EARTHWATCH INSTITUTE ANNUAL FIELD REPORT

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Completed by: Dr. Christina D. Buesching
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Dear Volunteers,

As the number of people in the world is increasing, so is their impact on our environment. Understanding these impacts and effects is a prerequisite for effective conservation and environmental management. Whereas some impacts, such as deforestation or hurricanes, may be immediate, others, such as climate change, are comparatively slow and manifest themselves only in long-term ecological trends. Thus, setting up long-term monitoring sites for scientific research in a variety of different climatic and geographic regions is paramount to establishing trends in our natural environment.

Many mammals are sensitive indicator species for changes in their natural habitat and are therefore well suited as candidate species to monitoring the status of ecosystems. Our Mammals of Nova Scotia project started in spring 2007 as a logical progression of our previous (and in a slightly different format still ongoing) Earthwatch Mammal Monitoring project in Wytham Woods in the UK. In both projects we aim to monitor all mammal populations in the study area to establish long-term trends in their abundance and distribution as "part of the bigger picture" of climate change as well as short-term population fluctuations in relation to environmental changes on a local scale. Many concepts we developed in England are now being tested and expanded upon in Nova Scotia.

At the end of our second field season in Canada it is time to reflect on what we achieved during the past year. We feel that it was again a very successful season and the Project benefited enormously from your efforts; not only did you help us to collect robust ecological data on a variety of species, but you also put in a lot of sheer physical effort with a number of practical tasks in the field: At our primary research site at Cook's Lake, we added substantially to our understanding of the long-term effects of clear cutting on small mammal populations as well as site-recovery; you collected a large amount of geographical and environmental data towards our multi-layered GIS Map; you started to compile site-specific species lists on birds and plants; and you helped us with a variety of practical tasks ranging from building bat boxes to developing new paths to clearing forest encroachment on our grassland. Most excitingly, however, you also helped us to develop a second field site at Eastport near the coast as comparison to our inland site at Cook's Lake. Climatic and geological conditions at the two sites are (although both typical for Nova Scotia) very different to each other, and thus we also expect differences in their ecology. First estimates of deer and snowshoe hare densities do indeed confirm that, although both

species are present at both sites, there are pronounced differences in their relative abundance with hares prevailing at the coast and deer inland.

As you realized, mammal monitoring can be very labour intensive work with many hours of watching and searching for field signs. The help of volunteers can make a real difference in this context. Finding, testing and evaluating appropriate methods of training volunteers and involving non-professionals in scientific research is therefore just as important to us. Over the past year we could again collect valuable information and experience on the suitability of different methods for the training of non-professional volunteers; and once again we realised that every volunteer can contribute valuable help to conservation and research efforts: some by sharing the hard labour of field work in inaccessible areas, others by patiently sitting still compiling species lists.

Therefore our thanks go to all our volunteers for your commitment and help, the Earthwatch Institute in Boston and in Oxford for supporting the project and recruiting volunteers on our behalf, and to our scientific colleagues at Oxford University's Wildlife Conservation Research Unit and Nova Scotia's Mersey Tobeatic Research Center for scientific discussions and collaboration.

Thanks for making our work so enjoyable!

Best wishes

Christina D. Buesching & Chris Newman

Reporting on research objectives

The main objective of our project is to investigate the impacts of environmental change on temperate terrestrial ecosystems with a special emphasis on endemic mammal populations. In most cases the factors responsible for environmental change are of anthropogenic origin and can range from localised impacts of human activities such as habitat exploitation (e.g. hunting or forestry) to impacts on the global athmosphere (e.g. climate change or air pollution). In all cases long-term monitoring and quantitative research is essential to develop a thorough understanding of the processes involved and the conservation management strategies necessary to maintain and enhance biodiversity.

However, whilst the explicit aim of our project is to establish from long-term data how representative terrestrial mammal populations respond to a varierty of changing environmental conditions, we strive to collect our data efficiently. Thus, we structure our monitoring efforts in such a way that records can be analysed under three complimentary objectives: *Firstly*, establishing high-quality baseline data to reveal long-term population trends; *Secondly*, to investigate short-term population-dynamic responses to local management and manipulation; and *Thirdly* to evaluate the best training programmes and deployment for volunteer helpers of variing expertise and ability in scientific data collection.

However, building up databases suitable for the investigation of ecological long-term effects of different environmental variables on a variety of species is difficult, as it requires by definition to monitor the same populations at the same study sites over a (large) number of years. Strict control over site management as well as the guarantee of scientific access to these sites are just two of the main prerequisites for successful long-term monitoring efforts.

Objective 1: Development of our inland monitoring site at Cook's Lake and establishment of a coastal long-term monitoring site at East Port

Work commenced on this objective: Yes

Due to its unique geographical position as a peninsula of the atlantic coast of the north American landmass, Nova Scotia's weather is very much dependent on the prevailing wind direction. Whilst winds from the south and east usually bring more temperate and wetter air which is thus often associated with precipitation, winds from the west and north tend to be associated with the influx of drier air from the continent, which tends to be much warmer than the air over the Atlantic in summer, but much colder in winter. Depending on the exact location and size of each weather system, wind direction, and thus climatic conditions can vary substantially within Nova Scotia on a comparatively small scale. In addition, geological processes and coastal conditions resulted in significant differences in soil conditions between inland and coastal regions with much more top soil (i.e. in many areas >2 meters) available inland compared to the typical <50cm along the coast. Although at first glance, fauna and flora appear to be very similar in the two habitat types, changes in environmental and climatic conditions are likely to have different effects and impacts on these two ecosystems. Therefore setting up long-term monitoring sites in both will not only facilitate valuable comparisons between ecosystems, but will also greatly increase our ability to study the different effects of climate change on temperate zones.
However, creating research sites suitable for volunteer-based long-term monitoring requires many different parameters to be met. While the site has to remain as undisturbed as possible to ensure that wildlife continues to behave naturally, it also has to be accessible and negotiable by less physically-able volunteers, and provide rudimentary facilities.

