Aquifer hydraulics, and the multi-decade legacy of non-point-source pollution

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and

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Grad Students: Troy Gilmore, Matt Burnette, Scott Becker, Casey Kennedy (PhD 2008, NCSU), Scott Leahy (MS 2007, NCSU), Brad Elkins (MS 2007, ECU)
Funding: USDA, NSF

Main Points

- most of the water in streams and rivers comes from groundwater
- at any given time, the groundwater discharging into a typical coastal plain stream ranges in age from a few years to several decades
- thus, at any given time, the N concentrations in streams and rivers represent the legacy of past (up to 50 years or more), not just present, N use
- practical implication: persistence and patience on a decadal time scale may be important when evaluating the effects of N management practices on surface water quality

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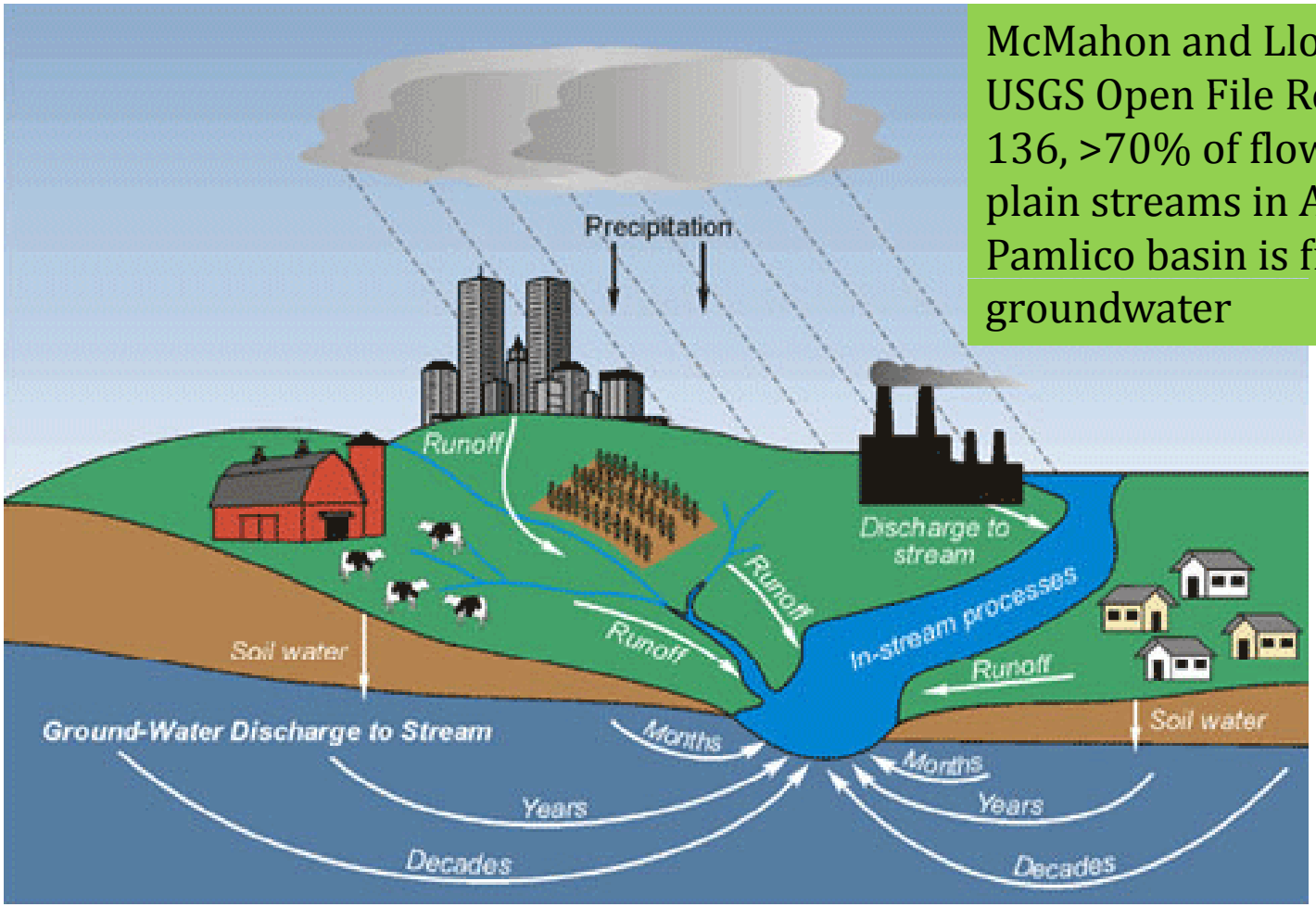
Groundwater Flowlines and Discharge at a Streambed



