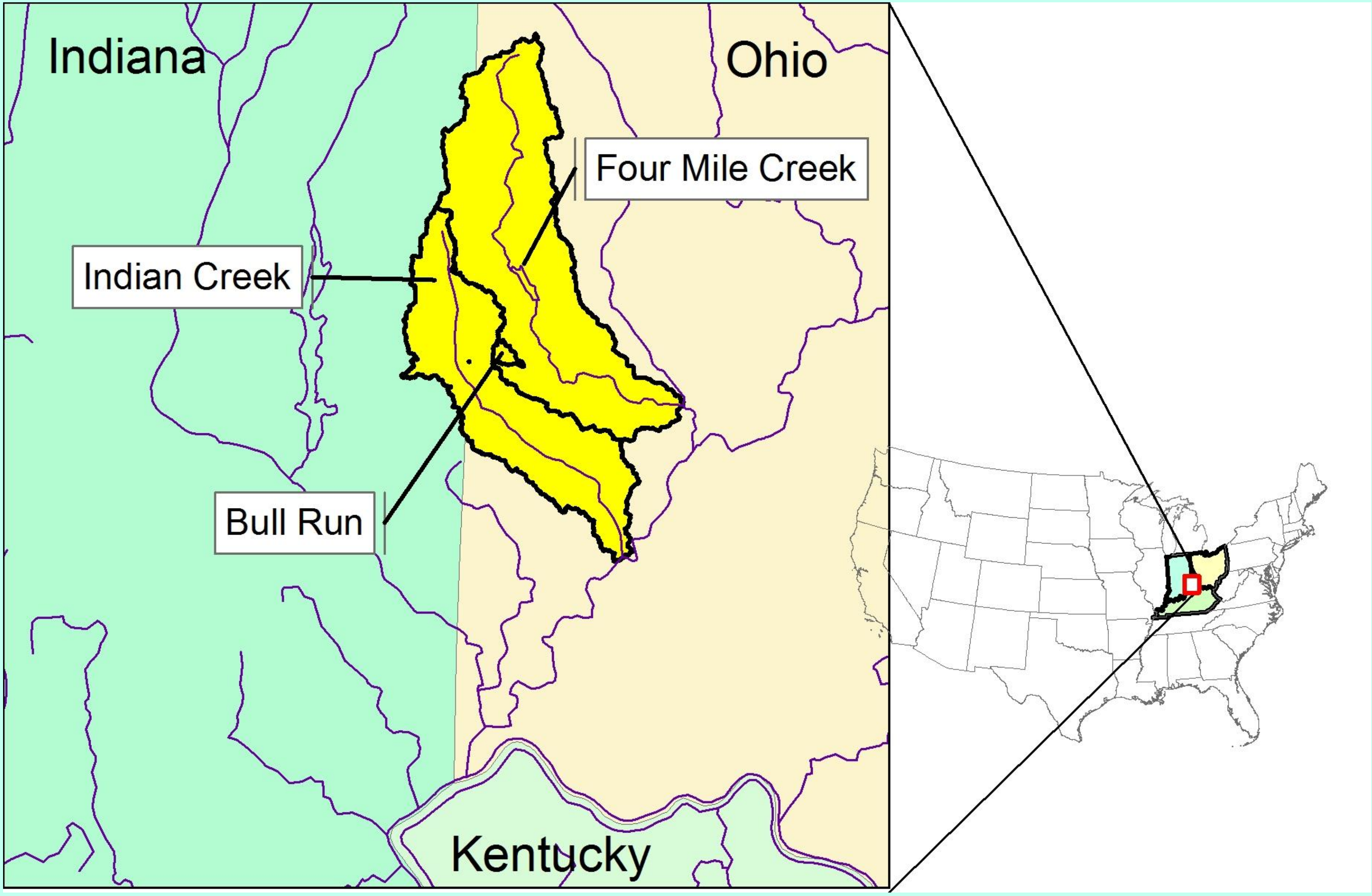
Impacts of channel incision on peak flows and stream processes

William H. Renwick & Monica T. Rakovan
Miami University
Oxford, Ohio, USA

Study Area


Indiana
Ohio
Four Mile Creek
Indian Creek
Bull Run
Kentucky

1930s Floodplain (now a terrace)

