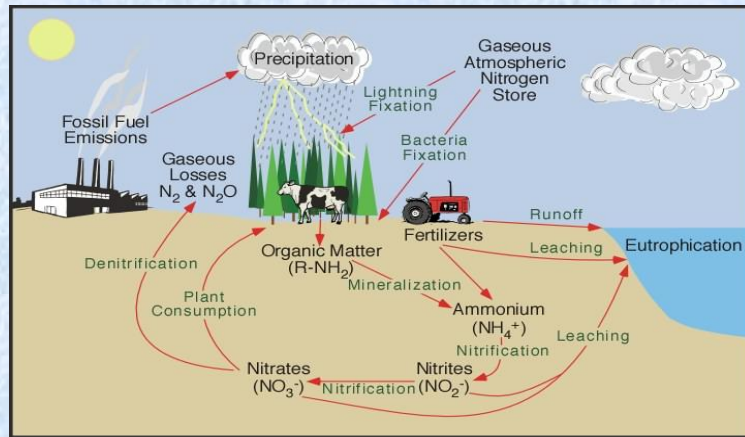


Nitrogen Cycling and Nitrogen Sources in the Silver Springs Basin



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Outline of Presentation

- Nitrogen cycling and transformation of forms of nitrogen
- Human alteration of the nitrogen cycle
- Nitrogen sources and loading to groundwater in the Silver Springs basin
- Planned studies

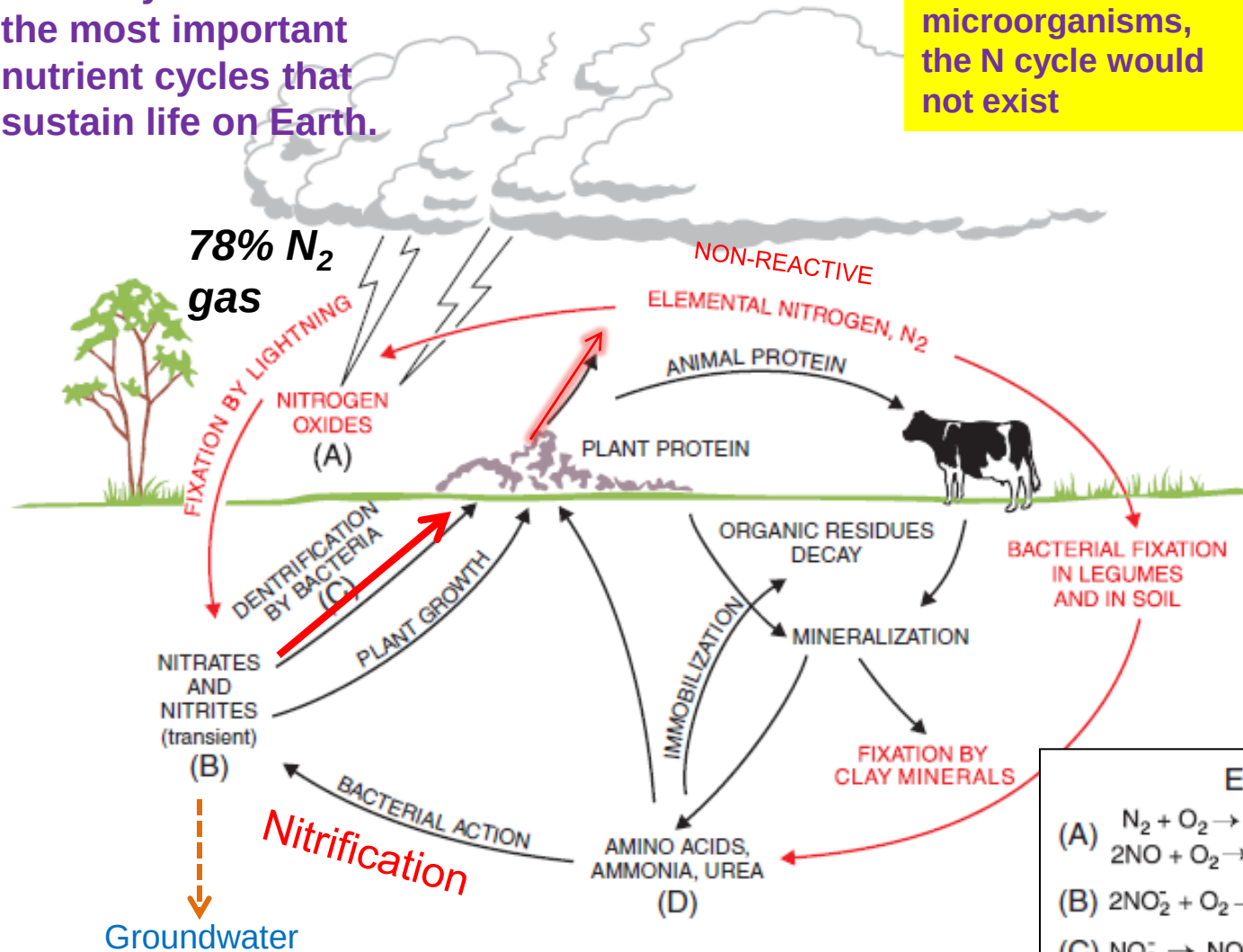


Nitrogen Cycle– Involves the Transformations of different forms (species) of nitrogen

The N-cycle is one of the most important nutrient cycles that sustain life on Earth.

