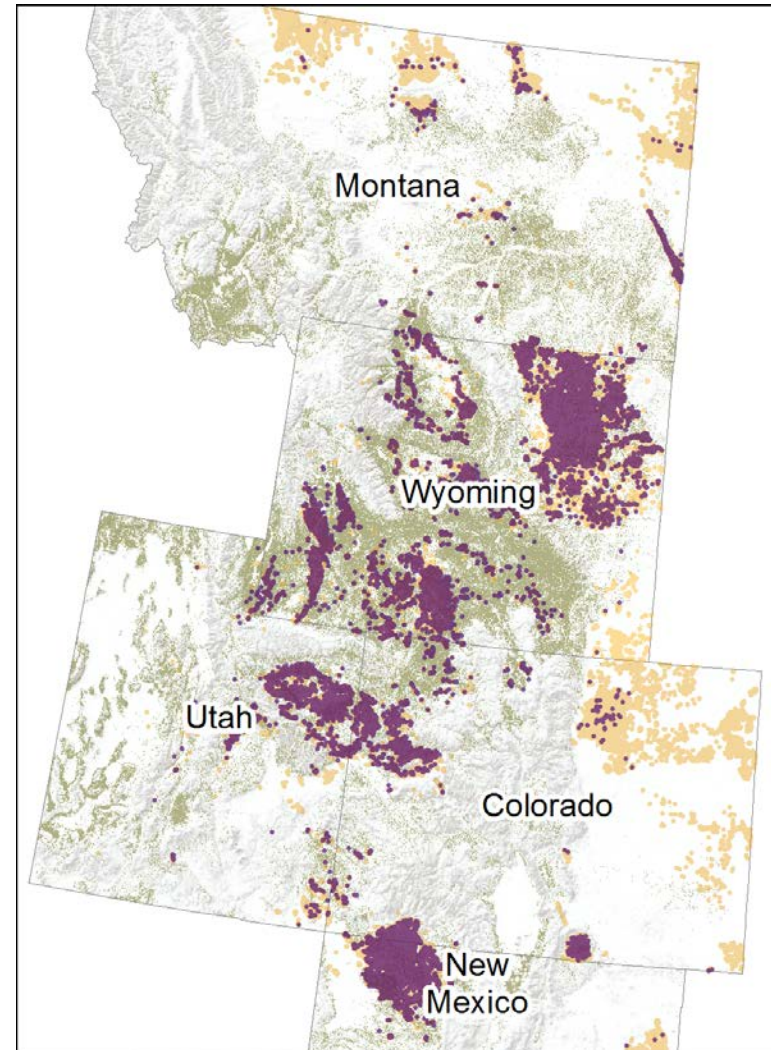


FERTILIZING WESTERN RANGELANDS

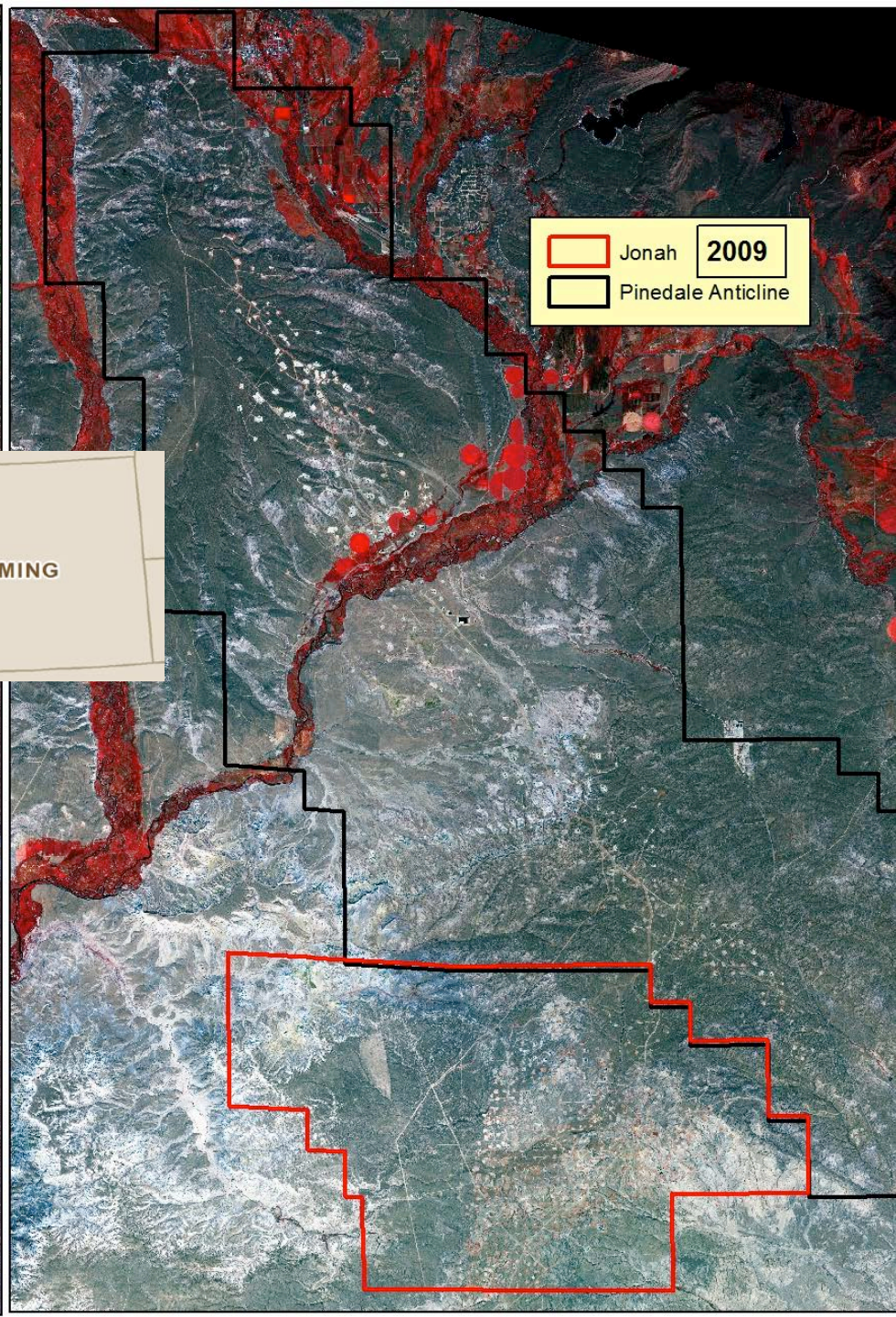
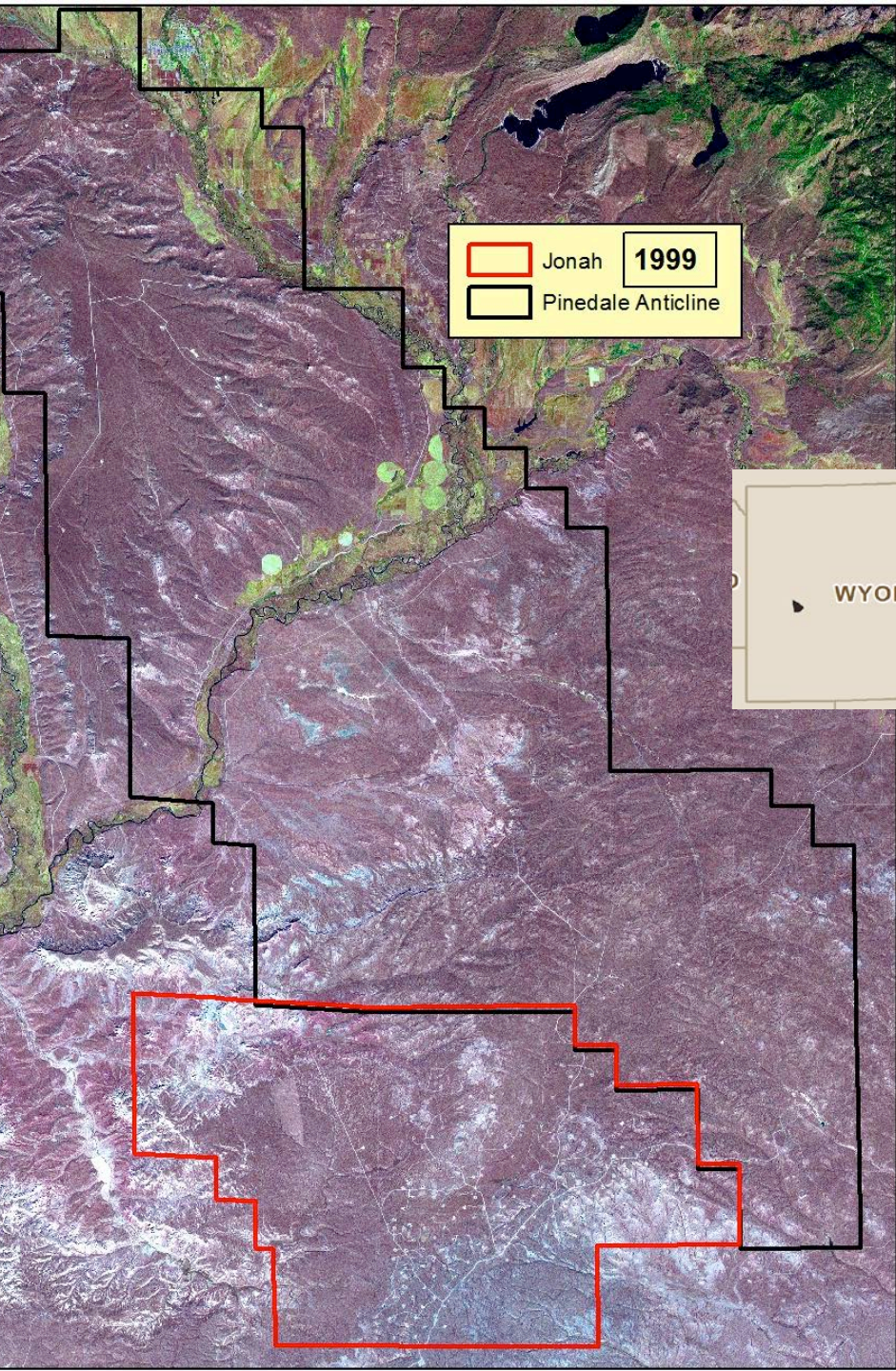
# Increased natural gas production



