“Fighting climate change: adapting forest policy and forest management in Europe”
Joensuu Forestry Networking Week

Integrating forest fire risk in forest planning

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• Fire is the most important hazard in southern Europe
  – It affects an average of 500,000 ha per year.
  – Fire has an impact on several aspects other than timber lost.
    • Human lives
    • Properties
    • Non-timber values from forest (recreational, soil protection etc…)

Source: Joint Research Center
http://effis.jrc.ec.europa.eu/
Fire scars from 2007 season

Greece: 84 casualties, 1000 houses, Olympia

Source: Joint Research Center
http://effis.jrc.ec.europa.eu/
Components of Fire

Define behaviour: rate of spread, intensity, severity and type of fire
Type of fire: Ground, surface, canopy (active or passive)
Effect of fuel on fire behaviour

- Fuel on fire effect depends on type, amount, allocation
  - Type (composition, dead/alive, size)
  - Allocation (vertical and horizontal continuity)

- Fire behaviour models have been traditionally focused on surface fires. (Rothermel Fuel Types)
  - Fuel load by category (live and dead) and particle size class
    (0 to 0.25 inch, 0.25 to 1.0 inch, and 1.0 to 3.0 inches diameter)
  - Surface-area-to-volume (SAV) ratio by component and size class
  - Heat content by category
  - Fuelbed depth
  - Dead fuel moisture of extinction.
Advantages and disadvantages of traditional approaches

- Fire behaviour models are able to predict the extent and effect of fire if the initial ignition point, the weather conditions, and the surface fuels are known.
- Some models even predict the possibility of canopy fires (surface fire intensity + canopy characteristics).
- Are useful to plan fuel management (analysis of fuel treatments)

- Limitations
  - Data demanding
  - Should consider specific characteristics for 1 fire event (historic conditions?)
  - Inaccurate for long term predictions
• Mortality models
  • Tree size
  • Fire intensity or severity
    • % scorched canopy
    • Deep consumed bark
    • Consumed litter etc…

• Difficult to predict in the future, depend on behaviour of specific event

Source: Fowler and Sieg. 2004
USDA Report RMRS-GTR-132, Rocky Mountain Research Station
http://www.rmrs.nau.edu/lab/people/jfowler/
Fire risk and forest management planning

- Forest structure and composition is closely related with fire behaviour and effect
  - Horizontal and vertical continuity of living fuels
  - Surface fuels are related with forest management (bushes, slash)

- This relation is not so easy to measure but:
  - Forest structure and composition can be predicted and simulated over long-periods
  - It can be used to estimate potential losses and benefits of fire
  - Through forest planning it can be integrated into a productive process (obtain more realistic predictions, reduce fire risk)
• Forest planning has as task to optimize the management of the forest to obtain a maximal amount of desired outputs (economic, ecologic, others..), or a minimal amount of undesired effects

• Forest planning requires:
  – 1) to know the existing resources,
  – 2) a prediction on how the resources (forest itself) will develop depending on the management alternative,
  – 3) the amount of different outputs that the forest will provide,
  – 4) information about the value of each of the outputs,
  – 5) and a way to compare the results of the different management alternatives (to optimize)
How to integrate the risk of forest fires

• Need to develop models that estimate probability of fire occurrence and damage depending on the stand characteristics (basic management unit).

• ...which should be defined from variables easily measurable in forest inventories, or predicted from existing simulation models.

• If the stand characteristics used to predict the risk of fire are under the control of the manager, the risk of fire can be modified.
Modelling the risk of forest fires for forest planning
Fire occurrence

\[ P_{fire} = \left( 1 + e^{-(b_0 + b_1 \cdot ELE + b_2 Dg + b_3 G + b_4 P_{hard} + b_5 \left( \frac{s_d}{Dg + 0.01} \right))} \right)^{-1} \]

- \(Dg\), \(G\) and \((SD/Dg+0.01)\); **stand structure**
- \(P_{hard}\) the proportion of hardwoods; **composition**
- \(ELE = \) transformed elevation

Source: Gonzalez et al., 2006
Annals of Forest Science 63: 169-176
http://www.afs-journal.org/
Stand damage and Tree survival

\[ y = b_0 + b_1 G + b_2 \text{Slope} + b_3 \text{Pine} + b_4 \left( \frac{G}{D_q + 0.01} \right) + b_5 \left( \frac{S_d}{D_q + 0.01} \right) + e \]

\( y = \) transformation of the proportion of dead trees \( P_{\text{dead}} \)
again management related variables or fixed ones (Slope)

\[ P_{\text{sur}} = \left( 1 + e^{-(b_0 + b_1 d + b_2 P_{\text{dead}})} \right)^{-1} \]

Source: Gonzalez et al., 2007
Annals of Forest Science. 64: 733-742.
http://www.afs-journal.org/
Fire risk depends on forest structure and composition.

Source: Gonzalez et al., 2007
http://www.efi.int/portal/virtual_library/publications/proceedings/
Use of the models in forest planning

• Already applied in:
  – Finding optimal forest stand management schedules
  – Forest and landscape level forest management planning applications
  – Scenario analysis

• Can consider as objectives:
  – Reduction of economic losses
  – Reduction of fire hazard
By optimizing different objective at stand level (under risk of fire) is possible to generate management prescriptions.

If fire is considered endogenous (management dependent), minimize the risk can be one objective.

Source: Gonzalez et al., 2005
Annals of Forest Science 62: 493-501
http://www.afs-journal.org/
Forest level planning

• A stand-level approach not enough
  – The risk of fire in a stand depends on neighbouring stands
  – Fires spread in a specifically spatial manner, forest and landscape level dimensions need to be taken into account
  – Different landscape configurations have different effect on the fire behaviour
  – Is possible to create "natural firebreaks"
  – New field of study (offers multiple possibilities and multiple questions must be solved)

• Landscape metrics
  – To measure the sizes, shapes and connectivity of forest patches, (can be used to modify the landscape configuration respect to a certain variable)
It is possible to allocate management operation in a way that a desired landscape configuration is attained using spatial optimisation.

Source: Gonzalez et al., 2005
http://www.springerlink.com/content/103025/
Still need to obtain more information about the effect of location and adjacency rules to improve forest level planning. Consider both endogenous and exogenous components of fire risk.

Adjacency rules should be similar to the ones in existing fire spread models, but considering that long term effect is what we are looking for.
My point of view

• Forest planning can be applied as the first step of an integrated fire prevention process.

• The risk of fire should be considered in ordinary silvicultural management and forest planning as a way to find efficient means to minimize fire damage cheaply.

• This step must be followed by other practices such as short term fuel management strategies in sensitive areas, and optimal allocation of the infrastructures supporting fire extinction efforts.
Adapting to Climate change (my opinion)

- Mediterranean areas
  - Conditions are bad enough (used to live with wildfires)
  - To many factors can affect fire risk
    - How fuel build-up will be affected (- risk) ?
    - More stress to trees (+risk) ? --- Other hazards?
    - Extreme fire weather will change? (Santa Ana, Mistral, Levante winds)
  - Improve forest management for current conditions is already a good approach and not only for fire

- Temperate areas
  - Extreme fire weather conditions will be more common
  - Are fire fighting resources ready?

Source: EFFIS Joint Research Center
http://effis.jrc.ec.europa.eu/
Thanks