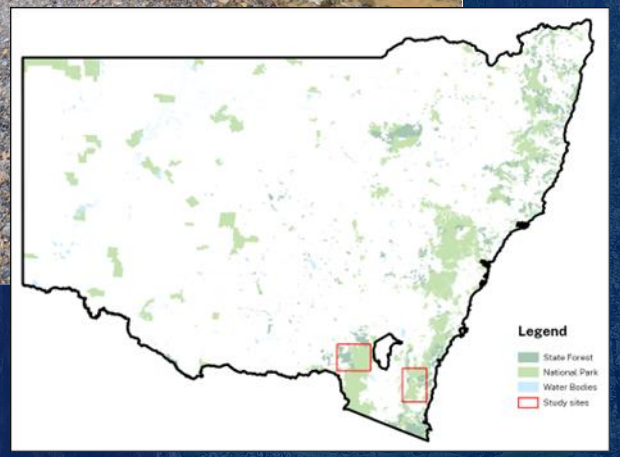
NSW GOVERNMENT Natural Resources Commission



Welcome

Coastal IFOA Monitoring Program 2023

Webinar 1: Forest waterways

Webinar will start shortly

NSW Forest Monitoring Steering Committee

Department of Primary Industries

Forestry Corporation

Planning and Environment

National Parks & Wildlife Service N.S.W.

Natural Resources Commission

Aboriginal Affairs

Local Land Services

The University of Melbourne

Australian National University

The University of Sydney

Forests and Waterways:
Managing erosion and sediment delivery from burned areas and forest roads

Webinar Hosted by the Natural Resources Commission

Petter Nyman[1,2]

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

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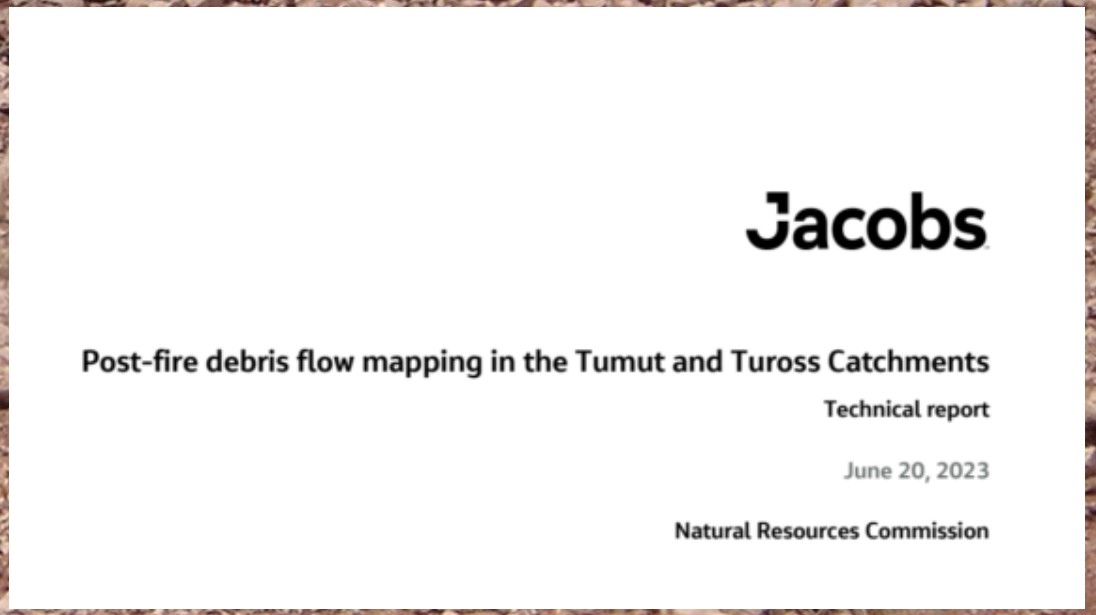
Overview

1. Post-fire debris flow mapping in southeast NSW forests
   - Project objectives
   - Debris flows and waterways: what is the issue?
   - Mapping debris flows as a method for quantifying landscape-scale response to bushfire
   - Debris flow response in the Tumut and Tuross catchments
   - Recommendations and ongoing model development
2. Tools for assessing and mitigating water quality risk from forest roads
   - Project objectives
   - Forest roads and waterways: what is the issue?
   - A model for assessing sediment delivery potential and mitigation options
   - Next steps and conclusion

Post-fire debris flow mapping in southeast NSW forests



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Jacobs

NSW GOVERNMENT Natural Resources Commission

Objectives

- To build a dataset for NSW that can be used in evaluating and modelling the impacts of bushfire on sediment delivery to waterways.
  - using **existing published methodology** for mapping erosion events that was developed in earlier research projects in Victoria and ACT.
  - **capitalize on the opportunity** for data collection that emerged with a large and high-severity 19/20 bushfires followed by several periods of intense rainfall.
  - **inform further empirical analyses** as well as the development and testing of post-fire catchment **risk assessment models.**

Recent bushfire events, a real concern for our waterways

Received: 24 February 2020 | Accepted: 1 July 2020
DOI: 10.1111/gcb.15282

LETTER TO THE EDITOR

Global Change Biology WILEY

Mortality events resulting from Australia's catastrophic fires threaten aquatic biota

Silva et al, 2022

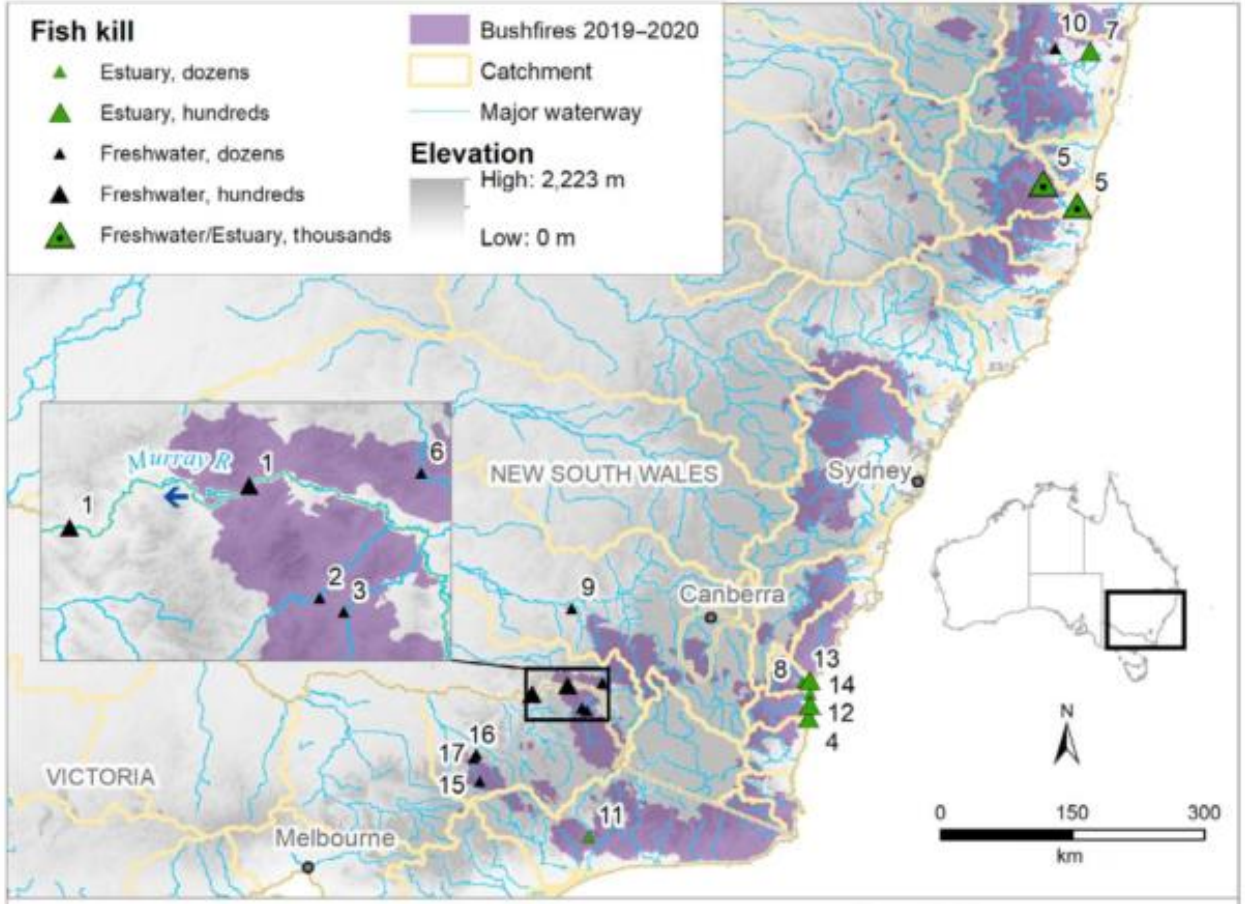


Figure 15. The Buckland River, a major tributary that delivered sediment from the upper Ovens catchment (pl credit. Kathy LeBusque)

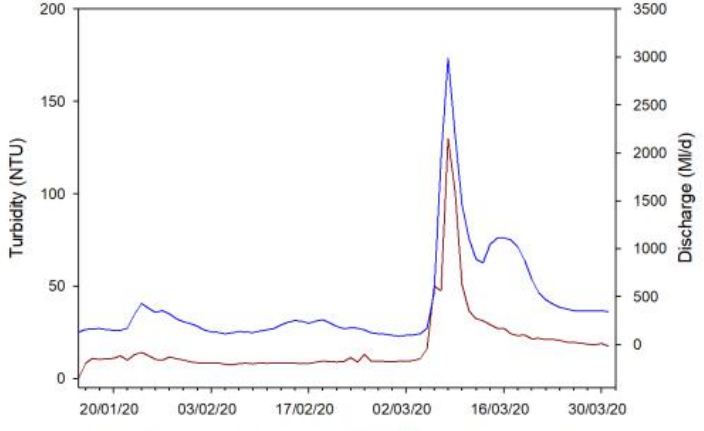
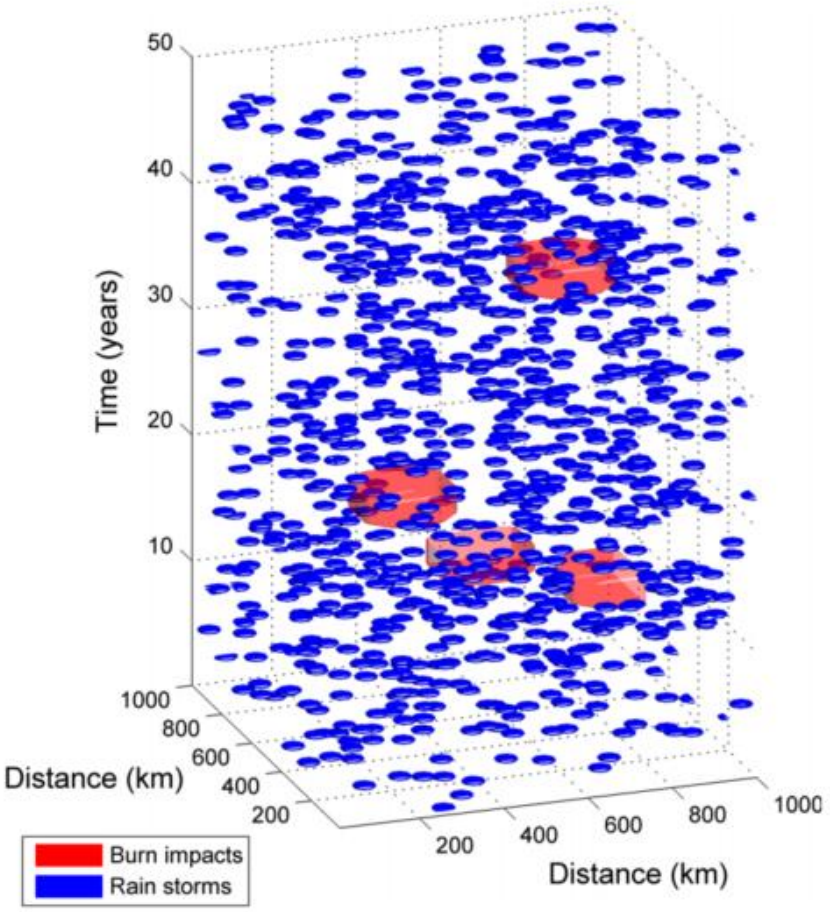


Figure 16. Discharge (blue line) and turbidity (brown line) in the lower Ovens river

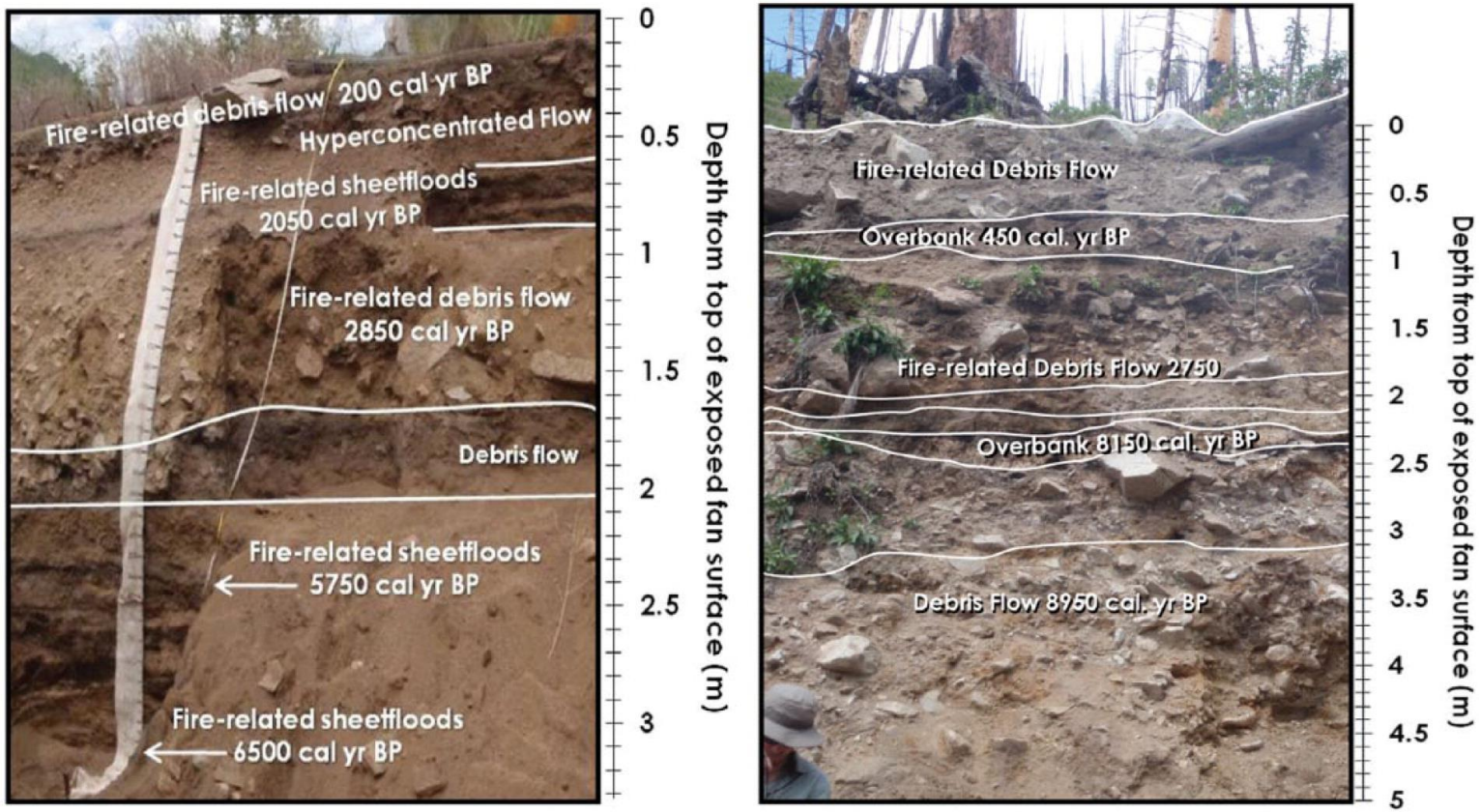
Joehnk et al, 2021

Background: why study post-fire debris flows?

Episodic and patchy erosion

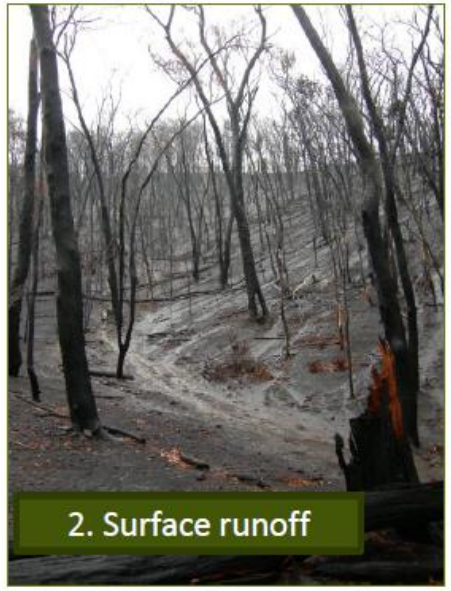


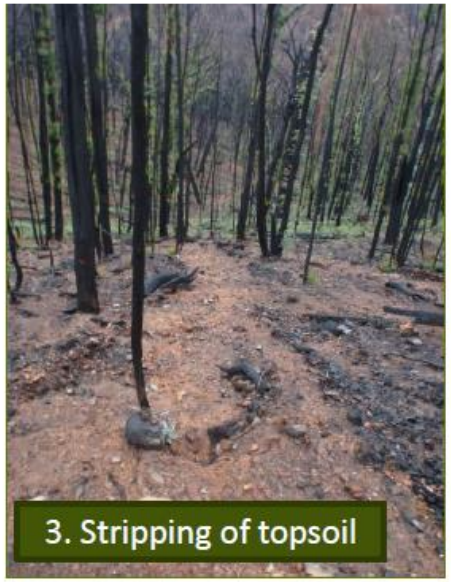
Jones et al, 2014 – fire and rainfall regimes



Riley et al, 2022 - Yellowstone

Background: what are post-fire debris flows?

