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Article

Crowd Sourcing for Conservation: Web 2.0 a Powerful Tool for Biologists

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Abstract: The advent and adoption of Web 2.0 technologies offers a powerful approach to enhancing the capture of information in natural resource ecology, notably community knowledge of species distributions. Such information has previously been collected using, for example, postal surveys; these are typically inefficient, with low response rates, high costs, and requiring respondents to be spatially literate. Here we describe an example, using the Google Maps Application Programming Interface, to discuss the opportunities such tools provide to conservation biology. Toad Tracker was created as a prototype to demonstrate the utility of this technology to document the distribution of an invasive vertebrate pest species, the cane toad, within Australia. While the technological aspects of this tool are satisfactory, manager resistance towards its use raises issues around the public nature of the technology, the collaborative (non-expert) role in data collection, and data ownership. We conclude in suggesting that, for such tools to be accepted by non-innovation adopters, work is required on both the technological aspects and, importantly, a cultural change is required to create an environment of acceptance of the shifting relationship between authority, expertise and knowledge.

Keywords: cane toad; vertebrate pests; participatory GIS; Google Application Programming Interface; collaborative knowledge

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1. Introduction

Conservation biologists have long recognized the importance of community knowledge in documenting the distribution of species. This is particularly true of species that are broadly distributed across private lands, can be readily identified, and/or are seldom encountered in targeted wildlife surveys. The conventional approach has involved the use of postal surveys of questionnaires regarding wildlife sightings, with respondents marking locations onto a paper-based map and returning the document. These have been used effectively within Australia for charismatic species such as the koala, *Phascolarctos cinereus* [1–3], and the platypus, *Ornithorhynchus anatinus* [4–6]. A similar approach has also been used to document the spread of the introduced pest species, the cane toad, *Rhinella marina* [7,8]. Whilst these methods yield valuable information, they are costly to conduct, and response rates are typically low. Data entry needs to be conducted before the data can be analyzed, and respondents require some degree of map interpretation or spatial literacy skills to ensure reasonable accuracy of data.

The advent and rapid uptake of Web 2.0 technologies, such as Google Maps [9] offers an exciting opportunity to engage with communities in data acquisition; that has only recently been realized by conservation biologists. Here, we discuss the potential benefits that this technology offers, using a prototype web interface that was developed to document the spread of the invasive cane toad in northern New South Wales, Australia, and identify some important issues associated with project implementation and adoption.

2. Background

The cane toad is a highly invasive species, introduced into Australia by the Queensland Cane Growers Federation in 1935 in an attempt to control insect pests in sugar cane crops [10]. The success of the species as a control agent is questionable, but remains unknown, largely because of the rapid adoption of agricultural pesticides soon after the initial releases. However, the cane toad has spread rapidly throughout tropical and sub-tropical regions of Australia, having not yet reached its bioclimatic limits. The cane toad is considered to pose a risk to elements of biodiversity that feed on frogs due to its toxicity, and as a result causes considerable concern to members of the public and conservation managers. In part, community concern is also because of its perceived ugly appearance and the possible threat posed to domestic pets via ingestion. Accordingly, when toads first arrive in an area, community angst is high and people want to be able to do something about the problem. This has resulted in large amounts of public money being directed towards community cane toad collections (‘musters’) and education strategies. To date, more public money has been invested in cane toads than any native species, despite the disproportionally high number of vulnerable native frogs in Australia [11]. The value of these musters is questionable, because they often occur in areas that toads have been long established, often in townships, rather than at the invasion front or at sites where satellite populations have recently established.

As for all the management of all invasive species, and especially for aggressively invasive species, determining the geographic distribution and, especially changes in that distribution, of cane toads is crucially important. This is because it is likely that efforts to undertake control would have greater

effect at breeding sites at the invasion front. While conventional mapping techniques by small numbers of employed specialists may be suitable for some species, for widespread and rapidly expanding populations, they result in inadequate data. Understanding the details of the rapidly changing patterns of spread and locations of the invasion front within the landscape is, therefore, vitally important to management and may provide insights into control, and this can best be done by harnessing the observational power of a large community of public recorders.

