OPTIMIZATION OF ECOSYSTEM SERVICES FOR LAND MANAGEMENT AND RESOURCE ALLOCATION IN AGROECOSYSTEMS.

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Background and Objectives

- The sustainable management of agricultural systems and the ability to provision a growing demand for food and renewable energy, will require a balanced consideration of different ecosystem services. Therefore, it is crucial to identify optimal management practices with a balanced consideration of different ecosystem services to maintain sustainable agricultural systems. It is also vital to determine optimal allocation of provisioning services to achieve the most efficient utilization of natural resources.
- This study shows a case study on optimization of ecosystem services for land management, and resource distribution in corn production systems in Larimer County, CO by:
  - Combining DAYCENT (a biogeochemical model) with GREET (a life cycle assessment model), and GMOS/NetSim (a network optimization tool) for measuring, valuing, and optimizing ecosystem services.
  - Developing of a multi-level optimization framework.
  - Applying the framework to corn production for a landscape in Larimer County, CO.

Materials and Methodology

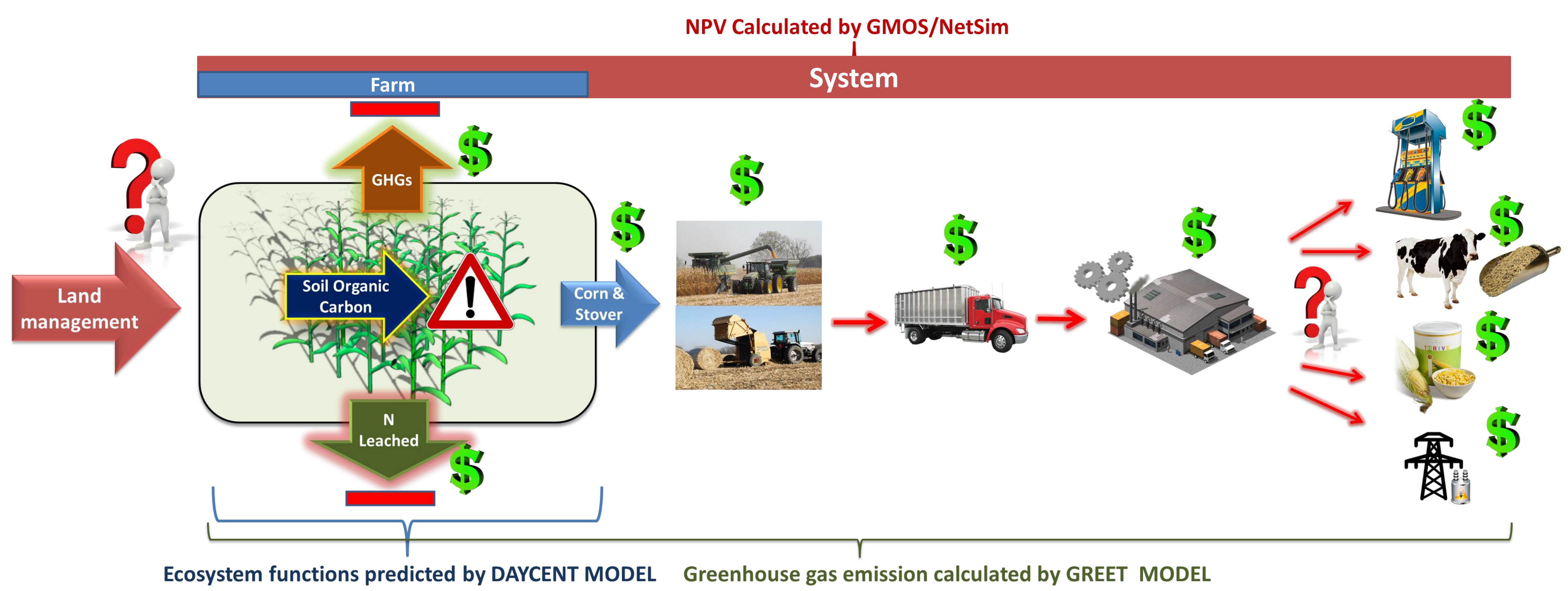


Fig 1: Framework for multi-level optimization of ecosystem services

