Chapter 26
Monitoring Wetland Mammals: An Ecological Case Study

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Introduction

The water vole (*Arvicola terrestris*) is a medium sized rodent that displays remarkable ecological plasticity throughout its European range. In stark contrast to its common name, water voles adopt a fossorial (underground dwelling) lifestyle in many regions of mainland Europe in which the occurrence of water is not a defining factor in their distribution (Strachan and Jefferies 1993; Strachan 1998). There, water voles inhabit mountainous terrain and grassland habitats and are regarded as a serious pest species of vegetable root crops in some European regions (Giraudoux *et al.* 1997; Morilhat *et al.* 2008). In contrast, the distributions of water vole populations in Britain (the species is absent from Ireland), the Netherlands and parts of Spain and France are closely associated with wetland habitats providing suitable opportunity for burrowing and abundant structured riparian vegetation (Carter and Bright 2003; Moorhouse and Macdonald 2008). Alarmingly, over the last 100 years, the British water vole population has undergone a dramatic and widespread decline (Jefferies *et al.* 1989; Strachan and Jefferies 1993) and the species is currently a priority Local Biodiversity Action Plan (LBAP) listed species of significant national conservation concern in Wales, England and Scotland (Strachan 1998; Strachan and Moorhouse 2006).

Research undertaken by the Vincent Wildlife Trust and the Environment Agency has clearly shown that the number of sites historically occupied by water voles is reducing significantly in all regions of Britain (Jefferies *et al.* 1989; Strachan and Jefferies 1993). The factors that have driven this alarming decline, in what was previously a relatively common mammal in Britain, are complex and not completely

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understood. However, it is generally agreed that modification and loss of wetland habitats, coupled with the active predation of water voles by feral populations of American mink (*Mustela vision*), are significant determining factors in the widespread decline of water voles (Woodroffe *et al.* 1990; Macdonald and Strachan 1999). Since the plight of the water vole in Britain was recognised and highlighted, significant effort has been invested in the identification and monitoring of local populations by a wide range of statutory and non-statutory organisations. In addition, a considerable amount of autecological research has been conducted on water voles, predominately on populations inhabiting linear wetland habitats such as rivers, ditches and canals. This research has revealed important insights into how water vole populations behave at both the local and broader landscape scale (e.g. Bonesi *et al.* 2002; Telfer *et al*. 2003) and into the relationships between water vole distribution, population density, different vegetation community types and mink (e.g. Woodroffe *et al*. 1990; Lawton and Woodroffe 1991; Rushton *et al*. 2000; Moorhouse and Macdonald 2005). This and other ongoing work is beginning to provide the information and tools necessary to successfully monitor, appropriately manage and safeguard the remaining British populations of water voles with the ultimate aim of restoring this important species to as much of its former range as possible.

Current Techniques Used to Monitor Water Vole Populations

The most widely used technique to monitor the activity of water voles is the standardised transect survey in which the presence/absence of distinctive field signs (including food caches, burrows, foot-prints, and, perhaps more reliably, faeces and latrines) are recorded over a defined distance of wetland edge (see Strachan 1998; Strachan and Moorhouse 2006). Live capture and release programmes (under controlled and licensed conditions) can also provide an extremely valuable and detailed source of population-level data. These techniques have recently been used by Oxford University to study several water vole reintroductions (Moorhouse *et al.* 2009). Over time this approach can provide information on the number of animals present, their respective range sizes and movement patterns in different water vole populations.

Study Site

This case study describes a recent water vole project undertaken at the National Wetlands Centre Wales (grid reference SS 532 984), a National Key Site for water voles in Wales, United Kingdom. This site provides an ideal location to study the water vole as it supports an established meta-population within a number of diverse, interconnected habitats including ponds, ditches and reed beds of varying size and complexity. Long-term data collection across multiple connected areas of the wetlands has provided a valuable insight into the dynamics of wild populations. This study focuses on two interconnected ponds, one relatively large and complex (Pond

A – 360 m circumference – Fig. 26.1) and one smaller and circular (Pond B – 80 m circumference). The two ponds are adjacent to one another and connected by a broad expanse of soft rush *Juncus effusus* pasture.

