A web-based biodiversity toolkit as a conservation management tool for natural fragments in an urban context

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THESIS

A thesis submitted in the partial fulfilment of the requirements for the degree Magister Scientiae, in the Department of Biodiversity and Conservation Biology, University of the Western Cape

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KEY WORDS

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ABSTRACT

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The collection of biological information has a long history, motivated by a variety of reasons and in more recent years is largely being driven for research and academic purposes. As a result biological information is often linked to a specific species or ecosystem management and is discipline specific, not relating to general management actions at a specific conservation site. The biological data that exists is often not consolidated in a central place to allow for effective management of conservation sites. Different databases and formats are often used to cover biological, infrastructural, heritage and management information. Biological information has traditionally not influenced real-time site-specific conservation management, with long term data sets being used to draw conclusions before they can influence management actions.

In order to overcome this problem of scattered and unfocused data a biodiversity database related to specific site management was developed. This study focuses on the development of this database and its links to the management of spatially defined sites. Included in the solution of scattered data are the applications of information management tools which interpret data and convert it into management actions, both in terms of long term trends and immediate real- time management actions as the information is received and processed.

Information systems are always difficult to describe in words as much of the layout and information is visual and hence difficult to convey I just the text of this document.

A breakdown of the resultant information system is outlined in detail in the conclusion section. During the development of a Biodiversity Database it was found that management tools had to be developed to integrated data with management. Furthermore it was found that human error was a significant factor in poor data quality; as a result an observer training programme was developed.

March 2016

DECLARATION

I declare that the "*A web-based biodiversity toolkit as a conservation management tool for natural fragments in an urban context"* is my own work, that it has not been submitted to any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete reference.

Dalton Jerome Gibbs March 2016

Signed……………………………….

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Preamble

For the past two decades my conservation career has been devoted to the management and survival of the natural remnants that still persist on the Cape Town lowlands. Often small and without grand landscape features to commend themselves to, these fragments nevertheless support an inordinate array of biodiversity that is amongst some of the most threatened to be found anywhere on earth. During this period I have seen the landscape around these remnants undergo profound changes in all spheres, with not only urbanisation, alien vegetation, increased fires and nutrient loading becoming common, but also sweeping changes in the political landscape. It is my experience that politics and administration can have and does have a profound impact on the funding, management and political will needed to maintain natural remnants in a highly urbanised landscape.

In the post 1994 period a major restructuring of local authorities occurred; with the formation of six local municipalities out of the plethora of local authorities that apartheid planning had spawned across Cape Town. In the early 2000's these were further consolidated into the unicity metropolitan authority; namely the City of Cape Town. With this came the opportunity to develop a comprehensive conservation plan to rationalise and consolidate existing conservation areas. It also allowed for the development of a biodiversity network, where the planning of contiguous conservation areas could be based upon their biodiversity value and not merely anthropomorphic reasons that had often been the case before. The development of a biodiversity network brought about the need for biological information to inform the decision making; data such as the vegetation type, species present, ownership, geological features and past history.

My first conservation post was the management of Rondevlei Nature Reserve, which is a small conservation area located in the south western corner of the Cape Flats. As one of the older conservation areas in Cape Town it had been established in 1952 to conserve water bird diversity and was used as a study site for migratory waders coming to southern Africa. As a result it has possibly the oldest continuous bird count in Africa, with monthly bird counts dating back to its establishment. For a number of years I undertook the function of surveying and recording these data; a task that required a considerable amount of time. Further in my career I took over the oversight of a number of conservation areas where a similar situation prevailed and substantial resources are being devoted to monitoring programmes and data collection.

Thus when it came to the formation of the unicity of Cape Town, there was a need to consolidate the available knowledge for the new conservation sites. What was immediately apparent to me was the large knowledge gap with all existing historical data. Thus where information did exist, this was often scattered, inaccurate and fraught with taxonomic errors. Much of the historical data were paper based, and where such information was digitised, it suffered from incompatible or obsolete software and was invariably outdated. I was also confronted by corrupted computer files and in some cases incompatible computer hardware that could no longer be operated. What I found alarming was that in many cases such obsolete computer software and hardware were only a few years old!

In many cases species information was gleaned from old specialist reports or taken from quarter degree museum records for the local area. This often resulted in out of range species from adjacent mountains or obsolete species names that have undergone taxonomic reviews being included in reports. Many species lists had also been drawn up by interested members of the public and whilst well meaning, these lacked the credibility that is needed for a reliable species record on which to base the future biodiversity planning and management network for Cape Town.
During the search for sound biological information, a lack of other site specific background information was discovered. Documents such as a site's proclamation gazette, building plans, erf map and site history amongst others, were missing. In many cases these documents were but a few years or a decade or two old. This gap in information pointed to a need for an archive function.

It occurred to me at this stage that many of the short comings in data collection, storage and archiving of information are not disciplines that are highlighted or taught in conservation training programmes. Having been affiliated to the training of conservation students in Cape Town for a number of years, I could see the gap between the information discipline that existed in practical day-to-day conservation management and that which was encapsulated in the training syllabus. This was particularly true for smaller conservation organisations, such as the City of Cape Town, where the organisation lacked staff dedicated to data collection and information archiving.

With these short-comings in mind, I set about developing a biodiversity information system for use in Cape Town; this involved close work with an information technology company as well as referring to work colleagues and experts for information. When embarking upon this course I also took into account the broader administrative environment in which the natural remnants are located; namely in a local authority structure which has an annual budget cycle, a five year political cycle and an ever changing list of priorities which are dictated by a changing socio-political landscape.

At the time I naively thought that developing a database would to be a simple matter, with the development of a desk-top programme that could be loaded on to on-site computers that staff could use; something simple such as Microsoft Excel was thought to be sufficient. However it was immediately apparent that such a programme would perpetuate the existing problems. Furthermore such off- line data collection could only be shared by email or physical collection on to a memory device and would need painstaking amalgamation of the data into a central repository. This method would, therefore be open to many chances of data loss through human error, theft, physical damage, virus attack or corruption of local hard drives. A desk-top based application would also exclude the participation of data collection by large numbers of people and members of the public. The solution had to be an online database, accessible remotely at all times and operated, stored and backed up off site. The rapid changes in information technology over the preceding decade, when I had begun my career in conservation, allowed for the development of such a database. With an ever expanding internet there are reduced hosting costs for websites, faster and more efficient personal computers. Indeed I envisaged that much of the work and administration done by conservation managers would be done on the ever increasing electronic platform of the personal computer.

I thus entered the digital world; an unfamiliar landscape when one's training is the biological world, a world where few rules exist without exceptions. In contrast the digital world needed a programme which consolidated information as definite fact, but allowed the flexibility to include the exceptions that the natural world invariably brings. Working with Robert de Jager of Table Bay Software we constructed a robust online database that would address the short comings of the past. In the initial stages we modified the architecture several times in order for the Database to be able to constantly report on the species data for a local specific site and simultaneously report at a regional Cape Town level.

After having assessed the development of the early version of the database being used by new managers, it became evident that not only biological information was needed for site management. This was in part driven by the changing nature of conservation, particularly in the urban context. What had become evident to me over the years was that conservation was a changing discipline, expanding into a variety of new field varying from sociology, criminology and information technology. Indeed in many aspects I find the tasks performed by the City's conservation staff are far more complex and varied when compared to that which a conservator performed a mere two decades previously.

To address these other needs a variety of tools were added to the database as it developed. Thus a repository was needed to consolidate and store basic background information pertinent to a specific site. Thus we developed an archive function for staff to be able to store important site information in an off-site repository.

During my years of conservation management, I have often been struck by the disparity between the resources devoted to data collection and monitoring at a site on the one hand, and the lack of management actions resulting from these data collection on the other. When confronted by the acid question of "So what?" the function of data collection does not stand up to scrutiny. Whilst data collection may provide meaningful species, regional and ecological research information as well as increase our greater understanding of species and ecosystems, it very seldom directs management actions at the site where it was collected. Thus, tools had to be developed that would interpret biological data for site managers to assist with site management actions.

I also noticed the growing list of factors that influence urban conservation areas, which increases as the landscape develops around them. These diverse influences need to be recorded and tracked in order to inform management actions and can be as diverse as changing user groups, sewage spills, frequency and causes of wildfires, or safety and security incidents. Thus tools are needed to deal with biological and non- biological events in order to provide for holistic natural area decision making. To this end a site calendar tool was built to record, track and prompt, a wide variety of events that affect a natural area in one way or another.
I have witnessed the loss of institutional knowledge at conservation sites numerous times when the site manager leaves with invaluable management knowledge locked up in their head, or at best recorded in a variety of non-secure mediums in different places. Without a universally accepted, accessible and safe means to record information such management information was not recorded. Thus the knowledge of

previous management actions is lost to the new site manager who builds a new set of management actions from scratch, which can have negative consequences on the veld.

A good example of successive management actions that need to be sequentially built upon by conservation managers is the fire regime. Given the fact that the majority of natural systems in Cape Town require fire these systems are extremely sensitive to the impacts of human intervention. Where fire has been withheld from natural remnants, one sees not only the negative biological impacts on species, but the dangerous build-up of fuel which can have negative effects on surrounding urban areas when consumed in a wildfire. The result can be not only an ecologically poor fire but one that has detrimental effects on the relationship with surrounding land-owners, which is vital in a local authority context.

The maintenance of a regular fire regime is an important ecological driver and is one of the few management actions that a conservator can exercise on a large scale at relatively low cost. However, the shortest fire frequency in Cape Town is in the region of six years for Renosterveld remnants and by default is longer than the present planning time frames. Worse still is the longer period for Strandveld with a 30-50 year fire interval. These time frames are beyond the planning time frames of the City with its five year political cycle. Likewise the nature reserves themselves have management plans that are revised every five years; an inadequate system to attempt to lay down long-term burning regimes for natural areas.

The calendar tool was thus developed with these long term management interventions in mind; something that was missing in conventional management plans and likely to fall outside the scope of institutional site knowledge. Thus, the ability to record past management actions and then prompt a repeat of them in the relatively far future, helps to overcome the human frailty of knowledge management over many years of successive managers.

I believe natural area management requires experience which cannot only be gained from the necessary theoretical training, but requires a period of experience on-site where the manager learns not only about the abiotic and biotic but also about the social factors that exert influence on a site. This experience needs to be over at least a year in order to experience a site in the heat of summer and the flooded conditions of winter. It is necessary for the manager to experience this seasonal variation first hand and understand its effect as a driving force on the ecosystem they are managing. Whilst it is recognised that the Database can never fill this experiential function; we nevertheless built an online function to record information regarding the people that are associated with a site under the “Contacts” function. This information is aimed at allowing a manager to record the most important people associated with their site and pass this onto the new manager.

Most conservation sites in Cape Town support conservation training in the form of conservation students who undergo a year of experiential training on a nature reserve. During this year the students undertake various projects, one of which is veld management that involves the survey of species at the site. In addition to the surveys, a research project is embarked upon, often focusing on a specific species. I have observed that the species chosen for both survey work or for research are often either charismatic or easily dealt with species. Despite extensive monitoring being conducted at a site this information very seldom informs the survey and research priorities being conducted at the site.

In order to help inform survey and research priorities the statistics function for a site was developed, which maintains a daily update of all species logged against a site and highlighting when these have not been recorded for a long period of time. This allows managers to target those species which have not been recorded during their monitoring programmes and are in danger of being lost to the site.

After a few years I analysed the data being collected and deposited into the biodiversity database, focusing on data entry errors. What I found was that the majority of such errors were as a result of observer error; bluntly put the staff collecting the data did not have the identification skills needed to collect reliable data. Whist purely anecdotal in my mind I believe there has been a general decrease in the field identification skills of students and staff entering the conservation field. Where previously I received students from training institutions who were competent in field identification of for example birds, this has decreased and a student with such skills is now rare.

The response to this finding led to three developments. Firstly the sighting tool that existed was refined so that species choices were limited to the site being dealt with to minimise erroneous sighting records.
Secondly when species are first recorded for a site they are verified by an independent group of experts in order to maintain data integrity. This independent review checks for species identification and also serves to assist site staff in their field identification skills.

Thirdly and more importantly though was an effort I embarked upon to train staff to a minimum standard in a particular faunal group. This has led to the “Observer Standards”, a series of training manuals and field based tests which formally qualify people in a particular faunal group. Apart from being issued a certificate, these qualifications also reflect against a person’s profile on the biodiversity database as a future reference to prove competency. In launching these initiatives I am hoping to create a culture of learning and install a level of professionalism in natural history to obtain accurate data to support site management.

With this experience and scenario in mind I set about trying to understand the needs of information management for conservation management and to develop a biodiversity database that would add value to the managers on the ground; those who are tasked to hold back the tide of extinction on the Cape Flats.

1. Introduction

Early data collection

In the modern digital age there is an increasing ability to deal with massive amounts of information at much greater speeds, manipulation and depth of interrogation. Because technocrats are besotted with data management they often forget that the compulsion to record, quantify and categorize biological information is by no means a new phenomenon, being part of the way people interpret the world around them (Posner *et al*., 1988). Whilst the technologies at our disposal are without parallel in human history, we should never lose sight of the fact that the collecting and management of biological information is practically as old as the human race (Clutton-Brock, 1999). As such we ask many of the same questions that our forefathers did whilst following in their footsteps of collecting, interpreting and maintaining biological information.

Early humans lived in hunter-gatherer societies, living off the land and as such relied on information about species they had encountered across the landscape (Diamond, 1997). Although often not maintained in a formalised system, the essence of this information would not differ greatly from what a biological database might hold today. This interaction between cultures and biodiversity is today studied in the multi-disciplinary science of biocultural diversity, where a society's language, culture and lifestyle are influenced by the biodiversity with which it interacts (Maffi, 2005).

Historically biodiversity information was often captured in oral traditions, although when examined one finds that such information usually retained the essence of what we today call primary biodiversity data. This is information relating to what was seen, where it was seen, when it was seen and who made the observation (GBIF, 2012). This information was the life blood of hunter gatherer societies who moved across the landscape taking advantage of natural events that occurred in different places and at different times. Such information was often retained by the elders and religious leaders of the group, being passed on in song, dance, myth and oral stories (Rose, 1997). Without it, a group would flounder and lose the wealth of information collected over generations.

The necessity to collect, refine and retrieve biological information became even more important as humans began the process of the domesticating of plants and animals in different places across the globe (Chaline, 2011). Two interesting trends developed at this stage in the domestication process, namely that the number of people dealing with biological information decreased and the length of time over which the information had to be retained increased. Indeed only 200 years ago 90% of the population were involved in food production, whereas today some 2% now support the other 98% in food production (Long, 1986). Task specialisation amongst humans occurred during the animal and plant domestication process, with some people being farmers who were particularly interested in certain individuals of a species. As such records had to go back not just to the present animals or plants at hand, but back through the successive generations to trace their lineage (Clutton-Brock, 1999).

Attempts to classify not just the information but the organisms themselves were made at this stage, probably best articulated in the writings of the Greek philosophers such as Aristotle (Schmitz, 2007). Centuries later with the "Renaissance" and the "Age of Exploration" biological data collection became something of an obsession for some societies (Purchell & Gould, 1992), the motivation being driven by as much curiosity as the financial lure of economically important species. Often collectors, whose knowledge of the outside world was limited, would focus on curiosities or artefacts linked to myth and legend. This style of natural history study and information gathering is probably best represented in the Baroque style collection of Peter the Great (1672 – 1725), Tsar of Russia. He established a museum collection or *Wunderkammer* where a vast collection of natural and human oddities were displayed for the public. When the museum opened in 1714 it was to the motto: "I want people to look and learn", although the biological information on display was often collected on the basis of the largest, smallest, most beautiful and most bizarre. Little was done to order or systemize these sorts of collections where emphasis was placed on the aesthetics of the collection (Purchell & Gould, 1992).

The subsequent "Age of Enlightenment" brought with it a more determined study of systematics and order, building on the new Linnaean classification system and an attempt to order the seemingly endless variety of life being encountered around the world. The search for new species intensified and is probably best epitomised by the Victorian collectors who during the latter half of the 19th century scoured the globe in search of new species (Fuller,1987). As a result biological information relating to species became more precise, providing not just locality information but also information how the species might be grown or propagated (Purchell & Gould, 1992). This biological information was not merely a footnote, but had direct economic value as the collected specimen could potentially provide some important product or be some significant species in a taxonomic group. Emphasis was placed on the accurate collection of these data and given the limited communication and transport of the time, the collector could usually not return or correspond with someone back home about the details of the specimen collection.

The introduction of the Linnaean classification system in the 1700's at last brought a standardised means to classify and collate species into a structured taxonomic system (Arvanitidis *et al*., 2011). As a result a growing number of naturalists collected specimens and these were classified according to the Binomial Nomenclature system set out by Linnaeus (Schmitz, 2007). This new system of species classification, whilst setting a definitive name for a species, did not come without its own set of problems when data was lacking. An example is from Charles Darwin. Whist collecting information and specimens of his legendary "Darwin's Finches" on the Galapagos Islands he made a number of mistakes when labelling his specimens. As a result when the eminent ornithologist of the day John Gould (1804-81) set about studying the specimens, Darwin had the problem of recalling from memory and notes what islands various specimens came from. This initially hindered the description of the new species (Chaline, 2011).

The Linnaean classification itself has had to adapt to the new taxonomic tools in use today, accommodating genetics, phylogeny, genome sequencing and a wide variety of molecular disciplines (Arvanitidis *et al*., 2011). As a result many of the rules, nomenclature and conventions employed in descriptive taxonomy have had to adapt, in some cases greatly assist by modern information technology developments, leading to what is termed "cyber-taxonomy" by many (Arvanitidis *et al*., 2011).

Data in the modern context and the Global Biodiversity Information Facility (GBIF)

The term "data" itself has also undergone a change in modern times. According to the United States National Science Foundation it was historically viewed as "Precise, well-defined representations of observations, descriptions or measurements of a referent (object, phenomena or event) recorded in some standard, well-specified way". The modern day definition has a broader definition based upon technological changes, now defining data as "Any information that can be stored in digital form and accessed electronically, including, but not limited to, numeric data, text, publications, sensor streams, video, audio, algorithms, software, models and simulations, images, etc." (Moritz *et al*., 2011).

Thus biological databases are by no means new, but until recently these were small in size and contained fewer than ten variables. The dissemination of data has historically been closely linked to the prevailing technologies of the day and have in recent years undergone massive changes as the available technologies have proliferated (Moritz *et al*., 2011). Global communications and the means to exchange large quantities of data accurately, quickly and cost effectively has allowed data to be freely exchanged between multiple users (Moritz *et al*., 2011). Similar to the communication revolution, the analysis of these data was traditionally limited to the depiction of graphs, charts or tables and was conducted on data sets that could be outdated by the time it was analysed (Wang, 2003). The advent of the modern computer however has radically changed this, allowing for datasets of millions of values to be analysed in real time by thousands of variables, allowing valuable information to be "mined" from large volumes of data which would otherwise show no discernible patterns (Wang, 2003).

Also important however are the specific indicators that need to be monitored by conservation managers; monitoring that may require significant time resources (Jones *et al.*, 2010). In order to be of use to a conservation manager, data must be converted into information that can lead to management plans and actions (Rabinowitz, 1997). For this to occur management tools are needed to interpret the data and inform the conservation manager of actions that have been and need to be taken at a conservation site.

The progress that has been made in the global acquisition of biodiversity information can largely be attributed to the IT revolution and the availability of the personal computer. Of course the changes that computing have brought to our view of the world around us, has caused people to fear them. This fear, defined as the irrational fear and aversion of computers, has even been named "cyberphobia" by psychologists (Long, 1986). As computers have become more common in our work and living places, it is expected that cyberphobia would decrease.

Numerous biodiversity database information systems exist on the internet, with several initiatives attempting to combine the disparate datasets. Arguably the largest of these is the Global Biodiversity Information Facility (GBIF) which some authors present as supporting some >177 million biodiversity records and >1 million species names (Gilman *et al.,* 2009); although that figure has grown to some > 200 Million records, of which 25.7% are specimen based (King *et al.*, 2010).

At the 1992 Rio Summit the global community recognised the importance of open access to biodiversity data to attain sustainable development. Furthermore it recognised the disparity of distribution in information globally. The minutes of the proceedings recorded that "*the gap in the availability, quality, coherence, standardization and accessibility of data between the developed world and the developing world has been increasing, seriously impairing the capacities of countries to make informed decisions concerning environment and development.*" Furthermore it recorded that "*there is a lack of capacity, particularly in developing countries, and in many areas at the international level, for the collection and assessment of data, for their transformation into useful information and for their dissemination.*" (Gilman *et al.,* 2009). In research fields as specific as Mycology a call was being made of international collaboration to formulate at least a species list of the known taxa of organisms on earth (Hawksworth, 1991).

These sentiments led to a meeting of the Organisation for Economic Co-operation and Development Committee for Scientific and Technological Policy in 1999 to call for the formation of an international body to coordinate the standardisation, digitisation, and dissemination of biodiversity data. Out of this the Global Biodiversity Information Facility (GBIF) was formed in 2001, with a mission to "*make the world's biodiversity data freely and openly available via the internet".* GBIF is thus the only biodiversity information sharing facility established by inter-governmental agreement (Gilman *et al.,* 2009).

Great strides have been made in the dissemination of biodiversity information. However, due to limited access to digital materials and electronic media in developing countries, large disparities still exist in the availability, capacity and access of this information between them and developed countries (Gaikwad & Jitendra, 2006). This "digital gap" is further reinforced through the publishing of scientific research and biodiversity information in journals that provide such information on a "pay to view" basis only. Much of the world's biodiversity is unevenly distributed with high proportions found in the developing countries who are least able to afford this "pay to view" biodiversity information, resulting in it being unavailable where it is needed most (Gaikwad & Jitendra, 2006).

It is not just the dissemination of data that can be an obstacle, but the cost of data where this is being sold can be a real issue. In response to the possible growing economic obstacle of disseminating data a wide variety of scientific organisations signed the Berlin Declaration in 2003, with 302 signatories. Likewise the Organisation for Economic Co-operation and Development (OECD) in 2004 also recognised the importance of open access to primary scientific data (Chavan & Penev, 2011). This declaration has led to initiatives such as the Conservation Commons and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) providing platforms to recognise the need for open access to primary scientific data once it has been used in publication (Chavan & Penev, 2011).

In addition to this the GBIF initiative provides open access information in an attempt to address data inequalities by providing a platform for information to be freely disseminated and has made inroads into bridging the “digital gap”. Online databases of both specimens and related information are available in what is termed “biodiversity informatics” (Gilman *et al.*, 2009). These efforts notwithstanding, in order for biodiversity information to be useful in management it not only needs to be available but also needs to be correctly interpreted; with appropriate software that serves the interpretive needs of the end user. This is particularly important where limited research resources are available or real time outcomes are needed by end users. Such software applications can often be quite specific, can have limited specific applicability and are thus expensive to develop. Thus certain biodiversity software tools also need to be made available on an open source basis (Gaikwad & Jitendra, 2006).

This combination of open access specimen data, biodiversity information and software tools can help establish a “virtual research space” to promote biodiversity research. This is illustrated in figure 1 below which details the flow of information through open access principles to researchers (Gaikwad & Jitendra, 2006).

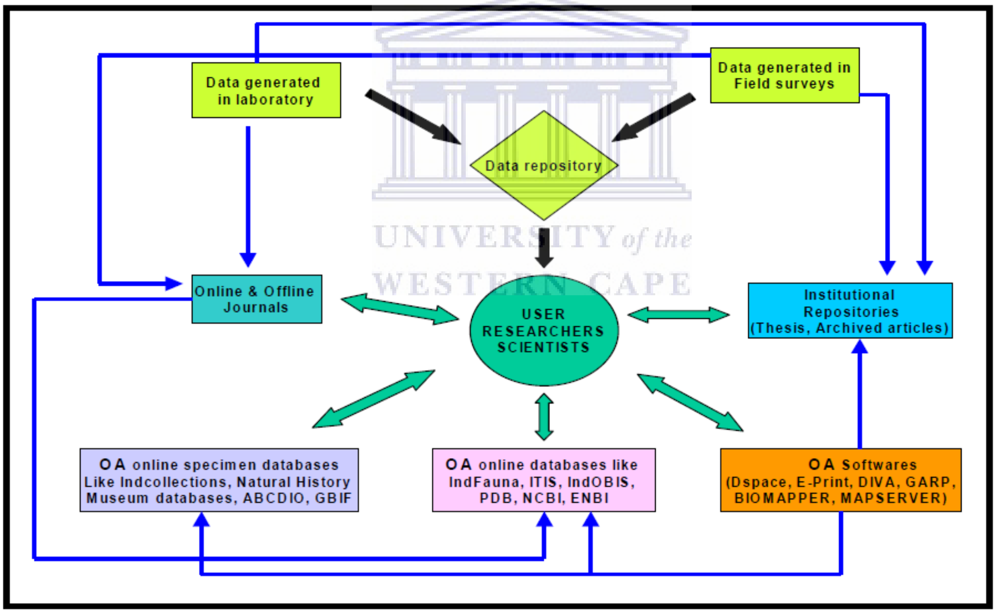


Figure 1: A diagrammatic representation of the open access to data and software, providing a “virtual research space” for biodiversity research (Gaikwad & Jitendra, 2006).