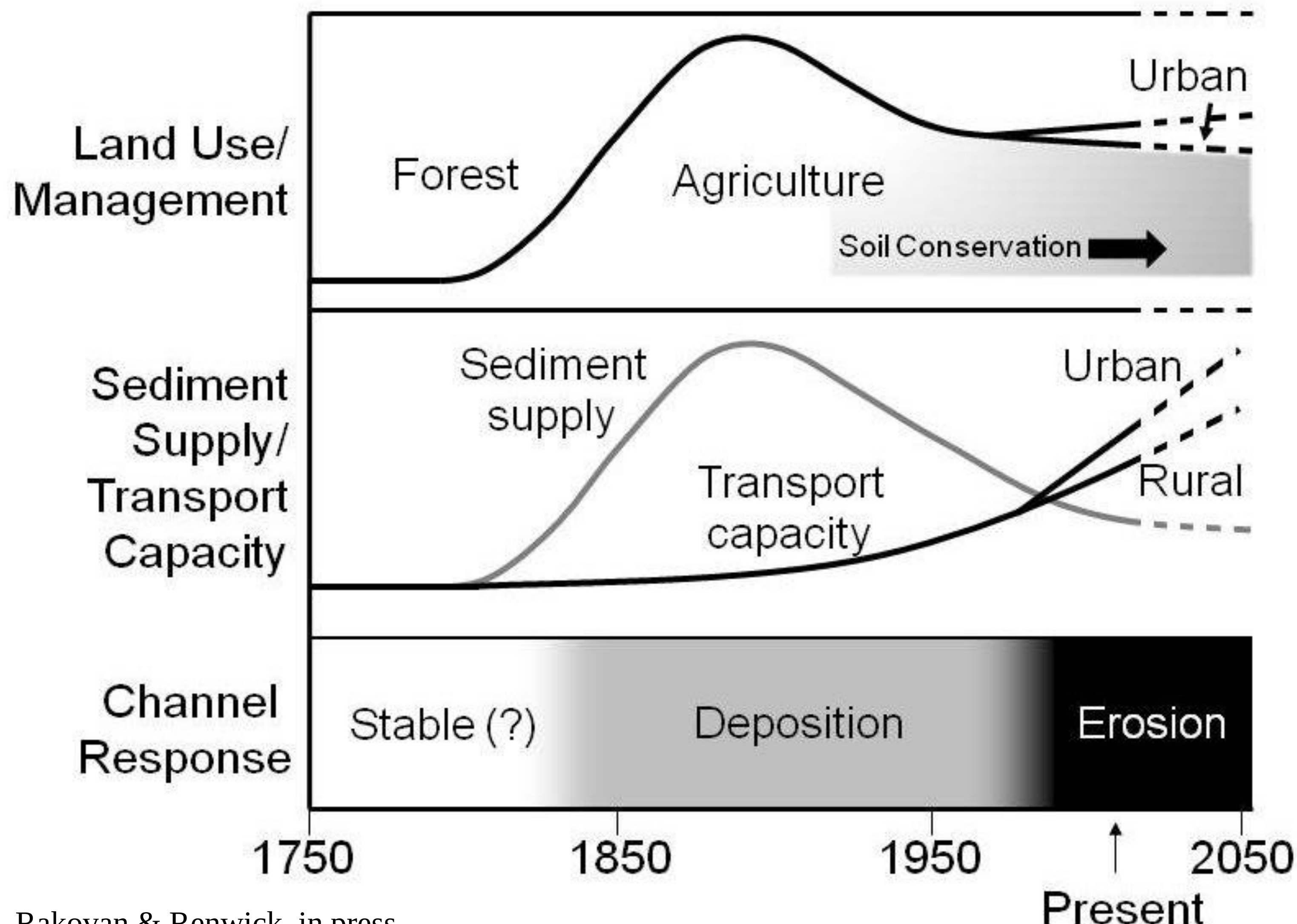
Approximate present bankfull elevation

Base of alluvium (historic stream bed)

Pleistocene till

Stream beds are now lower than ever before in the Holocene.

Historic land use changes and stream responses in southwest Ohio



Rakovan & Renwick, in press

Factors contributing to sediment supply limitation and stream incision

Sediment trapp
in impoundme

Soil Conservation

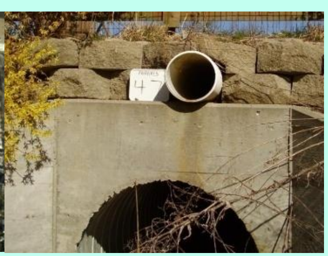
What is the effect of stream incision on hydrologic regime?

Is this effect sufficient to generate appreciable positive feedback, reinforcing incision?

