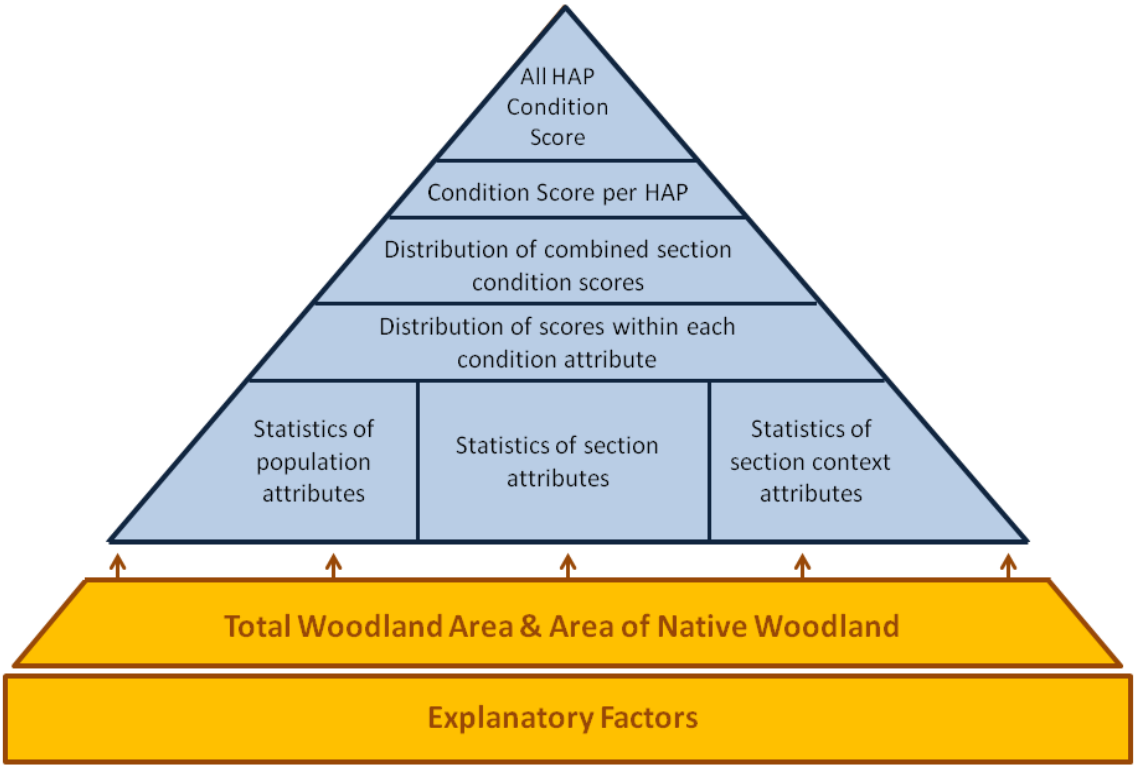
Reporting on Forest Condition



Draft Procedure

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(Supported by previous work from K. Kirby, the UKNWHAP Group and N. Barsoum)

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Introduction

In the 1990s the British Government signed a number of important global and pan-European agreements which led to commitments concerning the protection of forest biodiversity. These include the Convention on Biological Diversity (CBD) and the EU Habitats Directive. Contracting parties to the CBD are required to develop and enforce national strategies to identify, conserve and protect existing biodiversity. Article 7 of the convention deals specifically with the requirement to monitor biodiversity (see Box 1).

Box 1. Convention on Biological Diversity - Article 7

Each contracting party shall, as far as possible and appropriate, in particular for the purposes of Articles 8 to 10:

a) Identify components of biological diversity important for its conservation and sustainable use having regard to the indicative list of categories set down in Annex 1
b) Monitor, through sampling and other techniques, the components of biological diversity identified pursuant to subparagraph (a) above, paying particular attention to those requiring urgent conservation measures and those which offer the greatest potential for sustainable use;
c) Identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects through sampling and other techniques; and
d) Maintain and organise, by any mechanism data, derived from identification and monitoring activities pursuant to subparagraphs a, b and c above.

The text of the CBD overall recognises the role of indicators in assisting signatories to monitor the status of biodiversity. At an EU level the Ministerial Conferences on the Protection of Forests in Europe (MCPFE) have produced a set of criteria and indicators that are designed for monitoring aspects of sustainable forest management (MCPFE 2003).

The UK was the first country to produce a national biodiversity action plan in response to the CBD – this is known as the UK Biodiversity Action Plan (UK BAP). Since the creation of the UK BAP, devolution has led the four UK countries to produce their own country biodiversity groups and strategies. In 2007, however, a shared vision for UK biodiversity conservation was adopted by the devolved administrations and the UK government which is described in 'Conserving Biodiversity – the UK Approach' (Defra 2007).

The Forestry Commission has the role of lead partner for action and reporting on priority woodland habitats and is responsible at country and UK level for monitoring the status and trend of extent and condition of those habitats. The Forestry Commission has been conducting surveys on GB woodlands since 1924. Data collection for the latest inventory – the National Forest Inventory (NFI) - includes updated monitoring criteria, many specifically for BAP reporting and was started in 2009. The surveys have been designed for the specific purpose of enabling assessment of biodiversity value and general condition of British woodland though time and the data collected to date has been analysed throughout this period to identify trends within woodlands (see pages 7-11 for further information on NFI survey methodology).

This paper provides the outline of a proposed system for assessing HAP extent, type and forest condition using NFI data. The principal objective was to formulate a list of indicators of forest condition that is informative, enduring and suitable for extraction from the NFI and to produce a scoring system enabling condition to be assessed and compared regionally or nationally. The report details the background to the proposal as well as the attributes of assessment and suggested scoring mechanism. The paper will serve as a consultation document for consideration by the devolved countries and views are sought.

Background

In 1995 the UK, as part of the UK BAP, established a list of specific woodland Priority Habitats. To facilitate co-ordination of the native woodland habitat actions plans (HAPs) the Forestry Commission convened a steering group called the UK Native Woodland Habitat Action Plan (UKNWHAP) Group (2002 – 2009). The group was formed by representatives from expert organisations including Forest Research, Forestry and Timber Association, RSPB, Scottish Natural Heritage, NFU etc. The group was responsible for reporting progress against HAP targets and developing approaches to HAP monitoring, including factors to assess.

A specific task group was established in December 2008, at the request of the National Forest Inventory (NFI) programme board, to define biodiversity information needs at country and GB level for the goal of reporting on forest condition through the NFI. On the basis of country strategies and legal requirements the group established a series of indicators that it would be necessary or beneficial for NFI to measure (Table 1). In part these drew upon information collected in the previous form of the woodland inventory (NIWT) and

largely on the findings of the UKNWHAP group. Collectively the proposed indicators were designed to meet the reporting requirements for each country and at GB level. They also provided additional key information on biodiversity trends to help inform policy and enable monitoring of priority native woodland habitats.

In 2010 a task group of FC staff most of whom had been on the UKNWHAP group was convened. Nadia Barsoum was the group's representative from Forest Research. Part of the remit of the group was to assess the data that had, by then, been collected during the initial NFI surveys, with a view to establishing a method of reporting on forest condition. Nadia Barsoum liaised closely with the IFOS NFI team to consider the original list of biodiversity indicators alongside the NFI survey methods and initial data sets. Discussions between the task group members established that a traffic light system for each indicator could facilitate the overall interpretation of forest condition whilst maintaining transparency in the range of attributes accounting for condition overall. The group also determined that the term 'indicator' should be replaced with 'attribute' as not all the NFI variables represented a strict link to presence or absence of biodiversity. The term attribute will therefore be used in this document. Nadia Barsoum subsequently produced a report detailing a proposed list of attributes for assessing forest condition and provided provisional suggested thresholds for the 'scoring' of each one based on a traffic light system. These thresholds were derived from expert opinion, literature and estimates and were intended as a starting point for discussion and refinement only.

In spring 2013, Ben Ditchburn, Laura Henderson (Nadia's maternity replacement) and Keith Kirby met to assess the list, the proposed thresholds and how they may be scored against actual NFI data. Each attribute was considered independently for its validity in terms of assessing forest condition, for its possible correlation with other attributes and for its viability in respect of the NFI survey methods and data. The proposed thresholds for each attribute were refined and a suggested mechanism was developed in order to produce an overall forest condition score by region or country.

Samples of NFI data which are representative of the main woodland types across GB were then 'scored' using the refined list of attributes and their proposed thresholds. This enabled the key elements of the proposed scoring and querying mechanism to be tested and any potential problems to be highlighted. The scores were compared against each other and against expectations based on knowledge, the NFI database information and aerial photography.

Theme (in line with Common Standards Monitoring)	Biodiversity Attributes	Required NFI data - all at section level
Woodland Area	**Woodland Area by Priority Habitat (identified at the section level)**	We need **% cover of all species in all sections and all layers of canopy**, happy to just note presence if less than say 5% canopy cover. (Decision key needed using key tree species, and NVC)
	NVC	In native sections (defined by species mix): NVC using NWSS method Needs adaptation for England/Wales
	Woodland loss:	Ensure plots that become unwooded are revisited (unless lost to concrete). On return to plot and no longer wooded: 1) Reason? 2) Current species cover (I.e. ground/field layer) or road /hardcore/ concrete etc
Diversity of woodland structure	**Number of vertical storeys**	No storyes (in canopy, shrub, regen layers) in each section
	Cover of shrub layer	% cover of each species and total % cover in shrub layer (2-5m) all sections. Tree and shrub species. Most important where a canopy exists.
	Index of horizontal diversity	Sections from the map only. No additional field survey
	Young Growth	Planting year or 'established regen % cover' plus shrub layer % cover' in each section
	Old Growth	Planting year in each section
	Volume of Deadwood	Mensuration plot: DBH dead standing trees, and DBH along transect for fallen trees. All sections: quick deadwood method - *AND method to infer volume/ha for all sections/square to be agreed*
	Woodland edge	Where there is an edge to a permanent open areas, either internal or external, **1) whether it is sharp, or graded** (see FC bulletin on ride management), **2) broad woodland habitat** and the **3) broad open habitat**. Further discussion required
	Open areas	Broad Habitat type of open sections (those without potential to achieve canopy 20% cover)
Regeneration potential	**Regeneration present where expected**	For both height classes of regen in all sections: % cover of natural regen.
	Nativeness of regeneration	For both height classes of regen in all sections: % cover of each species of natural and planted regen.
	Naturalness of regen and canopy	In all sections: Naturalness of regeneration (nat/planted) and naturalness of canopy (consider NWSS method)
	Level of Browsing	In all sections: Browsing AND Bark stripping: severity/frequency of canopy, shrub layer trees and regeneration
Tree and shrub composition	**No of tree & shrub species per section**	Record all tree & shrub species in all sections (both native and non-native)
	Canopy cover	In all sections: canopy cover.
	Canopy share of native/ non-native species	% cover of all species in all sections (and count/presence below 5-10% threshold). Needs to distinguish canopy (1,2,n), shrub and ER layers and record composition of each
	Presence of veteran trees	In all sections: speies/DBH for each veteran Please keep pollarding y/n also..
Quality indicator	**Presence of invasive non-native species**	In all sections: % cover of each invasive species on list, (plus 'other' for specific invasive species of concern which may arise over time).
	Threats and damages	Assess Area of section affected by key threats: e.g. dumping, soil exposed, enrichment indicators, pheasant damage, dying or defoliated trees.(See NWSS list)

Table 1. Attributes proposed to be measured by NFI, Biodiversity Task Group 2009

Methodology – NFI data and survey methods

The National Forest Inventory comprises two principal data sets both of which will be used in the assessment of forest condition. A visualisation of the relationship between these is provided in Figure 1. The two sets are as follows:

I. Base Map Data: captured from aerial photography and updated with satellite and operational data. These data are used to establish Interpreted Forest Types (IFTs), total woodland area, woodland parcel size etc.

II. Field Survey Data: 15,000 one-hectare sample squares are surveyed on a 5 year cycle to assess fine-scale components of woodland composition across Scotland, England and Wales. The squares were chosen on a stratified random sample basis utilising a combination of a systematic grid and a random selection. The squares represent a 0.6% sample of all woodlands which is extrapolated up to represent 100% of woodland area regionally or for the whole of GB. The Forestry Commission applies rigorous and strict Quality Assurance processes upon the fieldwork to ensure the surveys capture a representative and unbiased picture of each square and woodland in turn.

Further information on the NFI methodology can be found at http://www.forestry.gov.uk/forestry/INFD-89Q9R3. The NFI Field Survey Manual is available on-line and describes in detail how data is collected.

Figure 1. Schematic representation of the NFI 'bulking up' process. This demonstrates the main data groups within the NFI and how they relate. The base NFI woodland map data (top) establishes the location and extent of all woodlands over 0.5 hectares. Within this area, a series of sample squares are chosen to target fieldwork. These estimate the detailed composition of woodlands. Once a survey square is established (second to bottom) a surveyor will stratify it into relatively homogenous strata; in this example agriculture (as denoted by the livestock) and broadleaved woodland (as denoted by the trees). Within the square a series of stand-level measures such as habitat and management type will be taken. The circular areas represent the detailed plots where all trees are mapped, their species, heights and diameters taken, amongst a series of other parameters such as regeneration and deadwood. National estimates are derived by 'bulking up' through extrapolating the data from the bottom right-hand corner of the figure to the top left.

Survey square data.