Water voles captured within the study site used the two ponds concomitantly and thus we regarded the ponds both as two separate entities and as a combined system when interpreting the results. This study highlights the need to consider the proximity of other potential habitats when monitoring the activities of water voles as they frequently move between suitable patches, provided they have the necessary vegetation corridors.

Aim

To develop a vegetation-based sampling approach for monitoring water vole activity within a complex pond system.

Methods

This study builds upon previous live capture and release approaches used to monitor water vole populations. Here however, we describe a new method of studying the movement patterns of water voles in relation to discrete stands of vegetation. In order to do this, it was necessary to identify a set of site-specific vegetation types, defined by the dominant plant species within each stand. These 'dominant vegetation types'

Fig. 26.1 Pond A – Optimal habitat with dense bankside vegetation. *Photo by Penny Neyland*

(DVTs) were mapped in the field onto recent ortho-rectified aerial photographs at 1:1250 scale and the boundaries subsequently digitised using Geography Information System (GIS) software. The respective movements of individually micro-chipped voles tracked over 16 months were superimposed onto this DVT matrix to establish the use by individual water voles of each DVT. Little information is available describing the population size, movement patterns and other ecological aspects of water vole populations occupying non-linear habitats such as ponds. We anticipated that our study would provide a detailed assessment of the local movements of a water vole population in distinct plant patches that may assist in the construction of empirically derived models that could potentially be used to predict water vole population densities under different ecological conditions. This case study and the approach it describes should augment the knowledge required for the effective monitoring and management of pond systems containing water voles and provide useful comparative data on the species' ecology.

Vegetation Surveys

Since water voles depend on the vegetation surrounding the water body as both a source of food and cover from predation, we mapped all of the bankside and emergent vegetation of the ponds together with the surrounding land use (tracks, trees/scrub). This provided a vegetation map onto which other activities such as trapping events and field signs could be mapped. In effect, this is a bottom-up description of habitat utilisation. Homogenous stands of vegetation were identified in the field and drawn onto the aerial photographs. Each stand was labelled according to the dominant vegetation type (DVT). Plant community associates were also noted as these often feature in the water vole diet, but were not used to define the map. The resulting field map was then digitised using Mapinfo Version 8.5 (MapInfo GIS is a product of the MapInfo Inc.) which creates colour-coded polygons corresponding to individual plant species and provides a way of visualising the vegetation patterns.

The DVTs serve as the experimental blocks or sampling units. Intensive field surveys together with capture data can be overlaid onto these sampling units to provide a multidimensional map of water vole habitat selection and utility. This multi-layered approach offers a holistic interpretation of water vole ecology and can serve as a baseline from which to develop further studies of wetland mammals.

Live Trapping

A total of 22 numbered single entry rat cage traps were positioned at 20 m intervals in the dense vegetation close to the edge of the ponds. The number of traps positioned in each study pond was restricted by the size of the pond, accordingly 18 traps were placed around pond A and 4 traps around pond B. All traps were provided with abundant dry hay and circa 150 g of apple. Traps were set for continuous periods of at least 5 days every month over a 16-month period. During each trapping

Fig. 26.2 Water vole in vegetation at National Wetland Centre Wales. *Photo by Penny Neyland*

period, every trap was regularly checked and fresh hay / apple provided as required (field voles, *Microtus agrestis* frequently consume apple bait without triggering the trap mechanism). Any water voles caught were examined whilst in the trap for injuries, parasites and other notable features, before being transferred gently to a netting bag. Each vole was then sexed visually and individually tagged using a single Passive Interrogation Tag (PIT) injected between the scapular. All re-captured voles were scanned using a hand held PIT reader to determine the identity of marked animals. In order to minimise the potential exposure risks to voles caught in traps, trapping was not conducted in either very hot or cold weather, or during periods of heavy and prolonged rainfall. The total amount of trapping effort expended during this project was 1,760 trap nights.