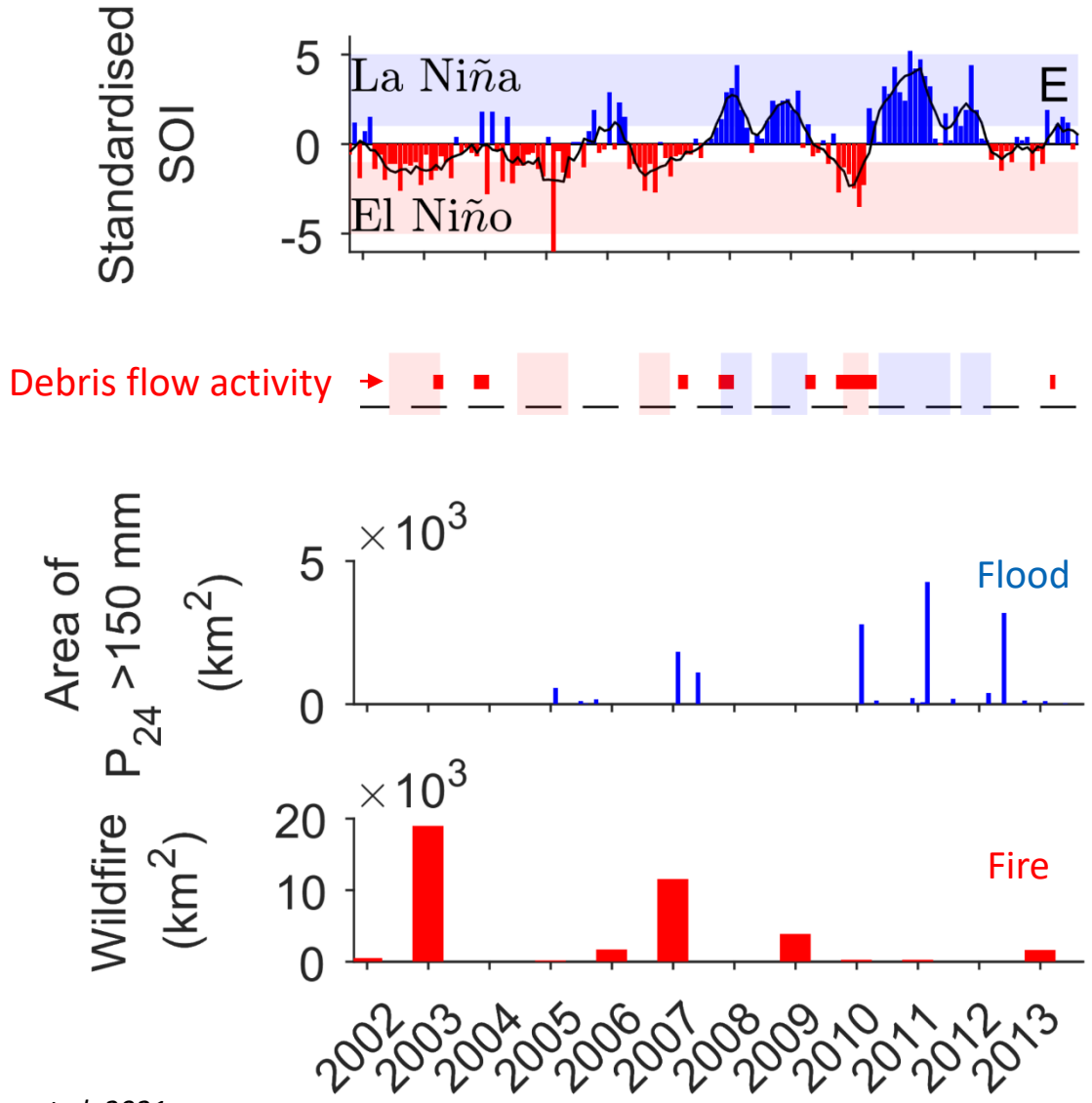




Debris flow in Tambo River Catchment (Feb 2020)

DELWP, 2020

Debris flows in SE Australia - regional context



Nyman et al, 2021

Periods of debris flow activity linked to regional hydroclimate (Nyman et al, 2019)

The future…

- **Intensification of ENSO**: Stronger and more frequent La Nina and El Nino
- **More downpours**. 15-20 % increase in hourly rainfall intensities per every degree of warming
- Higher temperatures and **more days with extreme fire weather**

Need baseline data to understand how catchments and waterways are impacted by regional hydroclimatic events and to identify how land management can contribute towards resilience

Research → consolidating/understanding → predictive models

Contents lists available at SciVerse ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Quantifying sources of fine sediment supplied to post-fire debris flows using fallout radionuclide tracers

Hugh G. Smith [a,b,*], Gary J. Sheridan [b], Petter Nyman [b], David P. Child [c], Patrick N.J. Lane [b], Michael A.C. Hotchkis [c], Geraldine E. Jacobsen [c]

[a] School of Geography, Earth and Environmental Sciences, University of Plymouth, Devon, PL4 8AA, UK
[b] Department of Forest and Ecosystem Science, The University of Melbourne, Victoria, 3010, Australia
[c] Institute for Environmental Research, Australian Nuclear Science and Technology Organisation, Lucas Heights, New South Wales, 2234, Australia

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Predicting sediment delivery from debris flows after wildfire

Petter Nyman [a,b,*], Hugh G. Smith [c], Christopher B. Sherwin [a,b], Christoph Langhans [a], Patrick N.J. Lane [a], Gary J. Sheridan [a,b]

[a] School of Ecosystems and Forest Sciences, University of Melbourne, Carlton, Victoria 3010, Australia
[b] Bushfire Cooperative Research Centre, 340 Albert Street, East Melbourne, Victoria 3002, Australia
[c] School of Environmental Sciences, University of Liverpool, L69 7ZT, UK

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Published online 5 April 2019

Debris flows in southeast Australia linked to drought, wildfire, and the El Niño–Southern Oscillation

Petter Nyman[1], Ian D. Rutherfurd[2], Patrick N.J. Lane[1], and Gary J. Sheridan[1]
[1]School of Ecosystem and Forest Sciences, University of Melbourne, Parkville, Victoria 3010, Australia
[2]School of Geography, University of Melbourne, Parkville, Victoria 3010, Australia

Journal of Hydrology 534 (2016) 407–426

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

A model for assessing water quality risk in catchments prone to wildfire

Christoph Langhans [a,*], Hugh G. Smith [b], Derek M.O. Chong [a], Petter Nyman [a], Patrick N.J. Lane [a], Gary J. Sheridan [a]

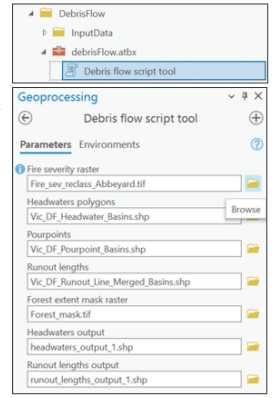
[a] School of Ecosystem and Forest Sciences, University of Melbourne, 3010 Parkville, Victoria, Australia
[b] School of Environmental Sciences, University of Liverpool, Liverpool L69 7ZT, UK

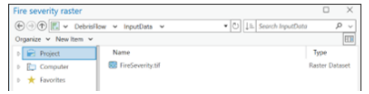
```
#### HEADWATERS ####
# Calculate debris flow AEP from fire severity.
# Reclassify fire severity raster to dNBR.
# Reclassification values (FROM, TO, NEW VALUE)
arcpy.AddMessage('Reclassifying input from fire severity to dNBR')
remaplist = RemapValue([[0, 0, 0], [1, 1, 100], [2, 2, 200], [3, 3, 400], [4, 4, 800], [5, 5, 1000]])
reclass = Reclassify("sevForest", "Value", remaplist, "DATA")

# Get pourpoints within burn area
arcpy.CopyFeatures_management(pourPoints, "pourpointsSub")
# Pourpoints fields to keep
keep = ["PourP_ID", "dNBR_U", "dNBR_L", "dNBR_H", "DF_AEP_U", "DF_AEP_L", "DF_AEP_H", "BASIN_NAME", "Slope",
        "Aridity", "HeadW_ID", "I12_c_U", "I12_c_L", "I12_c_H"]
fieldsList = []
fieldObjList = arcpy.ListFields("pourpointsSub")
# Loop through fields in pourpoints, deleting fields that are not required and are not in keep list.
for field in fieldObjList:
    if (not field.name in keep) and (not field.required):
        fieldsList.append(field.name)
arcpy.DeleteField_management("pourpointsSub", fieldsList)
arcpy.MakeFeatureLayer_management("pourpointsSub", "pourpointsSub")

# Get headwaters within burn area
arcpy.CopyFeatures_management(headWaters, "headwatersSub")
arcpy.MakeFeatureLayer_management("headwatersSub", "headwatersSub")

# Create zonal statistics using headwaters polygons and reclassified raster to calculate median dNBR for each
# headwaters polygon.
arcpy.AddMessage("Creating zonal statistics table using headwaters")
arcpy.sa.ZonalStatisticsAsTable("headwatersSub", "HeadW_ID", reclass, "zonalTable", "DATA", "MEDIAN")
# Perform join between pourpoints and zonal table
arcpy.AddMessage("Joining zonal stats to pourpoints")
arcpy.management.JoinField("pourpointsSub", "HeadW_ID", "zonalTable", "HeadW_ID", "MEDIAN")
# Assign AEP to pourpoint based on median dNBR from raster/headwaters zonal stats
# (U = unburnt, L =  low severity, H = high severity)
dnbr_u = 100
dnbr_l = 400
dnbr_h = 800
# Create list to pass into field calculator code block
dnbrList = [dnbr_u, dnbr_l, dnbr_h]
# String expression to pass into field calculator algorithm
exp = """assignAEP(!medDNBR!,
         {0},
         !DF_AEP_U!,
         !DF_AEP_L!,
         !DF_AEP_H!)""".format(dnbrList)
# This code block assigns the exceedance probability that most closely corresponds to burn severity to a new
# "dflow_AEP" attribute.
cb = """def assignAEP (meddNBR, dnbrList, dnbrU, dnbrL, dnbrH):
    if (min(dnbrList, key=lambda x:abs(x-meddNBR)) == dnbrList[0]):
        return dnbrU
    elif (min(dnbrList, key=lambda x:abs(x-meddNBR)) == dnbrList[1]):
        return dnbrL
    elif (min(dnbrList, key=lambda x:abs(x-meddNBR)) == dnbrList[2]):
        return dnbrH"""
# Assign relevant AEP based on median headwaters dNBR
arcpy.AddMessage('Assigning relevant debris flow AEP to headwater polygons')
arcpy.AlterField_management("pourpointsSub", "MEDIAN", "medDNBR", "Median dNBR")
arcpy.AddField_management("pourpointsSub", "dflow_AEP", "DOUBLE", "", "", "10")
arcpy.CalculateField_management("pourpointsSub", "dflow_AEP", exp, "PYTHON", cb)
```

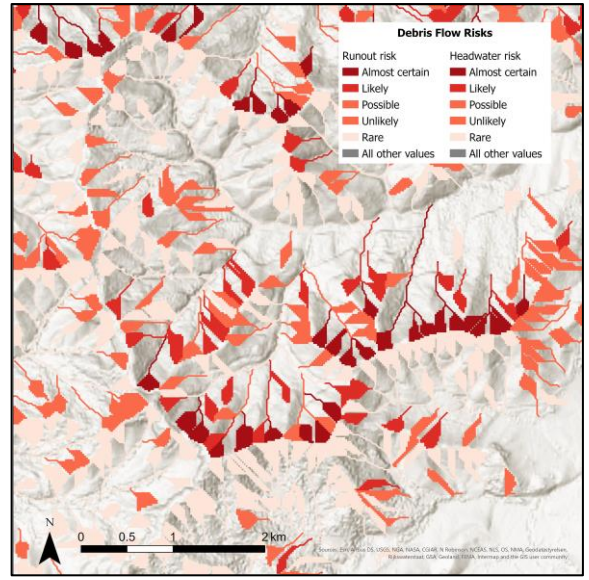
4.1 Debris Flow Tool inputs

The following steps describe how to open the Debris Flow Tool and add the user inputs to the Tool.

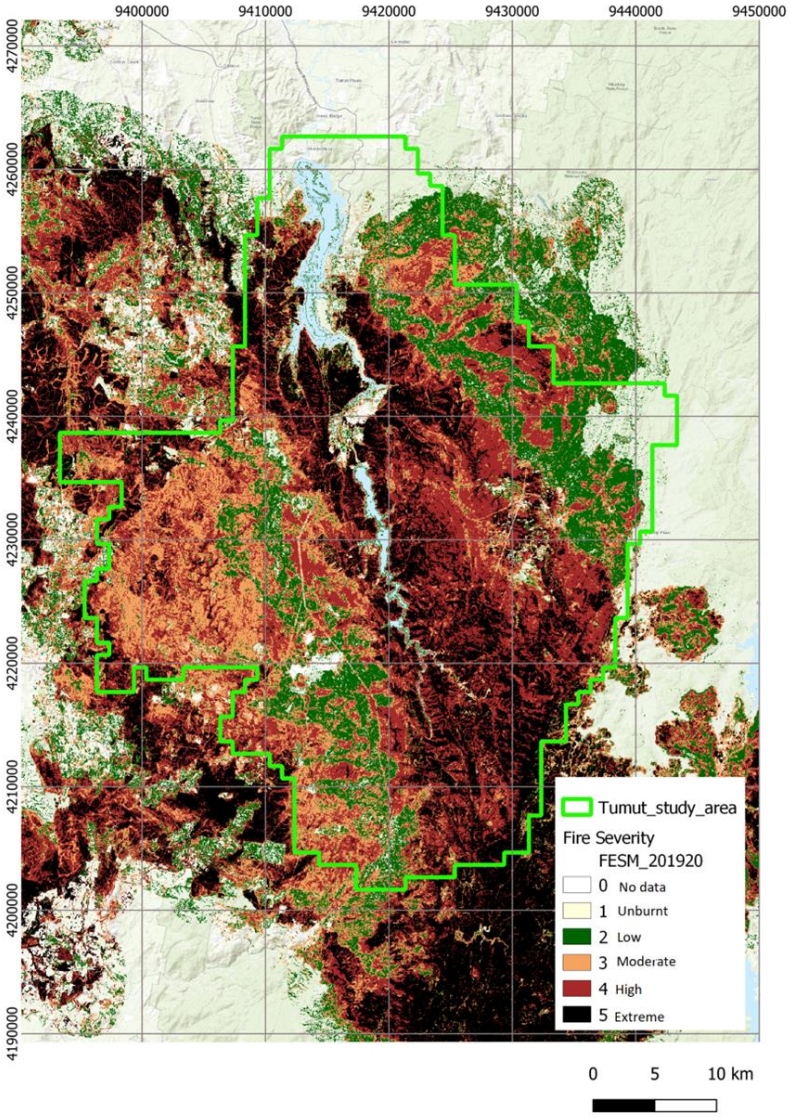
- Double click on the Debris Flow toolbox under the new folder connection in the Catalog pane
- Double click on the script to open the Debris Flow Tool under the Geoprocessing pane
- For each of the following input parameters, click on the folder icon to find the input file on your computer and click "OK" to add the input file to the Tool (see example for Fire severity raster):
  - Fire severity raster (this is the only file you need to find for your catchment area of interest)
  - Headwaters polygons
  - Pourpoints
  - Runout lengths
  - Forest extent mask
- For each of the following output parameters, click on the folder icon to select a location to put the output file on your computer:
  - Headwaters output
  - Runout lengths output
- Choose a name for each output file and click "OK" to save the location and name of each output file



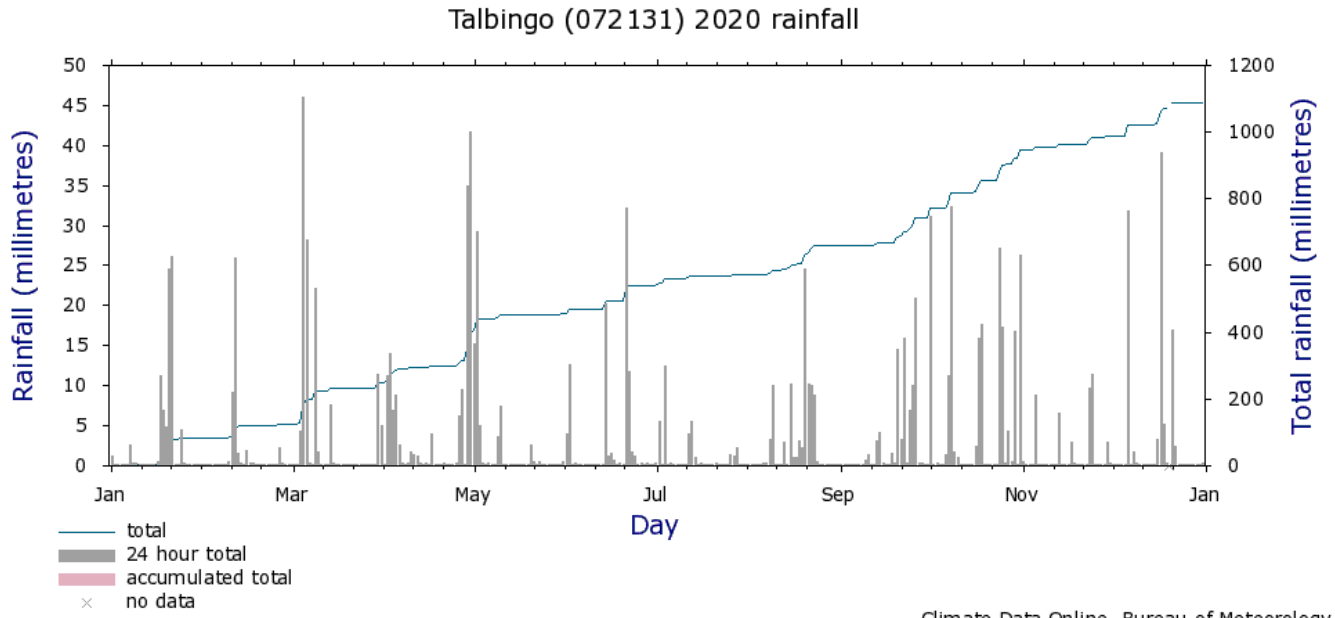




Debris flow mapping in southeast NSW – Tumut

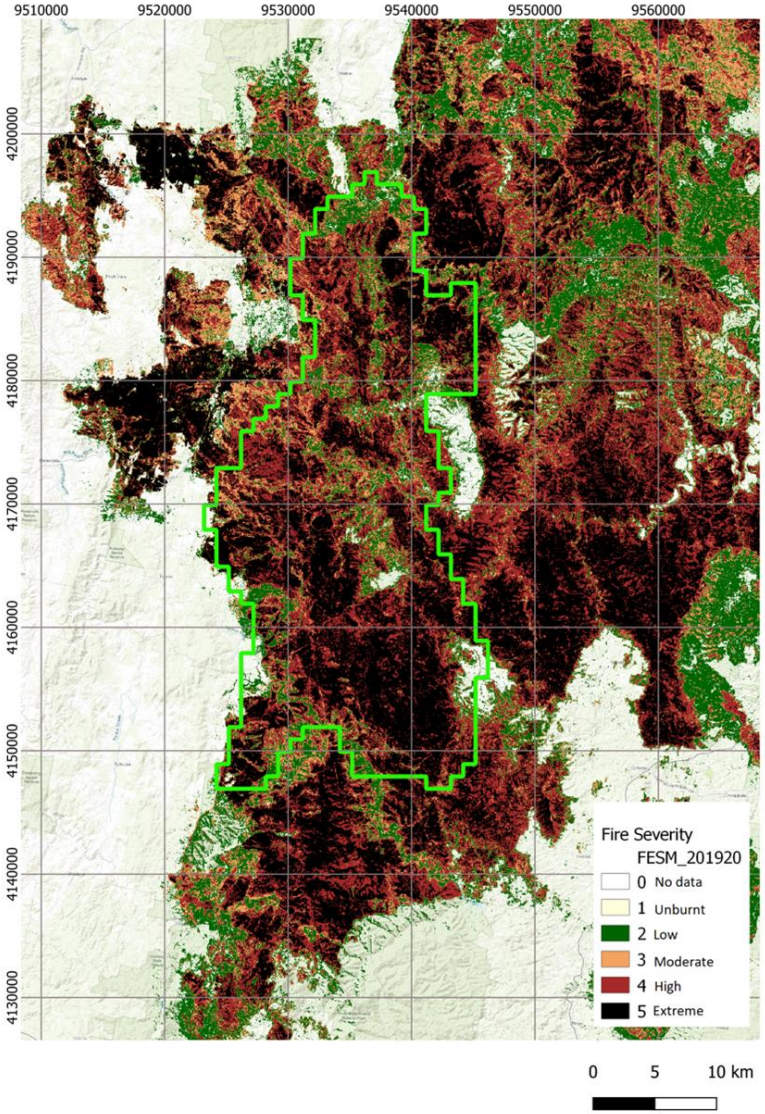


- Post-fire aerial imagery (10-15cm resolution) was captured for an area of about 1735 sqkm
- Large band of extreme fire severity fire (with full canopy consumption)
- Mixed forest types (18% wet; 67% dry; 13% non-native)
- Mean annual rainfall 950 to 1350 mm
- Some areas with extensive unsealed road networks

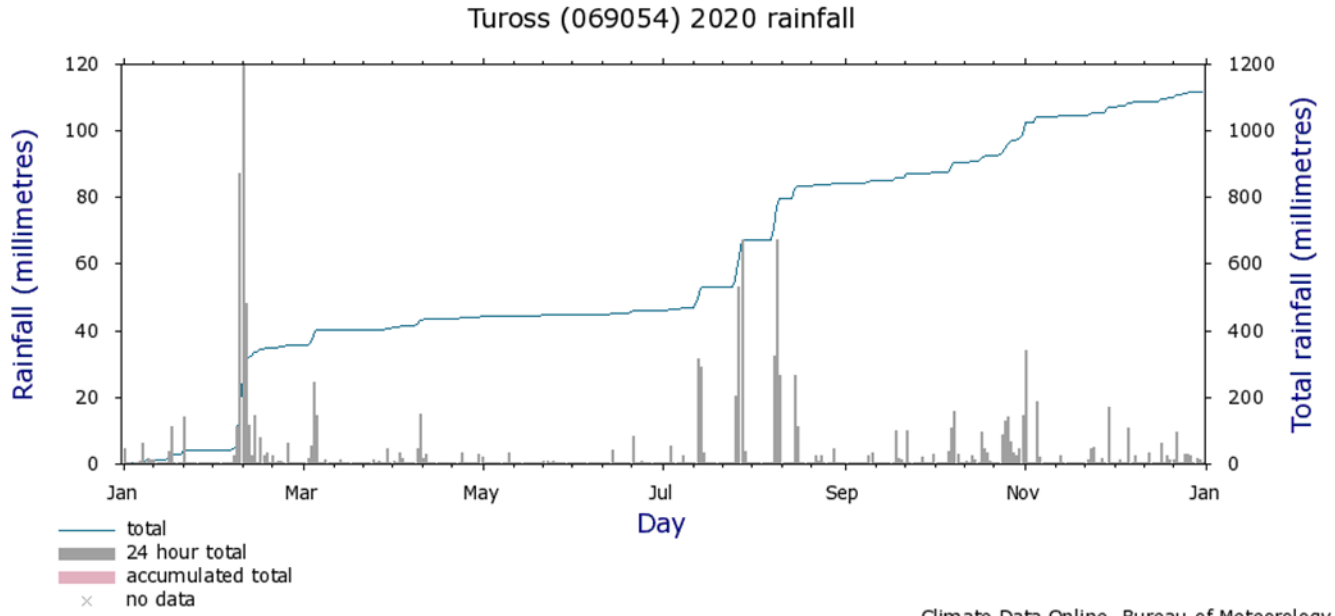


Note: Data may not have completed quality control.

