Czech University of Life Sciences Prague

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Bachelor Thesis

Small-scale regeneration of sessile oak stands in the conditions of multifunctional forestry

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BACHELOR THESIS ASSIGNMENT

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Forestry

Thesis title

Small-scale regeneration of sessile oak stands in the conditions of multifunctional forestry

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Objectives of thesis

The aim of the bachelor thesis is to analyze small scale regeneration systems of sessile oak. Based on the literature review and after suggestions of local experts experimental plots in selected forest stands with increased non-production functions of sessile oak will be established. Quantity and quality of natural regeneration with respect to micro-site conditions will be analyzed.

Methodology

- literature review
- selection of research localities
- establishment of experimental plots and data collection
- data analysis
- formulation of main conclusions and recommendations

The proposed extent of the thesis

40 pages

Keywords

sessile oak, non-production function, gap regeneration, woody plant quality

Recommended information sources

Březina I., Dobrovolný L. 2011. Natural regeneration of sessile oak under different light conditions. Journal of Forest Science 57(8): 359-368.

Götmark F. 2009. Experiments for alternative management of forest reserves: effects of partial cutting on stem growth and mortality of large oaks. Canadian Journal of Forest Research 39:1322-1330.

Poleno Z., Vacek, S. et al. 2009. Pěstování lesů III. – Praktické postupy pěstování lesů. Kostelec nad Černými lesy, Lesnická práce. 1012 p.

Schütz J.P. 1999. Close-to-nature silviculture: is this concept compatible with species diversity? Forestry 72: 359-366.

Schütz J.P. 2002. Silvicultural tools to develop irregular and diverse forest structures. Forestry 75: 329-337.

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Declaration

I declare that I have worked on my bachelor thesis titled **“Small-scale regeneration of sessile oak stands in the conditions of multifunctional forestry** " by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 19/4/2018

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Small-scale regeneration of sessile oak stands in the conditions of multifunctional forestry

Abstract

Sessile Oak (*Quercus petraea*) it is one of the species with economic and ecological importance, due to its good quality of wood and its share in the biodiversity of Czech forests. The natural proportion of oak in the Czech Republic is estimated to be about 19% of the forest area. The natural regeneration of sessile oak has been studied and it is still in the process of understanding since natural regeneration is very rare, especially in Czech Republic. Kunratický Forest is a recreational forest with an approach of uneven age forest, it is one of the forests with more frequent visits given its location and the biodiversity it presents. The forest soils present great ecological requirements for the seedlings of Sessile oak. The study was taken on the autumn 2017. The study presents 3 Research plot with different features. It was possible to obtain density of each research plot and specie composition. Other aspect was taken too as height structure, quality of regeneration, the effect of the game in the regeneration density and for last the microsite heterogenic. As result obtained there is many abiotic and biotic factors that make the survive of the seedlings of Sessile oak hard. The availability of the light inside of the gap play a important roll for the growing and quality of the stands and future mature tree.

Keywords: sessile oak, non-production function, gap regeneration, woody plant quality, silviculture, forestry, natural regeneration, ecology, multifunctional forest, site requirement.

Table of content

1. **Introduction**

Forest is one of the principal components of our natural environment with a influence on the environment of the human population. Empirical knowledge and science results and research unquestionably prove the necessity of live-giving natural effects of forest, the effects surviving for society purposes as secondary „on-producing functions“.

Regeneration of Forest is one of the main topics of Forestry, is the renewal of a forest crop by some mean or way (natural or artificial). Our goal is to understand how occur the regeneration of *Quercus petraea* or in English Sessile Oak, the effects of external factors and the effect of the human being in the conditions of multifunctional forests.

Oak is the second most economically important broadleaved specie in the Czech Republic. The Czech Republic is cover with 2 668 392 hectares of woodland, the total area of forestland in the Czech Republic has been constantly increasing. This is partly thanks to afforestation of new land, which exceeds the extent of transformation of forest land for other purposes, and partly thanks to the improvements as to the precision of data from the Land Register. In 2015, the forestland area increased in year-on year terms by 2 016.

The obtained results will help to understand the regeneration and how to improve it, counting on the features of the multi-functional, that means the coexistence of *Quercus petraea* with other species and the fight for light availability, space, animals, pests etc.

2. Literature review

2.1 Sessile Oak in the central Europe and Czech Republic

Sessile Oak has been known for difference names, Cornish Oak, Dumas Oak. With a huge influence in the life of the humans, from the first settlements having an economical and cultural important in the life of the Czech Republic and Europe.

Quercus spp. Grow in a wide range of site, the human activities for centuries affect the reproduction and survival of the specie.

Have a great ecological interest– known for their importance as habitat and food source for a great variety of insects, mammals, birds, fungi, lichens, and moss species (Bohn 2004).

Oak is the second most economically important broadleaved species in forest management in the Czech Republic (MZe ČR, 2012). The natural proportion of oak in the Czech Republic is estimated to be about 19% of the forest area, with a total stand area consisting of 96% high forest, 1.9% coppice-with-standards and 0.7% low forests (i.e., stands of generative origin with a longer rotation period).

The natural regeneration of oaks is relatively rare in the Czech Republic, due to the difficulty of the soils that have become muddy and because our oak trees are not usually produce many seed in such quantity.

Oaks (*Quercus spp.)* species appear in the early Holocene period, these spread on forest, happened in the response of climate warning .In the Atlantic period between ca 8000–4500 cal. yr. BP was a great moment of expansion of the *Quercus* species in the Czech Republic.

The natural regeneration of oaks is relatively rare in the territory of the Czech Republic, justifying its difficulty on heavily embedded soils and also because oaks are usually not kept in such quantity to ensure a natural restoration. However, this situation is not a problem for the Czech Republic alone. It shows that during the monitored 83 years, there was a rich flowering in Germany at the age of 36. However, the fruit matured only in the middle of the seed years (in 18 years).

2.2 Ecological requirement for oak stands

Sessile oak have a wide ecological niche: it is indifferent to the origin of the soil and tolerates profiles with pH between 3.5 and 9 and conditions from xeric to moist. The best forests they are found in calcareous soils, although they perfectly support siliceous soils, even in some cases, quite dry. You can live on stony, even rocky terrain if there are abundant rains, but prefers loose and well aired soils, so it is not finding comfortable in clay soils. It does not abound in the bottoms of valleys and ravines, with richer soils, where it is not able to compete with other species. This species it is common on mountain slopes and inland valleys, and may exceed 1,500 m altitude and even reach the upper limit of the forest (Fernandez, 2014).

2.2.1 Site requirements

The oak forests were classified as: Central European acidophilus oak forests (*Calamagrostio arundinaceae–Quercetum*) .Oaks have this wide capacity of growing can be found in different type of soils, from siliceous substrates to lime stones soils. *Quercus petraea* is then often rather found on well-drained shallow, stony and rocky, dry soils because the species is more sensitive to high groundwater levels and stagnating wetness (Aas G, 2002; Schmull M.2000) but more tolerant to drought the specie is for sensitive to more grand water. Climatically, *Quercus robur* has wider amplitude than *Quercus petraea*. While both species are well adapted to an Atlantic, sub-Mediterranean climate with mild winters, only *Quercus robur* grows well under oceanic and continental climate conditions. Therefore, *Quercus robur* is found further to the east, north, and south than *Quercus petraea.*

2.2.2 Light requirements of Oaks

Light is having a great influence in the growth, surviving, regeneration and competition. Oaks are relatively intolerant to shade and grow slowly under heavy shade, survival rates are relatively high under moderate shading is a shade-tolerant species and the light availability is a major factor.

The completion is with the other shade-tolerant species such as beech, horn beam or lime. Quercus petraea is able to survive at only 15% of solar radiant. However, at least 20% of relative radiation is required for its sustainable growth, with an optimum relative light intensity of 20-40% and 25-50% for one-year-old and two-year-old saplings, respectively. At older age, oak is rather a heliophilous species. Light reduction results in higher height increment, larger leaf area and a higher content of chlorophyll, but also in an insufficient development of the root system, lower metabolism, lower assimilatory capacity, and generally lower growth performances (Reif, Gartner 2007).

