

Meeting Water Quality Goals Under Climate Change in Mahantango Watershed

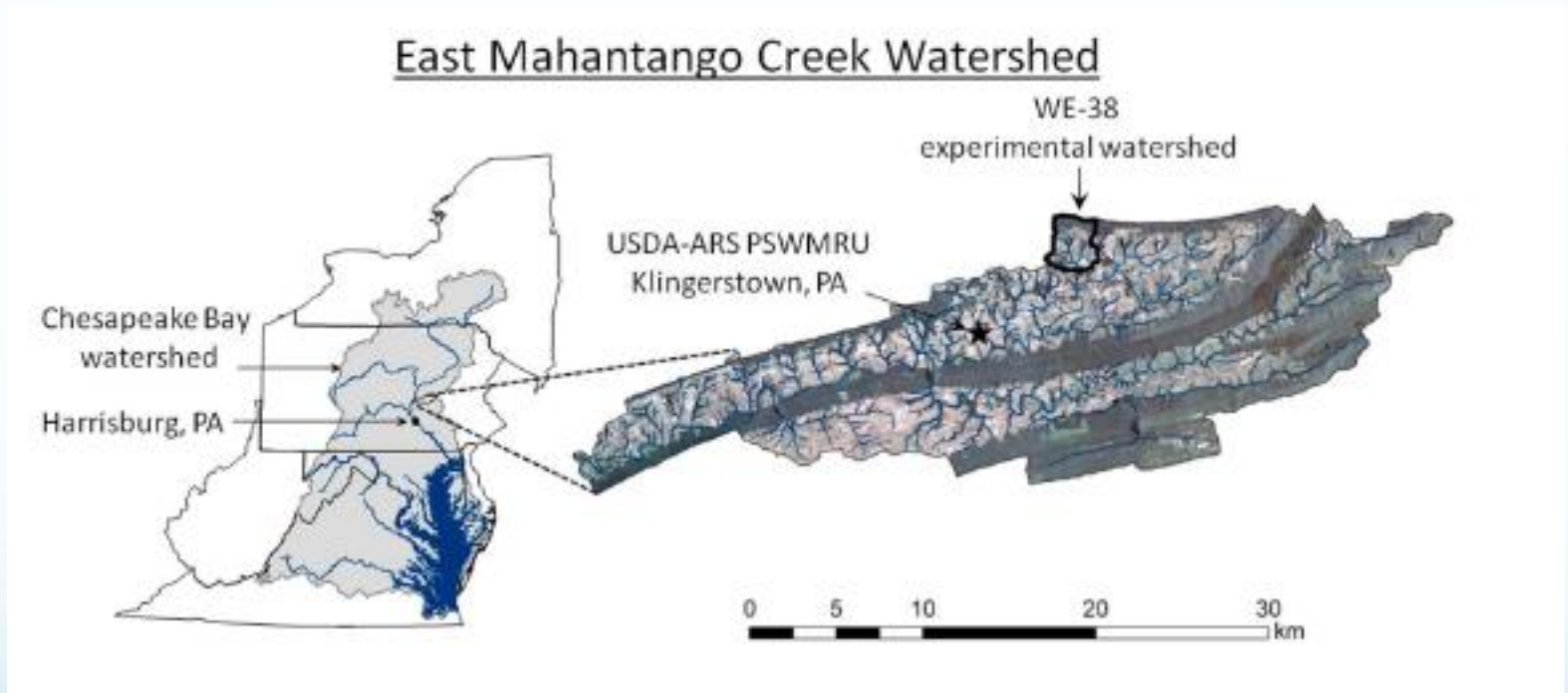
Darrell Bosch¹, Zach Easton², and Moges Wagena²

¹Agricultural and Applied Economics

²Biological Systems Engineering

Virginia Tech

Mahantango Representative Farm Based on WE-38 Watershed



Source: Bryant et al. WRR, 2011, Figure 1

- **Objective: To determine how climate change affects costs of controlling N loadings from agriculture.**

$$\text{N control costs} = \text{Farm net revenues with no constraint on N loadings} - \text{Farm net revenues with constraint on N loadings}$$

