Developing condition indicators for the management of habitats and species

By Clive Hurford

1 What are 'condition indicators'?

Condition indicators are the link between the conservation objective for a habitat or species and the monitoring project, they:

1. Describe the evidence that we will collect to give us confidence that we are achieving the aims stated in the Conservation Objective;
2. Combine upper and lower limits (or restoration targets) with concise definitions of habitat condition; and
3. Allow us to develop efficient and reliable monitoring methods that will inform site management

In effect, condition indicators are ecological shorthands for defining habitat condition.

In the case of monitoring conservation management actions, the key questions that the condition indicators must address are:

1. What do we want to achieve?
2. Where do we want to achieve it?
3. How will we know when we have achieved it?

Note that the first two questions are about the management of the habitat or species and that the third question is essential for monitoring them. Also, note that these are not statistical questions and they do not need statistical answers. However, these questions will ensure that a) the land manager is clear about what the management aims to achieve and b) the monitoring project can focus on the most appropriate attributes at the most appropriate locations. The link between what the management is trying to achieve and the attributes assessed in the monitoring project should be clear and transparent, and the rationale that underpins the selection of those attributes should be documented both in the management plan and in the monitoring project document, if these are stored separately. This will go a long way towards reducing the levels of management discontinuity that has plagued conservation management in the past.

2 Why do we need condition indicators?

Tables 1 and 2 show the results of an exercise carried out with the help of professional conservation managers. The purpose was to demonstrate the importance of clearly defined management aims. We tested this in four different habitats that we had already monitored. In each case, we took the conservation managers to a site that was unfamiliar to them and then asked them to walk around the site, keeping their own counsel, and consider the condition of the habitat (Table 1). Later, we gave the site managers a set of clearly defined condition indicators for the habitat and asked them to repeat the exercise (Table 2).

Table 1 The results of exercises asking professional conservation managers to use their professional judgement to assess the condition of a habitat on their first visit to a site.

Habitat	Number of site managers	First impression		Monitoring result
		Favourable	Unfavourable	
Dune grassland	4	3	1	Unfavourable
Coastal heath	10	2	8	Unfavourable
Marshy pasture	17	8	9	Unfavourable
Degraded mire	43	22	21	Unfavourable
Total	**74**	**35 (47%)**	**39 (53%)**	

Table 2 The results from the same conservation managers when asked to reassess the condition of the same habitats against clearly defined condition indicators. This level of agreement was achieved only because the condition indicators were unambiguous.

Habitat	Number of site managers	With condition indicators		Monitoring result
		Favourable	Unfavourable	
Dune grassland	4	0	4	Unfavourable
Coastal heath	10	0	10	Unfavourable
Marshy pasture	17	0	17	Unfavourable
Degraded mire	43	0	43	Unfavourable
Total	**74**	**0**	**74 (100%)**	

The results illustrate that, if there are no condition indicators to define what the management is aiming to achieve, then the chances of a new conservation manager continuing with the same management regime are no better than 50:50. By contrast, if clearly defined and unambiguous condition indicators are available, then the risk of a new recruit changing the management regime is very low. In our exercises, the conservation managers reached 100% agreement when clear and unambiguous condition indicators were available.

A further advantage of monitoring against carefully considered condition indicators is that it identifies which sites require maintenance management and which are in need of restoration. This allows us to prioritise our resources and ensure that the sites of high conservation value are secure before turning our attention to those in need of restoration. The importance of unambiguous condition indicators cannot be overstated, because they:

- Describe, in terms that are accessible to a non-specialist, what we want our management to achieve;
- Enable us to design efficient and reliable monitoring projects; and

- Increase the efficiency of or resource allocation by allowing us to prioritise repeat monitoring for sites where we are uncertain of the condition (if we know what the monitoring result will be, do we need to do the monitoring to confirm it?)

The first point is vital. There is no point in asking farmers or foresters to maintain and enhance the biodiversity on their land: this will make no more practical sense to them than it does to anybody else. It will be equally meaningless to them if we express our management aims in technical terms that they are not familiar with, for example, by referring to the extent of the various plant communities present. We must express our management aims in terms that are accessible to the conservation manager, the monitoring ecologists and the land managers. This is possible, even for the more complex habitats and difficult species, if we make good use of the knowledge that is already available from research and survey.

3 Developing condition indicators

Condition indicators for a habitat will typically comprise:

- An upper and/or lower limit for the overall extent of the habitat;
- An upper and/or lower limit for the extent of 'good quality' or 'optimum' habitat; and
- Unambiguous definitions for both the broad habitat and 'optimum' habitat.

Condition indicators for monitoring a species will also include an upper and/or lower limit for the size and distribution of the species population, as well as upper and lower limits for suitable (or optimum habitat) for the species.

If the integrity of a habitat is damaged, we would expect this to be manifested through habitat degradation or loss, resulting in changes in species composition and structure. Therefore, these are the attributes that we would typically use to define the desired habitat condition in the condition indicator table.

