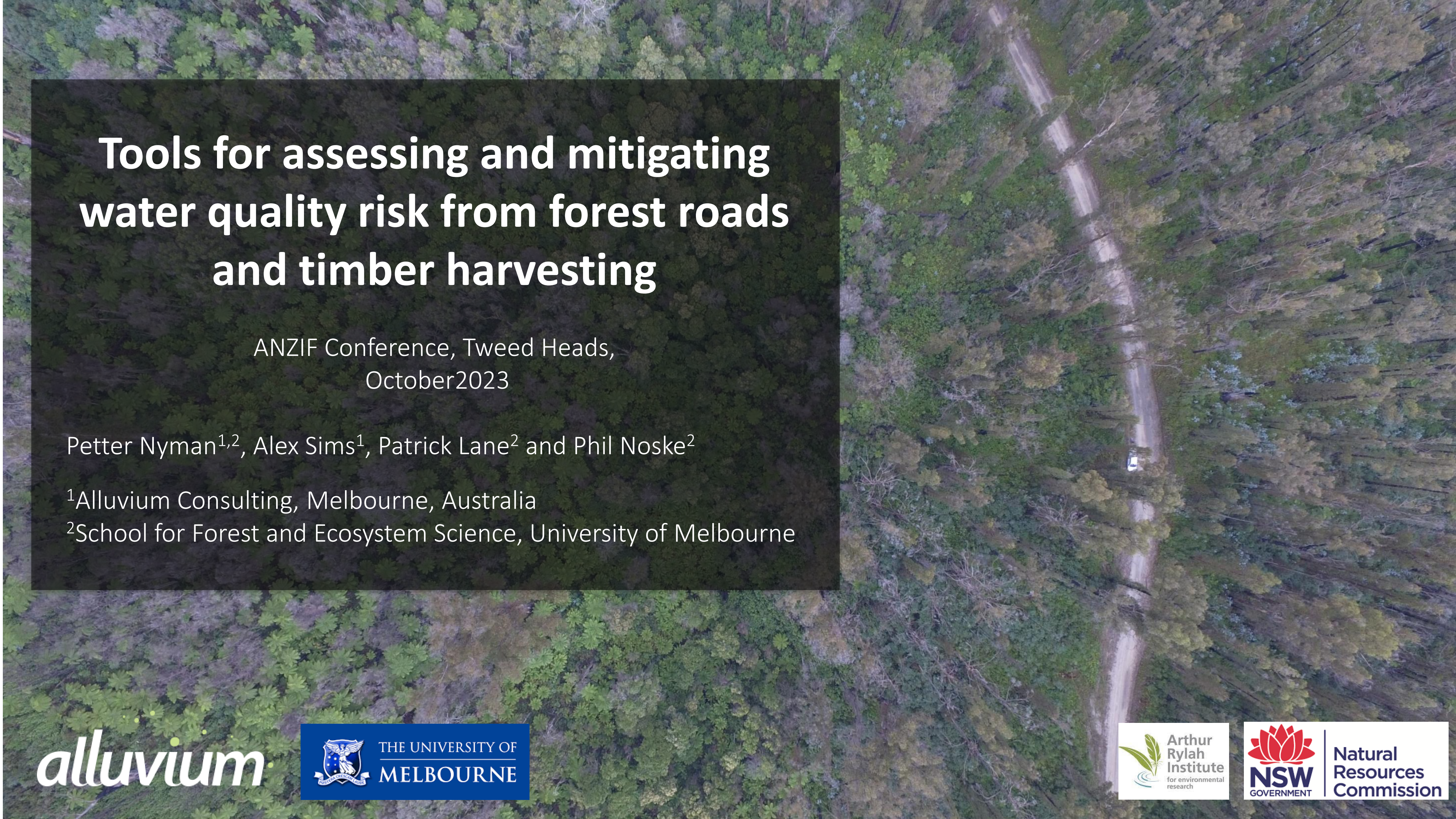


Tools for assessing and mitigating water quality risk from forest roads and timber harvesting

ANZIF Conference, Tweed Heads,
October2023

Petter Nyman[1,2], Alex Sims[1], Patrick Lane[2] and Phil Noske[2]

[1]Alluvium Consulting, Melbourne, Australia
[2]School for Forest and Ecosystem Science, University of Melbourne

alluvium

THE UNIVERSITY OF MELBOURNE

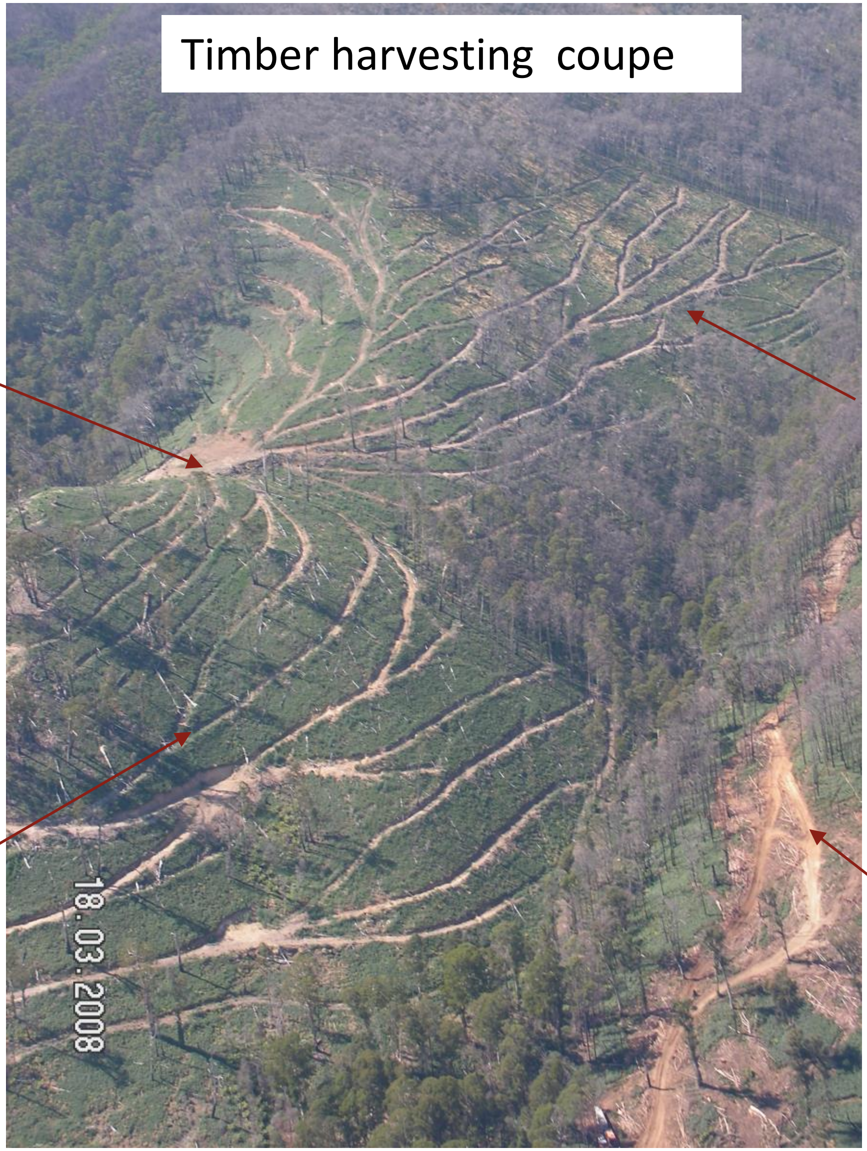
Arthur Rylah Institute for environmental research

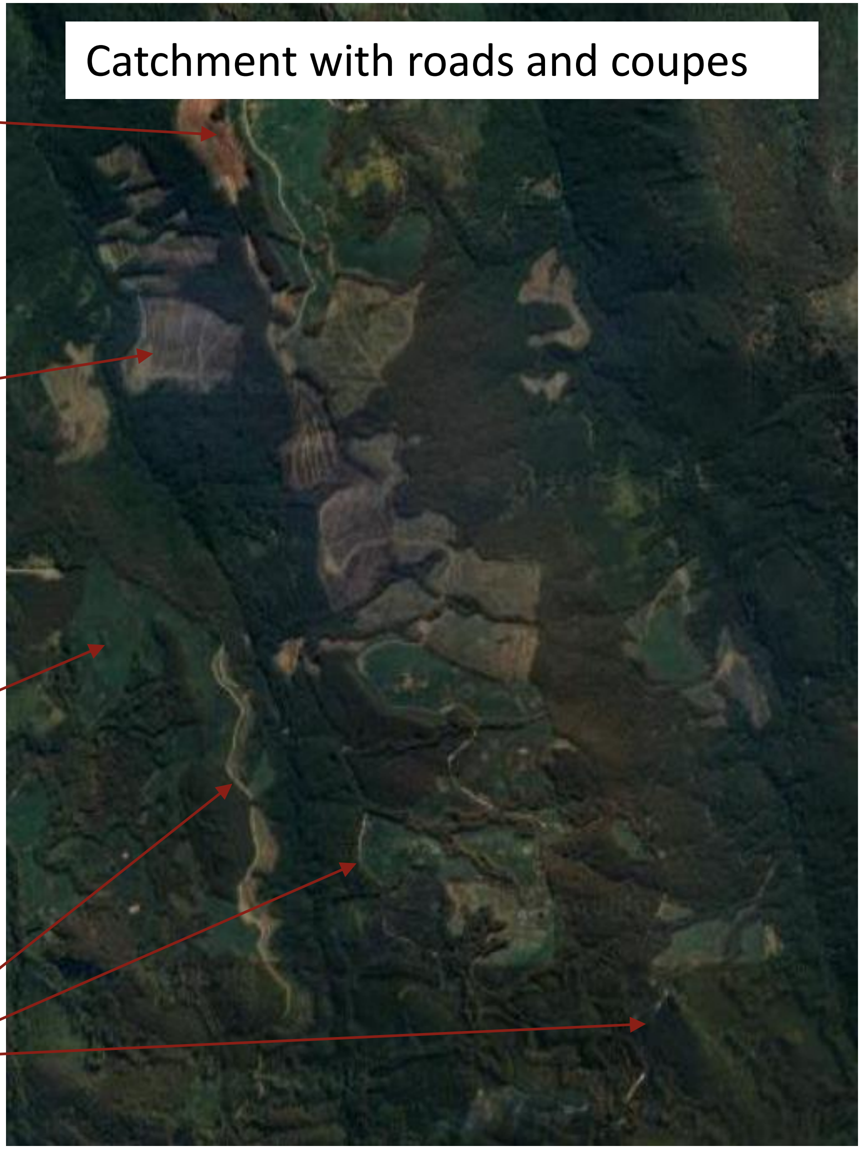
NSW GOVERNMENT | Natural Resources Commission