For the purposes of accurate sampling, squares are mapped at several levels:

1. Square – One hectare unit (see Figures 2 and 4)
2. Section: a discrete polygon or combination of identical polygons at least 0.05 Ha in extent. Sections are defined by individual stratum that are differentiated on basis of forest type, habitat, landuse, silviculture system, tree shrub composition, age, structure etc (see Figure 2). The minimum number of sections per square is 1 and the maximum is 20.
3. Component Group: Homogenous areas too small to map as a discrete section (see Figure 3).
4. Component / sub component: Individual elements (components) of the woodland or stand that cannot be separately mapped, such as different species in intimate mixtures, but equally may apply to micro habitats interspersed within woodland.
5. Plot /point (with transects): Circular sample plots for the collection of data on individual trees, regeneration and deadwood etc

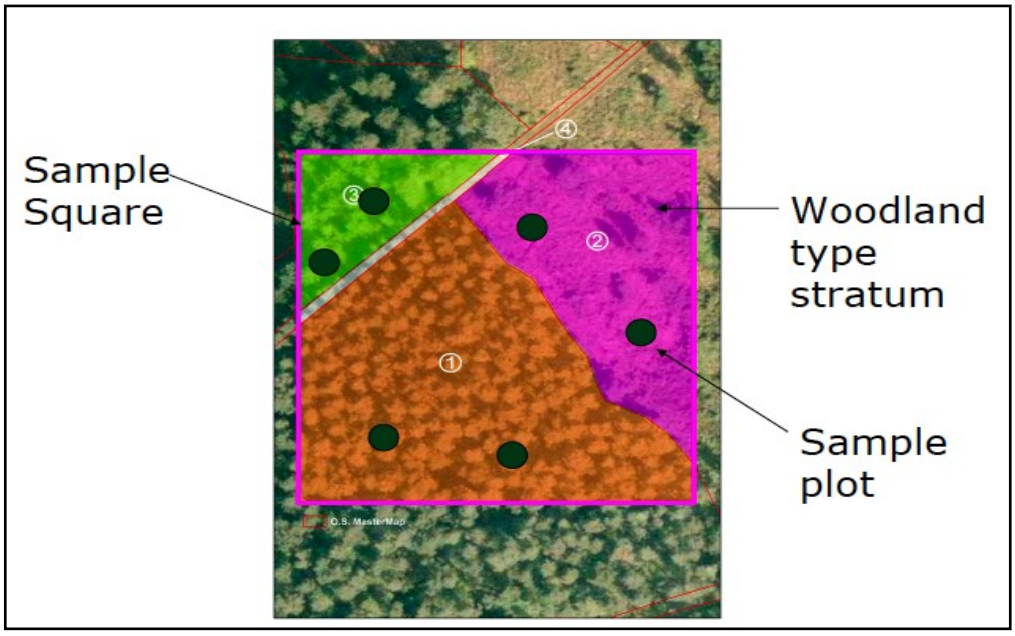

Figure 2. Example of a one hectare survey square divided into sections (in green, pink and orange) and distribution of circular sample plots

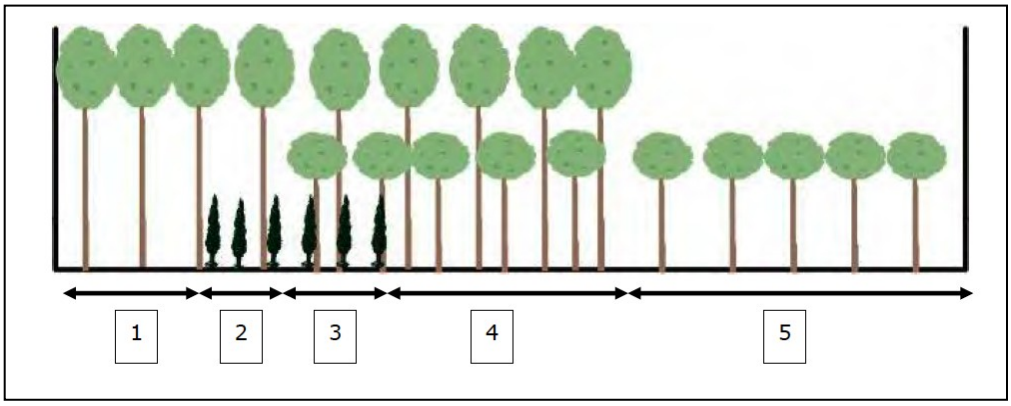

Figure 3. Visualisation of a section of Scot's Pine divided into five component groups

Figure 4. A typical NFI survey square set in a small broadleaved wood. This square has been divided into 3 unique strata within which a series of stand-level assessments are taken i.e. storey structure, habitat type, management etc. Within each strata there are two circular sample plots for data collection on individual trees. In this example over 60 trees have been mapped and measured

Sampling of the native woodland population

There are two principal methods for estimating the size of a woodland population: i) a full census in which all areas of woodland are assessed or ii) a sample survey where a small representative proportion of woodland is assessed. There are pros and cons to both methods. A census is accurate but can be expensive and can take a long time to undertake. A sample survey is less accurate but can be achieved with less resource and on a relatively short time frame. A full census approach tends to be more helpful for operational purposes in that it identifies the location of all components within a population. Sample surveys, however, can only give strategic evidence, or summaries at regional or national scale. Statistical science and survey design can help to maximise the accuracy of sample surveys and can quantify the extent of any inaccuracy by estimating standard errors. The NFI combines the benefits of both approaches by taking a full census of woodlands (base map data) but also assesses details of woodland composition through sampling. Sample surveys can raise questions over their ability to represent a population. Figure 5 illustrates how this is not an issue when assessing the area of native woodland.

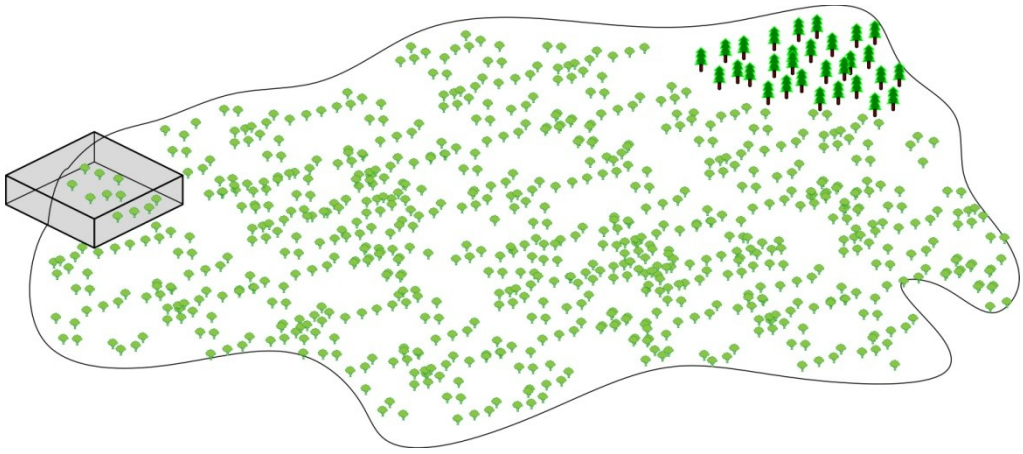

Figure 5: Sampling in Woodland. This woodland is primarily composed of native broadleaves but also contains an element of non-native conifer. The NFI sample squares are selected with probability proportional to woodland area and their selection is random. In this instance (and in most instances) the sample square has (and would have - through probability) fallen within the dominant woodland feature (broadleaves in this case). As such, this square will contribute to the assessment of woodlands as a 'pure' native broadleaved sample. There are, however, thousands of other samples within British woodlands. Through the laws of probability a smaller proportion of those that fall in woods of similar composition will fall within the non-native conifer areas. The number will be proportional to their relative area to native broadleaves. Therefore they will contribute to the assessment of woodland composition relative to their 'share' of overall woodland composition. Although this sample square may not be entirely representative of the woodland block it falls within, when all sample squares are combined, the assessment of woodlands will be representative of the woodland population as a whole.

Methodology - Defining nativeness

Devolved country requirements

Each country within Britain has slightly different criteria for assessing forest condition as summarised in Table 2.

	England	Scotland	Wales
Definition of native woodland	**>80%** native tree species	**> 50%** native tree species	**> 50%** native tree species
Extent of analysis	Forest Condition to be assessed on **Native Woodland only** (preferably by Hap type on a regional basis)	Forest Condition to be assessed on **all** woodland (preferably by Hap type on a regional basis)	Forest Condition to be assessed on **Native Woodland only** (preferably by Hap type on a regional basis)

Table 2. Devolved country specifications for defining nativeness of woodland and for assessing forest condition.

When considering the need to report against all HAPS within Great Britain, or against an individual HAP, the NFI team's view is that it is preferable to have a single definition of native woodland for Great Britain as this will facilitate ease of reporting, reduce complexity in developing reporting systems and will make the results for the individual countries comparable and able to be aggregated (as per the approaches advocated by the Office of National statistics and the standard NFI approach to statistics reporting). However the roots of the differences between the countries are recognised and will form the basis of the approach taken.

The NFI needed to have a standardised and scalable survey methodology suitable for all purposes across Great Britain. This led NFI to design a survey that enabled 'nativeness' to be assessed from its most granular level; a single native tree, to a full native canopy. This method has enabled a 'standard' NFI approach to define native, which has been set at a minimum of 50% native canopy cover over 0.5 hectares, but it also enables assessment of nativeness above and below this threshold. It therefore allows NFI to report on higher threshold percentages such as that required by England.

Reporting on Forest Condition

For consistency, comparability and to meet all countries' requirements, a condition score report will be established at 50% native canopy cover for each country and Great Britain.

Then, if a new definition of 50% for England cannot be sanctioned *, either:

A separate score will also be calculated for an 80% threshold of 'native' for England.

Or

The threshold for 'green status' of the 'nativeness of canopy' attribute will be set to 80% (instead of 90%) for all countries so that one assessment can be made for Great Britain, with England simply reporting only those woods with green status for canopy nativeness.

The approach taken will be discussed at the November meeting.

* This may not be as difficult as it may first appear. To date, analysis of the NFI data shows that whether 50% or 80% is applied will not significantly alter the values produced as circa 96% of broadleaved woodland has over 90% native canopy cover, as evidenced by initial analysis of the NFI sample squares.

For Scotland it was assumed that the required analysis of 'all woodland' would be split into two analyses: one for native woodland and one for non-native woodland separately. For the purpose of utility and consistency these figures will also be supplied for England and Wales. This interpretation needs to be confirmed prior to further analysis.

Defining the Native Woodland population

Introduction to defining the native population

In order to measure a population its unique characteristics or properties must first be defined. This enables it to be distinguished from other populations.

To measure native woodland, therefore, we must first define its population and thus differentiate it from others. This will enable determination of its total extent and distribution. Assessing the extent of native woodland has specific, particular complexities because it is not a discrete population but is mixed within a larger population of woodland. As such, native woodland is a subset of 'all woodland' within which it is often physically or geographically intertwined.

How we determine the specific native woodland sub population for the purposes of assessing its condition forms the basis of this section.

How the evolution of British Woodland has set its current composition and assessment

Woodland in Britain exists on a continuum of 'nativeness' from pure native woodland to pure non-native woodland - with a broad spectrum of mixtures in between. Compared to other countries, Britain has a comparatively large extent of non-native woodland. This is principally a product of Britain's history and the intensive interaction of man with the landscape.

Removal of woodland cover

It is almost certain that most of Britain's land mass would have been native forest if it were not for the extensive and progressive removal of woodland cover from the end of the last ice age (circa 8 – 10,000 years ago) until relatively recent times (circa 100 years ago). Human activity and woodland removal over time through animal grazing, burning or direct felling dramatically changed the character of the British landscape. This continued until Britain was left with approximately only 4-6% woodland cover at the turn of the 20th century. At this time the woodland was still primarily of a native composition, with only a very small representation of non-native species. The remaining woodland resource was significantly fragmented and broken into many thousands of small patches (see NFI Woodland Area report 2013 and Tables 3.i-xiii).

Re establishment of woodland cover

With the establishment of both a National Policy of woodland creation and the Forestry Commission, exotic conifers were planted on an extensive scale for most of the 20th century. Latterly an increasing element of native species were also planted. This increased woodland cover from an estimated 4-6% to the present day 13%. This history enables us to understand how non-native species became such a significant (indeed majority) part of the woodland population.

How and where this non-native element was established in relation to the native woodland is key to identifying the native population as a whole and in assessing condition. If, for example, all non natives had been planted separately, identifying native woodland would be relatively easy. Historically, however, the non natives were also planted adjacent to and within the existing native population. This gave rise to mixtures of native and non-native species both within intimate mixtures and within semi discrete patches or 'parcels' * within woodland. How to treat these mixtures is important in assessing the total HAP population and its condition.

*. Often new woodland was established within existing field and ownership boundaries, such 'units' will be referred to as 'landuse parcels' for the purposes of these reports. Homogenous planting within landuse parcels, if planted next to existing woodland, gave the individual parcels a semi discrete nature. The importance of this distinction will became more apparent as the paper progresses.

The configuration of non-native woodland relative to native also differs regionally. In lowland Britain, for example, circumstances led to non-native forests being established adjacent to or within existing native woodlands. This makes identification and measurement of native components difficult. In upland Britain, by contrast, non-native woodland was often isolated making identification and measurement more straightforward.

The large-scale clear felling that took place during the two World Wars of the 20th century devastated the native woods which existed at the time. NFI data indicates that currently over 80% of native HAP type species are less than 70 years old. In the post-war period many of these woods appear to have recovered by and large under their own regenerative processes, maintaining a near native cover and an age profile that indicates staged regeneration and canopy establishment. How much this process was facilitated by policy and management action is not immediately discernible from NFI data but it would have contributed to some degree. Where results of policy interaction are more apparent is on Plantations on Ancient Woodland Sites (PAWS). In these cases replacement with

exotic conifers was either ‘absolute’ with a complete ‘swap' from native to non-native canopy or through establishment of a mixture of native and non-native species. The latter was achieved either intentionally or through natural processes of native regeneration. Sites such as this where natives and non natives are intimately mixed are the hardest to discern and measure for condition purposes. Sites where all the native canopy was replaced are more difficult to identify, but would not qualify as native and are not thought to form a significant proportion of the population.

The resultant population

The NFI statistics on stocked area and standing volume of native and non-native species give an assessment of total woodland area, broken down into areas of native and non-native species. They show that across Great Britain the native to non native species occupancy is roughly 50:50. The reports do not, however, specify if these native and non-native species occupy the same spaces in intimate mixture or if they are discrete within woodlands or between woodlands. Establishing this is fundamental to assessing the total HAP area.

NFI intends to publish analysis of mixtures of species and woodland types. Initial analysis has shown that British woodland stands can be broadly categorised into the following classes:

- Stands of non-native species, with 90% plus non-native species
- Stands of native species, with 95% plus native species
- Mixed stands with natives and non natives intimately mixed.

These stands are either grouped with the same or are grouped within woodlands that contain a mixture of the three types. Tables 3.i-xiii give a breakdown of these. Interestingly the initial results indicate that PAWS do not form a significant element of the population, which contradicts the view that such sites tend to predominate within lowland woodland. Indeed initial analysis shows that most of these sites are in the mixed category above and in order of occurrence these form the lowest proportion of the above three. This interpretation is supported by data arising from the NFI map (detailed in the following tables) and by analysis of the NFI sample square data.

Further analysis of the NFI data, however, including vegetation assessments with ancient woodland maps may indicate a higher proportion of PAWS than is indicated to date, including sites where ‘absolute’ conversion of native canopy has occurred. The following tables give a breakdown of GB woodland broken into discrete woodland blocks and in turn into primarily ‘pure’ blocks (of either conifer or broadleaved) and mixtures.