****without microorganisms, the N cycle would not exist**

Before the 20th C, N fixation occurred via a limited group of micro-organisms and by lightning.



EXPLANATION

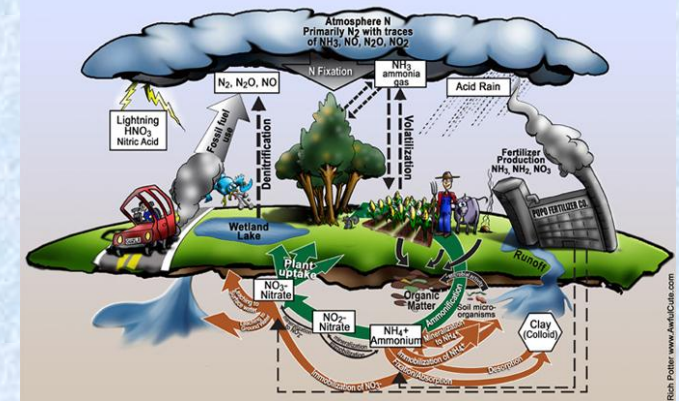
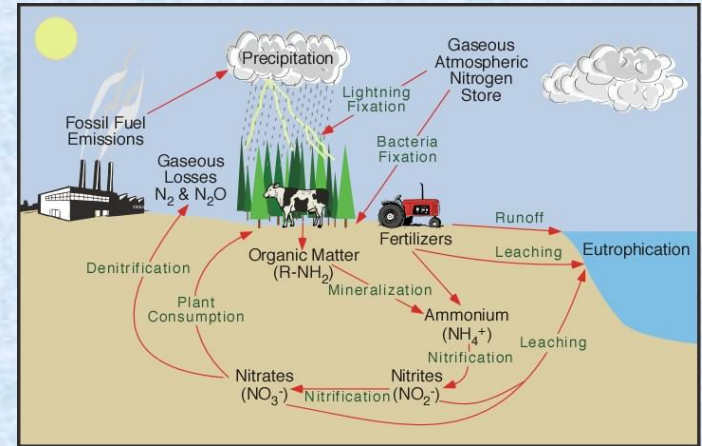
- (A) $N_2 + O_2 \rightarrow 2NO$
 $2NO + O_2 \rightarrow 2NO_2$
- (B) $2NO_2 + O_2 \rightarrow 2NO_3^- + \text{energy}$
- (C) $NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$
- (D) $2NH_4^+ + 3O_2 \rightarrow 2NO_3^- + 2H_2O + 4H^+ + \text{energy}$

N fixation is any process by which elemental N₂ reacts to form a compound.

Human alteration of the Nitrogen Cycle

Humans have more than doubled the annual transfer of N into biologically available forms as a result of three factors:

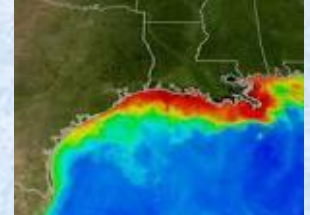
- Extensive cultivation of legumes (e.g. soy, alfalfa, clover)
- Chemical fertilizers (Haber-Bosch process; early 20th C.)
- Emissions (NO_x) from vehicles and industrial plants



Humans also have significantly contributed to the transfer of N_2 and N_2O (potent greenhouse gas) from the earth's surface to the atmosphere (climate change). Also, air pollution (smog).

Profound Environmental Consequences for the health of both ecosystems and people from increased availability of reactive forms of N:

➤ Eutrophication (algal blooms, red tide, hypoxia (dead zones))



➤ Water acidification



➤ Fish kills due to toxic effects of ammonia



➤ Human health, drinking water



Major Sources of N in Silver Springs Basin

➤ Atmospheric Deposition



➤ Fertilizers (cropland, turfgrass, etc.)



➤ Land application of treated wastewater/ biosolids



➤ Septic Tanks



➤ Animal wastes



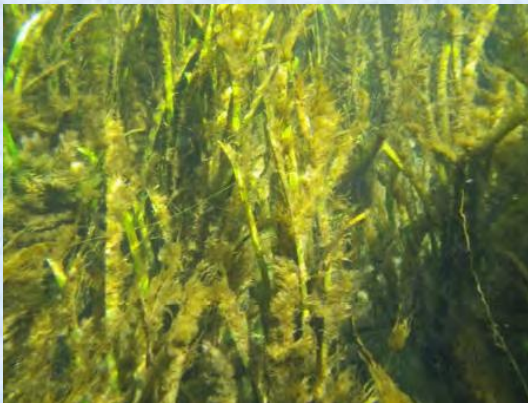
➤ Stormwater runoff



Impacts to Silver Springs Group



Algae on surface in area of Blue Grotto Spring (©Karst Environmental Services)