With the majority of humans now living in urban centres, it is within these confines that people will learn about and appreciate biodiversity and nature. Whilst usually associated with a more rural landscape the presence of nature and natural spaces is often central to the wellbeing of cities (Bowler, 2010), whose development so often compromises this asset (Sattler, 2009[1]). The biodiversity database developed here and its associated management tools attempt to provide a platform for the future management of such nature fragments and allow people to contribute toward their future survival (Copp & De Giovanni, 2007).

From research and examination of other biological databases that I have undertaken it is apparent that present examples on the internet and those used by some organisations are more geared toward the data capture. These data are then made available where it can be extracted primarily for research purposes. Such research may result in management recommendations, however, these are usually species linked and not usually linked to a whole site. In other cases these data may address a specific ecological issue, such as when a burn should take place, but do so as a recommendation separate from the site as a whole. Thus typically such a recommendation may come from a fire ecologist dealing with this specific issue.
It is my experience that modern conservation areas, in particular those in an urban context, present highly complicated management challenges (Knight *el al*. 2008) that include many non-biological facets (Holmes *et al.* 2012). Traditional databases do not address all such issues and impacts in one accessible place for the manager and do not integrate the diverse activities and impacts on urban conservation areas into one functional site.

As the biodiversity database presented here was developed, the need for management tools that record, interpret and motivate management actions became apparent. As a result a database has been developed that has a wider variety of management tools than were originally envisaged, providing some of the long term decision support needed by managers of natural fragments in an urban context.

Exploring the components of this document's title is perhaps the best way of determining what is being achieved. The title is "A web-based biodiversity database as a conservation management tool for natural fragments in an urban context". By examining these main components individually, the various elements and rationale of the database may become more evident. The first of these components is that it is web-based.

Having an internet web-based platform was an obvious choice to host a database that has to be accessed by numerous users simultaneously. Although connectivity and line- speed is an issue in many parts of Cape Town, the growth in this sector and the convenience made it an obvious choice.

The need for a biodiversity database was evident as in order to manage natural areas one needs to document the biodiversity on a site and be able to extract and manipulate that data in order to come to meaningful management decisions.

A conservation manager is in need of management tools that either interprets data that prompt management actions or are able to record and help repeat those management actions when needed. Thus the design of the database and its subsequent management tools are largely designed toward providing for the management of a site, and not primarily for any academic purposes.

The database that was developed and its subsequent tools are specifically designed to assist in the management of natural fragments; discreet entities of nature that are often engulfed in an urban landscape. These areas are often small and isolated; a patch work of sites with few linkages. Their underlying ecological processes are usually altered or broken and as a result they have impoverished biodiversity. Such fragments also often suffer from high and localised extinctions and need fine-tuned site-specific management actions to conserve as much as remains.

The biodiversity database was developed to be adaptive to the ever changing urban environment that the natural fragments are to be found in. To be of use to a natural resource manager a biological database must have tools that track real time trends and prompt management actions before ecosystems or species are compromised. Urban conservation areas are generally small and as such management tools need to be able to be scaled down to deal with fine detail conservation management; both at an ecosystem level and a species level.

During conservation planning for the Cape Floristic Region in 2003, it was found that three major problems had created the need for a systematic conservation plan for the region. These were namely; an outdated reserve network system that was not representative of the patterns and processes underpinning biodiversity, increasing threats to biodiversity, and a diminishing institutional capacity in conservation organisations (Cowling, 2003).

Accompanying the systematic conservation planning on the one hand there has to also be a planning component that accommodates the inherent uncertainty in ecosystems that support biodiversity (Lister, 1997). Furthermore the management activities in these conservation areas will need to be diverse, with clear objectives, well planned and yet adaptive enough to accommodate the routine and stochastic events in the ecosystems they try to maintain and restore (Lister, 1997). In order to achieve these apparently disparate objectives a biodiversity database is needed that will not only collect and archive information, but will also interpret biological information for managers on which to base management decisions.

It have been demonstrated that a gap exists between research, data, monitoring and the on-ground conservation actions that need to take place on a day to day basis in order to maintain conservation areas (Knight *et al.* 2008). In order for conservation areas to be effectively managed up to date data needs to be available to the managers. These data needs to be correctly interpreted so as to prompt effective management actions which will make maximum use of the limited conservation resources that are available.

This document is an attempt to explain and document what has been done to bridge the gap between information and conservation management through the collection and interpretation of data.

The biodiversity database that has been developed is an attempt to provide conservation managers with information and planning tools that are directly linked to the site that they manage. There have been many changes and iterations of this database in an attempt to refine the information that is served to support natural area managers in conserving biodiversity in an urbanising landscape.

2. Biodiversity Management in the Urban Context

The Cape Town example

The City of Cape Town (Cape Town) is a large (2 500 sq. km) metropolitan area on the south-western tip of Africa. As part of the Cape Floristic Region (CFR) it has a winter rainfall regime and is characterised by high species diversity, particularly of plants. The CFR is recognised as a biodiversity hotspot with high levels of endemism and globally recognised as a conservation priority (Cowling *et al*., 2003). People now have a global urbanisation rate of 50% (Sattler, 2009(1)) and like so many other urban centres across the world (Sattler, 2009(2)); Cape Town is experiencing a rapidly growing human population with high levels of immigration and urbanisation onto the Cape Town lowlands (Holmes, 2008). As such cities have become large expanses of human altered landscape which can be viewed as habitat types in their own rights where specifically adapted species can co-exist with humans.

Historical conservation initiatives in Cape Town began in the 1700s when the Dutch settlers acknowledged that timber and fire wood had become scarce and put limitations on the harvesting of this resource (Rebelo *et al*., 2010). Whilst these measures were to protect resources, conservation planning only came into being in the 1930s and was largely focused on the mountainous areas such as the Table Mountain chain, with the Cape Point area getting conservation status in 1938. As a result, the conservation estate in Cape Town was largely tied up in mountainous areas that did not encompass representative examples of Cape Town's vegetation types. This situation prevailed until the late 1980s, by which stage the plight of lowland vegetation and its associated species was dire (Rebelo *et al*., 2010).

By the late 1980's therefore some 13 Cape Town endemic plant species had become globally extinct and 18 % of South Africa's threatened plant flora occurred within Cape Town. This was despite Cape Town representing a mere 0.1% of the South Africa's surface area (Rebelo *et al*., 2010). Only by 1997 was some form of conservation planning for the Cape Town vegetation types implemented, with a study commissioned by the Botanical Society (Rebelo *et al.,* 2010). This study identified 20 Core Flora Sites which were necessary for the on-going survival of certain plant species.

This study was broadened in 2002, prioritising remnants city wide according to vegetation types, resulting in a network of sites which would require conservation in order to ensure the survival of vegetation types and species. This "Biodiversity Network" was re-evaluated once more in 2008, aligning it to the National Vegetation Map (Rebelo *et al*., 2010). The result was the identification of some 218 sites, covering 85 000ha scattered across Cape Town, covering some 34.18% of the City's surface area (City of Cape Town, 2010).

In order to draw up this Biodiversity Network natural vegetation fragments were analysed from aerial photography and underlying geology. Other factors such as fragment size, connectivity to other fragments, social factors and quality of the habitat were determined during ground truthing exercises that the author was involved in. Where species lists existed for sites, these were added to select sites based upon species presence (Rebelo *et al*., 2010). As a parallel process to this conservation planning exercise was the administrative and political amalgamation of the six local municipal and one metropolitan council into a single municipal entity, the City of Cape Town, starting in 2000 (City of Cape Town, 2006). Early in this municipal amalgamation process and the Biodiversity Network study, were the lack accurate species lists for many remnant sites. This was particularly evident for vertebrate fauna where no small animal surveys had taken place (Pers. obs., 2006). While compiling species lists I found that where biodiversity data was available it often suffered from a lack of validity. This stemmed from the records not being able to provide the minimum requirement of for verification; an example of such a set of criteria are those used in the Darwin Core data standards (Coetzer *et al*., 2013). These factors were established by the Biodiversity Information Standards (BIS); formerly known as the Taxonomic Databases Working Group (TDWG) (Coetzer, Moodley & Gerber, 2013), which comprises an international group of scientists.

The basic five factors are:

1 Who made the sighting record?
2 When was the record made?
3 What species was sighted?
4 How many individuals were there?
5 Where were the species sighted?

Of these five factors only the species in question and the site were usually listed. Upon examination it was found that a number of species lists for sites were taken from historical museum records for the quarter degree square in which the site was located. As a result sites that were located near to significant habitat changes (as example a mountain) and had proportionally more species that would be absent from the site than sites which bordered similar habitat types (Pers. obs., 2006).

Additionally existing species lists often had spelling errors, particularly the spelling of Latin names that do not readily occur on spell checkers (Dalcin, 2005). In some cases species lists had been complied on manual type writers and had been photo copied as the need arose. Additions to the species list were added manually to these lists, which perpetuated any taxonomic naming errors or did not take into account taxonomic name changes to species (Pers. obs., 2006.). This reduced the value of these lists in using them for conservation planning.

Conservation Management in an Urban Context

The present worldwide biodiversity crises can be primarily linked to five human related actions, namely pollution, over harvesting, alien invasive species, habitat destruction and habitat fragmentation. The high human population growth rate, with its resultant densely populated urban areas often exacerbate these problems, in particular the effects of habitat fragmentation (Delaney *et al*., 2010).

The equilibrium theory of island biogeography maintains that such fragments will lose species diversity until a more “relaxed” state of species equilibrium is attained (Bond, 1988). It is thus highly desirable to establish a conservation network that conserves not just habitat types, but also the underlying ecological process and dispersal corridors for species (Angold *et al*., 2006). This is due to biodiversity conservation measures not matching the scale at which biological processes take place (Henle *et al., 2010*). For this a landscape view of conservation is needed

(Henle *et al.*, 2010), a luxury that is not always available in a rapidly urbanising landscape. Thus in striving to conserve natural fragments management authorities are challenged to conserve as much connectivity as possible to maintain the integrity of habitats for highly endangered or endemic species. Indeed it has been argued that whilst the implementation of a conservation plan is most effective if it can be implemented immediately, in reality an implementation plan will take several years to be effective. The resultant conservation estate can thus be sub-optimal (Meir *et al.,* 2004), as the original conservation plan does not keep abreast of changes in the landscape. In the case of Cape Town several iterations of the Biodiversity Network have been generated, to do so required up-to-date information of what still remained (Meir *et al.,* 2004).

My understanding of conservation management has been formulated during 20 years of active management of the conservation areas on the Cape Flats of Cape Town. What I experienced was that there are essentially three attributes that a conservation manager has to manage on a conservation area; namely biodiversity, people and infrastructure (see Figure 2 below). Each one of these attributes interacts with the other two, forming an interacting triangle (see Figure 2 below). Thus infrastructure interacts with people as well as biodiversity. Biodiversity interacts with people and infrastructure and people of course interact with infrastructure and biodiversity. These interactions between attributes can be either positive or negative Regardless of whether these interactions are positive or negative their impacts have to be managed by the conservation manager in one way or another.

Practical conservation management involves balancing the often conflicting needs and demands of these three attributes without jeopardising the sustainability of a conservation site (METT, 2014).

In order to balance these conflicting needs a conservation manager must prioritise various management actions the often conflicting needs of biodiversity, people and infrastructure. In order for these management actions to be effective they need to be weighed up against a number of considerations which are amongst others;

1. at the right interval
2. in the right sequence
3. at the right intensity
4. in the right season
5. using the correct techniques and methodologies
6. within various legal parameters and mandates
7. taking cognisance of public opinion and social norms and
8. within budget (Pers. obs., 2014; METT, 2014).

In order to plan for these management interventions a conservation manager requires accurate and relevant information upon which to formulate conservation actions. These conservation actions will be further informed by the budget and resources available at the time (METT, 2014). Thus for this and other conservation activities the maintenance of a reliable, accurate and verifiable species list of a conservation site is one of the cornerstones of the conservation management of the site and its ecosystems.

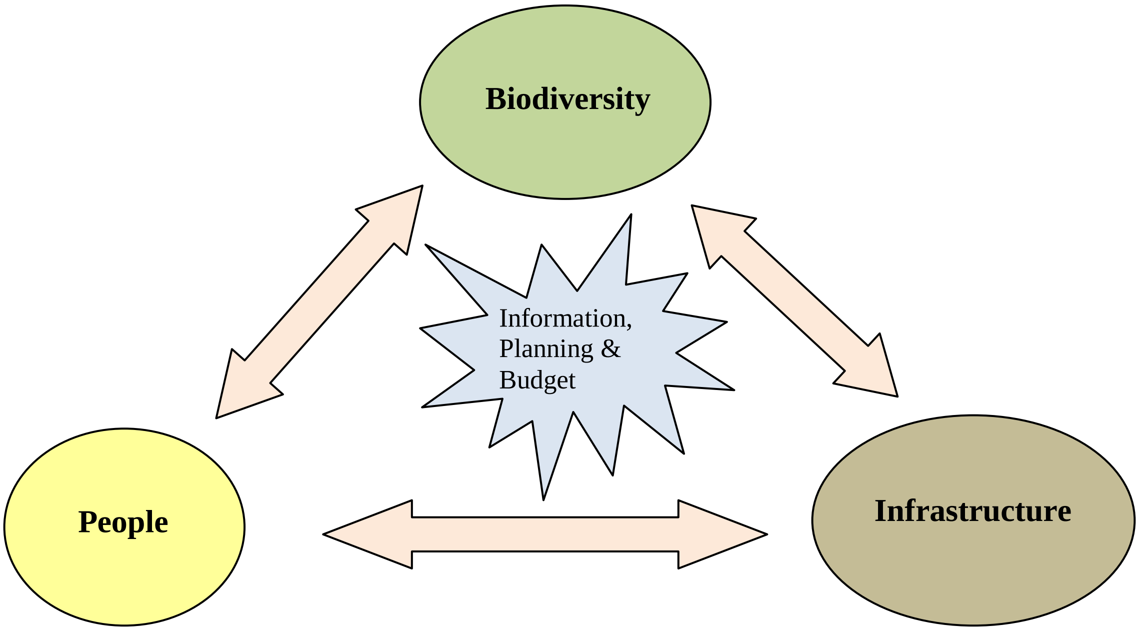


Figure 2: A diagrammatic representation of physical attributes in the management of a conservation site; influenced by planning, which is in turn informed by information.

Validating Historical Data

In order to provide a repository for species lists of conservation sites in Cape Town, I, along with others, developed an information system to support both old historical information and integrate future species sighting records. Support to develop this information system came in the form of advice from conservation managers and sponsorship for the design and development from an IT company. Information that was found to populate this new database can be broken up into two types; redundant information and new information.

Old historical information was obtained from species lists from sites that came from a variety of sources. These were often drawn up over the years by a variety of people; from consultants, conservators, botanists and interested members of the public. The source data were compiled from people's own observations, hear-say information, from literature, museum records and quarter degree square records.

Almost all the information which I obtained for Cape Town were observational records and where these might have referenced captured specimens, none of these were kept as specimens in a recognised collection. This is in stark contrast to the international norms where for example the GBIF dataset has 64% (114 Million) records that are observational based and 24% (42 Million) records based upon specimens (Gilman *et al.*, 2009). This disparity is not surprising since the Cape Town data sets originate from small conservation areas where data had mostly been collected by non-professional staff that had neither the time nor resources to maintain a specimen collection.

As mentioned earlier a major problem was the writing up of species lists by site managers or interested parties. As a result the Latin names given to species were often spelt incorrectly as species lists were manually compiled. Such errors were often perpetuated when the data were digitally passed from one manager to another.

These spelling errors lead to a number of teething problems in loading these historical data onto the database, with the system not recognising incorrectly spelt information and errors had to be dealt with manually and interpreted on a case-by-case basis. In a few cases no reliable match for a species could be found in the spelling and the species record was therefore discarded (Pers. obs., 2008).

In order to clarify the origin of the information, all historical information was loaded on to the database as a sighting record which we marked as "Historical Record". This would clarify its origin for any future users of the database. In order to achieve this an observer profile was created and named "Historical Record"; with all the historical records being loaded against this "observers" name. Thus all such historical records attempt to reflect that such records were based upon an inherited record of unknown origin.

The historical information was also all dated 1/1/1998 for two reasons; firstly because the first day of a year is an obvious date for a historical record to be created and secondly this is 15 years before 1/1/2013 when species that have not been verified for a site will be deemed to be "Lost to site" for their site. The bulk of the historical data was loaded in 2007, giving six years for species to be verified by site managers before the species moved on in the site species list to a "Lost to site" status. A species moves to a "Lost to site" status if it has not been recorded for 15 years at that site.

Subsequent to the loading of historical information, new recent information has been obtained from sighting records by conservation staff and members of the public. These records have come from *ad hoc* observations, field surveys and monitoring techniques such as camera traps. This information has either been captured as individual records or as bulk batch captures such as a bird count. Since they are new they are verifiable and have been subjected to the data verification techniques built in to the database (Chapter 10).

3. Information Management Systems

A database is an organized collection of data used for the purpose of modeling some type of organization or organizational process (Hernandez, 2003). Whereas historically such information has been collected before, the layout of the information in modern databases allows for a cross referencing of information that produces relational conclusions to be drawn which were not seen before. This relational database layout was designed by Dr. Edgar F. Codd in 1969 and has arguably become the most widely used database model in database management today (Hernandez, 2003).

A databases's primary function is the storage of large amounts of information in a structured way (Kriegel & Trukhov, 2003) according to rules specific to that dataset (Hernandez 2003). Thus data are collected according to the column or group that these data belongs to, which is essentially a data type (Kriegel & Trukhov, 2003). This organized collection of data can then be used for the purpose of modeling some type of organization or organizational process (Hernandez, 2003).

The 12 principles of a relational database design outlined by Dr Cobb are listed below (Hernandez, 2003).

1. The information must be logically presented in tables.
2. Stored data needs to be logically accessible by tables, primary key and column.
3. Where no values are given, these need to be treated as "missing information" and not as blanks or zero's which are real values.
4. Information about the database needs to be stored in the database itself.
5. A single language must be able to define the data, authorisations, transactions and data manipulation.
6. Views must be able to show updates to their base tables and vice versa.
7. A single operation needs to be able to update, retrieve, insert or delete data.
8. There is a logical separation between batch and end user operations and the physical storage and access methods of the database.
9. Batch and end-user operations are able to change the database without recreating it or the source data.
10. Constraints on the integrity of the data must be stored in the database and not in a separate application programme.
11. The language used for data manipulation in the database should not care where or how the physical data is distributed and should need to be changed if the data is centralised or distributed.
12. Any row processing done in the system must agree with column and group design.

Using these design principles from the start will reduce design flaws, increase accessibility and facilitate flexibility in the database structure as it grows over time. In order for a database to serve its purpose, several key criteria need to be built into the design and upheld during its operation (Connolly & Begg. 2016). Several were considered vital to the successful development and long term operation of the database; these are:

Sufficient capacity. A database needs sufficient capacity not just for its present data storage needs, but also to handle future data record storage as well as the capacity to archive historical data. Such storage capacity needs to not only have the technical capacity to store megabytes and terabytes of data, but be able to do so in a structured manner (Kriegel & Trukhov, 2003). This criteria was considered as the database was expected to grow over the years. Due to the real time nature of the way data was to be retrieved, it meant that very little data could be archived and hence sufficient up to date storage capacity would be needed.

Adequate security. Data that are stored need to be protected not just from deliberate human actions such as data theft and malicious attack but also from carelessness and accidental damage. Furthermore data needs to be protected from technical failures and natural disasters that may befall the storage site. Adequate security needs to cover such potential damage to the data integrity, but cannot be at such a level that access is hindered so as to make the data unavailable to authorised manipulation (Kriegel & Trukhov, 2003). This criteria was considered as the database was to be made available at all times to multiple users, some of which would not be vetted as formal users on the system beforehand.

Multiuser application. The database needs to be able to provide simultaneous access by several users who may be viewing the same information. The information offered must remain consistent to the multiple viewers; however the database must have internal structure rules to prevent data corruption by two or more users altering the same information at the same time. Likewise viewing access rules may need to be installed to limit certain data for certain viewers.

The database was designed to be used by conservation staff and public interest groups and as such needed to be accessible to multiple users simultaneously.

Efficiency. The data that are stored needs to be quickly accessed by users, allowing for the fastest access times to the raw data. Efficiency also relates to user queries of the database; where queries not only have to be answered as fast as possible, but should also reduce the amount of input having to be done by the user. This is achieved by efficient search algorithms which are designed and set up for common anticipated database enquiries.

The database was designed to be able to provide real time management options based upon the data and hence data storage had to be efficient to tap into.

Flexibility. The database needs to be able to accommodate several factors that are likely to change over time. Firstly the amounts of data are likely to increase; requiring a database design that will accommodate a growing data set without compromising the integrity of the data. Secondly a growing data set may necessitate an archiving of older data, which has to be accommodated in such a way as to allow easy access but not hinder algorithms dealing with more recent data. Thirdly the database may need to accommodate future changes in the way data are captured in the future, where additional data fields have been incorporated into the dataset without compromising the older dataset. Fourthly the database needs to be able to ensure the integrity beyond the lifespan of the hardware and software which supports it. This is vital given the short lifespan of technical hardware and software in the rapidly changing IT landscape, and finally the database needs to able to accomplish all this flexibility with no or as little down time as possible; allowing users to uninterrupted usage whilst background upgrading is taking place (Kriegel & Trukhov, 2003).

User-friendliness. As obvious as it may seem, databases are not written for the programmers who write them but users for the who often have little or no knowledge of the background programme. As a result the database needs to be easy to manipulate for various queries and data inputs that users might have. Typically users will access the database through a graphical user interface on different machines with different internet service providers. User-friendliness needs to take these various hardware factors along with security, efficiency and multi-user application into account when configuring the user interface.

Whereas historical databases may have been made up of a hundred or few thousand values, the modern computer allows for such databases to exceed millions of such values. These can also be analysed with far greater complexity than before, using thousands of variables if necessary, allowing patterns and value to be extracted from an otherwise meaningless mountain of data (Wang, 2003). Modern computers also allow databases to be analysed or "mined" in a real time context, recalculating information outputs continually as the data in the database are updated. This allows for trends and relationships to be discerned in a real time context, giving the data that has been gathered a greater value in helping to solve business problems (Wang, 2003).

The aim of data "mining" is often to reveal new hidden patterns, models or relationships between components of the database. This is done using a wide variety of techniques such as probability theory, information theory, estimation, uncertainty and graph theory (Wang, 2003). Data mining should not be confused with new ways of presenting information that is in the database, but rather new relationships that are revealed from analyzing the data. Such relationships can often be something unexpected by the user and it is important to have central questions that have to be answered to avoid the examining interesting but otherwise meaningless patterns that may emerge when large databases are analysed (Wang, 2003).

The Bayesian Data mining technique is often used in predictive modeling where the variable factors are known and based upon these a prediction of a variable or event may be made with a given degree of certainty. Named after Thomas Bayes (1703 – 1762), this technique was not used in the biodiversity database as no predictive relationships had to be determined. Future analysis of the database however may use this technique to provide a predictive model where the probability of a particular population of a species may survive in small urban fragments using known factors from the database such as species, fragment size, distance from other fragments, population size and vegetation type. Factored with social threat factors this technique could be used in the predictive modeling for the survival of certain populations of selected species in the urban context.

A factor that has become evident to me during the course of researching and developing this database is that the collecting of biological data was historically driven for scientific pursuits. Data collection criteria are often designed to collect information on species to answer overarching question on species and ecosystems. Outputs of these data collection were often products such as distribution maps, spatial mapping data, population census information or Red Data List criteria. As a generalization biological data have rarely been used to answer specific management questions relating to a particular species at a specific site. This phenomenon is in contradiction to the fact that in the Cape Town Nature Conservation organization where I am employed much valuable data are collected by site managers who rarely benefit from any management implications when it is gathered (Pers. obs.,2014). The biodiversity database attempts to capture, store and interpret biological data linked to a specific site in order to assist the site manager.