McMahon and Lloyd, 1995, USGS Open File Report 95-136, >70% of flow in coastal plain streams in Albemarle-Pamlico basin is from groundwater

http://www.chesapeakebay.net/images/groundwater.gif

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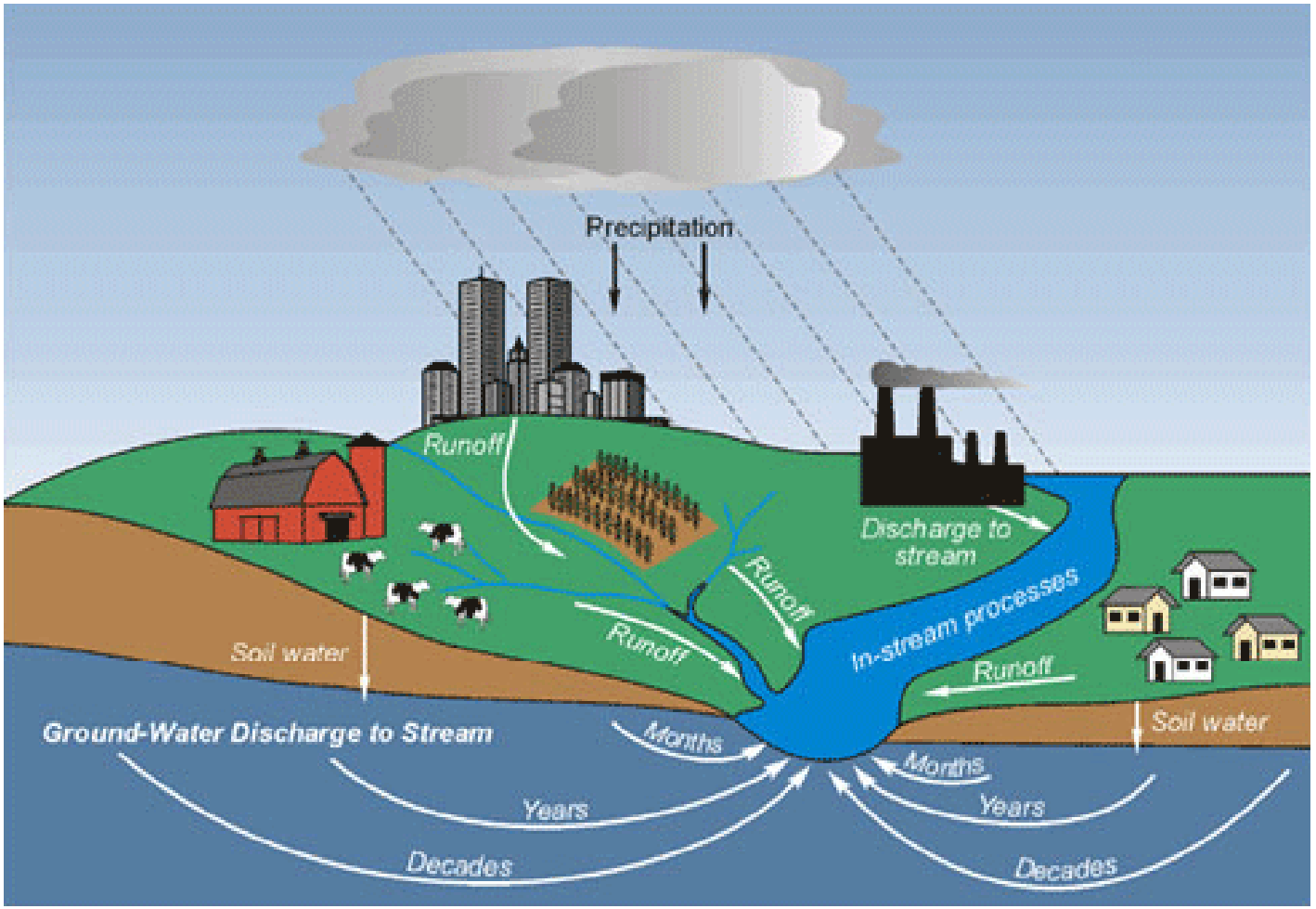

