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Citizen science and nature conservation

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If you think in terms of a year, plant a seed; if in terms of ten years, plant trees; if in terms of 100 years, teach the people.

Confucius

Introduction

The Convention on Biological Diversity (CBD 1993) stresses the '3 Cs': Conservation, Commerce and Community (also termed the '3 Es': Environment, Economy and Equity). Legislation in itself, however, cannot be the entire solution. A shift in our values and attitudes toward the environment is required to bring about changes in behaviour at all levels Agenda 21 of the CBD thus advocates specific criteria for tackling anthropogenic impacts and attitudes to address the human dimension in conservation.

The general public and corporations are both stakeholders in the biosphere and can be involved in nature conservation through citizen science (Irwin 1995) and corporate social responsibility (CSR: Henningfield et al. 2006). This involvement can take many forms, ranging from volunteer-based environmental clean-up days and implementation of species conservation measures based on established scientific knowledge, to public education in parks and museums, to collecting data on species distribution and abundance for monitoring purposes or for the purpose of testing scientific hypotheses (Leslie et al. 2004). Aside from the immediate benefits, long-term volunteer experience has also been linked to strong advocacy for the environment (Ryan et al. 2001), furthering environmental stewardship.

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While there are many advantages to using volunteers as citizen scientists (Toms & Newson 2006), there are limitations, too. Professional scientists often doubt the reliability of scientific data collected by amateur volunteers. Based on arguments from the House of Representatives asserting that 'volunteers are incompetent and biased', some public monitoring programmes in the United States are reverting solely to the use of professional scientists despite an absence of evidence corroborating these doubts (e.g. the US National Biological Survey: www.nap.edu/openbook.php?record_id=2243).

In addition, volunteers are not really a 'free' labour source. Financial and human resources are required to recruit, train and retain volunteers, and to recognize their accomplishments (Jacobson 2009). It is critical that projects relying on the help of citizen scientists minimize the costs and maximize the benefits of their volunteer programmes by understanding volunteer motivations and perceptions.

This chapter considers four key issues that need to be taken into account when working with volunteers: recruitment, motivation, training and deployment, and data validation. We then discuss the circumstances in which a citizen science approach should offer benefits for nature conservation projects.

Recruiting and retaining volunteers

The willingness to volunteer pervades all sectors of society. However, many organizations report a strong age and/ or gender bias in their volunteers, thus making targeted recruitment a necessity. The most suitable method of volunteer recruitment depends upon how many volunteers are required, the desired geographical reach of the project, the project logistics, whether any particular prior skills (e.g. competence in species identification) or physical abilities (e.g. scuba-diving) are needed for participation, and what kind of budget is available for publicity. The spectrum of volunteering opportunities for citizen scientists ranges from intensive and well-structured short- or medium-term residential projects (e.g. www.opwall.com, www.earthwatch.org, www.conservationvip.org) to long-term or open-ended projects, where large numbers of volunteers are asked to send in any records of specific observations they collect to a central data collection agency (e.g. National Biodiversity Network: www.opalexplorenature.org/nbn).

Whereas in the first case scenario, small teams of volunteers usually work under the direct supervision of one or several professional scientists from whom they receive intensive personalized field training, in the second scenario the relationship between citizen scientist and professional researcher remains largely anonymous, and training is usually restricted to written instructions and web-based material (e.g. the Mini Mammal Monitoring survey organized by the Mammal Society in the UK: www.mammal.org.uk; the Great Backyard Bird Count in the US: www.birdsource.org/gbbc). Some surveys utilize specifically designed software applications to facilitate easy and reliable data collection by volunteers, such as the iPhone app for recording and submitting records of different species of mammals killed on Britain's roads to the People's Trust for Endangered Species (http://itunes.apple.com/gb/app/mammals-on-roads/id446109227?mt=8). Such mobile applications can now be produced using customizable freeware (Aanensen et al. 2009).

The longer-running projects conducted, for example, by the British Trust for Ornithology in the UK and the Cornell Lab of Ornithology in the US demonstrate that many volunteers can reach a professional level of expertise (Greenwood 2007). Social networking offers the opportunity to exploit the full range of volunteer expertise by using more experienced and knowledgeable volunteers to guide and train less experienced ones. This is the principle behind iSpot (http://ispot.org.uk), which involves members of more than 90 specialist natural history societies, most of them run by volunteers, to help beginners and