It is important for conservation practitioners and academics alike to realise that this is not an academic research experiment . We are making practical management decisions that we have good reason to believe, based on past management practices, will either maintain or increase the conservation value of a habitat or species. The purpose of the monitoring is simply to tell us whether we have achieved this or not and, depending on how the monitoring project is set up, whether the management is moving the habitat in the right direction. The answer in will be either yes or no.

The general rule in business is that a company should invest c.85-90% in production and 10-15% on monitoring the quality of the product. The same is true in nature conservation. If all of the available funding is taken up by monitoring, there is no nature conservation. Sadly, this is all too often the case. For this reason, the 'management monitoring' being recommended here is both efficient and effective and designed to be an integrated component of a conservation management programme.

3.1 General guidance on target setting

As a general rule, it is useful to think about the conservation goals in the same way that other businesses might would have targets, i.e. to state what we expect our management to deliver in terms of the conservation product or yield.

However, unlike farmers, when dealing with issues relating to habitat extent, we rarely know the precise extent of the habitats on our sites. This is because our area estimates are often derived from habitat maps that incorporate an unknown magnitude of error, originating from a combination of personal interpretations of ambiguous habitat definitions and imprecise mapping methods. So, unless a habitat boundary is a) unambiguous, e.g. bordered by fences, hedgerows or walls, or b) can be reliably calculated from remote images, e.g. forests, expressing targets in hectares is problematic, as we have no way of knowing whether our target would represent an increase or decrease on what is already there. Furthermore, it is difficult to carry out precise area measurements on the ground, so setting targets based on hectare measurements will reduce the likelihood of a reliable, accurate or precise monitoring result.

3.2 Setting targets for the extent of a habitat

The most logical and practical way to inform the target setting process for condition indicators is to adopt a ‘top-down’ approach. This would mean that the national agency responsible for reporting to the EU (in the UK, for example, this would be JNCC), would assess the overall extent of the national resource for each Annex I habitat and Annex II species and provide each regional body with a target for how the sites in that region should contribute to the national resource. The figure that the member states provided to the EU should be available on the EU website.

In contrast, the responsibility for target setting in the UK has often been passed down to the individual site managers, who have no national overview and who are in no position to develop or implement a national strategy. This is probably the case in many other countries too, though in Sweden the responsibility is devolved, initially at least, to the County Administrations. When having to tackle this at the site level, one of the more practical ways to inform the target setting process for habitat extent involves collecting or collating survey information to identify: a) areas where the key habitat is currently present; b) which areas of the key habitat are currently in ‘optimum’ condition; and c) which areas in the vicinity have the potential to be key habitat.

In the relatively recent past, collecting this information could well have involved carrying out a field-based habitat condition survey (Hurford, 2006) and, in some cases, this might still be necessary. However, the increased availability of remote images, e.g. the open source Sentinel 2 images, and our improving image interpretation skills, mean that at least some of this information can now be gathered from remote images, using focused ground-truth exercises to fill any knowledge gaps. Logically, images illustrating the current and desired extents of the habitat should be referred to in the condition indicator table and should form an integral component of the site management plan (Nature Conservancy Council, 1989). The examples later in this document will illustrate how this approach can be applied.

3.3 Setting targets for the quality of a habitat

When developing habitat definitions for management and monitoring, we must be aware of the problems caused by ambiguity and observer variation: the scale of error associated with these is often far greater than any sampling error present in a monitoring project, especially if any of the attributes being assessed include subjective measures (Hurford 2006a).

Sampling trials using professional botanists have shown that assessing the cover of dominant or competitive species introduces unacceptably high levels of observer variation that are difficult to accommodate in any meaningful or scientific way. Vegetation monitoring and research projects often ignore the error associated with observer variation, presumably because incorporating it and combining it with sampling error would make it impossible to obtain a statistically significant result. However, the results of research or monitoring projects based on subjective measures that ignore the impact of observer variation are more likely to be determined by the person collecting the data than by any characteristic/s of the habitat. The bottom line is that if we want to design reliable monitoring projects we must use 'objective measures' that focus on frequency (presence or absence) and/or abundance: whether of associate species, critical species or assemblages of these species.

From a nature conservation perspective, it is logical to focus our monitoring on the more sensitive species associated with a habitat as, in most cases, these are the species that will define the conservation value of a habitat. It is very rare that we would consider a stand of habitat that is totally dominated by one competitive species to be of high conservation value if it is unable to support other species. So focusing our monitoring project on attempting to measure how much of a dominant species is present would rarely reflect what we are actually interested in, i.e. the diversity, frequency and abundance of the other species that we would expect to be present.

If we are only interested in monitoring the condition of the botanical components of a habitat, often we should be looking to assess changes in the frequency and abundance of the 'stress tolerators (and occasionally 'ruderals' depending on the habitat type), as identified by Grime, *et al*. However, the strongest conservation monitoring projects will also take account of the frequency and/or abundance of the key components of the fauna that we would expect to be present if the habitat was in a favourable state (see Example 1), including the birds, invertebrates and mammals. It is dangerous to believe that the typical fauna will be present if the floristic components of the habitat are in place. Decades, or centuries, of inappropriate management, e.g, high levels of grazing or frequent burning, could have removed all but the most robust species from a habitat.

