Interaction Among Forests, Mass Movements, and Streams and Implications for Aquatic Habitat

Stephen Lancaster (OSU) and Gordon Grant (PNW)

Thanks to: Shannon Hayes, John Green, Christine May


FISH HABITAT LOG
This log has been protected to enhance fish habitat. It provides fish with a resting and feeding station, and cover to escape predators. The landowner has cooperated in protecting this habitat. Please do not cut or remove


'00 8 10

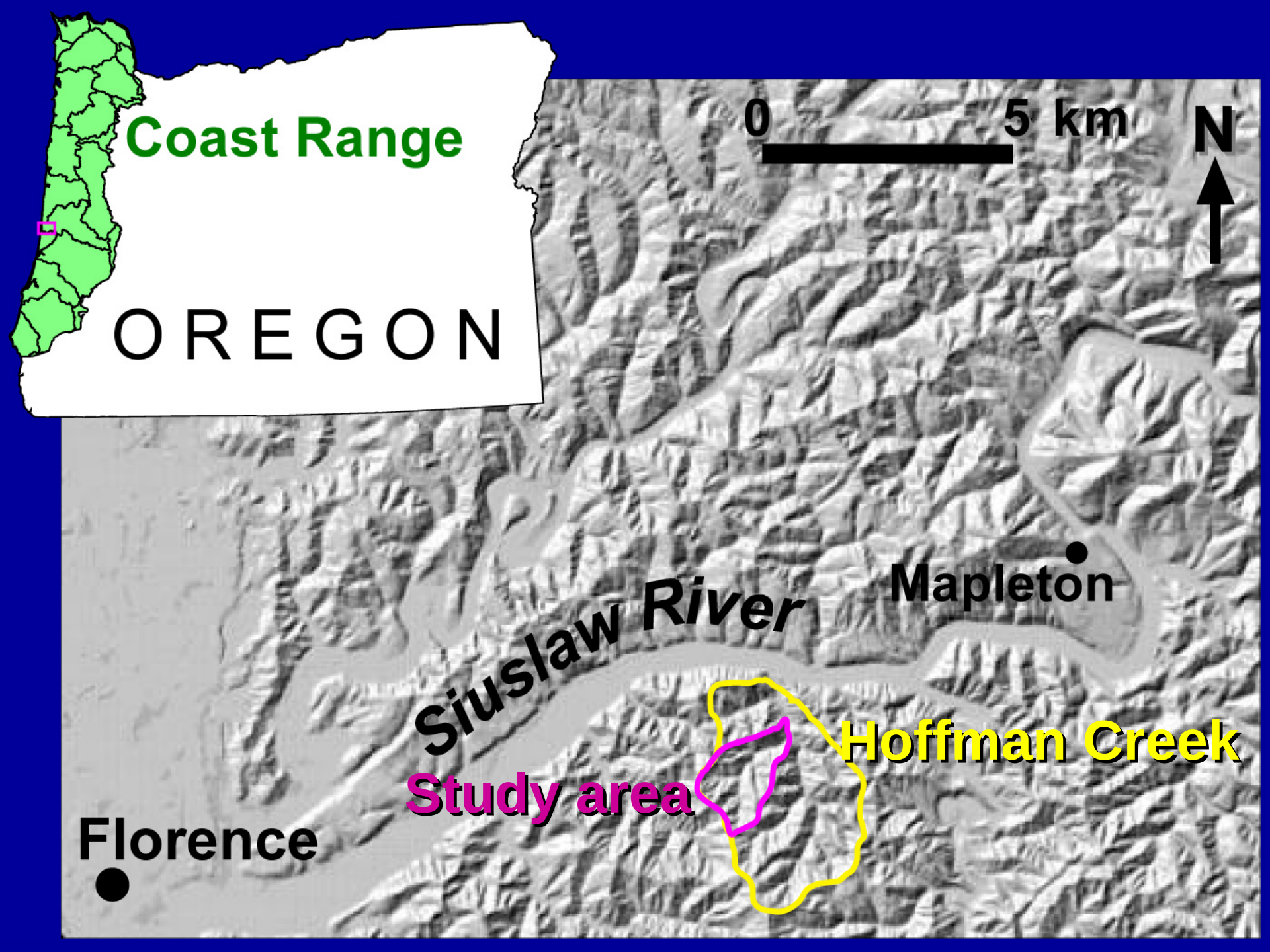
Objective: Quantify the effect of the forest on debris flows and sediment and examine the implications for aquatic habitat.

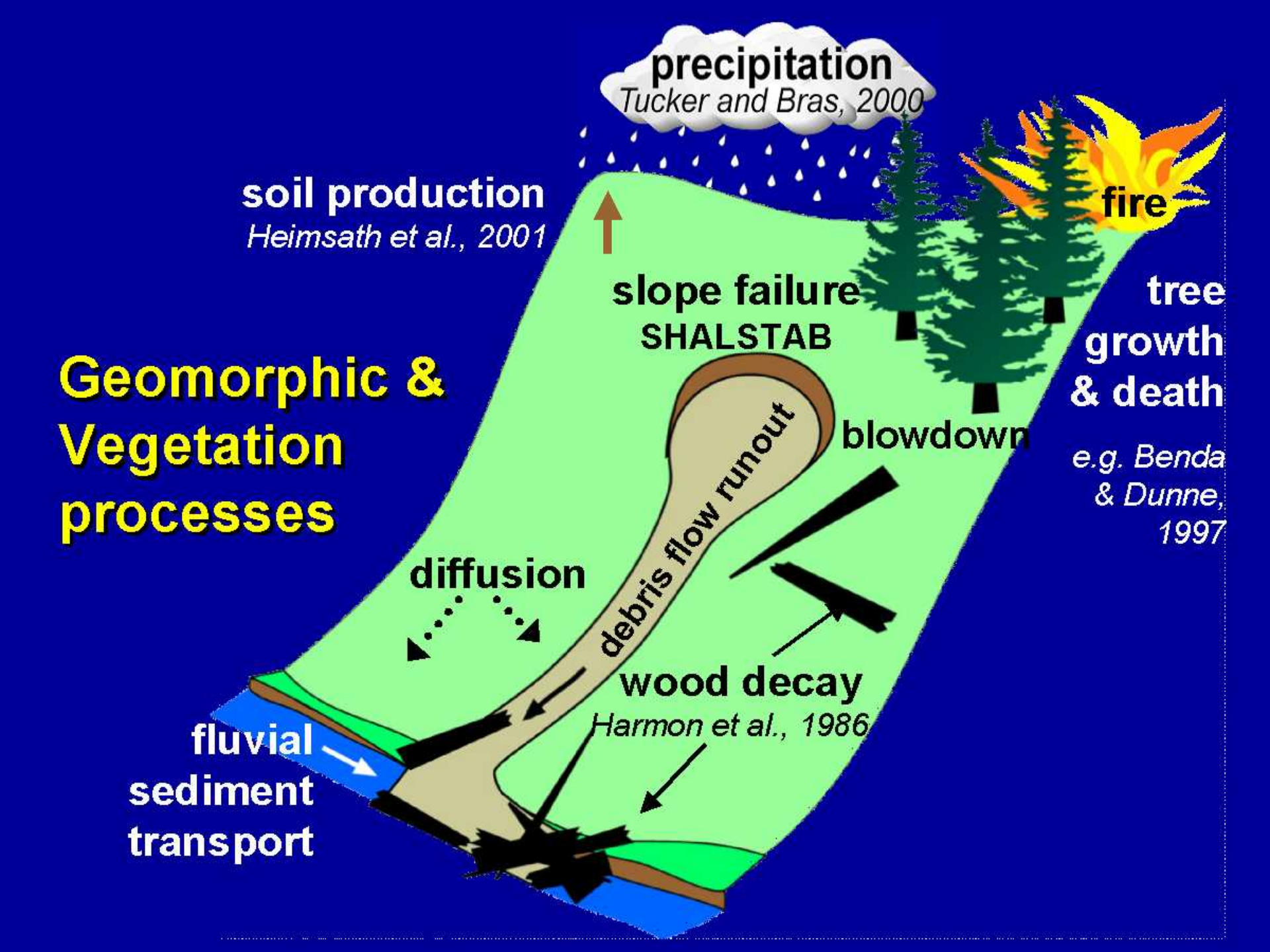
Questions

- Do trees matter for landslide initiation?
- Do trees and wood matter for debris flow runout?
- Does wood matter for sediment storage?
- Does wood matter for sediment output to larger, fish-bearing streams?
- Does the importance of history overwhelm our ability to derive meaningful information from simulations?
- Debris flows are a natural process to which local fauna have adapted. Can we so alter this process that it threatens those fauna?

