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Monitoring Nature: Research Developments

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This Thematic Issue is written and edited by the Science Communication Unit, University of the West of England (UWE), Bristol

Email: sfep.editorial@uwe.ac.uk

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EDITORIAL

Biological monitoring – new technology and the rise of citizen science

Conserving biological diversity is 'a common concern of humankind'. Or so says the Convention on Biological Diversity (Rio, 1992)¹, a global agreement which recognised, over 30 years ago, the detrimental impact that human activities can have on the natural world. Biological diversity or 'biodiversity' is a term often used to encompass the variation in all the forms of life on the planet. The Convention on Biological Diversity recognises the intrinsic value of organisms regardless of their utility to humans. It is also important to recognise the multitude of ways in which biodiversity is of critical importance to us including direct use of natural resources, indirect use (such as the 'services' provided by different species and ecosystems) and the enjoyment that we get from observing and interacting with the world around us.

Monitoring the state of nature, an important step in biodiversity conservation, has developed greatly since Rio, 1992. The aim of this Thematic Issue is to bring together the results of new technologies used for biological monitoring and the rise of citizen science initiatives which have taken it to new levels.

Monitoring nature and the efficacy of management and policy interventions

Just as important as monitoring the status of wildlife populations and the habitats they live in is assessing whether the management and policies put in place to safeguard their continued existence are having the desired effects. This is tricky and requires carefully designed and robust monitoring frameworks to disentangle the effects of specific interventions from those of other activities, changes in environmental conditions (such as weather), or random fluctuations that may affect wildlife populations.

The articles presented in this Thematic Issue confirm the huge potential of citizen science data collection and innovative monitoring techniques for improving effectiveness and cost-efficiency of biodiversity monitoring. Such initiatives will become increasingly important as a way of assessing environmental policy outcomes, including for biodiversity. EU Member States already rely on such data for their monitoring and reporting on progress made under the EU Birds and Habitats Directives². Furthermore, 25 EU member

states contribute to the EU's agri-environmental indicator 'population trends of farmland birds'³, which uses data collected by volunteer recorders to track the status of bird populations on agricultural lands.

Research developments

This Thematic Issue provides a flavour of recent work by scientists in the area of biodiversity monitoring to highlight both up-to-date approaches to conservation and evaluation, and how long-term monitoring data could be used more effectively in management and policy decisions.

Whilst we will never be able to monitor the status of every species on the planet, remote sensing offers the potential to assess changes in the status of the habitats they depend on. The efficacy and accuracy of using information from satellite or airborne images is reviewed for a range of habitat types in the article

1. <https://www.cbd.int/>
2. http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm
3. http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_population_trends_of_farmland_birds

'Using remote sensing to map natural habitats and their conservation status: Key recommendations for scientists and policymakers'. There is some way to go yet — some habitats are easier to map and monitor than others and much depends on the data resolution researchers are able to obtain, but the authors make a series of recommendations to encourage this technology being used more widely, and more effectively, than at present.

Researchers test the potential of genetic identification to quantify the impacts of environmental change and restorative management on biodiversity in **'DNA barcoding strengthens biodiversity monitoring'**. This work indicates that metabarcoding offers a reliable, cost-effective way of producing biodiversity information for policymakers and managers.

Monitoring species in regions such as Antarctica presents its own challenges. However, the article **'Remote penguins monitored using low-cost camera network'** shows how researchers can use networks of cameras to successfully monitor species in remote parts of the world.

Can we use 'indicator' species to predict areas important for nature conservation on a national or European level? This is the task described in **'New Natura 2000 sites can be located using indicator species method'** where the distribution of vascular plants in Lower Saxony (Germany) was used to predict the location of forests that should have high conservation priority. Whilst this method did not work well for all forest types, others were successfully predicted by the model and researchers suggest that this method could be adapted to other European countries using data from national monitoring programmes.

Two articles in this issue demonstrate the power of data collected by volunteers to detect changes in population trends of two very different taxa: bats and corals. **'Citizen scientists successfully monitor bat populations'** presents the results of a large-scale, 15-year programme, which has involved more than 3500 volunteers across nearly 4000 sites in the UK. The trend data indicate some recovery in the population sizes of bats from widespread historic population declines and, argue the researchers, demonstrate that volunteers can successfully monitor wild species and produce robust data suitable for policy purposes.

Ensuring that volunteer-collected data is high quality is vital and, in **'Volunteers can help on-going monitoring efforts of coral reefs by detecting long-term changes'**, researchers tested data from volunteers against those of professionals. Results indicated that, in line with professionals, volunteer divers were able to identify widespread decreases in the cover of live corals and increases in rubble and sand, and that this could help to detect early widespread changes that indicate the health of coral reefs.

