Quantifying the Effects of Climate Change on Runoff, Sediment and Chemical Losses for Different Watershed Sizes

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Background

- Average annual temperatures in the Midwest have increased over the last several decades
- Heat waves are becoming more frequent and cold periods becoming fewer
- Snow and ice are arriving later in the fall and starting to melt earlier in the spring
- Heavy downpours now occur twice as frequently as they did a century ago

Background

- According to the U.S. Global Change Research Program (USGCRP, 2009) assessments of the Midwest
  - Average summer temperatures are expected to continue increasing to the end of this century
  - Precipitation in the Midwest is likely to fall more frequently in heavy downpours
  - Between heavy rainfall events, there will likely be longer periods without precipitation

Implications of Climate change

Possible downsides

Overworked drainage systems lead to stream channel erosion

Increased ET may lead to increase plant-growth stress

Possible Upsides

Longer growing season
(Source: Southworth *et al.*, 2002)

Crop Yield / Climate Scenario	Lesser CC
Soybeans, late maturing	10-20% increase
Soybeans, mid maturing	20-30% increase
Soybeans, early maturing	20-30% increase
Winter Wheat	40-50% increase

Increased levels of carbon dioxide may increase yields in C_3 photosynthetic pathway plants

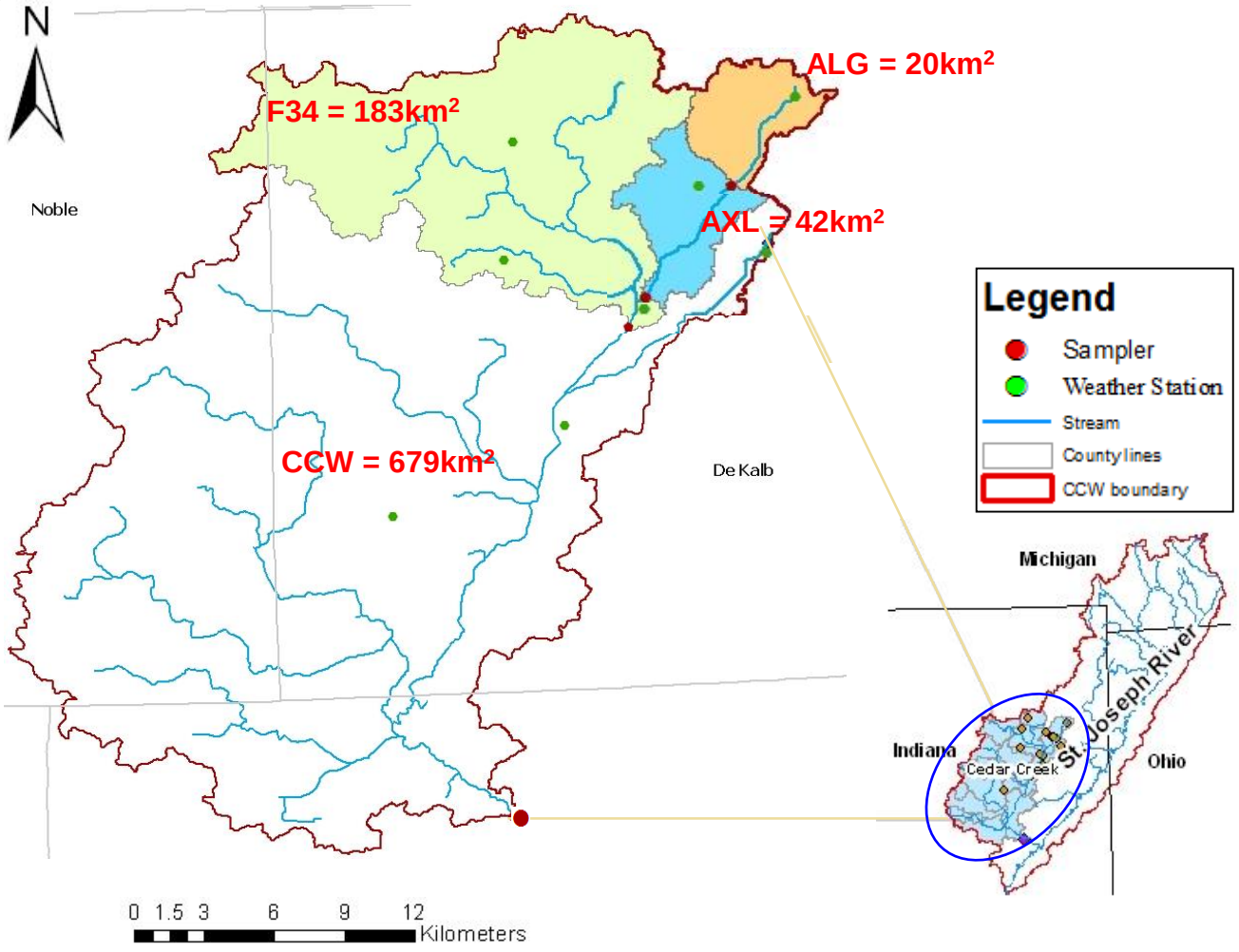
Objective

Quantify the effects of future climate conditions on surface runoff, sediment and chemical losses at different watershed sizes using the Soil and Water Assessment Tool (SWAT).

- Hypothesis

  Future climate conditions will have significant influence on runoff, sediment, atrazine, soluble nitrogen, total nitrogen, soluble phosphorus and total phosphorus losses under current agricultural practices and management conditions.

