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Forest stands characteristics of the *Salamandra atra aurorae* Trevisan habitat: a study at the "Bosco del Dosso" (Asiago, Italy)

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ABSTRACT

Anthropogenic habitat loss and the reduction of suitable habitat for a species have been implicated as among the key drivers of biodiversity crisis. *Salamandra altra aurorea* is considered to be critically endangered by the IUCN red list and is included as “priority taxon” in the European Union Habitat directive due to its very limited geographic distribution and the potential threat of habitat loss resulting from wood harvesting. My first goal in this study was to evaluate the characteristics of the habitat of *Salamandra atra auroae* in “Bosco del Dosso” in the plateau of Asiago, by focusing on various parameters, and investigating the influence of environmental and management factors. The second goal was to compare results on habitat characteristics with those of the previous year before any forestry intervention was carried out. This study is part of a larger project aimed at studying the habitat of this species and the effect of experimental forest exploitation on the subspecies under investigation. In 2015, for these reasons, based on the presence of the salamander recorded in 2014, 17 trees were cut from a total number of 50 trees. In 2015 there was a higher total number of vascular plant species in the herbaceous layer and, consistently, also the cover of this vegetation layer increased. The removal of the canopy could have had an affect also on the regeneration. The number of stones and bark pieces significantly increased between the two years whether the trees were cut or left standing. Based also on the observations of last year, this study highlights the importance of considering an important amount of shelters as stones and pieces of bark to better understand the habitat of *Salamandra atra aurorae* and the possible changes driven by forest exploitation.

Keywords: Forest exploitation, habitat loss, conservation, *Salamandra atra aurorae*

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1. Introduction

1.1 Habitat management for species conservation

The conservation of biological diversity has become one of the important aspects of managing forests in an ecologically sustainable way at the ecosystem and landscape levels. Biodiversity includes diversity at the genetic, species, landscape and ecosystem levels (Noss and Cooperrider, 1994)

Species loss is predominantly driven by habitat loss (Groombridge and Jenkins, 2002). Therefore, the important goal of conservation management must be to prevent habitat loss. Forest biodiversity conservation will depend on maintaining habitat across the full range of spatial scales. The maintenance of specific habitat characteristics is one important goal in forest biodiversity conservation, but what constitutes a suitable habitat is different for each species (Hansen and *al*., 1991). Furthermore, spatial extents are important. Many species find optimum conditions only within large ecological reserves that become strongholds for these species. Some species are intolerant of human intrusions, making it imperative to retain some areas, which are largely exempt from human activity (Wilcove, 1989).

The increasing of environmental problems, during the second half of the 20th century, including the loss of species and habitats, where many species were in danger of extinction and many habitat types were disappearing, allowed to the creation of protected areas and signature of several conventions as the Ramsar Convention in 1971, creating with that the first international network of protected areas (Douglas, 2012).

In Europe in 1979 a Directive on the Conservation of Wild Birds was adopted by the European Commission, whereas, the Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora was adopted on 21 May 1992, more usually known as the Habitats Directive. This Directive together with the former one, form the Natura 2000 network, the largest network of protected areas in the world with more than 26 000 sites and covering about 17.5% of the EU land territory (Sundseth and Creed, 2008). The natural habitats of the Directive are only a very select overview of the European natural areas diversity. There are natural or semi-natural areas with unique and particular geological, biotic and geographic characteristics. Annex II of the Directive establishes a list of 632 species in Europe with a precarious status and which their habitats must be protected.

Annex I lists some 222 different types of natural habitats (coastal habitats, dunes, freshwater habitats, heaths, thickets, grasslands, bogs, forests and rocky habitats). This list includes rare environments and small size, such as mobile dunes and the Alpine or Pyrenean rivers, or the types of habitats containing high biodiversity or essential habitats for migratory species.
These natural habitats are identified as priorities by an asterisk in Annex I, because they are seriously at risk of disappearance in Europe, given the current importance on their natural range.

The loss of biodiversity affects all the biomes (Blaustein and Kiesecker, 2002) and several specific taxonomic groups, including amphibians (Petranka, 1998). The overall loss results from a complex synergy between several local factors (habitat fragmentation from logging and urbanization, pollution and drainage of wetlands, introduction of exotic species and diseases), regional factors (acidification and contamination of wetlands) and global factors (climate change and increased UVB radiation) (Blaustein and Kiesecker, 2002).
One of the most important factors contributing to the decline of amphibian populations is the alteration and destruction of habitats by logging (Alford and Richards, 1999). The amphibians are particularly sensitive to the impacts of silvicultural treatments on habitat due to their biological and ecological characteristics: High longevity (compared to invertebrates and fish), small vital area, highly philopatric behaviour and high abundance (Pechmann and Wilbur, 1994). In addition, the permeability of their skin limits several amphibians to litter microhabitats and moist and fresh soil with pH value above 4 containing woody debris (Aubry, 2000).
These studies show that forestry interventions can cause considerable changes in the use of forest landscape of amphibians by the complete removal of the canopy that alters the humidity and temperature of litter and woody debris essential for the survival of the amphibians. Thus, the amphibian richness and abundance are usually much higher in residual forests compared to recently cut stands. Nevertheless, these studies have been carried out mainly in North America where silvicultural practices are completely different from those applied in other parts of the world, such as in the Alps. Indeed, there is a substantial difference in terms of spatial extent, frequency, and removal intensity.

1.2 *Salamandra atra aurorae* Trevisan and its conservation

Terrestrial salamanders are ideal indicator species for maintenance of biodiversity and forest ecosystem integrity (Welsh and Droege, 2000). The glaciations of the Pleistocene were important cause of speciation in biota, and as a result of this glaciation, a large number of species and subspecies of the genus Salamandra, are located in Europe and in the Mediterranean basin (Steinfartz, 2005). Two endemic subspecies are found in Italy, in the Prealps of Veneto, currently known as *Salamandra atra aurorae* (Trevisan, 1982) and *Salamandra atra pasubiensis* (Bonato and Steinfartz, 2005).

Salamdra atra aurorae (Golden Alpine salamander) is a subspecies of the Alpine salamander (*Salamandra atra*, genus *Salamandra*, family *Salamandridae*). The genus Salamandra consists of six species distributed in Europe and in the Mediterranean basin, four-spotted salamanders and two alpine salamanders:

- *Salamandra salamandra* (Europe)
- *Salamandra algira* (Northern Africa)
- *Salamandra infraimmaculata* (Middle East)
- *Salamandra corsica* (Corsica)
- *Salamandra atra* (European Alps including an isolated population in the Dinaric Alps of Serbia and Albania)
- *Salamandra lanzai* (Border region between France and Italy).

Golden Salamandra is characterised by yellow patches on its dorsal side interspersed on a uniformly black surface (Trevisan, 1990). *Salamandra atra aurorae* is ascribed to the Annexes II and IV under the Habitats Directive 92/43/EEC, which allows the creation of special areas suitable for the conservation of this sub-species of salamander listed as a priority species and require strict protection due to its very limited geographic distribution and the potential menace of habitat loss resulting from wood harvesting (Sindaco, 2006). Furthermore, it is also considered in great danger according to the criteria B1ab (III) of the IUCN Red List (IUCN, 2010).

