Economic Analysis of Innovative Agricultural Practices for Water Resiliency on the Albemarle Peninsula

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Pocosin Lakes NWR Stakeholder Meeting
September 26, 2023

Background

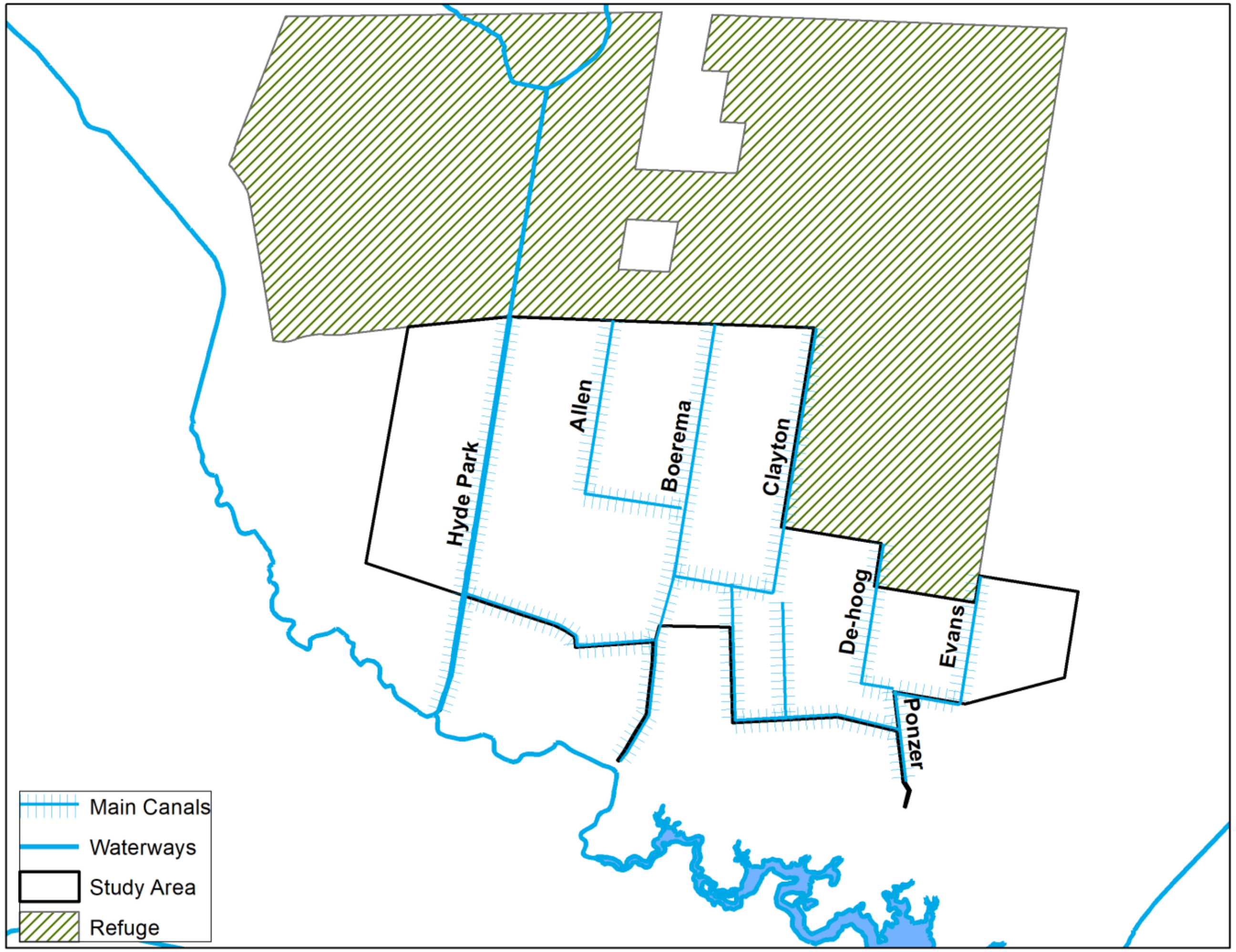
- Economic analysis of the Grassy Ridge Flood Reduction Study conducted by Kris Bass Engineering
  - Assesses a menu of potential water management and drainage canal modifications in terms of flood reduction and crop production
  - Estimates benefits and costs of the approaches
  - Identifies barriers to adoption
- Focus is on three approaches:
  - Conservation tillage
  - Controlled drainage structures
  - Two-stage ditches

