Which plant species dominate early post-fire vegetation in the Central Alps, and why?

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Abstract: In the exceptionally dry summer of 2003, a major wildfire burned 300 ha of forest in the central-alpine region of the canton of Valais, Switzerland. The burnt area ranges from 800 m a.s.l. to the timberline at 2100 m a.s.l. The establishment of dominant species during early post-fire succession may be an essential factor affecting the rate of natural reforestation, an important aspect of post-fire succession in the Central Alps. Since 2004, the recolonisation of vascular plant species has been monitored annually using systematic sampling with 154 sampling plots of 200 m^2. Two years after the fire, various species established at different altitudes. At lower altitudes, vegetation is dominated by *Conyza canadensis* and *Lactuca serriola*, whereas at medium altitude the grasses *Calamagrostis varia* and *Brachypodium pinnatum*, and the herbs *Epilobium angustifolium* and *Saponaria ocymoides* are most abundant. Early vegetation development is fastest above 1'400 m a.s.l., where vegetation cover already amounted to 45% in the second post-fire year. Tree regeneration is also more abundant at higher altitudes and seems to be facilitated by dominant *E. angustifolium*. Our preliminary results indicate that dominant species can act as 'switches' in vegetation development determining whether forest regeneration can establish or not. Further vegetation relevees in 2006 and the following years will show whether this can be confirmed.

Keywords: Forest fire, Central Alps, species dominance, vegetation switch, natural reforestation

1. Introduction

In the exceptionally dry summer of 2003, a major wildfire caused by arson took place in the central-alpine region of the canton of Valais, Switzerland. It burned 300 ha of forest along a vegetation gradient that ranges from mixed oak-pine (*Quercus pubescens*, *Pinus sylvestris*) at 800 m a.s.l. to spruce (*Picea abies*) and open larch (*Larix decidua*) forests at timberline at 2100 m a.s.l. Fire intensity was moderate to severe in large parts of the burnt area so that most plant parts in the duff layer were consumed. Consequently, post-fire succession is difficult to predict (Del Moral and Wood, 1993). It has been shown that fire can promote dominance of a few species or cause a shift from one dominant species to another (Stewart *et al.,* 2005). Since early successional plants can inhibit or facilitate the establishment of other species (Polley *et al.,* 2006), early post-fire establishment of dominant species may act as a 'switch' between several

alternative pathways of vegetation development (Wilson and Agnew, 1992). In the densely populated Central Alps, where forests often play an important role in the protection of villages from natural hazards, the question whether natural reforestation will establish or not is of predominant interest to forest managers and land owners. Thus, we addressed the following questions: (1) Which plant species dominate early post-fire vegetation in the Central Alps? (2) Does the establishment of dominant species vary with altitude? (3) How do dominant species affect the establishment of young trees?

2. Methods

The study site is located near Leuk in the central-alpine valley of Valais, Switzerland (46°20'N, 7°39'E). A wildland fire started by arson in 2003 burnt 300 ha of forest along a vegetation gradient ranging from mixed oak-pine forests (*Quercus pubescens*, *Pinus sylvestris*) at 800 m a.s.l. to spruce (*Picea abies*) and open larch (*Larix decidua*) forests at the timberline (2100 m a.s.l.; Fig. 1). The climate is typically continental with cold winters and dry summers. Mean annual temperature decreases from 8.6 °C at 640 m a.s.l. to 5.2 °C at 1500 m a.s.l., while annual precipitation increases from 600 mm at 640 m a.s.l. to 1000 mm at 1500 m a.s.l. (1961-1990; Aschwanden *et al.,* 1996).

Since 2004, the recolonisation of vascular plant species has been monitored in 154 quadratic sampling plots of 200 m^2, which were systematically sampled on a grid of 125 m cell size. Species abundance was estimated annually in the summer season using the decimal cover scale of Londo (1976). Tree regeneration was counted in one quarter of each sampling plot (50 m^2).