4. Administration

The decision to operate a live online database for biological sightings hosted on the internet was taken after much deliberation following the examination of existing systems. These traditional systems on reserves varied from paper based to a variety of software programmes on stand-alone personal computers. The turnover and loss of data, although never formally quantified, I considered was too high. Given the trends of connectivity, data access and data sharing, an online approach to data collection, management and access was a logical choice.

The situation that prevailed in Cape Town in 2006 when I embarked upon the development of a database is similar to the experiences of other conservation organisations, which have also been forced to move their information to a digital platform. An example of this is the Nature Conservancy of the United States of America; a non-governmental organisation that works both with private land owners and directly manages its own conservancy's (Groves *et al.,*1995). The Nature Conservancy started in 1951 and by the 1980's had developed an information system that incorporated both biodiversity and non-biodiversity information, such as land ownership, into a single system. Information was held in the form of paper maps, geographic information systems and biodiversity databases. This information was then incorporated into the Biodiversity and Conservation Data System (BDC) in the early 1990s; a DOS based programme that used DOS-based Advanced Revelation software platform (Beer, 2000). It is hosted at (www.mtnhp.org).

This system has similarities with the biodiversity database in the types of data collected and stored, but differs in not tying information to a specific site with an identifiable site manager. The Biodiversity and Conservation Data System covers a vast area (Beer, 2000) and is thus set up to interpret the information from a landscape perspective (Pers. obs., 2011).

As much as it was decided to use an online internet based platform for the City of Cape Town's biodiversity database and to use the "information highway", the speed and reliability of the connection to this highway is often in question. This draw back was exacerbated by the internal bureaucracy of the City of Cape Town. This made accessing the internet difficult and in many cases line speeds where too slow to service even the most basic of internet functions (Pers. obs., 2011). Recent developments in the IT infrastructure of Cape Town have improved the situation, notably the installation of a fibre optic cable system which started in 2005. By 2010 some 24 000km of optic fibre had been laid in 230km of cabling in Cape Town (City of Cape Town, 2010).

These problems notwithstanding the biodiversity database had to be hosted online in order for it to be accessible in real time and with ease to update information. Site managers, planners, members of the public or researchers can thus access information from the database. In the case of employees with the City of Cape Town who operate on the Cape Town internal network staff have to access the database information via a Cape Town proxy server.

A simplified sequence of an information request by a user is detailed in the diagrammatic representation below:

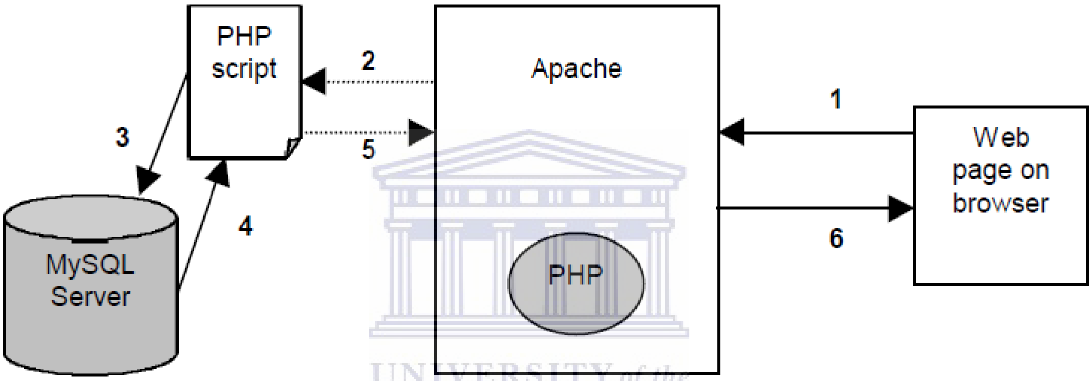


Figure 3: A diagrammatic representation of an information enquiry by a user.

A user requests information by clicking on a link on their web browser; which sends a request for **http://www.foo.com/foofoo.php3**. This is received by the Apache programme which gets the request for a PHP format script and is programme that **.php3** files are handled by the PHP pre-processor, so it tells PHP to deal with it. The **foofoo.php3** is a PHP script that contains commands. One of these commands is to open a connection to the sequel (SQL) database and grab some data. The data comes back from the database and **foofoo.php3** formats the appearance of the data before formatting it into HTML. At this point the HTML file goes back to Apache which sends it back to the user in response to their request. The user now sees a web page containing some information from the sequel database (Zhang, 1999).

The administration of the site can be divided into two components; namely the data administration and control of the underlying source code. The data administration had to provide flexibility for daily data input, correction and manipulation, yet had to be secure enough to prevent accidental or deliberate data tampering. This was achieved by having two levels of site administration for data; namely a site manager and an administrator:

The Site Manager: Site managers are given limited administrative rights to manage the data at their specific site. This allows them to insert, modify and delete information relating to specific site that they manage. A notable exception to this is the ability to delete a sighting record submitted for their site. As a result a site manager may accept, modify or reject a species site record, but cannot delete a species record from their site. The reason for this design is to that although a site manager can alter and correct an erroneous species for their site; they may find themselves in a situation where they cannot accurately determine what exactly the observer has seen. In this case they can reject the species record and it will not count towards their species list. However it was felt important to retain all sighting records for a site, even where the identity of a sighting was uncertain. This way old information could be referred to and perhaps a correct identification made in the future.

The Administrator: The administrator level allows the user to alter background values for the input data as well as alterations of the source code. This function is only undertaken by the IT project manager when needed.

5. GBIF: The Global Biodiversity Information Facility

As previously discussed the Global Biodiversity Information Facility (GBIF) came about from the deliberations of the Rio Summit in 1992; an event that many regard as pivotal to drawing international concern to global biodiversity loss (Arvanitidis *et al*., 2011). The Rio Summit also set the stage for the Convention of Biological Diversity (CBD), which highlighted the need for large quantities of relevant data in order to effect biological conservation across the scales of genes, species, ecosystem and political boundaries (Arvanitidis *et al*., 2011).

With this in mind GBIF's primary mandate is to facilitate free and open biodiversity information worldwide (King, Krishtalka & Chavan, 2010), whilst one of its primary mechanisms is to "*make the world's biodiversity data freely and openly available via the internet".* Of particular note at the time was the lack of capacity, collection and assessment of data in many of the developing countries that was identified as a major stumbling block (Gilman *et al.* 2009). Furthermore there was seen to be a need to incorporate environmental and biodiversity information in economic planning, and to reflect this in legislation and public expectations (Copp & De Giovanni, 2007). For this to happen it is argued that a well-informed public needs to be able to debate a wide variety of environmental issues with politicians and make informed economic decisions. In order for this to take place Copp & De Giovanni argue that a constant supply of new and historical biodiversity data are needed (Copp & De Giovanni, 2007).

In order to provide such a supply of new and historical biodiversity data can only be achieved by harnessing the information stored in databases, biological inventories, archives and museum collections. A global sharing of information from such disparate data sources can be achieved in two ways; firstly by building a query system that tracks, collects and serves information that has been queried and its location determined. The second method is to copy provided data to a central cache where it be accessed as needed. There are advantages and disadvantages to each of these approaches (Copp & De Giovanni, 2007).

The first method relies on data distributed across the internet. This is known as a "Data Distributed Network" and has data distributed on various servers across the span of the internet. This query system has the advantage of sharing the processing load on to the data providers and allows the owners of the data a greater control of data ownership and integrity. This also allows data owners to decide whose queries they wish to answer and the detail of information to be provided; thus managing their own data security (Copp & De Giovanni, 2007). This method also allows a user to be connected to the latest up to date data on the host server (see Figure 4).

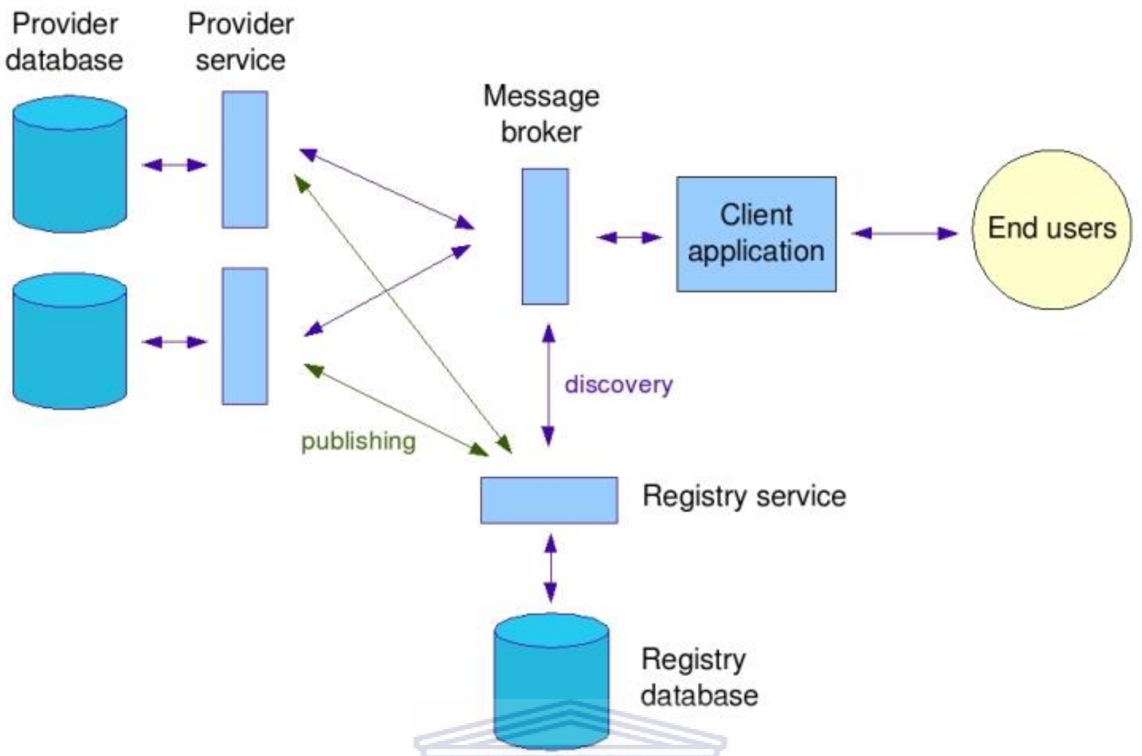


Figure 4: The components of a distributed biodiversity data network, which allows the owner of the provider database to determine which data is provided, at what level of detail and to whom it is provided (Copp & De Giovanni, 2007).

The second data provision method is the location, collection and storage of data in a centralised server. This method has the advantage of having a reliable source of data for users and is not affected by a host server's down time. The disadvantage is that the data collected may not be the most up to date information and constant downloads are needed to overcome this (Copp & De Giovanni, 2007). Furthermore without strong predetermined agreements data owners do not have direct control over the dissemination and utilisation of their data.

After evaluation GBIF was set up as a data distributed network, allowing data owners control of their data and sharing the processing load across the network. In 2010 the Global Biodiversity Information Facility appointed a task group to produce a report on a Global Strategy and Action Plan for Mobilization of Natural History Collections Data (GSAP-NHC). This task group came up with three recommendations in order to mobilise global biodiversity data through the discovery, capturing and publishing of data (King *et al.,* 2010). The first recommendation was that GBIF must facilitate access to non-digitised collections through the development of standardised meta-data templates which will capture the essence of the data. These templates would also provide an estimate for digitisation cost estimates where possible.

Secondly GBIF needs to work with collections and natural history institutions to increase the efficiency of species data capture and the quality of the information.

Efforts must also be undertaken to encourage not only professional institutions but also community organisations and citizens to digitise biological information.
Thirdly GBIF's role is to improve and promote the global infrastructure to increase the efficiency of publishing of natural history collection data. Mention is made of the data contained in collections in not just northern hemisphere collections, but also in largely unpublished collections in the southern hemisphere countries. Some of these southern hemisphere countries are biologically rich and do not have digitised biological information. The biodiversity database dealt with in this document would fall into this geographical category (King *et al.,* 2010).

As part of the GBIF software "toolkit" specific tools have been developed that assist in the process of converting old digitised data into extensible mark-up language (XML) format which is used in GBIF formats. In some programmes features that use a machine-learning based approach to improve the conversion performance have been developed to reduce errors (Hong & Heidorn, 2007).

Although by 2007 some 110 million records had been digitised and served on the GBIF platform, it was felt by some partners that this information was still not being effectively used for ecological research and conservation management (Flemons *et al*., 2007). The result was the development of a GBIF Mapping and Analysis Portal Application (MAPA) that allows users to interface data with a mapping format (Flemons *et al*., 2007). As was the experience in developing a much smaller biodiversity database within Cape Town one of the greatest technical hurdles was the delivery of large quantities of data over limited internet infrastructure (Flemons *et al*., 2007).

Since the establishment of GBIF there has been a decline in the number of taxonomists practising globally (Arvanitidis *et al*., 2011). One of the strategies to combat this trend is to employ the use of "citizen science" by mobilising members of the public in cyber-taxonomy projects with the observation and collection of biological information (Arvanitidis *et al*., 2011). The primary platform for cyber-taxonomy projects is the internet and a semantic-web platform that modern computers provide (Arvanitidis *et al*., 2011).

To assist with the social aspect of data collection GBIF launched an online collaborative environment in 2010 to improve communication with those involved in biodiversity informatics. Called the "GBIF Community Site", it aims to provide a platform for discussion, collaboration and information sharing amongst stake holders (González-Talaván, 2011). The GBIF Community Site provides free software tools that include: collaborative groups, online chats, forums, twitter accounts, messaging and file/image/bookmark sharing. The system allows for open ID based logins by users (González-Talaván, 2011).

The aims, objectives and development of GBIF summarised above were used in selecting some of the design features for the biodiversity database. A centralised data model was chosen; however the architecture allows for the linking in of the dataset as a de-centralised data model if needed in the future.

Attention was also given to developing the "citizen science" side of data collection in connecting with local "Friends" and interest groups attached to conservation areas.

Old records that were digitised were done so to meet the minimum information criteria for GBIF so as to be applicable to other datasets in the future. Training sessions were given by site managers to these groups on the operation of the database as well as species identification.

The biodiversity database aims to connect via the South African National Biodiversity Institute and to contribute records to the body of knowledge held in GBIF, contributing toward the to 30 million records that GBIF provides to users daily (Copp & De Giovanni, 2007).

6. Database Architecture

The decision to design the database around the hierarchical levels of local government was taken after much deliberation, but was felt to be necessary given the increasing importance that local governments now play in the conservation of biological resources and ecosystems that provide cities with ecological services (GBIF, ICLEI, 2012). Thus biodiversity information is needed in the design, development and management of a city so as not to compromise such ecological services. Flexibility was built into the architecture and design as far as was possible, allowing for information and records to be gleaned at various levels, while maintaining the underlying basis for local government management.

Although there are several functions on the database that can record biodiversity and infrastructure information at sites, these primarily make sense in the context of a site. A site is the primary level at which biological information is captured and reported, which underlines the primary function of the database to support the management of conservation areas particularly in urban areas where they may be spatially separated from other natural areas. Given that by 2050 70% of humans are expected to live in cities (Fontana, 2009), the database is built in an attempt to not only provide information to conservation managers, but also to connect an urbanised population living in the digital age with biodiversity in their day to day lives.

There are thirteen categories of functions in the database which can be accessed separately, but all have a common thread in being linked to a specific site. Hence each function, although it is relevant in its own, helps build a picture for specific site management.

The thirteen categories are:

6.1 Facilities
6.2 Sightings
  6.2.1 The GUID
6.3 Failed Search
6.4 Translocations
6.5 Sites
  6.5.1 Boundary Levels
6.6 Site Species List
  6.6.1 Lock Function

6.6.2 Species Name
6.6.3 Common Name
6.6.4 Class
6.6.5 Seen on
6.6.6 Seen on Site
6.6.7 Sighted By
6.6.8 Site Species Status
6.6.9 IUCN
6.6.10 Alien
6.7 Site Statistics
6.8 Species
6.9 Site Calendar
6.10 Population Management
6.11 Gallery Function
6.12 Thresholds of Potential Concern
6.13 Indicator Species

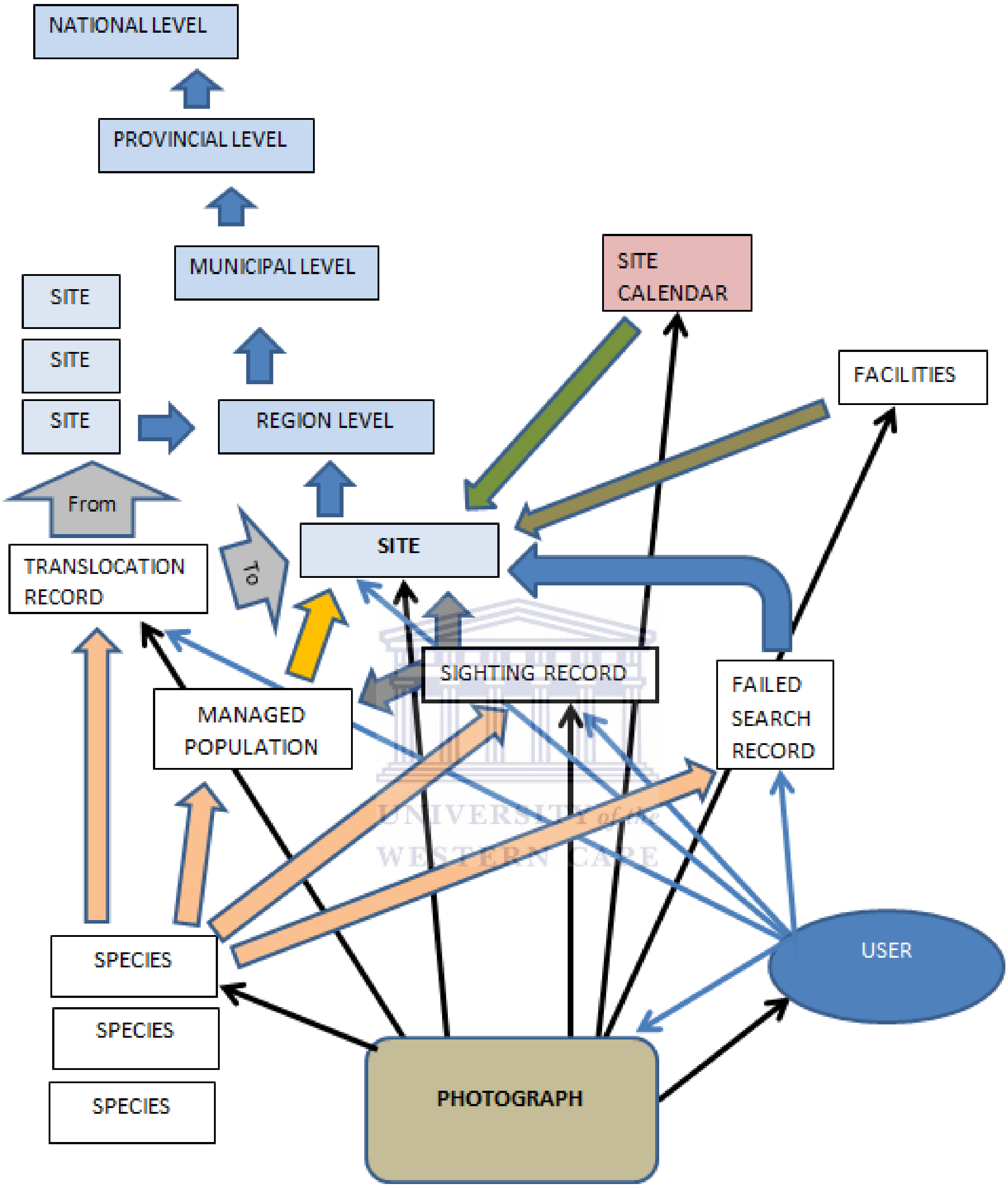


Figure 5: An Entity Relationship diagram of the Biodiversity Database depicting the major components and their relationship one to another. Various combinations of components make up the various functions available listed in Chapter 6.

The following is a breakdown of each of the categories and their associated functions:

6.1) Facilities

This function allows a site manager to list all their facilities of a fixed nature such as buildings, bridges, bird hides, hiking trails, etc. The term “facility” is used in its broadest context and includes minor items such as the fixed poles for fixed point photography or the corner markers of vegetation monitoring plots. Also included is a separate category allowing for the documenting of cultural heritage sites and structures.

The following attributes are to be found in a facilities record which has been attributed to a site:

- “Facility Type”: this is a fixed field option where the facility type is selected. This standardisation of terms allows for infrastructure to be searched for across various sites and the whole City with comparable results. The standardised terms have a definition included to explain the facility type for the user and avoid confusion.
- “Site”: this is a fixed field allowing for the infrastructure to be attached to a specific site in the database and hence becomes an attribute for that site.
- “GPS Locality”: the GPS locality is a fixed value, allowing the infrastructure to be located spatially.
- “Erf No.”: this allows for a building to be allocated against a specific erf within the city urban context.
- “Area”: this allows for the size of the facility to be recorded in square meters. A total surface area of developed infrastructure is an important indicator of how visitor facilities impact upon a site.
- “Contact Details”: the contact details for the manager for the site; this is particularly relevant for environmental education centres where groups would want to book visits.
- “Comments”: this free field allows for the recording of any information and history for the specific infrastructure item.
- “Photos”: for the attachment of reference photos.
- “Reference Material”: this allows for the attachment of any documents and is a permanent repository for scanned plans, leases, diagrams, etc.

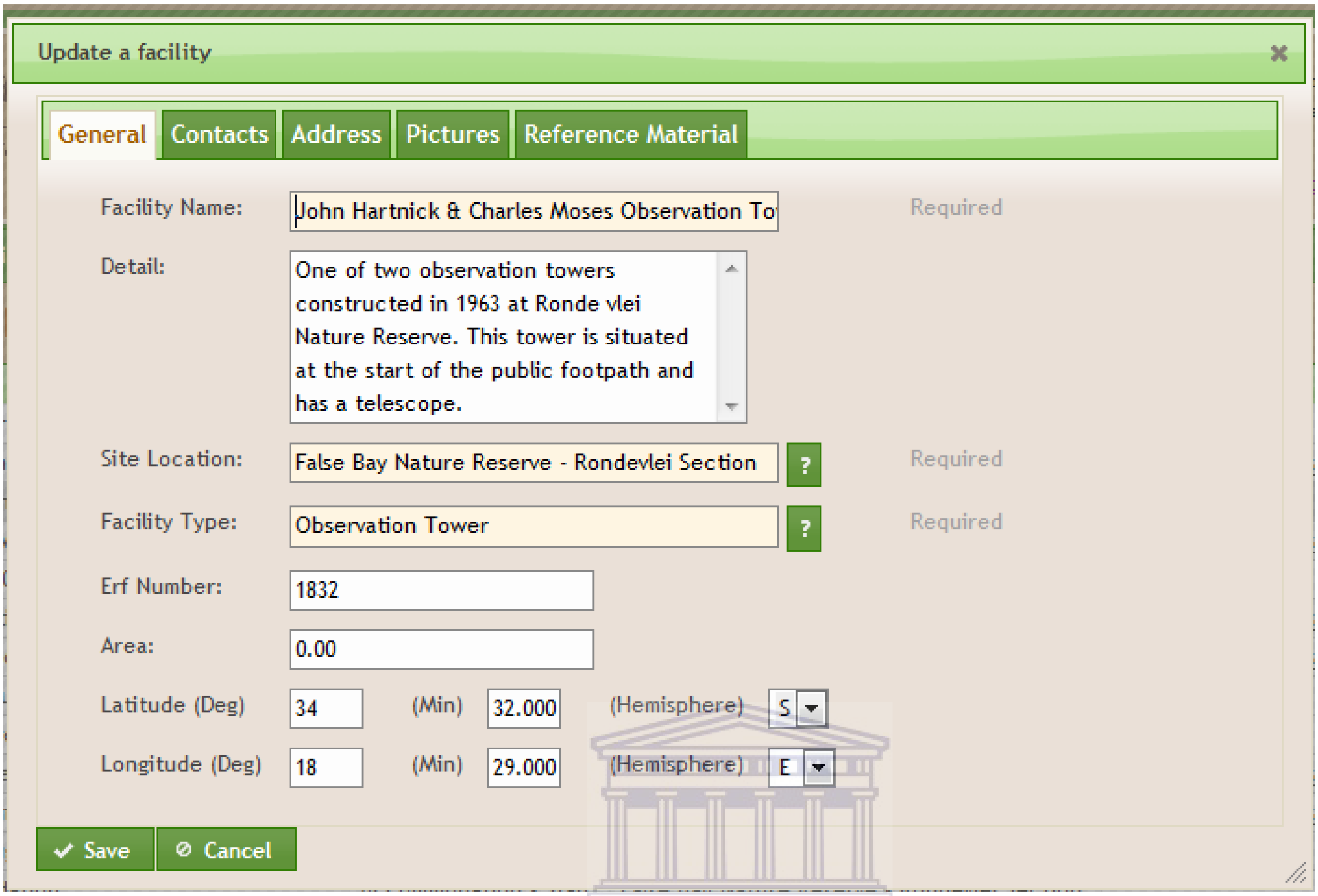


Figure 6: The background information for each facility listed at a site.