# Much of that NG is in sagebrush-steppe

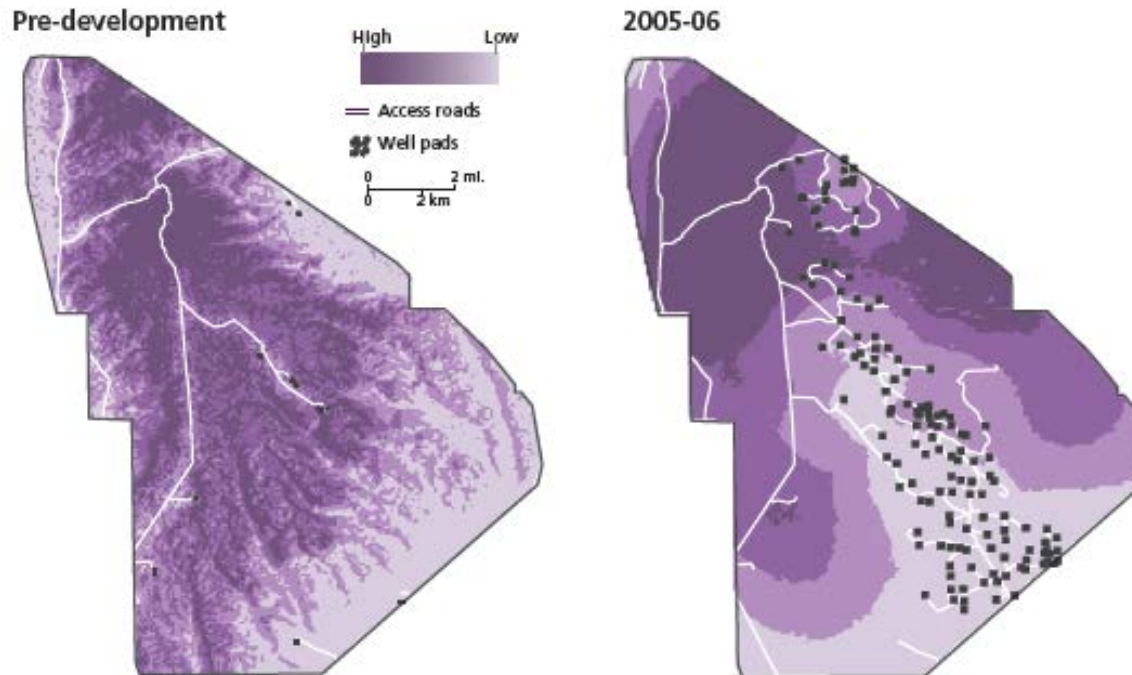


 Sagebrush  Wells in sagebrush  Wells in other vegetation types



# Habitat loss on winter range

## Mule Deer Predicted Level of Habitat Use



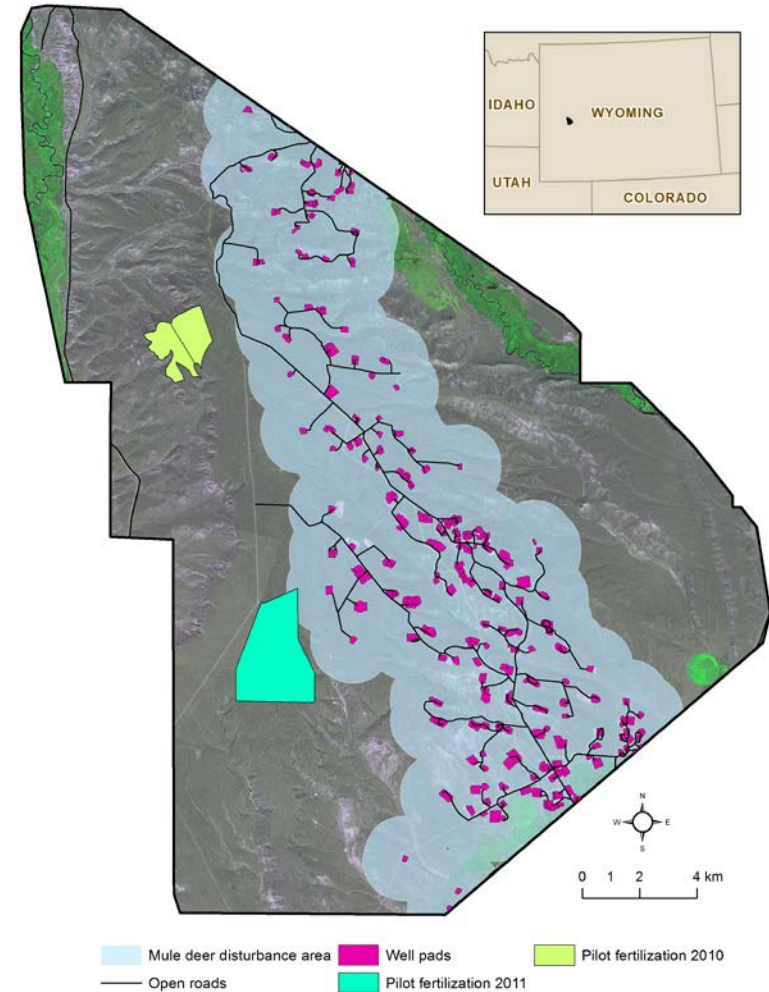
Sawyer et al. 2006; Map courtesy of the UW Migration Initiative

Since 2001, >40% population decline (Sawyer and Nielson 2011)

## FERTILIZING WESTERN RANGELANDS

# Mule deer declines

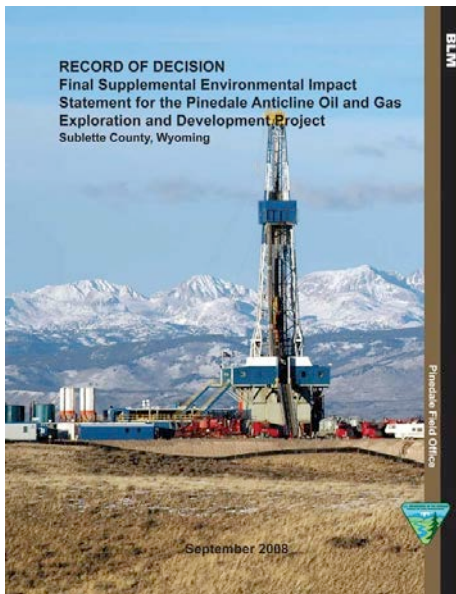
- Direct habitat loss
  - Indirect habitat loss
- } ↓ Nutritional Carrying Capacity



## FERTILIZING WESTERN RANGELANDS

# Mule deer declines trigger mitigation

2009 ROD required sequential mitigation if 15% decline in a year or average over all years (since 05/06)



### **On-site**

1. Protect flanks
2. Habitat enhancements

### **On-site/off-site**

3. Conservation easements

### **Modification of operations**

4. Change pace or pattern of development



## FERTILIZING WESTERN RANGELANDS

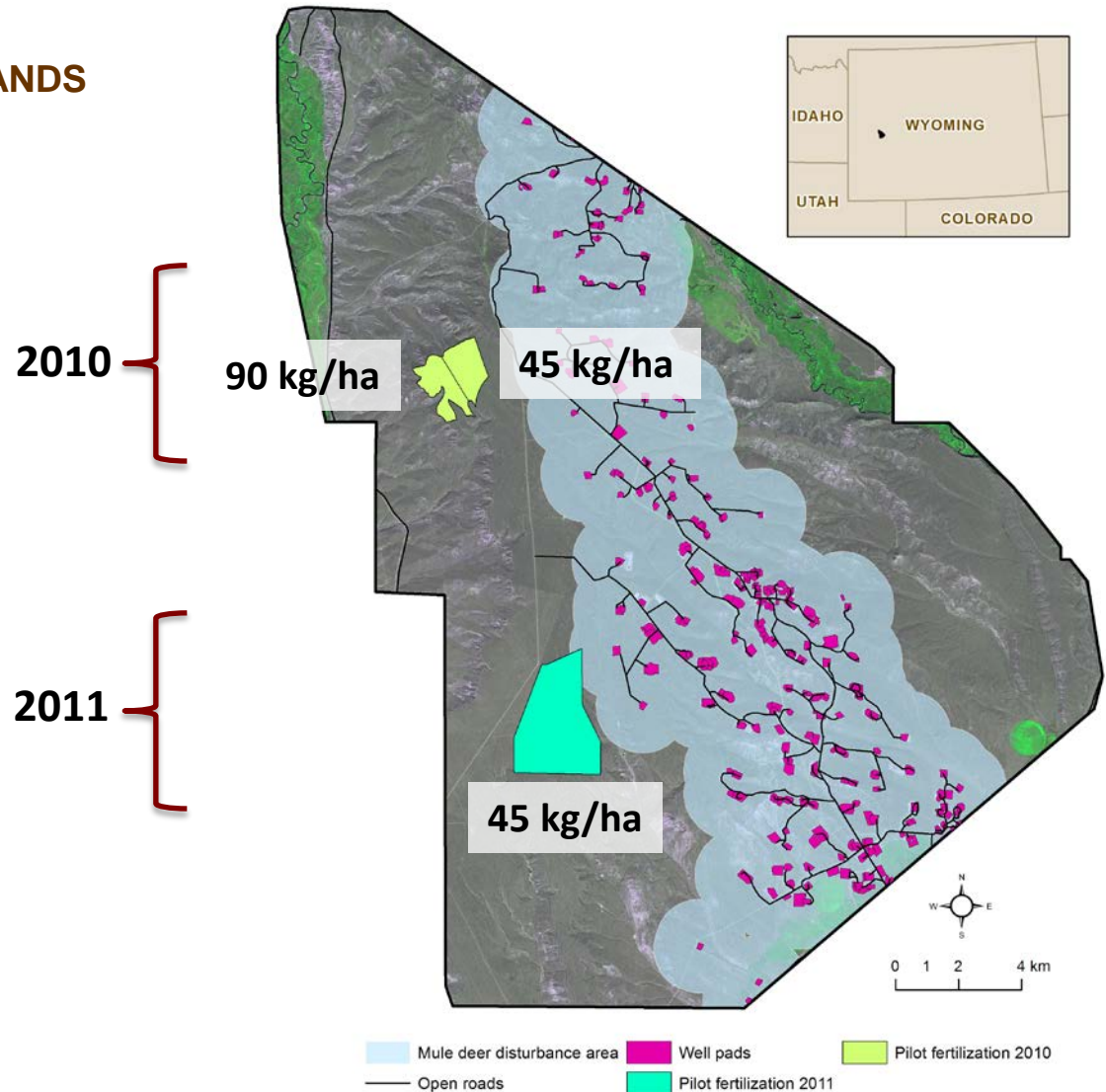
# How to mitigate energy development impacts through on-site habitat enhancements?



## FERTILIZING WESTERN RANGELANDS

# Sagebrush fertilization

- Pilot study initiated in 2010
- Federal approval of up to 30,598 ac (also in Rawlins DEIS)
- Goals: Improve production and quality/palatability



## Aerial applications of pellet urea

$(\text{CO}(\text{NH}_2)_2)\text{-N}$

~\$55/ac (\$54,430 in 2011)

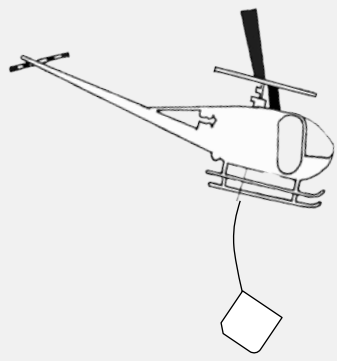




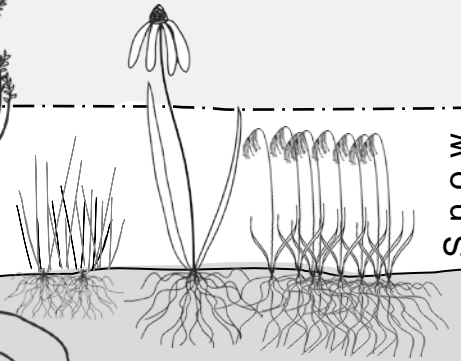
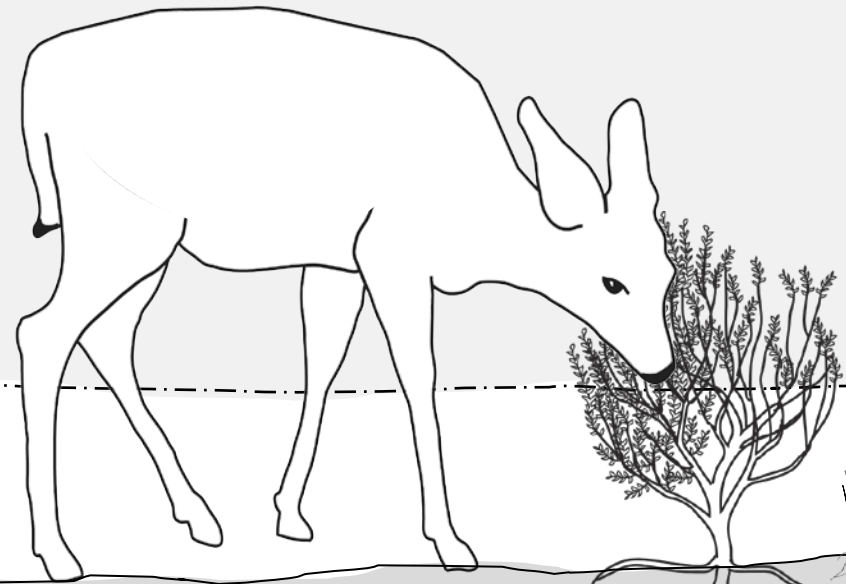
## FERTILIZING WESTERN RANGELANDS

# What are the likely benefits to wildlife and potential costs/risks?

- Literature review
- Range management + ungulate nutrition + semi-arid land biogeochemistry = 145 papers
- Korfanta, N.M., M.L. Mobley, I.C. Burke. 2015. Fertilizing western rangelands for mule deer: an assessment of benefits and risks. *Wildlife Society Bulletin*.