Great Britain				
Size class (ha)	Total area (ha)	Number of woods	% of total area	Mean wood area (ha)
Discrete broadleaved woodlands				
<2	141,943	145,294	29%	1
2 - <10	204,342	51,311	41%	4
10 - <20	67,914	4,979	14%	14
20 - <50	55,818	1,927	11%	29
50 - <100	16,993	257	3%	66
100 - <500	6,292	42	1%	150
500 and >	0	0	0%	0
All woods	**493,302**	**203,810**	**100%**	**2**

Table 3.i

Great Britain				
Size class (ha)	Total area (ha)	Number of woods	% of total area	Mean wood area (ha)
Discrete mixed woodlands (Mb and Mc)				
<2	13,485	14,026	61%	1
2 - <10	7,309	2,216	33%	3
10 - <20	872	63	4%	14
20 - <50	339	13	2%	26
50 - <100	0	0	0%	0
100 - <500	0	0	0%	0
500 and >	0	0	0%	0
All woods	**22,005**	**16,318**	**100%**	**1**

Table 3.ii

Great Britain				
Size class (ha)	Total area (ha)	Number of woods	% of total area	Mean wood area (ha)
Discrete conifer woodlands				
<2	21,236	20,722	21%	1
2 - <10	30,760	7,925	30%	4
10 - <20	11,915	857	12%	14
20 - <50	15,644	516	15%	30
50 - <100	11,489	169	11%	68
100 - <500	11,383	65	11%	175
500 and >	560	1	1%	560
All woods	**102,986**	**30,255**	**100%**	**3**

Table 3.iii

Great Britain				
Size class (ha)	Total area (ha)	Number of woods	% of total area	Mean wood area (ha)
Discrete transition woodlands				
<2	12,665	12,483	38%	1
2 - <10	12,467	3,366	37%	4
10 - <20	3,252	239	10%	14
20 - <50	2,740	95	8%	29
50 - <100	1,685	24	5%	70
100 - <500	765	5	2%	153
500 and >	0	0	0%	0
All woods	**33,574**	**16,212**	**100%**	**2**

Table 3.iv

Great Britain				
Size class (ha)	Total area (ha)	Number of woods	% of total area	Mean wood area (ha)
Multiple IFT woodlands including uncertain class				
<2	17,527	14,657	1%	1
2 - <10	143,782	29,998	6%	5
10 - <20	128,288	9,057	5%	14
20 - <50	251,190	7,973	11%	32
50 - <100	246,140	3,514	10%	70
100 - <500	616,327	3,082	26%	200
500 and >	949,473	617	40%	0
All woods	**2,352,727**	**68,898**	**100%**	**34**

Table 3.v

Great Britain				
Size class (ha)	Total area (ha)	Number of woods	% of total area	Mean wood area (ha)
All woodlands				
<2	206,855	207,182	7%	1
2 - <10	398,661	94,816	13%	4
10 - <20	212,241	15,195	7%	14
20 - <50	325,731	10,524	11%	31
50 - <100	276,307	3,964	9%	70
100 - <500	634,767	3,194	21%	199
500 and >	950,033	618	32%	0
All woods	**3,004,595**	**335,493**	**100%**	**9**

Table 3.vi

Great Britain		
Forest type	Total area (ha)	% of total area
All woodland by interpreted forest type		
Broadleaved	1,096,541	36%
Conifer	1,255,339	42%
Mixed	94,709	3%
Transition	398,087	13%
uncertain	160,598	5%
TOTALS	**3,005,274**	**100%**

Table 3.vii

Great Britain					
Single IFT woods	No woods	% of total number of woods	area (ha)	% total area for woodland type	% total woodland area
Broadleaved	203,810	61%	493,302	45%	16%
Conifer	30,255	9%	102,986	8%	3%
Mixed	16,318	5%	22,005	23%	1%
Transition	16,212	5%	33,574	8%	1%
Total	266,595	79%	651,867	22%	22%
Multiple IFT woods	68,898	21%	2,352,727	78%	78%
Grand total	335,493	100%	3,004,595	100%	100%

Table 3.viii

Table 3.vi shows the scale of fragmentation within British woods, with circa 335,000 individual woods, the vast majority of which are very small in area. It is notable that there are no discrete broadleaved woods over 500 ha and few over 50 ha. There are many discrete woodland blocks that are primarily broadleaved and by number and total area (70%) they are very small (less than 10 ha). Conifer woodlands tend to be larger on average. However, whilst primarily broadleaved woods form circa 17 % of the total woodland population and primarily conifer form 3.4 %, mixed woods form 79 % of woodland area. This leaves over 50% of native trees within mixed woods. Clearly these factors need to be accounted for appropriately when assessing the size of the native woodland population.

Fragmentation on this scale means that it is likely, on a series of levels, that all HAP woodland cannot act entirely as a single population as it is split into thousands of parts. This is especially true if a 'viable' population is defined as one in which its individual parts are mutually supportive of each other across the whole.

These statistics and others reported by NFI highlight the uniquely 'intertwined' nature of Britain's woodlands. Native species do appear to behave as an ecocline, colonising their respective ecological niches, but superimposed upon this pattern is the introduction of non-native species which have imposed a more 'digital' trend within British woodland: exotic species 'on' or exotic species 'off'.

This 'digital' nature is further evidenced by analysis of the NFI sample squares which show that in areas designated as HAPs, 96% have over 80% native canopy occupancy. For all woodland types similar patterns emerge.

The trend to establish woodland within existing landuse parcels and that these parcels were generally allocated to either native or non-native species reinforces this pattern. Spread or blurring between these two populations within land use parcels has been moderately minimal, with conifers rarely intruding on existing native populations, but native species consistently intruding at low levels into almost all non-native plantations to some degree or another.

As previously mentioned British woodland exists on a continuum of 'nativeness' from pure native woodland to pure non-native woodland (Figure 6)

100 % native Mixtures 100% non Native

Figure 6 The spectrum of mixtures on the continuum from native to non native

To establish native woodland area we must create a set of rules and assumptions to draw a line on this continuum to discern native from non native, separating predominantly native from non-native and creating a series of 'mixed' classes. Where we draw this line will impact on the size of the native population. For example if we set higher % thresholds to signify 'nativeness', we will 'filter off' more non natives and more woodland area. Setting higher thresholds would also impact upon the condition scores as we would be removing a higher % of non-native species from the assessment and this would certainly impact upon condition scores concerning native canopy occupancy.

Whatever thresholds are chosen, for the purposes of reporting a 'true and fair' picture NFI will report on all of the woodland on the continuum and what is excluded from the condition assessment will still be evidenced and in the public domain for consideration.

Tables 3.i-xi show that woodland is fragmented across the landscape and therefore it is surrounded or interspersed by other non woodland land uses. The continuum represented above therefore occurs within many of these discrete sub populations or individual discrete woodland blocks, isolated from other woodlands.

By any definition therefore native woodland within the wider woodland population can be:

- Discrete
- Mixed
- Absent

To ascertain the total native woodland area, a fixed set of rules therefore need to be developed to sort native woodland into these categories.

Separating Native from Non-Native populations

To separate native woodland from that of 'other' woodland we need to set down its defining characteristics in order to identify it for the purposes of assessment.

The characteristics that have been defined for separating nativeness to date include:

1. Nativeness of canopy (>50% Scotland & Wales, >80% England)
2. Minimum area (0.5 ha)
3. Maximum area – non set

This and previous NFI studies found that the woodland population is fragmented in nature, being composed of over 335,000 discrete woodland blocks distributed widely across the landscape. This makes applying definition 1. i.e. 'the % nativeness of canopy' problematic as, due to the fragmentation, it cannot simply be applied to the whole population. The threshold intuitively must be applied to a sub population over which % nativeness is assessed. Unfortunately that subpopulation was not defined when the definitions of native woodland and HAPs were set. In theory 'nativeness' of a population could be assessed over:

- A large geographic unit such as Britain, country or catchment.
- The whole woodland population.
- Any discrete woodland block.
- A discrete stratum within a woodland or any patch of woodland within a wider woodland (homogeneous sub stratum).

A large geographic unit such as Britain, country or catchment
Assessing a large geographic unit is impractical for Britain as woodland forms such a low proportion of the countryside. However, that is a matter of scale not approach. If Britain were 95% afforested and the woodland was contiguous – this approach would be practical and potentially desirable for some uses.

The whole woodland population This assessment level is also probably impractical for Britain due to the level of fragmentation but again this is an issue of scale. If all the woodland were contiguous, this approach could be practical and representative.

Any discrete woodland block This is a viable mechanism for assessing woodland for many purposes, such as native composition of a discrete block. However, when attempting to identify an entire sub population as we are when assessing 'nativeness' (and condition) the question of scale again becomes an issue. When applying this approach, the relative size of the discrete woodland to the relative size of the native patch, differentially drives which patches are included or excluded in the native area 'count'. With patches of a given or constant size excluded from the count in larger woods but included in the count in smaller woods. This ratio of wood size to patch size is a non linear relationship and leads to patches of the same sizes included as native in some circumstances, but not in others. Figures 7.i to 7.xi illustrate this point. Thus when applying this criteria to a range of sizes of native patches, many are differentially excluded from the total population assessment. This issue frequently arises as discrete woodland blocks range in size from 0.5 hectares to 50,000 hectares within Britain, and when applying percentages across the whole block, this will naturally

exclude native woodland patches of different sizes differentially. In summary this approach has the disadvantage of excluding significant patches of native woodlands that sit within or adjacent to non-native woodlands.

A discernible stratum within a woodland This approach treats a discernible homogenous stratum (or a patch of woodland) within a woodland as an entity in its own right irrespective of where it is situated. This approach is relatively 'blind' to whether a patch or stratum sits within a large wood, or a small wood, or as to whether that wood is primarily native or non native overall. It has the benefit of having a linear relationship with scale and will identify and count all significant patches of native woodland within non-native woodlands, irrespective of the scale of that discrete woodland.

By taking the above approaches into consideration it can be seen that applying the different methods to ascertaining nativeness, would impact differentially on the findings on total HAP area depending on which of the main strata of woodland types they were applied to:

- Discrete woodlands entirely composed of native species
- Recognisable sub stratum of native woodland within a wider woodland
- Intimately mixed woods
- No native species present

Choice of approach is therefore paramount in gaining a representative estimate of native woodland area across all types. Furthermore, through each approach, the filtering of different amounts of non-native woodland will impact differentially upon scores. The approach proposed should not treat these types differentially.

The following pages present some examples that illustrate some of these issues. They demonstrate the impact of applying the canopy occupancy threshold at the native patch level and at the whole discrete woodland block. A relatively constant patch size was chosen to demonstrate the non linear inclusion or exclusion of a relatively fixed unit of 2 ha of native woodland. This stand size was chosen as it is the average distinct native woodland size. In the first 3 examples the canopy is 100% broadleaf and the area is over the 0.5 hectare threshold. That being so, irrespective of whether the percentage canopy occupancy is assessed at discrete woodland block or patch, the entire woodland area would count as native.

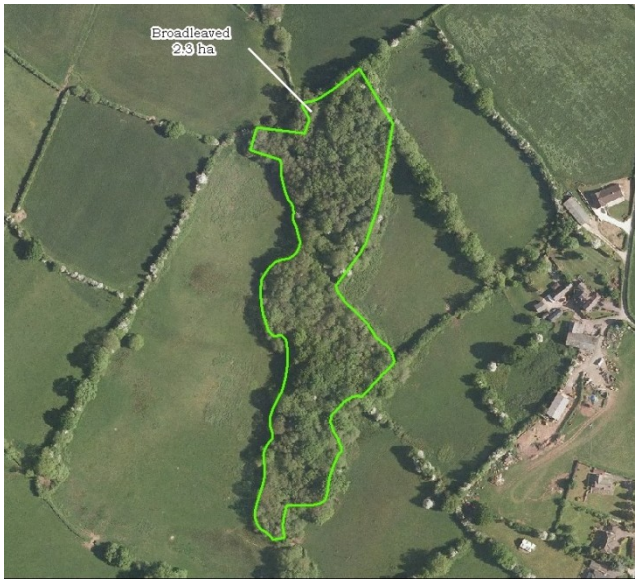

Figure 7.i. Three examples of a 'discrete' broadleaved wood of 100% native canopy

If however the entire canopy is not 100% native, the impact of assessing canopy occupancy at discrete woodland block level as opposed to patch begins to have an impact. In the example below the broadleaves occupy 100% of the patch and 52% of the discrete woodland block and whether assessing native occupancy at discrete woodland block or at native patch, the native area would be included in a native woodland assessment.

Figure 7.ii. A 'discrete' wood with both native and non-native canopy

In the following example the broadleaved element occupies 50% of the canopy and either method would account for the native woodland area of just over 2 ha.

Figure 7.iii. A 'discrete' wood with both native and non-native canopy

In the example below the native canopy in the patch north of the brook forms only 47% of the discrete woodland canopy and would by definition be excluded from the assessment of native area if that approach is applied. If the patch approach were applied, this area would be included in the assessment, as the area is over 0.5 hectares and is 100% native in canopy. The presence of the brook between the two patches reinforces the observation that woodland types tend to be established within 'land parcels', which are often semi discrete in nature even within a discrete woodland block.

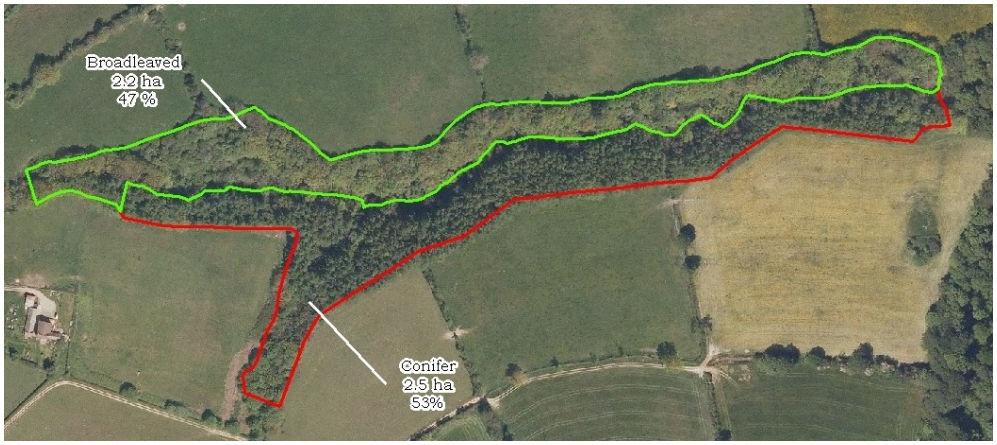

Figure 7.iv. A 'discrete' wood with both native and non native canopy divided by a brook

In the example below, a similar sized patch of 2 ha of native woodland would also be excluded if assessing at discrete woodland block as opposed to patch level. However the woodland is entirely surrounded by young conifers and it can be argued that this puts it at a condition 'disadvantage' as compared to a wholly discreet 2 ha broadleaved woodland patch as in Figure 7.i.

Figure 7.v. A 'discrete' wood with both native and non-native canopy. The broadleaved canopy is surrounded by conifer canopy

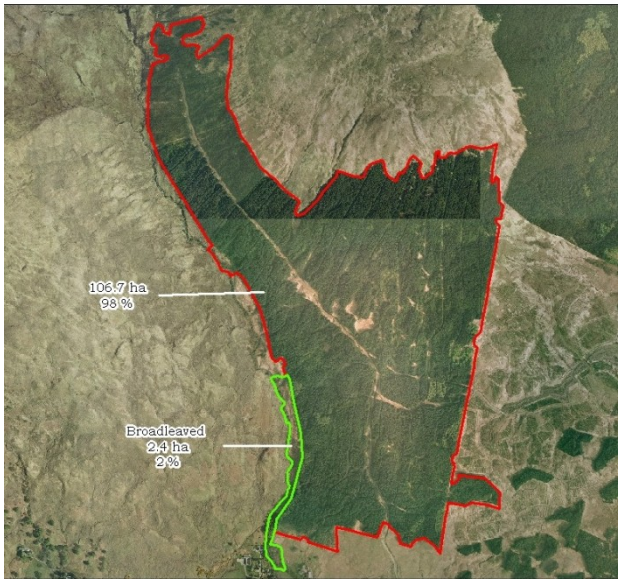

Figure 7.vi. A 'discrete' wood dominated by conifer canopy with an adjacent native canopy

In many examples small native patches are adjacent to larger conifer woods as in figure 7.v.i. In figure 7.vi the area would be excluded from the native woodland area assessment if assessing canopy occupancy at discrete woodland block level as opposed to patch. However compared to the previous example where the native stand was entirely surrounded by conifer this area is subtly different as only a proportion of the external boundary of the native area is in contact with the conifer. If a native patch is considered to be at a disadvantage by being entirely surrounded or 'contaminated' in some way by association with conifers, then this case for excluding such patches from classification as native is somewhat weakened by such examples. This factor is illustrated to a greater extent in the following example where only one side of a square block of native woodland is in contact with the conifer element of the discrete woodland block.