4 Identifying site-specific indicator assemblages in habitats prioritised for being botanically species-rich

The most effective botanical indicator assemblages will typically comprise a small number of stress-tolerating species that we expect to come under pressure if the equilibrium shifts in favour of competitive species. The purpose of the assemblage is to provide a reliable early warning of habitat change, which will allow us to make a prompt and appropriate management response before the conservation value of the site is diminished.

We can apply a similar approach for monitoring the restoration of a habitat, though in this case we would be looking for the reappearance of the species forming the assemblage to give us confidence that the habitat is recovering.

4.1 The process for identifying a site-specific botanical indicator assemblage

If we are familiar with our site and the species composition of the habitat that we are planning to monitor, then identifying a site-specific indicator assemblage should be straightforward. We have two basic scenarios, a) sites that are in optimal condition where we want an early warning of degradation, and b) sites that are degraded where we want evidence of recovery. In both cases, we should visit the site and identify three habitat states:

- Habitat patches that we consider to be of high conservation value;
- Habitat patches that we consider to be of low conservation value; and
- Habitat patches that are showing signs of moving from high conservation value to low.

This could be a meadow with areas of species-rich grassland over much of the site, but with ranker, species-poor grassland along one edge as a result of eutrophication from a neighboring field. Somewhere between these two extremes, we will find vegetation that is still of interest, but not as species-rich as the vegetation well distanced from source of the eutrophication: this vegetation should help to define the condition indicator assemblage.

One logical way to distil the assemblage is by recording a small number of relevés in each of the three habitat states and noting:

- All of the species present in each relevé;
- An approximate cover estimate for the dominant species;
- An approximate cover estimate for bare ground (if appropriate); and
- The height of the vegetation.

We should then tabulate the relevé data and arrange it in columns from left to right in terms of declining conservation value. This will draw attention to the species most likely to disappear as the cover of the competitive species, or the height of the vegetation, increases (see below).

4.2 A case study from Blanches Blanques in Jersey

We collected the data set in Table 11-1 from successionally-young dune grassland at Blanches Blanques in Jersey. We identified this phase of dune grassland development as the conservation priority due to the rare plant species associated with it: these included Dwarf Pansy *Viola kitaibeliana*, Early Sand-grass *Mibora minima* and Sand Crocus *Romulea columnea*.

Over a period of two hours, we selected eight relevé locations: four in open vegetation with more than 20% bare sand or moss cover, and four in vegetation that was still successionally-young, but with more than 50% cover of grass. Initially, we compiled a species list for each 1 x 1 m relevé and then noted cover estimates for bare sand, moss and grass, and the height of the vegetation.

A total of 40 species was recorded in the eight relevés, with a mean of 16.5 species recorded in Relevés 1-4 and a mean of 15.75 species in Relevés 5-8. Significantly, nine species occurred only in Relevés 1-4; these were Rue-leaved Saxifrage *Saxifraga tridactylites,* Parsley-piert *Aphanes arvensis,* Buck's-horn Plantain *Plantago coronopus,* Lesser Hawkbit *Leontodon taraxacoides,* Common Stork's-bill *Erodium cicutarium, Mibora minima,* Procumbent Pearlwort *Sagina procumbens*, Sand Cat's-tail *Phleum arenarium* and Cat's-ear *Hypochaeris radicata*. These are mostly stress-tolerating annual plants with an obligate requirement for open ground; they will begin to disappear as the habitat stabilises and becomes more suitable for competitive species.

It is impossible to predict which of these 'early warning' species will disappear first as the open sandy patches diminish, but it is clear from the data set that the annual plant assemblage breaks down as this starts to happen. However, our experience from other sites suggested that some of these species are not generally restricted to open sandy habitats, notably *Hypochaeris radicata, Leontodon taraxacoides*, and *Sagina procumbens*. Conversely, Common Whitlowgrass *Erophila verna* and *Viola kitaibeliana* are species that are strongly associated with open sandy habitats and, although they were recorded in Relevés 5 and 6, this was only because they were persisting in very small patches of bare sand. So, on the basis of the data that we collected at Blanches Blanques, and taking into account what we already knew of the species, a site-specific indicator assemblage for Blanches Blanques would comprise *Aphanes arvensis, Erophila verna, Erodium cicutarium, Mibora minima, Phleum arenarium, Plantago coronopus, Saxifraga tridactylites* and *Viola kitaibeliana*.

If we now examine the individual relevé data for the co-existence of these eight species, by looking down the columns in the spreadsheet, at least four of them were present in each of Relevés 1-4. No more than two of them were present in Relevés 5 and 6, and none was found in Relevés 7 and 8. This information, perhaps, but not necessarily, coupled with a positive cover target for bare sand or bryophyte cover and a negative target for vegetation height, could be used to define dune grassland of high conservation value at Blanches Blanques (Table 11-3).

