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Agricultural & Biological ENGINEERING

A Framework for Land Acquisition Strategy of Best Management Practices for Hydrology and Water Quality with a Rainfall-Runoff Model: Case Study in Michigan City, Indiana

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(Chen et al., 2020, In prep)

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Framework Sketch

Stakeholder Committee

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Hydrologic Modeling

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Stakeholder Meetings

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Parcel Visit

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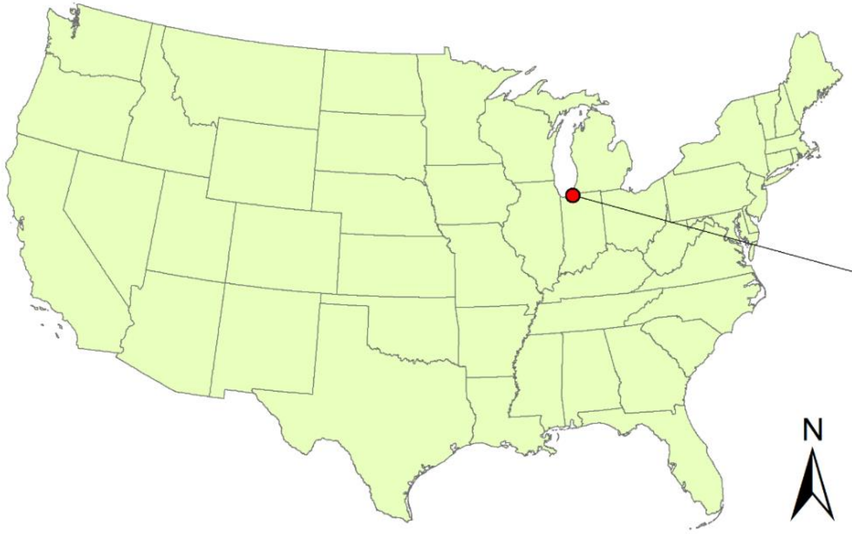
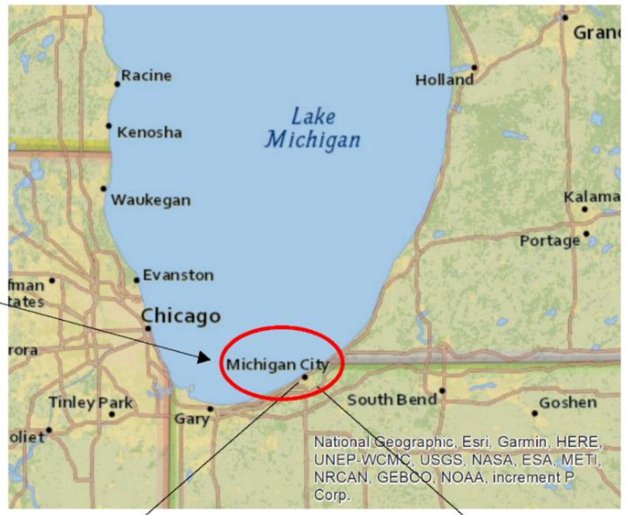
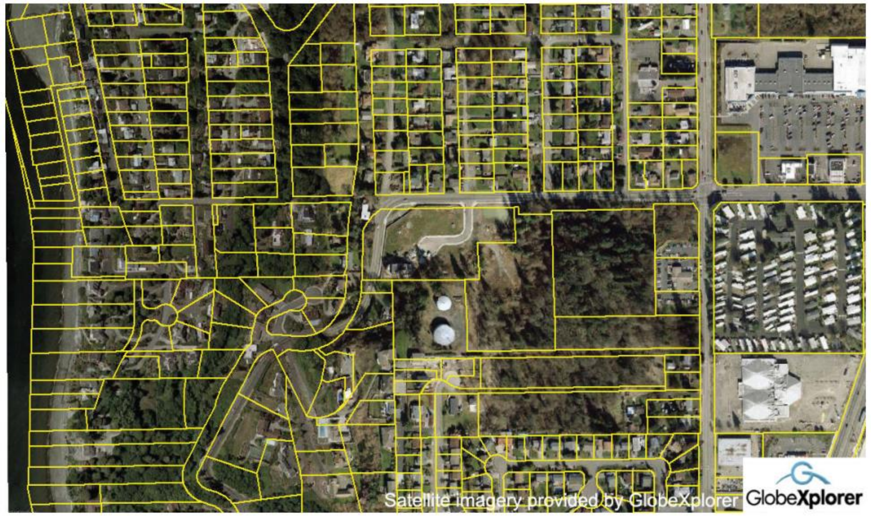
Decision Maker Meetings