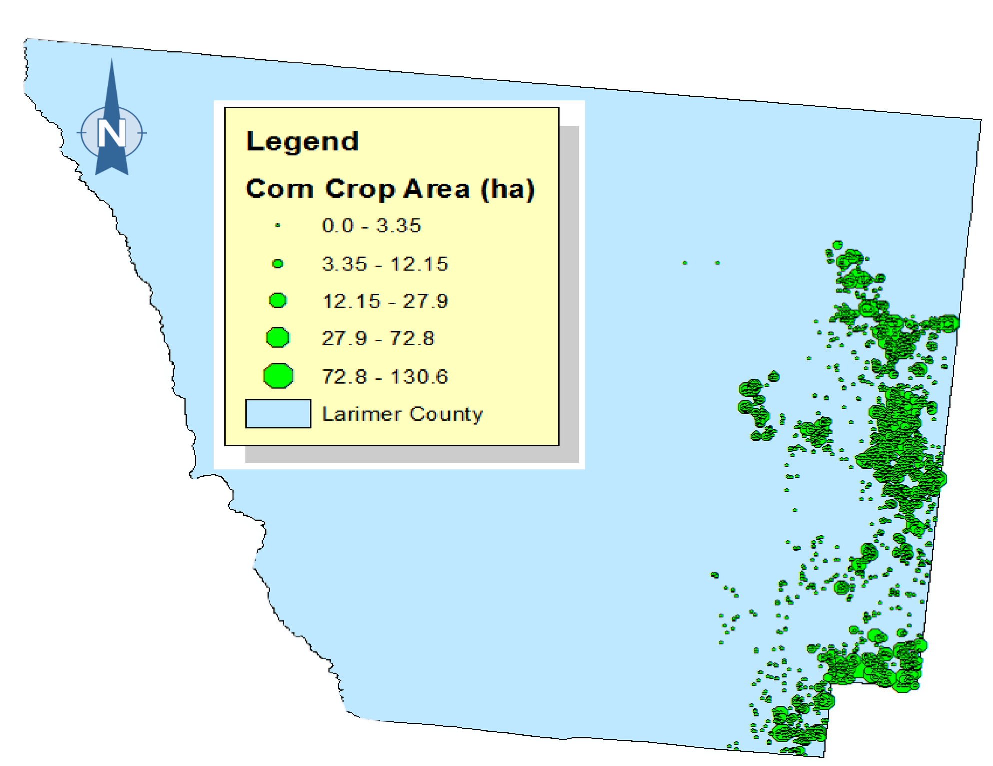


Fig 2: Corn Area in Larimer County, CO

LAND MANAGEMENT DECISIONS:

- **3 levels of tillage:** Conventional, Reduced, No till
- **8 levels of fertilization :** 0, 34, 67, 101, 134, 160, 202, 224 kg N/ha
- **4 levels of irrigation:** no irrigation (0 cm), limited (21cm), full (42cm), and excessive (53.3cm) irrigation
- **5 levels of stover harvest:** 0%, 22%, 35%, 52%, 83%

RESOURCE ALLOCATION OPTIONS:

- **Corn to ethanol via** dry or wet milling
- **Stover to ethanol via** gasification or fermentation
- **Stover to electricity**
- **Corn to cattle feed**
- **Stover to cattle feed**

DAYCENT Model:

- Soil data from SSURGO2
- Weather data from NARR
- Land use history baselines from CSU's EPA simulation (2011)
- Land management is assumed to remain unchanged during the simulation (30 years or 50 years)

GREET Model:

PATHWAYS	GHG EMISSION
Corn farming operation (mt CO_2e/mt)	0.3032
Corn harvest and handling (mt CO_2e/mt)	0.0881
WTP stover ethanol via fermentation (mt CO_2e/gallon)	0.0006
WTP stover ethanol via gasification (mt CO_2e/gallon)	0.0012
WTP corn Ethanol via dry milling (mt CO_2e/gallon)	0.0050
WTP corn Ethanol via wet milling (mt CO_2e/gallon)	0.0065
WTP electricity from corn stover (mt CO_2e/MWh)	0.0916

