**Wildfire cost assessment under future climate and rewilding scenarios in Barcelona metropolitan region (BCNFire)**

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**Code availability**: [GitHub - doschul/bcnfire](https://github.com/doschul/bcnfire)

**Background**

The Barcelona metropolitan region contains areas of agricultural land use abandonment. Previous research indicates on the one hand that biomass growing on these abandoned lands provide potential fuel for wildfire and associated hazards. On the other hand, future climate scenarios are likely to make biomass growth slower due to increased drought periods. This increases the available fuel for wildfires in the long run, but in the short run trees are going to die from drought exposure. While land abandonment creates unique possibilities for establishing diverse and resilient landscape by passively letting nature do the job, such a passive form of rewilding may come with an increased wildfire risk in the short term. Therefore, one management option is to remove deadwood from drought-affected trees via salvage logging to reduce available fuel. However, little is known about the cost of this management option and its benefits in reducing the fire risk.

**Research question**

What are the costs in terms of labor and the benefits in terms of avoided damage and fire fighting costs of performing salvage logging compared to a business-as-usual scenario without salvage logging? Answering this question aims to support the decision whether, when, and where to perform the salvage logging.

**Method**

We combine cost benefit analysis with risk assessment using a formal mathematical formulation of the decision with Monte-Carlo simulation. Similar decision analysis frameworks have been previously applied to agricultural and land use studies. Its strength lies in its flexibility to accommodate available data and measurements, and an explicit quantification of uncertainty. In principle, the approach consists of five steps. First, the decision is defined, in this case whether to carry out salvage logging in the Barcelona metropolitan region. In addition, all relevant variables that affect the decision are identified and linked in a formal model. In our case, the decision to do salvage logging is taken if its expected benefits exceed its costs. Therefore, we model costs of salvage logging in terms of required labor, and benefits in terms of reduced wildfire risk and associated avoided damages and fire fighting costs. Second, we model the current state of uncertainty by parametrizing the previously identified variables based on available knowledge. In this step, we use available data as well as parameter ranges provided by experts. Often, the initial estimates are uncertain and yield wide ranges of possible outcomes, which makes them uninformative. Third, we quantify the value of additional information for the parameters. The key idea is that we may not need better measurements for all variables – just for the ones that affect our final decision and thereby provide a measurable added value. If the outcome remains sensitive to certain input parameters, and we can therefore not make the decision with sufficient certainty, additional measurements are obtained and incorporated into the model (step 2). Once there is no significant gain from measuring parameters more precisely, we evaluate the final decision according to the risk preferences of the decision maker and provide a recommendation.

**Data**

Our study region is the Barcelona metropolitan region. As a key input, we use biomass and fire connectivity maps from (REF). These maps have been created for different future climate and management scenarios. Here, we focus on climate scenario XY and compare a business as usual (BAU) case without human intervention for biomass removal to a scenario with salvage logging (SAL). Values are provided in a 200 m resolution regular spatial grid. Biomass fuel values refer to the speed with which wildfire can spread in the corresponding cell. Its values range from zero meters per minute (no burning biomass) to 230 meters per minute, with a median of 25 meters per minute. Connectivity values are a unitless indicator that [DESCRIPTION]. We use connectivity values of neighboring cells to calculate direction and magnitude of fire spread over time. We model the extent to which any cell I burns at time t as a function of the status of its direct neighboring cells in the previous time period t-1, the connectivity value and the available biomass. The connectivity value is used to determine direction of spread, while biomass determines the potential rate of burn. Here, we linearly scaled the connectivity values between 0 and 1, where a value of one represents the highest connectivity observed in the BAU scenario. Correspondingly, we simulate an actual fire spread as potential speed (meter per minute, depending on biomass) multiplied by the neighboring cells connectivity value. We model time in discrete steps of five minutes. Figure 1 exemplifies how fire is expected to spread from randomly selected cells.

Next, we model fire spread for 1000 randomly selected ignition cells for a time horizon of three hours at five-minute intervals (t=0…36) for the two scenarios. Results in Figure 2 indicate that for any time horizon, there are fewer burned cells in the SAL scenario than in the BAU scenario. This is expected, since the potential fire spread values are lower or equal, resulting in slower spread.

Once we identify the burning cells (with a cell area of 200 x 200 m = 4 ha), we multiply the share of the cells that has burned with the respective landcover area observed in that cell. For example, a fully burned cell with an urban landcover share of 0.05 translates to a burned urban area of 1 \* 0.05 \* 4 = 0.2 ha. Figure 3 displays the distribution of burned landcover classes for the 1.000 model runs after 3 hours, i.e., t=36. While the majority of observations results in relatively small burned areas, the long tails in all cases indicate substantial risks of burning larger areas. The by far most affected landcover type is forest and shrubland, as expected from the available biomass fuel.

Finally, we use monte carlo simulation to assess the costs associated with each scenario. Table 1 shows the assumed input parameters (at this stage not realistic, just for illustration purpose!).

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Figure 1: Examples of simulated fire spread

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Figure : Total burned cells over time across scenarios for 1.000 random ignition points

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Figure 3: Distribution of affected landcover classes [ha]

Table 1: Input parameters for Monte Carlo cost simulation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **variable** | **lower** | **median** | **upper** | **distribution** |
| time\_horizon | 12 | NA | 36 | unif |
| houses\_per\_ha | 1 | NA | 20 | unif |
| house\_price | 20000 | 200000 | 1000000 | lnorm |
| agric\_land\_price | 10 | 500 | 5000 | lnorm |
| fire\_fight\_cost\_per\_ha | 10 | NA | 5000000 | lnorm |
| salvage\_logging\_cost\_per\_ha | 10 | NA | 200 | lnorm |

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Figure : Variable importance for decision