<u>Habitat and Trail Management</u>

Cook's Lake: Our primary field site at Cook's Lake comprises 330 acres (134 ha) of a diverse, but typical, mixture of coniferous and deciduous woodlands, hay meadows, ponds, streams, wetlands, and a lake. As the site is exclusively under the project's management, Cook's Lake is ideal as a long-term monitoring site to assess the effects of environmental and climatic changes on terrestrial mammals in temperate ecosystems, while simultaneously offering the opportunity to set up specific small-scale experimental treatments investigating the effects of anthropogenic manipulation of the environment, such as different habitat management strategies. However, to maintain biodiversity, some habitat types, such as hay meadows need active management to prevent succession. As the 30acres of grassland at Cook's Lake had not been cut for a number of years (between 10 and 25 depending on the field), in some places forest encroachment, esp. by white pine, eastern tamarack and ash, was already well established. With the help of our volunteers we cleared approximately 75% of the fields from tree saplings, facilitating the use of grass cutting machines in the future. We also kept the existing 4.3km of tracks, which we established in the previous field seasons open from encroachment, and created a new circular track (ca. 1km), which in part follows an old forestry road. The emerging network of trails not only makes the field site more accessible, but also enables volunteers to undertake systematic field sign transects. ***East Port***: Our new coastal monitoring site is situated on a glacial end moraine from the last ice age, and has some big bolders, which can be difficult to navigate for less able volunteers. Thus, our first aim was to create two paths (circe 800m) to make the site more accessible and enable volunteers to carry out monitoring tasks safely and efficiently.

Bat Boxes

Since the arrival of the first white settlers, the forests of Nova Scotia have been regularly cut over and used for timber extraction. Large hollow trees suitable as nesting or roosting sites are rare in the resulting secondary woodland, and thus many species such as flying squirrels, bats, or owls compete over this resource. During the field season of 2008, our volunteers built an additional 20 bat boxes of which 10 were deployed at *Cook's Lake* (resulting in a total of 37 boxes at Cook's Lake) and 10 at *East Port*, and which will form the basis of bat surveys in the future.

GIS Mapping

Detailed geographic maps depicting environmental features as well as habitat types are an important prerequisite to long-term monitoring and research to ensure inter-annual comparability of the data collected. Also, in the context of working with volunteers, detailed field-site maps are essential to help people orientate themselves and visualise the spatial context of their work. Our aim is for both monitoring sites to create multi-layered GIS databases overlaying the geographical maps, which will depict habitat types and important biological resources, such as clumped food sources (e.g. apple trees), nesting opportunities (e.g. veteran trees, bat boxes), animal burrows, important field signs (e.g. porcupine latrines, droppings of larger mammals), as well as the exact locations of our small mammal trapping grids etc.

In each team pairs of volunteers used handheld GPS devices to map specific environmental features in the study area. During the past field season, we expanded our GIS map of *Cook's Lake*, which we started in 2007, to include the newly established trail and bat box locations, as well as adding important mammal field signs, such as a marmot hibernaculum, bear droppings, porcupine latrines, and a fisher porcupine kill. At *East Port* we established a basic geographical map depicting the site boundaries and some of the most important habitat features, which will be expanded upon during the next field season.

Establishment of Site-Specific Species Lists

Ecology is the study of the factors affecting distribution and abundance of populations. Thus, comprehensive site-specific species lists are an important prerequisite to ecological monitoring. They enables us not only to relate fine-scale fluctuations in species distribution to environmental factors, but also to gather detailed knowledge about inter-specific interactions within one ecosystem.

Ultimately, we aim to establish detailed species lists for both monitoring sites representing all plant and animal taxa. However, due to the enormity of this task we concentrated primarily on mammals during 2007, adding reptiles and amphibians in 2008 for both sites, and birds at Cook's Lake. Whilst mammals, reptiles and amphibians will be listed individually each year to collect information on species presence over time, information on birds will be combined for all years due to the high number of similar species, which are often difficult to distinguish from one another for novice volunteers.

Species presence was determined either by direct observation or identification of field signs (A= Animal, B= Bones, T= Track, D= Droppings, R= Resting Site/ Den, F= Feeding Signs, H= Hair/ Fur, V= Vocalisation).

Cook's Lake			
	2006	***2007***	***2008***
Mammal			
White-tailed Deer	A,T,D	A,B,T,D,H	A,B,T,D,H
Snowshoe Hare	T,D	A,T,D,H	A,B,T,D
Porcupine	A,T,D,F	A,B,T,D,R,F,H	A,B,D,R,F,H
Beaver	R	T,R,F	T,R,F
Muskrat		D	
Eastern Red Squirrel	A,F	A,T,D,F	A,T,D,F,V
Flying Squirrel	A		A,D
Chipmunk	A,D,R,F	A,T,D,R,F	A,T,D,R,F,V
Groundhog		D,R	D,R
Meadow Vole	A	A,D,R,F	A,D,R,F,V
Red-Backed Vole	A	A,D	A,D,R
Rock Vole			A
Bog Lemming		A,D	A,D
White-footed Mouse		A,D	A,D
Deer Mouse	A,D	A,B,D	A,D
Meadow Jumping Mouse	A	A,B	
Woodland Jumping Mouse		A	
Little Brown Bat		A,V	A,D,V
Eastern Pipistrelle		A,V	A,V
Common Shrew	A	A	A,D,V
Pygmy Shrew	A	A	
Short-tailed Shrew	A	A,D	A,D,R,V
Striped Skunk		D,F	T,D,F
American Mink		D	T,D
Fisher		D,F	D,F
Otter		D	T,D
Raccoon	T,D	A,B,T,D,F,H	A,B,T,D,F
Black Bear	D	T,D	T,D,F
Red Fox	D	T,D,F	
Eastern Coyote	D	T,D	A,T,D,F
Bobcat		T,D	T,D

Amphibians			
Spring Peeper			A,V
Wood Frog	A	A	A,V
Leopard Frog	A	A	A,V
Bull Frog			A,V
American Toad		A	A,V
Eastern Red Eft			A
Salamander			A
Reptiles			
Garter Snake	A	A	A
Smooth Green Snake	A	A	A

Bird list for Cook's Lake

(Total number of species: 43)

Common Loon, Double-creasted Cormorant, Great Blue Heron, American Black Duck, Osprey, Cooper's Hawk, Spruce Grouse, Mourning Dove, Black-billed Cuckoo, Great Horned Owl, Barred Owl, Bold Eagle, Red-Tailed Hawk, Peregrin Falcon, Gos Hawk, Chimney Swift, Ruby-throated Hummingbird, Belted Kingfisher, Hairy Woodpecker, Downy Woodpecker, Northern Flicker, Pileated Woodpecker, Eastern Wood-pewee, Gray Jay, Blue Jay, American Crow, Common Raven, Black-capped Chickadee, Red-breasted Nuthatch, Hermit Thrush, Bicknell's Thrush, Cedar Waxwing, Red-eyed Vireo,Yellow Warbler, Townsend Warbler, Yellow-rumped Warbler, Palm Warbler, Black-and-White Warbler, Common Yellowthroat, Song Sparrow, White-throated Sparrow, American Goldfinch, Amereican Robin.

