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Application of a cost-benefit analysis to estimate the value of the protection function of forests against rockfalls

S. Dupire^{1,2}, M. Bruciamacchie³

How to economically quantify the protection against rockfalls naturally offered by mountain forest?



Forests offer several ecosystem services. In mountain areas, forests play an important role for the protection of human lives and issues against natural hazard such as rockfalls.

The aim of this study is to implement a method for the calculation of the economical value of this ecosystem service. Cost-benefit analysis has been adapted to this particular case.



1. TECHNICAL ANALYZES

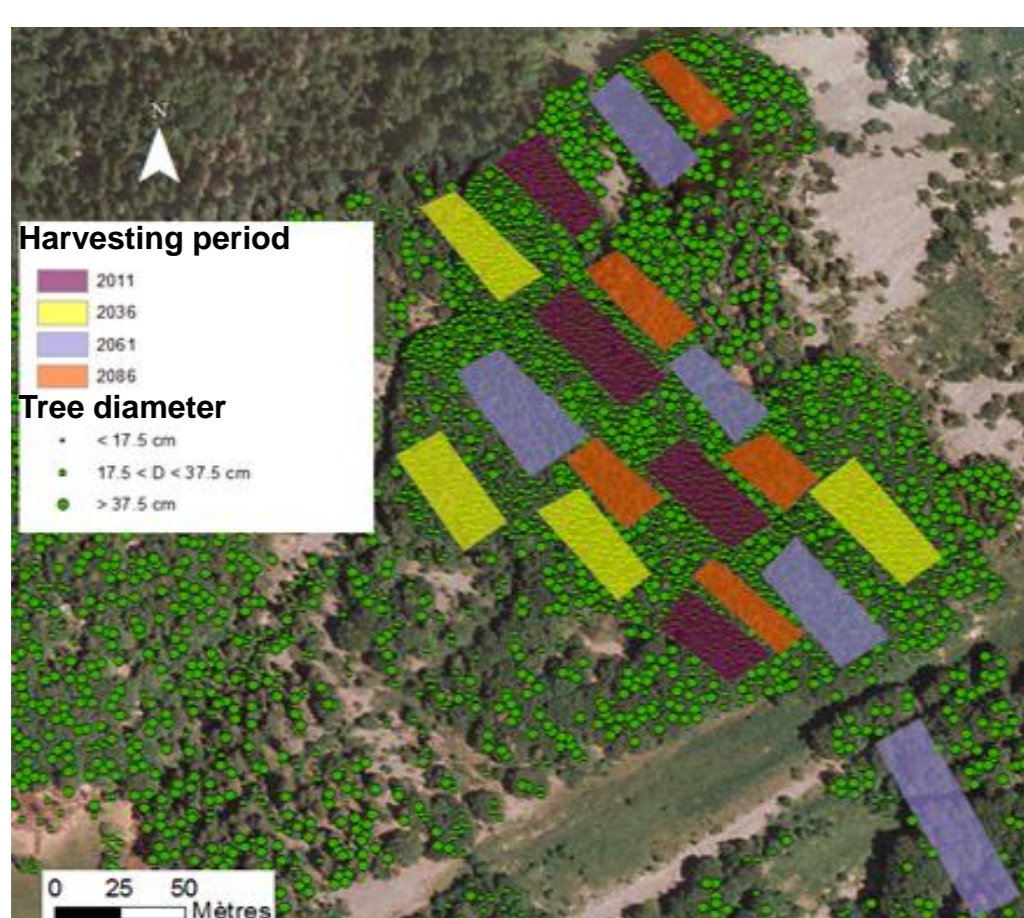
FOREST DATA

Stand structure

- Tree density
- Tree diameters
- Tree height
- Tree coordinates
- Coniferous/deciduous