This salamander is found only in an area of about 17 kilometers in length between the Val Postesina in Trentino and the Val di Nos (Veneto Region), on the Plateau of Asiago in Italy. The distribution is a few kilometers wide (Bonato and Grossenbacher, 2000). The habitat of S. a. aurorae includes wooded areas in humid mixed forest with *Fagus sylvatica, Picea abies* and *Abies alba* are the dominant tree species. The structure of these forests and the specific microclimate characteristics are very important for the survival of terrestrial salamanders as the *Salamandra atra aurorae* (Welsh and Droege, 2001).

The alteration of habitat is caused by some forestry activities, as cutting or removing trees and the roads, which were built in the forest to export the wood using heavy machines. These roads and activities have a negative impact on the natural habitat (Demaynadier and Hunter, 2000).

Deforestation, in general, exposes the salamanders to drastically altered microclimatic regimes (Ash, 1997), drying and compacting soil, and reducing the complexity of habitat destroying shelters and rocky surface (Gallese, 1990).

1.3 Objectives and research questions

This study is part of a two years study project on the habitat of the subspecies *Salamandra atra aurorae.* The study area has undergone in the winter 2014 an experimental cutting and skidding on a sample of plants, to study the effect of forest exploitation can have on the quality of the habitat.

The aim of this study is to characterize and study the influence of habitat characteristics of recently harvested stands compared to residual stands of mixed forest on salamander populations (*Salamandra atra aurorae*) as an amphibian species.
Regarding the objectives, the specific research questions are:
What are the main characteristics of the habitat of *Salamandra atra aurorae?*
What are the impacts of silvicultural operations adopted in the study area on the habitat features of *Salamandra atra aurorae*?

2. Theoretical background

2.1 Biological diversity

Biological diversity, or biodiversity, refers not only to the number and variety of species but also encompasses the diversity of ecosystems, and the genetic variation contained within species. It is considered to encompass: genes, individuals, demes, populations, metapopulations, species, communities, ecosystems, and the interactions between these entities (Delong, 1996). For conservation biologists, `diversity' almost always means number of entities. More recently, some scientists refer to structural and process diversity as key components of biodiversity, and when a species is reduced to a few individuals or only survive in captivity, it ceases to interact with its environment, so there is loss of biodiversity even without extinction of species (Simberloff, 1999).

The accelerating pace of species extinction and habitat loss stimulated the emergence of conservation biology, a fusion of ecology and evolutionary biology explicitly addressing the conservation of biological diversity (Soulé, 1985). Even though the potential consequences of species extinction have been hotly debated for more than 35 years (Tilman, 1999), the knowledge and understanding of the precise link between biodiversity and ecosystem functioning is still limited (Hector and Hooper, 2002)

2.1 Biodiversity conservation

Conservation biology is a discipline comprising both pure and applied science (figure 1). It focuses on the entire biota; diversity at all levels of biological organization; patterns of diversity at various temporal and spatial scales; and the evolutionary and ecological processes that maintain diversity (Soulé, 1985). The conceptual boundaries between it and other fields have become increasingly discussed. Botanists, ecosystem ecologists, marine biologists, and agricultural scientists were underrepresented in the field’s early years. The role of the social sciences in conservation biology has also expanded within the field (Noss, 1999).

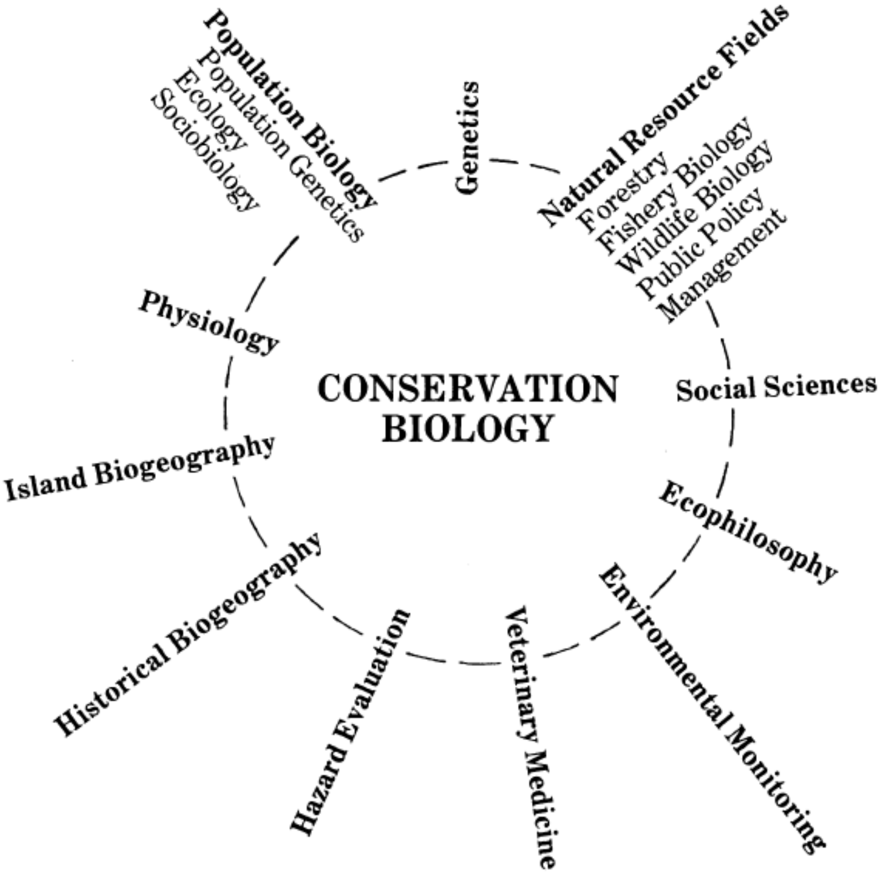

Figure 3: Multidisciplinary sciences of conservation biology (Soulé, 1985)

Different species have different ecological attributes, such as their scale of movement, life history stages, longevity, and what constitutes habitat. Each of these influences how a species "perceives" a landscape, as well as its ability to survive in a modified landscape (Fischer and *al*., 2004). Species show many kinds of responses to habitat fragmentation, some are advantaged and increase in abundance, while others decline and become locally extinct. Understanding these diverse patterns, and the processes underlying them, is an essential foundation for conservation.

2.1 Habitat loss

Habitat fragmentation is the term commonly used to describe human practices that destroy habitat. This usage is misleading because there are situations in which habitat can be removed without fragmenting the landscape whatsoever. The term habitat destruction refers to processes, particularly anthropogenic, that remove habitat cover. Habitat destruction can then be pictured as having two distinct components: habitat loss and habitat fragmentation (Fahrig, 1997).

Habitat loss is expected to produce a proportional decline in the number of species living in a particular landscape. As a result of the loss of habitat and extinction of species, most programs to sustain forest biodiversity have focused on the creation of protected areas, but reserves alone is insufficient to adequately conserve forest biodiversity (Sugal, 1997; Daily and *al*.,2001). Organisations, such as the IUCN, treaties and conventions were established for sustainable forest conservation (Wilcove, 1989).

Forest exploitation, as applications of silvicultural techniques, involving direct and indirect influences on the environment both in the forest component of the soil, atmosphere and water both the fauna and flora that grow in the forest habitats, through the impact on the different components over listed (Marchi and Piegai, 2001).

For many amphibians and other terrestrial species compaction and soil erosion, the removal and mixing of soil, and removing stumps are considered to be harmful. Amphibians are the vertebrate group most threatened not only for the number of species concerned, but also for the degree and change of habitat.