Semeniuk *et al.* [12] showed there are characteristics associated with ponds used as breeding sites by toads; knowing this, and understanding the invasion dynamics, could allow land holders to make modifications to such habitats prior to invasion, perhaps limiting the breeding success. It is also apparent that habitats previously thought not to be suitable for toads are now being invaded [13], suggesting that the species may be rapidly adapting to new environments [14,15]. Factors in addition to climate, such as the density of road networks, heterogeneous topography, and connectivity of patches and ponds, may result in differential invasion rates [16]. Time since establishment also influences movement and dispersal behavior [16,17] with accelerated dispersal occurring at the invasion front in northern Australia [18]. Inadvertent translocations also occur, making it difficult to predict the toad's current distribution. Landscapes into which the cane toad has moved, such as the north coast region of New South Wales, are complex, and require a large cohort of observers to monitor species movement, especially over time. It is important, therefore, to be able to provide real time mapping of the dynamic and complex distribution of this invasive animal over a large and diverse landscape. Crowd sourcing provides one means to achieve this.

2.1. The Approach

We developed a prototype web page in 2007, Toad Tracker, that interfaced the Google Maps Application Programming Interface (API) with a MySQL database [19,20] (Figures 1 and 2). The page allows users to report sightings via a simple point-and-click means, to populate spatial data into the database and to answer a short series of questions associated with their sightings (Figure 3). The website was developed as a means of demonstrating to conservation managers what could be achieved with the use of Web 2.0 technology and, as a pilot study, was promoted only to a small number of community groups via a series of information sessions. These sessions primarily focused on the nature and extent of the problem in northern New South Wales (eastern Australia) and highlighted the importance of documenting the cane toad's distribution. Participants were asked to test the interface in their own time, and to provide records of toad sightings. Feedback on the idea was sought from natural resource management agencies, with the intention being that an appropriate agency further develops and promotes the idea.

The Google Maps API allows the respondent to search for their desired location (e.g., a street address) and place a marker on the map for the toad sighting. For our purpose, the marker is not shared with other contributors, but rather it allows the project manager to harvest the spatial data with the data sent directly to the MySQL database upon submission. This approach was chosen because of concerns regarding data storage and security, and the need to protect the personnel information of respondents. Google maps does not currently impose an upper limit to the number of records stored by them when

using their API, but does reserve the right to impose a limit in the future [19]. This influenced our decisions when initially building the interface.

Figure 1. Outline of the Toad Tracker architecture.

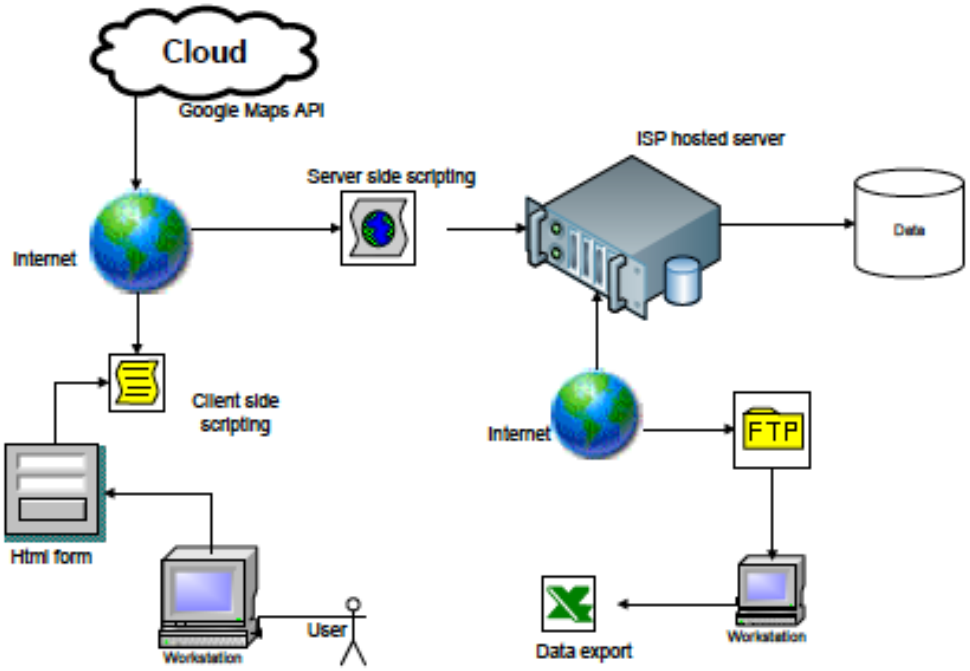


Figure 2. Outline of the Toad Tracker development sequence and data flow.