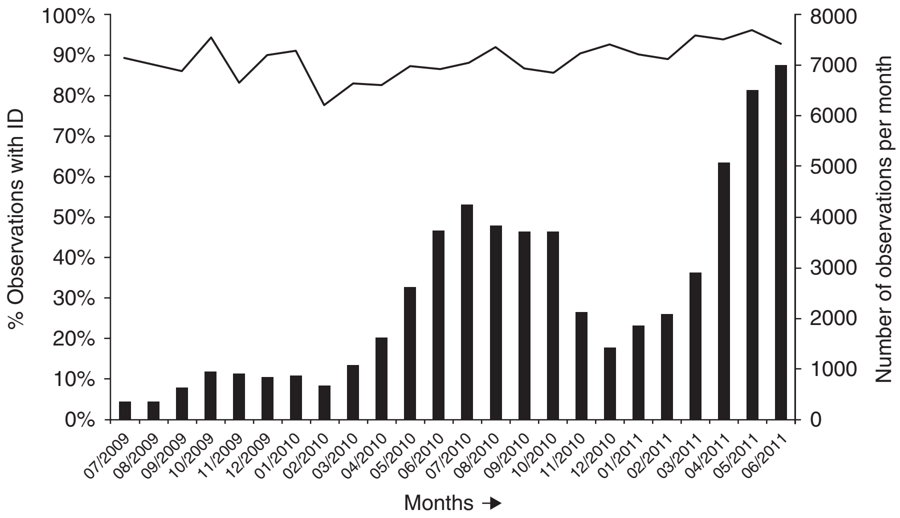

Figure 8.1 The number of observations submitted to the iSpot website during its first 2 years of operation (columns) and the percentage that were named by the social network (line).

non-specialists identify photographs of species that they submit to the website. Once validated, these data become a valuable addition to national biodiversity records. In its first 2 years of operation in the UK, iSpot volunteers made more than 66,000 observations of over 5000 species. Members of the Amateur Entomologists Society are one of the more active expert groups and between them contributed in excess of 2000 identifications to iSpot.

Because iSpot is new, its full potential is still to be realized, but the early signs are that it is highly scalable. The number of observations submitted doubled from 3500 to 7000 per month between June 2010 and June 2011, and the iSpot community proved more than capable of keeping pace with the task of supplying valid determinations (Figure 8.1). Ninety-six percent of observations have received a name, 77% at species level. These include two species of insect never recorded in the UK before, including the first record of the Euonymus leaf notcher moth, discovered by a 6-year-old girl. In a subsample of 2931 species observed on iSpot, 10% had a conservation listing, including 160 Biodiversity Action Plan priority species, 118 species on the UK Red List, and 102 nationally rare/scarce species. iSpot has recently been adopted by the South African National Biodiversity Institute. In its first few months of operation in South Africa, iSpot has reported an endemic species previously thought to be extinct and located an alien species that is a potential threat to endemic plants on Table Mountain.

The goal of an increasing number of conservation organizations is 'to help unite volunteers with scientific projects in need of voluntary assistance' (Mackney & Spring 2000). In some cases, individuals volunteer their time and labour, in others they are also expected to contribute to the cost of the research (Coghlan 2005). Web-based advertisements from (non-) governmental and professional organizations, research institutions or individual scientists offering volunteer placements are widespread. The Earthwatch Institute (www.earthwatch.org), for example, promotes a number of scientific projects in need of volunteer helpers to their members, who book a volunteering holiday package including food, accommodation, transport and insurance with the explicit expectation that they will work alongside professional scientists to collect important data to further scientific knowledge. Some Earthwatch projects can accommodate 10–15 volunteers per team, offer between five and 10 expeditions per year and run for several years. For example, the Mammals of Wytham Woods (www.earthwatch.org/aboutus/research/valuevol/) and the Mammals of Nova Scotia Projects (www.earthwatch.org/exped/buesching.html) have thus far benefitted from the combined help of close to 1000 residential volunteers, building up detailed comparative databases on a wide variety of terrestrial mammal species with an emphasis on small mammals and effects of habitat management on forest ecology. Here, 6–12 volunteers join two professional scientists for 1- or 2-week residential terms to survey for field signs and to lay out and check trapping grids. Simultaneously, the volunteers themselves are evaluated, and the veracity of their data tested and compared to those of the scientists (Newman et al. 2003). Volunteers pay their own travel as well as all expenses occurred on the project in addition to the staff costs and overheads incurred at Earthwatch offices, although the project scientists' salaries' are not covered by the volunteer contribution.

Even residential projects supported by the help of comparatively small volunteer teams of 10–15 people can utilize modern web-based communication tools to increase their outreach and conservation impact, as illustrated by Earthwatch's Life from the Field Teacher programmes, where sponsored teachers skype live from the project with their own (and other teachers') classrooms, regularly reaching thousands of students from the Mammals of Nova Scotia Project.

At the other end of the spectrum are large-scale, mostly web-based citizen science projects, such as the Evolution MegaLab (http://evolutionmegalab.org), directed at sampling a maximum number of populations of banded snails (*Cepaea* spp.) throughout their native geographical range (Silvertown et al. 2011). This project aimed to reach as many potential volunteers as possible throughout the whole of Europe (Silvertown et al. 2011). No specific skills were required for participation, and extensive institutional resources could be deployed in promotion. The project operated in 14 languages in 15 European countries and reached 5–10 million people through widespread publicity in the press, television and radio. To take the UK as an example, of the estimated 5 million who heard about the project, only about 1% visited the website, and of these only about one in 10 registered (Figure 8.2). The Swiss partners, in contrast, used a different approach by recruiting volunteers specifically from among members of Bird Life Switzerland, but achieved a similar rate of participation per head of national population (0.006%) to that obtained in the UK (0.005%).