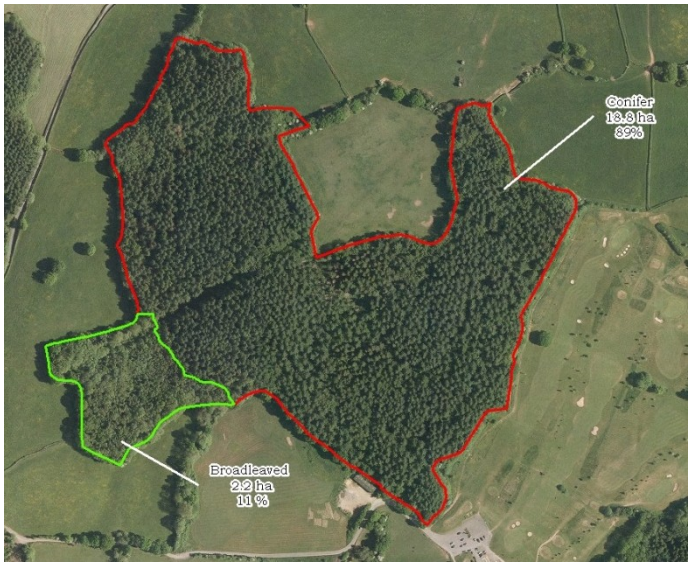

Figure 7.vii. A 'discrete' wood dominated by conifer canopy with an adjacent native canopy

To take account of such adjacent or 'surrounding' issues proportionally would require development of a complex set of rules and equally complex analysis, to consider the amount of contact a native patch has with conifers to determine if it counts as native or not. This could be based upon a total area to contact-area ratio, but this would be complex and arguably based upon a weak premise. The simpler alternative is just to acknowledge that patches of native woodland can be adjacent to many types of landuse and that these will generally not impact on the condition of the patch itself. If the adjacent land use is impacting greatly on condition this will be detected through the other stand condition measures.

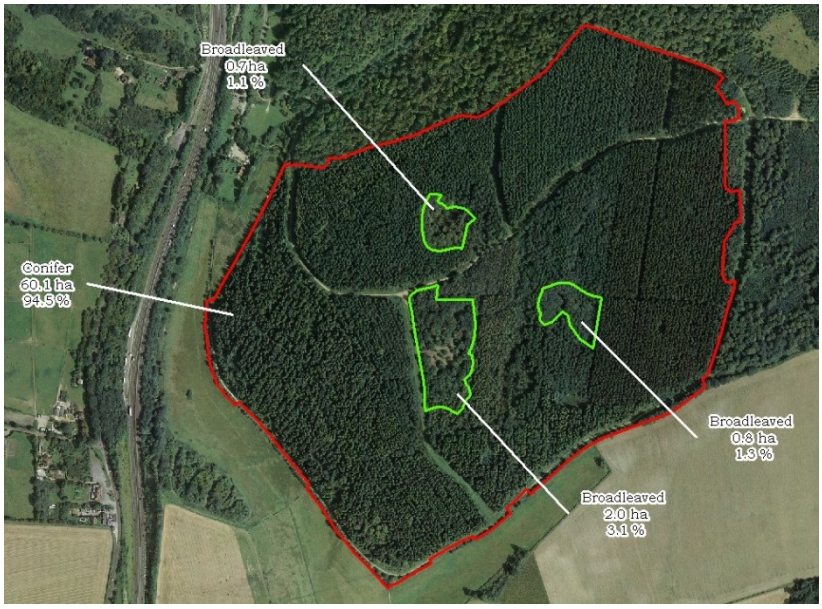

Figure 7.viii. A 'discrete' wood with both native and non native canopy, the broadleaved canopy surrounded by conifer canopy

The figure above illustrates patches of native woodland canopy entirely set within a matrix of conifers. If canopy occupancy thresholds are assessed at discrete woodland block level the native area will be excluded. If assessed at patch level the native area would be included.

The examples above indicate how applying the two main approaches to assessing canopy occupancy (of discrete woodland block and native patch) can result in quite different assessments of the total native woodland population. In each case the two approaches differentially exclude or include 2 ha areas of continuous native crown cover.

Intimate Mixtures

Figure 7.ix. An intimate mixture of native and non-native canopy

The above figure illustrates an intimate mixture of natives and non natives. Photography interpretation has shown this to be mainly broadleaved, but only assessment on the ground could establish if this were above the 50% threshold. There is a strong case that the mixture creates a reduction in condition and the level of this reduction needs to be quantified.

Figure 7.x. An intimate mixture of native and non-native canopy

The above figure illustrates an intimate mixture of natives and non natives. Photography interpretation has shown this to be mainly conifer but only assessment on the ground could establish if this were above the 50% threshold.

In figures 7.ix and 7.x both native and non-native species are intimately mixed, within the same area and /or 'land parcel' and the conifer and broadleaves are not discrete in nature. This will impact significantly on nativeness and condition of the native wood on many levels and needs to be quantified in detail.

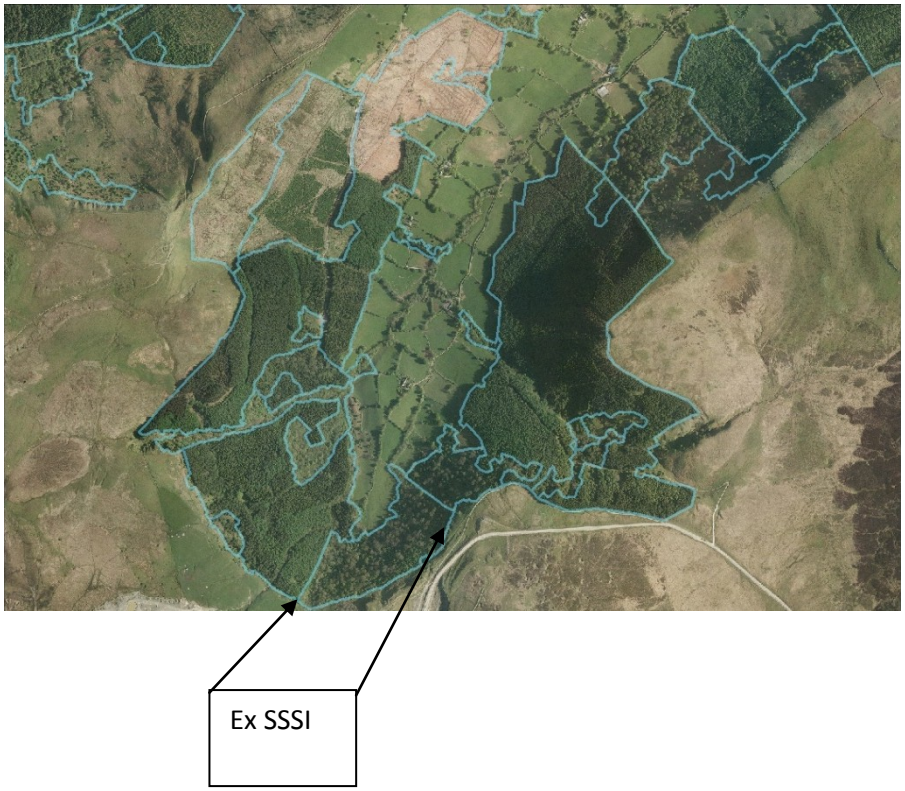

Figure 7.xi: An ex SSSI Woodland set within a conifer wood

The above figure shows a NRW woodland, which contains an ex SSSI Small Leaved Lime woodland which is connected on two sides with a larger conifer woodland. It is a good example of how, if assessed at a discrete woodland block levels, native woodland of significant status would be excluded. The stand in question is quite a rare example of this woodland type and was only removed from the SSSI register as it was just under a revised minimum area threshold.

Approach recommended

Assessing percentage occupancy of native species at a stand or patch level as opposed to a discrete woodland block was chosen as:

- No upper size threshold has ever been set or agreed on the area over which to assess canopy occupancy. This being so a 1 ha 100% native species block would count towards HAP targets, whilst if a 100ha woodland non native woodland block had 20 hectares of native species concentrated in one area or 'patch' within the block, the native area would not qualify for the HAP targets.

- If the purpose of condition monitoring is to identify native woodland under threat and to encourage management action to improve the condition of that wood, discounting 'patches' of native woodland within a larger conifer woodland, would run counter to that purpose.

- The NFI enables all native species to be measured from individual trees, to groups below the 0.5 ha threshold and to larger groupings. This allows woodland that is 'near' native to be extracted and studied within the NFI. Also if the definitions of what constitutes native change over time, these can be applied in query form to the NFI database and their associated areas estimated.

The principal downside for adopting this approach is that if native stands within woodland blocks composed purely of native species have a higher condition value than those forming part of a 'discrete' mixed woodland then this benefit is not explicitly measured as a factor of condition. However, the positive or negative influence of other types of adjacent landuse is also not taken into account when assessing condition at a discrete woodland block level. For example which adjacent land use would have a higher impact on the woodland condition of a 2 hectare native stand an industrial chemical plant or a conifer plantation?

On the basis of the above mentioned limitations NFI is recommending that nativeness be assessed at the stratum/patch/stand level as opposed to the discrete woodland level. This recommendation is made by taking account of; the 'digital' nature of most of our woodland where either principally conifer or principally broadleaves exist within a landuse parcel; the establishment of woodland within discrete landuse parcels ; and the non linear nature of excluding woodland patches when assessing percentage nativeness at a woodland scale .

However, the issue of whether a patch of native woodland is set within an entirely native wood or a mixed wood, is not taken account. It could be argued that the extent to which this occurs within the woodland population should be evidenced when building a picture of woodland condition. This could be assessed as an individual scoring factor in the 'stand context category', but as of yet it will be treated as an explanatory factor (see page 39). The rationale behind this is that all woodland has some benefit when aggregated together and trying to differentiate between the value of different types of adjacent land use would become involved.

Discerning the continuum between 100% native and less than 50% native

The following diagrams provide a visual summary of how NFI determine strata on the basis of the relative configurations of native and non-native species

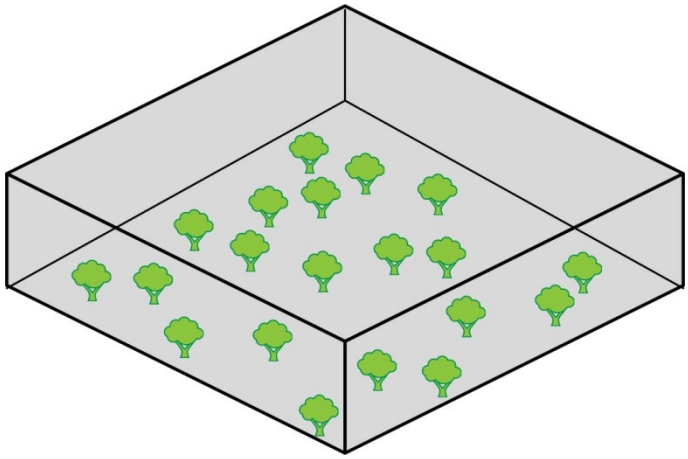

Figure 7.i. A 100% native sample. In this example the entire area of 1 ha is composed of native species and the entire area is classified as native HAP and will contribute to the national estimate of HAP area.

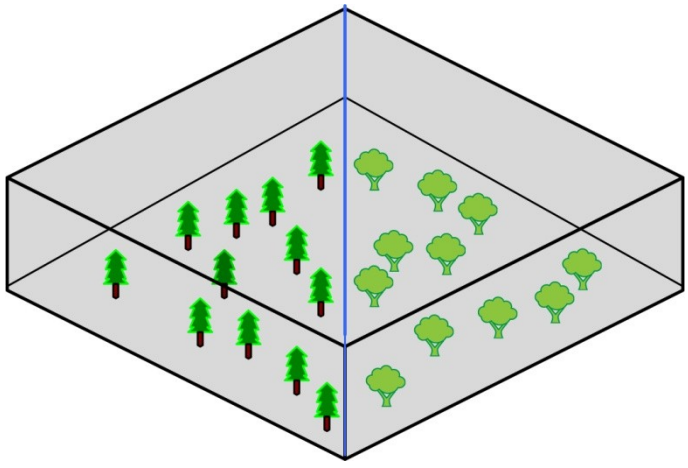

Figure 7.ii A sample with two strata, one native and one non native. In this example half the area (0.5 ha) is composed of native species and that half of the square is separated out as a section (as denoted by the blue line) and is classified as native HAP and will contribute to the national estimate of HAP area. The remaining half is classified as non HAP.

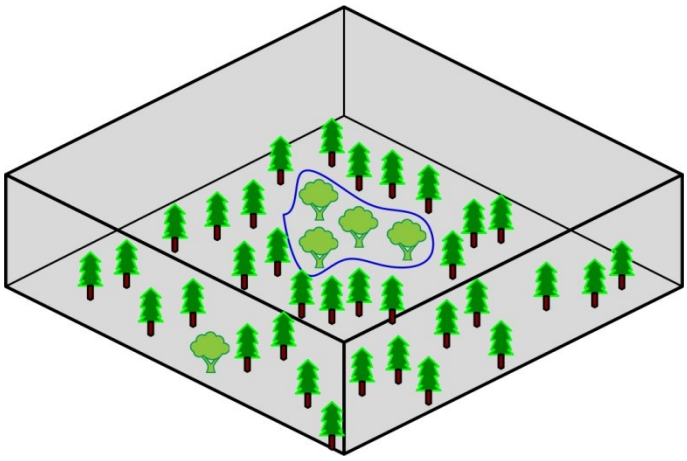

Figure 7.iii. A small area of natives within a conifer matrix. In this example a small isolated area (0.2 ha) is composed of native species and that area of the square is separated out as a section (as denoted by the blue line) and is classified as native HAP. As it is less than 0.5 ha it will not contribute to the national estimate of HAP area. The remaining area is classified as non HAP.

