

Post-Wildfire Soil Erosion, Flood, and Landslide Risks

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Southern Interior Forest Region (Nelson and
Kamloops)



Wildland Urban Interface Symposium 2008, Penticton



1. What happened after the 2003 fires?

Peter Jordan, Research Geomorphologist, Nelson

2. Development of risk analysis procedure and policy.

Ken Soneff, Forest Science Officer, Kamloops

3. The fires of 2007 in southeastern B.C. – application of the procedure to high-risk fires.

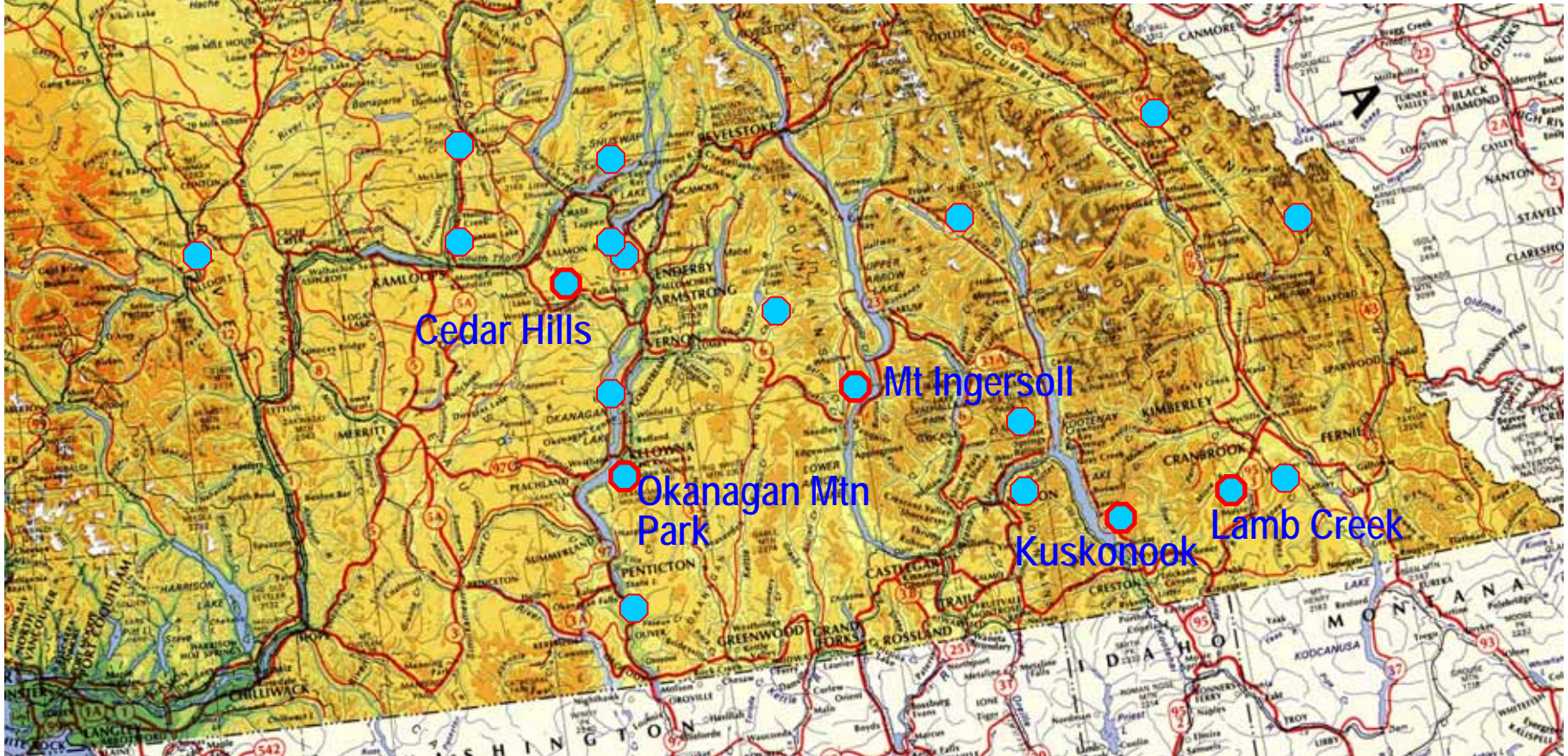
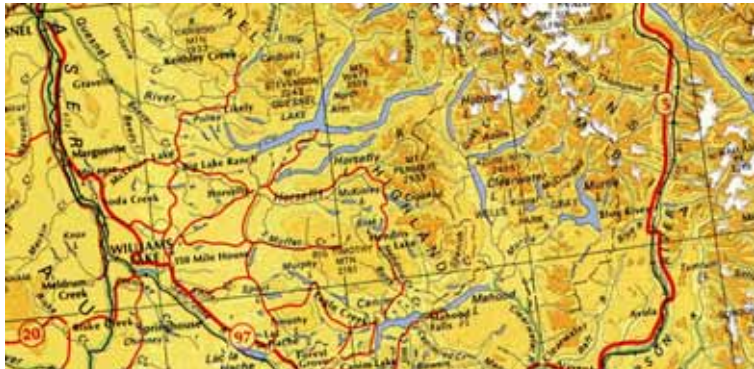
Peter Jordan

4. Research on effects of wildfire on soil erosion, streamflow, and mass movement.

Ashley Covert, Assistant Research Ecologist, Nelson

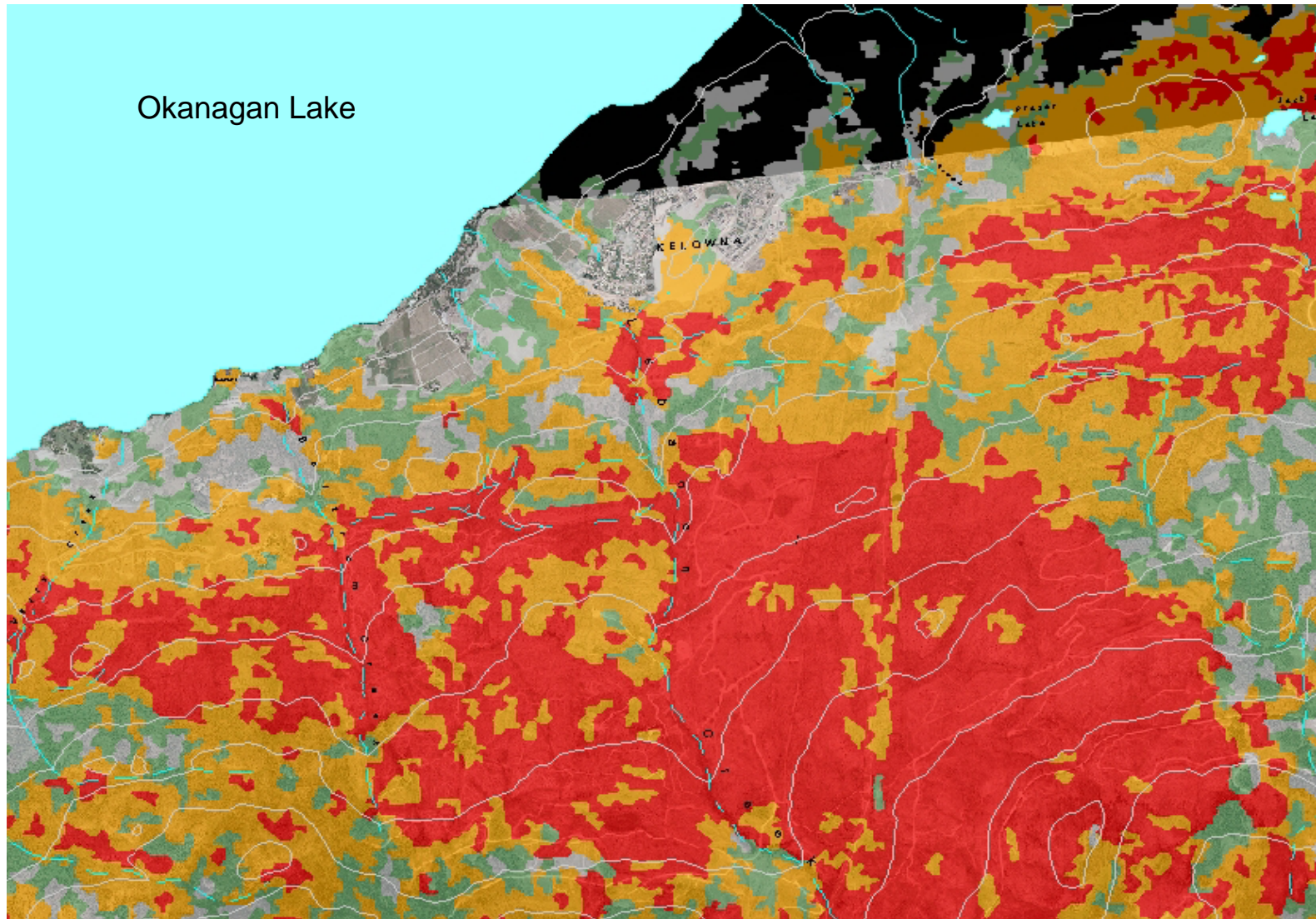
Landslide / erosion / flood events following 2003 fires

- Okanagan Mtn. Park Fire - 2003
- Cedar Hills - 2004
- Strawberry Hills - 2004
- Kuskanook - 2004
- Lamb Creek - 2004
- Vaseux - 2004
- Hellroar Creek - 2005
- McLure Fire - 2005
- McGillivray Fire - 2005
- Mt Ingersoll Fire - 2005





Okanagan Mountain Fire, 2003



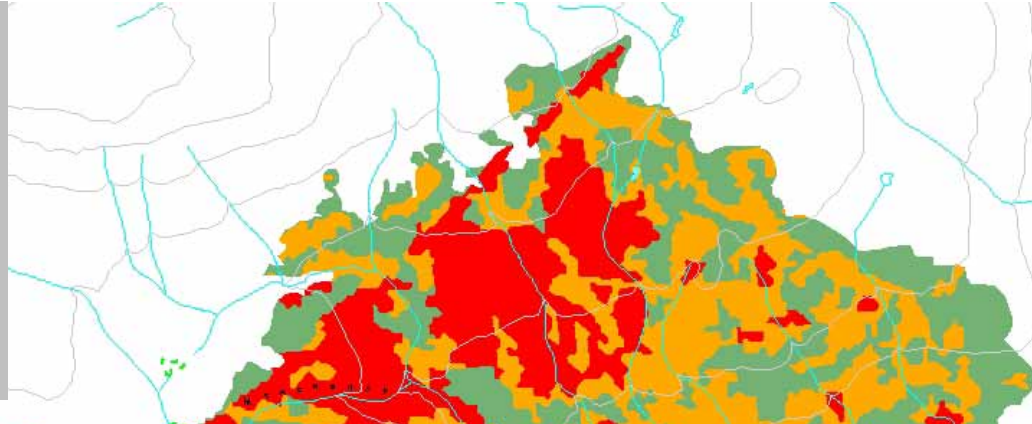
KELOWNA: Erosion event following 2003 Okanagan Mountain Park fire



Photos courtesy of Dobson Engineering Ltd.