2-4X background rates of N deposition/fixation

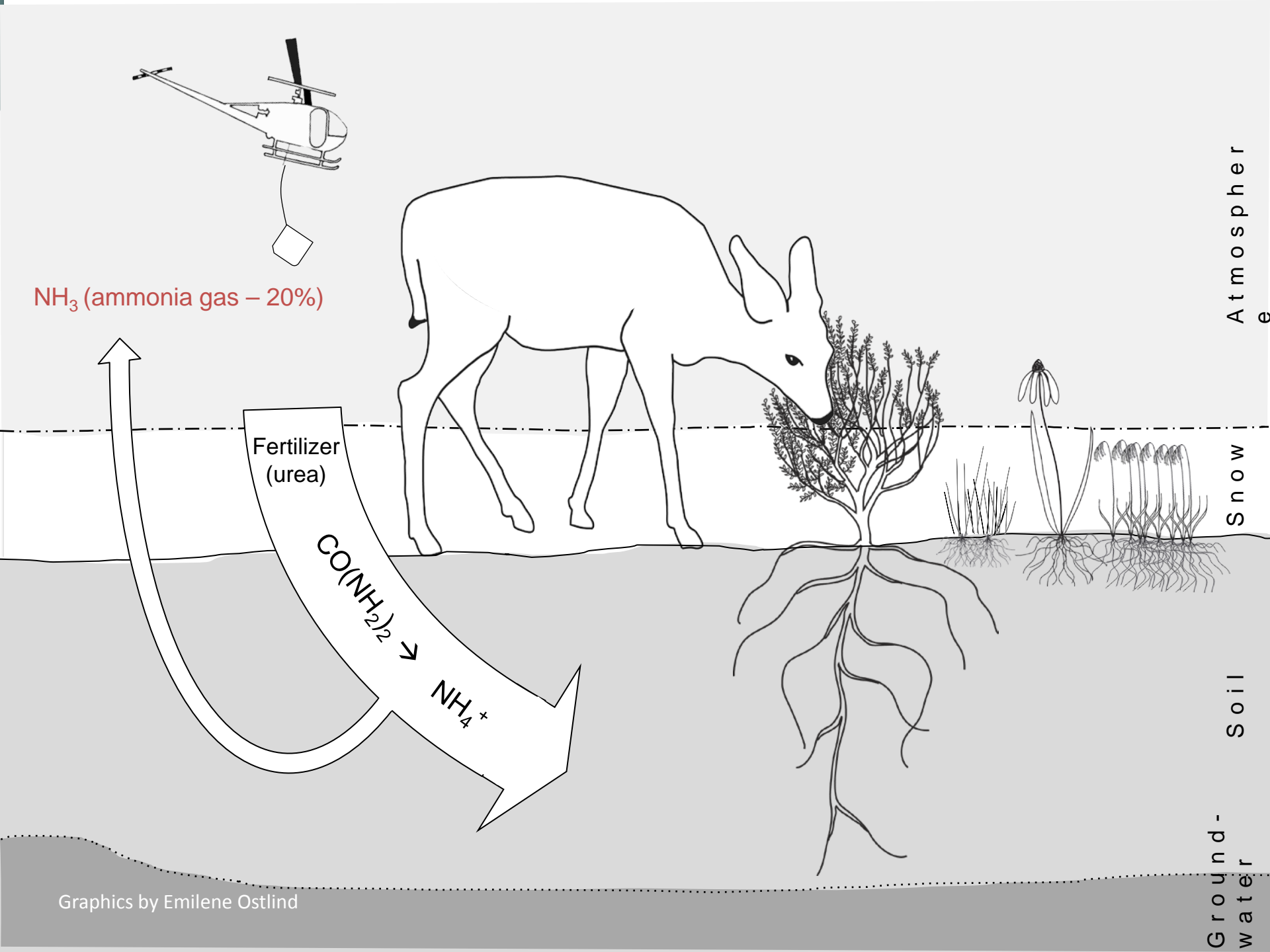


Atmosphere

Snow

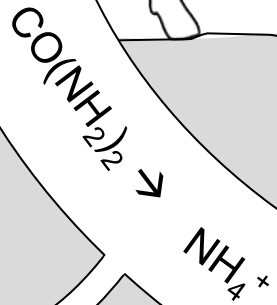
Soil

Ground-water



$\text{NH}_3$  (ammonia gas – 20%)

Fertilizer  
(urea)

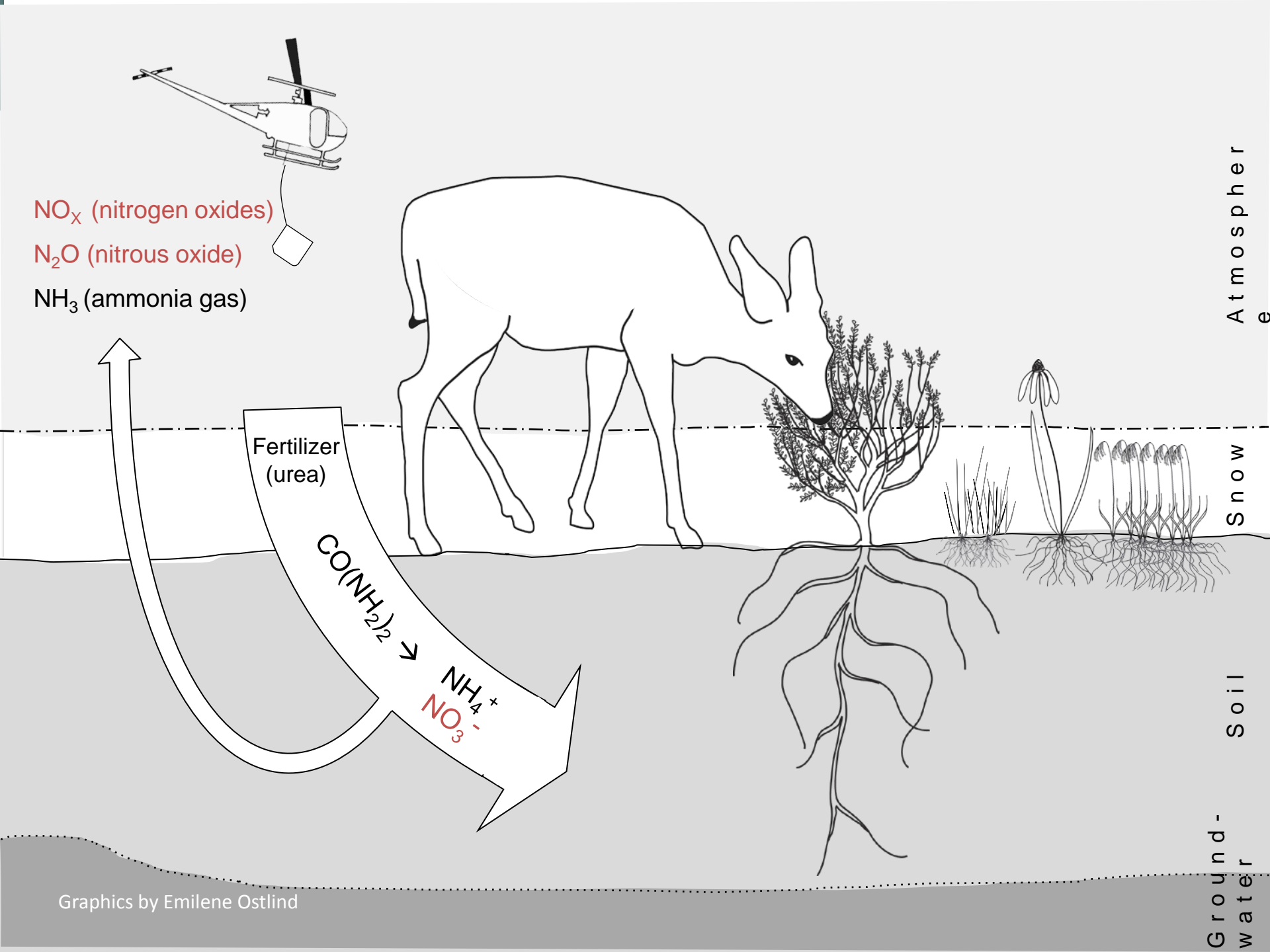


Atmospher  
e

Snow

Soil

Ground-  
water



$\text{NO}_x$  (nitrogen oxides)

$\text{N}_2\text{O}$  (nitrous oxide)

$\text{NH}_3$  (ammonia gas)

Fertilizer  
(urea)

