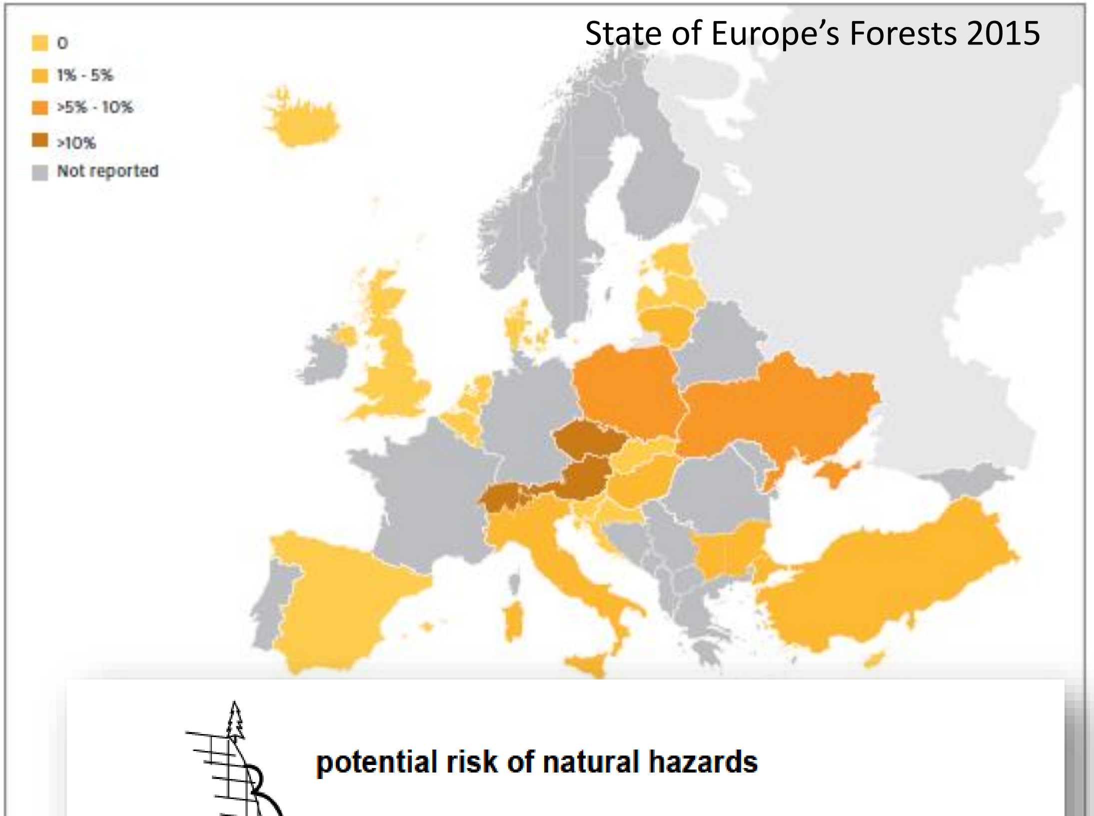
Root reinforcement dynamics in European coppice woodlands and their effects on shallow landslides

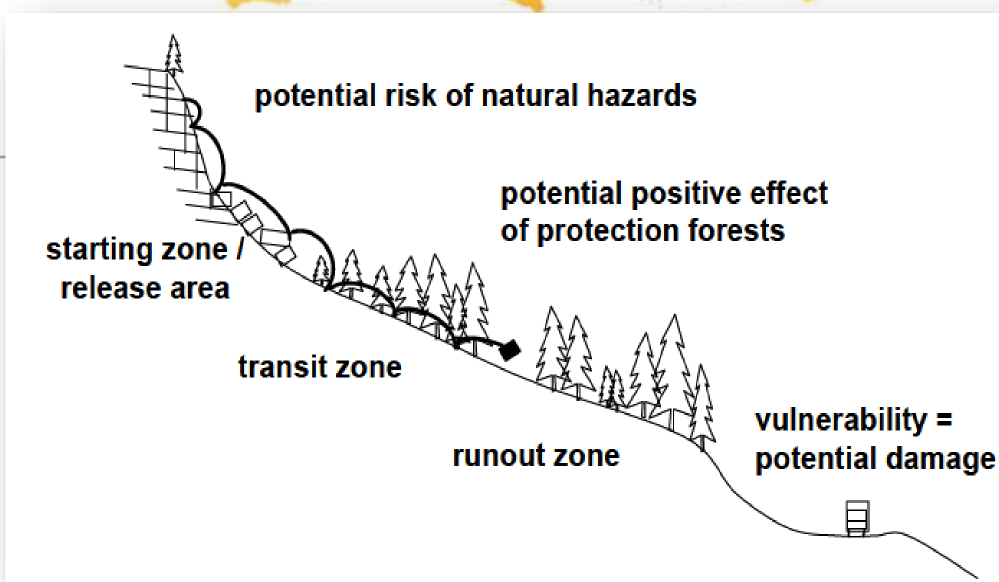
*Vergani C**, Giadrossich F, Schwarz M, Conedera M, Buckley P, Salbitano F, Pividori M, Piussi P, Lovreglio R

- Bern University of Applied Sciences, CH
- Swiss federal Institute for Forest, Snow and Landscape Research WSL, CH
- University of Sassari, IT
- University of Padua, IT
- University of Florence, IT
- Peter Buckley Associates, UK

Bern University of Applied Sciences

Ecosystem services: protection forests





✓ about 20% of European forests are reported as serving the protection of water supplies and prevention of soil erosion (**general protection function**)

✓ about 3.3 million ha (1.5 %) are designated for the protection of infrastructures against natural hazards: landslides, rockfall, avalanches, floods (**direct protection function**)

✓ importance of forest management to ensure the continuity and sustainability of the protective function

Coppice stands as protection forest / 1

Coppice management has a long tradition in Europe and developed in numerous forms.

High stem densities

Rapid regrowth from stools

Permanence of root system in the soil

Assets for the protective function?

Lack of studies investigating the suitability of coppice as protection forest.

Coppice stands as protection forest / 2

the development of adequate strategies in the management of protection forests depends on the natural hazards considered, on the environmental conditions and on the ecological needs of each species.