Overview

- The issue: soil disturbance, roads and erosion
- Management solutions
- Tool 1: Effectiveness of riparian buffers
- Tool 2: Managing road networks for water quality outcomes
- Tool 3: Cumulative impacts framework (conceptual)

The issue: soil disturbance, roads and erosion





The issue: soil disturbance, roads and erosion

Inadequate drainage → erosion from roads surfaces

Channelised flow at drains → resulting in high connectivity with streams

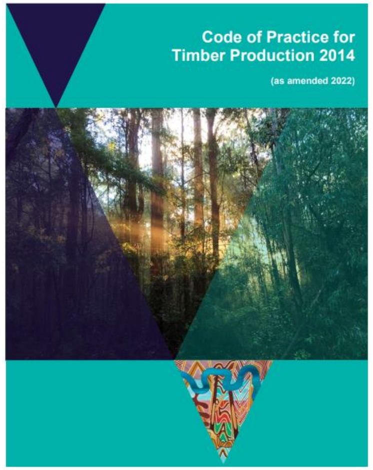
Crossings → Direct sediment input at stream crossings

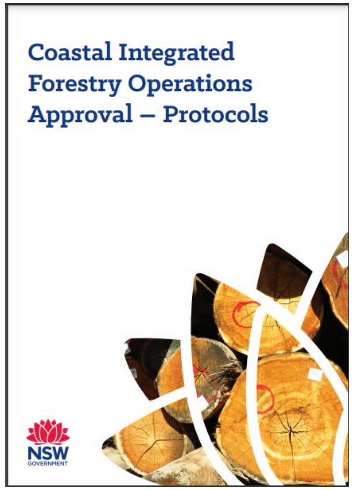
Lack of maintenance/rehab → persistent erosion and slow recovery

The issue: soil disturbance, roads and erosion

Water quality issues can be exacerbated by wildfire and rainfall extremes

Management solutions





COOPERATIVE RESEARCH CENTRE FOR
CATCHMENT HYDROLOGY

HYDROLOGICAL PROCESSES
Hydrol. Process. **20**, 1875–1884 (2006)
Published online 13 February 2006 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hyp.5940

Quantifying diffuse pathways for overland flow between the roads and streams of the Mountain Ash forests of central Victoria Australia

Patrick N. J. Lane,[1,2]* Peter B. Hairsine,[2,3] Jacky C. Croke[2,4] and Ingrid Takken[4]

[1] *School of Forest and Ecosystem Science, University of Melbourne, PO Box 137, Heidelberg, Victoria 3084, Australia*
[2] *Cooperative Research Centre for Catchment Hydrology, Canberra, ACT, Australia*
[3] *CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia*
[4] *School of Physical, Environmental and Mathematical Sciences, University of New South Wales, Canberra, ACT 2601, Australia*

HYDROLOGICAL PROCESSES
Hydrol. Process. **22**, 254–264 (2008)
Published online 24 July 2007 in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/hyp.6581
WILEY InterScience DISCOVER SOMETHING GREAT

A methodology to assess the delivery of road runoff in forestry environments

I. Takken,[1]* J. Croke[1] and P. Lane[2]

[1] *School of Physical, Environmental and Mathematical Sciences, UNSW@ADFA, Northcott Drive, Canberra ACT 2601, Australia*
[2] *School of Forest and Ecosystem Science, University of Melbourne, 123 Brown Street, Heidelberg, Victoria 3084, Australia*

HYDROLOGICAL PROCESSES
Hydrol. Process. **16**, 2311–2327 (2002)
Published online 27 March 2002 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hyp.1002

Modelling plumes of overland flow from logging tracks

P. B. Hairsine,[1,2]* J. C. Croke,[2,3] H. Mathews,[4] P. Fogarty[2,5] and S. P. Mockler[1,2,6]

[1] *CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia*
[2] *Cooperative Research Centre for Catchment Hydrology*
[3] *School of Geography and Oceanography, University College, University of New South Wales, Canberra, Australia*
[4] *Department of Earth Science, Colorado State University, USA*
[5] *Soil and Land Conservation Consulting, Canberra, Australia*
[6] *Department of Civil and Environmental Engineering, University of Melbourne, Parkville, Melbourne, 3052, Australia*

www.elsevier.com/locate/geomorph

Sediment concentration changes in runoff pathways from a forest road network and the resultant spatial pattern of catchment connectivity

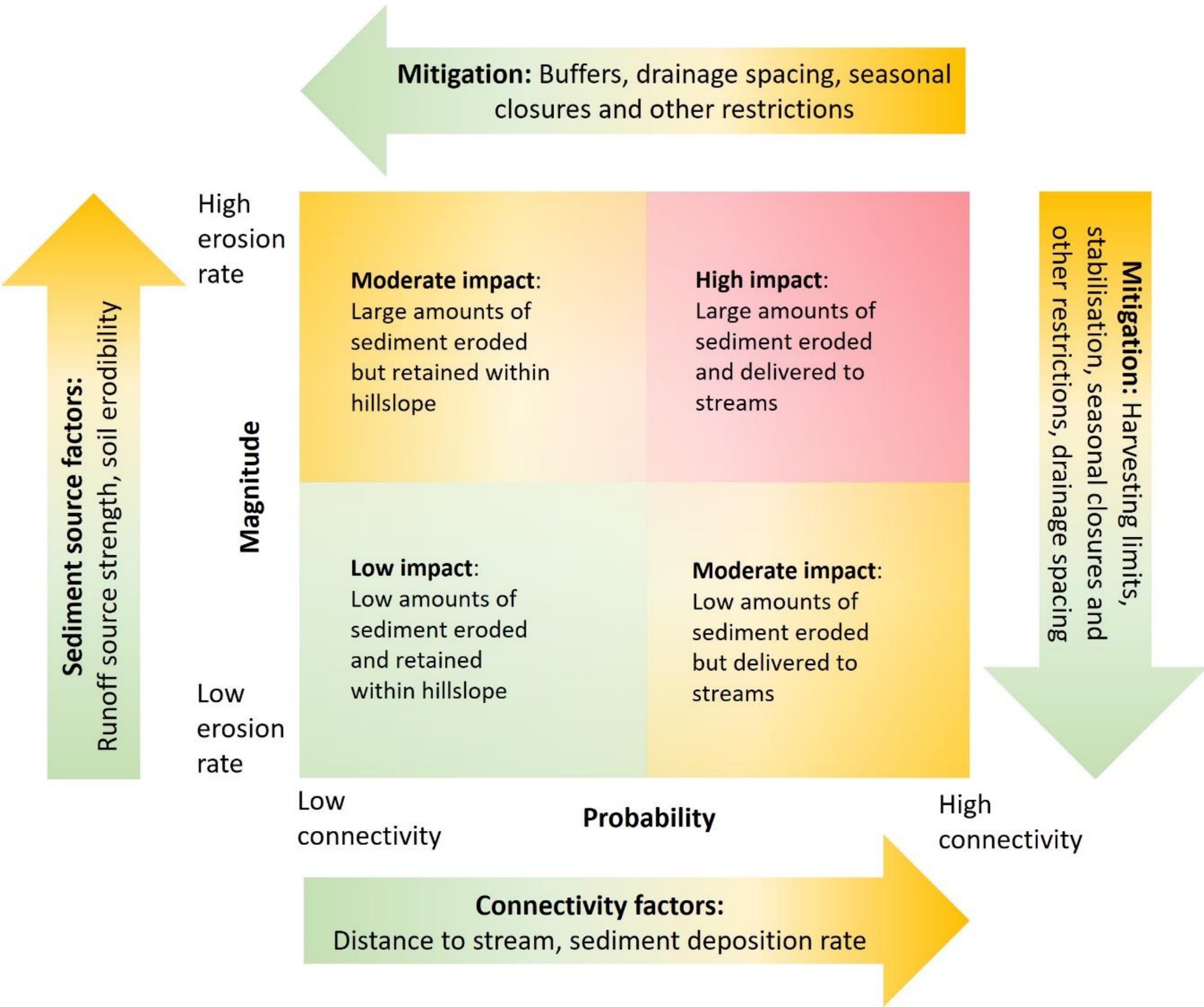
Jacky Croke[a,*], Simon Mockler[a], Peter Fogarty[b], Ingrid Takken[a]

[a] *School of Physical, Environmental and Mathematical Sciences, University of New South Wales at ADFA, ACT 2601, Australia*
[b] *Soil and Land Conservation Consulting, GPO Box 485, ACT 2614, Australia*

Received 28 May 2004; received in revised form 26 November 2004; accepted 29 November 2004
Available online 3 February 2005

Management solutions

- Buffers to reduce connectivity between disturbed areas and waterways
- Road design
  - Drainage spacing to reduce erosion from road surfaces and to minimise point discharge at drains
  - Crowning to reduce surface runoff on roads
  - Drains and erosion control at crossings
  - Road placement
- Seasonal closures
- Harvesting limits
- Rehabilitation



