Fire Management

INTERVENTION CATEGORY: MANAGEMENT

DESCRIPTION

Fire management involves the deployment of management activities that reduce forest fuels and thereby reduce the risk of catastrophic wildfire. Also commonly referred to as "forest fuel reduction", fire risk management typically involves mechanical thinning and/or controlled burns. Fire risk management is typically employed in areas where forests are prone to wildfires. The abrupt removal of forest cover and damage to ground cover and soils from catastrophic fires can be particularly problematic when rain falls on severely burned areas[1], as these rain events can cause large-scale erosion of unsecured hillsides, and produce flooding and debris flows that affect downstream infrastructure and communities. Accordingly, fire management seeks both to preserve the integrity of healthy forests and reduce the future risk of increased sediment and nutrient transport, which differs from other activities that are aiming to reduce current annual loadings of pollutants.[2, 3] Given the annual growth of vegetation and accumulation of fuels, treated areas must be maintained through recurring application of fuel management activities.[4]

The Nature Conservancy
Protecting nature. Preserving life.

AFD
AGENCE FRANÇAISE DE DÉVELOPPEMENT

PHOTO: © PHOTOGRAPHER / AGENCY

WATER SECURITY CHALLENGES (WSCs) ADDRESSED

TYPE		IMPACT	MAGNITUTE	DEPTH OF EVIDENCE BASE
Water availability	Groundwater recharge	Increased mean annual groundwater recharge	★☆☆	★☆☆
	Dry season flows	Maintained dry season flows	★☆☆	★☆☆
Disaster risk	Flood risk	Reduced peak discharge	★★★	★★★
Water quality	Erosion and sedimentation	Reduced on-site erosion and sediment yields	★★★	★★★
	Nutrients and pollutants	Reduced in-stream nutrient and pollutant concentrations	★★☆	★★☆

Wildfires in forested watersheds are often associated with costly sedimentation and flood risks.[5] Fire management seeks to avoid dramatic surges in peak flows by regulating surface runoff.[6] Post-fire peak flows have been documented to be up to 900 times greater than the unburned reference case for up to 15 years after a fire, when rainfall surpasses a certain threshold.[5] Siltation and pollution can occur when catchment areas lack protective vegetative cover due to wildfires. Due to enhanced erosion, surface water runoff carries increased amounts of sediment, nutrients, pesticides, fertilizers, and other pollutants or debris into rivers and reservoirs.[3] In some cases, post-fire runoff can release potentially toxic legacy sediments into vulnerable water systems.[7] The evidence base regarding water availability benefits is limited; managing forest density may decrease evapotranspiration, potentially enhancing groundwater recharge and baseflow.

OTHER BENEFITS

WHAT?	HOW?
Habitats/biodiversity	Habitat improvement through forest restoration and r educed risk of losing forested habitats to catastrophic wildfires.
Carbon sequestration	Reduced risk of losing biomass and stored carbon to catastrophic wildfires and reduced risk of forest conversion to vegetation types that sequester carbon at a slower rate.
Provisional ecosystem services	Reduced risk of losing food, fiber, timber, medicine and other resources provided by forest ecosystems. Excess biomass removed during fuels reduction activities can support forest product industries.
Recreation and tourism	Reduced risk of losing (economic) benefits of recreation to catastrophic wildfires.
Job creation	Manpower required for implementing fuel management activities, such as thinning.

LINKAGES TO CLIMATE CHANGE

Mitigation: Fire risk management especially relates to climate adaptation by increasing resilience of forests to fire, though a secondary mitigation impact concerns the avoidance of losing biomass to catastrophic wildfires which would have taken decades to regenerate.

Adaptation: The number of large forest fires and the length of the wildfire season have both increased globally in the past few decades. Wildfire trends are expected to continue due to increasing occurrence of drought and denser forests associated with historical forest management and fire suppression.[11] Effective fire risk management is required to protect water sources by addressing the WSCs highlighted in this factsheet.

DESIGN-ENABLING CONDITIONS AND TYPICAL CONSTRAINTS

- Different fuel reduction techniques are appropriate in different conditions, each with their own enabling conditions and constraints: manual undergrowth clearing, mechanical ground clearing, prescribed burning, and silvo-pastoralism.[4] When the fuel load is high at the initial opening, it is advisable to carry out a manual or mechanical undergrowth clearing, or to use prescribed burning. If the fuel load is low, other techniques can be applied: herbicides or silvo-pastoralism. Combination of these techniques are possible. Chemical fuel reduction is often applied in challenging terrain and when limited funds are available. However, the environmental impact of the chemicals involved (e.g., glyphosate) make it less appropriate from a NbS point of view.
    - **Manual undergrowth clearing** is a low-impact method, applicable under challenging topographic conditions and on stony soils, which allows for species-specific clearing. The price of labor can be a major constraint, depending on context.
    - **Mechanical ground clearing** can be constrained by environmental conditions, but is generally economically advantageous in easily accessible terrain. Impacts on soil (compaction and erosion) should be considered.
    - **Prescribed burning** eliminates and contains the vegetation in a confined area, which requires usage of natural or artificial barriers. Typical constraints are general reservations towards burning of forest stands and lack of knowledge on prescribed burning protocols. It is not restricted by topography. Climate conditions need to be considered. Smoke impacts to communities may also limit application of prescribed fire.[8]
    - **Silvo-pastoralism** uses forest areas for raising livestock. It can be very effective but needs to be well-managed, to avoid damage to regeneration. It can only succeed if the forest area is well-integrated within available pastoral resources of a stockbreeder. Another constraint relates to the present species, where non-palatable plants need to be eliminated.
- The periodicity of the treatments depends on the speed of vegetation re-growth, management objectives (tolerated maximum biomass loads), and financial capacities.[4]
- Fire risk management/mitigation plans should be developed in coordination with any forest users (beekeepers, recreational operators, graziers, etc.).[9]