Bulrush *Typha latifolia* and soft rush *Juncus effusus* are the most common dominant vegetation types (providing both food and cover) with yellow flag *Iris pseudacorus* and water-pepper *Persicaria hydropiper* as examples of community associates (and seasonal components of the water vole diet).

Analysis

Population densities are presented as the mean number of individuals per 100 m of habitat and calculated separately for each pond. The minimum number of animals alive (MNA) provides the most conservative population estimates (i.e. the least number of water voles on a pond during a given trapping session) and includes adults and juveniles. MNA was used as the population estimate for the site thus:

population density = (population estimate for site/length of trapped habitat) × 100 (Moorhouse and Macdonald 2008). If an animal was not trapped for a particular month the MNA was calculated from recaptures thereafter. The location and movements of individuals were plotted on the vegetation map (Fig. 26.3).

Current knowledge suggests that adult females exclude same sex individuals from their range during the breeding season (February–October) but overlap with males (Strachan and Jefferies 1993; Strachan and Moorhouse 2006). Females have been seen to overlap with other females when establishing territories at the onset of the breeding season or after territoriality breaks down during the onset of winter (PN personal observation). Live trapping throughout the year allows us to observe these overlaps that may be overlooked by other studies that focus on trapping during the breeding season only.

Results

Populations

The traps were occupied on 87 occasions, and 35 water voles caught over the duration of the study: these comprised 16 females, 14 males and 5 juveniles unable to be sexed (Fig. 26.4). Fourteen water voles were recorded only once. Seven voles moved between this site and adjacent ponds not included in this study.

Three voles were previously marked elsewhere within the wetland complex and immigrated into the study area. Eight voles (five males and three females) were caught repeatedly in the same trap within a given trapping session. Breeding was confirmed on both ponds by the presence of sexually active males and lactating females, and by the capture of young water voles.

The mean density of water voles (on both ponds as a combined system) decreased from approximately 3.5 voles per 100 m to less than one animal per 100 m during the breeding season of 2007 and subsequently dropped to 0.5 voles per 100 m, where it remained until early in the summer of 2008 (Fig. 26.4). The MNA data indicate that water vole numbers decreased on pond A from between two to four animals after November 2007 and then dropped to only one animal throughout the winter, until February. Two animals were then recorded on pond A from March onwards (in comparison to the previous March when 12 animals were caught), with a total of six recorded there in June 2008. There were fewer water voles on pond B, with a maximum of three animals recorded. No animals were caught on pond B between July 2007 and June 2008. Several water voles (both males and females) occupied ranges that were restricted to only one or two trap locations, most noticeably after the summer of 2007. This restricted movement of animals and overall low density of voles recorded throughout the latter part of the monitoring period may have been the result of an increase in rat *Rattus norvegicus* presence at the ponds (see Discussion) or simply one of the natural oscillations in population cycles common to most species of Microtine rodents (Lambin *et al*. 1998; Oksanen *et al*. 1999).