Management solutions – the role of models

Log landing

General harvest area

Snig track

Forest road

Year: 0

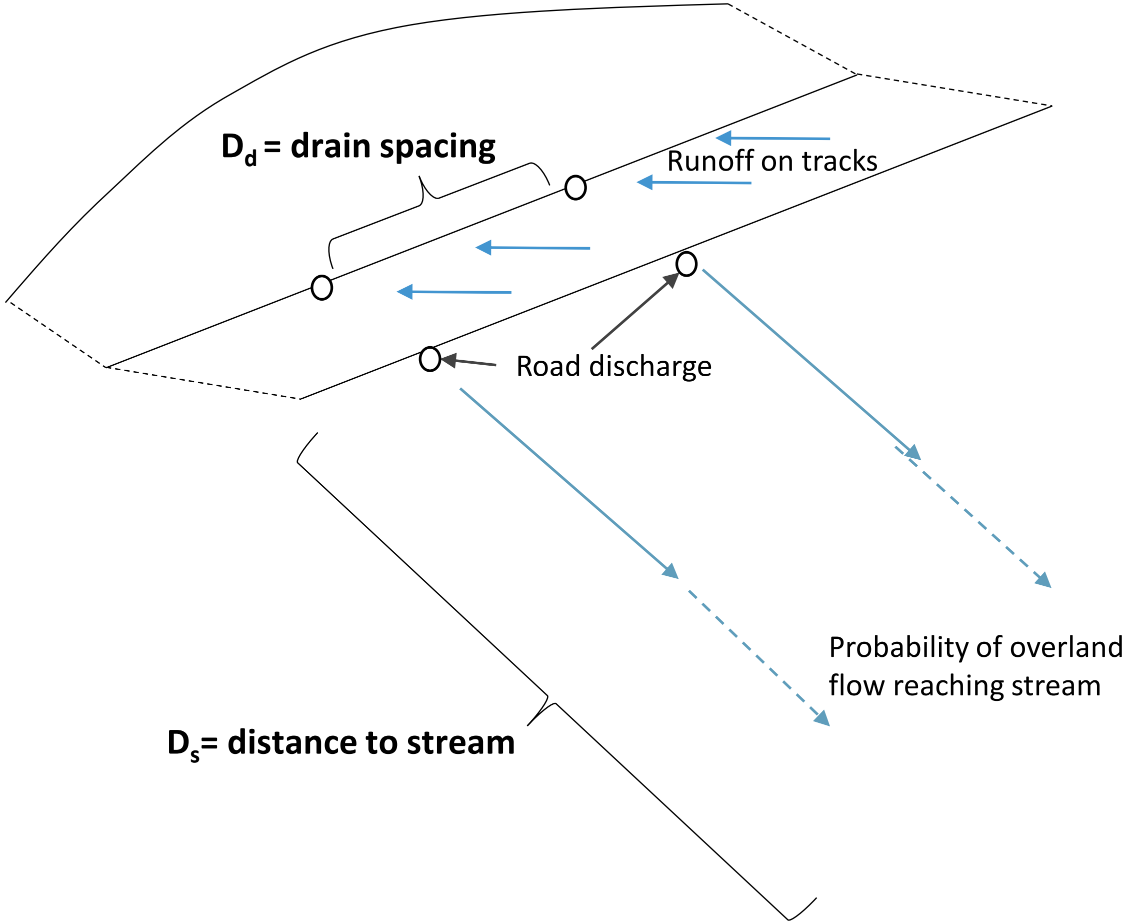
Year: -2

Year: -10

Road network

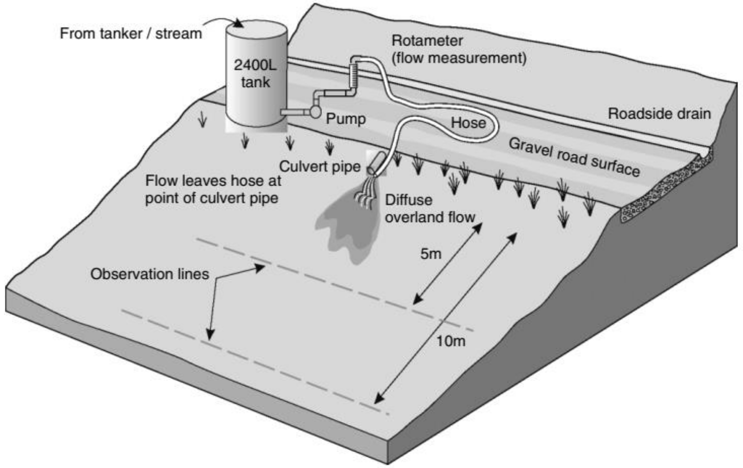
Case study 1: Effectiveness of riparian buffers

How far does surface runoff, that carries sediment, travel through vegetation in different forest environments before it's absorbed into the ground?



Hairsine et al, 2002

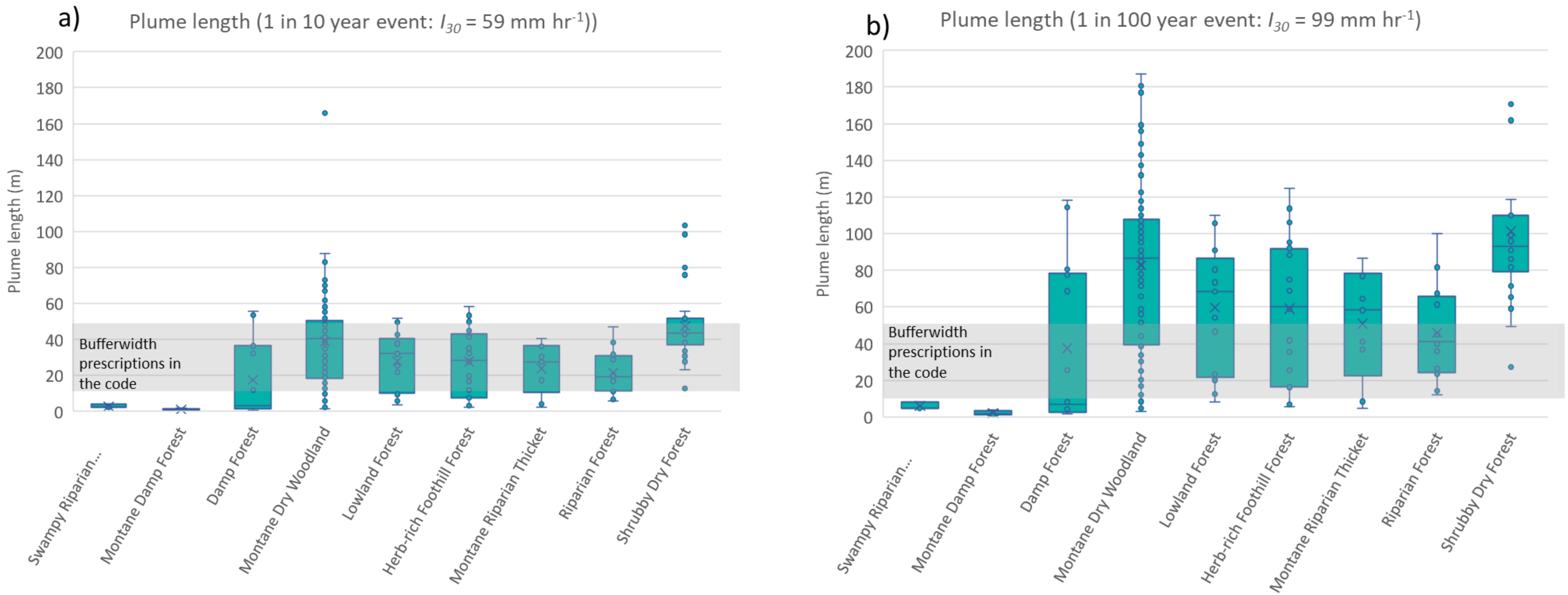
vbt5: This is the volume of water absorbed when the plume reaches 5 meters.



Case study 1: Effectiveness of riparian buffers

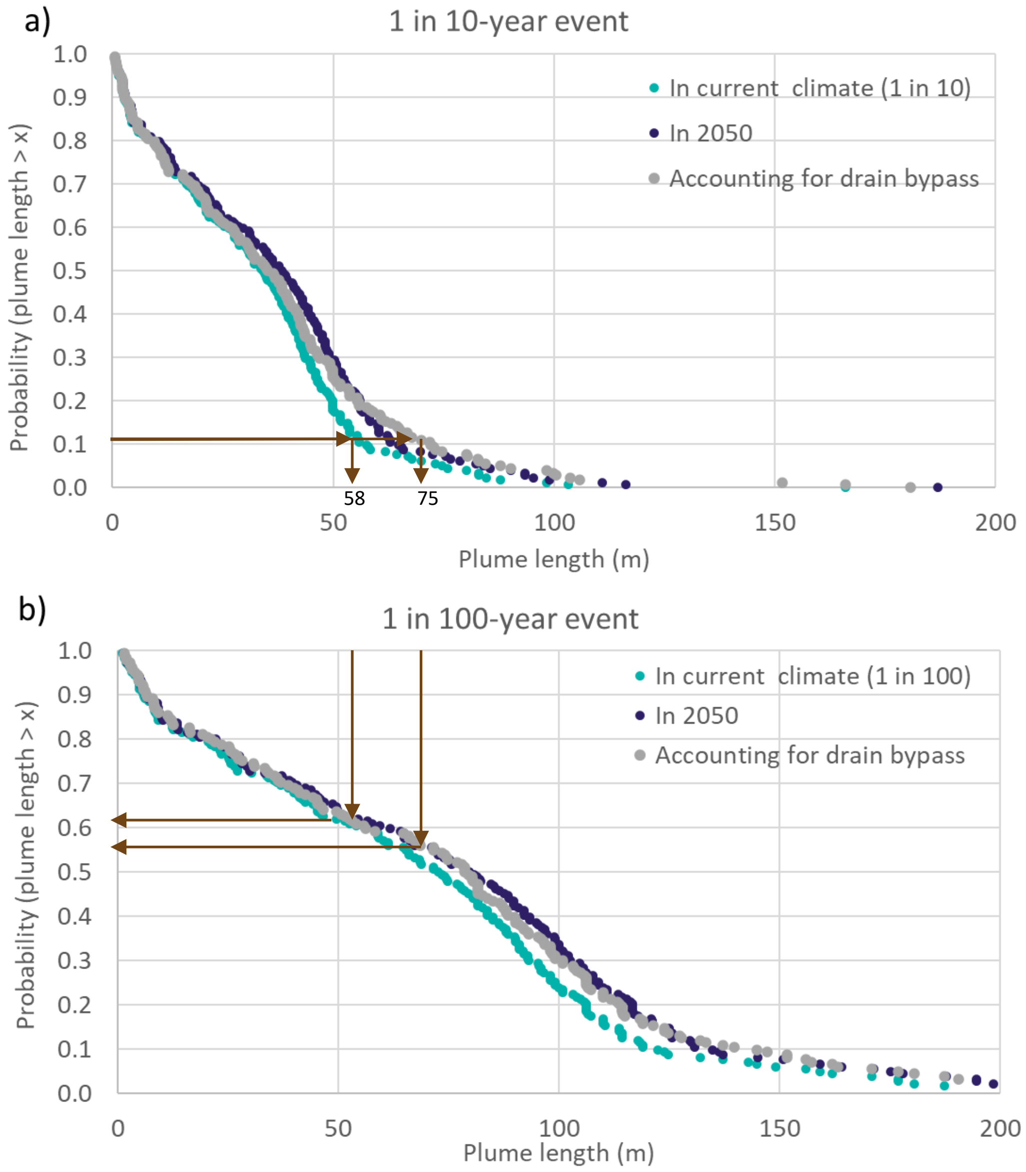
How far does surface runoff, that carries sediment, travel through vegetation in different forest environments before it’s absorbed into the ground?