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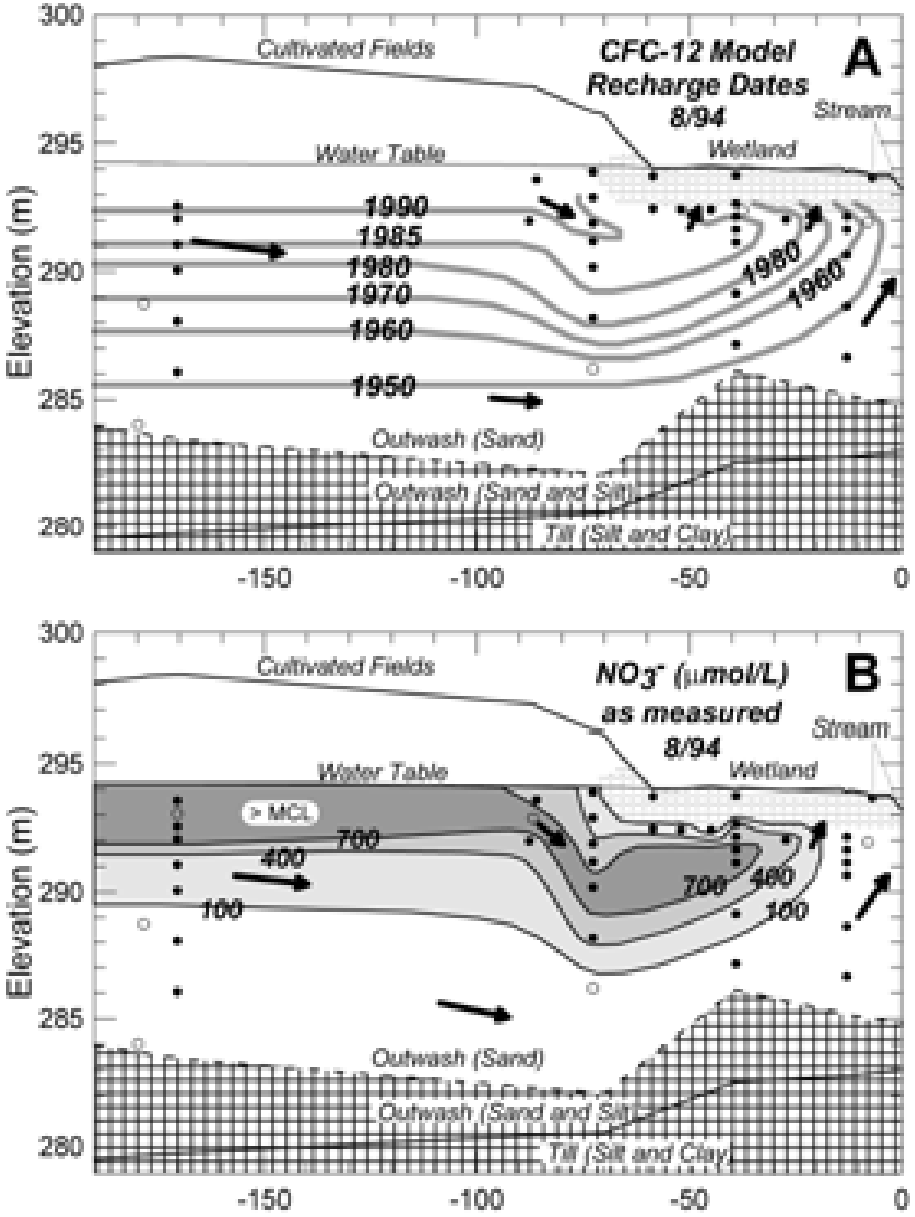
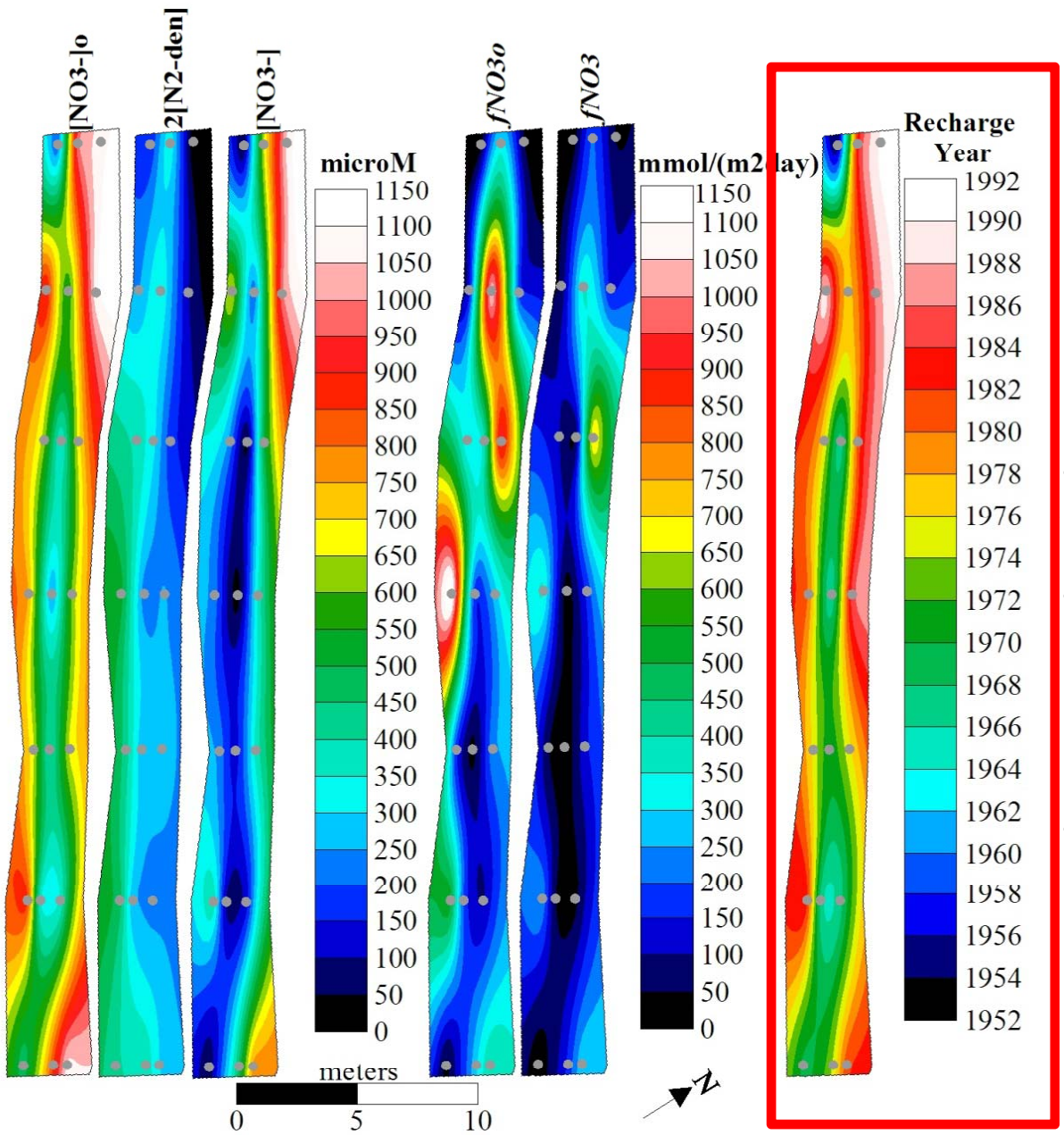