Management scenarios

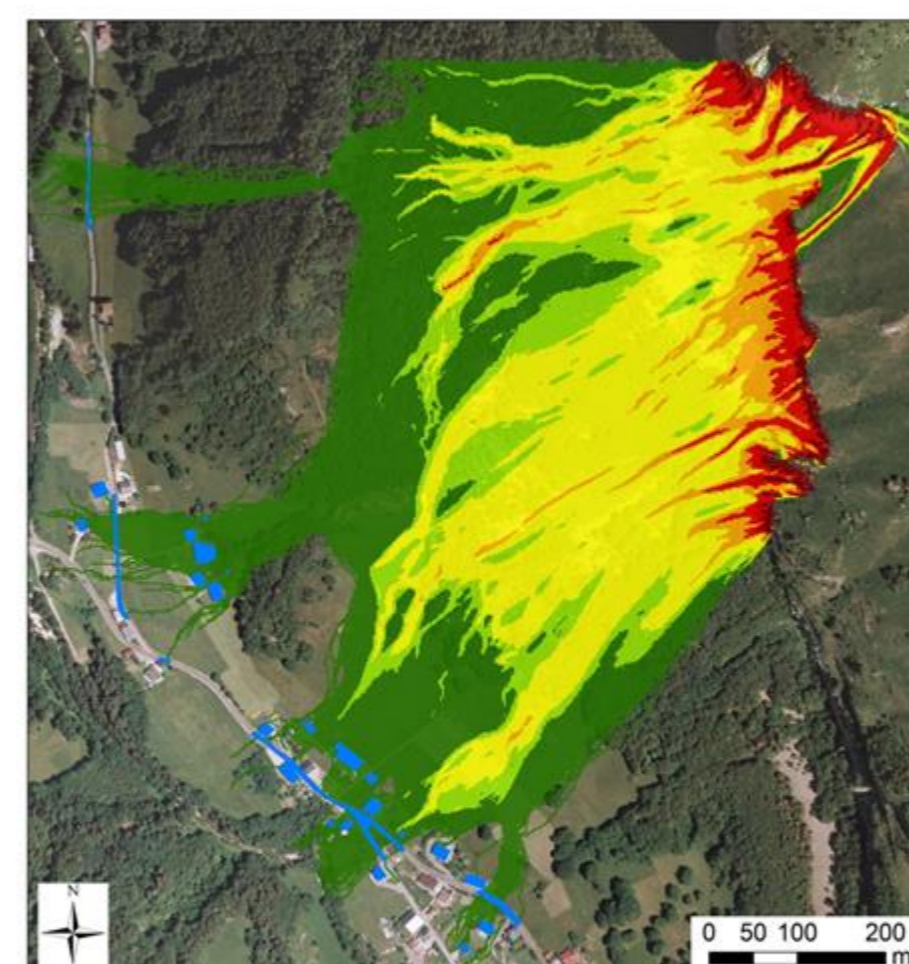
- No management
- Management to improve protection function