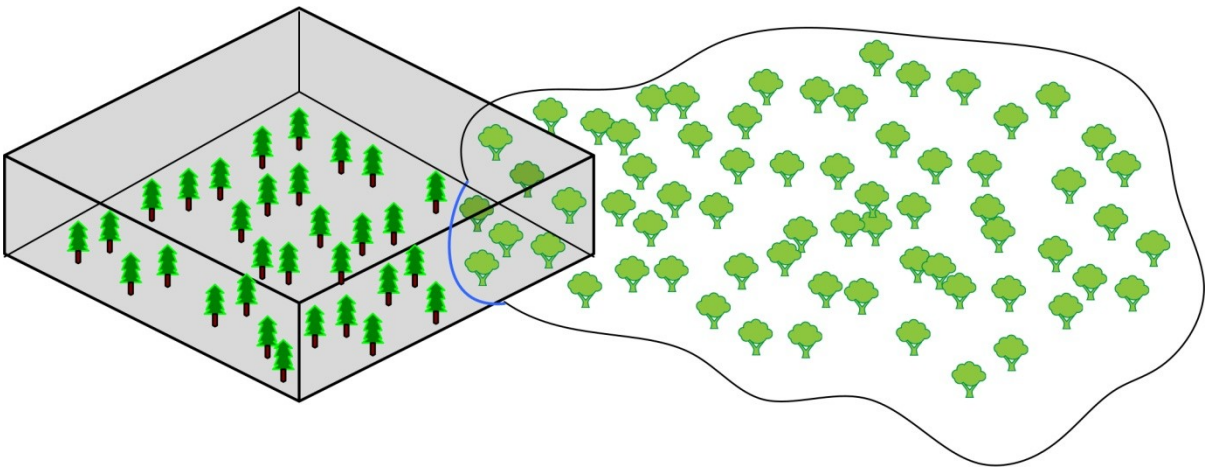

Figure 7.iv: A small sample of native within a 'Relevant Adjacent Stand'. Where an area of HAP within the sample square is less than 0.5 hectares, but the HAP continues outwith the sample square, the area of the entire HAP is mapped. If the entire HAP area is greater than 0.5 ha then the area of HAP within the sample square will contribute to the National HAP estimate, as it is a sample fraction of an area greater than 0.5 ha (the native woodland threshold).

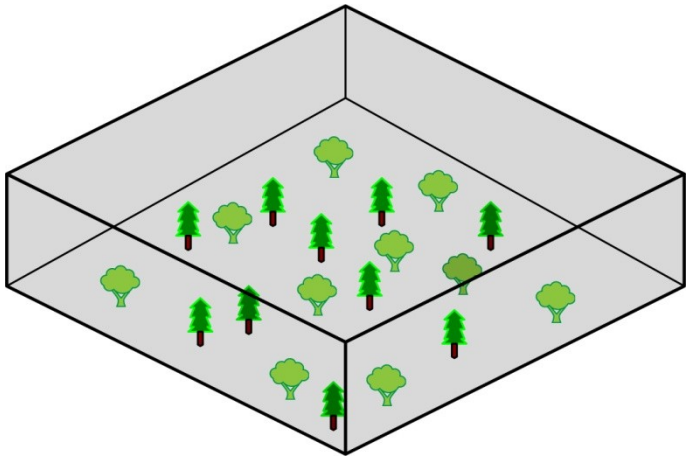

Figure 7.v A native intimate mixture. A central definition of a HAP is that at least 50% of the area is of the native species that constitutes that HAP. In this example the woodland within the sample square is an intimate mixture of native broadleaves and non-native conifers, at a 50:50 mix. The entire area therefore is classified as HAP, whilst the species proportions discern the site as in poorer condition than a site with a higher proportion of natives.

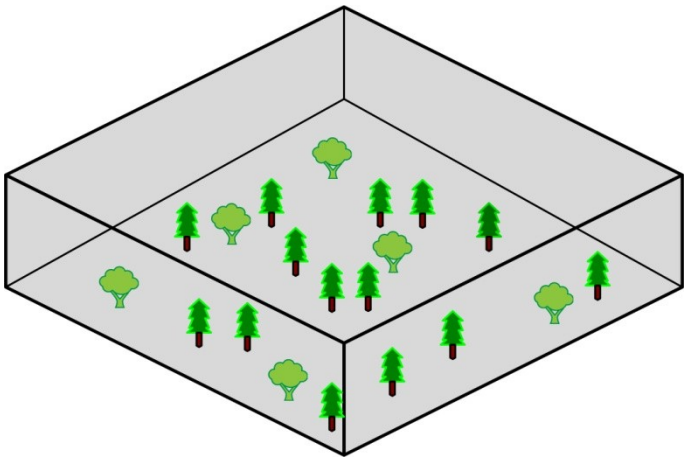

Figure 7.vi A non-native intimate mixture. In this example the woodland within the sample square is an intimate mixture of native broadleaves and non-native conifers, at a 30:70 mix respectively. The entire area therefore is classified as non HAP, whilst the species mixture measured within the survey identifies that the non HAP area has native species within it.

Scale of reporting: population versus section-level assessments

When assessing condition it is necessary to quantify each condition factor and preferably their relationship to one another. As the previous sections have demonstrated, when reporting on such factors that constitute forest condition it is conceivable to do this at either a population or a section level (see page 8/9 for description of a section as used by NFI). By 'population' in this context we mean the total quantity of an attribute within a specified geographic area i.e. region, country etc.

It is our considered view that the majority of assessment should be undertaken at the 'patch' and that each section/stand should be scored independently. This provides the following benefits:

- The distribution of scores that the sections achieve can be evaluated, but means can also be calculated across the whole population.
- The assessment will avoid the flattening of unusual distributions that could occur when averaging a score across the whole population. This flattening could result in the loss of key information within the population that may be unique or significant.

The issues concerning fragmentation of British woodland (see page 20) strengthens the case for assessing condition primarily at a section/stand/patch scale. The approach is likely to provide a fairer picture of condition, highlighting particular fragments in particular regions that are under threat, set against those fragments in those regions that are not. This targeting of discrete sub populations should also enable better targeting of management action.

We acknowledge that not all processes and factors contributing to condition will be captured at a section level but may occur at a wider scale. Whether processes occur at a section or meta-population level will depend on individual habitats and circumstances. For example, the average amount of regeneration in England may be 1500 stems per hectare, which looks quite positive, but this average may mask that in North Yorkshire stocking may be 20 stems per hectare whilst in the South Downs it is 3000.

It is probably fair to say that such disparities do not point to a natural cycle within a large population, but two isolated populations of the same type, under quite different circumstances. There is not enough evidence to substantiate whether British HAPS act entirely as a single population or as a series of discrete

populations but the evidence points to it probably being somewhere in between. The approach attempts to reflect this balance, assessing processes at the scale at which they are thought to occur, whilst erring on the side of caution by tending to assess at a lower level of granularity.

NFI data to date does, however, demonstrate that for broadleaf woodlands many regenerative processes can and do occur at a section or discrete woodland level, with close correlations between upper canopy species and lower canopy species and regeneration in a significant proportion of sites (see NFI Publication 'National Forest Inventory Interim Statistics on the Health of Ash trees in Great Britain). Furthermore, evaluating section statistics still enables landscape patterns to be apparent which could have been lost if averaged. It is our assertion that if sub populations are independently functioning it is better to err on the side of caution and display this information. The assumption that certain factors of condition in one area can subsidise or mitigate those in another is not substantiated and presenting data based on this basis could mask issues and be potentially misleading.

The balance of thought was that most factors play out within a very small area, such as individual wood or catchment, as opposed to across a country and that section-level assessments were more valuable in giving a detailed picture of woodland condition. This had also been the conclusion of the original biodiversity task group which specified that the indicators would be assessed at section/stand level (Table 1).

Exceptions to section-level assessment occur when the attribute is only applicable or statistically valid at a broader scale. In our proposal this includes the following (see later sections for more detailed information and reasoning):

- Veteran Trees
- Regeneration at population level
- Loss/gain in woodland area
- Size of woodland parcel
- Proportion of land cover as woodland

Reporting on Forest Condition

It is proposed that reporting on condition will be undertaken at a number of tiered levels (Figure 8). This will enable transparent interpretation of data on a series of levels taken from the base data (that describes in detail all the factors contributing to condition) up to a final single condition score. It is hoped that whilst recognising the need for a single 'flag' as to the condition of the whole population, the structuring and presentation of the supporting data that formed this single score will enable interrogation and analysis to facilitate a fuller understanding of condition and its contributory factors. It will also enable targeting of issues within sub populations of the entire HAP type and the identification of underlying trends or causes which could otherwise be masked within more 'broad brush' summary approaches. This should enable targeted approaches, management interventions and improvements to condition.

The levels of reporting are as follows:

- A mean all HAP condition score (combining all factors) across the reporting area
- A mean individual HAP condition score (combining all factors)
- The distribution of all scores across the population (combining all factors)
- Reporting on the distribution of *scores* for each forest condition attribute
- Reporting on the distribution of *actual values* for each condition attribute
- Reporting on 'explanatory factors'

Details of the scores and associated scoring system are presented in future sections.

Dialogue over the past decade has tended to concern the need to achieve a condition score per HAP and for all HAPs. Later feedback suggested also reporting on the underpinning data that forms the scores. If the purpose of condition scoring is to identify and improve upon poor condition then the underlying data would be required. The objective then became to create a mechanism where both scores and underlying data were integrated, transparent and scrutinisable so that cause and effect can be ascertained. To develop this approach assessment of condition was split into three basic levels:

- Condition factors most pertinent within the stand
- Condition factors most pertinent within the 'local area' (section context)
- Condition factors that belong to the much wider population as a whole.

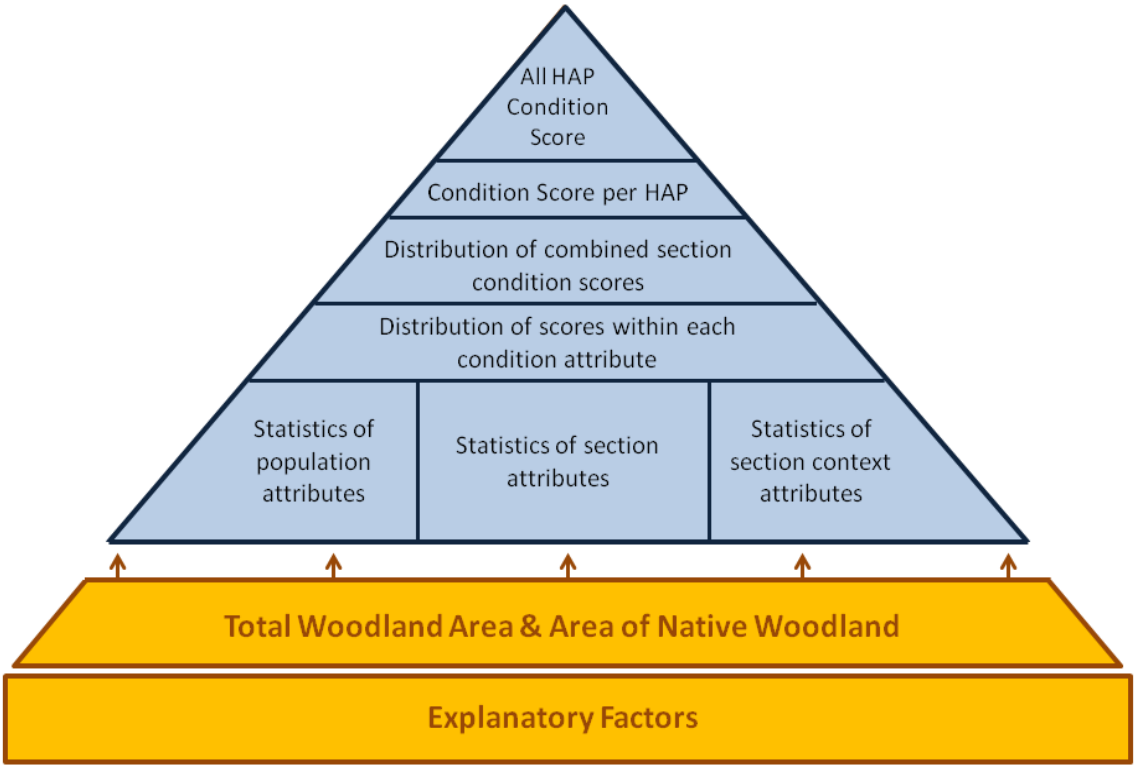

Figure 8. Representation of the tiers of reporting possible under the proposed forest condition assessment system.

This approach was taken to ensure that analysis and interpretation of condition factors was undertaken at the level at which the factor's natural processes operate. The majority of condition factors act in a multi causal and inter dependant fashion at the stand level and thus should be assessed at that level in 'situ'. For example, browsing is linked to regeneration, and regeneration is linked to storey development. This approach will enable trend and multi factorial analysis to be undertaken at the level at which they operate – the stand/section.

There are, however, other factors that occur outwith the stand that will have an immediate impact on stands in that immediate locality and not the wider total population of the HAP. Those would be factors such as discrete woodland block size and the % of woodland cover in a locality as a proxy for fragmentation. The 'section context' category was created to take account of such wider local influences on condition.

Other factors occur at the wider population scale, such as woodland loss. For example loss in one county may not threaten woodland in another, but it does threaten the population as a whole. Neither is it likely that any form of measurable condition factor within a wood or stand is impacted upon by woodland loss at a distant location. Such factors are best accounted for at the scale at which they operate, the whole population.

Attributes

In the spring 2013 meeting each potential attribute was considered independently and thresholds for scoring were discussed and evaluated. The process of examining the attributes determined that some were to be excluded from condition scoring and to be reported upon as 'explanatory factors' (see Box 2).

Box 2. 'Explanatory factors' versus forest condition indicators
There are some factors which, in many circumstances, can directly influence and drive the level of condition, but can also be present and have no material impact. An example would be a threat such as an industrial development, which may or may not impact upon condition. Such factors are considered as potential explanations of condition, but are not necessarily directly causal to condition. This formed the need for a category of 'explanatory' factors, which could be assessed alongside condition. Explanatory factors therefore do not form a part of the final condition score but they are reported in parallel as they are potentially driving the state of the condition attributes and should be considered. Keith Kirby coined the phrase 'explanatory factors' and identified the need to distinguish very carefully between actual forest condition and the drivers behind it.

It was also proposed that 'total woodland area' and 'area of native woodland' would not form part of the condition score but would be reported separately to provide an overall picture of woodland extent that would not be diluted by other factors. Detailed points of discussion on each attribute can be found in Appendix A.

To be reported in parallel	Components of forest condition score			To be reported in parallel
Scene setting information	Population/ global	Section Context	Section	Explanatory Factors
Total Woodland Area -	Veteran Trees	Size of woodland parcel	Open Space inc Adjacent land use and microhabitats	Woodland edge/buffer
Area Native/HAP type	Regeneration – population level	Proportion of land cover as woodland	Occupancy of nativeness	Woodland continuity
	Loss/gain in woodland area		Age Distribution	Stem density, diameter and distribution
			Vertical Structure	Natural disturbances
			Volume of Deadwood	Forest Management
			No of native species	Human influence - pollution
			Regeneration – section level	
			Grazing/herbivore damage	
			invasive species	
			Pests and Diseases	
			Ground Flora	

Table 4: Condition attributes stratified by level of reporting. Columns in orange are not included in final condition score but are reported separately in parallel.