Decision Variables: Practices to Reduce N Loadings

Nutrient management

Conservation tillage

Stream buffers

Off-stream waterers (pasture)

Cover crops (early, normal, and late planting)

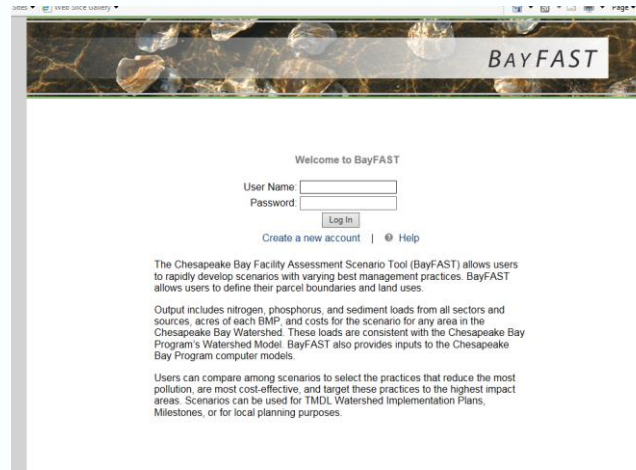
Removing land and/or livestock from production

Baseline loadings estimated with SWAT-VSA

Current climate projections for 1987-2010

**Climate change estimates projected for
2041-2064**

N loading reductions estimated with Bayfast



When more than one practice employed, use multiplicative reduction.

Example: if nutrient management gives 10% reduction and buffer gives 33% reduction, then with both practices in place:

$$\text{loading} = (1 - .33) * (1 - .1) * \text{loading with no practices}$$

Resource constraints

Land availability

400 ha cropland

23 ha pastureland

Livestock facilities

80 dairy cows

1 broiler house (242,000 birds/year)

Manure disposal

Manure must be spread on farm or sold

Resource constraints

Crop rotations

- 22 rotations varying from 1 to 5 years
- combinations of corn grain, corn silage, full season and double-cropped soybeans, wheat, alfalfa, pasture

Livestock feeding requirements

forage & grain requirements

Crop nutrient requirements

N, P, & K can be met from manure &/or commercial fertilizer

N Loading Constraints

Two parameter constraint

- 1) allowable loading—parametrically varied from 500 to 7,000 kg N
- 2) allowable probability of violating the constraint—parametrically varied from 0.5 to 0.05

Based on safety first approach (Qiu, Prato, and McCamley, AJAE, 2001)

- 2 climate scenarios
 - baseline (1987-2010)
 - climate change (2041-2064)
- 14 loading constraints
(500, 1,000, 1,500, ..., 7,000 kg)
- 10 probabilities of exceeding the constraint
(.05, .1,0.5)