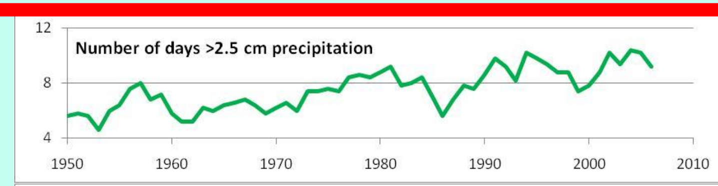
nnel
sion

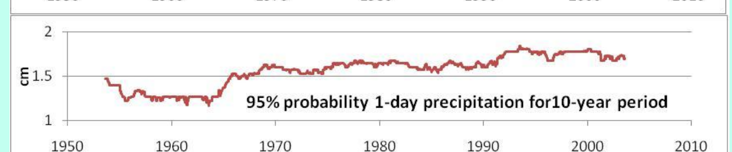
Flood
ge

Urba

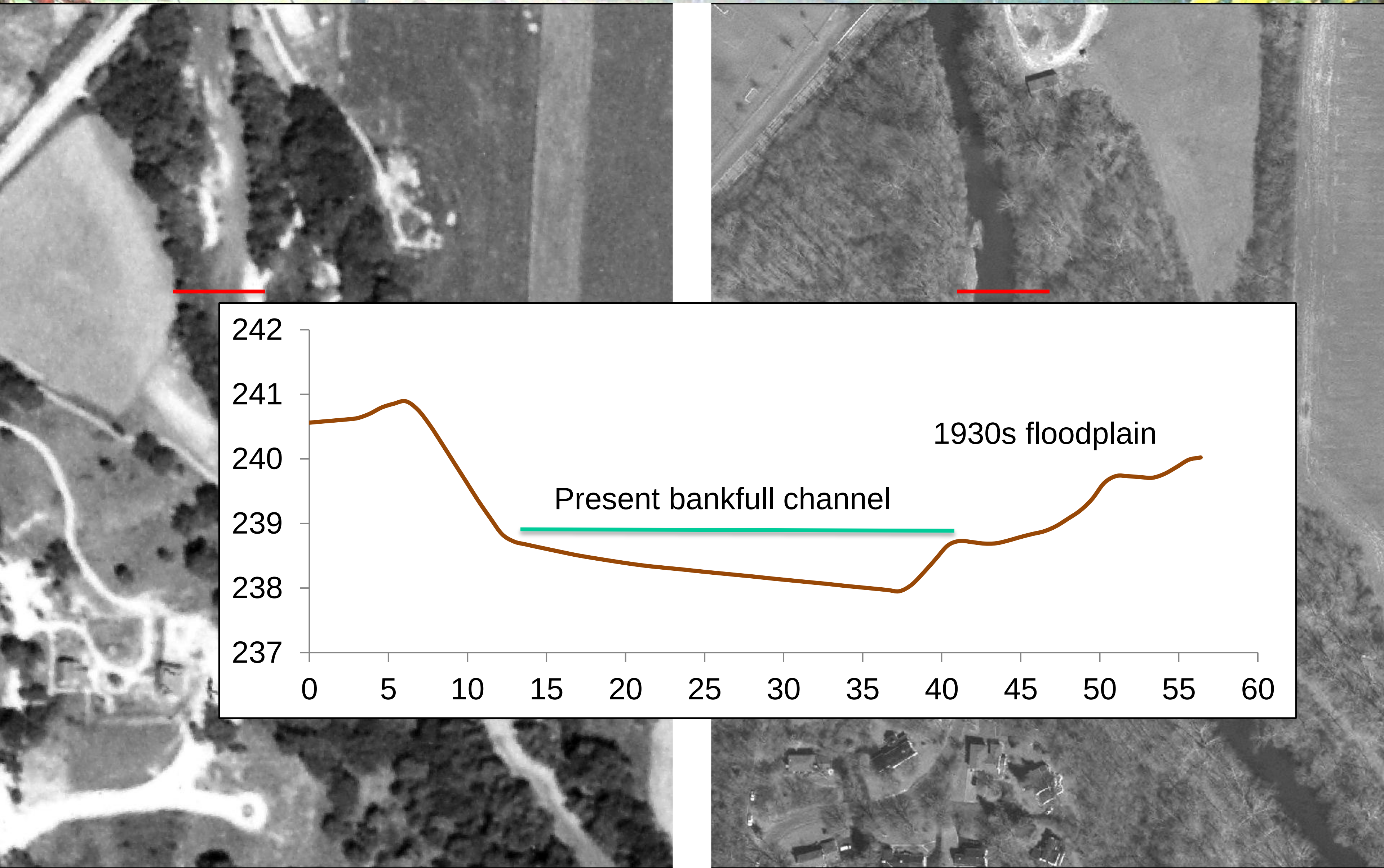


Climate change

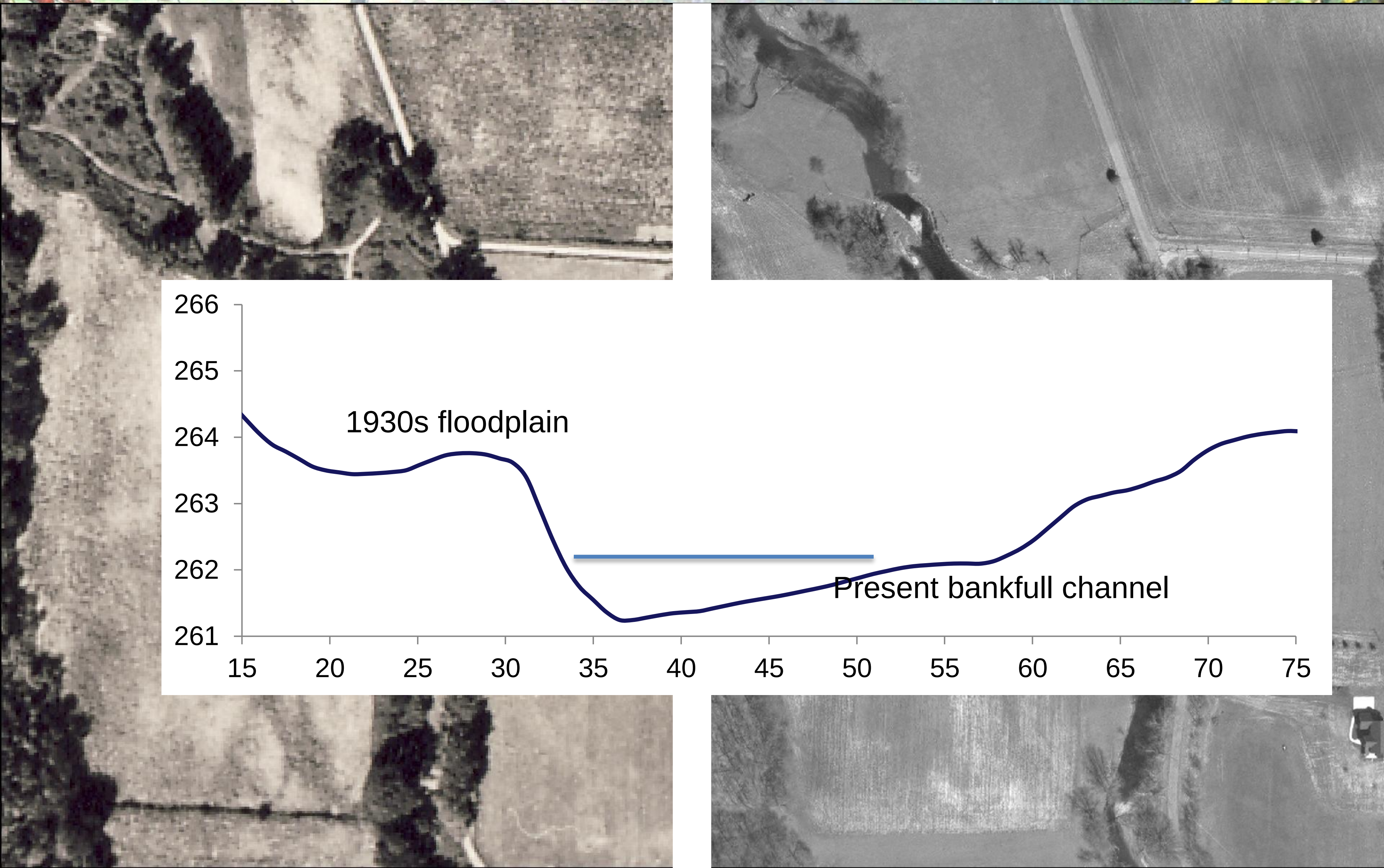




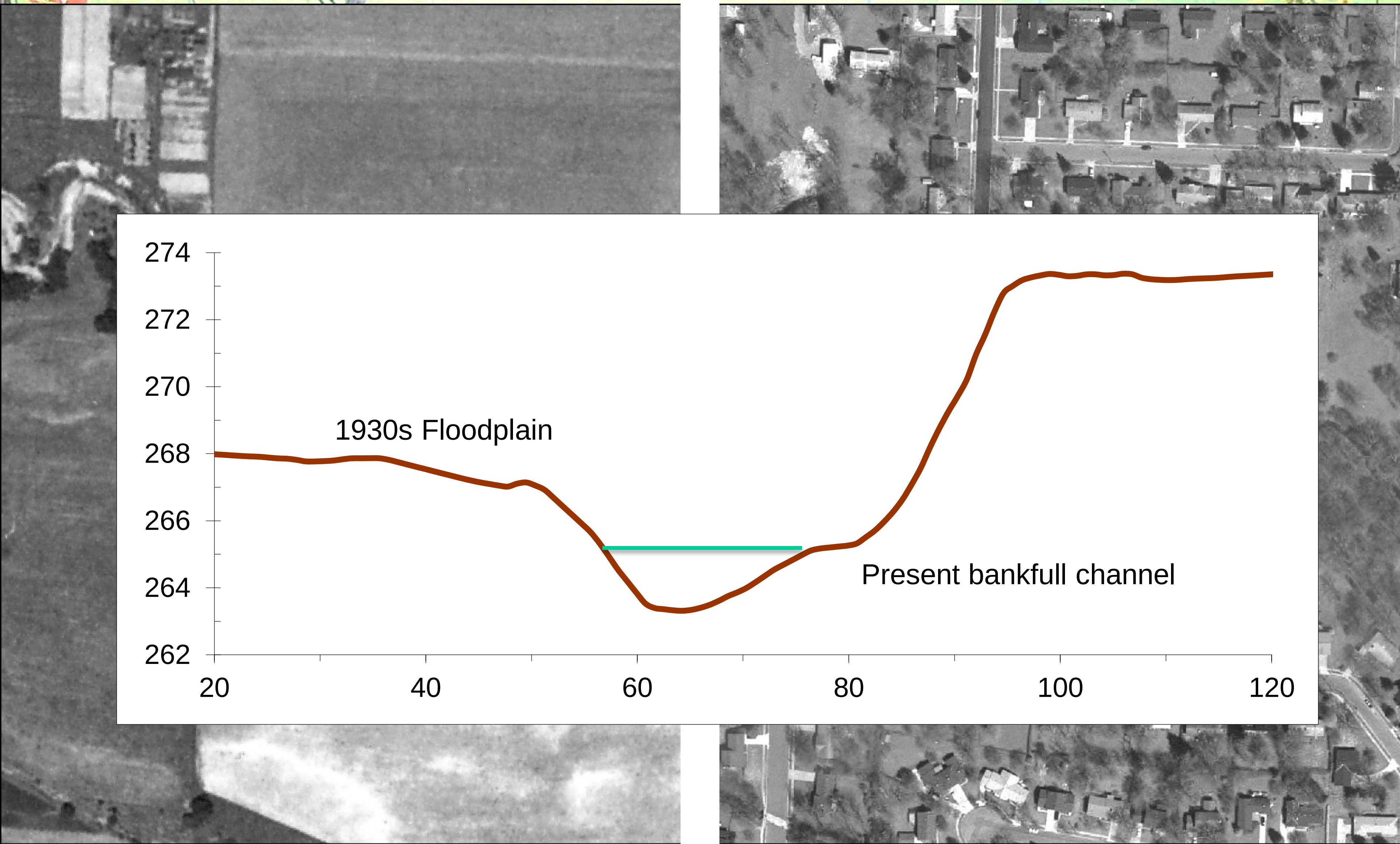
Four Mile Creek 1938 and Today