Whilst monitoring programmes provide quantitative data, the article **'How to ensure monitoring delivers effective, evidence-based conservation'** shows that most of the information used to assess the efficacy of management decisions in Australian marine protected areas is qualitative. Greater use of quantitative data would allow more transparent and repeatable monitoring say the researchers, and would be less subject to the possible biases of expert opinion.

Finally, it is important that scientists and policy makers communicate effectively about how the evaluation of conservation projects or policy interventions can best be carried out. In **'Evaluating conservation programmes: what are the best methods?'** researchers review different methods commonly used in evaluations and examine their strengths and limitations. Of five commonly used approaches the researchers argue that impact evaluations and systematic reviews are the most useful in answering the crucial questions of: what works, what does not, and why?

Many of the articles in this Thematic Issue demonstrate that new technological advances and the rise of citizen science could enable biodiversity monitoring on a scale not previously considered possible. None of this is likely without adequate and sustainable sources of funding, however, and the use of citizen science for monitoring should not be seen as a cheap and easy way to collect data. Both ensuring high-quality data and retaining motivated volunteers present challenges that require the willingness of the public to donate their time, carefully designed programmes, and highly trained professionals to oversee these. Long-term monitoring data on the status of species has sounded the alarm bells for many of our existing conservation policies — innovative approaches to biodiversity monitoring such as those outlined above are now needed to help us develop effective policies and management tools for the future.

Contact: christina.corbane@teledetection.fr

Theme(s): Biodiversity, Environmental technologies, Environmental information services

Using remote sensing to map natural habitats and their conservation status: key recommendations for scientists and policymakers

Monitoring and assessment of habitats is essential to evaluate biodiversity policy and improve the condition of valuable ecosystems. A new study has reviewed the value of remote sensing — using information from satellite or airborne imagery — for this purpose, and the authors make a series of key recommendations, including the importance of tailoring remote sensing output for policymakers.

“To halt the global decline of biodiversity, habitats need to be mapped and monitored so that their condition can be assessed and suitable policies put in place to improve the situation.”

Ecosystems are being increasingly degraded worldwide. To halt the global decline of [biodiversity, habitats](#)¹ need to be mapped and monitored so that their condition can be assessed and suitable policies put in place to improve the situation. To this end, the [EU Biodiversity strategy for 2020](#)² calls on Member States to map their natural and semi-natural habitats and the services they provide to people.

Remote sensing can provide essential data for this task; biodiversity can be mapped directly, or, in more complex cases, proxy measures related to wildlife can be used to indicate their presence and to assess their conservation status. For this study researchers reviewed the efficacy and accuracy of remote sensing for mapping forest, grassland, heathland and wetland. An example of suitable methods for detecting conservation status of forest habitats is also given.

For forest, the authors found that low spatial resolution imagery could only distinguish between major types, such as deciduous, coniferous or mixed. However, if high spatial resolution data (3–30 m) are available it is possible to analyse ‘image texture’ meaning that different tree species and even different tree ages may be identifiable. Hyperspectral sensors, which collect data across a wide range of the electromagnetic spectrum, can provide an even greater level of detail enabling the distinction of tree species based on reflected energy in response to pigment, nutrient, and structural differences.

For grassland habitats, moderate resolution images can be used to distinguish between only broad types of grassland such as fertilised versus unfertilised. High-level resolution is better but even when using an object-based analysis and combining this with data such as soil type, generally only a few dominant species can be distinguished

Heathland habitats are generally made up of heather species, grass and open soil. These distinct categories can be relatively easily distinguished by many types of remote sensing. If more subtle categories are needed, such as wet or dry heathland, the use of a natural habitat model is recommended, including data such as elevation and rainfall. For wetland habitats hyperspectral imagery at a sufficiently high spatial resolution is very successful, and has been shown to accurately distinguish between 27 types of salt marsh vegetation, for example.

Despite progress made towards accurate and reliable habitat monitoring and assessment through remote sensing, the researchers note that in practice it is not as widely used as it could be. To ensure that these powerful tools achieve their full potential they make five key recommendations:

1. A ‘common language’ with clearly defined terms is needed to ensure that those who produce the data and those who use it can communicate effectively.
2. The way the information is produced needs to be tailored to the managers and decision makers who use it. Again, good communication will be important for this.
3. Data should be formatted so that it can be easily combined with other monitoring and assessment data. For example, terms should be clearly defined and information on accuracy and confidence limits should be included.
4. It should be quick and easy to update maps with the latest information.
5. All remote sensing outputs should be aimed at policy support. This may include designing useful facets such as alerts for policymakers in near real time.