East Port	
	2008
Mammal	
White-tailed Deer	A,T,D
Snowshoe Hare	A,T,D
Porcupine	A,T,R,F,D
Beaver	F
Muskrat	R,T
Eastern Red Squirrel	A,T,D,F,V
Flying Squirrel	
Chipmunk	A,T,D,F,V
Groundhog	
Meadow Vole	
Red-Backed Vole	A
Rock Vole	A
Bog Lemming	
White-footed Mouse	
Deer Mouse	
Meadow Jumping Mouse	
Woodland Jumping Mouse	
Little Brown Bat	A
Eastern Pipistrelle	A
Common Shrew	
Pygmy Shrew	
Short-tailed Shrew	
Striped Skunk	
American Mink	D

Fisher	
Otter	T,D
Raccoon	
Black Bear	D
Red Fox	
Eastern Coyote	T,D
Bobcat	T,D
Amphibians	
Spring Peeper	A,V
Wood Frog	A,V
Leopard Frog	
Bull Frog	
American Toad	A
Eastern Red Eft	
Salamander	
Reptiles	
Garter Snake	
Smooth Green Snake	

Vegetation lists for both sites, as well as a bird list for East Port have been started, and future teams will contribute to these databases.

Objective 2: Establishing baseline data to reveal long-term population trends

Work commenced on this objective: Yes

2.1 Baseline Surveys (Distribution & Abundance)

Assessing changes in a species' distribution or abundance, and attributing these changes to specific factors, is only possible if accurate site-specific baseline data are accessible as background information, which can then be related to other factors such as changes in habitat (e.g. forestry operations) or climate change.

a) Field Sign Transects

Broad Cove

The 8km coastal transect along Broad Cove provides an introduction to field sign surveys to our volunteers on their first day. Whilst the main aim of this transect is to teach the new volunteer team as many field signs, such as foot prints, feeding remains, droppings, dens, and fur/ bones as possible, we also record for which species we could confirm their presence in this area. The table below shows the number of teams for both field seasons with whom we found evidence for different mammal species. Whilst some species, such as hares, deer, porcupines, raccoons, squirrels, and chipmunks were recorded reliably with each team, others such as muskrat and meadow voles, although abundant, are more difficult to observe, and thus get recorded only by a proportion of the teams. Some species, such as bear, bobcat and fisher are elusive and have comparatively large home ranges, and thus their detection is often coincidental. However, some species such as foxes and coyotes leave obvious and clearly identifiable field signs (esp. their droppings, which they use for scent marking), and their lower detection rate in 2008 is thus likely to reflect a true change in species presence along this transect.

Mammal	***2007***	***2008***
Snowshoe hare	5/5	7/7
White tailed deer	5/5	7/7
Porcupine	5/5	7/7
Beaver	3/5	4/7
Eastern red squirrel	5/5	7/7
Chipmunk	5/5	7/7
Muskrat	2/5	4/7
Meadow vole	1/5	0/7
Raccoon	5/5	7/7
Red fox	4/5	0/7
Coyote	5/5	4/7
Bobcat	4/5	1/7
Otter	3/5	3/7
Mink	3/5	2/7
Fisher	0/5	1/7
Black bear	0/5	1/7
Grey seal	2/5	3/7
Common seal	3/5	4/7

Bear Surveys at Thomas Raddall Provincial Park

This park is a coastal nature reserve south of Liverpool comprising 1675 acres with several picnic tables and overnight camping facilities. In recent years tourist numbers to Nova Scotia have declined due to an increase in fuel prices and the strong Canadian dollar. Thus, the coastal trails in the reserve are generally almost deserted.

Due to the large quantities of blueberries in the area, the park has always been frequented by black bears in late summer/ autumn. Increasingly, however, bears have taken to using the park year-round, and their field signs can be found readily throughout the area. We aim to record all bear droppings along the coastal trail with each team to establish seasonal and inter-annual variation in bear activity in this area. Unfortunately, as in 2007, bad weather resulted in cancelling the visit to Thomas Raddall for 2 teams, whilst the Park was still closed during the first two teams of the season. Thus, we have only data for 3 team visits during (August - October). All teams found bear droppings throughout the park, evidencing permanent use of this area by resident black bear(s).

Field Sign Transects at East Port ~ Meadow Trail

Field sign transects are widely accepted as a suitable method to survey large areas for presence/ absence of a variety of mammal species. One of the main attractions for using this method to conduct e.g. large-scale national surveys is its assumed capacity to produce reliable data if used by volunteers who received only minimal field training, but are supplied with a written guide to mammal field signs. However, if employing this method in ecological monitoring, two caveats have to be taken into account: *Firstly*, the field signs of some mammal species are easier to detect and identify reliably than those of other species, and *secondly*, some surveyors are better than others. Systematic studies investigating the factors (e.g. training, experience, fitness, eye sight etc) influencing the suitability of different volunteer surveyors are scarce.

The field sign transect at East Port will serve to evaluate the efficiency of different training methods, the suitability of field sign transects for different Nova Scotia mammal species, as well as which individual-specific factors might influence the quality and reliability of transect data. To achieve this evaluation, the Principal Investigators (PIs) walk the same transect as the volunteers on a regular basis throughout the year, and thus have accurate and up-to-date knowledge of which field signs can be found along the route. Teams are subdivided into groups of 3-4 volunteers, and their data compared to the list of mammals known to be present. Five teams between April and October walked took part in this survey.

East Port Meadow Trail	
Mammals known to be present	Recorded by % of volunteer sub-teams
Snowshoe hare	100%
White-tailed deer	100%
Porcupine	100%
Muskrat	35%
Eastern red squirrel	25%
Chipmunk	50%
Raccoon	50%
American mink	10%
Otter	50%
Beaver	70%
Bobcat	0%
Coyote	100%

b) Camera Traps

Modern digital camera traps with built-in passive infra-red motion detectors are increasingly regarded as a reliable and comparatively cost- and labour-saving censusing method; ideal for remote locations. In addition, camera-trapping is often classed as an objective technique, virtually free from observer-/ user error.