$\text{CO}(\text{NH}_2)_2 \rightarrow$

$\text{NH}_4^+$   
 $\text{NO}_3^-$

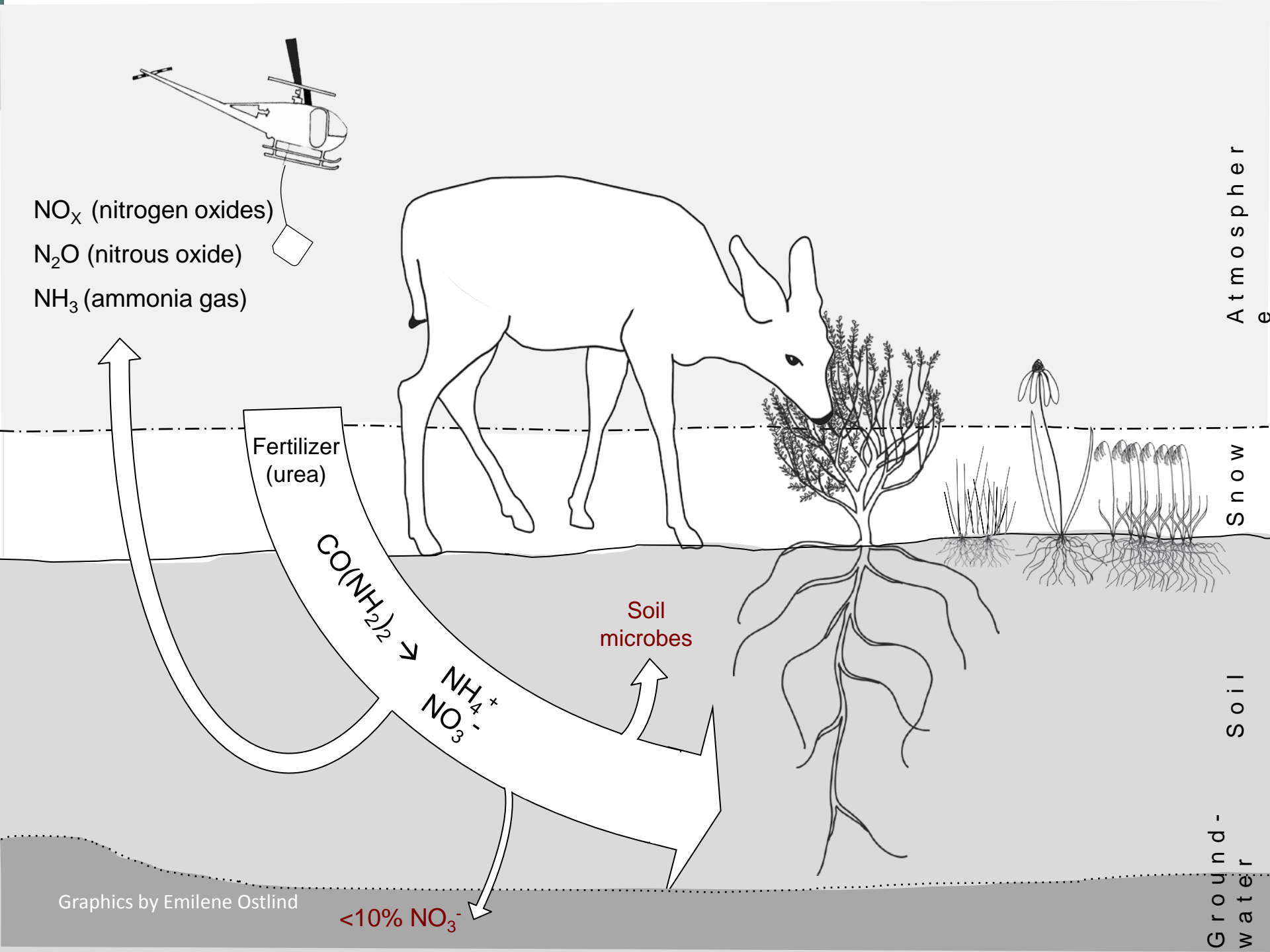
Atmospher  
e

Snow

Soil

Ground-  
water



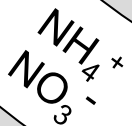


$\text{NO}_x$  (nitrogen oxides)

$\text{N}_2\text{O}$  (nitrous oxide)

$\text{NH}_3$  (ammonia gas)

Fertilizer  
(urea)