Source: Steen-Olsen, K., Weinzettel, J, Cranston, G., *et al.* (2012). Carbon, Land, and Water Footprint Accounts for the European Union: Consumption, Production, and Displacements through International Trade. *Environmental Science & Technology*. 46: 10883-10891. DOI: 10.1021/es301949t.

1. http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

2. <http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm>

Contact: dougwyu@gmail.com

Theme(s): Biodiversity, Environmental technologies

DNA barcoding strengthens biodiversity monitoring

Genetic identification of species through ‘metabarcoding’ offers a reliable, cost-effective way of producing biodiversity information for policymakers and managers, concludes an international study. The researchers show how the method can be used to help assess the impacts of environmental change and management on biodiversity.

“Traditionally, species are identified through their appearance by experts. Metabarcoding is a recently developed method which uses new technologies that identify species from a short sequence, or ‘barcode’, of DNA.”

To protect and conserve biodiversity it is important to know which species are present, and where. Naturally, species identification methods are central to this. Traditionally, species are identified through their appearance by experts. Metabarcoding is a recently developed method which uses new technologies that identify species from a short sequence, or ‘barcode’, of DNA. With metabarcoding, all captured specimens (e.g. insects caught in a trap) can be fed at once into a machine to be analysed and identified.

Metabarcoding thus has certain benefits over traditional, standard identification methods, the researchers suggest. For example, it needs much less taxonomic expertise and can be completed more quickly allowing more species to be identified within a study area. It can therefore replace the reliance on a small number of indicator species to infer the effects of environmental change on overall biodiversity. In addition, and unlike standard techniques, metabarcoding data can be easily viewed and checked by third parties in databases, such as the European Nucleotide Archive.

This study explored whether metabarcoding data can reliably answer policy and management questions. It compared information provided by metabarcoding with information from high-quality standard taxonomic methods for the same three case studies:

1. How does climate change affect biodiversity? Researchers gathered moths on a Chinese subtropical mountain to help monitor the effect of climate change on diversity at various altitudes. Both metabarcoding and standard methods detected the same moth communities at each location, and provided similar estimates of species richness.
2. Which ecological restoration methods are most effective? The effects of six different methods of converting grassy forest tracks into heathland habitat for arthropods, such as ants and spiders, were assessed in this UK case study. Both identification methods showed broadly the same effects on species richness. Metabarcoding data showed that three of the restoration techniques resulted in a move towards characteristic heathland arthropod communities. However, standard taxonomic data was only able to show effects for two of these three treatments, possibly because the dataset was necessarily smaller.
3. What are the effects of logging on biodiversity? Researchers explored the ecological effects of logging in a Borneo rainforest. Wildlife communities were surveyed in unlogged forests, forests logged once and those logged twice. In this example, the two methods screened different species: metabarcoding screened flying insects, whilst standard methods were used to survey birds and dung beetles (used as an indicator for mammals). Data produced by both identification methods suggested that forests that have been logged twice contain lower numbers of bird and insect species compared with unlogged forests. However, the standard techniques also showed that there were fewer birds and beetles in forests which had been logged once, whereas the insects screened using metabarcoding showed no difference. The

Source: Ji, Y., Ashton, L., Pedley, S.M., Edwards, D.P., Tang, Y., Nakamura, A., Kitching, R., Dolman, P.M., Woodcock, P., Edwards, F.A., Larsen, T.H., Hsu, W.W., Benedick, S., Hamer, K.C., Wilcove, D.S., Bruce, C., Wang, X., Levi, T., Lott, M. & Emerson, B. (2013). Reliable, verifiable and efficient monitoring of biodiversity via metabarcoding. *Ecology Letters*. 16(10): 1245–1257. DOI:10.1111/ele.12162. This study is free to view at: <http://onlinelibrary.wiley.com/doi/10.1111/ele.12162/abstract>

Contact: dougwyu@gmail.com

Theme(s): Biodiversity, Environmental technologies

DNA barcoding strengthens biodiversity monitoring (continued)

“Metabarcoding is therefore a reliable source of biodiversity monitoring information for policymakers, the study concludes.”

authors suggest that these differences may indicate that vertebrates are more sensitive to logging than flying insects. Most importantly, and despite their differences, the bird and dung-beetle dataset and the metabarcoding dataset still designated similar sets of land parcels to be protected under a systematic conservation plans.

The standard and metabarcoding methods produced similar results and policy implications across these three examples. Metabarcoding is therefore a reliable source of biodiversity monitoring information for policymakers, the study concludes. It does note that, currently, standard methods can be better at identifying sub-groups within a broader species, however.