The condition attributes were stratified into several classes (see Table 4 below):

- Those that commented on total area measures and did not form part of the condition score
- Population factors as applied to the whole population:
  - Veteran Trees
  - Regeneration at population level
  - Loss/Gain of woodland area
- Those quantifying the area surrounding survey squares (Section Context):
  - Size of woodland parcels
  - Proportion of land cover as woodland
- Those that measured a section's elements integral to its condition such as structure, composition etc.
- Those that were 'explanatory factors', as to this condition, that these would be reported on separately – (see box 2)

Attributes scored indirectly

Comparisons between the list originally proposed by the task group and the current proposal highlight a few attributes that are not now featured as unique forest condition attributes. These are listed below with the reasons for how they are accounted for in the proposed forest condition assessment

- **NVC** - NVC classifications are included in assessments of field/ground flora
- **Cover of shrub layer** – presence of shrub layer is accounted for within the Vertical Structure attribute
- **Index of horizontal diversity** – this was thought to be principally accounted for in the assessment of open space, which takes into account the internal and external open space to a section, including micro habitats and linear features (such as streams) as quality factors.
- **Canopy cover** – we have not included an exact measure of canopy cover – preferring to use a measure of ground vegetation as a better indication of light levels on the forest floor and overall health of the forest ground flora
- **Naturalness of regeneration and canopy** – we only account for natural regeneration in our assessment of the regeneration attribute.

Thresholds

In considering the forest condition attributes and thresholds it became clear that a 'benchmark' against which to mark or score woods had to be established. For the purposes of clarity it was determined that the desired state of forest condition was how that habitat would be if in its natural state. In other words a state as would be found in a well established natural reserve - in affect making the condition score an index of 'naturalness'. Such a woodland would form part of a sustainable forest network that is capable of propagating itself through the processes of natural regeneration and demonstrates resilience in light of threats such as climate change/disease/human pressures etc.

An alternative approach could have been to use benchmarks that are objective driven, such as one benchmark for plantations, another for SSSI, another for native woodland, coppice etc. This would have the advantage of tailoring how we judge good condition to how a certain type of woodland should be managed.

This approach was considered and it was thought that gaining agreement on a series of thresholds for each woodland type would be problematic, as objectives can be subjective in their nature. Furthermore, these thresholds would be embedded in objectives which could change over time or region, in turn changing the condition scoring system. The latter would make change monitoring problematic.

As the NFI aims to produce information that is enduring, transparent and objective, natural reserve status seemed the most appropriate benchmark. A small study of international approaches to monitoring condition confirmed that this was the approach generally taken.

Thresholds were based on a traffic light system as proposed by Nadia Barsoum which was deemed the best way to proceed for clarity. A helpful interpretation of the traffic lights (as opposed to Stop, Prepare, Go) was suggested to be: 'Urgent Action required', 'Some issues need addressing', 'No immediate concerns'. Such an interpretation may encourage a sense of action and possibility rather than a stop/go polemic.

The thresholds and how they are put together in the scoring approach are designed to rationalise the complex picture of woodland condition into a simplified structure and approach that can paint a strategic picture of woodland status and broadly flag the continuum of woodland condition. Such a broad categorisation cannot, however, supplant on site inspection and assessment of woodland. The thresholds were also, in part, determined by the range of data available and how the NFI records the data. (For example the thresholds for Vertical Structure are in part determined by the number of storeys that the NFI distinguishes.) A list of the attributes proposed to report on forest condition and their suggested thresholds are found in Table 5 overleaf.

Class	Attribute	Threshold	Notes
Population/global	Loss/gain in woodland area	Green: No Loss (or net gain) Amber: > 75% reduction in current loss rate Red: ≤ 75% reduction in current loss rate	Baseline loss rate to be determined
	Regeneration (population level)	Green: ≥70% stands have 'green' section level regeneration Amber: 40 – 70% have any regeneration Red: <40% have any regeneration	
	Veteran Trees -population level	Green: ≥ 0.2 trees per hectare Amber: ≥ 0.1 trees per hectare Red: < 0.1 tree per hectare	
Section Context	Size of woodland parcels	Green: > 20 ha Amber: ≥ 5 ha and ≤20 ha Red: < 5 ha	Size of woodland in which survey square is located
	Proportion of land cover as woodland	Green: > 20% woodland Amber: ≥ 10% and ≤20 % Red: < 10%	Based on 10 km^2 grid around survey square
Section	% Open Space	Green: 10 - 25% Amber: ≤ 10 % or 25 – 50 % Red: > 50%	Includes adjacent land use and microhabitats
	Occupancy of nativeness in canopy	Green: > 90% Amber: 75-90 % Red: ≤ 75%	
	Age Distribution of Trees	Green: All three categories present (see right) Amber: 2 categories present Red: All trees 0-50 yrs or 51-100 yrs	0-50 years 51-100 years Over 100 years
	Vertical Structure	Green: 4 or more storeys or complex Amber: 2-3 storeys Red: 1 storey	
	Volume of Deadwood	Green: > 80 m^3 per ha Amber: > 20 - 80 m^3 per ha Red: 0-20 m^3 per ha	
	No of native species – trees and shrubs	Green ≥ 5 Amber: 3-4 Red: 1-2	List of native species to be confirmed
	Regeneration – section level	Green: Seedlings and saplings present Amber: Seedlings or no regeneration Red: No category	
	Grazing/Herbivore damage	Green: No evidence of browsing or stripping Amber: < 20% browsing or stripping or both Red: ≥ 20% of browsing or stripping or both	
	Invasive species	Green: No invasive species found Amber: Presence of any from the hit list at < 20% cover Red: Any from hit list at > 20% cover or any presence of Rhododendron/Laurel	Hit list to be established
	Tree pests and diseases	Green: No evidence of pests, diseases, tree health issues Amber: Just evidence of dieback and specific evidence of the 'nasties' Red: Evidence of the worst diseases	Diseases to be classified
	Vegetation layer/ground flora	Green: ≥ 80% relevant NVC type and ≥ 50% field and ground layer Amber: < 80% and ≥ 50% relevant NVC and < 50% and ≥ 25% field + ground layer Red: < 50% relevant NVC type and < 25% field and ground layer	

Table 5. The proposed list of attributes used to score and report on forest condition and suggested thresholds.

Producing a forest condition score by country or region

The scoring for each attribute was done on a simple linear numerical system whereby each traffic light threshold was scored as follows:

- Green = 3
- Amber = 2
- Red = 1

On the basis of this, the maximum obtainable score for a single section in isolation is 48 and the minimum score is 17. Having a minimum score of 17 as opposed to zero recognises that all woodland holds some inherent biodiversity value.

A preliminary overall regional forest condition score calculator was proposed as follows (scores are formed from mean section scores across the reporting region):

- Green (no immediate concerns): overall mean score of 38 - 48 (possibly with additional requirement of no 'killer reds'*)
- Amber (some issues need addressing): overall mean score of 27 - 37
- Red (urgent action required): overall mean score of 17 - 26

*A 'killer red' is an attribute for which all woodlands need to achieve amber or green status to be deemed in good condition. A list of killer reds was not established and inclusion of this parameter is open to consideration/discussion.

A benefit of developing a three category assessment scale is that it is less sensitive to the affects of individual factors. One badly scoring attribute will not prevent a woodland or region from achieving 'green' status but its poor performance in the category can still be detected and therefore targeted for improvement.

The system detailed above employs equal weighting of all condition attributes. Whilst it is possible to adjust weightings it was decided that equal weighting helps to keep the condition scoring mechanism as simple and transparent as possible for all stakeholders. Sensitivity analysis applied to this assumption was undertaken by weighting some factors against others by moderate amounts and this was found to not impact on final scores.

Results

Testing the approaches

To date the NFI condition reporting /analysis tool (or software) has not been built. It was thought best to establish the basic principles of calculation before committing expenditure to final development. However in advance of the tool being developed a programme of data analysis was established to test the validity of the principles and approaches established. This analysis began soon after the commencement of the fieldwork programme in late 2009, with various quality assurance processes being applied to ensure that the relevant condition data was being captured accurately and without bias. Once enough data was collected some of the NFI field data that contributes to condition attributes were reported upon, whilst others were only analysed within the Forestry Commission.

Testing with NFI data in the public domain

Initially a series of existing and published NFI analyses were used to develop the ranges of the individual attributes and the thresholds set upon them. Examples of this would be:

- tree age distribution
- diameter distribution
- species composition
- discrete woodland block size distributions
- number of woodland blocks
- presence and levels of regeneration
- tree health factors
- levels of woodland loss
- levels of afforestation

This information gave the existing ranges of values for those attributes, which helped to inform commensurate scales and thresholds. They also gave insight into likely impact of each attribute upon whole population condition scores. For example the relatively low amount of old growth in most woodlands.

Testing with NFI Data not in the public domain

In addition to using data already in the public domain a series of 'ad hoc' analyses were undertaken quantifying ranges of data such as:

- deadwood
- further regeneration information
- browsing
- storey structure
- presence of native shrubs
- presence of minor tree species
- presence of micro habitats
- NVC and vegetation types
- veteran trees
- canopy occupancy of mixtures
- native canopy occupancy both within and without HAPs
- presence of invasive species
- woodland edge
- horizontal diversity
- stem density
- natural disturbances (wind blow, fire etc)
- human activity
- adjacent land use

The NFI team have now had over 3 years to become familiar with the data collected on these factors and a reasonable picture of the values, means and distributions has been built. This knowledge was used to help inform the ranges and thresholds set for scoring, alongside existing knowledge on condition. If required a verbal summary of what has been established to date can be given and can form part of the presentation.

Testing through manually scoring NFI squares

Until the NFI condition reporting tool is developed the approach to reporting and scoring cannot be completely tested in that all NFI sample squares cannot be 'automatically' scored giving final results. Therefore to test the approaches developed so far a selection of sample squares were manually scored.

Using the proposed scoring system detailed above, a number of NFI surveyed sample squares were evalutated. The squares were chosen randomly but stratified so that they included a SSSI, a plantation, a mixed lowland broadleaf, a wet woodland etc across the UK.

The range of scores obtained by the analyses lay between 28 (a Sitka spruce plantation) and 40 (a SSSI woodland). The spread of scores was approximately as expected with certain attributes such as Tree Pests, Invasive species, browsing damage etc having an effect that could not be anticipated without direct knowledge of the woodland. The process allowed us to test the attribute scoring against our instinctive knowledge-based expectations i.e. that a SSSI woodland would score well and a single species plantation poorly etc. (The Sitka plantation in this case had multiple stories, evidence of natural regeneration and good section context which prevented it falling into the red category overall as might have been anticipated).

Consensus was, on the basis of the number of squares studied, that the system was viable and clearly showed woodlands that required attention. It was also easy to decipher where the room for improvement was for each woodland block – and therefore easy to suggest management practices that may be beneficial on a site by site or regional basis.

As the system is developed, larger and larger samples can be tested to check and refine the assumptions and thresholds set to date

Outputs – Reporting

The approaches established in producing Official Statistics from the NFI to date will be applied to the derivation and reporting of statistics on condition factors. Official statistics procedures and protocols are the way that Government ensures that the key facts and figures that are produced in its name are reliable. Details of Official Statistics Procedures can be found at the UK National Statistics Authority website. An NFI paper covering how NFI manages the production of Official Statistics can be made available on request.

The general approach to producing statistics is that rigorous scientific and statistical methodology is applied and that methods and approaches are transparent. The methodologies and approaches used will be written up and published alongside the data produced and where possible standard errors are calculated and presented.

To ensure that the condition estimates produced are reliable, transparent in their derivation and repeatable, the ‘queries’ established in developing the report will be ‘hard coded’ into NFI software and analysis tools. This will have multiple benefits including:

- enabling the methodology to be 'fixed' so that:
    - It can be written up and published so when consumers use the information they will understand how it was derived
    - That the approach is consistent over time
    - That exactly the same approach can be used at a later date for the purposes of change comparison
    - Ad hoc reports of condition can be quickly run for different geographic areas using the same approach for comparison and aggregation of results, enabling NFI to run a responsive service

This was the approach taken with the NFI standing volume and production forecast estimates. More detail on these approaches can be provided on request. The actual data produced, papers and methodologies for timber statistics can be found at http://www.forestry.gov.uk/inventory

This does not preclude NFI and the countries developing other approaches to assessing condition and, as a full history of NFI data will be archived, these would be able to be retrospectively run against historical data giving revised or new time series.

How the Condition Reporting Tool will Work

Once the factors, thresholds and scoring mechanism are established, analysis queries will be written to calculate a score per attribute and a combined score for each NFI section, within each NFI square.

At present the NFI field work database includes two types of data; that collected within the field and 'derived' data. A current example of this would be that diameters, top heights and the number of stems within a plot are field data, but that these and others attributes are taken and further analysis and models are applied so that standing volume, BA and stocking density data is calculated and stored as 'derived' data in the NFI Growing Stock Records. A similar process will be established for calculating derived data on condition scores. These individual reports will then be held within the NFI database alongside each section (Figure 9).

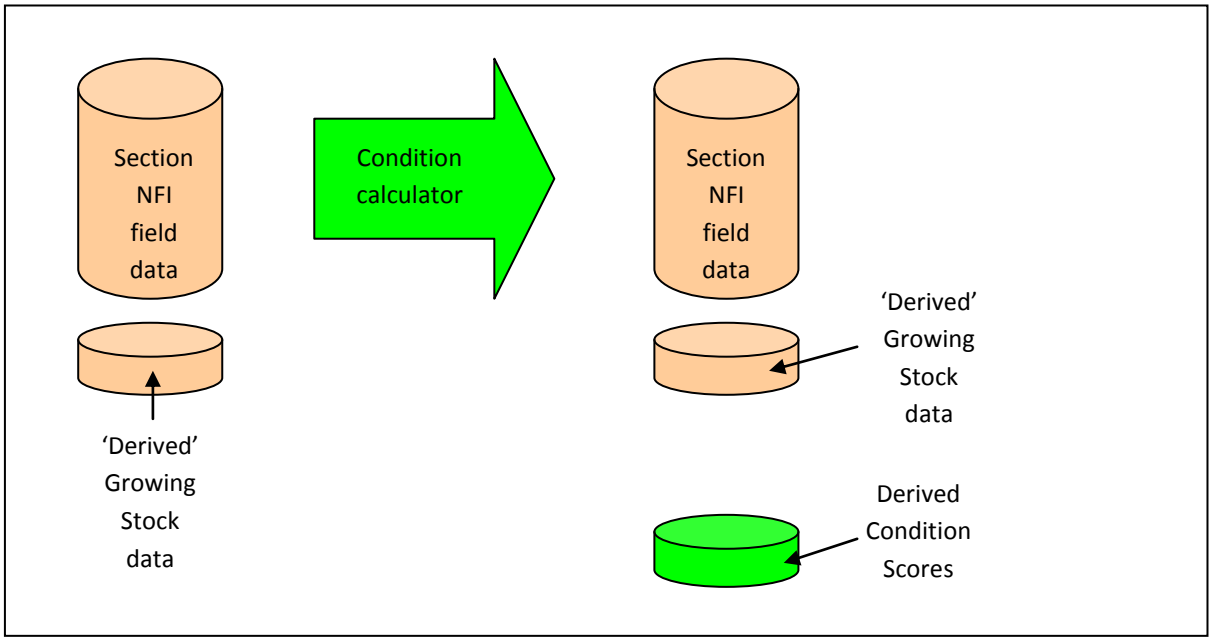

Figure 9. How NFI condition scores will be derived and stored in the NFI database

These scores will be stored in the database throughout the first cycle of the NFI. These will then be available for statistical and reporting purposes such as extraction and bulking up to a national estimate as highlighted in Figure 1 . Then, when the second cycle is undertaken and the new field data is collected a new field work table in the database for each section will be created alongside the tables from the first cycle. In turn, the condition calculator will be run against this new data and a second set of condition scores will be derived. These scores in turn will be reported upon and additionally will be compared in situ to the first set, giving changes in condition per section, per attribute, over time.