Soil  
microbes

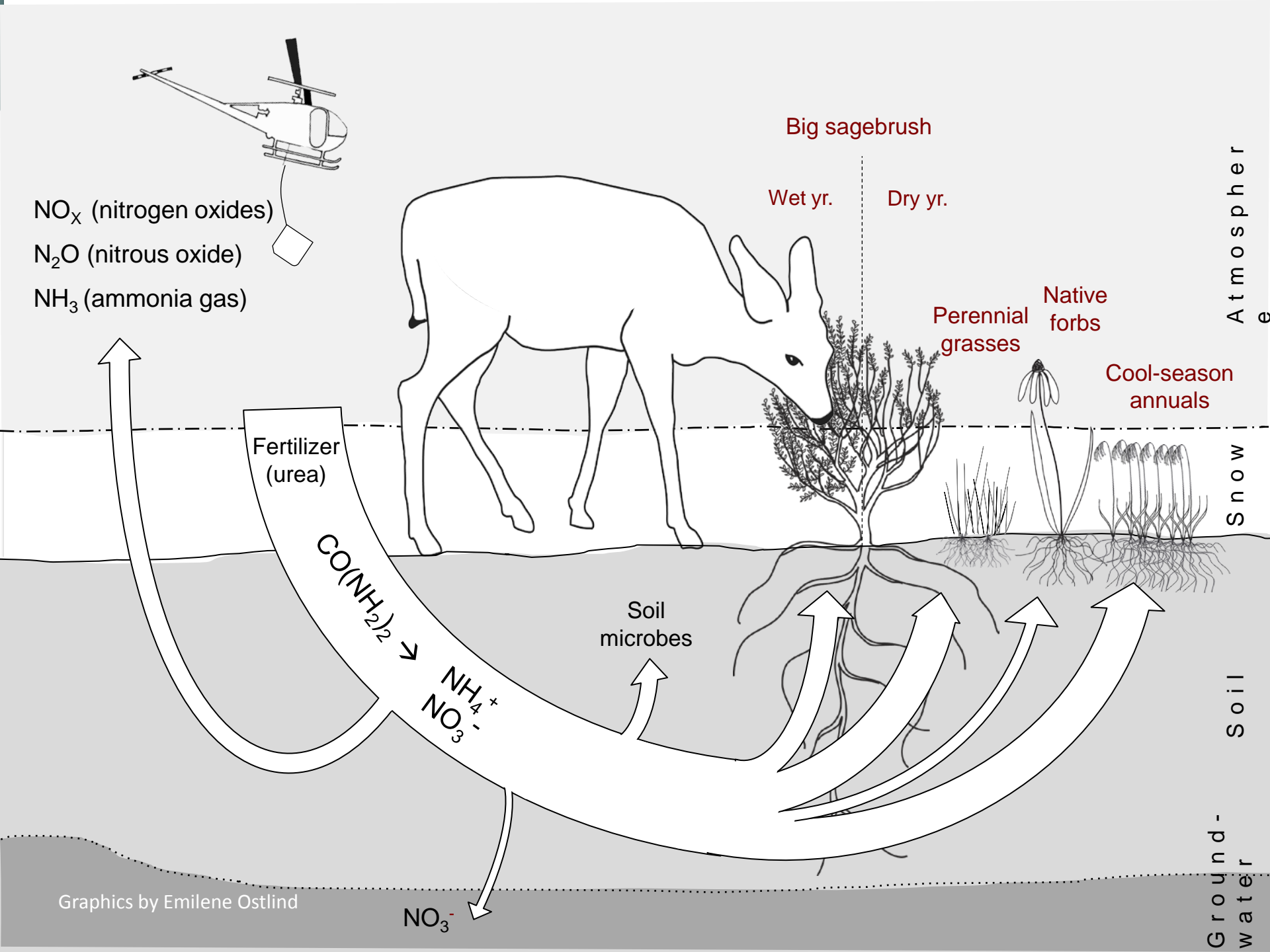
$<10\% \text{NO}_3^-$

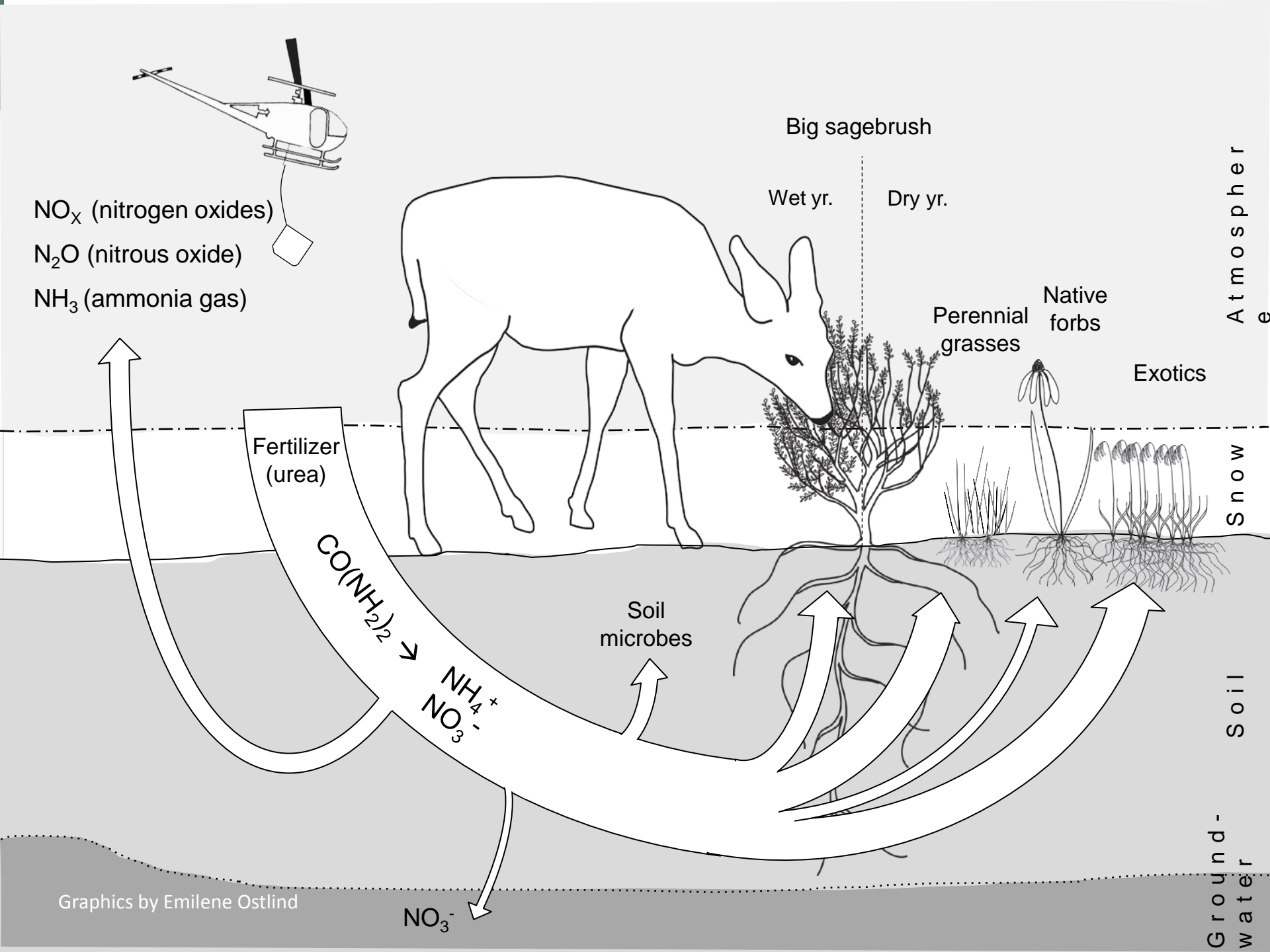
Atmosphere

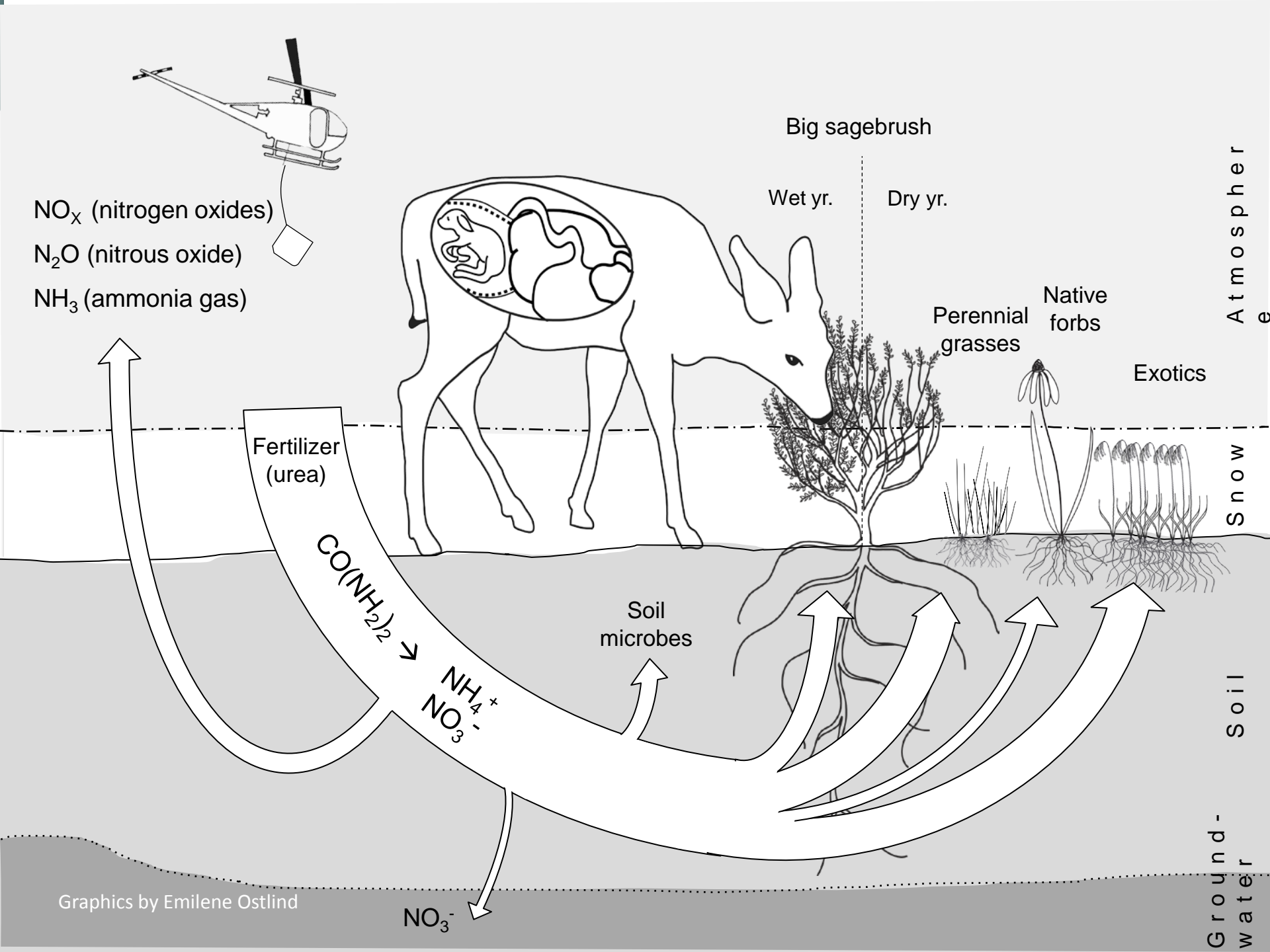
Snow

Soil

Ground-  
water







FERTILIZING WESTERN RANGELANDS

What are the likely benefits to wildlife and potential costs/risks?

DOES FERTILIZATION INCREASE SAGEBRUSH PRODUCTION, QUALITY, OR PALATABILITY?

## Fertilization might increase production



### ↑ Leader growth with N (sometimes)

- No effect at 31 kg/ha (Upper Green = 45.0)  
(Carpenter and West 1987)
- $\leq$  0-30% increase at 84-252 kg/ha (Barrett 1979)
- 36% increase at 34 kg/ha | 103% at 100 kg /ha  
(Bayoumi and Smith 1976)

DOES FERTILIZATION INCREASE SAGEBRUSH PRODUCTION, QUALITY, OR PALATABILITY?

Longer leaders = more digestible energy / cover

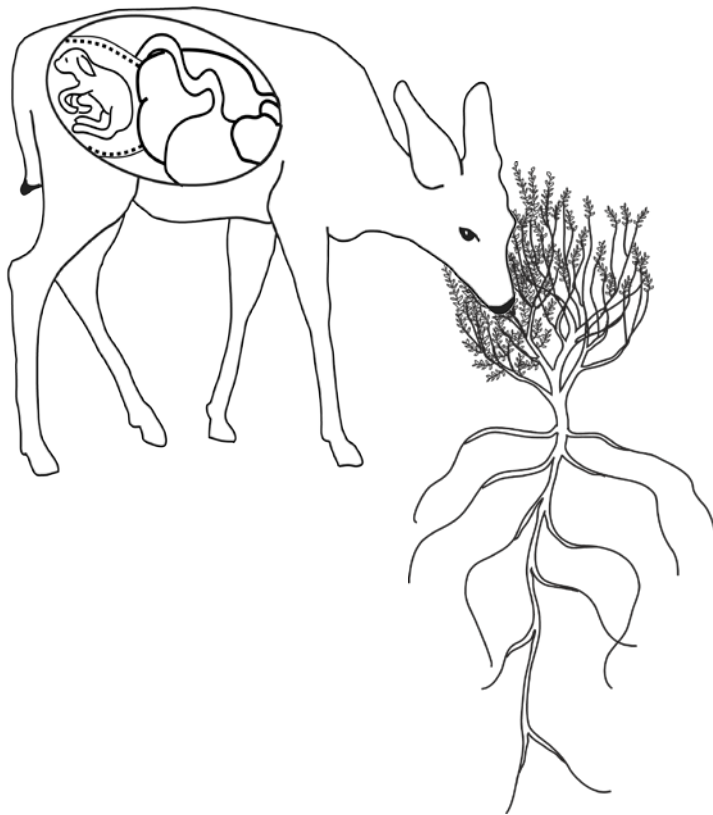


But....

- Minimal effect in low-precipitation years
- Transitory – decline in year 2  
(Bayoumi and Smith 1976)
- Is protein or DE limiting?

## BENEFITS TO MULE DEER

# Mule deer response to enhanced winter nutrition

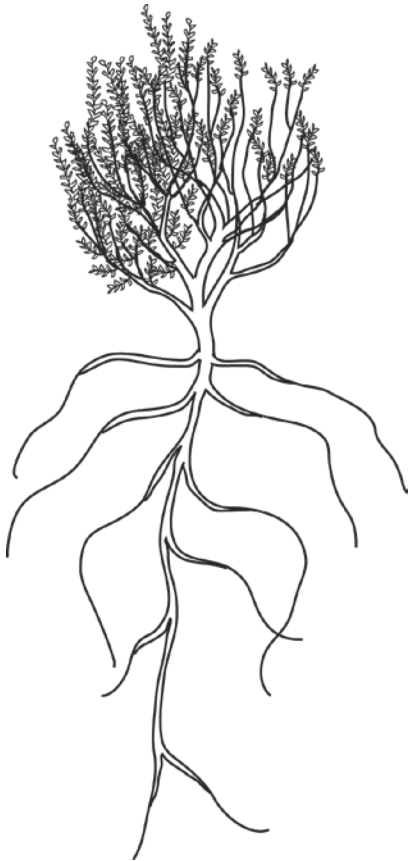


- Increased DE can improve fitness
  - ↑ Fetal and overwinter fawn survival
  - ↑ Adult female survival(Artificial feeding study; Bishop et al. 2009)
- Caveat:  
Artificial feed ≠ enhanced native forage



DOES FERTILIZATION INCREASE SAGEBRUSH PRODUCTION, QUALITY, OR PALATABILITY?

## No increase in crude protein of winter sagebrush



Increased crude protein of leaves and stems in  
spring/summer: 2.4-4.6% (Bayoumi and Smith 1976)

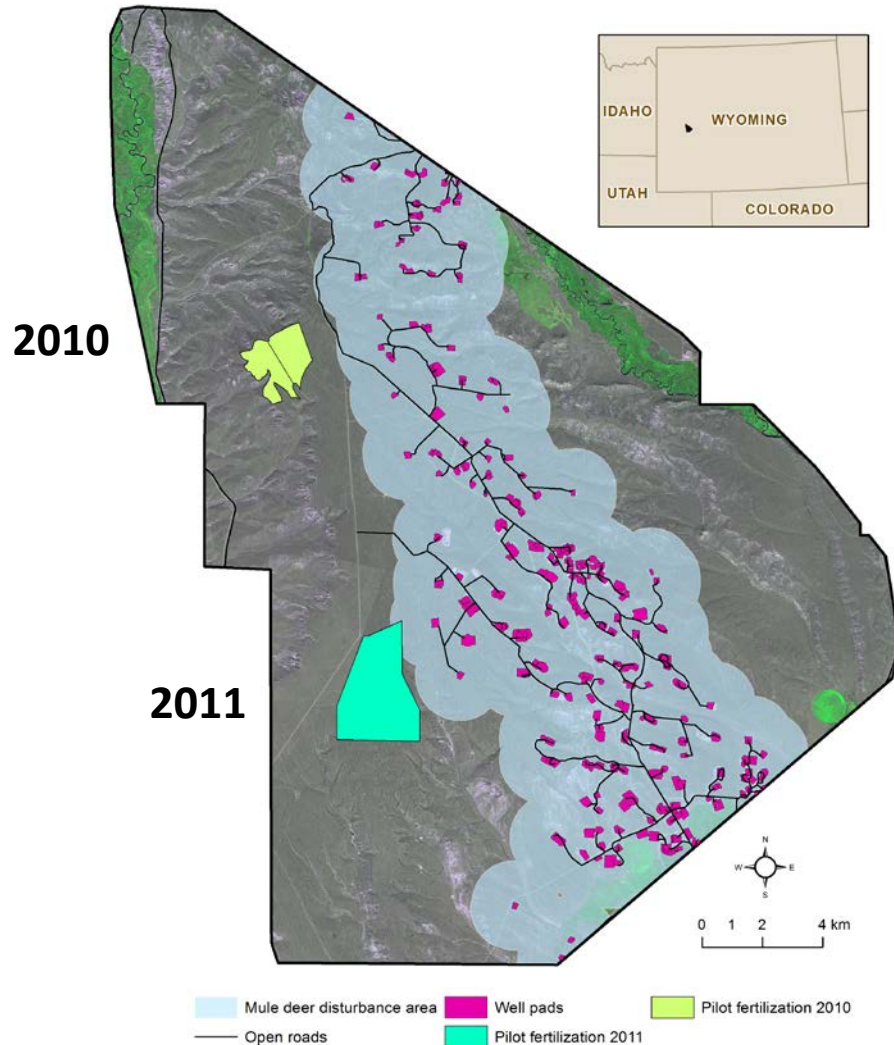
- **Transitory:** Increase in protein lost by fall (Barrett 1979)—leaf fall or translocated to twigs
- **High inter-annual variation** (precipitation-dependent?)

DOES FERTILIZATION INCREASE SAGEBRUSH PRODUCTION, QUALITY, OR PALATABILITY?

## Fertilization does not affect terpenoid compounds

- No significant effect on volatile oil concentrations at fertilization rates similar to Upper Green (Sneva et al. 1983)
- Mule deer: no relationship between terpenoid compounds and diet preference (Black Sagebrush: Behan and Welch 1985)
- Sage grouse: loss of monoterpenoids during digestion (Welch et al. 1989)






## Realized mitigation potential


- No significant difference in leader length (DE) between treatment and control plots


## BENEFITS TO WILDLIFE

# Limited benefits to sagebrush obligates



Crude protein 

Terpenoids (palatability) 

Digestible energy (DE) 