After the Bonn Convention of 23 June 1979 focused on the conservation of essential habitats for migratory species, it is the Berne Convention for the conservation of wildlife and natural habitats of Europe which is adopted on the initiative Council of Europe September 19, 1979. It is signed by European states and served as the foundation for the Birds and Habitats Directives. For the first time this agreement created real obligations for the Contracting States and was interested not only to wildlife species, but their living environments that shape their conservation. The convention included annexes of plant and animal species requiring protection but did not refer to networks of protected areas.

After heated discussion a Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora was adopted on 21 May 1992, more commonly known as the Habitats Directive (EC 1992). This directive includes measures for the strict protection of selected species and requires the designation of protected sites for selected habitats and species known initially as Sites of Community Importance (SCIs) and once designated as Special Areas of Conservation (SACs)(Sharp, 1998).

IUCN publishes and updates a Red List of threatened species. Its implementation is based on different criteria to classify species whose extinction risk globally is high, that is to say in order to carry out a global assessment. The recorded species can be divided into nine categories:

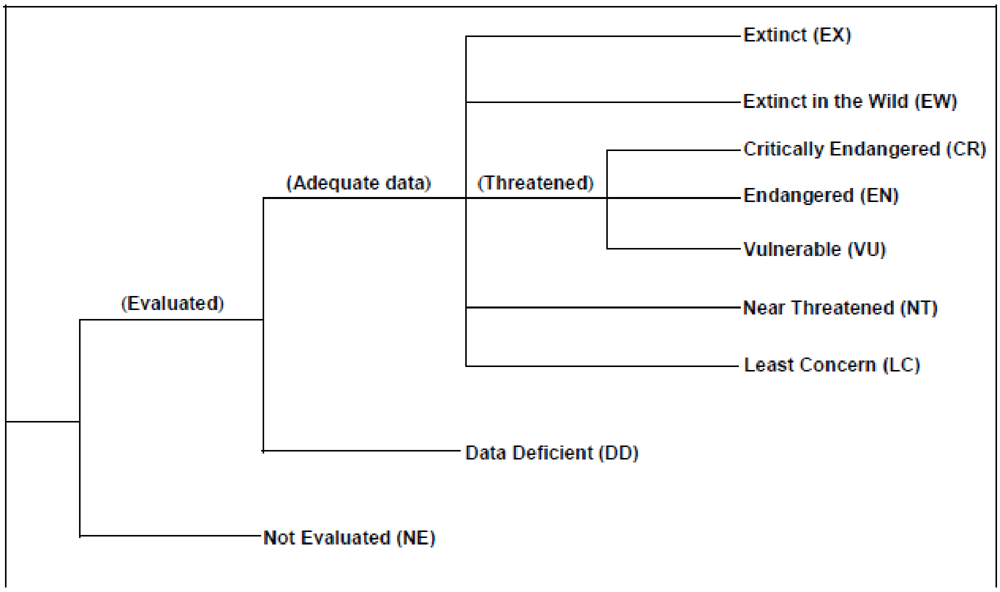

Figure 4: Structure of the IUCN Red list categories (IUCN, 2010).

The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. The general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk. However, while the Red List may focus attention on those taxa at the highest risk, it is not the sole means of setting priorities for conservation measures for their protection.

According to the IUCN Red List, S. a. aurorae is considered in great danger according to the criteria B1ab (III), this is because within a "useful area" extended less than 100 square kilometers, all individuals could be located in one place, locations characterized by a steady decline in the quality of its habitat, in “Bosco del Dosso” (IUCN, 2010).

3. Materials and methods

3.1 Study area

The study area is the “Bosco del Dosso” (Figure 3), in the “Sette Comuni” mountain plateau, located in Asiago in the Venetian Prealps, NE Italy. The forest of “Bosco del Dosso” is publicly owned by the municipality of Asiago and covers an area of 700 ha with altitudes ranging from 1300 to 1700 m.a.s.l.

Figure 3: “Bosco del dosso”

The Plateau of Asiago is characterised by a precipitation average of about 1460 mm per year and a temperature average of 8 °.

The warmest month is July with an average temperature of 17.5, while the coldest one is January where we reach an average of -1 ° C.

Rainfall is abundant with an absolute maximum in November and the minimum is registered in May and between August and September. The annual average is around 1500 mm.

The dominant tree species are silver fir (*Abies Alba* Mill.) in a carbonate soil, Norway spruce (*Picea Abies* L.) and *Fagus sylvatica*, the habitat suggested as ideal for *Salamandra atra aurorae.*

The rocky base on which insists the area is of sedimentary origin. Consists essentially of main dolomite, limestone gray and red ammonite. It is characterized by karst phenomena resulting in the absence of surface water, despite the presence of some perennial sources.

Faunal aspects: With regard to amphibians, the area is of great interest, in fact encompasses the distribution area of the historic Aurora Salamander (*Salamandra atra aurorae*), and is frequented by other amphibians as the alpine newt (*Triturus alpestris*), the common toad (*Bufo bufo*) and the mountain frog (*Rana temporaria*).

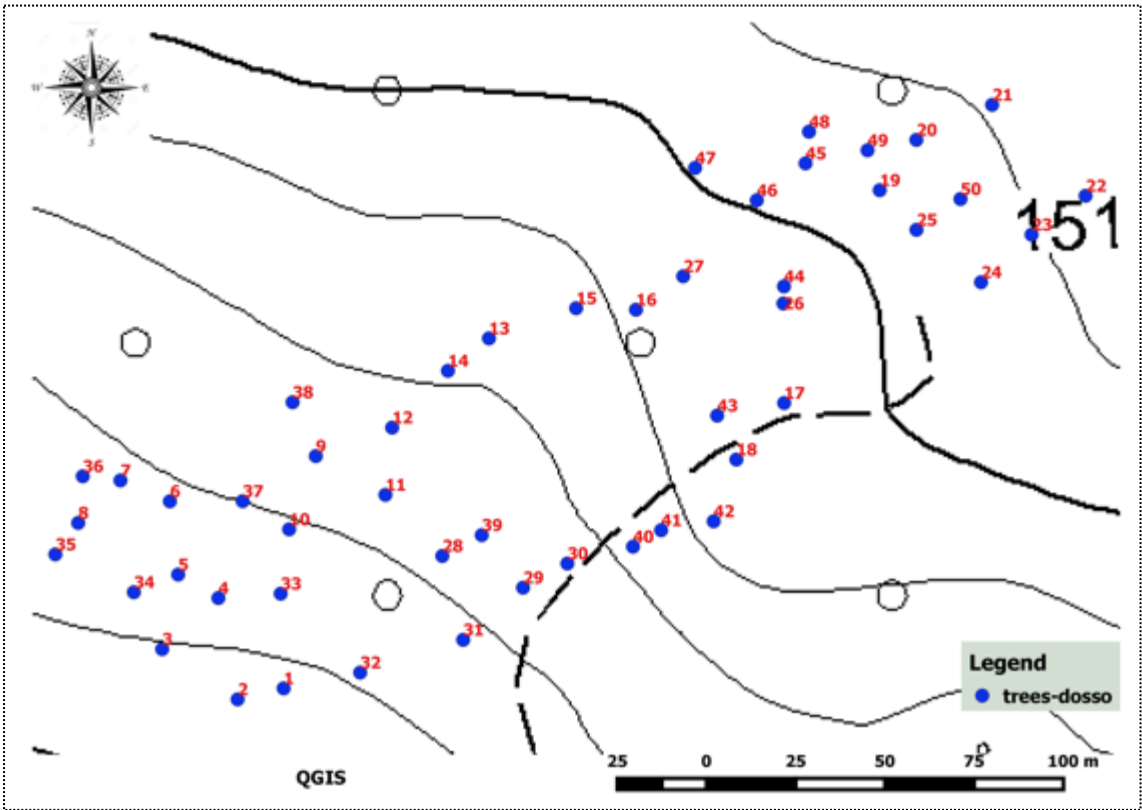

Figure 4: Distribution of trees used as a reference for the study in the "Bosco del Dosso"

