Comparison of invertebrates and lichens between young and ancient yew trees

Bachelor agro & biotechnology
Specialization Green management
3th Internship report / bachelor dissertation

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Foreword

My dissertation project and internship took place in an ancient yew woodland reserve called Kingley Vale National Nature Reserve. Kingley Vale NNR is managed by Natural England. My dissertation deals with the biodiversity in these woodlands. During my stay in England I learned many things about the different aspects of nature conservation in England.
First of all I want to thank Katherine Birch (manager of Kingley Vale NNR) for giving guidance through my dissertation project and for creating lots of interesting days during my internship. I want to thank my tutor Isabelle Joos for suggesting Kingley Vale NNR and guiding me during the year. I thank my uncle Guido Bonamie for lending me his microscope and invertebrate books and for helping me with some identifications of invertebrates. I thank Lies Vandercoilden for eliminating my spelling and grammar faults. Thanks to all the people helping with identifications of invertebrates: Guido Bonamie, Jon Webb, Matthew Shepherd, Bryan Goethals. And thanks to the people that reacted on my posts on the Facebook page: Lichens connecting people! I want to thank Catherine Slade and her husband Nigel for being the perfect hosts of my accommodation in England. For helping me to find my host I thank Bart Laleman. And of course I thank my parents for supporting me during my time in England (and throughout the year). I thank my lector Wim Peeters for lending me some books about yew trees. I thank the people that gave me some interesting trainee days during my stay in England: Mike Edwards (working with field crickets), Bob Epson (surveying dormice), Richard Williamson (guiding through a private part of West Dean Woods), and the people from the bomb disposal team. I want to thank the volunteers from the National Park that helped me installing my trapping stations. And of course I want to thank all the authors of the literature I used mentioned in the list of references.

Jonathan Clerckx
May 2015

Integrated bachelor dissertation

Title

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Abstract

This dissertation project is about biodiversity in yew woodland. The value of (ancient) yew woodland for other organisms is unknown. The project was carried out in Kingley Vale National Nature Reserve. This reserve contains an ancient and a young yew woodland. The oldest trees are older than 500 years, probably about 1000 years (but also 2000 years is a possibility). The young woodland is 100-200 years old. Thanks to the clear boundary between the ancient and the young yew woodland a comparison between the two was possible. The purpose of this dissertation is to investigate what kind of invertebrates and lichens are living in yew woodland and whether ancient woodland supports a higher biodiversity than young woodland. The invertebrates were collected at trapping stations (mainly with pitfall traps) and the lichens living on 30 different trees were examined. All kinds of identification tools were used for the examination of the invertebrates and lichens. And specialists were contacted when species could not be identified or when their identification was uncertain. The results show a larger biodiversity of lichens in the ancient woodland than in the young woodland. A comparison of the invertebrates shows some big differences in abundancy of certain species. The results of the comparison are a bit doubtful due to some differences in the environment between the young and the ancient yew woodland. The ancient woodland was situated in a valley and was mainly mixed with oak, while the young woodland was on a steep slope and mainly mixed with ash. Another reason why the results can be doubtful is the lack of previous experience in this kind of work. Nonetheless the results give an image of what species can occur in (mixed) yew woodland.

Keywords

- Yew trees
- Lichens
- Invertebrates
- Ancient woodland
- Comparison

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Technical data Placement Company

Name placement company:	**Natural England: Kingley Vale NNR**
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E-mail:	enquiries@naturalengland.org.uk
Director / Head of Service:	**Katherine Birch (Manager)**
Internship mentor:	**Katherine Birch**
Sector:	**Nature**
Division / Group within the internship:	**Area 14 (Sussex and Kent), Sussex Downs**
Number of employees:	**Kingley Vale NNR: 1**
Sales volume:	**/**
Products:	**/**
specialization:	**Reserve and protected land management**
Two relevant publications of the company:	**/**
Additional data:	**/**

1 Representation of the company

1.1 Natural England

Natural England is an advisor for the government for the natural environment. This is providing practical scientific advice on how to look after England's landscapes and wildlife. It is an executive non-departmental public body, sponsored by the Department for Environment, Food & Rural Affairs (DEFRA).
Natural England has around 2000 staff members in offices throughout England. There are about 149 offices with the headquarters in York (Natural England, 2015).

Natural England is responsible for (Natural England, 2015):

- helping land managers and farmers protect wildlife and landscapes;
- advising on the protection of the marine environment in inshore waters;
- improving public access to the coastline;
- supporting National Trails and managing 140 National Nature Reserves;
- providing planning advice and wildlife licences through the planning system;
- managing programmes that help restore or recreate wildlife habitats;
- providing evidence to help make decisions affecting the natural environment.

The NERC act (Natural Environment and Rural Communities) defines what Natural England is required to do (Natural England, 2014):

- promote nature conservation and protect biodiversity;
- conserve and enhance the landscape;
- secure the provision and improvement of facilities for the study, understanding and enjoyment of the natural environment;
- promote access to the countryside and open spaces and encourage open-air recreation;
- contribute in other ways to social and economic well-being through management of the natural environment.

In the chart below you can see how Natural England will deploy their resources on the business areas in 2014/2015. Only 8% is used for NNR management, while this is one of the most important fields of Natural England (Natural England, 2014).

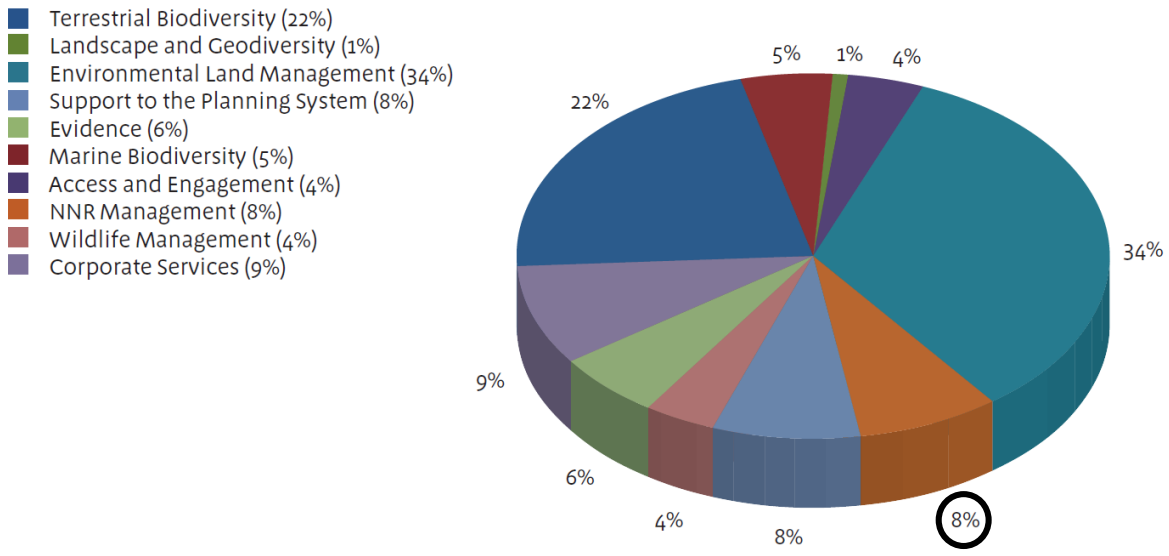


Chart 1: Resource utilised by key business areas

1.2 Kingley Vale NNR

Kingley Vale has a small office in West Stoke (nearby the reserve). In the office all the standard working materials are available. There are two vehicles (Landrover Defender 110 and Toyota Hilux), a tractor (Case McCormick 100) and an ATV Quad (Honda 500). Mowers: Wessex Flail (gentle hills, woody vegetation), Falc Flail (bigger areas, picks up cuttings), BCS Bank Commander Scythe (steep hills, cuts anthills, which is negative). Small machines: pole saw, two brushcutters, long reach hedgecutter, four hedgecutters and three chainsaws. Every machine has a HAVS tag (Hand Arm Vibration Syndrome). This indicates how long you can use the machine in question. This is based on the vibration magnitude and the noise level. Figure 1 shows the HAVS tag of a mower (BCS Bank Commander Scythe) and it says you may only work 22 minutes a day with the machine. All other machines at the reserve can be used longer, e.g. brushcutters can be used eight hours per day.

Figure 1: HAVS tag

Kingley Vale National Nature Reserve is 150 ha and consists of chalk grassland, scrub, mixed woodland (oak and ash) and ancient yew forest. Kingley Vale is owned by Natural England and the West Dean Estate[1]. Natural England has 93 ha of the reserve in freehold and 57 ha in leasehold of the West Dean Estate. Both owners have to protect and manage the reserve, but there can be differences in the managing method. Natural England shoots fallow deer females to reduce the population growth, while the Estate trophy shoots commercially, meaning that they prefer bucks with giant antlers.

For a few months in the winter sheep are placed on the reserve for grazing. There is no real danger the sheep will eat the poisonous yew branches because the fallow deer can eat the young shoots of yew. The fallow deer have a minor tolerance for the poisonous yew and they eat the young branches to a height where sheep cannot reach (about one meter high, see Figure 2). According to Eibenfreund Dr. Osthoff there is an important difference in toxicity between taxol and taxin. Taxin is hardly poisonous (in contradiction to the very poisonous taxol). Taxin is more abundant in young yew plants (Bosse, 2006). The sheep are used for grazing plants fallow deer do not eat, such as brambles. The length of the grazing season depends on the budget the office gets. Recently budgets have been cut down, so this winter only a small area was grazed by sheep. To move the sheep in the area, electric fencing is used.

Figure 2: Crown yew trees about one meter above ground level due to fallow deer

[1] Also known as Edward James Foundation

A car park is available for visitors, which is leased from a local farm. No motorized vehicles, cyclists or horses are allowed in the reserve except for managing. Appendix IV shows a map of Kingley Vale indicating the paths. Bridleways are open for cyclists, horses and pedestrians. The natural trail and footpaths can only be used by pedestrians. The area hatched red is open access area, which means you can leave the available paths there. The area owned by Natural England is open access area and the West Dean Estate area is a restricted area (only public footpaths and public bridleways can be used).

The manager, and only staff member, of the reserve is Katherine Birch. Normally every Thursday, a group of volunteers come to work in the reserve. These volunteers come from an organisation 'Phoenix Futures'. This organisation helps people with a troubled history with alcohol or drugs to recover. RTN is a part of the process to recover and stands for 'Recovery Through Nature'. There are a maximum of eight persons per group. Once a month another volunteer group comes to the reserve on a Friday. This is organized by The South Downs National Park Authority and is called the Volunteer Ranger Service (VRS). These volunteers are people that want to do something in nature. They are mostly retired people.

2 Goal

2.1 Introduction

This dissertation is about organisms living on or with yew trees in a yew woodland. Lichens and invertebrates will be examined on young and old yew trees. Little is known about the biodiversity of lichens and invertebrates on yew trees. This study was carried out in Kingley Vale National Nature Reserve. The nature reserve contains young, developing yew stands and a number of veteran yew trees. England has only a few yew woodlands marked as SACs (Special Areas of Conservation), which makes it important to protect these areas.
Figure 3 provides a map of England indicating the SAC yew woodlands.

2.2 Research issues

Yew is a conifer native to the UK. Very little is known about the organisms that live together with yew trees, so it is important to get a better knowledge of yew woodlands for a correct management. It is not known whether there is a difference in biodiversity in young and old yew woodland, so it is of ecological importance to understand the biodiversity that exists in yew woodlands. If (old) yew woodland appears to contribute to biodiversity, these habitats can be stimulated to expand.

2.3 Research questions

Do older yew woodlands offer an added value to the biodiversity of invertebrates and lichens in comparison to younger yew woodlands? What species of invertebrates and lichens live on/with yew trees? Is there a difference in species (biodiversity) of invertebrates and lichens that live on/with young yew trees as compared to veteran/ancient yew trees? If so, what exactly is the difference?

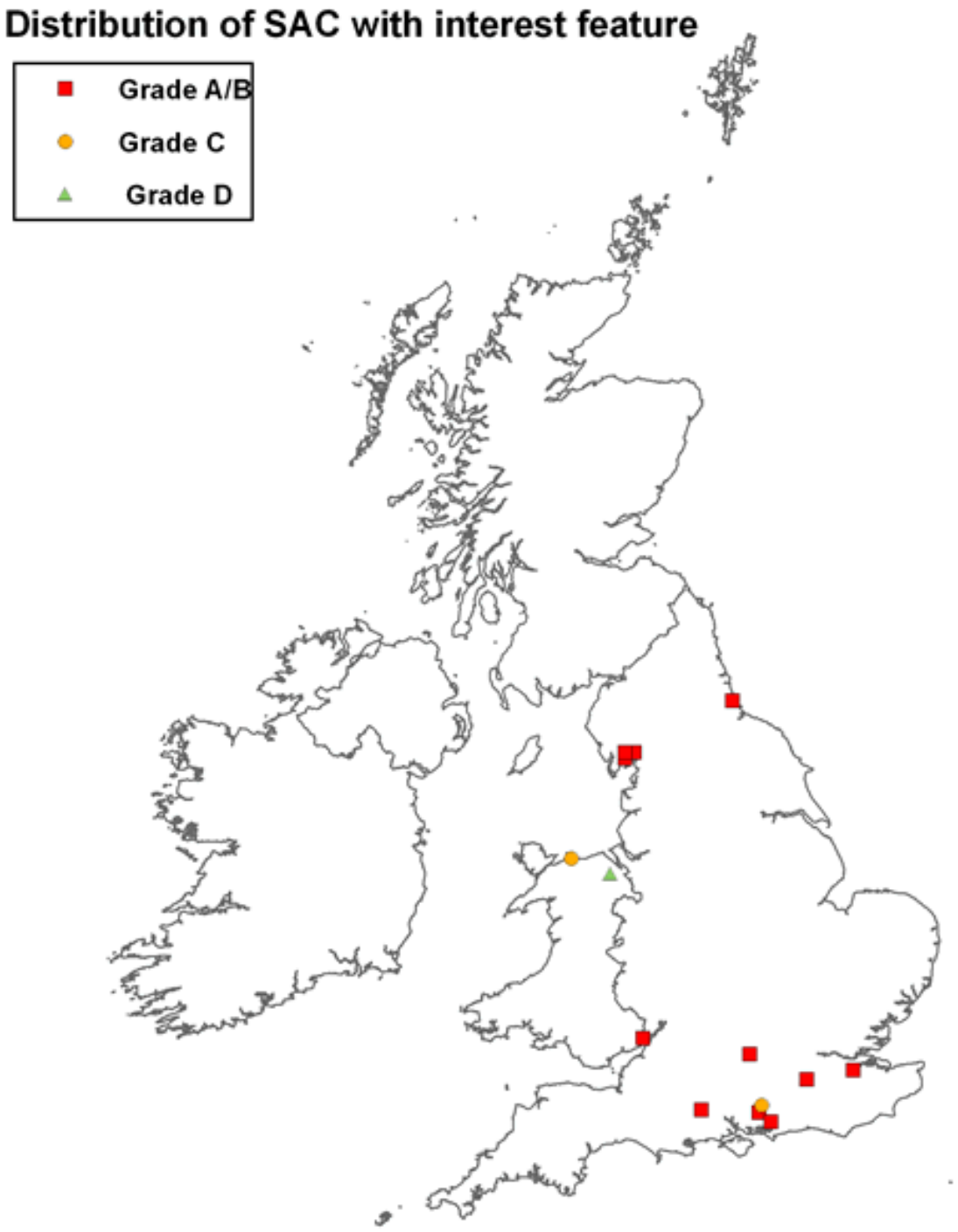


Figure 3: Yew woodlands in England with different grades. (Join Nature Conservation Committee, 2015)

Grade	***Explanation***
A	*Outstanding examples of the yew woodlands in a European context.*
B	*Excellent examples of the yew woodlands, significantly above the threshold for SSSI/ASSI notification but of somewhat lower value than grade A sites.*
C	*Examples of the yew woodlands which are of at least national importance (i.e. usually above the threshold for SSSI/ASSI notification on terrestrial sites) but not significantly above this. These yew woodlands are not the primary reason for SACs being selected.*
D	*Yew woodlands of below SSSI quality occurring on SAC's These are non-qualifying yew woodlands ("non-significant presence"), indicated by a letter D, but this is not a formal global grade.*

3 Introduction/Literature

3.1 Kingley Vale

Kingley Vale is a National Nature Reserve (NNR)[1] near Chichester, West Sussex, in southern England, lying within the new South Downs National Park (see Figure 4). It covers an area of 160 hectares and is part of the wider Kingley Vale Site of Special Scientific Interest (SSSI)[2] The reserve is a steep sided dry valley, the top of which offers stunning views of the surrounding area, including Chichester harbour and the Isle of Wight (Norton, 2012).

Figure 4: Map of South Downs National Park

The reserve is part of a Biodiversity Opportunity Area (BOA) in Sussex: Walderton to Welldown, including Kingley Vale. Sussex Biodiversity Partnership is developing a vision for implementing the Sussex Biodiversity Action Plan (BAP) by focussing on Biodiversity Opportunity Areas (BOAs). (Sussex Biodiversity Partnership, 2009) BOAs are areas where conservation action, such as habitat creation, restoration or expansion, is likely to have the greatest benefit for biodiversity (Biodiversityplanningtoolkit, 2014).
BOAs identify where the greatest opportunities for habitat creation and restoration lie, enabling the efficient focusing of resources to where they will have the greatest positive conservation impact, representing a more efficient way of delivering action on the ground. Identification of BOAs involved assessment of existing biodiversity and the opportunities for restoration and creation. BOAs do not represent a statutory designation or a constraint upon activities. They indicate where there are substantial opportunities to make positive changes for biodiversity,

[1] NNRs are areas managed for either (or both) the preservation of flora, fauna, geological and physiological features of special interest or to provide opportunities to study fauna, flora and their physical conditions. NNRs represent many of the finest wildlife and geological sites in the country. There are currently 224 NNRs in England with a total area of 94400 hectares.
[2] SSSIs are areas with protection of the most significant sites for the conservation of wildlife (species & habitats) and/or geology. There are over 4,100 SSSIs in England, covering around 8% of the country's land area. (Natural England, 2014)

and should be used to inform conservation strategies and place planning (Sussex Biodiversity Partnership, 2009).
A map of Sussex' BOAs can be seen in Appendix I (Sussex Biodiversity Partnership, 2009).

Kingley Vale is indicated as a Special Area of Conservation (SAC). This is a classification under the European Union's Habitats Directive of areas of value for species, plants and habitats. SPAs (Special Protection Areas) and SACs together form part of the Natura 2000 system. SACs are sometimes distinguished separately as Marine and Terrestrial SACs (Natural England, 2014).
Appendix II provides a map of Kingley Vale with different designations (NNR, SSSI & SAC) (MAGIC, 2014).

The reserve contains chalk grassland, scrub, mixed woodland (oak and ash) and ancient yew forest. This mosaic of habitats is important for insects and birds including a large variety of butterflies such as the chalkhill blue and brimstone. The reserve is one of the most important archaeological sites in southern England and has 14 scheduled ancient monuments, including Bronze Age burial mounds at the top of Bow Hill (206 m high) (Natural England, 2010).

Kingley Vale NNR has a yew woodland. A woodland is a habitat with trees as the dominant plant form. Individual tree canopies overlap and interlink, often forming a more or less continuous canopy which shades the ground to varying degrees. The amount of light reaching the ground (or stems) will determine the variety of lower plant species. The more different kind of plants there are, the greater the animal diversity will be (Countrysideinfo, 2014).
Appendix III gives a map of Kingley Vale with certain woodland acknowledgements. On the map you can see that the areas with the oldest yew trees (see 3.3 Yew trees in Kingley Vale) are designated as Ancient and Semi-Natural Woodland. In the wider area of these ancient areas it is a BAP Priority Habitat (MAGIC, 2014).

The site is managed by Natural England and has an information centre and a nature trail. (Norton, 2012) From the car park to the main entrance there is a walk of 15 minutes along the footpath. This footpath is easily passable, but in the reserve the path is steep and more difficult. The visitor centre is located at the main entrance of the reserve. This centre contains permanent displays and more information about the reserve (Natural England, 2010).
There is an hour-long nature trail through the valley and up its steep slopes. The trail follows numbered posts around the reserve. For each post there is a numbered question (Natural England, 2010).

The yew woodland needs no management other than for public safety. Fallow deer, roe deer, sheep, rabbits and hare keep a nearly stable situation in the grasslands that retains coarse grasses and afforestation. The grassland is either grazed or mown to keep back the scrub and to allow the more delicate plants to thrive (Natural England, 2010).
A map of Kingley Vale with the nature trail can be found in Appendix IV (Natural England, 2010).

Other significant maps can be found in Appendix V. The first map shows the parish boundaries in the reserve. Kingley Vale NNR lies on territory of Lavant, Funtington, Stoughton and West Dean. The part of West Dean is owned by the West Dean Estate, the rest is owned by Natural England. The second map shows all SSSI site units. Different numbers are assigned to different habitats. The third map gives condition of the SSSI units. This is called Integrated Site Assessment (ISA). The fourth map shows the public paths and open access land (green). Small paths within the NNR are not marked. The last map marks the 14 Scheduled Ancient Monuments (SAMs) of the reserve and two outside the reserve.

3.2 Yew trees

Yew (*Taxus baccata*) is a conifer with an irregular formed crown, native to Europe. It is a small evergreen tree, growing up to 20 m. Yew is normally dioecious (there are male and female plants), but some individuals can be variably monoecious (or they change sex over time). The trees are pollinated by the wind. The bark is brown and thin and comes from the stem in small papery flakes. The base of the flat dark-green needles are arranged spirally, but the stalks are twisted aligning leafs on two flat rows. On erect leading shoots the spiral arrangement is more visible. The aril of yew (only on female trees) is a fleshy, red structure that surrounds a single seed. All parts of yew are poisonous, except for the arils that have a sweet taste (but the seed in the aril is toxic).

Figure 5: Arils of yew (Encyclopedia of Life)

A yew has strong, valuable wood, but grows very slowly. Yew trees are among the hardest of the softwoods and have a remarkable elasticity, which makes them ideal for making products requiring resiliency (e.g. bows). The difference in properties between the heart- and sapwood increases the strength and flexibility. The difference in the wood properties create a natural laminated type of wood. Furthermore the heart- and sapwood have a clear difference in colour. Bows were made with this natural property, because the right usage of heart- and sapwood in one bow increases the strength and efficiency (e.g. English longbows). Due to this usage of yew wood there are barely old yew trees in Europe. They became nearly extinct for the weapon industry in the 13th century.

Figure 6: Colour difference between the heart- and sapwood (Encyclopedia of Life)

Yew trees can get very old, but estimating the ages of yew trees is very difficult. This is because of the hollowing of the trunk when the trees get old or maybe because multiple trunks can merge into one big trunk. When trees get older branches break out of the canopy more often. The heartwood that is exposed will slowly decay. Because the heartwood is rotting away slowly only older trees have hollowed trunks, which makes ring counting impossible. Some claims of yew trees being 5000-9500 years old are exaggerated however. The oldest yew trees are more likely in the range of 2000 years old. Yew has been accepted as the oldest living tree in Europe (Encyclopedia of Life, 2014).

Yew can grow on any type of soil as long as it is not too dry or, more importantly, too wet. Furthermore, yew can just as easily grow in the shade under big trees as in full sun. Yew can easily adapt to a changing situation as long as it is not a sudden change.
Another advantage of this species is that it will not become very high. However, although trees of up to 20 m do occur (e.g. in Hilliers Garden), most trees are hardly 15 m. Because the tree is rather low, it very often occurs that branches partially crack or just bend to the ground and go on growing. These branches can root so new trees are formed, which will add to the stability of the tree. In this way a ring of young trees is formed around a hollowing stem that can go on thickening.
When branches break, heartwood will be exposed and because heartwood is not able to form a reaction zone, will slowly rot. As the wood is not just very strong, but also very resistant to rot, it will have enough time to form a wall of healthy wood, thick enough to support the tree, although the tree is slow growing.
Yew has an exceptional advantage as it is one of just a few conifer species that is capable of forming young shoots from adventitious buds. When branches break, the tree has to recover.

Recovery costs energy, so the tree has to do as much photosynthesis as possible. Therefore it needs its leaves preferably to be as close to the broken branch as possible, which makes these adventitious buds indispensable. Without adventitious buds there would be no new branches, and for the trees' sake the more it forms, the better.
All these elements together can cause the tree to live nearly forever. In the juvenile stage, say the first five hundred years, the tree usually has a vast stem. But when the tree ages, this slowly evolves to a hollow ring, surrounded by young trees, while it happens that inside the hollow stem a new vast stem will be formed (Peeters, 2012).

A pure yew forest is established by the dense canopy and the greater lifespan of yew. In the succession ash and oak will disappear completely over time, because the shade prevents the seeding of the trees. Beech could survive permanently in the company of yew trees, because when a beech tree dies, a gap is formed, which can be taken by the shade resistant young beech trees (Rößner, 2006).
Yew can just as easily grow in the shade under big trees as in full sun. Yew seedlings can thus easily grow under the protection of big trees. As these trees become old and start to slowly die back, yew is able to adapt to the changing situation. They can easily withstand full sun, while seedlings of other trees will hardly get a chance, which will result in a closed canopy of a pure yew stand. In the end you will reach a yew forest as can be seen in Kingley Vale (Peeters, 2012).
When there is a sudden increase of light quantity on the trunks or branches, yew can grow epicormic shoots as reaction. These epicormic shoots often die back when the crown closes in the top. Fallow deer can eat new shoots thanks to their minor resistance against the poison. The crown of most yew in the reserve is about one meter above ground due to deer. That is why sheep are able to graze during the winter season (see 1.2 Kingley Vale NNR) (Birch, 2015).
In Figure 7 epicormic shoots on a horizontal branch on the ground, that has a dense ramification due to the grazing of fallow deer, can be seen.

Figure 7: Epicormic shoot grazed by fallow deer

Yew is a natural component of Ancient Semi-Natural Woodland (ASNW)[1], but most, younger yew woodlands have been colonised after the decline of extensive downland sheep-farming. (Norton, 2012) The reduction of sheep in this region (Hampshire-Sussex) happened during the Napoleonic Wars. Areas that were heavily grazed became fields with juniper, other shrubs and yew. Around 1830 the downland that was grazed by sheep was overgrown with juniper scrub. Around 1870 yew wood grew over the juniper scrub. This means Kingley Vales yew woodland is considerably younger than 200 years. But at the valley bottom there are some very old yew trees. One of these old trees died in 1950. The rings showed it to be 500 to 550 years old. More about the aging of yew trees can be found in 3.3 Yew trees in Kingley Vale (Packham *et al*., 1992).

[1] ASNW is woodland which has existed at least since 1700 and is usually of much older origin. It contains stands of native trees that are not obviously planted. ASNW is particularly rich in species compared to more recent woodland. (Howe, 2000)

3.3 Yew trees in Kingley Vale

There are 30 000 – 40 000 yew trees in the Kingley Vale woodland. In 2012, Peter Norton made a census of all yew trees in Kingley Vale with a girth over 3 m. He recorded the grid location, girth, height and sex of 57 yew trees. This is shown in Chart 2 below.