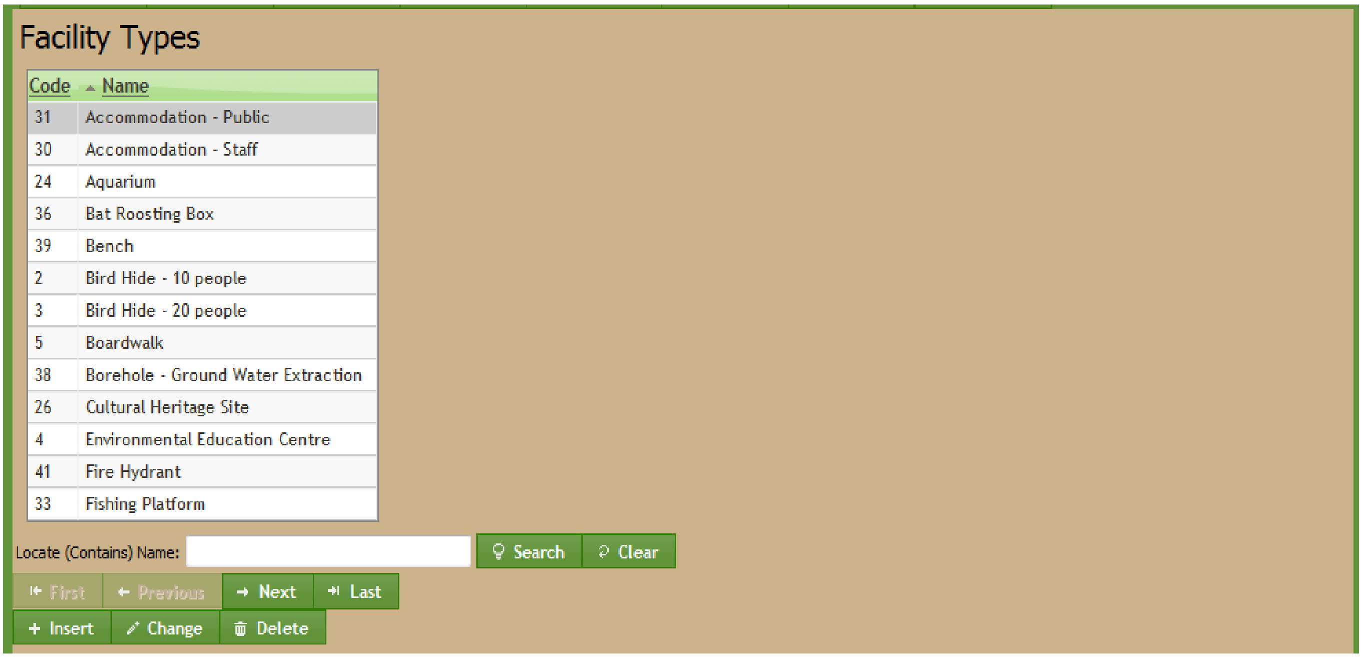


Figure 7: An example of some of the types of facilities listed on the database. Each has a definition embedded within it which can be referred to if there is any confusion as to what a facility type name to use.

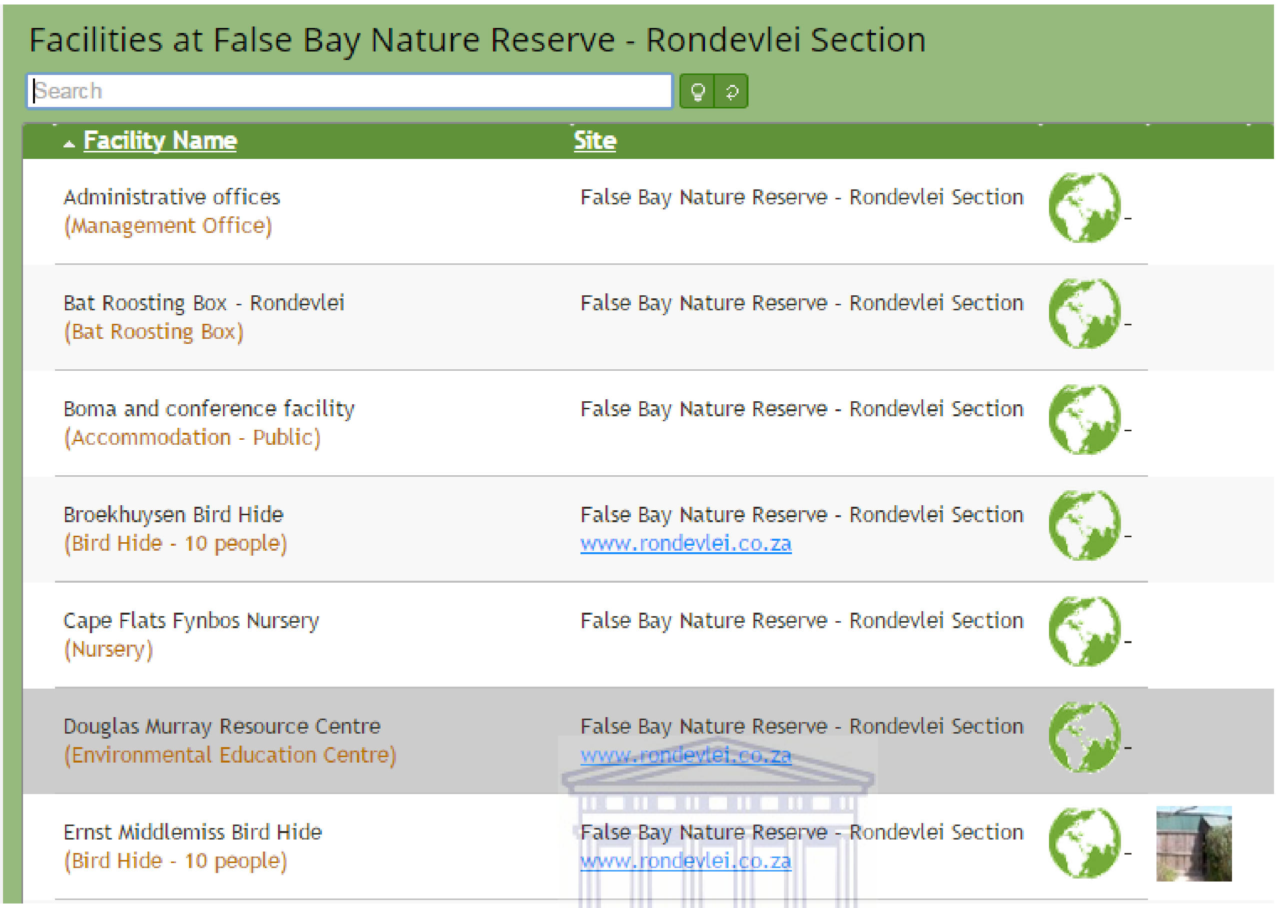
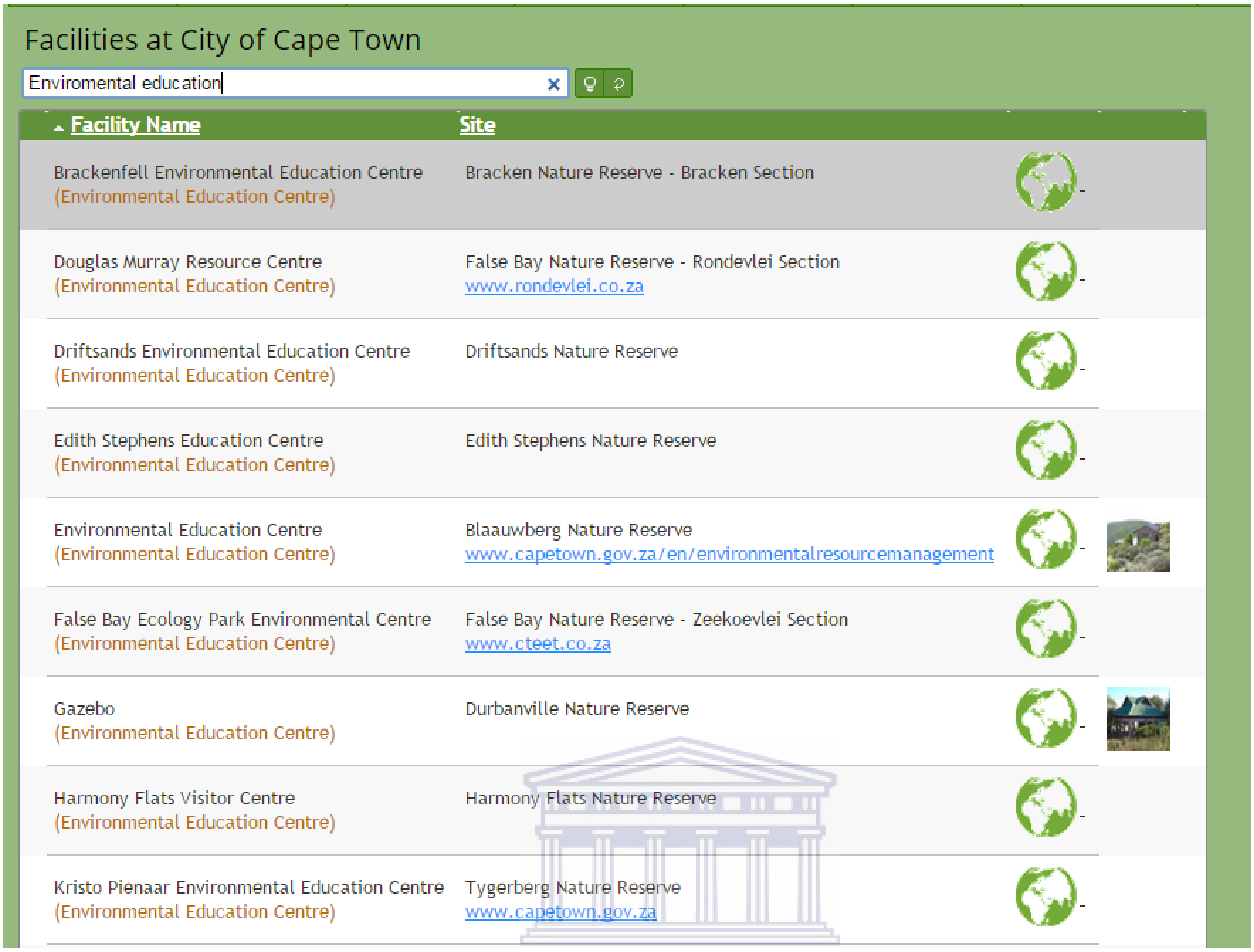


Figure 8: A list showing the facilities for a site with a search per facility name or type. Each listing can be opened up to provide the background information for the facility that is embedded into it.

A function has been built enabling the user to export the facility information as a Microsoft Excel spread sheet. This function can be performed at any boundary level, with the infrastructure for a site, cluster, region or the entire city available to be downloaded if necessary. This provides a quick means of determining what infrastructure is present on a site or selection of sites. At present this function allows a search to be refined by facility type, allowing the user to determine how many records for a certain type of facility there are.



Facilities at City of Cape Town

Enviromental education

Facility Name	Site
Brackenfell Environmental Education Centre (Environmental Education Centre)	Bracken Nature Reserve - Bracken Section
Douglas Murray Resource Centre (Environmental Education Centre)	False Bay Nature Reserve - Rondevlei Section www.rondevlei.co.za
Driftsands Environmental Education Centre (Environmental Education Centre)	Driftsands Nature Reserve
Edith Stephens Education Centre (Environmental Education Centre)	Edith Stephens Nature Reserve
Environmental Education Centre (Environmental Education Centre)	Blaauwberg Nature Reserve www.capetown.gov.za/en/environmentalresourcemanagement
False Bay Ecology Park Environmental Centre (Environmental Education Centre)	False Bay Nature Reserve - Zeekoevlei Section www.cteet.co.za
Gazebo (Environmental Education Centre)	Durbanville Nature Reserve
Harmony Flats Visitor Centre (Environmental Education Centre)	Harmony Flats Nature Reserve
Kristo Pienaar Environmental Education Centre (Environmental Education Centre)	Tygerberg Nature Reserve www.capetown.gov.za

Figure 9: An example of a facility search for "environmental education" centres in Cape Town on the database.

A future plan is to refine this search function to enable the user to determine the square meters of a certain type of facility and export this in a Microsoft Excel spread sheet. This will help ascertain what area of a site (or collection of sites) is covered by a particular type of facility. Once a facility type has been captured a synopsis of that facility is available under the listed infrastructure for the relevant site.

There is a Google Earth Map interface built into the database which is represented by a globe icon against the relevant entry. Upon activating the globe icon, the user is taken to a Google Earth street map that provides the locality of the facility. Also represented are the other facilities listed at adjacent sites. Upon moving upwards on the map layers more facilities are revealed, represented at a higher level as the numbers of facility items at a site. These facilities can be viewed by going to the site and querying these map markers. The map provides a more detailed view as the scale is decreased and one zooms in.

Upon zooming out, at the highest map elevation, all the facilities in Cape Town are represented by a number representing all facilities across Cape Town. The specific facility being queried is marked in blue; all other facilities are marked in green so as to differentiate between the map markers.

In order to deal with slow line speeds the Google Earth map was pre-set at specific levels, forcing the user to only view the map at particular levels. When moving up on the map view to a higher level, the map level was again pre-set to a particular scale. Further to this the map was also pre-set as a street map with the satellite image turned off in order to save download time. Users have the option of turning the satellite image on if needed. This loss of map resolution was felt to be necessary given the slow line speeds and connections experienced by many users in Cape Town.

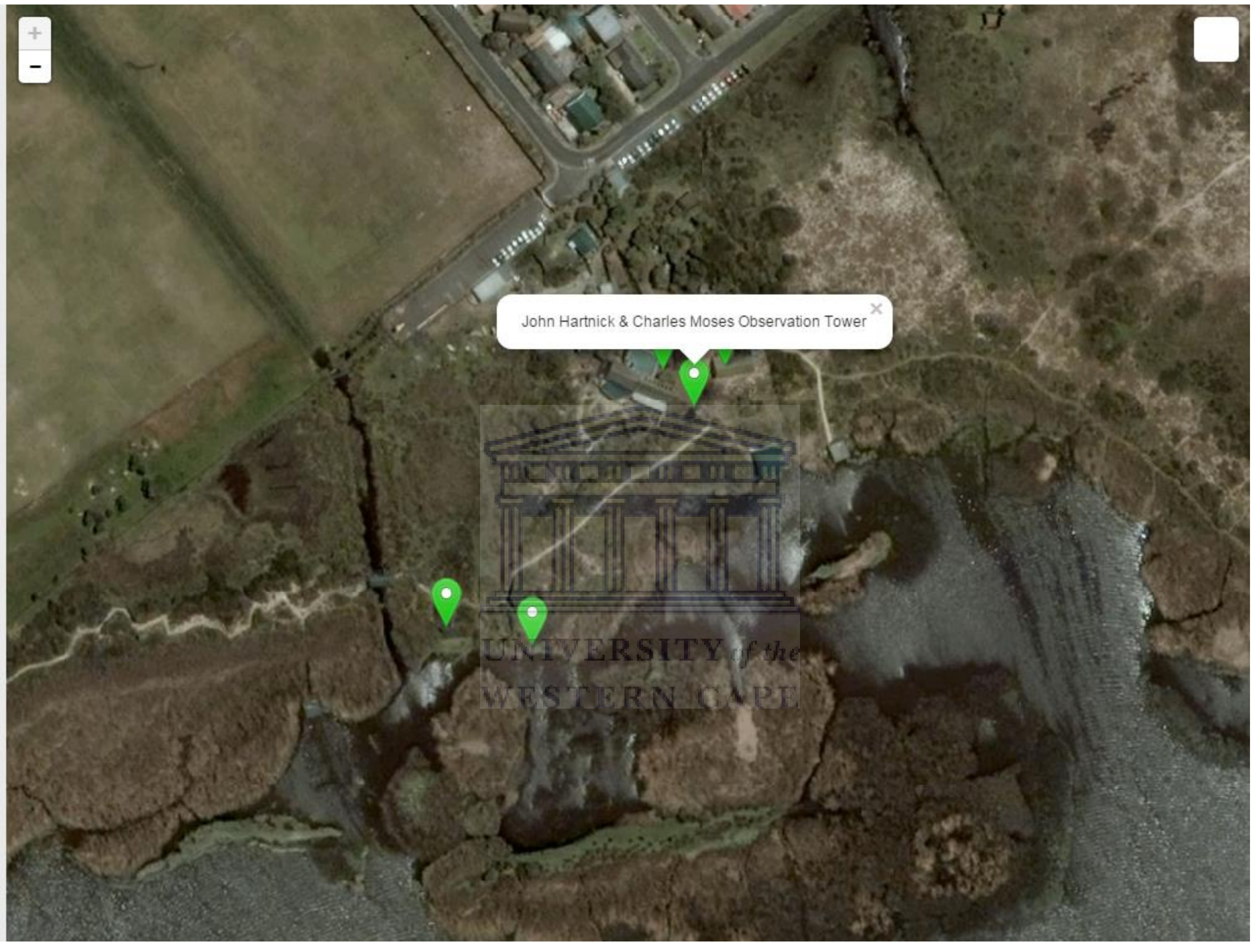


Figure 10: An example of a facility query at a site in the Google Earth satelite image view.

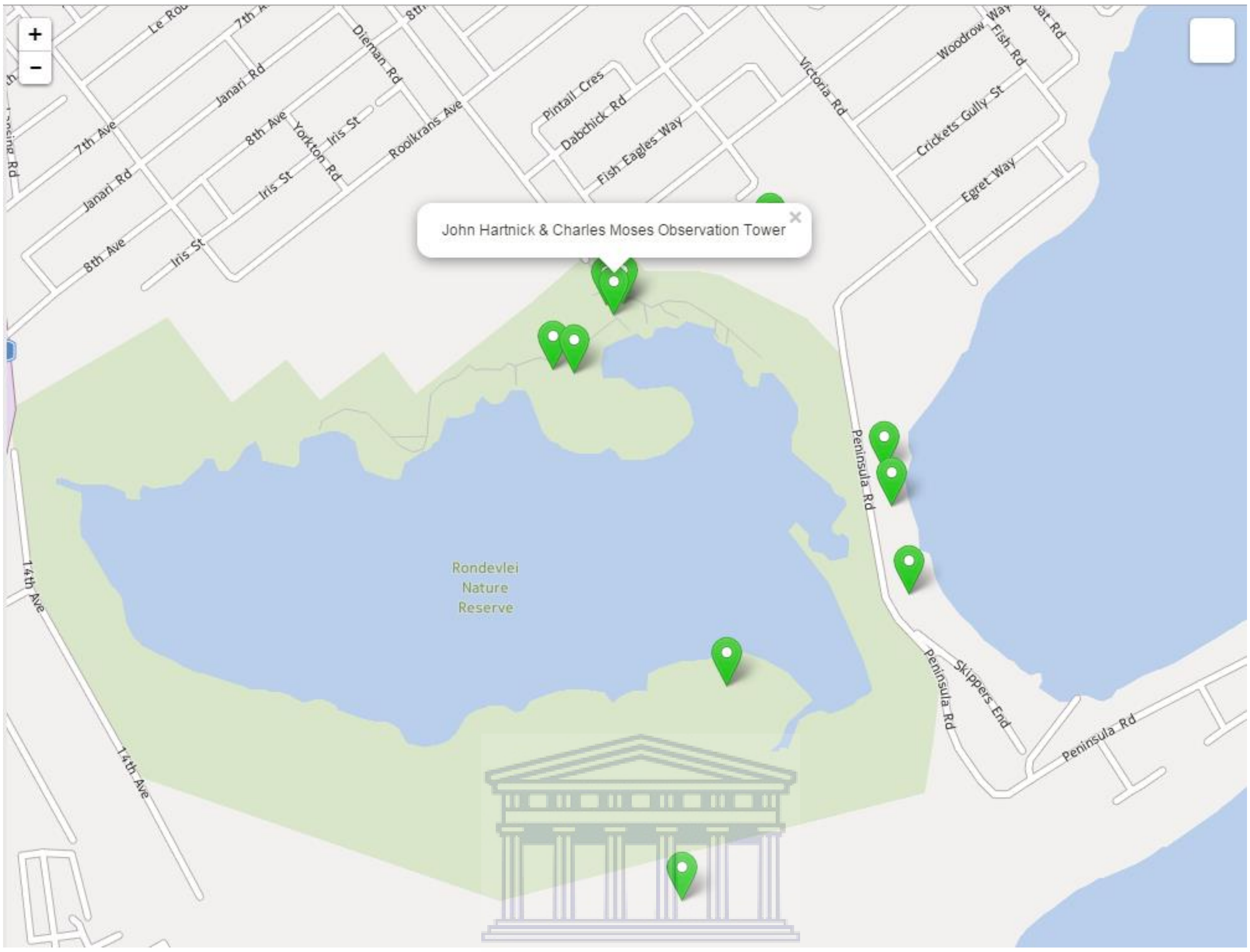


Figure 11: The same facility query in Google Earth street view at a higher elevation allowing the facility to be viewed in association with the rest of the surrounding facilities.

6.2 Sightings

This function is the cornerstone of the record keeping of species observed at a site. A sighting record, once accepted, becomes the basis for determining species lists at a site. The time elapsed since the last sighting for a particular species will also determine the “Site Species Status” category for that species at the site. The “Site Species Status” is a time based species list for the site, categorising a species based upon the date of the last sighting for that species. The “Site Species Status” categories are as follows:

“Present on site (0-10 years)”: is a category for species for which an accepted sighting record exists for within the previous 10 years.

“Previously known on this site (11-15 years)”: is a category for species that have an accepted sighting record older than 10 years, but less than 15 years.

“Lost to site (15 years +)”: is a category for species that have an accepted sighting record that is older than 15 years. Such a species is deemed to be extirpated for the site. The term "extinct" however has expressly not been used so as not to confuse the definition with the IUCN definition for extinction.

A sighting record has five vital pieces of information that will place the record against an observer in space and time. These five fields are compulsory and must be filled in by the observer. Since an observer is logged on, the database will automatically know who the person is, leaving four compulsory fields to be completed. The five basic fields of a sighting are:

- (When) "Date": this is either a free field that the observer can fill in, or select it from an automatic pop-up calendar.
- (Where) "Site": this allows for a site to be selected from the predetermined list of sites.
- (What) "Species": with the site information, the database will default to the species list for the site, allowing for the search to be shortened to the options for that site only. It also turns up a negative search if the species has never been recorded from that site before.
  The search option provided enables the user to search either by the common name or scientific name. Once a match is found, the relevant scientific name is displayed for insertion into the sighting form.
- (How many) "Quantity Seen": this is the numerical value filled in by the observer.
- (Who) "Observer": the database automatically tags the observer at the bottom of the record along with the time and date that the sighting record was created

These basic five input fields allow for enough information to reference a person's record both spatially and temporarily. Given the great variation that can be observed, there are a number of extra pieces of information which can be allocated against "pages" in the sighting. The first "page" of the sighting is the "**Required Data**" page. This page has the fields listed above, as well as the following optional fields:

- "Males & Females": this allows for the number of males and females in the sighting to be recorded. The number of these two fields cannot exceed the total quantity for the sighting record. However the combined total of males and females does not have to equal the sighting total. In some cases the observer may be able to determine that there is a certain number of each sex, but be unable to make out the rest of the group of animals. The alternative is that some of the individuals in the sighting are immature and a sex cannot be ascribed to them.
- "Immature": this attribute allows for any immature animals or seedling plants to be recorded. This attribute of the record signifies whether any breeding of that particular species has taken place on the site or if the site is used as a nursery area for the species.
- "Counting Method": this allows the observer to tag the record as an estimate of the sighting or an accurate count. This is important with larger groups such as flocks of birds which can be influenced by observer error; by choosing the "Estimated" option the observer is acknowledging that their quantity given is merely estimation and not an accurate count. This "direct count" method can be filled with potential pitfalls that vary from

observer confidence, to the observer ability to estimate a population size (Sutherland, 1996). The observer's ability to correctly identify a species is dealt with elsewhere, with this feature in the database deals with the numerical value being either "Estimated" or "Accurate". In order to speed up the sighting record time, this option is defaulted to "Accurate" unless the observer changes this to "Estimated" manually.