3.2 Study species

Salamandra atra is present in the European Alps with isolated populations in the Balkan Dinaric Alps in Slovenia, Croatia, Bosnia-Herzegovina, Serbia-Montenegro and northern Albania. It occurs at elevations between 400 and 2800m.a.s.l (more frequent between 800-2000m.a.s.l). The subspecies *Salamandra atra aurorae* is largely restricted to the Bosco del Dosso and Val Rensola in north-east Italy (between 1300 and 1800m.a.s.l); new localities extending to the east were discovered in the early 1990s (with a distance between furthermost sites of 15km2), and it is possible that this subspecies might occur in the entire forested high plateau of the area.

The period of activity of golden Salamander is from May to late September and spends the rest of the time in retirement (Bonato and Fracasso, 1998). Within this period; the activity depends on the weather, is dependent on a high humidity and is only active in periods after or during the rains. There are no differences in distribution between young ones and adults and even between males and females (Bonato and Fracasso, 2002). The behaviour of *Salamandra atra aurorae* changes with age. The young ones are not loyal to a particular area; otherwise adults can be faithful to a specific area for more seasons.

The females of this sub-species are longer and heavier than the males (Klewen, 1991).

Salamandra atra aurorae has a large dorsal spots; occasionally the spots are also laterally and ventrally. The yellow spot can vary from bright yellow to dark yellow (Figure 5). These spots have the ability to tack with time towards the dark brown color; this phenomenon was observed during a short period of captivity (Steinfartz, 1998).

Figure 5: Specimens of *Salamandra atra aurorae*

The cloaca is the most distinct characteristic variation between males and females. In males the cloaca cambers considerably outwards and on the outside it has a compact structure also for the offspring. The cloaca of the females is flat on the outside and runs acute-angled to the furrow of the underside of the tail.

Humid mixed mesophilic forest, often characterized by *Fagus sylvatica*, *Picea abies* and, to a lesser extent of *Abies alba* are the dominant tree species in the habitat of *Salamandra atra aurorae.*

Historically, *Picea abies* was not present on the Plateau of "Sette Comuni". Its presence is due to a tradition of growing forest, the loggers in favor of this species resulting in a decrease of *Fagus sylvatica* and *Abies alba* and replanting after the First World War. Dense forests of *Picea abies* are considered unfavourable for *Salamandra atra aurorae*, due to the fact that the modification of the original forest with high biodiversity is the highest structure and composition of forests (Barbati and Machetti, 2004). A natural development of the surface structure is important for the survival of terrestrial salamanders because of the abundance of shelters, humidity and food (Duelmann and Trüeb, 1986). Generally, the greatest density of salamanders is reached in forests older and structured, which are today rarely present in the entire distribution of *Salamandra atra aurorae* because of the traditional cultivation of the forest. The ecology of *Salamandra atra aurorae* is not so much linked to biotic factors such as the vegetation or the presence of other animals. The abiotic factors, such as hydrology, geology (limestone) and shelters (even the wood and bark), are by far the most important for survival, making the subspecies particularly stenotic.

Human settlements and the changes of development in this alpine region have been responsible for the loss and fragmentation of habitats of *Salamandra atra aurorae* (Sauro, 2006). Another threat is the collection also connected to the pet trade and general habitat alteration through excessive water abstraction from streams, and the removal of ground cover during forestry practices.

3.3 Data collection

In the study area 2 plots for 50 trees (=100 plots) were marked for the habitat survey. In the lower part, the substrate was largely non rocky with abundant shelter, mainly consisting of pieces of bark, stones and rotten logs, while in the upper part of the forest the soil was more rocky and the shelters were less abundant and mainly consisted of stones, whereas pieces of bark were absent.

The surveys were conducted from the beginning of June to end of July.

Data collection at the plant species level is essential for species identification and assessment of the abundance of each species, and this can be reaches only by a floristic survey. Floristic survey is normally carried out in a delimited area in which vegetation cover can be estimated, plants counted and species listed.

A plot size should be large enough to include significant number of individuals, in our case 50 plants (trees) were chosen, for each of them two plots on the opposite sides of the plant are delimited with rectangular shape of size 5x3m. All species in the herbaceous layer were identified and the cover values were assigned following the categories of Braun-Blanquet (1932) (Table 1). It is a semi-quantitative measure of assessing the abundance-dominance of each species in a given site. We distinguish 6 classes of vegetation cover as in the following table.

Species were most of the time identified on the field; this was done by making use of specialized books and specific species lists (Rothmaler and Jäger, 2009; Scortegagna, 2008). Those that were not immediately recognized were catalogued (plot ID number and date) and later recognized.

Table 2: Braun-Blanquet categories of cover

Braun-Blanquet categories	**% cover**
+	<1
1	1-5
2	5-25
3	25-50
4	50-75
5	>75

The line transect method was applied to assess local characteristics. Two line transects were used for each plot by dividing each side in two (Figure 6). The surveys were made at regular distances of 10 cm. Therefore, every 10 cm the feature that touches (i.e. overlapping) the line is recorded and this provides important information about the type of cover of the plot.

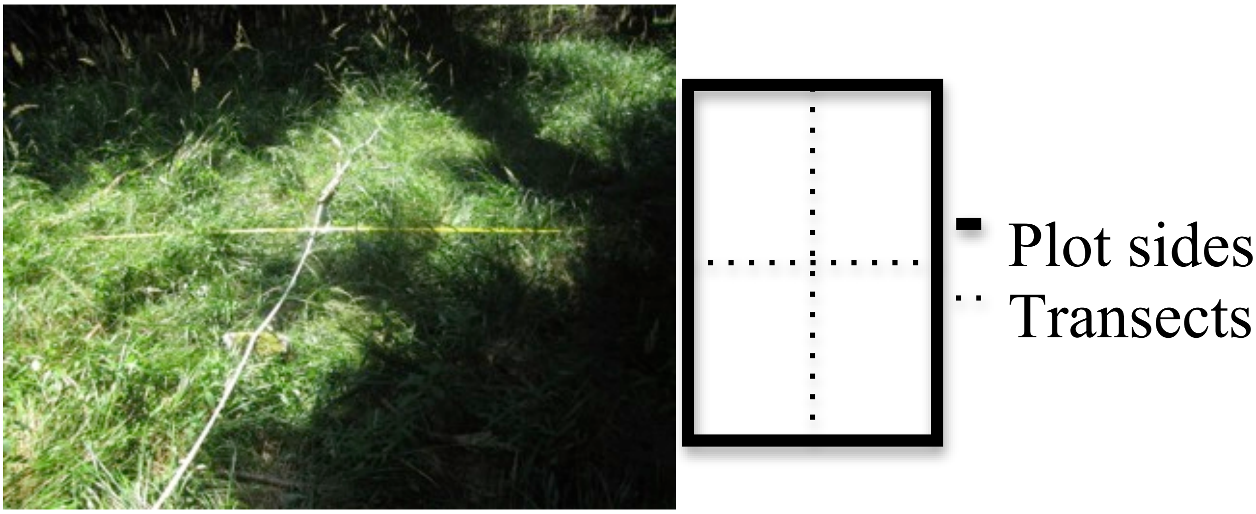

Figure 6: Line transects method

Normally, *Salamandra atra aurorae* is active during the night and during the day only after heavy rainfall. It is likely that, to protect themselves during the day, they hide in shelters under stones, bark and stumps. During each visit, every movable and potential shelter (stones, pieces of bark, deadwood, and stumps) was recorded. For these microhabitats features different measures were taken: number and diameter of deadwood exceeding 3 cm at mid length (Figure 7), the dimensions of bark and rectangular pieces of wood, diameter and height of stumps, and the dimensions of all the stones. The diameter was also measured for trees (the diameter at 1.30 meters). Regeneration was surveyed by counting the number of seedlings and samplings with diameter under 15 cm.