$$Plume\ lengt\ (l_{pred}) = 5\frac{V_{out}}{vbt5}$$ (Hairsine et al, 2002)



Case study 1: Effectiveness of riparian buffers

- **A new outcome-based framework: probability of exceedance curves**
  - what level of risk do we want to accept?
- Evaluated the effects of variable runoff from snig tracks due to:
  - Non-compliance in drainage structures
  - Climate chance related increases in rainfall intensity
- Framework provides transparency and evidence-base to optimise buffer widths as a mitigation measure
- Can deliver as a decision support **tool for setting buffer widths** according to risk appetite and hydrological setting.
  - Prototype tool developed in excel and as a geo[processing tool in for GIS software

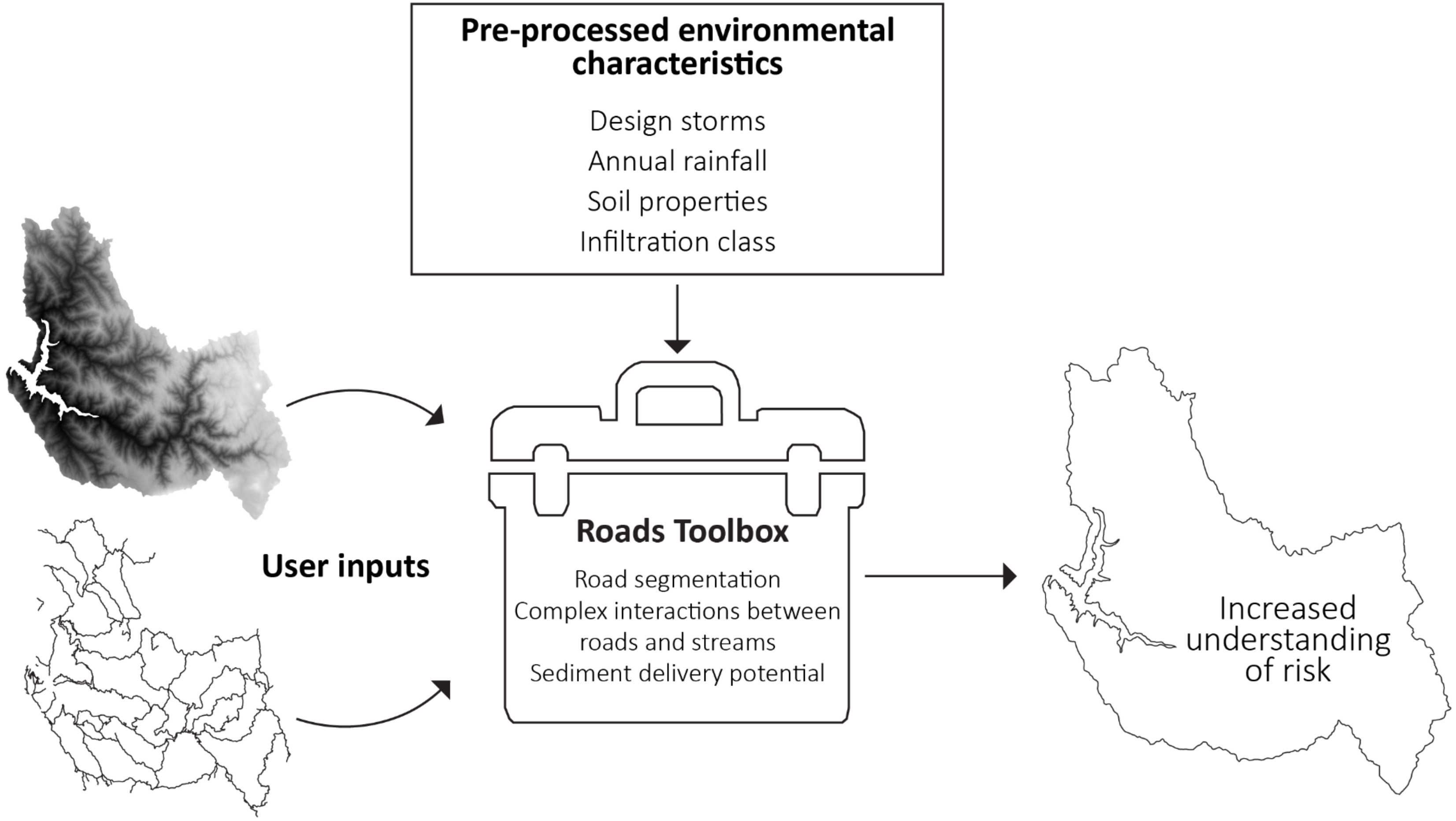


Case study 2: Managing road networks for water quality outcomes

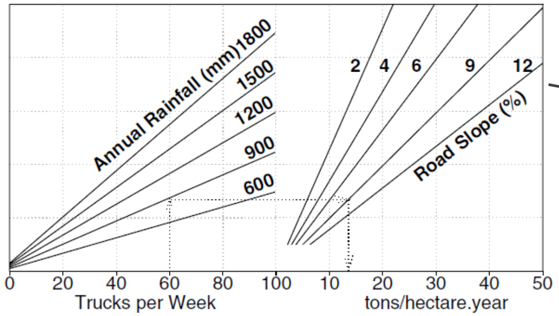
How much sediment delivery can I expect from my road network and how can this be best managed?

We designed a GIS toolbox to assess and quantify the risks to water quality from forest roads and to compare forest management practices. The tool's input requirements are (1) a DEM of the catchment and (2) the road network of interest.

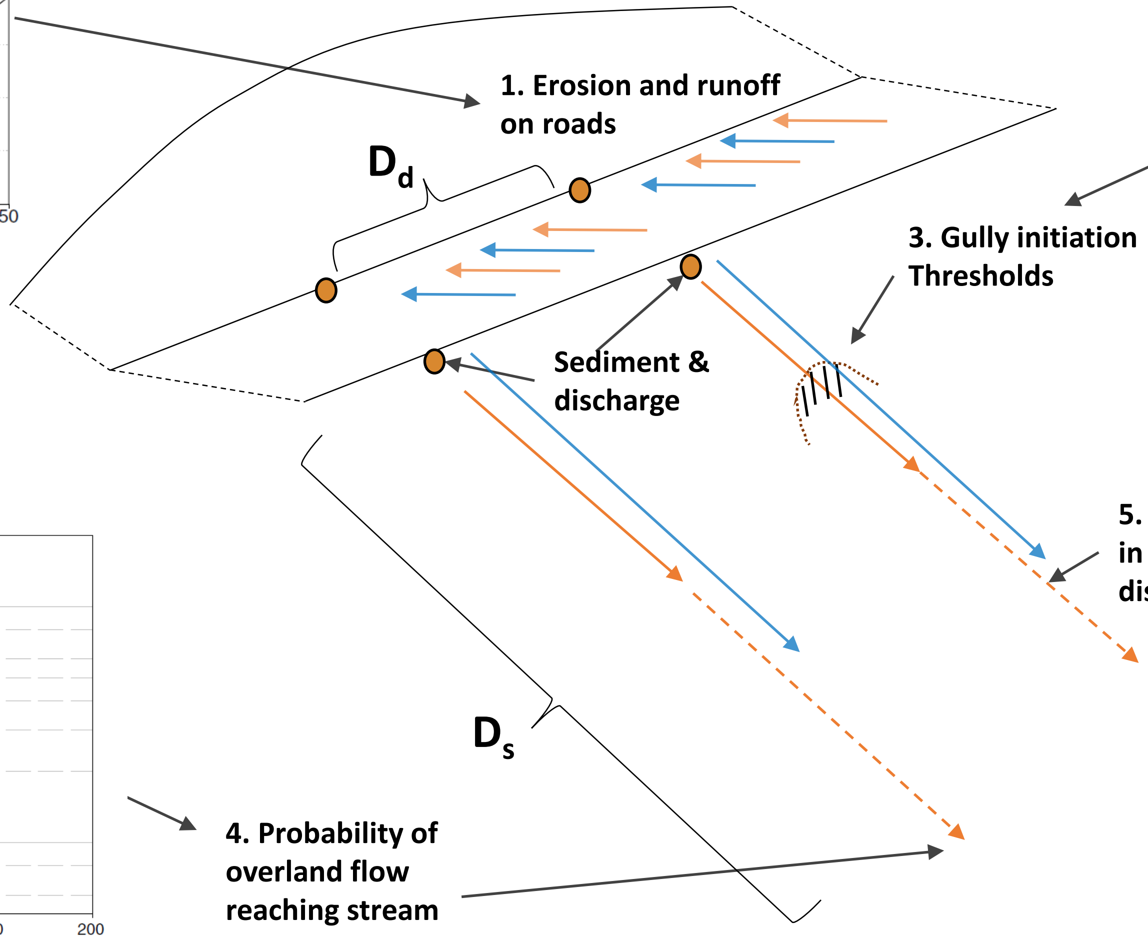
The toolbox has been developed in ArcGIS and outputs are generated through automated geoprocessing workflows.