Contiguous U.S. State

Top 20 parcels



Source: National land parcel data, 2007

(Chen et al., 2020, In prep)

Introduction

- Green infrastructure (GI) practices are on-site stormwater management approaches, including best management practices (BMPs) and low impact development (LIDs) (Chen et al., 2019)

BMPs
Retention ponds (wet)
Detention basins (dry)
Wetland basin
…

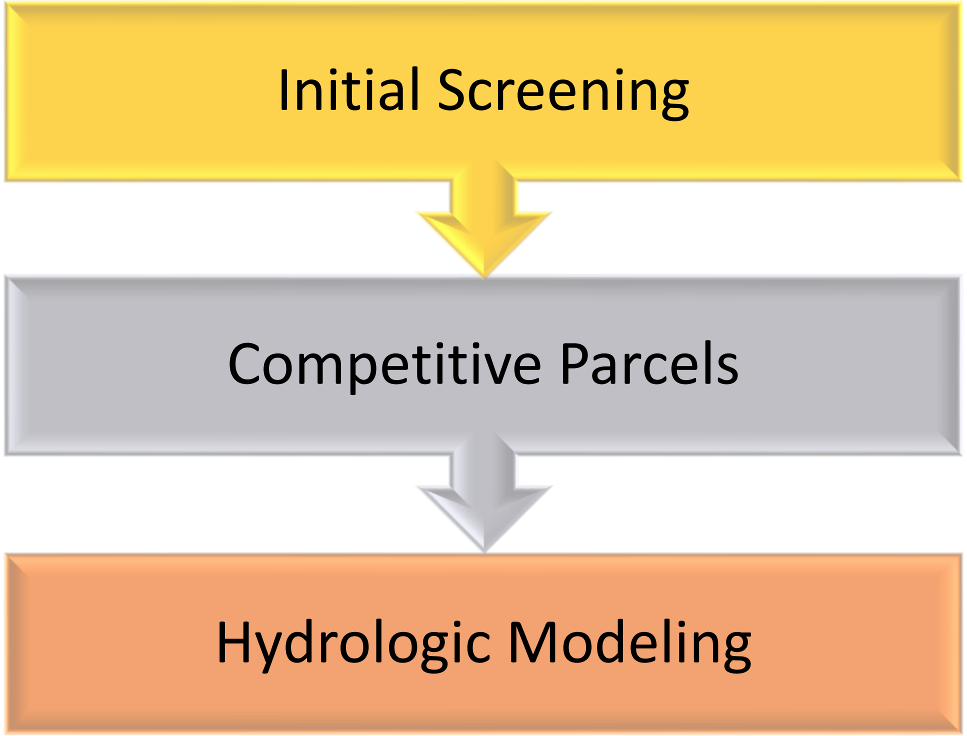
LIDs
Porous pavement
Green roofs
Rainbarrels/Cisterns
Bioretention systems…

Overall goal (Chen et al., 2020, In prep)

Providing recommendations for the land acquisition process in the city - to identify parcels that have greater potential to achieve environmental benefits.

Introduction (Chen et al., 2020, In prep)

- Detention basins (dry - grass-lined)
- Retention ponds (wet ponds)
- Wetland basin