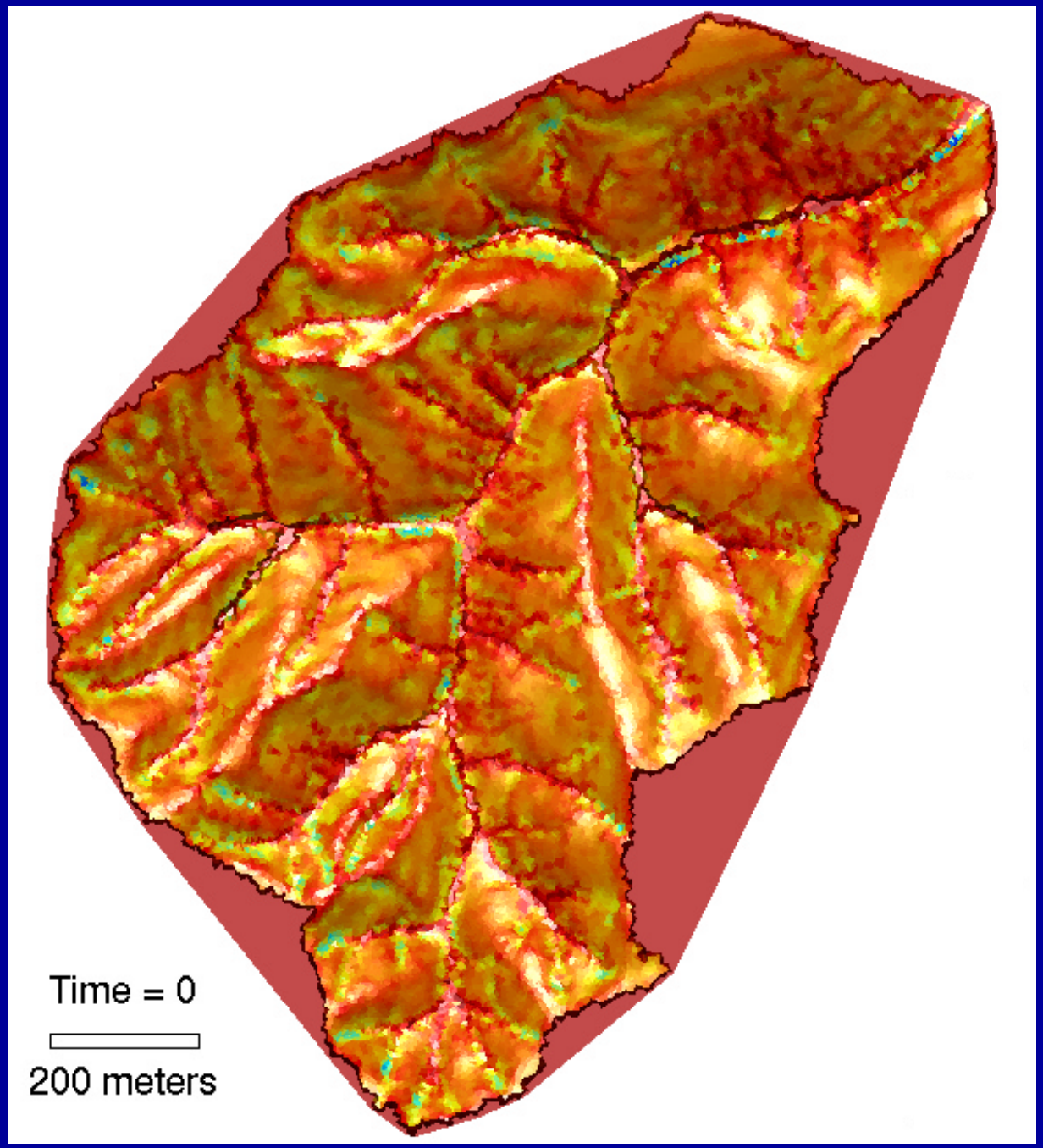
Methods

- Landscape-scale model that includes the necessary geomorphic and vegetation processes
- Field data for comparison with modeling results


Coast Range
OREGON
0
5 km
N
Siuslaw River
Mapleton
Hoffman Creek
Study area
Florence


precipitation
Tucker and Bras, 2000
soil production
Heimsath et al., 2001
fire
slope failure
SHALSTAB
tree
growth
& death
e.g. Benda
& Dunne,
1997
Geomorphic &
Vegetation
processes
blowdown
debris flow runout
diffusion
wood decay
Harmon et al., 1986
fluvial
sediment
transport

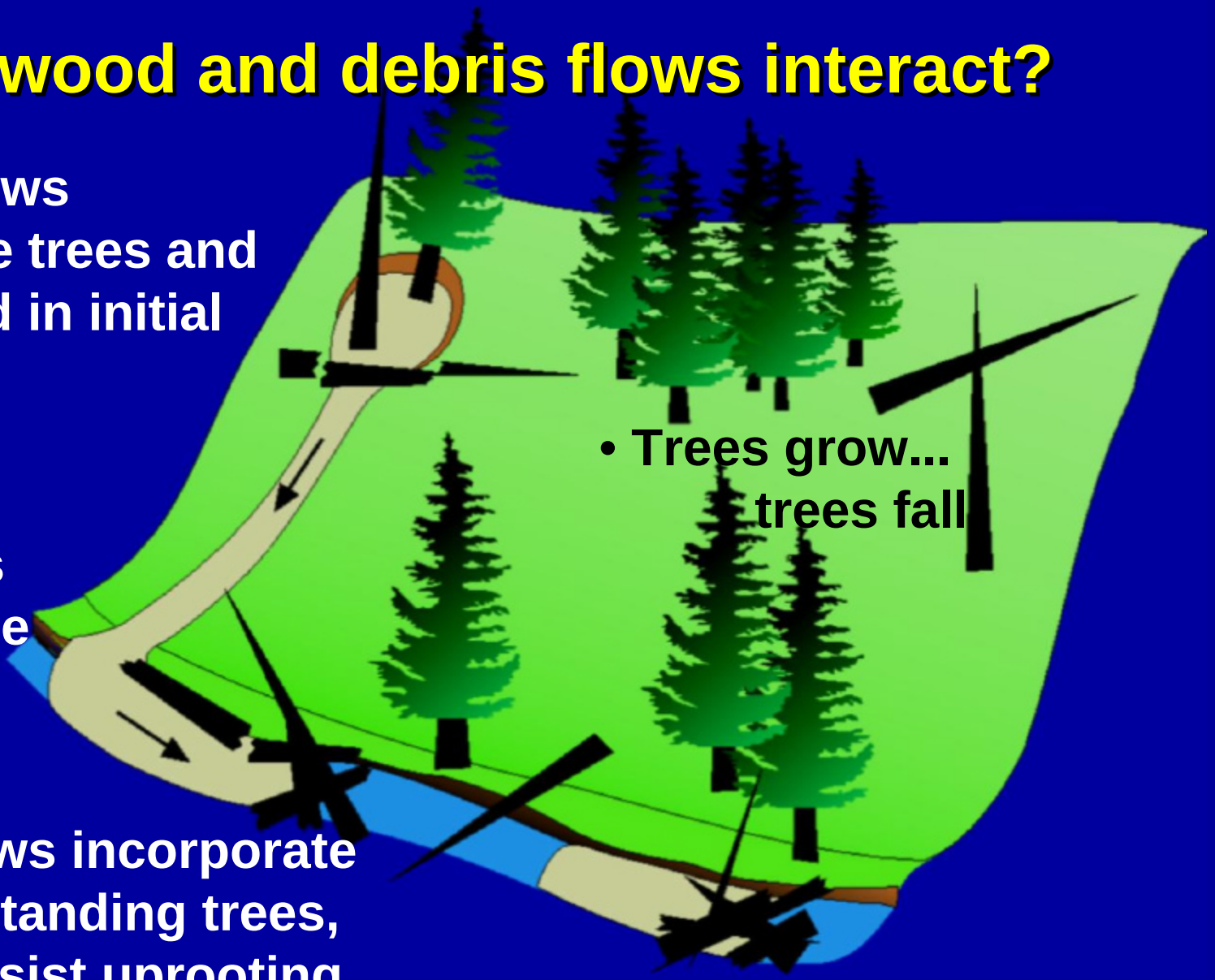
Initial conditions for 3000-year simulation



How do wood and debris flows interact?

- Debris flows incorporate trees and fallen wood in initial failure

- Wood in debris flows may increase resistance



- Debris flows incorporate fallen and standing trees, the latter resist uprooting

- Debris flows may scour sediment and wood deposits

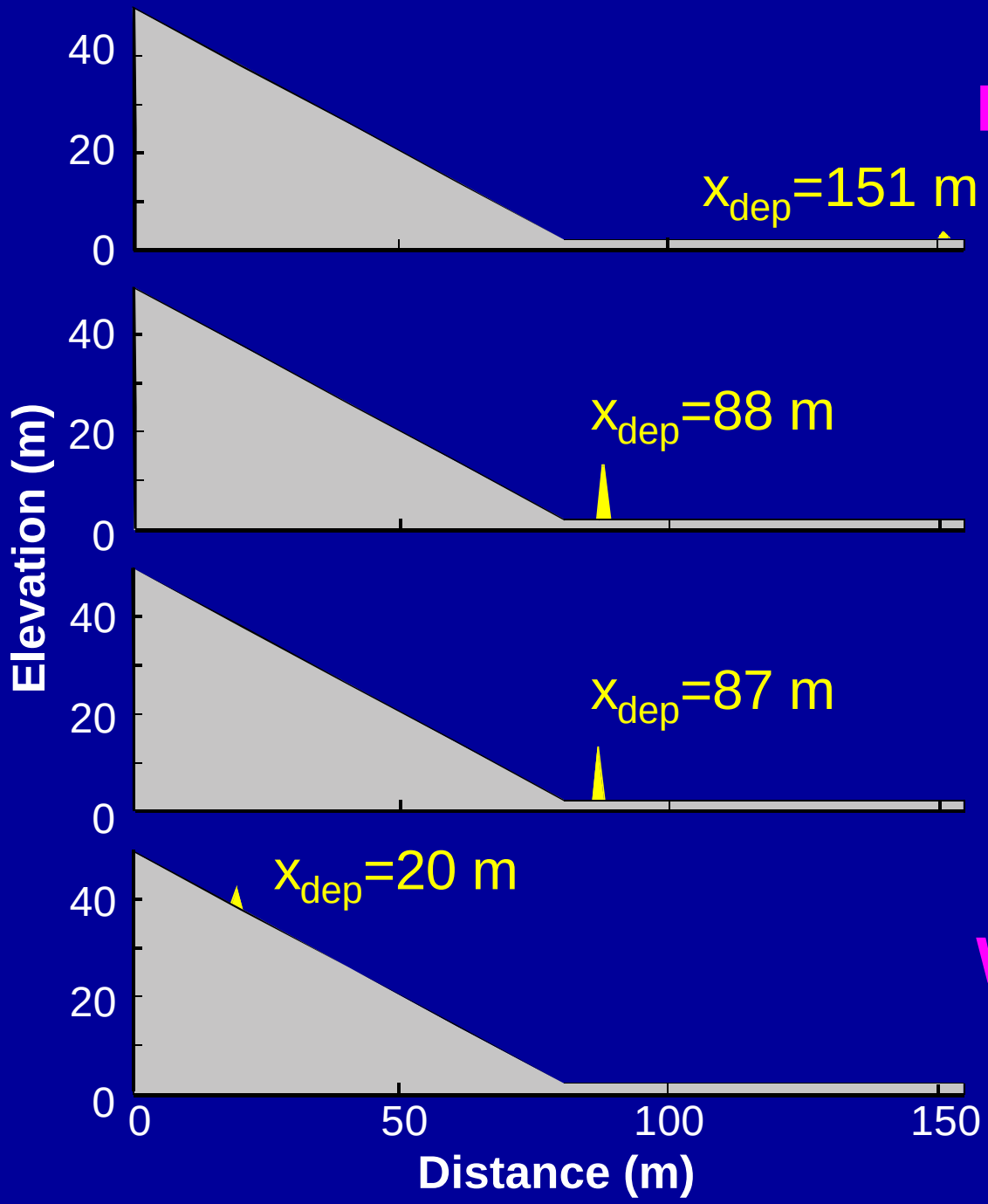
What is the effect of wood on debris flow runout?