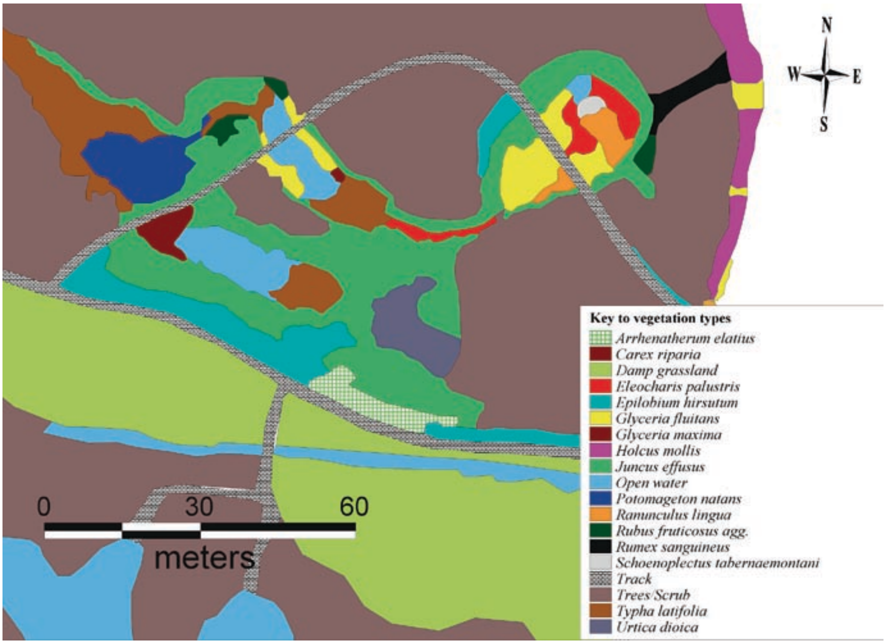

Fig. 26.3 The Dominant Vegetation Type (DVT) map for the water vole study area covered in this chapter.

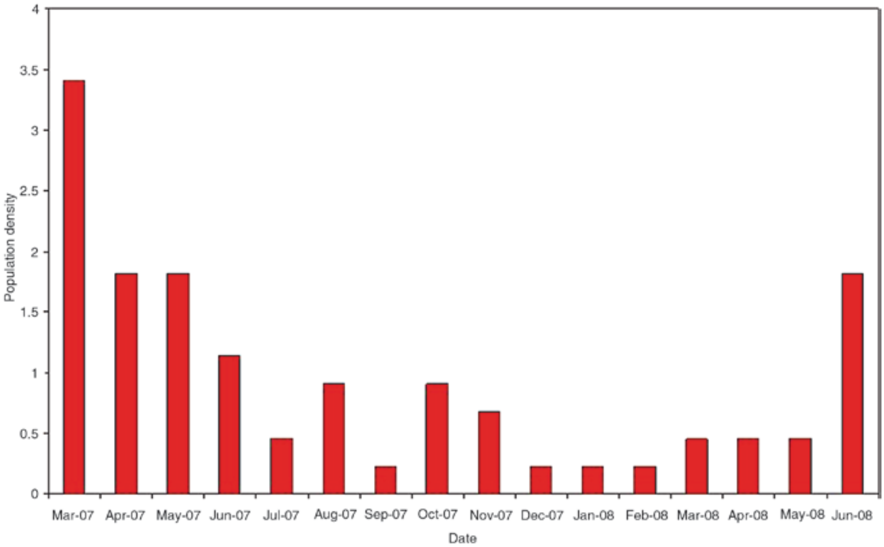

Fig. 26.4 Population density of water voles trapped on ponds A and B as a combined system (mean number of individuals per 100 m of habitat)

Dominant Vegetation Types

A greater number of water vole captures took place in soft rush (*Juncus effusus*) than any other DVT, reflecting to some degree that more traps were located in *Juncus effusus* than any other DVT. However, the number of captures was adjusted for unequal sample distribution in each patch to provide a true reflection of patch preference (Fig. 26.5).

Figure 26.5 clearly illustrates that water voles show a preference for specific DVTs. *Juncus effusus* supports the highest relative number of animals, particularly females (Fig. 26.6). *Typha latifolia* is also an important component of the habitat, particularly for males (Fig. 26.7) and juveniles. Females were associated with four DVTs whilst males and juveniles were restricted to two.