Model details

Written in GAMS version 22.8

MINOS solver

Runs on Dell computer, Latitude E7240

Windows 7 Professional

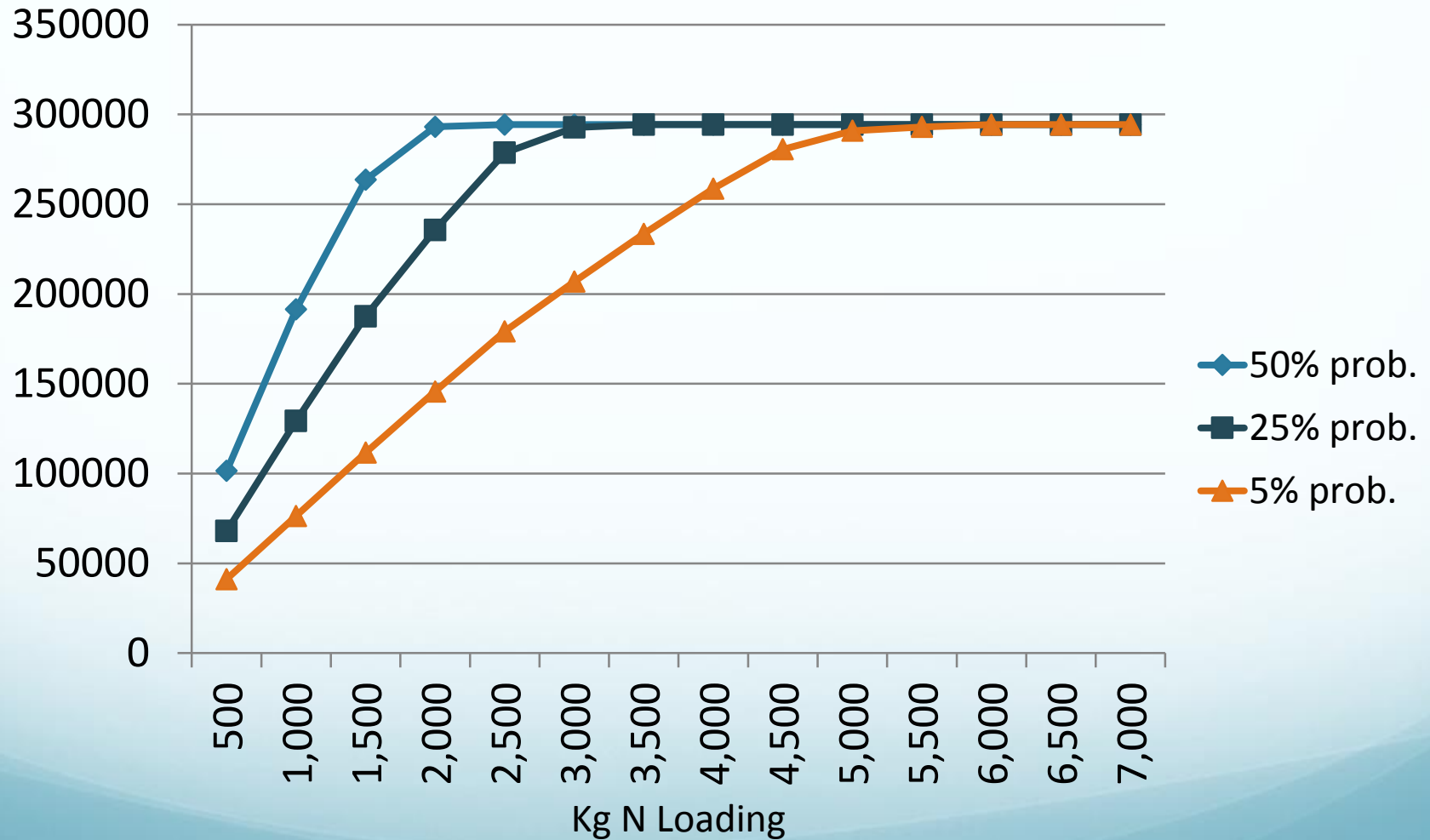
Approximate run time 8 minutes

Output exported to Excel