Figure 7: Measurement of deadwood diameter

A spherical densitometer was used to obtain reliable results on tree cover. Four measures were taken for each plot at the midpoint of each main segment of the transect. The spherical densiometer consists of a small wooden box with a convex or concave mirror, engraved with 24 squares, placed in it. The densiometer is used by holding it at breast height so that the observer's head is reflected from the edge of the mirror just outside the graticule. The curved mirror reflects the canopy above, and canopy closure can be estimated by calculating the number of squares (or quarters of squares) that the image of the canopy covers (Lemmon, 1956). The total coverage was estimated for the whole plot (from 0 to 100%) following a simple computation to convert point counts to percentage values as suggested by the producer of this tool.

Table 2: Summary of the instruments used in the field

Instrument	Measurement
Metric tape	Plot sides length and transects
Spherical densiometer	Forest overstory density
Tree calliper	Trees dbh, diameter of deadwood

3.4 Data analysis

Different approach and techniques were used to analyse the data and information collected. Quantitative data was analyzed using simple statistic techniques such as mean, standard deviation, frequencies and percentage. All these analysis were performed with the help of Microsoft Excel and R i386 3.1.0.

In order to achieve profound description of the plots, the data collected by the transect technique was categorized in 6 categories: moss cover, deadwood cover, litter cover, stone cover, bare soil cover, and vegetation. The percentage of each category was calculated for each plot.

In addition, the plots were categorized and divided in two groups: one referring to cut trees (17 trees were cut, therefore, 34 plots refer to trees that were cut), and the other referring to those trees that were not cut.

A preliminary analysis was carried out to understand the changes occurred in habitat features between the two years. Several authors have used the paired t-test to link habitat differences expressed also as proportions between paired plots (e.g., Ghosh-Harihar and Price, 2014; Bennett et *al*., 2015). This analysis enables to test whether two sets of data grouped in pairs are statistically different. In this study the pair is represented by the plot at the two different time periods (2014/2015). To understand whether changes have occurred between the areas referred to cut trees and areas referred to standing trees these were analysed separately. We also used mean values of the two plots for each tree.

4. Results

4.1 General results

In the 100 plots studied in the present work we found a total of 78 plant species. Calculating the relative frequency of the different plant species present, it appears that the species more frequent with relative frequency between 0.82 and 0.94 are: *Prenantes purpurea, Aposeris foetida, Calamagrostis arundinacea, Hieracium murorum, Euphorbia carniolica, Fragraria vesca, Phyteuma ovatum and Vaccinum myrtillus.*

Analysing the individual plots, it was found in one plot a maximum value of 37 plant species, and 25 plots contained, more or less, 20 plant species per area. Below, the histogram (Figure 8) shows the distribution of the frequency of plant species richness for different plots.

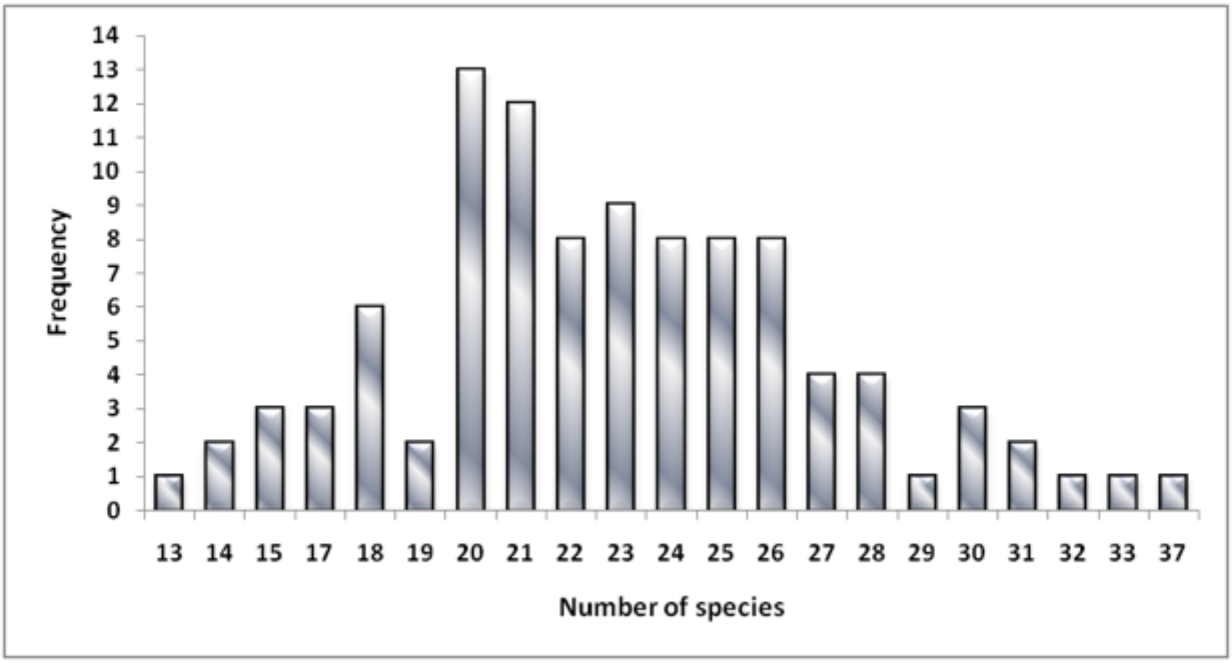

Figure 8: Distribution of the frequency of plant species

In the study area they were naturally present different types of shelters suitable for *Salamandra atra aurorae.*

4.1.1 Stones

In the 100 plots chosen for the study, there were a total number of stones equal to 323. The area occupied by the stones was calculated and then converted into a percentage, to know the rate occupied by stones in each plot. The results showed the existence of 28 plots without stones, while the plots 17A and 24A, stones occupy 5% of their area.

4.1.2 Bark

The total number of pieces of bark present in the study area is 534.

The maximum value of pieces of bark found in one plot is 28, while 18 plots contain no bark. The area occupied by pieces of bark was also calculated and converted to a percentage.

4.1.3 Stumps

The stumps are important because they represent a potential refuge for the salamander and are privileged places for the settlement of natural regeneration. The volume occupied by stumps within each plot and in the total study area was calculated. The larger diameter found is 75cm and 91cm for the height. Some stumps are located in the limit of the plot, in this case just the half that is measured. The tolal number of stumps found in the area is 61.