2.2.3 Competition

The reason *Oaks* often fail to capture growing space is due to their growth habit where more photosynthetic is initially allocated to root production than to shoot growth (Lorimer, 1993; Johnson et al., 2002). It is important to understand these adaptations and how they work, this physiological adaptation allows oaks to develop large root systems and consequently enables them to persist on droughty sites and to reproof vigorously following fire, grazing, or other disturbances that kill or injure the shoot (Lorimer, 1993; Johnson et al., 2002). This same physiological adaptation also causes oaks to have a slow juvenile shoot growth rate, which is a disadvantage on high quality sites (Helms, 1998). Where fast-growing competitors can accumulate on the forest floor and/or rapidly capture growing space following crown release (Hodges and Gardiner, 1993). This strategy is effective on dry-mesic or xeric sites where moisture may be limiting and a moderate amount of light reaches the forest floor, but it is a poor strategy on mesic sites where light levels are much lower (Dickson, 1991).

Invasion is likely to impact on the resident dominant species at a variety of stages in its life cycle, including the seedling stage. Seedling survivorship is an important aspect in the gap-phase theory of woodland dynamics (Whitmore 1989) Increased competition at the seedling stage may be critical for *Quercus petraea.*

2.3 Regeneration of Oaks

Sessile oak commonly in all Europe and Central Europe, *Quercus petraea* does not occur naturally as far in the northeast as *Quercus robur*. Sessile oak trees can have a long life of 800 years. Some of the features of Sessile oak are shared with *Quercus Robur*. Sessile Oak reaches fructification at the age of 40-50 years in open stands and 70-80 years in closed stands. Fruit production in open stands occurs almost every year, while in closed stands every 4-8 years (mast years) .The mature stand production is 0.7-2.0 t acorns ha-1, a well-developed free-growing oak produces 40-100 kg acorns year-1.Mast years with production exceeding 50 acorns. (Reif, Gartner 2007).

An important element on the regeneration of *Quercus spp*. is the pollen dispersal. Pollen dispersal kernels indicate both localized dispersal (mean 70–120 m).Seed dispersal is more restricted but long-distance dispersal events have also been inferred. Vegetative propagation have an important part in the regeneration of the *Oaks family*, however, current management regimes aim to natural regeneration and plantation.

Common to both *(Quercus robur, Quercus petraea)* species is that they are rather light demanding compared to other European tree species, and are therefore considered to be only moderate shade tolerant (Röhrig.2006) .In other sources it is classified differently: *Oaks* are relatively intolerant to shade and grow slowly under heavy shade; survival rates are relatively high under moderate shading.

One problem in cultivating oaks in Central Europe and North America is that oak forests frequently fail to regenerate naturally (Crow TR.1988;Watt.1988). The Regeneration of *Quercus spp*. has been studied (LigotG.2013), nevertheless the reasons of the varying success of the natural success regeneration is still not well understood. The theoretical background for this assumption is that the regeneration performance of oak seems to be subject to a variety of variables: before germination, acorn predation seems to be of large relevance for failing oak regeneration, later competition, insect pests, water supply, fungi and browsing. Natural and Artificial disturbance are considered to stimulate the natural regeneration (Harmer .1994; Shawn MW.1968)

2.3.1 Germination period

The acorn of Sessile oak star up their germination on beginning of autumn, the immature roots or radical develops rapidly. Epicotyls (immature stems) usually do not develop until the following spring (Shawn, 1968). In a small portion of germinant, shoots may begin to develop during autumn but overwinter as short succulent stem that require additional chilling to develop further. Epicotyl Dormancy is possible to happen, is the state of the acorn do not broke or does not germinate because it is exposed to low temperatures, can occur over winters.

Acorns have to survive over winter, require protection from desiccation and predation. Acorns maintain moisture of 40%. Freezing temperatures of -7°can be fatal for acorns.
Leaf fall take an important part in Protection of the new seedling, Acorns fall in the autumn during or somewhat before leaf fall, they are protected from desiccation and freezing by the current years leaf fall.

Conditions that favor acorns germination and seedling establishment in the field include a moist, friable soil that can be easy penetrate by the developing radical. A covering of leaf litter sufficient to prevent surface soil drying and accord desiccation and freezing also creates favorable conditions (Iqbal, 1972)

We already know that this has an important role, but it can also affect growth. The Thickness of the layer of leave can interfere with the entry of the radicle into the soil. A litter of 2-3 inches create a physical barrier to the epicotyl.

The Conditions favoring germination and seedlings in the field comprehend moist, a viable soil that could be reached by the radicle, covering of leaf that protects the acorn and soil desiccation and freezing. Fundamentally after the seedlings are established vary greatly they must pass through winter season, predation and germination condition.

Oaks seed have evolved several physiological and morphological characteristics that confer droughts tolerance, including large seed that provide food reserves for a protected period during and after germination, the rapid development of a long taproot, ability of photosynthesize and conduct water through the xylem under high water stress. the amount of light provided is an important factor on the photosynthesize of the seedlings, light levels under dense forest canopies often fall below 2% of that in the open.

2.4 Regeneration strategy

It can be expressed as the mechanisms that have evolved to facilitate the natural regeneration of the same species. Not all regeneration strategies serve or function in an environment, some particular ability of regeneration can be a disadvantage elsewhere.

Reproductive Mechanisms are Seedling and Sprout. Two mechanism used by oaks, in their regeneration strategy. Regeneration tactics may differ between habitats and disturbance regime. The continue dominance of oaks is depended on the seedlings sprouts fighting for space after a disturbance in the under storey (Gotmark) Seeding tactic is revealed by the number of seedlings that become established a heavy acorn crops. A species seeding may be boost by the dispersal of the acorns by rodents and others animals.

Species losses during the regeneration mostly occur by biotic factors, more particularly, by resources competition with other tree seedlings, adult trees or neighboring vegetation. (Messaoud, Houle, 2006; Olson, Wagner, 2011). Resources competition among tree seedlings is considered as a major determinant of seedling survival and growth. There are mechanisms may lead to tree species coexistence at the stand scale during the regeneration stage. (Nelson, Wagner, 2014).

2.4.1 Spatial Segregation strategy

Seedling from different species may spatially segregate and not interfere (Raventos, 2010) between each other. In such conditions, competition occurs only among conspecific seedlings and does not lead to any species loss. Spatial segregation between trees occurs at the stand scales (Wang et al., 2010). This may result from small-scale spatial heterogeneity in environmental factors (such as light availability), seed dispersal ability, or from interactions with other plant species (Grubb, 1977; Traissac, Pascal, 2014).

Like occurs in the multi-functional forest and managed forest, controlled development in the regeneration, may also lead to spatial segregation. Because of the small size of tree seedlings, segregation at very small scales (below 1 m) may be effective to prevent competition among tree species at the seedling stage. If the species are segregated at such small scales, they will eventually compete at later stages when the trees become larger and their zones of influence increase.

2.4.2 Intraspecific and interspecific strategy

Seedlings from different species may be mixed and strongly compete for below-ground or above-ground resources, but they may coexist as long as intraspecific competition is more intense than or equal to interspecific competition (Chesson, 2000; 2.2.1.2 Wilson, 2011).When the intra and inter specific competition are the same in both sides, the coexistence is unstable and if the intraspecific competition is higher the coexistence will be stable for both sides (Wilson, 2011). During the regeneration stage the difference competitive abilities between the coexistence species, mainly determined by differences in seedling height and in height growth rates, have been observed. If large differences in seedling height growth occur among tree species in mixed regeneration patches, they may lead to rapid differentiation in stature among species and eventually to the exclusion of slow-growing specie (Vickers, 2014)

2.5 Oak silviculture and management

The term silviculture usually implies maintaining a high degree of control over natural processes (Larsen, 1998). Forest management today not only seeks a focus on timber production but also ecological management (aesthetics, wildlife, biodiversity, recreational).