Study Area: Cedar Creek at Cedarville

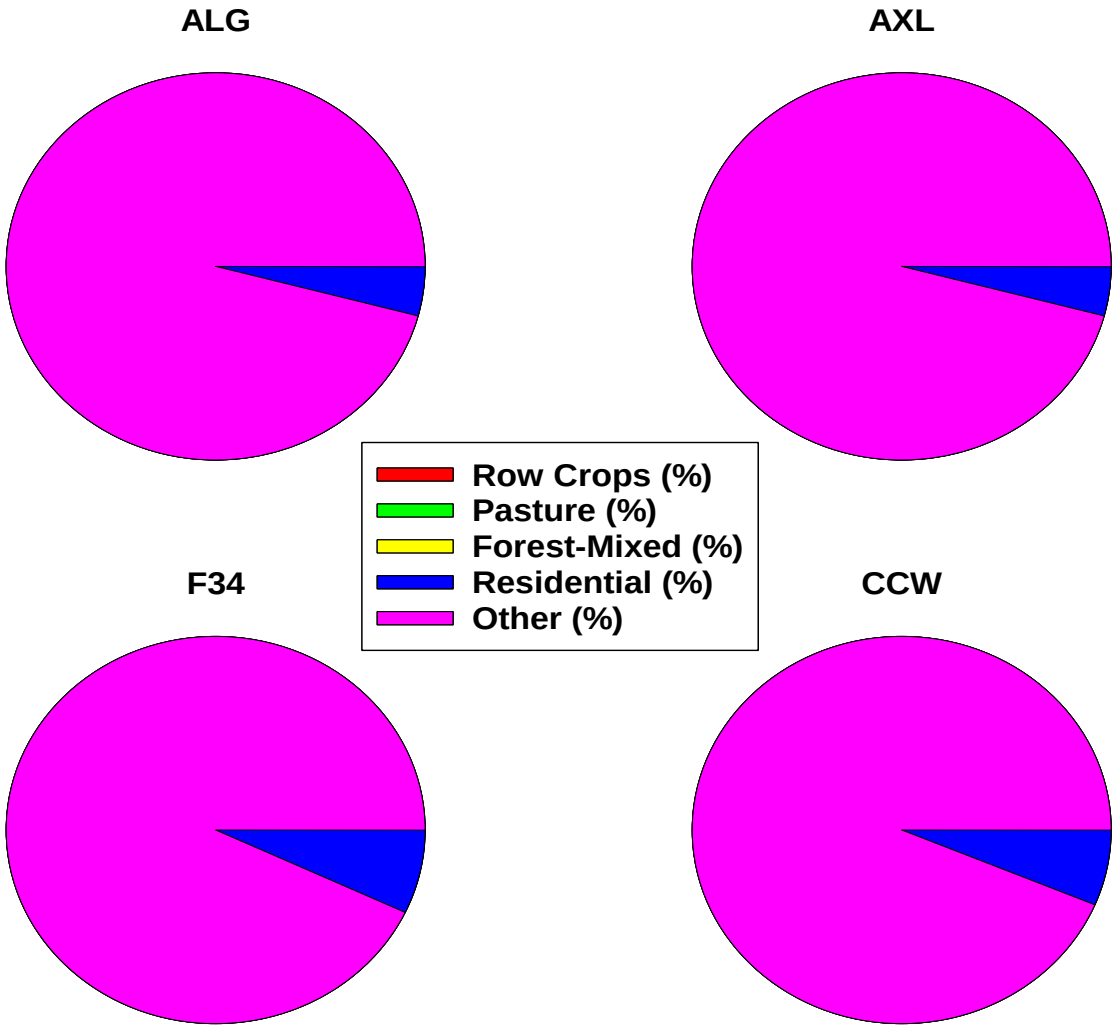


- Largest Tributary in SJRW
- Great Lakes Plain
- Topography
  - < 2% avg. slope
  - 277m avg. elev.
- Climate
  - 950 mm/yr. precipitation
  - 10 to 23^{0}C during growing season

ALG watershed

ALG Potholes

Study Area: Landuse Distribution

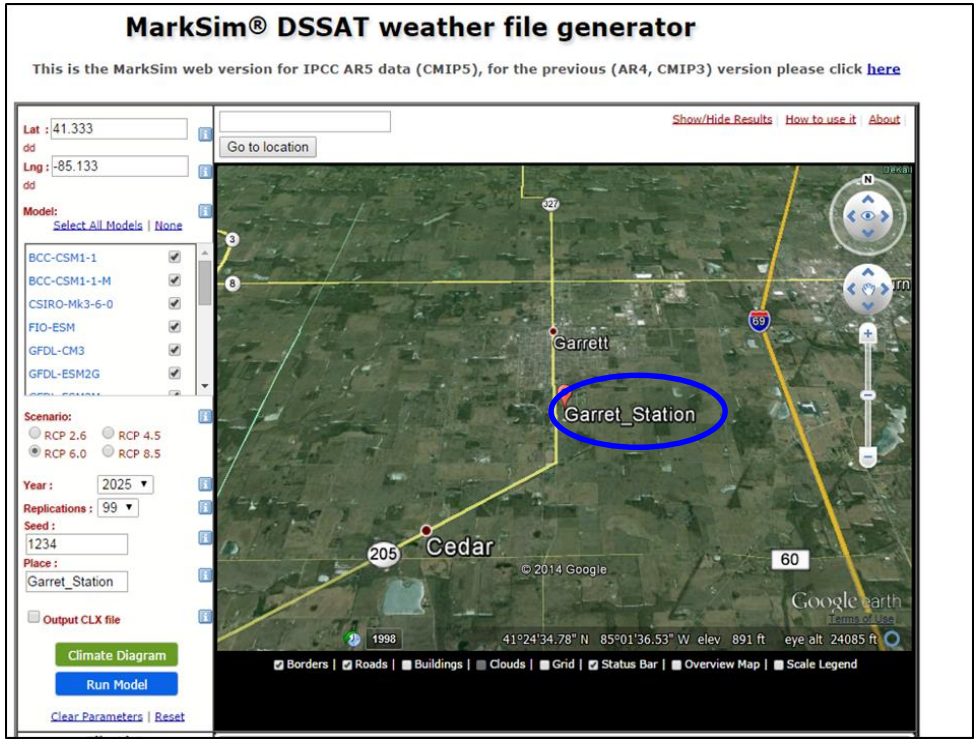


Soil and Water Assessment Tool (SWAT)