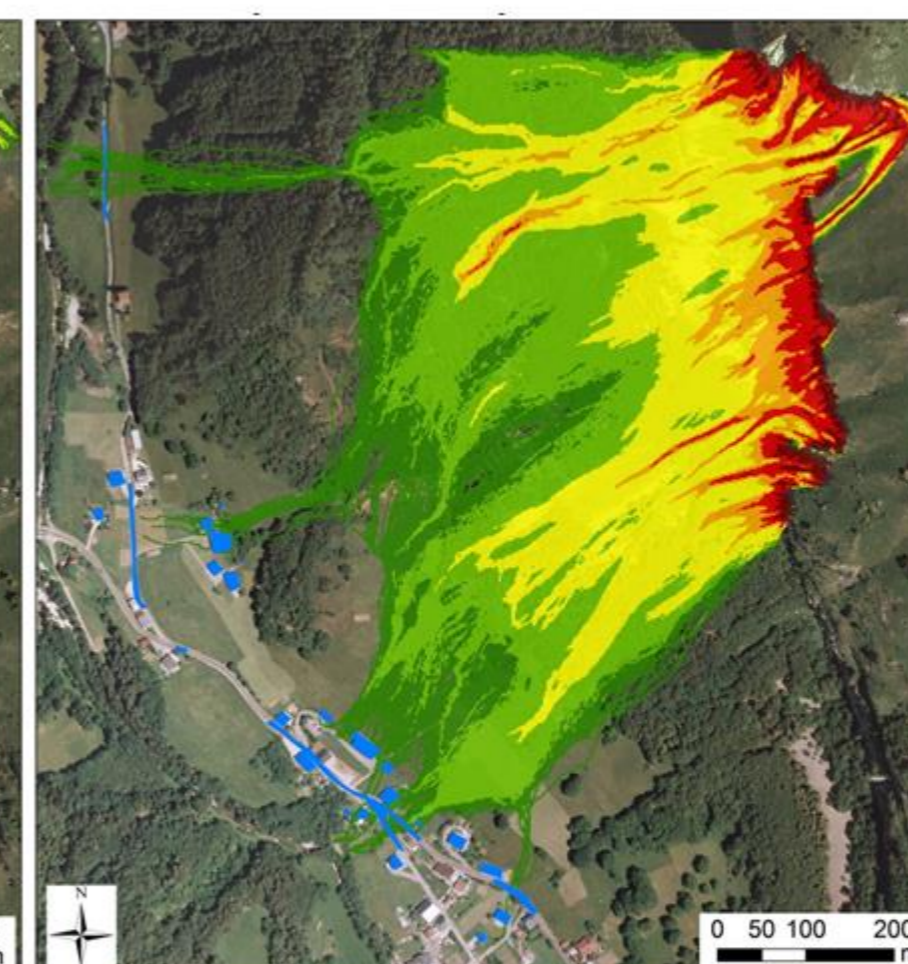
TOPOGRAPHY AND HAZARD DATA

Reach probability of the rock (ROCKYFOR3D)

Without forest



With forest



Topography:

- DTM
- Ground roughness
- Soil type

Hazard:

- Rock dimension
- Rock density
- Rock shape
- Start probability
- Propagation probability
- Rock energy