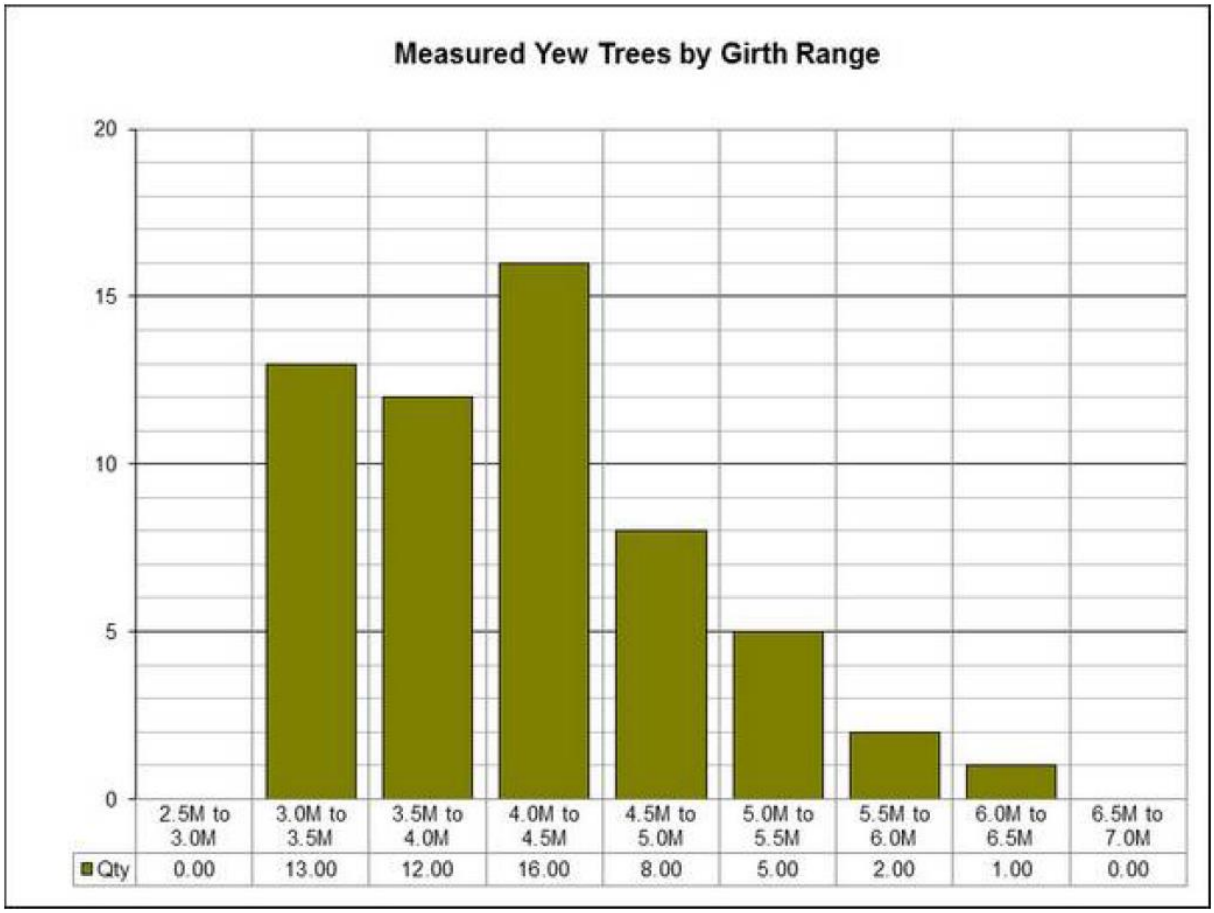


Chart 2: Measured yew trees by girth range (Norton, 2014)

The oldest (or biggest) tree has a 6.35 m girth. This is a veteran yew tree, but it is very difficult to set an age on this yew. There are 7 other veteran yews with a girth between 5 and 6 m. About 36 yews are notable trees with a girth from 3.5 to 5 m.
We cannot simply set an age on yew trees by girth measurements. At Monnington Walk in Herefordshire 42 yew trees were planted in 1628. In 2003 the girths varied from 1.47 m to 4.42 m. This example shows that measuring the age on the basis of girth ranges is surely not accurate (Hageneder, 2013). From the studies from Monnington Walk can be concluded that 90% of the yews with a girth over 4.9 m are older than 500 years.
Yew trees with a girth over 4.9 m are classed as 'veteran' yews (these yews are over 500 years old and may be up to 1200 years old), the yews with a girth above 7 m are 'ancient' yews (these are over 800 years old). Notable yews have a girth over 3.7 m and are estimated between 300 and 700 years old. Estimations of yews of several thousand years old in Kingley Vale are surely unrealistic, the oldest yew here is probably around 600 years old (Hindson, 2010).
The oldest yews are in the lowest areas of the valley. They reach a height of 17 m. The trees covering the escarpment are much younger (80 to 150 years old) and may reflect the change in land usage over the last 200 years. These younger trees are mostly bushy and hardly 10 m high (Norton, 2012).
A map with the yew trees from Chart 2 can be seen on Figure 8.

Figure 8: Location of yew trees with the largest girths by Norton (2014) (UK Grid Reference Finder) (Google Earth)

3.4 Lichens on (veteran) trees

3.4.1 General

A lichen is a stable symbiotic association between a fungus and algae and/or cyanobacteria. Like all fungi, lichen fungi require carbon as a food source (heterotrophic); this is provided by their symbiotic algae and/or cyanobacteria, which are photosynthetic. The lichen symbiosis is thought to be a mutualism, since both the fungi and the photosynthetic partners, called photobionts, benefit.
98% of lichen fungi are cup-fungi, or ascomycetes. Fully half of all ascomycetes and one in five of all known fungi form lichens. Lichen photobionts are the green algae or cyanobacteria that provide the simple sugars to their fungal partners. 90% of all lichens associate with a green-algal photobiont.
Lichens take very different forms. In almost all cases these are determined by the fungal partner, which produces the visible structure of the thallus that contains and supports its photosynthetic partner (The British Lichen Society, 2014).

There are different types of lichens: those growing in old woodlands and those in more open, drier, parkland situations. In Kingley Vale the lichens of the woodland will be examined. Lichens are very susceptible to sulphur dioxide and nitrous oxides. They are also sensitive to changes in light and humidity levels. The ideal conditions for woodland lichens are those with adequate light and shelter from drying winds. A mosaic of dense and open areas are ideal sites. Exposed heart can show special and rare floras (Read, 2000).
Because of their vulnerability to environmental changes, lichens are often used for measuring the air quality and the quality of ecosystems. More information can be found in 3.4.2 Lichen ecology.

It is important to have knowledge over different terms used for identifying lichens.
Most lichen fungi are ascomycetes, which produce spores in sac-like asci that are held in fruiting bodies for reproduction. The fruiting bodies can have different shapes:

- Apothecia (see Figure 9): the layer with asci is usually uncovered and visible. The apothecia can have many different forms. In Figure 9 the Lecanorine form can be seen.
    - Lecanorine
    - Lecideine
    - Arthonioid
    - Gyrose
    - Lirellate
    - Pin lichens
    - Podetia
- Perithecia (see Figure 10): flask-shaped structures that contain the asci. Mature spores are extruded through a central pore.

Figure 9: Apothecia (British Lichens)

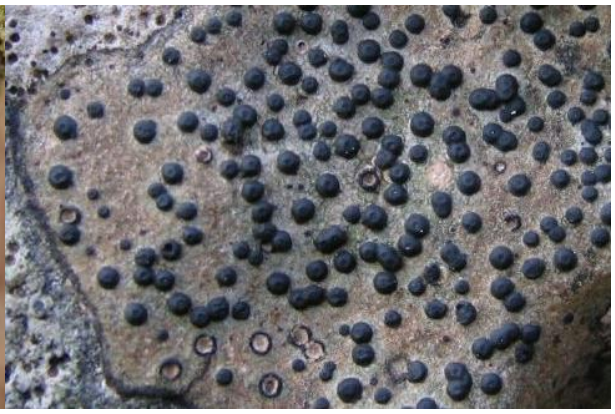


Figure 10: Perithecia (British Lichens)

The structure of the fruiting bodies, the asci and the spores are important features in the classification of lichens. Beside the identification through the different reproduction aspects, also the lichens form can have very different appearances. There are four basic lichen forms, each with various subcategories (British Lichens, 2014):

- Crustose (see Figure 11): lichens that grow completely attached to the surface.
    - Areolate
    - Rimose
    - Placodioid
    - Leprose
- Squamulose (see Figure 12): lichens have scale-like forms. Small squamalose forms can be confused with crustose lichens.
- Foliose (see Figure 13): these leaf-like lichens have a very distinctive upper and lower surface.
    - Foliose
    - Umbilicate
    - Foliose: jelly lichens
- Fruticose (see Figure 14): these lichens are shrubby, branched, beard-like or strap-shaped.
    - Cup lichens
    - Shruby lichens
    - Beard lichens
    - Hair lichens

Figure 11: Crustose lichen (British Lichens)

Figure 12: Squamalose lichen (British Lichens)

Figure 13: Foliose lichen (British Lichens)

Figure 14: Fruticose lichen (British Lichens)

Determination of lichens is difficult. The thallus colour described in books is usually that of dry material in good condition. But the colour can change in different conditions: when they are wet, when they grow on certain substrates and in poor conditions they can be covered in green algae. For further determination chemical tests or microscopic examination can be necessary. For the chemical tests potassium hydroxide (K) and/or bleach (C) are often used. These chemicals could have a reaction with certain lichens, then the lichens get a specific colour. The microscope can be necessary for examining the reproductive structures (The British Lichen Society, 2014).

3.4.2 Lichen ecology

3.4.2.1 Lichen Diversity Value

Lichen diversity is a good indicator of pollution from phytotoxic gases. Lichens respond relatively fast to a decline in air quality and can recolonize urban and industrial environments as a result of improved conditions within a few years. Lichens are also sensitive to other types of environmental changes, a common example being eutrophication. Lichens have also been used to estimate the ecological continuity of forests as they are also very sensitive to variations in woodland management, and to establish networks to monitor climate. The frequency of occurrence of lichen species on tree bark is used as a valuation of diversity, and as a parameter to value the degree of environmental stress (Asta *et al*., 2002).

For surveying the lichen diversity a monitoring quadrat is used. This consist of four quadrat segments with each five 10x10 cm squares. Each segment is attached vertically on the trunk, the lower edge of each segment must be placed 1 m above the ground level. The segments must be orientated in the four wind directions. In Figure 15 the placing of the quadrat segment is shown (Asta *et al*., 2002).
For calculating the Lichen Diversity Value (LDV) the sum of the frequencies (SF) of all lichen species on a tree must be taken. This is done for each wind direction separately. Then the means of these SFs (MSF) of all the sample trees in the area are calculated. When the MSFs of each wind direction are summed, the LDV is known. With the maximum and minimum LDV in the surveying area, the LDV classes can be determined. Figure 16 shows the ranges for the different classes. If the LDV classes fall into two categories, the evaluation becomes a combination of the two categories (Asta *et al*., 2002).

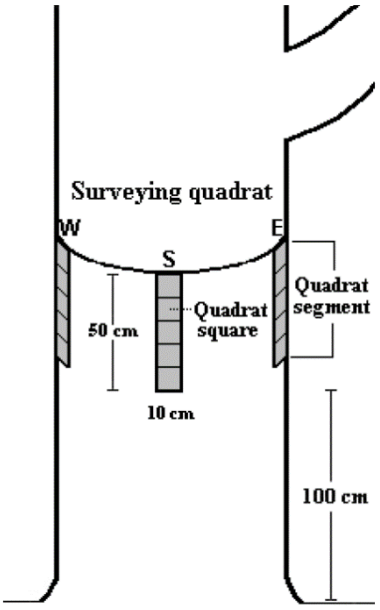


Figure 15: Placing monitoring quadrat (Asta et al.*, 2002)*

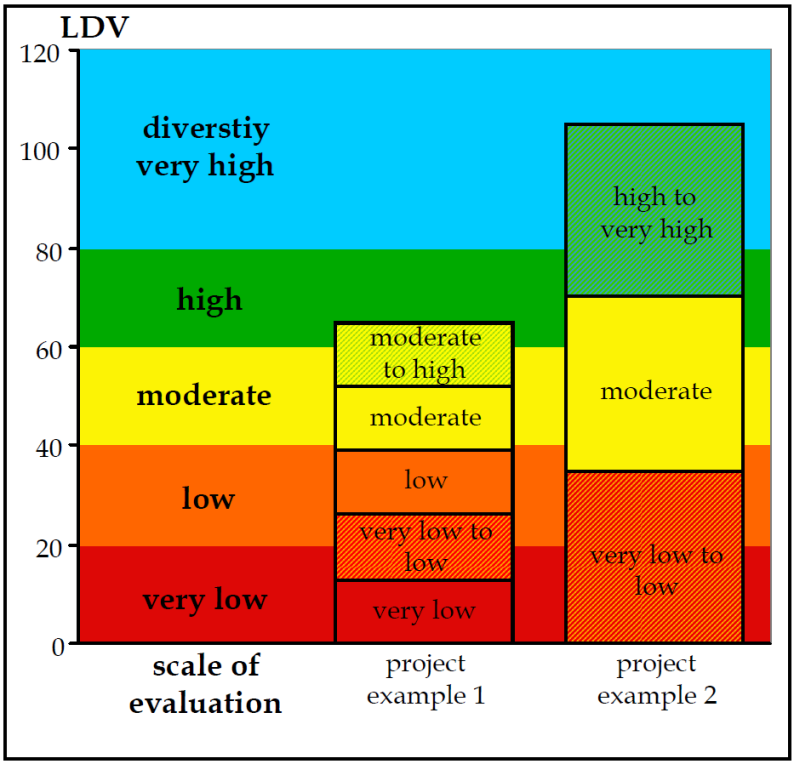


Figure 16: LDV evaluation classes (Asta et al.*, 2002)*

3.4.2.2 **Indices of ecological continuity**

For evaluating the environmental quality of woodlands, the species composition and associations are important. E.g. certain species of lichen occur in all, or nearly all, woodlands containing standard oak or ash trees, whether these are old high forests, coppice-with-standards, or areas of mature oak plantations. But a specific group of lichens is found only in association with mature old stands of oak or mixed oak forests. These findings led to a theory for the assessment of the maturity of woodlands or ancient woodland character. The assessment is done with indices of ecological continuity (Mulligan, 2009).

There is a Revised Index of Ecological Continuity (RIEC) and a New Index of Ecological Continuity (NIEC).
The RIEC serves for grading the 'ancient woodland' characteristics of deciduous woodlands of Great Britain and Ireland. This index consists of a base list of 30 indicator species made from previous field work by Dr. Francis Rose (in 1976). It is assumed that the 'best' woods will only achieve a maximum of 20 out of 30 indicator species. This is because of the differences in woodland structure and the geographical distribution of lichens in Britain. This means that if there are 20 RIEC species in a woodland, the RIEC value is 100%. As a formula: RIEC = n/20 × 100, where n is the number of Indicator Species. Below the RIEC value interpretation can be seen:

- 0–25% = no indication of ecological continuity; the woodland is either a plantation or has been clear-felled and regenerated, or coppiced.
- 30–45% = evidence of some degree of ecological continuity.
- 50–70% = strong evidence of ecological continuity.
- 75–100%+ = clear evidence of an ancient woodland with a long history of ecological continuity; the woodland has never been clear-felled or extensively coppiced, although trees may have been felled on a selective basis.

The NIEC was developed 16 years after the RIEC was made in 1976. This happened in response to advances in knowledge of the taxonomy, ecology and distribution of epiphytic lichens. The NIEC serves as a grading for woodlands for their conservation status, rather than just focussing on the 'old woodland' interest. The NIEC contains almost all indicator species of the RIEC. The NIEC is used in conjunction with the RIEC, but the NIEC has a broader application to assess the conservation importance of a woodland area.
If there are significant local or rare species in a woodland that are not included in the NIEC, these are called 'Bonus' species. The sum of the number of the main list species (NIEC) and the number of Bonus species is *T*. If *T* is higher than 30, the site can be considered to be of high conservation importance. When *T* is less than 20, the site has a limited conservation importance. But there are exceptions: when some endangered species are present on the site, the conservation importance can be high although *T* is lower than 20.
More indices of ecological continuity can be found in Figure 17, but these are not discussed here because Kingley Vale lies in the area of the NIEC.
Appendix VI shows the RIEC and NIEC lists.

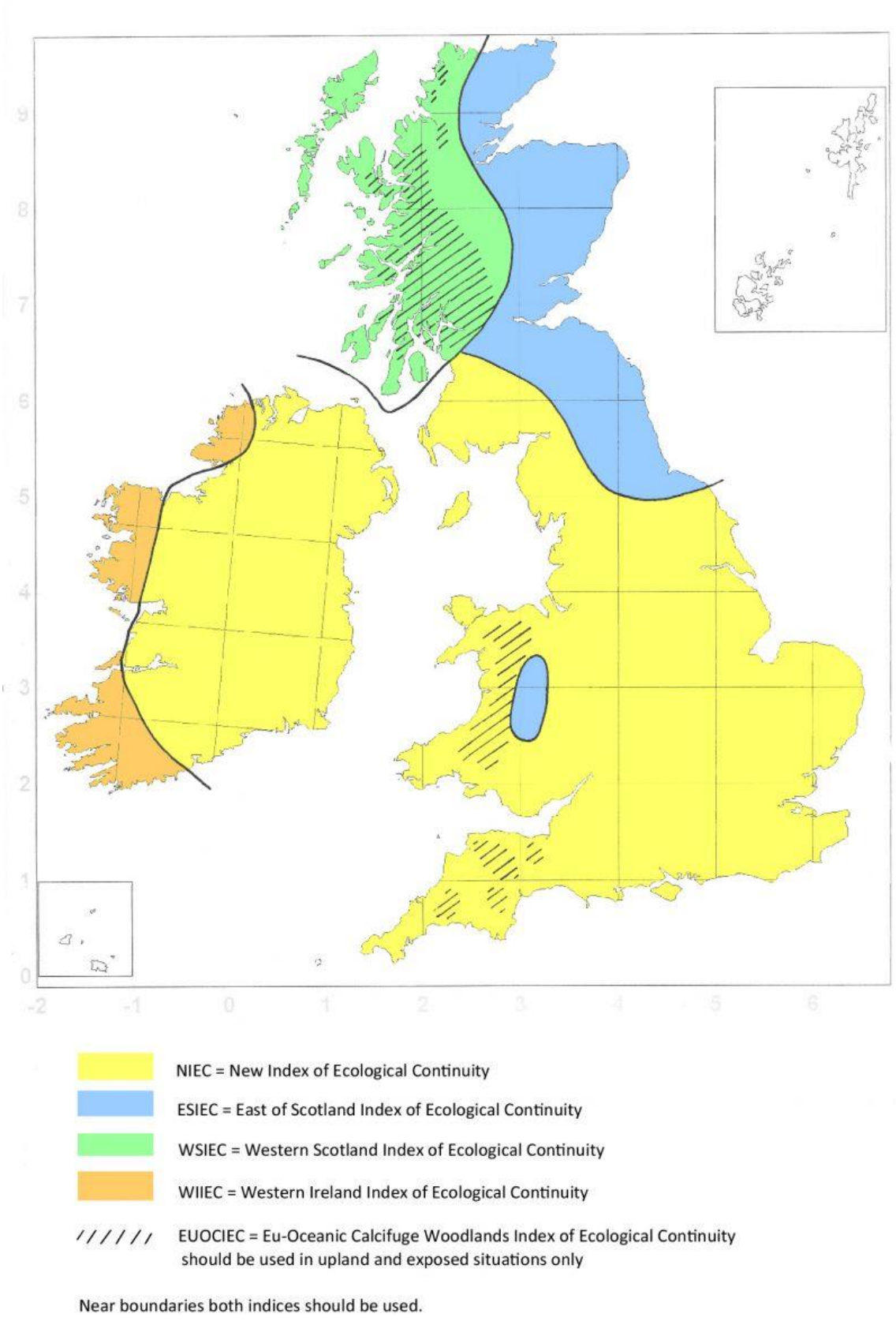


Figure 17: Map showing areas where each Lichen Index for Ecological Continuity for deciduous woodlands is appropriate (The British Lichen Society)

3.4.3 Previous research on lichens

3.4.3.1 Goals

- Wagner *et al*. (2014) examined lichen communities in two old-growth pine forests in Ontario (Canada). The purpose was getting a better understanding of lichen biota in old-growth forests, because old-growth forests are increasingly uncommon in Ontario. Therefore the lichen biota are especially examined on coarse woody debris (CWD) and on trees in a red pine dominating forest and a white pine dominating forest. Different types of CWD (e.g. log, stump, or snag), along with a variation in diameter sizes and decay stages were examined because they create a variety of habitats. This study provides information on lichen diversity and communities present on CWD and trees within these old-forest ecosystems. It yields baseline data to monitor changes and can serve as a control when comparing lichen diversity in old and young forests.

- Van den Broeck *et al*. (2006) made a report from a bio-monitoring for air pollution in Limburg (Belgium). The research was carried out for ammoniac (NH_3) and sulphur dioxide (SO_2), two substances that are acidifying. Lichens react strongly when concentrations of these substances change, so they are used as biological impact indicator. This method is more accurate than data from agricultural data, because it says something about direct deposition and not only about theoretical emission. High concentrations of sulphur dioxide is toxic for many lichen species, but some species can endure this. Ammoniac leads to a shift in species composition (acid lovers die and nitrogen lovers are stimulated). This is because ammoniac actually is a base that makes the bark less acid. The monitoring of these substances with lichens is based on the fact that some species react positively on concentration changes and others negatively.

- Nascimbene *et al*. (2008) studied lichen diversity on coarse woody debris (CWD) in a *Pinus-Larix* stand in the Italian Alps. The quality and quantity of CWD is a characterization of old-growth forest stands. In managed forests there is less volume of CWD and there are less different CWD types than in natural forests. Dead wood in managed forests consists mostly of stumps, logs and large snags are usually rare. The different types and decay stages of CWD create different habitats for different (red-listed[1]) species. Snags are more suitable CWD types for lichens than stumps and logs in wet habitats because they are generally drier and provide well-lit conditions. The aims of this study were:
  - Providing an evaluation of the effects of different types of CWD and wood decay on lichen diversity in *Pinus-Larix* forests of the Italian Alps.
  - Increasing the knowledge of the lichen biota on CWD in Italy.

- Neitlich & McCune (1997) examined hotspots of epiphytic lichen diversity in two young managed forests in Corvallis (USA). The two forests were 50 year old and 80 ha managed conifer stands. The goal of this study was to improve the basis for producing timber while conserving the biological diversity. It is the intention to promote biodiversity and fast recovery of old-growth forest taxa while harvesting timber is still possible. Little is known about variation of lichen diversity of young forest stands and how it differs between natural and manipulated young stands. In this study there were three objectives:
  - To quantify the range of variability of epiphytic lichen diversity in the two young, managed forests.
  - To quantify the relationship between the lichen diversity and fast measurable forest characteristics (e.g. presence of canopy gaps and old-growth remnant trees).
  - To test the idea that hotspots of lichen diversity could be quickly identified based on stand structure and the presence of certain key species.

[1] European Red-listed species are threatened with extinction at the European level. If these species live in a certain area, there should be an appropriate conservation action plan to improve the status of these species. (European Commission, 2014)

- Humphrey *et al*. (2002) studied lichen and bryophyte communities of planted and semi-natural forests. They looked at the influence of site type, stand structure and deadwood. The value of epiphytic bryophytes and lichens in woodlands are related to low pollution levels, continuity of woodland conditions, the survival of old trees and relatively open canopies ensuring adequate light for epiphytic growth. Habitat Action Plans (BAP) are developed to encourage restoration and expansion of the native woodland resource. The objectives of the study were:
  - Making an inventory of lichen and bryophyte species associated with Scots pine, Corsican pine, Norway spruce and Sitka spruce of different sites across Britain.
  - Relating bryophyte and lichen riches and composition to deadwood, climate and stand structure.
  - Comparing plantations with semi-natural Scots pine and oak woodland in similar climate zones and on comparable site types. Evaluating the potential of conifer plantations as a habitat for native bryophytes and lichens.
  - Proposing management strategies to enhance habitat quality for lower plants in planted stands.

3.4.3.2 **Methods**

- The field sampling method of Wagner *et al*. (2014) involved transects in a north-south orientation. They were at least 50 m from forest edges for eliminating the impact of forest edge effects. The transects were 20 m wide and 50 m to 200 m long with a minimum spacing between sampling units of 5 m. In this way similar microhabitats were limited. There were four substratum types sampled along each transect: trees, stumps, logs and snags. For each type there was a quota of 20 sampling units, so in total there were 80 sampling units per forest. Only the dominant tree species were sampled. Snags, stumps and logs needed to have a minimum diameter of 10 cm to be sampled and each of them had five plots. On the snags five plots were placed 40 cm above each other, which were north (10 snags per forest type) or south (10 snags per forest type) aligned. On stumps one plot was placed on top, north and west aligned plots were placed at ground level and south and east plots half way between the ground and the top of the stumps. For logs the first plot was placed at the broadest point, the rest were placed 40 cm from each other along the log.
  Identification was done with microscopes and chemical spot tests. For further examination thin-layer chromatography was used. Immature specimens were identified to the genus level.

- In the study of Van den Broeck *et al*. (2006) sampling points were used (in total 559 points). One sampling point consists of a small group (mostly 10) of trees (mostly English oak: *Quercus robur*). Per square of 4 x 4 km² three to five sampling points were chosen. If suitable English oak were missing, other *Quercus sp.* were chosen. Some poplar and ash trees were examined in this study. The position of the sampling points were defined with GPS. The sample trees were examined until 2 m height on the trunk. Other organisms than lichen were not recorded. The frequency of the lichen species per sampling point were defined by a six-part scale:
  1 only one specimen present,
  2 several specimens on one tree,
  3 meanly less than 1 per dm² at up to half of the trees,
  4 meanly more than 1 per dm² at up to half of the trees,
  5 meanly less than 1 per dm² on more than half of the trees,
  6 meanly more than 1 per dm² on more than half of the trees.

  Per sampling point the following data were noted:
  - the kilometer square (IFBL-square of 1x1 km on topographic map),
  - the date of the surveying,
  - the girth of the average tree (in m),
  - the number of examined trees,

- an encoding for the type of environment,
- the distance to the nearest cattle farm (in m),
- the distance to the nearest corn field (in m),
- information about local factors that could have an influence, such as grazing around the trees, influence of dogs or otherwise enriched sites (e.g. fertilized lawn), dusty sites (e.g. no grass around the tree base) and shading on the trunk.

If corn fields or cattle farms lie further than 1 km away from the sampling point, 999 was filled in. If these were missing in sight distance, 499 was filled in. Most sampling points were selected more than 300 m from a cattle farm, for avoiding local ammoniac sources.

- In the study of Nascimbene *et al*. (2008) ten logs, ten snags and ten stumps were randomly selected for the lichen survey. The decay stages were evaluated as in the study below (Humphrey *et al*., 2002). A sampling unit (CWD) had five sampling plots. A sampling plot was 10 x 10 cm and the plots were divided in 16 quadrats of 2.5 x 2.5 cm. This was used to measure the frequency of the species expressed as the number of quadrats. The sampling plots on logs were positioned on the upper side, starting from the broadest part of the log with 50 cm between each plot. The sampling plots on snags were positioned for five sampling units to the south and for five other sampling units to the north, starting from the base of the snag with 50 cm between each plot. The sampling plots on stumps were positioned on the upper surface with four plots in the external part at the four cardinal points. The Lichen diversity was evaluated considering three guilds of species: (1) all species, (2) nationally rare species and (3) calicioid species.

- In the study of Neitlich & McCune (1997) there were 35 plots of 0.38 ha per forest (in total 70 plots). Each site (forest) was divided into four similar units where alternative treatments would be installed. The 35 lichen plots were more or less equally divided among the four units. In each unit four to five plots were identified where the lichen diversity would presumably be the highest (= hotspots). These hotspots contained forest gaps, irregular areas and/or old-growth remnant trees. Irregular areas often contained wolf trees: these are trees having branches (dead or alive) of at least 6 cm in diameter and less than 3 m above the ground. The rest of the plots were placed in four to five ‘matrix’ plots chosen arbitrarily in the rest of the area. Then all epiphytic macrolichens growing above 0.5 m or laying in litter (originated from above 0.5 m) were identified. These lichens were given a score from 1-4:
    1 Rare: occurring once to three times in a plot.
    2 Occasional: occurring four to ten times in a plot.
    3 Common: occurring more than 10 times in a plot, but less than rating 4.
    4 Abundant: more than 50 % of all available branches and stems contained the species.

- The forest stands in the study of Humphrey *et al*. (2002) had four sample plots (of 1 ha), one for each growth stage. The four growth stages were:
    1 Pre-thicket: trees of 8-10 years with a crop height of 2-4 m and an incomplete canopy closure.
    2 Mid-rotation: trees of 20-30 years with a crop height of 10-20 m and a complete canopy closure. There is no understory.
    3 Economically mature: trees of 50-80 years with a crop height of 20-25 m. There is some understory development.
    4 Over-matured (beyond economic maturity, acquiring some ecological characteristics of natural old-growth forests): trees of 60-250 years with a crop height larger than 20 m and a depleting canopy. There is a well-developed understory and an accumulation of deadwood.