RELATION TO GREY INFRASTRUCTURE

INFRASTRUCTURE?	SERVICE PROVIDED BY GREY SOLUTIONS	TYPE OF RELATION
Off-river reservoir[5]	Flood control	Complementary
Pre-sedimentation basin[5]	Retention of sediments	Complementary
Water treatment infrastructure[5, 10]	Flocculation, sedimentation, filtration	Complementary
Access roads, fire breaks, automatic watering systems, lookout posts[4]	Forest fire protection	Complementary, Alternative

COMMON RISKS AND TRADE-OFFS

Depending to the specific context and the fuel reduction techniques applied, the following risks and trade-offs should be considered:

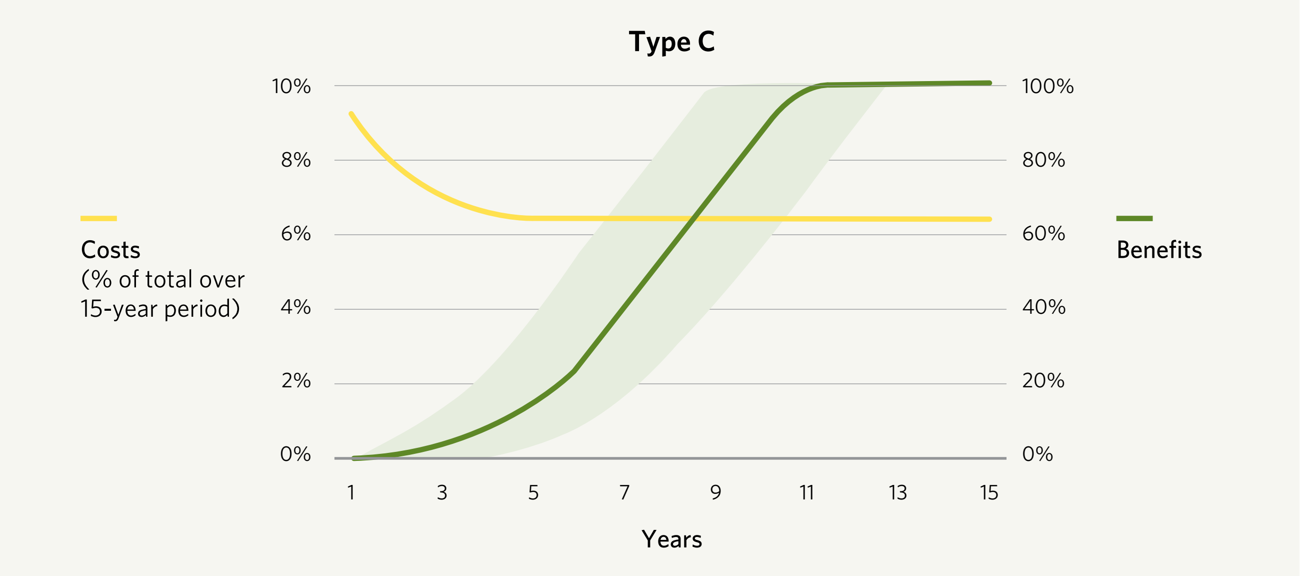
- Fuels management may expose bare soil increasing susceptibility to erosion on steep slopes Soil compaction can occur due to any heavy equipment used, although this is typically restricted to relatively small forest extents.[4]
- Prescribed burning involves a, usually minor risk of fire escape (including legal liability issues in case of damage) and potentially negative impacts on young plants or trees where forests have not evolved with fire.[4]
- Release of carbon occurs from prescribed burns and/or forest thinning, which should be viewed in relation to carbon sequestration benefits.
- Roads generally need to be built for fire management. if they are not already in existence. This can add to soil erosion and sediment loading.