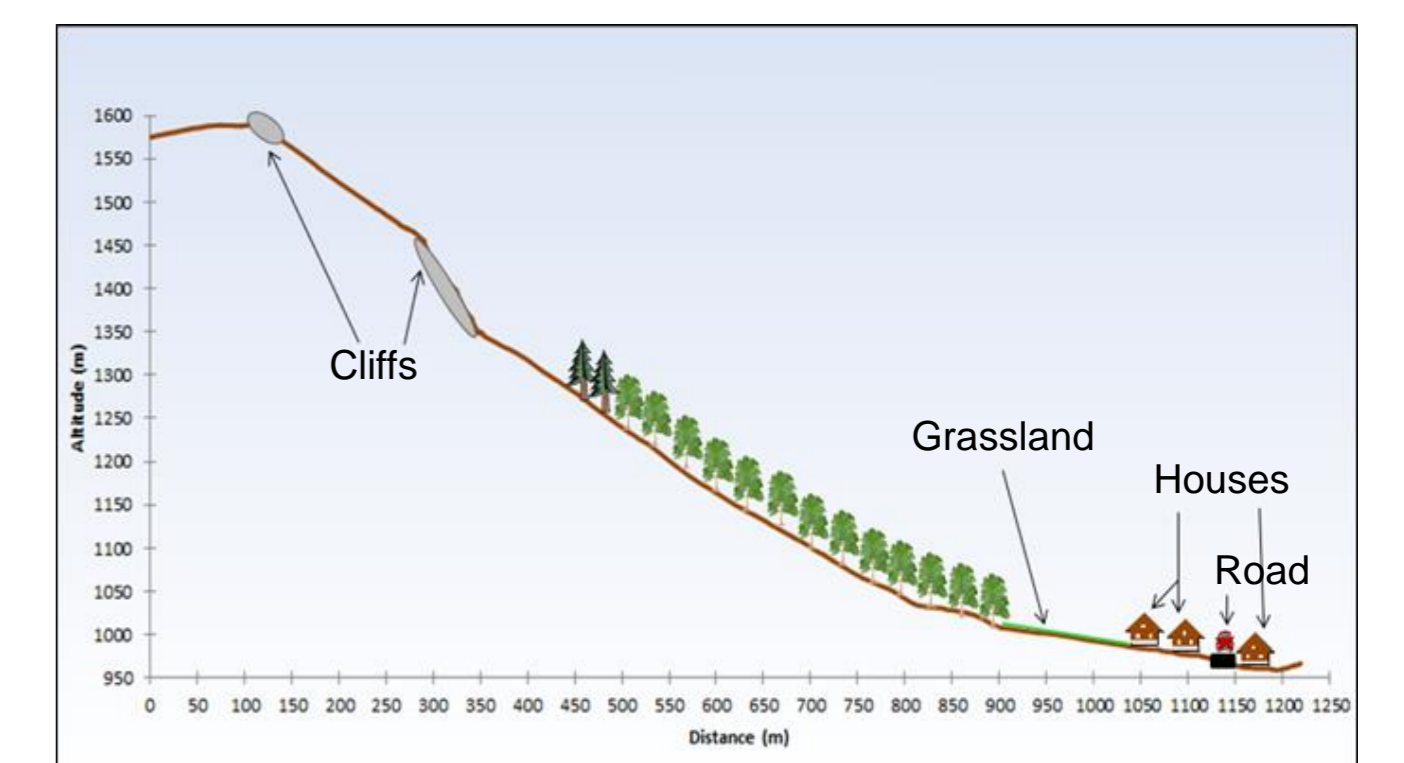
ISSUES DATA

Material issues taken into account:

- Houses, buildings... (Market value)
- Railways (Traffic)
- Roads (Traffic)