Indian Creek 1935 and Today



Bull Run 1938 and Today



Summary of modeling procedures

INPUT DATA

10m DEM

LiDAR DEM for channels

NLCD Land Use/Land Cover

SSURGO Soils

NOAA Precipitation Frequencies

HEC-HMS

Runoff hydrograph for main channel and tributaries

Calibration against observed flows

HEC-RAS

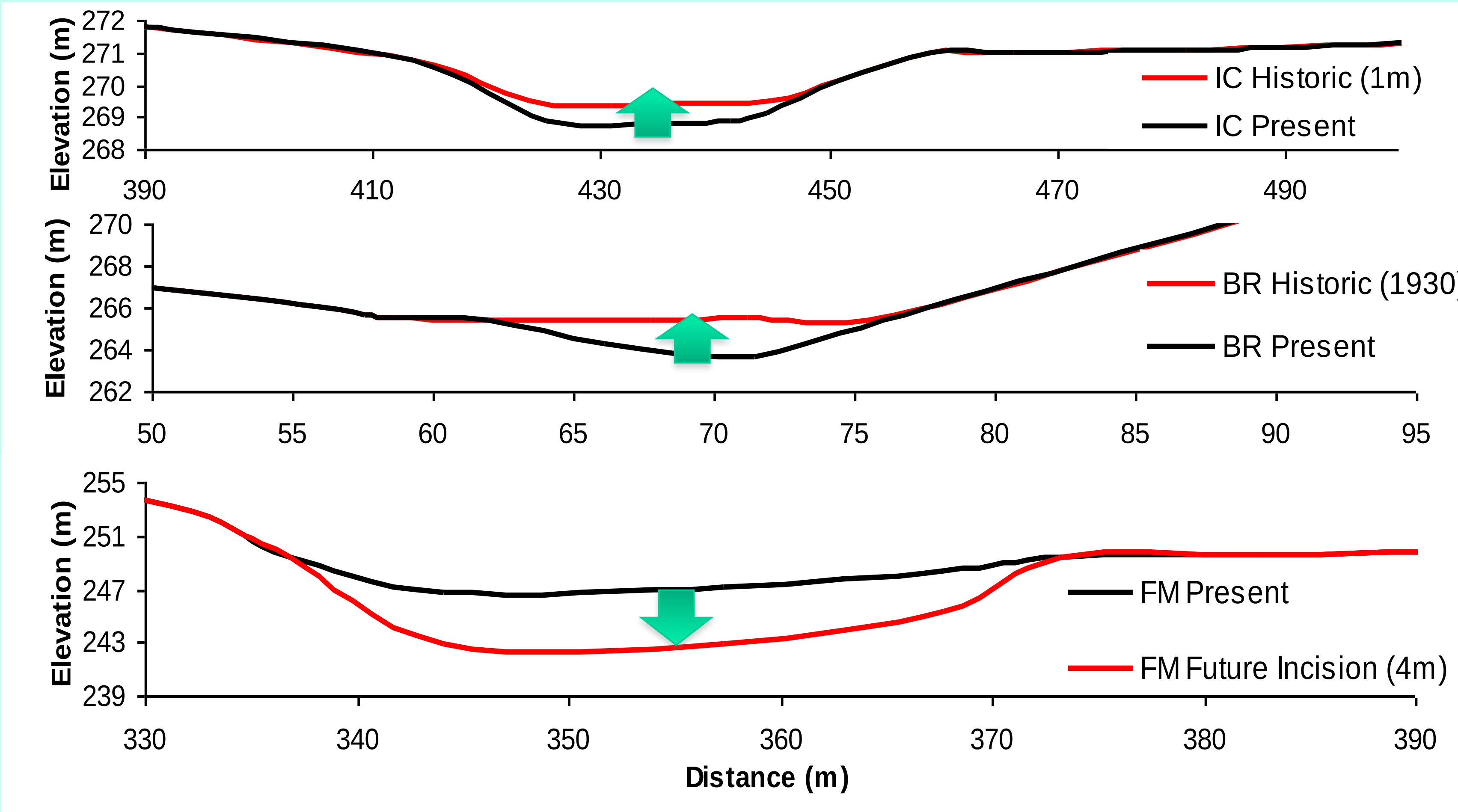
Flow routing through lower portion of watershed

1. Pre-incision
2. Post-incision

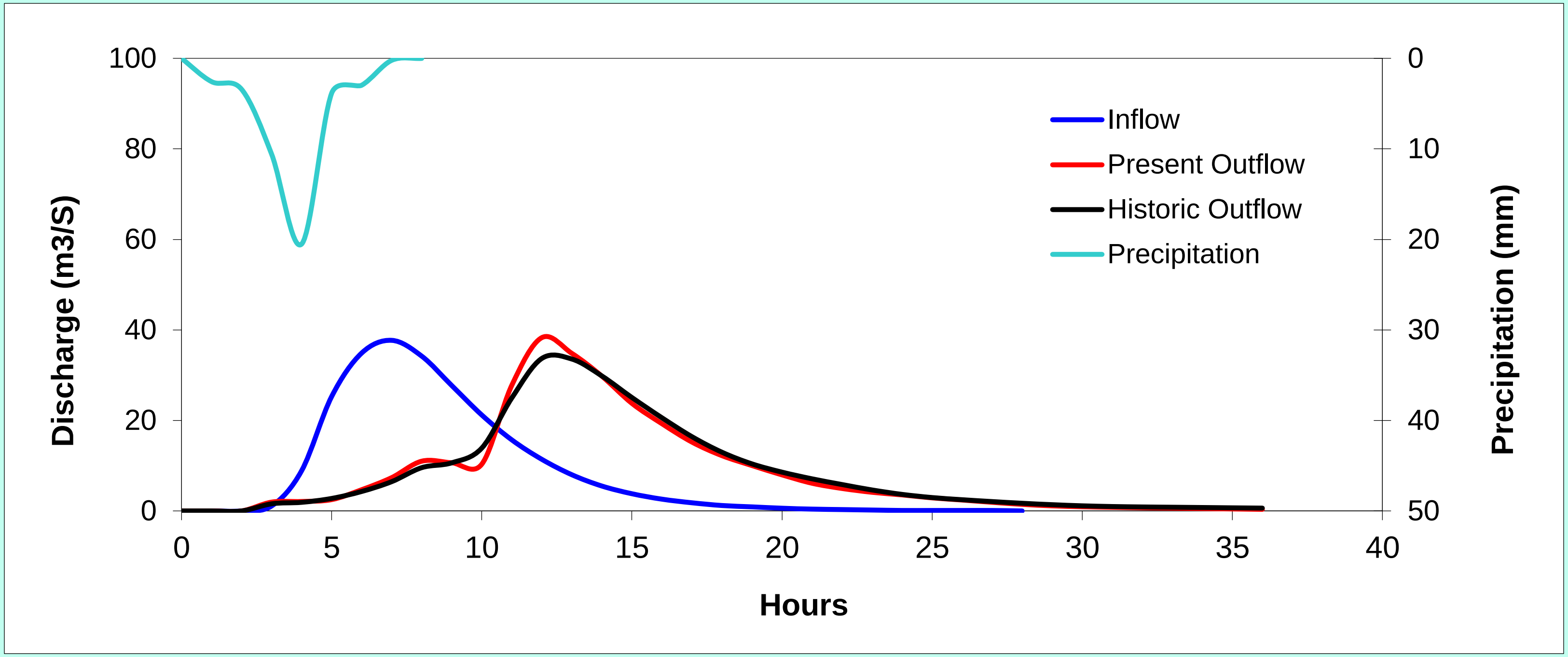
Historic and potential future channel incision