Across the three case studies, metabarcoding used 645 person hours to identify 163 individual animals, plus 520 hours for ‘background’ work, such as computer time. Standard methods used far more hours: 2505 in total, to screen 134 individuals.

Metabarcoding was estimated to cost US \$240–415 (€225–389) per individual. The authors of the study say it is not possible to provide a reliable estimate of costs for standard methods, but suggest that they are highly variable and often ‘expensive’.

Source: Ji, Y., Ashton, L., Pedley, S.M., Edwards, D.P., Tang, Y., Nakamura, A., Kitching, R., Dolman, P.M., Woodcock, P., Edwards, F.A., Larsen, T.H., Hsu, W.W., Benedick, S., Hamer, K.C., Wilcove, D.S., Bruce, C., Wang, X., Levi, T., Lott, M. & Emerson, B. (2013). Reliable, verifiable and efficient monitoring of biodiversity via metabarcoding. *Ecology Letters*. 16(10): 1245–1257. DOI:10.1111/ele.12162. This study is free to view at: <http://onlinelibrary.wiley.com/doi/10.1111/ele.12162/abstract>



Contact: colin.southwell@aad.gov.au
 Theme(s): Biodiversity, Environmental technologies

Remote penguins monitored using low-cost camera network

Scientists have successfully monitored penguins across the east Antarctic over eight years using a network of remote cameras. The research team present their results in a recent study which describes their method of remote observation as a useful, low-cost tool for monitoring a range of isolated land-breeding marine species.

“Although the technology provides less detail than direct methods, it opens up huge possibilities for monitoring remote populations of a range of species.”

Climate change, habitat loss and other drivers of biodiversity decline occur on a large spatial scale. With increasingly tight research budgets, there is growing interest in methods of monitoring wildlife which are both cost effective and large scale.

Photography has been used for many decades to monitor species in small-scale studies. The Australian team behind this study explored whether it could be used in a large-scale research. They focused on monitoring Adélie penguins (*Pygoscelis adeliae*), the most abundant breeding seabird on the east Antarctic coastline.

The researchers set up 21 solar-powered cameras in four regions of east Antarctica to photograph penguin populations at 12 breeding sites over eight breeding seasons. Each camera viewed 30–50 nests. The cameras had a cover to protect against harsh weather and were programmed to take and store photos once a day, every day for four months a year.

Research staff visited each camera once a year for maintenance and to replace the memory card. Images on the card were then analysed to identify the timing of two key breeding events: the penguins’ arrival at the breeding site and the first egg-lay. The number of chicks was also counted for the month of January to estimate breeding success. These measurements are used to monitor potential impact of fisheries and climate change.

Most of the cameras survived the harsh conditions without any problems; only a few needed minor repairs. Nearly all (99.3%) of the 5000 images taken were suitable for analysis. Most (71%) of those that could not be used were taken during a blizzard that limited visibility.

Three of the cameras were placed in a location where direct observation by people also took place. This meant that camera and direct observation data could be compared. The photo data indicated that the first arrival was, on average, 0.9 days later than suggested by the direct data. The first egg-lay was seen in camera images 2–6 days after direct observation.

These delays are fairly minor and consistent from year to year, however. They are probably due to the cameras’ limited coverage; egg-lay is difficult to view because parents sit tightly on their nests and continuous or frequent observation is needed.

Chick counts did not match up as well between the two sets of data: camera counts suggested numbers were stable but direct counts indicated numbers fell. This may be because the chicks were harder to spot in photographs when very young, early on in January, as they were closely guarded by parents. Therefore the study recommends counting chicks via photos when slightly older and away from their parents when it is possible to gain a more reliable count of numbers.

The researchers say that camera networks are still useful for monitoring change. Although the technology provides less detail than direct methods, it opens up huge possibilities for monitoring remote populations of a range of species. The researchers have recently expanded the network to monitor breeding populations of flying seabird species.

Based on this project, they estimate that a 10-year camera-based monitoring programme with 20 cameras in three locations would cost AUS\$200 000 (€144 000). This covers camera equipment and staff time. The cost is a tenth of the estimated AUS\$2 million (€1.4 million) needed for an equivalent direct observation programme.

Source: Southwell, C. & Emmerson, L. (2015) Remotely-operating camera network expands Antarctic seabird observations of key breeding parameters for ecosystem monitoring and management. *Journal for Nature Conservation*. 23: 1-8. DOI: 10.1016/j.jnc.2014.11.002.