  Stage 4 was not available in every forest.
  The volume, size and quality of deadwood were measured. Deadwood pieces that were recorded were logs, stumps and snags. The quality of the deadwood was visually determined with a five-pointed scale (decay classes):
    1 Bark is intact with small branches present.

2 Bark is loose or sloughing off, there is no sapwood degradation.
3 There is no bark and some sapwood degradation.
4 There is no bark and notable sapwood degradation.
5 There is a degradation of sapwood and heartwood.

The bryophyte and lichen species were recorded on each individual piece of deadwood within the sample plots. Each sample plot of 1 ha was divided into 4 quarters of 50x50 m. Two 10x10 m quadrats were arranged diagonally at the center of each quarter, giving eight quadrats per plot.

3.4.3.3 **Results**

- Wagner *et al*. (2014) made a table of the species that were found. The fields in the table consist of: species, site(s) (which forest), no. of observation (how many), found on only one substratum type (tree, snag, stump or log), occurs on trees (yes or no), occurs on CWD (yes or no), median decay stage (1 to 5), decay stage range (1 to 5). Several species were found only on one substratum. This means that for all research of lichen biodiversity in forests all types of substrate must be examined.
  In the red pine forest there was no difference in lichen diversity or species riches between the different substratum types. In the white pine forest, however, a difference was found: the logs were less divers and had less species than the stumps and trees. This supports other findings that showed that lichen riches is affected by the CWD type with stumps and snags having more species than logs. The trees in the white pine forest have a higher species riches than the stumps, snags and logs. The reason might be a lack of competition with bryophytes and a longer period of time in which a stable habitat was available to colonize and develop.
  In this study there was no difference between the species riches and lichen biodiversity in the different decay stages of CWD. This could be due to the limited number of samples of CWD in some decay stages. Other studies, however, yielded findings showing that lichen diversity and species riches differed in different decay stages of CWD. (Wagner *et al*., 2014)

- Van den Broeck *et al*. (2006) found 119 lichen species on trees throughout the province of Limburg. The ammonia load is calculated with the nitrophilous indicator value (NIV) and the acidophilic indicator value (AIV). NIV is calculated by making the sum of all nitrogen lovers[1] in a sampling point. Every tree is added in the sum for each nitrogen lover lichen species. Then the average number of species is calculated for each tree. Lichen species in large quantities (frequencies of 4 and 6: see 3.4.3.2 Methods) are counted double. AIV is calculated like the NIV, but with acid lovers[2] instead of nitrogen lovers. A high NIV is indicative of a high ammonia load, while a high AIV indicates a low load. A NIV higher than 7 means that there is a very serious contamination, a NIV between 1.5 and 3.0 points to a moderate influence of NH_3. The meaning of AIV values is vice versa. Throughout Limburg there is no place with an AIV value higher than 7, which means that in the entire region there is a certain rate of ammonia load present.

[1] *Caloplaca citrina, Caloplaca flavocitrina, Caloplaca holocarpa, Candelariella aurella, Candelariella reflexa, Candelariella vitellina, Candelariella xanthostigma, Lecanora dispersa, Lecanora hagenii, Lecanora muralis, Phaeophyscia nigricans, Phaeophyscia orbicularis, Physcia adscendens, Physcia caesia, Physcia dubia*, *Physcia stellaris, Physcia tenella, Rinodina gennarii, Xanthoria calcicola, Xanthoria candelaria, Xanthoria parietina, Xanthoria polycarpa.*

[2] *Chaenotheca ferruginea*, *Cladonia* sp., *Evernia prunastri*, *Hypocenomyce scalaris*, *Hypogymnia physodes*, *Hypogymnia tubulosa, Lecanora conizaeoides*, *Lecanora pulicaris*, *Lepraria incana*, *Parmelia saxatilis*, *Parmeliopsis ambigua, Placynthiella icmalea*, *Platismatia glauca*, *Pseudevernia furfuracea*, *Trapeliopsis flexuosa*, *Trapeliopsis granulosa*, *Usnea* sp.

The sulphur dioxide load is calculated with the Q-sum. This is the sum of Q-species, each with their specific value.[1] Many lichen species are susceptible to SO_2, which is why the species diversity is very low in contaminated areas. The higher the value of the species, the more susceptible to SO_2. Sampling points with a high Q-sum (80-100) have a great species diversity, which means there is a low SO_2 contamination.

- The study of Nascimbene *et al*. (2008) results in a total of 78 species. There were 31 species found on logs (of which 1 rare), 52 on stumps (of which 5 rare and 1 calicioid) and 49 on snags (of which 9 rare and 10 calicioid). Logs were the least divers in species, whereas stumps and snags were about equally divers, but the snags had more rare and calicioid species. Wood decay had a small negative effect on the total species riches, which decreased with increasing decay. This does not count for rare and calicioid species.

- In the hotspots of the study from Neitlich & McCune (1997) the species riches was 38 % higher in the first forest and 24 % higher in the second forest than in the 'matrix' plots. Hardwood gaps are gaps in the coniferous canopy where hardwood trees and shrubs grow in the understory filling the gap. The area of these hardwood gaps measured between 0.1 and 0.3 ha and had a distinctively higher lichen diversity. There were not many gaps and these were mostly small as the study was carried out in managed forest for a high wood production where gaps were considered unproductive areas. Small gaps (e.g. 25 m²) only had a slight effect on the diversity, while gaps of about 1000 m² or larger created a great boost in lichen diversity. The conclusion is that gaps, wolf trees and old-growth remnant trees should be protected to promote the majority of epiphytic macrolichens (especially those requiring a specialized habitat).

- In the study of Humphrey *et al.* (2002) 202 lichen species and 111 bryophyte species were recorded. Commonly recorded lichen genera were: *Cladonia*, *Parmelia*, *Pertusaria* and *Lecanora*.
  In Chart 3 the total number of lichen species of the different crop types can be found. In native oak (on upland) and Scots pine (on foothills) stands the lichen diversity was significantly higher than in the other crop types. For the different conifer stands the lichen diversity is decreasing from the left to the right on the chart. Most species were found on deadwood (grey), the other substrata (white) were living trees and rocks. The highest lichen diversity for the conifers were found in pre-thicket plots followed by over-mature plots, then mature plots and the mid-rotation plots had a complete canopy closure. This is because the mid-rotation and the mature plots had lower light levels. Low light levels are disadvantageous for lichen growth. Deadwood with classes 3, 4 or 5 were more species-rich than those with classes 1 or 2. Snags were the most species-rich deadwood type.

[1] *Amandinea punctata* (3), *Diploicia canescens* (4), *Evernia prunastri* (8), *Flavoparmelia caperata* (7), *Hypogymnia physodes* (4), *Hypocenomyce scalaris* (3), *Lecanora chlarotera* (4), *Lecanora conizaeoides* (0), *Lecanora pulicaris* (4), *Lecidella elaeochroma* (8), *Lepraria incana* (2), *Parmelia saxatilis* (10), *Parmelia sulcata* (6), *Parmelina tiliacea* (9), *Pertusaria albescens* (6), *Physcia aipolia* (9), *Physcia tenella* (5), *Physconia grisea* (5), *Platismatia glauca* (9), *Pleurosticta acetabulum* (7), *Pseudevernia furfuracea* (8), *Punctelia subrudecta* (6), *Ramalina farinacea* (7), *Ramalina fastigiata* (8), *Ramalina fraxinea* (10), *Usnea* sp. (12), *Xanthoria parietina* (7).

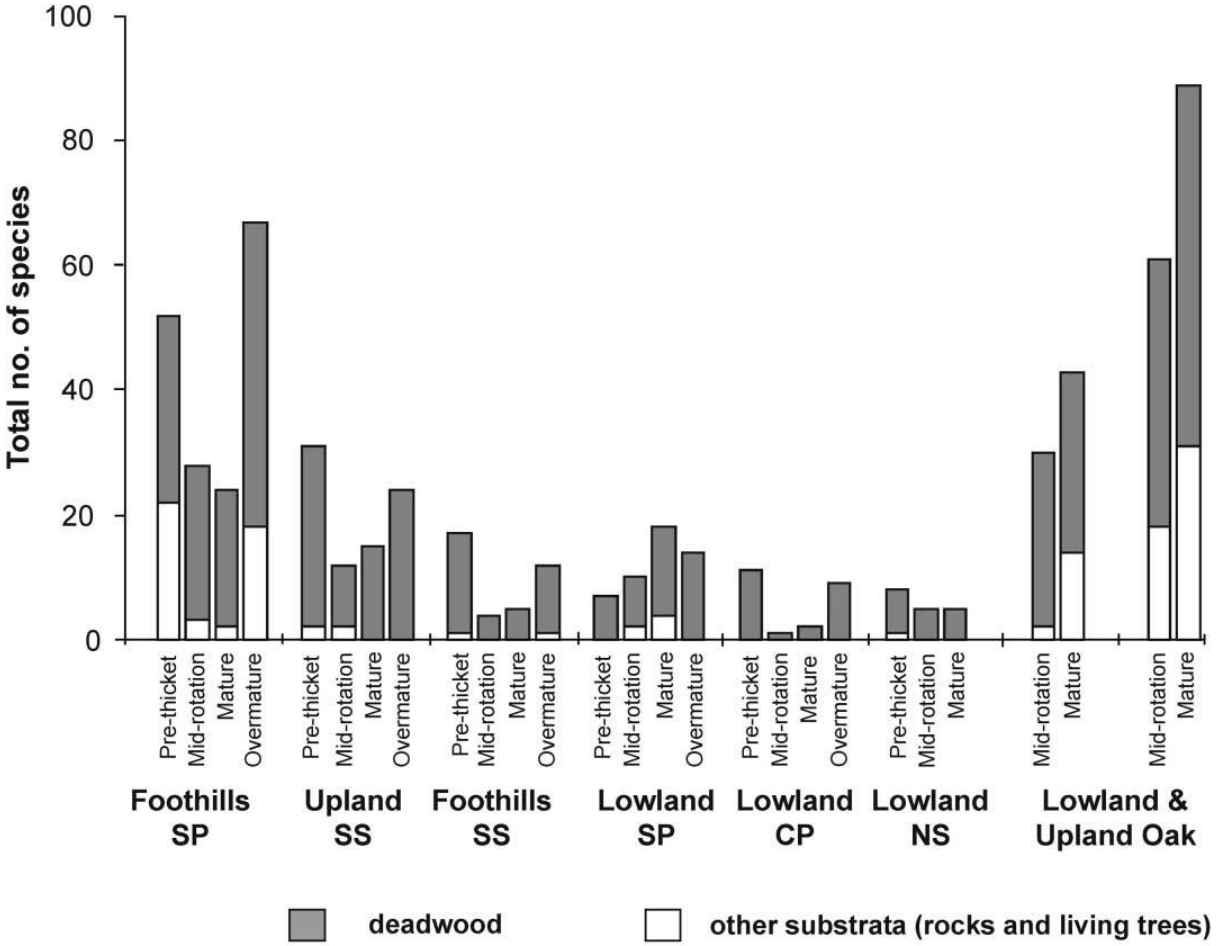


Chart 3: Total number of lichen species recorded in different stand growth stages of Scots pine (SP), Corsican pine (CP), Sitka spruce (SS), Norway spruce (NS) and oak within different climate zones (Humphrey et al., 2002)

3.5 Invertebrates on (veteran) trees

3.5.1 General

Invertebrates are animals that have no spine. They don't have an internal skeleton or bones. Like vertebrates, they generally have a heart, a nervous system, senses and mobility. Many invertebrates have different stages in their life cycle. Animals of the same species can have different requirements and habitats (Buglife, 2014).

There are different types of invertebrates: saprophytes, parasites and predators. Saproxylic species are the most threatened community of invertebrates. That is because much dead organic material is being removed. Yew (and beech) woodland is of particular value to saproxylic invertebrates (Buglife, 2014).

Good sites for invertebrates have a large number of old trees (especially native species), with plenty of dead wood. Trees that are native broadleaves are good, but these are less common in Kingley Vale. Also a good mixture of structure (e.g. open grassy areas and deep woodland, which is present in Kingley Vale) and adequate nectar sources is a great advantage (Read, 2000).

A good tree for invertebrates:

- Dead wood in the crown - hot dry wood supports a limited, but specialized range of species.
- Decay columns - brown rot and soft white rot are especially valuable.
- Rot holes in a variety of sizes, dampness and stages of decay, e.g. some water-filled and others dry and containing tree humus.
- Partly decomposed wood, burrows and cavities, resulting from actions of other saproxylic species.
- Sap runs or fluxes, where the sap oozes out of the tree.
- Fungal fruiting bodies and fungi present under the bark etc.
- Damage to the bark, e.g. lightning strike.
- Broken branch stubs that are good for invertebrate access, e.g. for egg laying.
- Nectar source nearby.
- Fallen branches left to lie near the tree in partial shade.
- Living tissue (i.e. the tree is alive) so that it can continue to produce more dead wood and shade the dead wood already on the tree.

Compared with other trees of the temperate zone, the number of invertebrates living with yew is small. But some species live on or from yew: *Hybocoptus decollatus* (maned balloon-head money spider) and the rare *Hyptiotes paradoxus* (triangle spider) are spiders found on yew. *Porcellio scaber* (woodlouse) and *Armadillidium vulgare* (pill bug) are commonly found in the vicinity of yew.
The most notable insect on yew is a parasite: the yew gall midge (*Taxomyia taxi*). This gall midge is the cause of artichoke galls, often seen on yew in Europe. Figure 18 shows the section of an artichoke gall. The pupation takes place in the gall, the adults only live about a day. *Taxomyia taxi* is parasitized by *Mesopolobus diffinis* and *Torymus nigritarsus*, both parasitic wasps (Hageneder, 2007).

Figure 18: Section of artichoke gall (Encyclopedia of Life)

The caterpillars of two butterfly species, *Ditula angustiorana* and *Blastobasis lignea*, can feed on yew leaves. These species are not restricted to yew, however.
Other insects on yew are *Hylotrupes bajulus* (longhorned beetle) and *Xestobium rufovillosum* (death-watch beetle), feeding on the sapwood of yew. *Otiorhynchus sulcatus* (black vine weevil, Figure 19) is a dangerous beetle that ringbarks yew shoots and attacks the roots of seedlings. They also damage apical buds, which leads to multi-stemmed (later multi-trunked) yews.
Ants can feed on the sugary aril pulp (thereby exposing the seeds, which improves seed germination). Wild honey bees can build a nest inside hollow yews (Hageneder, 2007).

Figure 19: Otiorhynchus sulcatus (black vine weevil) (Encyclopedia of Life)

3.5.2 Previous research on invertebrates

3.5.2.1 Goals

- Alexander (2014) made a study in Glen Tanar SSSI in Scotland. The canopy is completely dominated by Caledonian pine (*Pinus sylvestris* var. *scotica*). This site is known for its rare invertebrates. The study concentrates on Coleoptera and Diptera species. The purpose of this study is to monitor the site condition of invertebrates.

- Alexander (2011) made an invertebrate survey of Coill Eoin in Ireland. The overall objective was to assess the invertebrate fauna of the woodland in order to make management decisions to assist the nature conservation site. The specific aims are:
  - Assessing the impact on the invertebrates of the current woodland management.
  - Identify ecological differences between western and eastern halves of the wood.
  - Investigate if pollinating insects from Narrow-leaved Helleborine (*Cephalanthera longifolia*) occur in the woods.
  - Suggesting a monitoring protocol, using invertebrate species, to determine potential changes to the ecology of the woodland.
  - Identifying important invertebrate assemblages (indicating species habitat requirements).

- Rohr *et al*. (2007) developed a monitoring programme for invertebrates. The goal was to provide a heuristic model and guidelines for developing an efficient monitoring programme. In the case study, a monitoring programme was developed for the forests of Shenandoah National Park (USA). This study focusses on terrestrial arthropods because of their vital role in ecosystem processes, great diversity, sensitivity to environmental changes, etc.

3.5.2.2 Methods

- The date Alexander selected for survey (2014) was set on 26 June 2013, which was supposed to be the optimal time to find adults of the key species. Basic monitoring methods were used for catching/investigating the invertebrates. These were:
  - Large old trunks of living trees (sunny areas): investigating active insects at the base of cavities, sap-runs or other wet fluxes, rot holes. Exit holes of insects can provide signs of certain species (shape and size of the holes).
  - Aerial dead branches on living trees with a net.
  - Aerial living branches by beating them over a net.

- Standing dead trunks investigated like living trunks, but here is more decay. Dead trunks attract more warmth-loving species than living trunks.
- Fallen trunks & branches are investigated by breaking and turning them where possible.
- Fruiting fungi are inspected by tapping them over a net: investigating exit holes and breaking open a representative sample for larvae.
- Blossoms for searching nectar eating adult insects.
- Surrounding habitat by sweep-netting low over the field beneath the foliage.

➢ The survey of Alexander (2011) was divided into five sampling visits, each visit having a three days duration. Sampling between the visits was carried out with flight traps. There were permanent trapping stations placed across the wood, pitfall traps and flight interception traps. Each trapping station consisted of five pitfall traps and a single flight interception trap. For the walkover surveying sweep-netting, beating, hand-searching and direct observation techniques were used.
Pitfall traps are mainly used for fast-moving, ground-active invertebrates. The traps were standard wide-mouthed glass jam-jars a 6 cm diameter opening and 9 cm depth. They were placed vertically in the ground with the opening at the ground level. The traps were placed in a line with three meters between each trap. The traps were marked so they were easy to find. The traps were only opened during the sampling visits. In between these visits they were placed upside-down, so no invertebrates were trapped.
The flight interception traps were made from four 2l plastic bottles with the bases screwed on a wooden base. In the sides of the drinking bottles, cut windows were facing outwards. Then the wooden base was hung on a horizontal branch, about 1-1.5 m above the ground, using baler twine. So the bottles were hanging upside-down. The bottles were filled with a preservative solution: commercial antifreeze 50/50 with tap-water, plus a little washing up liquid to reduce surface tension. These traps were used to operate between the sampling visits. The captured invertebrates were killed and preserved in the solution.
Suction sampling works with a machine and is more expensive than the other sampling techniques. The suction sampling took place in May, for each trapping station there were five suction sessions.
For hand-searching methods see previous research, Alexander (2014).
Specimens that could not be determined in the field were taken for later identification (with a microscope).

➢ The guidelines of Rohr *et al*. (2007) propose three steps for developing a monitoring plan.
- Characterizing the community (inventory): obtaining baseline data of the invertebrates in the area by means of surveys.
- Identifying valid surrogates for biodiversity. Complete species enumeration is often impractical. Data from the first step are used to identify surrogates. The riches of one group can predict the riches of another. Surrogates can be used as indicators of environmental changes.
- Establishing efficient methods to monitor the surrogates. Identifying specimens can be more time consuming (and more expensive) than collecting. So, it is important to identify methods that collect mostly surrogates.

In the case study there were 16 plots (each 20 x 20 m) placed in each forest. They were placed at both sides of a stream: 10 m from its edge and 25 m space between the plots.
Sampling methods are described from another study in the same forest: Mahan *et al*. (2004). This is because the study of Rohr *et al*. (2007) only briefly described the sampling methodology. 11 collecting methods were used, which are described below (Mahan *et al*. 2004).
- Beating sheet: beating vegetation, see what falls on the sheet. This was done on five randomly chosen spots within the sampling plots.
- Branch clipping: cutting foliage bearing branches of 0.5 m length; before cutting the branches were enclosed with a 60 L plastic bag. Per sampling plot two overstory trees

were chosen, from which three branches were cut. Samples were taken in the upper and lower canopy.
- Canopy malaise trap: per plot two traps were placed. One in upper-canopy and another in mid-canopy, placed in two different trees (at least 5 m apart).
- Ground malaise trap: two traps were placed per plot. These malaise traps (canopy and ground) were placed for four days and were checked daily.
- Leaf litter: collecting leaf litter from the ground within a 0.25 x 0.25 m quadrant. Five leaf litter samples were taken per sampling plot.
- Light traps: placing traps with a 10-watt blacklight. One trap per plot for one night.
- Pitfall traps: placing six traps per trapping station with at least 10 m between each trap. They were made from drinking cups with the top at the ground level. In the cups 1-2 cm table salt covered with water was done as preservative. The traps were placed for four days and were checked daily. There were five trapping station randomly placed in the forest.
- Soil cores: five soil core samples were made per sampling plot. The samples are 5 cm in diameter and 2-5 cm deep.
- Substrate searches: turning logs and rocks in each sampling plot collecting all invertebrates that were encountered.
- Sweeping: five sweep samples per plot were taken to inventory invertebrates on herbaceous vegetation. One sweep sample consists of ten sweeps (one sweep at each step).
- Trunk traps: these traps were placed at five trees in each sampling plot. Trunk traps were placed four days and were checked daily.

3.5.2.3 **Results**

- In the monitoring of Alexander (2014) seven Nationally Scarce species were found. Four of these species are characteristic of Caledonian pine forest. None of the rarer species known from SSSI could be found. Older pines in the open are encroached by young pines. The young pines will not generate a good pine habitat, there is an uneven thinning introduced as soon as possible. Management recommendations are haloing individual veteran pine trees to create open spaces (sunny areas for insects) and the competition from the younger pine is eliminated. The forest needs some thinning areas favorable for invertebrates and creating some good pine tree conditions. The area needs low intensity grazing by large herbivores, which will create pine of diverse age structures and allow some trees to develop in the open.

- In the survey of Alexander (2011) a total of 825 invertebrate species were identified. The taxonomic groups that were investigated were: Mollusca (snails & slugs), Chilopoda (centipedes), Diplopoda (millipedes), Isopoda (woodlice), Araneae (spiders), Opiliones (harvestmen), Pseudoscorpiones (false scorpions), Thysanura (bristletails), Dermaptera (earwigs), Psocoptera (barkflies), Heteroptera (shieldbugs, plant bugs, etc), Neuroptera (lacewings), Butterflies, Larger moths, Microlepidoptera, Diptera (true flies), Aculeata (ants, bees & wasps) and Coleoptera (beetles). There is a rich fauna of beetles, two-winged flies, moths, barkflies and bugs, and at the woodland edge butterflies.
  The most notable assemblages are:
  - Wood decay: 112 invertebrate species (or 18%) of the total Irish saproxylic fauna was found. Old standard trees have support other saproxylic species than coppiced trees and shrubs.
  - Canopy of trees and shrubs are rich in beetles, bugs, moths and spiders.
  - 116 species were found on the ground layer.

  The impacts of cuttings are:
  - Increasing the abundance of saproxylic species in those parts of the wood.

- Favouring epiphyte species, because the light levels are increased in the wood. Invertebrates from the edges of the woodland can move to the inner woodland parts.
- Increasing the shade-demanding species, these invertebrates can tolerate temporary openings in the canopy.
- Creating a range of ground and flower-visiting insects.

In Table 1 the searching techniques which detected the most significant invertebrates can be found. The most productive techniques were hand-searching and using nets for sweeping and beating. But these techniques are difficult to quantify the species as they cannot be repeated in a standard way. Trapping techniques provide more objective data. Pitfall traps resulted in a low detection of significant species.

Key species	Hand search	Sweep net	Beating	Flight trap	Pitfall trap	Suction sampler
English Chrysalis Snail						+
Ash-black Slug	+					
Brown Snail	+	+	+			
Fungus gnats				+		
Canopy weevils		+	+			
Wood-decay beetles	+			+		
Bees	+					
Canopy spiders		+	+			
Barkflies	+	+	+			

Table 1: Sampling techniques revealing the more notable invertebrates (Alexander, 2011)

- In the study of Rohr *et al*. (2007) 8636 arthropods were collected. Specimens were identified up to family level. Genus and species were not identified mainly due to a lack of taxonomic specialists. In Table 2 shows the results of the different sampling methods. Number of specimens doesn't indicate the species but the total of arthropods found with this method.

Collection method	Strata	Samples/forest type	No. of specimens	No. of families
Beating sheet	Understory	5	202	47
Lower branch clip	Understory	6	50	19
Upper branch clip	Canopy	6	58	22
Canopy malaise trap	Canopy	2	75	25
Ground malaise trap	Understory	6	2601	81
Leaf-litter	Soil	15	3005	71
Pitfall traps	Soil	11	455	48
Soil cores	Soil	15	1365	37
Substrate searches	Soil	10	210	27
Sweeping	Understory	3	150	39
Tree trunk trap	Understory	5	465	54
Total		84	8636	167

Table 2: Statistics of the case study of Rohr et al. (2007)

4 Materials and methods

4.1 Materials

4.1.1 Materials for fieldwork

- GPS to fix the coordinates of the yew trees and trapping stations. GPS: Garmin GPSMAP 62st. Accuracy under tree canopy is 10 m.
- Compass to fix wind direction of lichen growth on trunk.
- Pitfall traps for catching invertebrates. One pitfall trap consists of two drinking cups with a diameter of 7 cm.
- Trowel for pitfalls.
- Chicken wire to cover the pitfall traps. This keeps other animals out and prevents large objects falling in.
- Flight interception traps for catching invertebrates.
- Cool Flow NTP (non-toxic, based on propylene glycol) for trapping solution. This product is not toxic for vertebrates.
- Water to mix with the Cool Flow (50/50).
- Ethyl acetate for taking invertebrates from active search. One drop on a piece of paper in a sampling tube kills the invertebrates quickly.
- Sample bags for lichens.
- Sample tubes for invertebrates.
- Checklist to fill in when taking samples (see appendix VII and VIII).
- Small knife for taking lichen samples.
- Camera for pictures of the examined trees and trapping station.

4.1.2 Materials for identifying

- Identification books for lichens and for invertebrates.
    - Lichens: an Illustrated Guide to the British and Irish Species
    - Invertebrates: Insects of Britain and Western Europe
- Hand lens (x 10 magnification).
- Microscope (x 20, x 30, x 40, x 60 magnification).
- Small dropper bottles with bleach (C) and potassium hydroxide (K) for chemical spot tests on lichens.
- 70% alcohol and 30% water for preserving invertebrates.

The purposes and use of most of these materials are explained in more detail during chapter 4.2.2 Sampling and Identifying.

4.2 Methods
4.2.1 Sampling locations
4.2.1.1 Lichens

Norton (2012) (see 3.3 Yew trees in Kingley Vale) used grid locations to map the biggest yew trees with the largest girth ranges. Most of these trees are close to each other (see Figure 8, pg. 18).
Sampling locations were at young and old sites of the woodland. The trees were randomly chosen in mixed woodland areas (see explanation for mixed woodland below 4.2.1.2 Invertebrates). At the older site, trees on the nature trail were not examined because the bark is often disturbed by passers-by. The locations of the examined trees can be seen on Figure 20. Coordinates can be found in chapter 5.1 Lichens.

Figure 20: Examined trees for lichens locations (Google Earth)

4.2.1.2 Invertebrates

Norton (2012) (see 3.3 Yew trees in Kingley Vale) used grid locations to map the yew trees with the largest girth ranges. Most of these trees are close to each other, a trapping station was set in this area (see Figure 8, pg. 18).
Two trapping stations were placed: one in the area with the older yew and one with the younger yew. All the old yew trees stood in a mixed woodland with i.e. oak and ash. There was a pure, young yew woodland, but no trapping station was set in there because it would not be a good comparison with the older yew in the mixed woodland. That is why the two trapping stations were set in an area with mixed woodland. On Figure 21 the location of the trapping stations can be seen on a map. Coordinates can be found in chapter 5.2 Invertebrates.

Figure 21: Trapping stations locations (Google Earth)

4.2.2 Sampling and Identifying

4.2.2.1 Lichens

Yews with a girth above 2.5 m (see 3.3 Yew trees in Kingley Vale) were examined as old (veteran) trees. Girths were measured above the roots (normally 30 – 50 cm above ground level). All other yew were listed as young trees. There were as many old trees as young trees examined to obtain a good comparison of the species that occur on the young and old trees. All sample trees were listed individually, each with their specific lichen species. Examined living yew trees stood at least 5 m away from each other. Only living yew trees were examined, but if dead wood appeared on these trunks, this was also examined. The trunks on the yews were examined to a maximum height of 1.80 m. The abundancy of the lichens was measured with a plot of 10x10 cm. An estimation of the percentage of the most dense area on the tree trunk was used to estimate the abundancy within the plot. This most dense area was the only spot used to look at the wind direction for the lichen growth. It could be that they grew all around the trunk, but this was not noted.
All collected lichens were placed in an individual sample bag. On each bag a code for the lichen sample was written, e.g. O4L2 was the fourth examined old tree and the second sample taken from that tree. On a survey table the girth trunk, the lichen code, the abundancy and the position on the trunk were written down. Appendix VII shows the survey table for the lichens.
Lichens were identified with the book: 'Lichens: An Illustrated Guide to the British and Irish species' (Dobson, 2005).
Other species were identified by specialists that have been contacted. On the Facebook group 'Lichens connecting people!' you find lichenologists that helped.