This leaves the conservation manager only one decision: how much of the dune grassland would have to be in this state for the habitat to be considered to be in optimal condition? In other words, at what point will the conservation manager take management control of the habitat if the dynamic processes slow down or stop. At this point we should take into account and, as far as dune systems are concerned, if we have enough successionally-young vegetation on a site, we will always have the potential for the later seral phases.

Table 3 A data set collected from different dune grassland habitat states at Blanches Blanques in Jersey. The crosses indicate that the species was present in that relevé.

Species name	**Relevé no**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Saxifraga tridactylites	+	+		+				
Galium verum	+	+	+	+	+	+	+	+
Sedum acre	+	+	+	+	+	+	+	+
Thymus polytrichus	+		+	+	+	+	+	+
Cerastium sp.	+	+	+	+	+		+	+
Euphorbia portlandica	+		+	+	+	+		
Viola kitaibeliana	+	+	+	+	+	+		
Aphanes arvensis	+		+	+				
Plantago coronopus	+							
Leontodon taraxacoides	+	+		+				
Leontodon autumnalis	+					+		
Erodium cicutarium	+	+	+	+				
Verónica arvensis	+						+	
Erophila verna	+	+	+	+	+			
Mibora mimima		+		+				
Geranium molle		+		+	+		+	+
Sagina procumbens		+						
Phleum arenarium		+						
Luzula campestris			+		+	+	+	
Trifolium dubium			+			+		
Vicia sativa			+			+		
Hypochaeris radicata				+				
Ranunculus bulbosus					+	+		+
Lotus corniculatus					+	+	+	
Centaurium erythraea							+	+
Vicia lathyroides								+
Species total	**15**	**15**	**18**	**18**	**18**	**14**	**15**	**16**
Bare sand	55	35	0	0	1	0	0	0
Grass cover	3	35	30	35	90	90	70	80
Moss cover	30	30	20	65	5	3	5	15
Vegetation height	2.6	2.5	4.0	3.5	4	4	5.5	6

In Table 3 above, initially we looked across the row for each species to identify those species only recorded in relevés 1-4, i.e. those associated with low sandy or mossy habitats (highlighted in green), as opposed to taller grass-dominated habitat. We then looked down the columns for each relevé to note how many of the species highlighted in green could co-exist in the open sandy habitats as opposed to the grassier habitats. This information informed the selection of the condition indicators in Table 3.

This approach to identifying site-specific condition indicators can be applied equally well in more stable, culturally managed, habitats. For example, the main threat to a grazed fen meadow could be drying out as a result of drainage. In this situation, we can record vegetation data from the stands of high conservation value on our site and from areas that are showing signs of drying, and compare the data sets in much the same way as we did for the phases of dune grassland development. The early indicators for drying out will be amongst those species present in the data collected from the stand of high conservation value but absent from data collected in the drier vegetation. We can also refer to texts like Ellenberg's indicator values for British Plants (Hill et al, 1999) to identify which of these species are likely to be the best indicators, i.e. least tolerant of drying out.

Similarly, if drying out is a perceived threat but there is no evidence of it yet, we can collect species data from the fen meadow vegetation and use Ellenberg's text to identify which of the species on our site are most likely to decline if drying out becomes a problem in the future.

Finally, we should also consider the detection rates for the species in our condition indicator assemblages. if we include a species that is either a) difficult to find or b) difficult to identify in an indicator assemblage, it is likely to compromise the monitoring result. We can avoid this by excluding these species and reducing the number of species that must co-exist at the monitoring points. So instead of asking for at least five of eight species to be present, it might be better to ask for four of seven.

4.3 Structuring a condition indicator table

When we have identified our condition indicators, we should ensure that they are defined and available in a concise and user-friendly format. Tables 2 and 3 illustrate one way of doing this.

Table 4. The structure of a condition indicator table.

Condition indicators	***Statement of intent here***	
Habitat extent	**Lower limit**	Refer to areas identified on maps or images for maintaining or restoring the broad habitat type
Habitat quality	**Lower limit**	State the proportion of broad habitat to be in a state of high conservation value
Site-specific habitat definitions here		
Broad habitat name here	Concise site-specific definition of broad habitat here	
Habitat class name here	Concise site-specific definition of habitat in a state of high conservation value	

The template illustrated in Table 4 can contain all of the essential information to guide both the management strategy and the monitoring project. If the conservation priority is a species, we simply add another row at the top of the table stating the lower limit for the population size on the site. The lower limit for the distribution of a species can be incorporated with the lower limit for population size, e.g. >50 individuals present in each of Areas A, B, and C (refer back to a map or remote image to identify these areas).

The information in Table 5 is concise and unambiguous. It states the overriding management aim for the site, and contains sufficient detail to inform the monitoring.

The site-specific-habitat definition for successionally-young dune grassland focuses on the co-existence of an indicator assemblage within a relatively small area of search (a 50 cm radius). This means that a) the recorder will soon become familiar with the appearance of the required habitat class and b) it will be possible to teach the land manager how to recognise the habitat class.