Objectives

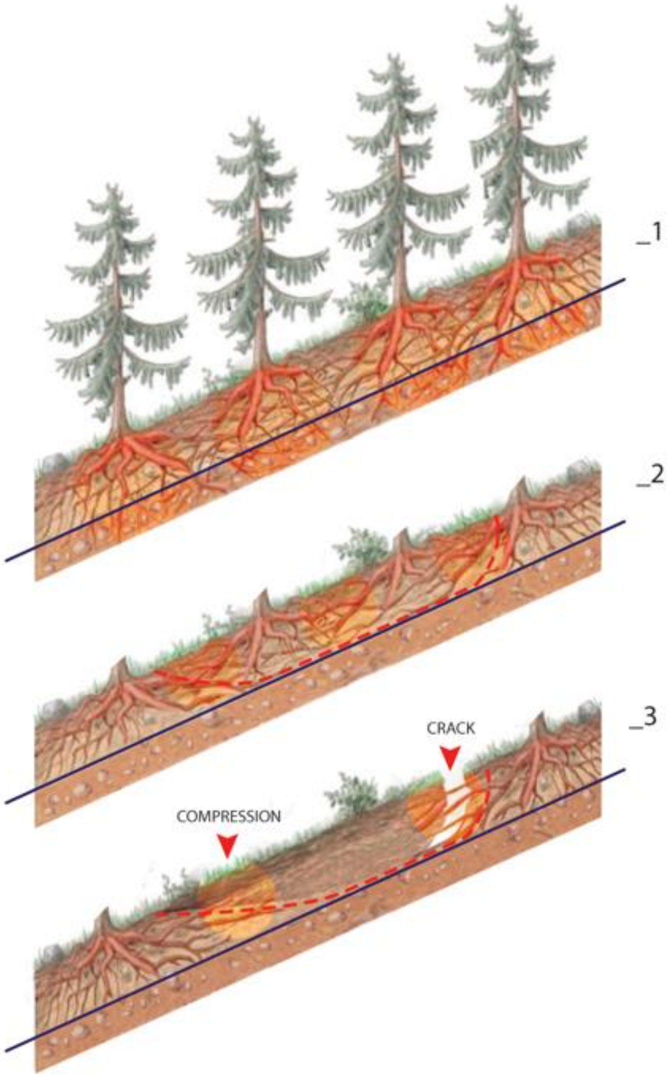
- ✓ Analyze the implications of coppice management on slope stability (shallow landslides) with focus on root reinforcement
- ✓ Collecting information about root development and distribution in coppice stands
- ✓ Formulate hypothesis on the dynamics of root reinforcement in coppice woodlands
- ✓ Discuss the effects on shallow landslides (protection function)
- ✓ Highlight the lacks of knowledge

Shallow landslides

- ✓ less than 2 meters deep
- ✓Volume up to 1000 m^3
- ✓triggered by rainfall events
- ✓ are considered the dominant process shaping the landscape of mountain catchments
- ✓ responsible for a substantial part of the total sediment delivery

Shallow landslides and surface erosion, even if both lead to soil loss and sediment transport, are two different kind of process and therefore the role of vegetation on them should be considered separately.