Human lives

- "Price" of the human life

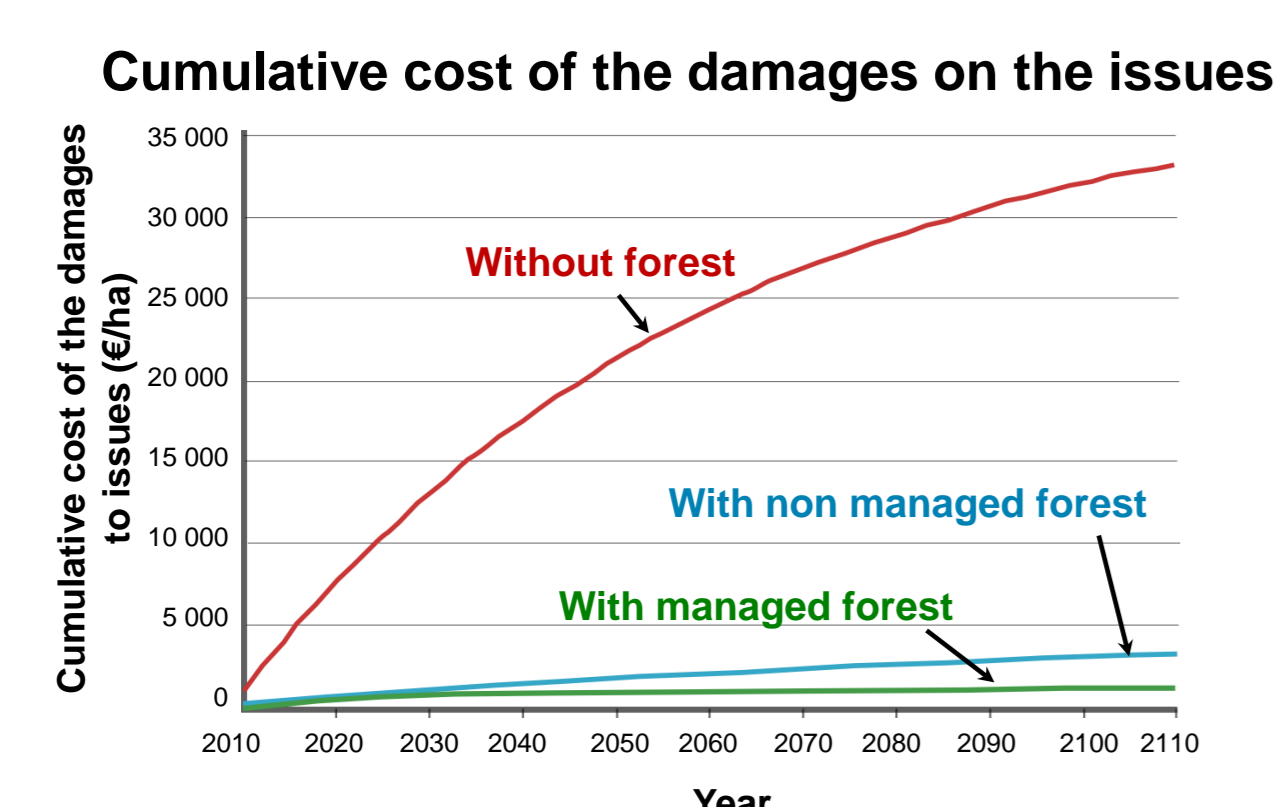


2. ECONOMICAL ANALYZES

ISSUE APPROACH: DAMAGES AVOIDED COST (DAC) METHOD

Calculate the cost of the potential damages according to different scenarios:

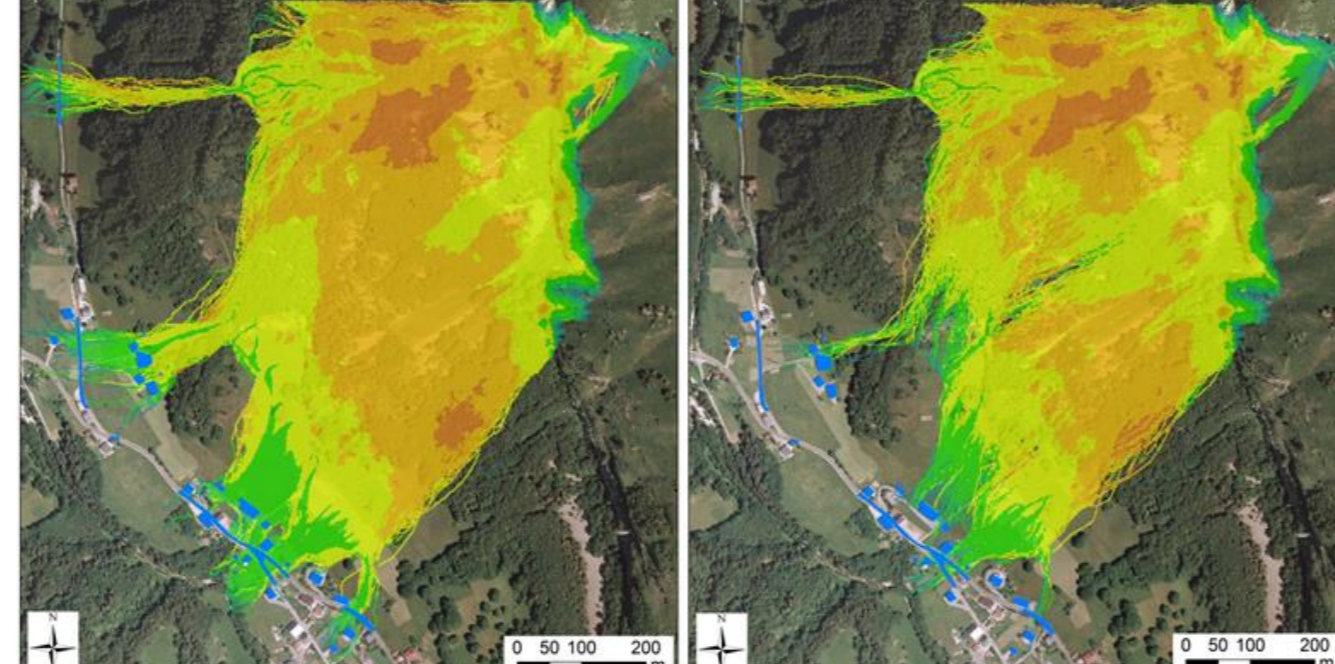
- Without forest
- With non managed forest
- With managed forest