Discussion

During the course of the study the numbers of brown rats (*Rattus norvegicus*) caught (and associated field signs) increased significantly. During October 2007 a routine clearance of *Typha latifolia* was undertaken on pond A. During the months after the clearance a substantial increase in rat activity was seen around the ponds. Furthermore, water voles trapped during this period occasionally exhibited injuries atypical of intra-specific fighting injuries (Forman and Brain 2006), and on one occasion the remains of a dead water vole were found in a rat food cache, although it is not clear whether rats predated or scavenged this vole. However, as it is highly likely that rats influenced the distribution and behaviour of the water voles on both ponds during the

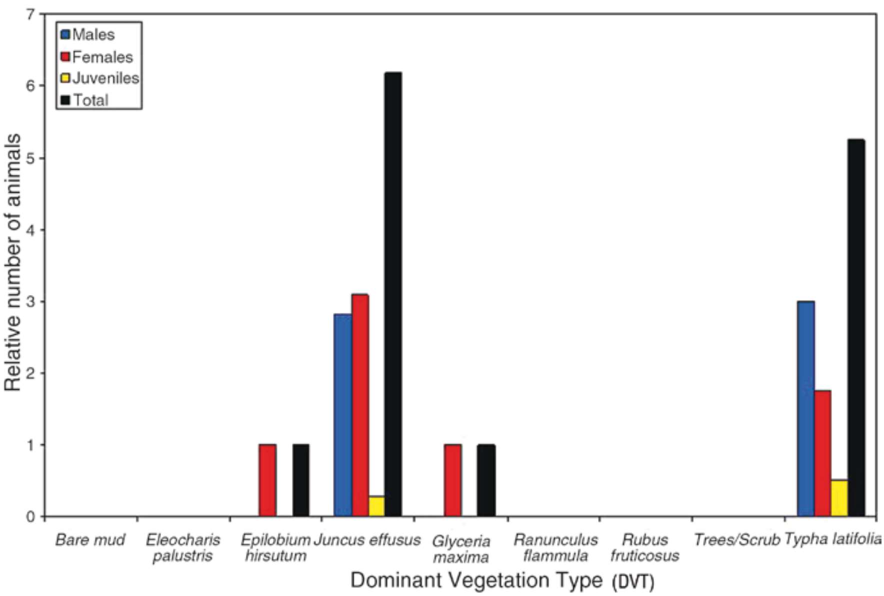

Fig. 26.5 Relative number of water voles caught per DVT (adjusted for unequal sample distribution in each patch)

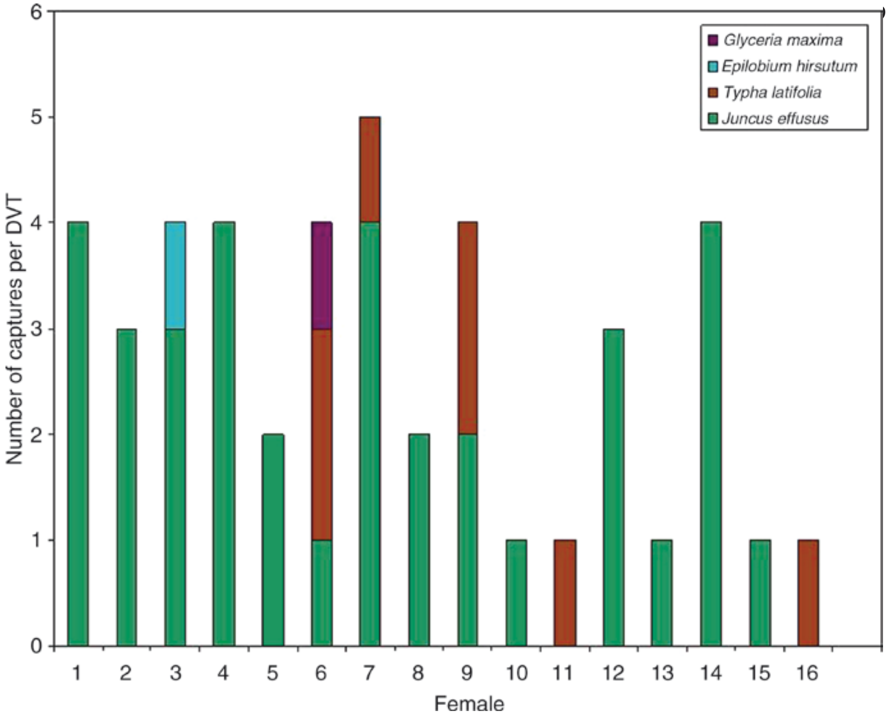

Fig. 26.6 The number of captures in each Dominant Vegetation Type for each female water vole