4.2.2.2 **Invertebrates**

For sampling the invertebrates stations were used. These consisted of five pitfall traps and one flight interception trap. Each trapping station had five pitfall traps and one flight interception trap. The pitfalls were placed as was done in the study of Rohr *et al*. (2007), but instead of 10 m in between the traps, the traps were placed at intervals of 1 m. Two drinking cups were placed one into the other, which made it easier to empty and replace the cups. The top of the cups had a diameter of 7 cm. The pitfalls were covered with chicken wire to prevent other animals disturbing the traps (see Figure 23). One professional flight interception trap was installed and was moved between the stations each week (see Figure 22). All traps were checked weekly.
In the traps a solution captured the invertebrates: 50% Cool Flow and 50% water. The solution must be propylene based because this is non-toxic to vertebrates. The traps were filled for about 1/4 to 1/3. Ethylene based products are mostly found, but these are toxic to vertebrates. Near these trapping stations an active search for invertebrates was performed. Therefore a search on and under all kinds of substrates and sweeping was performed. Once per week, when the trapping stations were checked, an active search was done. Every active search took about 10 minutes. Living invertebrates were placed in a specimen tube with a drop of ethyl acetate on a piece of paper. This ensured they died quickly. Eventually after 24 hours the invertebrates could be placed in the preserving solution (70% alcohol) for later determination.
Collected invertebrates were placed on a paper sheet and were sorted by similar appearance (taxonomic groups), e.g. all woodlice species were placed in a sample tube with a code. E.g. OPT3 was the third group of invertebrates that was collected on the old site. These codes were written down on a survey table. Other abbreviations used were: Y (Young site), AS (Active Search), FIT (Flight Interception Trap). For the active search only a few of each species were collected for identification, the rest of the same species was counted. Appendix VIII shows the survey table for the invertebrates. During the identification the invertebrates were counted. Unidentified species were kept aside.

Figure 22: Flight interception trap

Most of the species were identified with the book: 'Insects of Britain and Western Europe' (Chinery, 1993).
Spiders were identified using the book: 'Spiders of Britain and Northern Europe' (Roberts, 1996).
Other species were identified by specialists that have been contacted.

Figure 23: Pitfall with chicken wire

5 Results

5.1 Lichens

5.1.1 Old stand

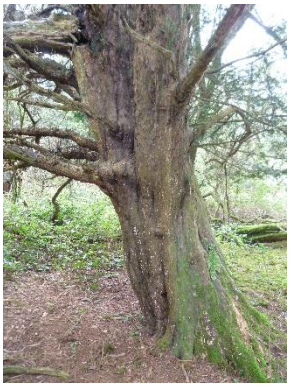
Tree coordinates:	**50°53'3.63"N 0°49'48.17"W**
Location:	Kingley Vale
Sampling date:	02/04/2015
Young/old yew:	Old
Code on map:	O1
Girth trunk:	4.85 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	15%	X			
Opegrapha sp.	25%		X		
Pertusaria flavida	30%		X		

Tree coordinates:	**50°53'4.07"N 0°49'47.24"W**
Location:	Kingley Vale
Sampling date:	02/04/2015
Young/old yew:	Old
Code on map:	O2
Girth trunk:	3.10 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	70%			X	
Opegrapha sp.	10%		X		
Pertusaria flavida	60%		X		
Pertusaria sp.	55%		X		

Tree coordinates:	**50°53'5.38"N 0°49'46.44"W**
Location:	Kingley Vale
Sampling date:	02/04/2015
Young/old yew:	Old
Code on map:	O3
Girth trunk:	3.15 m



		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	< 5%	X			

Tree coordinates:	**50°53'9.33"N 0°49'48.31"W**
Location:	Kingley Vale
Sampling date:	02/04/2015
Young/old yew:	Old
Code on map:	O4
Girth trunk:	2.90 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
No lichens					

Tree coordinates:	**50°53'11.33"N 0°49'48.26"W**
Location:	Kingley Vale
Sampling date:	02/04/2015
Young/old yew:	Old
Code on map:	O5
Girth trunk:	2.70 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
No lichens					

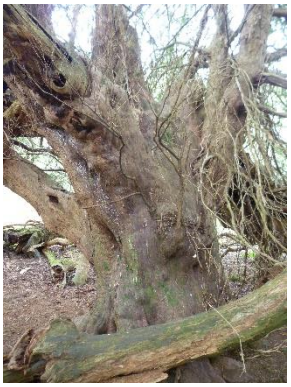
Tree coordinates:	**50°53'13.13"N 0°49'54.18"W**
Location:	Kingley Vale
Sampling date:	02/04/2015
Young/old yew:	Old
Code on map:	O6
Girth trunk:	5.25 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Fellhanera ochracea	30%			X	
Lepraria incana	70%			X	
Pertusaria flavida	15%		X		
Pertusaria sp.	< 5%			X	

Tree coordinates:	**50°53'14.70"N 0°49'55.73"W**
Location:	Kingley Vale
Sampling date:	02/04/2015
Young/old yew:	Old
Code on map:	O7
Girth trunk:	5.80 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Fellhanera ochracea	50%			X	
Lepraria incana	70%				X
Pertusaria amara	90%		X		
Pertusaria flavida	45%			X	

Tree coordinates:	**50°53'15.29"N 0°49'54.13"W**
Location:	Kingley Vale
Sampling date:	13/04/2015
Young/old yew:	Old
Code on map:	O8
Girth trunk:	4.05 m

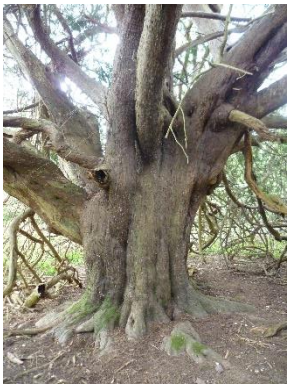


		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	30%	X			
Opegrapha sp.	90%				X
Pertusaria amara	20%				X
Pertusaria flavida	40%	X			

Tree coordinates:	**50°53'15.86"N 0°49'54.51"W**
Location:	Kingley Vale
Sampling date:	13/04/2015
Young/old yew:	Old
Code on map:	O9
Girth trunk:	4.30 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Pertusaria amara	15%	X			
Pertusaria flavida	30%			X	
Pertusaria sp.	10%				X

Tree coordinates:	**50°53'14.76"N 0°49'50.96"W**
Location:	Kingley Vale
Sampling date:	28/04/2015
Young/old yew:	Old
Code on map:	O10
Girth trunk:	4.55 m



		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Opegrapha sp.	30%	X			
Pertusaria amara	20%			X	

Tree coordinates:	**50°53'17.13"N 0°49'53.91"W**
Location:	Kingley Vale
Sampling date:	28/04/2015
Young/old yew:	Old
Code on map:	O11
Girth trunk:	5.90 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lecanora expallens	80%		X		
Lepraria incana	<5%			X	
Opegrapha sp.	40%			X	
Pertusaria amara	5%			X	
Pertusaria flavida	35%				X
Pertusaria sp.	15%			X	

Tree coordinates:	**50°53'17.22"N 0°49'55.65"W**
Location:	Kingley Vale
Sampling date:	28/04/2015
Young/old yew:	Old
Code on map:	O12
Girth trunk:	4.65 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lecanora expallens	15%	X			
Lepraria incana	30%				X
Opegrapha sp.	25%			X	
Pertusaria amara	10%		X		
Pertusaria sp.	<5%	X			

Tree coordinates:	**50°53'17.92"N 0°49'54.09"W**
Location:	Kingley Vale
Sampling date:	28/04/2015
Young/old yew:	Old
Code on map:	O13
Girth trunk:	6.40 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	<5%			X	
Pertusaria flavida	20%		X		

Tree coordinates:	**50°53'15.39"N 0°49'56.71"W**
Location:	Kingley Vale
Sampling date:	28/04/2015
Young/old yew:	Old
Code on map:	O14
Girth trunk:	4.50 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lecanora expallens	15%			X	
Lepraria incana	30%			X	
Opegrapha sp.	20%				X
Pertusaria amara	100%				X

Tree coordinates:	**50°53'13.57"N 0°49'53.28"W**
Location:	Kingley Vale
Sampling date:	28/04/2015
Young/old yew:	Old
Code on map:	O15
Girth trunk:	4.35 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	50%				X
Opegrapha sp.	15%		X		
Pertusaria flavida	30%				X

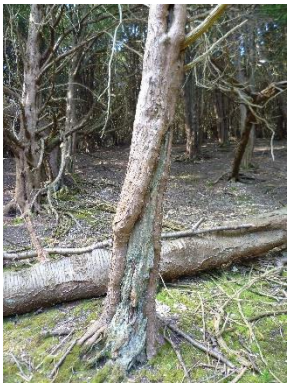
5.1.2 Young stand

Tree coordinates:	**50°53'2.83"N 0°49'56.59"W**				
Location:	Kingley Vale				
Sampling date:	08/04/2015				
Young/old yew:	Young				
Code on map:	Y1				
Girth trunk:	1.75 m				
		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	40%		X		

Tree coordinates:	**50°53'3.97"N 0°49'56.86"W**				
Location:	Kingley Vale				
Sampling date:	08/04/2015				
Young/old yew:	Young				
Code on map:	Y2				
Girth trunk:	2.30 m				
		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
No lichens					

Tree coordinates:	**50°53'6.26"N 0°49'58.83"W**				
Location:	Kingley Vale				
Sampling date:	08/04/2015				
Young/old yew:	Young				
Code on map:	Y3				
Girth trunk:	1.90 m				
		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	60%	X			

Tree coordinates:	**50°53'7.48"N 0°50'0.96"W**
Location:	Kingley Vale
Sampling date:	08/04/2015
Young/old yew:	Young
Code on map:	Y4
Girth trunk:	1.00 m



		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	70%		X		

Tree coordinates:	**50°53'9.96"N 0°50'3.22"W**
Location:	Kingley Vale
Sampling date:	08/04/2015
Young/old yew:	Young
Code on map:	Y5
Girth trunk:	1.05 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	< 5%		X		

Tree coordinates:	**50°53'12.29"N 0°50'6.84"W**
Location:	Kingley Vale
Sampling date:	08/04/2015
Young/old yew:	Youngs
Code on map:	Y6
Girth trunk:	1.50 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	5%			X	

Tree coordinates:	**50°53'12.71"N 0°50'9.37"W**
Location:	Kingley Vale
Sampling date:	08/04/2015
Young/old yew:	Young
Code on map:	Y7
Girth trunk:	1.20 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	10%			X	

Tree coordinates:	**50°53'15.84"N 0°50'13.25"W**
Location:	Kingley Vale
Sampling date:	08/04/2015
Young/old yew:	Young
Code on map:	Y8
Girth trunk:	1.30 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	50%		X		

Tree coordinates:	**50°53'17.98"N 0°50'12.47"W**
Location:	Kingley Vale
Sampling date:	08/04/2015
Young/old yew:	Young
Code on map:	Y9
Girth trunk:	1.40 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lecanora expallens	15%		X		
Lepraria incana	40%			X	

Tree coordinates:	**50°53'16.98"N 0°50'10.25"W**
Location:	Kingley Vale
Sampling date:	08/04/2015
Young/old yew:	Young
Code on map:	Y10
Girth trunk:	1.95 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	40%			X	
Pertusaria sp.	< 5%			X	

Tree coordinates:	**50°53'20.72"N 0°50'10.72"W**
Location:	Kingley Vale
Sampling date:	01/05/2015
Young/old yew:	Young
Code on map:	Y11
Girth trunk:	1.86 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	20%			X	

Tree coordinates:	**50°53'21.51"N 0°50'12.87"W**
Location:	Kingley Vale
Sampling date:	01/05/2015
Young/old yew:	Young
Code on map:	Y12
Girth trunk:	2.18 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lecanora expallens	100%			X	
Opegrapha sp.	<5%	X			
Pertusaria sp.	10%		X		

Tree coordinates:	**50°53'23.90"N 0°50'11.82"W**
Location:	Kingley Vale
Sampling date:	01/05/2015
Young/old yew:	Young
Code on map:	Y13
Girth trunk:	1.77 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	40%			X	
Pertusaria flavida	10%	X			

Tree coordinates:	**50°53'25.83"N 0°50'11.40"W**
Location:	Kingley Vale
Sampling date:	01/05/2015
Young/old yew:	Young
Code on map:	Y14
Girth trunk:	1.58 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Lepraria incana	15%			X	

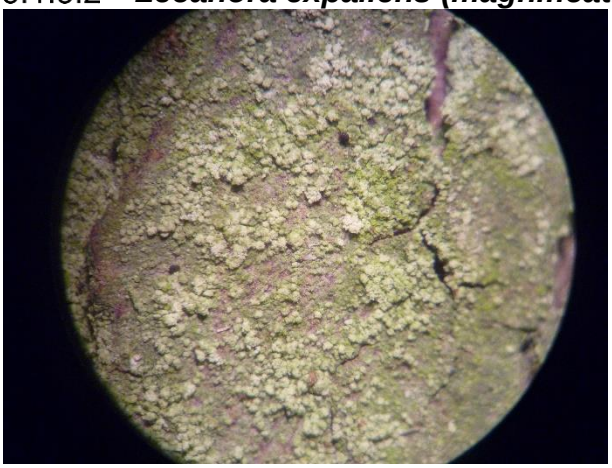
Tree coordinates:	**50°53'27.09"N 0°50'11.31"W**
Location:	Kingley Vale
Sampling date:	01/05/2015
Young/old yew:	Young
Code on map:	Y15
Girth trunk:	1.52 m

		Position on tree			
Species found	**Abundancy**	**Nord**	**East**	**South**	**West**
Fellhanera ochracea	60%			X	
Lepraria incana	5%			X	

5.1.3 Description lichens

5.1.3.1 *Fellhanera ochracea*[1] *(magnification 60x)*

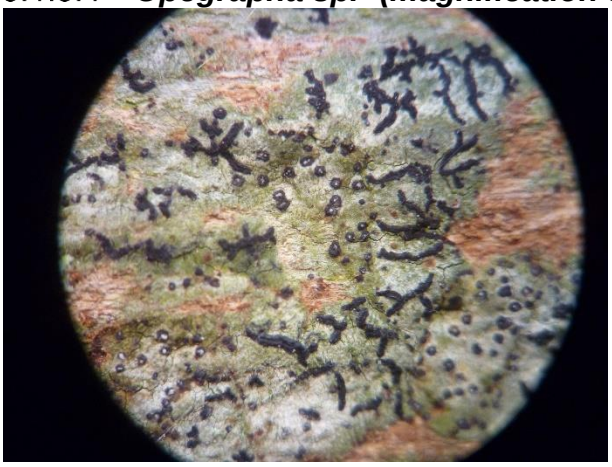
5.1.3.2 *Lecanora expallens (magnification 30x)*



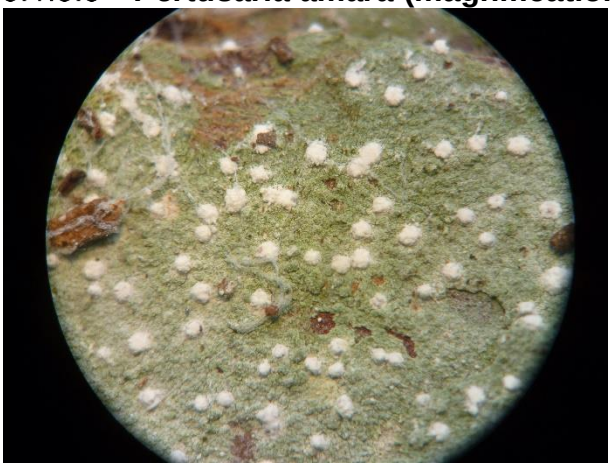
5.1.3.3 *Lepraria incana (magnification 30x)*

[1] Nationally Rare. Includes Red Listed taxa

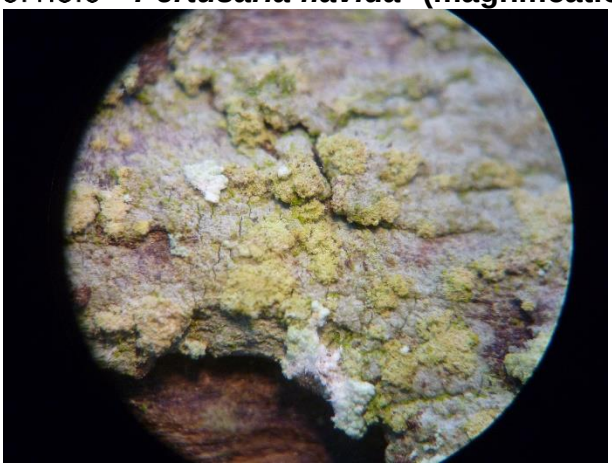
5.1.3.4 *Opegrapha sp.*[1] *(magnification 30x)*



5.1.3.5 *Pertusaria amara* (magnification 30x)

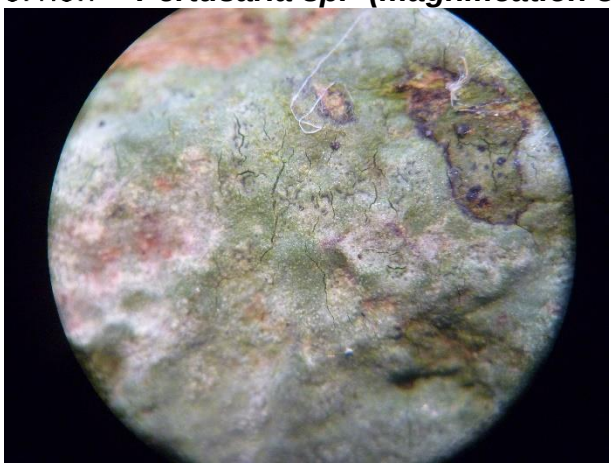


5.1.3.6 *Pertusaria flavida*[2] (magnification 30x)



[1] Species unsure: could be *Opegrapha prosodea*, *O. atra* or *O. vulgata*.
[2] Species unsure

5.1.3.7 *Pertusaria sp.[1] (magnification 30x)*



[1] Species unsure, because lichen was in young life stage.

5.2 Invertebrates

5.2.1 Old stand

Figure 24: View on trapping station at old site

Trapping station coordinates: 50°53'8.52"N 0°49'47.27"W

Location:	Kingley Vale		
Code on map:	TS1		
Date:	15/04/2015		
	Numbers found with		
Species found	**Pitfall traps**	**Active search**	**Flight interception trap**
Arachnida	**2**	**1**	
Amaurobius ferox		1	
Eutrombidium rostratus	1		
Tenebrio molitor	1		
Chilopoda	**2**		
Lithobius forficatus	2		
Clitellata	**6**		

Lumbricus rubellus	6		
Diplopoda	**6**		
Cylindroiulus punctatus	3		
Glomeris marginata	3		
Gastropoda	**2**	**4**	
Deroceras reticulatum	2	1	
Helix aspersa		3	
Insecta	**76**	**1**	**7**
Agonum gracilipes	5		
Empididae[1]			3
Helophorus brevipalpis	3		
Nebria brevicollis	17	1	
Orchesella villosa[2]	26		
Othius punctulatus	1		
Philonthus decorus	1		
Pterostichus melanarius	1		
Tipulidae[3]			1
Trypodendron domesticum			3
Larvae staphylinidae	21		
Larvae carabidae	1		
Malacostraca	**45**	**17**	
Oniscus asellus		5	
Philoscia muscorum	8		
Porcellio scaber	37	12	

[1] Species not identified
[2] An estimation of the amount of springtails was made during the active search.
[3] Species not identified

Date:	23/04/2015		
	Numbers found with		
Species found	Pitfall traps	Active search	Flight interception trap
Arachnida	**4**		
Amaurobius ferox	1		
Leiobunum rotundum	3		
Chilopoda			
Clitellata	**3**		
Lumbricus rubellus	3		
Diplopoda	**7**	**1**	
Cylindroiulus punctatus	2	1	
Tachypodoiulus niger	5		
Gastropoda		**1**	
Aegopinella nitidula		1	
Insecta	**97**		
Abax parallelepipedus	1		
Agonum gracilipes	7		
Calliphora vicina	1		
Empididae[1]	6		
Nebria brevicollis	25		
Orchesella villosa	38		
Philonthus decorus	1		
Pterostichus melanarius	2		
Quedius curtipennis	1		
Suillia variegata	1		
Larvae staphylinidae	13		
Larvae carabidae	1		

[1] Species not identified

Malacostraca	**78**	**46**
Oniscus asellus	2	16
Philoscia muscorum	8	
Porcellio scaber	68	30

Date:	29/04/2015		
	Numbers found with		
Species found	**Pitfall traps**	**Active search**	**Flight interception trap**
Arachnida	**1**	**4**	
Amaurobius ferox		4	
Leiobunum rotundum	1		
Chilopoda		**2**	
Lithobius forficatus		2	
Clitellata	**9**		
Lumbricus rubellus	9		
Diplopoda	**2**	**2**	
Cylindroiulus punctatus		1	
Polydesmus angustus		1	
Tachypodoiulus niger	2		
Gastropoda		**1**	
Limax maximus		1	
Insecta	**45**	**11**	
Abax parallelepipedus	1		
Forficula auricularia		1	
Nebria brevicollis	8		
Orchesella villosa[1]	24	10	
Othius punctulatus	2		
Larvae staphylinidae	8		

[1] An estimation of the amount of springtails was made during the active search.

Larvae tipulidae	2	
Malacostraca	**15**	**29**
Armadillidium vulgare		1
Oniscus asellus	1	7
Philoscia muscorum		2
Porcellio scaber	14	19

Date:	06/04/2015		
	Numbers found with		
Species found	**Pitfall traps**	**Active search**	**Flight interception trap**
Arachnida	**4**	**1**	
Amaurobius ferox	2	1	
Leiobunum rotundum	2		
Chilopoda	**1**	**7**	
Lithobius forficatus	1	7	
Clitellata	**4**		
Lumbricus rubellus	4		
Diplopoda	**14**	**3**	
Cylindroiulus punctatus		3	
Glomeris marginata	4		
Polydesmus angustus	2		
Tachypodoiulus niger	8		
Gastropoda	**2**	**5**	
Aegopinella nitidula	1	3	
Arion hortensis	1	1	
Limax maximus		1	
Insecta	**50**		**1**
Abax parallelepipedus	3		
Agonum gracilipes	5		

Nebria brevicollis	11		
Notiophilus palustris	1		
Orchesella villosa[1]	16		
Othius punctulatus	4		
Philonthus decorus	2		
Pterostichus melanarius	2		
Quedius curtipennis	1		
Tipulidae[2]			1
Larvae staphylinidae	5		
Malacostraca	**25**	**59**	**4**
Armadillidium vulgare	1		
Oniscus asellus	1	23	
Philoscia muscorum	7	3	
Porcellio scaber	16	33	4

[1] An estimation of the amount of springtails was made during the active search.
[2] Species not identified

5.2.2 Young stand

Figure 25: View on trapping station at young site

Trapping station coordinates: 50°53'3.76"N 0°49'57.31"W

Location:	Kingley Vale		
Code on map:	TS2		
Date:	15/04/2015		
	Numbers found with		
Species found	**Pitfall traps**	**Active search**	**Flight interception trap**
Arachnida	**8**	**2**	
Amaurobius ferox	4		
Damaeus onustus[1]	1		
Eutrombidium rostratus	1	2	
Leiobunum rotundum	1		
Tegenaria silvestris	1		
Chilopoda	**1**	**1**	

[1] Species not certain, it is of the family *Damaeidae*.

Lithobius forficatus	1	1
Clitellata	**7**	
Lumbricus rubellus	7	
Diplopoda	**25**	**6**
Cylindroiulus punctatus	1	1
Glomeris marginata	2	
Polydesmus angustus		1
Tachypodoiulus niger	22	4
Gastropoda	**1**	**3**
Aegopinella nitidula		1
Deroceras reticulatum	1	1
Pomatias elegans[1]		1
Insecta	**10**	**1**
Forficula auricularia	2	
Nebria brevicollis	2	
Philonthus decorus	2	
Phosphuga atrata		1
Quedius curtipennis	4	
Malacostraca	**99**	**17**
Armadillidium vulgare	48	5
Philoscia muscorum	2	
Porcellio scaber	59	12

[1] Empty shell: meaning this could have been dropped by an animal (e.g. a bird).

Date:	23/04/2015		
	Numbers found with		
Species found	Pitfall traps	Active search	Flight interception trap
Arachnida			
Chilopoda			
Clitellata			
Diplopoda	**31**	**3**	
Cylindroiulus punctatus		2	
Glomeris marginata	3		
Polydesmus angustus	5		
Tachypodoiulus niger	23	1	
Gastropoda		**2**	
Aegopinella nitidula		2	
Insecta	**21**	**15**	**2**
Bombus lapidarius	2		
Bombus terrestris	6		
Nebria brevicollis	5		
Orchesella villosa[1]	5	15	
Otiorhynchus singularis	1		
Philonthus decorus	1		
Pterostichus melanarius	1		
Tipulidae[2]			2
Malacostraca	**332**	**10**	
Armadillidium vulgare	78		
Oniscus asellus	3		
Philoscia muscorum	6		
Porcellio scaber	245	10	

[1] An estimation of the amount of springtails was made during the active search.
[2] Species not identified

Date:	29/04/2015		
	Numbers found with		
Species found	Pitfall traps	Active search	Flight interception trap
Arachnida	**7**		
Amaurobius ferox	6		
Leiobunum rotundum	1		
Chilopoda		**2**	
Lithobius forficatus		2	
Clitellata	**9**		
Lumbricus rubellus	9		
Diplopoda	**15**	**4**	
Cylindroiulus punctatus		1	
Glomeris marginata	5	2	
Polydesmus angustus	1	1	
Tachypodoiulus niger	9		
Gastropoda	**2**	**1**	
Aegopinella nitidula		1	
Discus rotundatus	1		
Pomatias elegans	1		
Insecta	**34**	**10**	
Abax parallelepipedus	1		
Agonum gracilipes	1		
Amara aenea	1		
Bombus terrestris	1		
Dromius agilis	1		
Forficula auricularia	4		
Nebria brevicollis	3		
Orchesella villosa[1]	15	10	

[1] An estimation of the amount of springtails was made during the active search.

Othius punctulatus	2		
Pterostichus melanarius	1		
Quedius curtipennis	1		
Larvae carabidae	1		
Larvae staphylinidae	1		
Larvae tipulidae	1		
Malacostraca	**483**	**35**	**4**
Armadillidium vulgare	164	3	
Oniscus asellus	2	1	
Philoscia muscorum	5	5	
Porcellio scaber	312	26	4

Date:	06/04/2015		
	Numbers found with		
Species found	**Pitfall traps**	**Active search**	**Flight interception trap**
Arachnida	**8**		
Damaeus onustus[1]	2		
Leiobunum rotundum	6		
Chilopoda	**1**	**1**	
Lithobius forficatus	1	1	
Clitellata	**19**		
Lumbricus rubellus	19		
Diplopoda	**26**	**14**	
Cylindroiulus punctatus	1	4	
Glomeris marginata	12	3	
Polydesmus angustus	6		
Tachypodoiulus niger	7	7	

[1] Species not certain, it is of the family *Damaeidae*.