Debris flow mapping in southeast NSW – Tuross

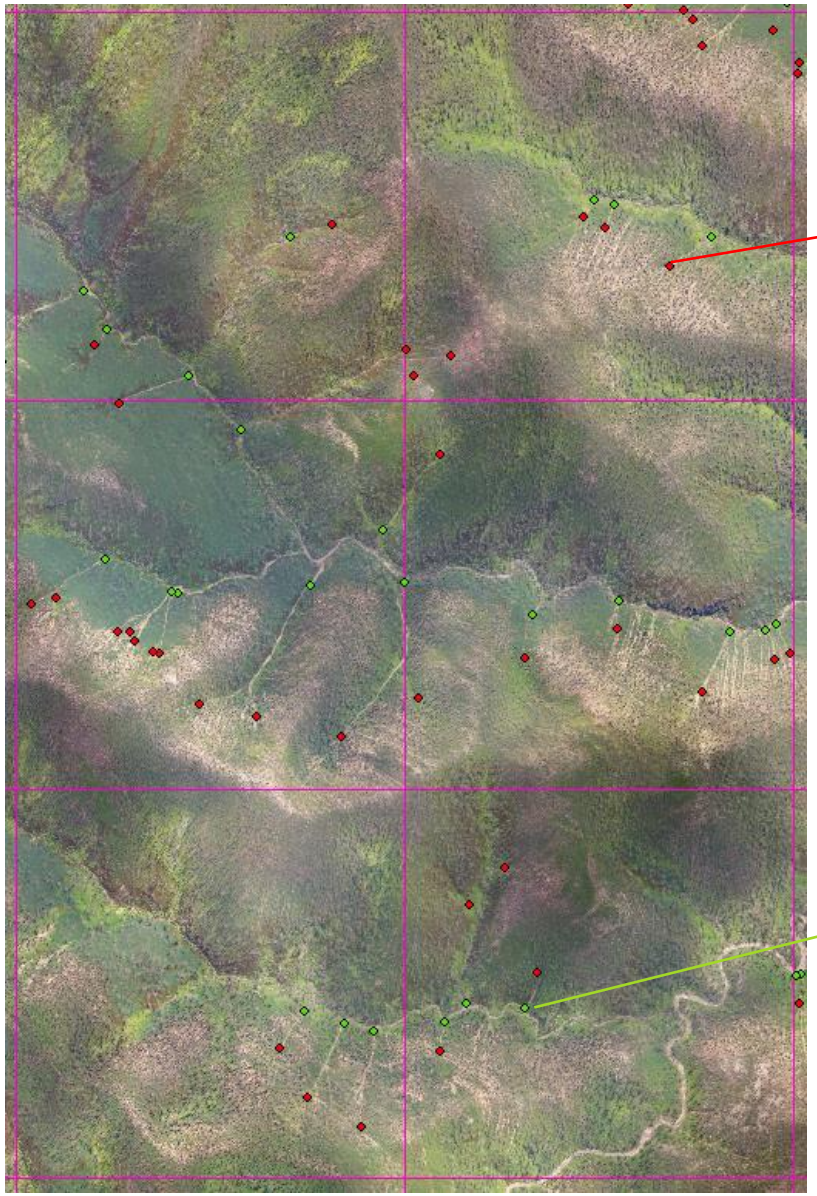


- Post-fire aerial imagery (10-15cm resolution) was captured for an area of about 737 sqkm
- Extreme fire severity in large proportion of the area
- Mostly native forest (33% wet; 60% dry; 3% non-native)
- Mean annual rainfall 800 to 1000 mm.
- Few roads



Note: Data may not have completed quality control.

Debris flow mapping in southeast NSW



Debris flow initiation point

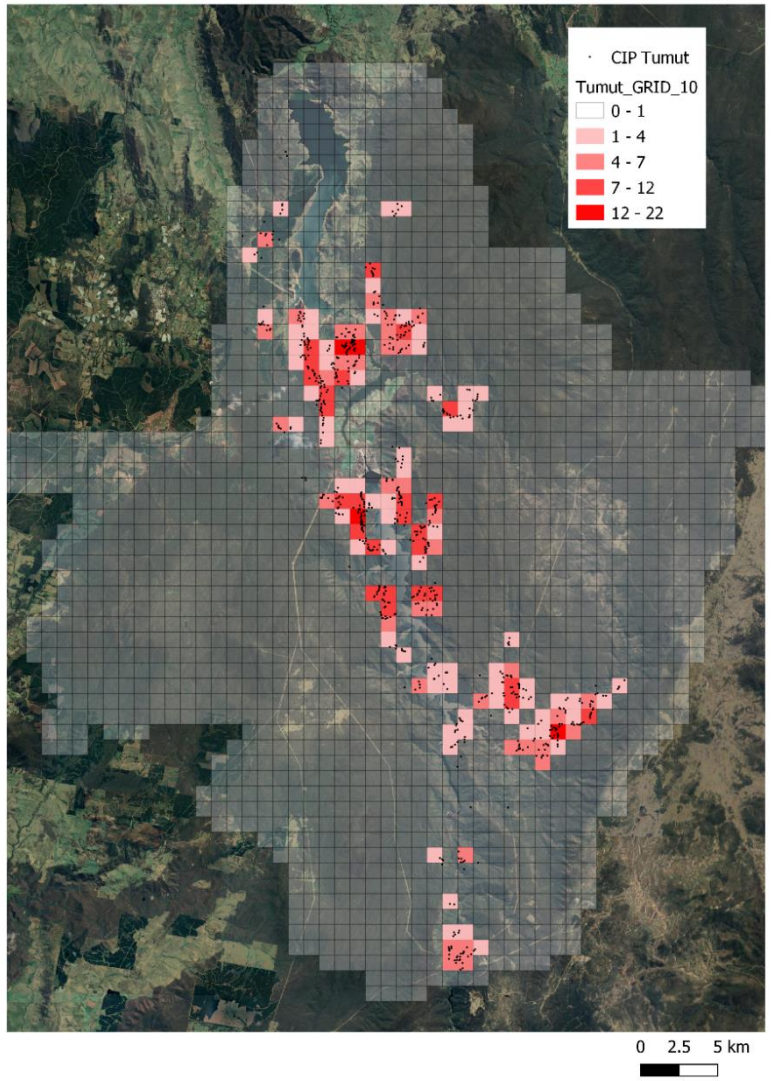
where it starts

Debris flow fan

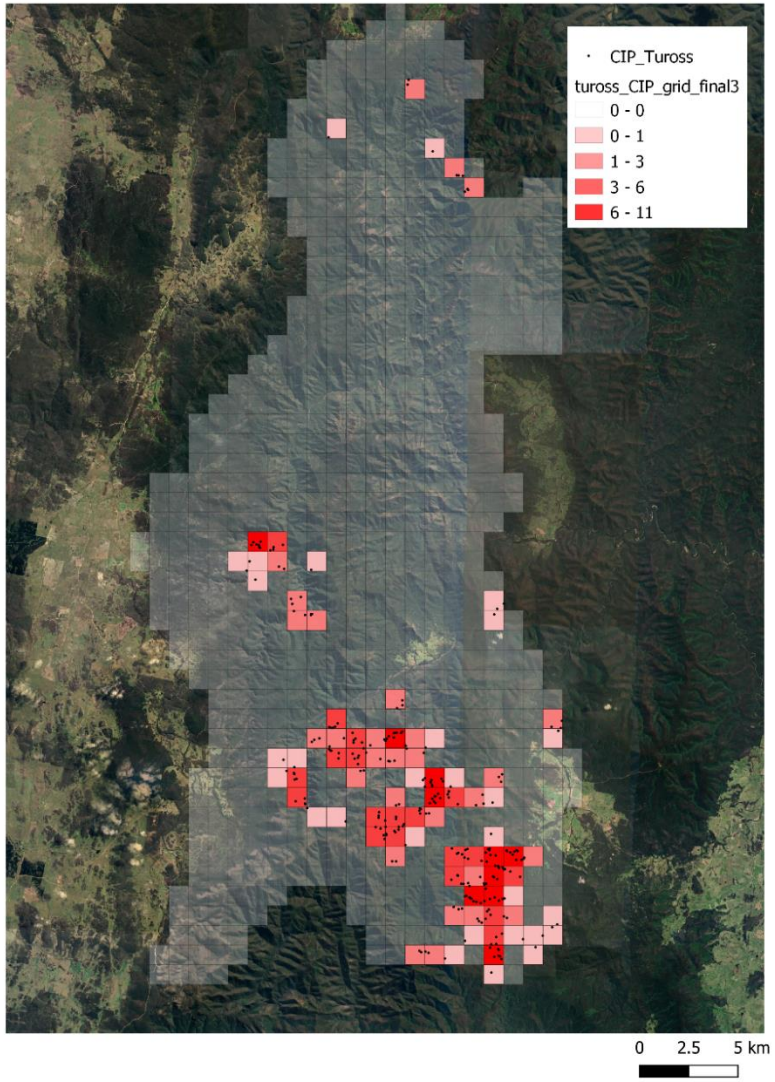
where it ends

Debris flow densities in southeast NSW

Tumut

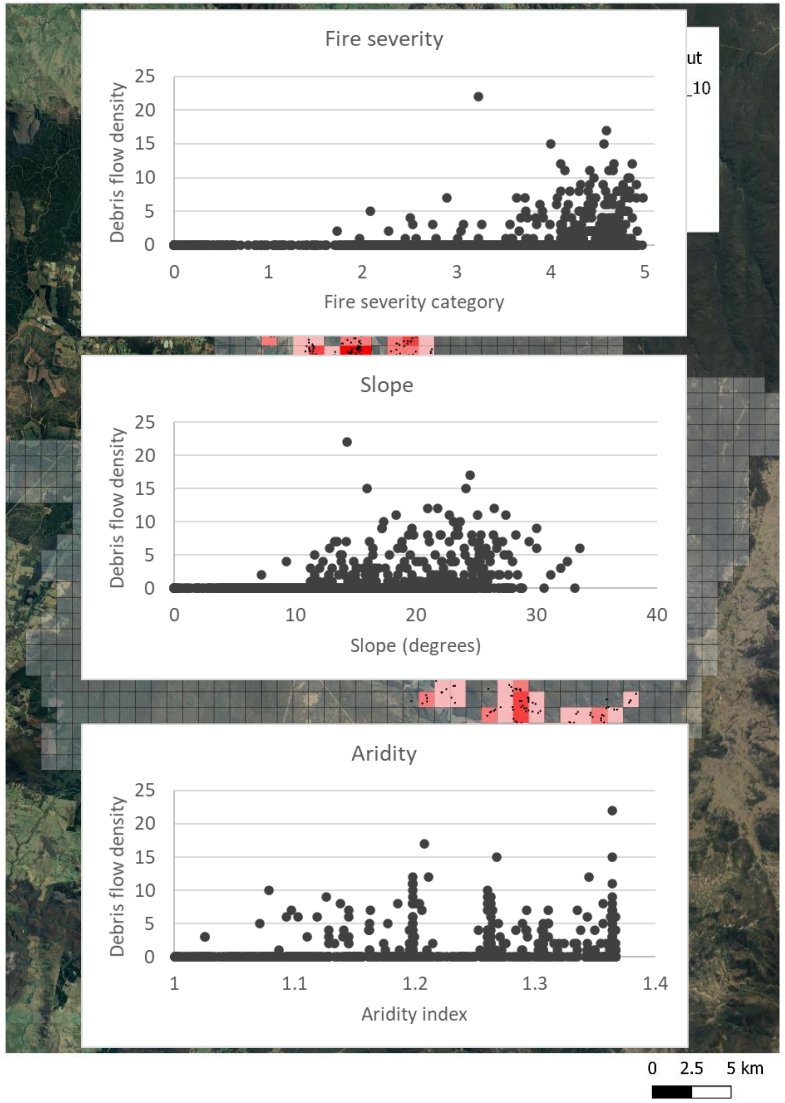


Tuross

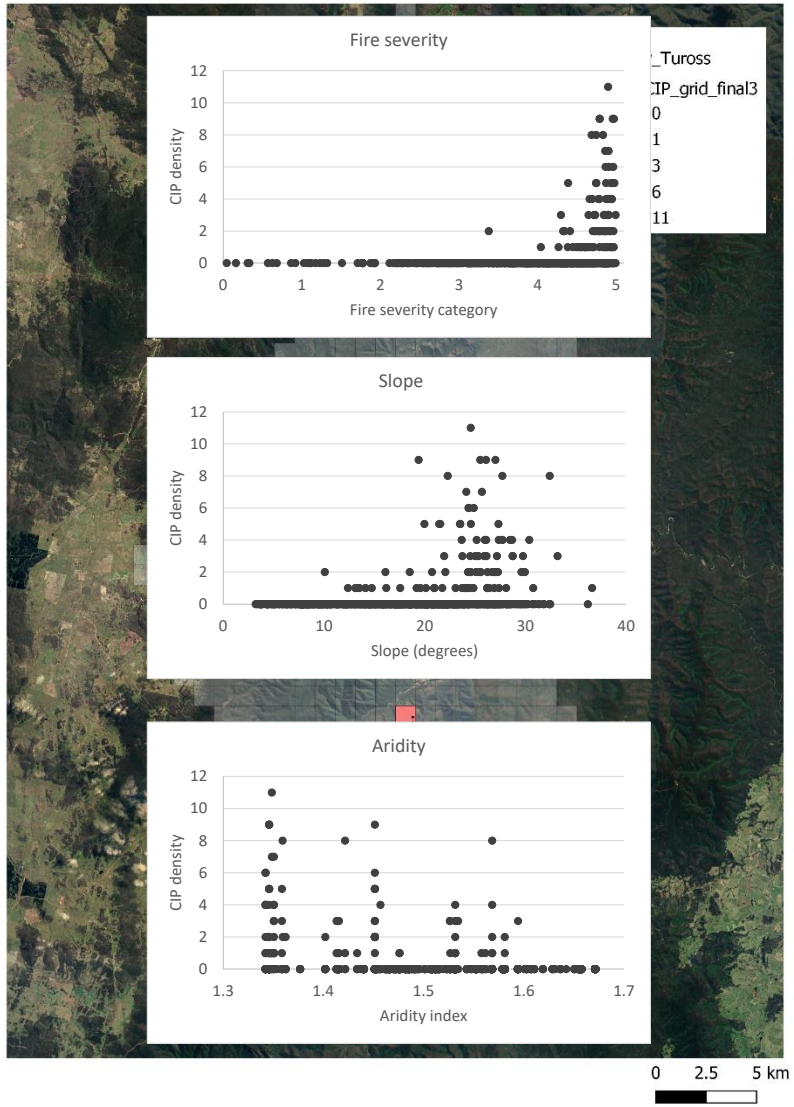


Debris flow densities in southeast NSW

Tumut



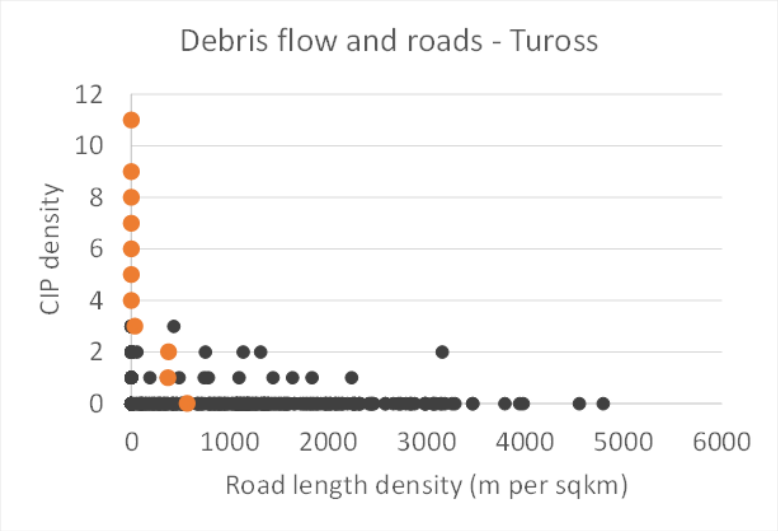
Tuross

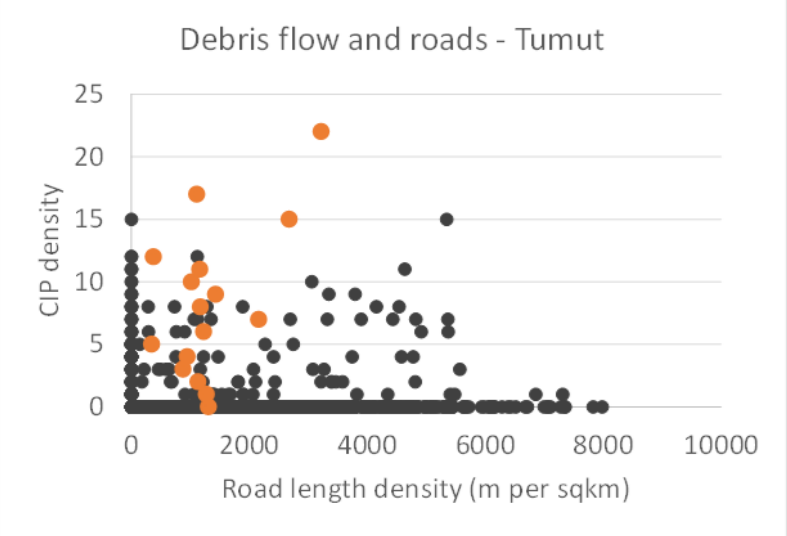


Debris flow densities in southeast NSW

Effects of forest roads, land use and forest cover – **preliminary** assessment

Forest roads →





Forest type →

Geology →

Attribute	Area (sqkm)	% of area	Debris flow density (#/sqkm)
Vegetation			
Wet forest	208	33	0.15
Dry forest	441	60	0.55
Non-native	20	3	0.00
Lithology			
Igneous	372	50	0.03
Metamorphic	364	49	0.72