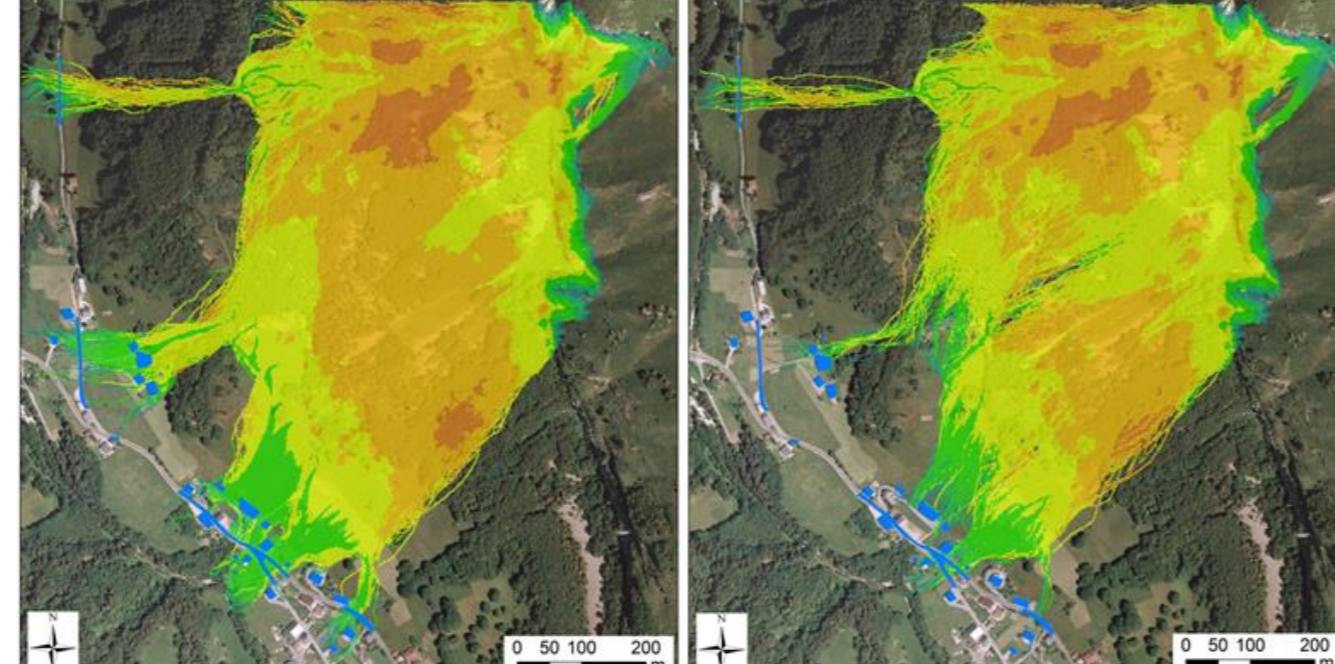
Value of the protection function against rockfall with DAC method =
Damages without forest – damages with forest = **30 000 €/ha**

Maximum energy of the rock (ROCKYFOR3D)