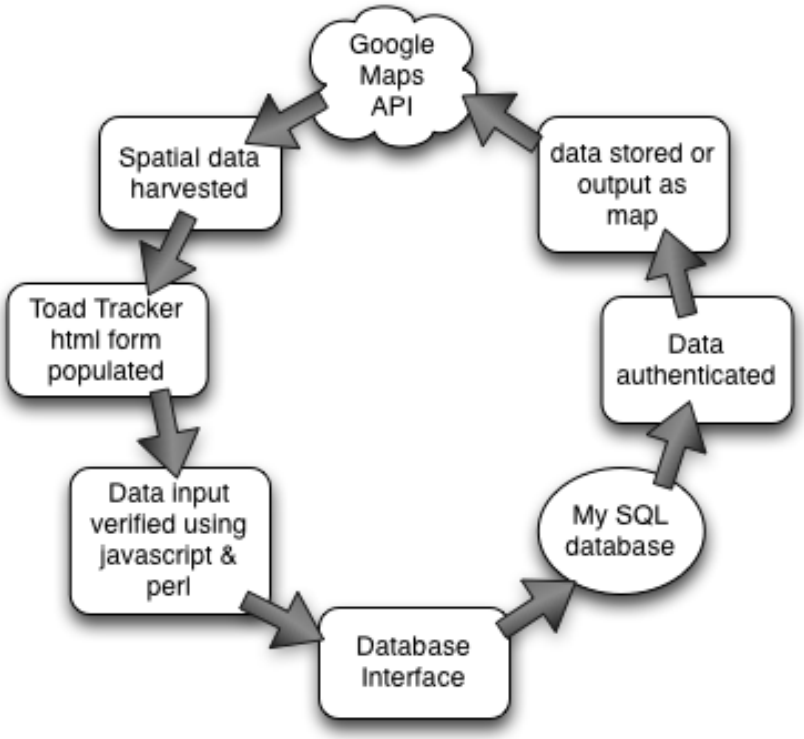
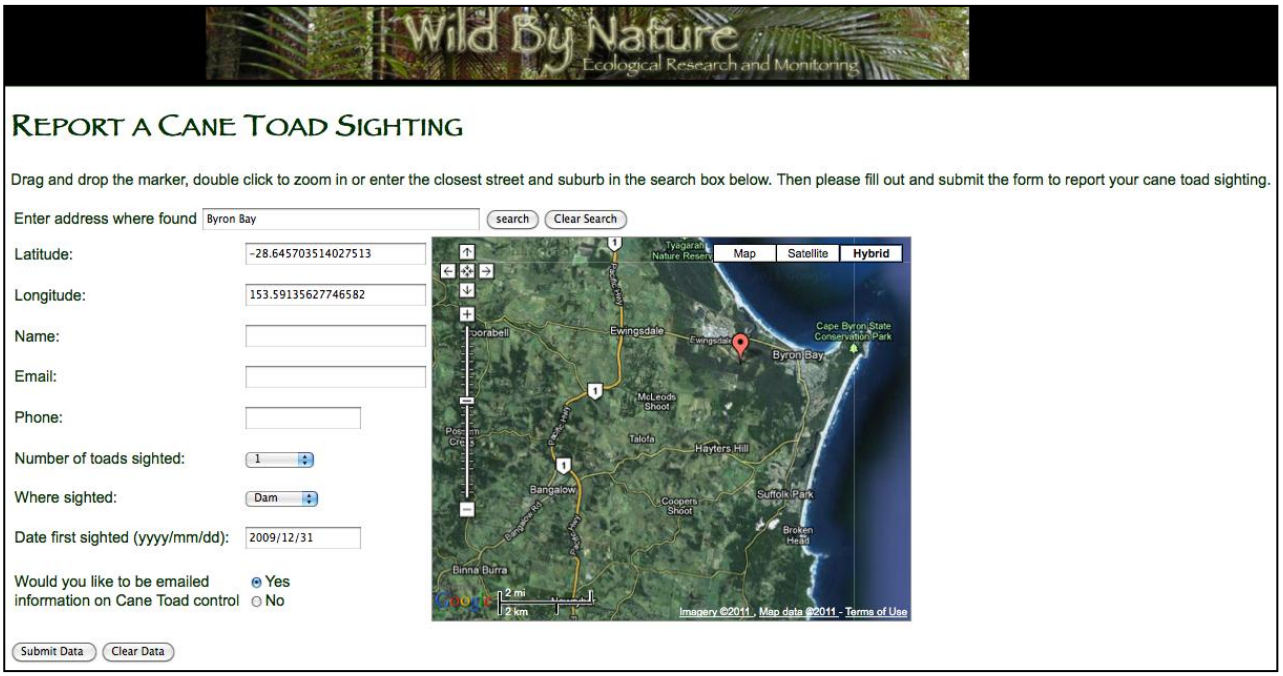