Many silviculturists have been experimenting with alternative methods of regenerating oak forests. A cutting treatment similar to shelter wood has successfully been used to establish oak reproduction, mainly through sprouting, but the over story must be removed within a decade or the reproduction will not be recruited into the over story (Schlesinger et al., 1993).

Oaks require a more complicated level of pre-harvest treatment than other eastern hardwood species. For example, the need to develop and maintain a component of oak reproduction in the understory often requires understanding the interactions among overstorey density, site productivity, life histories of interacting tree species, and other factors. This knowledge then can be used to identify opportunities for influencing stand structural development, implementing treatments, and monitoring treatment effectiveness (Oliver. 1991)

2.5.1 Advantage and disadvantage of natural regeneration

Natural or Artificial regeneration have same approach, renewal of seed crops. Foresters look for the perfect way to have best quality stands.

Advantage: The biological differences between planted and naturally regenerated seedlings can influence both early and late growth. Transplanting shock is avoided in naturally established seedlings, and root distribution is better than it is in planted seedlings. Furthermore, naturally established seedlings have much longer roots in proportion to shoots than nursery seedlings of the same species, the nursery stock has more top and a proportionately smaller, more loosely anchored root (Stein, 1978). Naturally regenerated stands may serve as genetic reserves (Neale, 1985). Nursery seedlings are best planted early in the spring, when access to upper-elevation sites is often prevented by snowpack and poor road conditions. Natural regeneration avoids this problem as well as several others, including the difficulties of selecting suitable planting spots and digging holes in rocky soils.

Disadvantage: Failures of natural regeneration are common in clearcuts on hot, dry south slopes, on sites where frost is a hazard, and on sites where seed sources are inadequate (Helgerson, 1982). Artificial regeneration is the only means available. When natural regeneration fails and a site must be planted, the delay is expensive (Horton, 1985).

Artificial and natural regeneration require essentially the same conditions following establishment. Both grow best free from an overstory and both suffer from vegetative competition; thus, release is commonly necessary. The initial size advantage enjoyed by planting stock is sometimes maintained and increased in the field if the initial shoot-to-root ratios are sufficient for rapid early growth (Smith et al. 1968). Perhaps the clearest disadvantage of natural regeneration is its inability to benefit from genetic improvement programs that increase survival and growth. A commitment to natural regeneration is a commitment to forgo the benefits of planting genetically improved stock (Streeby 1977).

2.6 Main factors influencing the occurrence of seed years of oak spp. in the Czech Republic

The success of natural regeneration is conditioned by a number of biotic and abiotic factors (Van Ginkel, 2013), in particular the climatic conditions (Pérez-Ramos, 2010). Stand structure (Nopp-Mayr, 2012), seed predation (Focardi, 2000) or annual shoot browsing (Bobiec, 2011, Jensen, 2012). There are many factors that the acorns must confront for their survival.

Late frost and insect pests predominantly *Tortrix viridana* and *Thaumetopoea processionea* affect the first blossoms. Other part of the acorn are consumed by birds and squirrels and attacked by insect pests while still on the tree. Losses occurring after seed fall are even more substantial. Seeds on the ground are subjected to a complex of negative abiotic and biotic factors, mainly predation (insects, birds, mice, squirrels, and ungulates), water availability, late frost, fungal attack and diseases (Reif, Gärtner, 2007). In other part there is a positive roll, other animals that help to the dispersal of the acorns, for example jays being able to spread acorns up to several kilometers. One of the important problems for the acorns are the ungulates cause in autumn acorns represent a highly attractive food and this can be a decisive impact on the destruction on seeds and sampling production. (Kollmann, Schill 1996, Gómez 2003).

Successful natural regeneration of oak stands is suppressed by ruminant ungulates, Such as roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*), that can cause significant damage to stand regeneration by retarding tree growth or preventing seed emerge (Kuiters, 1996, Bokdam, Gleichman 2000).

2.6 Research locality and its characteristics

2.6.1. Historical development

The place where we took our data is in Kunratický forest, colloquially called Kunraťák (the north-western part is called Michelský les and is also known as Krčský les or Krčák) is a wooded contiguous area of approximately 300 hectares in the territory of the capital city of Prague, is the largest forest in the city. Located in the Kunratický Forest is isolated from other forest areas by urban development, which does not allow free migration of animal communities. Annually, the forest is visited by about 678 thousand visitors who use it for short-term relaxation easily accessible in Prague.

Almost the whole territory of the Kunratice Forest is historically connected with the person of Vaclav IV, who bought the extensive Kunratice estate in 1407. The estate was bought from the debtor of the Olbramovice family to use this space to stay in nature and hunt. From these reasons to build hunting castle here. The new castle, also called Wenzelstein, was built in 1410-1412, but in 1419 by Václav IV. He's dying in the castle. A year later the castle was conquered by the Hussites and today is only a ruin from the New Castle at Kunratice. In 20th century the territory of the Kunratický forest passed through interesting property development. In 1923, m.16 Prague bought the central part of the forest and in 1928 the capital was donated around the New Town Castle. The northern part has been owned by Charles University since 15th century in 1963 she moved to Prague. The southern part of the forest was confiscated in 1947 Korbe from Weidenheim. Interestingly, the part of the forest near Chodov was After World War II; it was afforested on the original agricultural land. Neither Kunratický the forest did not avoid so-called "spruce mania" in the 20th century. (Humlová, 2015)

2.6.2. Present status and functions

The Kunratice Forest is an "island" of greenery in the dense settlements of panel housing estates, which is why it is frequently visited. There are several marked hiking trails for pedestrians and cyclists. One of the marked trails has a forest theme. The high traffic of the forest carries with it several problems, such as vandalism and a large number of discarded rubbish. Another problem is the anniversary of the Great Kunratický Running Tournament. Each year, the number of runners involved increases, which affects local nature, especially due to the fall of plants. Of course, visitors are continuously repaired and refurbished waste bins, benches, picnic sites with a public fireplace, playgrounds and arbours (Humlová, 2015).

Despite the cultural character of the Kunratice forest here on acidic sites forests of oak woods and oak-horn groves prevail. "The socio-recreational potential of the forest is qualified, maximum possible forest ecosystems' functional capacity (value produced functions) to produce humanly under optimal ecosystem conditions social effects to meet the physical and mental needs of the person (optimization physiological processes of the organism) "(Vykot ,2003). Most prominent the tree is oak winter (*Quercus petraea*), 36%. Non-original monocultures of spruce (*Picea abies*) artificially planted at the beginning of the 20th century have 23% representation. Another coniferous tree more abundant in the stand is the pine (*Pinus sylvestris*), with a 14% incidence. We can find the valleys of the Kunratice stream chick pea and alfalfa, in which alluvial sap (*Alnus glutinosa*), Ash (*Fraxinus excelsior*), Willow (*Salix spp.*), Poplar (*Populus spp.*). The surrounding 17 streams of the brook grow in common hornbeam (*Carpinus betulus*) and other rare communities. Between coniferous species can also find smaller quantities of non-native trees such as larch European (*Larix decidua*) and Douglas (*Pseudotsuga*). Forest diversity is supplemented by representatives of shrubs. In the Kunratice Forest there are especially raccoons (*Padus avium*), Common Hazel (*Corylus avellana*), Common Hawthorn (*Crataegus leavigata*) and Blood (Cornus sanguinea). Interesting examples are the specimens of the giant sequoias (*Sequoia dendron giganteum)* growing in a former Kunratice forest nursery. Real rarity is the dawn redwood (*Metasequoia glyptostroboides*). With the Kunratický Forest, the Michel Forest is a whole, which is connected to the north and spreads over Michle and Chodov. On its territory formerly was the restaurant Hájovna (Humlová, 2015)

All forests owned by the capital city of Prague are manage by Forest Stewardship Council of Czech Republic, Prague has been the holder of an international forest ecological Forest Stewardship Council. Forest management certificate, makes forest management a natural attraction for forests close to nature, taking into account the significant non-production mission of Prague forests. As part of FSC certification, so-called reference areas have also been defined which territories that have been excluded from intensive forestry use. Parts of reference areas whose species composition and structure are similar to the supposed natural state are in the non-interventional regime (except for insect pest control measures and forest fire safety interventions). In these stands it is possible to encounter, for example, dead trees (marked with blue colour on the trunk), which are left to natural decays and do not remove the forest, etc. (Humlová, 2015).