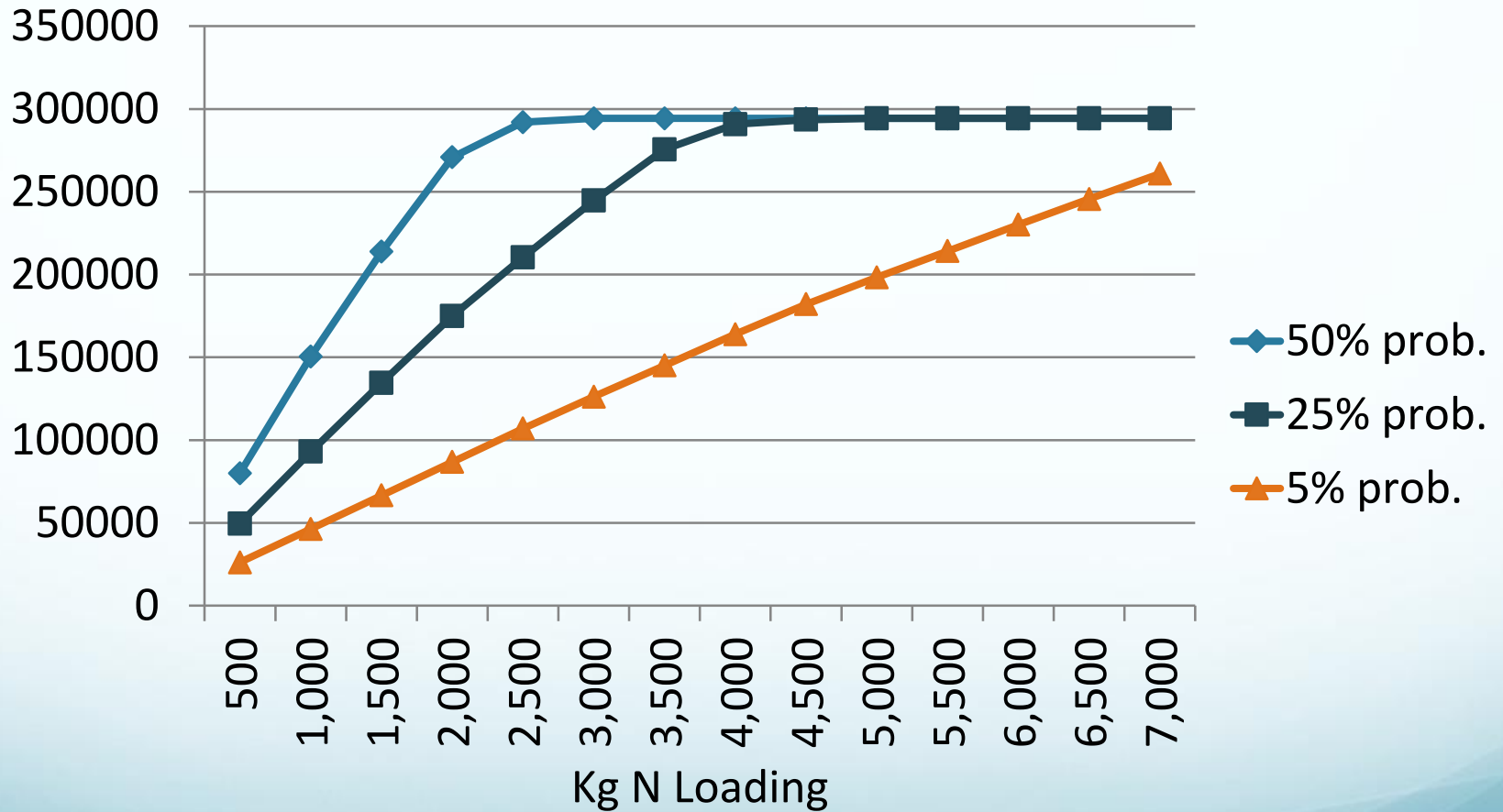
NO₃ loadings (kg/ha) from corn

	Mean	Standard deviation	Coefficient of variation
Baseline (1987-2010)	3.6	3.5	1.0
Climate change (2041-2064)	4.0	6.6	1.6