Crop	Date	Management Operation	Rate
Corn	22-Apr	Nitrogen Application (as Anhydrous Ammonia)	176.0 kg/ha
	22-Apr	Phosphorus (P_2O_5) Application (as DAP/MAP)	54.0 kg/ha
	22-Apr	Pesticide Application (as Atrazine)	2.2 kg/ha
	6-May	Tillage, Offset disk plow (No-Till on 20% ALG & AXL)	
	6-May	Planting	
	10-Oct	Harvest	
Soybeans	10-May	Phosphorus (P_2O_5) Application (as DAP/MAP)	40.0 kg/ha
	24-May	No-Tillage, drill (100% ALG & AXL) (50% F34 & CCW)	
	24-May	Planting	
	7-Oct	Harvest	
	20-Oct	Tillage, Chisel plow (30% mixing)	

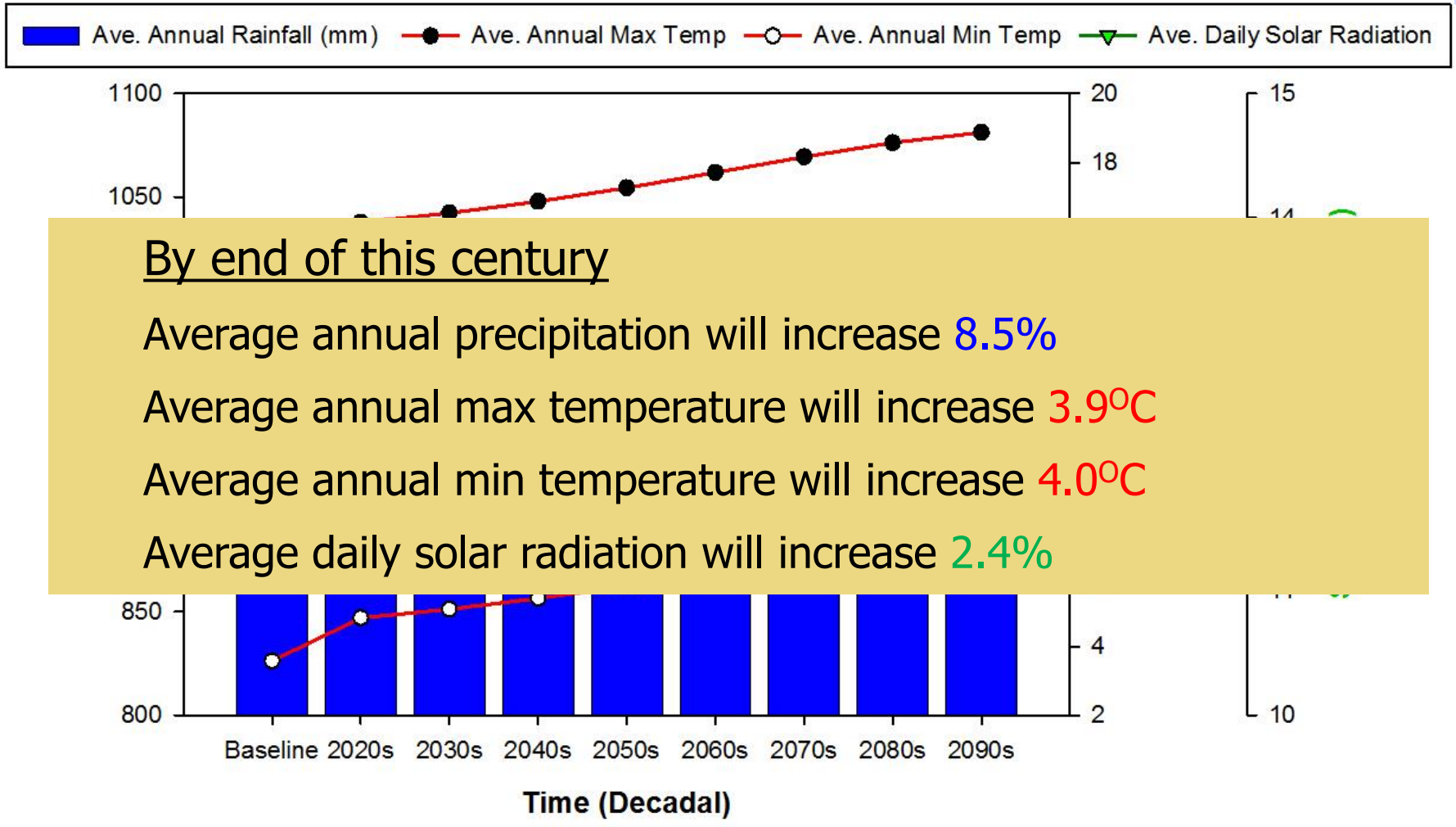
Generating future climate files for SWAT

MarkSim Decision Support System for Agrotechnology Transfer (DSSAT) weather file generator