Without forest



With forest

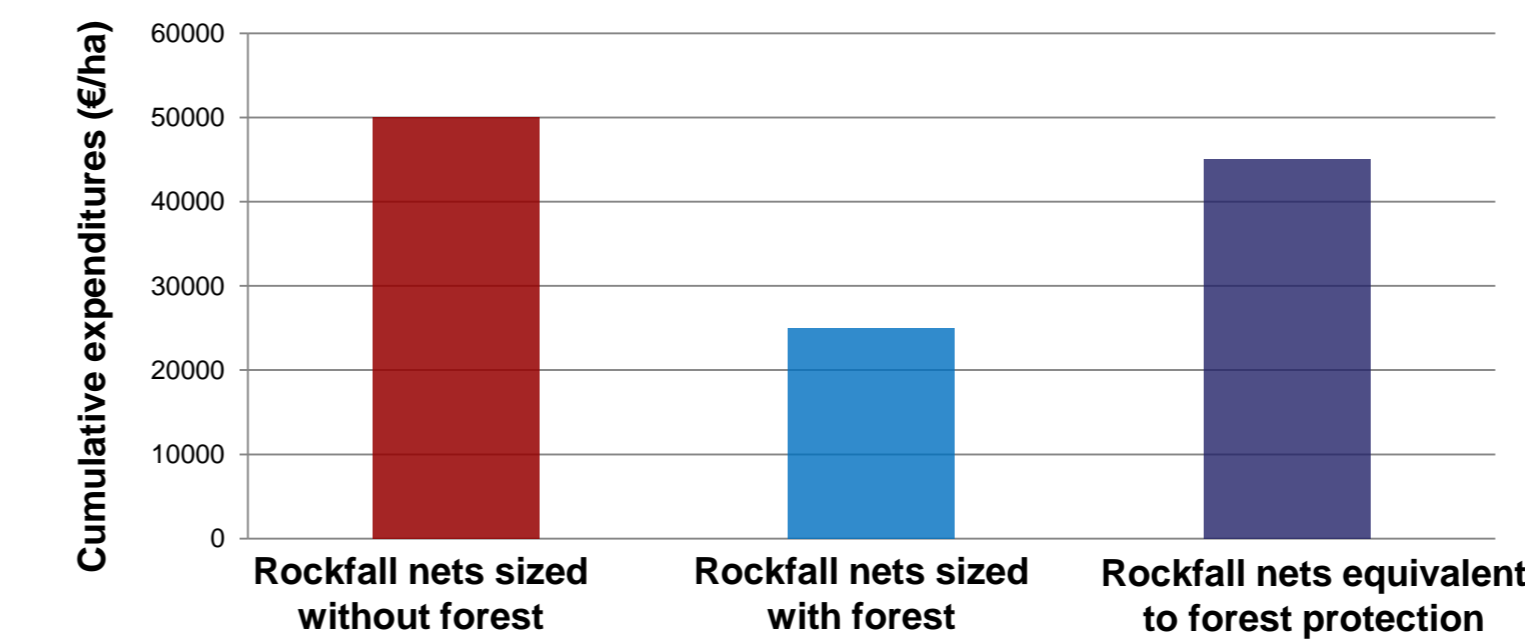


HAZARD APPROACH: SUBSTITUTE COST (SC) METHOD

Calculate the cost of a civil engineering structures equivalent to the protection offered by the forest. 3 scenarios are tested:

- Rockfall nets stopping 100% of the rocks, sized without taking into account the forest
- Rockfall nets stopping 100% of the rocks, sized taking into account the forest
- Rockfall nets offering the same protection than forest

Expenditures (investment + maintenance) on 100 years



Value of the protection function against rockfall with SC method =
Cost of rockfall nets equivalent to forest protection: **45 000 €/ha**



Rockfall nets

Results and perspectives:

This study concerned 6 pilot areas (4 in France, 1 in Switzerland, 1 in Italy). The method is highly linked to the rockfall model called Rockyfor3D. The value of this ecosystem service can be calculated with a cost-benefit analysis. The DAC method is complex to realize but provides a good idea of the importance of the protection offered by the forest. SC method is easier to implement and can be very useful when forest and civil engineering are complementary (mainly on linear issues such as road and railways). On the 6 pilot areas, the calculated value varies from 6 000 €/ha (issue = small mountain road) to 100 000 €/ha (issue = college and residential area).