Modeling channel incision

Individual channel cross sections were manually adjusted in the Graphic Editor in HEC-RAS to simulate historic incision of 1 m and 2 m and 4 m of future incision.

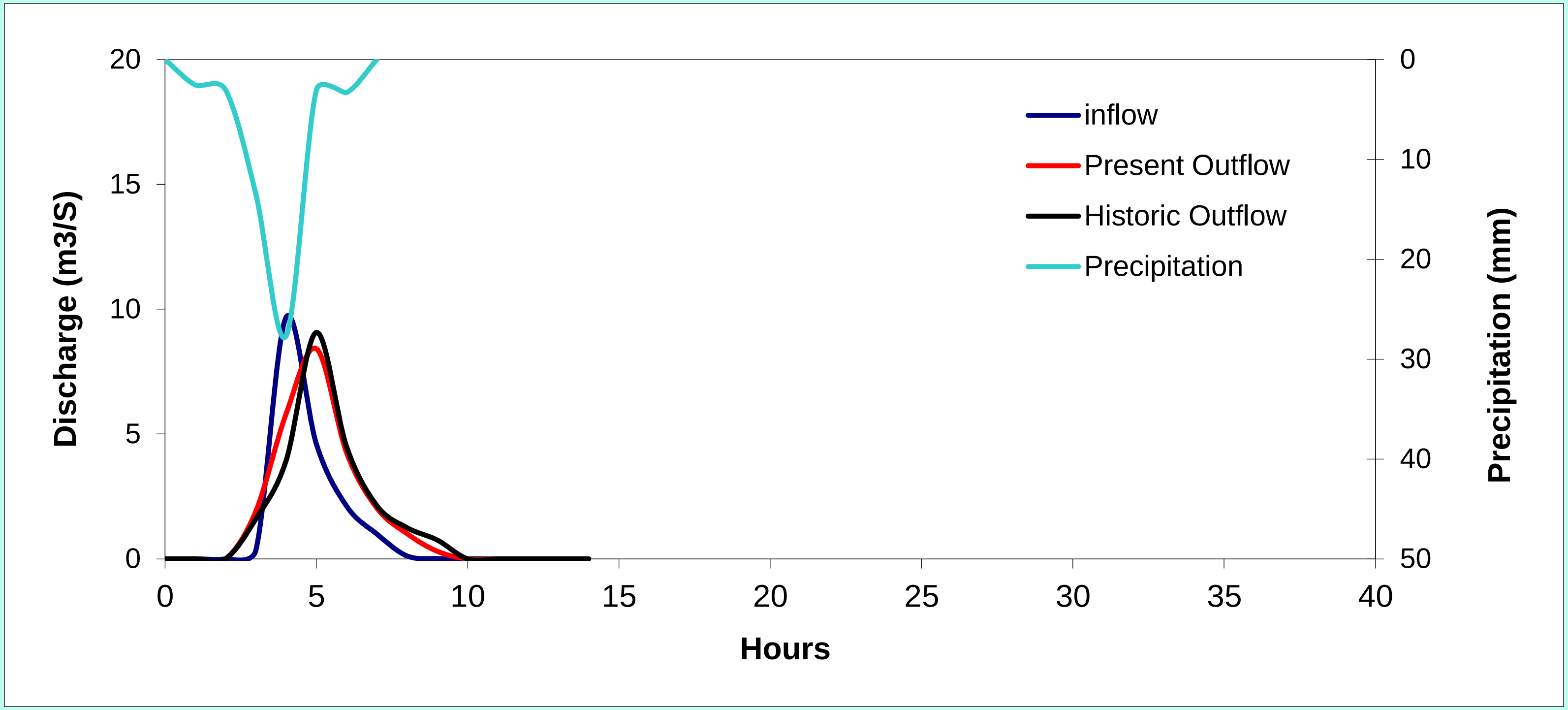


Indian Creek historic and present incision modeled results



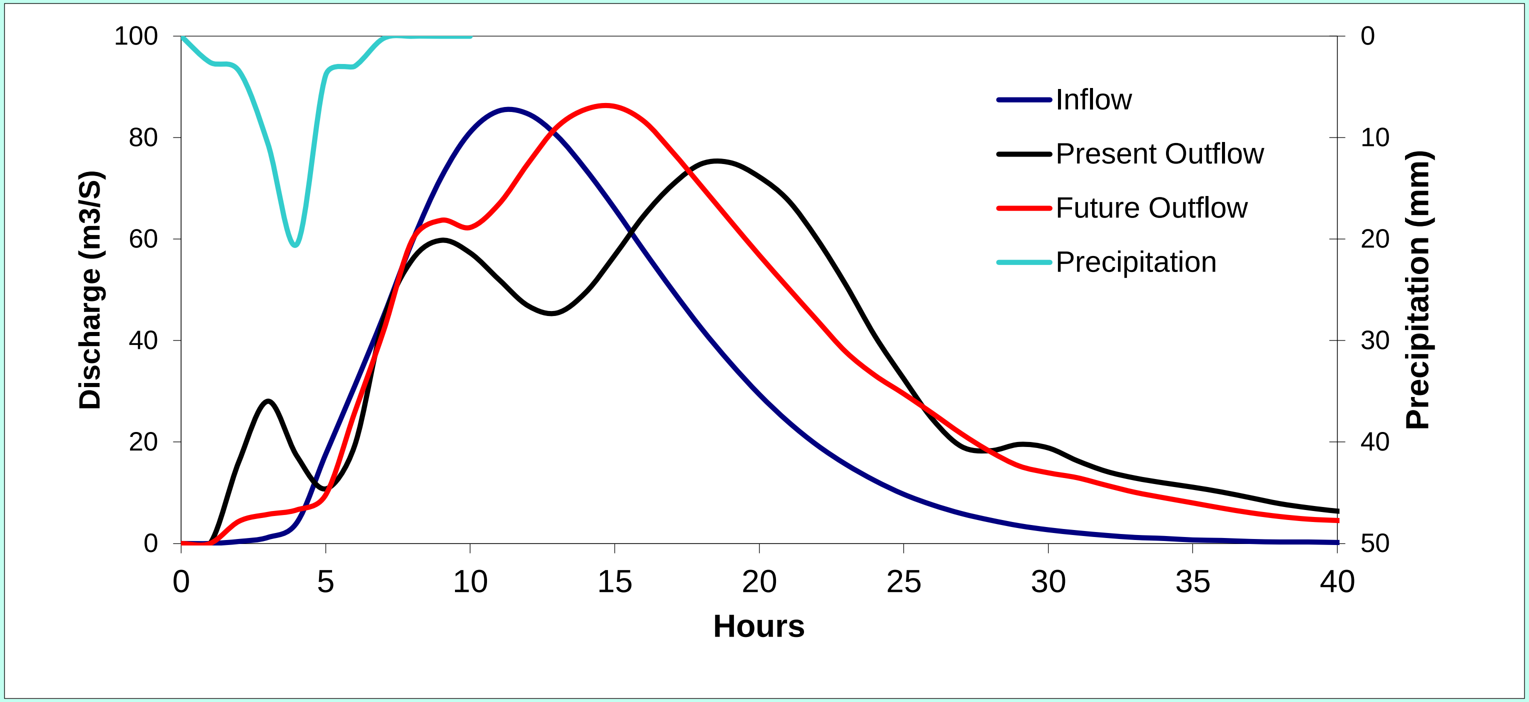
Averages of all sections in reach	Historic	Present	**% change**
Avg Peak Q (cms)	35.3	37.8	**+6.7**
Avg Channel Velocity (m/s)	1.2	1.2	**+4.3**
Avg Stream Power (kg/m S)	0.2	0.3	**+28.5**
Avg Max Channel Depth (m)	0.9	1.4	**+30.6**

Bull Run historic and present incision modeled results



Averages of all sections in reach	Historic	Present	**% change**
Avg Peak Q (cms)	10.0	10.1	**+1.3**
Avg Channel Velocity (m/s)	1.2	1.6	**+27.7**
Avg Stream Power (kg/m S)	0.4	1.0	**+56.3**
Avg Max Channel Depth (m)	0.4	0.7	**+42.2**

Four Mile Creek present and future incision modeled results



Averages of all sections in reach	Present	Future	**% change**
Avg Peak Q (cms)	76.5	83.6	**+9.3**
Avg Channel Velocity (m/s)	1.2	1.3	**+11.7**
Avg Stream Power (kg/m S)	0.3	0.5	**+37.4**
Avg Max Channel Depth (m)	2.2	2.8	**+30.0**

Summary of results

Indian Creek (present 1m incision)	• Little effect on the magnitude or timing of peak flows • Moderate increase of velocity, stream power and flow depth at present
Bull Run (present 2m incision)	• Little effect on the magnitude and timing of peak flows because of small drainage area • Substantial increase of velocity, stream power and flow depth
Four Mile Creek (4m future incision)	• Substantial increase in magnitude of peak flow and reduction of lag time • Substantial increase of stream power and flow depth in future incision

Conclusions

- Although further model calibration and testing is needed, initial results suggest that incision can contribute to large increases of channel velocity, stream power and flow depth.

- These increases generate a positive feedback by that enhances channel incision. This helps explain incision that is unprecedented in post-glacial time.