Model experiments:

1) Null case: Debris flows do not incorporate wood
2) Wood incorporation: Debris flows incorporate wood
3) Root-rip: Debris flows incorporate wood + resistance of standing trees
4) Wood resistance: Debris flows incorporate wood + resistance of standing trees + resistance proportional to wood constituent

Field data:

- debris flow runout lengths and deposit map
- wood and sediment deposit volumes



Null case

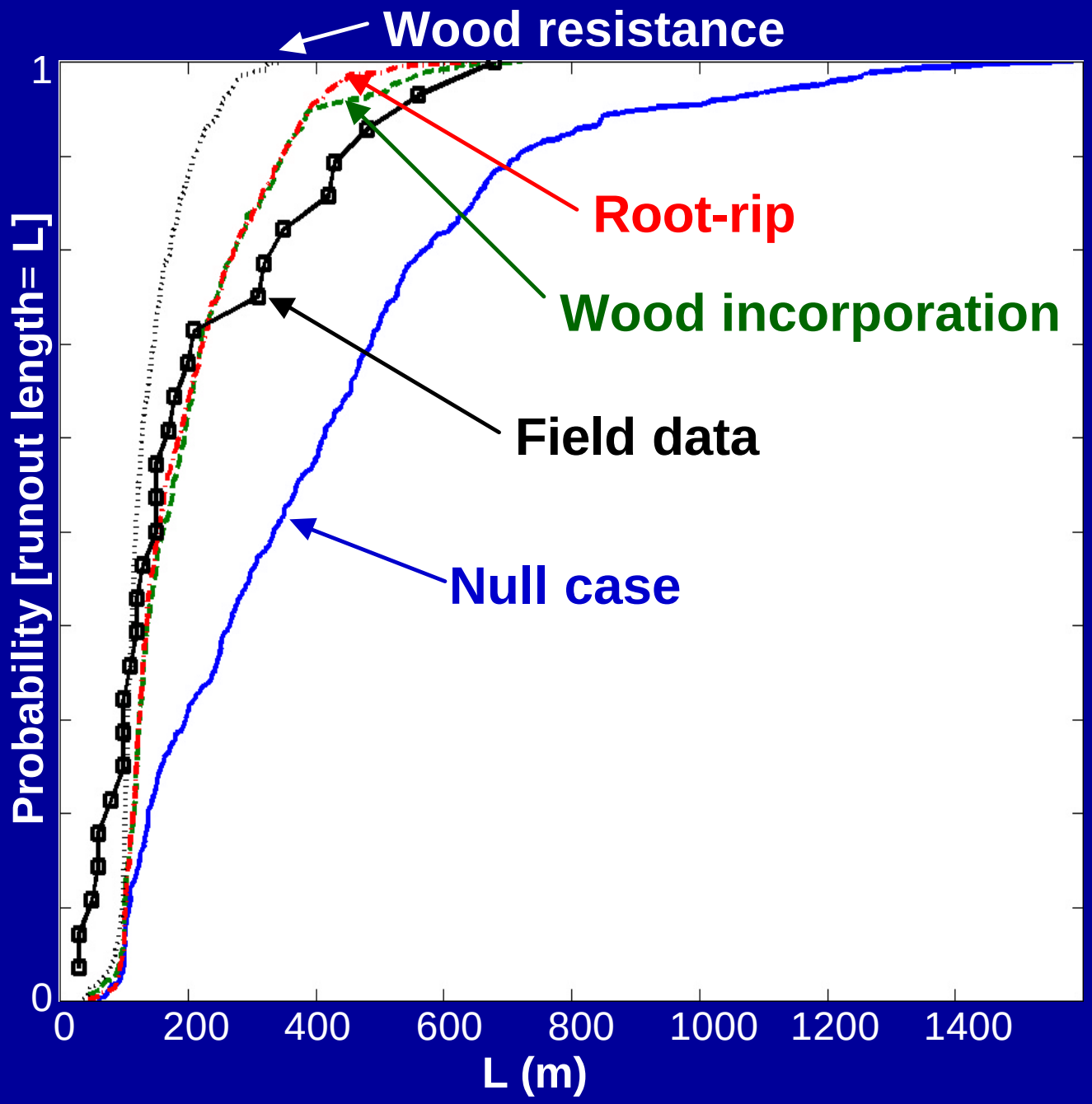
Wood incorporation

Root-rip

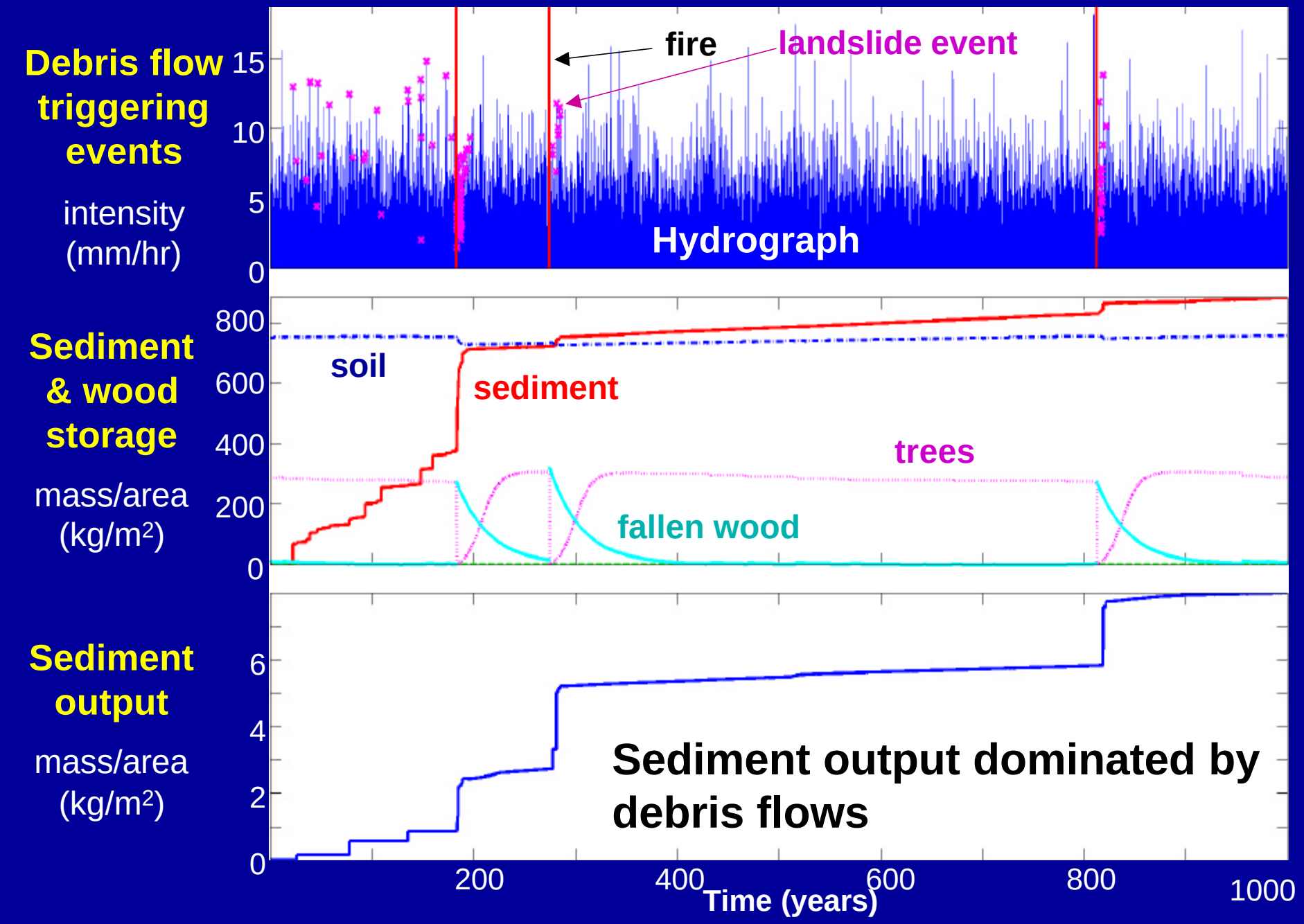
Wood Resistance

Simulation results: Debris flow runout lengths

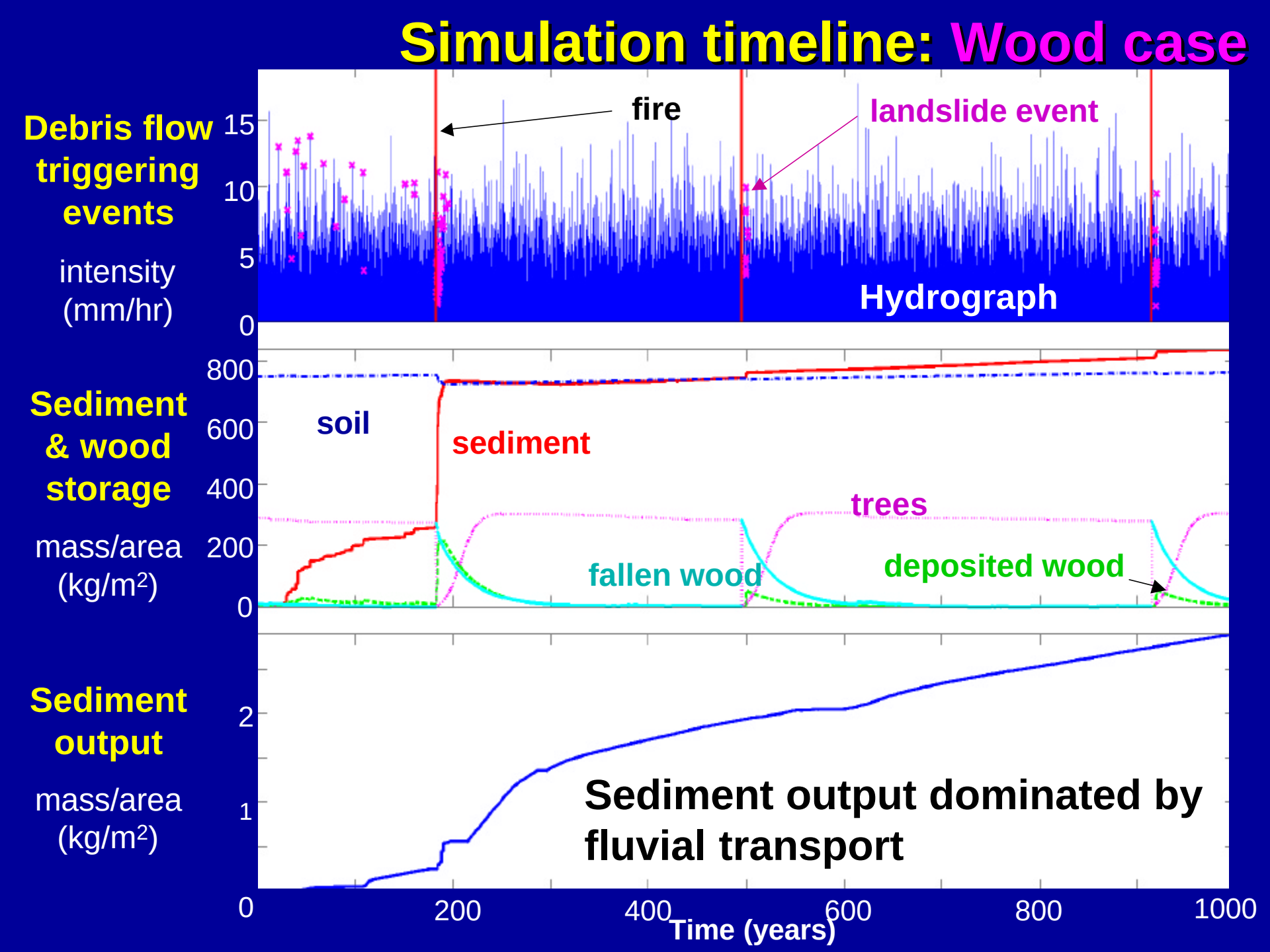
Cumulative distribution functions of modeled runout lengths compared to field data