Figure 3. A screen shot of the Toad Tracker interface.



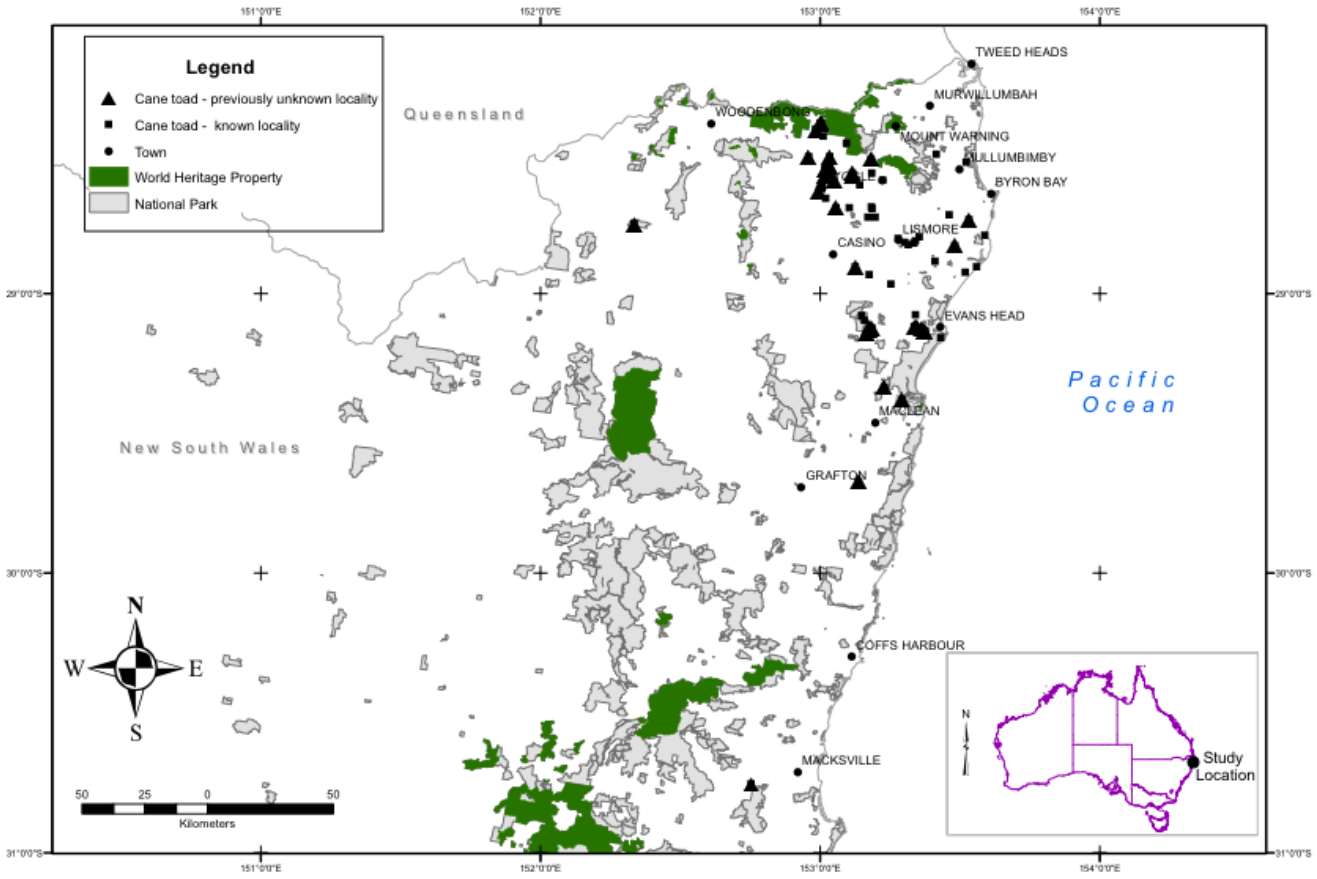
3. Results and Discussion

The pilot study has demonstrated that a relatively simple Web 2.0 adaptation can provide a valuable management tool for conservation biology. Our pilot community engagement and mapping exercise resulted in the submission of over 300 sightings of cane toads into the database during its pilot phase, and generated considerable interest from the community. Whilst the records were dominated by locations from around people's dwellings or on roads, several of the records were from locations not previously known to be occupied by toads (Figure 4). Importantly, toads were recorded in several key conservation areas, in terrain thought to be either too remote or too elevated to support the toads. Not only were they present where they were thought they should not be, the localized distribution patterns has forced conservation managers to re-assess their understanding of routes and modes distribution into the new territory. These records demonstrate that toads are continuing to spread into new areas, and that our previous understanding of the process of spread was limited. The records also demonstrate community knowledge can greatly assist in documenting this [13]. While we could extend this commentary on the details of the data collected, for example, by mapping data according to different risk areas based on cane toads population density using some form of geostatistical estimator, such a discussion would be more appropriately recorded in an ecological management (rather than Web 2.0) paper. In the meantime, Figure 4 illustrates the expansion of the recorded distribution of the cane toad in the study area by the end of this pilot project.

Our important observations here lie in reflecting in the utility and uptake of such a mapping tool, and it is this theme we wish to continue in this paper. Surprisingly, despite the success and utility of this tool—while we have not logged details of usage statistics, we note that for a tool focusing on a geographically limited phenomenon, there has been, impressive usage, with over 1000 hits up to the time of writing—there was resistance from conservation managers within government departments to the adoption of the idea, and as such the promotion of the web page was limited. These responses drew