2.6.3 Fauna of Kunratický Forest

Is common Found different species of mammals like mouflons, roe deer, rodents, forest badger. Also birds like jays, straw balls and bricks. A major problem is the free-running dogs that prevent the nesting of some bird species nestling on the ground or just below it in the Kunratický Creek area. In the Kunratice Forest we can see the mouflon as the only forest in Prague.

European Mouflon is considered native through long establishment in the Mediterranean islands of Corsica, Cyprus, and Sardinia. The absence of fossils in Corsica, Sardinia and the Italian peninsula points toward an origin of mouflon in the Mediterranean due to human action (Pedrotti, 2001), European Mouflon prefers open or half-open areas, with a lot of sunshine and a residual quantity of snow. They poorly tolerate long period of snow (due to limited length of legs), it could cause important migration, they occur in hilly and forest regions, if rocky and steep zones are present (Tosi, Lovari, 1997). It has features more runner from climber. This species prefers large space with south, south-east, and south-west exposition, altering with woods and rock (Cicognani, 2002)

Mouflons were planted in Bohemia in the second half of the 19th century. In the 1960s it was planted directly in Kunratice. Mouflons live in groups and enjoy extreme slopes with stunning rocks. Their features are the developed horns that males use in battles. In the Kunratice Forest, however, mouflons cause problems - they decimate all herbs and decaying trees.

Due to the proximity of the urban area, the flora is greatly damaged either by the high degree of air pollution or by the direct pressure of an ever-expanding development, extremely high attendance, often associated with vandalism, soil mudslinging, damage to young parts of plants or the degradation of subsoil (predominantly mouflon) .

Is common to find *Carabus coriaceous*, 44 species of beetles for example *Magdalis barbicornis*, also is possible to observe butterflies *Synanthedon conopiformis, Opostega salaciella*, etc. Spiders living in the forest *Eresus kollari, Eresus moravicus.*

Species of molluscs, several species of gastropods are observed here, such as the *Acanthinula aculeate* and in the zone of the creek is common to find *Clausilia pumila*.

3. Materials and Methods

3.1 Research locality and its characteristics

The research was done in forest stand 149A12 (Fig. 1), age class VIII, forest site type 2K5. Prevailing soil type are Cambisols. Forest stands in the area are declared as special-purpose forests with increased recreational function are serve as perfect example of multifunctional forestry.

Despite the cultural character of the Kunratice forest here on acidic sites forests of oak woods and oak-horn groves prevail (Humlová, 2015)

Forest type presents in the site Beech-Oak in an acidophilus soil (Fig 2.). Soil - shallow to medium deep, + gravel, drying, type (B) o - forest types -metallic, with shiny, bionic, fescue shaded, slightly glabrous with furry hair. Beech-Oak forest is often found between 350 to 400 m over the sea level, with a temperature from 0º to 8º Celsius.

Soils with predominant bra unification process (browning). During oxidative weathering of primary minerals, which (Fe_2O_3, Al_2O_3), clay minerals are formed, and clay minerals are formed. Enriches clay soil at the site of its origin. The horizon turns brown with hydrolysis released amorphous iron oxides and hydroxides and iron rich complexes which are diffusely dispersed over the surface particles and soil element .Annual rainfall 600 to 60 mm. weak aluminium overlap, with cane reed, degraded - blueberry (often secondary); on sunny slope. (Voukon, 1990)

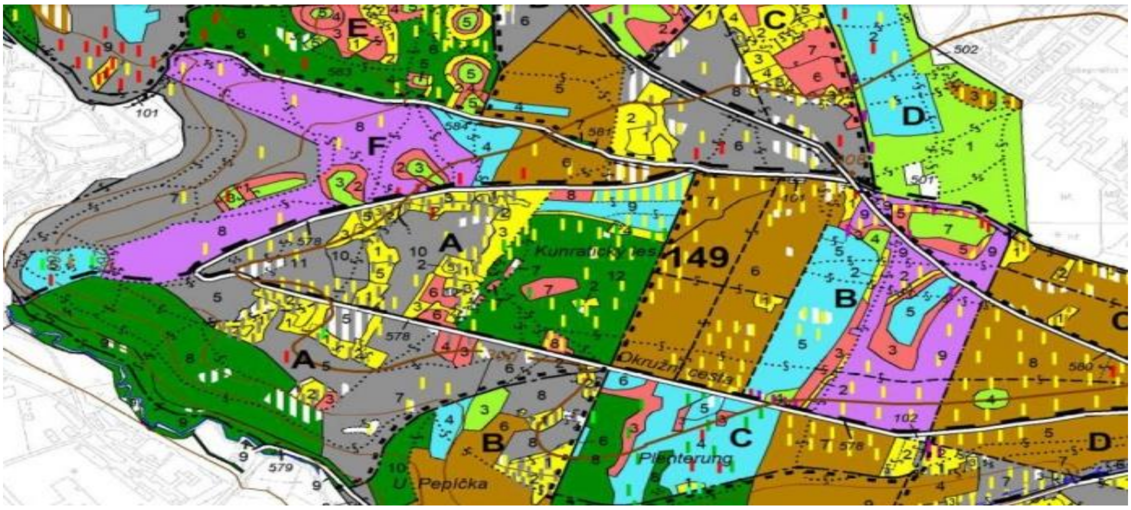


Fig 1. Map of forest stand in Kunratický Forest.

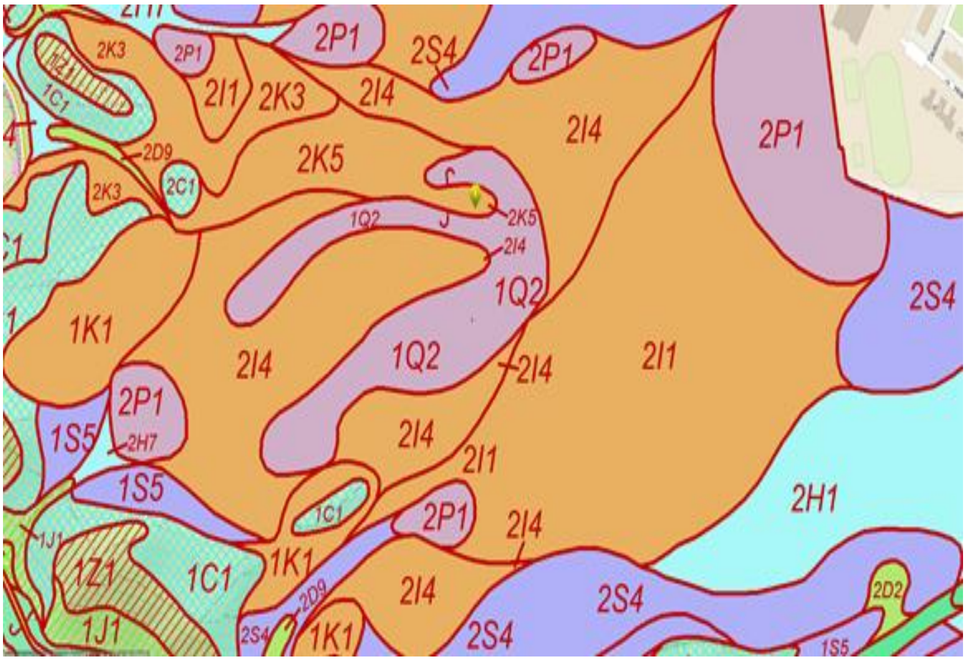


Fig 2. Soil composition on Kunratický Forest.