These differences will form the basis of change reporting in condition over time. As the NFI cycles continue the same process will be followed building a new 'score point' for each section with each new cycle, building a time series of change in condition, both for the overall score and for each attribute. Effectively this will create a stand history of condition. This will enable very detailed tracking and pinpointing of the rate of change, its location and its causes. Such changes can, in turn, be analysed alongside the explanatory data. For example the presence of regeneration in a section could be traced over time through its development into the lower storey structure and eventually into the upper canopy. Any impediment or unexpected block in this development could be correlated to the incidence or browsing, invasive species or pests, or an explanatory factor such as social abuse like fire.

Discussion

It is felt that a practical and relatively transparent way of assessing HAP area has been established. This in itself is an important development as Great Britain cannot currently quote to any degree of accuracy what area is associated with each HAP or the total HAP area.

A practical way of assessing woodland condition has also been established which has taken into account the majority of factors as recommended by experts. The system proposed is not the only way condition could be scored, but it is reasoned, flexible, transparent and repeatable method that aligns to most international approaches.

The difficulties in establishing an estimate of native woodland area and its condition are manyfold, primarily due to the UK's high proportion of non-native woodland and how this was established alongside and within existing native woodland. The absence of a unilateral definition of what constitutes native woodland was a fundamental issue but it is hoped that an acceptable solution has been proposed.

Once a proposed method for establishing the area of native woodland had been established, producing an assessment of its condition was the next objective. The UKNWHAP group had spent several years establishing which factors should be assessed and this work provided a solid foundation for progress. Establishing a system of combining and scoring attributes required careful consideration of the scale at which the analysis should be undertaken i.e. should it be at a national level for the whole HAP population solely, or at a smaller scale such as discrete woodland block or stand level.

A conclusion was reached to assess most factors at stand, some at discrete woodland block, some in the local area and others across the whole region or wider population. This allows for a pragmatic balance in accounting for the main dimensions at which condition processes occur and an assessment of all the factors that impact upon condition at the scale or level at which they function.

The thresholds set for assessing each condition factor have been chosen with the aim of identifying threats to condition at a scale where management action can be taken and have been structured in such a way as to be as transparent as possible.

The benchmark against which condition has been judged is that of a natural reserve in good condition. This is a well understood and relatively objective criterion which should not need to change over time. Maintaining a consistent approach will facilitate the detection of any changes in condition in the future.

Setting thresholds for scoring against natural reserve status was not always straightforward. Woodlands in Britain are so denuded that for some attributes we have a weak evidence base as to what their 'natural' state should be. Looking to evidence in the few natural reserves we have, good quality SSSIs and similar less-disturbed woodland habitats within Europe and North America helped in this process.

Further work

Once the condition calculator is complete, the data can be further analysed to ascertain if there are additional trends or patterns to be found within certain groups of woodlands and woodland types. Such work may identify that certain HAP types are dependent on significantly different biological and regenerative processes. Such a finding may mean that they have different thresholds for condition. This could lead to the development of separate condition scoring mechanisms which are individually tuned for specific HAP types.

There is also additional scope for assessing whether certain management systems merit alternative benchmarks. The most obvious candidate for this is coppice, which despite serving a valuable ecosystem niche, will not generally score very highly due to management intervention preventing full stand development. However coppice does serve as an excellent habitat function and maybe that could be recognised in tuning its thresholds.

Appendix A

The following tables show a detailed breakdown of each biodiversity attribute, points of discussion, thresholds and rationale behind threshold setting. Attributes highlighted in orange represent those that will not form part of the forest condition score but that will be reported on separately in parallel. Attributes highlighted in blue are those that will form part of the overall forest condition scoring (see Table 4).

Attribute	**Area of Native Woodland**
Definition	Total area of native woodland – by HAP type if required

It is widely acknowledged that native woodland is one of our richest sources of biodiversity and that any loss is not sustainable. The Biodiversity Strategy calls for HAP area gain. It is proposed that the forest condition score will assess area loss of all HAP types together. Area by individual HAP type or assessments of ancient woodland loss can be made as a separate analysis if required. Total Native Woodland Area will be reported at a country and regional level*.

Three main parameters are used to determine if a woodland is native or not :

1. The presence of native species within an area or piece of woodland
2. The area of the piece in question (0.5 ha)
3. The proportion of native species within that piece (50%, 80% etc)

The NFI determines these parameters to assess the area of native woodland within GB. HAP status is assigned at component group and component level in sections, within the NFI squares. The NFI was additionally designed in such a way that these parameters are measured on a continuum, for example the NFI determines % of native canopy occupancy from 1% to 100% and size of piece from 0.001 ha to greater than 0.5 hectares in size. This enables different thresholds for % occupancy and area to be set when querying the data to determine the area of native woodland under different definitions of native woodland. Through this sensitivity, analysis can be undertaken to assess the impact of altering the thresholds set in the current definitions of native woodland. This approach is explained in full in the section entitled 'Defining Native Woodland'

Once the second cycle of the NFI is in place (2015 to 2020) a direct measure of woodland loss per HAP will be available. Until then, there is no definitive measure of woodland loss in the UK. There are two proxy sources of data though; unconditional felling licences and comparisons between the NIWT woodland map and the NFI woodland map. The felling licences indicate what may be deforested under FC sanction, but omits illegal felling, loss through natural processes and planning consent. The map-based estimates are solely for the period between the maps (roughly 1995 to 2013) and identify only clearfell sites and sites which have undergone permanent landuse change that is identifiable in aerial photography. Neither directly identify HAP loss. The map-based estimates run at approximately 150 to 200 Ha of woodland area per annum and early analysis indicate that 50% of this may be HAP. This is the best measure available but is likely to be an underestimate as deforestation in transition is difficult to separate from normal felling and restocking. Until the second cycle of the NFI this measure will have to suffice as the best available. Measures of the proportion of recently established HAP can also be made against native woodland area – area of HAP woodland and area of newly established/potential HAP woodland. The newly established HAP being considered as a sub population of the overall HAP resource, which can be reported upon separately.

* It is hoped that individual HAP type area will also be reported upon at a country and regional level, but statistical viability will be determined by issues of sample size and size of HAP population. There may not be enough sample data to analyse and report upon individual HAP types at these geographic levels.

Attribute	**Loss/gain in woodland area**
Changes in woodland area are taken into account through deforestation or afforestation. These will be evaluated as described in the woodland area section above.	
Threshold:	Green: No Loss (or net gain) Amber: > 75% reduction in current loss rate Red: ≤ 75% reduction in current loss rate
Rationale for thresholds	England: The aim is to have an increase in native woodland cover (Natural Environment White Paper; Biodiversity 2020 Strategy) Wales: Aim to increase woodland cover or at very least have no net loss in cover Scotland: By 2nd half of 21st century woodland expanded by 25% of land area.
Limitation	Baseline figure to be established

Attribute	**Regeneration (at population and section level)**
Definition	Number of natural seedlings and saplings per hectare
Only native regeneration will be included in the forest condition score. Planted trees will be accounted for in the Young Trees section of vertical structure. Regeneration in NFI is accounted for by presence of seedlings (<50 cm height) and saplings (>50 height and < 4cm diameter if > 1.3 m). Coppice stems that meet these thresholds are considered to be saplings.	
Threshold	**At section level:** Green: seedlings and saplings present Amber: seedlings or none Red: no category **At regional level:** Green: ≥70% stands have 'green' status regeneration at section level Amber: 40 – 70% have any regeneration Red: <40% have any regeneration
Rationale for thresholds	There are circumstances where no regeneration is acceptable at a section level but no regeneration at a regional level is not sustainable. Therefore this attribute is measured on two scales. At a section level there is no red threshold for the category. On a regional level regeneration must be found in a minimum of at least 40% squares to reach amber status. The setting of the threshold is not defined in literature. Currently around 40% of broadleaf stands have regeneration. As it is generally acknowledged that the current levels are too low we used this as a baseline percentage. More research into other European country thresholds should be undertaken.

Attribute	**Veteran Trees**
Definition	Average number of veteran trees per hectare
Veteran trees are determined in NFI by DBH per species and/or by the presence of three or more characteristics such as rot holes, hollowing of trunk, bark fluxes etc. A provisional assessment of the NFI data indicates that levels of veteran trees in Britain are very low, with very few surveyed squares of native woodland containing veteran trees. Therefore this attribute is best assessed over a wider sample such as at a regional or country-wide level, as the vast majority of stands would score 0.	
Threshold	Green: ≥ 0.2 trees per hectare (i.e. ≥ 1 tree per 4 ha) Amber: ≥ 0.1 trees per hectare (i.e. ≥ 1 tree per 10 ha) Red: < 0.1 tree per hectare (i.e. < 1 tree per 10 ha)
Rationale for thresholds	It is known that an increase in the number of veteran trees is desirable for biodiversity and it is therefore recommended that new and old trees are singled out now to achieve veteran status in the future. For some trees this could take many years however the red threshold reflects current estimated status so amber could be achieved within a few NFI cycles if suitable old trees are retained.

Attribute	**Size of woodland parcels**
Definition	Size of woodland in which survey square is located
'Size of woodland parcel' would be measured as the size of the woodland in which the NFI survey square sits. The size of a woodland parcel can affect a woodland's capacity to function as a woodland ecosystem, with very small areas unable to fully maintain the unique properties of a woodland habitat. Small size also decreases a wood's resilience to events such as disease, climatic events etc. Size of the woodland within which a section is located, when assessed in combination with the proportion of land cover of woodland in the local area, provides a proxy measure of the fragmentation and connectivity in that area. This measure is based upon the assumption that small fragments of woodland in areas of low woodland density generally provide less of an ecosystem service than that of small fragments of woodland in high woodland density. Whilst large woodlands in areas of higher woodland density serve the most.	
Threshold:	Green: > 20 Ha Amber: ≥5Ha and ≤20 Ha Red: < 5 Ha
Rationale for thresholds	There is some evidence in the literature and expert advice indicating that woodlands of less than 3 - 5 ha are of insufficient extent to fully function as a woodland ecosystem (Bell 2003). In many circumstances their physical size restricts the capacity of the woodland to modify the environment through shading, air disturbance etc. Furthermore, they cannot support significant areas of open space and many woodland species are known to not inhabit woodlands less than 5-10 ha. Woodlands of 20 ha and upwards are large enough for significant management systems and can support areas of open space and a larger range of woodland species.

Attribute	**Proportion of land cover as woodland (all woodland)**
'Proportion of land cover as woodland' would be assessed on a grid square basis with a 10 km^2 resolution. All woodland would be measured in this category in recognition that any woodland cover reduces habitat fragmentation, contributes to connectivity and is likely to provide more biodiversity habitat than equivalent areas of arable land or other land uses. A relatively small resolution is beneficial to comment on connectivity and allows land owners to act at the landscape scale.	
Threshold:	Green: >20% woodland Amber: ≥10% and ≤20 % Red: < 10%
Rationale for thresholds	Setting a target threshold for proportion of land cover was difficult as it had to strike a balance between the current level of woodland cover and a level which would not significantly impact on condition through high fragmentation and poor connectivity. Finding the point between what is obviously a low current level (when compared to woodland cover without human interaction or in comparison to other temperate countries) and what we may aspire to in the British countryside was problematic. A point where fragmentation and connectivity were not thought to significantly impact on condition was chosen – that of 20%. Current woodland cover in the most afforested counties was taken into account when setting this, as several exceed this threshold. It could be argued that, at anything below 75% condition is impacted, particularly in reference to supporting larger native mammals, but that requirement has to be balanced against the landscape that we have and the often equally valuable habitats that have replaced woodland.

Attribute	**% Open Space**
Definition	Area of open (non-treed) areas
Open space is assessed either as mappable discrete patches of open area within a wood or as a percentage of open areas within each section. Open space is categorised in NFI in two ways 'permanent' and 'temporary'. Permanent is space which is not likely to ever become woodland such as buildings and lakes. Temporary is space such as rides and paths that could in time become wooded. Some of the sub categories within permanent open space are liable to be beneficial for biodiversity (ponds, forest tracks) and should be included in the forest condition score and some are less beneficial or detrimental (buildings etc) and should be excluded or down weighted. The list of open space categories has been classified accordingly. All open space deemed to be beneficial or neutral for woodland biodiversity will be included in the open space percentage. The open space assessment will include linear features, edge, microhabitats and adjacent land use. Open space within each square will be attributable to HAPs. (For instance – if a square is 45% HAP and 45% non-native conifer and 10% open space – the open space should be proportionally allocated to each forest type).	
Thresholds	Green: 10 - 25% of good quality open space (SSSi measure) Amber: ≤ 10 % or 25 – 50 % Red: > 50%
Rationale for thresholds	% of open space thresholds follow the recommendations formulated for assessing SSSI woodlands (Kirby 2002)
Limitations	Need to establish a list of beneficial /detrimental open space

Attribute	**Occupancy of nativeness**
Definition	Percentage of canopy that is native species
Occupancy of nativeness is the % of native trees in the upper canopy or across the section if the structure is complex	
Thresholds	Green: >90% Amber: 75-90 % Red: less than 75%
Limitations	Nativeness needs to be clarified – which species to include – is it regional. Sycamore? Sweet Chestnut? Beech (regional?) etc

Attribute	**Age Distribution of Species**
Definition	Presence of tree species in three age classes (0-50 yrs, 51-100 yrs, 100+ yrs)
Tree age is assessed by NFI on the basis of estimated date of planting or establishment. These ages are then calibrated by comparison to a selected set of tree age records and increment boring samples. It is proposed to split the age classes of trees into three categories that approximately reflect their development stages 0-50 yrs; 51-100 yrs and over 100 years.	
Threshold	Green: All three categories present Amber: 2 categories present Red: All trees 0-50 yrs or 51-100 yrs
Rationale for thresholds	As the proposed condition score uses natural reserve status as its benchmark, the natural lifespan of tree species needs to be taken into account. Tree ages that extend to the natural lifespan of a species are generally indicative of a habitat that has not been heavily harvested or interfered with, though occasionally it has to be acknowledged that natural processes such as wind and fire may remove older trees. As most broadleaved species have natural life spans of 100 years or greater (up to 500 plus in some cases), the upper threshold of 100 years plus was set to separate long-lived trees from those that have been established within recent times. A threshold of 0-50 years was chosen to discern the sizeable proportion of the population that falls within this age category, as established within the NFI and previous surveys. This arises principally from the devastation of woods in the two world wars and the subsequent restoration and new woodland establishment initiatives. Division of ages into three categories of 50 years acknowledges the benefit to biodiversity of a variety of age groups.