Cedar Hills Fire, 2003

- 1620 ha fire, 2003
- Rainstorm June 2004
- ~ 50 gully failures
- 2 hillslope failures
- Damage to 3 homes & 1 vehicle
- Highway closure



Cedar Hills Fire, 2003



Unconfined
overland flow



Loss of confinement
on fan

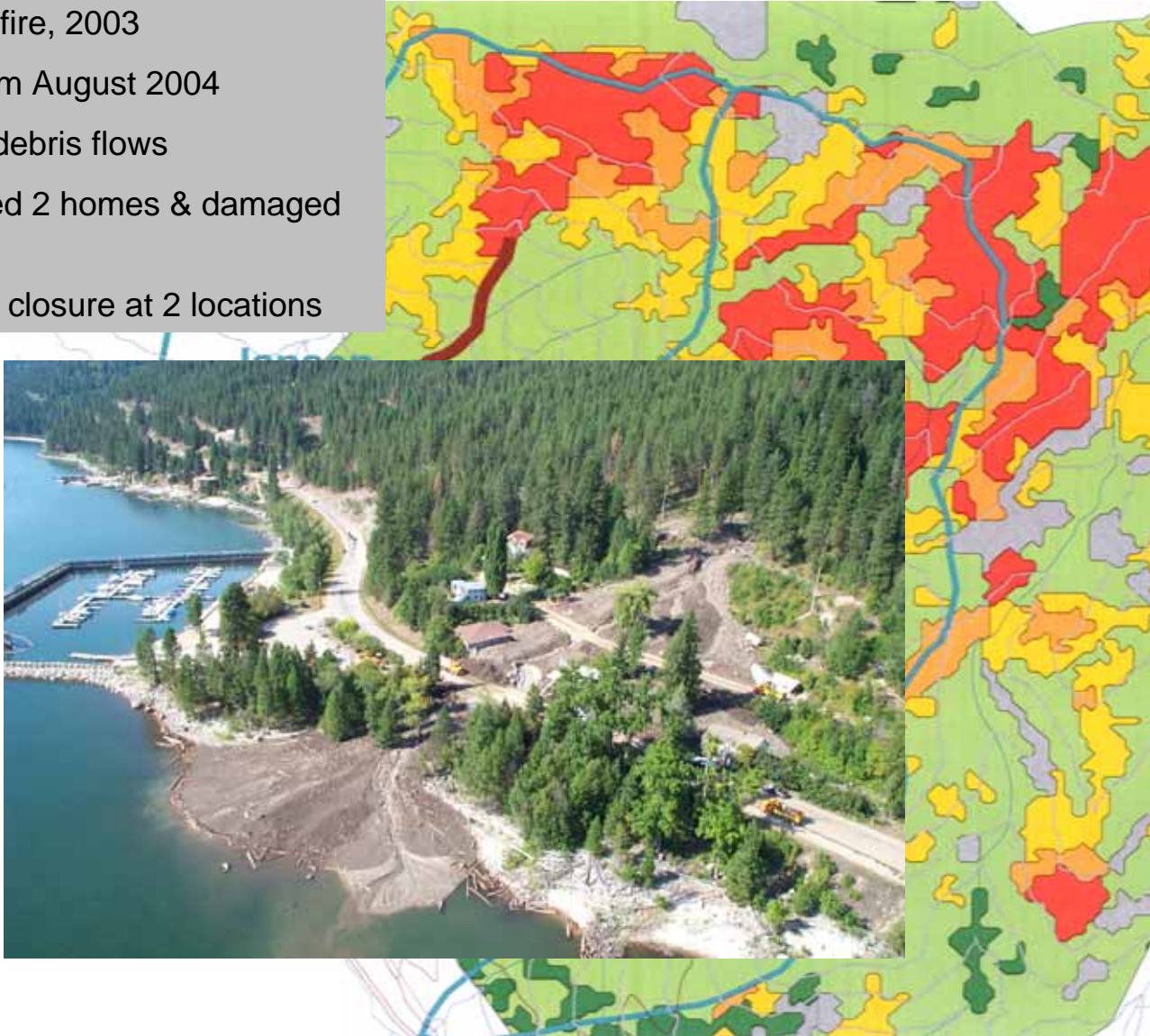


Flow confinement
in gullies

Photos courtesy of
Grainger Associates
Consulting Ltd.

Kuskanook Fire, 2003

- 4839 ha fire, 2003
- Rainstorm August 2004
- 2 major debris flows
- Destroyed 2 homes & damaged others
- Highway closure at 2 locations





The 2003 fires occurred when soils were drier than usual. This led to a number of erosion events from 2003 to 2005, likely as a result of water-repellent soils. At Kuskanook, the results were devastating.



This was an unusual debris flow event:

- It was very large (20,000 – 30,000 m³).
- It happened in mid-summer, which is rare – almost all debris flows in this region occur during spring snowmelt, or occasionally in late fall.
- Large mass movement events following wildfires have not been previously reported in this region in recent history.

This debris flow, and several similar events following the 2003 fires, led the Southern Interior Forest Region to develop a risk assessment procedure, and to seek research funds to study the process.