(from Böhlke et al. 2002)

Vertical cross-section: groundwater age and nitrate

- Agricultural watershed in Minnesota
- Samples collected 1994 (•) and 1993 (∘)
- Age increases with depth in recharge area, isochrons bend upward toward discharge area



(Kennedy et al., 2009, *Water Resources Research*)

Age and Nitrate in Streambed Groundwater

- West Bear Creek, NC, data from 2007
- band of low [NO_3^-], low f_{NO3}, and greater age runs down center of streambed
- pattern of age consistent with expectation for flowlines in unconfined aquifer

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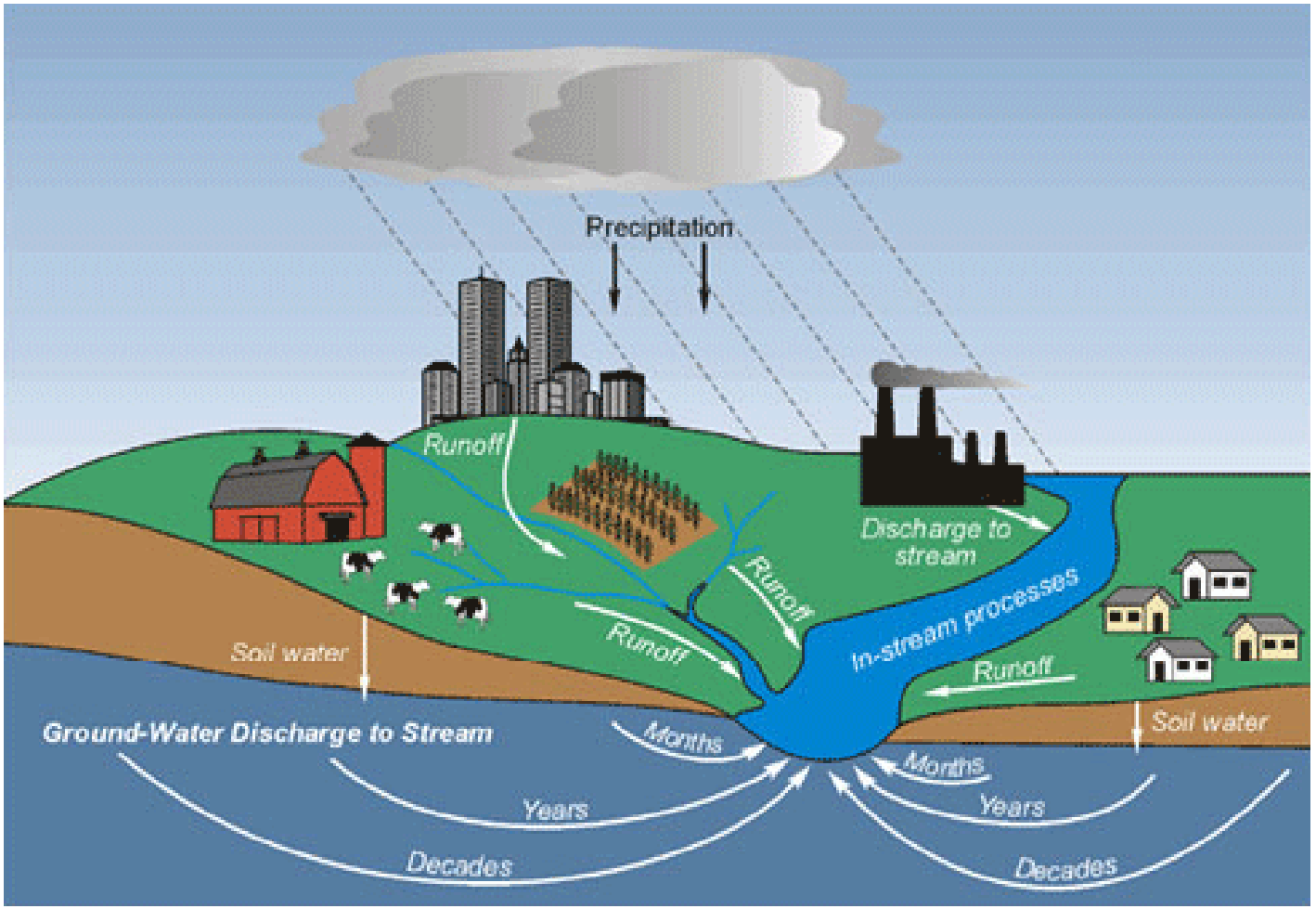

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Related Points