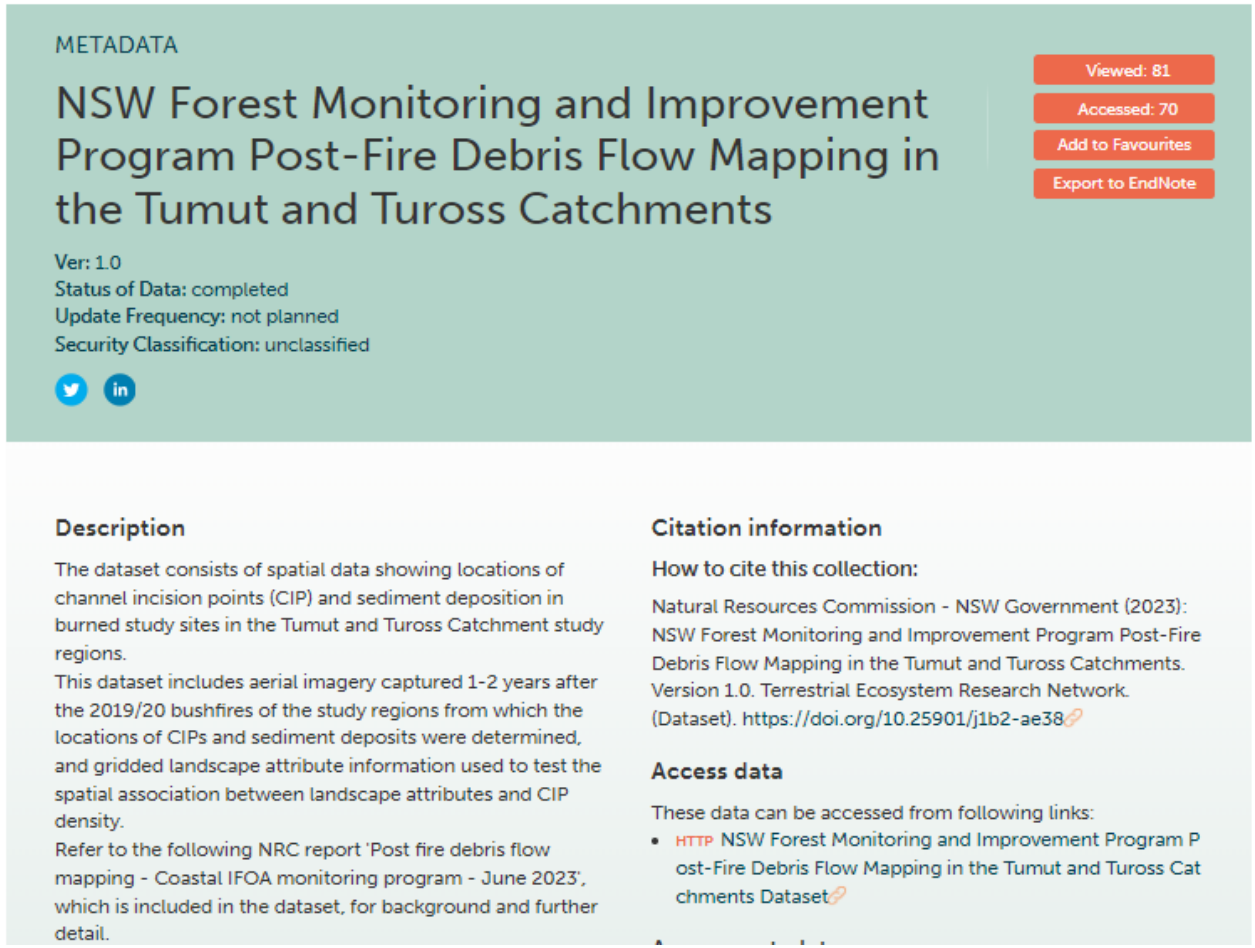
Attribute	Area	% of area	Debris flow density (#/sqkm)
Vegetation			
Wet forest	316	18	0.03
Dry forest	1162	67	0.58
Non-native	242	13	0.43
Lithology			
Igneous	1345	78	0.41
Metamorphic	355	21	0.65

Debris flow densities in southeast NSW

tern
Ecosystem Research Infrastructure

Data Discovery

https://portal.tern.org.au/metadata/TERN/13884dec-2031-4cdf-9041-f1fe82210d77



METADATA

NSW Forest Monitoring and Improvement Program Post-Fire Debris Flow Mapping in the Tumut and Tuross Catchments

Viewed: 81
Accessed: 70
Add to Favourites
Export to EndNote

Ver: 1.0
Status of Data: completed
Update Frequency: not planned
Security Classification: unclassified

Description

The dataset consists of spatial data showing locations of channel incision points (CIP) and sediment deposition in burned study sites in the Tumut and Tuross Catchment study regions.
This dataset includes aerial imagery captured 1-2 years after the 2019/20 bushfires of the study regions from which the locations of CIPs and sediment deposits were determined, and gridded landscape attribute information used to test the spatial association between landscape attributes and CIP density.
Refer to the following NRC report 'Post fire debris flow mapping - Coastal IFOA monitoring program - June 2023', which is included in the dataset, for background and further detail.

Citation information

How to cite this collection:

Natural Resources Commission - NSW Government (2023): NSW Forest Monitoring and Improvement Program Post-Fire Debris Flow Mapping in the Tumut and Tuross Catchments. Version 1.0. Terrestrial Ecosystem Research Network. (Dataset). https://doi.org/10.25901/j1b2-ae38

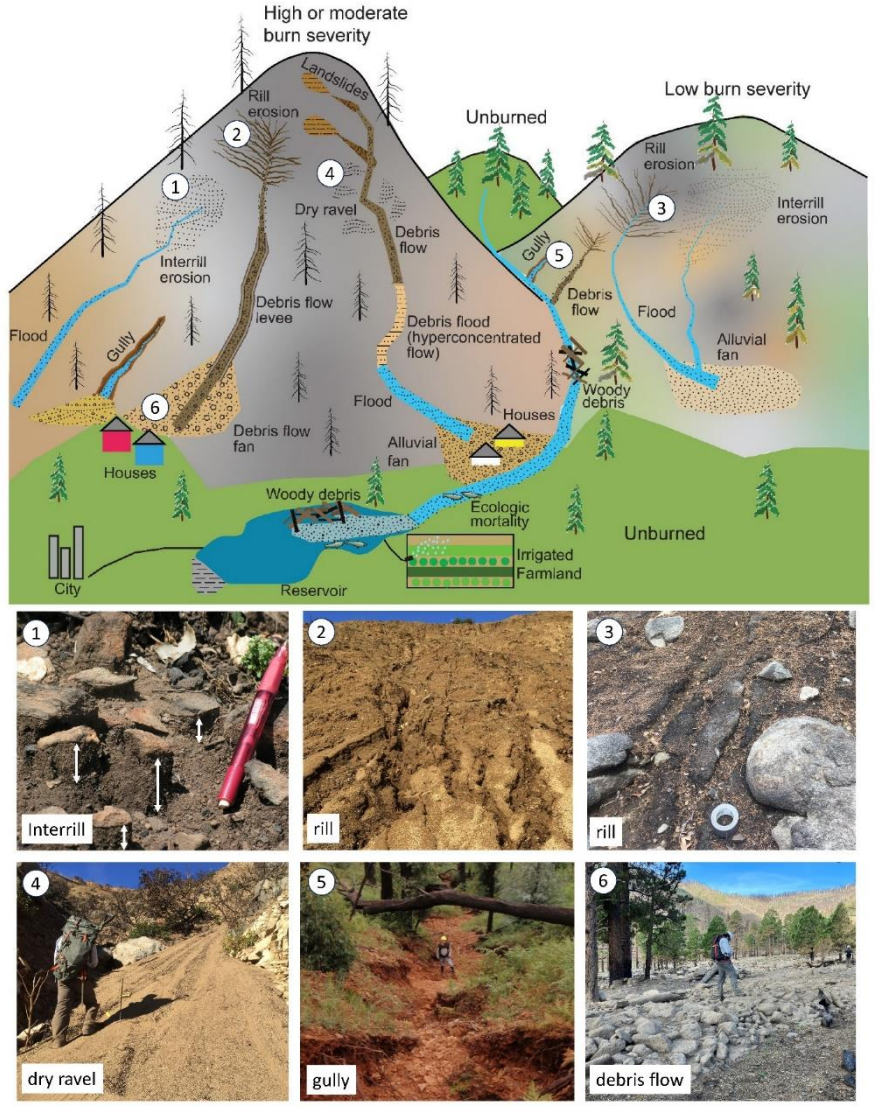
Access data

These data can be accessed from following links:

- HTTP NSW Forest Monitoring and Improvement Program Post-Fire Debris Flow Mapping in the Tumut and Tuross Catchments Dataset

Recommendations

- Use datasets to **conduct empirical analyses** that quantify the relative importance of fire severity, terrain, aridity, geology, and anthropogenic factors in causing variability in debris flow frequency. Develop high-resolution aridity index for NSW.
- Develop **conceptual models of sediment dynamics** in forested catchments of NSW, considering disturbance events and management activities that might promote catchment resilience
- Initiate research programs for **quantifying sediment sources and building sediment budgets** for forested catchments
- **Facilitate a process for knowledge exchange** and data sharing amongst relevant agencies and researchers
- **Water quality monitoring programs coupled with opportunistic field campaigns** to better understand the ecological implications and water supply risks associated with sediment pulses



McGuire et al, in review

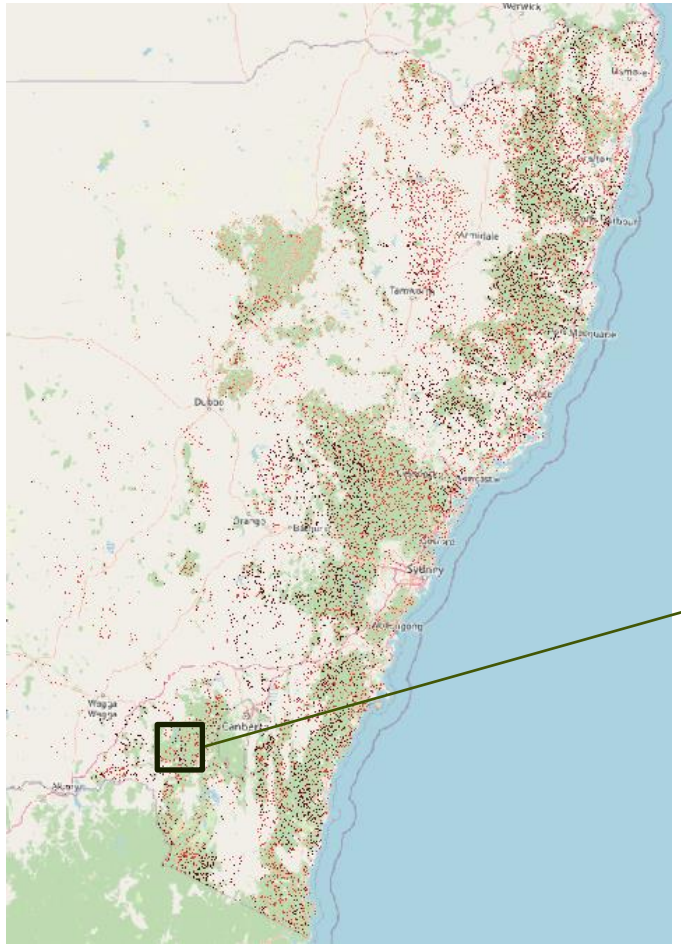
Outcomes to date – susceptibility model v1

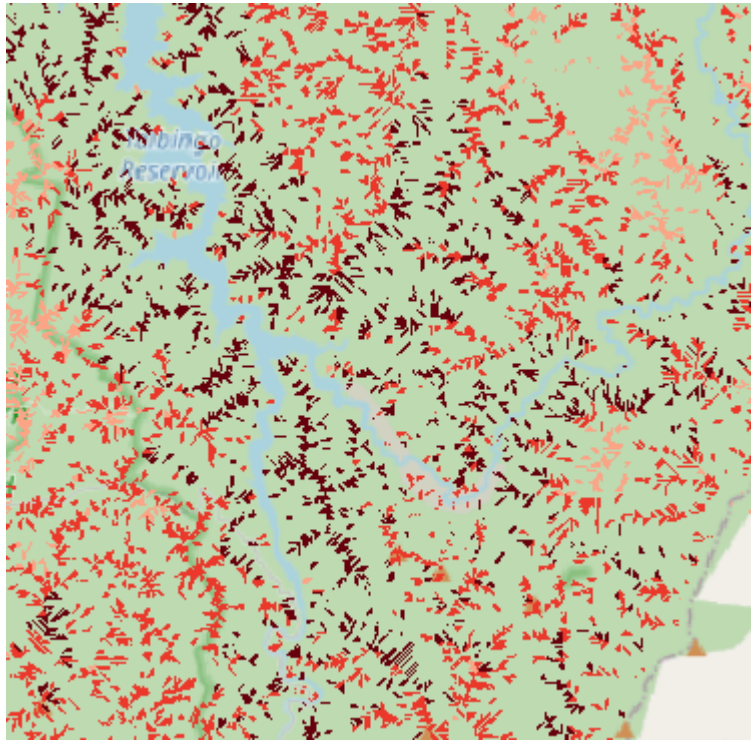
Neda Sharifi Soltani (neda.sharifisoltani@environment.nsw.gov.au) & Zacchary Larkin
Estuaries & Catchments Team | Water, Wetlands & Coastal Branch | Science, Economics and Insights Division |

Post-fire debris flow susceptibility model for NSW developed and tested using data and methods outlined in the NRC report.

Logistic regression:

- Aridity index layer
- Slope (created based on DEM 5 meter)
- Fire severity
- K-factor Rusle (soil erodibility factor)
- Geology (dominant lithology)



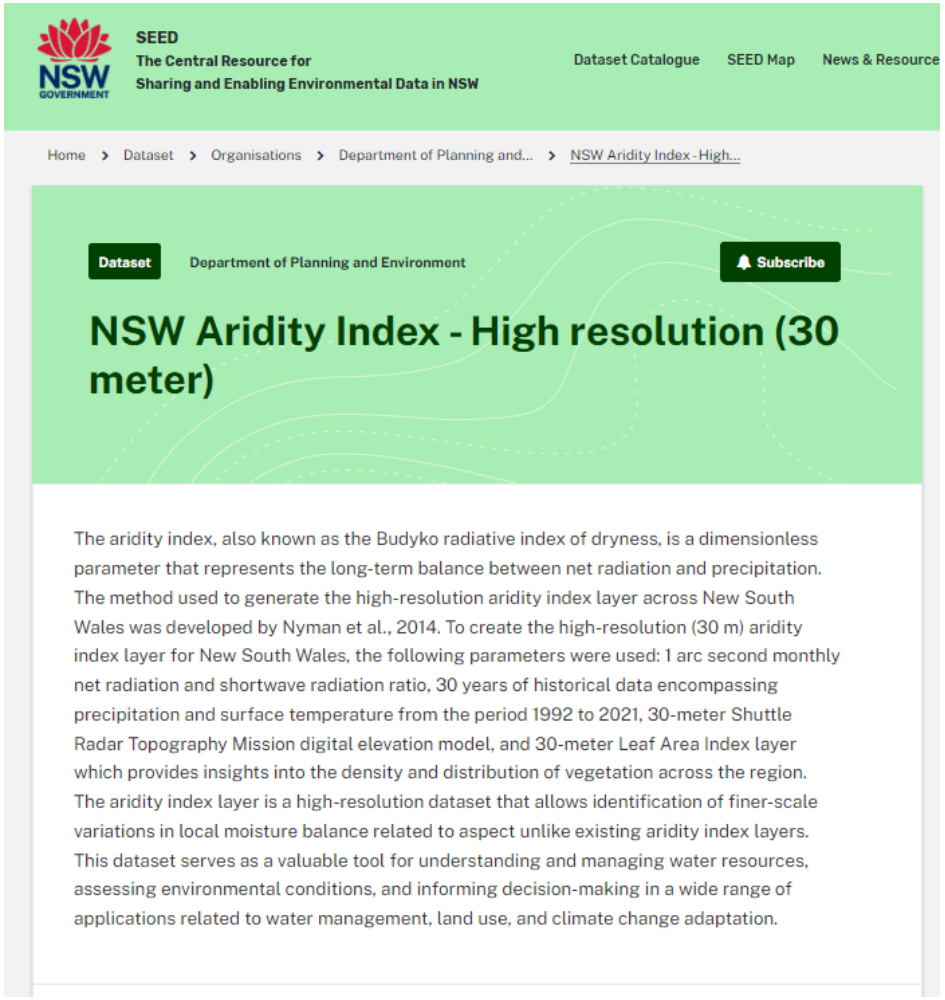


Debris flow likelihood

- High
- Moderate
- Low

Outcomes to date

Neda Sharifi Soltani (neda.sharifisoltani@environment.nsw.gov.au) & Zacchary Larkin
Estuaries & Catchments Team | Water, Wetlands & Coastal Branch | Science, Economics and Insights Division |