Gastropoda	**11**	**5**
Aegopinella nitidula	2	3
Arion hortensis	1	
Deroceras reticulatum	2	2
Helix aspersa	1	
Merdigera obscura	1	
Pomatias elegans	4	
Insecta	**58**	
Abax parallelepipedus	1	
Agonum gracilipes	3	
Bombus lapidarius	1	
Empididae[1]	1	
Forficula auricularia	2	
Halyzia sedecimguttata	1	
Kyklioacalles roboris	1	
Nebria brevicollis	7	
Notiophilus palustris	2	
Orchesella villosa	28	
Othius punctulatus	2	
Philonthus decorus	1	
Pterostichus melanarius	4	
Larvae staphylinidae	2	
Larvae tipulidae	2	
Malacostraca	**724**	**37**
Armadillidium vulgare	376	6
Oniscus asellus	4	6
Philoscia muscorum	6	
Porcellio scaber	338	25

[1] Species not identified

5.2.3 Description invertebrates

5.2.3.1 Arachnida (arachnids)

5.2.3.1.1 Amaurobius ferox

http://srs.britishspiders.org.uk/portal/p/Welcome

5.2.3.1.2 Damaeus onustus (magnification 60x)

5.2.3.1.3 Eutrombidium rostratus (magnification 30x)

5.2.3.1.4 ***Leiobunum rotundum***

http://srs.britishspiders.org.uk/portal/p/Welcome

5.2.3.1.5 ***Tegenaria silvestris***

http://srs.britishspiders.org.uk/portal/p/Welcome

5.2.3.2 Chilopoda (centipedes)

5.2.3.2.1 ***Lithobius forficatus***

http://eol.org/

5.2.3.3 Clitellata (annelid worms)

5.2.3.3.1 Lumbricus rubellus

http://eol.org/

5.2.3.4 Diplopoda (millipedes)

5.2.3.4.1 Cylindroiulus punctatus

http://eol.org/

5.2.3.4.2 Glomeris marginata

http://eol.org/

5.2.3.4.3 ***Polydesmus angustus***

http://eol.org/

5.2.3.4.4 ***Tachypodoiulus niger***

http://eol.org/

5.2.3.5 **Gastropoda (snails & slugs)**

5.2.3.5.1 ***Aegopinella nitidula***

http://eol.org/

5.2.3.5.2 ***Arion hortensis***

http://eol.org/

5.2.3.5.3 ***Deroceras reticulatum***

http://eol.org/

5.2.3.5.4 ***Discus rotundatus***

http://eol.org/

5.2.3.5.5 ***Helix aspersa***

http://eol.org/

5.2.3.5.6 ***Limax maximus***

http://eol.org/

*5.2.3.5.7 **Merdigera obscura***

http://www.mollbase.org/list/

*5.2.3.5.8 **Pomatias elegans***

http://eol.org/

5.2.3.6 **Insecta (insects)**

*5.2.3.6.1 **Abax parallelepipedus***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.2 ***Agonum gracilipes***[1]

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.3 ***Amara aenea***

http://www.colpolon.biol.uni.wroc.pl/index.htm

[1] Nationally Notable A

5.2.3.6.4 ***Bombus lapidarius***

http://eol.org/

5.2.3.6.5 ***Bombus terrestris***

http://eol.org/

5.2.3.6.6 ***Calliphora vicina***

http://eol.org/

5.2.3.6.7 ***Dromius agilis***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.8 ***Forficula auricularia***

http://eol.org/

5.2.3.6.9 ***Halyzia sedecimguttata***

http://eol.org/

5.2.3.6.10 ***Helophorus brevipalpis***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.11 ***Kyklioacalles roboris***[1]

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.12 ***Nebria brevicollis***

http://www.colpolon.biol.uni.wroc.pl/index.htm

[1] Nationally Notable B

5.2.3.6.13 ***Notiophilus palustris***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.14 ***Orchesella villosa (magnification 30x)***

5.2.3.6.15 ***Otiorhynchus singularis***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.16 ***Othius punctulatus***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.17 ***Philonthus decorus***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.18 ***Phosphuga atrata***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.19 ***Pterostychus melanarius***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.20 ***Quedius curtipennis***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.21 ***Suillia variegata***

http://eol.org/

5.2.3.6.22 ***Tenebrio molitor***

http://www.colpolon.biol.uni.wroc.pl/index.htm

5.2.3.6.23 **Trypodendron domesticum**

http://eol.org/

5.2.3.7 Malacostraca (woodlice)

5.2.3.7.1 Armadillidium vulgare

http://eol.org/

5.2.3.7.2 Oniscus asellus

http://eol.org/

5.2.3.7.3 Philoscia muscorum

http://eol.org/

5.2.3.7.4 ***Porcellio scaber***

http://eol.org/

6 Discussion and general conclusion

6.1 Lichens

The comparison between the old and the young yew trees gave a clear difference in result. Lichens in the ancient woodland are generally more abundant and more species were found on the oldest (biggest) yew trees. A few remarks must be made, however.

- Probably the most important remark is that there was no pure, ancient yew woodland available. Therefore a mixed young woodland was necessary for more or less similar circumstances. The ancient woodland was mixed with oak (*Quercus robur*) and the young woodland had a lot of ash trees (*Fraxinus excelsior*). Thanks to the mixed woodland there was more light under the canopy reaching the trunks than there was in pure, yew woodland.
- Due to the nature trail in the ancient woodland there are a lot of passers-by. This can have an influence on the lichen species, their density and their position on the trees, because the trees are often touched or climbed. So an attempt was made to only examine old yew trees that grew on less visited areas.
- Another element that could affect the lichens was that the young woodland grew on steep slopes whereas the ancient woodland was at the bottom of the slope. The influence of the wind and the light is different on both sites.
- There was only a small area with ancient woodland where the old yew trees grew close to each other. The young woodland covered a larger area, but was sometimes difficult the reach due to the steep slopes. There younger yew trees were examined that stood further away from each other than the older yew trees.
- The old yew trees generally contained some dead parts on their trunks. On the dead wood other lichen species were found. The lichens that were found on the dead wood could spread onto the living trunk, but they were less abundant there. Most young trees did not have dead wood on their trunks, which could be a reason for the difference in the result.

Other findings:
Due to the lack of knowledge about lichens I sometimes collected some fungi that looked a bit similar to lichens. E.g. *Amylostereum laevigatum* is a crust fungi that was often found on the yew trees. Because of these mistakes I examined some trees without any fungi on them. This is not a real problem because a nihil result is also a result eventually.
Two older trees that were examined had no lichens. These trees had a well-developed canopy around the trunk base and had no dead parts on the trunks. These trees can be found in 5.1.1 Old stand as O4 and O5. O5 was surrounded by other yew trees and had a denser shade than the other examined trees. This suggests that lichens don't thrive in a pure yew woodland. On the other hand there were a lot of fallen trees in the young yew woodland on the steep slope. These gaps in the woodland provide a good light source and some of the most common lichens can colonise these spots (e.g. *Lepraria incana*).

Despite these remarks this project will give a general view of the lichens that can grow on yew trees. My results prove that the ancient yew woodland contains more species and that they are more abundant than in the younger yew woodland. This increases the ecological value of ancient yew woodlands.

Table 3 shows the number of species that were found on each tree that was examined. It is clear that the diversity on the old trees is bigger than the one the young trees.

Tree number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Maximum**	**Average**
Old	3	4	1	0	0	4	4	4	3	2	6	5	2	4	3	6	3
Young	1	0	1	1	1	1	1	1	2	2	1	3	2	1	2	3	1

Table 3: Lichen species per tree number

In the tables below the abundancy of each lichen species on each tree can be found. The tables show the maximum abundancy and the average abundancy of each species. The column 'present on trees' shows how many of the 15 examined trees contained the species. Almost all lichen species were more abundant on the old trees, except for *Lecanora expallens* and *Lepraria incana*. There was a larger number of old trees supporting the lichens per species, except for *Lepraria incana*. The numbers are very variable. That was probably caused by the fact that it was mixed woodland and that the slope had many different effects on the trees.

Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Maximum	Average	Present on trees
Old	0%	0%	0%	0%	0%	30%	50%	0%	0%	0%	0%	0%	0%	0%	0%	50,00%	5%	2
Young	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	60%	60,00%	4%	1

Table 4: Abundancy of Fellhanera ochracea

Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Maximum	Average	Present on trees
Old	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	80%	15%	0%	15%	0%	80,00%	7%	3
Young	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	100%	0%	0%	0%	100,00%	8%	2

Table 5: Abundancy of Lecanora expallens

Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Maximum	Average	Present on trees
Old	15%	70%	5%	0%	0%	70%	70%	30%	0%	0%	5%	30%	5%	30%	50%	70,00%	25%	11
Young	40%	0%	60%	70%	5%	5%	10%	50%	40%	40%	20%	0%	40%	15%	5%	70,00%	27%	13

Table 6: Abundancy of Lepraria incana

Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Maximum	Average	Present on trees
Old	25%	10%	0%	0%	0%	0%	0%	90%	0%	30%	40%	25%	0%	20%	15%	90,00%	17%	8
Young	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	5,00%	0%	1

Table 7: Abundancy of Opegrapha sp.

Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Maximum	Average	Present on trees
Old	0%	0%	0%	0%	0%	0%	90%	20%	15%	20%	5%	10%	0%	100%	0%	100,00%	17%	7
Young	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0,00%	0%	0

Table 8: Abundancy of Pertusaria amara

Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Maximum	Average	Present on trees
Old	30%	60%	0%	0%	0%	15%	45%	40%	30%	0%	35%	0%	20%	0%	30%	60,00%	20%	9
Young	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	10,00%	1%	1

Table 9: Abundancy of Pertusaria flavida

Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Maximum	Average	Present on trees
Old	0%	55%	0%	0%	0%	5%	0%	0%	10%	0%	15%	5%	0%	0%	0%	55,00%	6%	5
Young	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	10%	0%	0%	0%	10,00%	1%	2

Table 10: Abundancy of Pertusaria sp.

The tables below show the position of each lichen species on each examined tree. The position was chosen by the most abundant spot on the trunk. So it is possible that some lichens were growing around the trunk of the examined tree, but this was not recorded during the survey. If nothing is filled in this means that there were no lichen on that tree. Most lichens were most abundant on the southern side of the trunk, which can be easily explained: lichens need light to develop. In total 27 lichens were most abundant on the southern side of the trunk. Moreover there were 15 lichens on the eastern side, 13 lichens on the northern side and 10 lichens on the western side.

Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	N	E	S	W
Old						S	S									0	0	2	0
Young															S	0	0	1	0

Table 11: Lichen position on tree of Fellhanera ochracea

Tree number	1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	N	E	S	W
Old											E	N		S		1	1	1	0
Young									E			S				0	1	1	0

Table 12: Lichen position on tree of Lecanora expallens

Tree number	1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	N	E	S	W
Old	N	S	N			S	W	N			S	W	S	S	W	3	0	5	3
Young	E		N	E	E	S	S	E	S	S	S		S	S	S	1	4	8	0

Table 13: Lichen position on tree of Lepraria incana

Tree number	1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	N	E	S	W
Old	N	E						W		N	S	S		W	E	2	2	2	2
Young												N				1	0	0	0

Table 14: Lichen position on tree of Opegrapha sp.

Tree number	1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	N	E	S	W
Old							E	W	N	S	S	E		W		1	2	2	2
Young																0	0	0	0

Table 15: Lichen position on tree of Pertusaria amara

Tree number	1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	N	E	S	W
Old	N	E				E	S	N	S		W		E		W	2	3	2	2
Young													N			1	0	0	0

Table 16: Lichen position on tree of Pertusaria flavida

Tree number	1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	N	E	S	W
Old		E				S			W		S	N				1	1	2	1
Young										S		E				0	1	1	0

Table 17: Lichen position on tree of Pertusaria sp.

6.2 Invertebrates

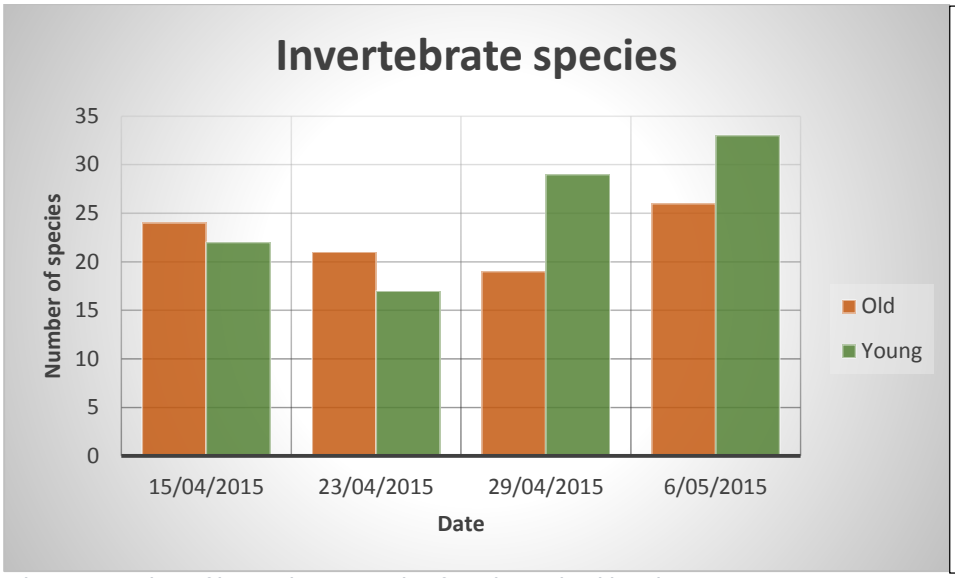
With respect to the invertebrates there was an evident difference in some of the species that were found. The largest difference occured between the abundancy of the woodlice in the young and the old site. Some remarks (mostly similar to the ones of 6.1 Lichens) must be made however.

- First of all there was the mixed woodland, which provided more light and less toxicity in the immediate vicinity. Except for this, the difference in tree species could also have an effect on the invertebrates. Oak and ash will probably have different effects on the invertebrate species. Oak trees are known for their rich biodiversity with respect to invertebrates that can live on them.
- Secondly the trapping station on the young site was close to some grassland. This could have had a large effect on the invertebrates that were found. E.g., bumblebees were found in some pitfall traps at the young site.
- Furthermore, more dead wood was available at the trapping station of the young woodland. Dead wood is an important food source and provides good hiding places for many invertebrate species.
- As a result of the nature trail that goes through the ancient woodland, it was difficult to find a safe spot for the trapping station. Therefore it was placed on a sheltered area with a few oaks and bramble surrounding the site.
- The survey was carried out only during a short period, from April to May, whereas a lot of invertebrates only show up in a later period of the year. Consequently, the project gives an idea of the invertebrates that occur in spring, but does not provide a comparison for a whole year.

Other findings:
Due to the lack of experience in surveying and identifying invertebrates, some species were probably not identified. E.g., when I thought some specimens belonged to one species, I sometimes heard from specialists that they were in fact different species.
In the yew woodlands trapping station a lot of yew flowers fell into the pitfalls. The smallest invertebrates were probably not always counted correctly as they might have been removed by accident with the flowers.

Despite these remarks, this project gives an overall picture of the biodiversity of invertebrates in a mixed yew woodland. It is difficult, however, to say whether the difference in results are due to the difference in woodland age or to the difference between other elements (e.g. oak versus ash, slope versus flat, amount of dead wood). In total 45 species were identified, two flies were identified to the family and three different larvae were found. This provides a total of 50 different invertebrates collected during the survey. On the old site 38 different species were found during the full surveying period. On the young site 44 species were found.

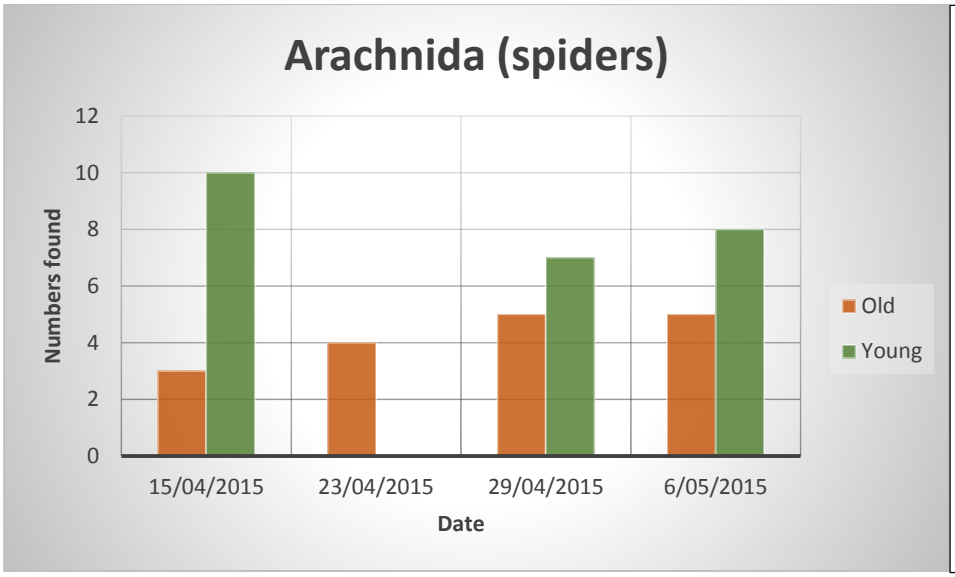
Chart 4 shows the number of invertebrate species that were found on each checking date of the trapping stations. The first two weeks the trapping station with the old yews had more species than the young site and in the last two weeks it was the other way around. The reason might be that the old site had suffered more from the bad (rainy) weather conditions of the last weeks.
The trapping station in the old site had an average of 22 species and the station in the younger site had an average of 25 species. The old site had a maximum of 26 species and a minimum of 19 species. The young site had a maximum of 33 species and a minimum of 17 species.
The amount of species has risen for both sites. The old site had a slight increase from 24 species on the first check to 26 on the last. The young site had a larger increase, from 22 to 33 species.
The difference between the old and the young site will probably be the cause of the remarks mentioned above. E.g., more dead wood on the young site could provide more invertebrates.



Maximum:
Old: 26
Young: 33
Average:
Old: 23
Young: 25
Minimum:
Old: 19
Young: 17

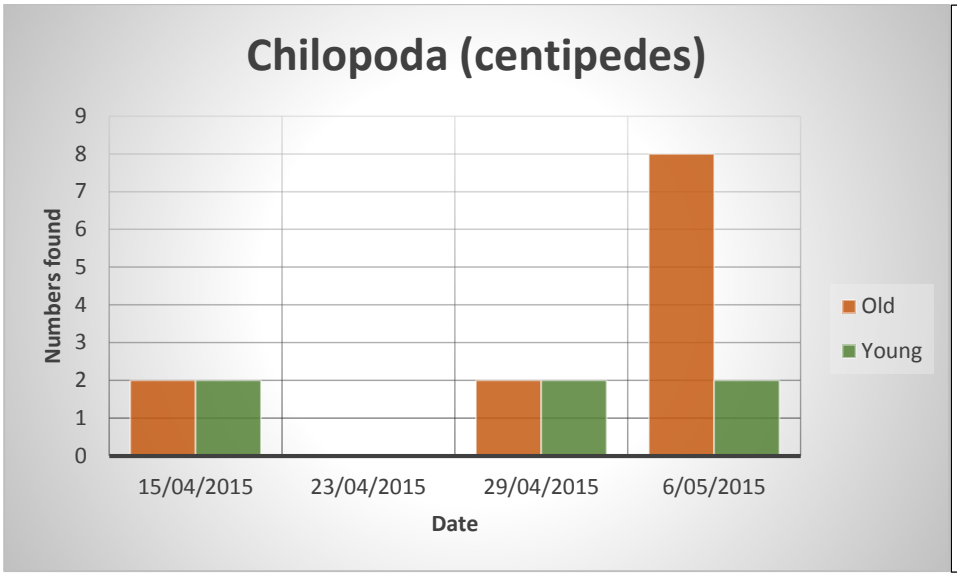
Chart 4: Number of invertebrate species found per checking date

The following charts show the number of invertebrates per class of invertebrates. Mostly the young site has a larger number of invertebrates. For the insects (Chart 10, Insecta) the old site has the largest numbers, which could be due to the old oak trees nearby (oaks are the trees supporting the largest biodiversity of Europe). But the numbers are greatly reduced after the second inventory on the old site, whereas the numbers on the young site kept on growing. A possible explanation is the bad weather. The old site was more exposed to rain and wind than the young site.
The quantities of millipedes and woodlice are a lot higher in the young yew woodland then in the old yew woodland. The main reason probably is the larger amount of dead wood around the trapping station of the young woodland. The four data show that the amount of millipedes steadily increased during the survey time.



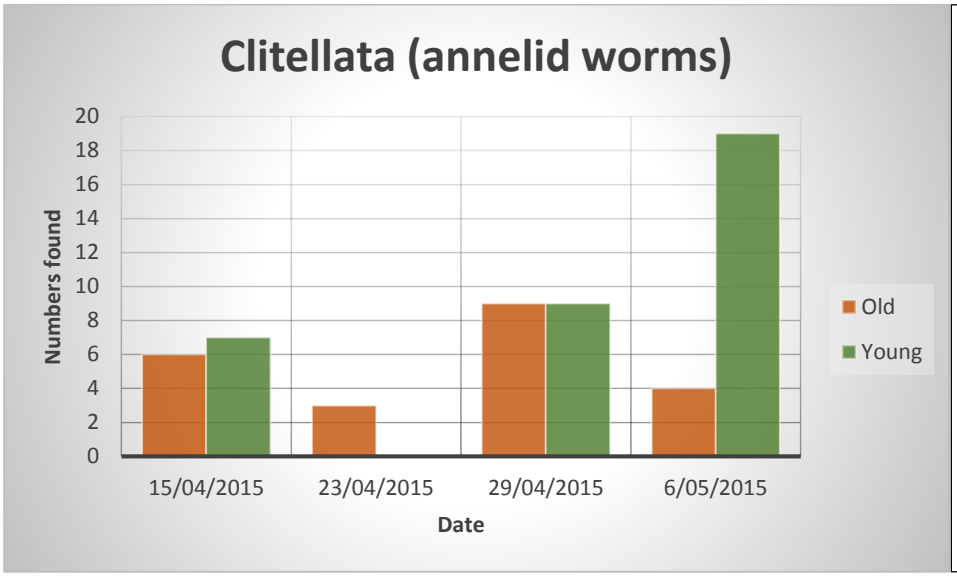
Maximum:
Old: 5
Young: 10
Average:
Old: 4
Young: 6
Minimum:
Old: 3
Young: 0

Chart 5: Number of Arachnida found per checking date



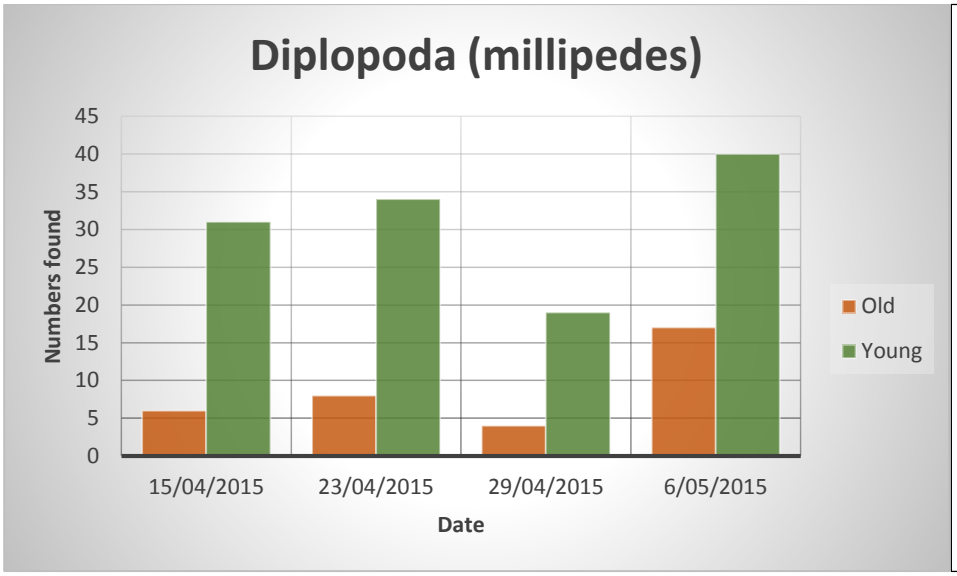
Maximum:
Old: 8
Young: 2
Average:
Old: 3
Young: 2
Minimum:
Old: 0
Young: 0

Chart 6: Number of Chilopoda found per checking date



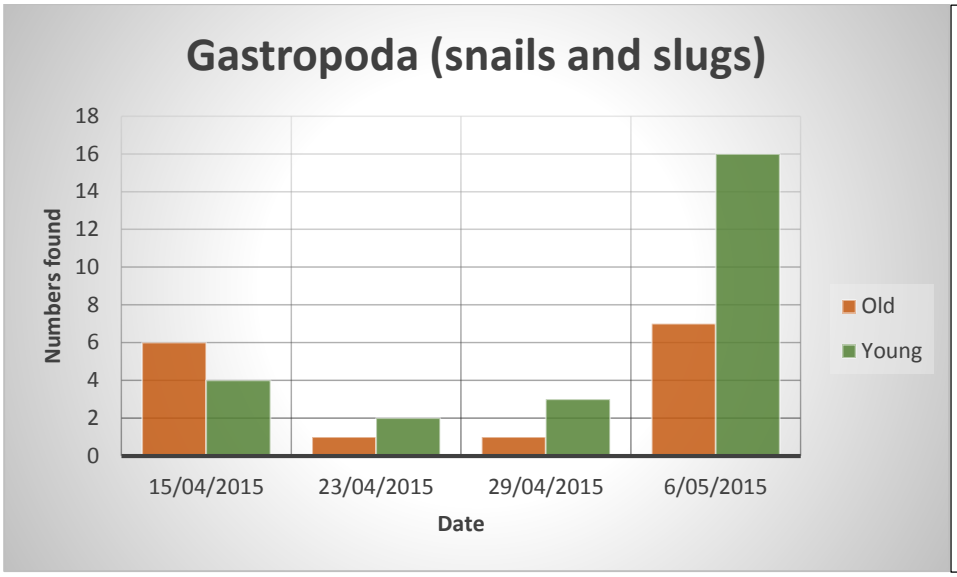
Maximum:
Old: 9
Young: 19
Average:
Old: 6
Young: 9
Minimum:
Old: 3
Young: 0

Chart 7: Number of Clitellata found per checking date



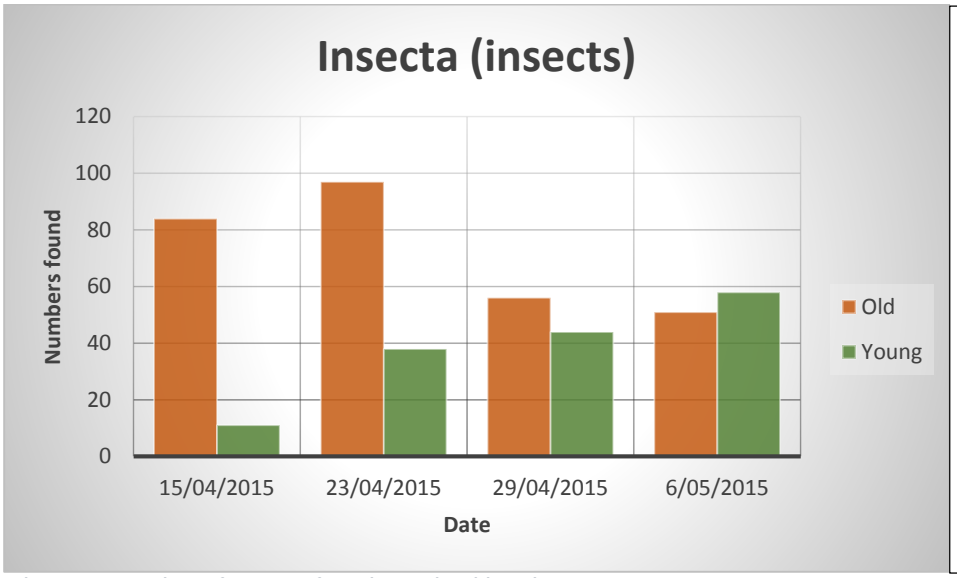
Maximum:
Old: 17
Young: 40
Average:
Old: 9
Young: 31
Minimum:
Old: 4
Young: 19

Chart 8: Number of Diplopoda found per checking date



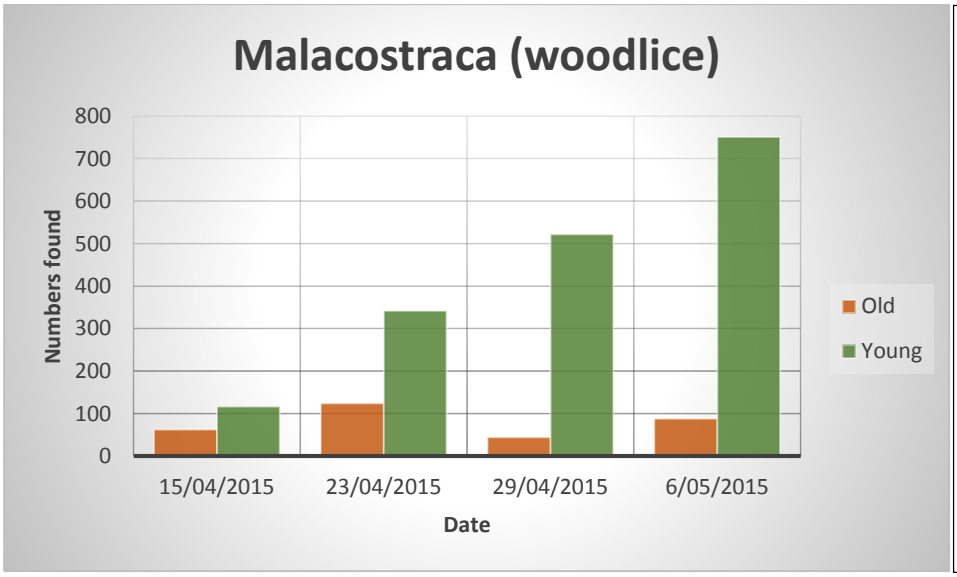
Maximum:
Old: 7
Young: 16
Average:
Old: 4
Young: 6
Minimum:
Old: 1
Young: 2

Chart 9: Number of Gastropoda found per checking date



Maximum:
Old: 97
Young: 58
Average:
Old: 72
Young: 38
Minimum:
Old: 51
Young: 11

Chart 10: Number of Insecta found per checking date



Maximum:
Old: 124
Young: 751
Average:
Old: 80
Young: 433
Minimum:
Old: 44
Young: 116

Chart 11: Number of Malacostraca found per checking date

6.3 General

Due to my lack of knowledge on this project the results are not completely reliable, but it can give a general view on the biodiversity of yew woodland. Invertebrates form a large group of animals and are very difficult to identify. So normally this study should have been more specialized instead of considering all invertebrates. Only non-flying insects, for example, could be examined. If there would have been experts available specialized in different fields of invertebrates, the project could have been expanded.
Furthermore, the differences with respect to the environment between the young and the old yew woodland (see Table 18) create a questionable comparison.