Root reinforcement



Giadrossich et al., 2016

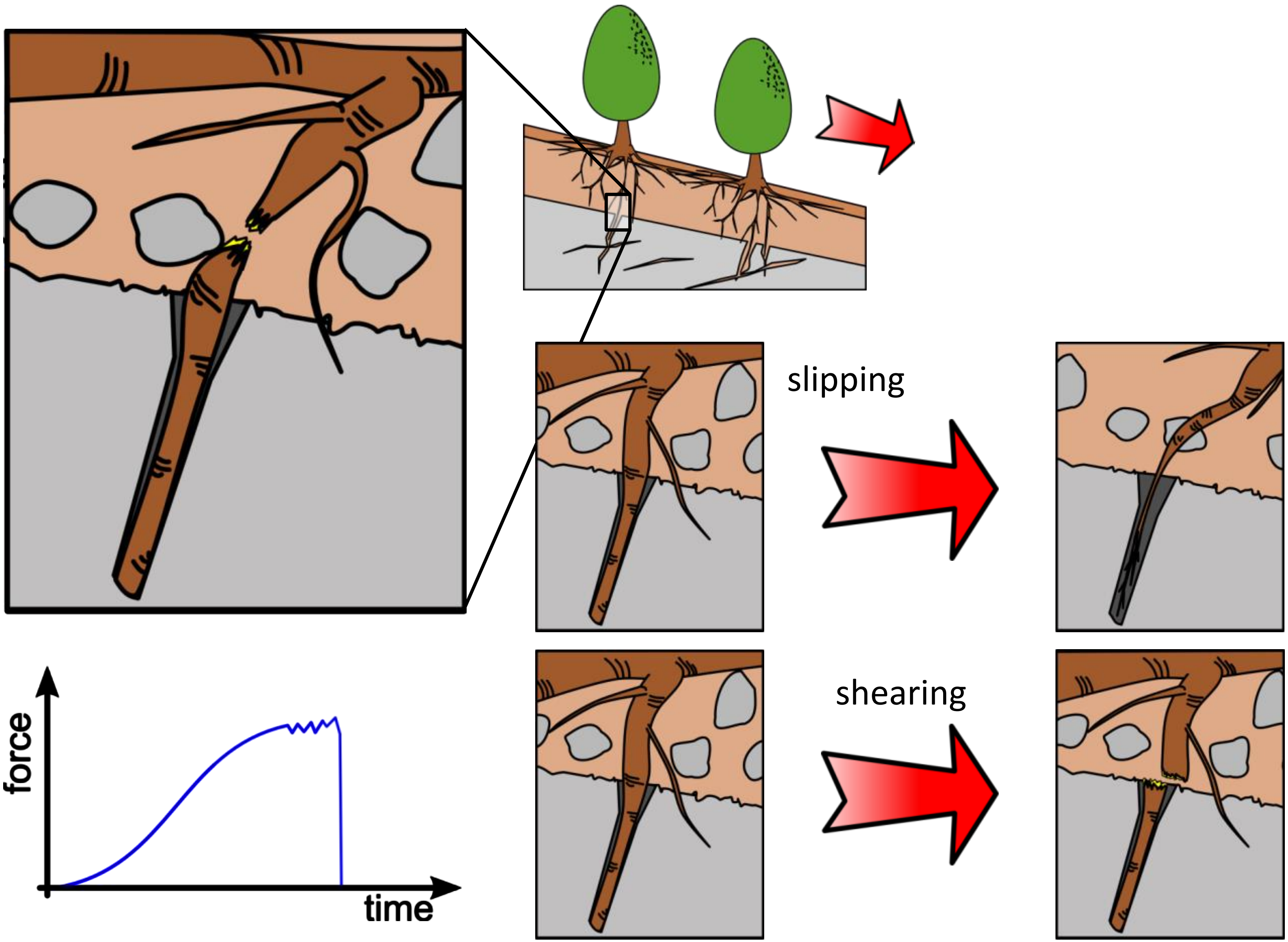
1 - basal reinforcement

2 - stiffening and buttressing

3 - lateral reinforcement

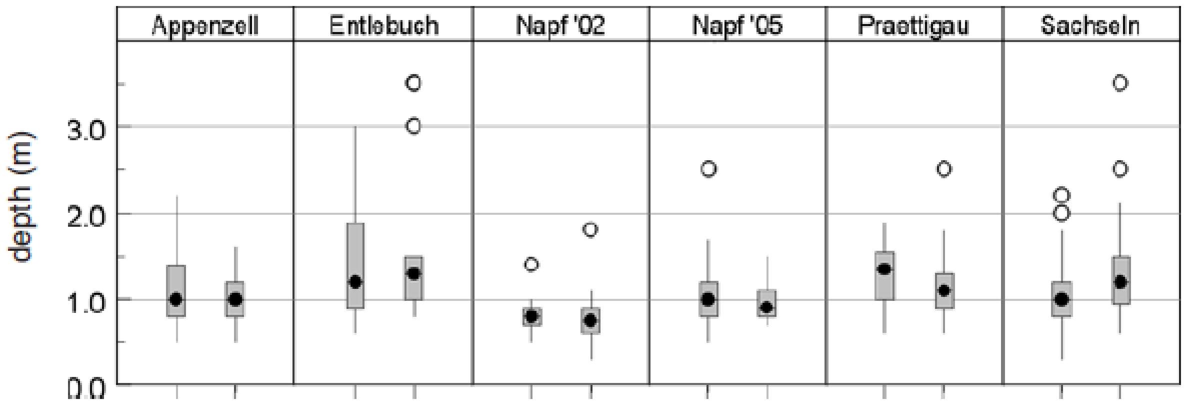
Basal reinforcement

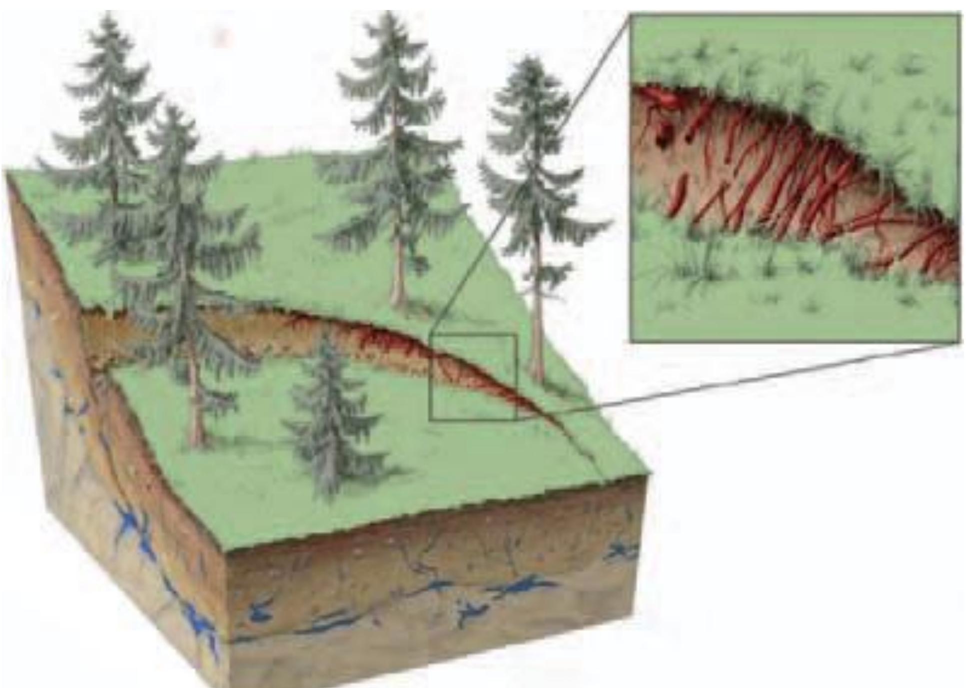
Chiaradia., 2010



Lateral reinforcement

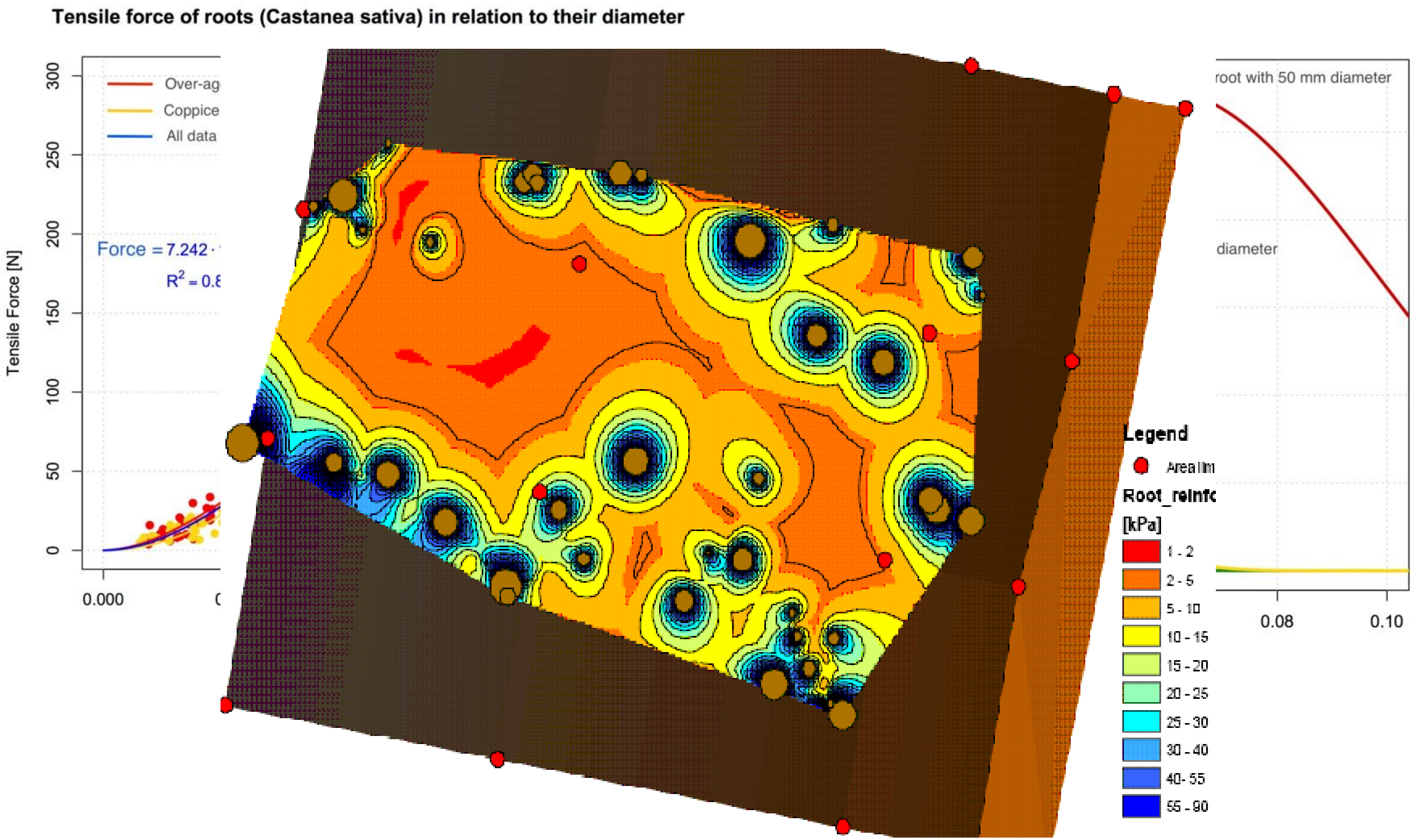
Rickli and Graf, 2009





Schwarz et al., 2010

Root reinforcement estimation



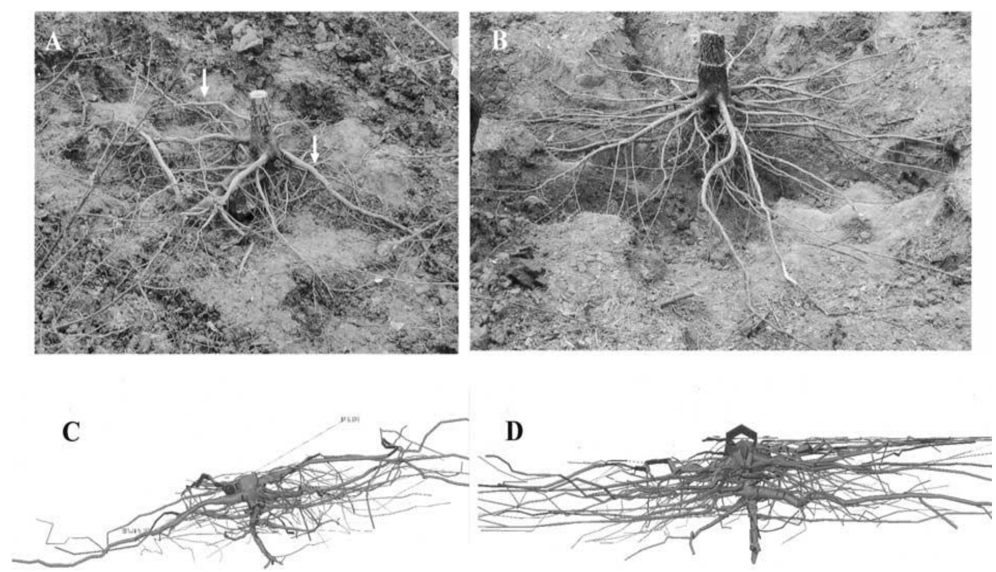
Schwarz , 2010

Root system characteristics in coppice stands: root distribution and root system architecture

✓The **root distribution** depends on the **species** (Philipps et al., 2014).

✓ **Vertical distribution** depends on several factors like the species and the environmental conditions (soil type and depth, water and nutrient availability, etc…). The majority of the roots is concentrated in the **upper 30 or 50 cm** of the soil (Al Afas et al., 2008; Berhongaray et al., 2015; Lee, 1978; Friend et al., 1991, for poplar; Bédénau and Auclair, 1989b for birch-oak coppice stands; Di Iorio et al., 2013 for beech), which is typical of forest soils (Stokes et al., 2009).

✓**Slopes** also appear sometimes **to influence root distribution,** with the larger roots orientated uphill, assisting soil anchorage, as observed in downy oak
and manna ash by Chiatante et al. (2003) and Di Iorio et al. (2005)



Root system characteristics in coppice stands: effect of coppicing on root system development

The root system of **different species** seems to **react differently to coppicing** (Bernetti, 1995; Bédénau and Pagès, 1984; Amorini et al., 1990; Bagnara and Salbitano, 1998)

Species	Sprouting	Effect of coppice on the root system
Oak	vigorous sprouting behaviour; survivor of the stool decreases with increasing age; sprouts are mainly in the upper part of the stool	Mainly regenerate a new root system
Chestnut	vigorous sprouting behaviour; maintains ability to regenerate sprouts after coppicing; sprouts are mainly in the basal part of the stool	Mainly regenerate a new root system
Beech	weak sprouting behaviour; survival of the stool decreases with increasing the age; sprouts are mainly in the upper part of the stool, (few) root suckers	Mainly regenerate a new root system
Birch	weak sprouting behaviour; survival of the stool decreases rapidly after few coppice cycles; sprouts from adventitious buds and root suckers	Mainly keep the old root system