Contact: h.culmsee@dbu.de; heike.culmsee@bio.uni-goettingen.de
 Theme(s): Biodiversity Land use

New Natura 2000 sites can be located using indicator species method

A new method for identifying forest sites to protect under the Natura 2000 network — as well as reviewing existing sites — is presented in a recent study. The modelling approach predicts the location of certain types of high nature value habitats using existing data on the distribution of key indicator species. The study demonstrates the method using the case of a German federal state, Lower Saxony.

“The researchers say their indicator species method could be easily adapted to other European countries using data from national vascular plant monitoring programmes and by identifying locally relevant species.”

It is likely that more sites will need to be protected by Natura 2000¹ under the EU’s Biodiversity Strategy to 2020² as part of efforts to stop increasing biodiversity loss. However, identifying which sites are most important to include can be challenging due to a lack of existing data on wildlife, and the time and expense of surveying habitats.

Therefore, the authors of this study developed a method which uses computer modelling to predict where high nature value sites are likely to be — these sites include any habitat that is of interest for nature conservation on the national and/or European level — and may encompass several different criteria, such as habitat type, rareness, or biodiversity hotspots. In this particular study, ‘high nature value’ refers to those forest habitats that are important at the European level and therefore protected under Natura 2000. It can also be used to assess the suitability of existing sites for protection.

The study focuses on forest habitats in Lower Saxony as a case study of how the method could be used. The researchers gathered data on plant species in the state from a monitoring programme that has been in place since 1982. Over 1500 volunteers and professionals have submitted data to the programme on sightings of vascular plants (land plants which have tissue for conducting water and minerals within the plant), including herbs, grasses, shrubs and ferns.

They also gathered information from existing habitat surveys on the known location of the region’s ‘forest communities’, i.e. tree species growing together in the same location. These were assigned corresponding Natura 2000 habitat types, where appropriate, as listed in the Interpretation Manual of European Union Habitats.

Key indicator vascular plant species, or ‘diagnostic species’ were identified using a computer algorithm. This considers which plants are likely to occur together, and not occur with other groups of species. It also considers which plants are strongly associated with certain forest habitat types.

The researchers then produced maps of the diagnostic species and habitat distribution. Information about where these plant species occurred (indicator plant species), was used to predict the location of different forest types. These allowed the researchers to develop computer models that predict where researchers would be most likely to find habitat locations with a high nature value.

The model had poor predictive ability for some forest types, such as beech, oak and hornbeam forests on weakly to strongly acid soils, because there were not enough plant species that were strongly associated with these habitats. However, a number of upland forest types were successfully predicted. These included broad-leaved forest communities on dry limestone soils, Carici-Fagetum and Galio-Carpinetum forests.

Generally speaking, habitat types could be predicted more successfully if they had a higher number of indicator species, or if the species were strictly forest dwelling. The researchers say their indicator species method could be easily adapted to other European countries using data from national vascular plant monitoring programmes and by identifying locally relevant species.

Source: Culmsee, H., Schmidt, M., Schmiedel, I., Schacherer, A., Meyer, P. & Leuschner, C. (2014). Predicting the distribution of forest habitat types using indicator species to facilitate systematic conservation planning. *Ecological Indicators*. 37: 131–144. DOI:10.1016/j.ecolind.2013.10.010.

1. http://ec.europa.eu/environment/nature/natura2000/index_en.htm
2. <http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm>

Contact: kate.barlow@cantab.net, pbriggs@bats.org.uk
 Theme(s): Biodiversity, Environmental information services

Citizen scientists successfully monitor bat populations

Bat populations are showing signs of recovery in the UK, according to a citizen science programme. The authors of a recent study which reports the programme's findings say that this shows volunteers can successfully monitor wild species and produce robust data suitable for policy purposes.

"Although the technology provides less detail than direct methods, it opens up huge possibilities for monitoring remote populations of a range of species."

EU Member States are required to monitor bats under the [Habitats Directive](#)¹. Bat species represent around a fifth of the world's mammal species and provide essential ecosystems services, such as pollination. However, many European populations declined significantly in the 20th century largely, it is thought, as a result of habitat loss.

The study reports findings of the UK's [National Bat Monitoring Programme](#), a joint government-NGO initiative. Between 1997 and 2012 more than 3500 volunteers monitored and recorded sightings of 11 different bat species across 3727 sites in over 2000 surveys a year.

This citizen science programme is a rare example of a large-scale monitoring scheme which uses standardised methods for assessing population trends at a national scale.

It consisted of four survey types, each designed to monitor different species. For example, the common pipistrelle (*Pipistrellus pipistrellus*) was monitored using bat detectors to assess the activity of foraging bats and by colony counts of individuals emerging from summer roosts. In contrast, the greater horseshoe bat (*Rhinolophus ferrumequinum*) was surveyed both in summer roosts and in hibernation. Eight of the 11 species were monitored using two survey types.