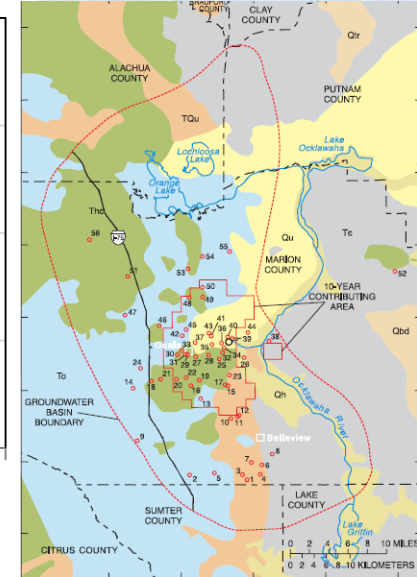
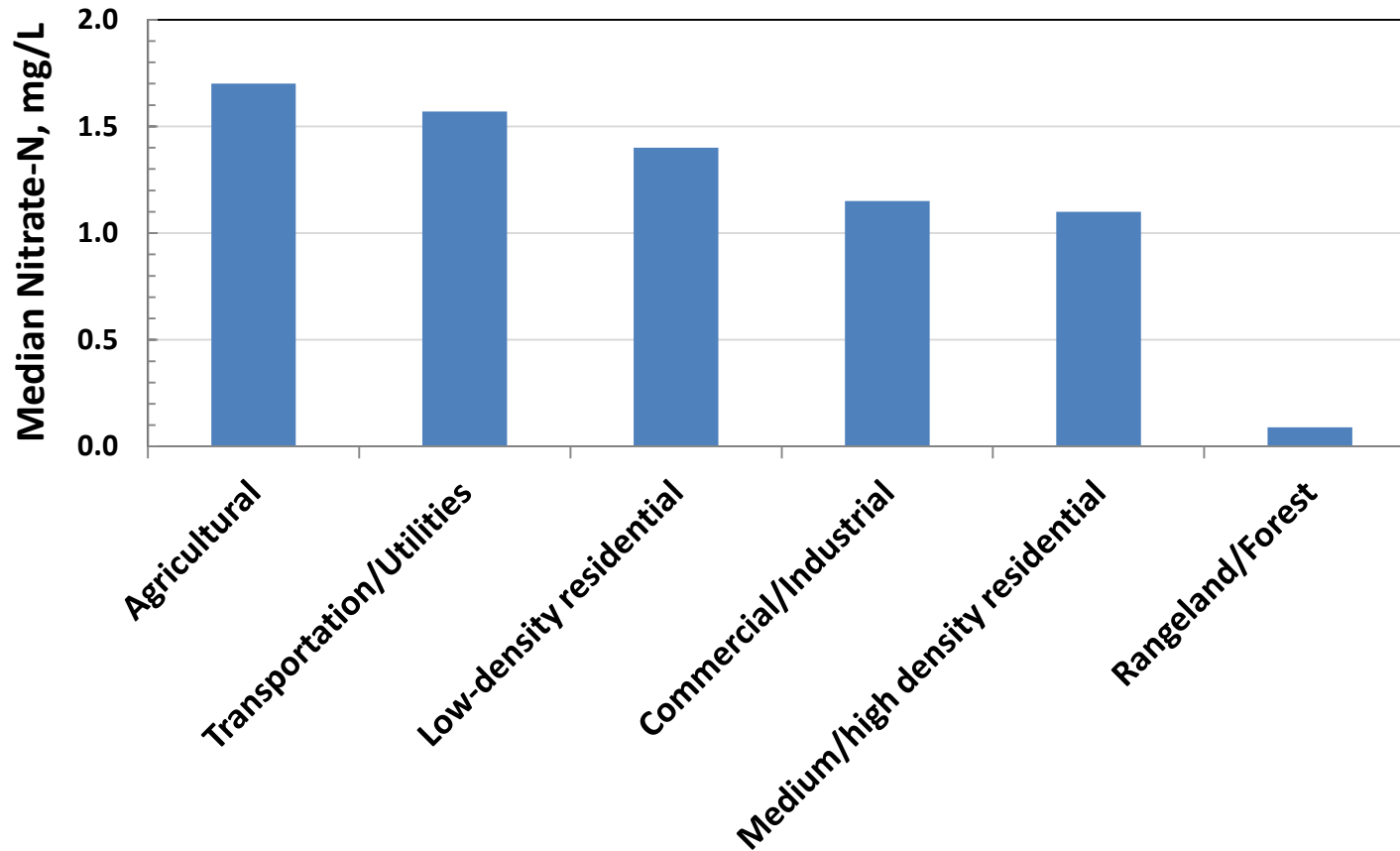


Algae coating macrophytes, Upper Silver River, (©Karst Environmental Services)

- Algal biomass increased ~171% over past 50 years
- Lower average annual biomass of submerged aquatic macrophytes
- Decrease in rates of emergence of aquatic insects
- Decrease in populations of fish-eating birds
- Low populations of catfish and mullet
- Decline in average gross primary productivity ($\text{g O}_2/\text{m}^2/\text{d}$)
- Decline in community respiration rates
- Decline in ecological efficiency
(Munch et al., 2006)