Tools for assessing and mitigating water quality risk from forest roads

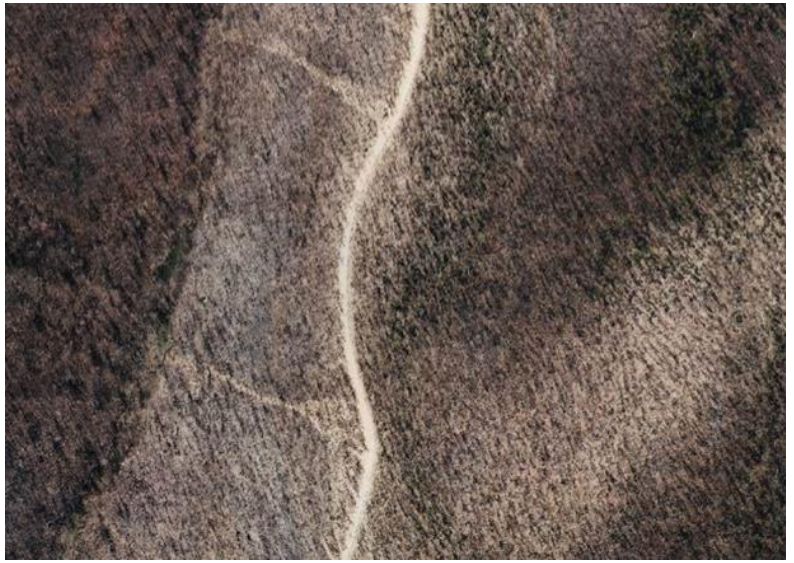
alluvium

THE UNIVERSITY OF MELBOURNE

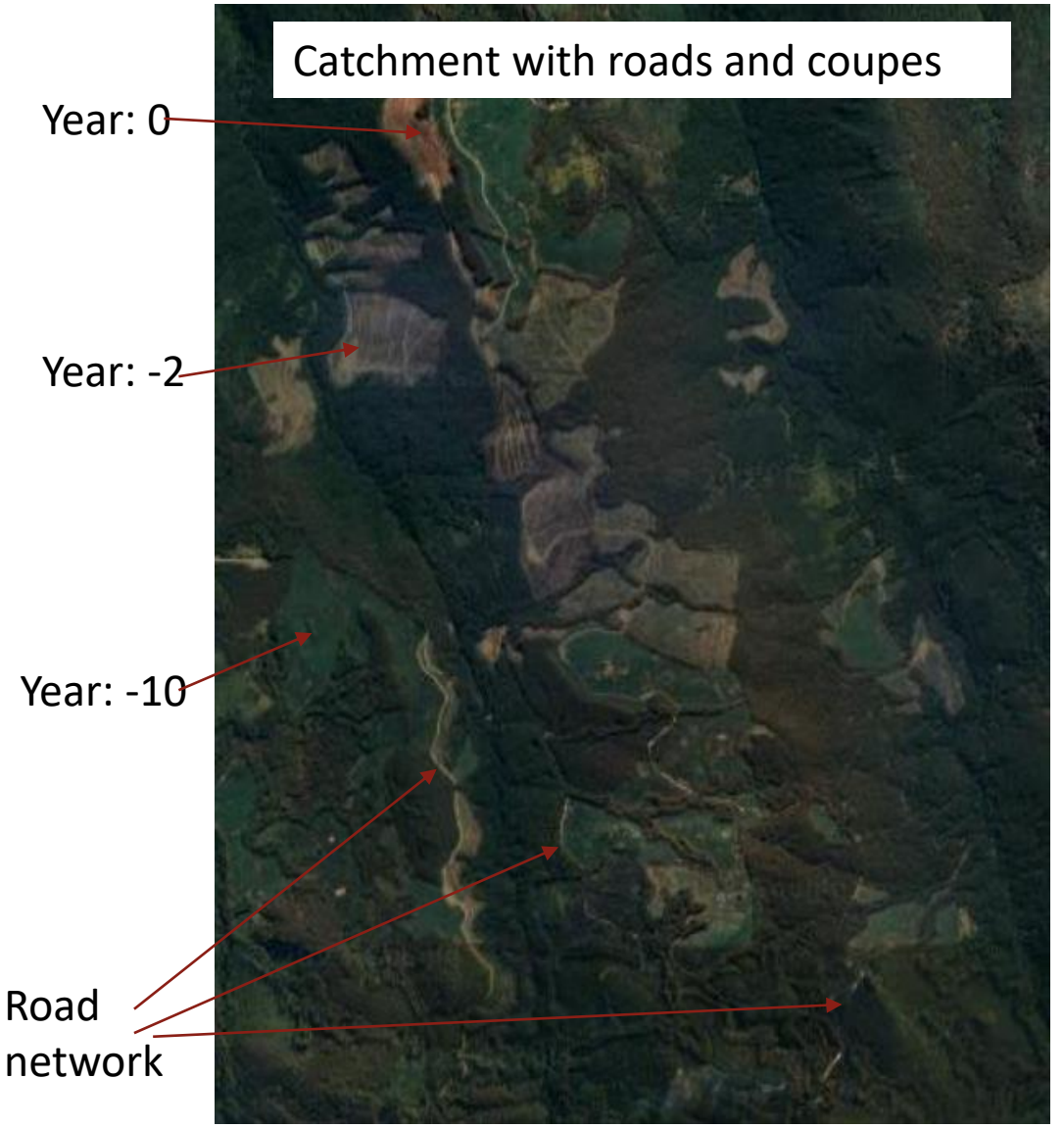
NSW GOVERNMENT Natural Resources Commission

Objectives

- To develop an evidence-based methodology to assess the effectiveness of forest road network design and management in reducing impact on in-stream water quality. Specifically:
  - **apply existing methods to ensure forest road network design and management maintains catchment functions in providing high quality surface water.**
  - *Field component: establish a field survey method to assess the adequacy of existing road drainage to reduce soil erosion and protect water quality,*
  - *Field component: select and assess a sample of forest road networks across different forest tenures in NSW,*
  - **present the findings and suggestions for the adaptation of forest road network design and management to improve mitigation effectiveness**
- The methodology for evaluating the forest road network is developed as part of a broader program in the IFOA for monitoring and evaluating waterway health in relation to forest management and timber harvesting.



The issue: soil disturbance, roads and erosion



The issue: soil disturbance, roads and erosion

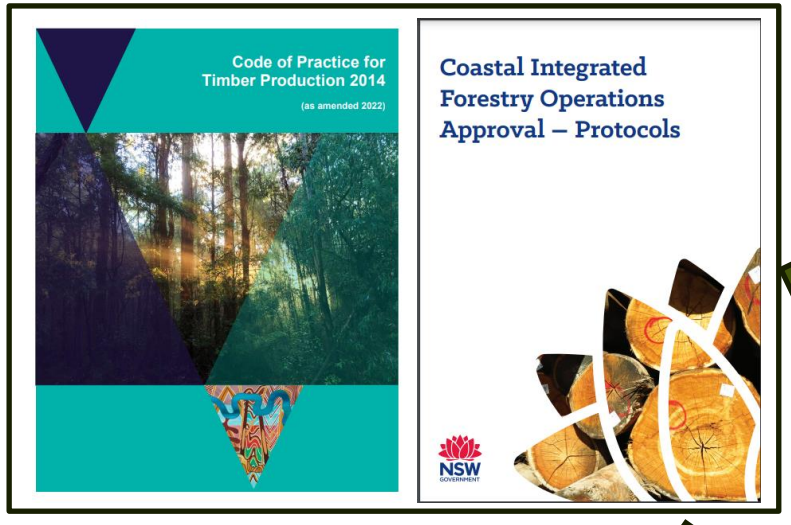
Inadequate drainage → erosion from roads surfaces

Channelized 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

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. **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*

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

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*

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*

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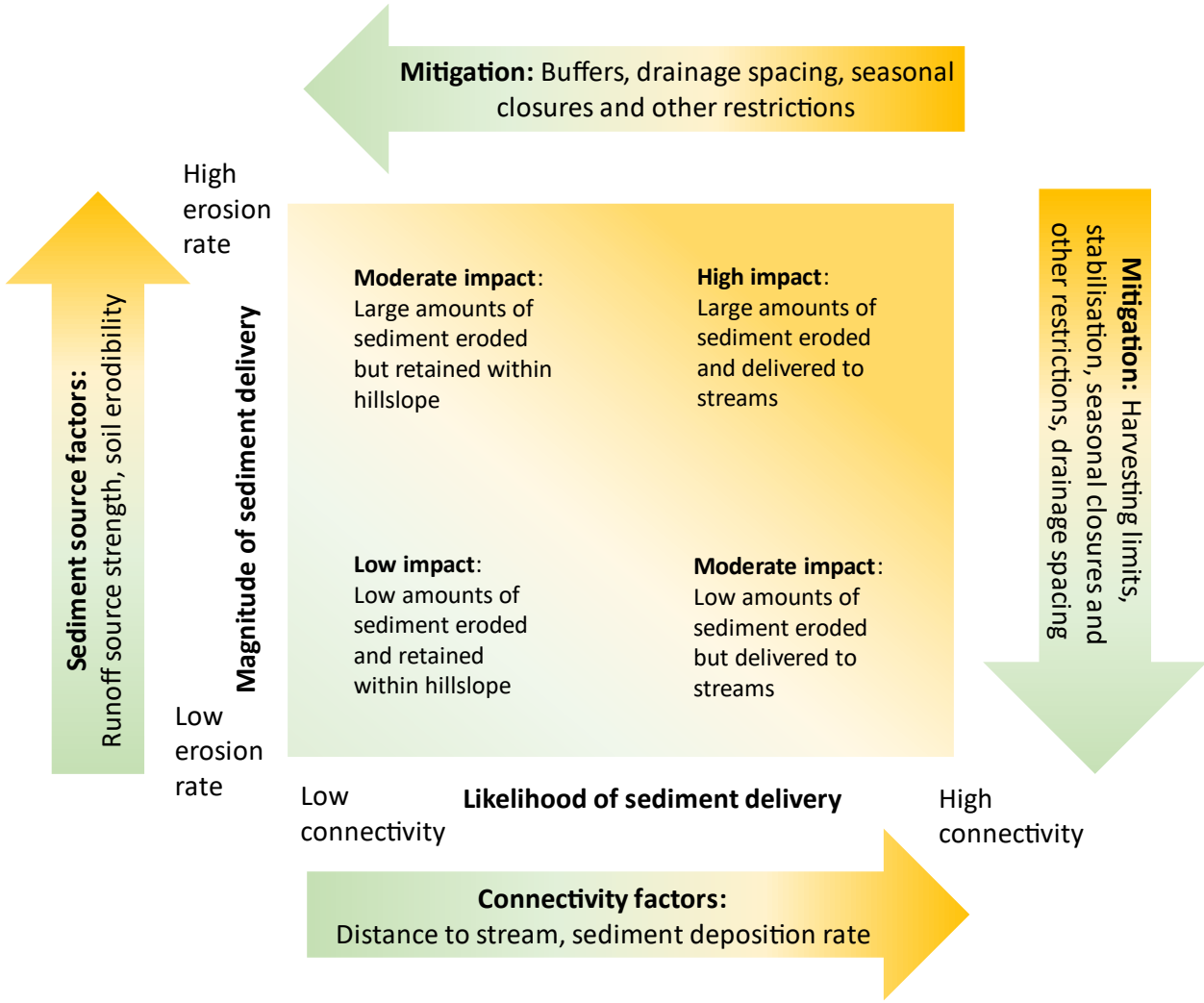
Available online 3 February 2005

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

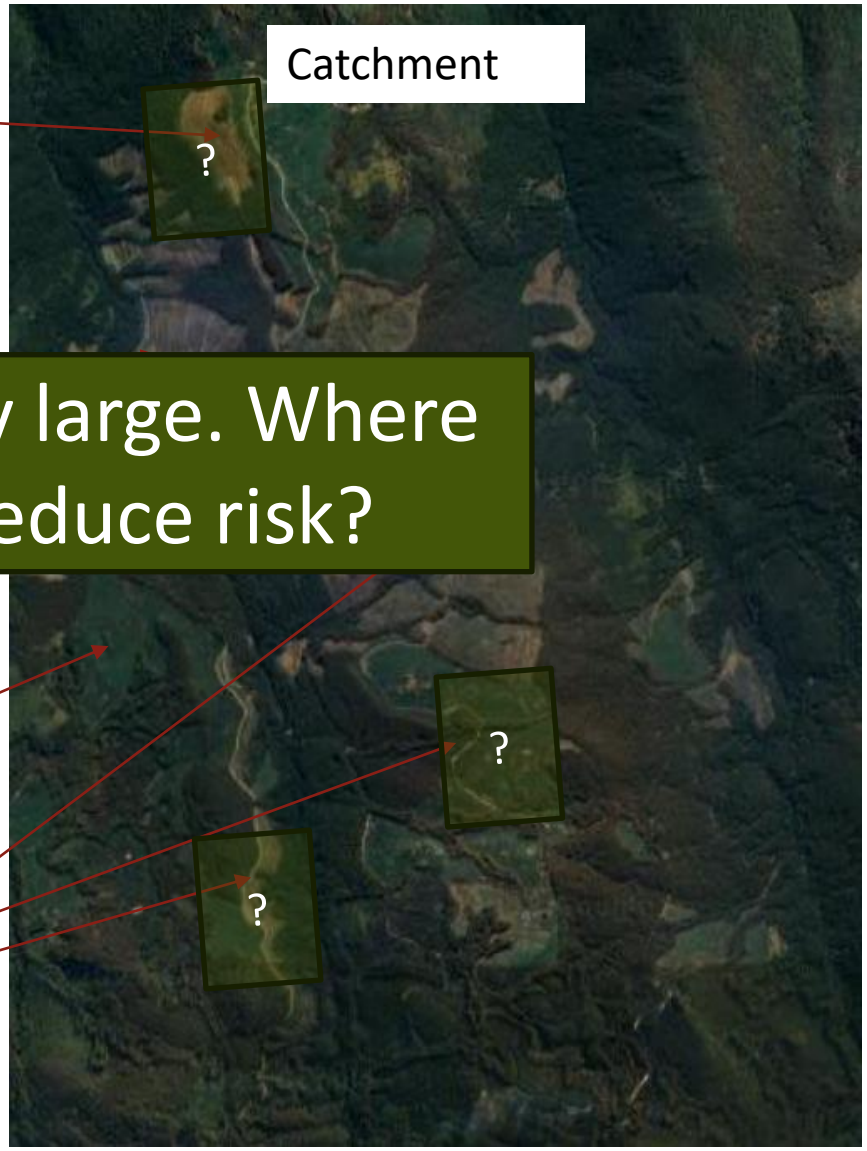


Management solutions – the role of models

In-couple road

Forest road

The forest road network is very large. Where do we focus our efforts to reduce risk?



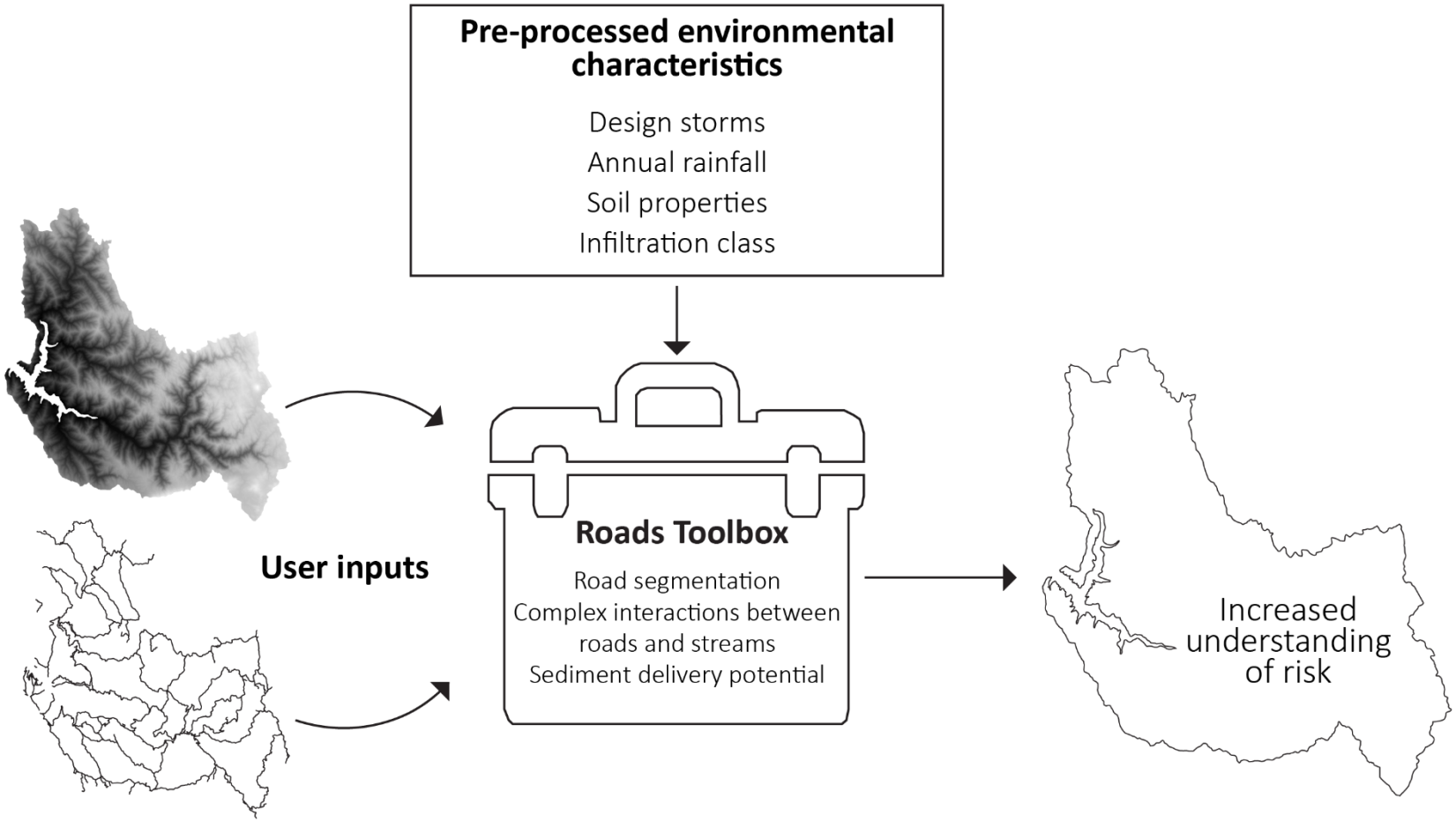
Road network

Forest roads toolbox: Evaluating road networks for water quality outcomes

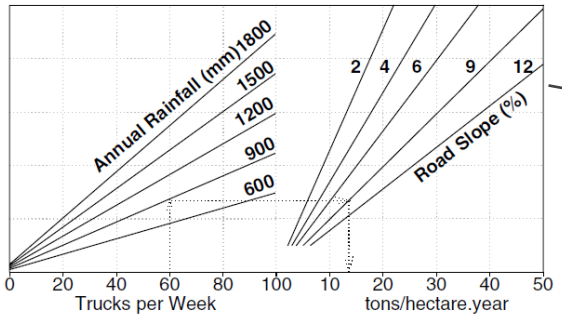
How much sediment delivery can I expect from my road network and how can this be best managed?

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.

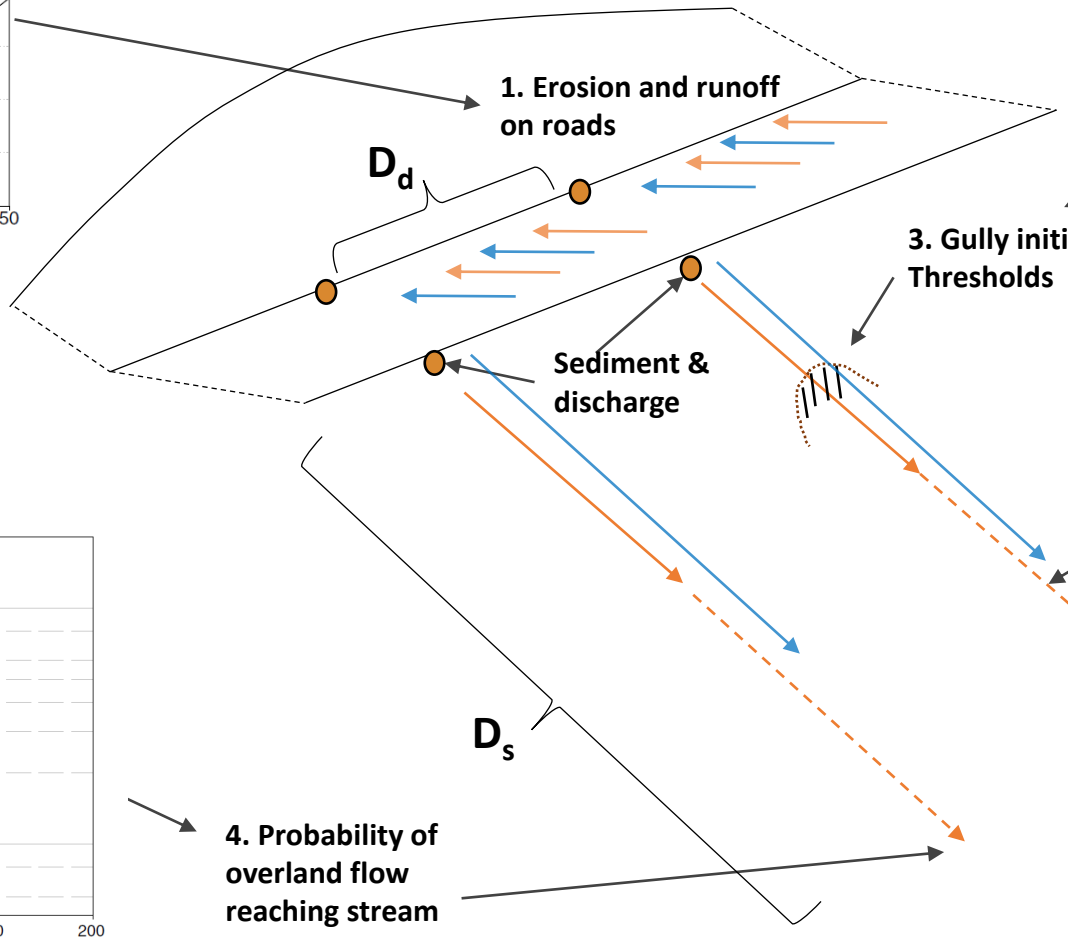
The toolbox has been developed in ArcGIS and outputs are generated through automated geoprocessing workflows.