- Downscaled climate projections from the IPCC 5th Assessment Report (AR5)
- Ensemble mean of 17 GCMs from CMIP5 model family, simulated under RCP 6.0 scenario (RCP = 6.0 W/m^2 or 850ppm CO_2 equivalent in 2100)
- Allows download of multiple replicates of future climates

Future Climate - Garrett, IN (Lat: 41.33, Lng: -85.13)



By end of this century

Average annual precipitation will increase 8.5%

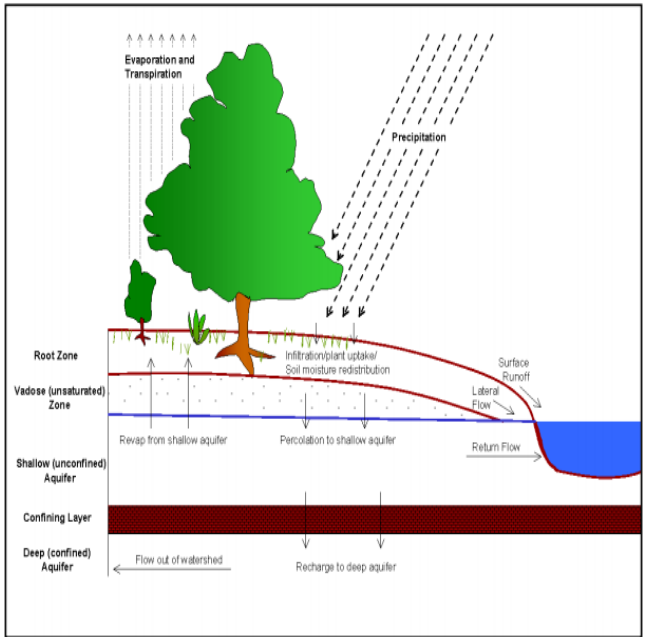
Average annual max temperature will increase 3.9^{O}C

Average annual min temperature will increase 4.0^{O}C

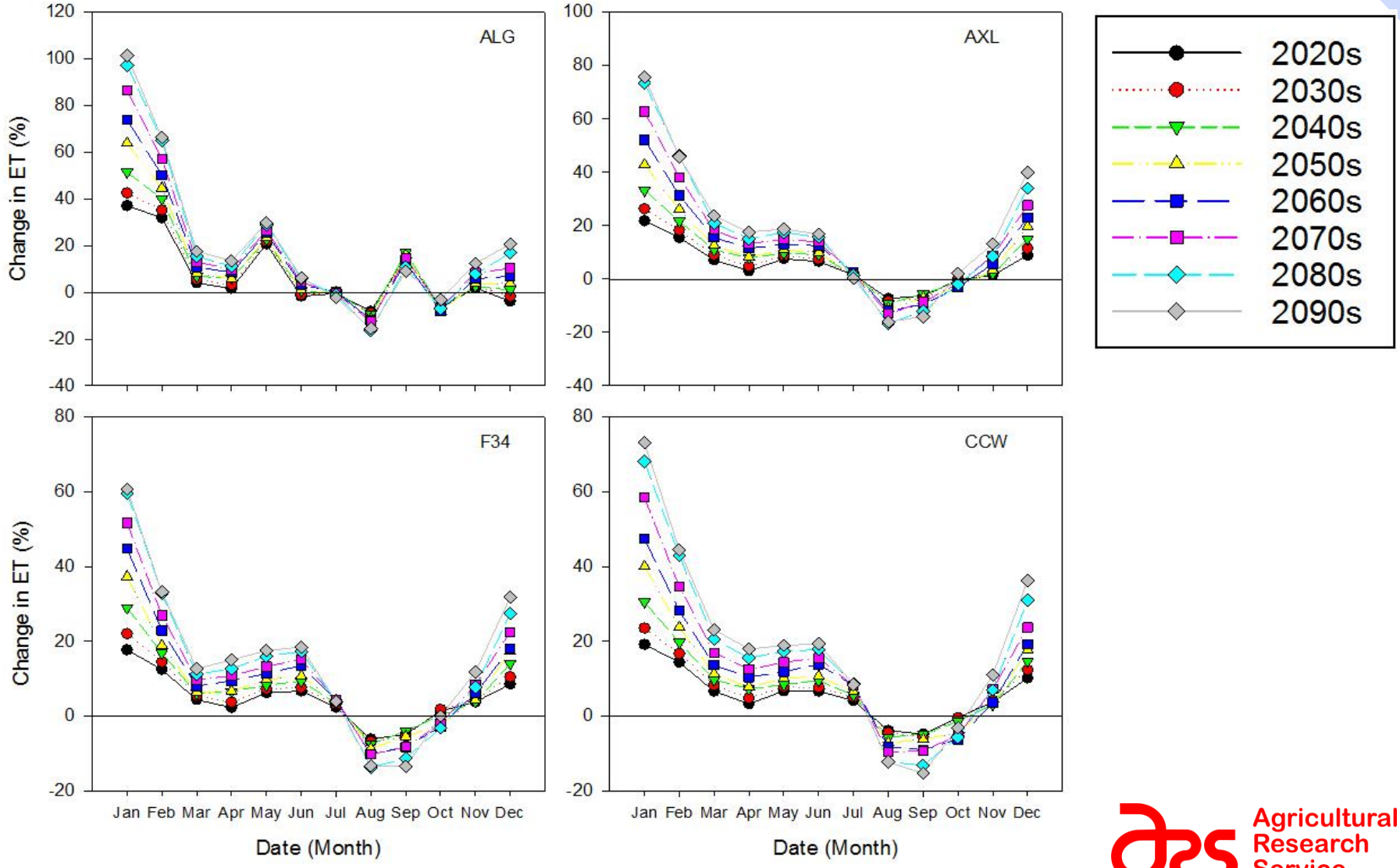
Average daily solar radiation will increase 2.4%