Land Use and Nitrate Concentrations

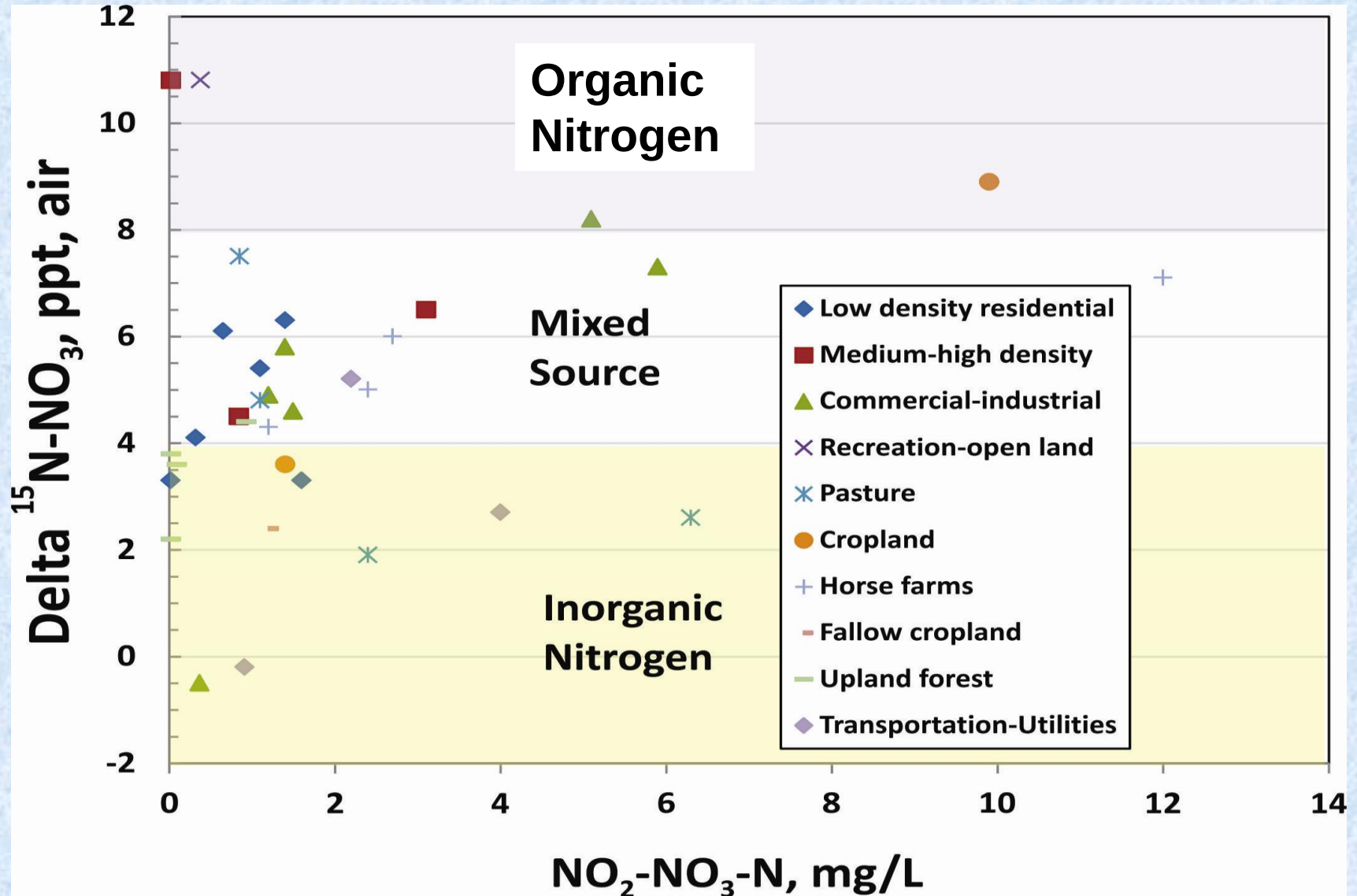
Median Nitrate-N concentrations in groundwater
(56 wells) grouped by 1995 land use (Phelps, 2004)