Key Findings

- All three menu items are beneficial in aggregate to society
- Example farm-level benefit-cost calculations suggest individual voluntary adoption will be heterogeneous
  - Where benefits are high relative to costs, landowners will tend to favor adoption, while those seeing higher costs are likely to oppose adoption efforts
- Cost-effective adoption of these practices is highly dependent on coordinated adoption
  - The greater the heterogeneity in the ratio of benefits to costs, the less likely a group is to coordinate
- Benefits are highly dependent on their as-of-yet undocumented performance in reducing flooding in a novel setting

Problem: Excess Water

- The study region is between the Refuge and the Pungo River
  - drained in the early- and mid-20th century via surface ditches and canals
  - Area north lacks slope for drainage
  - Drainage north-to-south, canals drain both the Refuge and the study region
- The region remains extremely flat with mean elevation above sea level between 5 and 10 feet
- Key spatial heterogeneity in terms of upstream/downstream, canal gradient, and location relative to the Refuge

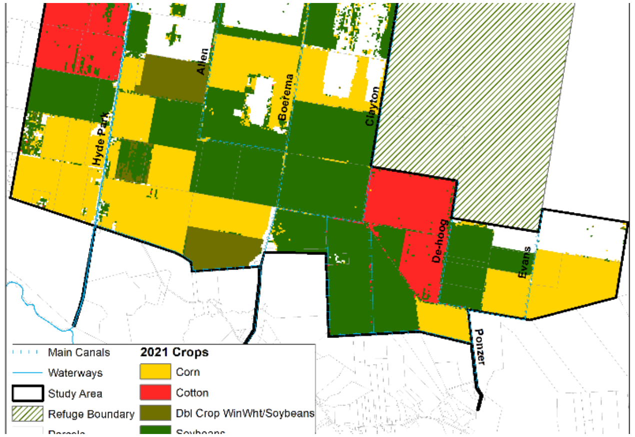


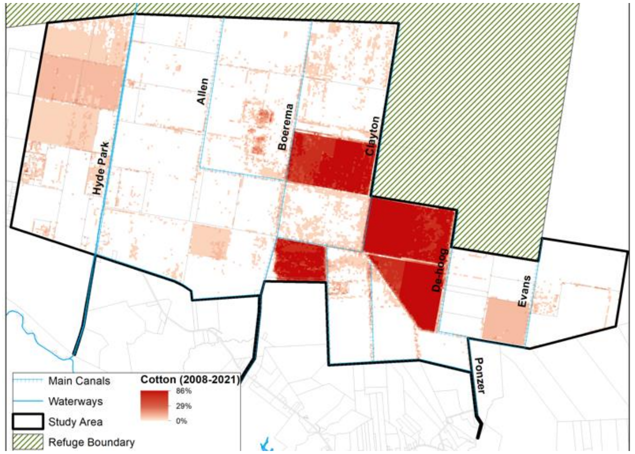
Canal Characteristics

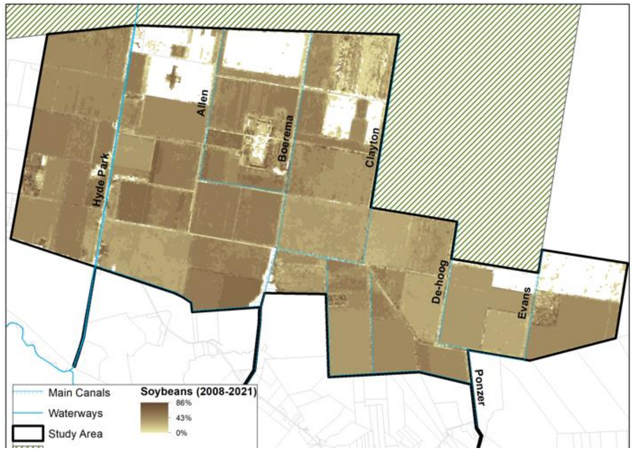
Canal	Upper Reach Slope (%)	Mid Reach Slope (%)	Down Reach Slope (%)	Drainage within Study region (%)
Hyde Park	0.02	0.05	-0.007	0-61
Allen	0.05	0.08	0.03	0-36
Boerema	0.02	0.09	-0.01	0-57
Clayton	0.03	0.03	0.04	0-11
De-Hoog	0.015	0.003	0.004	0-21
Evans	0.01	0.01	0.01	9-18
Ponzer	0.08	0.09	0.09	20-25