Attribute	**Vertical Structure**
Definition	Number of vertical storeys
The vertical storeys categorised by NFI are: • Complex (multiple integrated storeys with no clear delineation between them); • Upper; • Middle; • Lower; • Young trees; • Shrub layer (woody and native); Field and ground layers are not included as a part of vertical structure but form part of a separate attribute.	
Threshold	Green: 4 or more storeys or complex Amber: 2-3 storeys Red: 1 storey
Rationale for thresholds	The development of several separate storeys is indicative of more advanced stand development and is a strong indicator of a stand's capacity to regenerate itself over time. More storeys tend to provide more habitat niches and often a greater diversity of tree and other species. The upper limits of the threshold represent the maximum amount of storeys that tend to exist in GB within native woodland and the lowest that of plantations or intensively managed areas.
Limitations	At present the 1 hectare NFI sample square may be split into several sections and each section into 1 to 4 wooded storey strata. Within these storey strata a single tree within a storey would constitute a storey. This storey could be viewed as 'in-substantive' or not having a significant influence on structure. However a section is never larger than 1 hectare and most are less than 0.4 ha: a single tree will often impact on condition in that scale of area. If further evidence proves that such 'thin' storeys do not contribute to condition, it could be proposed to set a minimum of occupancy of, for example, 5 trees to qualify as a 'substantive' storey. At present the protocol does not hold such a definition and takes the position that a single tree within a small strata can contribute significantly to the biodiversity of an area, for example a veteran tree.

Attribute	**Deadwood**
Definition	Volume of deadwood per hectare
It is suggested that separating the type of deadwood (standing, fallen and stumps) for the purpose of reporting on forest condition regionally or nationally could render the analysis too refined. One overall score for deadwood is more appropriate to keep reporting simple, understandable and transparent. Should further analysis about type of deadwood be necessary separate reporting would be available and will be part of NFI outputs. NFI currently measures standing deadwood (height, diameter and level of degrade) in the plots, number of pieces of lying deadwood in the transects (plus diameter and degrade) and number of stumps in the plots by size class and a single representative stump for measures of species group, height, diameter and degrade. A deadwood volume calculator is currently being developed to convert measures for lying deadwood and stumps to actual volumes per ha. Standing deadwood has already been calculated and the ranges studied.	
Threshold	Green: > 80 m^3 per ha Amber: 20-80 m^3 per ha Red: 0-20 m^3 per ha
Rationale for thresholds	The target of >20m^3 deadwood per ha is accepted as desirable in UK Forestry (Humphrey and Bailey 2012) . We have, therefore, taken anything less than this figure to fall in the red category. Provisional analysis of NFI data indicates that the highest amount found in any square was 400m^3 ha and literature reviews suggest that up to 50% of biomass in a natural reserve may be contained in deadwood. Research has found that in UK unmanaged semi natural broadleaved woodland deadwood volumes are 50 – 100 m^3 per Ha and in Germany 50-200 m^3 per ha (Green and Peterken 1997). Other research has found 250 – 400 m^3 per ha plus in natural reserves in the UK and in Europe (Christensen et al 2005). Given its importance for biodiversity: invertebrates, small mammals, birds, bryophytes etc, 80m^3 is proposed as a viable and appropriate upper target.
Limitations	An extensive evidence base for the amount of deadwood that natural reserves would support in GB does not exist, so setting a threshold was problematic and a 'low' target threshold was chosen to be conservative. This ties in with initial estimates of standing deadwood arising from the NFI and exploratory estimates of lying deadwood and stumps which all show that levels of deadwood in GB are very low. This threshold may be open to challenge, with some calling for levels as high as 200 m^3 plus.

Attribute	**No of native tree and/or shrub species**
Definition	Average number of native tree and shrub species per hectare
Threshold	Green: ≥ 5 Amber: 3-4 Red: 1-2
Rationale for thresholds	The NFI method to identify even a single separate tree species within one ha as opposed to 'rounding down' minor observations, as with NIWT and other methods, means that this is an accurate estimate of the range of species within woodland and has 'drawn out' the presence of minor species. The thresholds were based upon the existing literature on the main woodland and HAP types and the number of species that they can support when in good condition. Analysis of NFI data on SSSIs and better quality HAPs also supported these ranges, with the vast majority of native woods having 3 or more native species. Consideration was put to scoring rarer species (such as Wayfarer trees) higher, but in the spirit of keeping the scoring simpler this was discounted and is not thought to weaken the condition scores derived. NFI have a list of those species it defines as native which can be referred to. Points of note are that Sycamore is counted as native, pine and beech within their zones only.
Limitations	The approach defined assesses condition and this factor at either section or component group. These are relatively small areas, but as samples of patches of native woodland they are representative. An alternative to this approach would be if this factor was assessed over a larger area, such as a section, group of sections or at woodland block level. Here the number of species would score more highly within the condition estimate. This difference may be a source of contention.

Attribute	**Herbivores/Grazing**
Definition	Presence and extent of browsing and bark stripping damage per section
NFI surveys indicate if evidence of browsing and bark stripping are present and assess the severity in both cases (<20%, 20-80% or > 80%).	
Threshold	Green: No evidence of browsing or stripping Amber: <20% browsing or stripping or both Red >20% of browsing or stripping or both
Rationale	The thresholds are designed to rationalise the complex picture of herbivore activity and its impact upon condition into a relatively transparent and easy to interpret scale. The aim is to categorise the NFI data collected into bandings that distil out the key factors concerning herbivores that will impact upon condition. These key factors were determined to be; • no presence and no impact on condition • some presence and the potential to impact on condition • presence and negative impact on condition. No presence of the damage associated with herbivores in stands will form green status, some presence as amber and significant damage as red. The aim is to distinguish between the woodlands with no problem (and no damage) from those with high levels impacting on structure and condition. The amber category is to identify those areas at risk with some signs of damage, flagging that these sites run the higher risk of developing into areas with significant damage. This approach aims to guide management intervention as to where it is not needed, where it is needed and where it is likely to be needed. For the purposes of condition assessment browsing and stripping damage are grouped together, as is the height distinction of these activities (0.5 m; 0.5 – 1.8; >1.8m). This approach was taken on the broad assumption that all types of damage can be equally negative across tree species over time if left unchecked. It is however acknowledged that the different herbivore species associated with browsing or stripping at the different heights identified within the NFI can have quite different impacts on different tree species at different tree ages. For the purpose of condition assessment we are fundamentally assessing presence / absence and degree of severity so broad groupings would suffice to quantify those basic thresholds. This has the additional benefit of keeping the analysis and interpretation simpler. However how the types of damage impact differently on different types of trees species, at different stages in the trees life cycle are of interest and can be reported upon separately.

Attribute	**Invasive species**
Definition	% cover of invasive species
The NFI survey manual features a list of invasive species that are noted if found present along with the % of their cover. Some of these species are arguably more problematic than others. We propose that a specific 'hit list' be established as invasives that are most detrimental to forest condition. These are likely to include Giant Hogweed, Laurel, Himalayan Balsam, Japanese Knotweed, Snowberry, Buddleia, Shallon, Rhododendron. The list will need to be considered and finalised.	
Threshold	Green: No invasive species found Amber: Presence of any from the hit list at < 20% cover Red: Any from hit list at ≥ 20% cover or any presence of Rhododendron/Laurel

Attribute	**Tree pests and diseases**
Definition	Evidence of pests and diseases and/or dieback
NFI fieldwork looks for both the presence and absence of a selected list of 'higher risk' tree pests and diseases and a series of observable tree health indicators. Through this NFI can monitor or at least flag high risk threats to woodland. A similar risk-based approach was taken to setting thresholds for accounting for these factors within the condition scoring mechanism, with higher risk factors - those which are known to potentially have a significant negative impact upon woodland condition, scoring 'worse' than others. This approach produces a specific 'hit list' defining which pests/diseases and tree health indicators are most likely to be detrimental to forest condition in that they are likely to have a direct and negative impact on structure. These are likely to include: Chalara fraxinea, dothistroma needle blight, longhorn beetle etc For example, the presence of crown dieback may be an indicator of poor tree health, but it may also signify the development of veterans within the canopy. To discern between the two would require a more complex analysis of the data than is proposed and in the vast majority of instances crown dieback of either form would not lead to a significant drop in condition, at least without the presence of any other specific indicator of pests and diseases. As the purpose of the reports is to highlight issues for further investigation crown dieback is registered, but not as a high risk. As such its presence has a threshold of amber.	
Threshold	Green: No evidence of pests or diseases or tree health issues Amber: Just evidence of dieback and specific evidence of the 'nasties' Red: Evidence of the worst diseases

Attribute	**Vegetation layer/ground flora**
NFI measures the following data in relation to canopy cover and vegetation development: 1. Mappable 'discrete' open space 2. % of intimate open space within a stand 3. Stems per hectare and crown size 4. % occupancy of vegetation across the section / component of: a. Shrub layer b. Field layer c. Ground layer 5. Composition of each layer (abbreviated species list) 6. NVC Measures 1, 2 and 4 a are taken account of in the condition factors of open space, storey structure and number of native species respectively. It is proposed that vegetation is accounted for by assessing the presence and extent of the field and shrub layer and the presence and extent of a relevant NVC to the HAP type	
Threshold	Green: ≥ or = 80% relevant NVC type and ≥ or = 50% field and ground layer Amber: < 80% and ≥ 50% relevant NVC type and < 50% and ≥ 25% field and ground layer Red: < 50% relevant NVC type and < 25% field and ground layer
Rationale for thresholds	A relevant NVC type indicates that the site has been woodland for an extensive period and that the full range of taxa associated with that HAP type are present to have been classified. Those taxa and are likely to be serving a positive role in the woodland ecosystem, supporting fauna and other plant taxa. The presence also is indicative of a stand in good condition with a well developed canopy structure, open space in the crown, good light levels and acceptable levels of grazing. The presence of a substantive field and ground layer evidence the same and the additional benefit of the physical presence of non woody habitat.

Explanatory Factors –

Attribute	**Woodland Buffer Zone/Edge**
Definition	Open areas of at least 10m width within or adjacent to square with abrupt, tapered or variable edge

It is proposed that this attribute should be evaluated as part of the presence of open space being considered a quality factor when evaluating the value of open space within and without the woodland, alongside water features etc. Whilst it is a measure of good practice to consider edge profile in the UK Forestry Standard it is suggested that in respect of assessing forest condition nationally it was not of equivalent importance or scale to other attributes such as regeneration or proportion of native species within the canopy etc. Percentage of open space is included as a forest condition attribute and felt to be significantly more important. Edge profile is not used as an indicator in international agreements.

Attribute	**Woodland Continuity**
Definition	Areas that have been continuously wooded for at least 200 years; PAWS; woodland established on afforested land (not PAWS)

It is acknowledged that areas which have been continuously wooded for several centuries may have particularly rich seed banks and species compositions and good overall development. Such sites can also be seriously denuded. It is also possible to have high levels of forest species richness within woodlands which were more recently established – especially woodlands with varied vertical structure, open space, deadwood etc. Therefore long term continuity of woodland is not always exclusively representative of species richness etc – for instance restored PAWS sites may not always yield the expected re colonisations. As woodland continuity cannot be directly correlated to good condition and there are other measures of the woodland that do assess good condition it is proposed that Woodland Continuity is assessed as an explanatory variable and is not to be included in the final condition score.

NFI surveyors are trained to assess woodland continuity as best they can in the field and this data could be further analysed as a distinct query if required. However this assessment is only indicative and comprehensive analysis and quantification of Woodland Continuity requires consideration of additional historical maps and documentation.

Attribute	**Stem density, diameter and distribution**
Definition	Number of stem classes

It is proposed that stem diameter and distribution would be highly correlated with Age Distribution of Species. Vertical structure also provides some measure of distribution of different sized trees so it was felt that there was no requirement to assess the attribute separately. Therefore it is recommended that Stem Density diameter and distribution does not form a unique component of forest condition score.

Attribute	**Natural disturbances**
Definition	Evidence of windthrow and fire

It is proposed that natural disturbances are an explanatory factor (see Box 2). An unsustainable amount of windthrow or fire will result in poor vertical structure, species composition, open space, deforestation etc so the decline in these thresholds will indicate impoverished woodland. Accounting for Natural Disturbances as well as these affected indicators could lead to 'double counting'. Therefore it is recommended that natural disturbances do not form a unique component of the forest condition score.

Attribute	**Human Influence – Forest Management and land use**
Definition	Proportion of native woods under active management

It is suggested that human influence is an explanatory factor (see Box 2). Excessive or inappropriate management may result in poor structure, species composition, open space, deadwood etc. Conversely management may improve these factors, so any decline or improvement in these attributes will indicate a wood in poorer or better condition respectively. It is therefore hard to make a direct connection between the level and type of management and good or bad condition. This is contingent on the wood itself: the extent and type of management needs to be appropriate to local conditions/species, stage of woodland development as well as at a landscape level. Therefore it is recommended that Forest Management does not form a unique component of the forest condition score.

Attribute	**Human Influence – Pollution**
Definition	Proportion of squares that have litter, fly tipping, dog fouling, vandalism etc

Human influence such as litter, vandalism etc is suggested to be an explanatory factor (see Box 2) in forest condition. NFI surveys monitor sections that contain physical pollutions such as fly tipping and dog fouling etc and also chemical pollutants in rivers and water courses. However, physical pollution may be present but not directly impacting on forest condition. Localised litter or vandalism may have an influence on a small section of the woodland - if the pollution has a far reaching affect on species composition, structure, tree health etc this would be reflected in the corresponding attribute score. Streams and ponds, pollution scores can be separately analysed if required.

Attribute	**Microhabitats: water features**
Definition	Number of squares containing water features

It is suggested that water features are representative of *landscape* condition not forest condition specifically. The presence of a water feature can be highly beneficial for biodiversity but it does not strictly contribute to the condition of a forest (for instance any individual woodland parcel with no water features could still be an exemplary forest and should not be 'penalised' for the absence of water). Water features are included in the open space attribute as an example of 'good' open space. On this basis it is suggested that water features are not included as a unique contributor to the forest condition score.

Attribute	**Adjacent Land Use**
Definition	

The land use adjacent to a patch of woodland can have a profound effect on the species and functioning of the woodland ecosystem. It can act as additional habitat, a buffer, or as a barrier. The adjacent land use therefore may contribute to the forest condition but it is not a direct measure of the woodland condition itself. In many cases it is difficult to accurately assess land use as being favourable or unfavourable to the woodland. If non wooded land falls within an NFI survey square, however, it is assessed as open space and surveyed accordingly. It is proposed that Adjacent Land Use is an explanatory factor (see Box 2) and that its contribution to forest condition score will be accounted for within the Open Space attribute assessment and not form a unique forest condition indicator. The Open Space assessments include an evaluation of land use and whether it is beneficial or detrimental to woodland condition.

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