Another successful example for such a targeted approach is the Protea Atlas Project (http://protea.worldonline.co.za) which, aside from collecting scientific data about the distribution and survival strategies of the 370 different species in the Proteaceae in South Africa, also aimed to encourage amateur involvement in botany and to stimulate public awareness about South African conservation issues. Volunteers were recruited by organizers giving dozens of talks and visiting 42 of the annual flower shows in the western and southern Cape throughout the duration of the project. Help with protea identification was given at the shows, and information was obtained from visitors with local knowledge about species' localities and common names. Posters advocating collection of local distribution records mapping local proteas were designed for each flower show, and later donated to local libraries, information centres and museums. Media coverage heightened awareness of the project, but recruited few volunteers.

During the 10-year duration of this project, 1455 people approached the management team, although 18% of these did not express any further interest in the project. A further 52% ordered identification and sampling kits, but did not send in any data. Some 478 volunteers (30%) sent in data, with 97 of them sending in more than 50 localities and 12 contributors submitting more than 1000 localities. The top 10 volunteers collected 52% of the data. Throughout the project, a high profile was maintained by giving publicity to newly discovered range extensions, new taxa, local threats

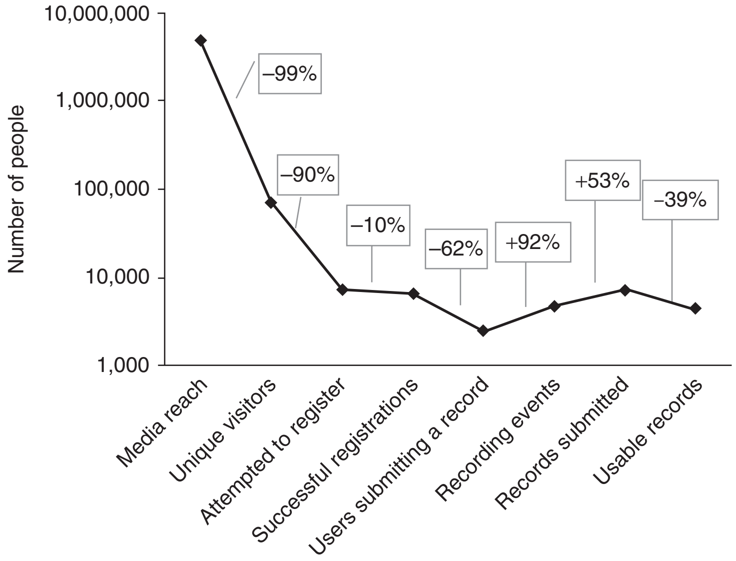

Figure 8.2 A recruitment curve for the Evolution MegaLab showing the numbers with an opportunity to see publicity about the project in the UK press and other media through to the number actually participating and the number of samples submitted. Percentages show the loss or gain in numbers between each stage. From Worthington et al. (2011).

identified during atlassing and by organizing outings and courses in atlassing and plant identification. The organizers estimated that with atlassing teams, over 1000 people contributed to the Protea Atlas Project, excluding ancillaries who joined walks, hikes and trips in which mapping was a focus of the excursion. A substantial number of conservation officers, including 90 novices and 22 experts, contributed data to the atlas.

Volunteer motivation

Researchers and habitat managers have long recognized that understanding volunteer motivation is a valuable component of volunteer management (Cnaan & Goldberg-Glen 1991; Harrison 1995; Omoto & Snyder 1995). Yet little research has been conducted on factors affecting recruitment and retention in citizen science and conservation. Motivated volunteers serve significantly longer than volunteers who do not have their needs met through service (Jacobson et al. 2012). A successful recruitment and retention plan can minimize many of the common challenges that supervisors face, such as attracting good volunteers who can work the appropriate hours, and who bring unique and valuable perspectives, expertise or training to a programme (Hager & Brudney 2005). The recruitment message should therefore be tailored to the audience being sought, and should not only address how volunteers can help meet the specific needs of the organization but must also emphasize the benefits to the volunteers themselves, and how their motivations will be satisfied. To maximize their appeal, some recruitment drives such as the Mini Mammal Monitoring Project (www.mammal.org.uk) offer different methodological approaches (in this case from field sign surveys to life trapping) to appeal to beginners and experienced volunteers alike on a sliding time scale (from one hour to several days), whilst emphasizing the urgent need for voluntary participation as well as the potential for social involvement in regional groups.