Old yew	**Young yew**
Mixed with oak (*Quercus robur*)	Mixed with ash (*Fraxinus excelsior*)
No slope	Steep slope
Passers-by	Few passers-by
Small area	Larger area
Few fallen trees	More fallen trees (more light)

Table 18: Environment differences between old and young yew woodland

Nevertheless this project gives an idea of the species of lichens and invertebrates that can live in a yew woodland. It also indicates the importance of having old trees (for the lichens) and the amount of dead wood and the variations in microclimate (for both lichens and invertebrates).
The older yew woodland clearly supports more lichen species than the younger woodland. The lichens on the older yews mostly cover a larger area than the lichens on the younger yew trees. So it can be confirmed that an ancient yew woodland has a larger value for lichens than a young yew woodland.
The comparison of the invertebrates is less obvious. Most of the invertebrates probably come from the deciduous trees and the available dead wood nearby the yew trees. The younger yew woodland has a larger amount of species and mostly a larger quantity of invertebrates per class. But the age of the yew trees is probably not the reason for these differences.

A few last remarks that could be considered in similar projects in the future are given below.

- A minimum of practical experience/knowledge of the subject is strongly recommended before performing the actual survey on either lichens or invertebrates.
- Choosing a more specified subject for this study will provide more exact results (e.g. only Coleoptera or only lichens and no invertebrates). If specialists in different fields of invertebrates are available and can be contacted, the study could be enlarged.
- Before setting up the trapping stations, sites must be searched presenting the most similar circumstances, except for the element of the comparison.
- A different study that could have given more accurate results, is comparing pure with mixed yew woodland.

7 Bio-ethics

In this chapter, the subject is viewed from sustainable development (people, planet, profit).

The definition of sustainable development is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. It is intended that the three elements of sustainable development (social, environmental and economic) should be in balance. (European Union, 2015)

- Planet (ecological importance): the dissertation deals with the biodiversity (lichen and invertebrate diversity) in yew woodlands. Yew is a native tree in England, so it is important to know what species can live in a woodland dominated by yew. If it seems that the older (veteran) yew trees have a greater biodiversity value, these yews can be better protected in the UK. Younger yew stands can be protected to develop to veteran yew sites for the future. The study is carried out only over a short period of time, but nevertheless it will give a better insight into the biodiversity in yew woodlands. Lichens do not have a negative effect on yew trees. These organisms are a symbiosis between algae and fungi. Some invertebrates can parasite on yew, e.g. yew gall midge and black vine weevil.

- People (social importance): the reserve is, besides the natural value, important as a recreation area. There is even a nature trail with all sorts of questions about the nature reserve. Besides the woodland there is also a chalk grassland and archaeological sites with 14 scheduled ancient monuments. If my study proves that there is an important biodiversity in the yew woodland, it could be more protected or the woodland could be extended. Nature lovers can be attracted and experience a higher amenity if they know there is a notable biodiversity in the woodland. Yew is poisonous, so it should not be eaten by visitors. This can be mentioned at the entrance of the reserve. However, most of the people visiting Kingley Vale NNR know that yew is poisonous.

- Profit (economic value): Natural England is financed by DEFRA (Department for Environment, Food & Rural Affairs). For managing the nature reserves volunteering groups of people are worked with. If this study shows a great ecological importance of yew woodlands, more volunteers could be attracted for managing the reserve. If the results indicate a change in management strategies would be advisable and some cuttings would be carried out, maybe the wood could be sold.

  Conclusion: this dissertation is mainly based on the environmental pillar (in particular with respect to biodiversity). It has a good social importance (on the recreational level), but the direct economic value is low. If the management is as profitable as possible, there will be a financial advantage.

8 Public honourable article

The smaller lifeforms in the ancient yew woodland of Kingley Vale.

Introduction

Figure 26: This yew tree contains both old, death branches and young, living shoots

Kingley Vale is a National Nature Reserve with outstanding ancient yew trees. Yew (*Taxus baccata*) is a small, evergreen coniferous tree. Yew are normally dioecious, having separated male and female trees. All parts of the yew are very poisonous except for the arils (red, gelatinous appendage surrounding the seed), but the seeds within the arils are poisonous as well.
Yew is called both the tree of life and the tree of death. The tree of life mainly because it can grow very old due to the regeneration capacity and the vegetative reproduction by branches bending to the ground (layering). Yew can also be used for medical purposes: cancer is being treated with taxol that is found in yew leafs. But even the simple fact that yew is an evergreen tree that lives on when all other trees seems to be dead makes it a real tree of live that is a true symbol for resurrection. Therefor it has been planted since a long time on graveyards, or graveyards were built around them. This makes it also a tree of dead as it guards over the graveyard. Furthermore there is no understorey in the yew woodland because of its deep shade all year round and the ground that contains a toxicity level as a result of the leaf litter. This toxity of almost every part is another aspect of its reputation of being a tree of dead. The yew tree on Figure 26 above contains both old, death branches and young, living shoots. The oldest yew trees growing in Kingley Vale are definitely older than 500 years. The oldest tree can be even up to 1000 years old, but other sources claim he is more than 2000 years.
An important question that can be asked therefore is: “What can live on and around these dominant and deadly trees?” Kingley Vale NNR is well known for its ancient yew trees, but another important section of the reserve has a large quantity of young, pure yew woodland. A next question can be: “Is there a difference in biodiversity between the ancient and the younger yew woodland?” Unique in this reserve is that the ancient and the young yew woodland are clearly divided, which gives us a good opportunity to make a comparison between the two. This study will provide an effort to tackle these questions.

What was examined?

This study focusses on lichens growing on the yew trees and on invertebrates that thrive in this woodland. Lichens are not just one organism, but they consist of two different kind of organisms: fungi and algae or cyanobacteria (called photobionts). This is a symbiotic lifeform where the photobionts provide food (i.e. carbon) for the fungi and the fungi provide nutrients and protection from the environment. Due to the toxicity of yew and the deep shade under its canopy lichen growth is limited. Figure 27 on the right shows the lichen to be found the most: *Lepraria incana*.

Figure 27: Most found lichen: lepraria incana

Invertebrates are all animals that have no bone structures in their bodies (i.e. endoskeleton): e.g. insects, worms, snails…. Most invertebrates have an exoskeleton, a hardened structure on the outside of the body: e.g. insects, snails, woodlice…. But some invertebrates like slugs and worms, have neither endo- nor exoskeleton. Figure 28 on the right shows a mite that was found during the survey.

Figure 28: Example of an invertebrate: a mite

Collecting specimens

Lichens were examined on the living yew trunks up to 1.8 m high. Old and young yew trees were examined separately with 2.5 m girth range of the trunk as a separation. There were 15 old and 15 young trees examined. During the examination the abundancy of the lichen species were estimated in a quadrat of 10x10 cm. The estimation was carried out on the most covered spot on the trunk. The orientation of the different lichenspecies on the trunk were also taken in account. This information was noted on a survey table, with a code for every lichenspecies found on the tree. Lichenspecies of each tree were collected in a separate sampling bag, and each bag was coded as in the survey table.

Invertebrates were collected at two trapping stations, an area that was chosen to collect the invertebrates with pitfall traps, flight traps and active search. A pitfall trap consists of two drinking cups placed in the ground. Each trapping station had five pitfall traps placed in a line 1 m apart from each other. All pitfalls were covered with a piece of chickenwire to keep large organic matter out of the traps. A pitfall trap is shown on Figure 29 on the right. One flight interception trap was available for the project. This trap was switched between the two trapping stations. These traps were about ¼ filled with a trapping solution, made of 50% Cool Flow NTP and 50% water. This solution is non-toxic to vertebrates. The traps were emptied every week. When collecting the invertebrates an active search was carried out around the trapping station. An active search means examining invertebrates on the ground, under logs and barks, on trunks of the yew trees….

Figure 29: Pitfall covered with chickenwire

Results

Each tree that was examined for lichens had a separate table. Each table contains the following information: GPS coordinates, date, young or old tree, tree code, girth trunk, species found, abundancy of each species and its position (wind direction) on the trunk. Eventually 15 old and 15 young yew trees were examined. After comparing the results it was shown that the oldest yew trees support more lichens (both quantity and diversity) than the younger yew trees. Table 19 below shows the number of species found on each examined tree. Tree 4 and tree 5 don't have any lichen, which is probably due to shadow. These trees had a dense canopy around their trunk and grew in a more pure, yew woodlandspot creating a deep shade covering the trunk.

Tree number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Maximum	Average
Old yew	3	4	1	0	0	4	4	4	3	2	6	5	2	4	3	6	3
Young yew	1	0	1	1	1	1	1	1	2	2	1	3	2	1	2	3	1

Table 19: Number of species on the examined trees

For the invertebrates there is one table for the trapping station of the ancient woodland and one for the young woodland. Each table contains the following information: GPS coordinates, trapping station code, dates, species found and the numbers that were found with the different methods (pitfalls, flight trap and active search). The traps were on the reserve for four weeks and were emptied four times (once each week). After comparing the results, the numbers of species were not very different between the old and the young site. But there were some large differences in the amounts of invertebrates. E.g. the quantity of woodlice was much higher in the young woodland than in the old woodland. Chart 12 below shows the number of species that were found per date the invertebrates were collected.

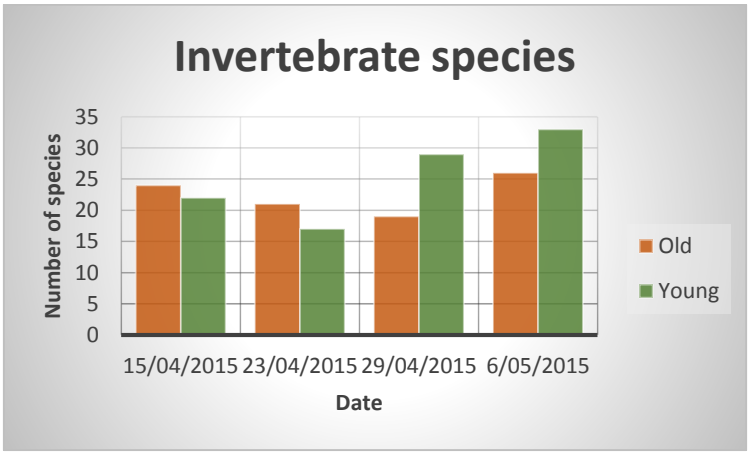


Chart 12: Number of species found per date

Remarks

Important to know is that the woodland was mixed with some deciduous trees. The ancient woodland was mainly mixed with oak (*Quercus robur*) and the younger woodland was mixed with ash (*Fraxinus excelsior*). There is pure, young yew woodland available in the reserve, but to make a logical comparison with the mixed, ancient woodland, this pure woodland was not used.

There was more dead wood available around the trapping station of the young yew woodland, which probably supported more invertebrates. Moreover the trapping station in the young woodland was more protected from the wind and the rain, offering a better chance for invertebrates to thrive.
During the examination the experience on identifying the species of both lichens and invertebrates grew enormously, thus having an effect on the results. The results became more reliable to the end of the project as they were on the start.

Conclusion

The comparison may be a bit questionable (mainly for the invertebrates) due to the remarks above. But nonetheless the results give a general impression of what species of lichens and invertebrates can live in a yew woodland. It also indicates the importance of having old trees (for the lichens) and the amount of dead wood and the variations in microclimate (for both lichens and invertebrates).

Figure 30: View on the coombe of Kingley Vale NNR

9 Presentation of the daily work

- Day 1: Wednesday 01/04/2015
  In the morning we went to the reserve and Ms. Birch suggested some places where I could place my trapping stations. The oldest yews stand in a mixed forest with ash and oak trees. So the trapping stations will be placed in a mixed forest woodland and not a pure yew woodland. There are pure yew stands in the younger woodland. But for a good comparison between the younger and older stands, all trapping station will be placed in mixed stands with yew as the main species. At the older yew stands there are many visitors, so the safety of the trapping stations is difficult to guarantee.
  Woodland and grassland are mixed in the reserve and fallow deer keep the grassland open. We crossed a place where some ash trees were felled to create an open space around some yew trees that were suppressed by the higher ash trees. This action is called halo release or halo thinning. Around some off the stumps of the felled trees there was set an enclosure the see the development when they are not grazed by the deer. In the enclosure, coppice developed by ash shoots and brambles.
  Ms. Birch told me about the different designations an area can get. Kingley Vale has a national (NNR), European (SSSI) and an international (SAC) designation.
  In the office we installed a microscope on the computer. If I cannot identify some species I can make a picture with the microscope and send it to a specialist.

- Day 2: Thursday 02/04/2015
  Collected samples of lichens for later determination. The lichens were taken from the old trees. All examined trees where marked in a GPS. Each tree had its own code e.g. O2: this is the second old trees that was examined. A picture was made of these trees, so they could be recognized if there was searched for. Each sample (specie) was place in a sample bag. On each sample bag there was a code written e.g. O5L2: this is the fifth old tree and the second lichen sample. Other abbreviation used was Y for Young yew trees. The notes that have been taken are visible in the results (abundancy, position on tree).

- Day 3: Friday 03/04/2015
  Samples of the day before where identified. *Pertusaria multipuncta* was identified with the book: Lichens, an illustrated guide to the British and Irish species (Dobson, 2005). This is a crustose lichen with white soralia and grey thallus. It reacted with K[1]: brown thallus and yellow soralia.
  Schismatomma niveum was the second lichen identified. The thallus type is crustose, but it looks like a leprose thallus. Thallus is pale grey, it reacts with K to a pale yellow.
  The third lichen was *Lepraria incana*. Thallus type: leprose, grey to green-grey. It has no chemical reactions.
  One lichen I could not identify, pictures of that lichen will be send to a lichen specialist.

- Day 4: Monday 06/04/2015
  Further examination of the lichen samples.
  First lichen was *Lepraria lobificans*: it looks like *Lepraria incana*. But the thallus of *Lepraria lobificans* is a bit greener, while *Lepraria incana* is a bit bluish. Thallus type is leprose and it reacted with K to a faint yellow.
  Second lichen that was identified was *Opegrapha prosodea*. This is a crustose lichen with black lirellate fruiting bodies. The thallus is grey to greenish grey. No chemical reactions. This is a less common lichen that is mainly found on old oaks and yews.
  One lichen I could not identify, pictures of that lichen will be send to a lichen specialist.
  All other samples that were taken (on 02/04) are the same species as the ones described above.

[1] K: potassium hydroxide (see 4.1.2 Materials for identifying)

- Day 5: Tuesday 07/04/2015
  In the office of Kingley Vale I connected the GPS to the computer and searched how to put the coordinates in a map on the computer. Some preparations where done for setting the trapping station. The traps could not been placed yet, because the trapping solution was not available until Friday. A microscope was connected to the computer to make some pictures that I could send to lichen specialists.
  At the reserve the flight interception trap was hung in a tree at the old yew stands. There was no trapping solution, so no invertebrates were trapped until Friday. On the nature trail of Kingley Vale there stands an old yew tree that has a large branch that could fall down soon. To take out the branch, half of the crown should be removed. So there are some signs to make a diversion of the trail. The signs are often removed by visitors of the reserve. If there are no signs to guide the visitors, Kingley Vale would be responsible if an accident occurs. So new signs were attached to some posts.

- Day 6: Wednesday 08/04/2015
  Samples of lichens were collected from the younger yew trees. See day 2.

- Day 8: Friday 10/04/2015
  The two trapping stations were placed in the morning with four volunteers from National Park (South Downs). This is organized by the Volunteer Ranger Service (VRS). Also a trapping station, only with pitfall traps, was placed in a grassland for a national survey of the invertebrates in grasslands. For my trapping stations five pitfall traps were placed per station and two fly traps were hung in a tree. One flight interception trap was placed in the old yew station, this will be placed at the young station after one week. Ten pitfall traps were placed in the grassland. A 50/50 solution of non-toxic propylene glycol and water was used as a trapping solution. The pitfalls were covered with a piece of chicken wire to prevent other animals interfering with the traps.
  When we were placing the pitfalls at the younger site we found a two inch smoke mortar bomb. We needed to call the police to come and look at the bomb. Then he called the army and a bomb disposal team came to explode the mortar. We needed to wait a long time, so we only finished or trapping stations. Normally we would have checked some dormice boxes. Around six to eight bombs are found each year left by Canadians after World War II.

- Day 9: Monday 13/04/2015
  The trapping stations were checked, but were not emptied yet because there were only a few invertebrates caught. When checking the traps another mortar was found nearby. This time it was a high-explosive 2 inch mortar (see Figure 31). I called the reserve manager (Katherine Birch), who called the police and they called the bomb disposal team. When waiting for the disposal team I took lichen samples from the old yew trees. The reserve has had a scouting for the bombs two times, but they are still found because animals can dig them up.


Figure 31: Two inch mortar

- Day 11: Wednesday 15/04/2015
  Traps were emptied and refilled with the trapping solution. Trapped invertebrates were laid on a paper sheet to sort the different kind of invertebrates (sorted by clearly visible different species). They were counted and divided in different tubes, each tube got a code. E.g. OPT3 was taken at the old site from the pitfall traps and it was the third kind of invertebrates. Other abbreviations used were: Y (Young site), AS (Active Search), FIT (Flight Interception Trap). The same code was used on the survey table. A short active search (15 minutes per trapping station) was performed, but only a few species were caught. In the flight trap only a few species were trapped. The flight interception trap was moved from the old to the young trapping station.

Pitfall traps had clearly the best results. A few species were identified after collecting all invertebrates.

- Day 13: Friday 17/04/2015
  In the morning we went to a hazel coppice woodland in Slindon for checking dormice boxes (see 10 Activities not in function of your thesis). After that invertebrates were identified.

- Day 14: Monday 20/04/2015
  Information for chapter one (1 Representation of the company) was collected. We looked at the machines that are stored at the office. Every machine has a tag that mentions how long you can work with the machine in question. We looked at maps to see where sheep are used in the grazing season (winter). The grazing area is fenced with a temporarily electric fence. After a few weeks the sheep are moved along with the fence. There are about four areas that should be grazed during winter.
  The data obtained during the BeeWalk was inserted on the website. On iRecord some other observations were posted. iRecord is a bit similar to the website Waarnemingen.be in Belgium. Records of rare species are mostly checked by the organisation before they are posted on the website. Some mails were send to people that can help with lichen and invertebrates identification.
  Furthermore the self-evaluation document and technical data of the company was filled in and some daily reports were corrected and completed.

- Day 17: Thursday 23/04/2015
  Collected invertebrates like Day 11. After collecting I began with identification.

- Day 18: Friday 24/04/2015
  Identified the invertebrates.

- Day 19: Monday 27/04/2015
  First see 10 Activities not in function of your thesis. After this I worked on my project in the office.

- Day 20: Tuesday 28/04/2015
  First see 10 Activities not in function of your thesis. After this I collected new lichens from old trees (see Day 2).

- Day 21: Wednesday 29/04/2015
  First lichens were identified in the office. Then the trapping station were checked like Day 11. The trapping station on the old site was more affected by the rainy weather then the trapping station on the younger part. Less invertebrates were found at the old site then previous checks.

- Day 23: Friday 01/05/2015
  First we went to the West Dean Woods (see 10 Activities not in function of your thesis). Then lichens were examined on the young yew trees in the reserve.

- Day 24: Monday 04/05/2015
  Identified invertebrates caught on Day 21.

- Day 25: Tuesday 05/05/2015
  First I worked on my dissertation project. I inserted the data from the lichen survey on Day 23. Thereafter we went to the reserve (see 10 Activities not in function of your thesis).

- Day 26: Wednesday 06/05/2015
  Collected invertebrates from the trapping stations. This was the fourth and last time the trapping station were checked. All the traps were cleared and taken. Thereafter I worked at my dissertation results.

- Day 28: Friday 08/05/2015
  Identified invertebrates from Day 26.

- Day 29: Monday 11/05/2015
  I sorted the invertebrates that were not identified yet. These will be brought back to Belgium to some specialists on flies, spiders and beetles. Lichens were examined and identified.

- Day 30: Tuesday 12/05/2015
  Working on my dissertation results. Pictures of unidentified lichens were send to specialists.

10 Activities not in function of your thesis

- Day 7: Thursday 09/04/2015

Normally every Thursday there is a volunteer group that helps with the management of the reserve. The volunteers come from an organization called Phoenix Futures. This organization helps people to recover from a drug or alcohol addiction. Going out to nature reserves is part of the process and is called 'Recovery Through Nature' (RTN).
There were eight volunteers and four other persons (including myself). It was a translocation day, so we worked on a different site. The place where we went was north of Kingley Vale and had a very different soil structure. It was a sandy, acidic soil without flint and with gentle hillsides. In Kingley Vale there are lots of flint in the ground, which creates rough, steep hillsides due to erosion.
The site we were at is called Lord's Piece. It is part of a big estate (Barlavington Estate) that is turned into a heathland with public access. The site is about 80 acres large and a rare species of field cricket is living there, called *Gryllus campestris*. This is the only place in England where the Field cricket lives. It was thought to be extinct in England until 1970. Then it was recognized as a rare and endangered species. But not much was done to help it survive until 1990, thanks to the introduction of a grant scheme by the Government for farmlands. In 1991 the restoration of the heathland began: trees were felled and the area was bulldozed, revealing a sandy soil beneath. Then the typical heathland plants began to grow there again and the crickets population grew. Now the area is grazed by 40 cattle owned by the Estate. There is not really a grazing schedule needed for this site, but mob grazing would be good, however.
This cricket lives in burrows and cannot fly. The burrows of the Field crickets have a more or less horizontal hole, which is different from the Minotaur beetle, which makes vertical holes. The crickets live on sandy, acidic hills with a southern orientation. They need short grassy areas with warm patches of bare ground.
Mike Edwards has a license to work with the Field crickets, so he guided us during the day. To work with rare species you need a license. A license can be obtained by working under the supervision of licensed people with the species in all its life stages. Therefore you need to find at least two persons with a license to work with. Mike Edwards got his license by researching the Field cricket in Belgium.
The purpose of the day was to expand the population of the Field crickets by catching them and moving them to some other suitable grasslands nearby. There were lots of burrows at the site thanks to recent management of the sward height. We caught the Field cricket by poking a small wire in their burrows. By tickling the crickets they came out of the burrow, then quickly put a finger in the hole (so the cricket does not go back in) and catch it. Males and females were needed to create a new population. The difference between the two is that female has a clearly visible ovipositor between the two cerci. The females that already moulted once had a longer ovipositor (see Figure 32). After three to four moults they can reproduce. The caught crickets were placed in a sack with a note for male or female (or both if a couple was in the sack). In total there were 15 couples caught and about five individual males. Having more males is beneficial as when they aggregate they will draw in female. Not all males we found were caught because there were much more males than females. The crickets were released

Figure 32: From left to right: male back, female back, female back (moulted once), male at burrow

in three grasslands nearby, on each site five couples were placed. After a few weeks the new populations should be checked as this is when the males will be calling.

- Day 10: Tuesday 14/04/2015

  I went to Worthing (which is the area office) with Katherine Birch for a meeting of the Natural England team Sussex Downs. In the morning there should have been a lesson on how to use ArcGIS, but the teacher could not come. So in the morning I worked at my dissertation document.

  The meeting was with a few members of Natural England that work in Sussex. It was a general update on what each person was doing and had done the past few weeks.

  A person who is responsible for farmland schemes spoke about farmland birds, wild flowers on farm margins and Cluster Farms. Cluster Farms are different farms working together by using machinery, land, water, livestock from each other with a prospect of benefit for all working amongst them.

  Another person talked about an unprotected heathland that is under threat. The landowners want to make a golf course on the area. But the site has a national importance for multiple species that live on the site and for the habitat itself (acid grassland). The heathland is unprotected because there were huge cuttings in staff members and budgets of Natural England in the last few years because of a Government change. Normally the site would have been protected, but due to the lack of staff members it did not happen. The heathland is on the edge of the county and the land on the other county has an SPA designation. Natural England wants to protect the area with a SSSI designation, but there is lots of evidence required to accomplish that. Evidence about the importance of the heathland with e.g. protected species that live in the area. It is possible the golf course will be built because Natural England is constrained since the last Government change. However staff are working hard to prevent this.

  One person there was responsible for the water management in Sussex farmlands. The water quality is not very good due to lots of sediments and pesticides from farms and houses end up in open water. Near the open water crops should be cultivated that hold the ground surface and do not need lots of pesticides (no potatoes should be cultivated in these areas).

- Day 12: Thursday 16/04/2015

  In the morning a bumblebee survey was held with the volunteers (RTN). The survey is held ones per month from April to September. It is part of a national recording scheme to monitor the abundance of bumblebees across the UK. It is called the BeeWalk. It is the intension to monitor bumblebee population through time. Declines in populations can be detected, the effect of climate change. On this basis the data collected will inform the management of the habitats and surrounding area. The walk is about 1.5 km long and it takes about one to two hour (depends on how many bumblebees are found). It is important to walk the same route every time, because this gives a better comparison between months and years. Notes taken before the walk were temperature, wind strength, sunny/cloudy, date, start time and after the walk the end time. It was the first survey of the year and only four bumblebees were caught and identified. One was a queen of *Bombus terrestris* and the other three were queens of *Bombus lapidarius*. Queens of bumblebees are much larger than the others and they can sting if handled inappropriately.

Figure 33: Route of the BeeWalk

After the BeeWalk we cleared a part the sides of the path from the car park to the entrance of Kingley Vale NNR. No machines were used due to bird nesting season. Materials that were used: slashers, loppers, hedge shears and forks.

- Day 13: Friday 17/04/2015

In the morning we went to a hazel coppice woodland in Slindon owned by the National Trust. Dormouse boxes were checked for the protected hazel dormouse (*Muscardinus avellanarius*). It is the only dormouse native to the UK and they can be found in the South-East of the country. To work with dormice a dormice license is required. We went in the woodland with two people from the National Trust. The survey starts in April and ends in October. It is a national survey called "The National Dormice Monitoring Program" for the "Peoples Trust for Endangered Species". All participating sites need to do the survey at about the same dates. There were 50 nest boxes that were checked for the dormice. The nesting boxes were hung on a branch of hazel. There is a hole at the side of the branch. In the 50 boxes we found two dormice, one wood mouse, one hornet and a few empty nests of birds, wood mice and dormice. That is a good result for the first survey of the year. In the winter dormice go in hibernation in nests on the ground. When they become active they make nests higher in the coppice (nest boxes). The nests of dormice consist of shredded material, wood mice nests consist of leaves and bird nests have much moss. A few notes are taken when finding a dormouse: date, number of the nest box, weight of the mouse, active or torpid and gender.