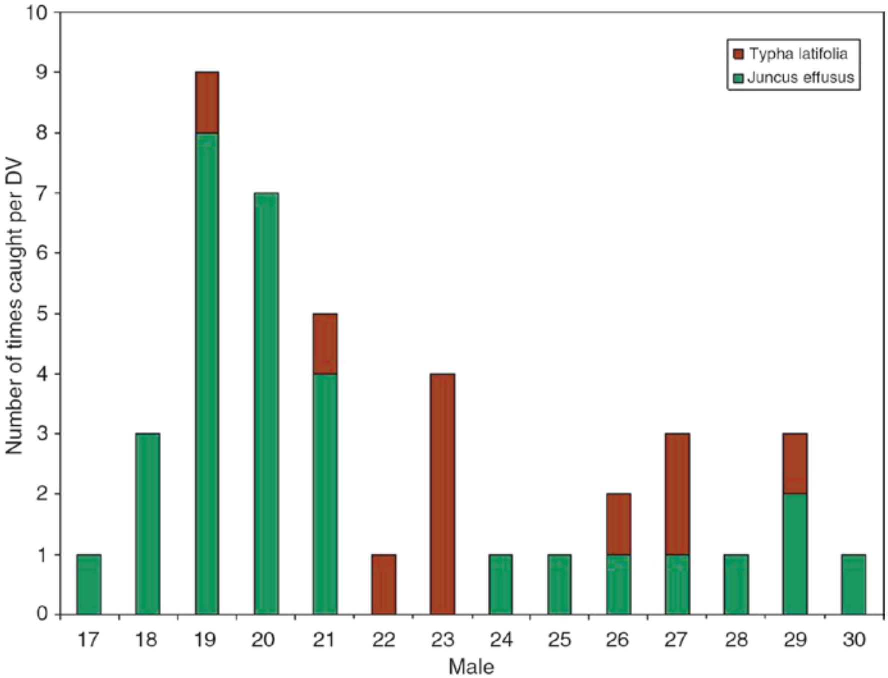

Fig. 26.7 The number of captures in each Dominant Vegetation Type for each male water vole

study period, density estimates are likely to have been influenced by this. Accordingly the following discussion will focus on the DVT approach rather than comparatively interpreting our data in light of similar studies describing water vole populations.

Water Vole Activity in DVTs

Water voles were trapped most frequently in two DVTs, *Juncus effusus* (primarily) and *Typha latifolia*. Both of these vegetation types provide consistent cover and food throughout the year and their importance to water voles has been recognised in other studies (Carter and Bright 2003; Strachan and Moorhouse 2006).

Females used four different DVTs namely *Juncus effusus, Typha latifolia, Epilobium hirsutum* and *Glyceria maxima*. Most use was made of *Juncus effusus*, which provides year-round food and cover, with the soft pith used to line the nests during breeding season (DWF & PN, personal observation): perhaps unsurprisingly, all sexually active females were associated with this DVT.

Epilobium hirsutum was occasionally used by females; this plant is rich in nitrogen (PN, unpublished data) and is therefore of particular nutritional benefit to water voles (particularly breeding females) that require this element for the production of proteins and nucleic acids.

Monthly field surveys revealed that young leaves of *Epilobium hirsutum* are frequently found in food piles from February onwards (when fresh growth occurs) and the species is foraged upon throughout the breeding season (PN, personal observation). Males were only caught in two DVTs, *Juncus effusus* and *Typha latifolia*, whereas newly weaned juveniles were captured only once in these DVTs and were presumably operating in the vicinity of mothers. The importance of *Typha latifolia* to water voles should not be underestimated, as recent observations indicate that this plant is exploited as an important source of food throughout the winter months (DWF & PN unpublished data). Furthermore, as we only studied above ground habitat utilisation, the field survey results should be treated with caution as many food caches (and sources of food) are located underground. Frustratingly, our inability to study them underground limits our understanding of their behaviour.