People are motivated by various needs. Psychologist Abraham Maslow developed a simple hierarchy of people's needs which translate into general motivations. His theory posits that once people fulfil their physiological needs for food and health as well as safety and security, they progress to addressing personal drives for a sense of social belonging, self-esteem and ultimately self-actualization. Volunteer opportunities can satisfy many of these same drives for social affiliation, personal achievement and esteem.

A number of studies have examined the personal and social functions that are served by initiating and sustaining a particular helping behaviour, such as volunteerism. Research on the motivations of 569 volunteers for Florida's Fish and Wildlife Conservation Commission (FWC) used a functional framework to measure the relative importance of seven primary motivations. Based on a web-based questionnaire, volunteers ranked a series of 30 items that corresponded to seven primary motivations. Each item was scored from 1 (very unimportant) to 7 (very important) and resulted in the following average scores for each motivation category: (6.3) help the environment, (5.2) have opportunities for learning, (5.0) enhance their use of the environment, (5.0) express their personal values, (4.8) be involved in effective projects and esteem, (4.8) engage in social interactions, and (3.4) further their career goals (Jacobson et al. 2012). An earlier study of volunteers for five environmental organizations in Colorado found similar motivations, with helping the environment and related items, such as assisting an environmental cause, seeing improvements in the environment and preserving natural areas for future generations, being among the highest motivational factors (Bruyere & Rappe 2007). Other studies have found that volunteers are motivated by similar factors, such as 'gathering new experiences' (Pearce & Lee 2005), 'being adventurous' (Moscardo et al. 1996), 'learning about the environment' (Manfredo et al. 1996), 'supporting an organization/scientific project' (Bonjean et al. 1994), 'escaping their daily routine' or 'experiencing an entirely new direction in life' (Buesching & Slade 2012).

Motivations of volunteers can vary widely among individuals and can change with time. Age-related differences were seen in the Florida Wildlife Agency study. Younger volunteers were more interested in opportunities offering career development (Jacobson et al. 2012). Different expectations were associated with national and cultural identity as well as societal class and educational background among volunteers in the Earthwatch programme (Buesching & Slade 2012), which has approximately 20,000 members globally and places more than 4000 volunteers per year. The majority of these volunteers come from only three countries: Britain, the USA and Australia, and more than half of all residential conservation volunteer organizations are based in the UK (Coghlan 2005). The largest proportion of volunteers on the Mammal Monitoring Projects in the UK as well as in Nova Scotia came from the UK (ca. 78% in the UK compared to 30% in NS) and the US (ca. 8% in the UK compared to 54% in the US), followed by Australia (ca. 6% in both countries) and Japan (ca. 5% in both countries), whilst all volunteers from other European countries (Germany, France, Holland, Switzerland) contributed only ca. 3% on both projects.

Understanding such national differences in participation and in what motivates volunteers presents a challenge. Differences in cultural expectations relating to division of labour, recreation, career development and financial decisions are all involved (Buesching & Slade 2012). As in some countries, such as the USA, all costs related to volunteering are tax-deductable, residential environmental volunteering programmes can be a cost-effective alternative to conventional eco-holiday travel.

Of a sample of 611 volunteers from the Earthwatch Institute participating in the two residential Mammal Monitoring Projects, approximately 25% were motivated foremost by the opportunity for interacting with other like-minded people and enjoying the social aspects of their activities or participating in a new activity, especially after reaching a turning point (e.g. divorce or unemployment) in their personal life (ca. 25%). However, volunteer recruitment and project design usually focus on the scientific importance of the work. Recruitment and volunteer retention might thus be greatly enhanced on many projects if these aspects are emphasized when designing a programme. In addition, committed volunteers are often more strongly motivated by social considerations, e.g. at environmental stewardship programmes in Michigan, volunteers who were oriented to volunteering for social reasons, and for whom project organization played an important role, were more committed to their work (Ryan et al. 2001). Items such as seeing familiar faces and having fun were important predictors of commitment to their volunteer programme. Creating time for volunteers to socialize during their work activities is thus important for the retention of long-term volunteers. For web-based research activities, regular feedback from organizers, group postings, social networking and other activities may satisfy social drives.

For people who choose to volunteer for achievement opportunities, emphasizing the chance to learn new skills through participation in a project will help to keep them satisfied. On the Nova Scotia Mammal Monitoring Project, approximately 25% of volunteers signed up with the explicit hope and expectation of learning new skills, such as mammal trapping and field sign identification, relevant to their career (e.g. biology students, environmental consultants), and/or to obtain references by the projects scientists for future job or college applications. More experienced and knowledgeable volunteers for Christmas Bird Counts are given the opportunity to share their birding expertise with new volunteers, and receive recognition from their peers through local and regional tallies and reports. In 2010, during the 110th Christmas Bird Count in North America, and more recently Latin America, 60,753 observers counted a total of 55,951,707 birds. Bird count participants can follow feeder observations on websites and see final tallies published in local newsletters and national journals. Extensive media coverage of compiled data provided reinforcement for volunteers. In 2007, when Audubon released their 'Common Birds in Decline' report (Butcher & Niven 2007), more than 700 articles appeared in print and extensive coverage of the bird counts occurred on radio and TV (Bancroft 2007).