The second page of the Sighting Record form is the "**General**" page. Here additional optional information related to the sighting can be recorded. These fields are:

- "Habitat": this field allows for the observer to select the habitat type where the sighting was made from a predetermined list for the relevant site. This field is useful for any specific study on a species and its habitat preferences have to be determined. For the purposes of information, a broad definition is given for "Habitat" which includes man made structures and the built environment.
- "Vegetation": this field allows the observer to select from the predetermined list of relevant national vegetation types for the site.
- "Health Status": this field has predetermined options relating to the health status of the organism. These can vary from "Alive" to "Dead", with multiple options in between. This allows for the recording of rehabilitated animals as well as signs of herbivory or harvesting on plants.
- "Cause of Death": if an organism is dead, this field allows for a reason to be ascribed from a predetermined list. A wide variety of causes are catered for, varying from natural predation, to pollution events and unknown causes.
- "Sighting Type": this field relates to the method used to determine the identity of the organism. This can vary from a visual sighting to a captive or herbarium specimen. The sighting method used has bearing on the accuracy of identification of the organism. For example an accurate identification of a shrew species will necessitate having a trapped specimen and should be reflected as such in this field to add authenticity to the sighting record.

On this sighting page, the use of certain combinations of "Health Status" and "Cause of Death" functions will result in the activation of management cascades. These will be discussed in greater depth latter, but at this stage the concept of a management cascade needs explanation. Thus for example if a sighting were made for a fish species and it is noted in the record that the fish's health status is "dead" and the cause of death is "water pollution event", then the system will duplicate the sighting record through to a predetermined number of email addresses. These would be people who need to be immediately informed about such a pollution event, such as a Water Pollution Department or similar.

The third page of the Sighting Form is the "**Location of Sighting**" page.

This relates to the spatial location of the sighting within the boundaries of the site. A sighting thus can have three levels of "coarseness" to define where it is. At the first level, a sighting record at a minimum is ascribed to a site on the Sighting Page as a compulsory field, but the exact location of the sighting record on the site is not determined.

Secondly, on the “Location of Sighting” page, the record can be ascribed to a specific management block of the particular site. A sighting record ascribed to a management block is thus spatially placed in the centre of the management block when the specific GPS co-ordinates are not known or provided.

The final level of detail for a sighting record is a specific GPS co-ordinate, which places the record at a specific point within the site boundary. The database is set up in such a way that GPS co-ordinates can be entered in any of three formats and the other two formats are automatically calculated. The three formats used are:

Decimal degrees
Degrees & decimal minutes
Degrees, Minutes & Seconds

The sixth page of the Sighting Form is the “**Comments**” page. This free field allows for any further comments that could not be captured in other pages and fields. This is an important feature, as given the varied nature of biological information that could be gathered it would be a bewilderingly long format to capture all the conceivable options for all fauna and flora records. It was felt that comments in this section could be useful for future attempts to find a specific species and could relay site specific information that cannot be built into a standard reporting template.

The seventh page of the Sighting Form is the “**Photo**” page. Here an observer can attach a photograph(s) of their record. This will obviously help the site manager in verifying the record as well become available to other users through the gallery section. Photos are stored against the relevant species and displayed with the sighting record, providing a knowledge section for other users.

The eighth page of the Sighting Form is the “**Sighting Status**” page
This page on the sighting report is only visible to a site manager or an administrator and is the point where a sighting record is accepted, rejected or left pending. Thus a site manager is the only person who can verify and accept a sighting record for a site; their decision being influenced by factors such as:

- Has the species already been recorded from their site?
- What are the chances of the species being seen?
- Was the season correct for that particular species?
- Is the observer experienced with this group of species?
- Are there other similar species that it could be confused with?
- Are there any corroborating records from other sources for this sighting record?
- Was the record made on the basis of a specimen in the hand, a visual sighting, audio call or some other sign of the species such as spoor?

A new sighting record elicits an email to the site manager and observer, alerting the site manager of the new record and confirming with the observer that their record has been received. The site manager must then moderate this record under the “**Sighting Status**” page on the relevant sighting record. When a site manager moderates the sighting record status, they can set the status as either “Accepted” or “Rejected”; the observer will receives an email confirming the moderation that the site manager has done to their record and what status the record now has.

From: notify@biodiversity.co.za [mailto:notify@biodiversity.co.za]
Sent: 10 April 2014 08:36 AM
To: dgibbs@telkomsa.net
Subject: A sighting of Aonyx capensis on 8/08/2013 was moderated by Tamaryn Allan

Dear Tracy Gibbs

A sighting of *Aonyx capensis* on 8/08/2013 was moderated by Tamaryn Allan

The sighting details are as follows:
Sighting Date : 8/08/2013
Species Name : *Aonyx capensis*
Common name(s) : Cape Clawless Otter
Site : False Bay Nature Reserve - Rondevlei Section
Quantity Seen: 4
Health Status: Alive

The sighting status has been set to : Accepted

Figure 12: An example of a email to an observer confirming the moderation of their record by the site manager.

The ninth page of the Sighting Form is the “**References**” page.
This page allows the observer to add a document file about the sighting record which could not otherwise be captured. For example a Google Earth file can be attached to determine the extent of a population that had been surveyed. A population of a plant species for example cannot be represented by a single GPS point and needs to be expressed by a polygon matching its shape. Thus a file image or reference document can be attached to give meaning to the sighting record.

It should be noted that a sighting record does not make provision in its basic form for comments about behaviour. Although behavioural comments can be added to the “Comments” section, there is no sighting section on behaviour. The purpose of the sighting form is to provide sighting information about a species, its relative abundance, the habitat and vegetation type it occupies and its health status. This information is to provide managers with a picture of species presence and well-being and not to tackle specific species related research questions. Additional information, for example behaviour, will have to be dealt with by creating a specific research form to capture this information. Since the database was developed to provide information for direct management related to a site, such a research related format was not explored further although the architecture allows for such future development. The financial costs involved in building such non-essential research search functions were also prohibitive.

Once a sighting has been made it appears in both the “**Manage Sightings**” section of the specific site against which it was made, as well as in the “**All Sightings**” page. The latter is a page that users are taken to upon logging in and shows the latest sighting activity on the database.

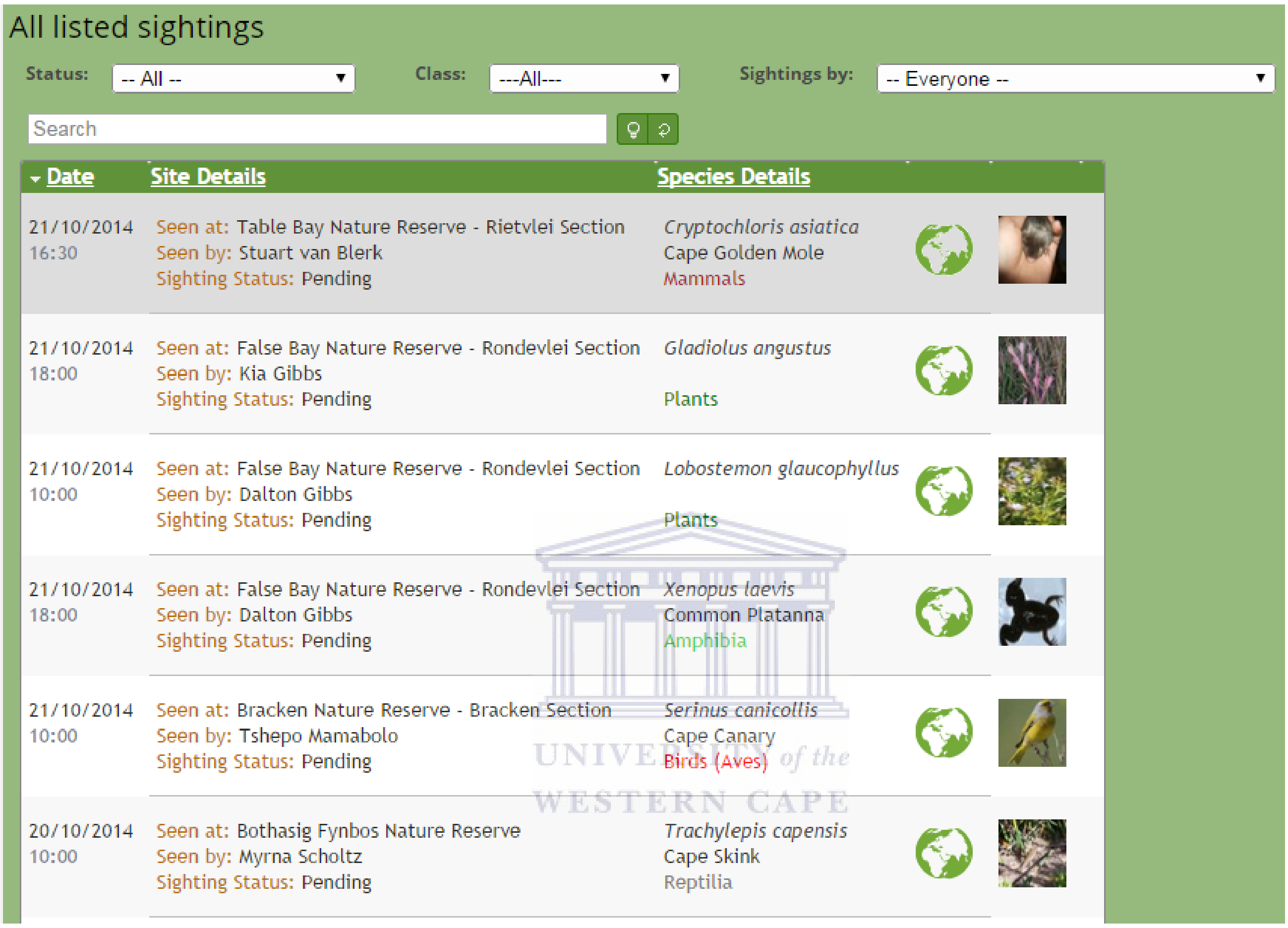


Figure 13: The listing of all sightings made on the database, showing a synopsis of the sighting record. The Google Earth map appears as the green globe icon on the right.

Reference photographs.
Reference photographs are displayed on the “**All Sightings**” page, allowing a user to click on them and view a library of all photographs taken of the selected species. If a photograph has been entered in a sighting record however, upon opening the record only, that photograph is shown as a reference to the relevant sighting.

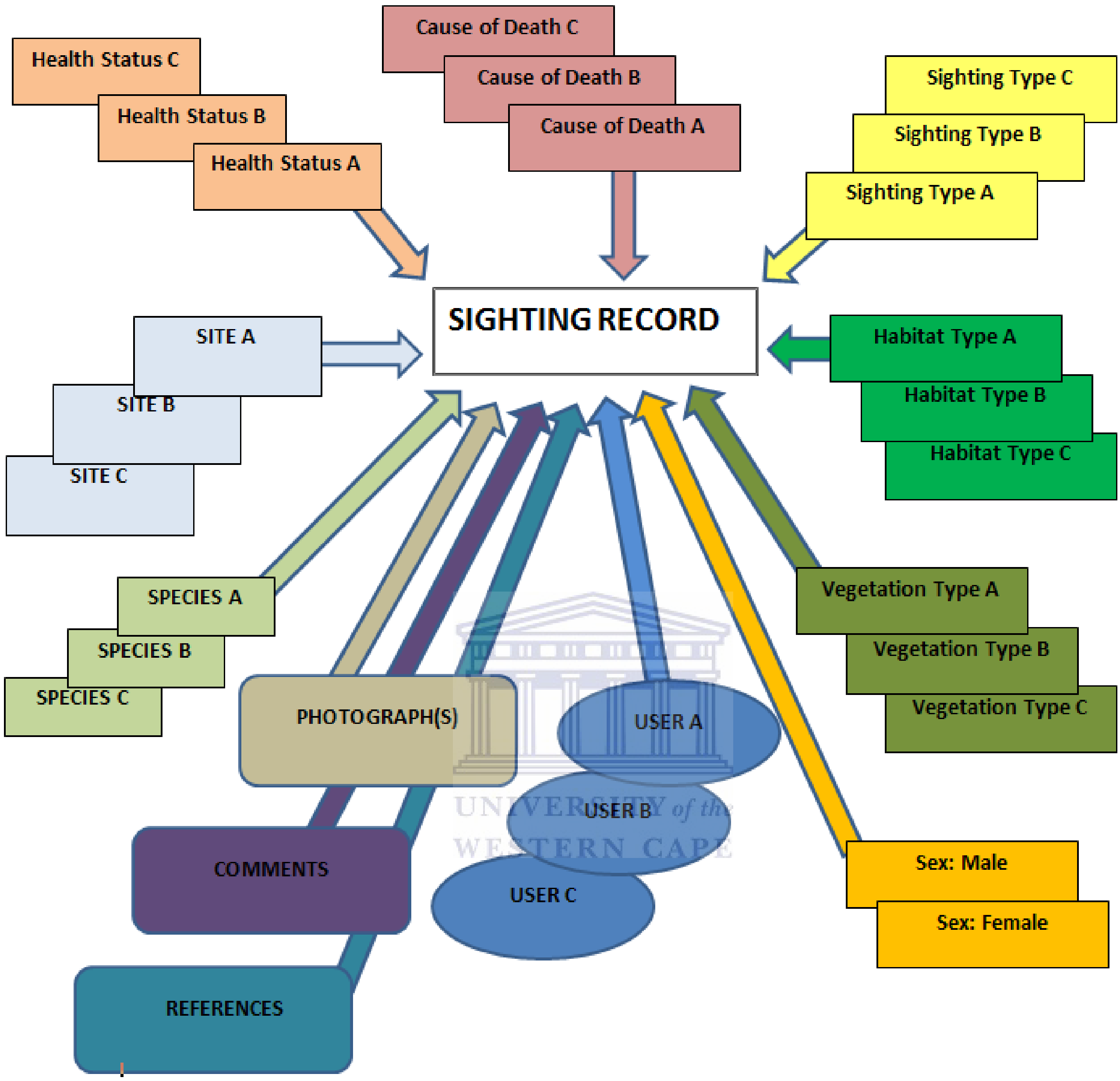


Figure 14: An Entity Relationship diagram of the major components and available options for a user to select from for a sighting record and their relationship one to another.

The Google Earth Map interface.
Once completed, a sighting is listed with a globe icon against the relevant entry which has the same functionality as the map interface for the facilities functions. Again a Google Earth street map is use to provide the locality of the sighting. Also represented are other sightings of the same species made at the relevant site.

Upon moving upwards on the map layers more sighting records are revealed at adjacent sites, represented at a higher elevation as the number of sightings. This provides the user with a quick assessment to judge their record against; an absence of any other records of a species at nearby sites can indicate one of the following; the species is rare or a vagrant, the species is a site endemic, the species is cryptic and under collected or the adjacent sites are under surveyed. In contrast if the adjacent sites have large numbers of records of the observer's species then it is a quick indication that this is all likelihood a common species.

As in the facilities function, in order to deal with slow line speeds the Google Earth map was pre-set at specific levels, forcing the user to only view the map at particular elevations. When moving up on the map view to a higher elevation, the map level was again pre-set to a particular scale. Further to this, the map was also pre-set as a street map with the satellite image turned off in order to save download time. Users have the option of turning the satellite image on if desired. This loss of map functionality was felt to be necessary given the slow line speeds and connections experienced by many users in Cape Town.

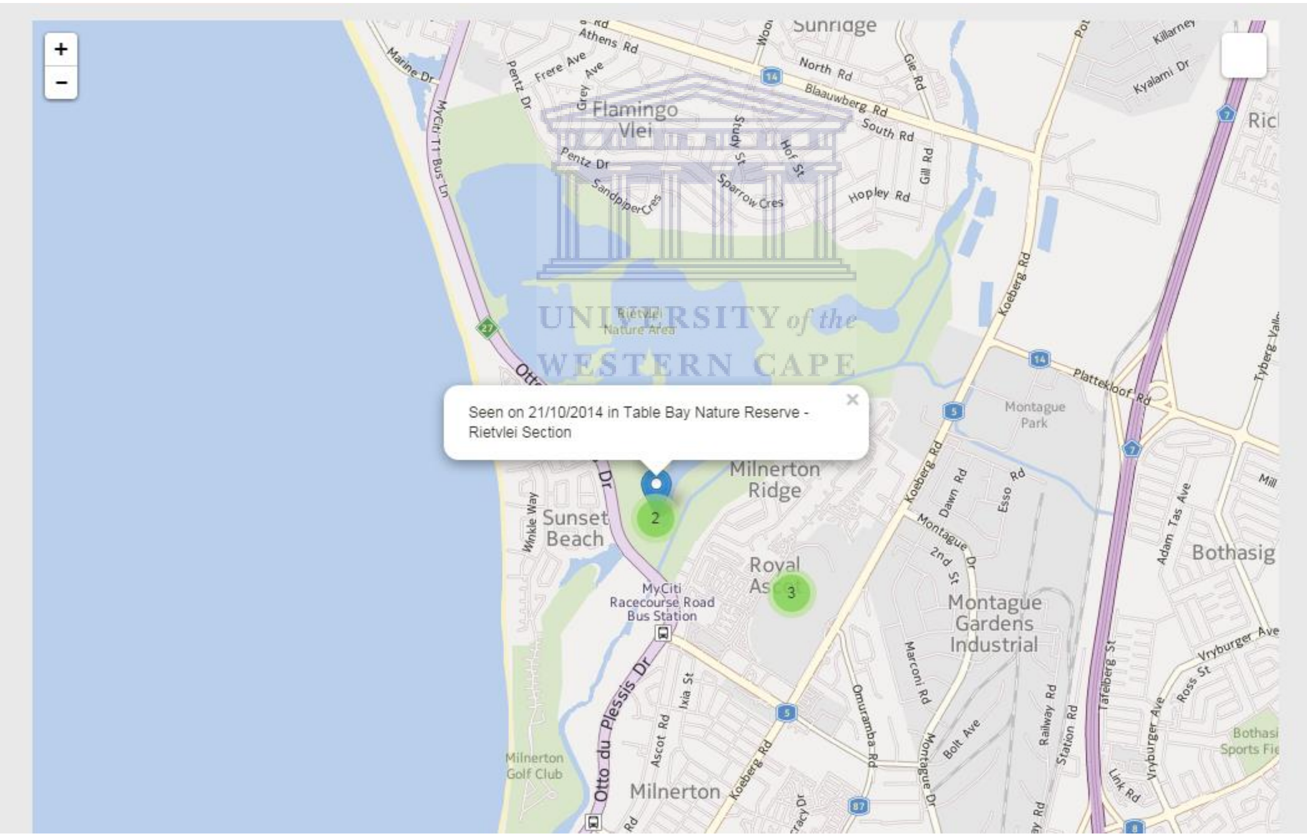


Figure 15: A Google earth map showing a record of a Cape Golden Mole at Table Bay Nature Reserve – Rietvlei Section. The numerical 2 indicates that there are two other records at the site, whilst the nearby numerical 3 indicates that there are three records of this species at the nearby Milnerton Race Course Site.

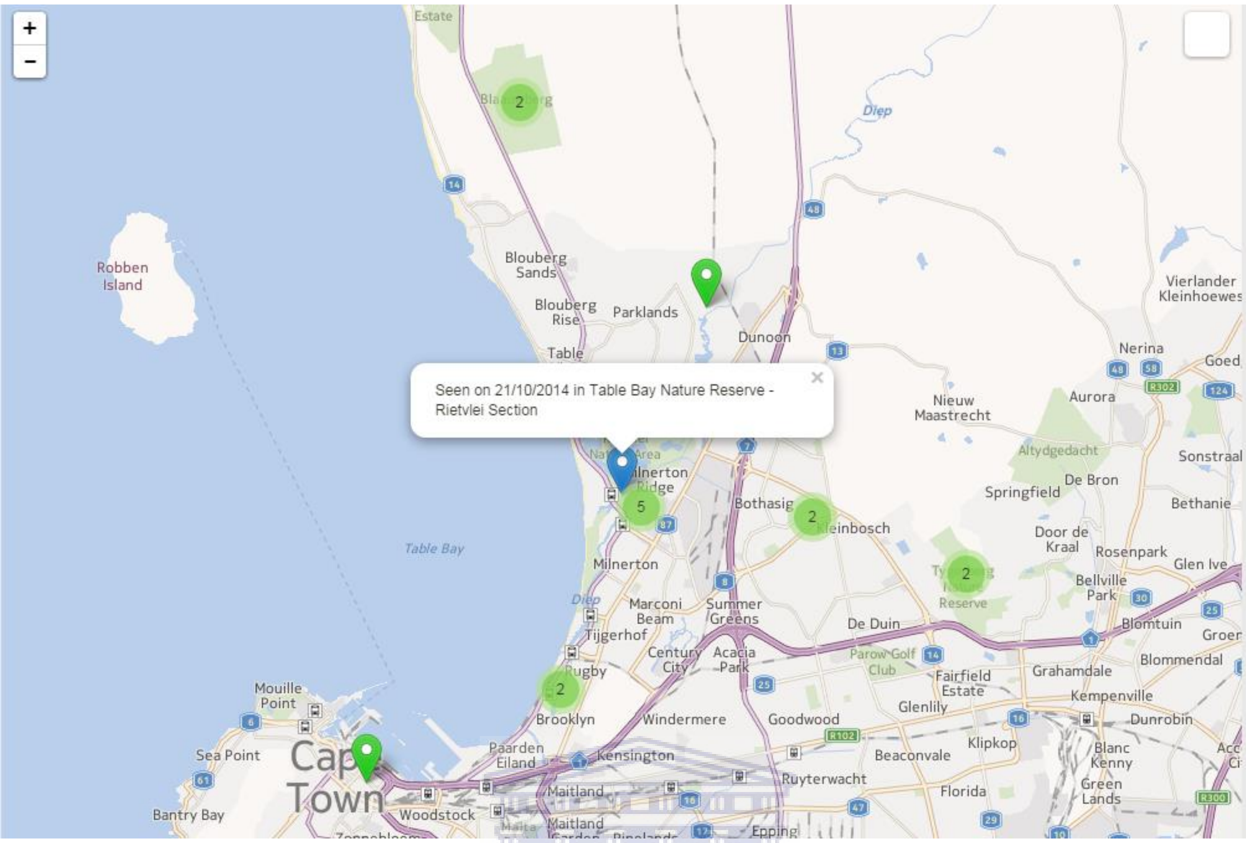


Figure 16: A Google Earth map of the same sighting record viewed at a higher elevation. The record being queried is marked with the blue marker, whilst the number values indicate the quantity of records of the same species at other sites in Cape Town. The map has also amalgamated numbers where the elevation of the map cannot accommodate the finer detail; thus the three record at Table Bay Nature Reserve and the two records at adjacent Milnerton Race Course are displayed as five records.