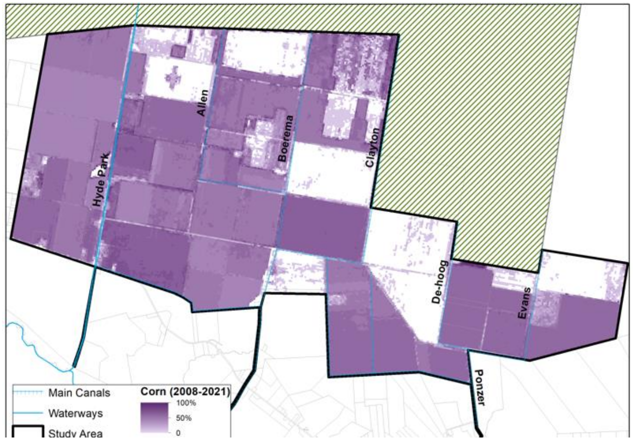
Cropping Patterns

- Mostly corn-soybean rotations
- Boundary areas near refuge tend to be less intensely cropped
- Overall averages will be used to estimate losses due to flooding



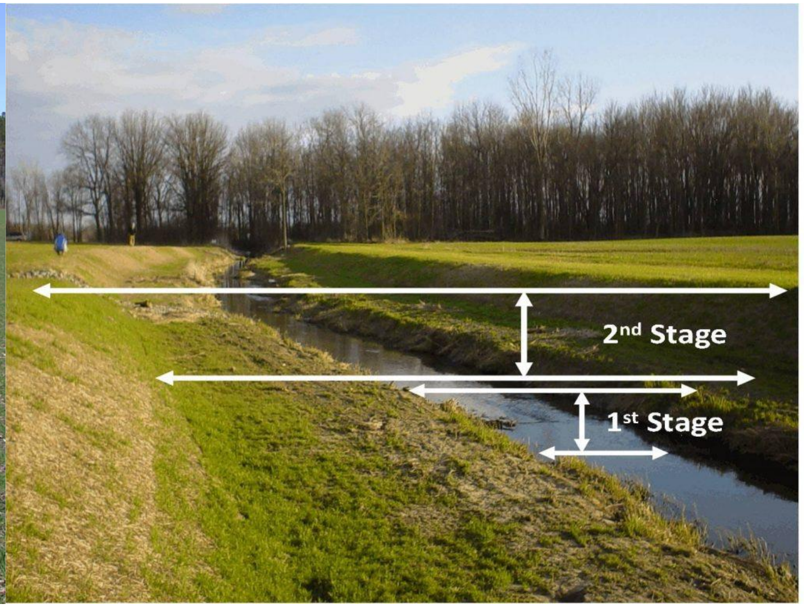






Solution Options

- Conservation tillage: Practices that reduce the intensity or frequency of field tillage: cover crops and no-till
- Controlled drainage: The use of water control structures to reduce drainage and raise water tables
- Two-stage ditch: Modification of a drainage canal to form a floodplain-like second stage during high water



Benefit-Cost Analysis

- Scale: Global v. local
  - Nutrient example
- What benefits to include?
  - Nutrients (global only)
  - Flood control requires assumptions on current losses and loss prevention
  - Yield increases
- What costs to include?
  - Construction and maintenance costs
  - Cost share programs
  - Coordination costs

Conservation Tillage

- CT is expected to have small costs or even benefits of implementation
- Enterprise crop budgets from the NC State Department of Agricultural and Resource Economics
  - Corn: net income before fixed costs drops from $188 to $171(fertilizer costs)
  - Soybean: increases from $318/acre to $331/acre
  - Cotton: increases from $176/acre to $182/acre.
- It is difficult to get equipment on the field during wet times, so most may be using low-till practices already
- The implementation of conservation tillage affects only the agricultural areas down slope
- Flow from the NWR is not affected by CT, and so the ability of this approach to reduce runoff is limited to what can be achieved on agricultural fields.