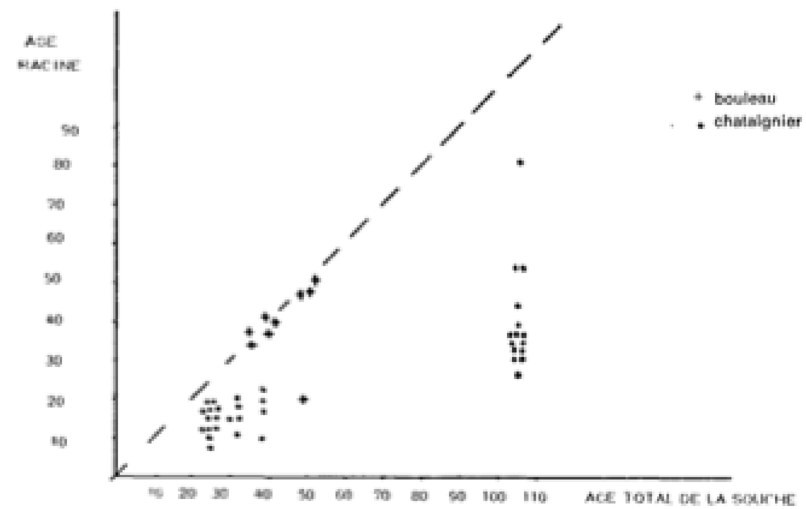


FIG. 1

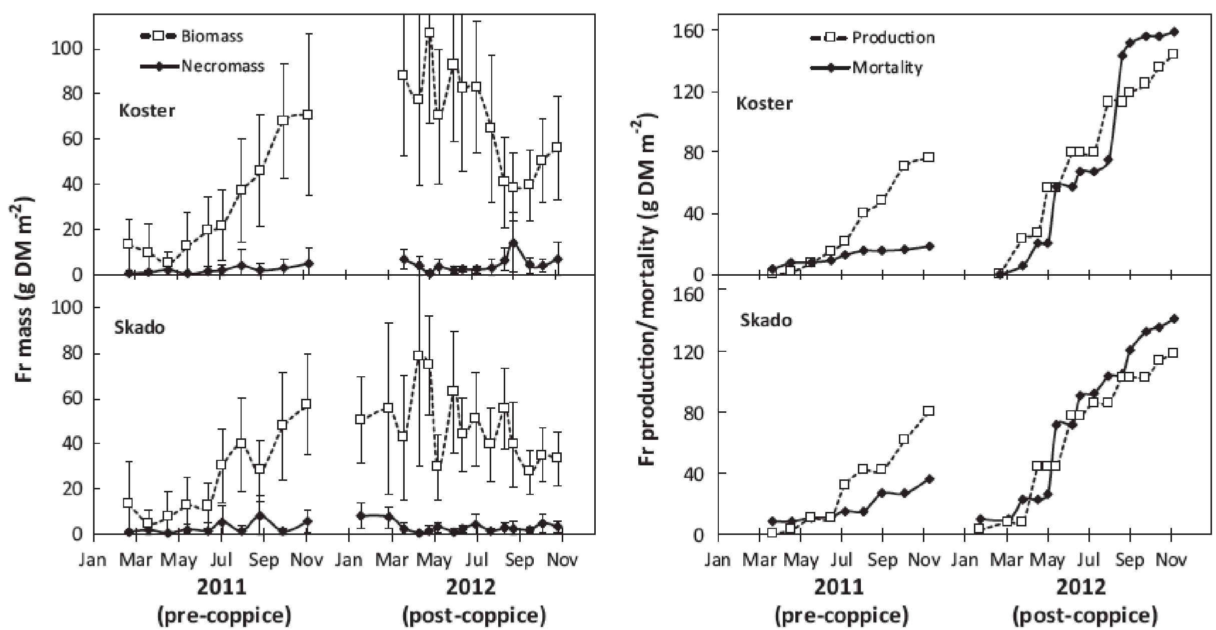
Représentation graphique des résultats de comptage.

The removal of shoots results in inhibited production and secondary thickening of root biomass during the first two and half year of shoot generation, while there is a continued unimpeded increase in root biomass of uncut trees; regular cuttings slow root development and remove the need of larger roots (Wildy and Pate, 2002; Crow and Huston, 2004; Lee, 1978)

Root system characteristics in coppice stands: fine root dynamics in coppice

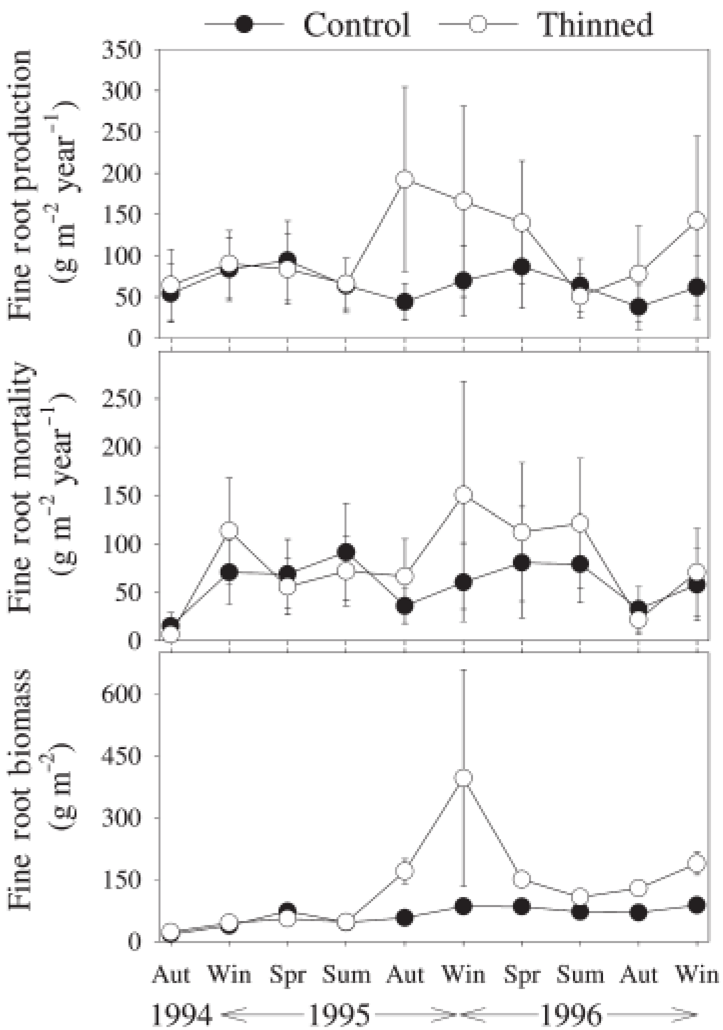
Fine root biomass in forest tree stands generally develops in three phases: rapid increase after a clear cut harvest up to a maximum of fine root biomass; a decrease during the maturation of the stand; and a steady state in mature stands (Claus and George, 2005) .