- Some N that entered groundwater many years ago is just now discharging to streams, and more is yet to come
- The flux of N from groundwater to surface water responds gradually, over many years, to changes in the N inputs to groundwater
- Response with time may be highly non-linear, depends heavily on geology/hydrogeology
- Nitrate concentration is a function of age in most coastal plain groundwater (older groundwater less contaminated)

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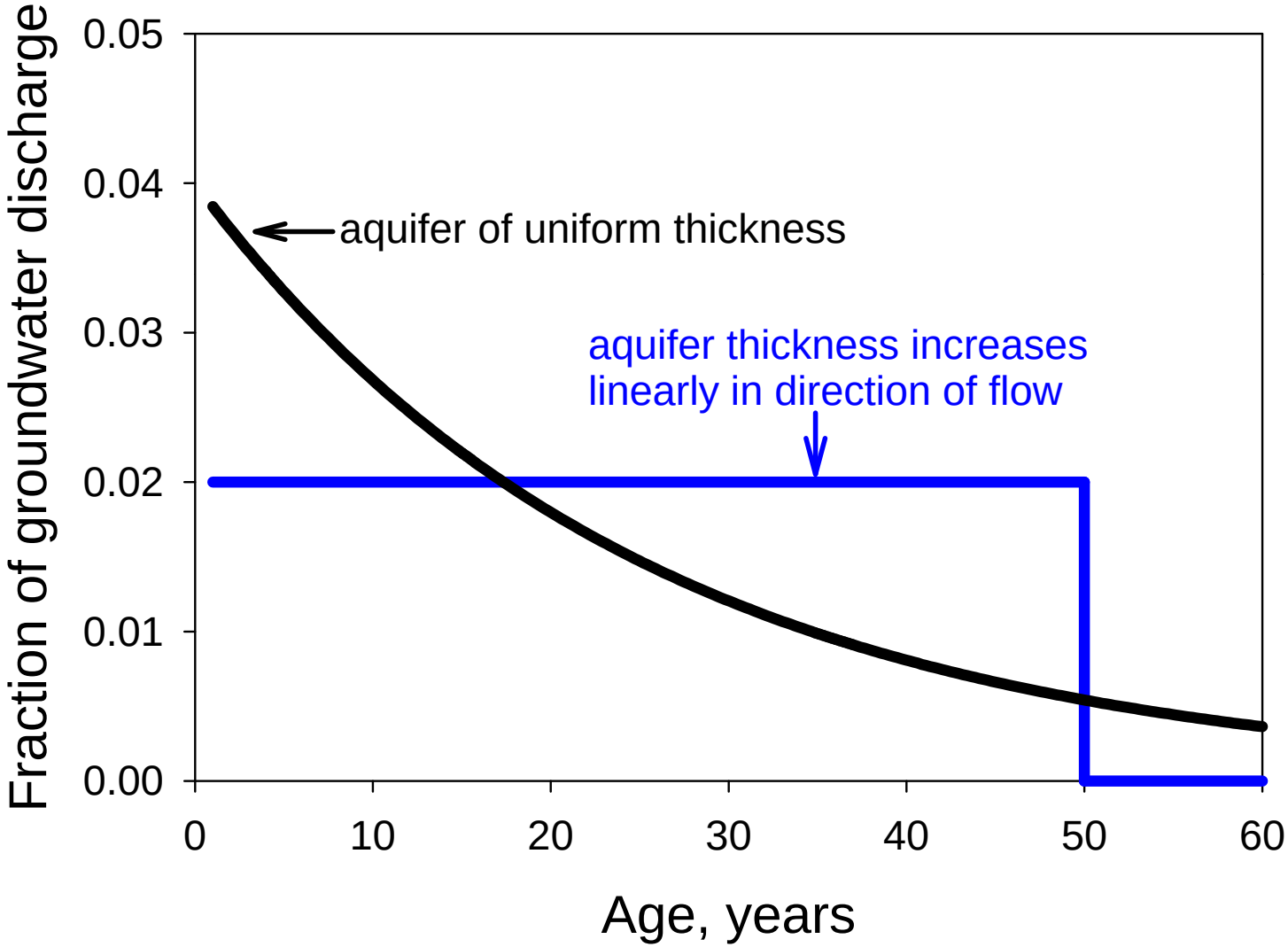
Age distributions in the groundwater discharge from two uniform aquifers with mean transit times of 25 years