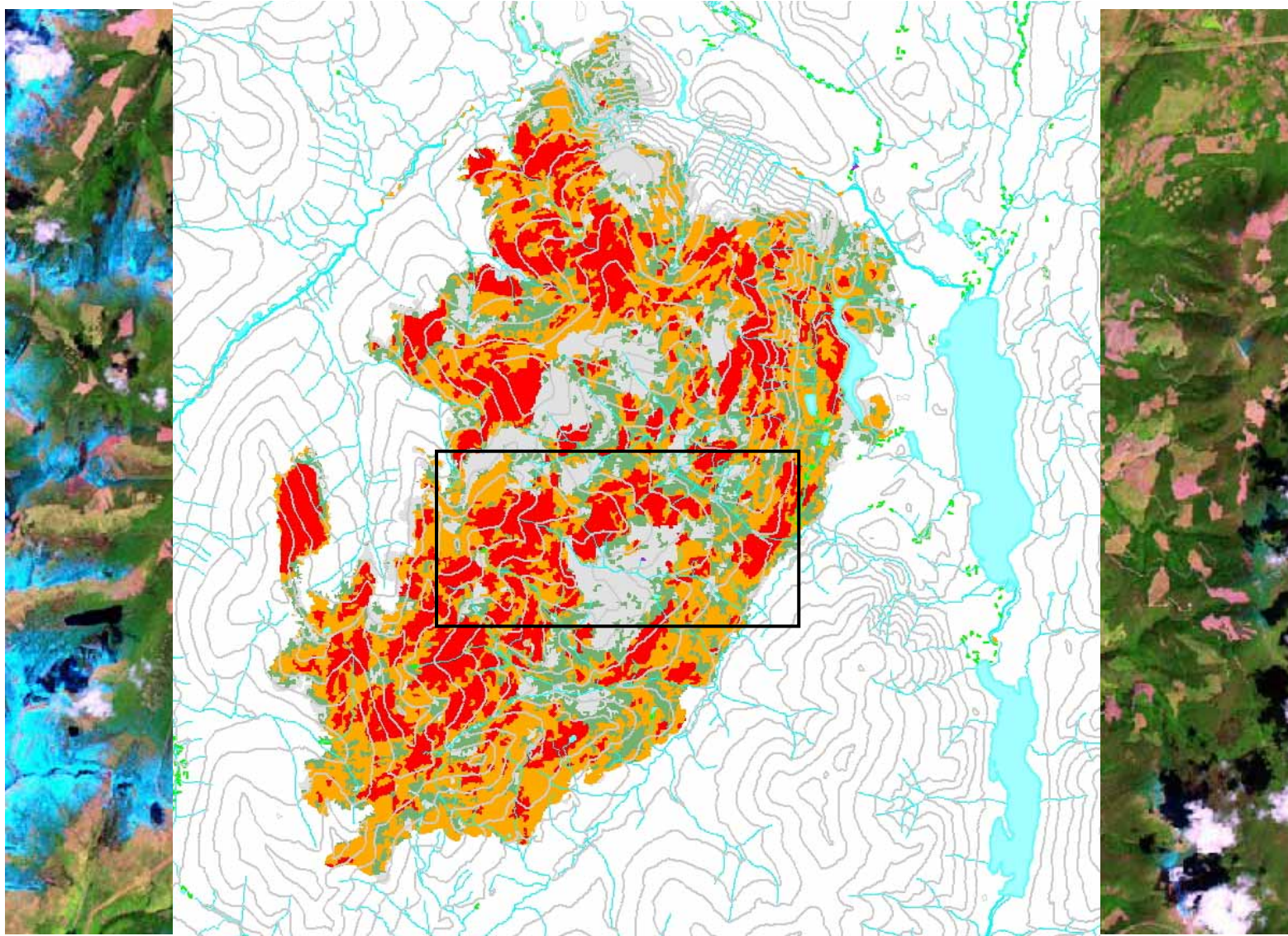
Kuskonook Cr fan in 1994



August 2004



Lamb Creek Fire, 2003

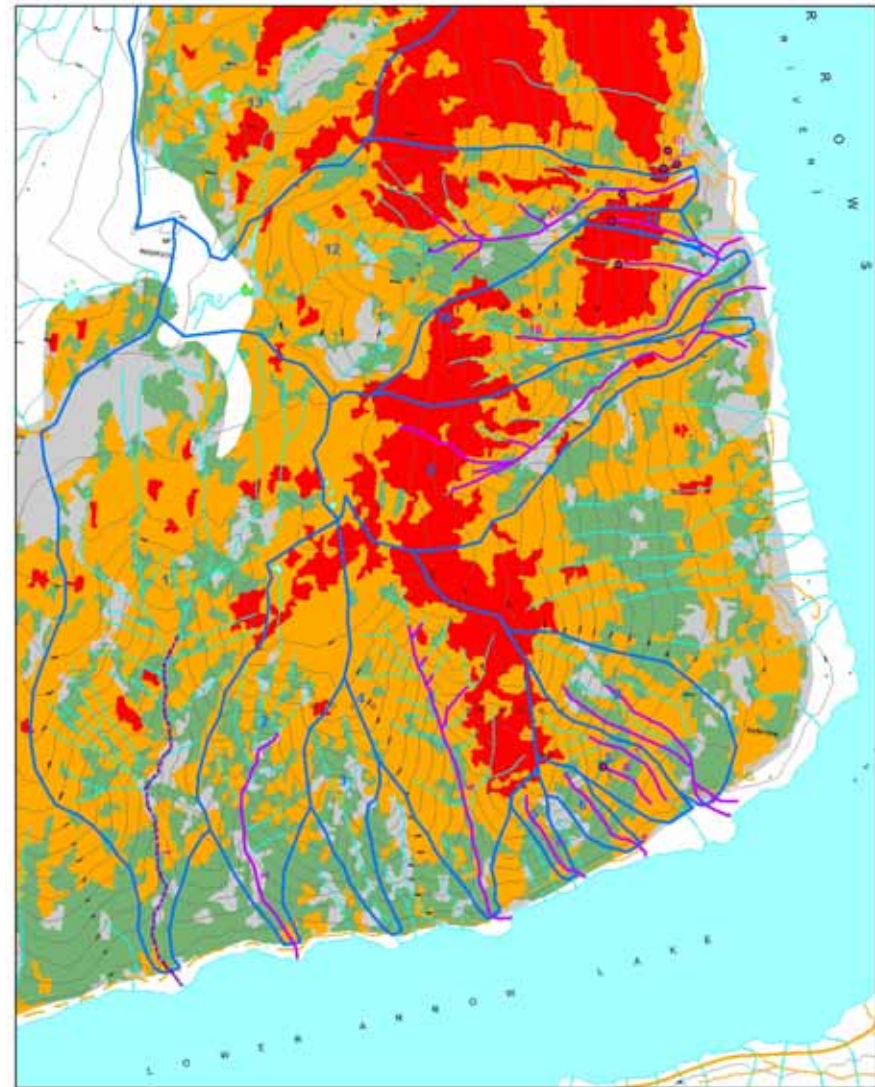
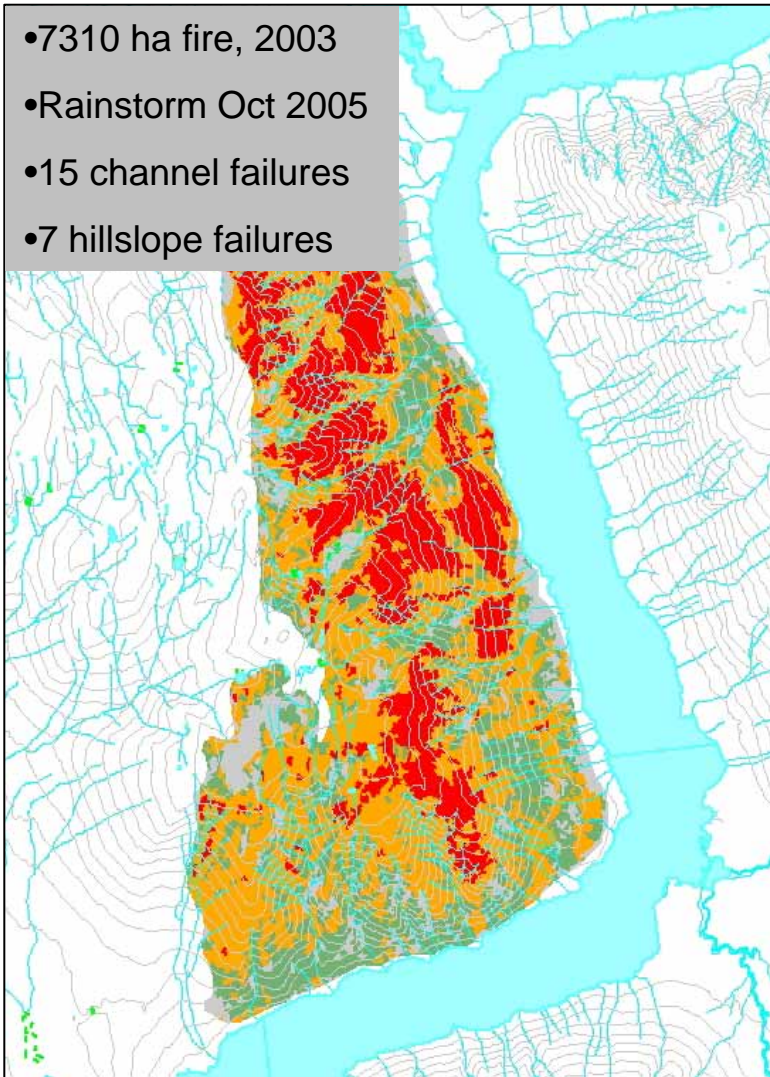


Lamb Creek Fire, 2003



Ingersoll Fire, 2003

- 7310 ha fire, 2003
- Rainstorm Oct 2005
- 15 channel failures
- 7 hillslope failures



Ingersoll Fire, 2003



Post-Wildfire Natural Hazards Risk Management

Policy and procedures completed, or under development:

- Ministry of Forests and Range (MFR) policy backgrounder completed in 2007 – the policy has been submitted for approval.
- Southern Interior Forest Region (SIFR) Standard Operating Procedure was developed in 2005-2006, - latest draft February 2007 – tested in 2006 and 2007.
- MFR and Provincial Emergency Program (PEP) draft memorandum-of-understanding to clarify agency roles and responsibilities.
- MFR Risk analysis procedure – what we do, when we identify a fire that presents possible risks of post-wildfire natural hazards.

Outline of the risk management process (based on CSA standards)

- What is risk?
Risk = Hazard X Consequence
(e.g. probability of a hazardous event occurring X probability of the event impacting the element at risk)
- Communication with stakeholders about risks is important at all stages.
- MFR risk analysis procedure only deals with the first 3 steps.
- Steps 4 – 6 include evaluating whether or not risks are tolerable, developing strategies to control or mitigate risks, and acting on these strategies.

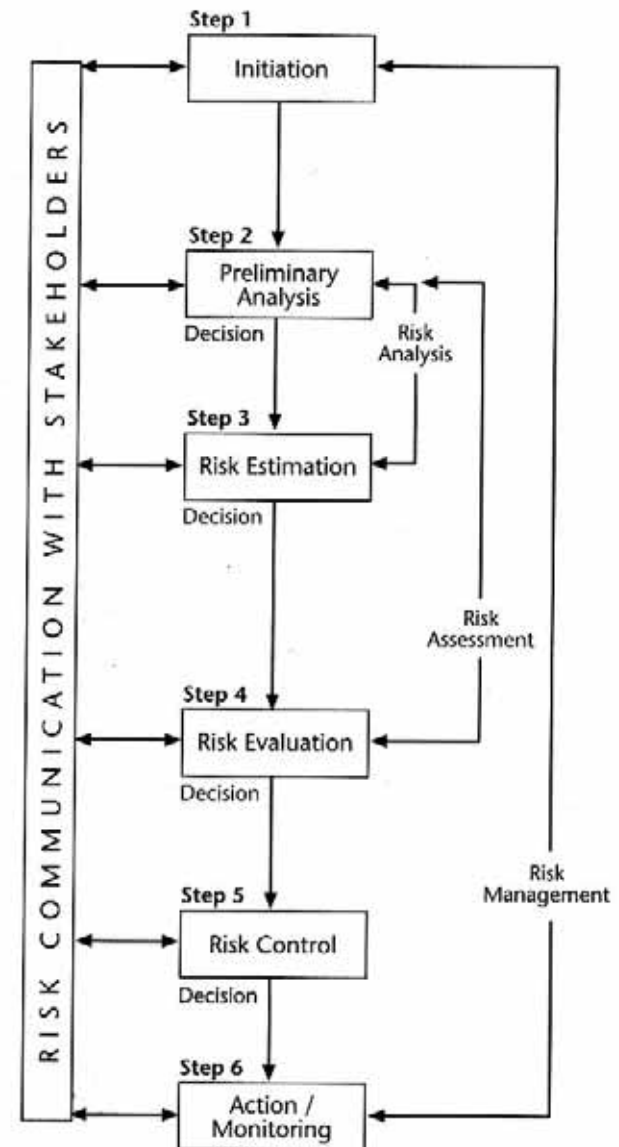


FIGURE 2 Six steps in the decision-making framework for risk management (adapted from CSA 1997).

Background – how did we get here?

- 2003 Fire Storm – interface fires in the Kamloops and Southeast Fire Centres.
- SIFR specialists staff were involved with Protection fireguard rehabilitation operations.
- Increased awareness of post-wildfire natural hazards.
- There appeared to be no legal/regulatory mandate to deal with potential hazards.
- Recognition of professional obligations.
- After the 2003 fires, MFR sent information about potential risks to various agencies, local governments, etc – response was mixed.

THE FILMON REPORT

- *“The provincial government, in partnership with local governments, should examine watershed restoration as soon as possible, to identify areas of severe watershed destruction and develop a plan for protection and rehabilitation of these areas.”*

FPB REPORT

- Forest Practices Board released a report on post-fire site rehabilitation (FPB/SIR/12) (February 2005)
- It mentioned the lack of defined responsibilities in managing the increased risk from natural hazards.

NATURAL HAZARDS MITIGATION FUND

- In 2005-06, the Natural Hazard Mitigation Fund provided support for engineering and planning projects.
- Ministry of Forests & Range received funding from the NHMF for development of a risk analysis procedure.

Risk Analysis Procedure:

- Based in part on the US Forest Service BAER (Burned Area Emergency Response) program.
- Screen all fires using the Protection database – typically include all interface fires, and fires >100 ha near highways, in community watersheds, etc.
- Preliminary flyover or ground reconnaissance if there is a concern.
- A risk analysis is conducted where warranted (soil, stream channel, or landslide hazards and consequences).
- The main objective is to identify risks, and warn or inform affected stakeholders.
- Risk reduction or mitigation strategies depend on stakeholder involvement (e.g. land owners/managers).