Finally, it is good practice to provide the rationale behind the selection of the condition indicators, and to store this with the site management plan and details of the monitoring project. This information will be important for future site managers responsible reviewing both the management of the site and the monitoring project.

Table 5 This example of a condition indicator table incorporates the information distilled from the data collected in the dune grassland habitat at Blanches Blanques in Jersey (Table 3).

Condition indicators	**The dune grassland habitat at Blanches Blanques will be in optimal condition when:**	
Habitat extent	**Lower limit**	Extent of dune grassland habitat outlined on the map in Figure 1 of the site management plan (1998 version).
Habitat quality	**Lower limit**	>20% of the dune grassland vegetation is in a successionally-young phase of development
Site-specific habitat definitions		
Dune grassland vegetation	Vegetation growing on a sandy substrate that is dry throughout the year. *Ammophila arenaria* is locally dominant and likely to be present within any 10 m radius. Trees and scrub absent.	
Dune grassland vegetation in a successionally young phase of development	Vegetation where more than three of *Aphanes arvensis*, *Erophila verna*, *Erodium cicutarium*, *Mibora minima*, *Phleum arenarium*, *Plantago coronopus*, *Saxifraga tridactylites* and *Viola kitaibeliana* are present within a 50 cm radius.	

5 Examples of condition indicators and the rationale underpinning them

This section provides examples of condition indicators that cover a range of different habitats and species. None of these are research projects, so statistical sampling methods are not only unnecessary, they are also inappropriate. The condition indicator tables state, in clear and measurable terms, how to assess whether the habitat at that location is in a favourable state.

Sampling trials have shown that the most reliable conservation monitoring projects will focus on collecting frequency or abundance data, possibly combined with some measure of structure, such as vegetation height. We should use these 'objective measures' for conservation monitoring wherever possible and avoid using subjective measures, e.g. recording estimates of vegetation cover. The levels of observer variation associated with subjective measures should prevent us using them for any monitoring exercise that has consequences, ecological or financial.

5.1 The importance of 'typical species' in conservation management and monitoring

Although the term 'typical species' is loosely defined in the EU Habitats Directive, their importance should not be understated. For the purpose of this guidance, 'Typical species' are defined as "Species that we would expect to be present if a habitat was in a favourable (or optimum) state'. This definition is in keeping with the spirit of the EU Habitats and Birds Directives.

In the UK at least, and possibly in many other European countries, assessments of habitat condition have often focused only on the botanical components of a habitat. So, for example, a European dry heath habitat in the UK could be considered to be in favourable condition if it comprises two species of ericoid and one species of Ulex, irrespective of whether it supports any species of bird or invertebrate. In reality, historic management of upland habitats in the UK have created large stands of heath, mire and grassland virtually bereft of associate species: for the purposes of nature conservation these habitats should not be regarded as in a favourable state.

The presence of 'typical species' that are well distributed and that co-exist above stated levels of frequency and/or abundance is the most appropriate means of separating the habitats of truly high conservation status from those of little or no current conservation value.

When developing condition indicators for a habitat we must also consider whether any dependent vulnerable species are, or should, be associated with it. If so, then the requirements of this, or these, species should be taken into account when defining the favourable state for the habitat. The following sections provide a series of examples of condition indicators for different situations.

6 Examples

Example 1 The condition indicators incorporating the typical species for the Watercourses of plain to montane levels with Ranunculion fluitantis and Callitricho batrachion vegetation (H3620) habitat

The condition indicators in Table 17.3 take into account not only the data collected in July 2006, but also of the results from the observer variation sampling trials carried out in the summer of 2008 (Hurford & Guest, 2010).

The targets in were set on the basis that the sampling would take place under optimum conditions in the month of July. In effect, the condition indicators state that the Ranunculion habitat of the Western Cleddau will be in favourable condition if:

1. There is sufficient channel cover of Ranunculion macrophytes;
2. The macrophyte species present suggest that the trophic status of the river is stable;
3. Enough families of clean-water benthic invertebrates co-occur along the length of the river; and
4. The fauna that we expect to be associated with the vegetation is present.

<table>
<tr><th>Condition indicator table</th><th colspan="2">The Ranunculion habitat of the Western Cleddau will be in favourable condition when, in each of Sections 1-5 (see management plan), during periods of low flow and good water clarity in the month of July:</th></tr>
<tr><td>Habitat extent</td><td>Lower limit</td><td>The major cover-forming aquatic plants cover more than 150 m^2 of river channel</td></tr>
<tr><td>Habitat quality</td><td>Lower limit</td><td>1) Four or more aquatic mesotrophic indicator species are present in each of Sections 1-5

2) On average, five or more clean-water benthic invertebrate families should be present in Sections 1-5, with no less than three families present in any one section

3) Gammarus spp. are present in all sections and Asellus spp. are rare or absent in all sections