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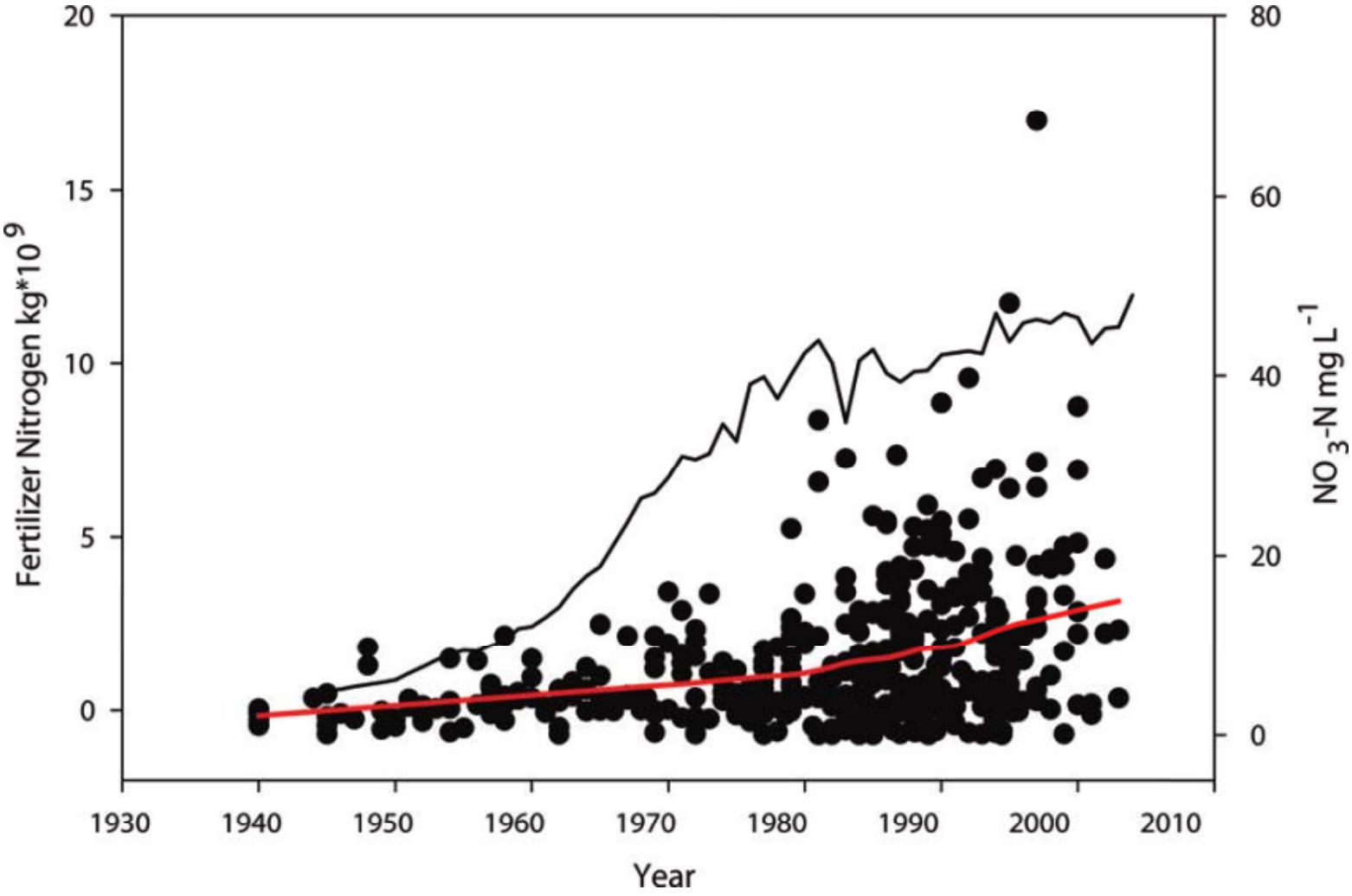
N Use, and Initial [NO_3^-] vs. Time 20 Watersheds Across the US