4.1.4 Deadwood

The importance of this component in forest ecosystems in Italy is recognized only recently. In the past, the dead wood in the forest was seen as a disturbing element, and was almost completely removed during the management operations, because of its negative impact in terms of plant protection from forest fires (Marziliano, 2009).

In the 100 plots studied was found a number of 1271 piece of deadwood. The diameter vary between 3 and 15 cm. By analyzing the number of the dead wood and the diameter measured during the field, we note that the dimeters more frequent are between 3 and 4 cm, thus due often to fallen branches by natural and human causes.

4.1.5 Regeneration

Natural regeneration is the process by which the forest is naturally renewed; it is based on the recruitment of young plants deriving from seeds (seedlings).

It can successfully occur only if a sufficient amount of growing space is available for seed germination and subsequent growth of seedlings. Canopy trees strongly determine the understory light and tend to reduce the growing space for the recruitment of young trees into the canopy layer, thus consolidating their dominance (Borghetti and Giannini, 2003).

In the study area, the species with a high rate of regeneration is *Picea abies* with a percentage of 61.45%, following by *Abies alba* with (34,73%) and small rate for *Fagus sylvatica* represinting 5% of the total regeneration.

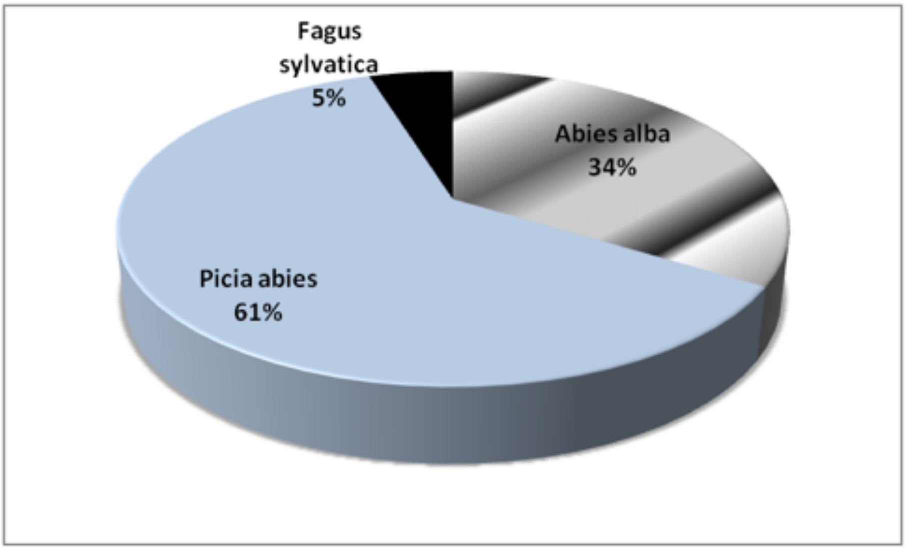

Figure 9: Percentage of regeneration of tree species

4.1.6 Trees and tree cover

A total of 24 trees was recorded in the study area with an average of 0,24 and a standard deviation of 0,67. The most abundant tree species is *Picea abies* with 16 specimens, and for *Abies alba* a total of 8 trees were found, including a plant with a 75 cm of diameter.

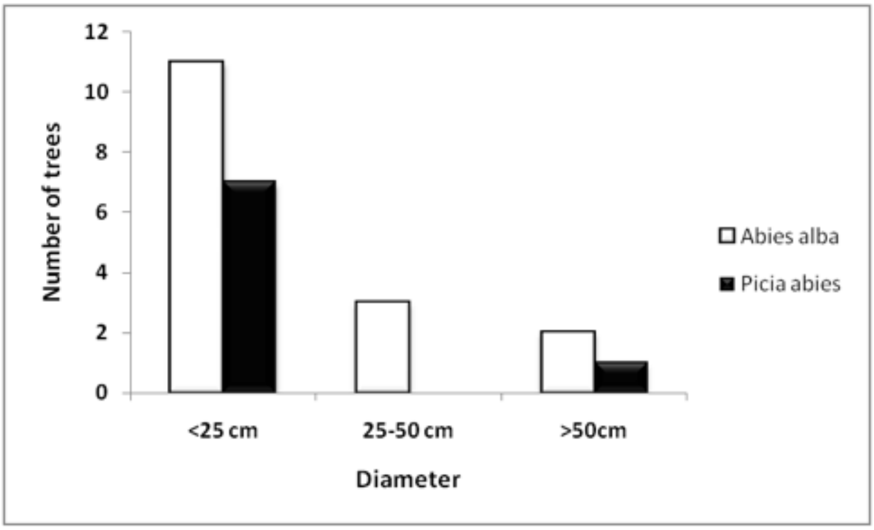

Figure 10: Diameter distribution of tree species

The study area is a dense wooded area and from the analysis of data collected by the spherical densiometer, the tree cover average is 86.61%. Tree cover ranges between 58.66% and 100%.

4.2 Micro-habitat cover

By estimating the percentage of moss, litter, deadwood and vegetation of different areas of study, we can have data about type of cover, not only herbaceous, present in the study area.

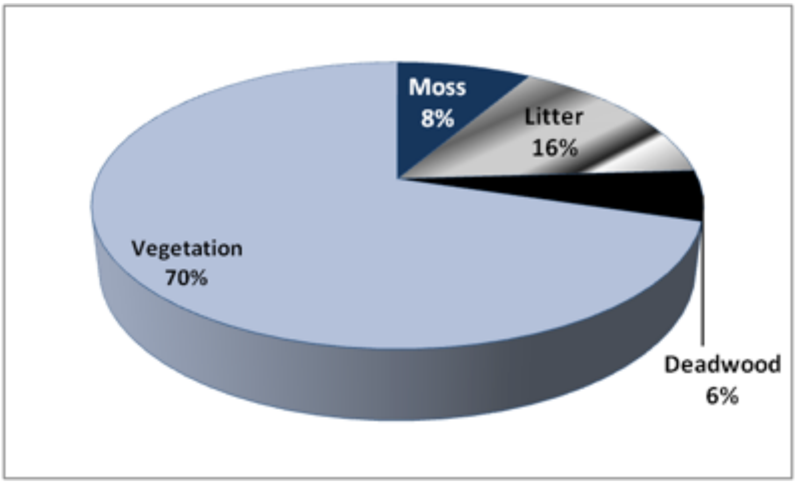

Figure 11: Percentage of different individuals along the line transect

4.3 Comparison between no cut plots and cut plots

The study area was studied last year before the intervention, and application of some silvicultural operations. This year, the same area was the subject of several actions of cutting trees with a total of 17 cut trees, that means 34 plots given that for each tree, two plots on the opposite sides of the plant are delimited.

A comparion of all the variables between the tho groups (with and without cut trees) was established.