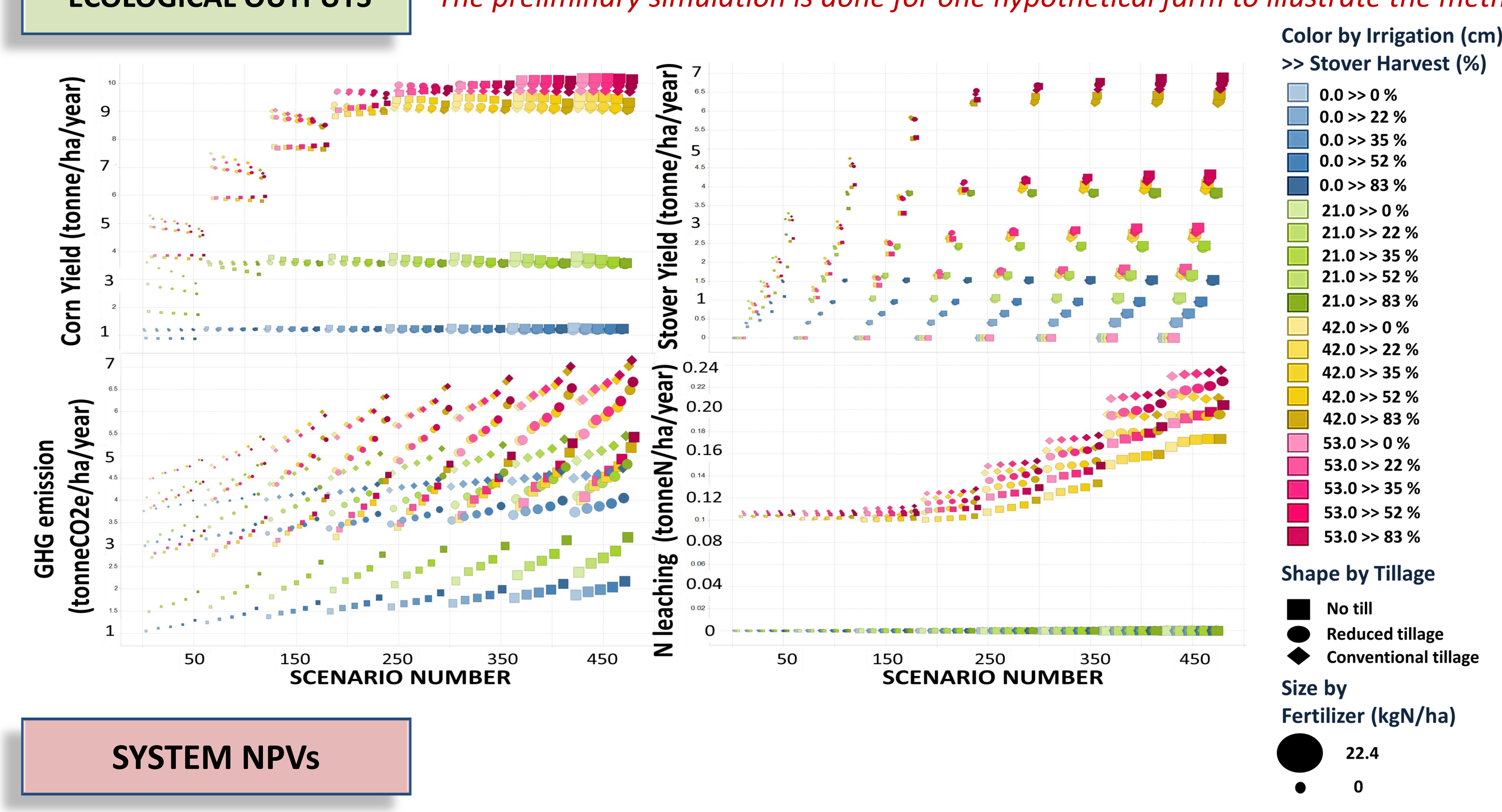
GMOS/NetSim Model:

Stream	Unit	Supply Costs	Externality Costs	Other Production Cost	Demand Price
Fertilizer	$/kgN	$0.88			
Irrigation	$/cm	$1.29			
Corn	$/mt			prod cost = -2.20* yield+ 198.87	$195
Stover	$/mt			$47.83 for 22%, and $56.28 for >22%	$72
Ethanol	$/bbl			$13	$70
GHG emission	$/mt CO2eq/ha		$60		
GHG emission benefit	$/mt CO2eq/ha				$60
Animal feed (DDGS)	$/mt				$217
Electricity	$/MWh			$ 5.0	$94
Organic N leaching	$/mt		$910		