To evaluate the suitability of this relatively new technique for the use by amateur volunteers as well as trying to capture some of the more elusive mammals on film, we again deployed 6 camera traps with each of the 7 teams totalling 208 trap nights. We took 214 photographs of animals capturing images of raccoons (54 pictures), deer (31 pictures), snowshoe hares (3 pictures), chipmunks, squirrels, crows, ravens, and blue jays.

Our results in 2008 confirmed our observations from the previous field season: This seemingly simple monitoring technique requires far more technical explanation and biological field experience than generally assumed. In scientific papers the exact deployment of infra-red cameras (e.g. camera angle, partial obstruction of field of view, location in relation to animal field signs, etc) is rarely detailed in the methodology. However, our experience show that most volunteers make at least one of the following three mistakes when setting up cameras in the field:

1) They underestimate the importance of ensuring a completely unobstructed field of view for the camera resulting in grass blades or small branches swaying in the wind triggering the camera's motion detector, thus taking pictures of "nothing".

2) They mis-judge the camera angle either angling them too acutely towards the ground or sky, missing the animal that ate the provided bait, or angling them to one side, thus catching only part of the desired area on film. Cameras set at water bodies also often suffer from high reflection of the built-in flash on the water surface, thus over-exposing the picture.

3) They set cameras in less than ideal places, not recognising more suitable locations, for example trying to capture deer when they are jumping over a fence (and missing the shot altogether due to the delay of the camera trigger), rather than setting them up to capture deer whilst grazing.

Our training experiences from the past field season show that the first two points can be addressed with very specific explanation and demonstration in the field to ensure that amateur volunteers set up camera traps correctly. However, interestingly, to ensure that more than an average of 75% of the volunteers understand the correct method of deployment and enable them to set up their own cameras accordingly, the technique needs to be demonstrated step-by-step at an actual site in the field, and it is not enough to just describe each step holding a camera and using "imaginary trees" to tie it onto.

Training volunteers to recognise suitable camera locations in the field, however, is much harder and appears to require first-hand experience of observing animals in their natural environment (e.g. deer grazing at the edge of a forest). Since the start of this project we had 4 avid hunters and 3 park rangers, and all 7 of these volunteers were highly successful in choosing camera locations, which returned a comparatively large number of deer and raccoon pictures, whereas many other volunteers, although trying to mimic their choices were far less successful.

Over the next field seasons, we will continue to develop appropriate explanation and training in the optimal deployment of camera traps, as this is a technique which could be used in the future by volunteers to affect large-scale biodiversity monitoring programmes (e.g. garden and school-yard surveys).

c) Small Mammal Trapping: Long-term Monitoring

Small mammals are sensitive environmental indicator species as their numbers respond rapidly to environmental perturbation, such as habitat modification (e.g. land management work), climate change or altered predation pressure (e.g. over-hunting, disease etc.). As they are at the bottom of the food chain and represent the preferred prey for many mammalian (e.g. foxes, bob cats, ermine, weasel) and avian predators (owls, hawks), small rodent abundance has a direct, albeit delayed effect on predator abundance. However, inter-annual variation in rodent density usually varies according to a cyclical pattern due to rapid breeding and maximisation of reproductive output and the following over-exploitation of

food-resources and increase in social stress with resulting lower reproductive output, which in turn lead to population crashes. Thus, to draw meaningful conclusions about the population trends in small mammal abundance, long-term monitoring data are needed.
To record baseline data on yearly small mammal abundance, we established two long-term monitoring sites at ***Cook's Lake***. Site-1 consists of 50 trapping points in grassland and 50 in adjacent, predominantly coniferous, forest; Site-2 comprises 50 trapping points in hardwood bush and 50 in adjacent (predominantly deciduous) forest. Both grids are trapped for three successive nights twice yearly. Trapping at these long-term monitoring sites is carried out in May to establish small mammal over-wintering survival and in September/October to record autumn peak numbers (it being too hot to trap on open grassland in mid-summer). However, unfortunately it proved to be impossible during the field season of 2008 to trap these grids in spring due to the very small May team size together with a lower-than-average physical fitness score, whilst grassland trapping in autumn was referred in favour of much needed grassland management work. However, the hardwood bush and the 2 forest grids were trapped in autumn, and the long-term monitoring database will be continued in 2009 as planned.
At ***East Port*** we established one long-term trapping grid comprising a mixture of mixed secondary forest, hardwood bush, and some open areas, which will be trapped twice yearly in April and September/October to compare small mammal abundance in this coastal site to the inland site.

All volunteer teams were trained in trap deployment, trap checking and rodent handling; recording species, sex, age, reproductive status and weight were for each capture. The numbers caught were translated into numbers present using a simple capture-mark-recapture formula intended for the use of amateur naturalists:

$P= (N+R) \times M / R$

where $P=$ Population estimate

$M=$ Total number of individuals marked

$R=$ Total of animals recaptured that day

$N=$ Total number of new/ unmarked animals that day

d) Deer Censusing: Dropping Counts

White-tailed deer arrived in Nova Scotia approximately 200 years ago. As they have shorter legs and a smaller body mass, deer were historically excluded from many habitats by snow and melt water related flooding, providing moose with refuges from deer during the winter season. However, a warming climate, and the related reduced snow cover and longer growing seasons now favour the smaller deer, which need less sustenance, and are often also agile enough to jump into people's gardens and vegetable patches. In addition, white-tailed deer carry a parasitic and highly infectious nematode worm *Parelaphostongylus tenuis,* which causes fatal brain degeneration in moose. Therefore, numbers of white-tailed deer are now increasing to the point of competitive exclusion of moose across mainland Nova Scotia, a trend which is mirrored by other deer species worldwide in temperate habitats. In Nova Scotia deer have now reached the point of pestilential concern (deer are a major cause of RTAs and spread ticks infected with Lyme borrealiosis), whereas moose are now listed as provincially threatened.

Wildlife managers have long recognized the need for efficient means of estimating white-tailed deer *Odocoileus virginianus* populations. A range of methods can be used to survey for deer, from visual observations and distance sampling, through to recording field signs. A frequently used method is to carry out "standing crop faecal counts" (aka pellet group inventories) using 10x10m plots to extrapolate deer abundance based on faecal accumulation rates (known from captive deer), degradation rates and the overall area utilised by the deer population. Sub-teams of 5-6 volunteers survey each square by lining up and searching through the plot carefully. The number of deer droppings is noted (a dropping is defined as a pile of 5 or more pellets) along with all other mammal faeces.