**** More than one upgradient nitrogen source may contribute to a well.**

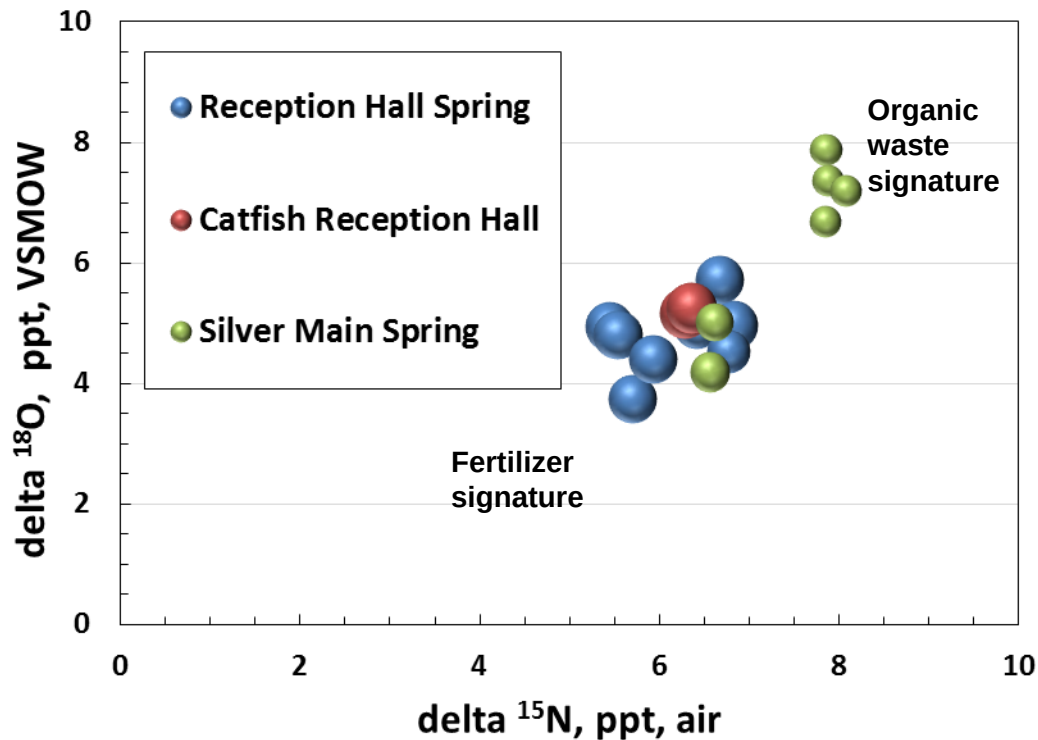
Nitrate concentrations, nitrogen sources, land use (1995)

Plot generated from Phelps (2004) data

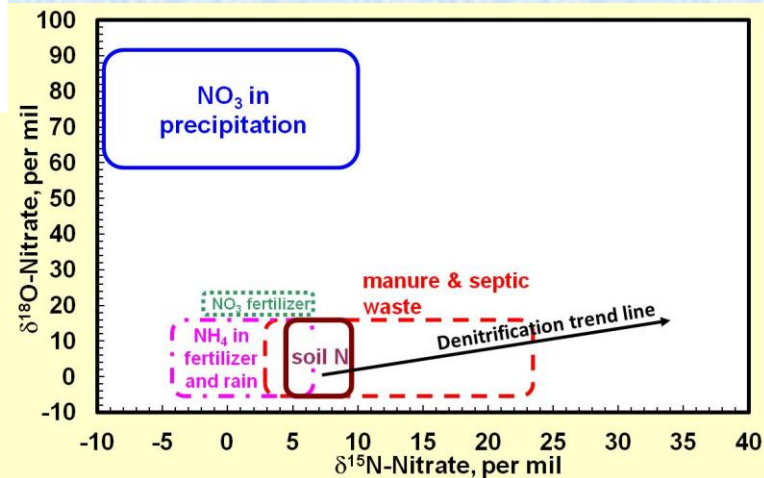


Spring water samples collected 2011-2012

Nitrate isotope composition



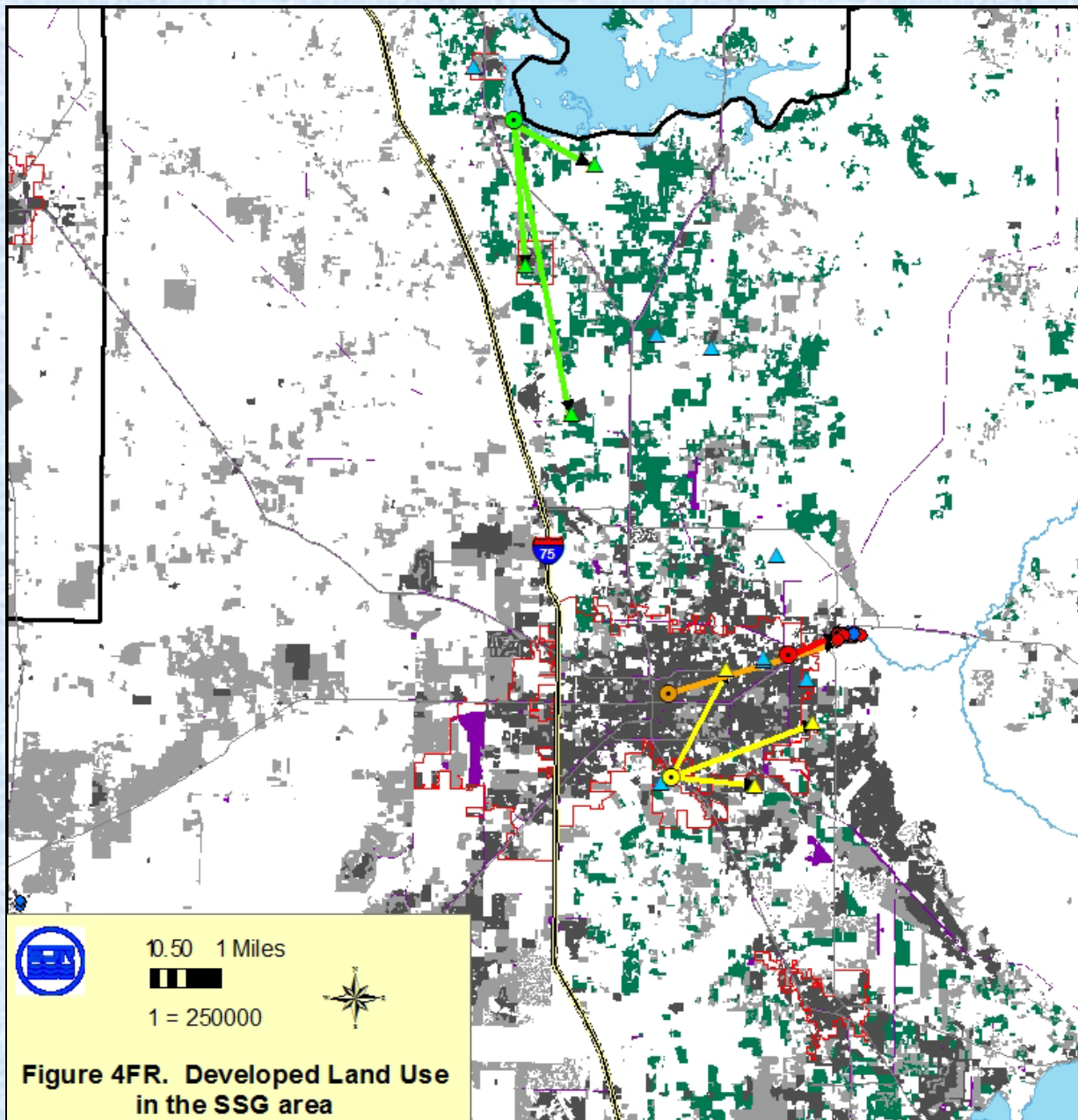
Sources of nitrate:



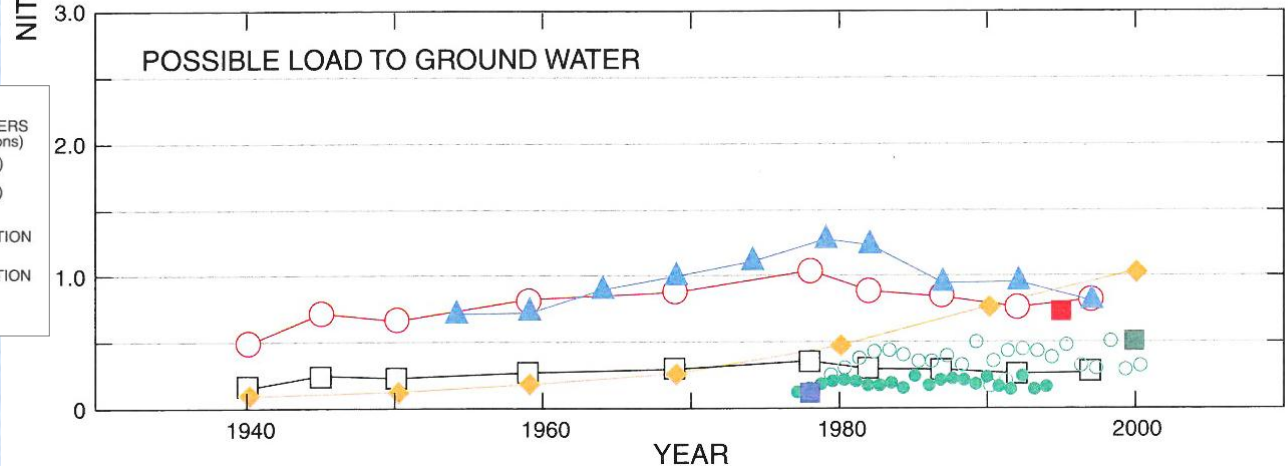
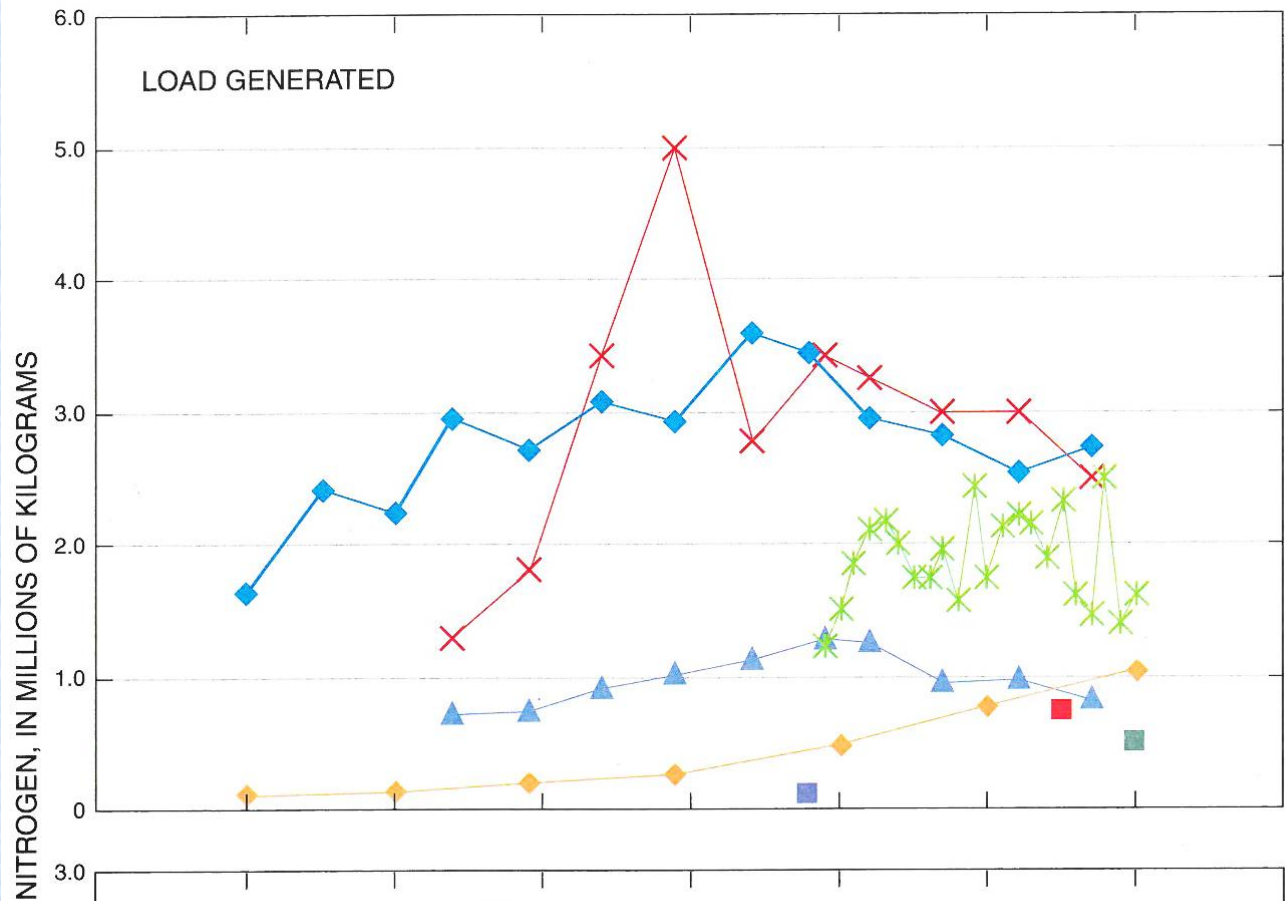
SJRWMD dye-trace study (2011)