4) Fresh signs of L. lutra activity are present in each section

5) Salmonids and C. gobio are present in each section

6) Either or both of Calopteryx virgo or Calopteryx splendens is present in each section, with both species present in at least one section</td></tr>
<tr><td colspan="3">Site-specific definitions</td></tr>
<tr><td>Major cover-forming aquatic plants</td><td colspan="2">Batrachian Ranunculus spp., Myriophyllum alterniflorum, Callitriche brutia, and Fontinalis spp.</td></tr>
<tr><td>Aquatic mesotrophic indicator plant species</td><td colspan="2">Batrachian Ranunculus spp., Myriophyllum alterniflorum, Callitriche brutia, Fontinalis squamosa, Chiloscyphus polyanthos, Lemanea fluviatilis</td></tr>
<tr><td>Clean-water benthic invertebrate families</td><td colspan="2">Leuctridae, Perlodidae, Chloroperlidae, Ephemerellidae, Heptageniidae, Odontoceridae, Goeridae, Brachycentridae, Sericostomatidae</td></tr>
<tr><td>Fresh signs of L. lutra activity</td><td colspan="2">Tracks in silt or mud in the river channel, or spraints that are still oily</td></tr>
<tr><td>Salmonids</td><td colspan="2">Salmo trutta or Salmo salar</td></tr>
<tr><td>River channel</td><td colspan="2">A gently sloping bed of substrate submerged under water</td></tr>
<tr><td>Rare</td><td colspan="2">Less than five individuals per completed kick sample</td></tr>
</table>

Rationale underpinning the condition indicators

The five monitoring sections are 50m stretches of river that are distributed along the length of the river, every section must meet the requirements stated in the condition indicator table for the Ranunculion habitat to be considered in a favourable state. The lower limit for habitat extent focuses on the area of river channel covered by aquatic mesotrophic macrophytes. The requirement for four or more of the mesotrophic indicator species to be present provides confidence that the trophic status of the river is remaining relatively stable: all of these species have a Species Trophic Rank rating of 6 to 9 in the MTR methodology. Five of these six indicator macrophyte species have been shown to have high detection rates in observer variation sampling trials (Chapter 14). The remaining targets were informed by the results of a baseline sampling exercise carried out in 2006 and focus on the distribution and co-occurrence of important fauna expected to be associated with the Ranunculion habitat in this river.

Example 2. Condition indicators for arable plants

Condition indicators	To maintain the arable weed flora at Newton Farm in optimal condition where:	
Extent and distribution	**Lower limit**	In one margin of at least three different fields planted with cereal or root crops: >50% of the vegetation has two or more of *Kickxia elatine*, *Spergula arvensis* and *Stachys arvensis* within a 50 cm radius of each sample point, And when Each of the three species is present in >30% of the sample points And when *Chrysanthemum segetum*, *Fallopia convolvulus*, *Lamium amplexicaule*, *Lamium hybridum* and *Misopates orontium* are present in at least one of the cereal or root crop field margins.
Site-specific habitat definitions		
Field margin	Vegetation within 4 m of any field boundary	
Root crop	Fields planted with Swedes or Turnips	
Cereal crop	Fields planted with Spring Barley, Wheat or Oats	

Rationale underpinning the condition indicators

We selected the eight species in the condition indicator table for one or more of the following reasons, for being:

- Sensitive to herbicides and/or nitrogen applications; or
- Listed among the 100 most rapidly declining species in the UK; or
- Locally scarce.

The condition indicator table has a lower limit for three discrete attributes: 1) the co-occurrence of three key species at monitoring points, 2) the frequency of three key species in the monitoring areas, and 3) the continued presence of six locally scarce or nationally declining species within the farm boundary (Hurford, 2006b).

All of the species named in the condition indicator table are archeophytes that were introduced to Wales before 1500 A.D. They all prefer moist, rather than damp, fertile soils and cannot tolerate dense shade (Hill *et al*., 1999). Corn Spurrey *Spergula arvensis* and Field Woundwort *Stachys arvensis* also prefer arable land with a soil pH of 6.0 or less, which is becoming increasingly rare in the UK (Grime, 1990).

In this instance, we used the baseline monitoring results to inform the lower limit for the co-occurrence of *Kickxia elatine, Spergula arvensis* and *Stachys arvensis*. These species were selected for the following reasons:

- All three species are abundant at Newton Farm compared with other local farms;
- *Kickxia elatine* is locally scarce in Wales, while *Spergula arvensis* and *Stachys arvensis* are among the fastest declining species in the UK (Perrin *et al*., 2002);
- Neither *Spergula arvensis* or *Stachys arvensis* can tolerate rises in soil pH;
- All three species are vulnerable to shading and herbicide applications; and
- These species regularly co-exist within small habitat patches at Newton Farm.