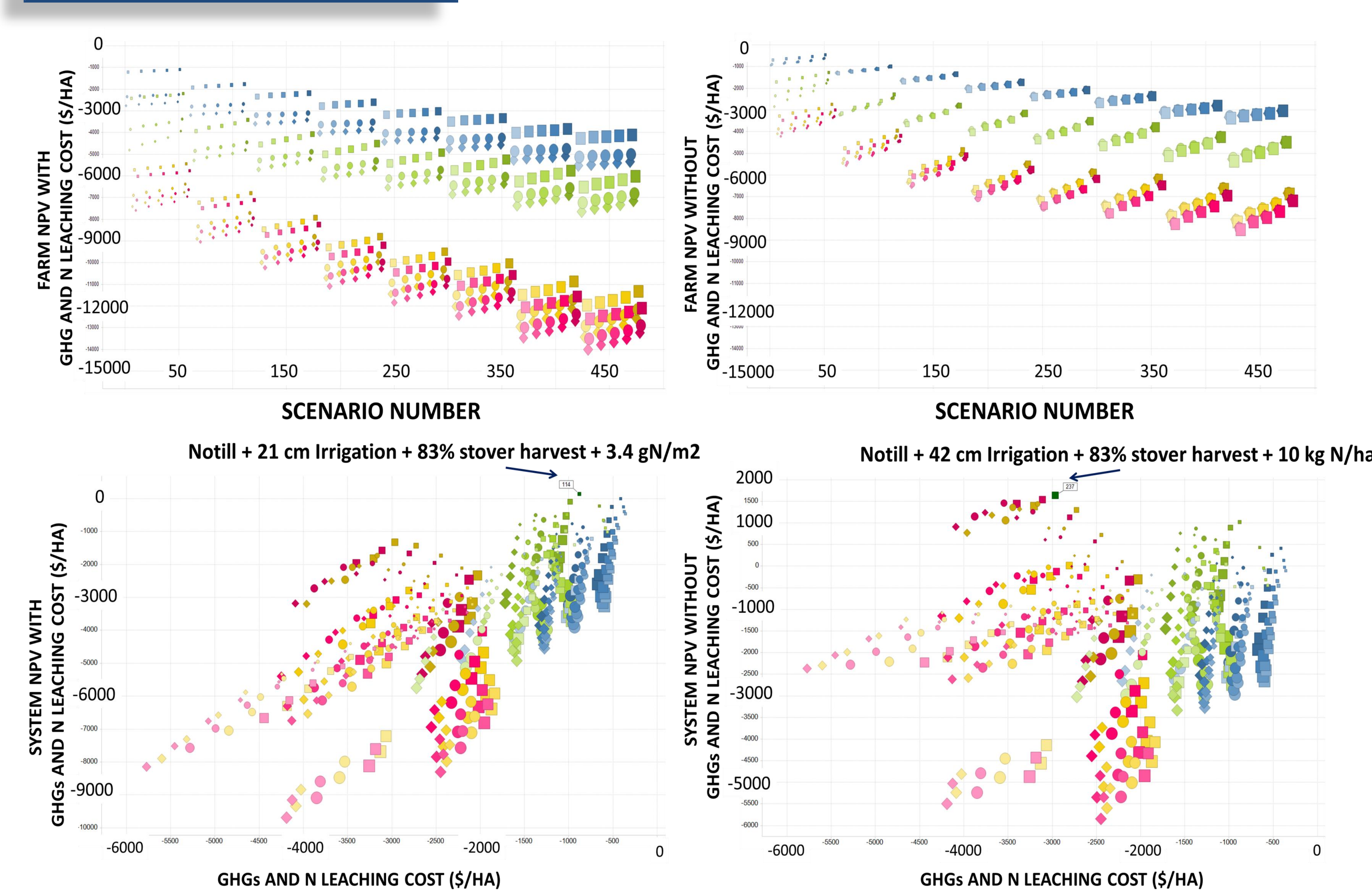
Preliminary Results

ECOLOGICAL OUTPUTS

The preliminary simulation is done for one hypothetical farm to illustrate the methodology



SYSTEM NPVs



- ✓ Irrigation is limiting factor for corn and stover yields.
- ✓ Yields reach an asymptote at fertilizer level of 13.4 kg N/ha
- ✓ Yields decrease with higher tillage
- ✓ High corn yields come at the expense of other ecosystem services
- ✓ Ecological value of other ecosystem services mitigates the decrease in corn yields on NPV
- ✓ Ecosystem services benefit to a farmer $500-6,000/ha
- ✓ Ecosystem services benefit for the system is $360-5,800/ha

FUTURE WORK:

- Applying the methodology for landscape optimization of corn production area in Larimer county, CO
- Conducting sensitivity analyses with production costs, externality costs and prices.