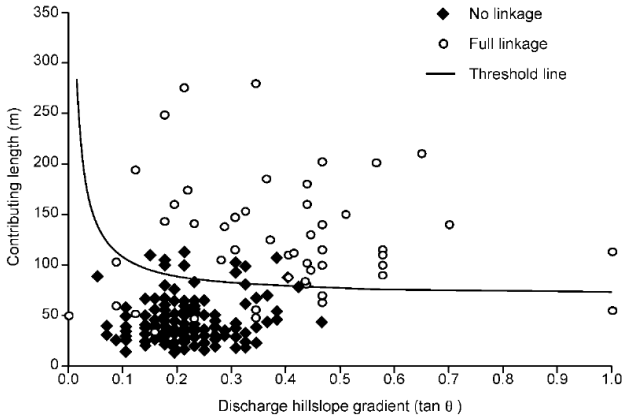


Forest roads toolbox:
Evaluating road networks for water quality outcomes

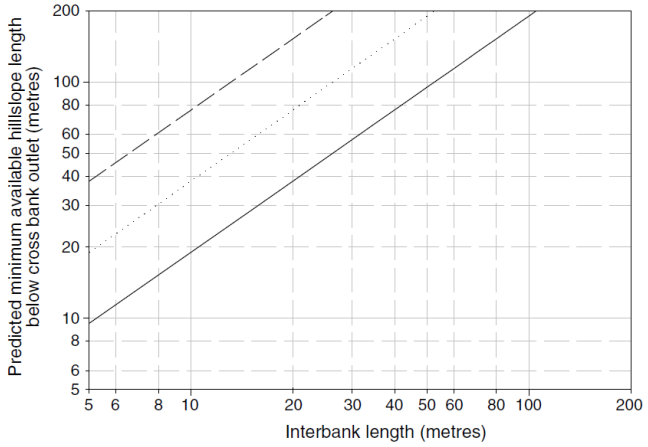


Sheridan and Noske, 2007

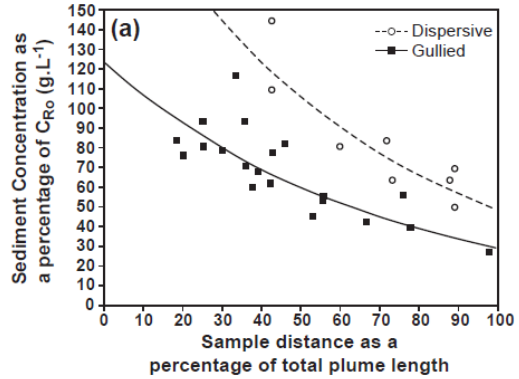




Croke et al, 2001

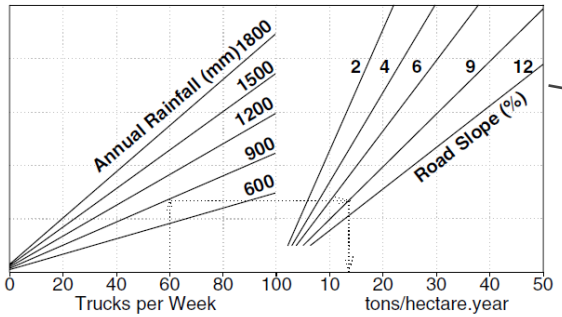


Hairsine et al, 2002

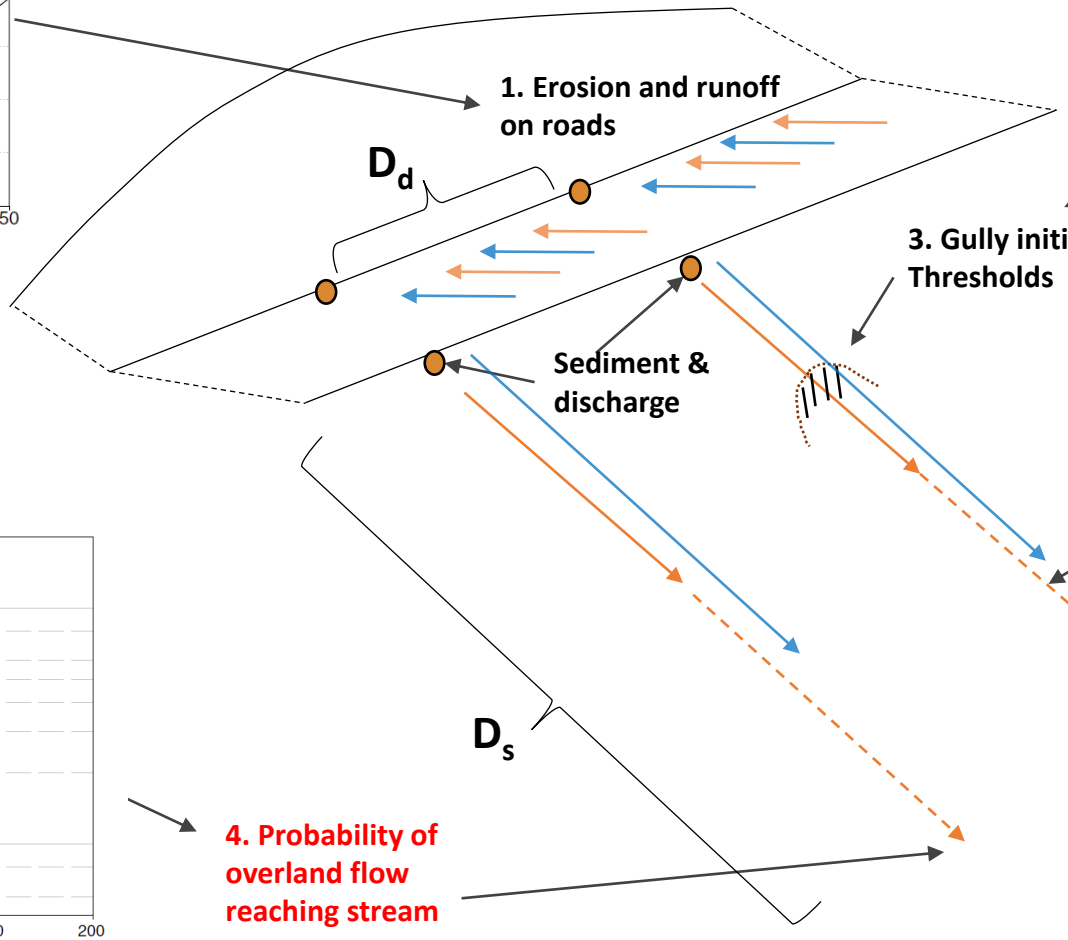


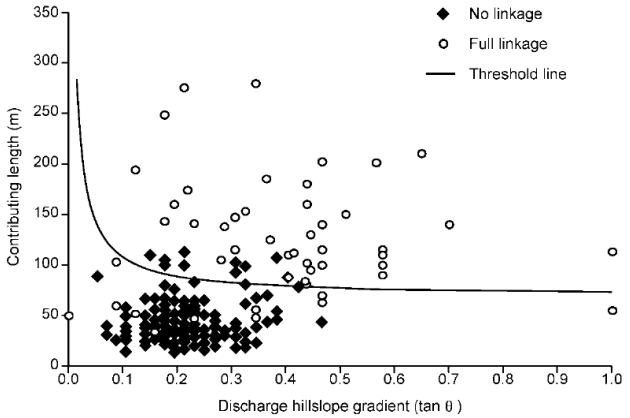
Croke et al, 2005

Forest roads toolbox:
Evaluating road networks for water quality outcomes

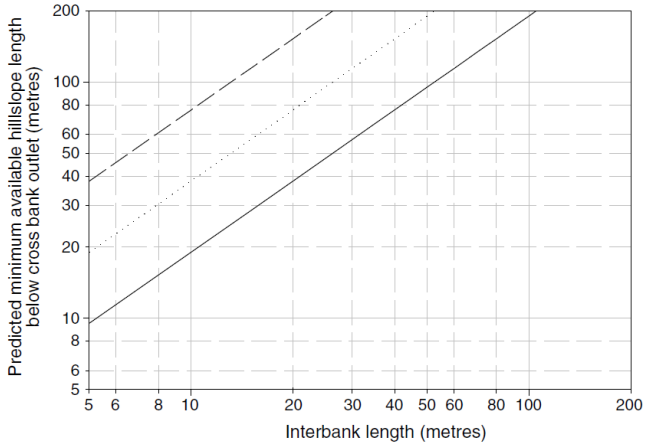


Sheridan and Noske, 2007

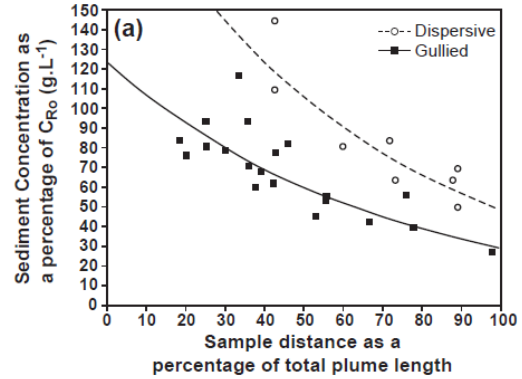




Croke et al, 2001



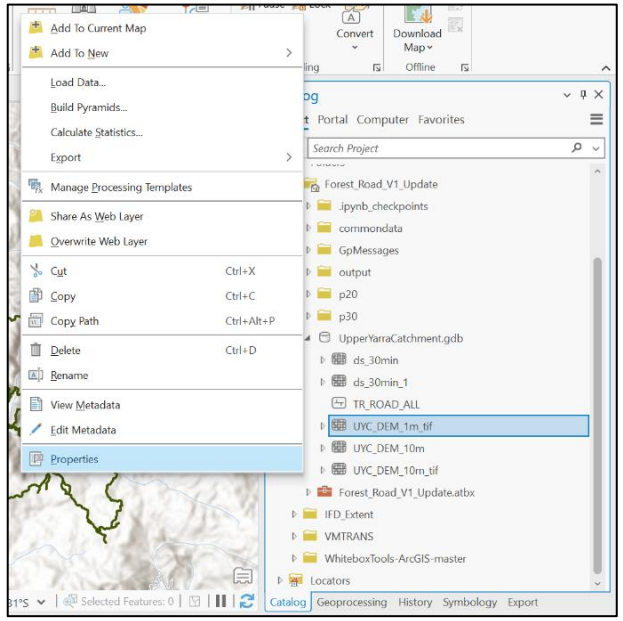
Hairsine et al, 2002

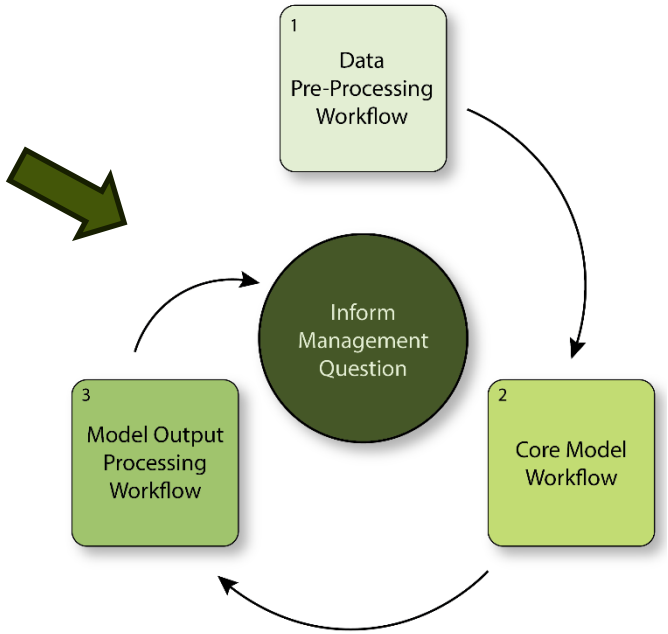


Croke et al, 2005

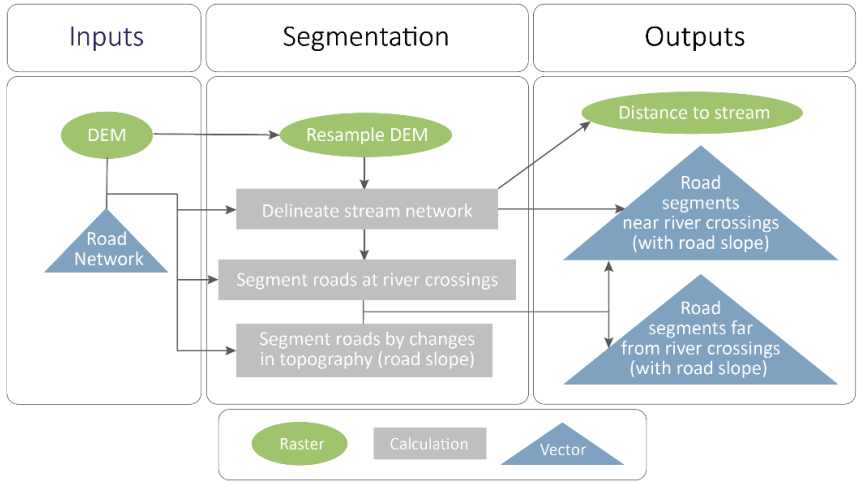
Forest roads toolbox: Evaluating road networks for water quality outcomes

ArcGIS toolbox





1)



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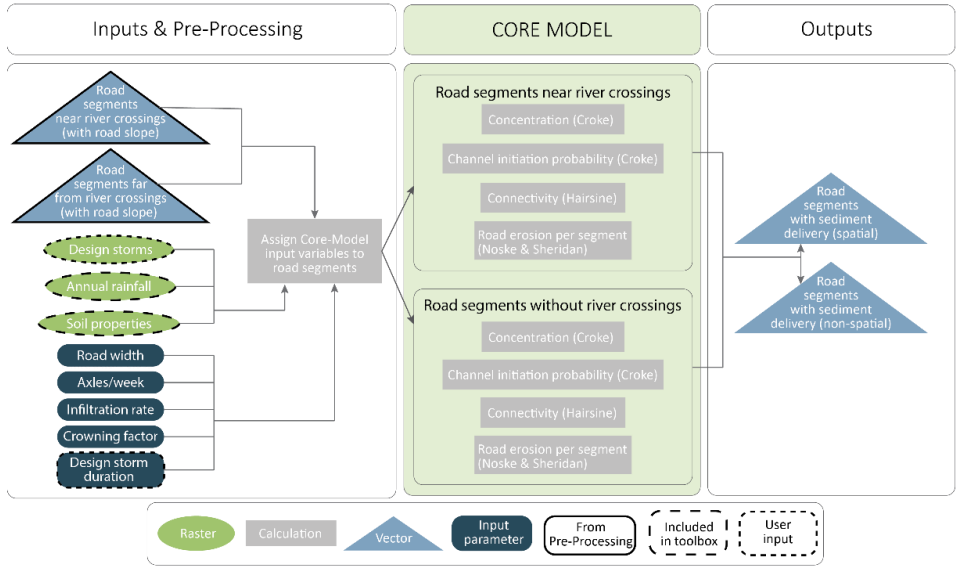

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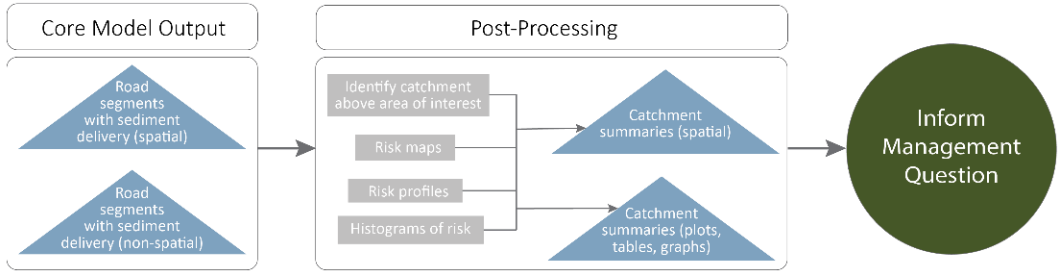
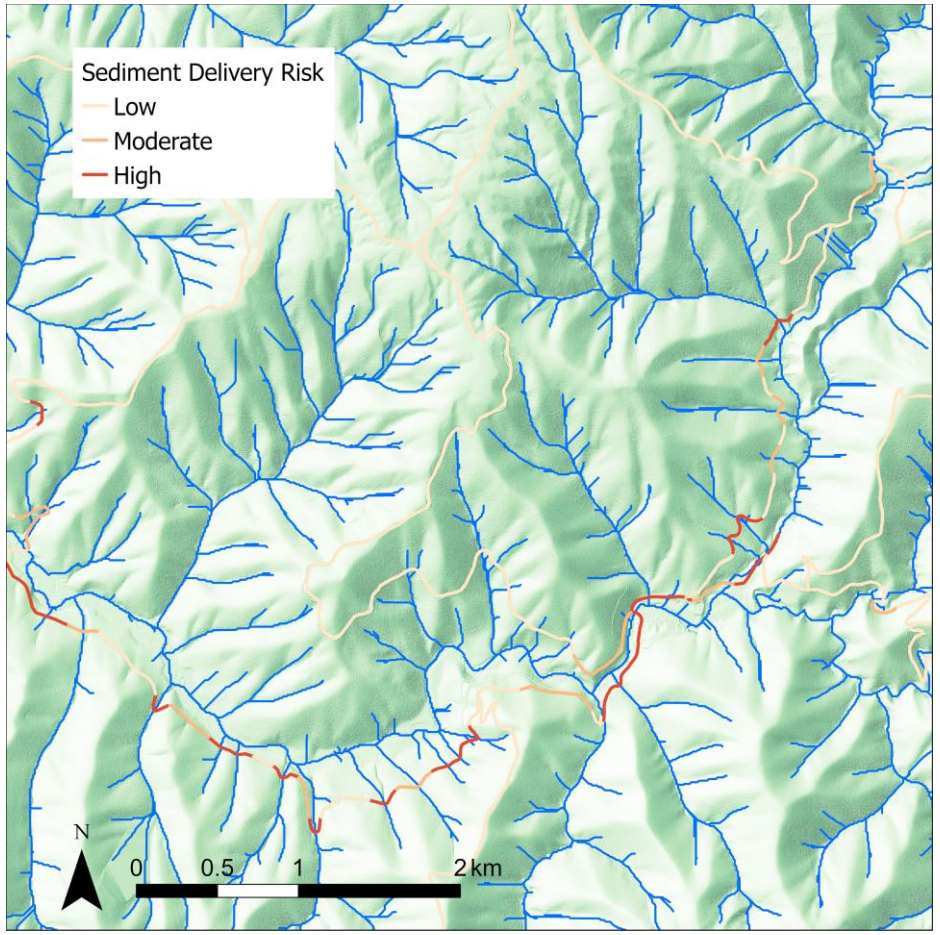