3.2. Data collection

The data have been taken during the autumn of 2017. The site presents three research plot (RP) that are identified by small gap, big gap and canopy gap. Each is divided in 2 transections; each transection that crosses the RP has a distance of 30 meters in which we measured it from South to North, West to East. **Small gap** number have an early stage of regeneration ; The **Big gap** present old growth stands with a height from 1 to 3 meters (Fig.3) and the **Canopy** present sampling under a shade environment (Fig.4). With a tape measure it was measured the 30 meters long; every 5 meter was measured a subplot of 1 m². In each subplot was taken the measurements of 3 samples. The measures that were taken were the diameter of the lower part of the stem or root collar near soil surface, second in consideration was the height of the seedling. Other features that were taken were quality of the stands, divided in 3 categories: Q1: Straight individual, Q2: some deformation of the stand, Q3: plagiotropic – full growth deformation; and for last browsing effect of the game in the seedlings.

Fig 3. Big gap, seedlings under the mother tree.

Fig 4. Canopy gap.

3.3. Data evaluation

With the data collected from the site, characteristics from each RP were taken. The results it is expected to respond some aspects of natural regeneration on a small scale and how the characteristics of a multifunctional forest influence. With the use Microsoft Excel created the graphs and tables. All the information was set to define the questions related to the work.

Table 1. Basic characteristics of research plot (RP)

Research plot	ID	Size (m²)	Number of subplots
Small gap	1	310	13
Big gap	2	615	13
Canopy	3	no data	13

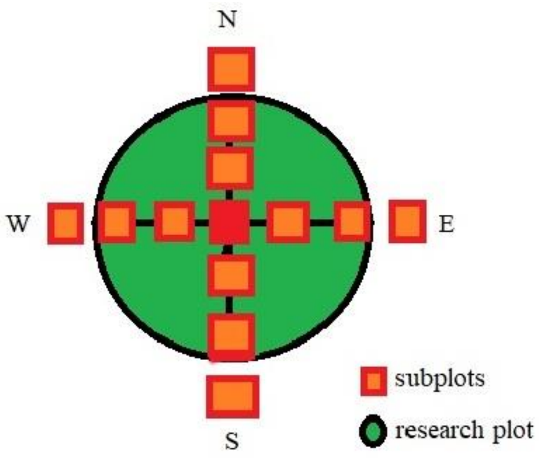
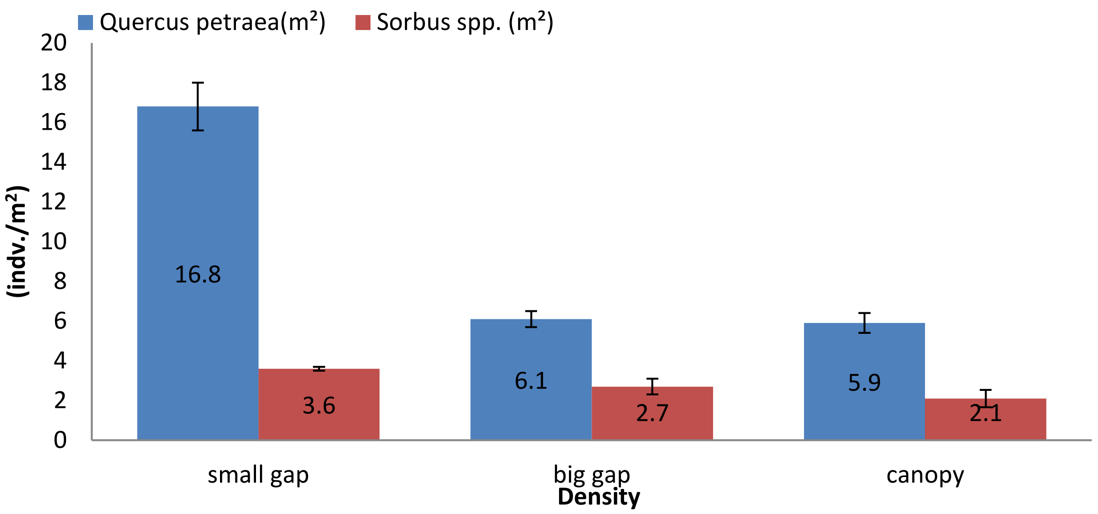


Figure 5. Basic design of the experiment, position of transects and subplots representing different positions within the gaps.

4. Results

4.1 Regeneration density and tree species composition

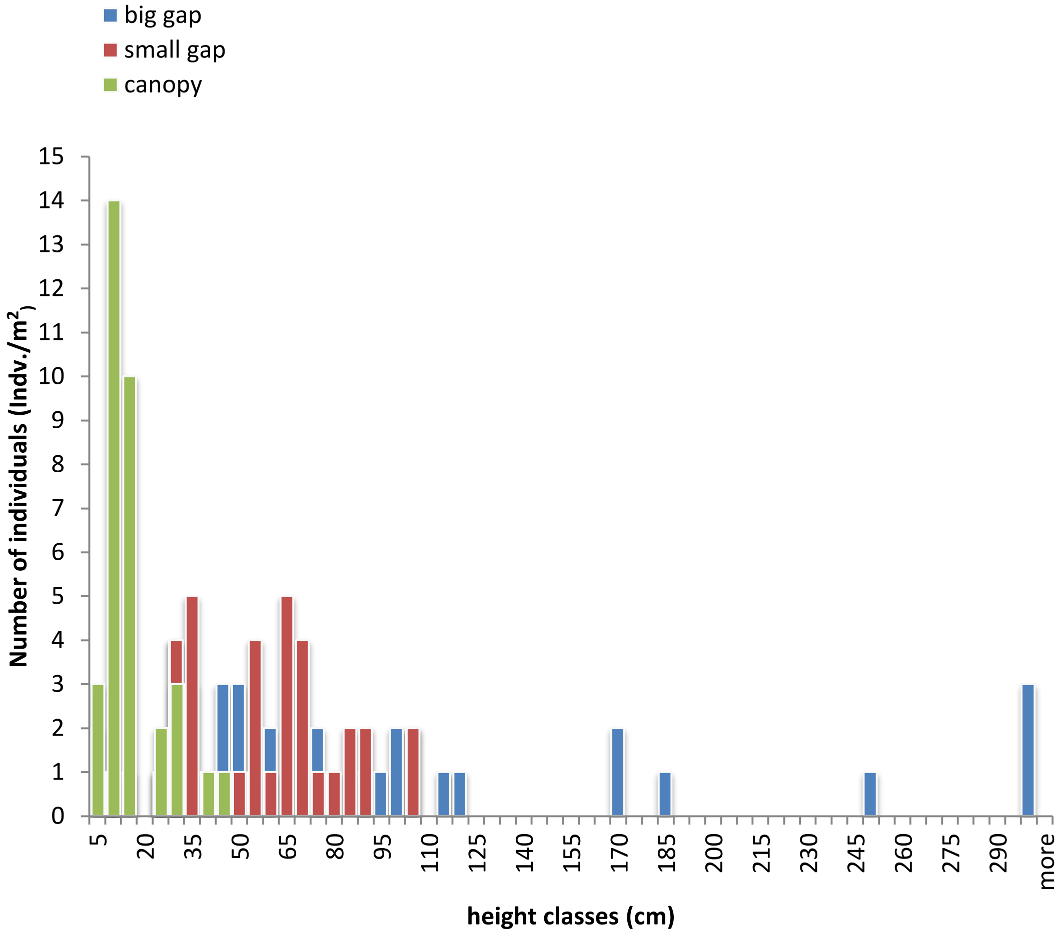
Regeneration density from each RP and the tree species composition majority was between *Quercus petraea* and *Sorbus spp.* Special part of the research and main purpose in the approach of a natural forest management.