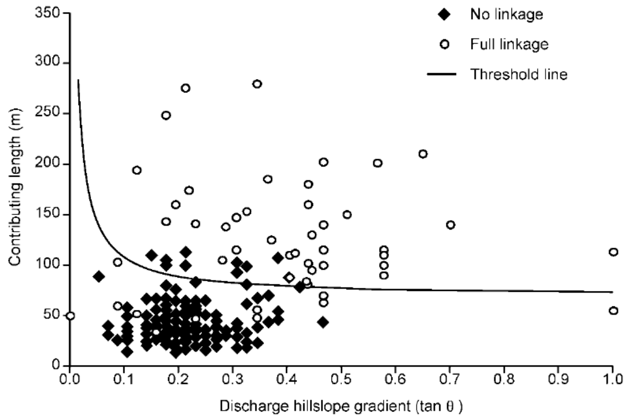


Case study 2: Managing road networks for water quality outcomes

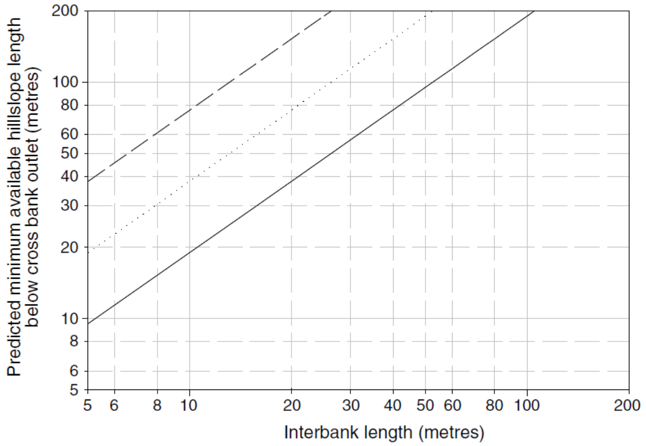


Sheridan and Noske, 2007

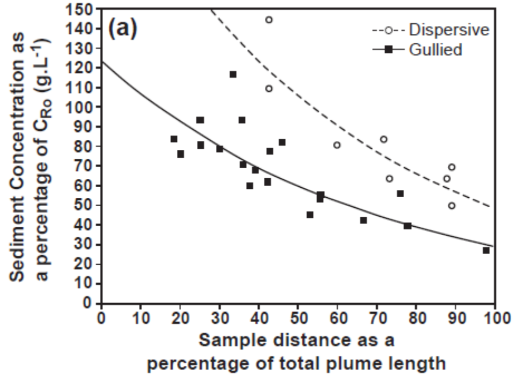




Croke et al, 2001



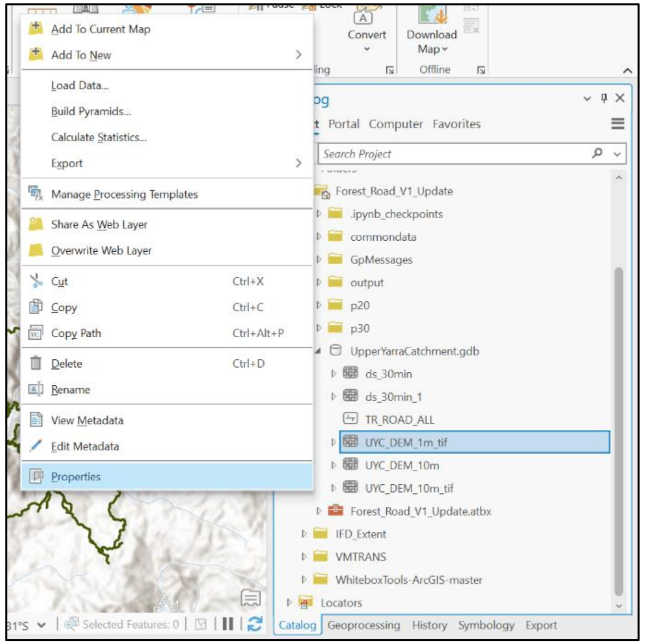
Hairsine et al, 2002

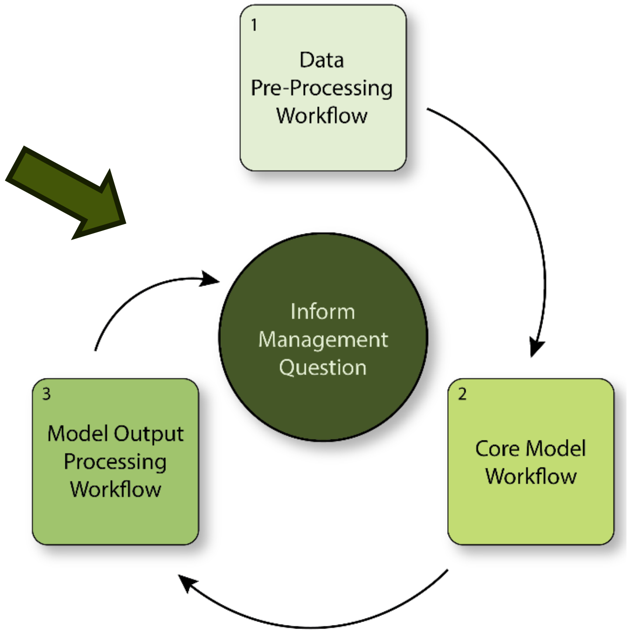


Croke et al, 2005

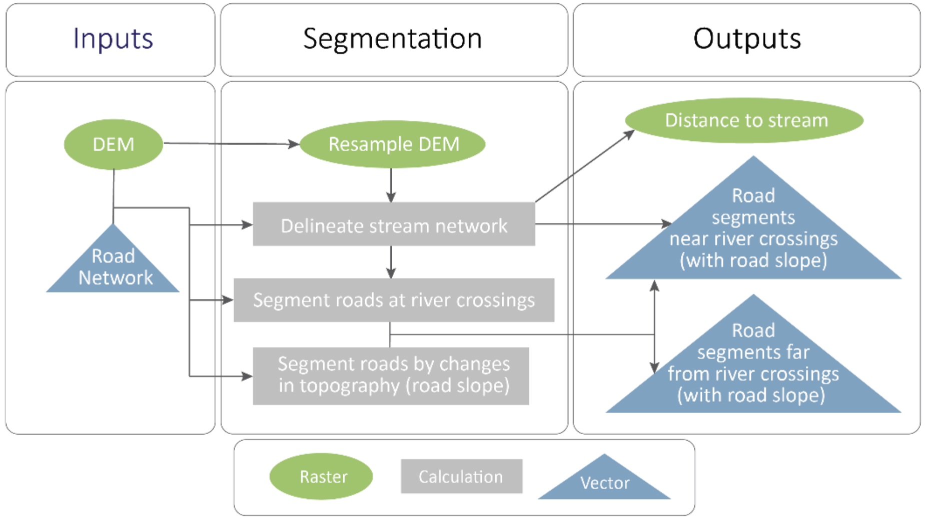
Case study 2: Managing road networks for water quality outcomes

ArcGIS toolbox

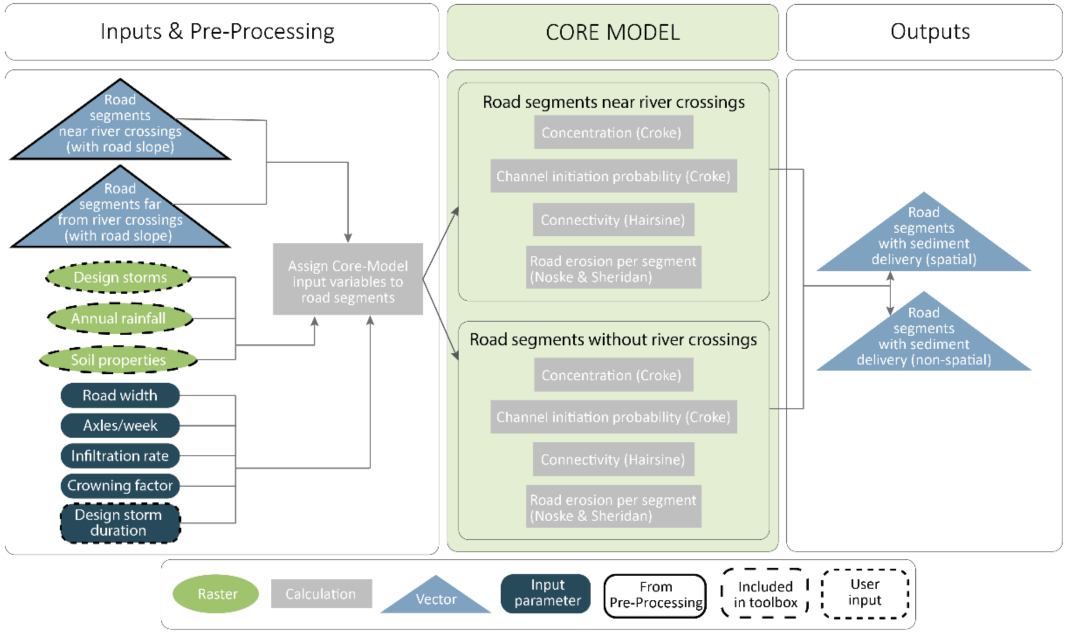




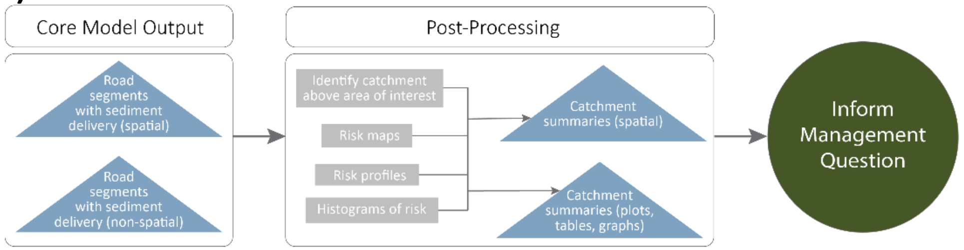
1)