(Puckett et al., 2011, *Environmental Science & Technology*)

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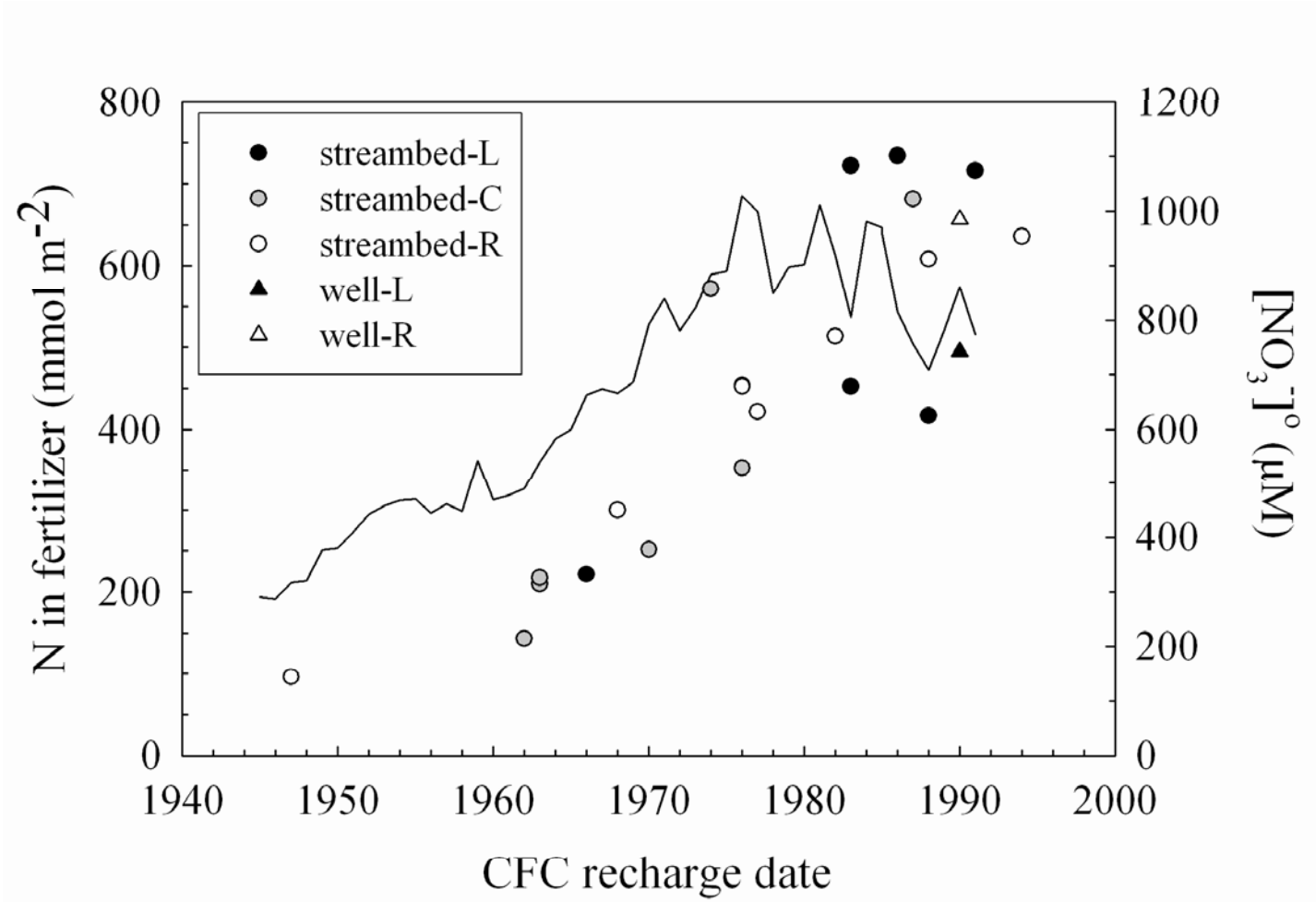
N Use, and Initial [NO_3^-] vs. Time West Bear Creek Watershed, NC