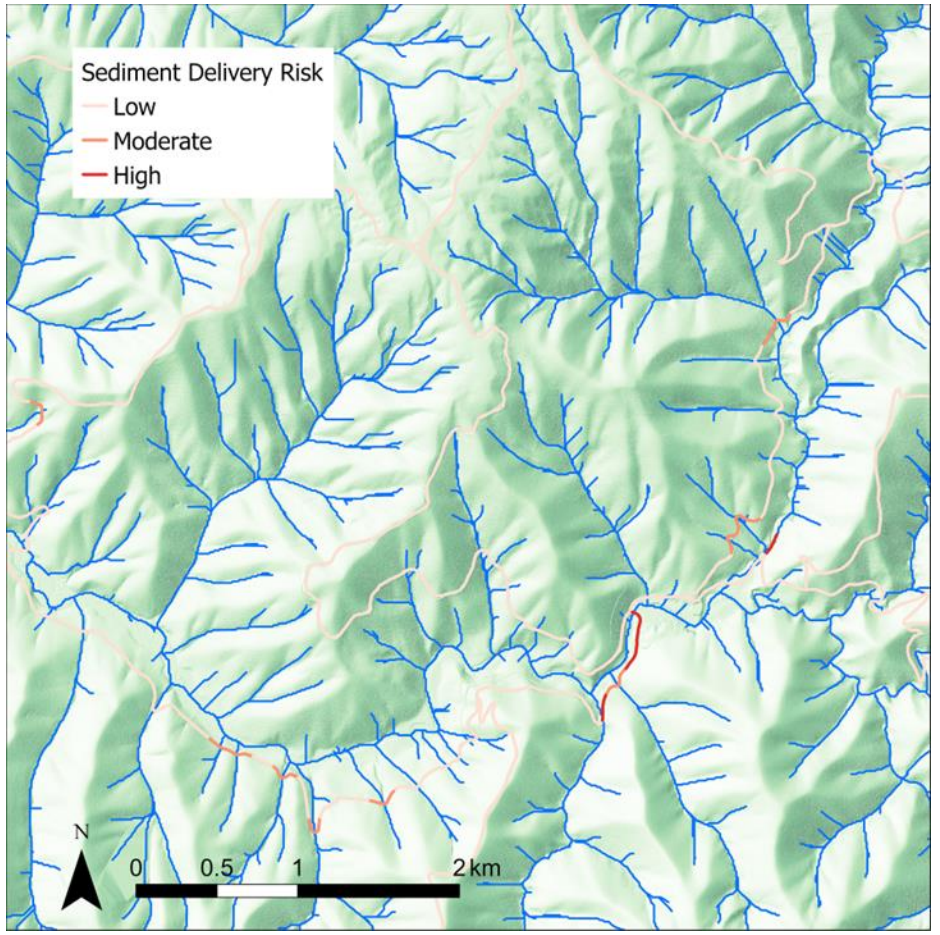
Forest roads toolbox:
Evaluating road networks for water quality outcomes

Effects of crowning:

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



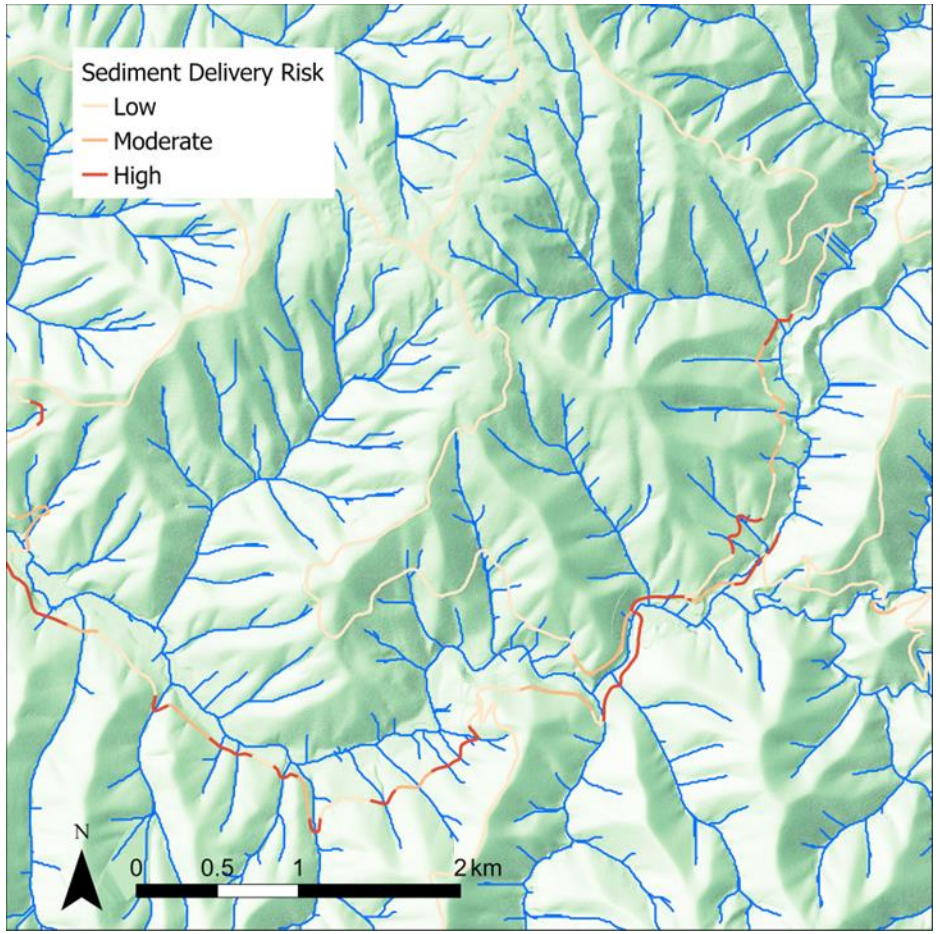
Crowning factor: **0.5,** Storm AEP: 1 in 10 year



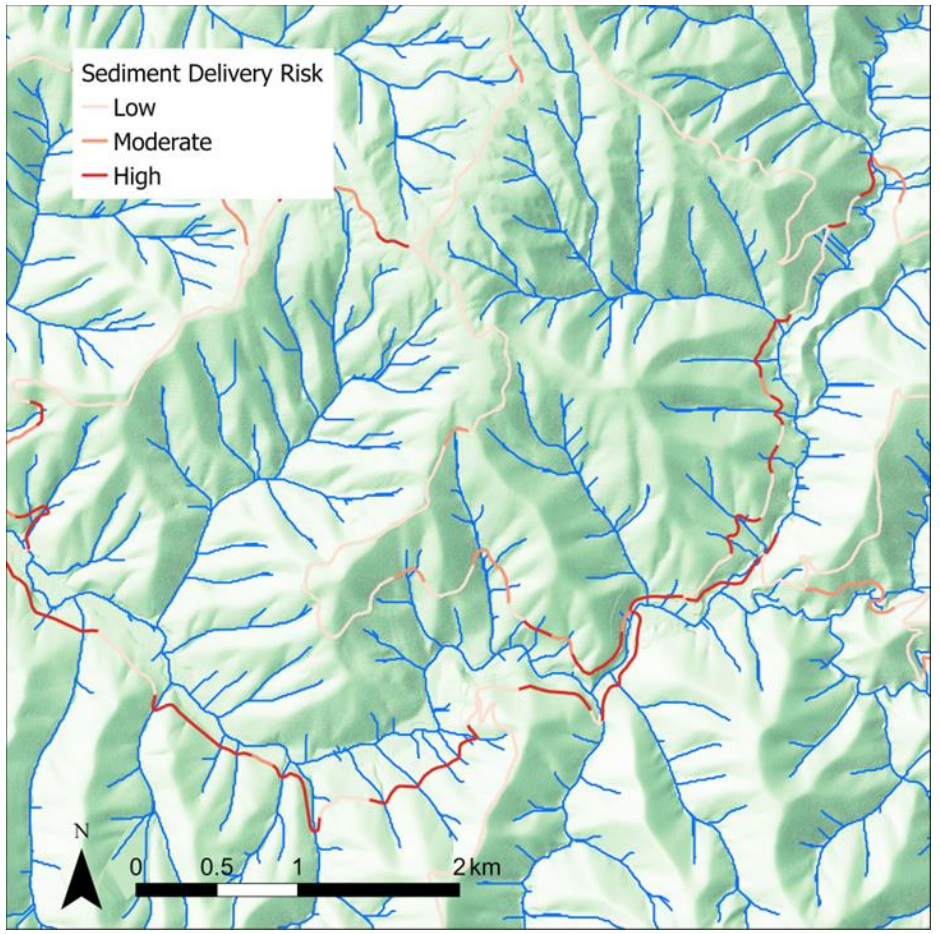
Forest roads toolbox:
Evaluating road networks for water quality outcomes

Effects of rainfall event:

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



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



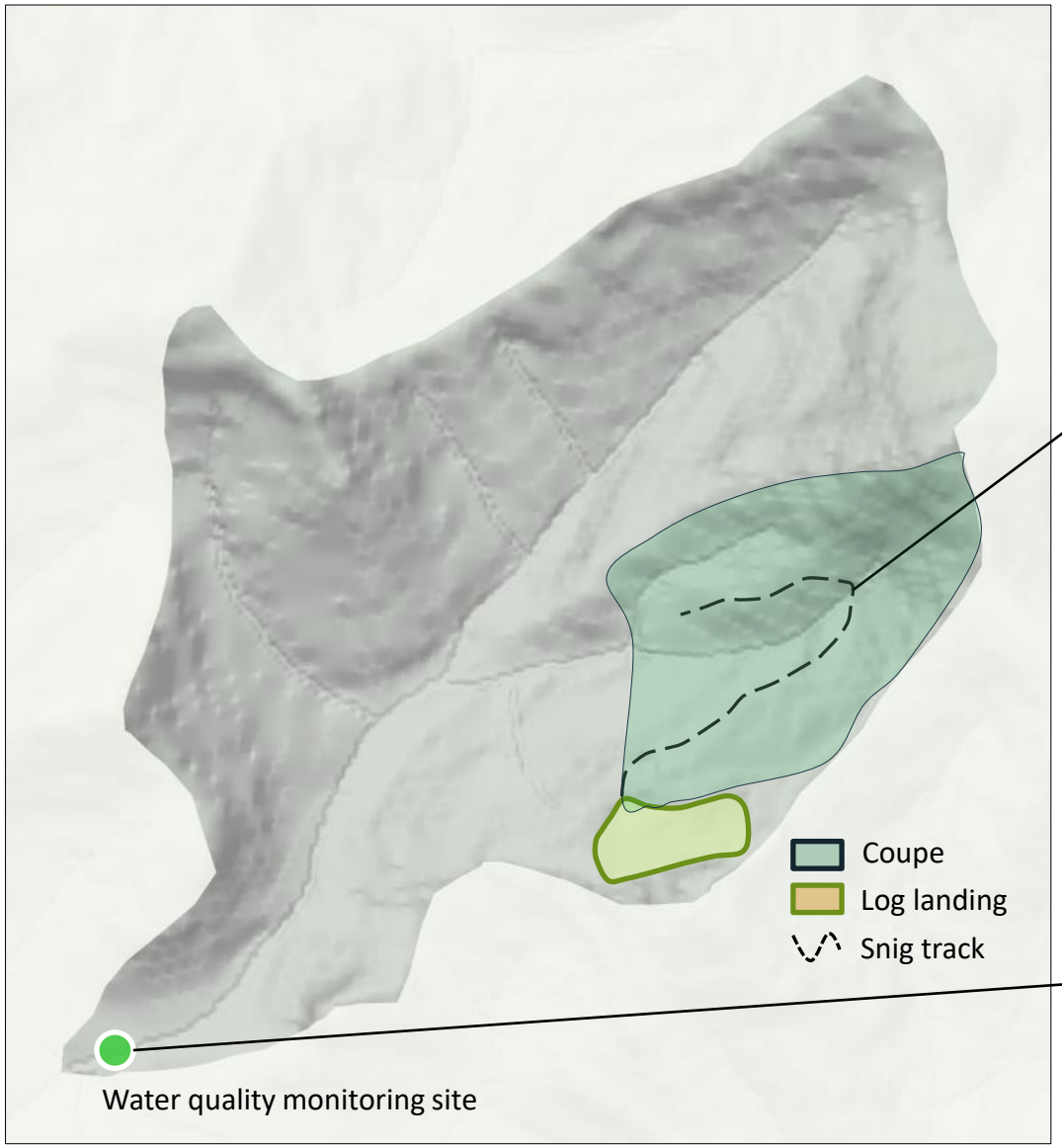
Forest roads toolbox: Cumulative impacts framework (conceptual)

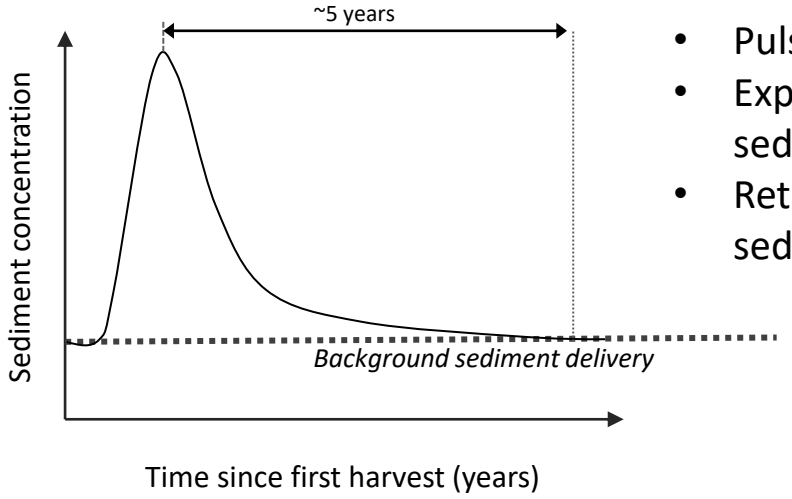
What is the cumulative impacts of sediment transport in catchments due to forest roads and snig tracks? What are the sediment delivery trajectories for different management scenarios?


Overgrown/recovered snig track

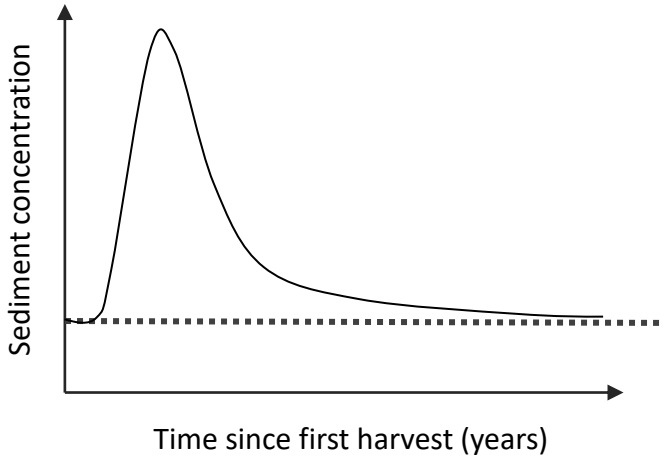

Permanent road, direct connection

Single snig track



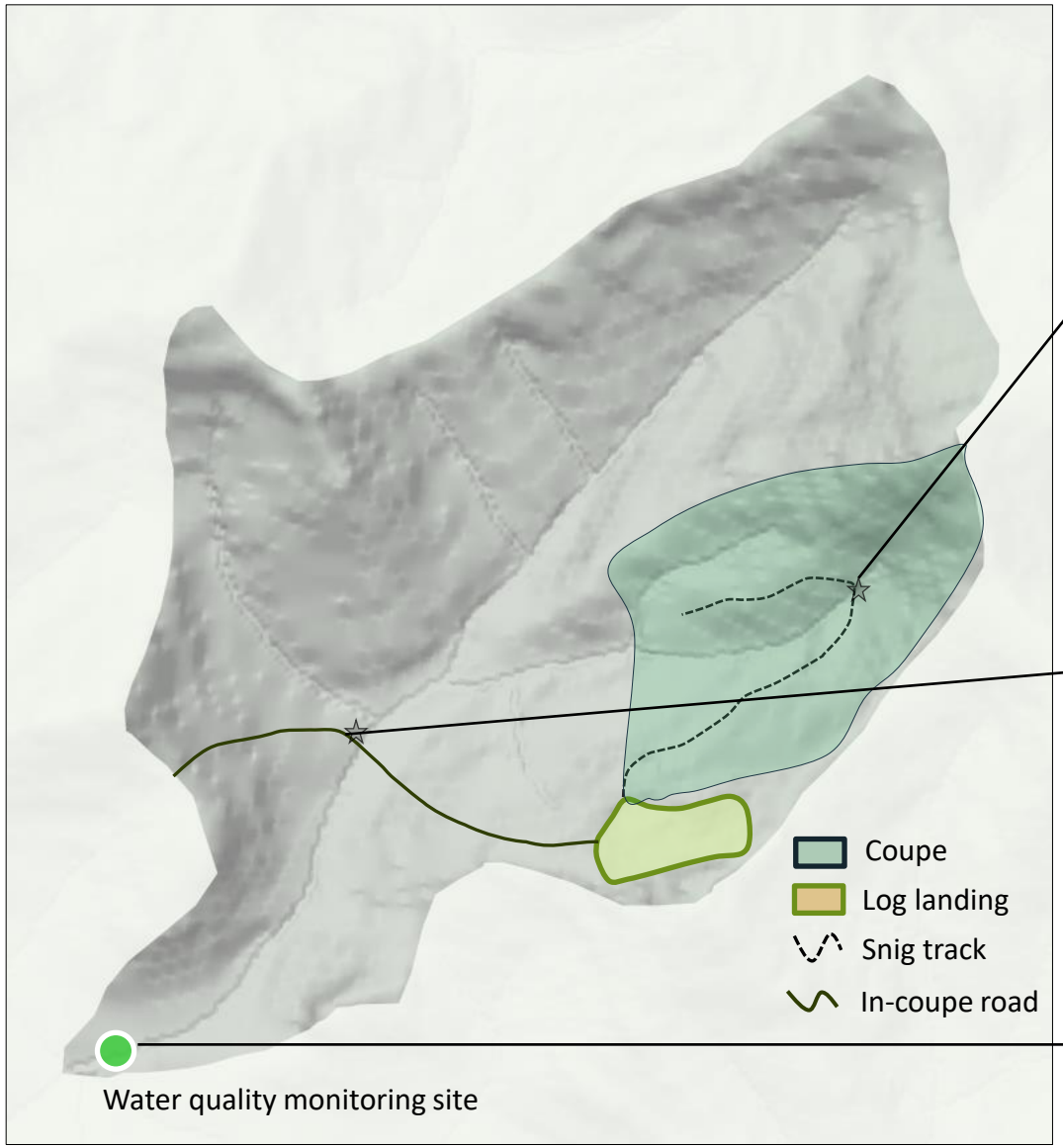


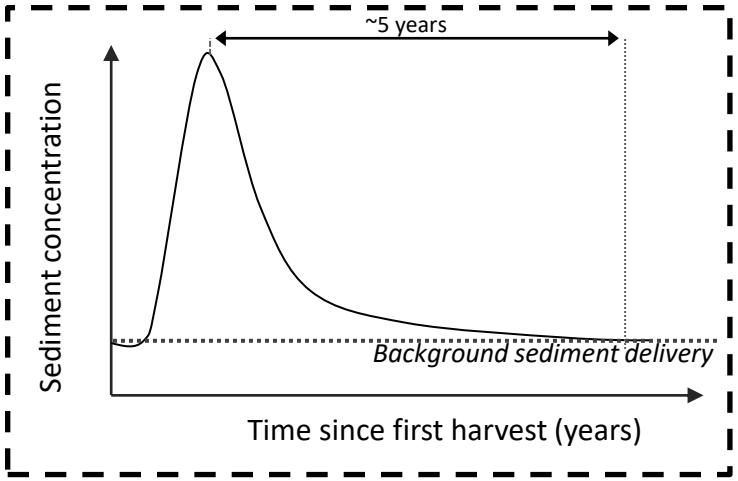
- Pulse disturbance
- Exponential decrease in sediment delivery
- Return to background sediment delivery rate