Volunteers seeking a feeling of esteem or power might benefit from working independently and having control over a part of the project. Researchers have found that more proactive volunteer activities, such as native plant and stream restoration tasks, are more likely to result in greater frequency and strength of commitment of volunteers than simple manual tasks, such as clean-up activities (Ryan et al. 2001). These activities allowed participants to develop their skills in identifying native plant or aquatic species. Similarly, a content analysis of volunteer newsletters found that the tangible results of ecological restoration work are an important factor in motivating volunteers (Schroeder 2000). In short-term residential projects, volunteer motivation and data quality are both enhanced if volunteers participate in the analysis of data during their stay (Newman et al. 2003; Foster-Smith & Evans 2003; Buesching et al. submitted). Many citizen science projects require supporting activities, such as data input or fence maintenance, and it is important to link these activities to the ultimate objectives of habitat management and to conservation outcomes in order to show volunteers the importance of their completion (Buesching & Slade 2012).

Training of volunteers

Appropriate training is considered increasingly as the most important factor affecting volunteer performance (Brandon et al. 2003; Newman et al. 2003; Foster-Smith & Evans 2003; Blackburn & Frank 2010; Danielsen et al. 2005). Whilst many volunteer-based surveys are conducted by mailing written instructions or web-based training manuals to participants

(Janzen 2004; Cohn 2008), often using field guides, video and an online quiz to train volunteers (Silvertown et al. 2011), several studies have emphasized the importance of hands-on practical training, which needs to include the actual volunteer tasks (e.g. spotting field signs) in a natural setting (Newman et al. 2003; Foster-Smith & Evans 2003).

For example, volunteers for the Protea Atlas Project were given intensive training, either by atlas staff or by other volunteers. The project team led volunteers on numerous field trips to nature reserves, unexplored areas, hot-spot areas, and to farms at the invitation of landowners. In addition, regional co-ordinators also ran weekend and camping trips to areas within their region. Generic skills such as map reading, species identification, estimating population sizes, interpreting the geology, landscape and vegetation, filling in forms, and standardized monitoring techniques all need to be considered in training volunteers. An obvious error to avoid is to focus volunteer training purely on the project-specific techniques, while neglecting support skills (such as map reading or correctly using GPS) that are just as important to the project (Buesching et al. submitted).

For many monitoring tasks, 2–3 hours of practical field training by a professional scientist has been shown to be sufficient (Newman et al. 2003; Foster-Smith & Evans 2003). For example, if provided only with written instructions, drawings of field signs and a map and compass to survey a woodland area for badger setts and latrines, volunteers found only 10% of badger setts and none of the latrines known to be in the area. In contrast, volunteers having been shown one sett and one latrine were able to find 90% of all main setts, 67% of smaller outlying setts, and 56% of latrines (Newman et al. 2003).

Training has to start at the basics, without the assumption of prior volunteer knowledge, to ensure methodological coherency in data records (Macdonald et al. 2002; Newman et al. 2003; Buesching & Slade 2012). Often, complete novices can be better suited than experienced volunteers to studies where methodological consistency is crucial, because prior knowledge implicitly produces methodological preconceptions (Newman et al. 2003). For example, when conducting standing crop faecal pellet count surveys in experimental plots with known numbers of droppings, novice volunteers found 75% (no previous experience), whilst experienced volunteers (>15 plots surveyed) found only 67% (professional field biologists consistently found 74% in this study; Newman et al. 2003). Frequent supervision, especially during the initial training period (Newman et al. 2003), with follow-up spot-checks and intensive training sessions concentrating on specific issues, minimizes observer errors and enhances volunteer performance significantly (Foster-Smith & Evans 2003). The inclusion of some theoretical background and context, detailing why the particular research project in question is important, has been shown to enhance volunteer motivation and comprehension significantly (Martinich et al. 2006), leading to more consistent results (Mumby et al. 1995; Newman et al. 2003). Performance is considerably improved if, during follow-up sessions, the consequences of incorrect task performance are explained, too, rather than just reiterating the correct techniques (Cook & Berrenberg 1981; Newman et al. 2003).

Data validation and analysis

Despite scepticism about the validity of volunteer data, many researchers rely on the use of volunteers in scientific data collection. Scientists expect to collect data, reliable and accurate enough to test hypotheses, and by using volunteers they expect to carry out more work than they could on their own (Crall et al. 2010; Devictor et al. 2010). However, studies generally show that novice volunteers take significantly more time to accomplish a task compared with professional biologists, although with increasing practice they usually achieve similar speed and efficiency (Newman et al. 2003; Foster-Smith & Evans 2003; Buesching & Newman 2005;

Bueschimg et al. submitted). Even such straightforward tasks as laying out random 10 × 10 m survey quadrants in forests for standing crop faecal counts takes a group of six inexperienced volunteers three times longer than one experienced researcher (Buesching et al. submitted).