Steps in the procedure:

What MFR Forest Sciences/Engineering specialists will do each fire season

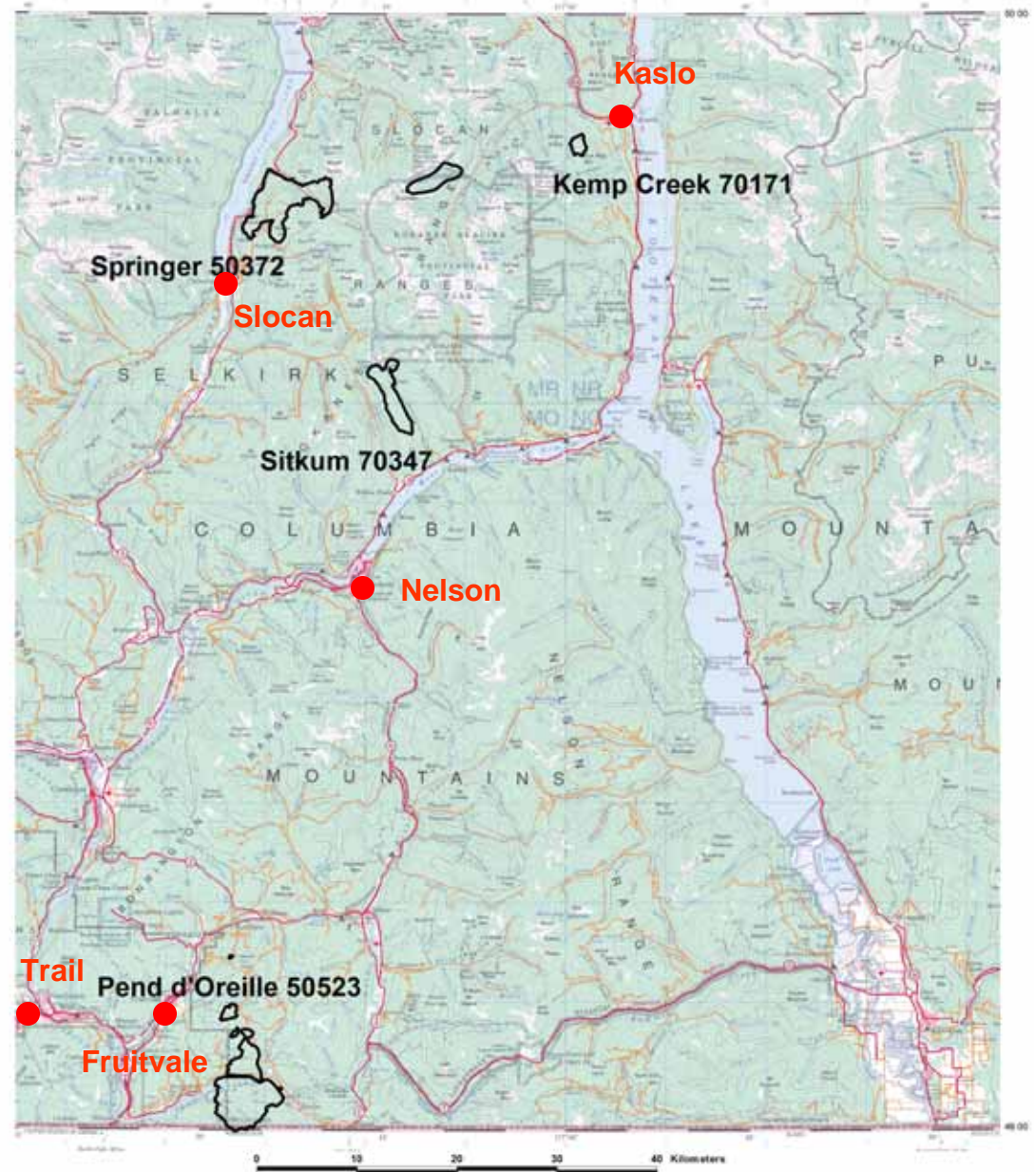
- Screen all wildfires in potential high-risk areas (interface areas, highway/industrial corridors, community watersheds).
- For fires of concern:
 - map burn severity based on helicopter aerial photographs;
 - field work on the ground: test soils to determine burn severity;
 - identify areas of high landslide, debris flow, or flood hazard;
 - inspect elements at risk (e.g. alluvial fans, highway culverts).
- **For high risk fires:**
 - inform PEP who contacts affected stakeholders;
 - prepare satellite-based burn severity maps, and do more detailed ground investigations;
 - make recommendations on defensive works or treatments.
- Work is done by MFR research and engineering staff; consultants will be used in bad fire years.

Summary of MFR Role and Responsibility

- Screen wildfires and conduct risk analyses.
- For high risk fires: inform PEP who contacts affected stakeholders and warns them of the risks.
- May make recommendations on defensive works or treatments.
- We consider mitigative works on Crown forest within the burn perimeter
 - may undertake mitigative works if likely to be of benefit to reduce risks to public safety or infrastructure
- **Our mandate is limited to Crown forest, but we will provide information on risks affecting other areas.**

2007 Fires in South-East BC

- Springer Creek – 3137 ha
- Pend D'Oreille – 3969 ha
- Sitkum – 1075 ha
- Kemp Creek – 200 ha
- Hamill – 1528 ha
- Penstock – 315 ha

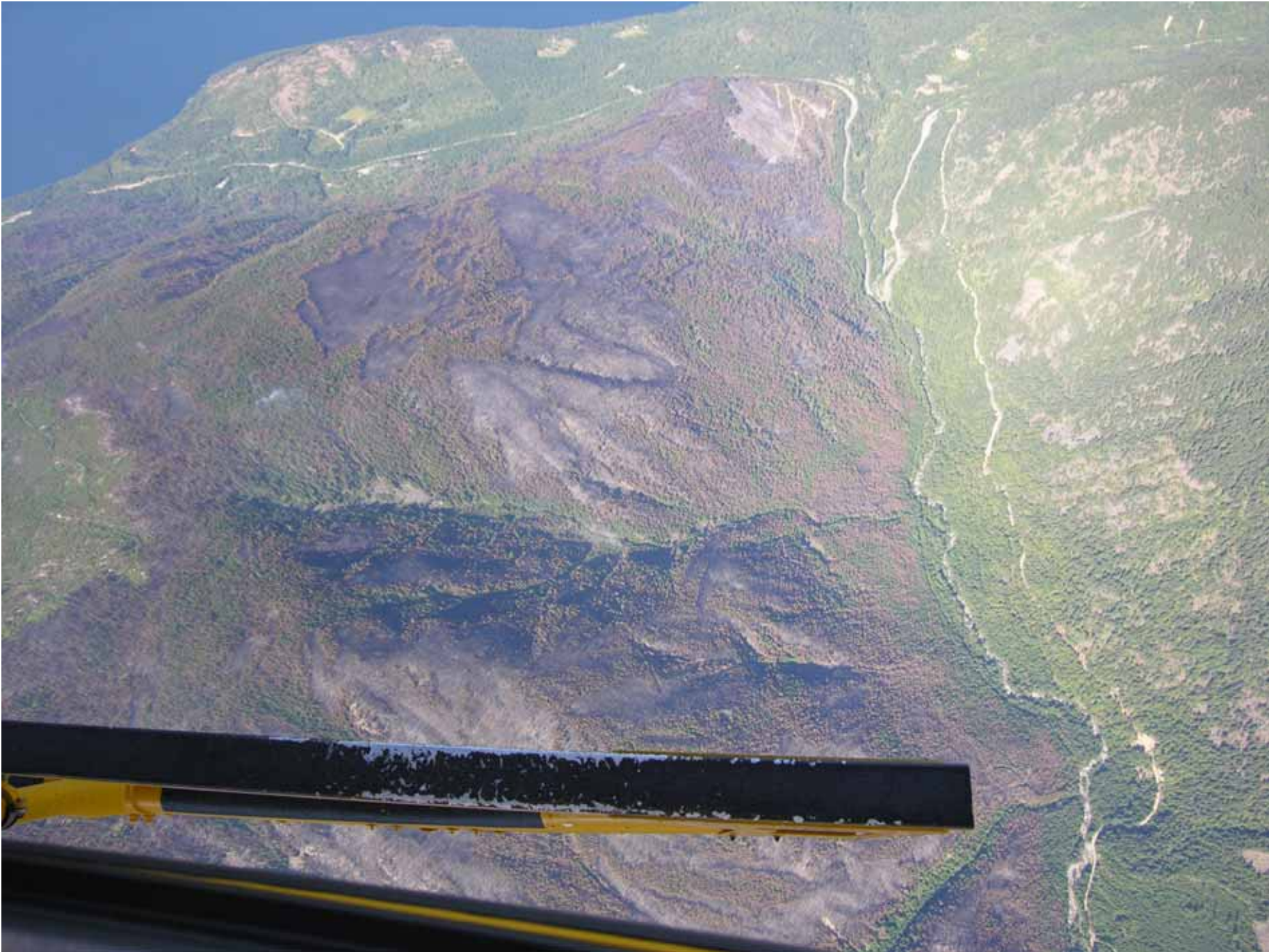


What the BC Forest Service did for 2007 fires

- One SIFR specialist (Jordan) screened all wildfires in SE Fire Centre, and did preliminary field reviews of some fires with Protection staff
- Once several fires were of serious concern, we assigned a coordinator (Curran) to assist risk analysis teams, and be responsible for communication with PEP, Fire Centre, others
- Risk Analysis teams (lead by Jordan, Nicol and Alcock)
- - mapped burn severity based on helicopter aerial photos
- - field work on the ground: test soils, inspect channels & fans
- - identified areas of high landslide or debris flow hazard
- For highest risk fires:
 - informed PEP who contacted affected stakeholders of the risks
 - prepared hillslope soil mitigation plans (Curran)
 - assisted Forest Districts in implementation of mitigative treatments