2)



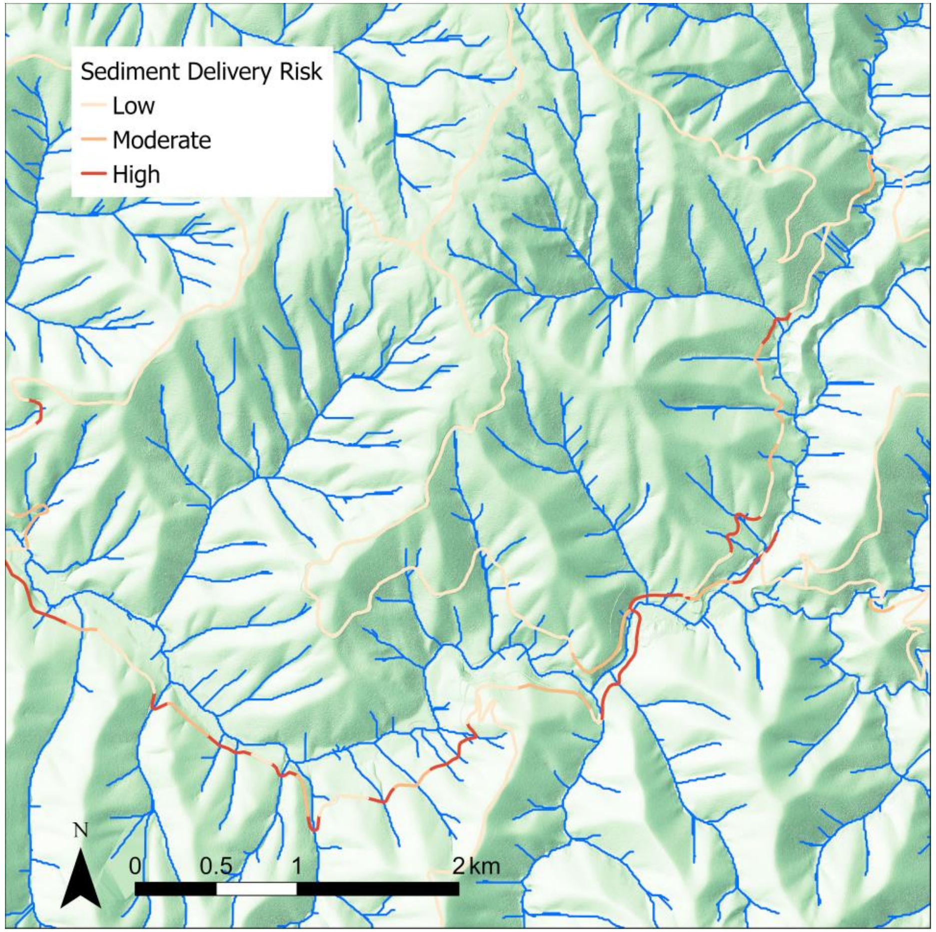
3)



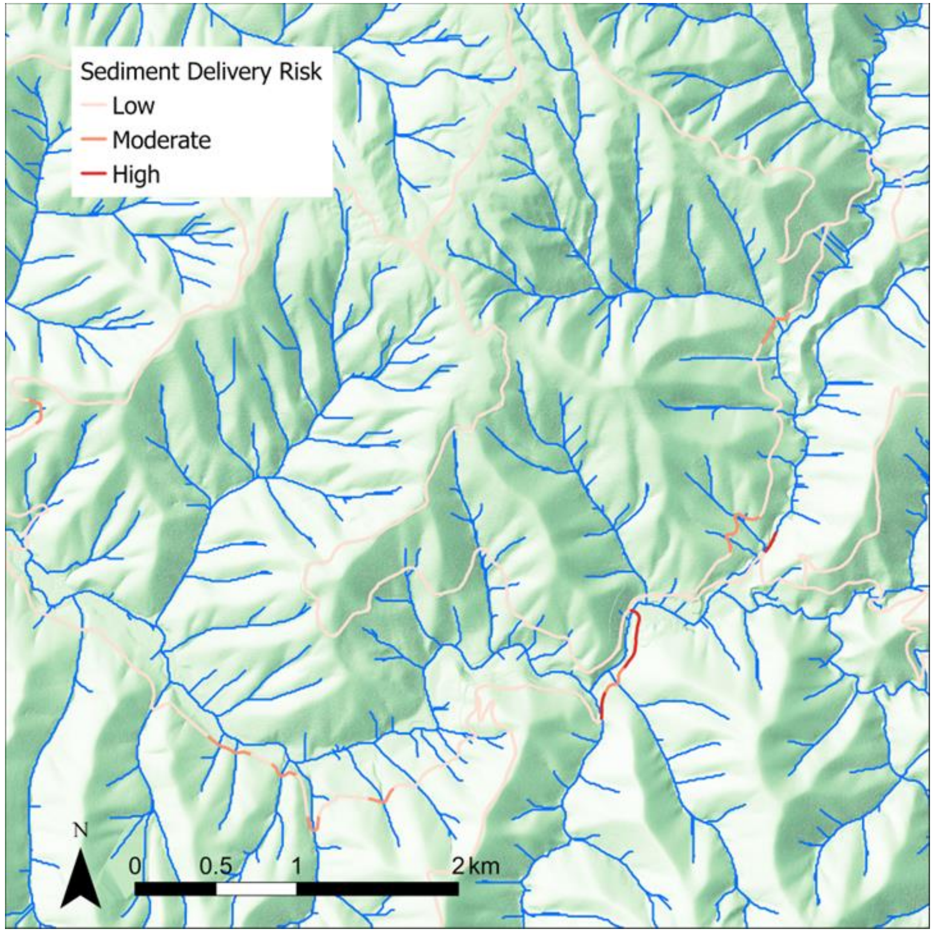
Case study 2: Managing road networks for water quality outcomes

Effects of crowning:

Crowning factor: 1, Storm AEP: 1 in 10 year



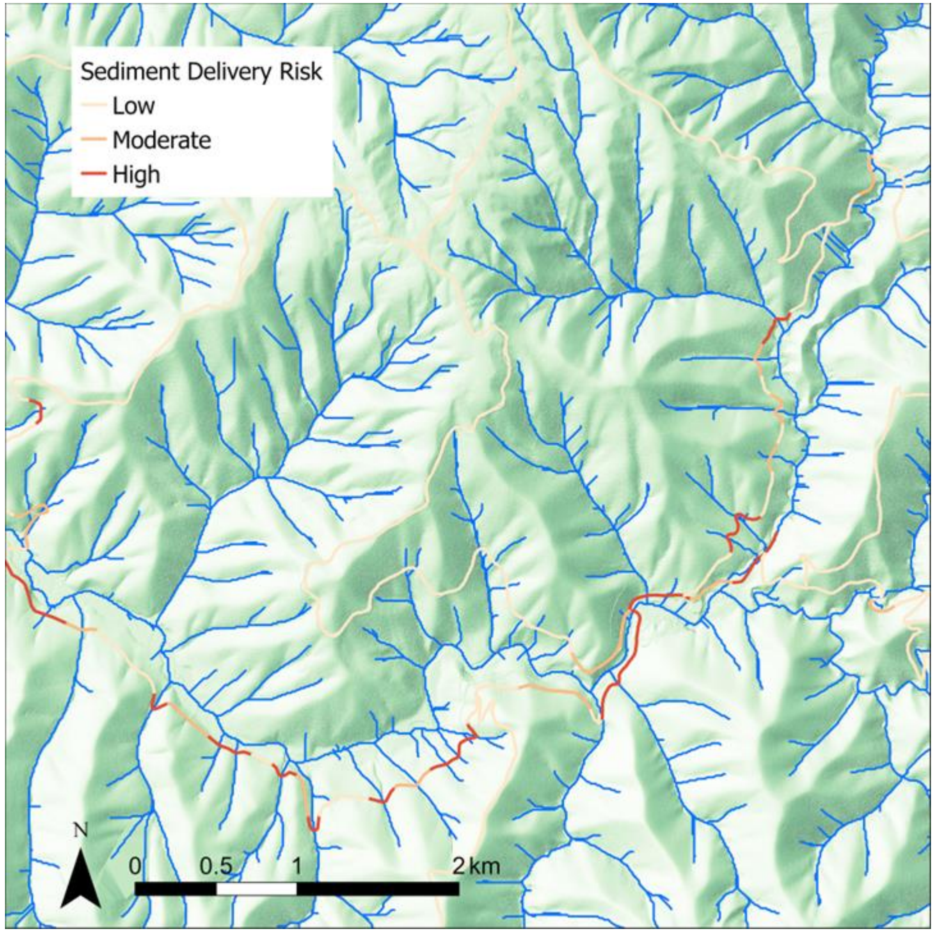
Crowning factor: **0.5,** Storm AEP: 1 in 10 year