Simulation timeline: Null case

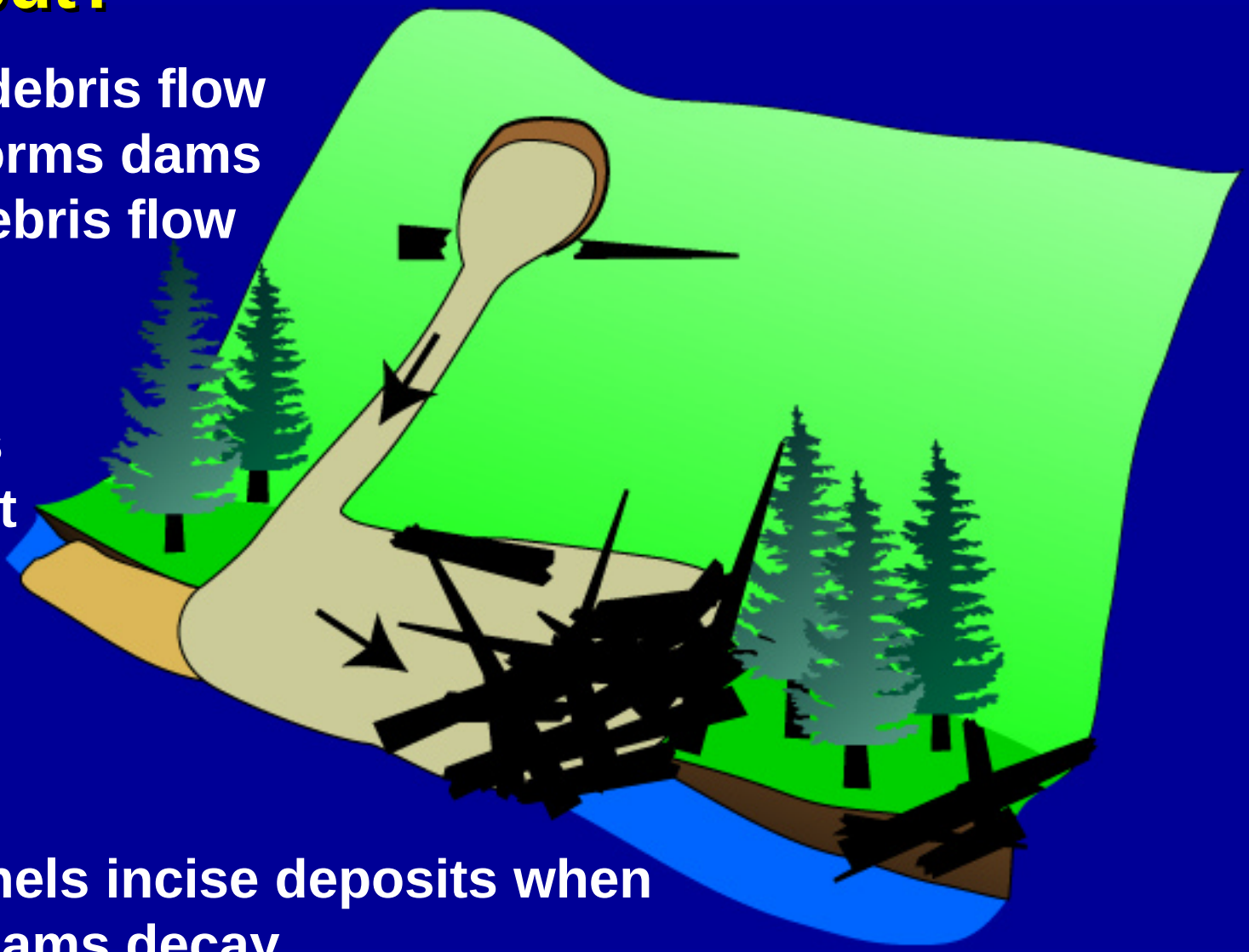


Simulation timeline: Wood case



How does wood affect sediment storage and output?

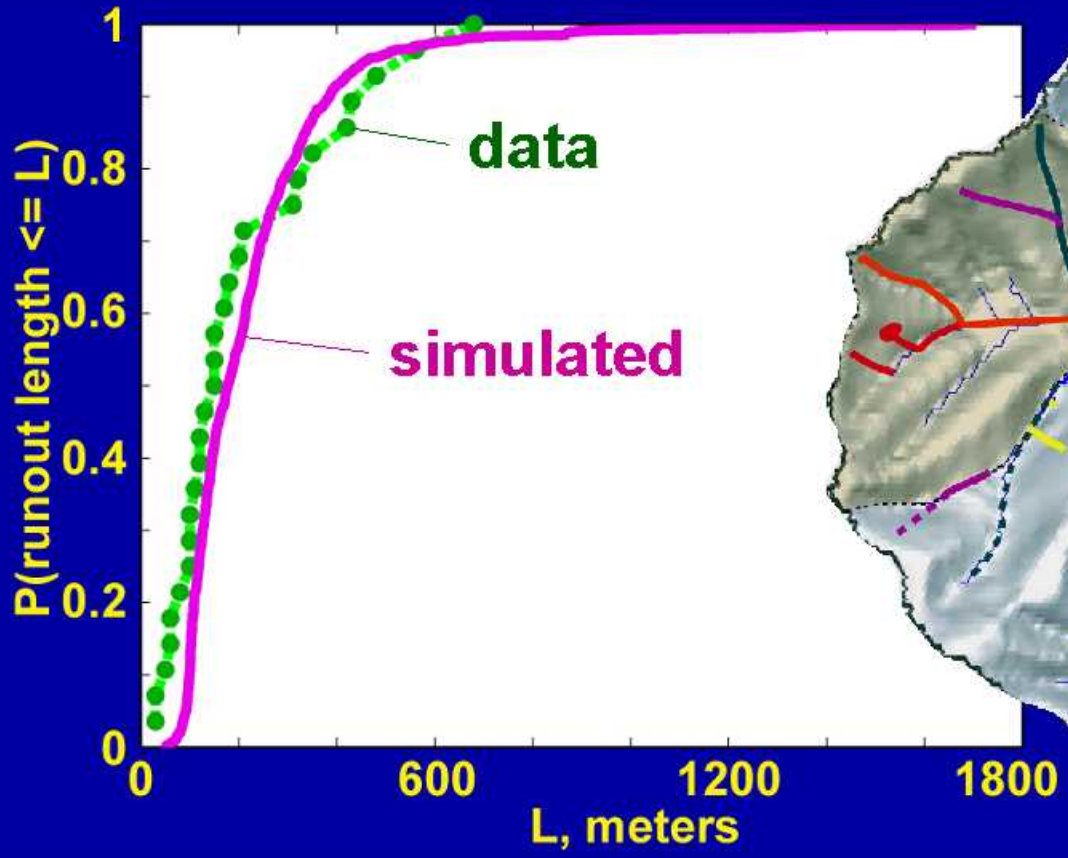
- Wood in debris flow deposits forms dams that trap debris flow sediment



- Wood dams trap sediment transported from other sources

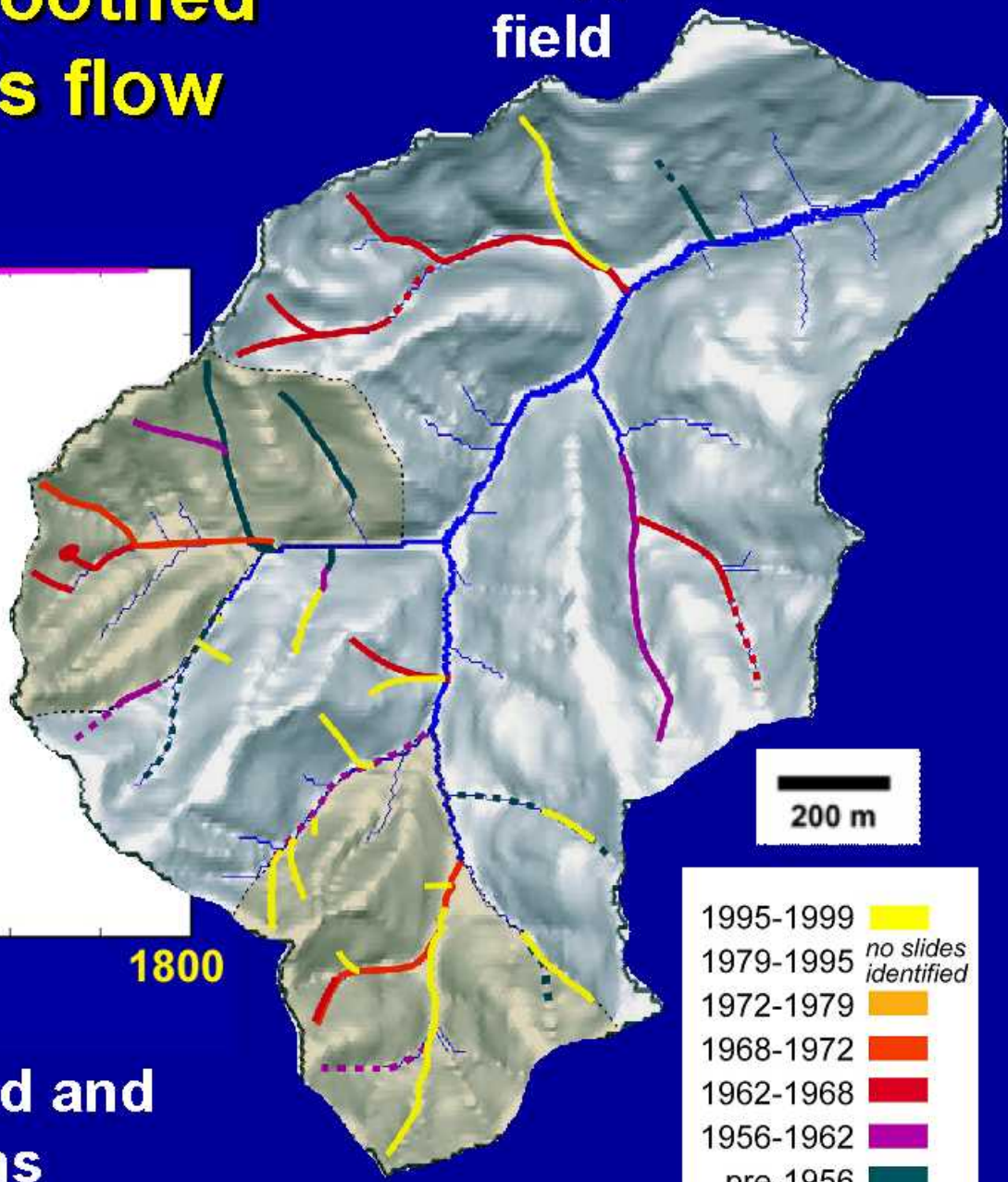
- Channels incise deposits when wood dams decay