Graph 1. Comparison of number of individual and regeneration density from each Research plot (RP).

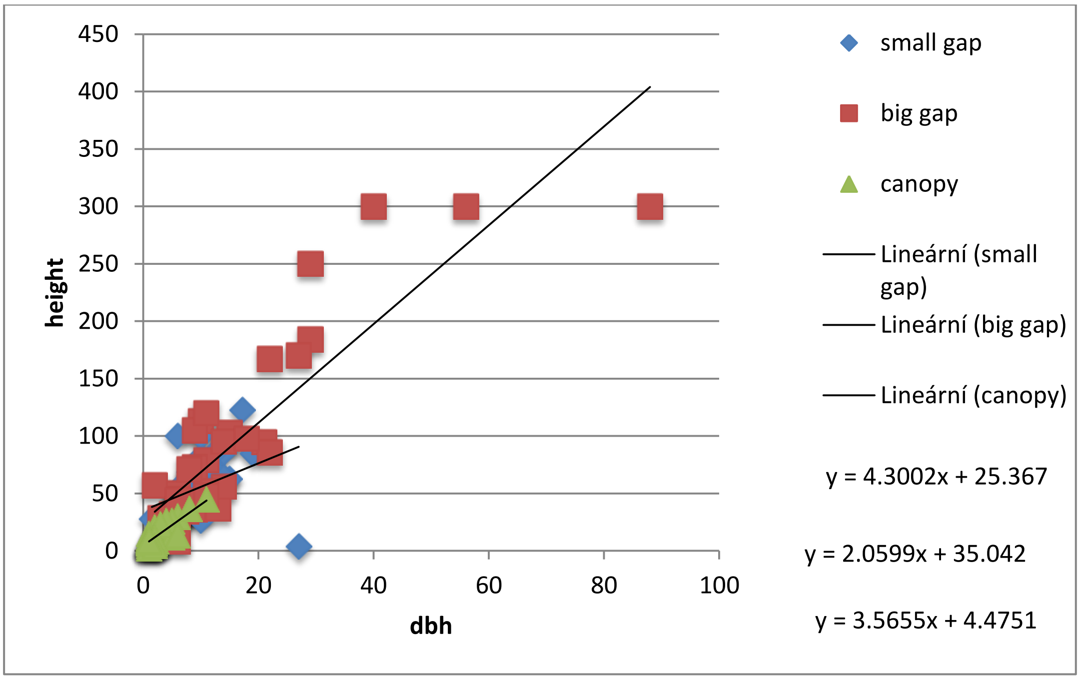
4.2 Height structure and quality of natural regeneration

The height and diameter, characteristics of the seedlings that take importance for the growth and the competitiveness for the space ground; this features influence on the quality of the stem during the growth stage.



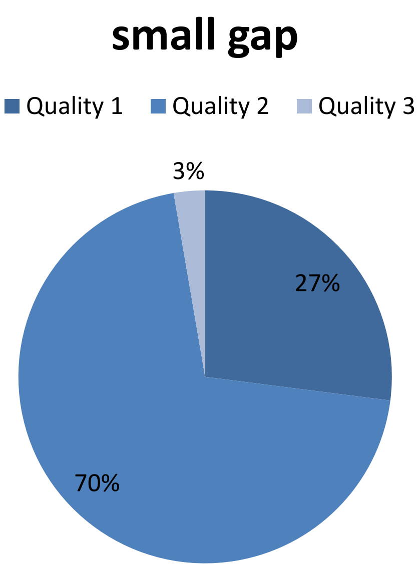
Graph 2. Height classes structure from each Research Plot (RP) showing the difference and spatial distribution.

Spatial distribution of the height for each RP. Showing from the canopy on the bottom with the lower height, continue the other research plot showing the continuity of the growing and the difference of size.

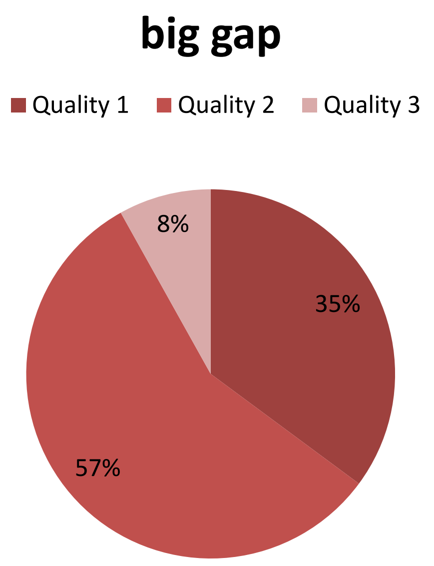


Graph 3. Height curves for oak on particular research plots (RP).

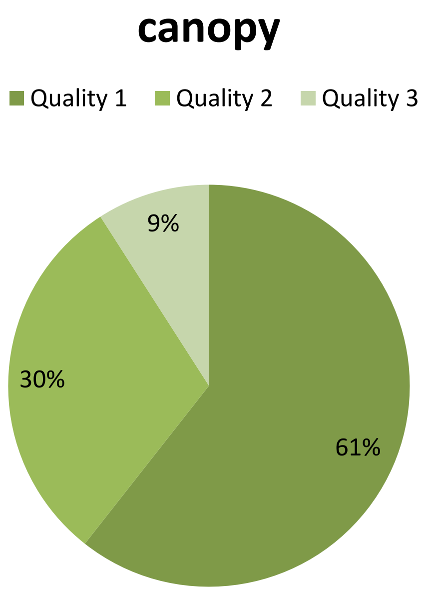
Aspect to take is the effect of the quality of the stem on the development of the seedlings, presented in percent. Each of the RP have a different growth stage therefore each RP show unequal value.



Graph 4. Percentage of quality of the stem in the small gap.



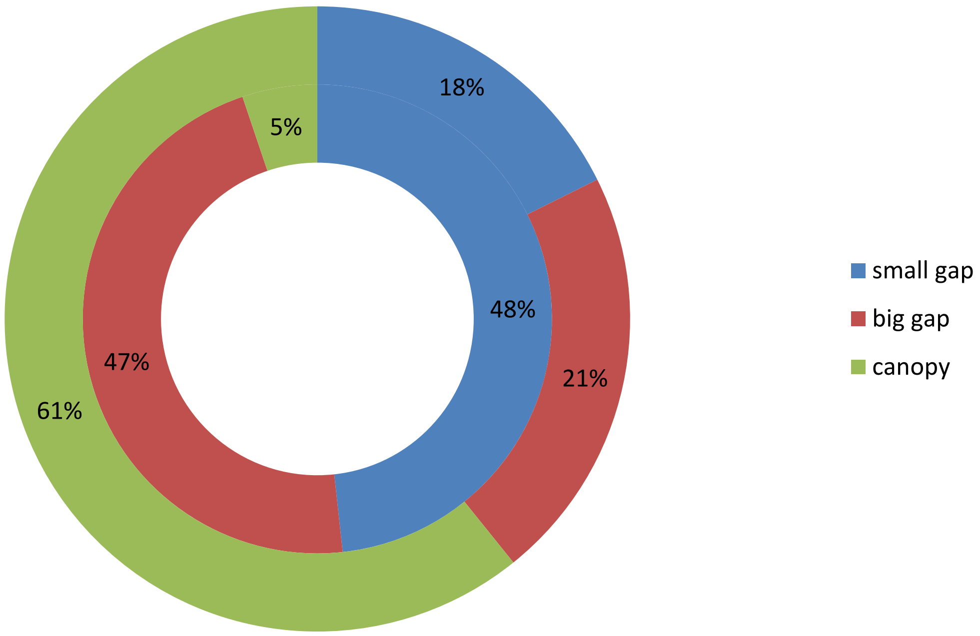
Graph 5. Research Plot(RP) Big Gap showing percentage of quality stand.