Volunteers received training in bat identification and how to use equipment to detect and identify echolocation calls of different species. They were trained to use the same methods so that results from across the programme could be easily combined and compared.

Results show signs of recovery for bats in the UK. All species monitored were either stable or increasing in number, according to at least one of the four survey types. Lesser horseshoe bats (*Rhinolophus hipposideros*) showed particularly encouraging trends — an increase of 65–75% between 1999 and 2012 shown from both the hibernation surveys, and the roost surveys.

Where two survey types were used per species, there were differences in the results emerging for four species. For instance, common pipistrelle (*Pipistrellus pipistrellus*) populations appeared to increase significantly in surveys which detected bats acoustically as they hunted for insects, but to fall significantly using roost count data. Further analysis is needed to understand these trends, but they could be explained by bat behaviour. Populations of common pipistrelle are particularly challenging to count accurately in roost surveys because it moves between sites more often than some other species, for instance.

However, statistical analysis suggested that the data from each survey type and for each species were robust enough to detect significant declines in bat populations, should such declines occur. Specifically, if a species would have declined by over 50% over 25 years, it would be possible to issue a 'Red Alert', i.e. a call for conservation action, on the basis of the data.

The study estimates that the citizen scientists invested a total of 19 000 hours each year, worth £276 975 (€372 800) in staff time (assuming £75 (€100) a day for roost count volunteers, and £150 (€200) a day for volunteers in higher skill level surveys). The scheme also engaged the public with wildlife and raised awareness of bat conservation.

The study concludes that this programme proves volunteers can gather robust data, provided that training is offered and that methods are standardised, to avoid biases in data. These key features apply to a wide range of schemes, survey methods and species and should be considered in other citizen science monitoring programmes.

Source: Barlow, K.E., Briggs, P.A., Haysom, K.A., Hutson, A.M., Lechiara, N.L., Racey, P.A., Walsh, A.L. & Langton, S.D. (2015). Citizen science reveals trends in bat populations: The National Bat Monitoring Programme in Great Britain. *Biological Conservation*. 182: 14–26. DOI: 10.1016/j.biocon.2014.11.022.

1. http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

Contact: gforrester@uri.edu

Theme(s): Marine Ecosystems, Biodiversity

Volunteers can help on-going monitoring efforts of coral reefs by detecting long-term changes

Citizen scientists are increasingly playing an important role in monitoring environmental conditions around the world. There have been concerns, however, that the quality of volunteer data might not match the reliability of data collected by professional scientists. A new study has found that both citizen scientists and professional scientists were able to identify widespread decreases in the cover of live corals and increases in rubble and sand, during two long-term monitoring programmes of coral reefs. These results show that volunteers can indeed play a meaningful role in the conservation of these reefs, say the authors of this study.

"...citizen scientists can make valuable contributions to monitoring, for example, in helping to detect early widespread changes that indicate the health of coral reefs."

This study assessed two programmes that monitor coral reefs in the British Virgin Islands, to establish whether scientists and volunteers were able to produce comparable results from monitoring data,

One programme, run by University of Rhode Island (URI) scientists, monitored eight coral reef sites from 1992 to 2012. The other programme was run by volunteers from the Reef Check organisation, which monitored four different reef sites from 1997 to 2012.

The researchers were particularly interested to find out if the Reef Check programme could identify long-term changes in the coral reefs, as such changes can be difficult to detect, but are vital for conservation efforts.

For Reef Check monitoring, divers swam along fixed 100 x 5 m (0.05 hectare), transects, or paths, on the four reef sites, counting fish species, invertebrates and benthic (bottom dwelling) organisms, such as corals. URI divers recorded fish, invertebrate and benthic species along shorter 30 m transects that were not fixed, but instead placed at different locations within 0.6 hectare monitoring sites during each visit.

The researchers identified 12 indicators, such as the presence of parrotfish, sea fans and hard corals, common to both programmes, which could be used to compare survey results between the two programmes.

In seven instances, observers from the URI and Reef Check programmes surveyed the same sites at the same times. In all cases, for each fish species of interest, Reef Check volunteers repeatedly counted more fish than the URI observers. When looking at long-term changes, the researchers found that URI observers identified increasing numbers of parrotfish, but declining numbers of snappers, whereas the Reef Check observers did not find these changes. One explanation for this, say the researchers, is that counting fish consistently takes a lot of practice and cross-checking between divers, and the volunteers simply don't have the time to do this.