If sufficient quadrats are sampled across all habitats (and power analysis suggests at least 80 quadrats) then an accurate estimate of the white-tailed deer (or moose) numbers that must be present to leave the "carpet density" of droppings observed, can be calculated. Three other factors interact with this estimation:

- The human observer's ability to find all droppings present
- The human observer's ability to identify droppings accurately to species level
- The degradation rate of the droppings (i.e. their survival rate in the environment), providing the accumulated standing crop.

At ***Cook's Lake*** we randomly selected 152 10x10m quadrats during the 2008 field season to accurately represent all habitat types and cover all parts of the reserve area. In total we found 251 deer droppings (minimum: 0 droppings/plot; maximum: 14 droppings per plot depending on habitat type). On the basis of 1 white-tailed deer producing on average 25 droppings per day, and an average dropping degradation rate of 40 days in this habitat and climate, our results suggest a density of 22 deer per km^2. This translates into ca. 30 deer using the area of Cook's Lake at any given time during the field season (compared to an estimated density of 12 deer/km^2 in 2007). However, Lunenburg County is recognised as a deer "hot-spot", and our figures from ***East Port*** suggest much lower deer densities of 10.5 deer per km^2, thus averaging 16.3 deer per km^2. However, these results are still approximately 17-fold higher than the 2003 government figures of a mean provincial density of 0.93 deer/km^2 for mainland Nova Scotia. One confounding factor inflating our deer estimates could also be the extremely dry summer of 2008, which lead to deer droppings drying out and potentially being discernable in the environment much longer, than in wetter periods, when fungi, insetcs and worms tend to break down many fresh droppings immediately. However, officials are now recognising the trend of severely increasing deer numbers throughout the province and are increasing hunting quotas as well as running government campaigns to raise awareness in the population, asking people not to feed deer during winter. In the 2008 field season we will set up clearance plots to re-affirm faecal degradation rates under different climatic conditions as well as continue try to identify and count individual deer captured by camera traps (during the past season we could identify at least 5 individual deer at Cook's Lake from our remore cameras).

e) Monitoring Snowshoe Hare Density

Snowshoe hares occupy an interesting niche in Nova Scotia's ecosystems: Whilst they are an important, and often preferred, prey species for both, coyotes and bob cats, and thus help to sustain predator numbers, they simultaneously compete with deer as well as many small mammal species over fresh grass and herbs. However, in many areas of Nova Scotia grass and herbs are comparatively rare, and the grazing impact of rabbits can be considerable. Hare numbers are traditionally estimated by counting the number of droppings along a 10m survey strip of 1m width. However, we found that this method is extremely prone to observer error, as only one person is involved in each survey, and the ability of detecting hare droppings appears to vary greatly between volunteer monitors (Thus, we will conduct a specific study during the next field season investigating which individual-specific factors, such as experience, red/green blindness, physical suptleness, contribute most to this variation amongst volunteers). Therefore, we are currently testing alternative methods to estimate hare numbers by A) counting the number of hare dropping piles in 10x10m quadrats as in deer estimates; B) calculating the percentage of 10x10m quadrats, which contain hare droppings as a simple yes/no ratio; C) count the number of individual hare pellets per 10x10m quadrat. ***Method A*** returned an average of 3 piles/ quadrat for Cook's Lake. However,at East Port hare densities are much higher, and the discrimination of discrete droppings piles was impossible in most areas. ***Method B*** showed that at Cook's Lake 60.5% of the sample quadrats (= 92 out of 152 plots) contained hare droppings compared to 100% (= 14 of 14 plots) at East Port, therefore suggesting a 1.6 times higher hare density at East Port. ***Method C***, however, returned an average of 62.8 single pellets per quadrat (314 pellets in 5 sample quadrats) at Cook's Lake compared to an average of 807 pellets per quadrat (11297 in 14 plots) at East Port, thus suggesting a 12.8 times higher population density of snowshoe hares at the coastal site. We will continue to evaluate these different methods throughout the 2009 field season to increase sample sizes.

f) Recording the Climate

Whilst during the field season of 2007 we had deployed two basic weather stations at Cook's Lake to record wind speed, wind direction, temperature and total rainfall minus evaporation over the preceding 24 hours. One station was set up in dense coniferous forest, whereas the other one was placed on the open grassland. As expected, the grassland station recorded much more dramatic variation in all parameters than the sheltered forest station. However, as measurements varied greatly in the space of very short-term intervals, and had thus to be read simultaneously and at exactly the same time every day, other field work often needed to be planned around the weather recording times. In addition, data collection proved to be prone to observer-errors, and thus we decided for the field season of 2008 to use the official government-recorded weather data instead, until the project can afford automatic weather stations with built-in data-loggers.

Objective 3: Sustainability & Resource Management: Investigating short-term population-dynamic responses to local management and manipulation

Work commenced on this objective: Yes

Since the decline of the fisheries in the 1960s and 70s, and the recent decrease in tourism numbers, forestry (e.g. paper-mulch production, Christmas tree plantations, fire wood and building timber harvesting operations) is one of Nova Scotia's most important remaining industries. As part of a governmental initiative to enhance forest quality throughout mainland Nova Scotia, 4 forest compartments at Cook's Lake were clear-cut and replanted in 1992 with a mixture of native coniferous and deciduous trees (see map page 4).

a) Small Mammal Trapping: Assessing the Impacts of Forest Management

To evaluate the effects of this management strategy on the native small mammal fauna, we started a trapping programme at ***Cook's Lake*** in 2007 comparing small mammal abundance and species richness in each of the four clearings with the surrounding forest. We continued and expanded this work in the field season of 2008, trapping each clearing and adjacent forest plot twice over the summer. Each time we set 50 Longworth traps (live traps for small rodents) in one of the 4 Clearings and 50 in an adjacent forest grid, with each trapping grid covering 0.5ha. Traps were left in the same position for 3 nights and were checked twice daily, in the morning and late afternoon. For every capture we recorded the trap location, species, sex, age (adult/ juvenile), reproductive status, and body weight. Upon first capture, every animal received a fur clip identifying it as "caught before" and its place of capture (i.e. Clearing or Forest). Small mammal abundance was quantified over each 3-night trapping interval using capture-mark recapture techniques (CMR). In a total of 2700 trap nights we captured 573 individuals belonging to 10 different species (red-backed vole, rock vole, meadow vole, bog lemming, short-tailed shrew, common deermouse, white-footed deermouse, chipmunk, red squirrel, northern flying squirrel). As expected, population densities of all small mammal species was lowest in spring and highests in autumn (Fig. 1). Interestingly, in the forest habitat the total number of individuals utilising the area more or less doubled between the start of July (=trap up 1) and middle of August (= trap up 5), and then level out, whilst numbers in the clearings continued to rise throughout the season (trap up 9 = end of October).