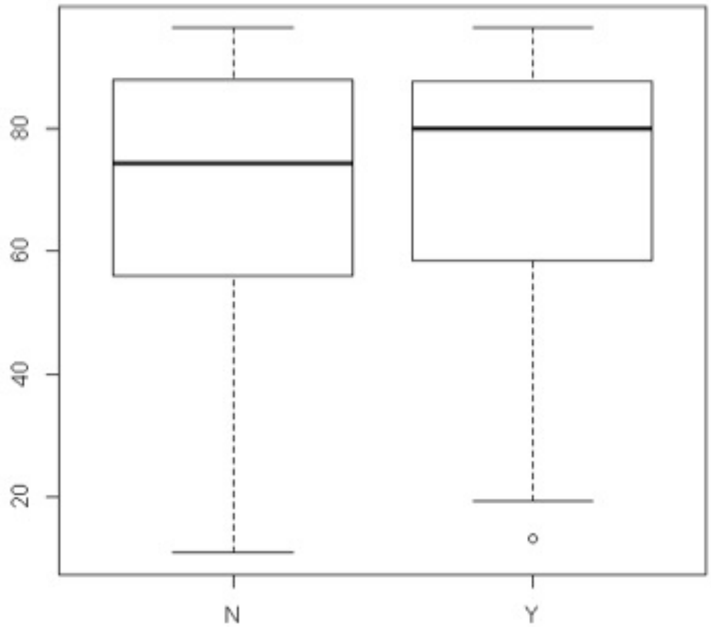

Figure 12: Representation of rate of vegetation in plots with (Y) and without cut (N)

The boxplot above shows the differences concerning the vegetation in the two groups. It shows that herbaceous layer in the plot qui with forestry interventions is more abundant in comparison with the vegetation in other natural plots.

Concerning the deadwood, the comparison showed that plots were tree extraction was carried out contain a large number of pieces of deadwood in comparison with other plots (Figure 13).

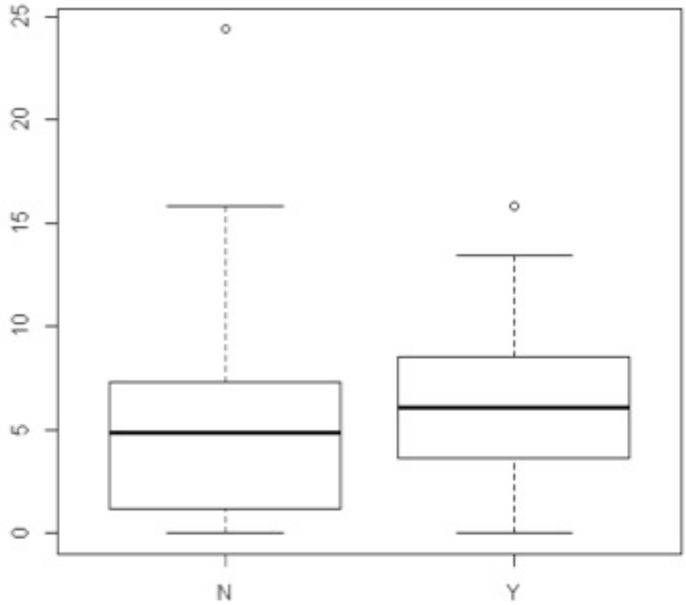

Figure 13: Representation of number of deadwood in plots with (Y) and without cut (N)

The results have illustrated that moss cover does not different between the plots (Figure 14). The soil is much more covered in moss in natural plots than in the plots with cutting trees.

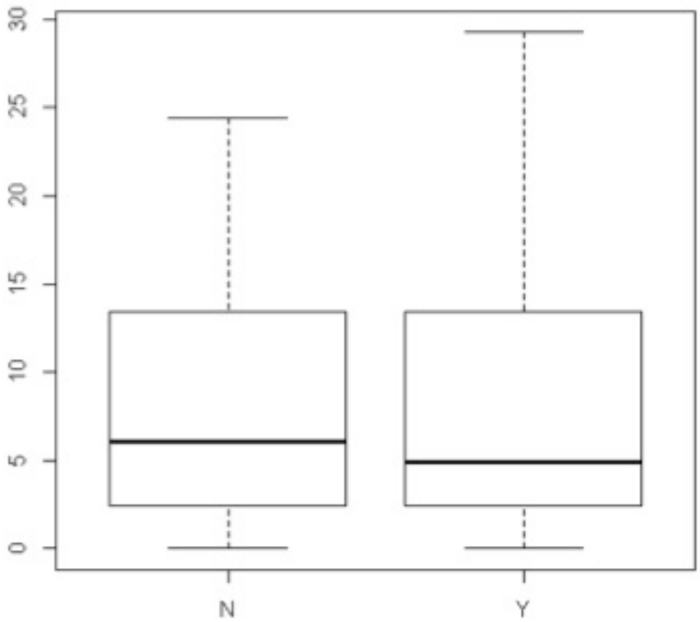

Figure 14: Representation of the rate of moss in the soil of plots with (Y) and without cut (N)

The removal of the canopy and cutting trees affects the degree of the penetrating light and temperature in promoting the development of the herbaceous layer, but it has a negative correlation with the regeneration of seedlings. The found results showed that the rate of regeneration is much higher in the normal plots without cutting.

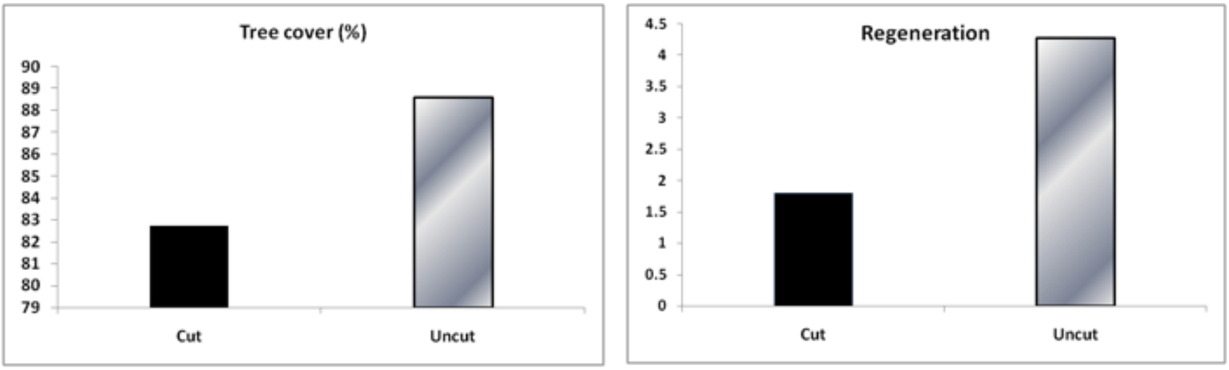

Figure 15: Percentage of tree cover (left) and regeneration (right) in the plots with and without cutting

4.4 Changes between the two years

Concerning the plant species, the more frequent herbaceous species are more or less the same in comparison with the survey established last year, with some differences in the percentage of cover (Table 3).