Nevertheless, analysis of important benthic indicators from both programmes revealed similar long-term trends. For instance, both programmes identified widespread decreases in the cover of live corals and increases in the cover of rubble and sand. This is important, as identifying long-term and widespread, as opposed to local changes, is crucial in monitoring the health of coral reefs and being able to make appropriate conservation decisions.

This study shows that citizen scientists can provide data consistent with professional scientists' assessments. There were differences between the professionals and volunteers for some of the measures of biodiversity, as some are easier to assess than others. Nonetheless, citizen scientists can make valuable contributions to monitoring, for example, in helping to detect early widespread changes that indicate the health of coral reefs.

Source: Forrester, G., Baily, P., Conetta, D., Forrester, L., Kintzing, E., Jarecki, L. (2015). Comparing monitoring data collected by volunteers and professionals shows that citizen scientists can detect long-term change on coral reefs. *Journal for Nature Conservation*. 24 1–9.

Contact: prue.addison@gmail.com

Theme(s): Biodiversity, Marine ecosystems

How to ensure monitoring delivers effective, evidence-based conservation

Long-term biological monitoring is key to effective, evidence-based conservation management, new research concludes. However, greater collaboration is needed to ensure that scientists understand what kind of information is needed by conservation managers. In this way the data can deliver answers for the most important management questions.

“The results showed that although the monitoring programmes provided quantitative data, the material used to inform the efficacy of management decisions was qualitative.”

Evidence-based management is a crucial part of effective conservation. ‘Management effectiveness evaluation’ is a framework designed to facilitate this, and encompasses every stage, from defining the conservation objective and planning to assess conservation outcomes. While qualitative data, such as expert opinions, can be used in such evaluations, quantitative data (i.e. numeric measurements) are often more appropriate, especially for measuring ecological condition. Quantitative condition assessments allow more transparent and repeatable monitoring, and are less subject to the possible biases of expert opinion.

To investigate the use of long-term quantitative monitoring in the management of [marine](#) protected areas (MPAs), researchers for this study interviewed 20 individuals from five management agencies encompassing seven long-term monitoring programmes from across Australia. Interviewees were either managers or scientists and all had intimate knowledge of their monitoring programmes.

The results showed that although the monitoring programmes provided quantitative data, the material used to inform the efficacy of management decisions was qualitative. In other words, experts would interpret the data and provide their opinion. This results in a loss of key benefits, the researchers argue. The programmes, which had been running for durations of 12–27 years, provided a large amount of useful data which could have been used for objective, transparent ecological condition assessments.

The interviewees felt that data collected through long-term monitoring had been valuable for informing management. For example, it provided information on habitat distributions which was useful for decisions such as changes to the siting of MPAs. It was also helpful for invasive alien species control, compliance efforts and educational programmes.

The management effectiveness evaluation framework was used by the management agencies, but it was common for management decisions to be made without following it. This might be partly to do with the time scales, the researchers say. The evaluations were often only carried out every 5–10 years, often as a part of external reporting. This is generally not frequently enough to help with on-going management decisions, the researchers say.

The researchers make four key recommendations to improve the use of long-term monitoring data and ensure effective management:

1. Ensure that management is evidence-based. Management effectiveness evaluation should be a ‘closed loop’; this requires that assessments of conservation outcomes feed directly into new management decisions.
2. Invest in effective long-term monitoring. Stronger collaborations between management and the scientific community are also needed to ensure that monitoring really provides answers to the questions asked by managers.
3. Use quantitative ecological condition assessments rather than qualitative. This will be facilitated by better collaborations, as the data will be designed to provide the information managers need.
4. Increase the frequency of evaluations to ensure that the evidence really drives management, rather than only being used for reporting.

Source: Addison P.F.E., Flander, L.B., Cook C.N. (2015). Are we missing the boat? Current uses of long-term biological monitoring data in the evaluation and management of marine protected areas. *Journal of Environmental Management*. 149: 148-156. DOI: 10.1016/j.jenvman.2014.10.023.

Contact: m.mascia@conservation.org, sharonpailler@gmail.com

Theme(s): Biodiversity, Environmental information services, Sustainable development and policy assessment

Evaluating conservation programmes: what are the best methods?

Monitoring and evaluation of conservation projects is vital to ensuring their success. However, there is currently a lack of clarity about the different methods available and the ways in which they can complement each other. For this study the researchers explore the characteristics of five approaches — ambient monitoring, management assessment, performance measurement, impact evaluation, and systematic review — and examine their strengths and weaknesses.

“Impact evaluations and systematic reviews, which provide a clear, scientific, evidence base, are likely to be particularly useful in answering the crucial questions of: ‘what works, what does not, and why?’.”