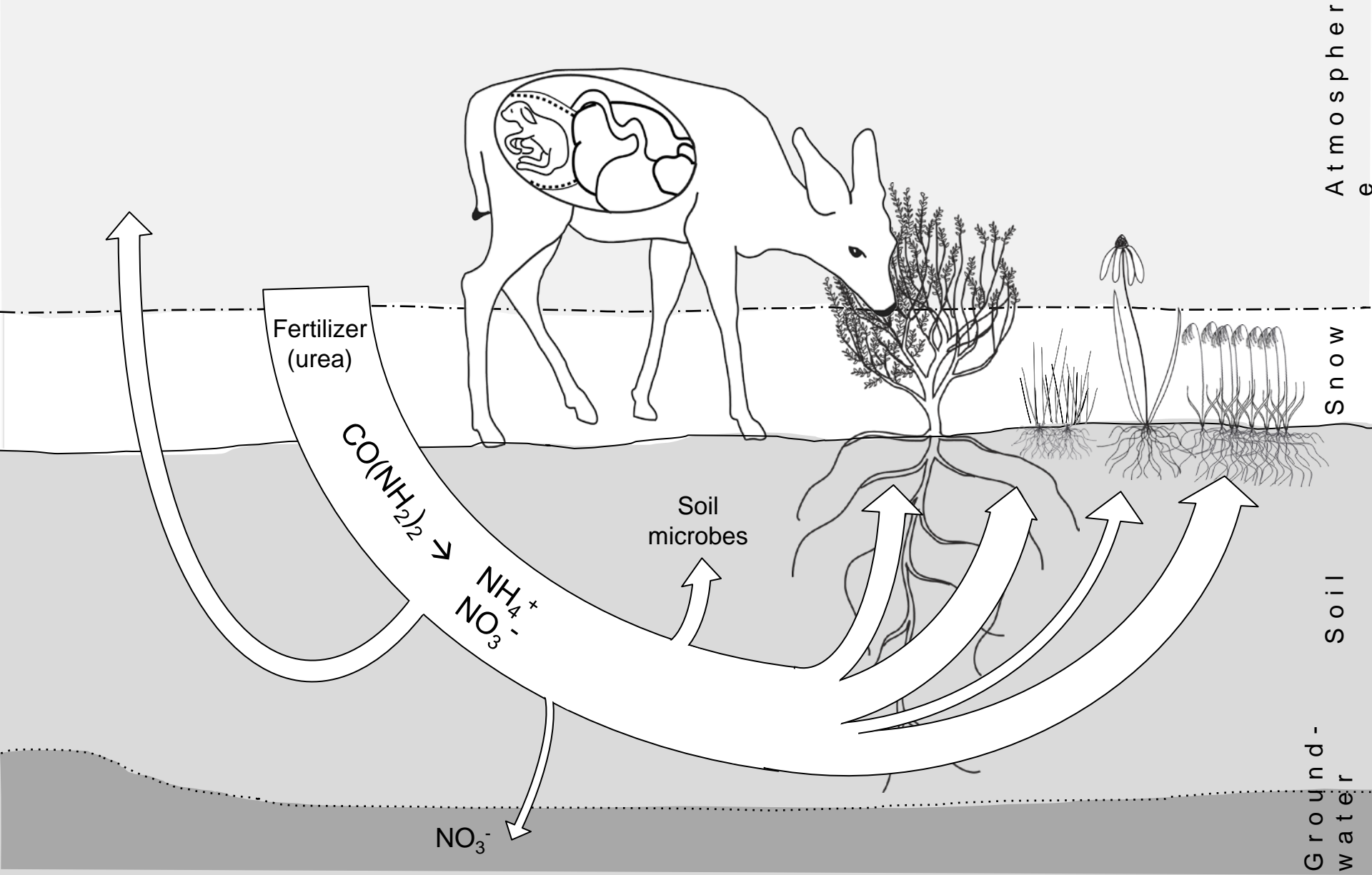
Sagebrush cover 

## FERTILIZING WESTERN RANGELANDS

What are the likely benefits to wildlife and potential costs/risks?

# Atmospheric consequences

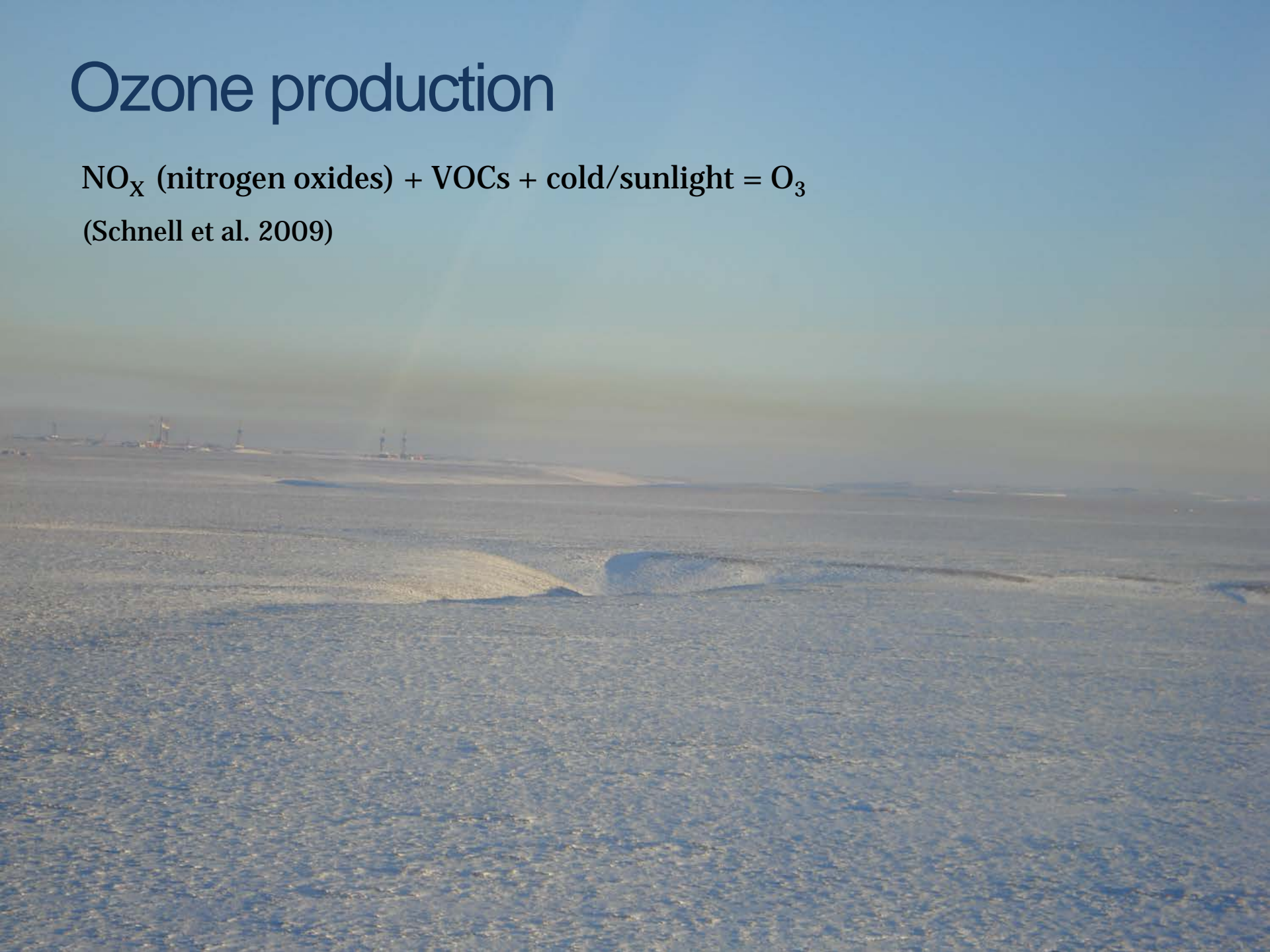
NO<sub>x</sub> (nitrogen oxides)



# Ozone production

$\text{NO}_x$  (nitrogen oxides) + VOCs + cold/sunlight =  $\text{O}_3$

(Schnell et al. 2009)

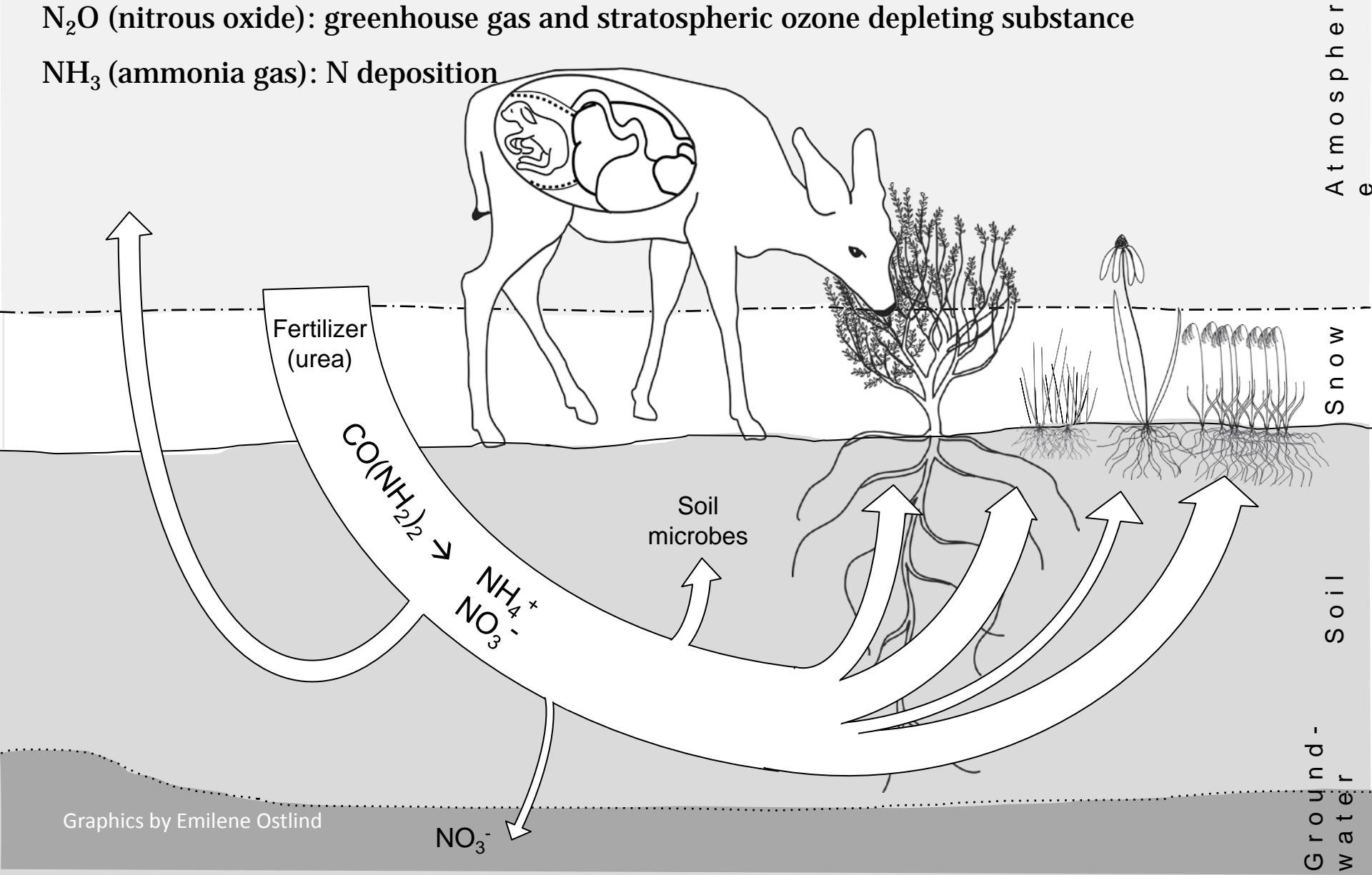


# Atmospheric consequences

$\text{NO}_x$  (nitrogen oxides)

$\text{N}_2\text{O}$  (nitrous oxide): greenhouse gas and stratospheric ozone depleting substance