It is important that volunteer data should be of equivalent quality to those collected by professionals, or that their quality is consistent and can thus be validated, as shown, for example, in visual badger counts at setts, where volunteers consistently counted 60% of all badgers that were known to live at each sett from long-term trapping records (Newman et al. 2003). Pilot studies (for example, marine: Darwall & Dulvey 1996; Foster-Smith & Evans 2003; woodland mammals: Newman et al. 2003; Buesching & Newman 2005; Buesching et al. submitted) indicate that, with appropriate training, volunteers are capable of mastering many monitoring techniques. Individual variation between volunteers is, however, considerable (Ericsson & Wallin 1999; Barrett et al. 2002; Genet & Sargent 2003) and influenced by individual-specific characteristics, such as gender, fitness and enjoyment/boredom (Buesching & Newman 2005; Buesching & Slade 2012).

Some volunteering programmes afford the opportunity to evaluate the effects of different individual-specific characteristics on volunteer performance, and thus formulate generalized guidelines for researchers to employ new volunteers on their likely strengths and weaknesses. Analyses based on a sample size of 750 volunteers from 65 teams on the UK and Nova Scotia Mammal Monitoring Projects showed that, when evaluated by one male and one female observer on performance of a variety of different tasks on a scale of 1 (= unreliable work/data quality) to 5 (= very efficient/data comparable to professional standards), men scored higher generalized averages than women (Newman et al. 2003; Buesching & Slade 2012; Buesching et al. submitted). The standard deviation among women, however, was much higher than among men (Newman et al. 2003; Buesching & Newman 2005) and in addition, women improved significantly more with training and experience than men (Buesching et al. submitted).

To ensure data quality, it proved important that the tasks be well within the volunteers' physical abilities, as fitness has been shown to be correlated with data veracity, while age (between 11 and 86), if corrected for fitness, had little or no effect on volunteer abilities (Newman et al. 2003; Buesching et al. submitted). Nevertheless, in general, different age classes show different task-specific strengths. Older people are generally more patient and are thus usually well suited to fine-scale monitoring at a leisurely pace, e.g. species lists, bird calls, direct observations (Newman et al. 2003; Buesching et al. submitted) while younger volunteers are usually more energetic and are thus predisposed to more active tasks, e.g. transect walking through difficult terrain (Buesching et al. submitted). Some volunteers also have certain task-specific disadvantages, e.g. red/green colour blindness prevents easy discrimination of animal droppings (especially deer and hare) against a green background (e.g. moss) (Buesching et al. submitted).

Aside from these individual differences, volunteers in general have a lower 'boredom threshold' for repetitive tasks than professionals, resulting in carelessness and thus considerably lower data reliability (Mumby et al. 1995; Martinich et al. 2006; Buesching & Slade 2012). Similarly, some volunteers may consider a task as too demanding to complete, for example due to bad weather or terrain, resulting in loss of or incomplete data, which may violate the sampling methodology (Cook & Berrenberg 1981; Basinger 1998; Buesching & Slade 2012). In addition, many novice volunteers display a tendency to disregard non-events (e.g. the absence of field signs) or undervalue common events (e.g. repeated findings of field signs of the same, common, species), in favour of seeking out the rare and 'more exciting' observations, resulting in considerable data bias (Macdonald et al. 1998; Brandon et al. 2003; Genet & Sargent 2003; Foster et al. 2003; Danielsen et al. 2005; Buesching & Slade 2012; Buesching et al. submitted).

Data validation on non-residential long-term citizen science projects, however, proves more difficult. The web-based Evolution MegaLab survey, for example, used a number of indirect methods to validate the data submitted (Silvertown et al. 2011), of which one was a web-based quiz testing the volunteer's snail species identification skills. However, the original intention of using individual quiz scores to weight the reliability of the data submitted by each volunteer had to be abandoned in order to maximize data collection. Only about 20% of the users who submitted data also participated in the quiz. While this low participation rate made the validation of individual volunteer data impossible, the quiz results nevertheless proved useful in determining the possible extent of species misidentification (Silvertown et al. 2011). For example, the quiz showed that users had difficulty telling juveniles of the species *Cepaea nemoralis* from adults of *C. hortensis*, which resulted in the researchers' decision to include only adult *C. nemoralis* in the analyses (Silvertown et al. 2011).