Figure 34: Hazel dormouse in torpor

Next to the coppice woodland there is a project to recreate woodland after it disappeared during the First World War. It is the largest woodland creation undertaken by the National Trust (75 ha), it is called "The Rise of Northwood". To get the new woodland the following techniques were used: direct seeding, planting and natural colonisation. All trees need to be protected against fallow deer grazing. Volunteers help establishing to woodland.

- Day 15: Tuesday 21/04/2015

We went to Kingley Vale to look at the fences around the reserve. All anthropogenic obstructions of the reserve have to be checked every six months. If an accident should occur due to a weakness in an obstruction, Kingley Vale NNR would be liable. A part of the fences we checked should be replaced. But due to the lack on budget this will be difficult to accomplish. There are other priorities that are more important for nature conservation. Then we emptied the pitfalls of the national survey in the grassland (placed on Day 8). All the collected invertebrates were put on 70% alcohol. These will be sent to the person that organises the research (Jon Webb). We placed a stealth camera to look at a badger set. Another camera was placed by an old badger set that is probably in use by a fox with cubs.

In the office we looked at some maps of Kingley Vale that will need some improvements. The maps showed the SSSI area, Scheduled Ancient Monuments (SAMs), Integrated Site Assessment (ISA), the different access permissions and the landowners around the NNR. These maps will be improved by an apprentice in Natural England. They can be found in Appendix V.

During the day there were two apprentices from Natural England. Their project is called Nurturing Nature where they learn conservation skills, this is supported by the National Lottery. The first period of the apprenticeship is three months. Then, if you are accepted by your supervisors, you can do an 18 months training. It is practical training meant for people that want a career change. The two apprentices have 18 months training within area 14. Area 14 consists of Sussex, Kent and Surrey.

- Day 16: Wednesday 22/04/2015

  We went to Ashburnham Place for a lesson in identifying bryophytes (mosses and liverworts). The site is stewarded by the Ashburnham Christian Trust. It is about 9 ha and is open to public. It consists of gardens, lakes and woodland. The site is known for its rare species of mosses and liverworts. There are about 132 species and they are being researched by Tom Tooley from the British Bryological Society (BBS). This lesson was arranged for Natural England staff members by Carole Mortimer (Sussex Field Unit). Identification was done with the book: Mosses and Liverworts of Britain and Ireland. The Field key was not used to identify the species because the key is too difficult to use and not all species of the book are in the key. Instead a picture gallery of the mosses and liverworts was used (also available in the book).
  Species we identified:
  - *Brachythecium rivulare*
  - *Brachythecium rutabulum*
  - *Calliergonella cuspidate*
  - *Chiloscyphus polyanthos*
  - *Conocephalum conicum*
  - *Dichodontium pellucidum*
  - *Dicranum scoparium*
  - *Diplophyllum albicans*
  - *Isothecium myosuroides*
  - *Mnium hornum*
  - *Orthotrichum diaphanum*
  - *Pellia endiviifolia*
  - *Pseudoscleropodium purum*
  - *Rhytidiadelphus squarrosus*
  - *Rhytidiadelphus triquetrus*
  - *Riccardia chamedryfolia*
  - *Scapania nemorosa*
  - *Thamnobryum alopecurum*
  - *Thuidium tamariscinum*
  - *Zygodon viridissimus*

- Day 19: Monday 27/04/2015

  30 dormice boxes were checked in Kingley Vale NNR. The boxes were installed in November 2014 in an area where dormice were seen before. The boxes are new to this area and it is not an optimal habitat for dormice (i.e. no coppice woodland and no hazel). One box contained an empty nest. It is not certain if it was from a dormouse or a wood mouse, because both nest characteristics were present.
  Some people informed us that two gates were damaged. The gates were lifted out of their hinges and the hinges were stolen. We went to a shop to buy new hinges. The gates were to be replaced on Thursday with the RTN volunteers. The gates should be replaced quickly because people with motorcycles or bikes could go in the reserve.
  After this we went back to the office to work on my project. Also I installed a key safe on the wall for some volunteer wardens.

- Day 20: Tuesday 28/04/2015

  We placed a new welcome sign at one of the entrances of Kingley Vale. The sign is a big sticker and while we attach it on the board we rubbed it in with water and soap. This makes it easier to get the sticker in the right position. These signs last for about three years. After this we checked the stealth camera's that were placed on Day 15. The first camera had about 300 pictures. The second one (with the fox) had less than 40 pictures. We took the memory card from the first one to check the images in the office. Some chores were done at the office and then I left to collect new lichens from the old trees (see 9 Presentation of the daily work).

- Day 22: Thursday 30/04/2015
  The two gates that were damaged (see Day 19) were mended with volunteers from the RTN. Hinges were placed on the hanging post. The gates must be self-closing (kissing gates). Therefore the hinges were not placed in a vertical line above each other. One hinge was placed on the right side of the post and the other was placed on the left side. Because of this difference the gate is out of balance and closes by itself. Hereafter we cleared some brambles from the sides of a bridleway to improve passage and to prevent overgrowing of the path.

- Day 23: Friday 01/05/2015
  We went to a private part of the West Dean Woods in the morning. Richard Williamson was the custodian of the reserve and guided us during the morning. The site has a SSSI designation and is being managed by the Sussex Wildlife Trust. The work in the reserve happens mostly by volunteers. The area is about 25 ha and it mainly consists of hazel coppice. A part of the area is divided in different compartments (22 in total), each lot is about 0.5 ha and is coppiced every eight years. Other parts (north of the reserve) are not being coppiced and in there dormice boxes are present for the national survey (see Day 13). The high forest is dominated by oak and birch.
  The site was known for its big colony of wild daffodils. In the coppice some willow trees were kept for the caterpillars of the Purple Emperor (*Apatura iris*). Where the coppicing was carried out this winter, birch trunks were left. The birch trees were cut at a height of about 1.5 m. This was done with the intension to make some nesting opportunities for the marsh tit (*Poecile palustris*). There were two places marked were adder's-tongue fern (*Ophioglossum pusillium*) grew. A few oaks were protected because of their rich lichen flora (especially beard lichens). Thereafter I went to the reserve (see 9 Presentation of the daily work).

- Day 25: Tuesday 05/05/2015
  The stealth camera at the badger sett was checked. There was a badger with a large swelling on his shoulder. The footage of the cameras needed to be checked often to see if the swelling gets worse and if the badger is weakening. The footage was send to a Badger Group (Badger Trust is a national charity created to protect badgers). Another camera was placed at an annex sett of the previous one, it was probable that there were cubs at this sett. Then the pitfall traps in the grassland were emptied (see Day 15).

- Day 27: Thursday 07/05/2015
  There was a meeting, arranged by the National Trust, about a LIFE (Financial Instrument for the Environment) project for bats. The meeting took place in Slindon. The meeting was arranged to get information and ideas from people that are involved in nature conservation to create a good case for European LIFE funding. First there were a few presentations. The area of the project was mainly based in the South Downs National Park of West Sussex. Under LIFE, there is up to 60% co-financing for nature and biodiversity projects, 75% is possible if the project would be focussed on priority habitat or species. There are about 17 species of bats in the UK and they are all uncommon. The project focusses on two of the rarest bat species of the UK: the barbastelle (*Barbastella barbastellus*) and the bechstein (*Myotis bechsteinii*). The bats need oak woodland with a dense understorey. Veteran oaks are required to provide good roosting places. The bats uses cracks, old woodpecker holes, and other scars on the trees to rest. Barbastelle typically forage within 7 km of the roost, but sometimes they can been seen up to 18 km from the roost. The bechstein however, forage only up to 700 m from there roost. This means that the bechstein needs a good, large habitat, while the barbastelle could go to other woodlands nearby. Water (e.g. ponds) is also an important feature in habitat for the bats.
  We went outside on the Slindon Estate to look at a few roosts of barbastelle bats. We saw two roosts in oaks with a damaged crown and one in a beech with a long vertical gap. Roosts in beech are not usual, normally they are only found in oak. Thereafter we went to a recently restored barn, owned by the National trust, which provided good opportunities to go in

hibernation. Some roof tiles were placed at an angle to allow the bats access into the barn roof. At the end of the day, people could make some comments for what could be done for the LIFE project. Places with oak woodland were marked and the owner of the land was noted on a large map of the project area.

- Day 31: Wednesday 13/05/2015
  The BeeWalk (see Day 12) was done with the two apprentices (Day 15). Only two bumblebees were found. One *Bombus lapidarius* and one *Bombus pascuorum*, both queens. Some other notable animals that were seen during the walk are: two sparrowhawks (*Accipiter nisus*), two green hairstreaks (*Callophrys rubi*), common blue (*Polyommatus icarus*), grizzled skipper (*Pyrgus malvae*), dingy skipper (*Erynnis tages*) and two common lizards (*Zootoca vivipara*). After that we went to the West Dean Gardens.

11 Personal vision

11.1 Personal vision of the placement company.

My dissertation and internship took place at Kingley Vale National Nature Reserve. The reserve is managed by Natural England. There is only one staff member of Natural England working at the NNR: the reserve manager Katherine Birch. There used to be more staff members at the reserve, but for financial reasons of the government they needed to leave the reserve. All over the country Natural England suffered from these financial cuttings. The employees and the budgets are greatly reduced. As a result the management of the reserve has become more difficult the past few years. Only the essential maintenance and restoration work can be performed during the year. Sometimes there is a small amount of money available for certain projects, e.g. a bat surveying project that will start this year. Some weekly volunteers are helping with the management from RTN (Recovery Through Nature). These had a troubled history involving drugs and alcohol. Consequently they were not always very reliable and often needed surveillance while working.
I think there should be at least one more staff member at the reserve. During my internship it seemed that the reserve manager was most of the time busy answering mails and phone calls. If this work could be divided, more work could be done on the reserve. If Kingley Vale NNR would have a larger amount of money available, some important works could be implemented. For example, a small pond in the reserve often dries out, whereas this could be an important wildlife pond with some excavation works. There is one pond available in the reserve, but this one is often disturbed by the dogs of visitors in the reserve. Furthermore, the fence needs to be replaced in a part of the reserve.

11.2 Personal vision of my internship and my performance.

I chose to do my internship in England to learn how management and nature conservation is organized there. And I must say that I learned a lot about that. Except for Natural England I also got to know some other companies involved in England's nature, such as the National Trust, Sussex Wildlife Trust, Forestry Commission and South Downs National Park. Furthermore I learned much about managing protected animal species (dormice, field crickets, bats, badgers). And I got to know how licences are used to work with these protected species. For my dissertation project there was a list available with the subject I could discuss. I chose a subject from the list literally, not knowing its difficulty as I had no experience of similar projects. Eventually it turned out that I'd better specified the subject. On the other hand I learned much more by taking a broad subject. And my mentor (Katherine Birch) guided me wherever she could, e.g. by contacting some specialists with respect to invertebrates and lichens and by lending me some books to identify the species I found.
If students would go to Natural England for an internship in the future, this should be linked to their dissertation project (integrated dissertation). I had about 13 days that were not linked to my dissertation. So it is important to know that students will spend about 50% of their time working on their dissertation subject during the internship. But this could be different at other reserves. I recommend students to have their internship at Natural England if they are interested in nature and its management. It was a very educational and fascinating period of time in my studies.

Appendices

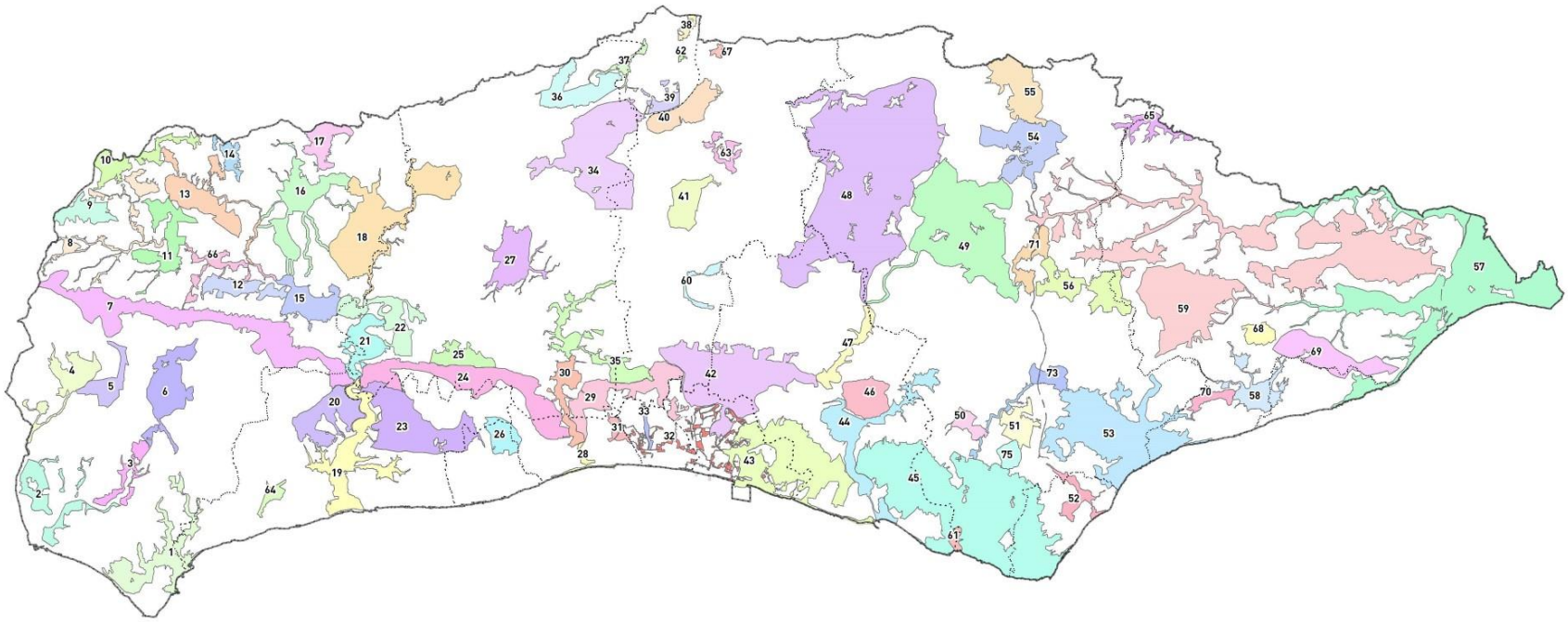
Appendix I

Biodiversity Opportunity Areas (BOAs) in Sussex, March 2009
(See map below)

1 - Chichester Coastal Plain
2 - Chichester Harbour
3 - Fishbourne and Chalk Streams
4 - Westbourne Chalk Streams to Compton Tributaries
5 - Walderton to Welldown including Kingley Vale
6 - Lavant Watershed
7 - Western Escarpment
8 - Hampshire Rother watershed
9 - Rogate Common
10 - Weavers Down to Lynchmere
11 - Stedham, Iping Woolbedding Crescent
12 - Heyshott
13 - Snapes Copse and Verdley Wood
14 - Black Down
15 - Barlavington, Coates and Rother
16 - Ebernoe with watercourse flightlines
17 - Chiddingfold Complex
18 - The Mens and buffer and associated Barbastelle flightlines
19 - Climping to Houghton
20 - Arundel Park
21 - Houghton to Coldwaltham
22 - Parham to Fittleworth
23 - Clapham to Burpham Downs
24 - Central Downs - Arun to Adur
25 - Lower Adur Arun Watershed
26 - North-East Worthing Downs
27 - Knepp Estate with Fluvial Extensions
28 - Shoreham Estuary and Beach
29 - Adur to Newtimber including Mill Hill
30 - North Bramber Floodplain
31 - Crooked Moon to Thundersbarrow
32 - Brighton & Hove Urban Green Network
33 - Benfield to Hangleton
34 - The St Leonards Watershed
35 - Woods Mill Stream to Adur
36 - Rusper Ridge
37 - Ifield Brook
38 - Gatwick Woods
39 - Tilgate and Furnace Green
40 - Worth Forest
41 - Lower Adur Ouse Watershed
42 - Stanmer and Ditchling Downs
43 - East Brighton Downs
44 - Lewes Brooks and the Ouse Valley
45 - Seaford to Eastbourne Downs
46 - Lewes Downs
47 - Mid Ouse Floodzone
48 - Western Ouse Streams and Ashdown Forest
49 - River Uck and its Headwaters
50 - Cuckmere Ouse Watershed
51 - Wilmington Woodlands and Watershed
52 - Eastbourne Marshes
53 - Pevensey Levels
54 - Medway, Ouse, Rother Watershed
55 - Eridge and Broadwater
56 - Pevensey, Rother, Cuckmere Watershed
57 - Romney Marsh Area
58 - Coombe Haven and Marline
59 - Rother, Brede and Tillingham Woods
60 - Burgess Hill Green Crescent
61 - Lower Cuckmere Reaches
62 - Grattons Park
63 - Ardingly Reservoir
64 - Lidsey Rife
65 - Bewl Water
66 - Western Rother
67 - Copthorne Common
68 - Great Wood Area
69 - Hastings Fringe
70 - Bexhill Fringe
71 - Cuckoo Trail Habitat Link
72 - Heathfield Habitat Link
73 - Pevensey & Cuckmere Valley Link
74 - River Cuckmere Habitat Link
75 - Wooton Manor Grasslands Link

Biodiversity Opportunity Areas (BOAs) in Sussex, March 2009.

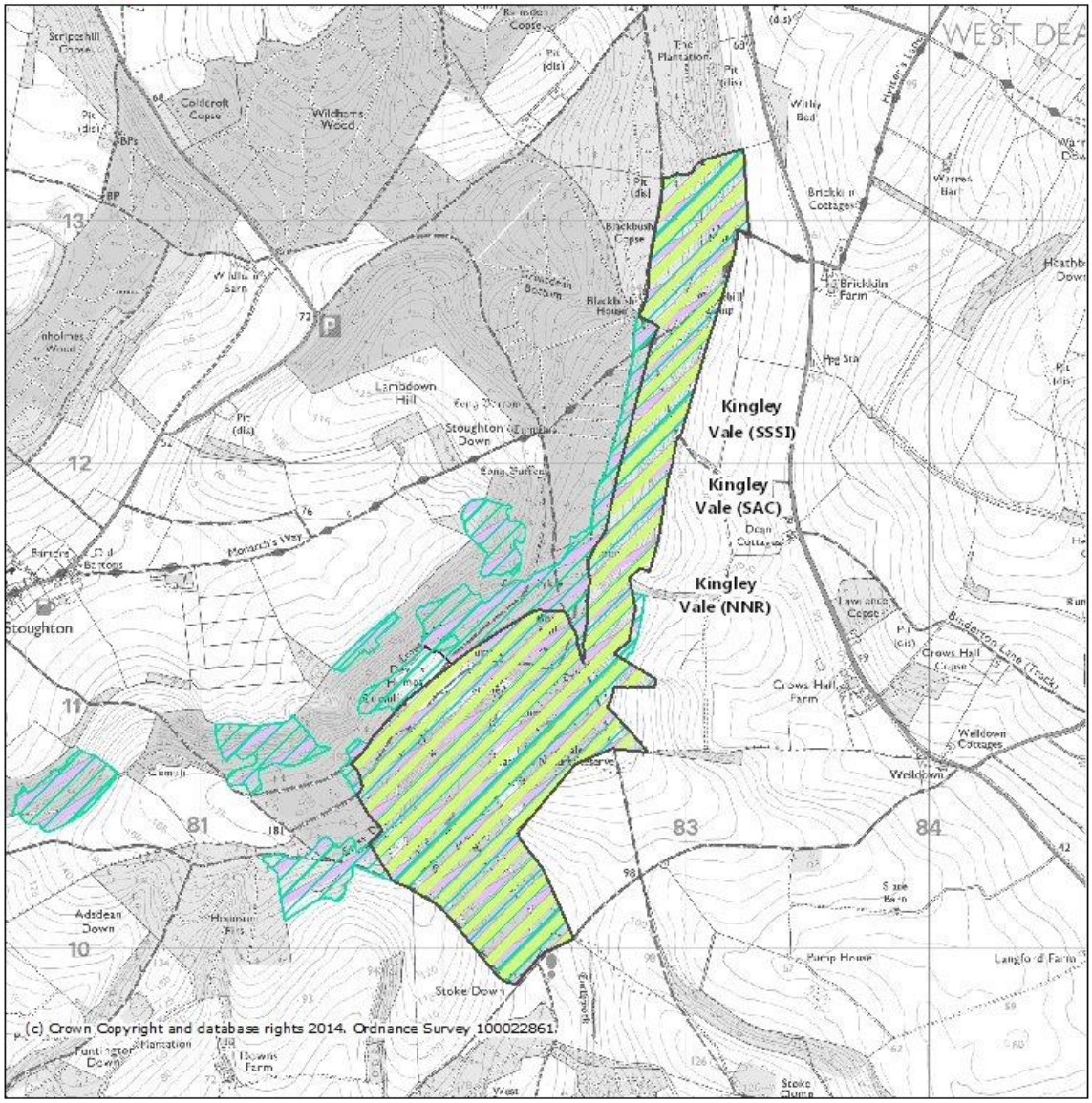
Sussex Biodiversity Record Centre
website: www.sxbrc.org.uk
email: sxbrc@sussexwt.org.uk
Tel: 01273 497553
Fax: 01273 494500
Woods Mill
Henfield
BN5 9SD



Appendix II

MAGIC

Designations



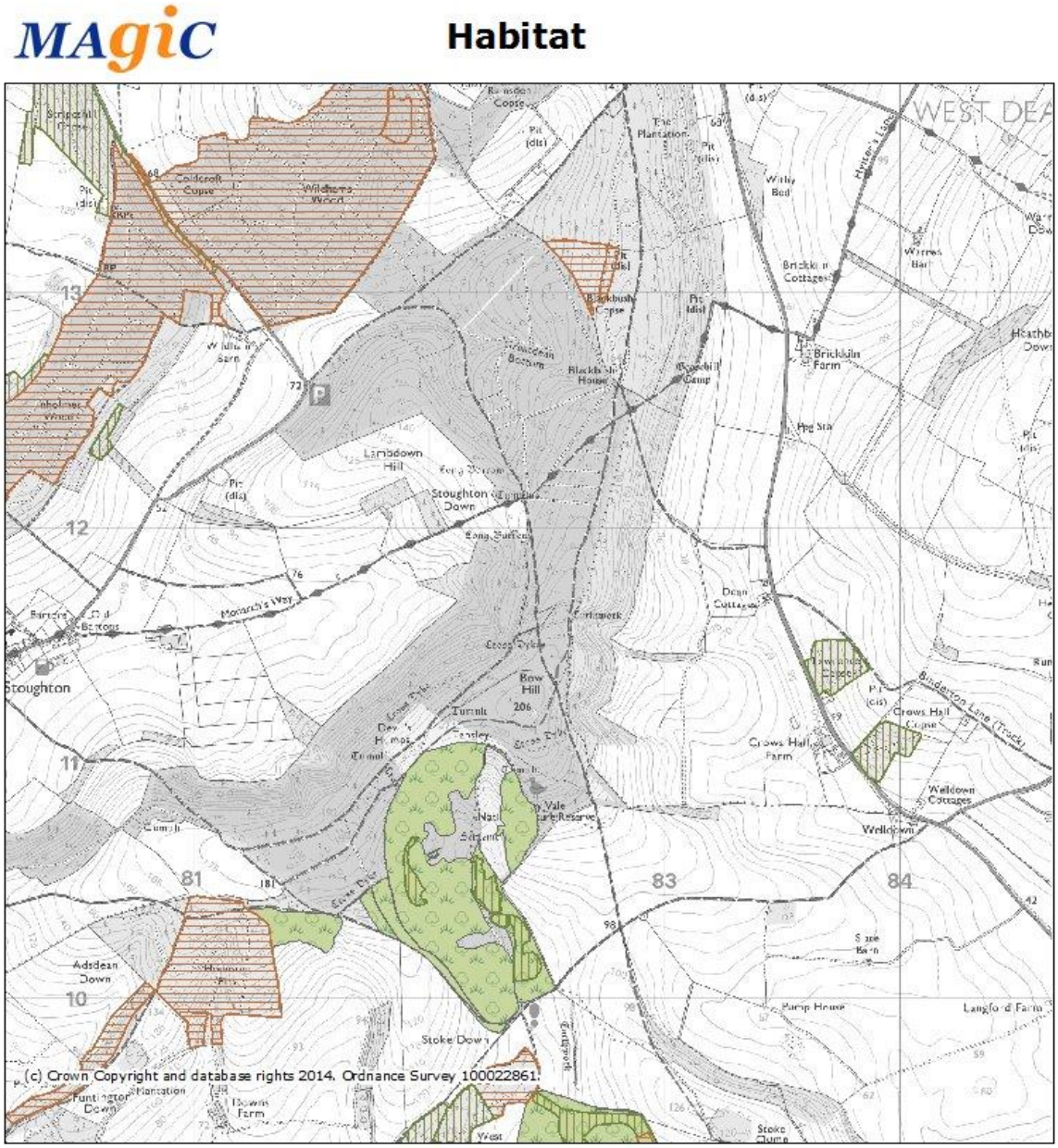
Legend

- National Nature Reserves (England)
- Sites of Special Scientific Interest (England)
- Special Areas of Conservation (England)

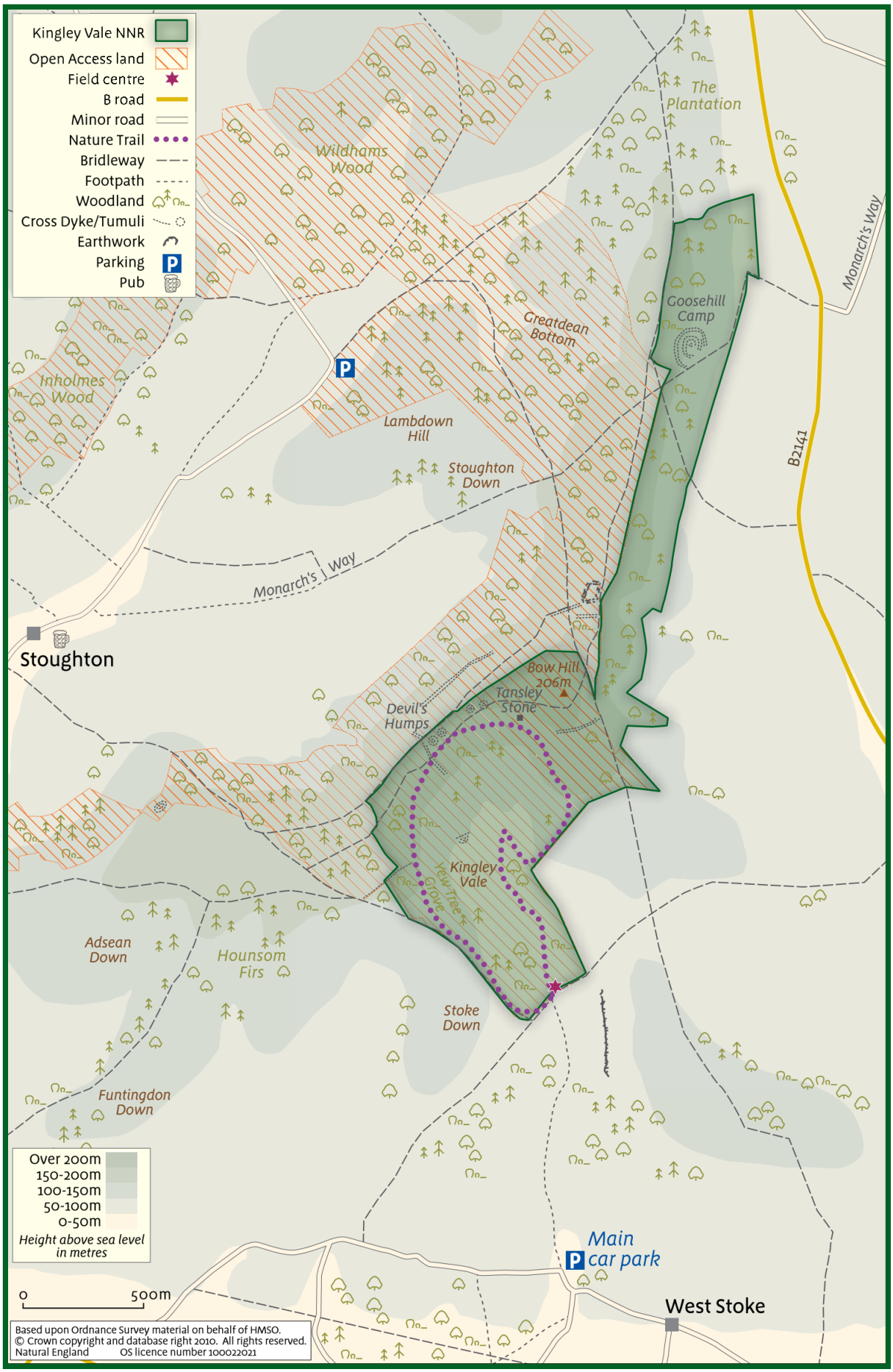
Projection = OSGB36
xmin = 476700
ymin = 108900
xmax = 488100
ymax = 114400

Map produced by MAGIC on 26 December, 2014. Copyright resides with the data suppliers and the map must not be reproduced without their permission. Some information in MAGIC is a snapshot of the information that is being maintained or continually updated by the originating organisation. Please refer to the metadata for details as information may be illustrative or representative rather than definitive at this stage.

