The effect of prescribed fire severity & burn patchiness on runoff & erosion

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Runoff & erosion after a wildfire can affect water quality
Debris flows are an example of extreme post-fire erosion.
• Prescribed burning = deliberate use of fire to achieve objectives
• Little is known about its effects on water quality
Fire regime + Rainfall + Site features → Post-fire runoff & erosion
Fire severity and burn patchiness can be manipulated in a prescribed burn.
Fire severity

Considered an important factor, but few studies compare different fire severities.
Burn Patchiness

Key factors: patch arrangement & density
Study by Robichaud & Monroe (1997) in a North American ponderosa pine forest
Aims of study were to quantify the:
• effect of prescribed fire severities on runoff and erosion
• runoff and sediment trapping efficiency of unburnt patches
Site description

- North-facing slopes
- Shrubby foothill forest (EVC)
- Clay-loam soil
- Burnt April 2009

Study site in Upper Yarra catchment
Methods

- Runoff tanks in transects beneath 100m of hillslope
- Runoff & sediment concentration measured after rain
100 m

20 m

High severity
Low severity
Unburnt
Low severity above:
10 m unburnt patch
5 m unburnt patch
1 m unburnt patch

100 m

20 m

Unburnt
Low severity
High severity

Unburnt
Low severity
High severity
Results

Evidence of rainfall splash erosion
Results

- High fire severity: 2058 g m⁻¹
- Low fire severity: 1671 g m⁻¹
- Unburnt: 1.4 g m⁻¹
Results

1000+ times more sediment on burnt hillslope
Results

Only 13% more sediment from high severity.
Results: compared to instream suspended sediment yields in a similar unburnt catchment (Bren & Turner, 2007)

Total sediment load (g m$^{-1}$)

- High fire severity: 2058 g m$^{-1}$
- Low fire severity: 1671 g m$^{-1}$
- Unburnt: 1.4 g m$^{-1}$

= 1% of total suspended sediment in stream
Results: compared to instream suspended sediment yields in a similar unburnt catchment (Bren & Turner, 2007)

= 100 x more suspended sediment in stream
Intense storms were very influential.

Results

- Cumulative sediment load: $I_{30} = 44 \text{ mm h}^{-1}$
- ARI = 10 years

- High severity: $2058 \text{ g m}^{-1}$
- Low severity: $1671 \text{ g m}^{-1}$
- Unburnt: $1 \text{ g m}^{-1}$
Revisit objective 1

Effect of prescribed fire severities on runoff and erosion...

- burning substantially increases runoff & erosion
- fire severity is less important (in the context of prescribed burning)
Low fire severity  

High fire severity
Does patchiness help prevent water quality impacts?
Sediment trapping efficiency varied as a function of patch width.
Sediment trapping efficiency varied as a function of patch width.
Results

Intense storm very influential
Excluding 27-Nov-09 rainfall event
(all other events with ARI < 1 year)
Results

Excluding 27-Nov-09 rainfall
(all other events with ARI < 1 year)
Trapping efficiency varied as a function of patch width & rainfall intensity
Revisit objective 2

Quantify the runoff & sediment trapping efficiency of unburnt patches...

- unburnt patches are effective sediment traps
- trapping efficiency depends on patch width & rainfall intensity
Management implications

- Prescribed burning could affect water quality
- Those impacts may be reduced by maintaining unburnt patches
- Fire severity is less important
The diagram illustrates the percentage of different conditions in an upslope and downslope area, with the following color coding:

- **Unburnt** (green)
- **Burnt & not connected to hillslope outlet** (yellow)
- **Burnt & connected to hillslope outlet** (yellow with green dots)

The percentages for the downslope area are as follows:

- 20%
- 100%
- 60%
- 70% sediment reduction

The diagram shows the distribution of these conditions across the downslope area.
Patchiness reduces the impact of burning on water quality under moderate rainfall conditions.

What about more intense rainfall?
• Patchy burn
• 9-months of recovery
• Steep terrain
• 39 mm in 2 h
• Debris flows are probably unavoidable
• But burn patchiness may reduce their magnitude
• More research is needed
Conclusions

- Burning increases the sediment yield >1000 x
- Only 13% more sediment generated for high severity compared with low severity
- Unburnt patches trap 92-99% sediment for rainfall events with an ARI < 1 year
- For more intense rainfall events (ARI = 10 years) the 1 m unburnt patch is ineffective
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Questions...