The potential to use volunteers to validate data should not be overlooked. Not all interested volunteers can do field work, and many field volunteers also enjoy the social camaraderie of office work. Coupled with computer checks to detect possible errors in identification, coding and methodology, a history of volunteers' previous corrections and proforma responses to common problems, data checkers can play a major role in detecting errors of identification. For example, InstantWILD is a wildlife monitoring project that involves the general public in identifying photos of species taken by camera traps. Cameras are placed in remote locations in countries such as Mongolia, Sri Lanka and Kenya and when an animal triggers the camera a photo is automatically taken and instantly sent to both a website (www.edgeofexistence.org/instantwild/) and an InstantWILD cellphone application. The general public then has the opportunity to identify the species using a basic field guide. In cases of consensus the species is allocated to an appropriate bin (such as lion or elephant), otherwise the images are binned for further evaluation by experienced volunteers and professional scientists. During the first week following the launch of the InstantWILD app, it was downloaded over 60,000 times.

Office volunteers can also help to develop methodologies as well as training field volunteers, most especially new recruits who may be too shy to admit their inexperience. During data collection, the Protea Atlas Project staff provided constant feedback (based on automated reports of inconsistencies and cross-referenced identifications with herbarium and other atlas data) to the atlassers on what errors were made when filling in site record sheets and noted any potential misidentification/out-of-range observations for validation and further attention. This practice improved the quality of the data received by the project, with the end-result that after 10 years of data collection, an extremely comprehensive and reliable data set for proteas in South Africa now exists.

Conclusions

The advantages of using citizen science volunteers in conservation research are clear (Toms et al. 1999): they can provide an inexpensive and potentially large labour force (Bruyere & Rappe 2007; Pfeffer & Wagenet 2007), they usually contribute at least indirectly to the costs of the research, and the volunteers themselves gain fulfillment and knowledge (Sharpe & Conrad 2006). Local involvement also contributes to Agenda 21 targets and can improve management responses (Danielsen et al. 2010). For example, the Protea Atlas Project discovered eight species new to science, rediscovered two species previously thought to be extinct, confirmed two suspected extinctions and established the extinction of two additional species, advancing our knowledge of species' geographic ranges considerably. Increased distributional ranges were found for over 33% of species (some increased by over 100 km), and significant populations were added within known areas of distribution for at least 33% more. This project revealed that the centre of richness for the Cape Floral Kingdom was not the Kogelberg, as previously thought, but in the Western Riviersonderend Mountains. The atlas data have been used, and continue to be used, in numerous scientific studies (Thuiller et al. 2004; Bomhard et al. 2005; Midgley et al. 2006; Manne et al. 2007; Latimer et al. 2009) as well as by conservation authorities for assessing development applications and designing integrated development plans (Rebelo et al. 2011).

Conversely, citizen science brings with it a unique set of challenges and potential drawbacks (Buesching & Newman 2005; Dickinson et al. 2010): training and supervising volunteers takes scientists' time away from professional research, data are prone to higher intra- and interobserver variability, and some tasks continue to require professional involvement to conform with statutory regulations relevant to the working environment, e.g. animal handling licensing procedures and welfare considerations, as well as health and safety requirements (Buesching & Slade 2012).

While many of the challenges of maximizing team success and participant enjoyment are well-researched social science paradigms (Cook & Berrenberg 1981), they have not yet been recognized by the biological sciences well enough to develop more optimal team and project management. Recruiting agencies often use 'conservation output and delivery' as project selection criteria, but then evaluate the ongoing success of the project in terms of 'volunteer enjoyment' and marketability; thus, function and gratification are not necessarily linked intrinsically (e.g. Macdonald et al. 2002). For scientists it is important to recognize that volunteers participate in projects partly also for social reasons, in order to feel part of a group of like-minded people (Coghlan 2005), rather than participating exclusively to benefit scientific understanding. Anecdotal reports show that by fostering 'team spirit' (e.g. by follow-up reports on the progress of the project), volunteers are more likely to return (Miles et al. 1998). By definition, volunteers give up their free time to help without monetary reward (Campbell & Smith 2006). Volunteerism is therefore exemplary of prototypic planned helping (Clary et al. 1996, 1998), which calls for planning, sorting priorities and matching personal capabilities and interests with the type of intervention (Brown 1999).

To optimize the data quality and quantity provided by volunteers, researchers must understand which factors affect volunteer performance most (Newman et al. 2003; Buesching & Newman 2005; Buesching & Slade 2012), and then find ways to optimize and mitigate these factors, as appropriate, by allocating tasks to the best suited individuals (Mackney & Spring 2000), and by offering a varied programme to avoid monotony (Mumby et al. 1995; Martinich et al. 2006; Buesching & Slade 2012). Data collection protocols need to be designed to minimize interobserver errors (Basinger 1998), and methods need to be easy to understand and to perform without requiring special government licences. At the same time, training techniques have to be optimized by the scientists (Cook & Berrenberg 1981; Newman et al. 2003).