Appendix III



Appendix IV


Kingley Vale NNR
Open Access land
Field centre
B road
Minor road
Nature Trail
Bridleway
Footpath
Woodland
Cross Dyke/Tumuli
Earthwork
Parking
Pub
Wildhams Wood
The Plantation
Monarch's Way
Goosehill Camp
Greatdean Bottom
Inholmes Wood
Lambdown Hill
Stoughton Down
B2141
Monarch's Way
Stoughton
Bow Hill 206m
Tansley Stone
Devil's Humps
Kingley Vale
Yew Tree Grove
Adsean Down
Hounsom Firs
Stoke Down
Funtingdon Down
Over 200m
150-200m
100-150m
50-100m
0-50m
Height above sea level in metres
0
500m
Main car park
West Stoke
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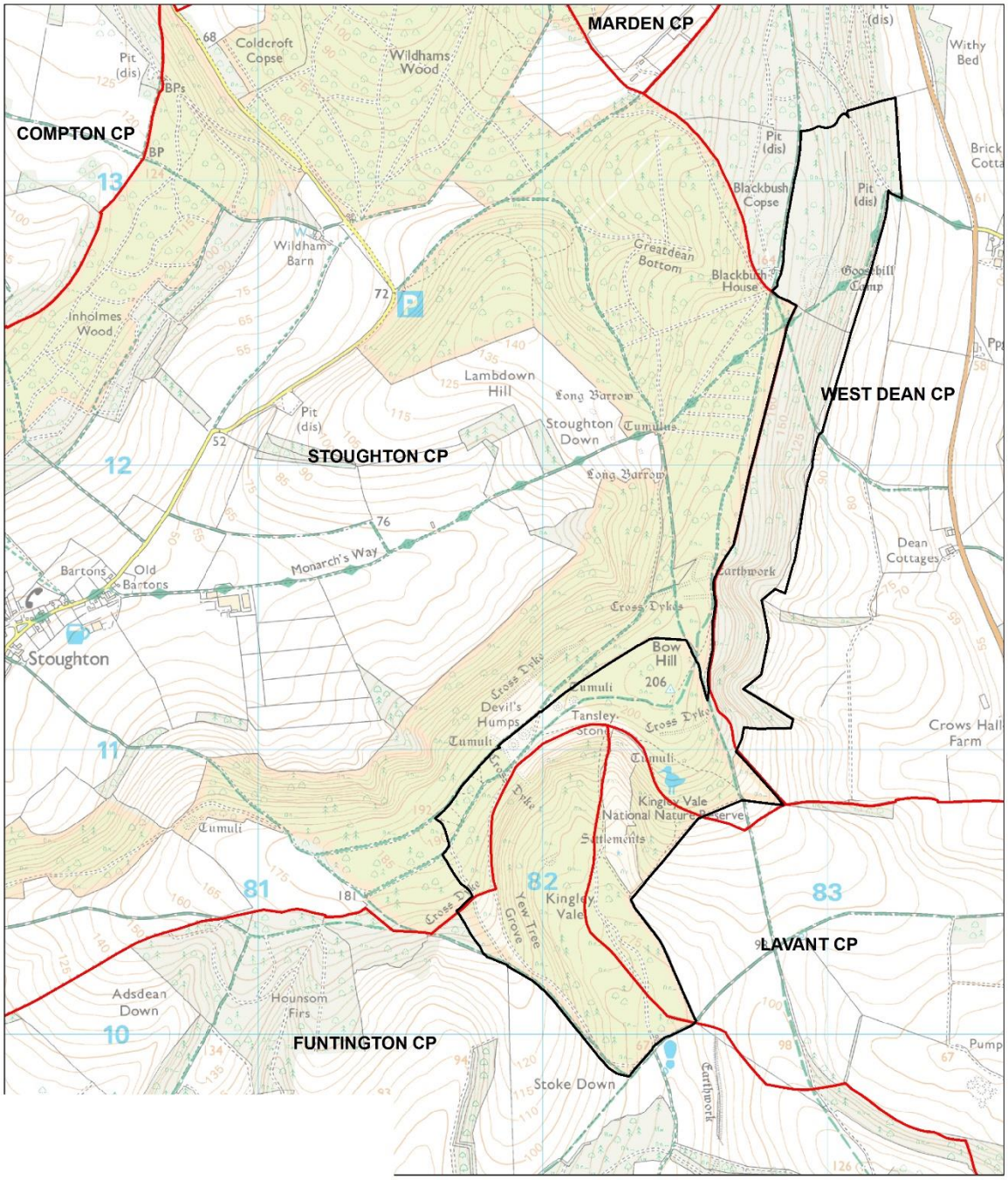
Appendix V

Kingley Vale National Nature Reserve
Figure 1: Parish Boundaries (Management Plan 2015-2020)



Legend

NNR Boundary

Parishes (Maffengland98 inc. parish no) © Ordnance Survey

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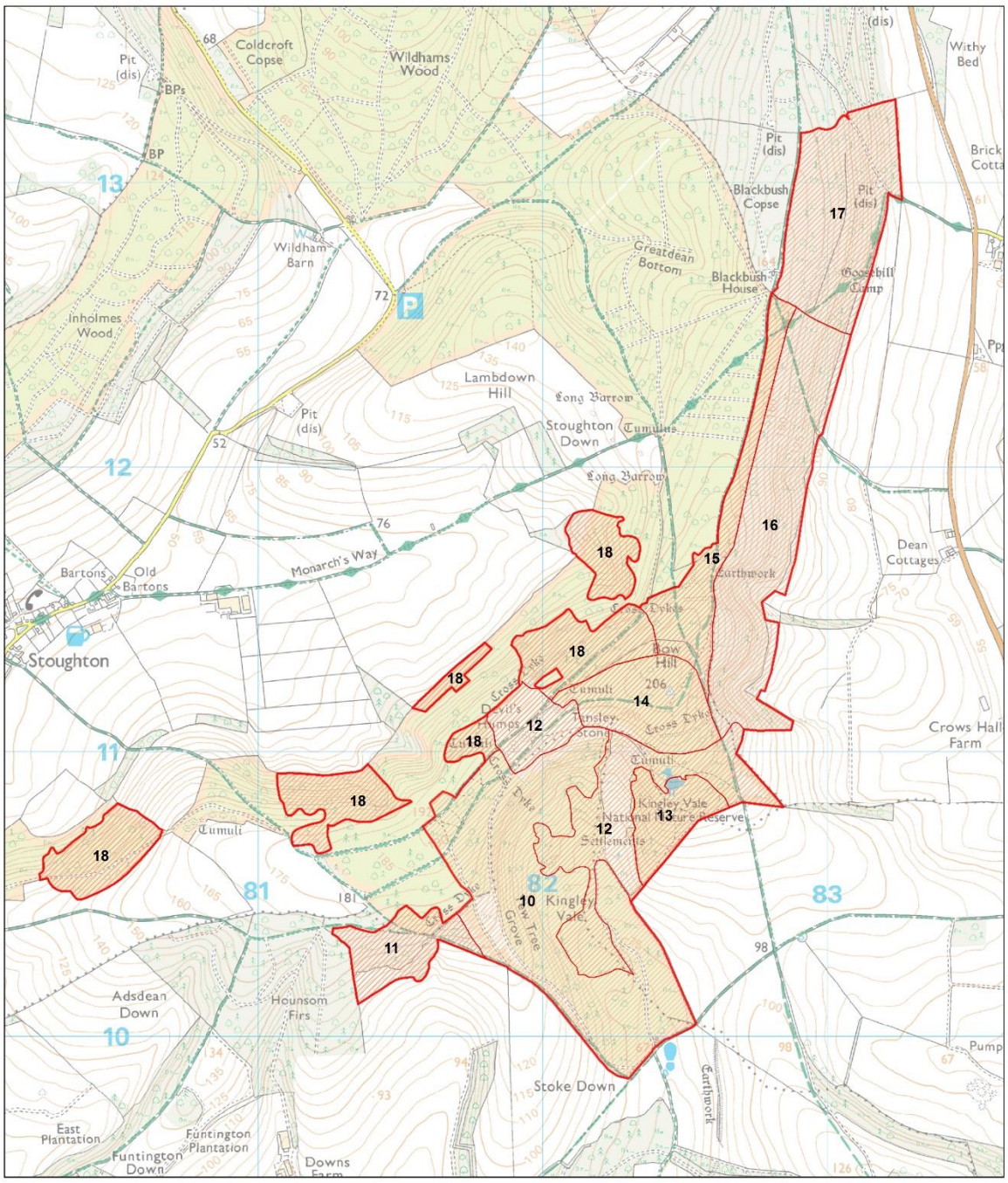
Meters 0 125 250 500 750

Scale (at A3): 1:12,500 N

Map produced by Steve Walker.
South Downs Team
Date:01/03/2015. Map Reference: xxxxxx

NATURAL ENGLAND

Kingley Vale National Nature Reserve
Figure 2: SSSI Site Units (Management Plan 2015-2020)



Legend

Sites of Special Scientific Interest (SSSI) © Natural England

SSSI Site Units

Meters 0 125 250 500 750

Scale (at A3): 1:12,500

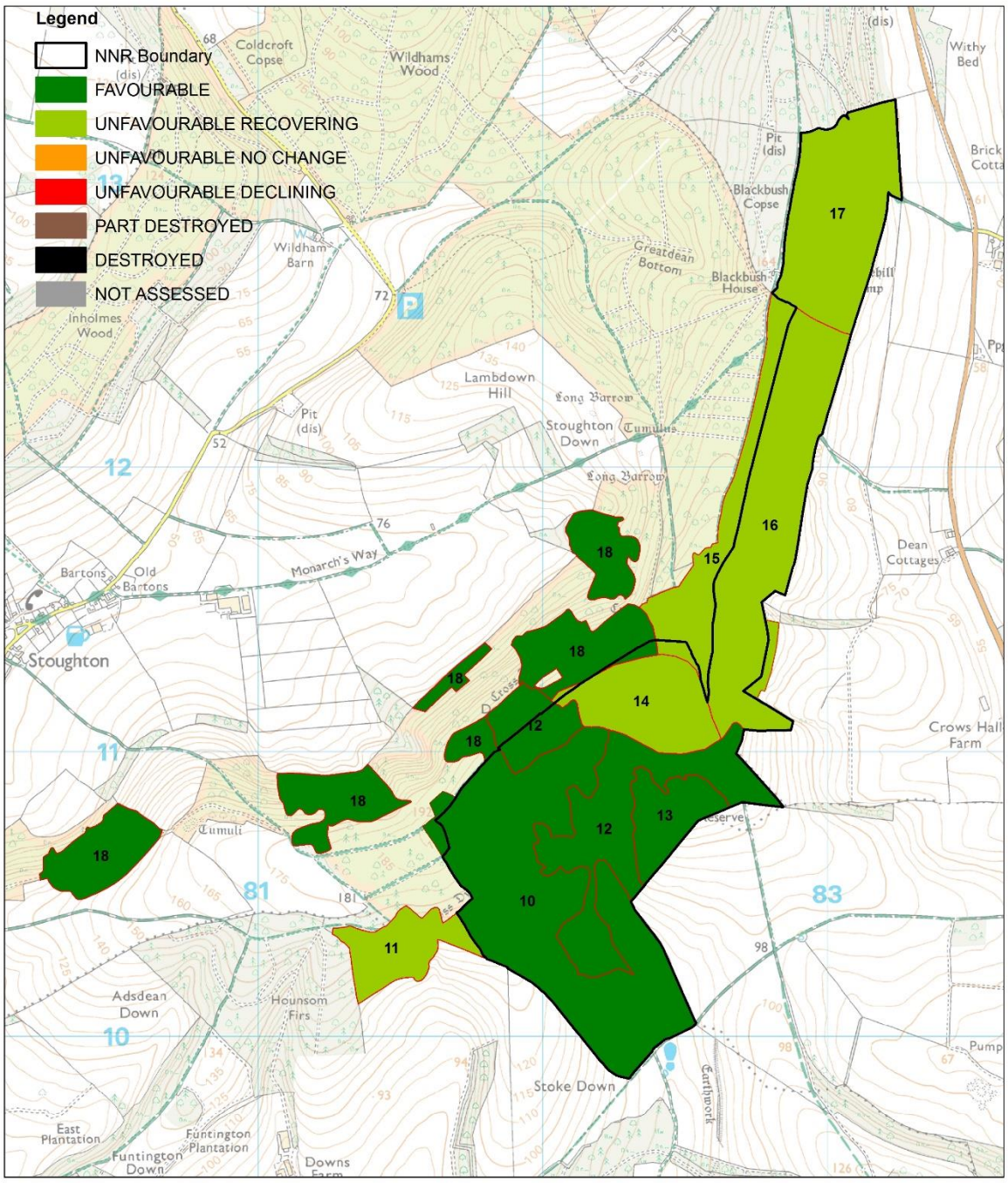
Map produced by Steve Walker.
South Downs Team
Date:01/03/2015. Map Reference: xxxxxx

N

NATURAL ENGLAND

Kingley Vale National Nature Reserve

Figure 3: Sites of Special Scientific Interest Condition Units (Management Plan 2015-2020)



Legend

NNR Boundary

SSSI Site Units

Meters 0 125 250 500 750

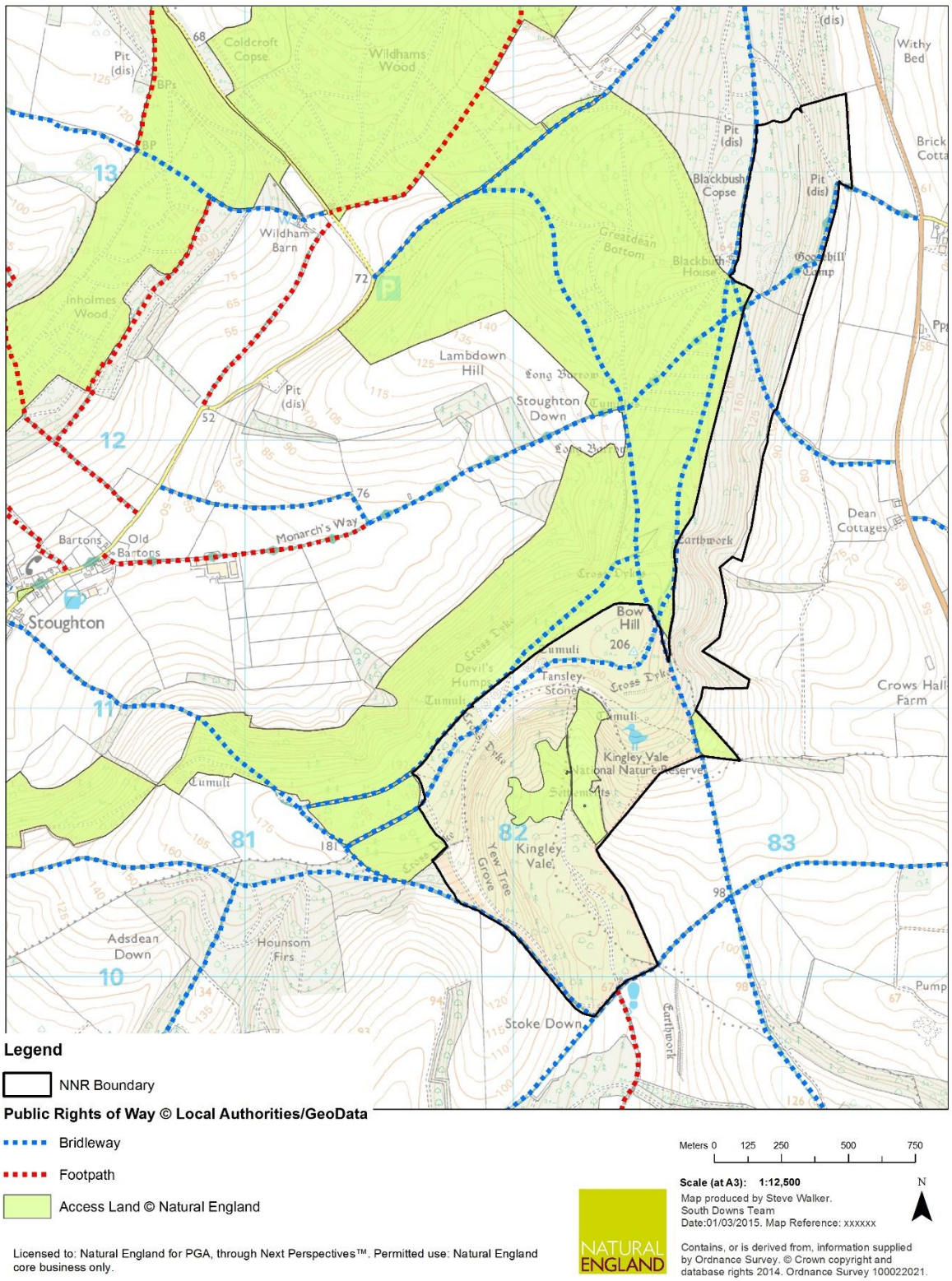
Scale (at A3): 1:12,500

Map produced by Steve Walker.
South Downs Team
Date:01/03/2015. Map Reference: xxxxxx

N

NATURAL ENGLAND

Kingley Vale National Nature Reserve
Figure 4: Access Land & Public Rights of Way (Management Plan 2015-2020)



Legend

NNR Boundary

Public Rights of Way © Local Authorities/GeoData

Bridleway

Footpath

Access Land © Natural England

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Meters 0 125 250 500 750

Scale (at A3): 1:12,500 N

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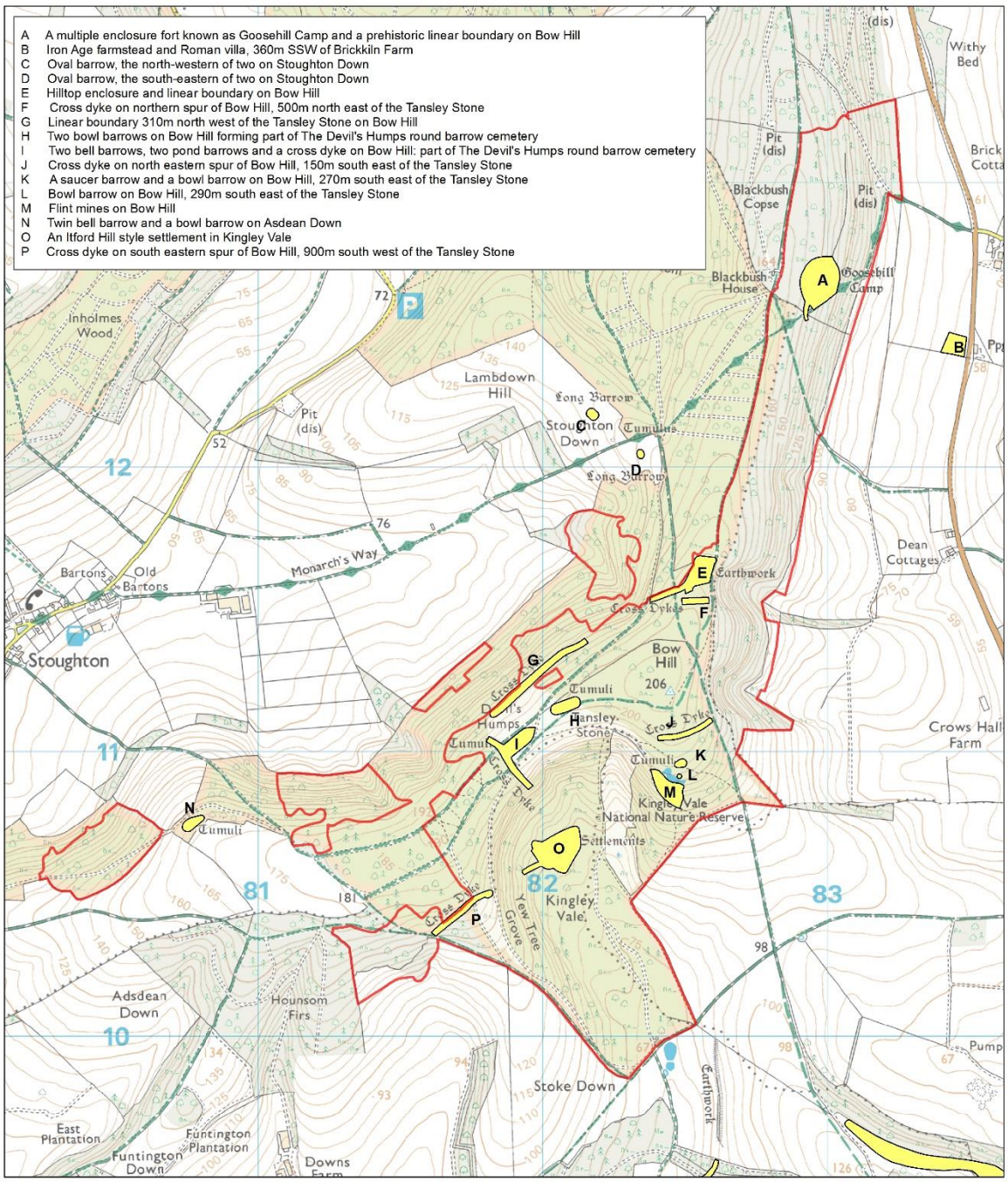
NATURAL ENGLAND

Kingley Vale National Nature Reserve

Figure 5: Scheduled Monuments (Management Plan 2015-2020)



Legend

Sites of Special Scientific Interest (SSSI) © Natural England

Scheduled Monuments © English Heritage

Meters 0 125 250 500 750

Scale (at A3): 1:12,500

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NATURAL ENGLAND

Appendix VI

RIEC - Revised Index of Ecological Continuity

Anisomeridium ranunculosporum
Arthonia vinosa
Biatora sphaeroides
Catinaria atropurpurea
Cresponea premnea
Degelia atlantica/or plumbea/or Parmeliella triptophylla
Dimerella lutea
Enterographa crassa
Lecanographa lyncea
Lobaria amplissima
L. pulmonaria
L. scrobiculata
L. virens
Loxospora elatina
Nephroma laevigatum
Pachyphiale carneola
Pannaria conoplea
Parmotrema crinitum
Peltigera collina
P. horizontalis
Porina leptalea
Punctelia reddenda
Pyrenula chlorospila/or macrospora
Rinodina isidioides
Schismatomma quercicola/or Pertusaria pupillaris
Stenocybe septata
Sticta limbata
S. fuliginosa/or sylvatica
Thelopsis rubella
Thelotrema lepadinum

NIEC - New Index of Ecological Continuity

Main species

Agonimia allobata
A. octospora
Anisomeridium ranunculosporum
Arthonia astroidestera
A. ilicina
A. vinosa
Bacidia biatorina
Biatora epixanthoides
B. sphaeroides
Buellia erubescens
Catinaria atropurpurea
Cetrelia olivetorum *s. lat.*
Chaenotheca sp. (excl. C. ferruginea)*
Cladonia caespiticia
C. parasitica
Collema furfuraceum/or subflaccidum*
Cresponea premnea
Degelia atlantica/or plumbea*
Dimerella lutea
Enterographa sorediata
Heterodermia japonica
Lecanactis subabietina
Lecanographa amylacea
L. lyncea
Lecanora jamesii
L. quercicola
L. sublivescens
Leptogium cyanescens
L. lichenoides
L. teretiusculum
Lobaria amplissima
L. pulmonaria
L. scrobiculata
L. virens
Loxospora elatina
Megalospora tuberculosa
Micarea alabastrites/or cinerea*
M. pycnidiophora
Mycoporum antecellens
Nephroma laevigatum
N. parile
Ochrolechia inversa
Opegrapha corticola
O. prosodea
Pachyphiale carneola
Pannaria conoplea/or rubiginosa*
Parmeliella parvula
P. triptophylla
Parmotrema crinitum
Peltigera collina
P. horizontalis
Pertusaria multipuncta
P. velata
Phaeographis sp. (excl. P. smithii)*
Phyllopsora rosei
Porina coralloidea
P. hibernica
Punctelia reddenda
Rinodina isidioides
Schismatomma niveum
S. quercicola/ or Pertusaria pupillaris*
Stenocybe septata
Sticta fuliginosa/ or sylvatica*
S. limbata
Strangospora ochrophora
Thelopsis rubella
Thelotrema lepadinum
Usnea ceratina
U. florida
Wadeana dendrographa

The maximum total above is 70, but the following rare species are among those that can be considered as **Bonus species**:

Anaptychia ciliaris
Arthonia anombrophila
A. anglica
A. arthonioides
A. zwackhii
Bacidia circumspecta
B. subincompta
Buellia hyperbolica
Bunodophoron melanocarpum (S England only)
Catillaria alba
Caloplaca herbidella
C. lucifuga
Collema fragrans
C. nigrescens
C. subnigrescens
Cryptolechia carneolutea
Fuscopannaria mediterranea
F. sampaiana
Hypotrachyna endochlora
H. sinuosa
H. taylorensis
Leptogium burgessii
L. cochleatum
Megalaria grossa (S England only)
M. laureri
Menegazzia terebrata
Mycoporum lacteum
Opegrapha fumosa
Parmelinopsis horrescens
P. minarum
Parmeliella testacea
Parmotrema arnoldii
Porina rosei
Pseudocyphellaria crocata
P. intricata
P. norvegica
Pyrenula nitida *s.str.*
Ramonia sp.* (excl. R. interjecta)
Rinodina colobinoides
Schismatomma graphidioides
Sphaerophorus globosus (S England only)
Sticta canariensis/or dufourii*
Teloschistes flavicans
Usnea articulata

*Note that only one species is counted when alternatives or "sp." are given.

Appendix VII

Lichens							
Young/old							
Date:							
			Position on tree				**Comments**
Girth tree	**Lichen code**	**Abundancy**	**Nord**	**East**	**South**	**West**	

Appendix VIII

Invertebrates				
Young/old				
Date:				
	Found with			**Comments**
Invertebrate code	**Active search**	**Pitfall traps**	**FIT**	

List of abbreviations

AIV: acidophilic indicator value

ASNW: Ancient Semi-Natural Woodland

BAP: Biodiversity Action Plan

BOA: Biodiversity Opportunity Area

CWD: Coarse Woody Debris

e.g.: for example

FIT: Flight Interception Trap

HAVS: Hand Arm Vibration Syndrome

i.e.: that is

LDV: Lichen Diversity Value

LIFE: Financial Instrument for the Environment

MSF: Means of Sums of Frequencies

NIEC: New Index of Ecological Continuity

NIV: nitrophilous indicator value

NNR: National Nature Reserve

No.: number

RIEC: Revised Index of Ecological Continuity

RTN: Recovery Through Nature

SAC: Special Area of Conservation

SAM: Scheduled Ancient Monuments

SF: Sums of Frequencies

SPA: Special Protection Area

SSSI: Site of Special Scientific Interest

UK: United Kingdom

VRS: Volunteer Ranger Service

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