Simulation with smoothed initial profile: Debris flow runout lengths

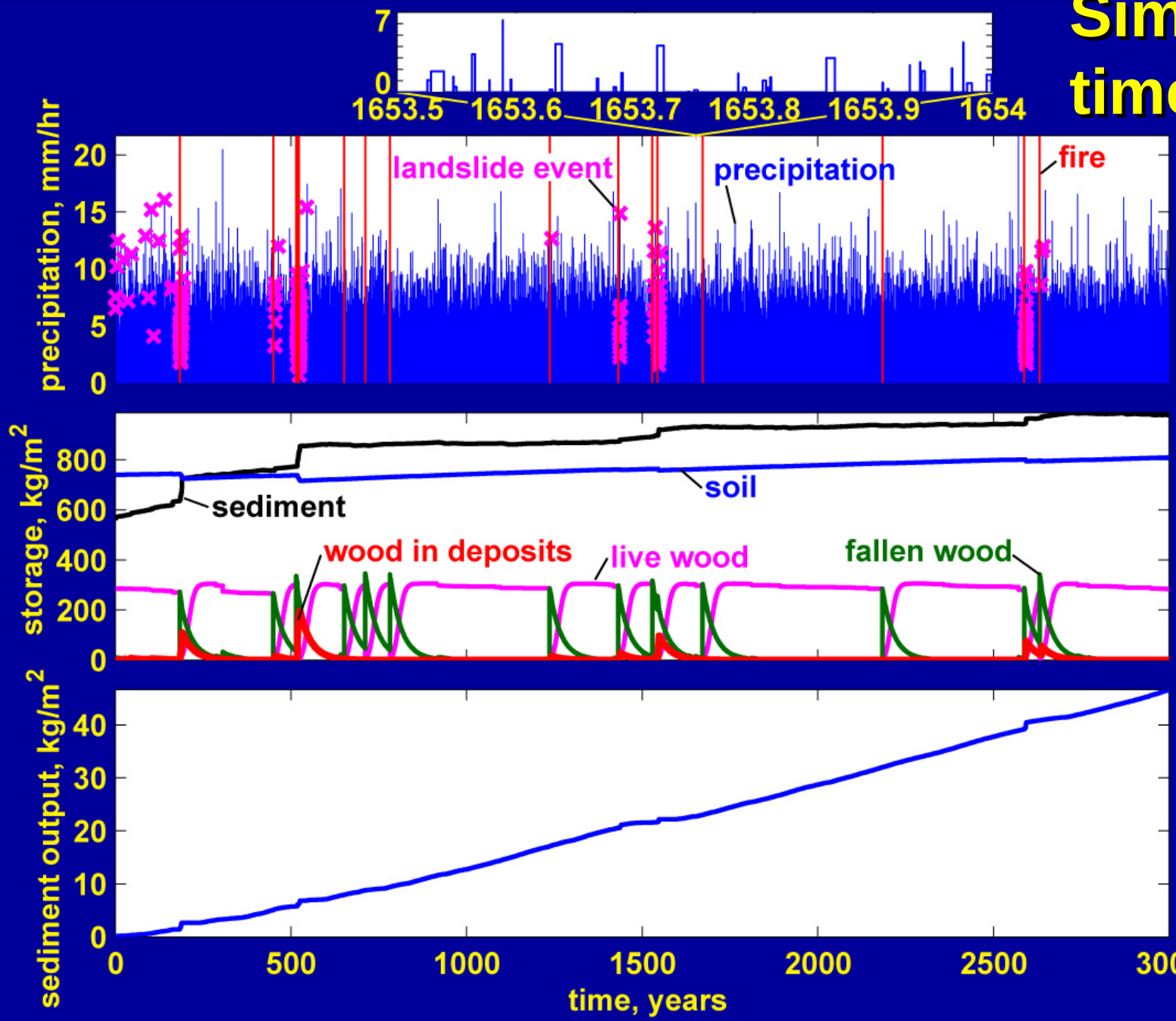


Comparison of observed and simulated runout lengths

Mapped in the field

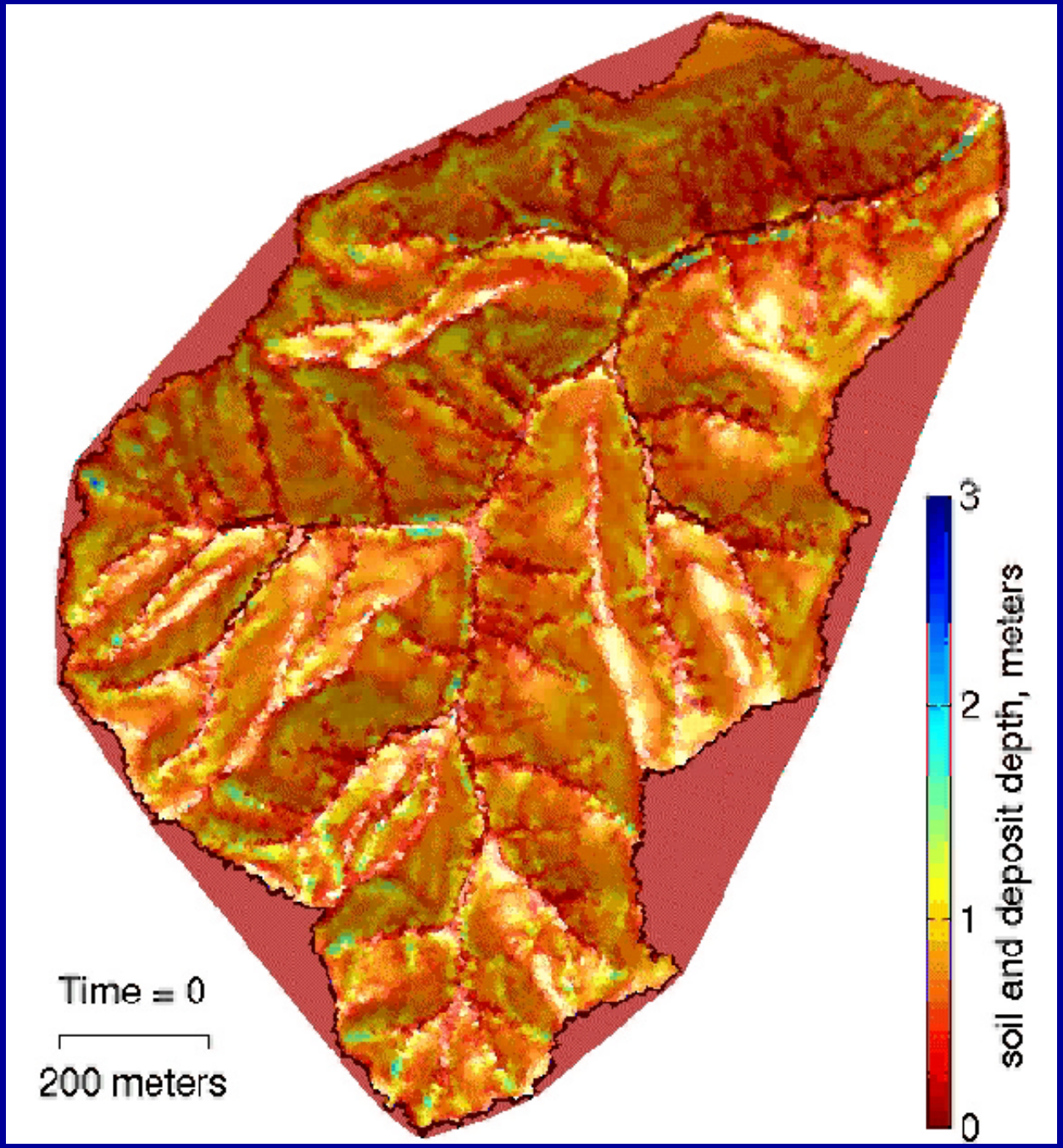


Simulation time line

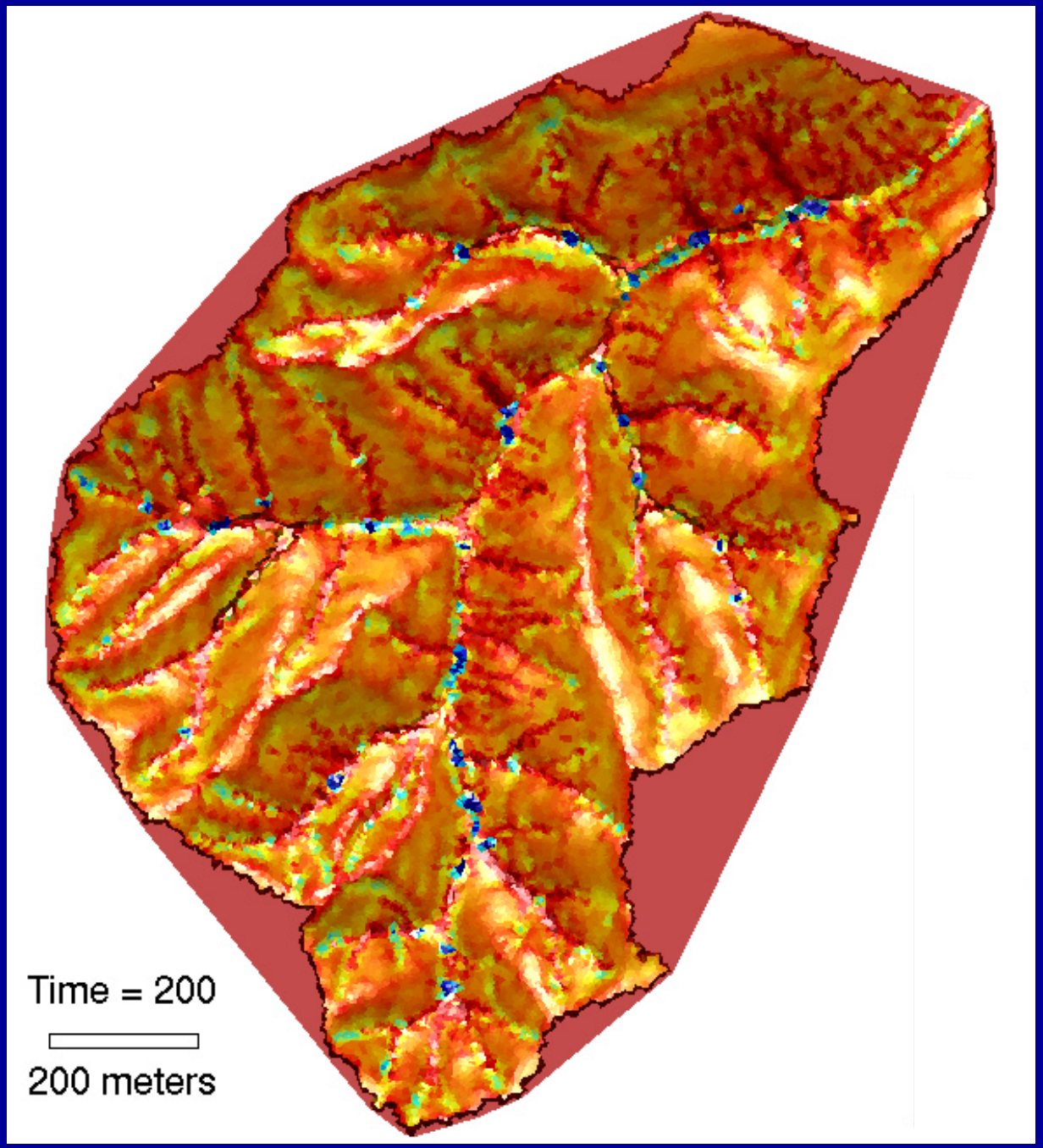


Deposited wood suppresses sediment output

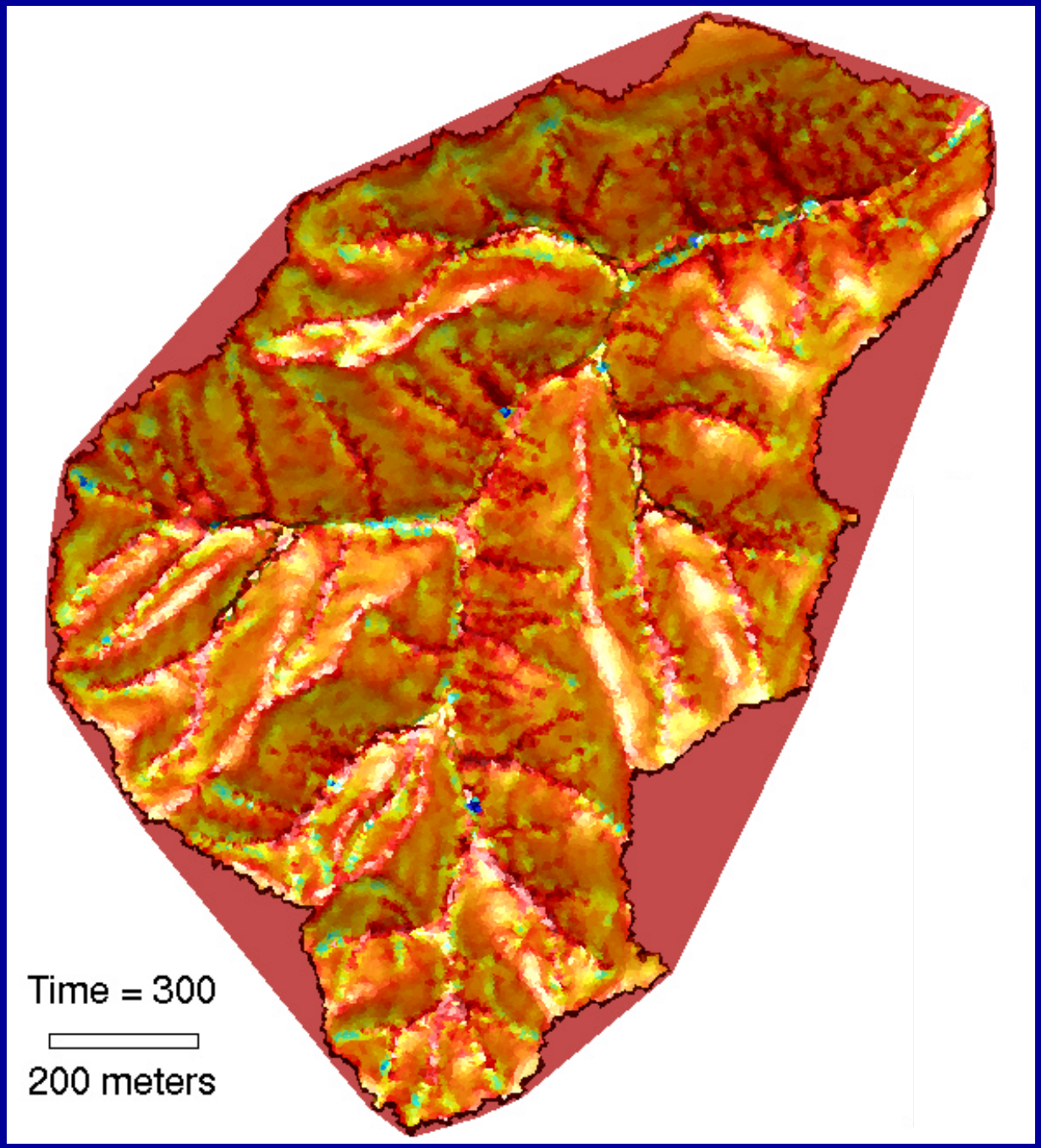
Animation of 3000-year simulation

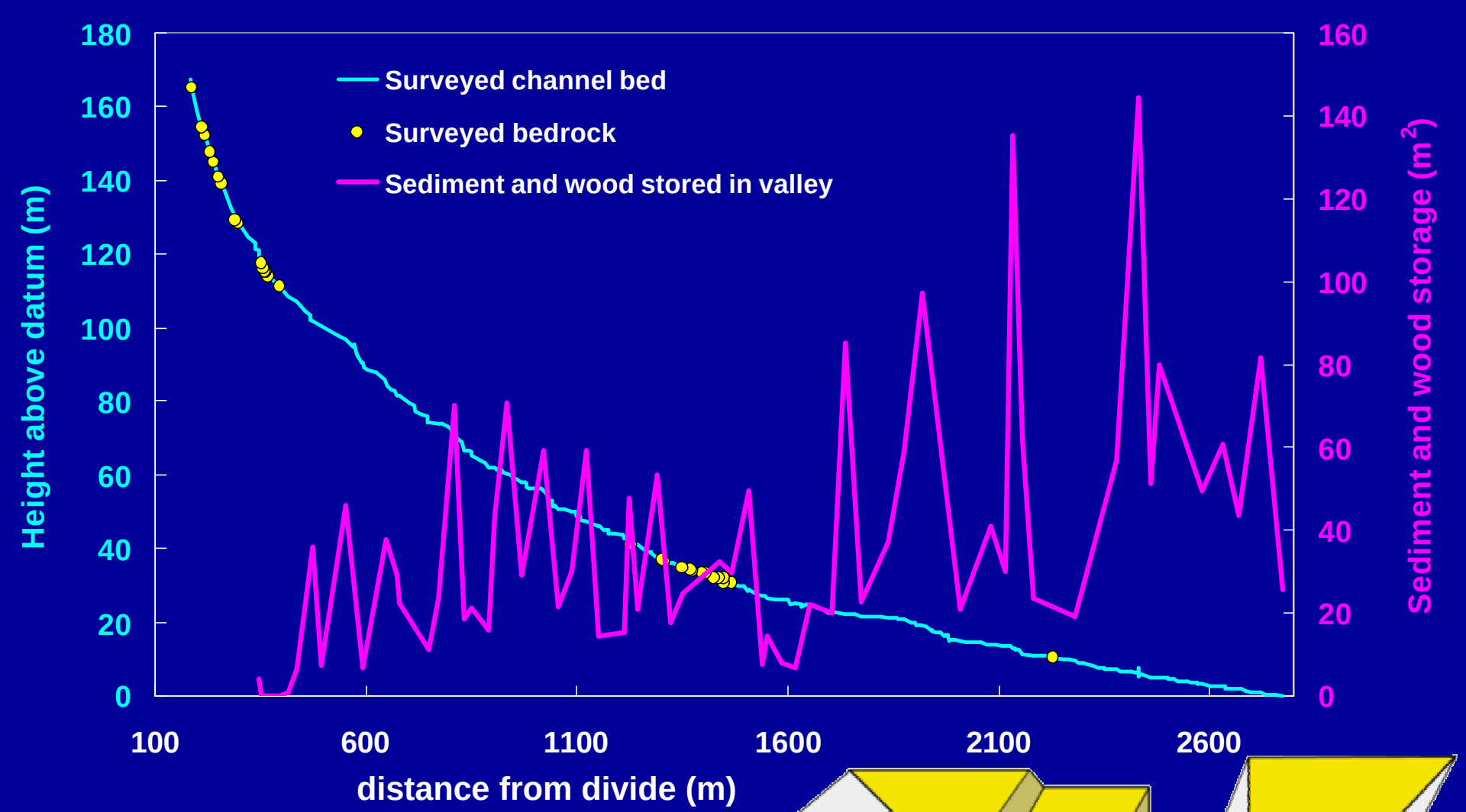


Post-fire



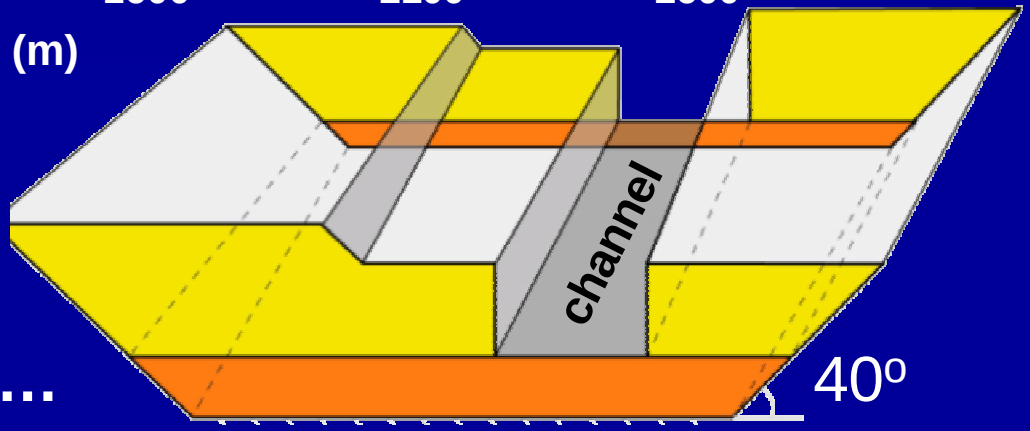
Post-fire
+ 100 yrs



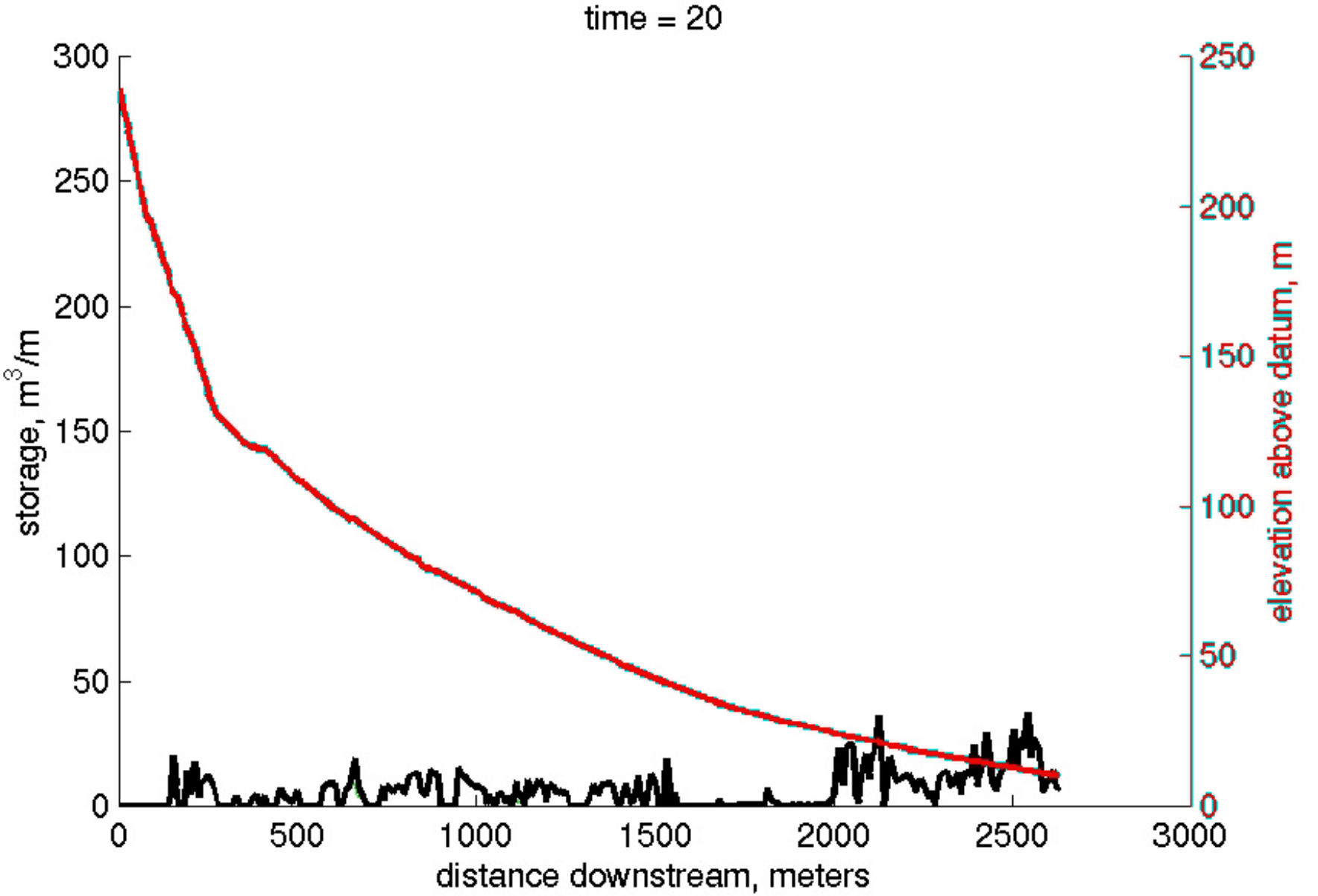


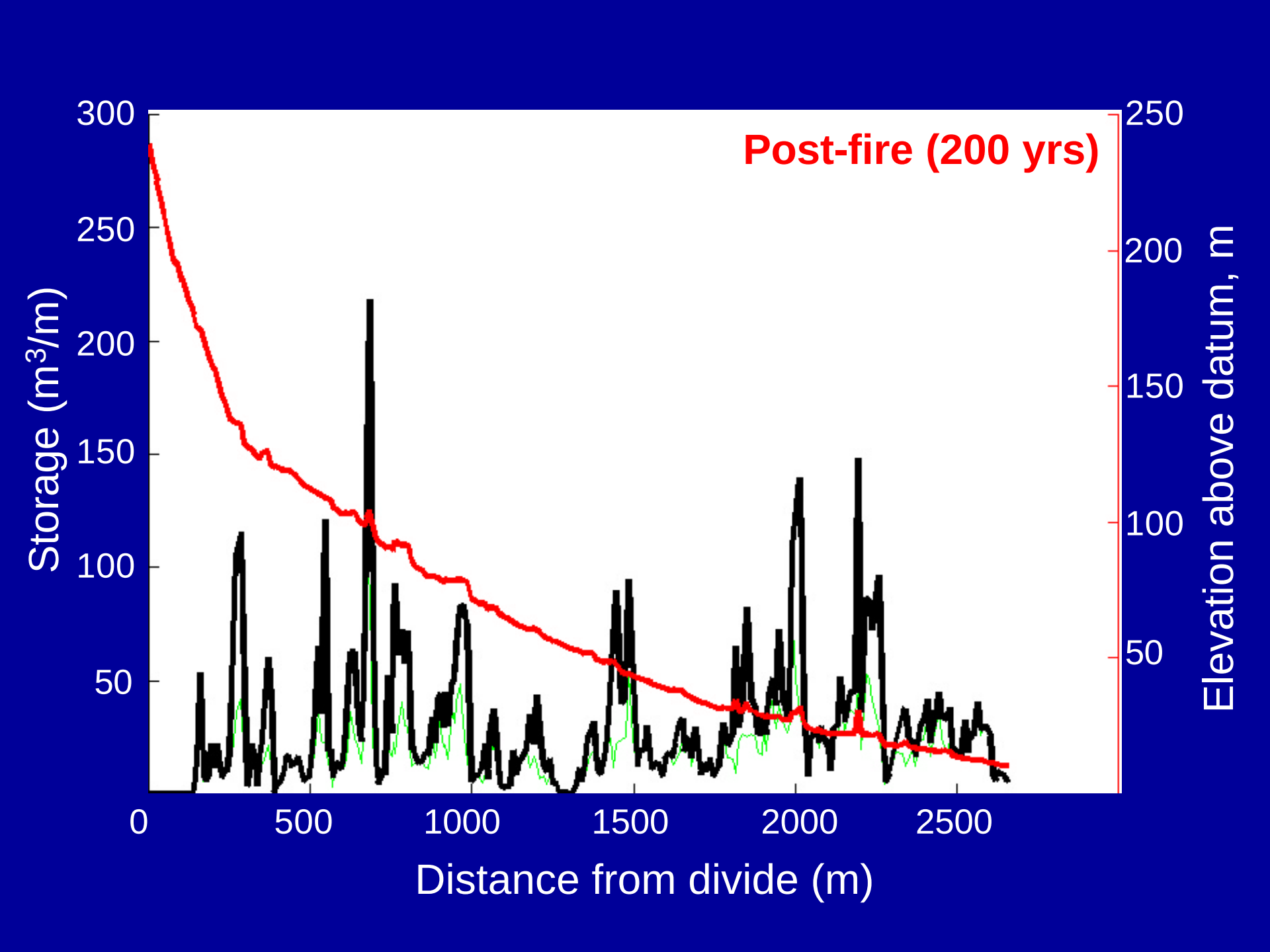
Valley storage and main channel profile

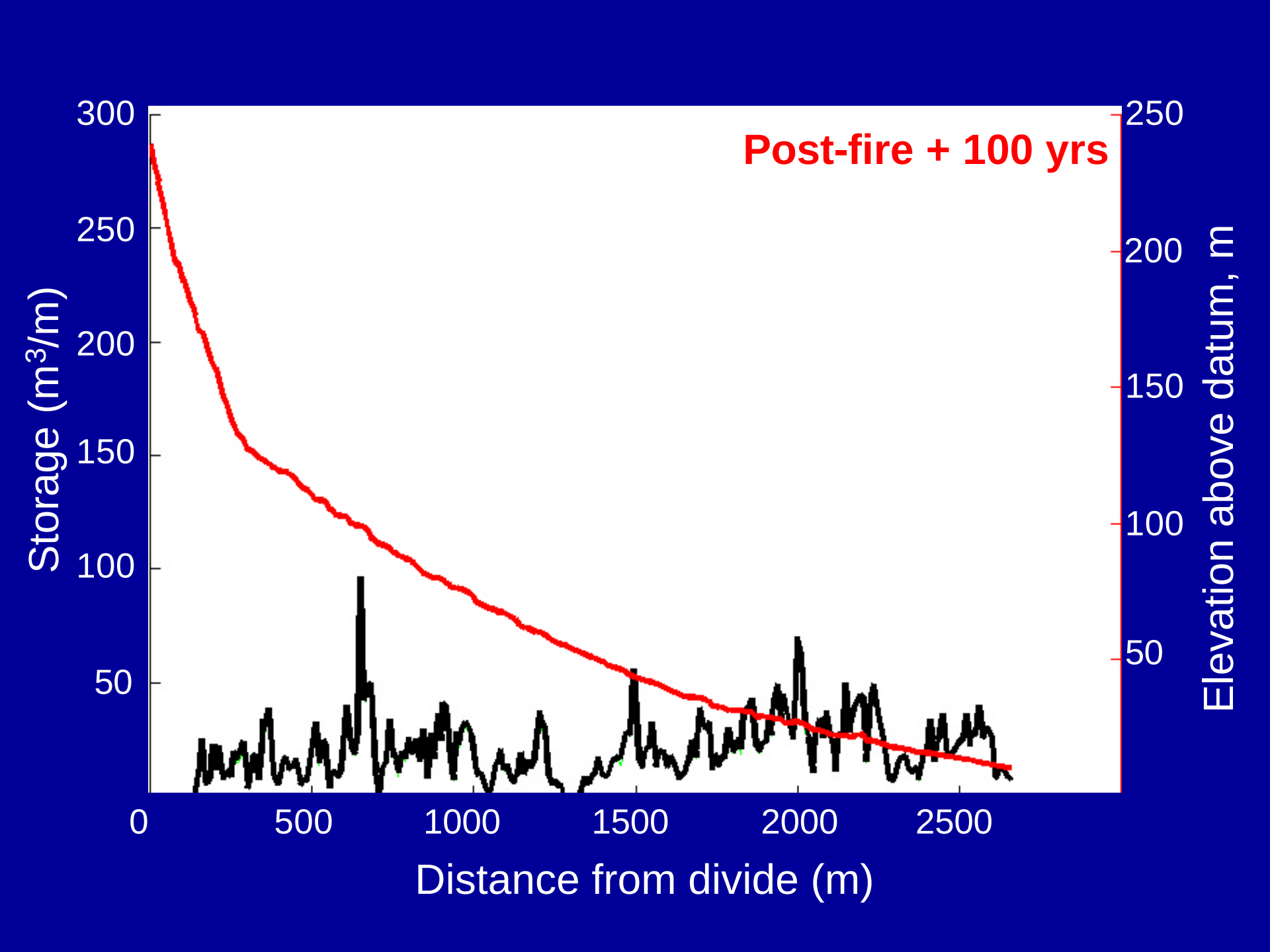