In Table 8.1 we offer some considerations to help anyone planning a project to decide whether using citizen science is a viable option. Factors to take into account in this context involve not only quantifiables, such as the ratio of fixed to variable costs, but also the value of engagement with volunteers *per se*: educational outreach and project publicity, the availability of volunteers, the suitability of the tasks required and the ease with which the data collected may be validated.

However, in addition to the obvious benefits of citizen science outlined above, there is a wide variety of more subtle benefits of involving the public in environmental research projects. Experiences from the Evolution MegaLab and the Protea Atlas Project show that working with volunteers is not always a cheap option. However, both projects aimed not only to collect scientific

Table 8.1 When is a citizen science approach appropriate?

Issues to be considered	Suitability of a citizen science (CS) approach
Project objectives	
Education/outreach	Appropriately designed, CS can be an effective tool if learning objectives and audiences are identified clearly
Project duration/ legacy	Since CS incurs set-up costs, it is more cost-effective if the project is of long duration and/ or a legacy effect is desirable. Resources for long-term monitoring and data maintenance must be in place
Accessibility of the scientific objectives	The scientific rationale behind the project must be easily explainable to a lay audience in order to recruit the volunteers to participate using CS
Project budget	
Overall cost	If low cost is an over-riding factor, CS may not be the cheapest option. Even if volunteers pay to participate (e.g. Earthwatch volunteers), they will require scientists' time and supervision, which will incur costs. Recognition of service must match volunteer expectations
Fixed costs	Staff time needs to be devoted to managing volunteers, which could be a cost burden on a small project or one that fails to recruit enough volunteers
Project design	
Health and safety	Major safety issues may make CS unviable
Geographical area to be sampled	The larger the area to be sampled, the more worthwhile it will be to invest in a CS approach
Sampling protocol	A robust and easy-to-apply protocol for CS volunteers must be devised
Data validation	Mechanisms must be in place to validate the data
Volunteers	
Recruitment	Projects involving charismatic species or habitats attract volunteers, as do opportunities to help the environment, be part of a well-organized programme, learn something new, join a social group or affiliate with people with similar values. Is there a readily available pool of volunteers from which to recruit and obvious channels for recruiting them? Recruitment materials should address the many reasons why citizens volunteer
Skills, training and supervision	Are special skills required by volunteers? Is appropriate training provided? Can staff and/or experienced volunteers provide ongoing training and supervision? Is the research project organized effectively?
Feedback/ recognition	How will feedback to volunteers be provided? Can a volunteer's personal contribution be tracked and recognized? Rewarding volunteers through recognition is how an organization expresses thanks for donated time, energy and expertise. Recognition should be frequent and meet the expectations of the volunteers
Time commitment	How much of a time commitment is required from volunteers? Is there more than one role/ level of involvement for volunteers? For long-term projects, how will interest and affiliation be maintained?

data but also to educate the public about local and national conservation issues and raise awareness for the project objectives. In 2010, the year after its official end, more than 1000 new records were submitted online to the MegaLab database, showing that a citizen science approach leaves a valuable and unique legacy in terms of public education and outreach. More than 10 years after the Protea Atlas Project finished, volunteers recruited then are making significant contributions to iSpot and to Custodians of Rare and Endangered Wildflowers (CREW) in South Africa, a citizen science project monitoring threatened species (www.sanbi.org/programmes/threats/

custodians-rare-and-endangered-wildflowers-crew-programme).

Although most people committing to volunteering are likely to belong to an already environmentally aware subsector of the population (Coghlan 2005), a surprisingly large number of volunteers (on the Mammals of Nova Scotia Project almost 50%) are motivated by curiosity, tourism motives or because they want to make a new start in life (e.g. after divorce, job redundancy, etc.). Many organizations also offer a number of fully sponsored places either to employees of specific companies or to teachers, students or similar. In addition, opportunities arise to recruit volunteers from unconventional sources, such as resettlement programmes after prison or drug/alcohol rehabilitation courses involving people without any prior conservation experience/interest (Newman et al. 2003). Such volunteers are thus likely to be somewhat uncertain how to behave correctly in this (new) situation, and will orientate their behaviour based on their fellow volunteers and team leaders (Abrams et al. 1990). In all cases, social alignment with other participants on the project (and the scientists) could be expected to lead to a more environmentally responsible attitude and behaviour of volunteers on the project. These small voluntary changes in behaviour can translate into an altered self-image reflecting greater environmental awareness and an altered perception of these volunteers by their social environment (Schlenker et al. 1994). As Wilson (1986) emphasized, fostering biophilia through understanding and first-hand experience of the natural world is likely to result in heightened compassion and raised environmental awareness (see also Chapter 9).

Advocacy for nature conservation has been linked to long-term volunteering (Ryan et al. 2001), thus demanding that we make citizen science programmes as effective as possible for our science, citizens and the environment. The development of mobile apps for monitoring could bring large numbers of new volunteers into conservation and could become a major source of data in the future.

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