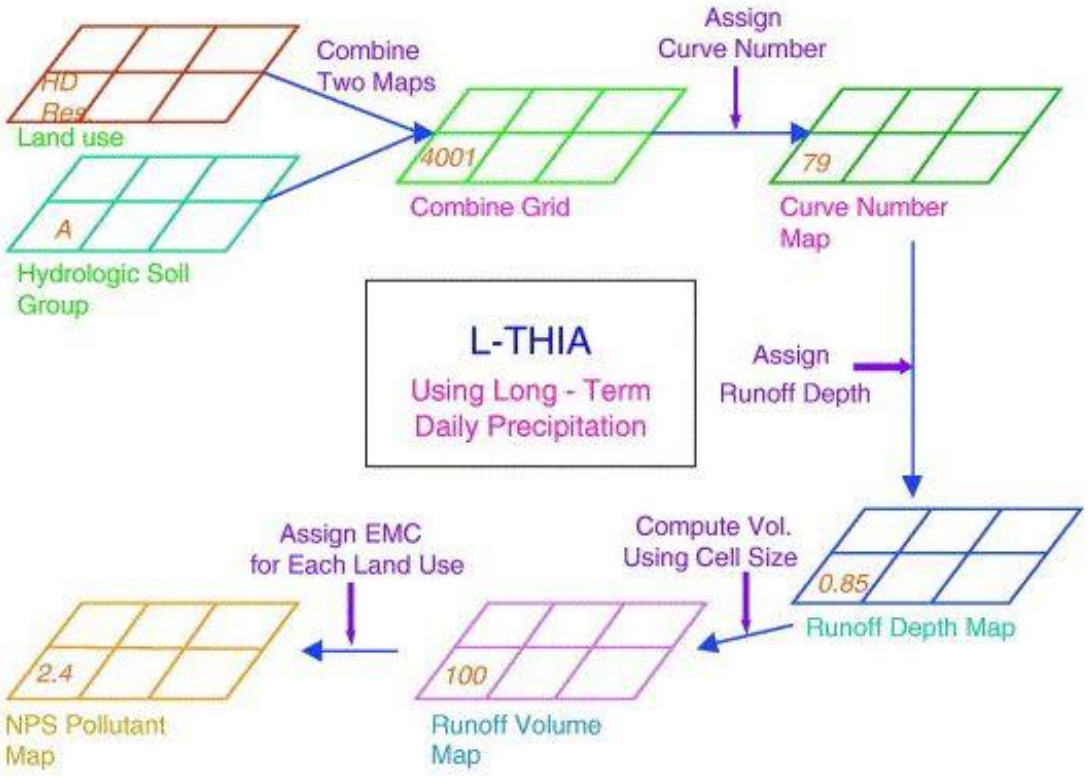
Source: https://www.montgomerycountymd.gov

Source: Massachusetts Department of Environmental Protection

Methods and Materials

Model

❖ The Long-Term Hydrologic Impact Assessment- Low Impact Development Model (L-THIA-LID) 2.1 model can evaluate the performance of BMPs and LIDs at watershed scale (Liu et al., 2015, 2016; Chen et al., 2019)



❖ A total of 12 GI practices are represented in this model

Modified CN Method (Sample et al., 2001)
Bioretention systems
Rainbarrel /cistern,
Green roof,
Open wooded space
Porous pavement
Permeable patio

Percent Runoff Reduction Method (Liu et al., 2015)
Detention basin (dry pond)
Retention pond (wet pond)
Wetland basin
Biofilter-grass swale
Wetland channel
Biofilter-grass strip

Methods and Materials

Data (Chen et al., 2020, In prep)

- Precipitation: daily precipitation (1998-2017) from the National Climatic Data Center
- Land Use: National Land Cover Dataset (NLCD) 2011
- Soil: hydrologic soil group data from Soil Survey Geographic (SSURGO) database
- Other data: DEM, streams, imperviousness 2011

BMP	Site Suitability Criteria (Shoemaker et al., 2009; USEPA; 2004)				
	Drainage Area (m^2)	Drainage Slope (%)	Imperviousness (%)	Hydrologic Soil Group	Stream Buffer (m)
Wet Pond	> 101171 / 25 acre	< 15	> 0	A–D	> 30.48 / 100 ft
Dry Pond	> 40469 /10 acre	< 15	> 0	A–D	> 30.48 / 100 ft
Wetland	> 101171 / 25 acre	< 15	> 0	A–D	> 30.48 / 100 ft

Methods and Materials

❖ Total Cost of practice implementation (Arabi et al., 2006):

$$Tc = Cc \times (1+s)^{dl} + Cc \times Rmc \times \left[\sum_{i=1}^{dl} (1+s)^{(i-1)}\right]$$

Cc: Construction cost

Rmc: Ratio of annual maintenance cost to construction cost

s: Interest rate (4.5%)

dl: GI practice design life: 20 years

❖ Cost per unit reduction per year/cost effectiveness (Liu et al., 2015): $C_{ur,y} = \frac{T_c}{nR}$

R: runoff volume reduction (m^3) or pollutant loads (kg)

Tc: total cost of implementing practices

n: practice design life

Cost of GI practices: Construction and annual maintenance costs (Liu et al., 2015)		
GI	Construction cost ($/$m^2$ drainage area)	Annual maintenance cost (% of construction cost)
Wet pond	1.22	4
Dry Pond	1.41	4
Wetland	1.55	4