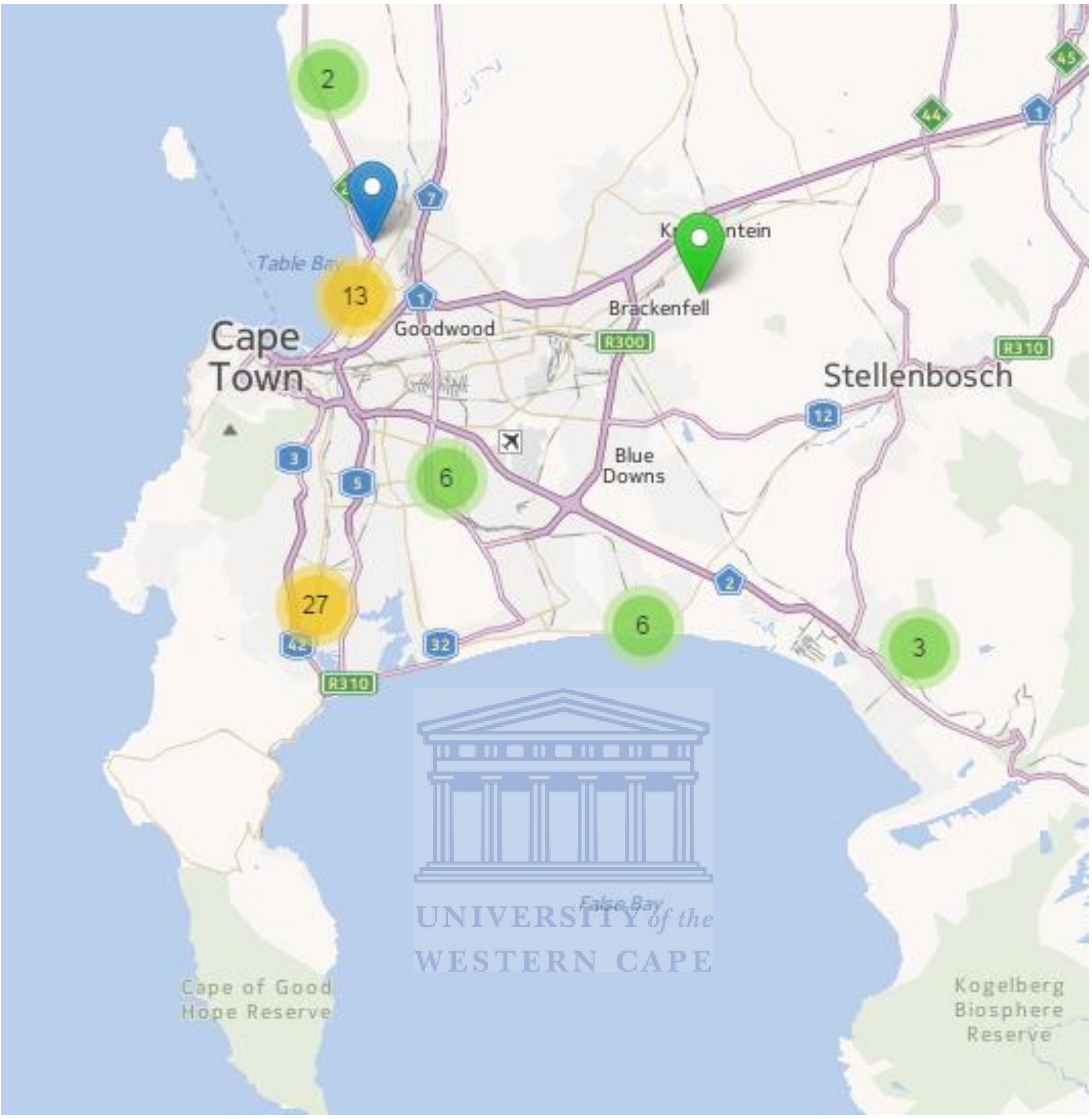


Figure 17: A Google Earth map showing records of Cape Golden Mole across Cape Town, with the original query marker in blue.

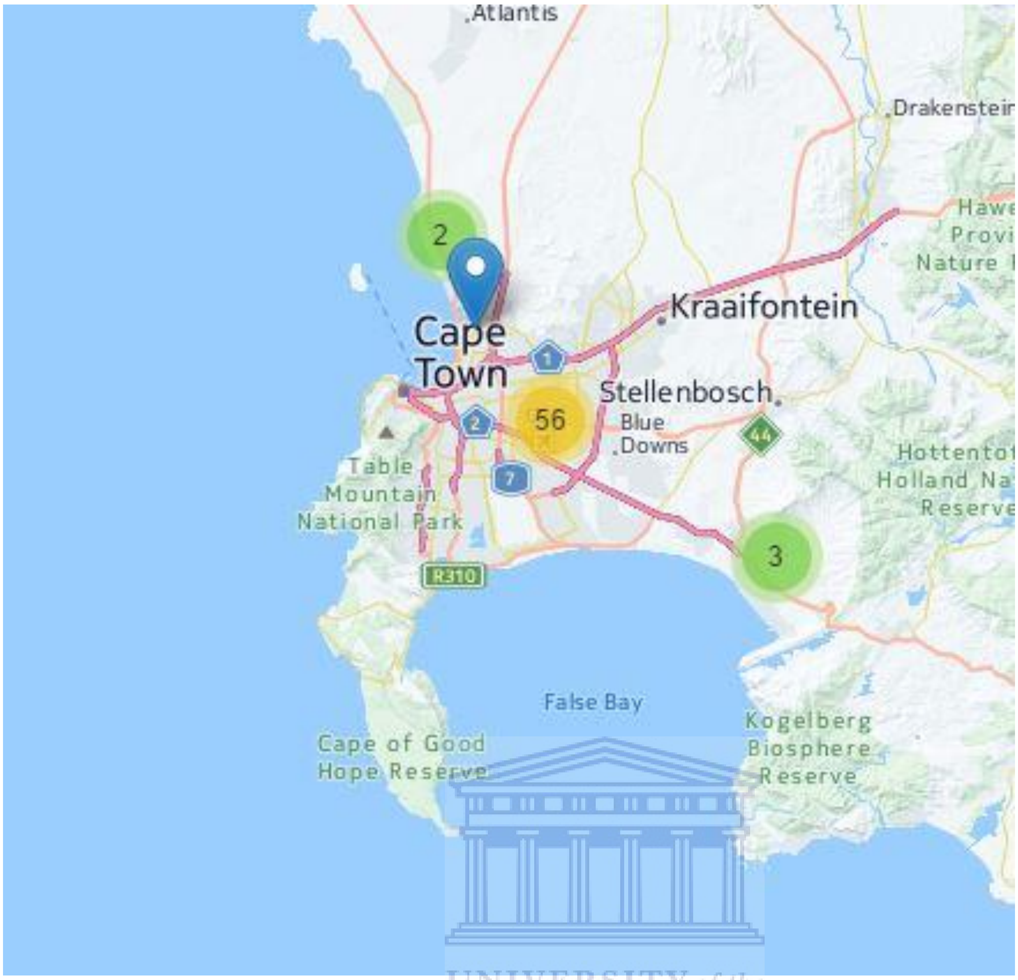


Figure 18: A Google Map at the highest elevation for Cape Town, showing the original record marked in blue and all other records combined and represented in the numerical value 56. Three outlying records are displayed on the eastern side of Cape Town (numerical value 3). This illustrates a large gap between the western records (number 56) and the eastern ones.

6.2.1) The GUID

In order to track down specimens and records, the international convention is to ascribe a unique attribute to the record so it can be categorised and tracked down when needed. Such a “tag” is a GUID, the acronym GUID standing for “Global Unique Identification”. This is a unique series of numbers, letters or combination of both that will allow for quick reference and provide a means of tracking the record to a database.

On the biodiversity database each input function object gets a GUID ascribed to it, allowing each separate item to be traceable. This applies to each site, photograph, sighting record, translocation record, user and species. This allows each object, not just sighting records, to be easily accessible. The GUID used to reference these items is built from a combination of the server central processing unit (cpu) number, date, time of record creation and a unique random six string alpha-numeric sequence (De Jager, Pers. comms., 2014). This arrangement of known factors (server number, date & time), combined with a random alpha numeric sequence accommodates potentially high volumes of records and data logging while reducing the risk of GUID duplication.

This particular GUID arrangement lists the server code first, so as to facilitate data searches; particularly when record numbers or high numbers of users may necessitate data to be served off more than one server. The server presently being used to host the database is a scalable Inter® Zeon ® CPU E-276 O @ 2.60GHz. Four processors run the server with 8GB RAM that support a 64 Bit Windows 2012 R1 server operating system and Microsoft SQL as the backend programme (De Jager, Pers comm., 2014). The incoming data portal is a 2 GB load balanced data line.

With the assignment of GUID's to an ever growing global biological database, the question of GUID identity and rules governing the ascribing of a new GUID to an object that has changed has had to be delineated (Güntsch *et al.*, 2011). This has been done largely by the Pan European Species directories Infrastructure (PESI, www.eu-nomen.eu/pesi) who developed a strategy for the assignment of GUID's to information objects that have undergone a change (Güntsch *et al.*, 2011).

6.3 Failed Search

This function is much like a sighting record, but documents the absence of a sighting a specific species. Thus if a specific species is searched for and not found, this fact can be documented. Since the absence of a species at a site can in some cases be ascribed to the lack of searching, if a search is undertaken, this needs to be documented. Thus the certainty that a species has disappeared from a specific site is increased if repeated searches, using the correct survey method, have failed to find it.

This concept of a "negative" sighting may be unusual in a system which deals with "positive" records which document a sighting of a specific species at a specific place and time. The failure to see a species is however nevertheless a "positive" fact that the species was not found. This information needs to be documented in order to draw conclusions about the certainty of the absence of a species from a site.

The Failed Search record has the following pages and criteria:

The first page of the Failed Search record is the "**Required Data**" page, which has the same main points of "What, When, Who, Where" that a Sighting Record has. The "How Many" is however not needed, as a Failed Search record obviously refers to a zero count. However three additional fields have been added to the Failed Search, these are; details of the search method used, the duration of the search and the number of people involved in the search. These three additional fields have bearing on the reliability of the record and the certainty that a species is in fact not present at a site. Thus the "Required Data" page for the failed Search record has the following fields:

- "Date": this is either a free field that the observer can fill in, or select it from an automatic pop-up calendar. Both options are provided to deal with the slow lines speeds in providing a calendar for the user.

- “Time”: this free field allows the observer to record when the search started. This time is important in the search for certain species, such as amphibians, which may only be evident at for example night.
- “Site”: this allows for a site to be selected from the predetermined list of sites.
- “Species”: with the site information, the database will default to the species list for the site, allowing for the search to be shortened to the options for that site only. It also turns up a negative search if the species has never been recorded from that site before.
- “Search Method Used”: this field is completed by the observer from a predetermined list of search methods. This allows for continuity in terminology between observers and records.
- “Duration of Search”: this allows the observer to record the duration of the search in a free field of hours and minutes.
- “Observer”: the database automatically tags the observer at the bottom of the record.
- “Number of Search Party”: this free field allows the observer to record the number of people (in numerals) involved in the search, which gives an indication of search effort.

The second page of the Failed Search record is the “**General**” page, which as the following criteria:

- “Management Block”: this allows the observer to indicate in which management block of the site the search took place. This is draw from a predetermined list of management blocks for the site.
- “Vegetation Type”: this allows the observer to indicate in which vegetation type the search took place in. This is drawn from a predetermined list of vegetation types loaded for the site.

The third page deals with the “**Location of Search**” which deals with the spatial location of the search within the boundaries of the site. A failed search record can have three levels of “coarseness” to define its location. At the first level, the record at a minimum is ascribed to a site on the “Required Data” page as a compulsory field, but the exact location of the sighting record on the site is not determined. Secondly on the “General” page, the record can be ascribed to a specific management block of the particular site. A sighting record ascribed to a management block is thus spatially placed in the centre of the management block when the specific GPS co-ordinates are not known or provided.

The final level of detail for a sighting record is a specific GPS co-ordinate on the “Location of Search” page, which places the record at a specific point within the site boundary. The database is set up in such a way that GPS co-ordinates can be entered in any of three formats and the other two formats are automatically calculated is the same format as used in a Sighting Record.

The sixth page of the Failed Search Form is the “**Comments**” page.
This free field allows for any further comments that could not be captured in other pages and fields. This is an important feature, as given the varied nature of biological information that could be gathered it would be a bewilderingly long format to capture all the conceivable options for all fauna and flora records.

6.4 Translocations

The translocation function documents the movement of organisms from one site during deliberate management actions. A translocation record is similar to a sighting record, but differs in having two sites recorded – an origin site where the organism(s) came from and a receptor site where the organism(s) was taken to. A reason for the translocation is also recorded; providing a context as to why the species was introduced to a particular site. This will allow future management to determine why a species is present and if it arrived as a result of a specific management action.

The translocation function allows for a search by species against a site, area cluster, region or city wide level. This provides a comprehensive list of all translocations made for the species that has been queried. As in the case of sightings, translocation records can also be exported as a Microsoft Excel spread sheet for a site, area cluster, region or city basis. A future function will allow the user to search for one of the translocation reasons, allowing them to download the result as a Microsoft Excel spread sheet.

6.5 Sites

Site Background Information & Setup
The concept of a "Site" is central to the architecture of the database and is the minimum reporting level for information. At its simplest level a site is defined as a physical area with set spatial edges, however it can also viewed as the area in which data is collected. As a result the database defines the site as the "data collection boundary". This distinction is important, because the boundary within which data is collected for a site is not always the same as the legal or managed boundary for a site. For example if a public road transects a conservation area this is not legally part of the conservation area neither is it managed as such, but information from this road where it intersects with the conservation site is important. Road kill from such sites are important and provide records that are included into the conservations site's long term database. As a result the road is included as part of the site for the purposes of data collection.

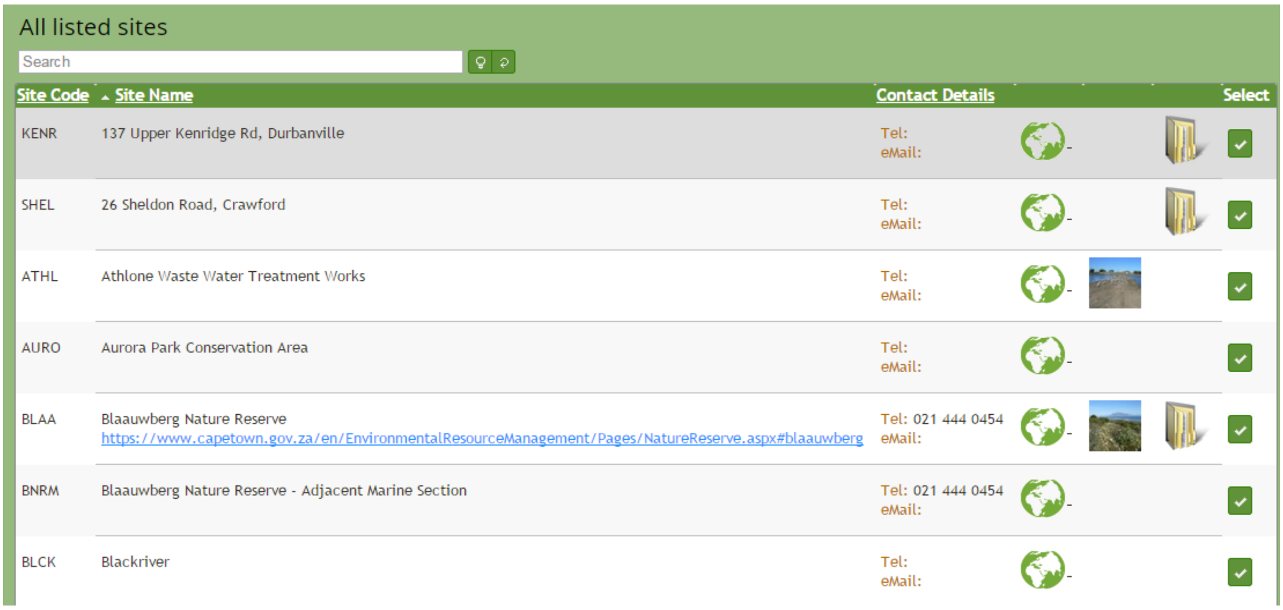
The concept of a site, with its associated sighting records, is central to placing a sighting record against a firm spatial point. For reporting purposes, several sites can be combined to form a better picture of biodiversity and trends in an area. However a sighting record cannot be ascribed to anything but a site. A site itself can be further sub divided into management blocks. Ideally such management blocks should follow clear hard boundaries, such as roads, fire breaks, canals or paths which are likely to be permanent fixtures in the landscape. Management blocks should also preferably encompass different ecosystems or vegetation types if applicable. Management blocks would thus often have different management actions and fire regimes.

The term "Site" was deliberately chosen to avoid the use of legal terms such as "Nature Reserve" that relate to legally constituted conservation areas. Thus a site may constitute any area where information is to be collected, such as a public garden, formal conservation area, or even private garden. Regardless of the legal status of the site, observational information can be collected and either used to track the biodiversity on the specific site or be combined with other sites in an area, or form part of a regional biodiversity report. Naturally the name of the site can reflect its legal status such as Nature Reserve or National Park - if this is the case.

When a site is created on the database, it is established with background information that is not overtly displayed. This background information is important to put the site into context and acts as a repository for this vital information relating to the vegetation types, habitat types and regional spatial position. This information is also important as these fields are drawn upon when creating a sighting record. This background information is summarised under the headings below:

- Site background information: when a site is created reference information can be added to the background of the site for permanent record. Important background information such as; the site's proclamation notice, building plans or the site's management plan, can be added for reference.
- Site photo gallery of general pictures featuring the site, landscape, staff or infrastructure.
- Management blocks: here the management blocks for the site are listed and can easily be referenced. With each management block entry created there must be an explanation field that allows the site manager to give a description of the management block to clarify any confusion on the visual maps.
- Vegetation types: the national listed vegetation types of the site are listed here, allowing for a quick reference to the vegetation being conserved by the site. The area covered by a specific vegetation type at a site is also recorded here.
- Habitat types: a variety of habitat types are loaded for the site; these are referred to when creating a sighting that can be linked to a specific habitat type. These habitat types are selected from a predetermined fixed field of habitat types to ensure continuity of names across a variety of users. Each habitat type created has an explanation field attached which allows for a descriptor of the habitat type to make selection easier for the user. It should be noted that "artificial" or anthropogenic habitat types have been included although these are often excluded in biological surveys. Their inclusion is to allow for the urban usage of the database, where sites may be of an urban nature with corresponding habitat types.
- Region: a site is allocated to one of the four conservation regions in Cape Town; at this point the site is ascribed to one of these four regions for statistical reporting purposes.

Once a site has been created it is listed with the other sites in alphabetical order. A Google Earth icon is displayed in the information entry, which upon activation, allows the user to spatially view the site on a Google Earth street map.



All listed sites

Site Code	Site Name	Contact Details	Select
KENR	137 Upper Kenridge Rd, Durbanville	Tel: eMail:	
SHEL	26 Sheldon Road, Crawford	Tel: eMail:	
ATHL	Athlone Waste Water Treatment Works	Tel: eMail:	
AURO	Aurora Park Conservation Area	Tel: eMail:	
BLAA	Blaauwberg Nature Reserve https://www.capetown.gov.za/en/EnvironmentalResourceManagement/Pages/NatureReserve.aspx#blaauwberg	Tel: 021 444 0454 eMail:	
BNRM	Blaauwberg Nature Reserve - Adjacent Marine Section	Tel: 021 444 0454 eMail:	
BLCK	Blackriver	Tel: eMail:	

Figure 19: An example of all listed sites, with the reference photos and files displayed on the right hand side. The Google Earth icon on the right hand side allows the user to open a Google Earth map to display the site's spatial orientation.

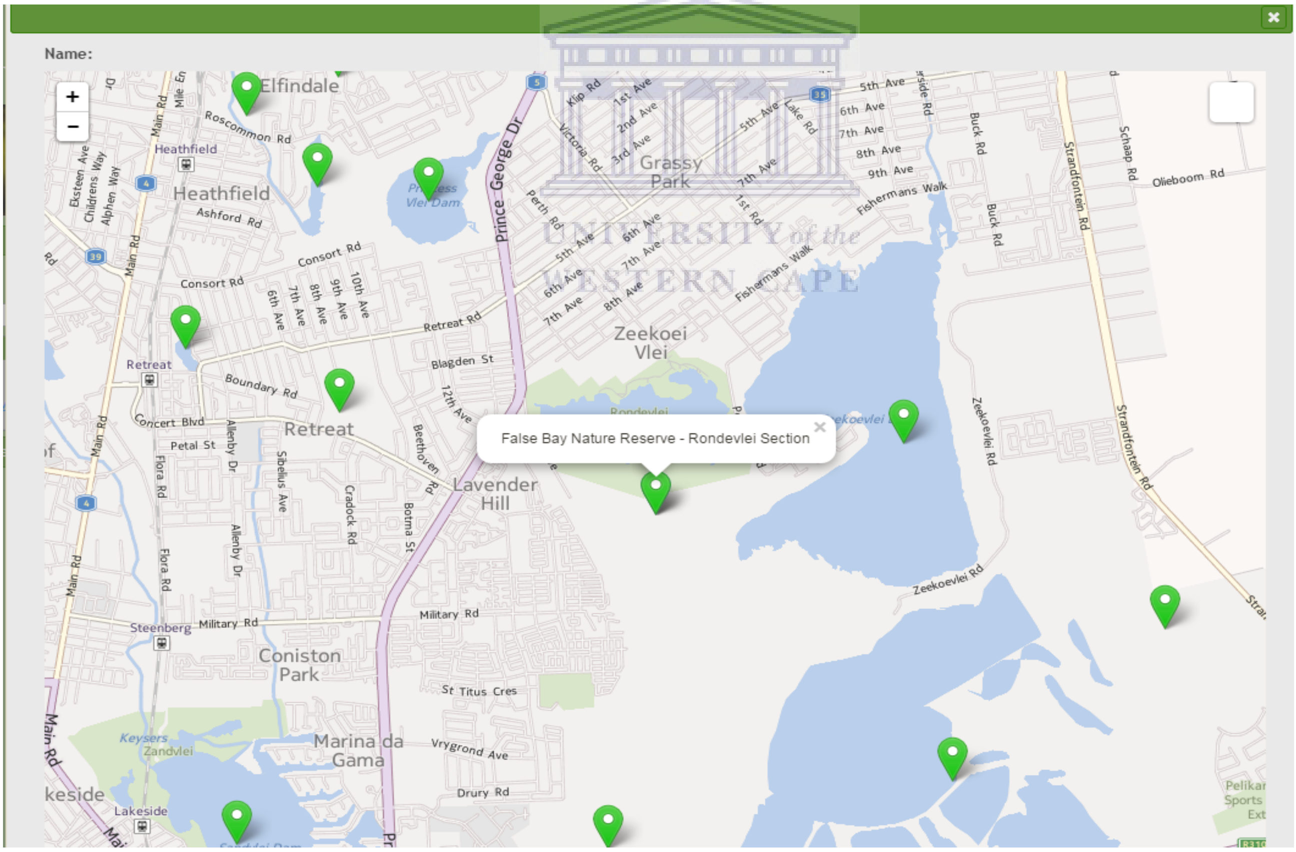


Figure 20: The Google Earth map in street map view showing other sites in relation to the selectied site which in this case is False Bay Nature Reserve – Rondevlei Section.

6.5.1 Boundary levels

The database tracks and records biodiversity at a site; however for conservation managers this information becomes important when it can be compared to other sites. Such comparisons may need to vary from comparing the data sets of an adjacent site, to comparing data from a selection of sites. For the purposes of management the database has boundaries that match those of the conservation management structures of the City of Cape Town; although at a higher level the Provincial and National boundaries are set out.

For conservation purposes Cape Town has been divided into four conservation regions; namely South, North, Central and East (Cape Town, 2003). Thus a collection of sites are found within a region; with four regions making up the City of Cape Town. The ontology of this layout is designed in such a way as to provide species lists, statistics, infrastructure lists and calendar layouts for each "level" to determine localised patterns of infrastructure, management actions, species distribution or species vulnerability.

For the purposes of analysis, it was found that an additional level, the "area cluster" level was needed. Where a site and region are a predetermined boundary, it was found that species and sighting information was needed on an *ad hoc* basis for "clusters" of sites. These may be a collection of sites in a specific area, for example in an isolated valley or sharing similar ecological features such as all having wetlands. Unlike the other boundary levels that are fixed, the "area clusters" are flexible and can be set up on an *ad hoc* basis, providing species lists and statistics for any collection of sites placed together. Thus whilst a site, region and the city boundaries are set, an area cluster boundary can vary and be altered depending on what needs to be reported on.

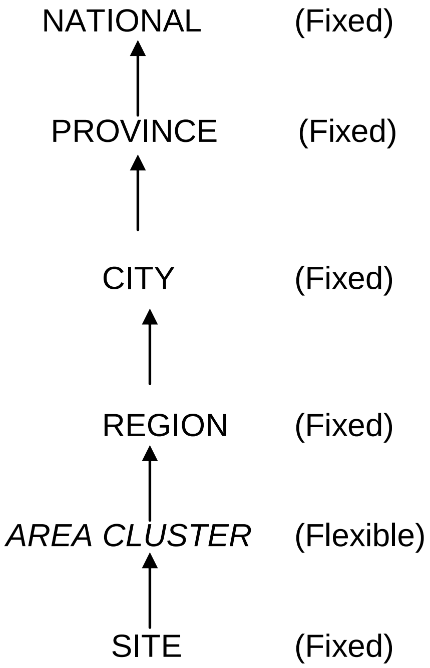


Figure 21: A schematic layout of the hierarchical arrangement boundaries of data sets in the database.