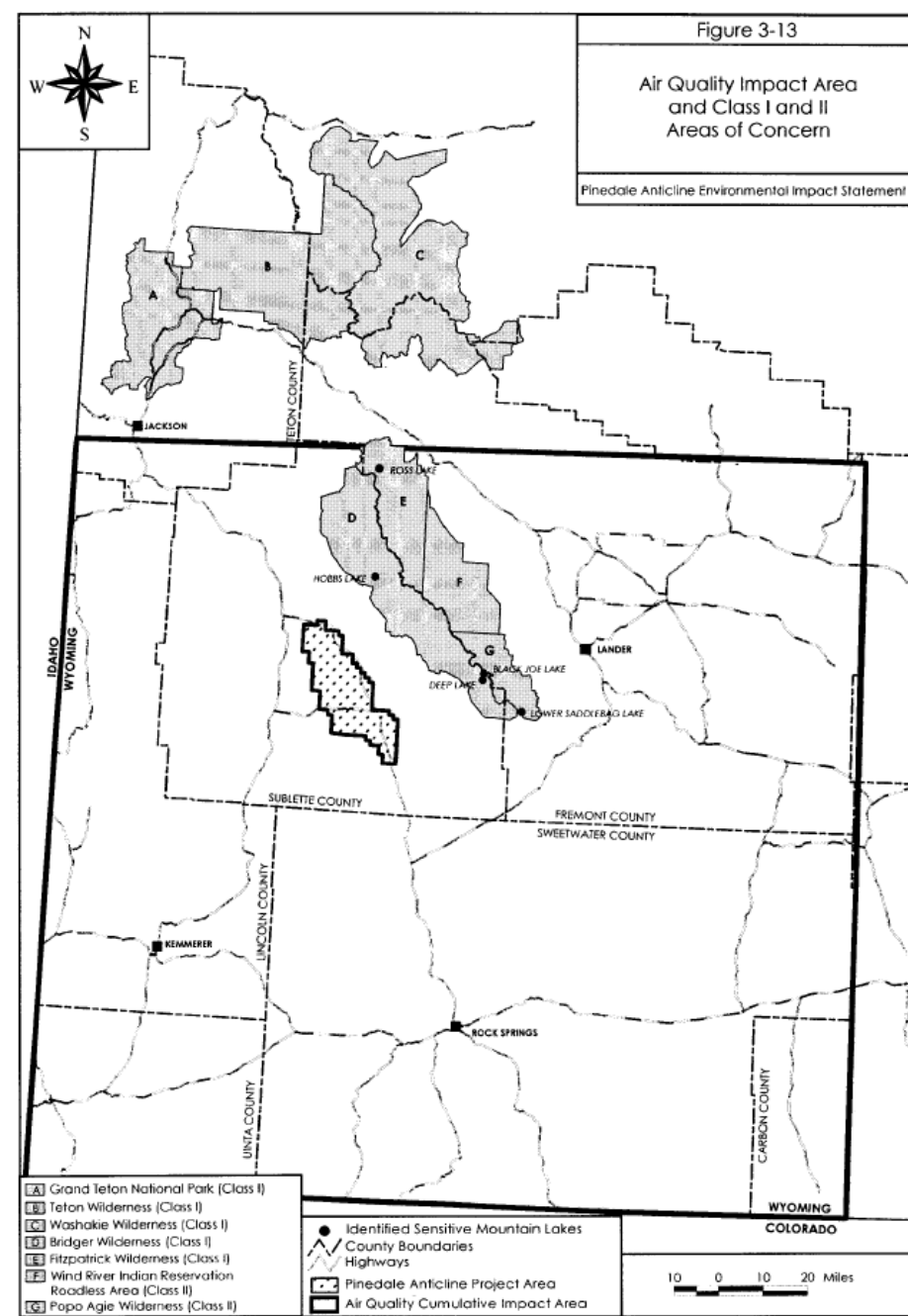
$\text{NH}_3$  (ammonia gas): N deposition





# Ammonia gas

Major source of N deposition in  
Class I Airsheds (Ellis et al. 2013)



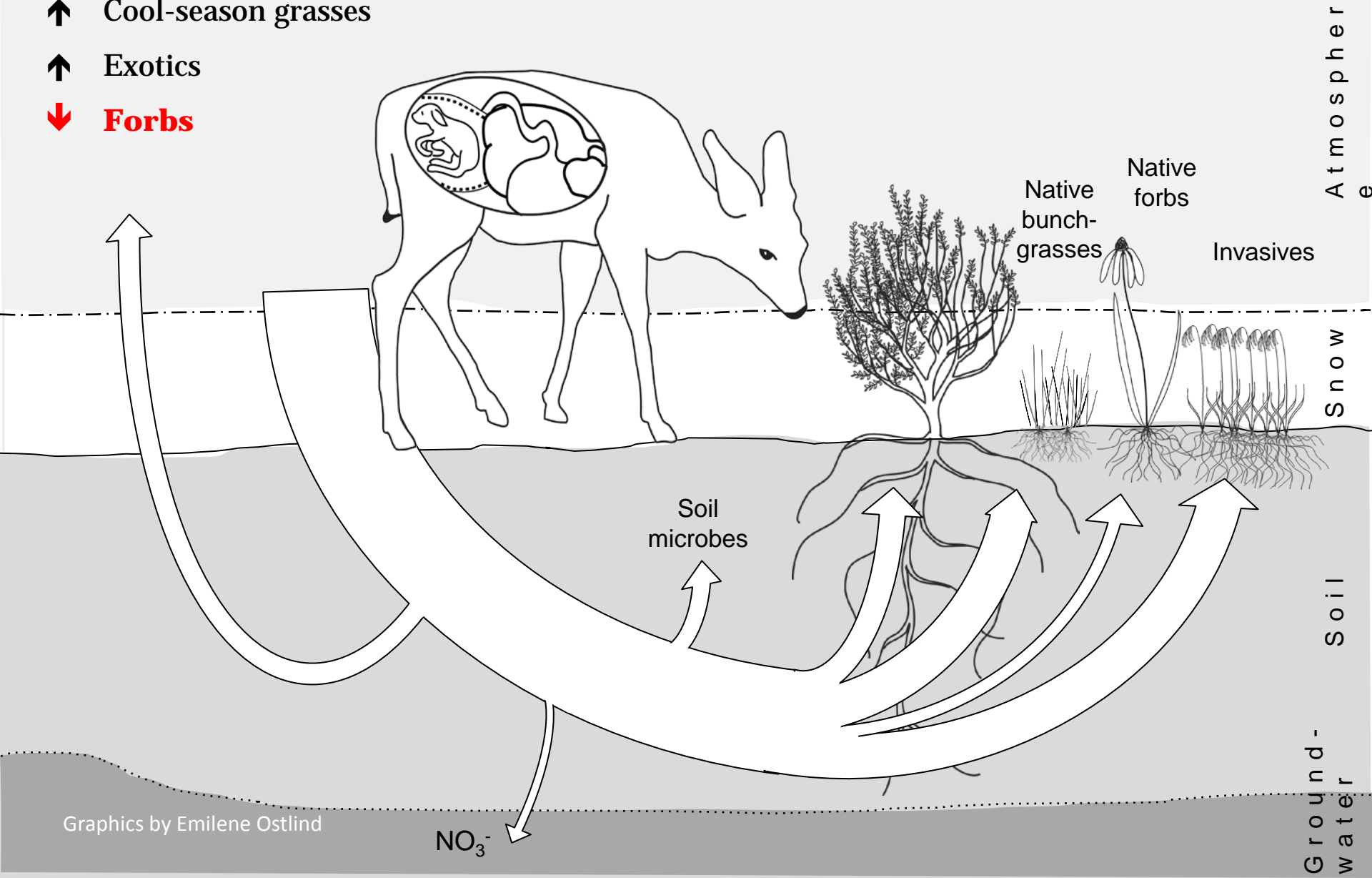
# Ecosystem shifts seen in shortgrass steppe

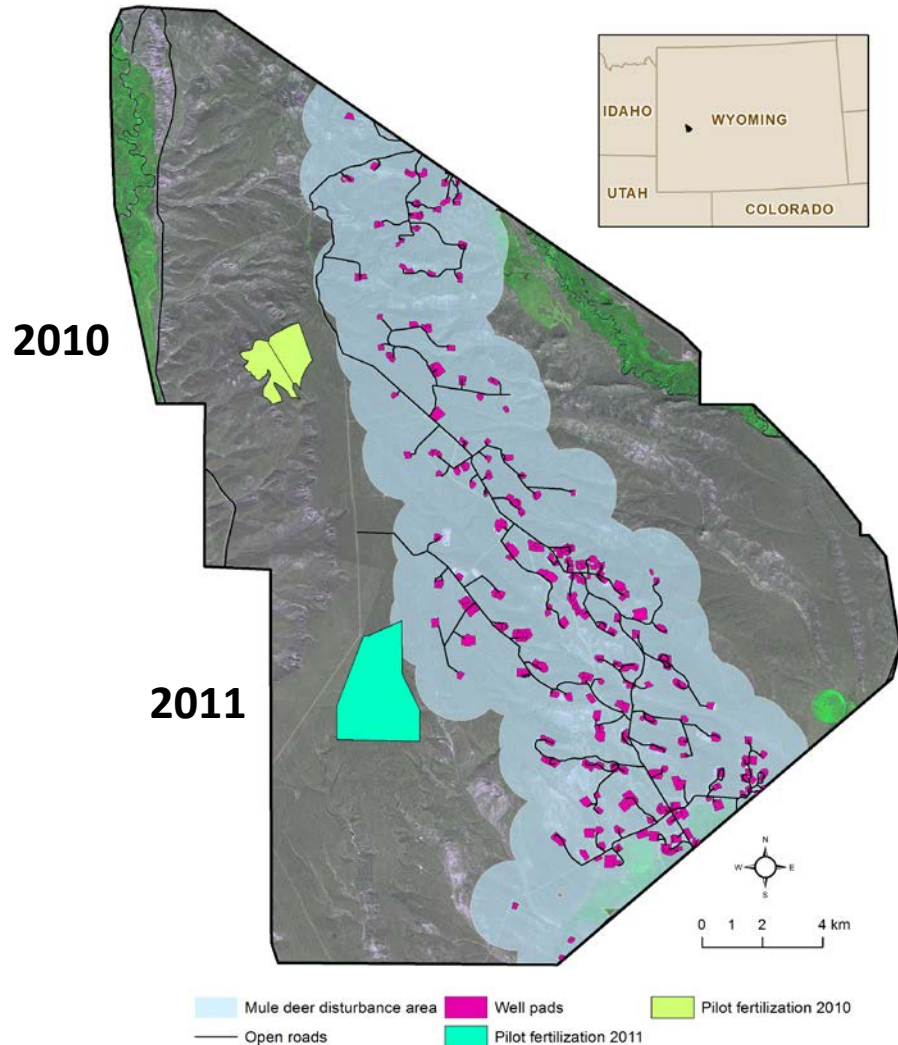
Effects are often persistent, irreversible, and delayed (Milchunas and Lauenroth 1995, Vinton and Burke 1995)

↑ Cool-season grasses

↑ Exotics

↓ **Forbs**





## Expense

- \$55/acre (from PAPO)
- To treat 30,000 acres = \$1.65M annually
- Opportunity cost?

## What are the likely benefits to sage grouse and potential costs/risks?

### BENEFITS

- On-site strategy
- Increased sagebrush cover / digestible energy under certain conditions

### RISKS AND COSTS

- Exotics → ecosystem shifts, change in fire regime
- Loss of forbs (brood habitat)
- Atmospheric/water pollution
- Expensive
- Transitory and uncertain benefit



# Minimizing risks

1. No application where there are weeds
2. Long-term monitoring for ecosystem shifts and invasions before widespread treatment
3. Application timing?



P.S.....