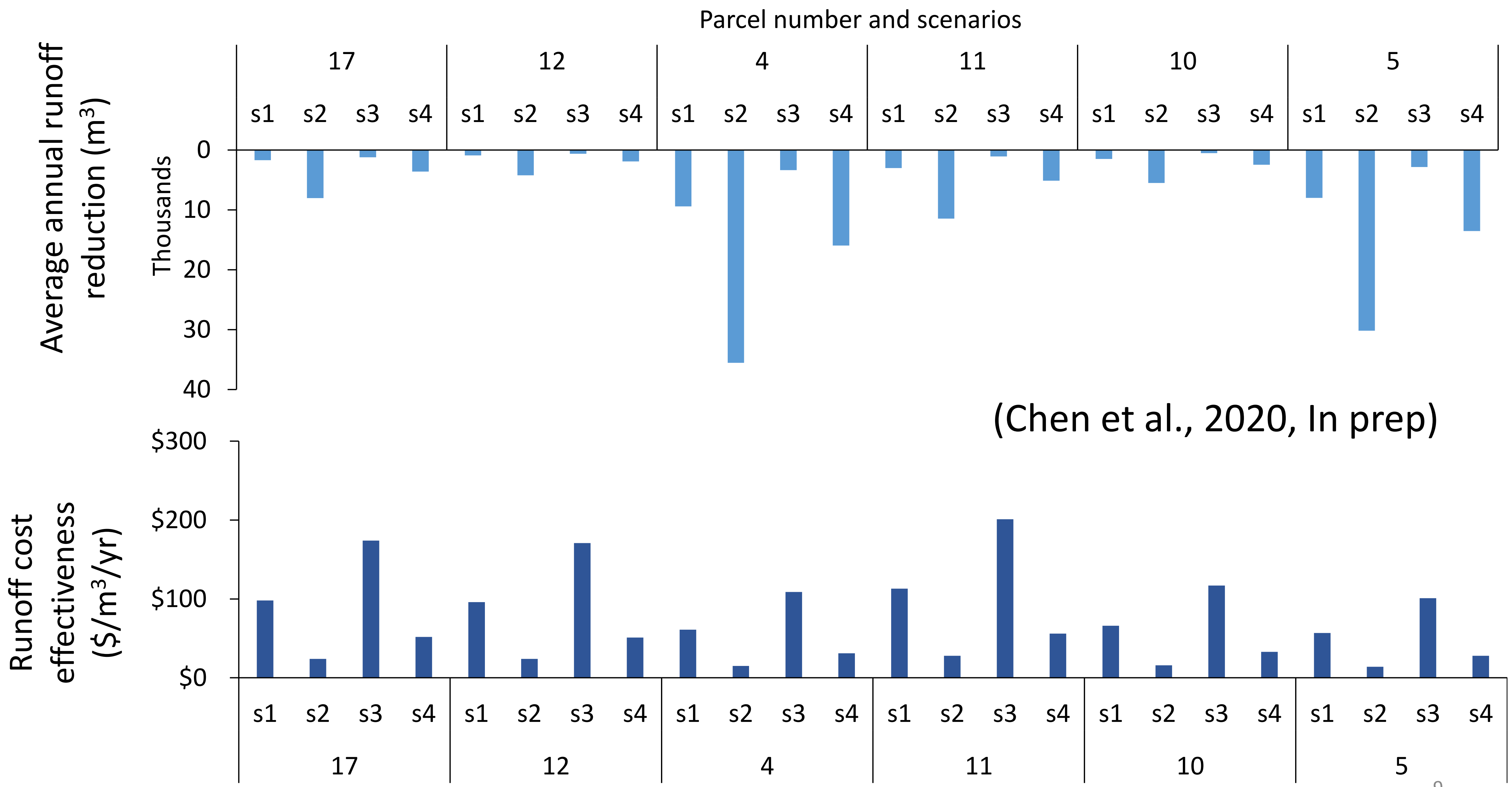
Methods and Materials

Four scenarios are simulated for six competitive parcels (Chen et al., 2020, In prep):

- S1: all suitable areas are implementing wet pond
- S2: all suitable areas are implementing dry pond
- S3: all suitable areas are implementing wetland
- S4: three BMPs are equally implemented in suitable areas

- Calibrated L-THIA-LID 2.1 model from Crooked Creek watershed (Liu et al., 2015) was used in this work (similar rainfall, similar topography, similar development/land use types)