attention to several issues surrounding Web 2.0 and the Geoweb. We consider two here: data ownership, and whether such an approach represents a new discipline "neogeography" or is simply another new tool.

Figure 4. Distribution of records of cane toad observations collected using the Toad Tracker interface, and illustrating the distribution of records outside the previously known distribution.



With regards to data ownership issues, while we can demonstrate clearly that the technical aspects of our approach are manageable, and can provide an important information portal and data collection tool, the adoption of such a tool by management is problematic. Their concerns stem largely from issues surrounding data ownership, with suggestions that a privately run database was not an appropriate tool. It was not the intention, in establishing the prototype, to impose a "privately run database" for a public service, but rather to demonstrate to government officials what could be achieved with this use of Web 2.0 technology. Such tension probably arises from the fundamental nature of such technological development: This use of Web 2.0 has been described as typically engaging geographical techniques, tools and practices that are traditionally beyond the scope of professional geography [21]. For some officials, there also appeared to be a lack of understanding as to why this approach was innovative. Perhaps somewhat naively, it was thought that the research utility would suffice to convince managers of the acceptability of the tool. We were comfortable with the public/private nature of data and the database, in ways that the managers were not. The implication

here is that managers and others who are not involved directly with the innovation, but may be required to take on board the new technology—probably the early innovation uptake majority of a workforce [22]—require more than technical understanding and training to allow them to comfortably adopt the Web 2.0 technology. This is especially so where there are new forms of technology, changes in conventions of data ownership [23], and new ways to generate data.