Controlled Drainage

- Benefits: N&P reductions, flood control
- The cost and installation ~$4,000
  - NRCS EQIP cost-share of 75%
- Placement of the structures will be on the lateral ditches:
  - Hyde Park: 6; Allen: 3; Boerema: 5; Clayton: 2; Ponzer: 3; De Hoog: 2; and Evans: 2
- Each lateral will have two structures, providing 46 structures to cover the approximately 10,000 acres in the study area
- Efficacy dependent on coordination across the canal
  - Fall entirely to downstream fields: no incentive for upstream users to manage water tables to limit downstream flooding

Two-Stage Ditch

- Benefits: P reductions, flood control
- Costs: Transport and disposal of spoil and lost production
  - There is currently no federal cost-share program for two-stage ditches in NC
  - The Regional Conservation Partnership Program (RCPP) offers one path to cost share, as it is more likely to support innovative solutions to conservation problems

Two-Stage Ditch

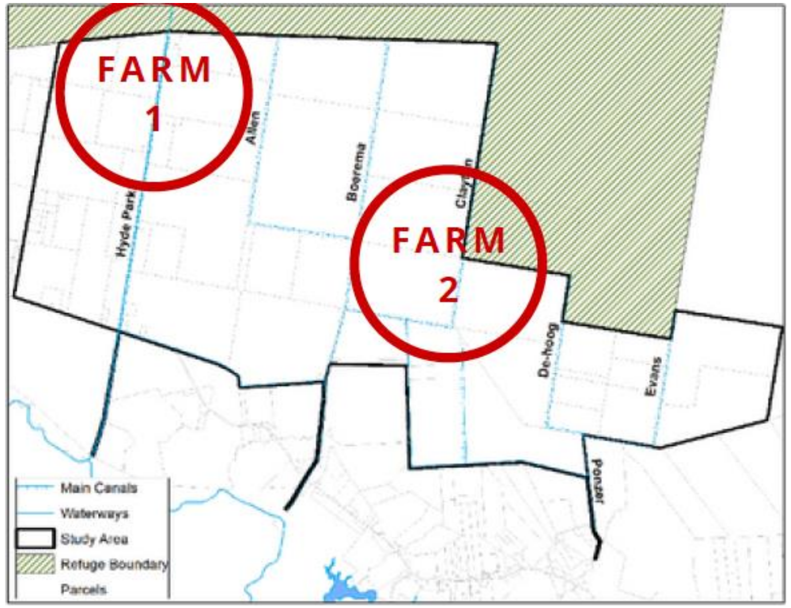
	Farmland Length (ft)	Below Farm Length (ft)	Added Width (ft)	Added Depth (ft)	Total Fill Volume (ft^3)	Reduced Acreage (acres)
Allen	14,595	-	43	5.72	3,589,786	14.41
Boerema	16,959	6,663	70	2.74	4,530,700	27.25
Clayton	19,270	-	62.7	4.45	5,376,619	27.74
Dehoog	9,377	-	62.7	4.45	2,616,324	13.50
Evans	10,210	-	62.7	4.45	2,848,743	14.70
Hyde Park	20,979	6,160	60	5.86	9,542,054	28.90
Ponzer	2,065	4,252	90	2.695	1,532,188	4.27
Total	93,455	17,075			30,036,414	130.75