Ambient monitoring involves monitoring social and ecological conditions over time and in different areas, and tracking any changes. It is used to provide information on wildlife population sizes, the condition of ecosystems, or changes in human land use practices. Such monitoring is independent of any conservation interventions and does not attempt to assess their outcomes or impacts but rather records the broad environmental context. However, ambient monitoring can complement other assessment approaches, as the data collected can often be analysed for these other methods.

Management assessment measures the management capacities and activities associated with a conservation intervention. It does not assess the outcome of conservation interventions directly, but is based on the assumption that a well-managed initiative is more likely to be successful. Concerns over this type of monitoring and evaluation have been raised by scholars, as management assessments are generally filled out by project managers themselves, and may therefore be biased. As well as this, the links between management and successful conservation outcomes are not yet clear.

Performance measurement monitors the progress made by a conservation intervention towards its objectives. For this, indicators are specially designed to track progress towards goals, the improved status of a species or ecosystem, for example, or poverty reduction among local residents. Performance measurement is widely applied and can be very useful to decision makers. However, its weakness is that it cannot isolate the effects of the conservation intervention against other conditions; therefore the true causal effects of the intervention remain uncertain.

Impact evaluation aims to reveal the causal effects of the conservation intervention by comparing what happened with the intervention to what would have happened without it. This can be done by applying the intervention in some areas but not in others, and comparing the outcomes. Or by careful identification of areas that would be suitable for comparison. However, as conservation projects often have unique or rare characteristics it can be difficult to find appropriate comparisons.

A systematic review collates and appraises all available evidence regarding a particular research question. It is a structured process that aims to maximise transparency and minimise bias and can be used as evidence for decision makers as to whether an intervention works or not, and in what contexts. A systematic review is a valuable resource; however, it is only as good as the evidence it reviews, and is therefore most effective in situations where there are many well-designed studies regarding an intervention’s impact.

The researchers conclude that clearly defining the evaluation question is crucial. Once this is established the appropriate monitoring and evaluation techniques can be identified and any synergies between them can be maximised. Impact evaluations and systematic reviews, which provide a clear, scientific, evidence base, are likely to be particularly useful in answering the crucial questions of: ‘what works, what does not, and why?’.

Source: Mascia, M.B., Pailler, S., Thieme, M.L., Rowe, A., Bottrill, M. C., Danielsen, F., Geldmann, F., Naidoo, R., Pullin, A.S. & Burgess, N. D. (2014). Commonalities and complementarities among approaches to conservation monitoring and evaluation. *Biological Conservation* 169: 258–267.

Further Reading

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News Alert articles

Drones can be used to study birds without affecting their behaviour — with some precautions – May 2015

Drones — unmanned aerial vehicles — may be used in close proximity to bird populations without causing disturbance, finds a new study. Drones hold the potential to monitor species and areas that are difficult to reach. The authors advise that, when used with caution, drones could become a valuable tool in the monitoring of species, particularly in protected areas.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/drones_can_be_used_to_study_birds_without_affecting_their_behaviour_415na3_en.pdf

Citizen science could address impact of global change on biodiversity – April 2015

Citizen science holds the potential to address some of the biggest concerns facing biodiversity researchers, according to a new study. The study found that volunteers already save biodiversity research huge sums of money, but that their contributions are underused.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/citizen_science_could_address_impact_of_global_change_on_biodiversity_410na4_en.pdf

Citizen scientists help reveal effects of roads on frogs and toads – January 2015

Roads reduce the species diversity and distribution of frogs and toads, a new US study reports. The large-scale study used data from a national citizen science programme in which members of the public help monitor amphibian populations.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/citizen_science_helps_reveal_effects_of_roads_on_amphibians_400na7_en.pdf

Wind turbine risks to seabirds: new tool maps birds' sensitivity to offshore farms – November 2014

A new tool has been developed to map the sensitivity of seabirds to offshore wind farm development. The Seabird Mapping and Sensitivity Tool (SeaMaST), currently for use in English waters, combines information on the sensitivity of seabird species to wind turbines with data on the birds' distributions. It provides maps that can be used for both the offshore wind farm industry and marine spatial planning.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/wind_turbine_risks_seabirds_395na2_en.pdf

New tool predicts ecosystem restoration success – November 2014

A new approach to predicting whether a degraded ecosystem can be successfully restored is presented in a recent study. The researchers who developed it show how it works with the case of peatland restoration. Their method uses a computer model to link restoration success or failure with plant species and management techniques on the sites.

http://ec.europa.eu/environment/integration/research/newsalert/pdf/new_tool_predicts_ecosystem_restoration_success_394na4_en.pdf

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