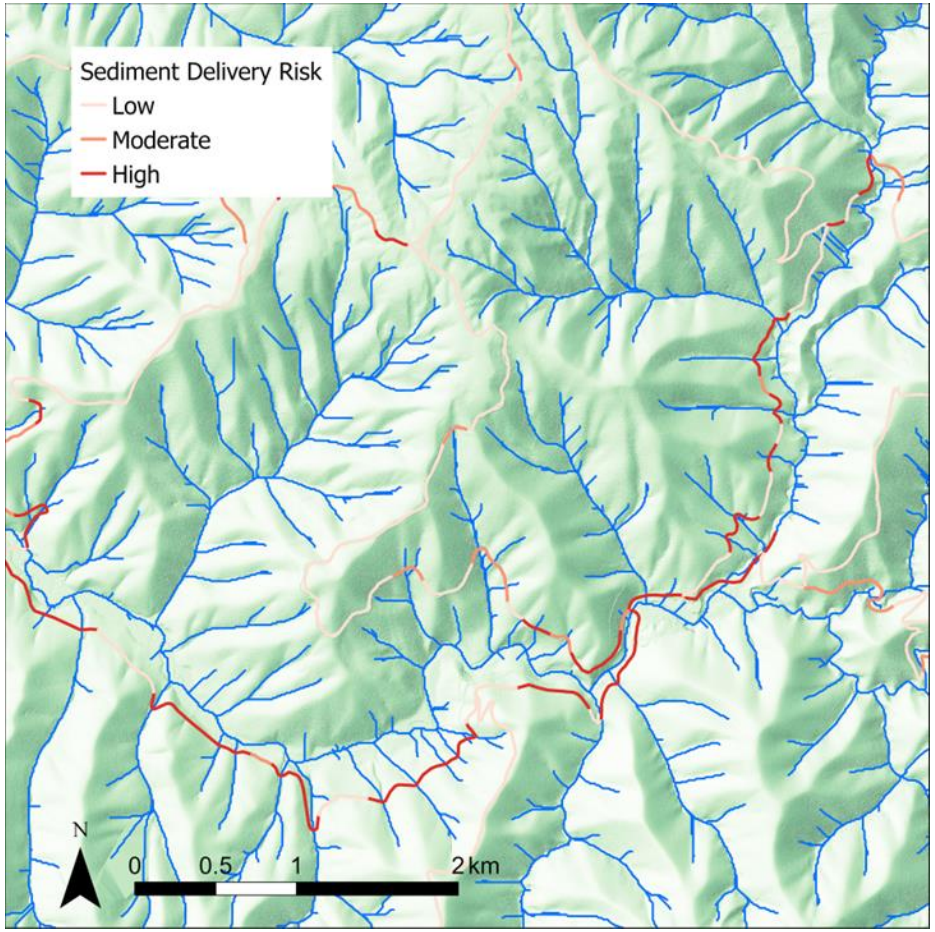
Case study 2: Managing road networks for water quality outcomes

Effects of rainfall event:

Crowning factor: 1, **Storm AEP: 1 in 10 year**



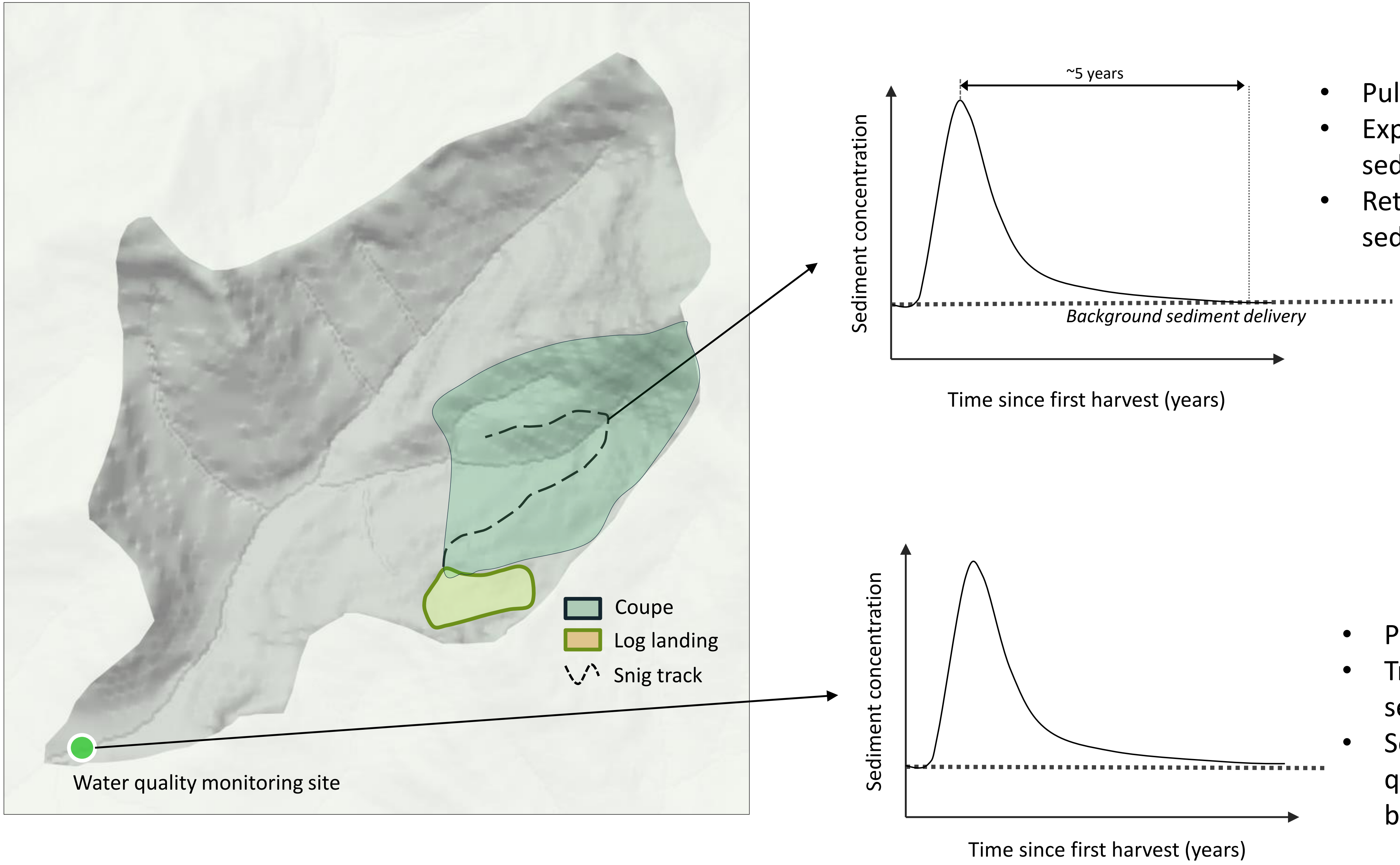
Crowning factor: 1, **Storm AEP: 1 in 50 year**



Case study 3: Cumulative impacts framework (conceptual)

What is the cumulative impacts of sediment transport in catchments due to forest roads and snig tracks? What are the sediment delivery trajectories for different management scenarios?

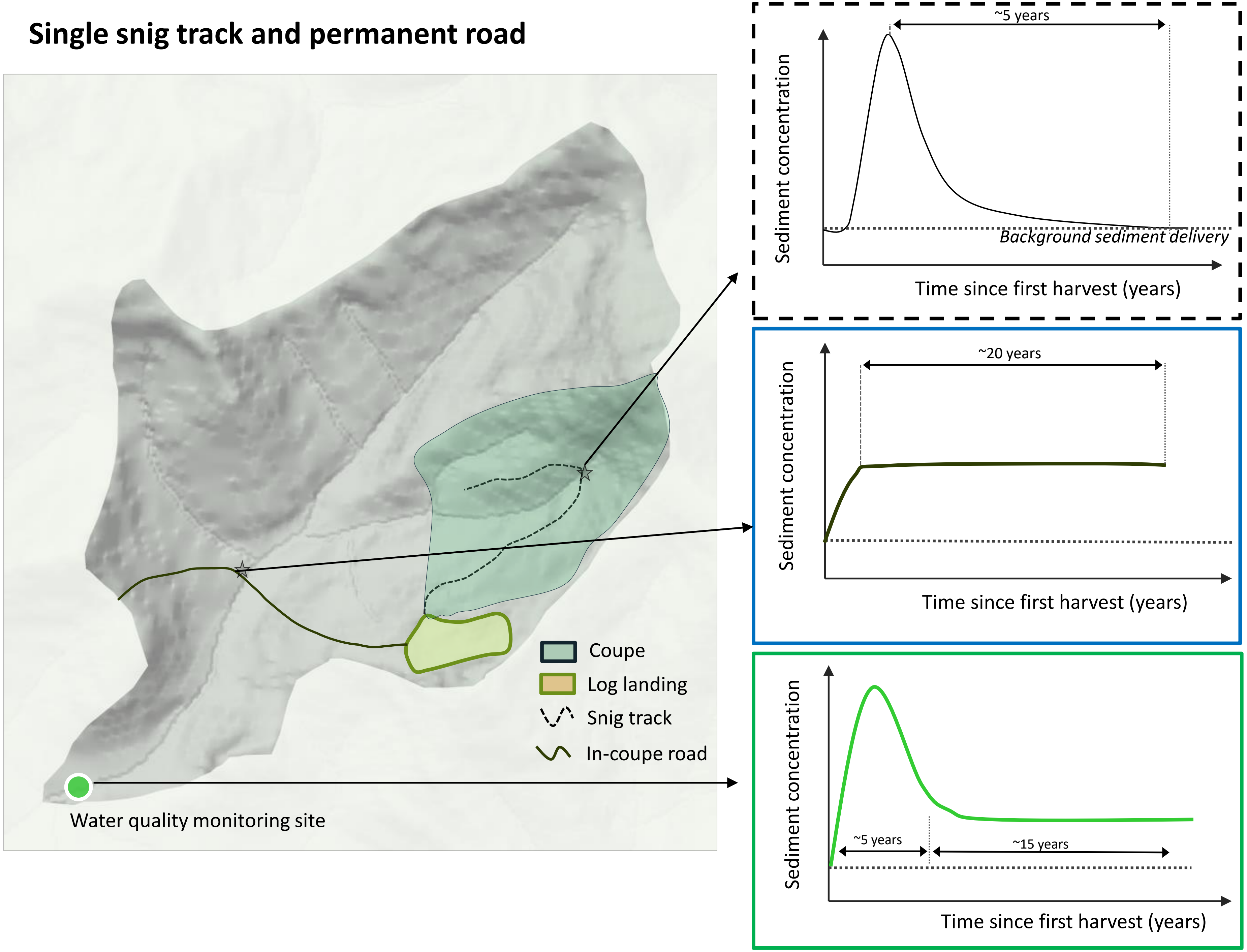
Single snig track



- Pulse disturbance
- Exponential decrease in sediment delivery
- Return to background sediment delivery rate