Global CBA

Conservation tillage	Controlled drainage	Two-stage ditch
Total Benefits	**Total Benefits**	**Total Benefits**
Phosphorus: $0	Phosphorus: $92,329/year	Phosphorus: $145,088/year
Nitrogen: $0	Nitrogen: $89,040/year	Nitrogen: $0/year
Flooding: $100,191/year	Flooding: $100,191/year	Flooding: $453,184 per year
Total: $100,191/year	Total: $281,560/year	Total: $598,272/year
Total Costs	**Total Costs**	**Total Costs**
	Amortized costs: $14,765	Land: $20,920
	Maintenance costs: $738	Construction: $221,730
		Culverts: $8,024
Total: $16,987/year	Total Costs: $15,503 /year	Total: $250,675./year
Benefit-Cost Ratio: 6:1	**Benefit-Cost Ratio: 18:1**	**Benefit-Cost Ratio: 2.4:1**
Flood Control Ratio: 6:1	**Flood Control Ratio: 6:1**	**Flood Control Ratio: 1.8:1**

Farm-Level Benefits and Costs

- Key assumptions
  - How much cropland is damaged by water each year
  - Crop insurance
  - EQIP cost match
  - Effectiveness of measures at reducing flooding
  - Costs and who bears them



Farm-Level CBA

	FARM 1 A 100-acre farm growing cotton on the upper Hyde Park Canal that loses 25% of crop on flooded land.			FARM 2 A 100-acre farm growing soybeans on the middle reach of Clayton Canal that loses 50% of crop on flooded land.		
	CT	CD	2-STAGE	CT	CD	2-STAGE
Flooding	2,402	2,402	6,409	796	796	7,958
Construction	-	(321)	(2,268)	-	(328)	(2,268)
Subsidy	-	241	1,505	-	241	1,505
Ongoing Cost	600	(16)	-	1,300	(16)	-
Coordination	(1,800)	(1,800)	(1,800)	(1,800)	(1,800)	(1,800)
Total	1,202	409	3,846	296	(1,197)	5,395
Net Per Acre	12	4	38	3	-	54

Drainage Coordination Problem

In order to secure the necessary cooperation for efficient work…some legal method of compulsion has been found necessary… All the persons interested may not agree as to the necessity for the improvement, and even if they do, when it comes to deciding what lands shall be embraced in the project, where the ditches shall be located, how the work shall be done, and particularly, what each individual landowner shall pay, differences of opinion are sure to arise. To overcome this diversified sentiment…drainage laws have been found necessary.

--1907 report to the U.S. Senate on the status of *Swamp and Overflowed Lands in the United States*

Drainage

Table 2: Year of Drainage District Legislation

State	Year	State	Year
Ohio	1859	Texas	1905
Indiana	1863	Mississippi	1906
Michigan	1869	Virginia	1906
Kansas	1879	Louisiana	1907
Illinois	1879	Florida	1907
Nebraska	1881	South Dakota	1907
Iowa	1884	North Carolina	1909
Minnesota	1887	Tennessee	1909
North Dakota	1895	New York	1909
Wisconsin	1899	Georgia	1911
Missouri	1899	South Carolina	1912
Arkansas	1904	Kentucky	1912

- Drain tile first used in Upstate New York in 1835
- Series of Swamp Land Acts allocate land to states for drainage
- Broadly unsuccessful; necessity of drainage laws for coordination
- We examined development after passage of laws relative to well-drained lands

Coordination Challenges

- While benefit and cost estimates are useful in considering policies affecting the entire region, aggregation is likely to obfuscate key heterogeneity
- Because the investments are made by individual landowners, understanding this heterogeneity is the key to understanding landowner adoption decisions
- Study region does not have an organized framework for coordinated drainage management
- Yet a key challenge lies in the need for canal-wide adoption of each measure to secure full benefits
  - The fields in the study region that are not typically cropped border the Refuge, and thus see little to no reduction in water tables due to CD/CT
  - The benefits of two-stage ditches generally increase for farms upslope, as shown in the GRFRS modeling exercise

Drainage Districts in North Carolina

- Coordinated framework for information collection and transfer about drainage practices and organizations
- 1909 law allowed for districts
  - Missing information on what areas are in/out of districts
  - Lack of best practices for creation and operation of districts

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