Example 3. Condition indicator table for Wolverines *Gulo gulo*

Condition indicator table for population restoration		**The Wolverine *Gulo gulo* population in Västerbotten County will be restored to favourable condition when:**
Distribution	**Lower limit**	Natal dens are present in all Areas A, B, C, D, E, F and G (i.e. in all Sami villages outside the coastal area, see Fig. 21-3)
	Upper limit	None set
Population size	**Lower limit**	In Areas A1–F1 (the mountain breeding area) >15 natal dens in total are present in any year and in Area A2–G (the forested inland) >10 natal dens in total are present in any year and in each of Areas A–G (Sami villages) >2 natal dens are present in any year
	Upper limit	Will be determined starting from the levels of damage inflicted by Wolverines when lower limit has been passed
Habitat quality	**Lower limit**	In Västerbotten County attitudes of Reindeer herders towards Wolverines are more positive than in 2004 and indications of poaching are at the same level or fewer than in 2004

Rationale underpinning the condition indicators

The lower limit for distribution draws attention to the need for the Wolverine population to expand out from the mountain area (Areas A1–F1) into the surrounding forests (Areas A2–G). The lower limit for population size in the mountains reflects the maximum number (15, 15 and 16) of dens found there since surveillance started in 1996. The lower limit for the total number of dens in the County is based on the minimum national level for Wolverine reproductions and the relative abundance of Reindeer in Västerbotten (Schneider, 2006).

The number of natal dens is a crude indicator of the number of Wolverines present in an area (Landa *et al*., 1998). Not all females reproduce every year, and the number of females reproducing may differ significantly between years. Therefore, the results of den surveys of several consecutive years should be used to find trends in the population, rather than drawing conclusions from the results of one single year. Multiplying the number of dens by 6.4 renders an approximate number of individuals in a given area.

Human attitudes are the most important habitat variable for Wolverines (and other predators) in the County. The Wolverine population has not increased greatly since the species was protected in 1969. It is assumed that illegal poaching is the main reason for this. If this is the case, and attitudes remain the same, the Wolverine population should stay at the same level, whereas if attitudes become more positive, mortality should decrease and the population should increase, and approach favourable condition. For obvious reasons, the illegal killing of Wolverines is difficult to measure. However, there are indicators that we can use to get an idea about the extent of poaching:

- Confirmed poaching (if Police investigations show that illegal killing has occurred);
- Snow mobile tracks following Wolverine tracks in the snow;

- Killed Wolverines are found;
- Injured animals are observed or tracked;
- The numbers of dead young in natal dens are unusually high. Multiple dead kits in a den indicate that the mother has died or that the young were killed inside the den.

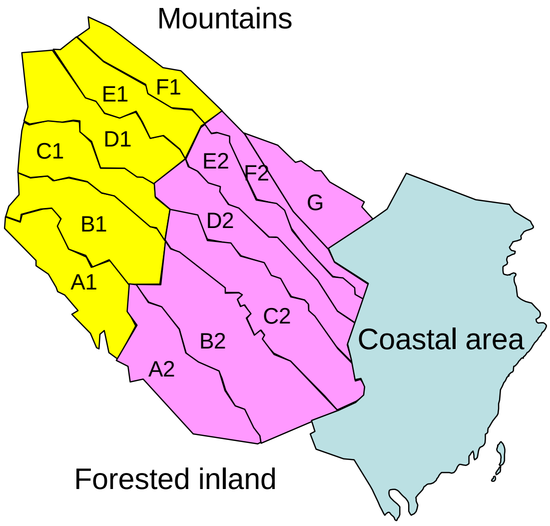

Figure 1 Västerbotten County is subdivided into three zones, the current breeding area of Wolverines in the mountains, an expansion zone in the forested inland, and the coastal area, where Wolverines are welcome but where no active management towards Wolverine establishment is conducted. Mountains and inland are subdivided according to the Sami villages (A–G) having their grounds there. This division is not made for the wintering grounds along the coast, where in total 15 Sami villages are represented in the County.

Example 4. Condition indicators for the snail *Vertigo angustior*

Condition indicators	**To maintain the *Vertigo angustior* population on Whiteford Burrows NNR in favourable condition where:**	
Population range	**Lower limit**	*Vertigo angustior* is recorded as present in Section C, plus any three of the remaining five Sections (see Fig. 24-3 in management plan), during a 15-minute sampling period in each section.
Habitat extent	**Lower limit**	Current extent of *Iris*-dominated marsh in 2000 (see Fig. 24-3)
Habitat quality	**Lower limit**	In sections A - F (see Fig. 24-3), the proportion of the vegetation recorded as optimal *V. angustior* habitat is as follows: Section A = 20%; Section B = 25%; Section C = 12%; Section D = 25%; Section E = 20% and Section F = 15%.
	Upper limit	All of the vegetation is optimal *V. angustior* habitat
Definition of Iris dominated marsh	In any 50 cm radius, *Iris pseudacorus* is present at a density of >5 plants	

Definition of optimal *V. angustior* habitat	Within any 50 cm radius > 10 *Iris pseudacorus* plants are present; and the cover of *Lotus pedunculatus* is between 10 and 60%*; and where *Juncus maritimus* forms <10% cover *; and *Samolus valerandii*, *Ranunculus sceleratus*, *Schoenoplectus tabernaemontani* and *Oenanthe lachenalii* are absent