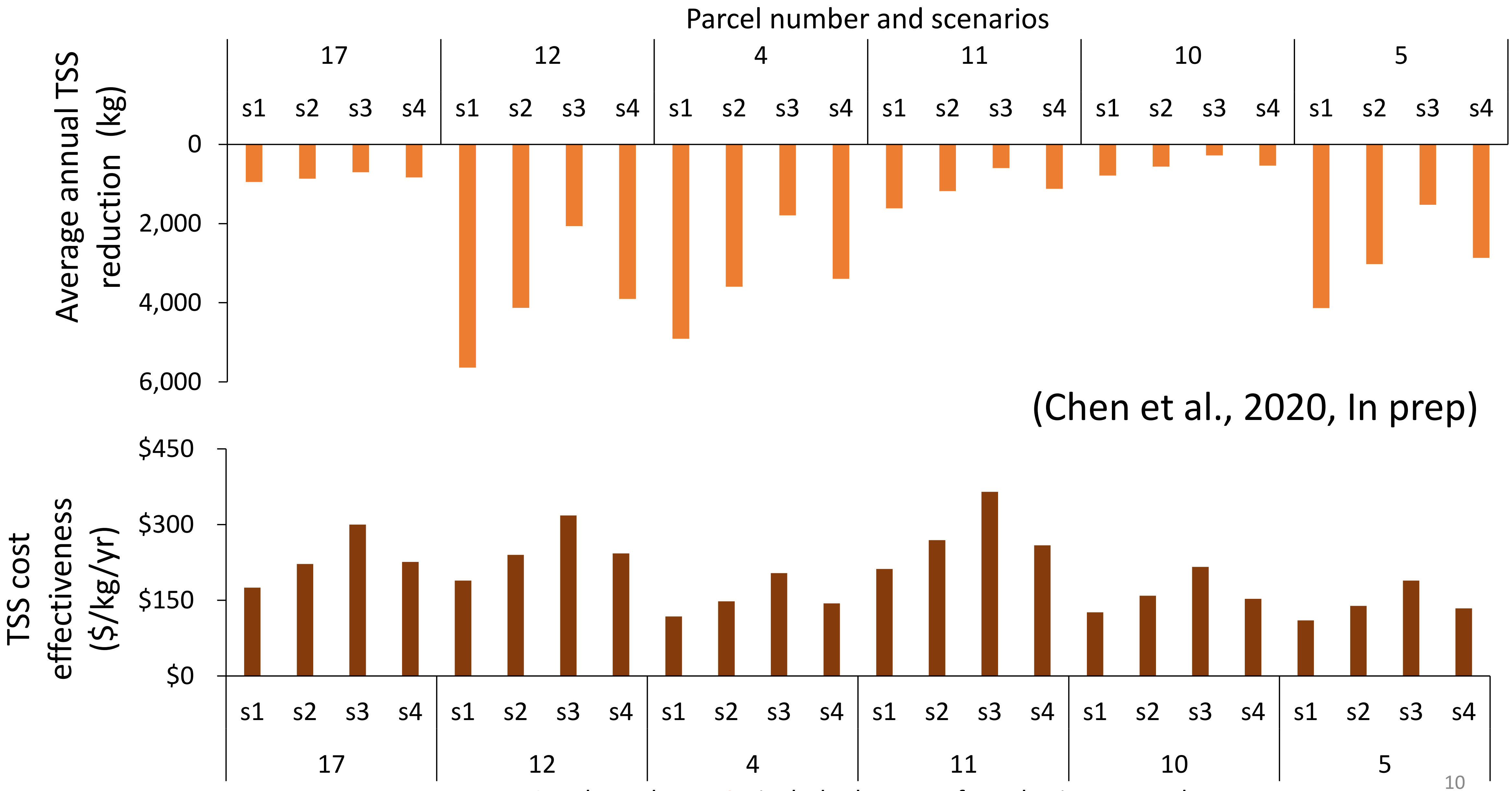
Results and Discussion



(Chen et al., 2020, In prep)

Cost here does NOT include the cost of purchasing a parcel.

Results and Discussion



(Chen et al., 2020, In prep)

Cost here does NOT include the cost of purchasing a parcel.

Conclusions

- Dry pond: greatest runoff reduction, most cost-effective for runoff reduction, could also achieve substantial sediment reduction.

- Wet pond: greatest sediment reduction, most cost-effective for sediment reduction.

- Generally, the parcels with the larger suitable areas for BMPs and larger drainage areas that flow through them provide the most significant opportunities to address runoff and water quality issues.

(Chen et al., 2020, In prep)

Thank you!

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