SWAT model simulations

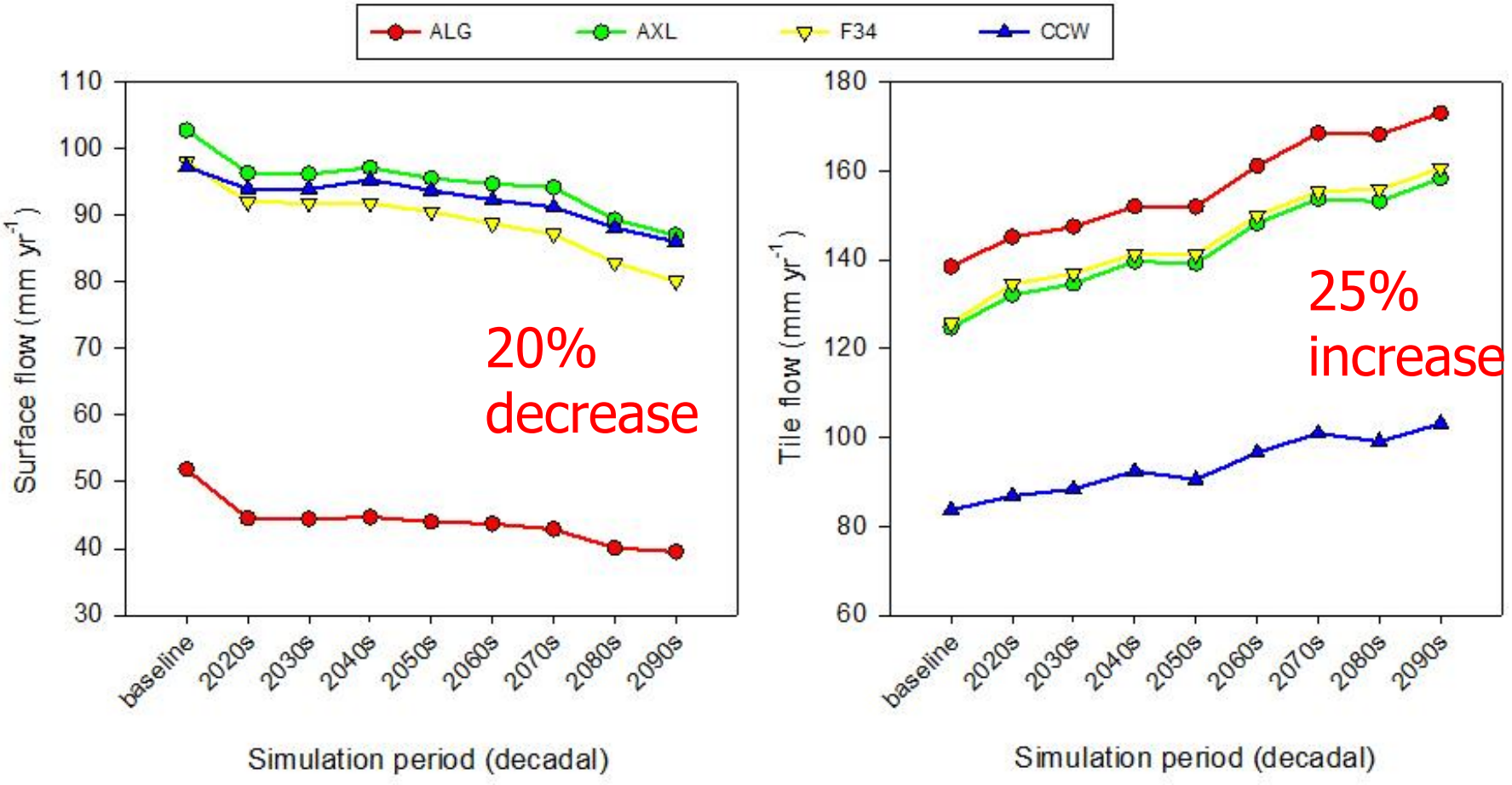
- Simulate hydrology, sediment, atrazine, nitrogen and phosphorus at four watershed sizes
- Simulations performed at daily time-step and summarized annually
- SWAT warm-up (2001 – 2005); calibrated (2006 – 2009); and validated (2010 – 2013) for streamflow, soluble-N, total-N, soluble-P and total-P
- Baseline climate - 1961 - 1990
- Future climate - 2020 - 2099