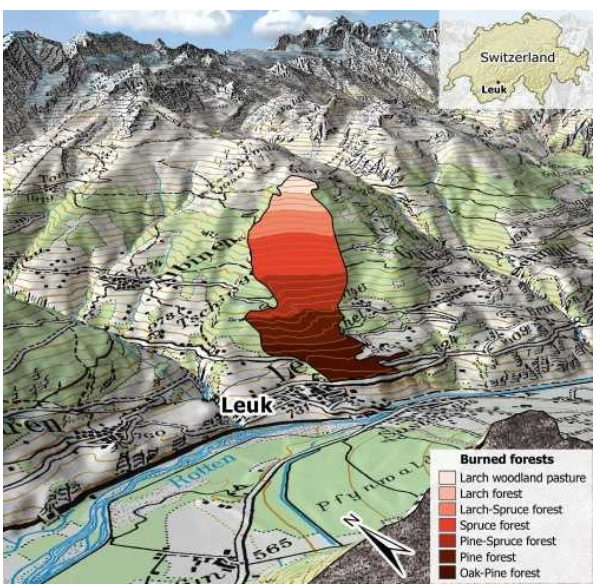

Fig. 1. Study site near Leuk in the central-alpine valley of Valais, Switzerland, 46°20'N, 7°39'E (2006 Swisstopo BA067917; image calculation with RaVis ©, Geoinformationsysteme ETH Zürich, elaboration: P. Krebs, WSL). The shading from brown to light red represents the vegetation gradient from mixed oak-pine forests (*Quercus pubescens*, *Pinus sylvestris*) at 800 m a.s.l. to open larch forests (*Larix decidua*) at timberline (2100 m a.s.l.).

3. Results

Two years after the fire, diverging trends in vegetation development are already discernible at different altitudes. In plots lower than 1'200 m a.s.l. vegetation is dominated by drought resistant and persistent species such as *Conyza canadensis* or *Lactuca serriola* (Table 1, Fig. 2). Overall, vegetation is still rather sparse at this altitude covering on average 29.1% of the sampling plots. At medium altitude between 1'200 and 1'400 m. a.s.l., where fire intensity was most severe, vegetation is also sparse (22.6% cover) but dominated by different species: mainly the grasses *Calamagrostis varia* and *Brachypodium pinnatum*, as well as the herbs *Epilobium angustifolium* and *Saponaria ocymoides*. In contrast to lower and medium altitudes, early vegetation development is much faster above 1'400 m a.s.l. In the second post-fire year, vegetation cover already amounted to 45% with *E. angustifolium* as the most dominant species.

Tree regeneration is also more abundant at higher altitudes (Table 2, Fig. 3). In contrast to coniferous saplings, a large proportion of deciduous saplings were already taller than 10 cm two years after the fire. Above 1'400 m a.s.l., the number of saplings between 10 and 130 cm is correlated with the cover of E. angustifolium in deciduous but not in coniferous trees (Fig. 4).

Table 1. Cover of plant species dominating at different altitudes two years after a forest fire in Leuk, Switzerland (mean ± SE). Bold font indicates dominant species at a given altitude.

Species	Cover (%)			
	800 - 2100 m a.s.l.	< 1'200 m a.s.l.	1'200-1'400 m a.s.l.	> 1'400 m a.s.l.
Overall vegetation	36.4 ± 2.1	29.1 ± 3.9	22.6 ± 3.6	45.0 ± 2.7
Conyza canadensis	0.7 ± 0.2	**1.6 ± 0.8**	0.7 ± 0.2	0.3 ± 0.1
Lactuca serriola	0.4 ± 0.1	**1.0 ± 0.4**	0.5 ± 0.1	0.1 ± 0.0
Brachypodium pinnatum	1.0 ± 0.3	0.7 ± 0.5	**1.3 ± 0.4**	1.1 ± 0.5
Calamagrostis varia	2.1 ± 0.4	0.3 ± 0.1	**2.6 ± 1.2**	2.7 ± 0.6
Epilobium angustifolium	5.9 ± 1.1	0.4 ± 0.1	**1.6 ± 0.7**	**10.1 ± 2.0**
Saponaria ocymoides	1.5 ± 0.2	0.8 ± 0.1	**1.1 ± 0.3**	1.9 ± 0.4

Table 2. Number of saplings in different height classes two years after a forest fire in Leuk, Switzerland (mean ± SE).