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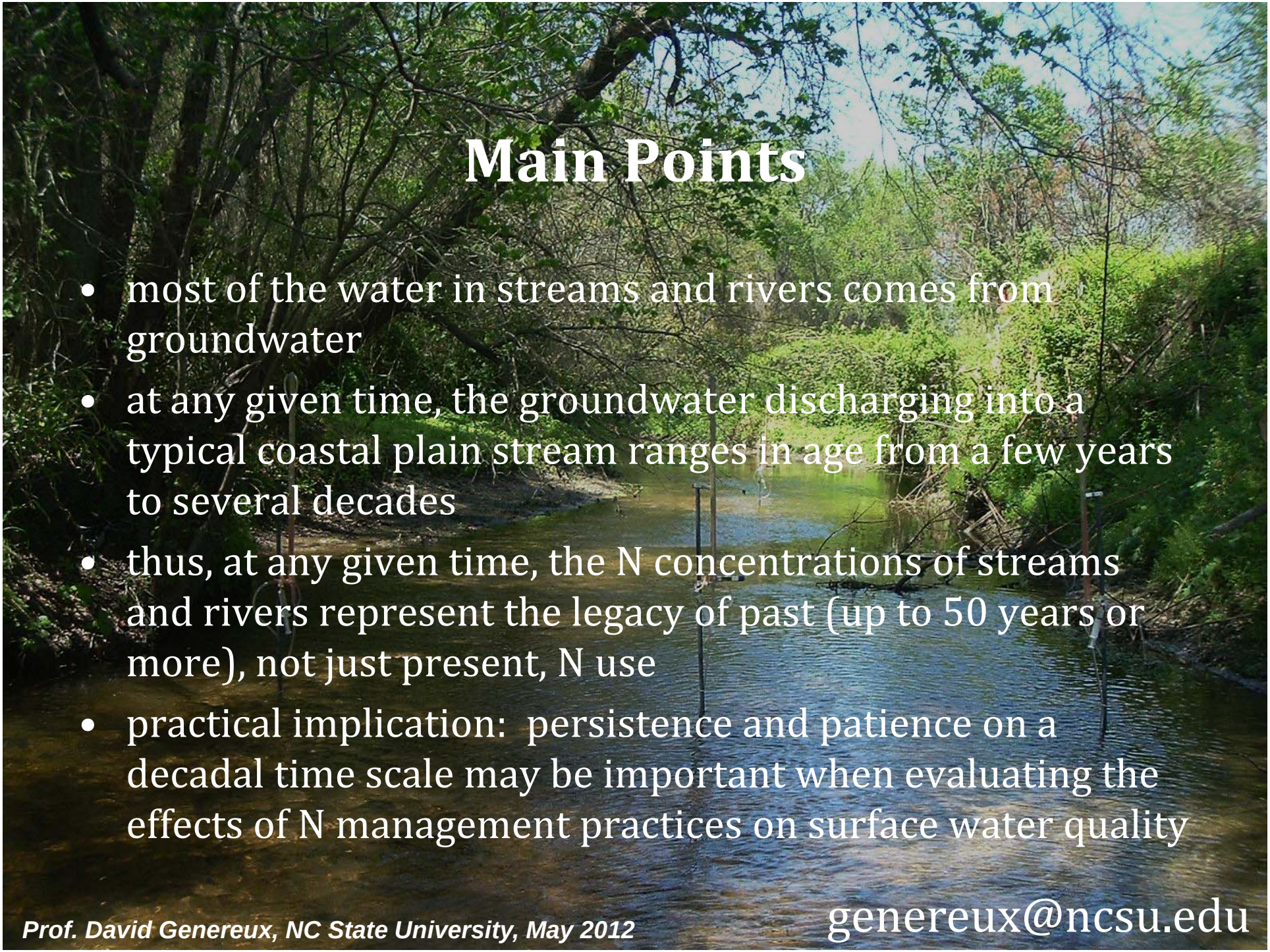

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