The notion of data ownership is of interest, because the basis of Web 2.0 lies in collaboration, re-use, and sharing of data [23]. Behaviors and attitudes towards ownership and copyright in today's technological environment challenge traditional concepts of copyright and intellectual property [24]. These are notions that may continue to challenge scientists, publishers and authors for years to come—indeed, it has been argued that such notions may need to be re-conceptualized rather than merely modified and accepted by users—but they provide a platform for harvesting knowledge on a scale not previously available; this is especially so where data collection is a collaborative activity engaging non-specialists [25]. Keen [26], for example, describes the Web 2.0 phenomenon as "the cult of the amateur", and is highly critical of the value of sites such as Wikipedia. The slogan that drives Wikipedia is that "no-one knows everything, everyone knows something". There is a growing awareness that the relationships between public and private, state, civil and corporate, expertise and authority, etc. are both being challenged and changed [25,27]. However, and perhaps more importantly but less explicitly, there is a critical intellectual shift as power is shifting the professions to Web 2.0 communities, reflecting the more widespread postmodern changes in the social conceptualization of knowledge and authority [21]. Such a shift is likely to present a significant challenge to pragmatists, such as environmental managers, trained in the sciences. The consequence is a suspicion of apparent weaknesses of such new methods, of the risks to trust in information not being collected (controlled) by experts, but seemingly being mediated through business models and commercial systems, and in unconventional methods that do not confirm to established professional practices [21,28]. In the context of Web 2.0 for conservation biology, for example, data will always require verification—ideally by "experts"—despite the clear need to address the adage that, "you can't be everywhere at the same time". Tools such as Toad Tracker facilitate contributions from amateurs that can inform research being conducted by experts, saving time and money.

Accepting such a change in relationships between experts and the public requires a culture shift. While some agencies seem resistant, there is a significant growth of major providers of geographic information—who have conventionally been part of the traditional geography industry—such as state surveying and mapping departments, making the cultural shift, and adopting the culture and tools of neogeography [29]. However, for some agencies, perhaps those less embedded within the geography industry, technological innovation is occurring faster than managers can respond, and this has implications for the geospatial aspects of Web 2.0, particularly in relation to privacy [28]. The issues and concerns of geospatial scientists, as they witness their expertise being 'googlized' [28], are similar to those that information scientists and librarians lived through as powerful meta searching engines were developed that enabled cross platform and cross database searching. What many librarians perceived as a dumbing down of catalogue and database searching has actually resulted in increased accessibility to information for the end user. Similarly, the perception of Google maps as a dumbing down of cartography results in increased availability of mapping data to the general public. However, it is also creating new ways of communicating via maps. This may ultimately lead to improvements in

spatial literacy, and thus improvements in spatial literacy [28], as it becomes increasingly easier to view the world from above. As Web 2.0 tools are adopted in innovative ways, therefore, the principles underlying them will become increasingly accepted and adapted to achieving outcomes [30]. This means that the contextual and cultural ground rules need to be carefully revised and developed: we need to examine and develop new social rules in the light of the new social ecology required to encourage innovation and allow for modified forms of knowledge creation [29]. Developing new social contexts—for environmental managers, for example—will create the conditions for a new engagement between the logic of collaborative or open source technology and the management systems using it [29].