Risk Analysis – Springer Fire





Risk Analysis - Springer Fire

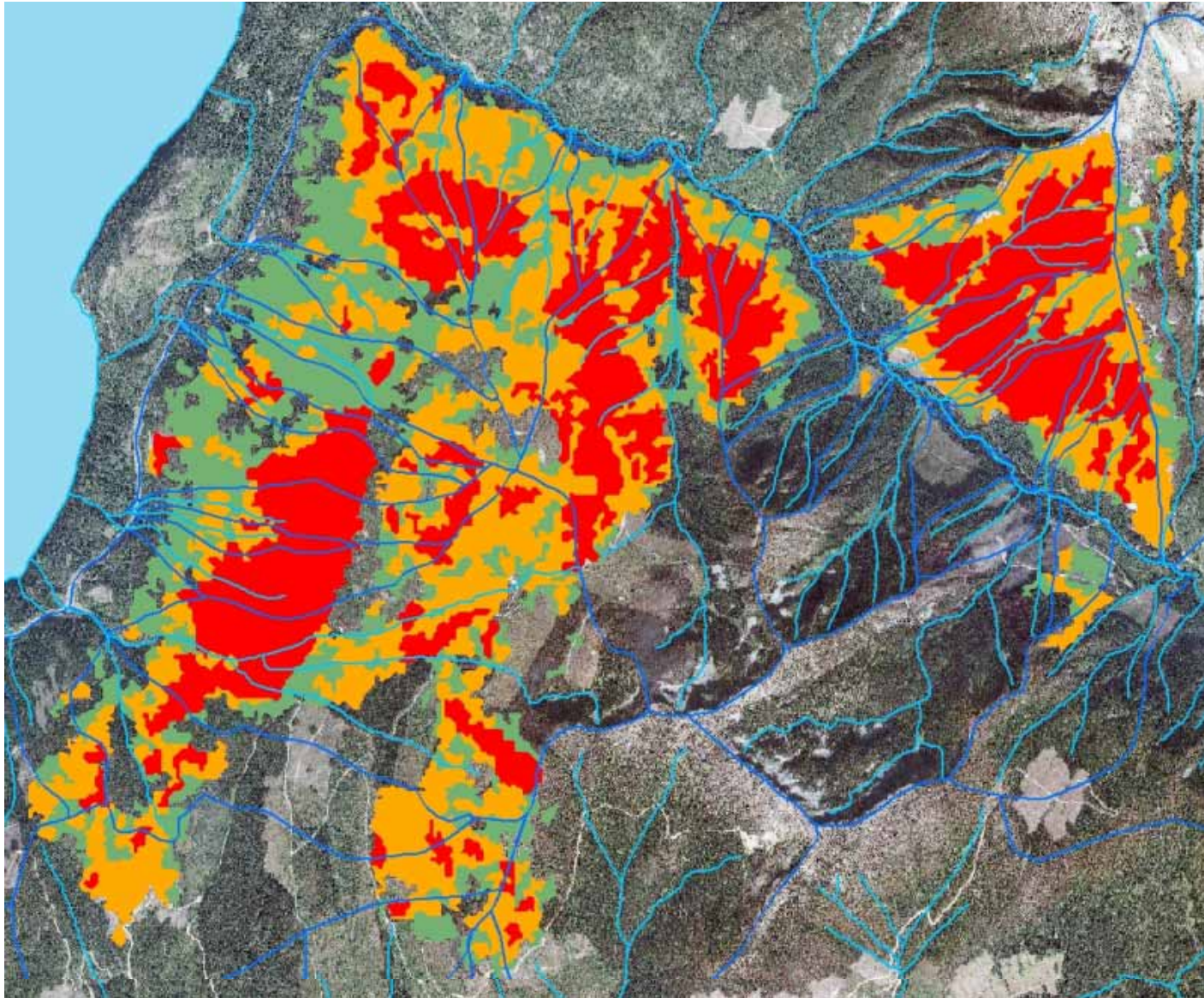


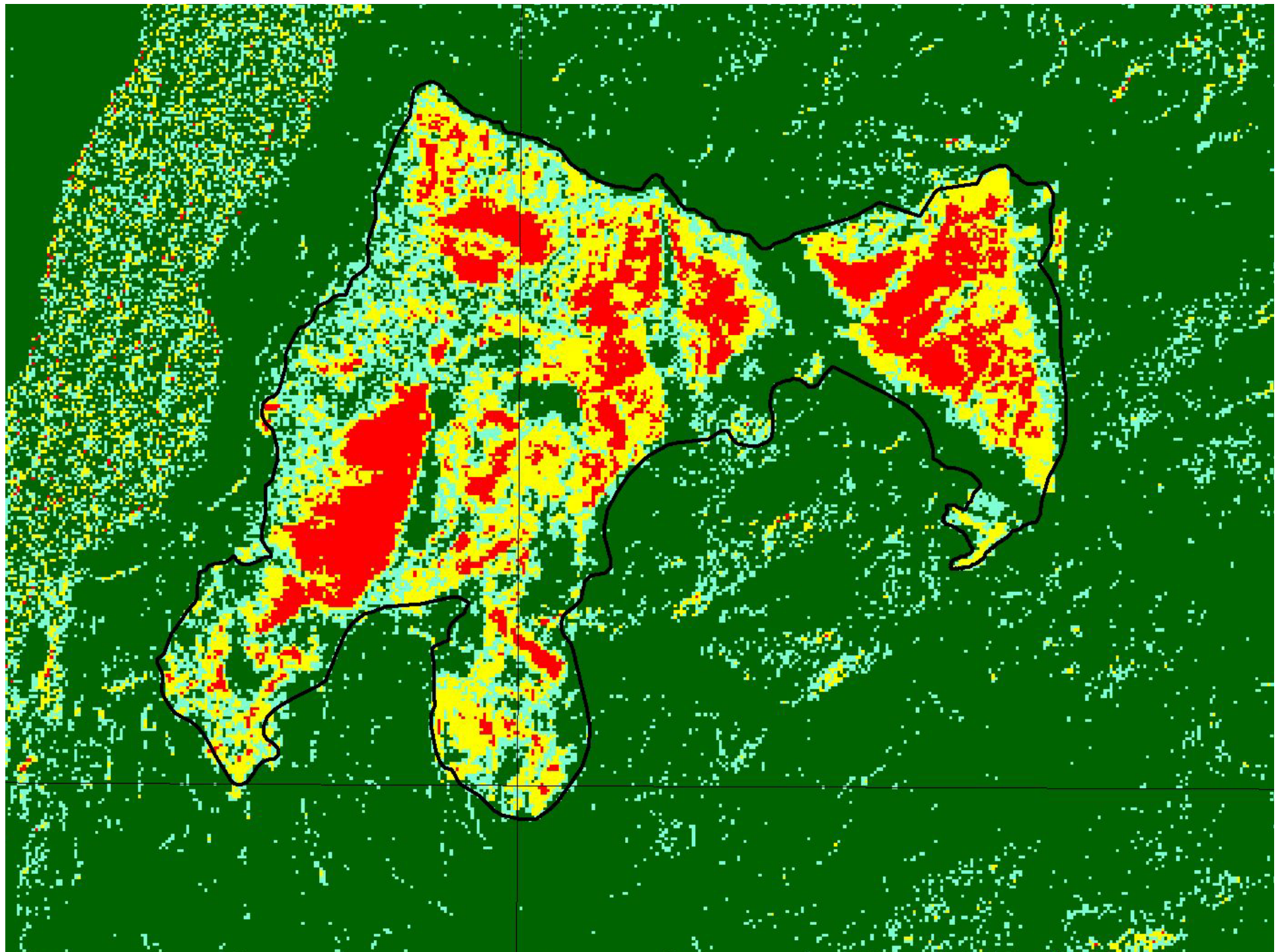
Risk Analysis – Springer Fire



- Ground truth burn severity maps
- Test for water repellency
- Assess hazards

Springer Fire – Vegetation Burn Severity Map

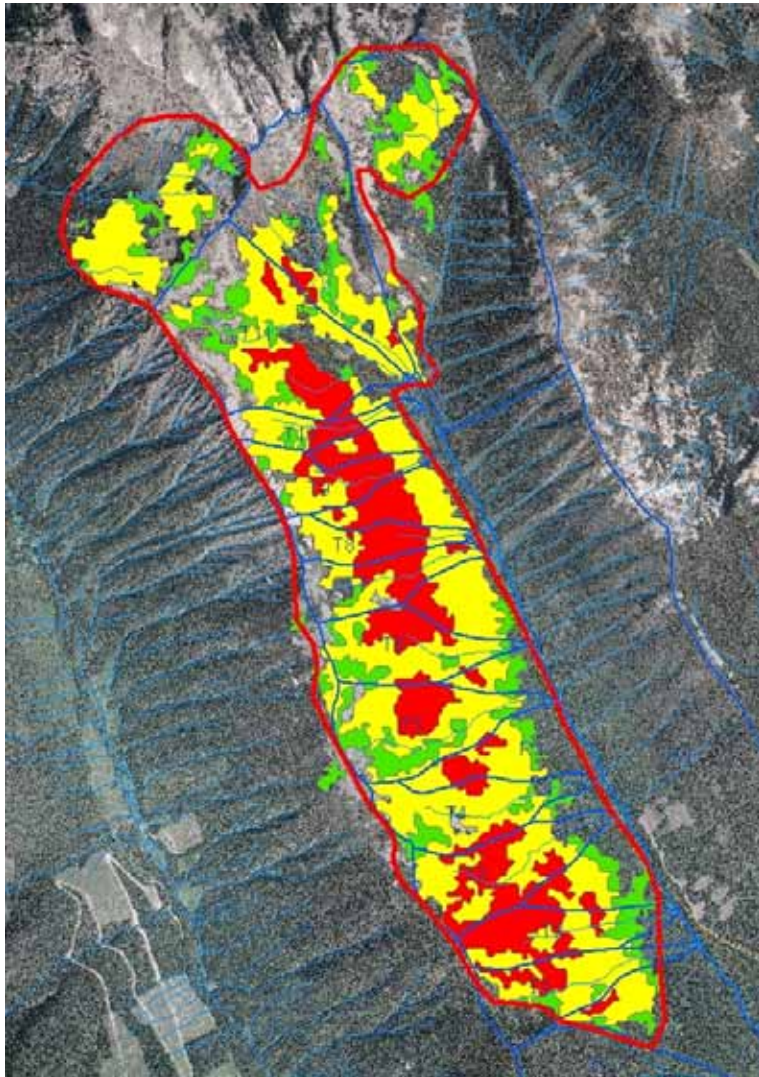




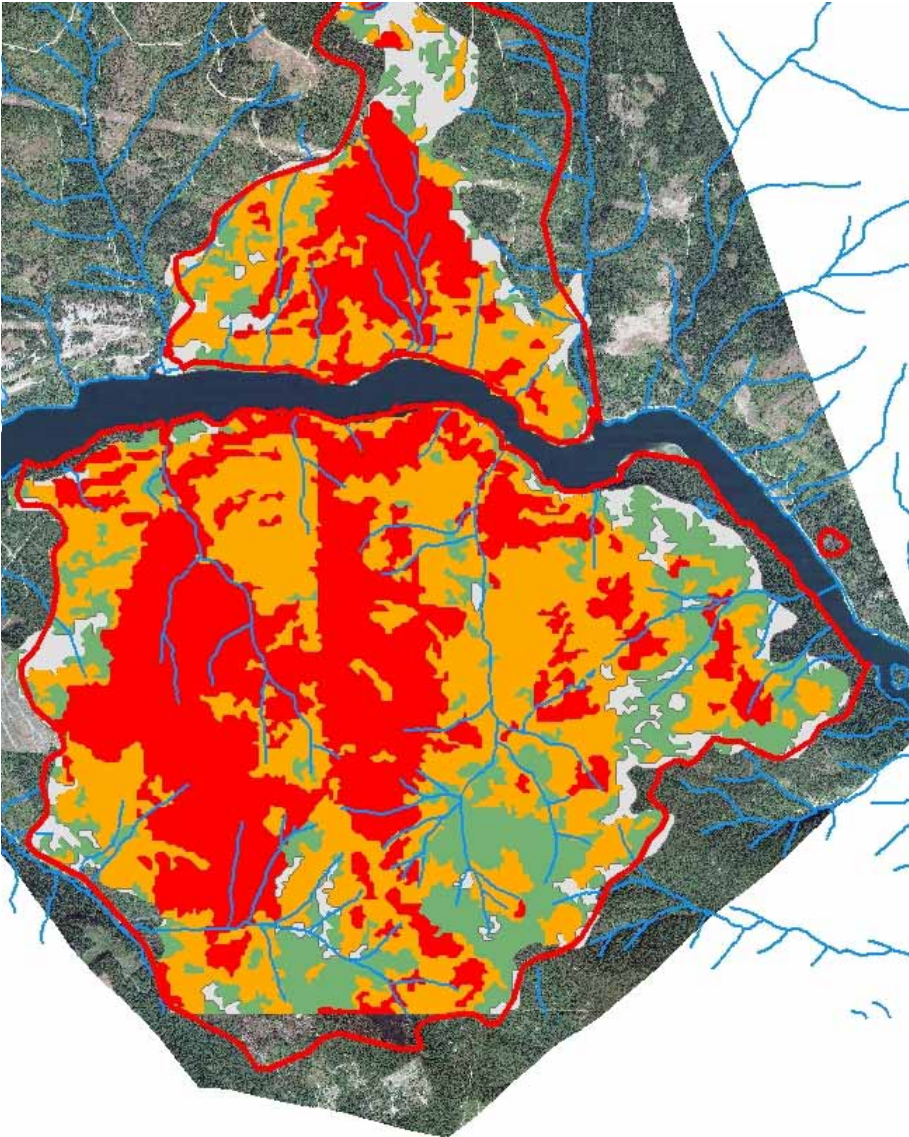
Risk Analysis – Sitkum Fire



Sitkum Fire



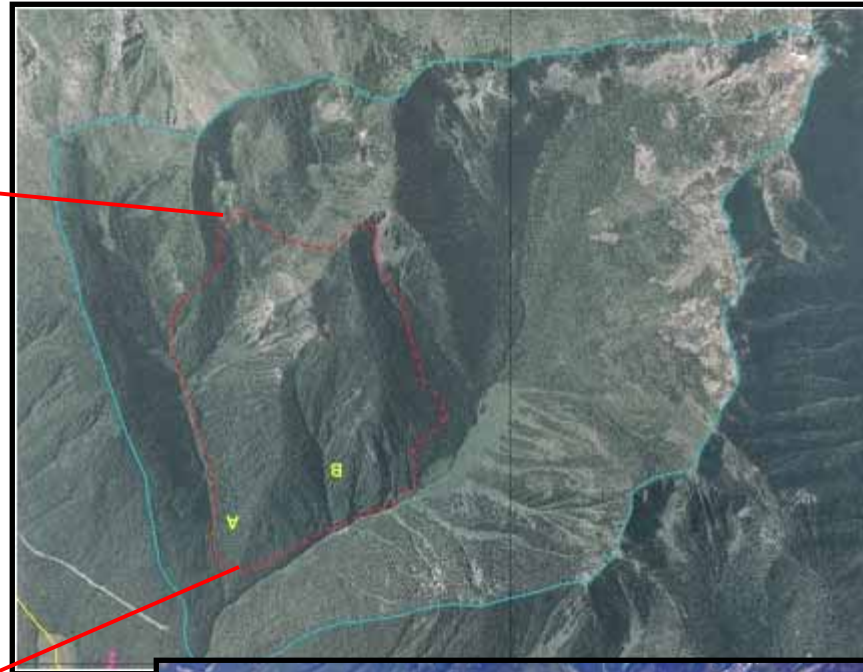
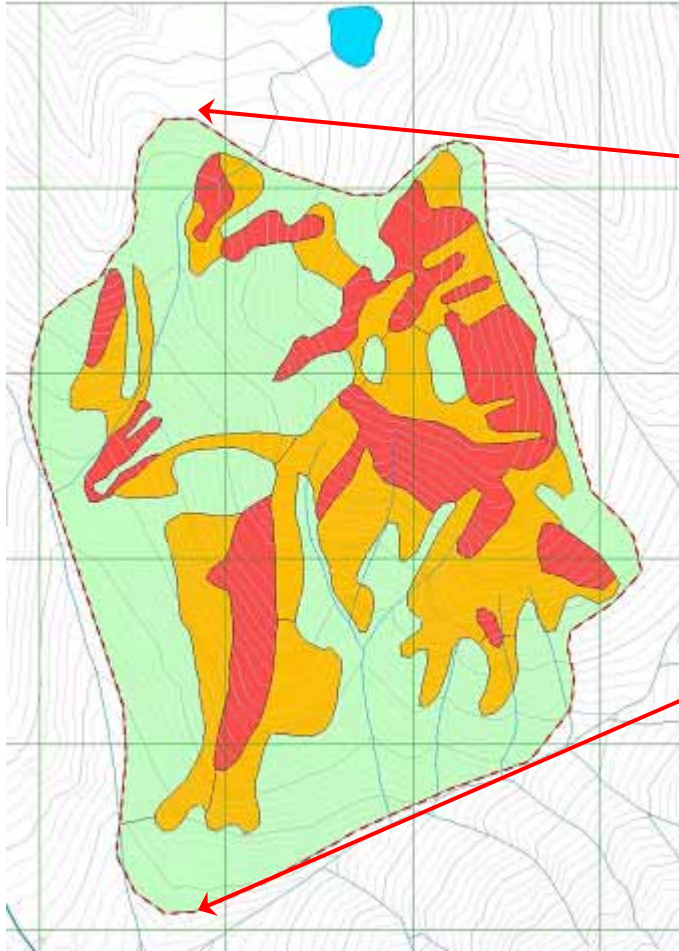
Pend D'Oreille Fire



Kemp Creek Fire – Kaslo community watershed



Kemp Creek Fire



- **Summary of 2007 Fires:**

- Springer: High hazard (debris flows, snow avalanches)
Moderate-High consequence to public safety
High risk – mitigation treatments recommended
- Sitkum: Moderate incremental hazard (flooding)
Moderate-High consequence to public safety, water quality
Moderate-High risk – mitigation treatments recommended
- Pend d'Oreille: High hazard (erosion, debris flows)
Low consequence to infrastructure, none to public safety
Low risk
- Kemp Creek: Moderate incremental hazard (flooding, erosion)
High consequence to water supply, low consequence to public safety
Risk is low (public safety) to high (water supply)

Mitigation (and other risk management) Options:

- Avoidance of the hazard
- Defensive structures in channels and on fans



Mitigation (and other risk management) Options:

- Engineering treatments – upgrade creek crossings, cross-drain culverts etc (forest roads, non-status roads, highways)



Mitigation (and other risk management) Options:

- Broadcast treatments of burned areas
 - straw mulching
 - contour log felling



Mitigation (and other risk management) Options:

- Reforestation – can speed hydrologic recovery where equivalent clearcut area is a concern.
- Grass seeding – generally not effective (and can compete with planted trees) but fall rye can be useful.

Overland Flow and Soil Erosion



What's going on??

Wildfire

Ground Cover Consumed

(moderate - high severity, untreated)

Exposed /
Water repellent
soil

Overland Flow ↔ Soil Erosion

loss of
top soil, seed,
nutrients

Debris Flows ↓ Flooding

- Risk to human life, property, infrastructure
- Sedimentation of streams
- Degraded water quality & aquatic habitat

High
Intensity
Rain Storm

Ground Cover Remaining

(Low severity or hi/moderate treated with mulch)

Protective
soil cover

Minimal Overland Flow ↔ Infiltration

soil moisture
retention

Minimal Soil Loss ↓ Vegetation Recovery

- Soil recovery
- Restoration of hydrologic cycle

Generation of Overland Flow

- **Drought conditions** can lead to unusually **severe burning** of the litter and surface soil
- High Severity burns and dry mineral soil can become **water-repellent** or **pores become clogged** with ash and charcoal
- Result is **increased overland flow**, particularly during **summer thunderstorms**



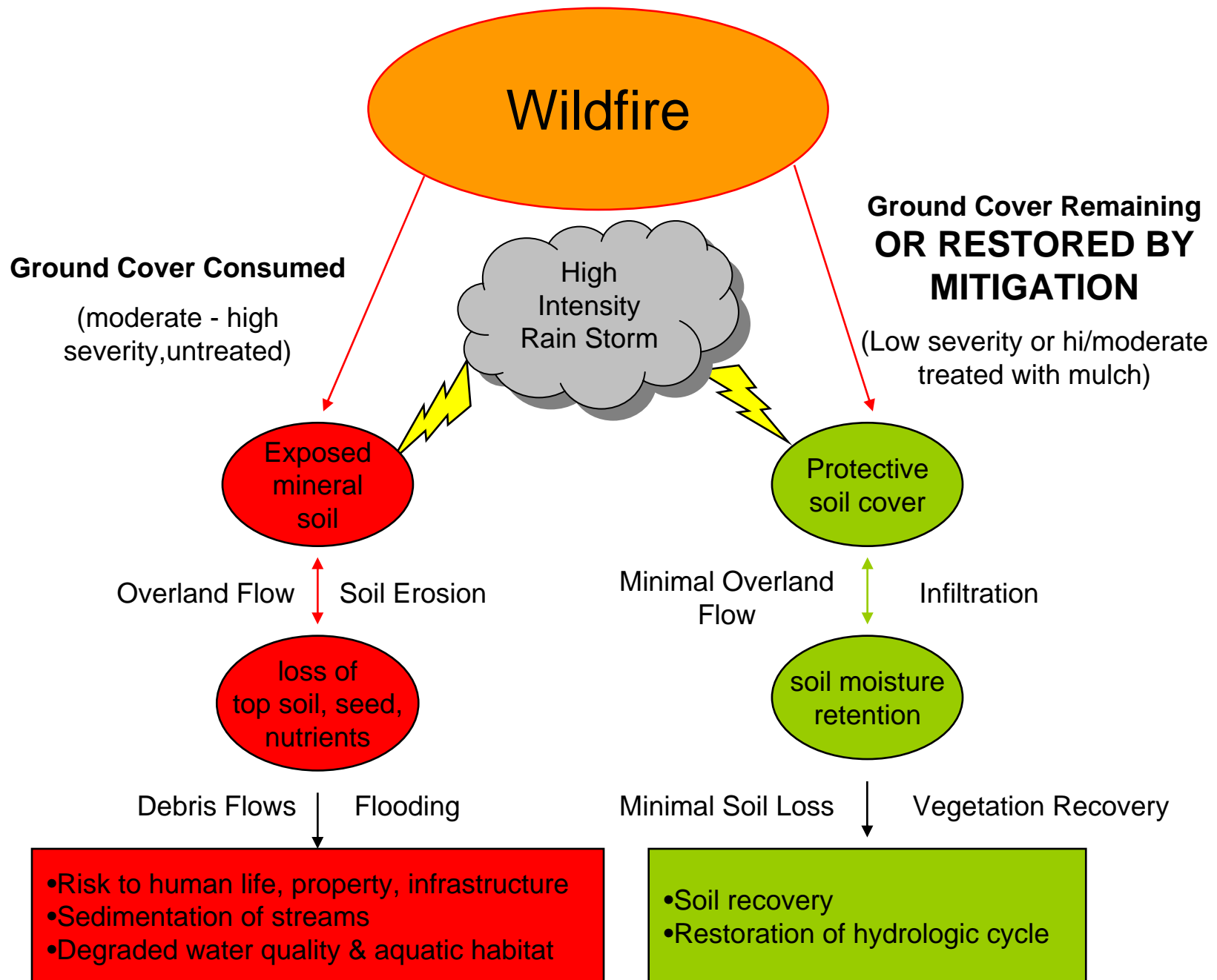
Overland Flow Leading to Soil Erosion

- Water repellent soils occur at 0 to 5 cm, and creates a “**tin-roof**” effect
- Surface erosion from overland flow causes **sediment bulking** in gullies/channels
- Summer thunderstorm with intensity of 10mm/hr for 30 minutes can cause debris flows or flooding











Wildfire Erosion Research Project

- What was the driving force behind 2003 and other post-fire erosion events in BC:

Soil type, soil moisture (DC), rainfall intensity, basin configuration, fire intensity, burn severity, water repellency ?