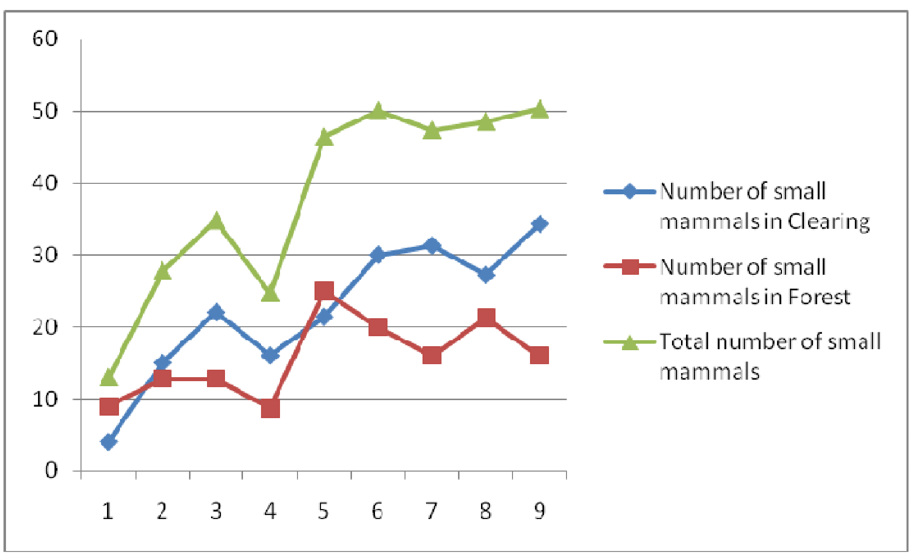


Fig. 1: Combined densities of all small mammal species (voles, mice and lemmings) over the course of the summer

Red backed voles are forest specialists, relying on vegetation cover for protection from predators. Their numbers stayed comparatively low in the clearings for the first half of the summer, until their density suddenly quadrupled in this habitat in late September, while staying stable in the forest (Fig. 2). Whilst the forest provides a relatively stable habitat throughout the year, the clearings are home to a wide variety of berries and flowering plants, which all bare seed in late autumn. Thus, when the red-back vole population reaches carrying capacity in their forest habitat voles appear to disperse into the clearings, which by then provide dense vegetation cover in the form of annual and perennial plants as well as the thick leaf cover of the planted tree saplings in addition to rich food supply.

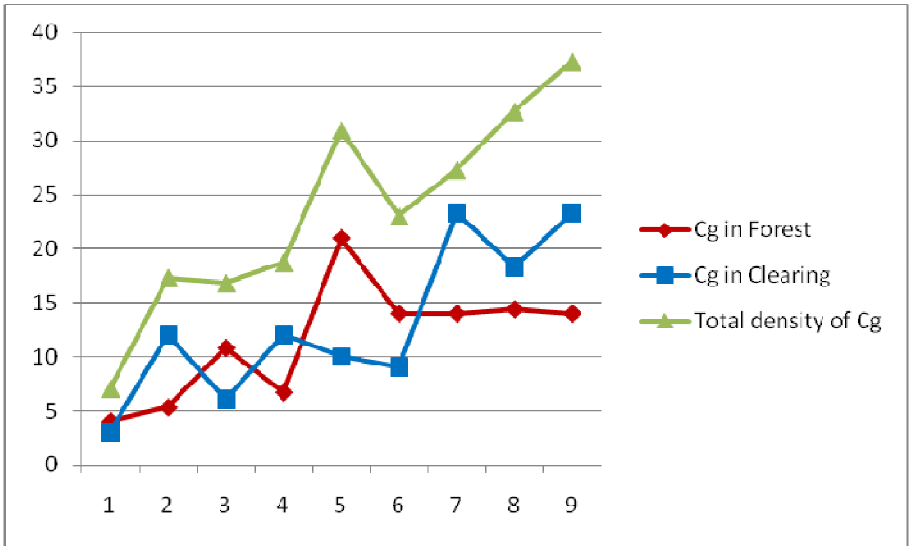
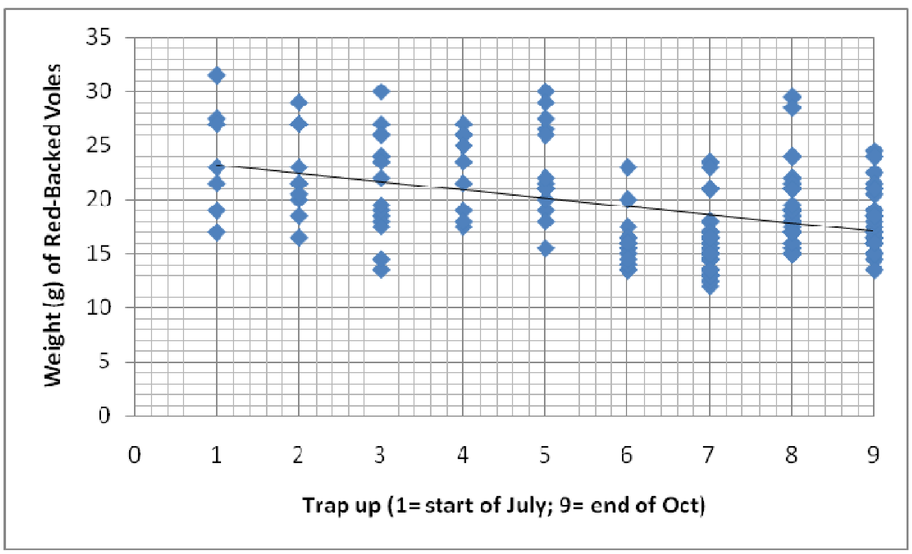


Fig. 2: Population densities of red backed voles in different habitats

However, whilst population density of red backed voles increased over the summer, their body mass decreased (see Fig. 3).



Interactions between habitat quality, intra- and inter-specific competition, and species-specific coping mechanisms (e.g. dispersal or changes in body size/ weight) are complex, and a plethora of data is needed to perform valid statistical tests. Over the next field season we will continue to add to this data set and will analyse the complex relationships between these variables in detail. Therefore all data shown above should to be treated as "trends" rather than firm results at this point.

b) Three-dimensional habitat use by small mammals

In the field season of 2009 we plan to include in this investigation, how different small mammal species use the three-dimensional habitat structure in the clearing compared to the forest. This research will mirror a study on the arboreal behaviour of wood mice and bank voles in the UK, which we carried out with the help of Earthwatch volunteers on our previous "Mammals of Wytham Woods" project, and which we published last year (see "Communications of Results").