Table 3: Abundant herbaceous species

Species	2014	2015
Prenantes purpurea	97%	94%
Aposeris foetida	92%	88%
Calamagrostis arundinacea	81%	88%
Euphorbia carniolica	87%	85%
Hieracium murorum	80%	87%
Fragraria vesca	83%	82%
Phyteuma ovatum	76%	82%
Vaccinum myrtillus	60%	82%
Oxalis acetosella	77%	77%

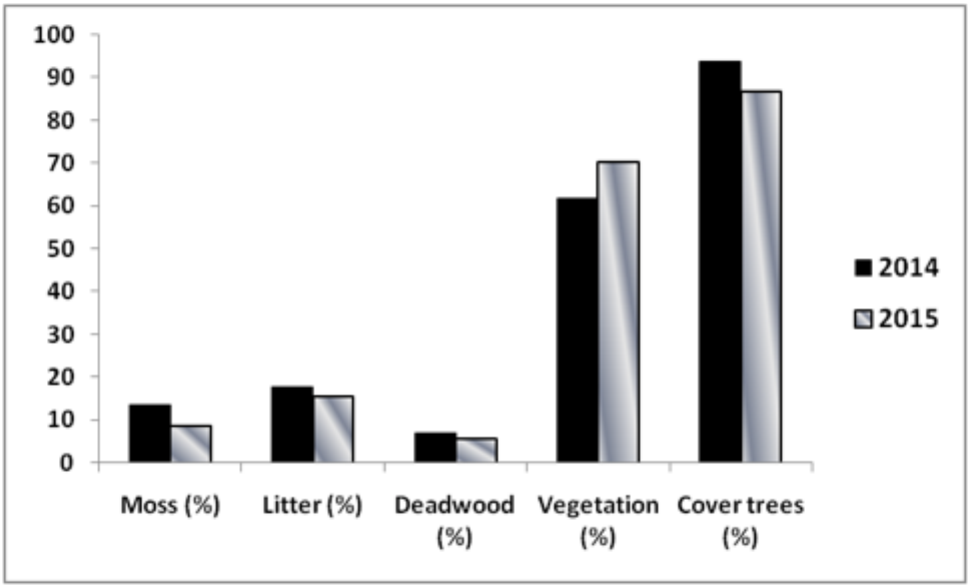

Figure 16: Comparison of different variables between 2014 and 2015

The graph above shows a decrease, this year, in the percentage of moss existing in the plots studied. After cutting operations, the normal result is a decrease in the percentage of the cover trees (Figure 16).

Concerning the shelters as potential refuge for golden salamander, the comparison with the results of the last year showed an important increase in the number of stones and pieces of bark, while a decrease in the number of the deadwood. The number recorded concerning the stumps is the same as the last year.

Table 4: Total number of stones recorded in the plots for the two years

	2014	**2015**
Stones	260	323
Deadwood	1367	1271
Bark	356	534
Stumps	61	61

To better understand these changes comparisons were made analysing changes in the cut against the uncut areas.

Table 5: Comparison between habitat features in the areas where trees were cut and not

Variable	Uncut (df=32)			Cut (df=16)		
	t	**p**	**Mean diff**	**t**	**p**	**Mean diff**
Stone cover (cm2)	-1.3786	0.1776	-230.1	-2.2482	0.03901*	-156.4
Number of stones	-2.7428	0.0098**	-0.8	-0.88072	0.3915	-0.4
Regeneration (no.)	-2.7094	0.0107*	-1.3	-0.34794	0.7324	-0.2
Number of wood pieces	1.9021	0.0662	1.6	-0.13593	0.8936	-0.2
Basal area of wood peaces	0.21597	0.8304	4.1	-1.1934	0.2501	-43.3
Number of stumps	-0.373	0.7116	-0.03	0.56569	0.5795	0.06
Volume of stumps	-1.7909	0.08277	-9740	-1.3993	0.1808	-14386
Number of trees	0.59409	0.5566	0.04	1.4606	0.1635	0.1
Basal area of trees (cm2)	0.54274	0.5911	67.9	1.212	0.2431	101.8
Cover of bark	-0.64598	0.5229	-97.4	-1.7433	0.1005	-707.2
Number of bark pieces	-2.6813	0.0115*	-1.4	-2.2327	0.04021*	-2.8
Tree cover	8.352	<0.001***	5.3	6.6157	<0.001***	10.2
Moss cover	-0.0555	0.9561	-0.07	0.018709	0.9853	0.04
Litter cover	6.1313	<0.001***	7.6	5.5853	<0.001***	6.7
Deadwood cover	4.4679	<0.001***	3.3	3.1544	0.0061**	2.4
Vegetation cover	-4.9394	<0.001***	-8.8	-2.9405	0.0096**	-7.2

p<0.05*, p<0.01**, p<0.001***

Changes between years are consistent between cut and uncut areas. Changes were recorded for stone quantity, regeneration, bark pieces, tree cover, deadwood cover, litter cover and vegetation cover.

5. Discussion

The reduction of suitable habitat for a species is a major cause of biodiversity loss (Darren and al., 1998). To define the conservation status of a species is necessary to evaluate various parameters, which go to define its distribution in geographical (distribution area), ecological (habitat) and quantitative (population) terms. Among these, the habitat is the most affected negatively on the conservation status of wildlife.

Salamanders derive benefits from a forest with an intact cover, so that a humid microclimate is maintained within the forest, and the presence of numerous shelters in the ground makes the habitat more suitable for its survival (Welsh and Droege, 2001). Indeed tree cover is generally high in the studied areas and, even though it decreased compared to the previous year, cover remained high even after tree extraction. This decrease promoted the enrichment of the herbaceous layer and reduced the cover of other habitat characteristics (e.g., litter cover).

In general number of vascular species increased comparing the herbaceous layer between years. Nevertheless, the most abundant species are more or less the same. An important increase in the number of stones, deadwood and pieces of bark between first and second year was observed. Obviously, certain habitat features did not change. For example, the number of trees or stumps within the plots is similar.

The high number of pieces of wood on the ground and the important presence of bark can be seen as a positive sign for the salamander. Furthermore, similar changes were recorded when comparing habitat features over the two years separately for plots where trees were cut or left standing.

It is important to mention that some habitat features, such as stones and pieces of bark, were, to a certain degree, manipulated in particular in the first year by the biologists in order to increase the possibility of encountering the species. Furthermore, fresh branches derived from the cutting of 2015 were grouped outside the plots while other deadwood pieces were maintained in the plots. Therefore, changes of these habitat features may be linked to human activities.

The findings of the study raise several management implications two of which are worth to be highlighted here. Preliminary observational reports indicate that the *Salamandra atra aurorae* is widely present in the area. The high number of information gathered on the habitat features will help in determining which factors play an important role for the species. Similar changes have occurred where trees were cut or left uncut. This indicates that the extraction of timber following the precautionary approach applied in this project (e.g., winter operation with iced soils and with the presence of snow) may represent an

important step to understand whether exploitation influences the presence of the salamander.
The second one is increase the degree of protection of *Salamandra atra aurorae* in the areas of presence, controlling and eliminating activities damaging the species and the environment itself. Finally it is essential to expand and complete the knowledge of *Salamandra atra aurorae*, its effective distribution and favourable parameters for its survival.

6. Conclusion

In this work was presented the study of different characteristics of the habitat of *Salamandra atra aurorae,* started last year before the experimental silvicultural operations.

The sutdy sites are characterized by a high tree and deadwood cover. Some changes have occured in the study sites from last year. The total number of vascular plant species increase in the hearbaceous layer and, similarly, their total cover increased. Tree cover even it decreased compared to the previous year, cover remained high even after tree extraction.

Changes were recorded for stone quantity, regeneration, bark pieces, tree cover, deadwood cover, litter cover and vegetation cover. Nevertheless, some increased while other decreased, but this trend was consistent among areas were trees were cut or left uncut. For example, bark pieces were significantly more frequent this year and this habitat feature is thought to be a shelter for the *Salamandra atra aurorae*.

This study represents only one step of the large project on the habitat and management of the forest where *Salamandra atra aurorae* lives. Further analysis is needed to better understand the relationship of this subspecies with the habitat features and with the experimental silvicultural operation that has been carried out.

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Annexes

Survey spread sheet

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DATA

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