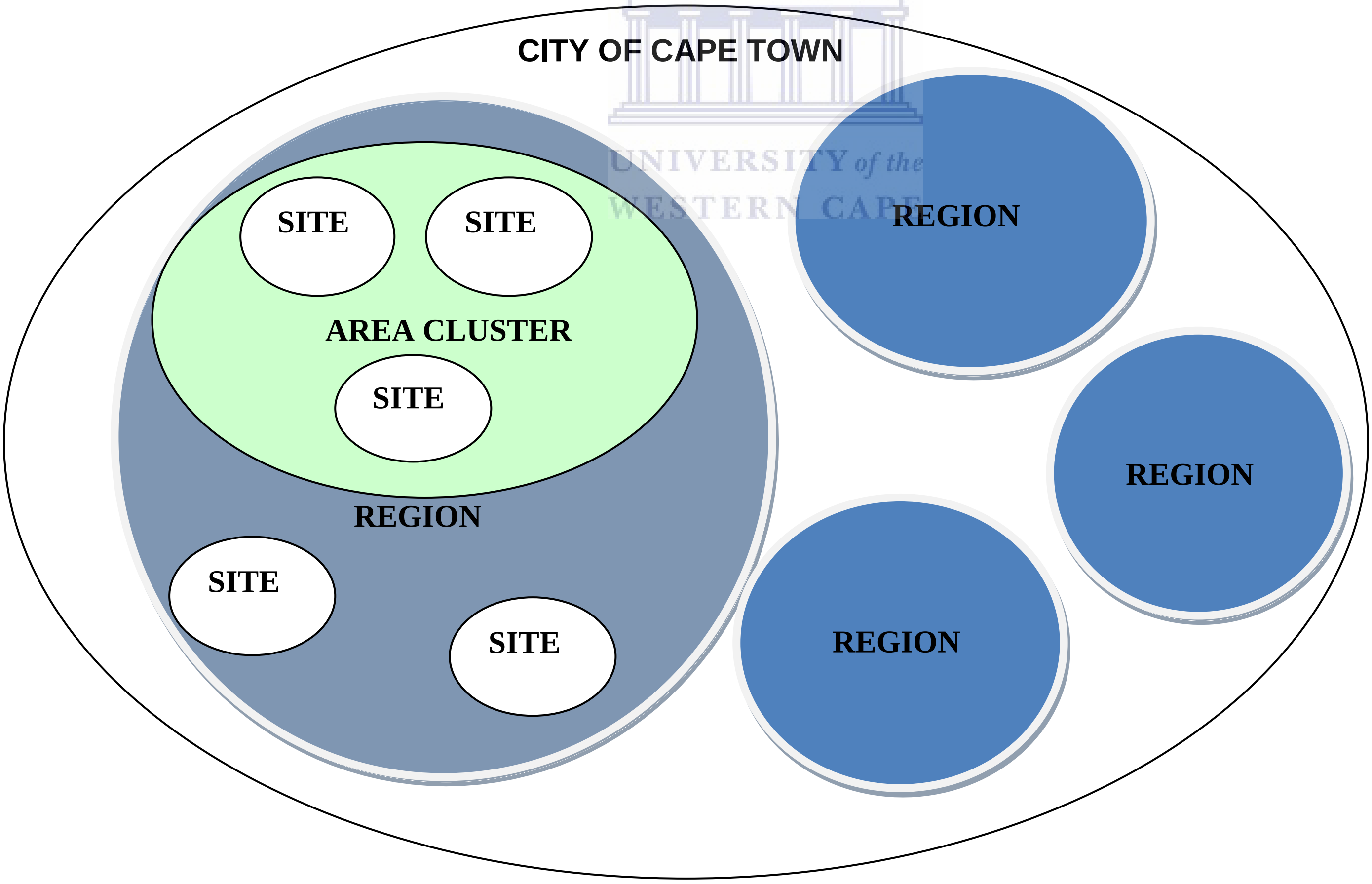


Figure 22: A diagrammatic representation of the spatial layout of boundary layers in the database.

6.6 Site Species List

Species lists can be viewed as the primary descriptor for the biodiversity of a country, allowing effective conservation planning (Giovani *et al*., 2012). In a similar vein the Site Species List is the primary descriptor offered to a site manager as a management tool that takes species information, sighting records, conservation status and date into account. This provides a succinct summary of the biodiversity to be found at a site.

As its name suggests, the Site Species List is linked to a specific site, or as the architecture indicates and can represent a Region or the City at a higher level of interrogation. The Site Species List contains the following components; a lock function, species name, common name, taxonomic class, date, locality, observer, site species status, International Union for Conservation of Nature (IUCN) status and the alien status. Each of these components will be dealt with individually below.

6.6.1 Lock Function

This function on the Site Species List indicates to the user whether the information about a particular species is locked or not. If information about a particular species were locked, only the site manager would be able to see this species appearing on the Site Species List.

Thus when a visitor or person examines the Site Statistics (see section 7.8 below) they may find a site total of (for example) 100 plant species. If one of these plant species were to be locked however, when the visitor opened the Site Species List they would only find 99 species listed. The 100th plant species would not appear and would also not be searchable in the sighting records lodged at the particular site. This is a security feature to protect locality information about species that are prone to illegal exploitation and collection.

The architecture for the locked function is engineered using a “top down” approach; thus if a species is locked at a City level, all records of this species will be automatically locked at the respective sites. A site manager would not be able to alter this at a site level and reveal the records to a visitor on the site. Likewise they could not influence the lock function at another site of which they are not the manager. This approach is relevant to species that are at risk within the general context of the city level, but there are also occasions where species may be at localised risk.

In such cases a site manager may then lock the species at a site level, blocking records of it only at this particular site. This action will have no effect on this species listed at other sites. Should the threat to the particular species pass, the site manager has the administrative power to unlock the species records once again.

6.6.2 Species Name

As the name suggests, this section of the Site Species List lists the relevant species. The colour of the text to display the species names changes depending on whether the species is locally indigenous (black), alien (blue) or is listed in terms of the IUCN criteria as threatened (red).

6.6.3 Common Name

Here the common name or names are listed next to the species name. The text in this field is also colour coded as in the case of “species name” above. Common names were derived from species lists provided by the South African national Biodiversity Institute (SANBI). Alternative common names can be manually added to species under the “Species” function, allowing for local common names to be incorporated into a species list if required.

6.6.4 Class

In this field the relevant class of organisms is displayed. This allows for Site Species Lists to be filtered according to taxonomic classes such as birds, mammals, reptiles, etc.

6.6.5 Seen on

This field provides the date of the most recent sighting of the particular species at the site. All the sighting records for a particular species can be located in the “Manage Sightings” function which is located on another tab on the Site page.

6.6.6 Seen on Site

This field provides the site where the most recent record of the species was located. This function only appears when a user examines a Regional or City-wide Site Species List, which are levels above a site. If the user were looking at the Site Species List at a particular site, this field would be irrelevant as all the species would be linked to that site.

6.6.7 Sighted By

This field provides the name of the observer for the most recent sighting. With the advent of the Observer Standards being implemented (see Section 14), an icon will displayed next to the observers name indicating if they are qualified in the identification of a specific class of animals.

6.6.8 Site Species Status

This field is only relevant at the site level and allows a site manager to set the status of a particular species at their site. This allows a species to be assessed at a site level and recorded accordingly, and thus allows a comparison between the global (IUCN) state of the species and how the population is faring at a specific site.

By giving the species as site specific status, this field also indicates whether the species breeds at a particular site or not.

6.6.9 IUCN Status

This field displays the current IUCN status as published by the South African Red Data Book for the relevant class of organism. As the database is constructed to incorporate Provincial, National and if needed a Continental level, the IUCN status is set at the national level. This sets all the site species lists at the lower levels.

The setting of the IUCN status at a National level fixes the status and it cannot be changed by a site manager at a lower level.

6.6.10 Alien

This field displays whether a species has been deemed to be alien to the specific site.

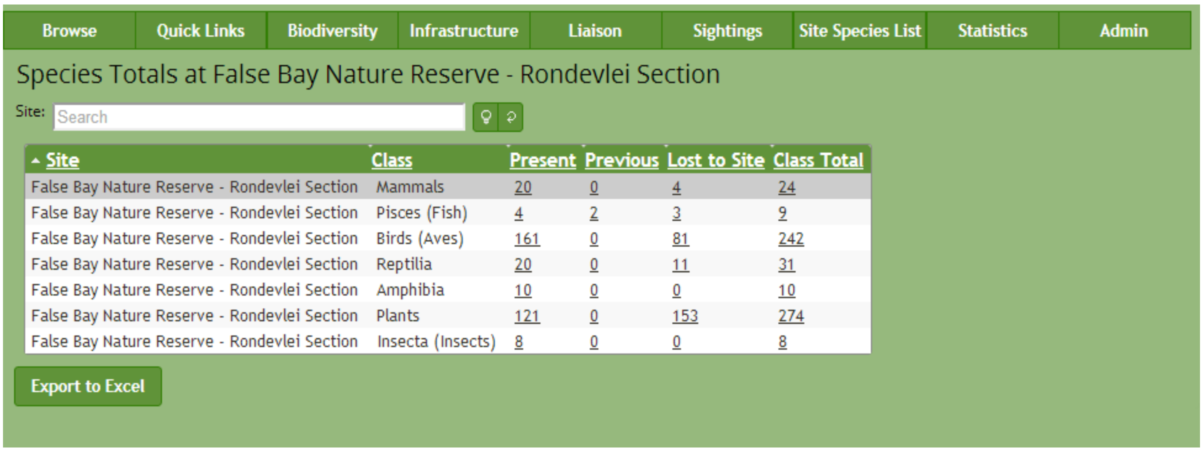
Similar to the “Locked” function, this function has a top down hierarchy. If a species has been set as “Alien” at a regional level it cannot be reset by site managers at sites in that particular region. Likewise, site managers can set their own alien status for a species at their specific site. This allows a species to be listed as an alien at site whilst possibly being indigenous to a nearby site in the same region. Given the complexity of species distribution in Cape Town, such anomalies are more common than expected when species lists are expressed at a specific site level.

6.7 Site Statistics

The Site Statistics provide a quick overview of the species totals at a particular site, displaying four totals per class group. These are;

- a total of all species observed in the class
- a total for all species in the “Present” category for which a sighting record has been made in the past 10 years or less
- a total for all species which are in the “Previously” known category for which a sighting record was last made between 10 – 15 years ago
- a total for all species which are in the “Lost to Site” category for which a sighting record was made > 15 years ago.

The numbers in the Statistics columns are hot-linked so that when clicked on take the viewer directly to a list of the species in question. The statistics of the species totals can also be exported in a Microsoft Excel table format.



Site	Class	Present	Previous	Lost to Site	Class Total
False Bay Nature Reserve - Rondevlei Section	Mammals	20	0	4	24
False Bay Nature Reserve - Rondevlei Section	Pisces (Fish)	4	2	3	9
False Bay Nature Reserve - Rondevlei Section	Birds (Aves)	161	0	81	242
False Bay Nature Reserve - Rondevlei Section	Reptilia	20	0	11	31
False Bay Nature Reserve - Rondevlei Section	Amphibia	10	0	0	10
False Bay Nature Reserve - Rondevlei Section	Plants	121	0	153	274
False Bay Nature Reserve - Rondevlei Section	Insecta (Insects)	8	0	0	8

Figure 23: An example of the species statistics totals for False Bay Nature Reserve – Rondevlei Section.

The species totals reflected in the Site Statistics table are drawn up from the most recent sighting records; taking the most recent record for each species. As described above, once a species has not been recorded for a period greater than 10 years it move out of the “Present” category and into the “Previous” category. A further 5 years absence will move the species into the “Lost to Site” category. The Site

Statistics are generated at 02:00 every day when the biodiversity database server goes off line for a short period (De Jager, Pers. comms., 2014). At this time statistics are recalculated for each site, region and a city list.

The Site Statistics function thus provides a daily synopsis of the species information at a particular site and brings immediate attention to a species that has not been seen for >10 or >15 years. One of the future functions would be to develop an automated alert to inform site managers of species that have negatively moved between categories. Such species need to be investigated as to why they have not been sighted in the prescribed period, with species in the “Previous (10 – 15yr)” category receiving the highest attention.

Of course the reason a species has not been sighted can be attributed to a number of reasons and may not mean that it is locally extinct. The absence for a sighting record for >15 yrs can be attributed to one of the following reasons:

1) No one has conducted a search or made a record of the species.
2) A search has been conducted, but carried out in the wrong season, habitat, time, weather conditions or using the wrong collecting method.
3) The species in question was originally recorded as a vagrant and has not reappeared at the site. A good example of such a scenario would be a vagrant bird species which may only appear once at a site.
4) The original sighting record has been misidentified and therefore the species will never be found at the site.
5) The observers at the site are unfamiliar with the species in question and are unable to locate it.
6) The species has become locally extinct at the site (ie “Lost to Site”).

These scenarios are examined in the Data Validation section (Chapter 13) in more detail. A good site manager will use the Site Statistics as a cue to target survey efforts of staff, students, visitors and researchers towards species of concern at the site. These would be resident breeding or regular visiting species that have not been recorded for >10 yrs and are no longer found at the site (ie. “Previous”). Such species, regardless of how globally common, are local site indicators to changes that may be occurring at a site (Reid *et al.,* 1993).

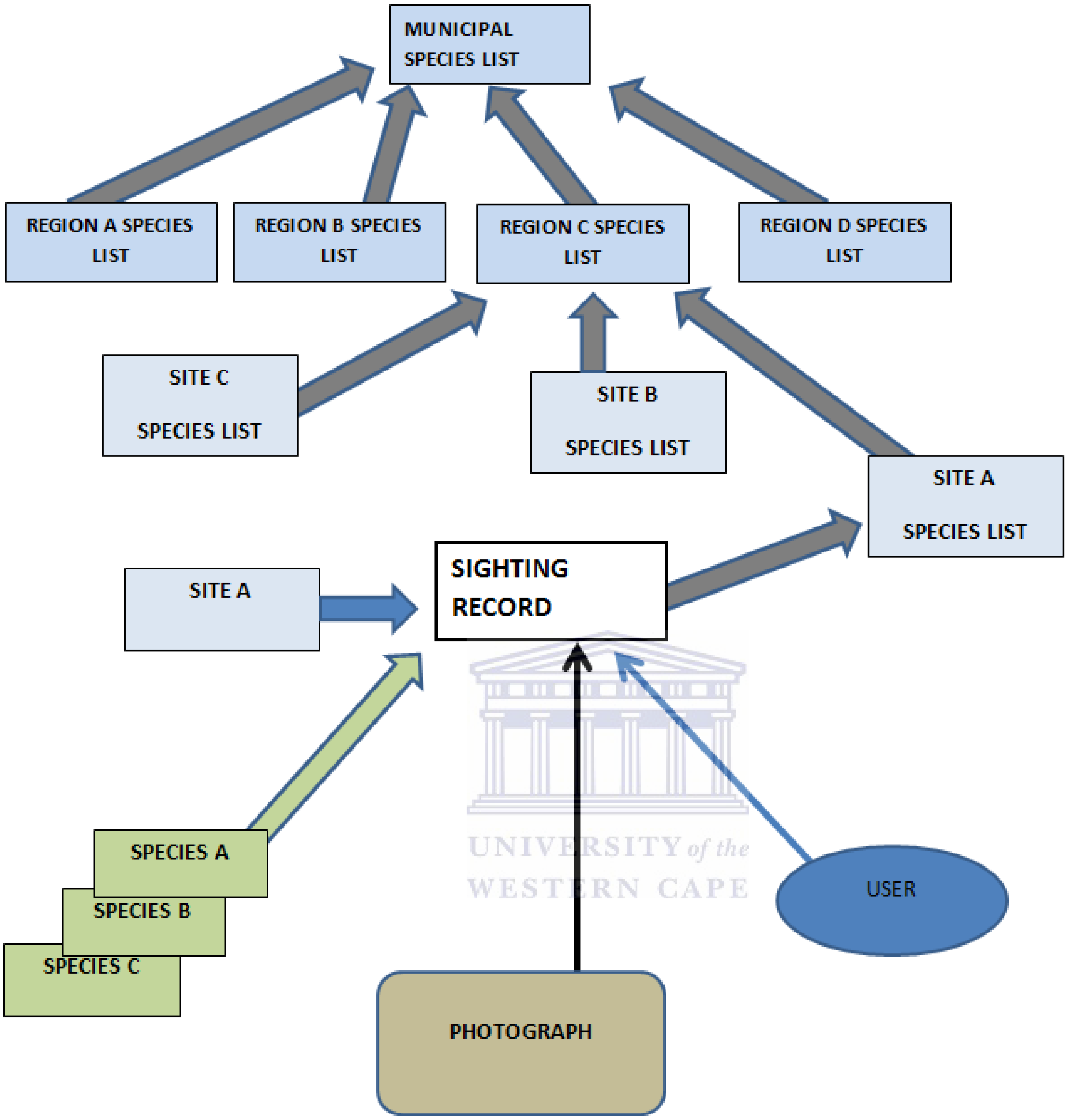


Figure 24: An Entity relationship diagram displaying how a sighting record influences the regional and City-wide (municipal) species lists.

6.8 Species

This function is the background species list that the database uses to reference a species in a sighting record. All the amphibians, birds, fish, mammals, plants and reptiles of Southern Africa have been loaded, with each species (and sub-species) receiving a specific reference number in the Sequel database. This number is used to connect a species with a sighting record. When inserted onto the database, the only compulsory field for a species is its Class affinity, defining whether it is a bird, plant, fish, etc.

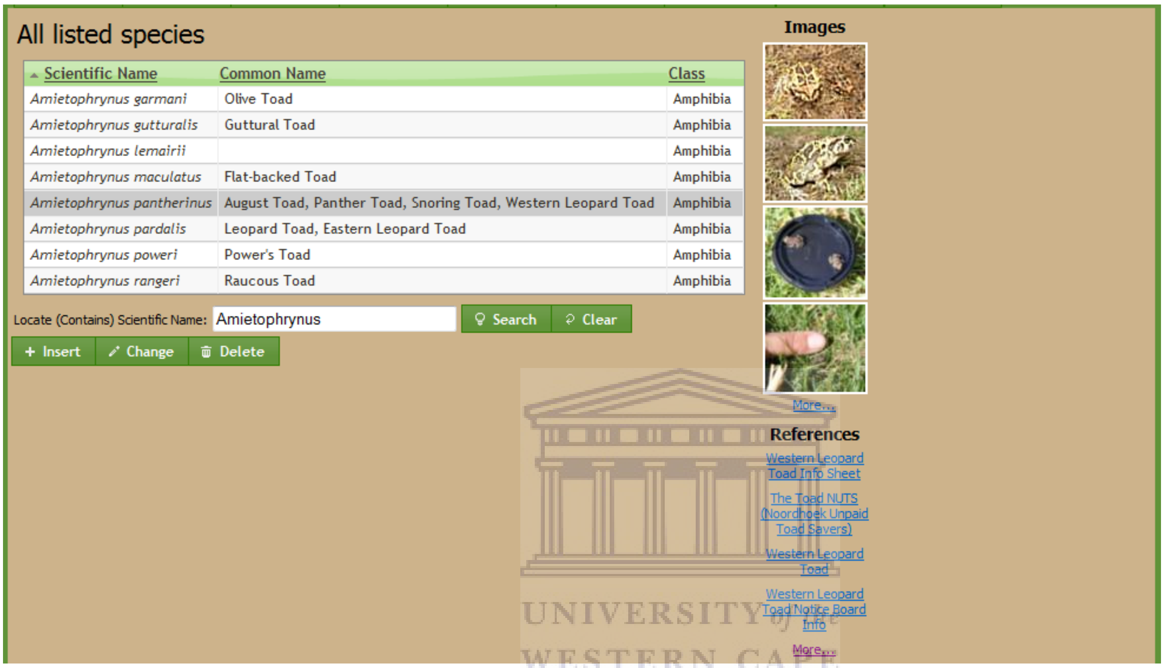


Figure 25: An example of the database species list with a search for the toad genus Amietophrynus. The resultant gallery photos and document information is displayed on the right hand side of the screen.

In the case of insects, arachnids and crustaceans, only certain selected species were allocated species numbers and entered onto the database. Given the difficulty in species identification amongst invertebrates, it was decided to restrict insect species to well known, easily identifiable groups such as butterflies, certain moths, dragonflies and scorpions. Selected pollinators, such as Honey Bee (*Apis mellifera*), were included as their presence and numbers can positively or negatively affect other specialised pollinators (Picker *et al.,* 2002).

Also included was the Long-tongued Fly (*Moegistorhynchus longirostris*), an easily identifiable specialised pollinator of a number of plant species (Picker *et al.,* 2002). Including species that require specialised skills for identification would result in species being listed against a site that could not be found again and hence result in numerous missing species in the long term.

Where invertebrate surveys have been conducted, these lists however can be attached to the relevant site as a reference document that is then not linked directly to the sites species list and will hence not have to be verified every 10 years.

Once a species has been entered onto the database and allocated a species number, certain attributes can then be designated to the species. One set of attributes allocated are related to the taxonomic classification of the species, with order and family being allocated as separate attributes. This architecture was chosen so as to facilitate the reallocation of a species to a new family if reclassified.

A reference photograph can be added and there is no set standard for this. Although the photo is a reference, it is not forming part of any long term reference strategy such as fixed point photographs that need a consistent format in order to be comparable (Rabinowitz, 1997). Apart from photos, reference documents can also be attached against species, providing information for database users. Many species already have excellent online information available about them and hence a URL has been added to automatically connect the user to the relevant website.

6.9 Site Calendar

The Site Calendar allows a manager to perform four important management functions at one entry point; these are plan, document, report & archive.

Conservation managers should base their management decisions on good science which is rooted in evidence and an understanding of the landscape that they are conserving (Sutherland *et al.*, 2004; Pullin *et al.,* 2004). This is however not always the case as a study of conservation areas in the east of England revealed that only 2% of management actions result from scientific publications and 10% from expert advisors. A huge 32% of management actions were attributed to common sense, a surprisingly high number for management that needs to be grounded in science in order to be effective. Could this statistic perhaps also be rooted in the influence that emotions have on the human decision making process (Damasio, 1994)? Furthermore it was also found that very few management actions were documented so as to provide the basis for future evaluation and repetition (Sutherland *et al.,* 2004). The lack of documentation is a key starting point in order to allow for future evaluation, monitoring and scheduling of management activities. The Site Calendar function on the biodiversity database hopes to fill this need.

Many conservation management activities are repetitive, being repeated over and over across seasons and years. These management cycles can be dictated by ecological functioning such as annual flooding or fire cycles, but can also be dictated by anthromorphic factors such as budget cycles of an organisation or regular social meets.

Fauna and flora monitoring programmes are common activities on protected areas, characteristically repeating the same methodology at regular intervals over long time frames in order to determine population trends. Other management activities, for example ecological burns, are conducted as single events with greater intervals, usually years apart. Between these ecological burns there is no activity to remind managers that it should happen again, and the danger exists with management activities that future managers will not be aware that they should perform such actions.

Indeed any long term management action needs to be undertaken with an information support mechanism that will notify future managers of both the historical management activities that have taken place and those that need to be done. This would help address the concerns raised in the research cited above; where many conservation actions take place without reference to scientific research and previous management action records (Pullin *et al.*, 2004).

As we have seen earlier, a conservation manager is constantly managing the interaction between Nature; People and Infrastructure. As a result the conservation manager of any site will need to conduct a variety of management actions, which need to move through five distinct stages; these are:

Plan ➡ **Execute** ➡ **Document** ➡ **Report** ➡ **Archive**

Plan – a manager will plan a certain action, taking into account a variety of factors such as season, budget, site history, resources and priorities.

Execute – the manager will execute the management action with the planned resources or will be executing an unplanned action such as responding to a wildfire or pollution event.

Document – the manager will document the management action that was conducted. In some cases this may mean documenting an unplanned event.

Report – the manager will invariably be submitting reports regarding the activity that has taken place at their conservation site(s).