Graph 6. Percentage of quality on the research plot (RP) Canopy.

4.3 Game damage

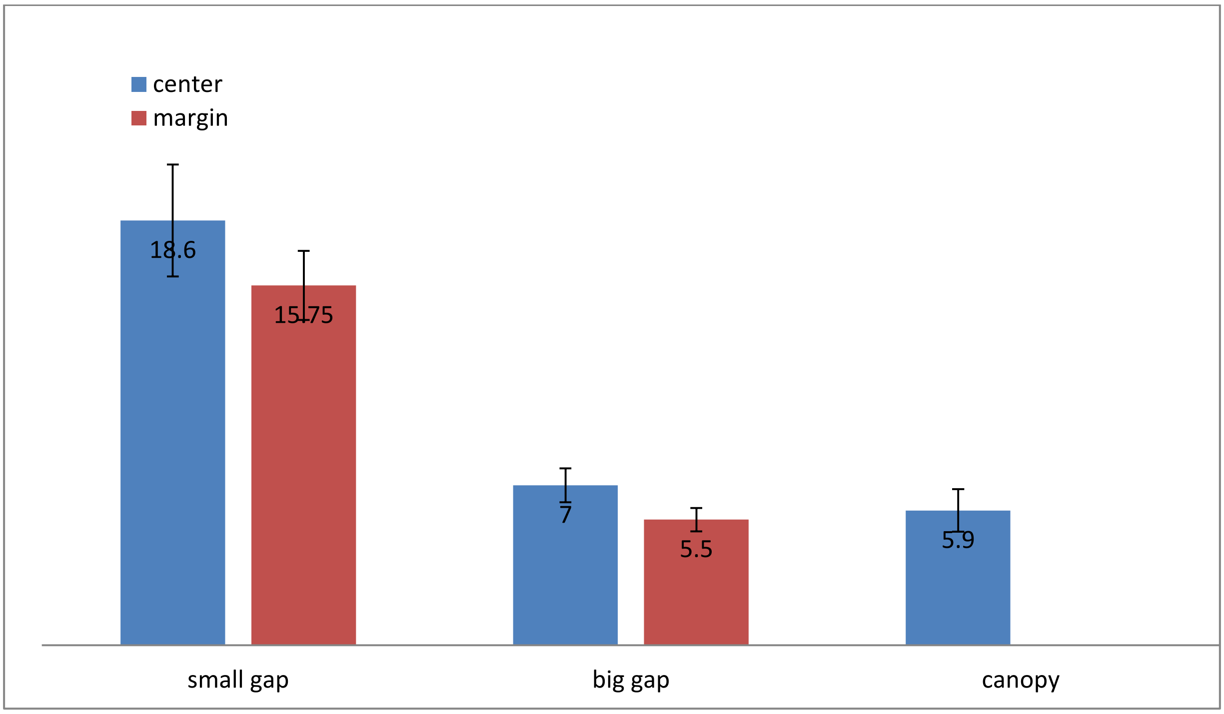
As part of the collected data, the browsing effect on seedlings and samplings is one of the most important aspects of the study, since this is one of the most common problems in natural regeneration and its effect on the mortality and quality of the population from the gap. Every RP present a different percent of browsing.



Graph 7. Game damage on percent for every Research plot (RP). Inner circle shows the percentage of positive browsing (yes browsing), the outsider circle shows the negative browsing effect (no browsing).

4.4 Microsites heterogeneity

As one of the aspect of Sessile oak seedlings as light demanding specie. Since the availability of light in the gap concentrates more towards the centre, the density of the Research Plot have a distribution and this where the heterogeneity take part.



Graph 8. Show the difference between the central density regeneration and margin density of each Research plot (RP).

5. Discussion

As the obtained result reveals that Small gap show a major quantitative regeneration density that is the major part with more density regeneration, showing us the first stages of growth of the seedlings. It worth mention the tree composition, *Quercus petraea* presented a 16.8 (indiv/m^2), *Sorbus spp*. 3.6 (indiv. /m^2), Big gap presents *Sorbus spp.* density 2.7 (indiv. /m^2) and *Quercus petraea* 6.1 (indiv./m^2) . Canopy presents *Quercus petraea* 5.9 (indiv. /m^2) and Sorbus spp. 2.1 (indiv./m^2) Quercus petraea is the dominant specie on the research area.

Sessile oak seedlings have been shown to have a preference for light levels higher than 15–20% of full sunlight, meaning that gaps of at least 17–20 m diameter or beneath a broken to open canopy are suitable regeneration sites (Lüpke, 1998). Small gap and big gap presented the suitable diameter size for the natural regeneration. The different in density between the small gap and big gap it's because the competition of forest floor vegetation and mortality. Seedling survival is affected also by other factors, mainly light conditions, intraspecific competition and competition of other low plants (Jonášová, 2004).

The size of the gaps is a important aspect on the result of the density. The highest density and frequency of small oak seedlings were found in gaps of 100 – 150 (9094 ha − 1) and 51 – 300 m^2 (13 392 ha − 1) (Dobrowolska, 2006), this prove why the research plot small gap present a better regeneration density. Vitality of oak regeneration was lower under the tree canopy than in gaps (Dobrowolska, 2006).Density in Canopy was lower than the others Research plot. Small gap present a central density of 18.6 (indiv. / m^2) means that the centre of the small gap have individual per hectare 18.60000. Minimum accepted on the Czech Republic 13 00000 individuals per hectare (Příloha č. 7,2004). Research gap presents a greater density value than the minimum accepted.

The results for height structure show the different in height between each Research plot. Small gap shown the height class with a minimum of 4 cm and maximum of 123 cm. Meanwhile the big gap showed a minimum 8 cm and maximum of 300 cm. The Research plot Canopy gap shown a height minimum 2.5 cm and a maximum 45 cm. Light demanding species would thus allocate preferentially resources to height growth and hence risk dying from light starvation (messier, 1999). Large-area and small-area (suitable particularly in larger tracts of oak stand where there is an interest in achieving various age structures) shelterwood felling (Röhrig, 2006)

The Average dbh for the small gap is 9.5 mm with a max. 27 mm and min. 1.5mm. For the big gap average 15.3 mm and with a max. 88 mm and min. 2 mm and the canopy gap showed an average of 2.5 mm with a max 11 and min 1 mm.

Small gap shows that seedlings presented 70% in Quality 2 with a 48% of positive browsing. This mean that the game commonly visit the site , with a preference on the small gap.Young oaks seem to be preferred and heavily browsed by deer in many areas, influencing stand development (Peterken, 1965). The Big gap presents a 57% quality 2 and 35% quality 1. Also the big gap shows 47% of browsing 1% less.

Leaves of broadleaves may be mainly eaten in young forest 21-/48% of the leaves of small trees were eaten, and the proportion increased over the summer (Selas, 1999). As the result of the RP, small gap presented a 28% browsing damage, big gap had a 27%; 1% percent less. Control measures on ungulate population could also be adopted (Ligot, 2013)

The obtained result from the central density and margin density from research plots , prove that gaps are generally very small and the periods with transmitted direct radiations are very short (Chazdon, 1991). The availability of light under the canopy shade make the density is lower, but make that the stem of the seedling have a quality 1 or perfect stem.The lack of oak saplings under the stand canopy is most probably the result of unfavourable light conditions (Ljapova, 1982). Oak stumps under open canopy (shelterwood management system) regenerated better than those in clear-cut areas (Polanský, 1956). Moreover the research plots shown that density on them are greater.

6. Conclusion

Kunratický forests, a place with the intention of supplying the needs of the population of the surrounding areas and with the need to maintain the park's biodiversity. A multifunctional forest with a huge history of changes. The forest presents the favorable conditions for the growth of the seedlings,

For the Silvicultural aspect focused in the production of the forest, the creation of gap and crown reduction, making like this the light available and more favorable for the oak seedlings.