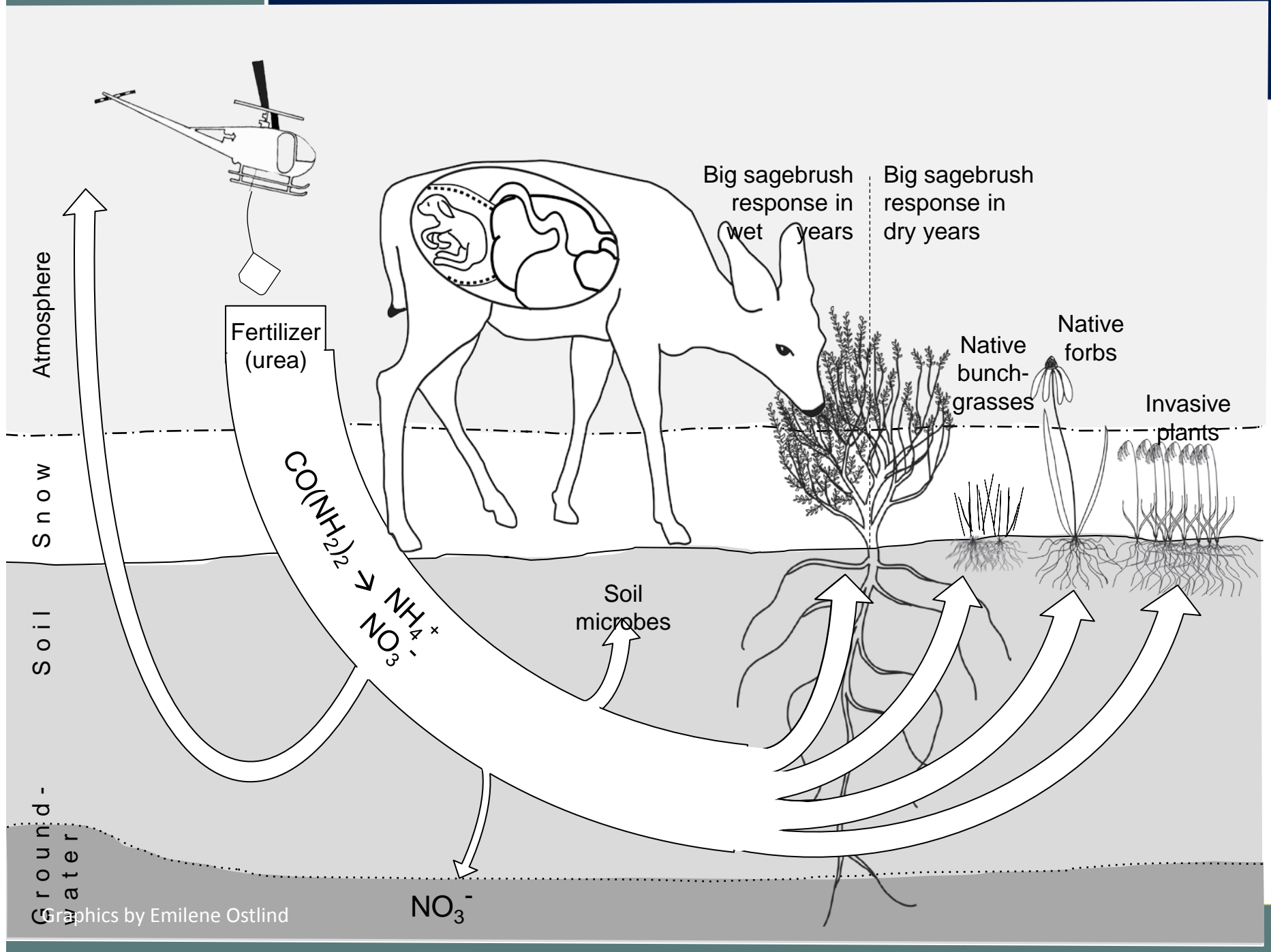


# Thanks

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UW Ruckelshaus Institute of Environment and Natural Resources



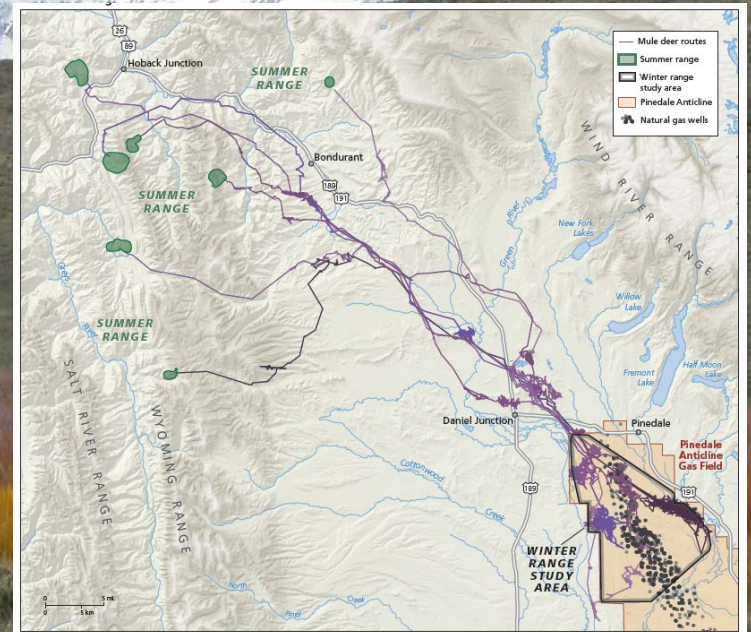
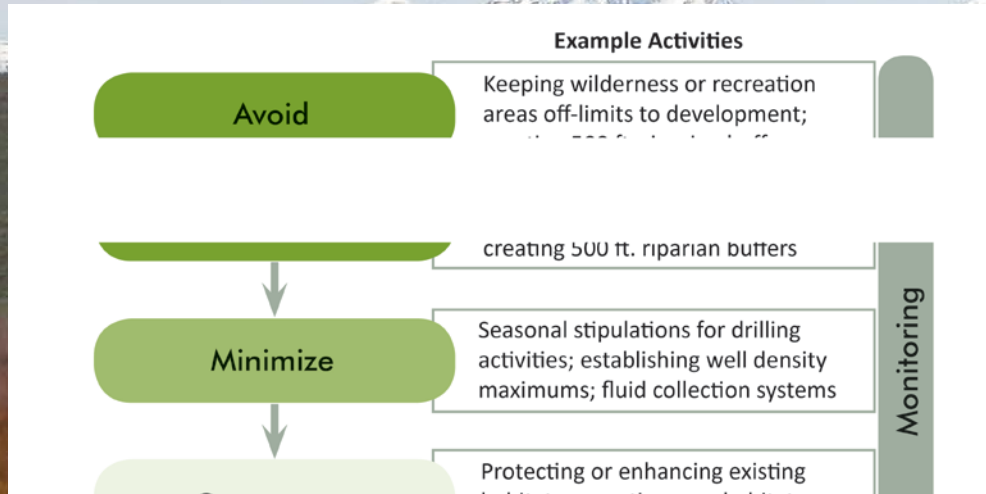


Graphics by Emilene Ostlind



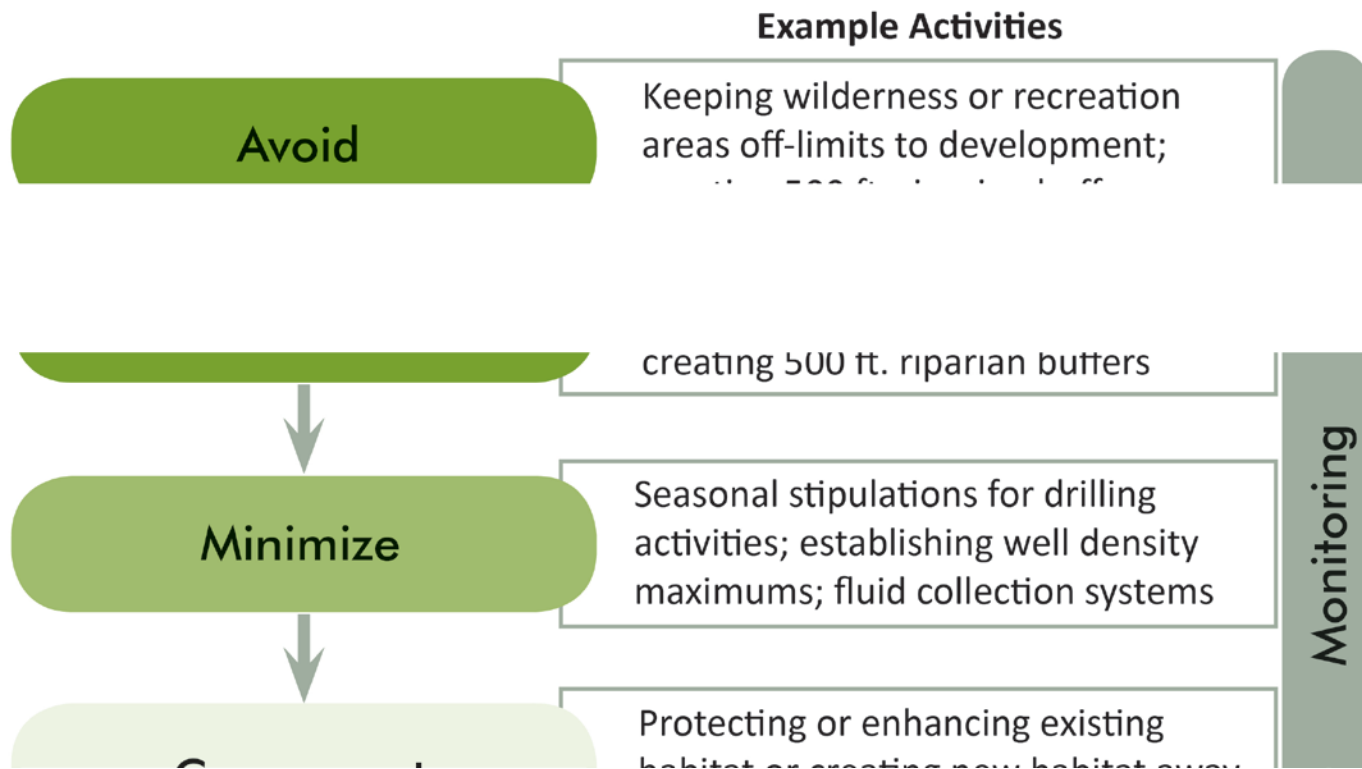
# Alternatives

1. Avoidance of initial impacts
1. Successful reclamation
1. Protection/management of summer and transitional ranges



# Alternatives

## 1. Avoidance of initial impacts



# Alternatives

1. Avoidance of initial impacts
2. Grazing management

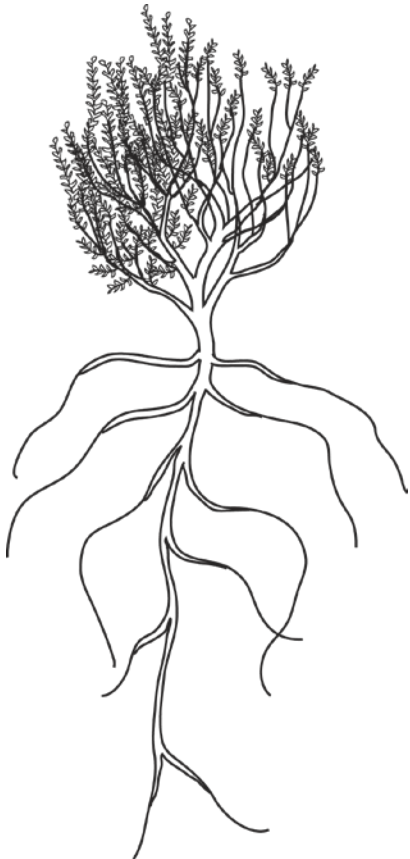


and summer ranges

Realrancher.com

## BENEFITS TO MULE DEER

# What's limiting for mule deer?



- White-tailed deer selected diets with higher digestible energy than protein (Bertheaux et al. 1998)
- Wyoming Big Sagebrush overwinter crude protein content in leaves/stems: 8.3 - 14.5% (Welch and McArthur 1979, Wambolt 2004)
  - Exceeds 7.5% crude protein maintenance requirement