Within ~ 5 mi of SSG, Travel times are on the order of one week to several months.

The variety of N sources and numerous direct/indirect inputs to groundwater flow system along these flow paths did not allow the ranking of specific locations or land use for nutrient loads to groundwater.



Nitrogen Source Loading in Marion County

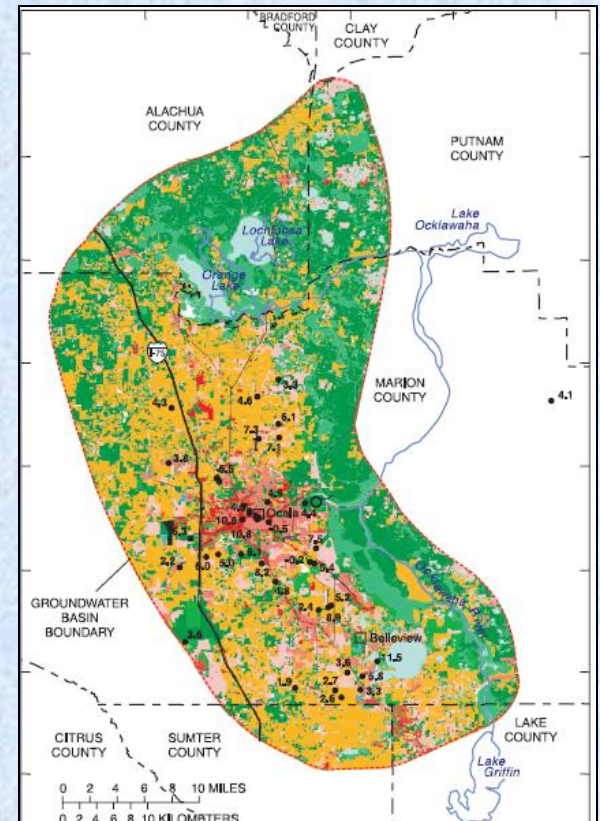


Phelps (2004)

Limitations of the USGS Nitrogen Loading Calculations:

- The study used 1995 land use data, and land uses have changed substantially in the past 18 years
- The wastewater N load was based on population and did not differentiate between the loads from septic tanks and municipally treated wastewater.
- There were no estimates of nitrogen loads to groundwater from storm-water runoff that enters drainage wells, sinkholes, and swallets.
- Nitrogen loads for Marion County were not separated out for Silver Springs and Rainbow Springs springsheds.