Generally an enhanced growth of fine roots is observed after coppicing: carbohydrate reserves seem to be mobilized preferentially for the growth of fine roots (Bédénau and Auclair, 1989); influence of time of cutting and rotation period (Berhongary et al., 2015; Ma et al., 2014; Dickmann et al., 1996).



Berhongaray et al., 2015

Root system characteristics in coppice stands: comparisons between coppice system and other silvicultural systems



Lopez et al., 2003

✓ Not coppiced trees display a powerful rooting with many coarse roots, coppiced trees show more fine roots instead of structural roots (Bédénau and Auclair, 1989);

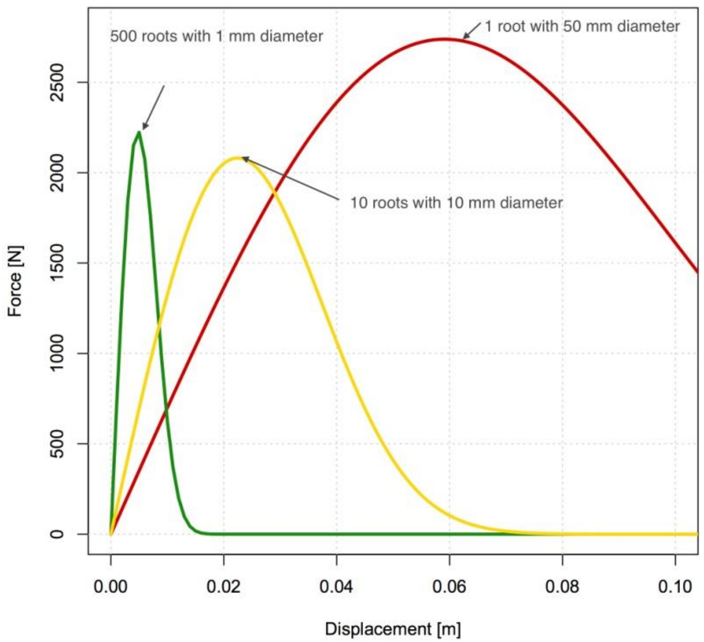
✓Thinning in coppice system (conversion cuttings) seems to stimulate the emission of fine roots and a general movement of root biomass into shallower layers (Lopez et al., 2003; Montagnoli et al., 2012; Di Iorio et al., 2013).

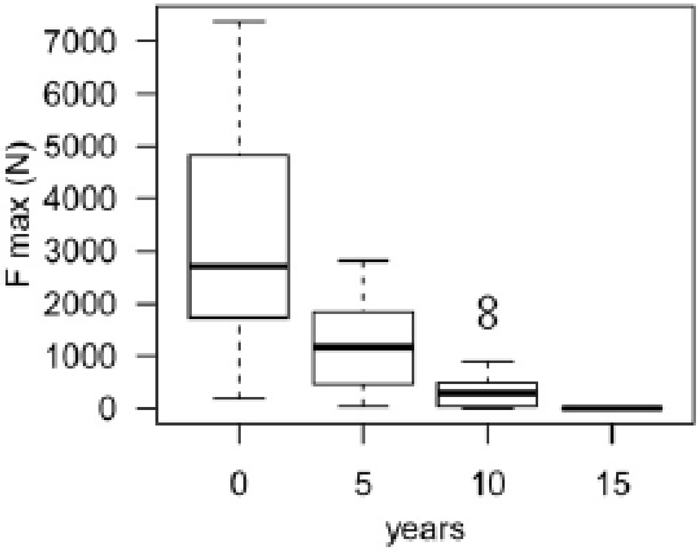
Implication of coppicing on root reinforcement mechanism

✓ Root mechanical properties: vary with species; no effect of coppicing (Bassanelli et al., 2013)

✓ Vertical root distribution: we can consider basal root reinforcement very low in forest soils; can be very relevant for shallow soil (< 1 m depth)

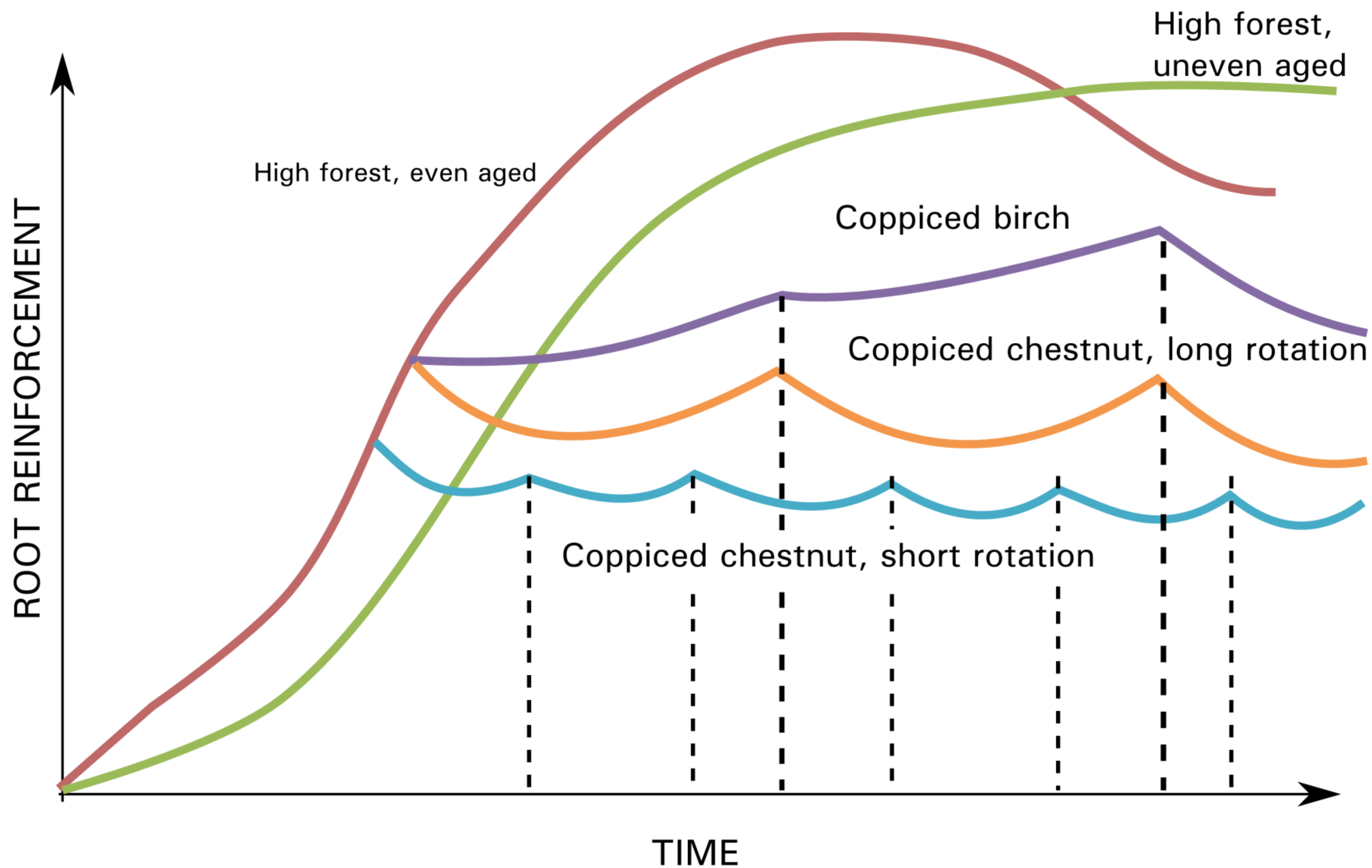
✓ Root distribution in diameter class and root dynamics (growth-decay)