At the pond scale (in this study c. 440 m in total perimeter), water voles displayed different ranging behaviours – with some permanently on the ponds, some regularly moving between the study ponds and other ponds nearby (c. 200 m away), and other more transient animals that were caught only once or very infrequently. Water voles have been seen to use both underground tunnel systems and overland routes to travel between ponds and ditches separated by concrete paths and rank grassland habitats at the study site. As such, to ensure that water voles are free to move between ponds, it is important to protect terrestrial areas that link wetland patches together, both above and below ground.

Analysis of patch-based data gathered over a longer time period and larger spatial scale at the study site will provide further clarification of the extent and nature of localised water vole movement patterns within and between different ponds and other habitat patches. However, based on the results from our study, the following section outlines our recommendations for management and monitoring water voles at NWCW.

Recommendations for Conservation Management and Monitoring

Water vole distribution and activity is strongly related to a variety of habitat parameters, particularly vegetation structure and composition. It is important that vegetation is mapped in order to monitor successional processes of change as well as water vole population density and distribution in given areas to be managed. The approach described in this case study provides a useful and easily standardised method of monitoring activity of water voles at the habitat level. It also provides a common ground to facilitate comparisons between locations and habitat types with varying plant species composition and physiognomy and water vole population density. Live trapping provides the most robust and accurate estimate of population density and combined with field surveys can give a comprehensive and synergetic description of habitat utilisation, and given adequate resources is the recommended method of monitoring water vole populations.

However, live trapping is time consuming and must be undertaken by skilled (and licensed) individuals who may not be available or affordable to site managers. Where live trapping is impractical field surveys of vole activity can be undertaken, although it should be noted that these only give an indication of habitat utilisation and not occupation, unless drum-marked latrines are present (indicative of breeding females). It is important to note that the absence of water vole field signs does not automatically imply the absence of water voles as much water vole activity is confined to underground burrow systems. The Condition Indicator Table (Table 26.1) and recommendations are based on the best available data and techniques at the current time and are specific to the NWCW. Ongoing research involving a number of habitat types and water vole population densities over a 3-year period is currently being conducted and analysed. This additional research will facilitate further refinements to the DVT approach and will ultimately provide a more robust and generic monitoring tool for this and other wetland species.

Rationale Underpinning the Condition Indicator Table

The population targets are set to take account of known annual fluctuations in rodent populations and set at a level that we would expect to see exceeded in a healthy population at least once in every 3 years. These figures are based on research on the ponds described plus observations from six other ponds within the metapopulation complex at NWCW. Habitat targets set to take account of distribution and extent of various vegetation types. Stands of vegetation (i.e. DVTs) should be spread across each pond.

A pond in isolation may be declared unfavourable if all recommended DVTs are not present and there are no habitat corridors linking to more favourable ponds.

Table 26.1 The Condition Indicator Table for the water vole population at the National Wetland Centre for Wales

Condition indicator table	The water vole *Arvicola terrestris* population at the National Wetland Centre for Wales will be in favourable condition when:	
Population size	Lower limit	In any 3-year cycle Minimum of 20 individuals (MNA) including at least one juvenile are known to have been present in Areas A and B (collectively) (see map) And/or Signs of water vole activity are present in at least 20% of the bankside; with a minimum threshold latrine density typically 6.4/100 m (25% of these drum-marked)
Habitat quality	Lower limit	In each of Areas A and B >1% of the total pond area is open water (with at least 1 continuous patch of open water over 1.5 m^2 in extent) At least 95% of the bankside is vegetated (no more than 5% of the bank should be covered by bare ground/mud, with no areas of bare ground >1 m^2) >50% of the bankside vegetation should be dominated by *Juncus effusus* and >5% by *Typha latifolia* – with at least one DVT present of *Epilobium hirsutum* (>3.5% of the pond/ditch edge) and one DVT of *Carex riparia* (>1% of the pond/ditch edge) <10% of the bankside vegetation should be dominated by trees/scrub Habitat corridors should be present between areas A and B
Site-specific definitions		
Signs of water vole activity	Food-piles (aggregations of cut vegetation of identified plant species circa 10 cm in length) And/or Latrines (water vole faeces of varying age in aggregations) that may/may not be drum marked (See field survey recommendations)	
Bankside	Area of habitat within 5 m of open water with/without submerged macrophytes (e.g. *Potomageton natans*) or with emergent vegetation (e.g. *Typha latifolia*/*Eleocharis palustris*/*Ranunculus lingua*/*Glyceria fluitans*)	
Open water	Open water includes water with / without submerged macrophytes (e.g. *Potomageton natans, Glyceria fluitans, Lemna* sp., etc.)	
Habitat corridors	Continuous terrestrial vegetation / necessary substrate in which to burrow linking different ponds, providing protection from predation whilst travelling above/below ground	
Juvenile	Water vole weighing less than 140 g	