After the results and discussion, there are still features that have not been taken into account. Is not easy to reach a certain decision, but it is clear that the gap with shelter wood method, As mention in the result the size of the gap take a significant role on the process of regeneration. Taking into account that the interactions of the shade provide by the border gap and mother tree of the major trees influences growth and quality of the seedlings.

At the end the approach of the park is a natural old forest. As I said above on the future the other characteristics must be taken and to know which the method is that would work best in the Kunratický Park. he study has not yet been completed yet there is much more to see.

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8. Appendices

Table 1. Data collected from the Small gap. Showing quality of the stand, Browsing damage, dbh at collar root and height of the stand.

Small gap													
		sample 1				Sample 2				sample 3			
Subplots	number of individuals	D(mm)	H(cm)	Q	B	D(mm)	H(cm)	Q	B	D(mm)	H(cm)	Q	B
Plot 1	14	10	35	2	no	10	27	3	yes	5	24	1	yes
Plot 2	2	2	13	1	no	2	6	1	no				
Plot 3	14	10	100.5	2	yes	8	69	2	yes	7	59.5	2	no
Plot 4	27	19	85	2	yes	12	71	2	no	13	89	2	yes
Plot 5	31	14	62.7	2	yes	14	64	2	yes	5	31	1	no
Plot 6	15	12	76.5	1	yes	14	86	2	yes	9	51	1	yes
Plot 7	19	6	1.28	2	yes	27	4	1	yes	7	52	2	yes
Plot 8	16	7	47	2	no	6	31.4	1	yes	4.5	28	2	yes
Plot 9	29	17.2	123	2	yes	10	82.3	2	yes	8	65	2	no
Plot 10	11	11	67	2	yes	11	66	2	yes	1.5	28	1	no
Plot 11	10	11	68.3	2	yes	15	63	2	yes	7	50.4	2	yes
Plot 12	12	10	62.2	2	yes	13	52	2	yes	6.5	28	2	no
Plot 13	19	8	48	1	yes	5	33	2	yes	6	31.7	1	yes

Table 2. Data collected from the big gap,

Big gap													
		sample 1				Sample 2				sample 3			
Subplots	Number of individuals	D(mm)	H(cm)	Q	B	D(mm)	H(cm)	Q	B	D(mm)	H(cm)	Q	B
Plot 1	5	9	105	2	yes	14	95.3	2	yes	4	22.4	2	no
Plot 2	4	7	43.6	1	no	11	48	2	yes	6	45	2	yes
Plot 3	4	56	300	2	no	88	300	2	no	2	57	3	yes
Plot 4	5	22	167	1	no	27	170	2	yes	6	44	2	yes
Plot 5	11	22	85.6	2	yes	8	71	1	yes	18	97.6	1	yes
Plot 6	5	29	250	1	no	40	300	1	no	11	120	1	yes
Plot 7	2	5	26.7	1	no	3	28.4	1	no				
Plot 8	11	9	36	2	yes	7.5	34.4	2	no	6	33	2	yes
Plot 9	6	15	103	1	yes	11	79	2	yes	10	112.9	2	yes
Plot 10	6	29	184	2	yes	13	37	3	yes	6	50	2	yes
Plot 11	9	21	94.6	3	yes	14	56	1	yes	11	52	2	yes
Plot 12	6	11	50	2	yes	5	32	2	yes	9	73	3	yes
Plot 13	5	6	28	1	yes	6	8	1	yes	5	29.3	2	no

Table 3. The data collected from the Canopy .

Canopy gap													
subplots	number of individuals	D(mm)	H(cm)	Q	B	D(mm)	H(cm)	Q	B	D(mm)	H(cm)	Q	B
Plot 1	9	3	23	2	no	1	11.6	1	no	6	14	2	no
Plot 2	8	1	10.6	1	no	1	8	1	no	2	11	1	no
Plot 3	3	1	9.5	2	no	1	8.4	3	no	2	4.8	1	no
Plot 4	5	1	7	1	no	1	7	1	no	1	7.6	2	no
Plot 5	0												
Plot 6	1	1	2.5	2	no								
Plot 7	5	2	6.9	1	no	2	8.8	1	no	1	9	1	no
Plot 8	11	2	15	1	no	2	20.8	2	no	1	9.5	1	no
Plot 9	3	1	6.8	2	no	2	10.3	1	no	1	15	1	no
Plot 10	8	1	4.8	1	no	2	13.4	2	no	2	11.5	2	no
Plot 11	5	2	8.7	3	no	2.2	8.3	1	yes	5	12	1	yes
Plot 12	11	6	30	2	no	11	45	3	no	5	26	1	no
Plot 13	8	8	36.7	2	yes	2	10	1	no	4	26	1	no

Figure A. Measurement of the transection inside Research Plot (RP).

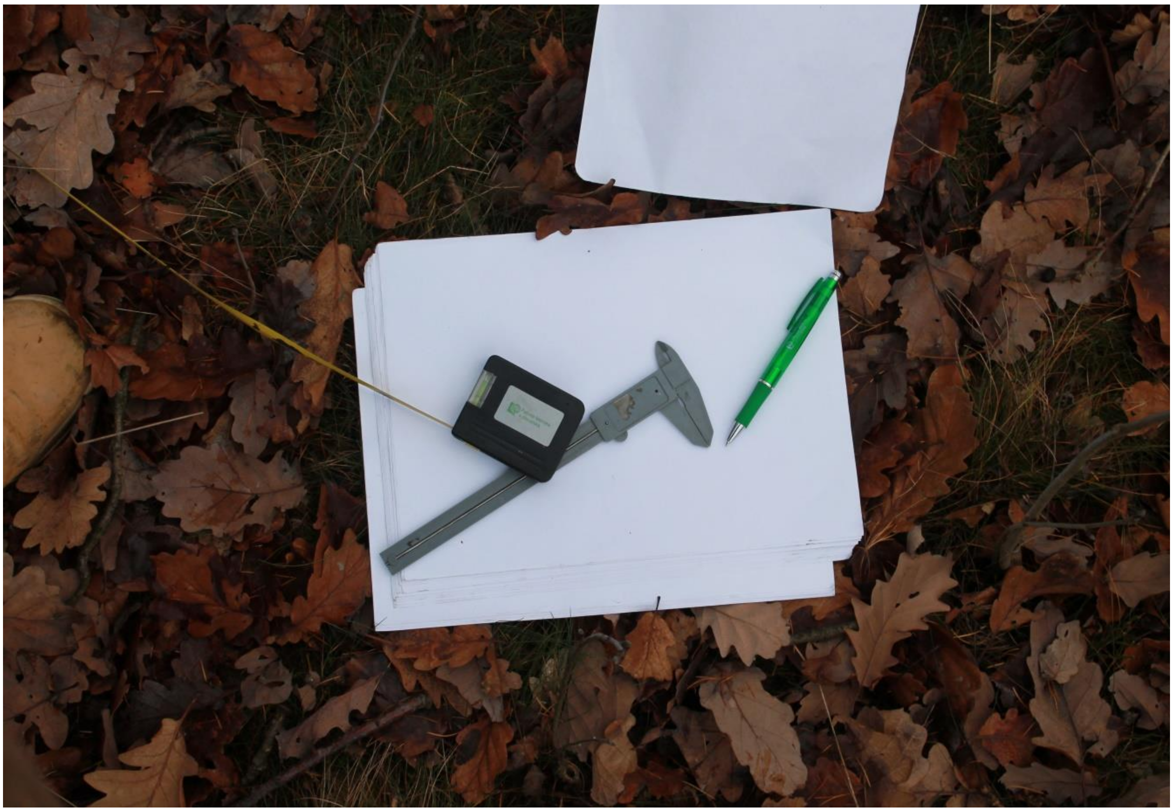

Figure B. Instruments for measure the plot