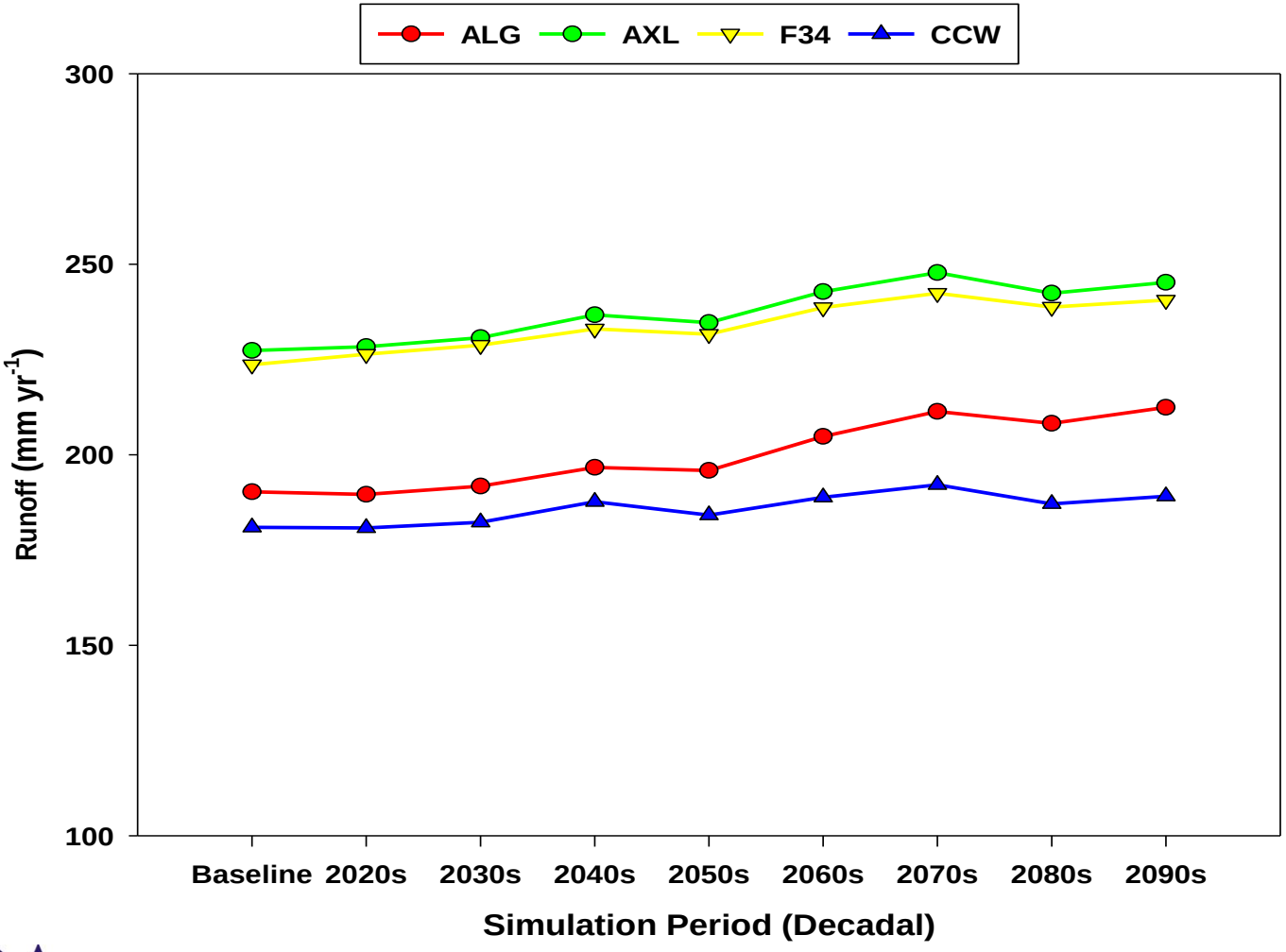
Results: Increasing temperature and precipitation caused increased monthly ET.