Part of a solution to developing the new social context may lie in demystifying the new and emerging technology. In this context, and in the light of our example, we close on a question: is this a "neogeography" or just a new tool? With the growth of the concept of neogeography over recent years [31–33], from a mapping perspective, in the last five years, the notion of map making has shifted rapidly with the advent of Web 2.0 tools such as Google maps. Geospatial web tools are creating new ways of communicating an increasingly diverse range of ideas via maps, although whether this expansion of options really represents a significant challenge to cartography or the evolution of a new geography, is a moot point. It is worth considering, because it does have implications regarding the reception of such new technology by non-innovators, both information users and information creators. Here we demonstrate the value of the technology in extended conventional data collection, increasing the potential of such data collection for conservation managers. While it is important for such managers to accept and adopt the technology, for the full benefit to be realized, it is equally important that geographers and cartographers embrace these technologies in ways that the fundamentals of paper-based map communication—the long established advantages of the cartographic tradition—are incorporated into the new approaches. In making this claim, we close on a reflective question, for which we, at present, have no specific answer. We present it, however, because we consider that it is something many "official" users of neographical tools will need to ask—and answer—as part of their path to adopting not only the new technologies, but, more importantly, the cultures of the new technologies and their applications. The experience and views described in this paper reflect our own professional experience and disciplinary backgrounds, backgrounds that are not dissimilar to many specialists. The question is this: how do the intellectual conventions and experiences of specialist users wishing to engage neogeography align with published views that the methodology of neogeography, rather than making "claims on scientific standards, … tend[s] toward the intuitive, expressive, personal, absurd, and/or artistic, [and] may just be idiosyncratic applications of 'real' geographic techniques[; t]his is not to say that these practices are of no use to the cartographic/geographic sciences, but that they just usually do not conform to the protocols of professional practice." [34,35]?

4. Conclusions

Given the success of the prototype, both in terms of strong use and impact on the environmental management issue, it is appropriate to consider an update of the tool. Interestingly, at the time of writing this manuscript, a new participatory web-interface called Toad Scan has recently been launched by the Department of Primary Industries (a state government authority in New South Wales).

The adoption by the government of the tool is important, in its recognition of its utility and relevance to environmental management, and represents official acceptance of the need for a next generation version of the tool; it mirrors the experience of uptake or adoption of such technology by official or mainstream agencies elsewhere [29].

The new Toad Scan interface is a vast improvement on our crude use of Web 2.0 to document toad distribution, and demonstrates the utility of participatory GIS in addressing this conservation problem, as was our initial vision. All records held in our Toad Tracker database have now been incorporated into Toad Scan (excluding any contact details) and Toad Tracker now redirects users to Toad Scan. Whilst government authorities have been slow to embrace the geoweb approach, we consider the full potential of such technological adaptation has yet to be realized.

The notion of a network of willing participants in a data collection exercise across a broad landscape, is a very powerful management option for conservation biology, and could be extended in some interesting and innovative ways [36–38]. For example, the technology could easily allow users to participate in the submission of geo-tagged audio files via smart phones [21], and a coordinated approach would allow a network of participants to collect these files at the same point in time. Participants would go to their local pond (say on the first night of Spring), record 10 minutes audio of frog calls, and upload the geo-tagged audio file to a web site. Instantly, the raw data for a patch occupancy study has been collected on a scale not previously possible. Improvements in call recognition software [39,40] allow such files to be searched for characteristic patterns (e.g., the call of a cane toad), resulting in a data set that identifies which ponds are occupied and which ones are not. Whilst there are limitations to the approach, especially in terms of the spatial patterns of participants, the possibilities are indeed exciting.

Whilst Web 2.0 technology offers new and interesting ways of conducting participatory citizen science, there needs to be fruitful collaborations between researchers, conservation managers, policy makers, software developers and end users in order to achieve meaningful conservation outcomes [36–38]. This paper uses the example of an application developed to allow community-based collaborative data collection for a natural resource management issue, the understanding of the population distribution dynamics of a pest species. The application can be demonstrated to work, and therefore contributes to the view that, by demonstrating what can be achieved and applying these approaches to new fields of endeavor, it is possible for potential users, such as environmental managers, to recognize the true geospatial potential of Web 2.0 tools. However, the experience of its implication raised practical social issues, rather than technical issues, regarding its acceptance and rapid adoption by the professional community. In particular, concerns around ownership of the application, the tool and the data, stemming from the public nature of the technology and the role of non-specialist data collectors—the community-based collaborative providers of data—require us to consider the role of culture change. In parallel to the technological development, there needs to be consideration of the potentially significant shifts in attitude towards knowledge, authority and ownership required for a profession to adopt such tools with comfort.

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