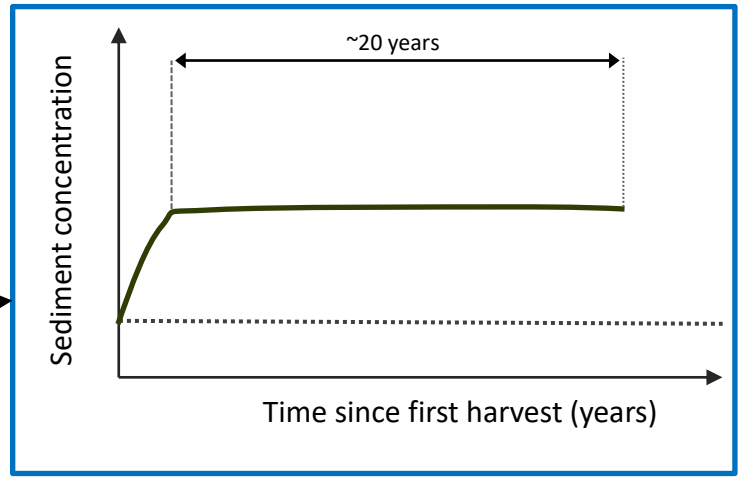
- Pulse disturbance
- Tributary inputs dilute sediment concentration
- Sediment concentration quickly declines to background level

Single snig track and permanent road



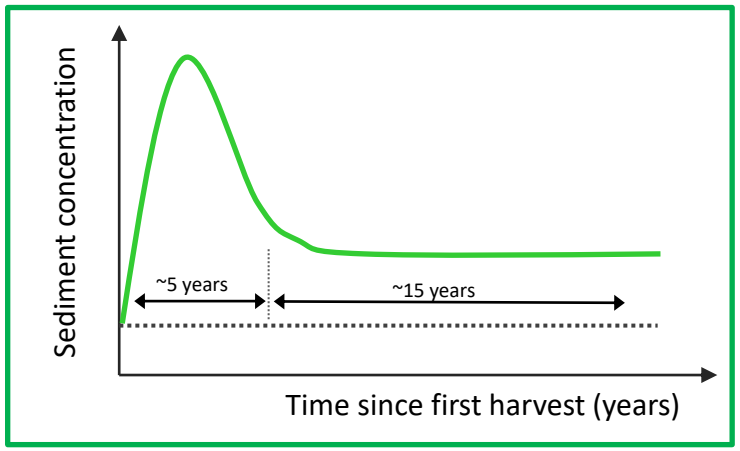


Single pulse disturbance



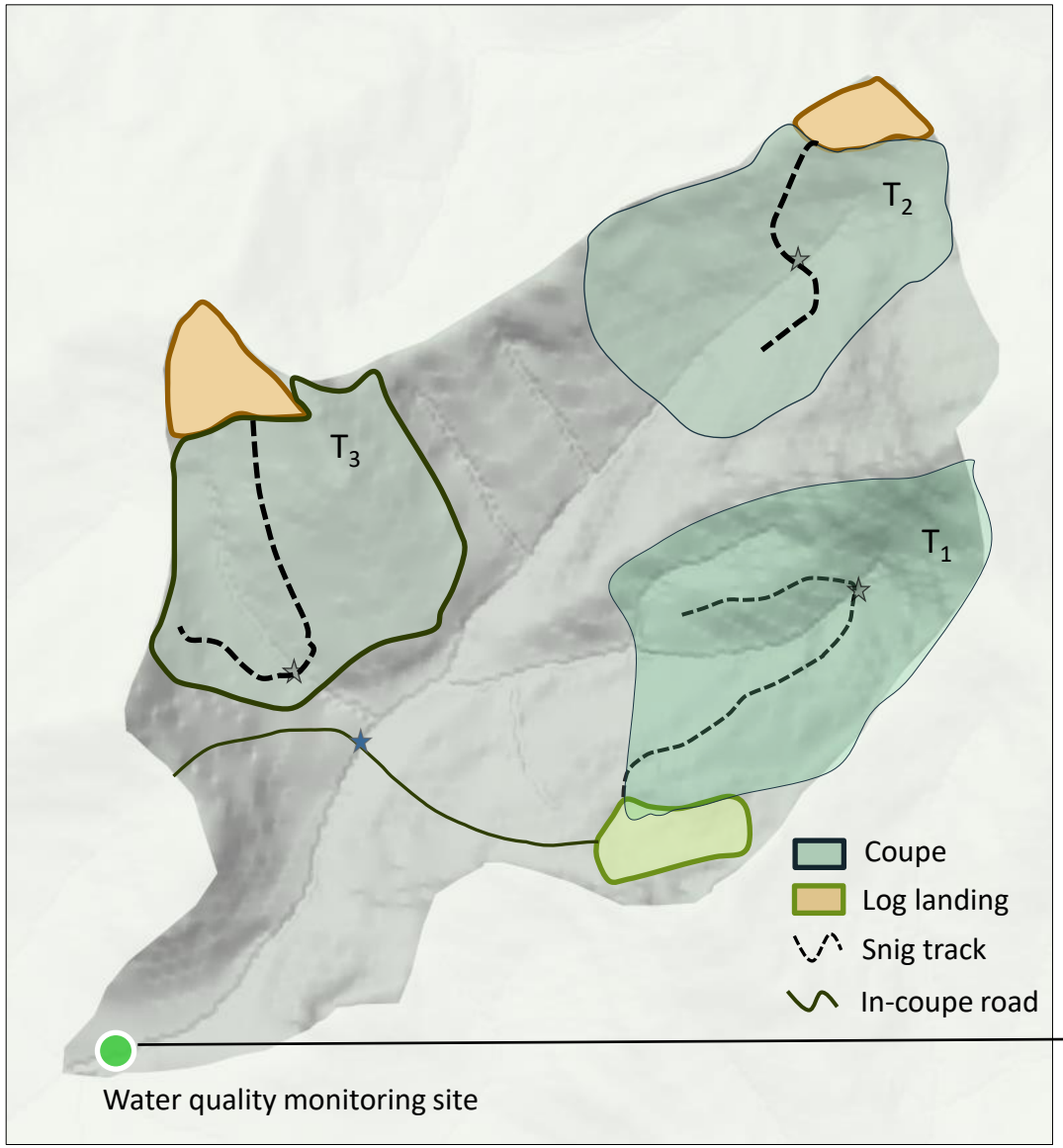
Single press disturbance

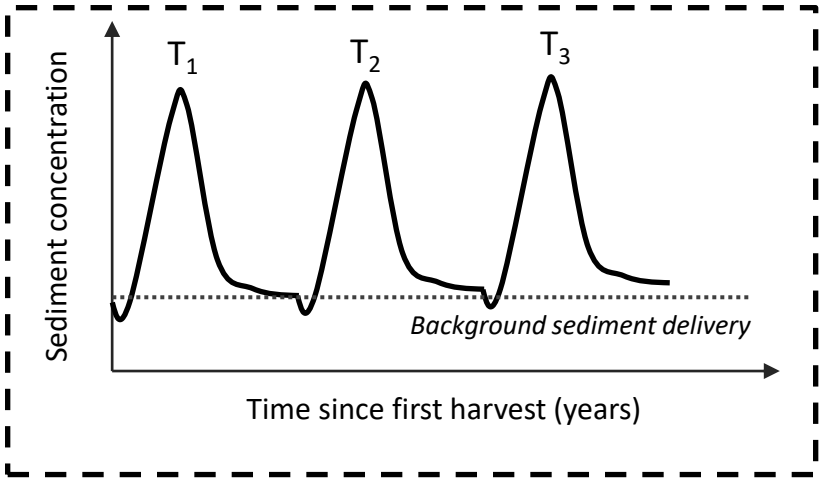
- Sediment delivery remains permanently elevated above background levels
- Local variation dependent on traffic, vegetation, soil type etc



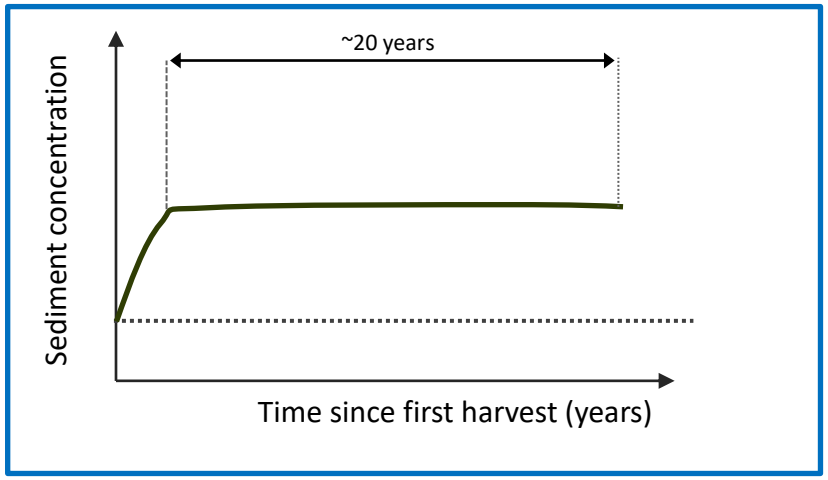
Combined signature
An initial spike in sediment concentration, then decline, but sed. concentration remains elevated above background levels

Multiple snig track and permanent road: staggered harvest

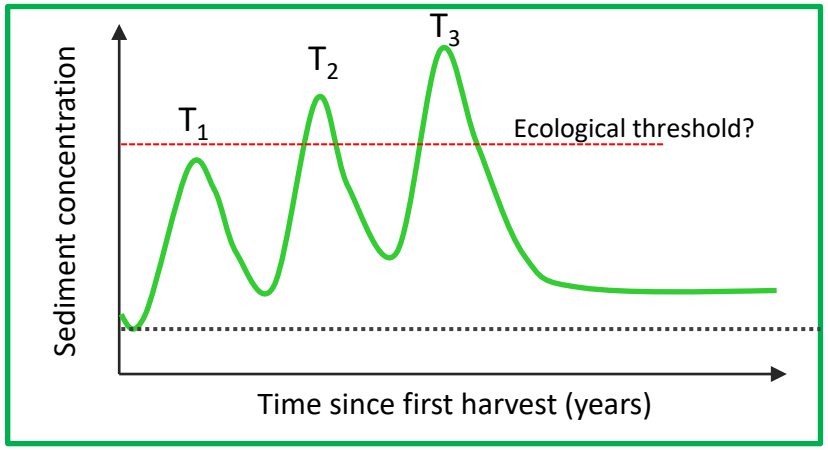




3 x pulse disturbances, staggered over time



Single press disturbance



Combined signature
Cycles of spike and recovery following each harvest

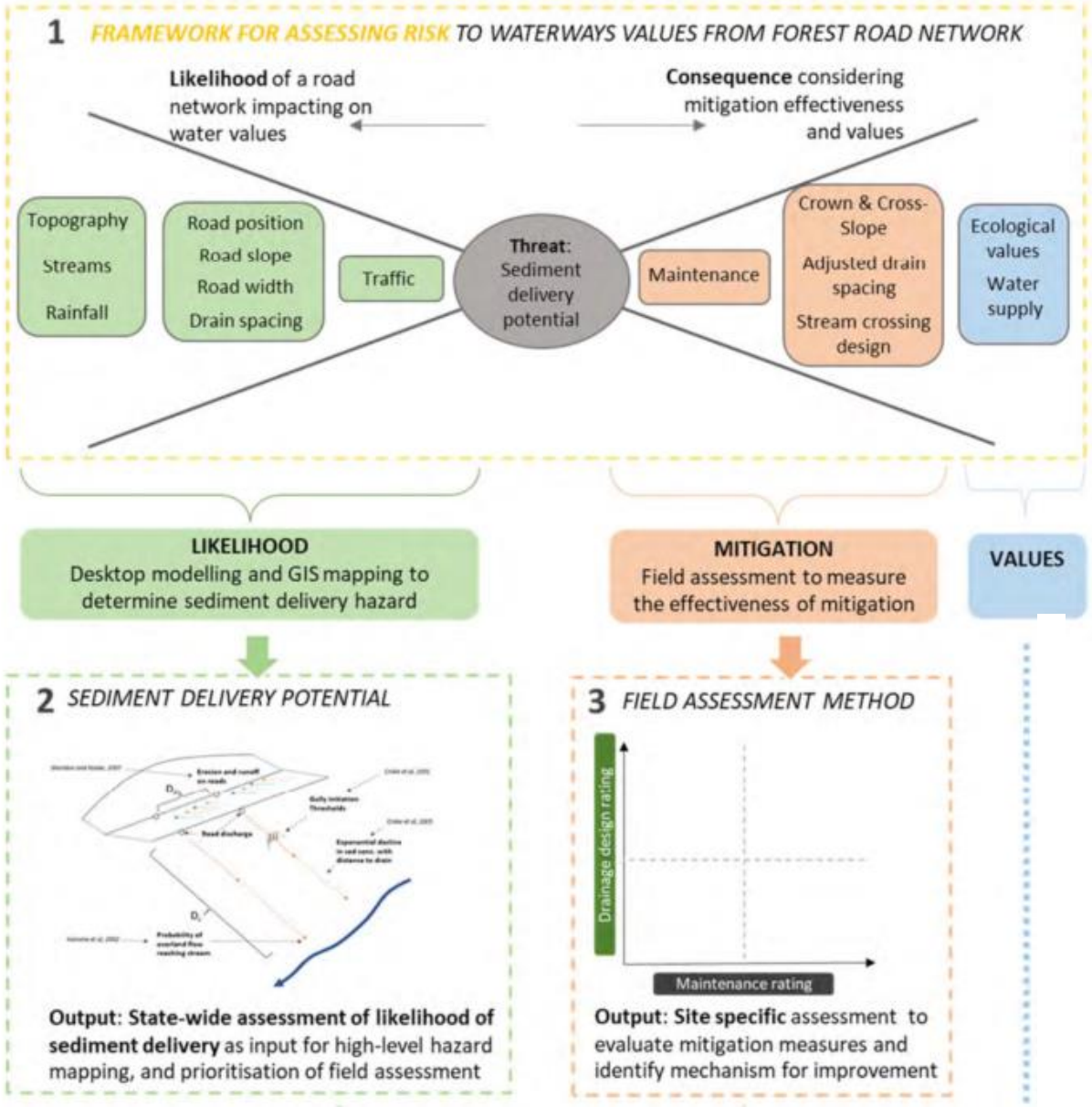
Concluding remarks

- 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. No time for planning.
    - Governance, legacy roads

- Models help us refine and focus our management interventions to achieve outcomes that factor in local conditions and uncertainty
    - The sediment delivery threat from roads varies across landscapes
    - The risk varies depending on the values we are managing for
    - The risk varies with rainfall conditions(and other bushfire disturbance), 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

Concluding remarks



What are the implications of these projects for forest management in NSW?

- Need to understand the **management levers and our priorities**
  - Where are likely opportunities to intervene to protect the things we care about. e.g.
    - Ecological values
    - Water security for our cities
    - Recreation

- Need a **long-term, and a landscape scale focus** to ensure strategies are effective and contributing towards resilience
  - Enhance the ability of the catchments to function under increasing pressures from bushfire, drought, extreme rainfall and anthropogenic disturbance.
  - Move away from responsive mode. Think about the big picture.

- Gaps in data and research. But low hanging fruits from better **consolidation and synthesis of existing research**. Need strong conceptual models and frameworks to guide our research efforts.

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.

NSW GOVERNMENT Natural Resources Commission

Q&A

Dr Petter Nyman, Alluvium Senior Scientist

Dr Peter Hairsine, Centre for Water and Landscape Dynamics at the Fenner School of Environment and Society, Australian National University

NSW GOVERNMENT Natural Resources Commission

Upcoming Webinars

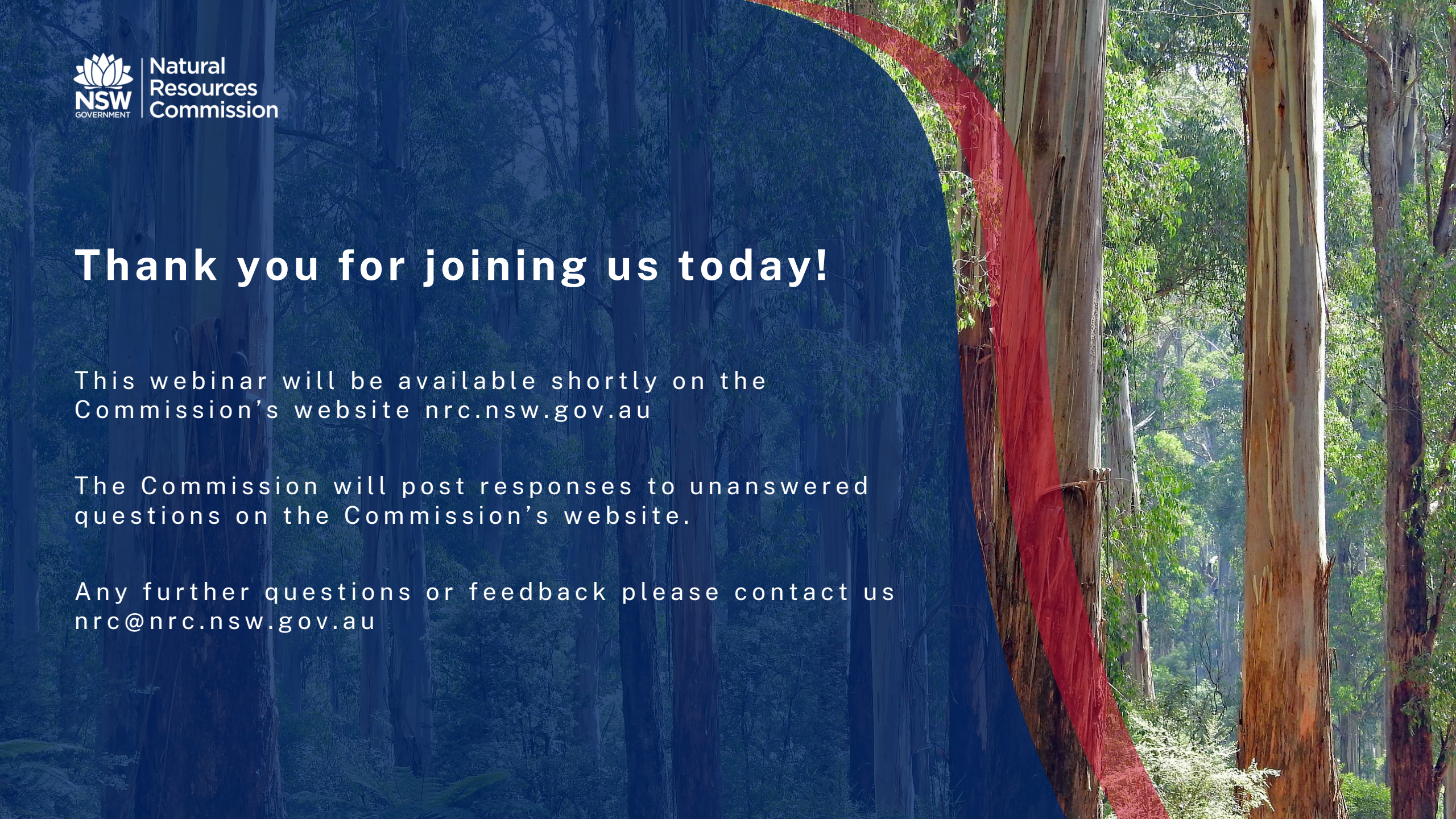
Webinar 2: Forest Biodiversity - species monitoring – 4 December 3-4pm

Registrations are now open

Webinar 3: Forest Carbon - Forest carbon of NSW forests – 13 December 12.30-1.30pm

Registrations are now open

To register please visit our website **nrc.nsw.gov.au** or LinkedIn profile “Natural Resources Commission”



NSW GOVERNMENT Natural Resources Commission

Thank you for joining us today!

This webinar will be available shortly on the Commission's website nrc.nsw.gov.au

The Commission will post responses to unanswered questions on the Commission's website.

Any further questions or feedback please contact us nrc@nrc.nsw.gov.au