	800 - 2100 m a.s.l.	< 1'200 m a.s.l.	1'200-1'400 m a.s.l.	> 1'400 m a.s.l.
Deciduous trees <10 cm	1.5 ± 0.4	1.9 ± 1.1	0.7 ± 0.2	1.7 ± 0.5
Deciduous trees 10-130 cm	6.6 ± 1.2	3.1 ± 1.0	6.1 ± 2.0	8.3 ± 1.9
Coniferous trees <10 cm	1.4 ± 0.3	0.4 ± 0.2	1.4 ± 0.6	1.9 ± 0.4
Coniferous trees 10-130 cm	0.4 ± 0.2	0.6 ± 0.5	0.0 ± 0.0	0.6 ± 0.2
	n = 154	n = 37	n = 33	n = 84

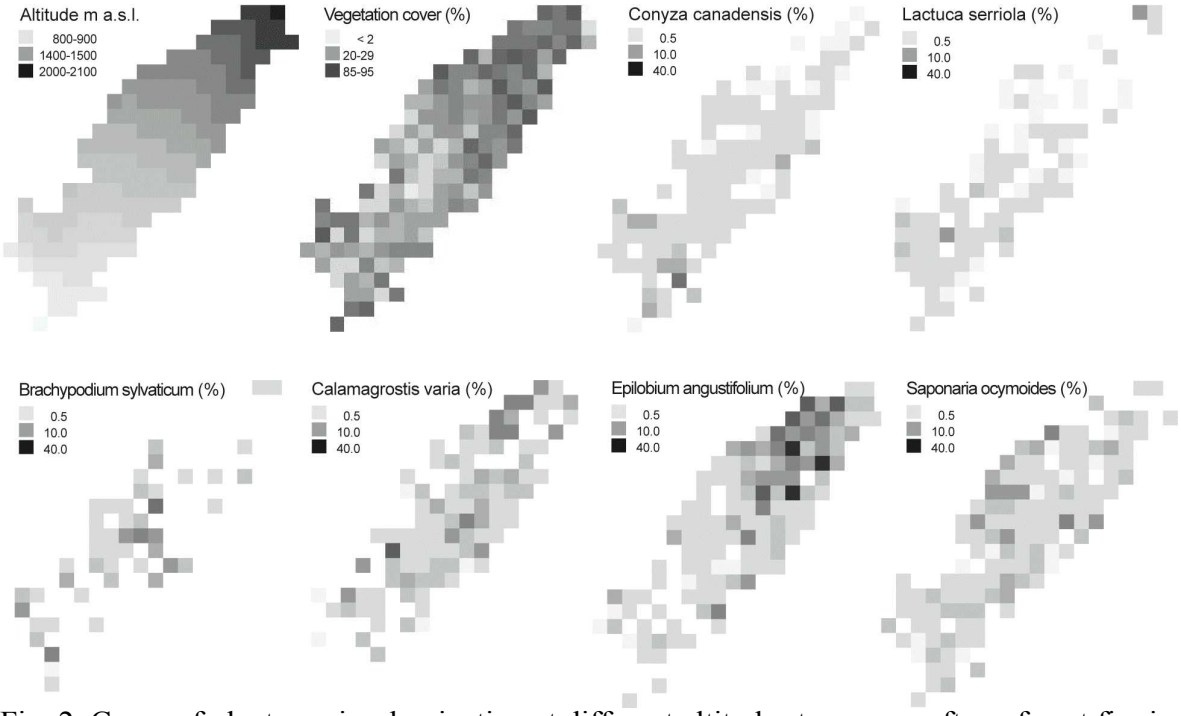

Fig. 2. Cover of plant species dominating at different altitudes two years after a forest fire in Leuk, Switzerland. Each square represents one of 154 sampling plots.

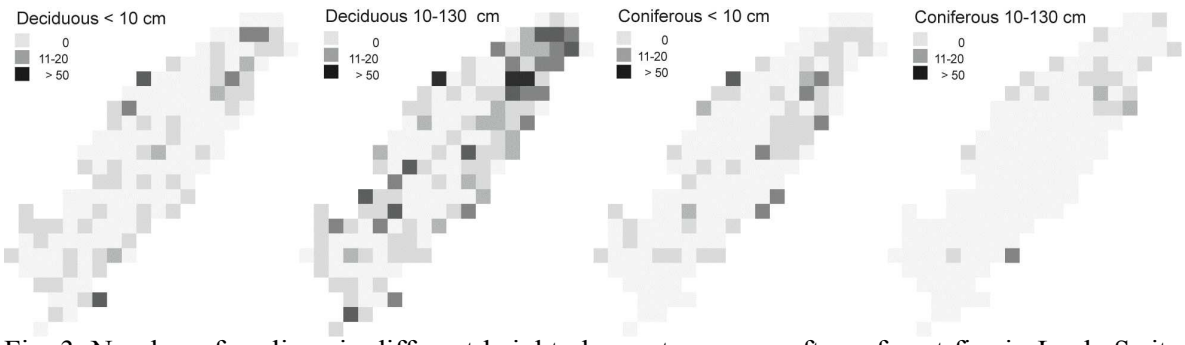

Fig. 3. Number of saplings in different height classes two years after a forest fire in Leuk, Switzerland. Each square represents one of 154 sampling plots.