Results: Average annual surface runoff & tile flow

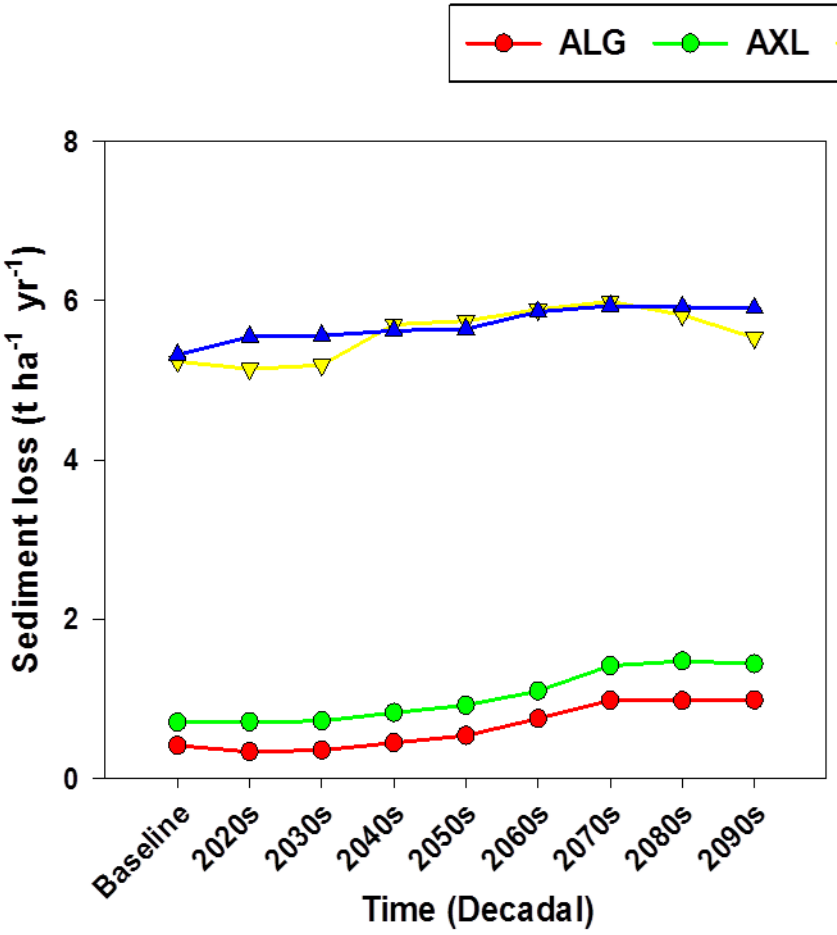


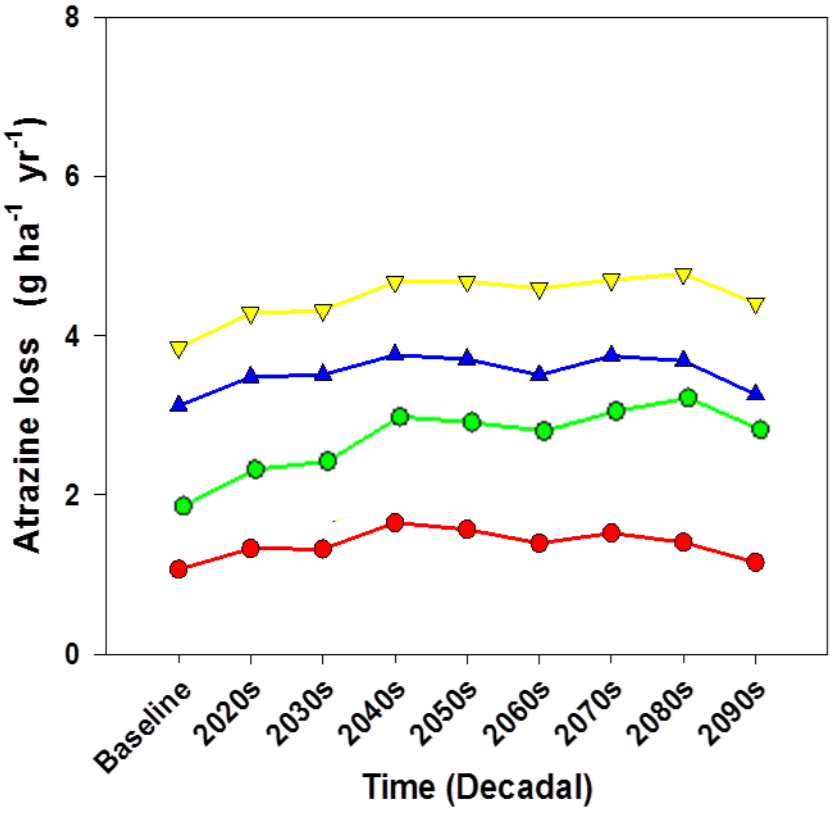
Results: Overland flow + Tile flow



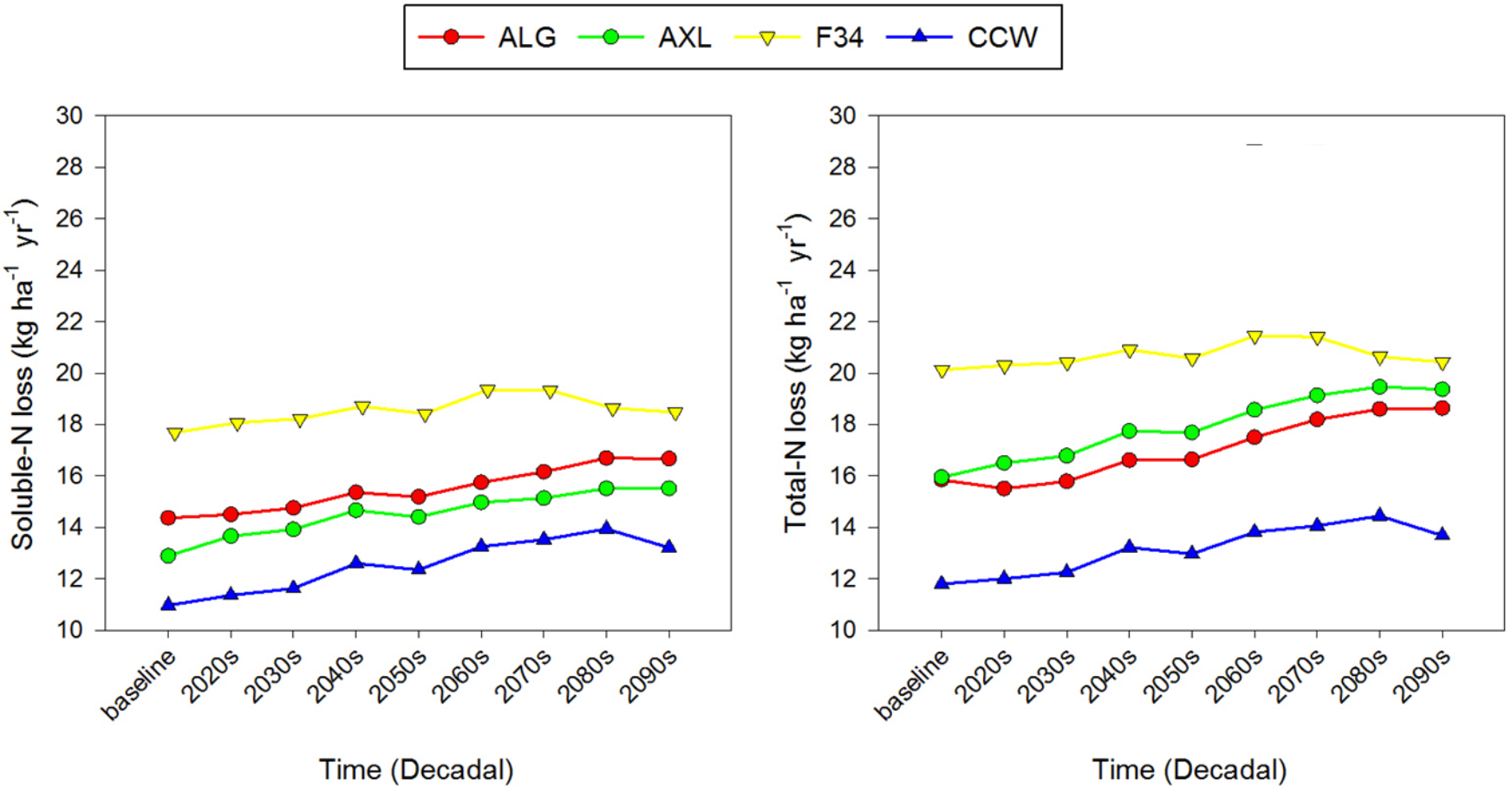
8.7% Increase

Results: Average annual sediment & atrazine losses

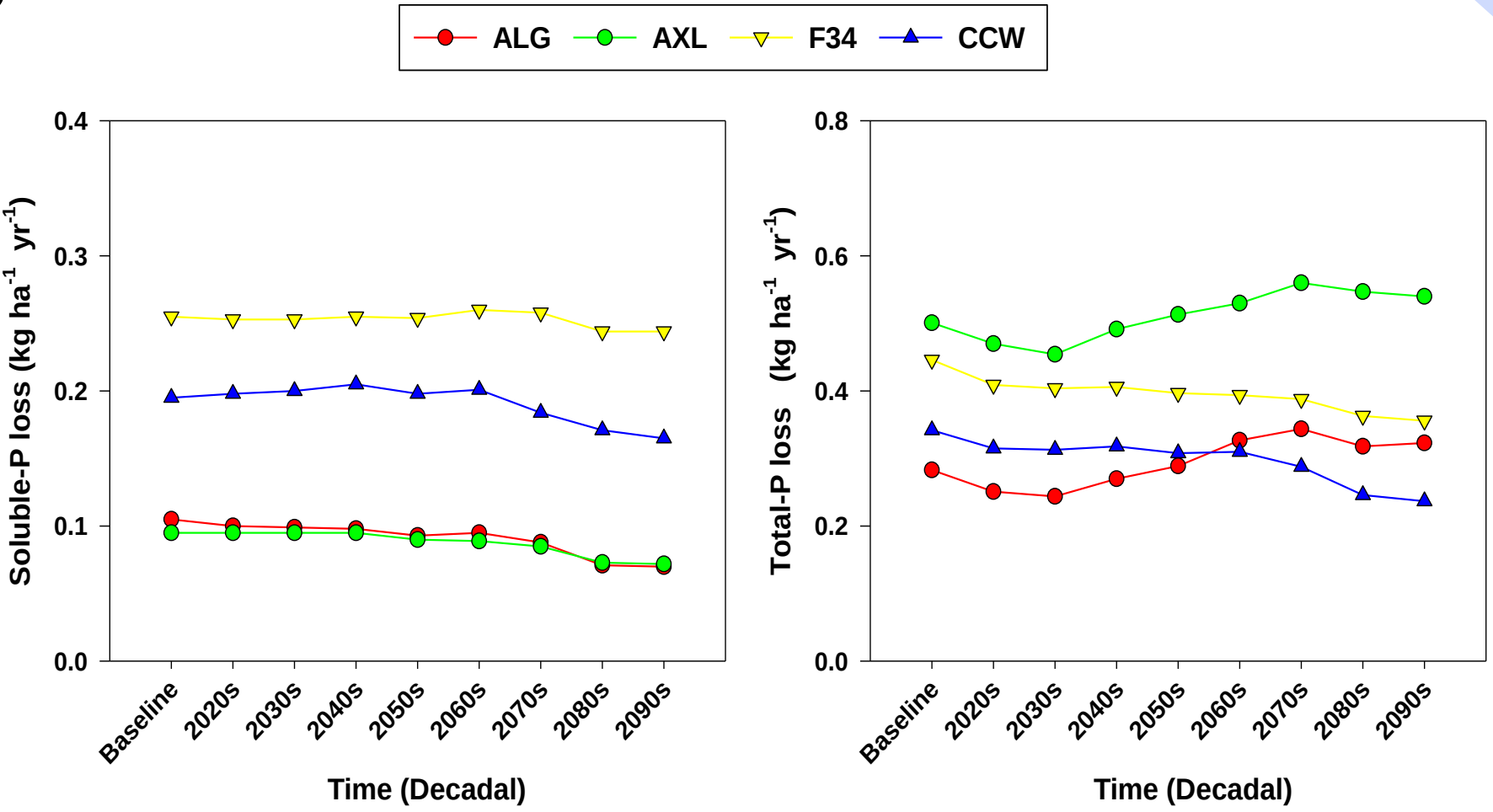




Results: Average annual soluble-N & total-N losses



Results: Average annual soluble-P & total-P losses



Summary & Conclusions

- Surface flow will likely decrease as tile flow increases due to an increasing number of day with smaller rainfall events
- Increasing temperatures also increased infiltration and reduced surface runoff by ~40% during winter months
- Average annual sediment and atrazine losses remained relatively constant towards the end of the century at all four watershed scales (varying slightly with rainfall volume).
- Average annual loss for both soluble-N and total-N will increase slightly towards the end of this century at all four watershed scales.

Summary & Conclusions (cont.)

- Average annual soluble-P and total-P decreased gradually toward the end of this century especially in the larger watersheds where sediment loss was relatively constant. In addition, higher soil temperatures increased plant phosphorus uptake.
- **Projected future climate changes in northeastern Indiana to end of this century will affect runoff, soil loss, and subsequently nutrients and pesticide losses, though not at an alarming rate.**
- **There was no noticeable effect of watershed scale under future climate conditions.**

Thank you...