Rationale underpinning the condition indicators

After six years of surveillance, a comprehensive survey and detailed research into population dynamics for a Ph.D., the most controversial decision taken was to drop population abundance from consideration as a condition indicator in favour of presence/absence data. This was deemed necessary because of the variability in sample size caused by changes in weather conditions at the time of sampling. Turf extraction might have allowed us to overcome this obstacle but a pragmatic assessment of the resources likely to be available for monitoring led us to conclude that this was too labour intensive. Research has also shown that *Vertigo* species undergo large annual fluctuations in population size (Cameron, 2003: Pokryszko, 1990) and that the peak breeding period varies considerably from year to year. We also felt that there was insufficient information on behaviour under different weather conditions and fluctuations in snail density to allow us to set a meaningful target for abundance.

Having decided on presence/absence as the indicator value for the snail population, we needed to ensure that the range was being maintained and hence we mapped all patches of optimal habitat and used these as our sampling stations. Loss of the snail from the current area of highest density was considered unacceptable so presence here is mandatory. We also decided that loss (or a decline below levels of detection within the sampling period) would be permissible in up to half of the remaining patches, given that patch condition may alter from year to year in response to environmental parameters, before condition was deemed unfavourable.

Vertigo angustior on Whiteford Burrows is closely associated with stands of vegetation in which *Iris pseudacorus* is frequent. The snails frequently occur within the dead leaf sheaths at the base of the plants and are believed to graze on micro-fungi and algae growing on the *Iris* leaves. It is therefore important to manage the transition zone such that *Iris* remains as a significant component over a substantial area. Within the *Iris* marsh, however, there are clearly areas that are more favourable to *V. angustior* and these coincide with herb-rich vegetation in which Greater Bird's-foot Trefoil *Lotus pedunculatus* is conspicuous or *Pulicaria dysenterica* and/or *Filipendula ulmaria* are present. These herbs may not be of direct relevance to *V. angustior* but their presence may indicate certain moisture regimes that suit the snail. Snail density declines when the vegetation becomes rank or the water table is too high. These conditions are indicated within the *Iris* marsh by the presence of Brookweed *Samolus valerandii,* Celery-leaved Buttercup *Ranunculus sceleratus* and Parsley Water-dropwort *Oenanthe lachenalii* or where *Juncus maritimus* becomes established.

* Note that, although the authors chose to use targets for vegetation cover in this example, the subjectivity associated with these could have been removed by replacing them with min/max abundance attributes, e.g. at least three plants of *Lotus pedunculatus* and no more than ten spikes of *Juncus maritimus*.

Example 5. Condition indicators for a *Nardus stricta* meadow enclave in Krkonoše NPA

<table>
<tr><th>Condition indicator table</th><th colspan="2">The species-rich Nardus stricta meadow habitat in Sklenářovice will be in optimal condition when:</th></tr>
<tr><td>Condition indicator: Proportion of sampling points with habitat of high quality</td><td>Lower limit</td><td>At least 40% of the sampling points in the enclave meet the criteria for high quality Nardus stricta meadow habitat.</td></tr>
<tr><td colspan="3">Site-specific habitat definitions</td></tr>
<tr><td>High quality Nardus stricta meadow habitat</td><td colspan="2">Vegetation where at least four of the following seven plant species co-exist at any 0.5x0.5m sampling point:

Carline acaulis, Crepis mollis ssp. hieracioides, Gymnadenia conopsea, Leontodon hispidus, Potentilla erecta, Rhinanthus minor, Rumex acetosa

And where the cover of Geranium sylvaticum is obviously less than 20 %.</td></tr>
</table>

Rationale underpinning the condition indicators

In this example, the condition indicator table was informed by the results of a baseline monitoring survey. Using survey data gathered by experienced regional botanists, transect lines were situated within the patches of vegetation identified as high quality *Nardus stricta* meadow habitat (Hurford & Březina 2017).

Depending on the size of the habitat patch, up to three parallel transects lines were situated in each patch. Each transect line was 20-50m long with sample points distributed at 2m intervals. The proportion of the sampling points that passed the criteria for high quality *Nardus stricta* meadow habitat now forms the lower limit for repeat monitoring events.

The monitoring is scheduled to be repeated every 3–5 years. The changes between baseline and present-day proportion of plots with habitat of high quality classified into three categories:

1. Significant positive change (more than 10 % increase),
2. Significant negative change (more then 10 % decrease) and
3. No significant change (remaining cases).

Each category will be visually represented by the corresponding traffic-light colour (red, green and yellow, respectively). The monitoring was established in 2012–2014 and the second census of data was carried out in 2017 (all the activities were performed during the LIFE CORCONTICA project). The complete data collection done on 85 transects situated on 21 localities. Additional collected data: (i) change in frequency of selected endangered and invasive plant species, (ii) change of species composition in 17 phytosociological relevés, (iii) hundreds of pictures of the vegetation. The results were presented in the GIS environment during an internal management workshop in Spring 2018 and discussed in the context of the known management practices.

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