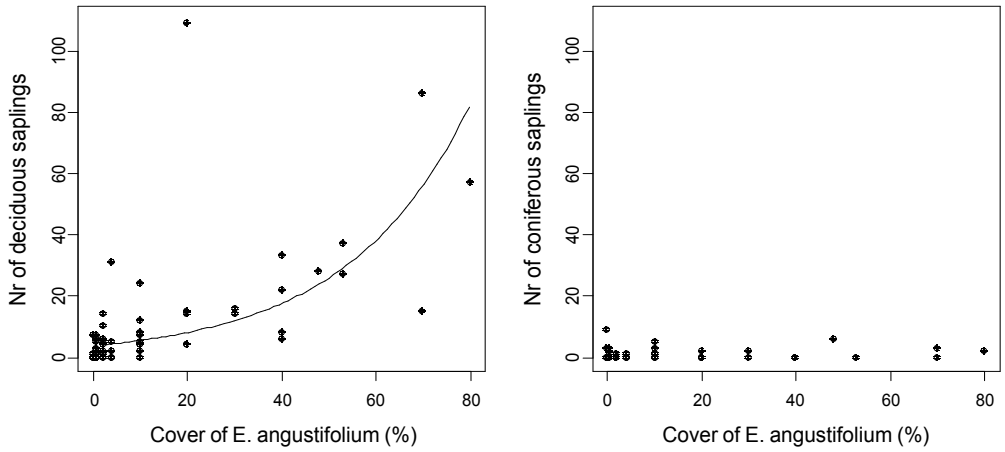

Fig. 4. Number of saplings (10 - 130 cm) in relation to the cover of *Epilobium angustifolium* in the upper part of the burnt forest area in Leuk, Switzerland (1'400 m - 2'100 m a.s.l.; n=84). y= exp(1.332+0.038x).

4. Discussion

According to the classification by Doyle (2004), burn severity was high in large parts of our study site in Leuk, Switzerland. With a few exceptions at the border of the burnt area, all trees were scorched to the top and almost no plants survived the fire above ground. Especially at lower and medium altitudes, most of the duff layer was consumed (cf. Wohlgemuth *et al.,* 2006). Consequently, recolonisation of the burnt area had to occur by resprouting rhizomes having survived in the soil or by seed input from adjacent areas. Two years after the fire, vegetation was dominated by anemochore species such as *Conyza canadensis* or *Epilobium angustifolium*. This is concordant with the study by Wang and Kemball (2005), who found that invaders represented the largest plant group in severely burnt boreal forests, whereas seed bankers and resprouters were dominant in lightly burnt and scorched forests, respectively.

As a result of the continental climate of the Central Alps and the high radiation due to the southern aspect of the burnt area, water resources are an important limiting factor for colonising plants in Leuk. Thus, it is not surprising that drought resistant and persistent species such as *Conyza canadensis* or *Lactuca serriola* dominate the early post-fire vegetation in the lower parts of the burnt area. Similarly, water deficiency could be the reason for the sparse tree regeneration below 1400 m a.s.l. Alternatively, dominant species are known to inhibit the establishment of other species (Polley *et al.,* 2006), e.g. dense cover of grasses may prevent tree seedlings from rooting (Cater and Chapin, 2000). However, early colonising species may also improve growth conditions for other species, e.g. by altering availability of water or nutrients (Cater and Chapin, 2000). This kind of facilitation is especially effective after severe disturbance events such as volcanic eruptions or severe fires (Del Moral and Wood, 1993). The correlation between cover of *E. angustifolium* and number of deciduous saplings above 1'400 m a.s.l. indicates facilitation of tree regeneration by *E. angustifolium*. Consequently, we expect natural reforestation at high altitudes to be fast though at first limited to deciduous species. In contrast, we expect tree establishment at lower altitudes to be slow and restricted to areas adjacent to unburnt patches or the intact forest. Between 800 and 1200 m a.s.l. slow reforestation will probably be due to water deficiency, while tree establishment between 1200 and 1400 m a.s.l. might be hindered by dominating grasses.

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