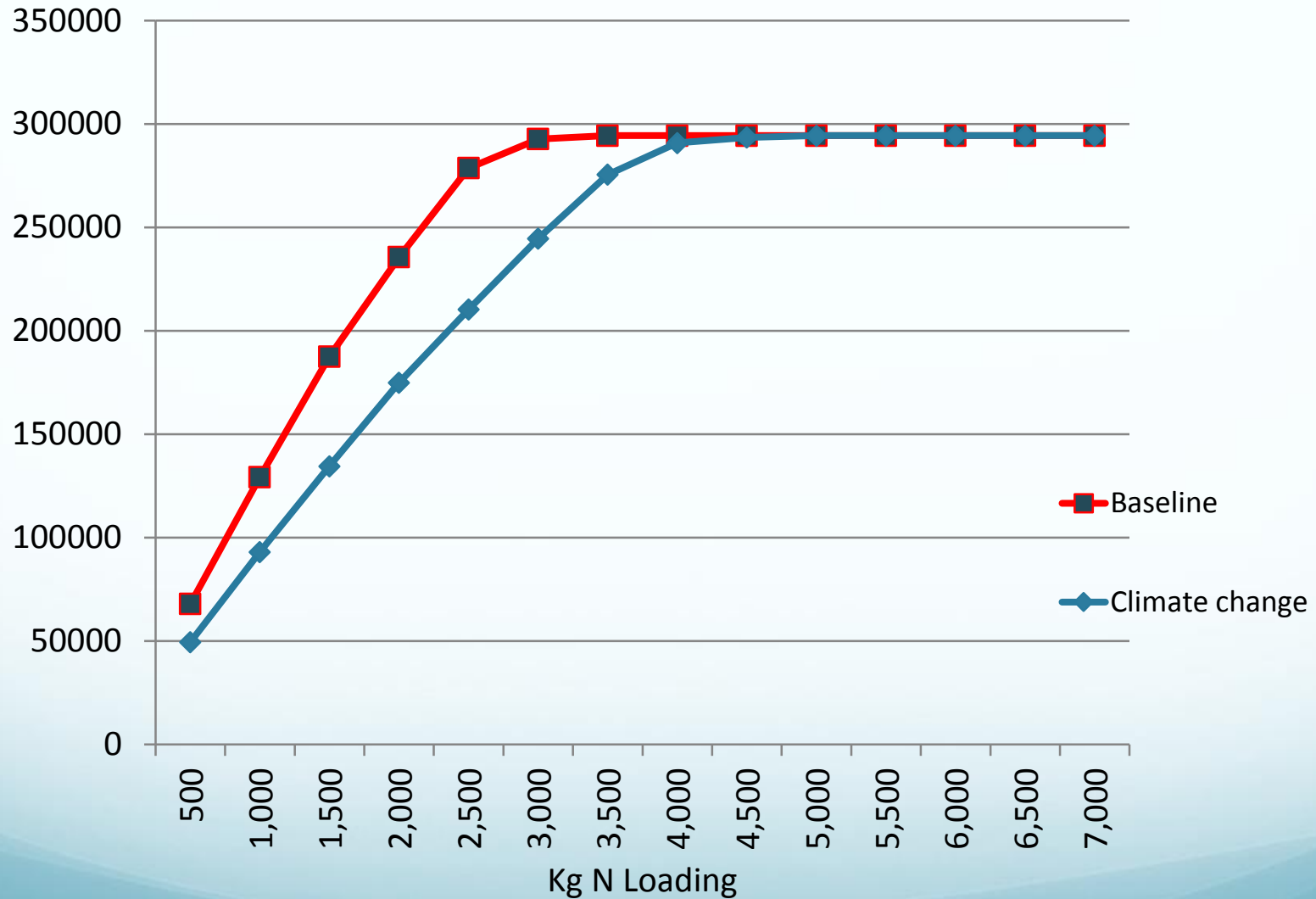
Baseline Climate Scenario: Farm Net Revenues with 3 Probabilities to Exceed the N Loading Limit



Climate Change Scenario--Farm Net Revenues with 3 Probabilities to Exceed the N Loading Limit



Farm Total Gross Margins Under Baseline & With Climate Change: 25% Probability of Exceeding the N Loading Limit



Future Directions for Economic Modeling

Complete the analysis for Mahantango

Extend analysis to South Fork Shenandoah

- Appalachian Valley and Ridge- dairy, mixed livestock and poultry production systems on acidic shale