- Pulse disturbance
- Tributary inputs dilute sediment concentration
- Sediment concentration quickly declines to background level

Single snig track and permanent road



Single pulse disturbance

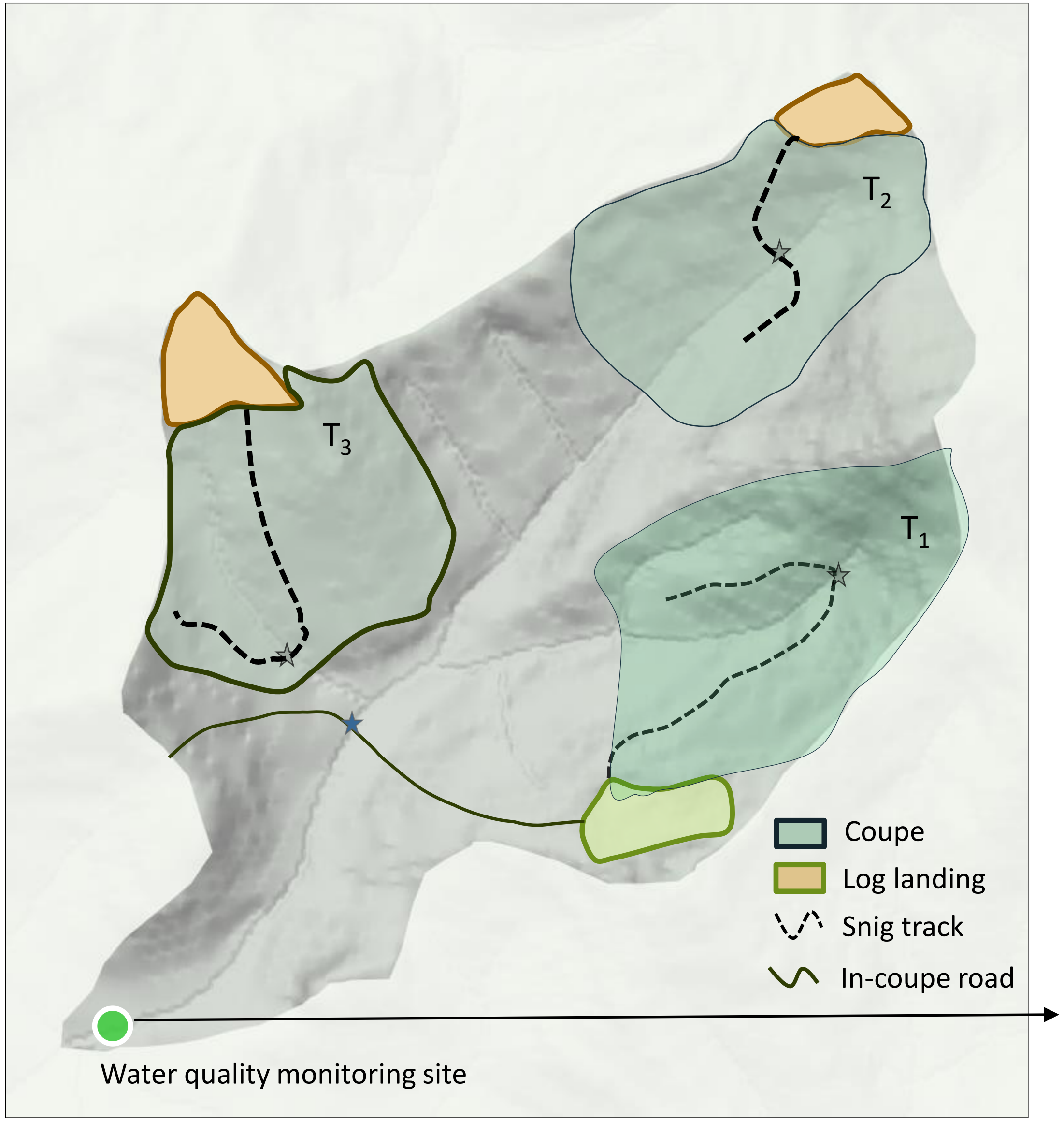
Single press disturbance

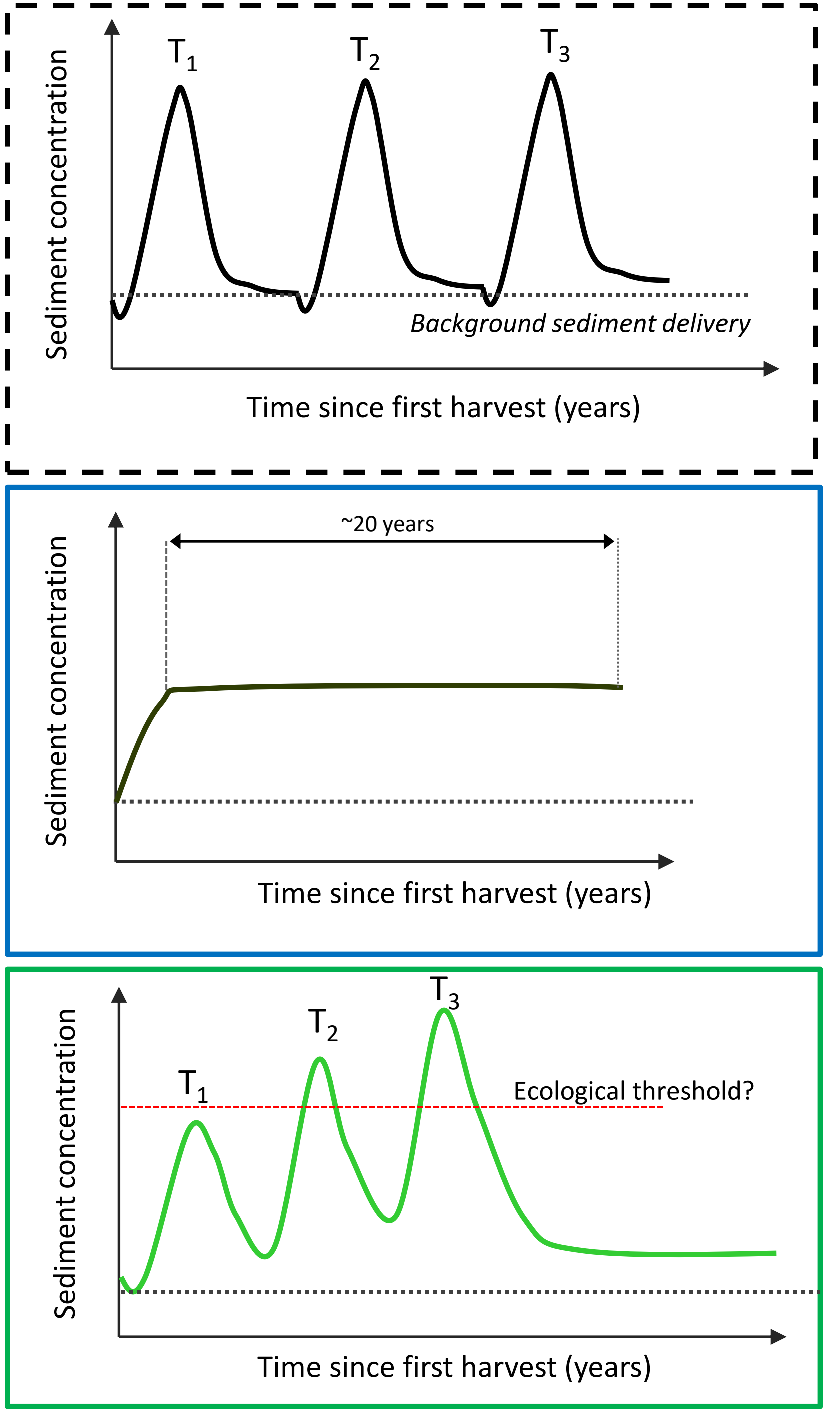
- Sediment delivery remains permanently elevated above background levels
- Local variation dependent on traffic, vegetation, soil type etc

Combined signature

An initial spike in sediment concentration, then decline, but sed. concentration remains elevated above background levels

Multiple snig track and permanent road: staggered harvest





3 x pulse disturbances, staggered over time

Single press disturbance

Combined signature
Cycles of spike and recovery following each harvest

Conclusions

- Codes/prescription/protocols/standards are important. They help ensure mitigation measures are in place and the sector apply best practise in managing impacts on water quality.
  - But there are circumstances where things don't go to plan
    - Wildfire, extreme rainfall events
    - Lack of maintenance, limits on funding,
    - Roads for firefighting, built as part of emergency response
    - Governance, legacy roads,

- Models help us refine management solutions to achieve outcomes that factor in local conditions and uncertainty
  - The sediment delivery hazard varies across landscapes
  - The risk varies depending on the values we are managing for
  - The risk varies with rainfall conditions, and this is not always considered in standards

- Decades of field experimentation and empirical research provide us with the fundamentals to build models to help focus and refine our mitigation efforts.
  - Model development and testing is an ongoing process.
  - There are low-hanging fruits in the tools that we have presented, that are sufficiently robust to improve the effectiveness of risk mitigation

Questions?

alluvium

We are passionate about the protection and restoration of waterways, catchments and water resources. We strive to make a positive difference to the world we live in.