We will also collect more detailed data on the age structure of each population at different times of the year to understand what factors are regulating population growth, and thus ultimately population survival. This study will use the same techniques and mathematical models as we used in a population study of badgers (see "Communications of Results").

c) Botanical Surveys

To further investigate the recovery of the forest ecosystem after this management technique of clear cutting and replanting, we carried out botanical surveys of the tree composition and average growth height during 2007. In the next field season we plan to compare the species composition and average growth height of the non-woody plants in the understorey of clearings and forest.

Objective 4: Optimising the Use of Non-Professional Volunteers in Scientific Data Collection

Work commenced on this objective: Yes

On all continents private individuals and governments alike become increasingly aware of the speed with which our natural environments are changing due to the human impact on our biosphere. In many cases climate change and the effects of industrialisation are not only threatening precious ecosystems but sometimes also the very foundations of human civilisation (e.g. lowering water tables; increasing natural disasters etc.). A growing number of national and international obligations therefore call for biodiversity monitoring and appropriate mitigation of our actions; a task so substantial that there is a recognised need to engage and involve the public's assistance in collecting these data. Several organisations, including Earthwatch, aim to facilitate the use of volunteers in scientific research and environmental monitoring. However, many professional scientists still doubt the validity of scientific data collected by volunteers.

Our work with Earthwatch volunteers on the mammal monitoring project in the UK proved the importance of appropriate hands-on field training as the most significant factor affecting the validity of data collected by volunteers, although individual-specific factors such as gender, physical fitness in relation to the respective task etc. also influenced the suitability of individuals as research volunteers.

Building on our work in the UK and our involvement with establishing a national "Mammal Tracking Partnership", we continue to assess the quality and veracity of volunteer data in comparison to data collected by professional scientists as part of our Mammals of Nova Scotia project. In addition to evaluating different training techniques and establishing species monitoring protocols suitable for use by amateur volunteers, we are researching factors influencing the suitability of individual volunteers for specific tasks. Whilst in the past we concentrated on factors, which could easily be quantified, such as gender, age, fitness, experience, we are increasingly aware of the importance of more subjective variables, such as volunteer motivation, enjoyment, theoretical understanding of tasks, and team dynamics. To analyse the effects of these factors we take into account variables such as if volunteers are on sponsored places (and the conditions of the grants) or self-paying, if their participation is likely to increase their career chances, how team composition affects volunteer performance etc. Understanding the effects of motivational parameters on volunteer performance and enjoyment is key not only to optimise scientific data output, but also to maximise volunteer enjoyment, and thus hopefully a continued volunteer interest in the particular research field.

In our second field season we were joined by 56 volunteers distributed over 7 teams. Team sizes ranged from 4 to 13 volunteers. One of the teams had exceptionally good team dynamics, four teams worked well together and had no team-related difficulties, whereas two teams showed tendencies to subdivide into smaller sub groups, as reflected in their feedback forms. To maximise scientific output, each team therefore had to be managed differently with the teams with the best dynamics needing the least supervision and motivation by the PIs. This result is reflected also on an individual level with "happier", i.e. more motivated volunteers being more reliable in carrying out tasks correctly, thus collecting not just more data, but also more reliable data. As expected, our preliminary analyses indicate that there is a strong positive feedback between volunteer motivation and volunteer achievement. Thus, to maximise benefits in terms of data output as well as continuing volunteer involvement in the future, it is crucial to assign match volunteers to tasks appropriate to their individual abilities rather than to expect each volunteer to carry out each task equally efficiently.

Whilst many of these factors influencing the relationships of volunteer achievement and data quality become self-evident with Principal Investigator (i.e. team leader) experience, we are currently analysing our data on the correlation of volunteer motivation, sense of achievement, and data validity under scientific criteria to provide guidelines for the most effective ways of involving volunteers in environmental monitoring projects.

Project development

In the past two field seasons we had a gazebo with mosquito netting as our base at the field site. However, as it doesn't provide secure storage room, we need to take all food items and some of the field equipment back to the accommodation each day. Also, during heavy rain fall and strong winds, the gazebo offers only limited shelter. Therefore, we are currently considering the (financial) viability of building a cabin at the site. This would not only provide secure storage, but would also offer the possibility to set up a basic field laboratory with a microscope, office supplies, field guide books etc, which would allow less physically fit volunteers to spend some of the time in the field sitting analysing samples or entering data. In time, this cabin could be fitted with satellite internet access, which would allow "Live from the Field" teachers to truly teach live from the field.

Non-technical summary of results

What is/ are the **significance**/ **benefits** of your research at the following levels?

- Local (to the area of the research site): ***Cook's Lake*** will be protected from development and will be managed by the PIs for maximum biodiversity according to our findings. We are actively talking to neighbours around the research site to interest them in our work and results and trying to encourage them to manage their land according to similar biodiversity-based principals.
  We found our new site at ***East Port*** by talking to neighbours about our work, convincing them that land management for biodiversity is becoming increasingly important. They are committed to our long-term monitoring goals, minimising non-biodiversity orientated land management at the site.

- National / Regional: As our project only just concluded its second field season, it is still too early to take our results to policy makers, as the data only represent a snapshot of the status quo rather than meaningful trends. However, we are trying to talk to as many land owners and hunters as possible about our results to achieve conservation through education. We strongly believe that, if areas are to be protected from housing/ commercial development, people have to recognise their (financial) value for other endeavours, such as eco-tourism. Tourism figures are falling in Nova Scotia, and many, mostly younger, people are leaving the province to find employment in other parts of Canada. Raising awareness of the environmental richness in this area could help to develop sustainable eco-tourism in Atlantic Canada. Our partner, the Mersey Tobeatic Research Institute is developing outreach programmes to interested parties throughout Canada to attract eco-tourists to Nova Scotia's National Parks, and is seeking advice and exchange of experiences from us. Several of our EW volunteers have come back or planning to come back to Nova Scotia on nature holidays, and at least one volunteer bought a holiday cottage in Cape Breton after visiting our project.