- How can we predict it and protect life and property?
- Gain information to improve procedures and mitigation options

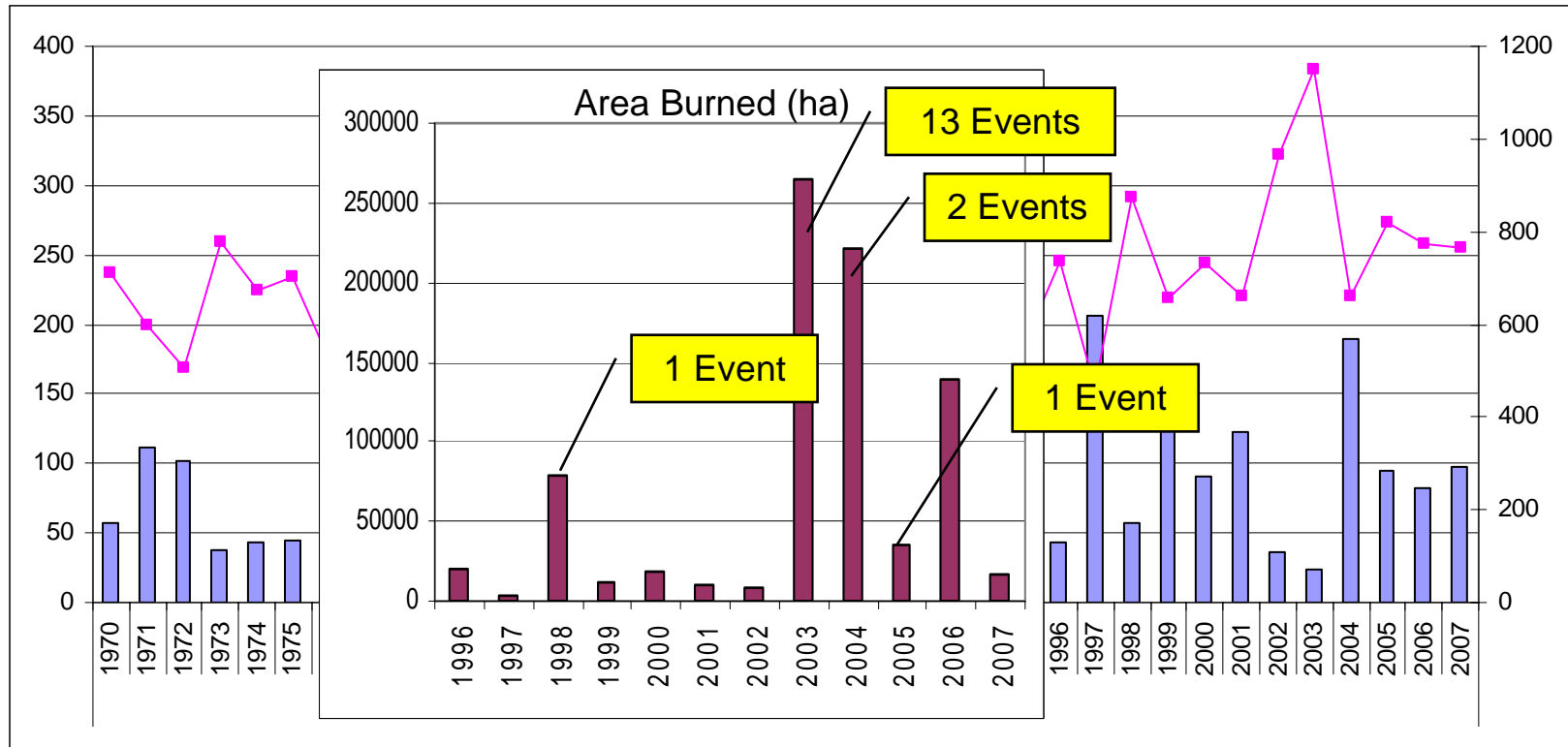


Wildfire Erosion Research Project

Knowledge Gaps

- How common is severe water repellency following fires in this region?
- How can we predict when it will be a problem (e.g., antecedent moisture conditions in duff/soil (DMC?), soil texture, fuel type and supply, burn severity)?
- How long does water repellency persist?
- How applicable are research results from the U.S. to B.C. (where soil and climate conditions are somewhat different)?

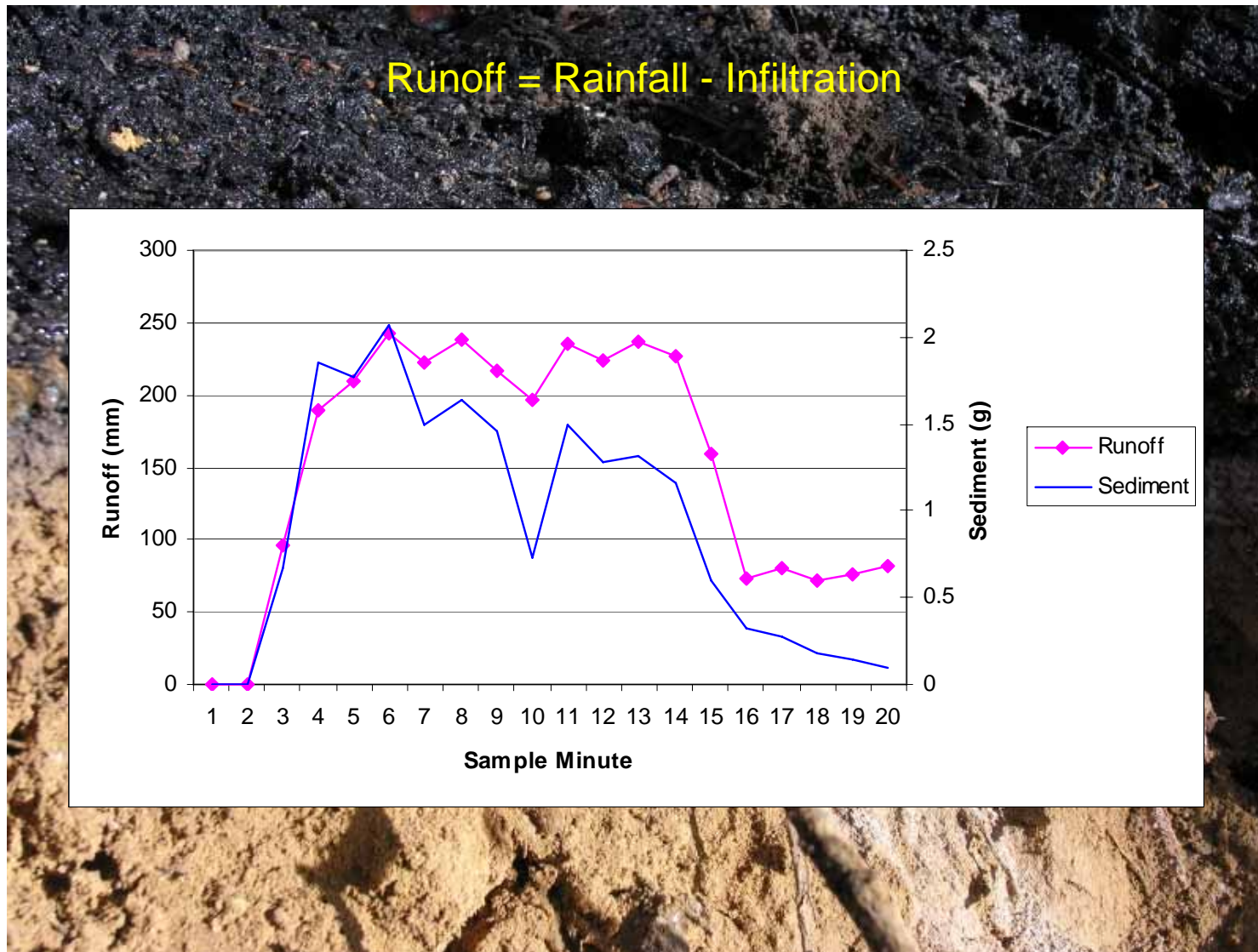
1. What is the role of pre-fire weather on burn severity and post-fire erosion events?