Thanks!

Jonathan Remo, Southern Illinois University

Departments of Geography and Geology and Institute of Environmental Sciences, Miami University

Uncertainties and Assumptions

- HEC-RAS may not be appropriate for small streams such as these.
- Local variations in channel widths & depth may have significant effects on model output.
- Modeled incision only; no width changes.
- LiDAR (<1m resolution) channel cross-sectional data are not accurate for channels that contained significant water at the time of the survey

Stream and Basin Characteristics

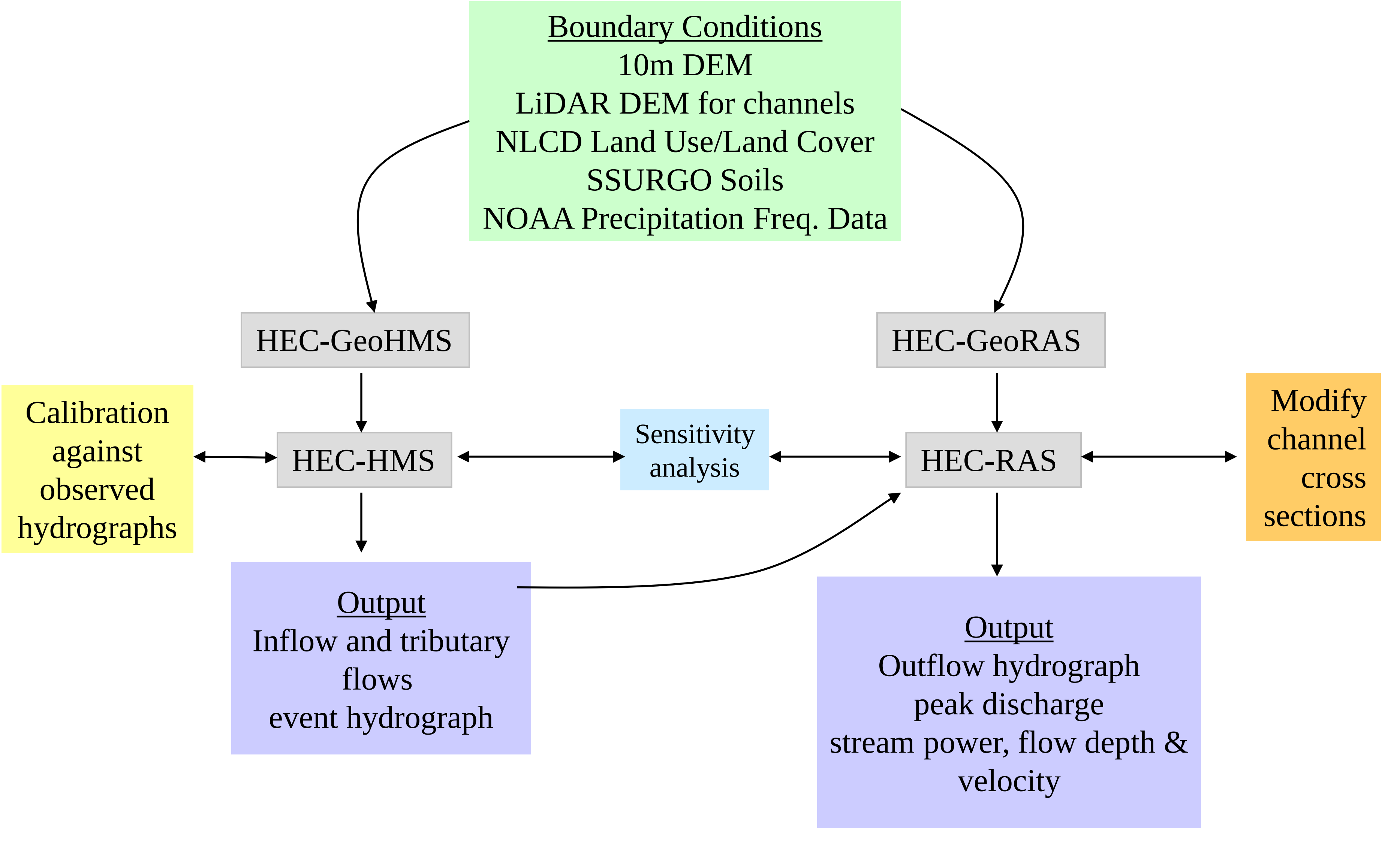
Site	Water-shed Size (km^2)	Average Slope ratio	Mean Annual Discharge (m^3/s)*	Estimated Incision since 1930s (m)**	Current Land Use (% of watershed)
Four Mile Creek	848 430***	0.003	8.9	2-4	Agricultural: 74 Development: 10 Forest: 16
Indian Creek	270 215***	0.003	2.8	1-2	Agricultural: 74 Development: 9 Forest: 17
Bull Run	5	0.01	0.05	2-3	Agricultural: 50 Development: 26 Forest: 21

*NHD Plus data; ** estimated based on aerial photos and observations; ***study reach

Sensitivity analysis

- Sensitivity analysis of Mannings coefficients (0.025-0.04) of the channel found that differences of Q range from 0-3.5%, channel velocity from 7 to 48%, stream power from 2 to 58% and flow depth from 1 to 13%.

Modeling Procedures



Modeling effect of incision on flow hydrographs

- A reach beginning in mid-catchment and continuing to catchment outlet was selected.
- Passage of a ~2-year, 6-hour event was simulated in HEC-RAS.
- Peak velocity, stream power, and flow depth were averaged through the model reach