measured in the field…

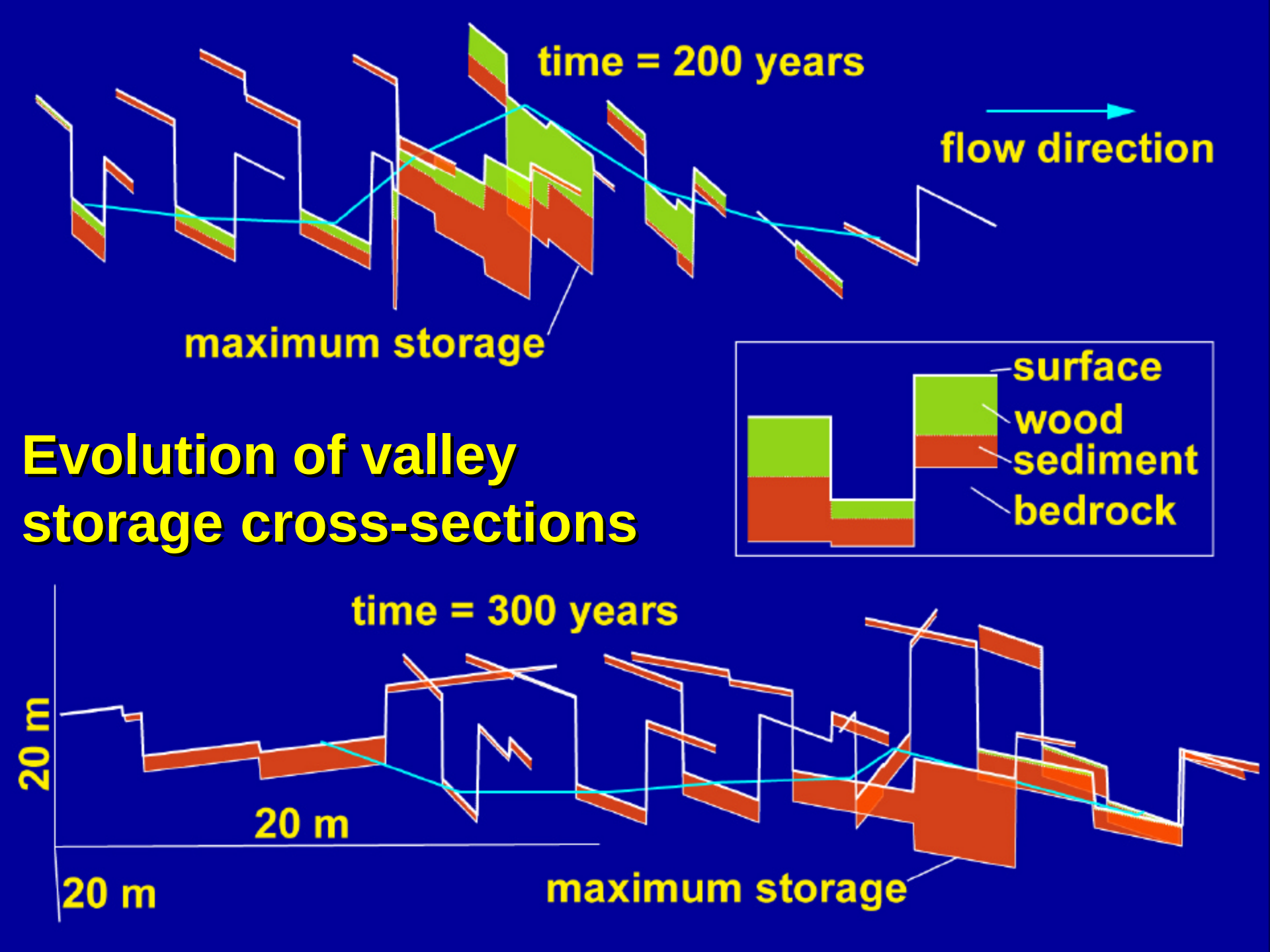


…and simulated over time




Post-fire (200 yrs)
Storage (m3/m)
Elevation above datum, m
Distance from divide (m)
300
250
200
150
100
50
250
200
150
100
50
0
500
1000
1500
2000
2500

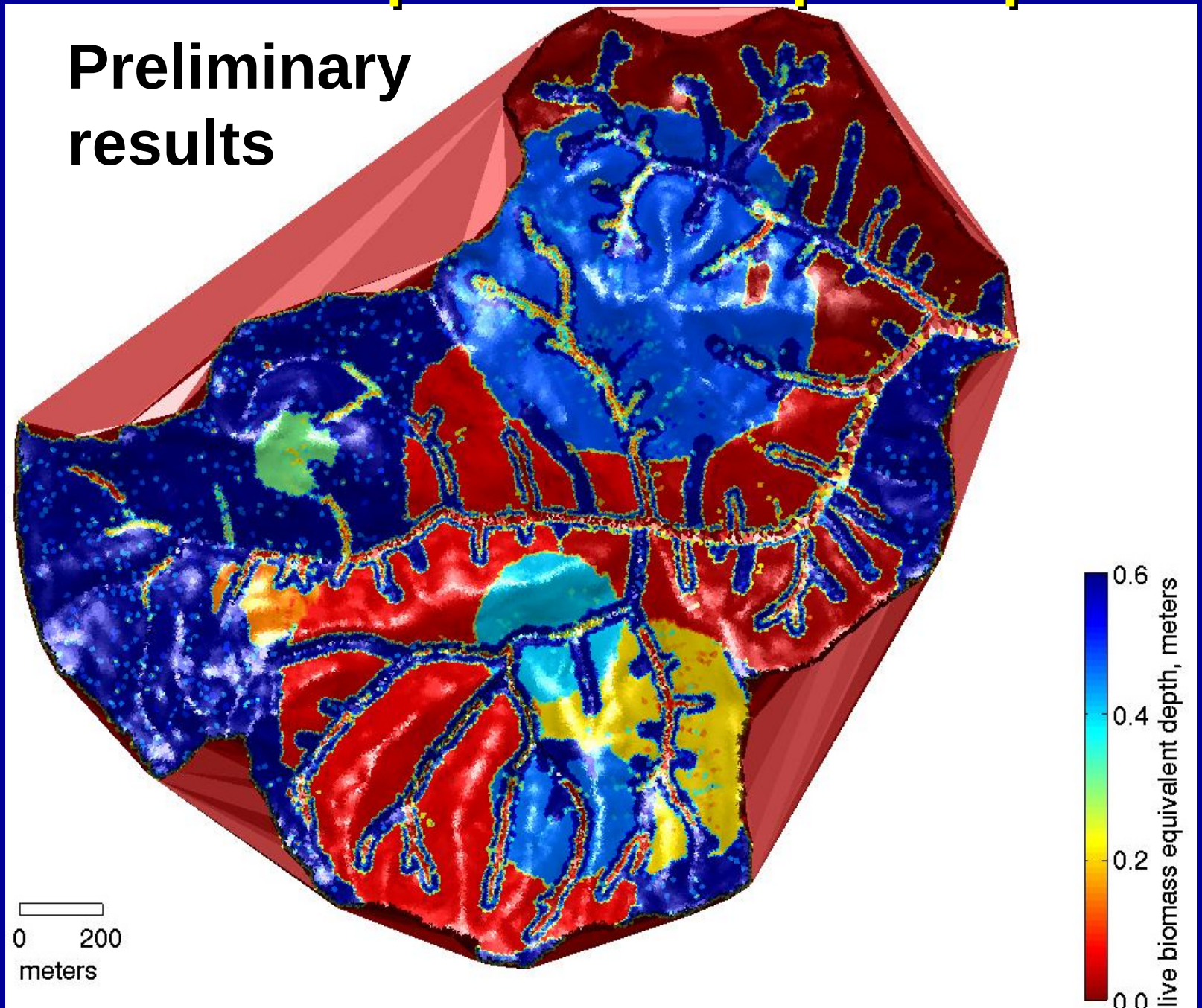

Post-fire + 100 yrs
Storage (m3/m)
Elevation above datum, m
Distance from divide (m)
300
250
200
150
100
50
250
200
150
100
50
0
500
1000
1500
2000
2500


time = 200 years
flow direction
maximum storage
surface
wood
sediment
bedrock
Evolution of valley storage cross-sections
time = 300 years
20 m
20 m
20 m
maximum storage

Next step: Forest harvest effects

Cedar Creek
9-4-89 USDA-F 1089-68, 69
989-36

Simulation of riparian buffer prescriptions:



Conclusions

- Trees matter for landslide initiation.
  - ➢ Decreased root strength increases landsliding.
- Trees and wood matter for debris flow runout.
  - ➢ Wood removal may increase debris flow runout lengths by 100% or greater.
  - ➢ Longer debris flows would lead to altered and more direct impact to fish-bearing streams.

Conclusions

- Wood matters for sediment storage:
  - Wood from debris flows forms dams that hold back sediment.
  - Woody dams increase sediment storage and residence times.
  - Much old sediment is stored high in the system behind debris dams.
- Wood matters for sediment output:
  - Wood slows release of sediment from small channels.
  - Slow release decouples hillslopes and channels.
  - Wood may “stall” disturbance-generated sediment pulses (“dynamic capacitance”).

Conclusions

- The simulations, coupled with field work, have much to teach us, but the lack of an “initial history” still leads to some uncertainty.

- Debris flows are part of a natural process that has effects necessary to maintain good aquatic habitat, but we have the capacity, through wood removal, to drastically alter that process. The effects of that alteration are still unknown because the presence of “legacy wood” delays the impacts of our actions.

Fin

http://www.fsl.orst.edu/wpg