1995 Land use



Phelps (2004)

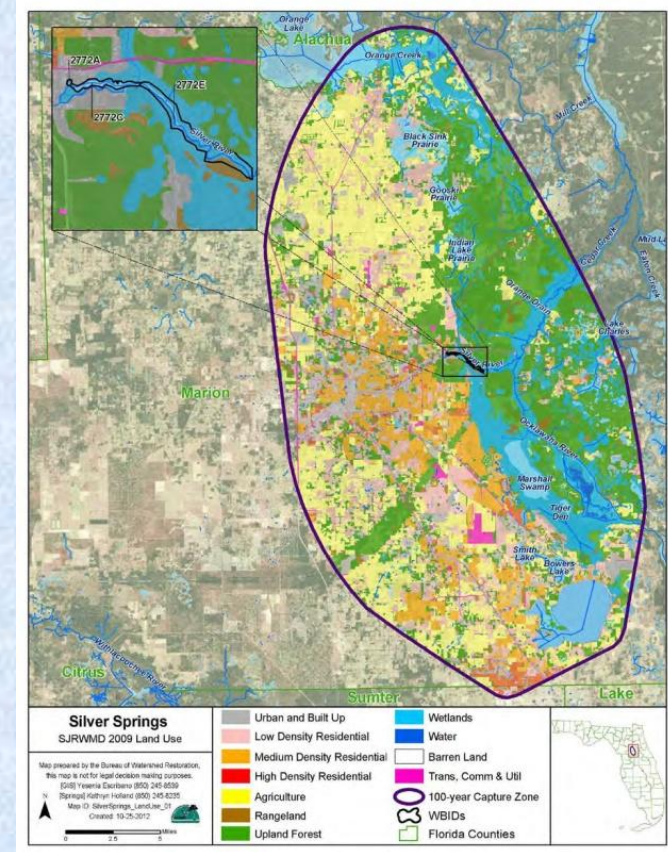
Land Use (2009) within **100-yr capture zone** (Hicks and Holland, 2012)

Land Use	Estimates
Atmospheric Deposition	Average potential input is 3.5 lb N/acre/year
Septic Tanks (OSTDS)	48,617 homes with OSTDS
Livestock	240 horse farms; cows, etc.
Fertilizer	39 golf courses; 23 container nurseries; improved pastures and hayfields, other agricultural lands; residential lawns
Wastewater	104 domestic and industrial wastewater facilities
Stormwater	8 facilities with NPDES permits; numerous stormwater drainage wells and stormwater runoff to sinkholes and swallets

Plans: Detailed Inventory of Nitrate Loads in the Silver Springs BMAP

- **Prepare a detailed inventory of N source inputs in the Silver Springs basin and in vulnerable sub-basins within the larger springshed area using recent (2009) land use information.**

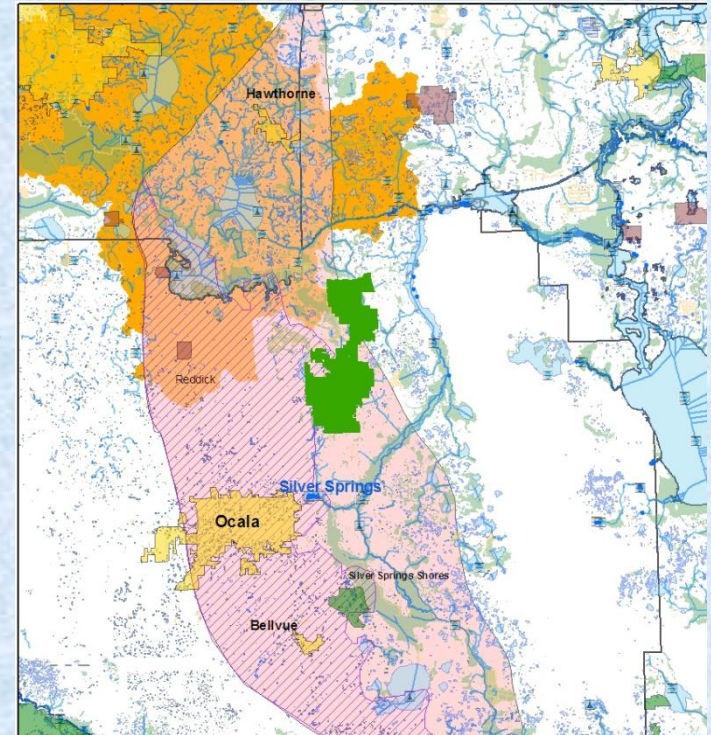
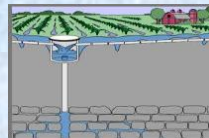
Major sources include fertilizers (cropland, turfgrass), septic tanks, atmospheric deposition, land application of treated wastewater, livestock, and stormwater runoff to drainage wells and sinkholes.



**2009 Land use
SJRWMD**

Plans: Estimate groundwater N loads and monitoring

- **Estimate annual loads to groundwater using N source inputs and nitrogen attenuation factors (environmental processes that naturally reduce nitrogen loads to groundwater). Focus is on most vulnerable areas.**
- **Monitor groundwater quality in vulnerable areas of the springshed focusing on three sources: fertilizers, septic tanks, and stormwater runoff to drainage wells and sinkholes.**



44% of springshed is unconfined;
But this area contains 80% of septic tanks, 68% of agric., and 68% of urban land use

Questions ??

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