MONITORING OPPORTUNITIES

- Monitoring of potential ignition sources and climate conditions.[9]
- Several well-established satellite-derived data products exist to assess historical and current fire wildfire frequency and extents: Fire occurrence and extent: Terra/Aqua (MODIS FIRMS)*, MODIS Burned Area Product, SPOT VGT Burned Area.[12]
- Many other global-scale datasets are available for assessing wildfire risk and post-fire impacts.[13]

IMPLEMENTATION COSTS AND TIMING OF BENEFITS

Wildfire risk management is commonly implemented as a cost-avoidance strategy in the face of extreme and costly disruptive events.[5] Upfront investments in wildfire prevention, biomass reduction, and watershed restoration are more successful and cost-effective than firefighting and post-fire slope stabilization.[14] The distribution of costs in time relates to the two phases of fuel removal: (i) initial treatment which is often expensive because fuel load can be high, and (ii) the undergrowth clearance for maintenance intended to limit the reaccumulation of hazardous fuel loads. This work must be carried out regularly, with a frequency depending on vegetation growth and the applied technique.[4]



---

* https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms

Prescribed burning in Madison, New Hampshire, U.S. (source: National Geographic)

EXAMPLES

Well-documented cases of fire risk management cases, including assessments of costs and benefits, are mostly available from North America, Australia, and (to a lesser extent) Europe. Some examples are given below:Sierra Nevada, United States.[3]

Denver, Colorado, USA[5]

Brief description: Investments were primarily made in fuel reduction and reforestation treatments in "zones of concern", with the goal to restore 38,000 acres of land over five years. The objective is to lower risk of catastrophic wildfire, reducing risks of substantial built infrastructure costs (dredging, variable treatment costs) associated with sedimentation. Total costs of $33 million were paid by Forest Service and public utility (Denver Water).

Lessons learnt:

- The investment was justified by the costs of previous major wildfire events. Denver Water incurred $26 million in costs after two devastating fires to manage post-fire sedimentation. Fire suppression costs were another $47 million, the Forest Service spent another $37 million on post-fire restoration and stabilization, and private insured property losses were an additional $38.7 million.

Melbourne, Australia[15]

Brief description: Melbourne relies on forested catchments for 80% of its water supply, in which Eucalyptus forests are highly flammable. Post-fire erosion rates are potentially >100 times greater than normal. Hydrodynamic modelling indicates a large wildfire in the Upper Yarra Reservoir could result in water being untreatable for a year or more. Melbourne Water has invested millions in research programs to inform fuel reduction, firefighting efforts, and post-fire response.

Lessons learnt:

- It is estimated that the savings to Melbourne Water from better management and understanding of risks is in the millions of dollars.
- Scenario analyses with debris flow modelling coupled with hydrodynamic modelling are highly valuable to assess potential biophysical impacts of wildfires and justify fire management investments.

REFERENCES

1. Cannon, S. H., Gartner, J. E., Wilson, R. C., Bowers, J. C. & Laber, J. L. Storm rainfall conditions for floods and debris flows from recently burned areas in southwestern Colorado and southern California. *Geomorphology* **96**, 250–269 (2008).
2. WWAP/UN-Water. *Nature-Based Solutions for Water. Unesco* (2018).
3. Browder, G., Ozment, S., Bescos, I. R. & Gartner, T. *Integrating Green and Gray: Creating Next Generation Infrastructure.* (2019).
4. FAO. International Handbook on Forest Fire Protection – Technical guide for the countries of the Mediterranean basin. 1–163 (2009).
5. World Resources Institute. *Natural Infrastructure: Investing in Forested Landscapes for Source Water Protection in the United States. World Resources Institute* (2013).
6. Altamirano, M. A., de Rijke, H., Basco Carrera, L. & Arellano Jaimerena, B. *Handbook for the Implementation of Nature-Based Solutions for Water Security. NAIAD project* (European Union H2020) (2021).
7. Murphy, S. F., McCleskey, R. B., Martin, D. A., Holloway, J. A. M. & Writer, J. H. Wildfire-driven changes in hydrology mobilize arsenic and metals from legacy mine waste. *Sci. Total Environ.* **743**, 140635 (2020).
8. Haikerwal, A. et al. Impact of smoke from prescribed burning: Is it a public health concern? *J. Air Waste Manag. Assoc.* **65**, 592–598 (2015).
9. New Zealand Forest Owners Association Inc. Forest Fire Risk Management Guidelines. 1–40 (2018).
10. Sham, C. H., Tuccillo, M. E. & Rooke, J. Effects of Wildfire on Drinking Water Utilities and Best Practices for Wildfire Risk Reduction and Mitigation. *Water Res. Found. Denver, CO. 98 p.* 98 (2013).
11. Hallema, D. W., Robinne, F. N. & Bladon, K. D. Reframing the Challenge of Global Wildfire Threats to Water Supplies. *Earth's Futur.* **6**, 772–776 (2018).
12. European Commission. *Evaluating the impact of Nature-Based Solutions: A Handbook for Practitioners.* (2021) doi:10.2777/2498.
13. Robinne, F. N. et al. A spatial evaluation of global wildfire-water risks to human and natural systems. *Sci. Total Environ.* **610–611**, 1193–1206 (2018).
14. Robinne, F. N. et al. Scientists' warning on extreme wildfire risks to water supply. *Hydrol. Process.* **35**, 1–11 (2021).
15. Canning, A. et al. Bushfire management national good practice operational guidelines for the Australian water industry. 42 (2020).