Vergani et al., 2016

Implication of coppicing on root reinforcement mechanism: conceptual hypothesis



The problem of instability in overaged chestnut coppice stands

Conedera et al., 2010

- -Connection to slope stability?
- Keeping coppicing?
- Conversion to high forest?
- Favouring the development of **simmetrical root systems**
- Natural regeneration in the gaps?

Riparian vegetation, channel processes and riverbank stability

Different authors suggested maintaining **managed coppice forest** in the active erosion zone along riverbanks and gullies (Rudolf-Miklau and Hubbl, 2010; Fortier et al., 2013). In this case, **multi-aged coppice system** could be a way to increase the magnitude and continuity of root reinforcement in the mean term.

Although along riverbanks coppice woodlands would be the best compromise between stability and risk due to large wood debris, the cost of maintaining this practice is sometimes difficult to sustain. In many cases, the management of coppice woodlands along rivers results too onerous for local communities.

Conclusions

✓The effect of coppicing on shallow landslide processes must be differentiated (it depends on disposition to landslides, species, ecological conditions,location, i.e. steep slopes or riverbanks, type of coppice management).

✓On hillslopes prone to shallow landslides, the management should aim to increase the extension of root systems and especially the presence of coarse roots. This aim may be fullfilled with different strategies depending on the species, the environmental conditions, the local multi-functional role of the forest and the resources of the community.

✓An overall comparison between species is not possible, but the slope and management conditions should be always carefully evaluated.

✓Geomorphological characteristics (hollows, slope inclination) should be considered in order to optimize the stability of trees, allow the conversion of coppice to high forests, and increase the stability of the slope through coarse roots.

✓Over aged coppice are not a solution as discussed by Conedera et al.(2009), but a good planned conversion to high forest could be a better alternative in comparison to keep coppicing, at least for the species which renew their root system.

Research gaps

✓ Measures of root distribution (comparison between coppice before cut, coppice after cut over aged coppice, high forest); particularly measures of lateral root distribution related to tree position and dimension in order to characterize spatial heterogeneity of root distribution (and therefore reinforcement) at the stand scale. Most of the present work are indeed carried out without reference to tree position and dimensions.

✓ Measures of pullout tests in field, including also coarse roots, in order to characterize root mechanical properties of the different species.

✓Monitoring of the effects of different coppice management systems on root reinforcement, in order to discuss the possible different kind of management.

✓ Another important aspect related to the slope stability are the hydrological conditions in coppice stands: no studies are available on this topic.

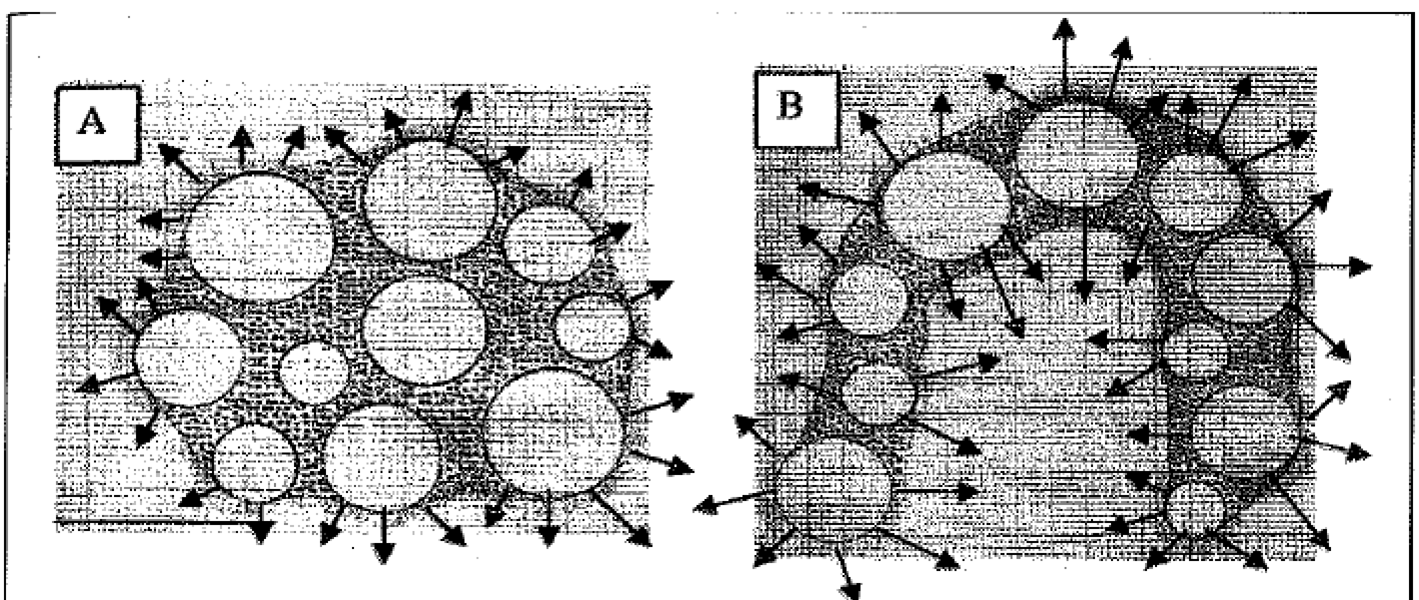
✓ Erosion is another important process which is heavily affected by land use: a review about the long term effect of the forest management and in particular of different coppice management techniques on the erosion process is needed.