- International: National and international obligations to monitor anthropogenic impacts on our biosphere are growing. However, to understand specific effects of specific actions detailed long-term baseline data are needed as comparison. Collecting these

long-term monitoring data on an international scale is beyond the financial funds and the capacity of the work-force of professional biologists. Therefore, amateur volunteers are needed to help with the enormity of this task. However, training novice volunteers to an acceptable standard for scientific data collection in minimal time requires optimisation of training protocols and volunteer deployment as well as the use of methods resilient to observer-induced variation. Our project, besides collecting monitoring data itself, which contribute to our scientific knowledge about the impact of climate change and habitat management strategies on mammals, aims to find such methods, and to assess and optimise different training regimes for volunteers.
We are currently developing teaching resources and talks on climate change, which interested volunteers will be able to download from our web site. As we have many teachers on sponsored places on our project, we are planning to develop outline lesson plans for different age classes, which teachers can then adapt to their own requirements.
In addition, we give many talks to naturalist societies and professional scientists alike for education purposes, and we continue to be board members of the Mammals Tracking Partnership in the UK, which we advice on the best deployment of amateur volunteers on monitoring projects.

Communication of results

Printed: peer reviewed scientific publications; books / book sections; reports, management plans or policies; fact sheets, brochures, leaflets, pamphlets, posters, academic dissertations, annual reports, proceedings of conferences or workshops; letters; newsletters.

The publications from the past year listed below are recent results of our climate change and mammal monitoring work in England, which was carried out with the support of EW volunteers, and which forms the basis for comparative studies of our EW project in Nova Scotia.

Buesching C.D., Newman, C. Twell, R. & Macdonald, D.W. (2008). Reasons for arboreality in wood mice *Apodemus sylvaticus* and Bank voles *Myodes glareolus*? *Mammalian Biology*. 73:318-324.

Macdonald D.W., Newman C., Nouvellet P. M. & Buesching C.D. (in press). An analysis of European badger (*Meles meles*) population dynamics: Implications for regulatory mechanisms. *Journal of Mammalogy*.

Buesching C.D. & Macdonald D.W. (in press). The Mammals of Wytham Woods. Book chapter. Blackwell Publishing, Oxford.

Macdonald D.W., Newman C., Buesching C.D. & Nouvellet P. M. (subm.). Direct and indirect climatic impacts on mammalian population dynamics: Evidence from a Eurasian badger (*Meles meles*) population. *Journal of Mammalogy.*

Kaneko Y., Newman C., Buesching C.D. & Macdonald, D.W. (subm.). Variations in badger (*Meles meles*) sett temperature and humidity, from a high-density population: Differential cub survival between main and subsidiary setts. *Journal of Zoology*.

Digital: database; internet - websites, email group/ blog/forum; CD Rom, e-newsletter

During the field season we wrote regular updates for the Discovery Channel's Live from the Field Blog (organised by EW Europe)

We have set up a project website www.wildspirits.ca, which will help to introduce people to the research on the effects of climate change in temperate ecosystems. The site also includes a "Members" section, where former volunteers can access our annual project reports, scientific articles which resulted from our work with Earthwatch volunteers, and teaching materials pertaining to climate change and mammal monitoring.

Mass media: broadcast production; film; TV, radio, print (newspaper/ magazine coverage); Press releases; press conference; interview, article creation; press trip

The *Experience Life Magazine* published an article (Head Out: Disappearing Destinations) featuring Warren Stortroen's Earthwatch volunteering experiences, who came on our project as his 50^{th} Earthwatch trip.

We were involved in a number of articles and press releases by our volunteers (e.g. Live from the Field teacher fellows; our Swiss volunteer Pascal Gelin: "Urlaub bei den Mausen" im Anzeiger der Stadt Kloten) as well video conferences with their schools, broadcastet to their schools, and sometimes also local television (e.g. by our fellow Chris Bosetti).

Meetings and conferences: presentations/ lectures; conferences; workshops; training sessions; discussions; local community meetings and events.

- We organised two field trips (for a total of 60 people) for the local wildlife trust (BBOWT) and one trip for the People's Trust of Endangered Species (20 people) in Wytham Woods, UK, each including an introductory talk about our mammal monitoring work with the Earthwatch Institute in England and Canada
- June 08: Invited talk in Buckingham, UK about "Volunteers in Wildlife Monitoring: How can you help?" (Dr Christina Buesching)
- November 08: Invited talk at the Ecological Society of the University of Bath about "Working with Volunteers in Ecological Monitoring: The Pros and Cons" (Dr Christina Buesching)
- March 09: Talk at Earthwatch Europe about Monitoring a changing climate with the help of Earthwatch volunteers (Dr Chris Newman & Dr Christina Buesching)

- March 09: Field course for Oxford University's Dept. of Continuing Education in mammal monitoring

Educational resources: lesson plans; resource packs

Based on our experience with Earthwatch volunteers, we are developing the Mammal Monitoring module and course book for the collaborative initiative between Oxford University's Department for Continuing Education and Earthwatch Europe. This teaching resource will be available to former volunteers on our website.

Educational Opportunities

Does your project directly or indirectly involve the following groups in your research topic?

- Local communities

- Students
  We are preparing two manuscripts on volunteer data validation with Mr Eric Kightley, who helped with Teams 2&3 during the field season of 2007.
- Early career scientists
  Mr Jim Jones, Doormouse Conservation Officer with the People's Trust for Endangered Species, visited our project on Team 5 to gain additional experience in small mammal trapping and working with conservation volunteers. We are currently preparing a manuscript for publication with Jim on the impact of deer grazing on small mammal populations, analysing data collected with Earthwatch volunteers in the UK.
- Other groups
  Over the past 2 field seasons we had a number of teachers on sponsored places (Dodge Foundation as well as Live from the field), who are relaying their volunteering experiences and newly aquired knowledge and understanding back to their students. We are striving to help these teachers to make the information more accessible to their students, and we are developing teaching materials for mammal monitoring suitable for different school subjects and age classes.

Acknowledgements

We would like to thank all our volunteers for their hard work and tireless commitment to this project and the staff at Earthwatch for their excellent project management, volunteer recruitment and continuing support. Prof. David Macdonald and the Wildlife Conservation Research Unit at Oxford University provided welcome scientific support and camaraderie. Mrs Kathy Megivern and Mr Marvin Talso contributed much appreciated material support to the project. Our special thanks go to Dee and Brian Hughes of Freeware.com for their ongoing material support as well as for allowing us to use their land as a long-term monitoring site.

AND THANKS TO OUR SUPPORTERS