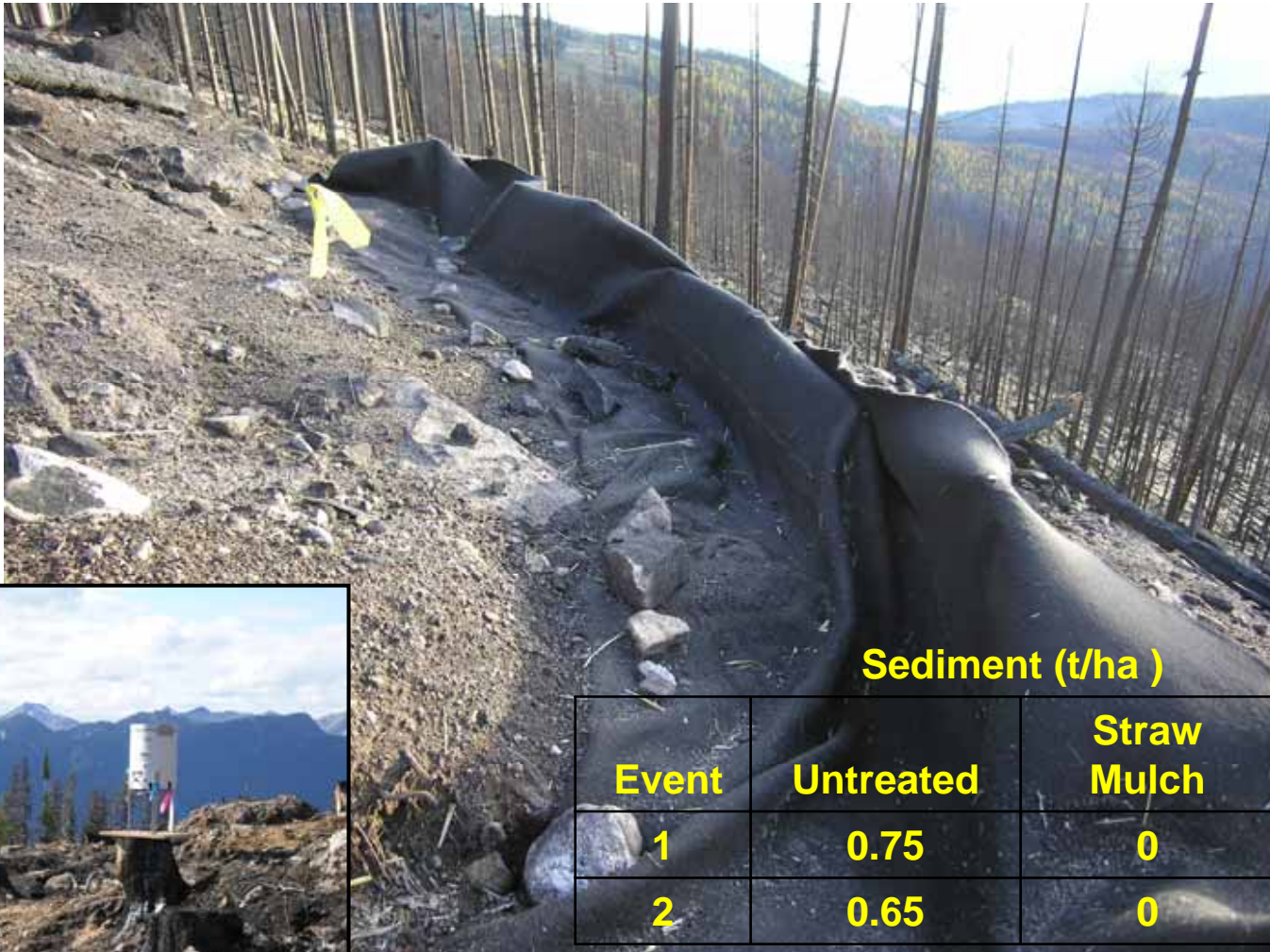
Total Rainfall for June, July and August

Max Drought Code (DC) Index for June July and August

2. How do water repellency and burn severity affect infiltration, runoff and hillslope erosion?

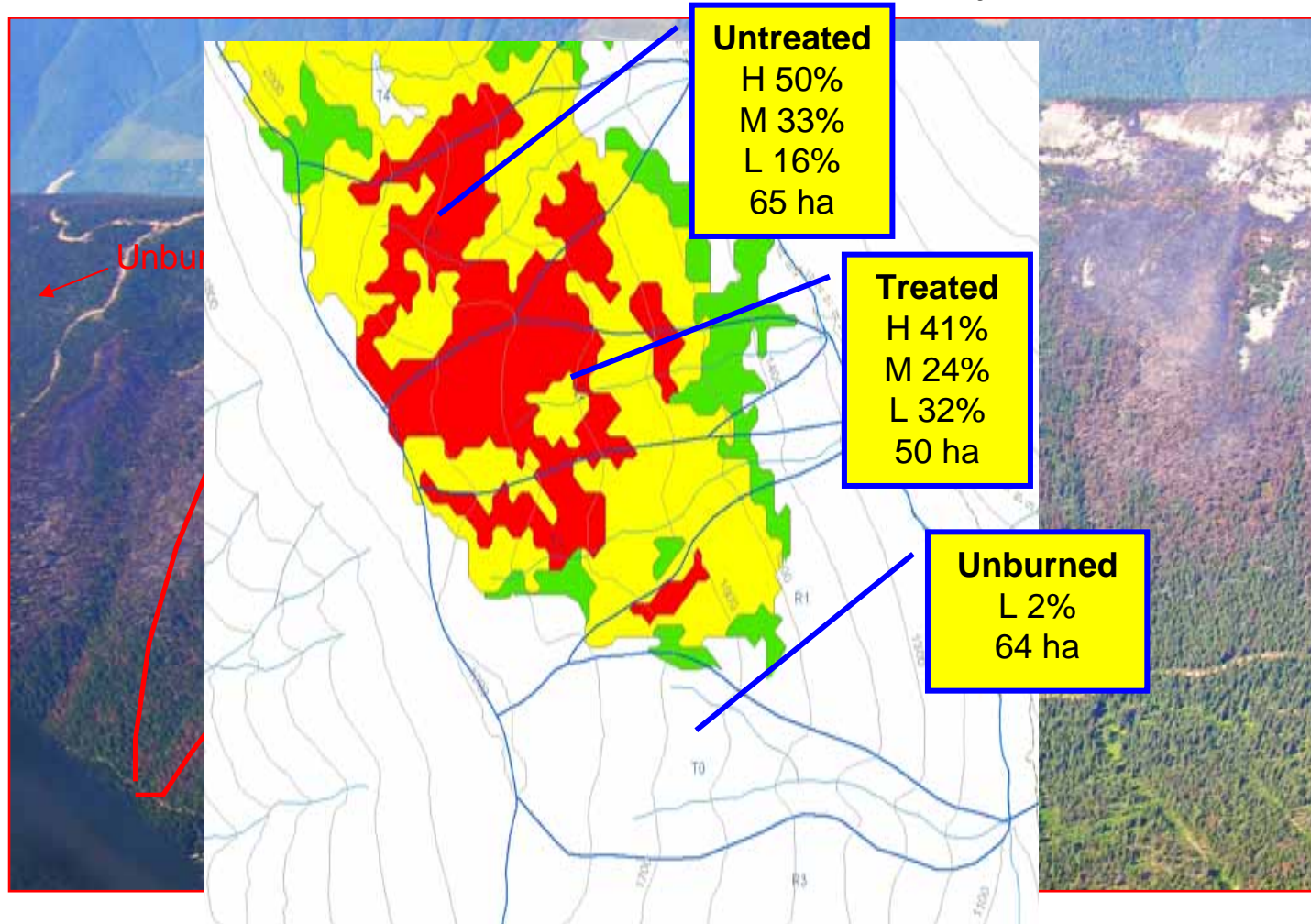


2. How do water repellency and burn severity affect infiltration, runoff and hillslope erosion?



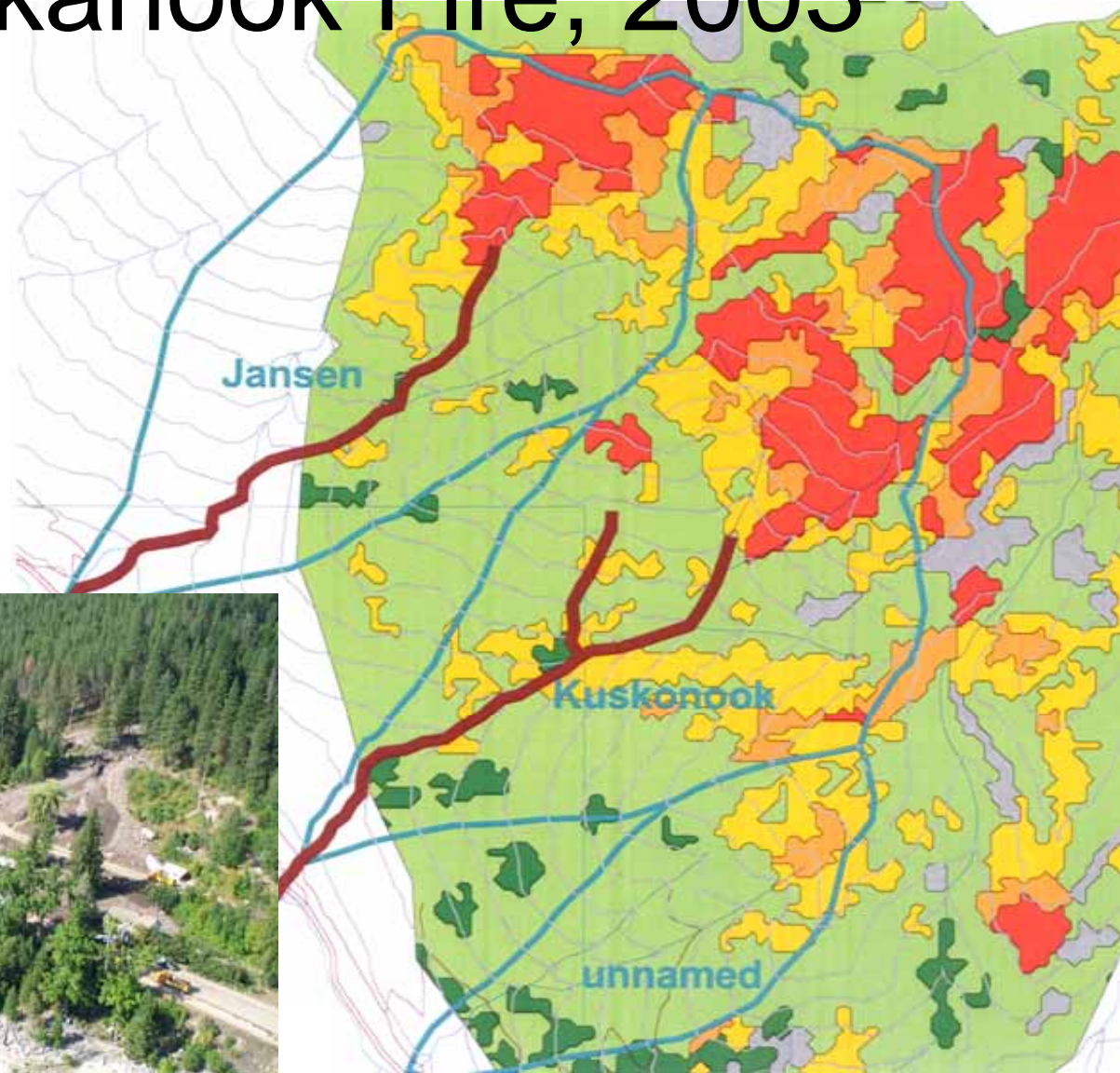
Event	Sediment (t/ha)	
	Untreated	Straw Mulch
1	0.75	0
2	0.65	0

3. What role do watershed size and extent of burn severity play in channel failure initiation?
- “Paired” Watershed Study



Sitkum Fire, 2007

Kuskanook Fire, 2003



What Are Our Options?

- Increase our knowledge and understanding of post-fire erosion processes in BC
- Educate the stakeholders about these risks
- Mitigate after a fire – mulch, channel barriers, road upgrade/deact., berms, planting etc.
- Consider fuel management in upper watershed basins
- Warn people not to build their \$\$\$ homes on alluvial fans

11/05/2003