Thank you for the attention!!!

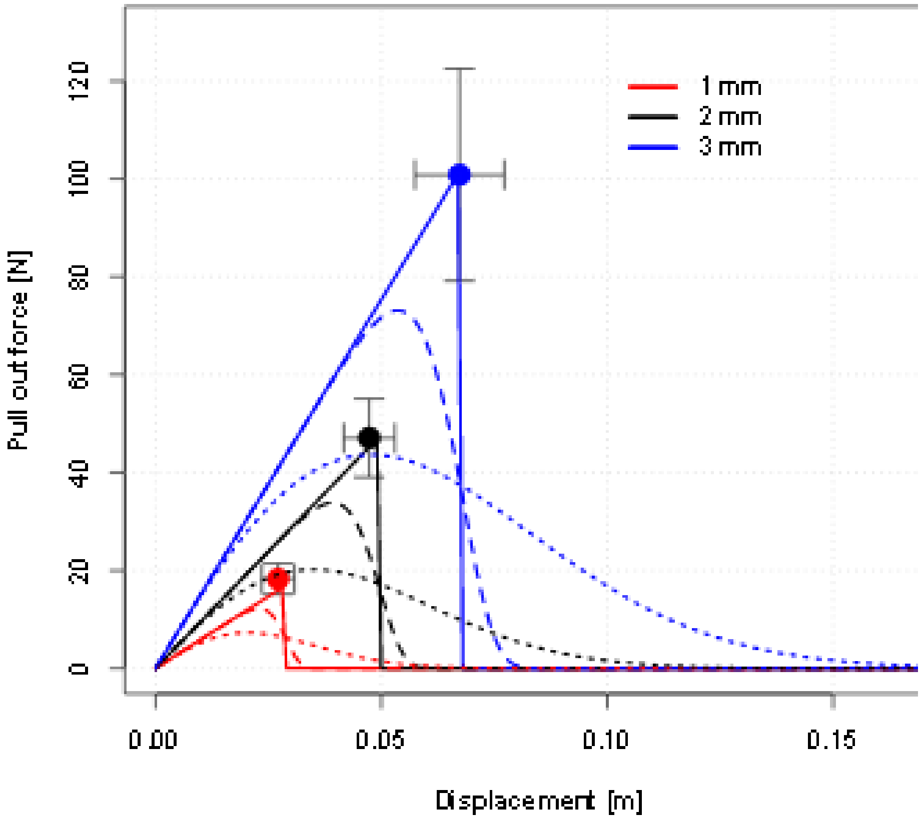
Root system characteristics in coppice stands: root distribution and root system architecture

Some pioneering studies investigated the organization of the whole root system in multistem stools.
In chestnut stools, each subunit formed by **clumps of shoots** has an **independent root system**, even if transport across adjacent clumps and roots is not excluded (Aymard and Freydon, 1986).
In beech (Bagnara and Salbitano, 1998): in stumps with several live shoots, different root systems belonging to the different shoots can be clearly distinguished.

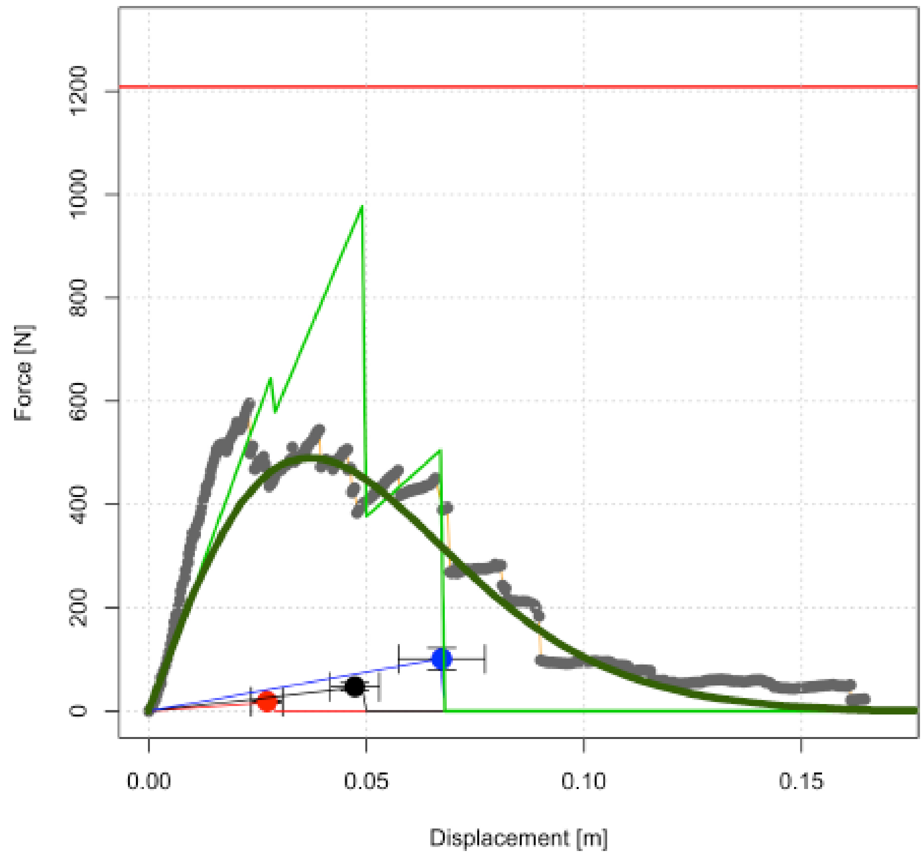
Bagnara e Salbitano, 1998



Root reinforcement estimation



Schwarz et al., 2010



Schwarz et al., 2013