Water Vole Field Survey Recommendations

In the first instance a DVT map of the site that requires management or monitoring should be created. This provides a baseline onto which movements of individuals and the results of field surveys can be plotted. In addition to the vegetation map, plant community associates should be noted for each DVT as these will assist in species identification of plants in food-piles during field surveys.

Note that after surveying each DVT ensure that vegetation remains undisturbed; return any swards of vegetation back to their original arrangement ensuring that the ground below is not exposed otherwise voles returning to their food-piles (Fig. 26.8) and latrines (Fig. 26.9) are more visible to aerial predators. If field surveys suggest

Fig. 26.8 A food-pile of *Iris pseudacorus* in a stand of *Juncus effusus*. *Photo by Penny Neyland*

Fig. 26.9 Water vole latrine with fresh and drum-marked pellets. *Photo by Penny Neyland*

that the habitat is occupied by a breeding population (i.e. in a favourable condition) then a trapping survey can be undertaken. Trapping should be conducted for at least one breeding season however at least three breeding seasons are required to reveal true population processes. Recommendations for water vole food-piles and latrine field surveys are outlined in Tables 26.2 and 26.3 respectively.

Table 26.2 General information on water vole food-piles

Food-piles - mark location of each on DVT map	
Plant species	Identify to species level. Unskilled surveyors can use a key to identify any unknown species. There are a number of plants that may be confused; using a key, hand lens and internal structure of the stem will aid in classification. Once a food-pile has been located there is usually evidence of feeding on nearby vegetation (since water voles are predominantly patch based foragers). This can also aid in identification of the species in the food-pile.
Length	c. 10 cm long N.B. Take care not to confuse water vole food-piles with those of field voles, *Microtus agrestis* (which are much shorter and often covered in small faecal pellets).
Angle of cut	Rodents cut vegetation at a 45° angle across the stem.
Distance from edge of water body	Mostly within 50 cm, but up to 200 cm on this site.
Notes	Care should be taken when comparing species that are superficially similar, particularly if the flowering spike is not present, e.g. *Juncus effusus* and *Eleocharis palustris* (the two can be distinguished by the arrangement of the pith, which is cylindrical and fills the stem in *Juncus*, but cross-hatched and paler in *Eleocharis*). *Typha latifolia* and *Iris pseudacorus* may also be confused in food piles, (the former has a fleshier and less glaucous blade).

Table 26.3 General information on water vole latrines

Latrines – mark location of each on DVT map	
Faecal pellet size	About 10 mm long, cylindrical, rounded at tips N.B. Take care not to confuse with rat pellets which are of a similar size but have a pungent smell, or field vole pellets which are a similar shape but only a few mm long
Drum-marked	Look for drum-marked pellets that have been marked with scent and crushed into the ground, these indicate the presence of breeding animals
Distance from edge of water body	Mostly within 50 cm, but up to 200 cm on this site
Notes	Latrines themselves are not necessarily indicative of breeding but are deposited at range boundaries. Small aggregations of faeces may deposited by animals that are moving through more transient areas, rather than actually occupying them

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