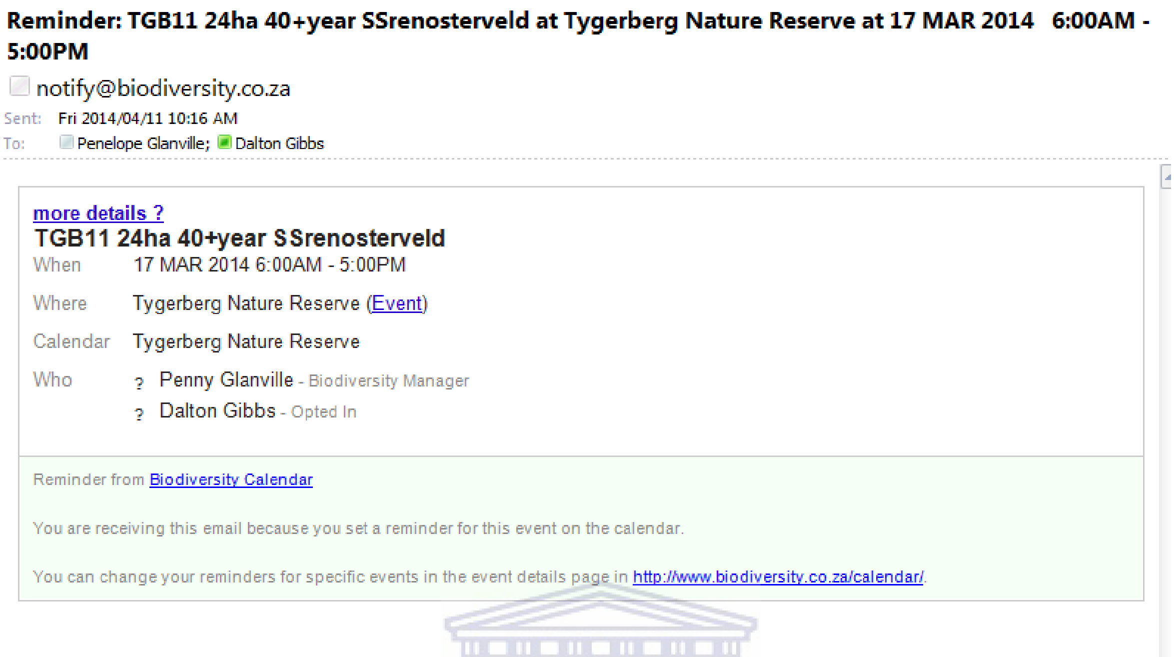
Archive – the manager needs document what management action has taken place for a future manager to reference.

To this end a "Site Calendar" was developed as a management tool to facilitate four of the above stages, these being the planning, documentation, reporting and archiving of management actions. A manager can plan and then document the management actions that have taken place and the calendar function will automatically report on the event at a predetermined time interval. The calendar function also automatically archives the management event for future reference.

Thus of the five management steps (plan; execute, documents, report, archive), the manager has to only do the first three, with the calendar function doing the rest automatically.

The calendar function operates much like an electronic calendar, allowing a user to set up future management activities which will send a reminder before the event at a pre-set date. These management activities can be either be established as once off events or created as activity cycles which will repeat at set intervals. An example of which would be fauna monitoring which may involve a regular monthly count and are then pre-set against the site calendar into the future. The user however has the option of also creating a shorter sequence of activity events which can be stopped after a predetermined number of events.

Such an example would be a number of limited term fauna counts that are used to determine a quick of assessment of a specific species and are not to be repeated in the future.



Reminder: TGB11 24ha 40+year SSrenosterveld at Tygerberg Nature Reserve at 17 MAR 2014 6:00AM - 5:00PM

notify@biodiversity.co.za

Sent: Fri 2014/04/11 10:16 AM

To: Penelope Glanville; Dalton Gibbs

more details ?

TGB11 24ha 40+year SSrenosterveld

When 17 MAR 2014 6:00AM - 5:00PM

Where Tygerberg Nature Reserve (Event)

Calendar Tygerberg Nature Reserve

Who ? Penny Glanville - Biodiversity Manager

? Dalton Gibbs - Opted In

Reminder from Biodiversity Calendar

You are receiving this email because you set a reminder for this event on the calendar.

You can change your reminders for specific events in the event details page in http://www.biodiversity.co.za/calendar/.

Figure 26: An example of an email notification sent to a manager for an event that is due on their Site Calendar. The text with "more details" is a link that allows the user to move from the mail directly to the event on their Site Calendar.

A future proposal for the Site Calendar is for the system to prompt a manager on how to conduct a certain management activity. For example if the manager selects as their activity types "Fire – Planned Ecological ", the calendar will respond by presenting the manager with the guidelines for planning and conducting an ecological burn (See Appendix 4). This document is the cumulative knowledge that is obtained from managers, City Fire Services and ecological scientists on ecological fires. This method of "information prompting" will help address some of the deficiencies in management practices being based solely on common sense and traditional land practices (Pullin *et al.*, 2004).

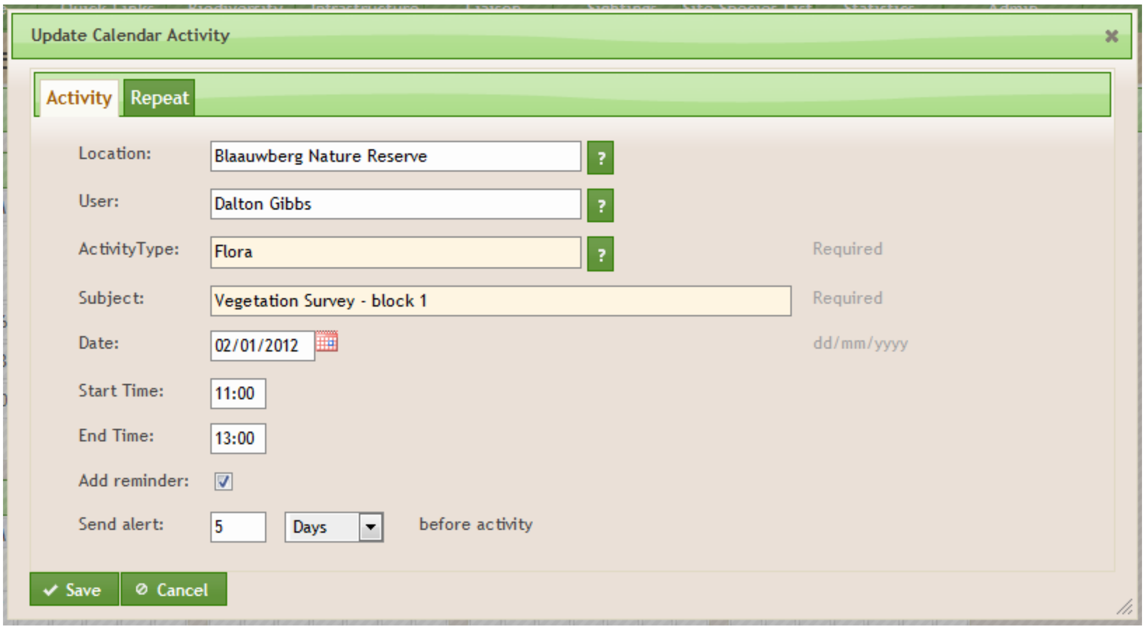


Figure 27: An example of a management action on the site calendar, with the second page showing how the repeats can be set up (below).

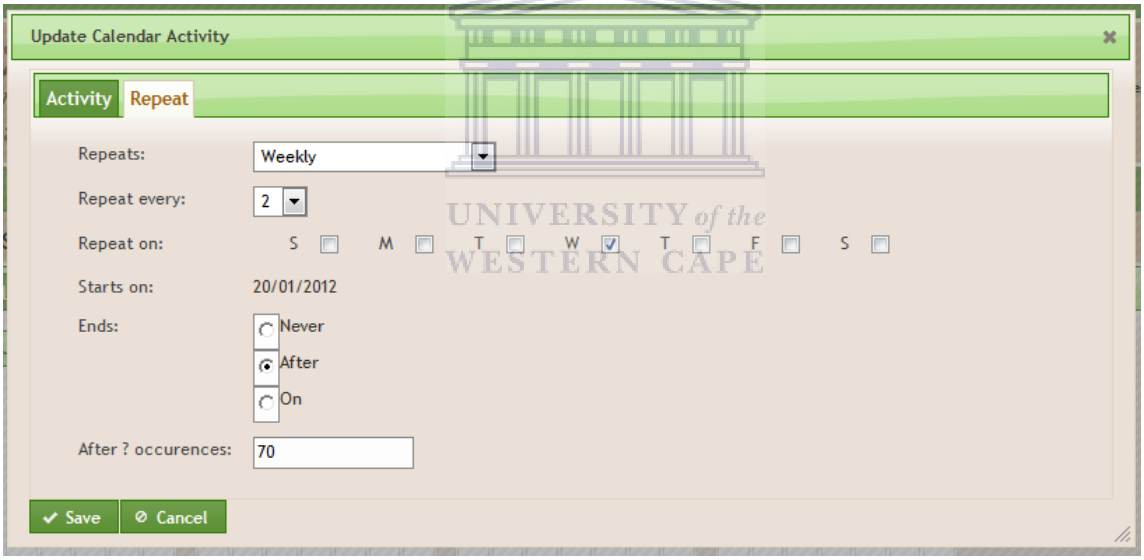


Figure 28: The site calendar allowing one to set a management action for a limited or limitless sequence into the future. In this example case the management action is set for every two weeks on a Wednesday and ends after 70 occurances.

Unlike an electronic diary however, the Site Calendar also provides an attachment file of how to do the action, and records whether the action has been completed. This allows management actions which have been planned and conducted today to be recorded and prioritised for action at set intervals in the future.

The Site Calendar function however does not just allow for the scheduling of future events, but can also be used to log events retrospectively. A wildfire for example by definition cannot be a specifically planned event; however it has important bearing on future management activities. Thus a calendar event for example a wildfire can be created retrospectively to document the event.

The Site Calendar has a “Site Activity” list, which lists in table form all the historical and planned events for a specific site. This list can be refined and allows the user to search and produce a report of all the events of a certain activity type, for example a list of all fires that have occurred at a site. This can be further refined by selecting one specific Activity type, for example a search for all the wildfires at a site by selecting “Fire – Unplanned Wildfire”. Any specific activity event listed in the report can be opened up and the information viewed, which can include photographs, shape files or other documents that have been attached by the previous user.

There are six management activity groups in the Site Calendar which encapsulate 36 activities performed by conservation manager of conservation sites. Although this list is not exhaustive, it aims to capture the basic activities which conservation managers do in the course of their management duties. Some of these activities are then divided into logical sub categories. For example the activity type of “Fire” can be sub-divided into four different activities that can take place under this heading; these are:

Fire – Fire Preparation & Planning
Fire – Fire Mapping
Fire – Planned Ecological
Fire – Unplanned Wildfire

Each activity type is colour coded, with base colours linked to a theme, for example all water activities are a shade of blue. The calendar activities are listed below:

1) Fauna
    a. Fauna – Fauna Mortality Event (Light brown)
    b. Fauna – Invasive Fauna Management (Dark Brown)
    c. Fauna – Indigenous Fauna Management (Light Brown)
    d. Fauna – Monitoring (Red Brown)

Figure 29: Example of colours and calendar options for Fauna management.

2) Flora

    a. Flora – Indigenous Flora Management (Light Green)
    b. Flora – Invasive Flora Management (Dark Green)
    c. Flora – Monitoring (Green)
    d. Flora – Restoration & Rehabilitation (Light Green)

Figure 30: Example of colours and calendar options for Flora management.

3) Water
   a. Water - Monitoring
   b. Water – Water Level Management
   c. Water – Pollution Event

Figure 31: Example of colours and calendar opitons for Water management.

4) Fire
   a. Fire – Planned Ecological (Orange)
   b. Fire – Post Fire Mapping (Yellow)
   c. Fire – Preparation & Planning (Yellow)
   d. Fire – Unplanned Wildfire (Red)

Figure 32: Example of colours and calendar options for Fire management.

5) Soil (all Soil activity types are mark brown)
   a. Soil – Management
   b. Soil – Mapping & Monitoring

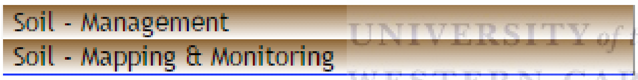


Figure 33: Example of colours and calendar options for Soil management.

6) Infrastructure (all infrastructure activity types are marked the same grey colour)
   a) Infrastructure – Cultural Heritage Site Management
   b) Infrastructure – Demolished/Destroyed
   c) Infrastructure – IT Backup
   d) Infrastructure – Litter Clean Up
   e) Infrastructure – Maintenance
   f) Infrastructure – New Construction
   g) Infrastructure – Small Plant & Equipment
   h) Infrastructure – Vehicles

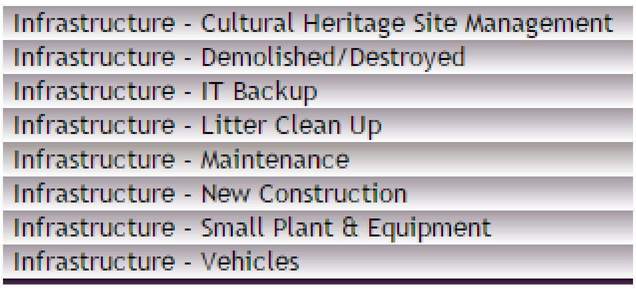


Figure 34: Example of colours and calendar options for Infrastructure management.

7) People (all people activity types are marked the same colour purple)

a. People – Environmental Education Programmes
b. People – External Organisation Meeting
c. People – Health & Safety
d. People – Internal Organisation Meeting
e. People – Public Event
f. People – Staff Administration
g. People - Staff Appointments & Resignations
h. People – Staff Training
i. People – Volunteers

Figure 35: Example of colours and calendar options for People management.

8) Public Event   (all Law Enforcement activites are the same colour dark blue)

a) Law Enforcement – Incident
b) Law Enforcement – Planning & Patrols

Figure 36: Example of colours and calender options for Law Enforcement management.

Since the “Activity Type” field is a fixed field and users are restricted to one of the activity types listed above, this improves the search function as the fields are limited. The user can also describe the “Activity Description” as a free field. This colour coding allows the user to see the type activities on the annual site calendar at a site at a glance. A filter function on the side allows the selection to be refined by turning off the other activity types until only a particular management activity type is showing, for example only for “Fire – Unplanned Wildfire” which would show what wild fires have taken place at the site.

Alternatively by selecting all the three fire activities by leaving the associated colours of fire switched on, a report for all fire related activities for the site can be generated. A further calendar filter function allows this report to be restricted to a certain time frame, for example a list of fire related activities between 1/1/2010 and 1/1/2012.

Users can also give their activity a description, which is a free field and allows the user to give the event a unique title. This activity description is a displayed as a short heading and appears when the user hovers over the activity event on the calendar. This activity description also appears on the Site Activity list where a search function allows a user to search for a specific description or key word. This search function is however subject to the original user having used such a key word or phrase in their original description. As long as a particular key word or phrase had been used in the original description, the search function in the Site Activity against the Activity Description list produces a more accurate result. This is because it narrows the search results against a specific description and does not give merely a generalised report against an Activity Type.

The scheduling of the Site Calendar allows for a management actions to be scheduled at any period of time – a day, week, month, every year, etc. The management action can also be scheduled to fall on a specific day of the week, for example the first Wednesday of the month, if this is the specific day that the management action should take place on.

When a management action becomes due, there are three possible outcomes. Firstly if the management action has been completed it can be marked as finished. It may not have taken place on the day planned for, but the outcome date can be modified in the system.

Secondly in some cases the management action may have to be postponed, if for example an ecological burn cannot be conducted due to weather conditions. In this case a new scheduled management action date can be created, but the action is not cancelled and the database will record who made this amendment to the management action sequence.

Thirdly a management action can be cancelled outright if the circumstances have changed to such an extent that the action now longer applies. In this case the past history of this management action sequence will be kept against the site and never be deleted.
A future function being built in is to have an approval function, so that a management action sequence can only be deleted from a site when approved by a higher manager than the site manager. This is to safe guard a manager simply not wanting to do a task, or the loss of a valuable management action sequence that has been happening over a long period of time.

By retaining all the management actions (and their methodology) of a site, it allows future managers to perhaps resurrect these management actions sequences if needed and build on an existing dataset.

If the Site Calendar is set on a month time limit, the resultant calendar becomes a convenient monthly work schedule for the staff managing the site, as the example below demonstrates. This could be printed out and used as staff work instructions.

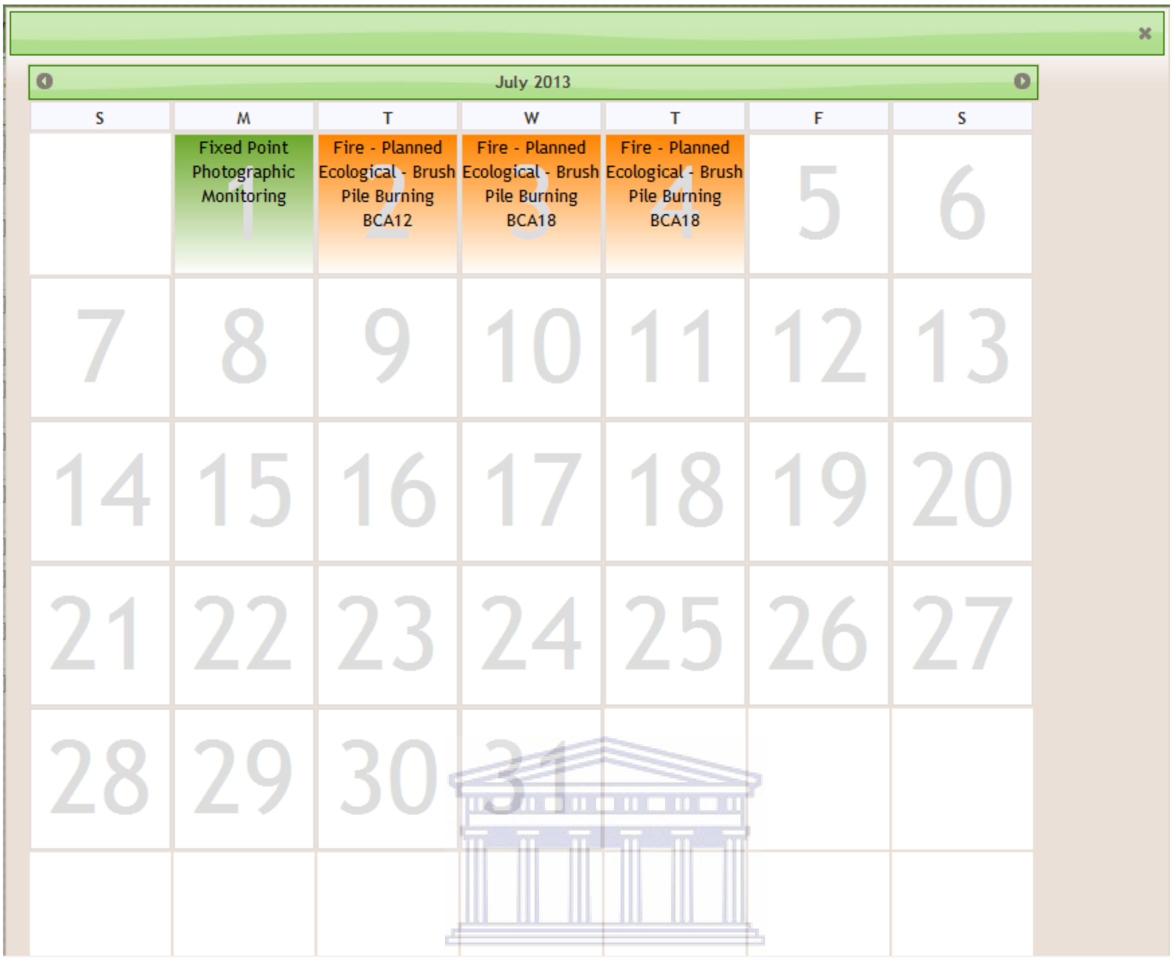


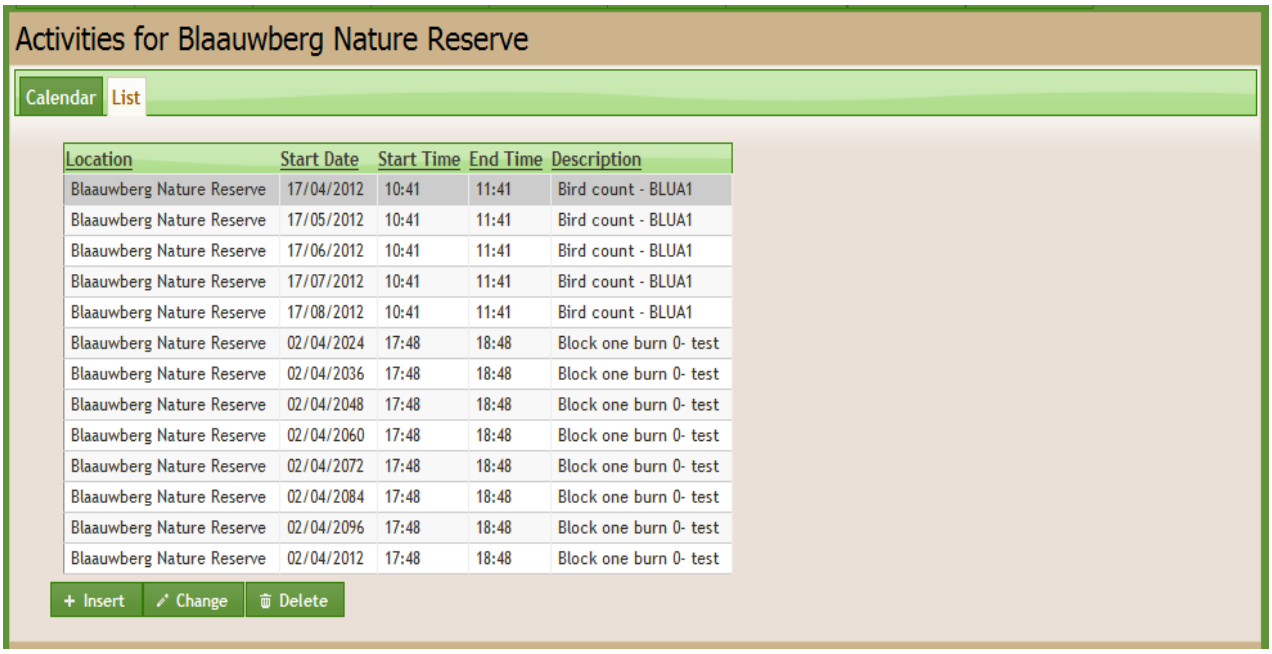
Figure 37: An example of the monthly planning for Blaauwberg Nature Reserve. Each event displayed can be interrogated and opened up.

Figure 38: An example of a site calendar with the management actions colour coded. This view gives an overview of the year and is an annual planner for the site manager.

As with other boundary levels, the calendar function at the area, region or city level will show all the management actions listed for the sites below it. This at a glance will show all the management actions, or a certain selected type, for all the sites below it.

The site calendar at a higher level thus retains all the past and future management actions in a region or across the entire city boundary, allowing managers to search these records. This provides a reference system for all management actions carried out at a site; recording what was done, by whom and with what methodology. As at a site level, the list is searchable under different criteria, and hence all past and future management actions matching a certain description can be found.

A future development that is proposed is to have a separate information sheet for each different Activity Type. Thus when a person opens an activity on the Site Calendar for a specific event they automatically create a report at the same time; maximising their time. For example when they create an event for a “Fire – Wildfire”, the template is automatically that of a fire report which is then completed. Presently managers are completing a separate off line word document which they then have to attach as a separate document. This is a duplication of effort.



Location	Start Date	Start Time	End Time	Description
Blaauwberg Nature Reserve	17/04/2012	10:41	11:41	Bird count - BLUA1
Blaauwberg Nature Reserve	17/05/2012	10:41	11:41	Bird count - BLUA1
Blaauwberg Nature Reserve	17/06/2012	10:41	11:41	Bird count - BLUA1
Blaauwberg Nature Reserve	17/07/2012	10:41	11:41	Bird count - BLUA1
Blaauwberg Nature Reserve	17/08/2012	10:41	11:41	Bird count - BLUA1
Blaauwberg Nature Reserve	02/04/2024	17:48	18:48	Block one burn 0- test
Blaauwberg Nature Reserve	02/04/2036	17:48	18:48	Block one burn 0- test
Blaauwberg Nature Reserve	02/04/2048	17:48	18:48	Block one burn 0- test
Blaauwberg Nature Reserve	02/04/2060	17:48	18:48	Block one burn 0- test
Blaauwberg Nature Reserve	02/04/2072	17:48	18:48	Block one burn 0- test
Blaauwberg Nature Reserve	02/04/2084	17:48	18:48	Block one burn 0- test
Blaauwberg Nature Reserve	02/04/2096	17:48	18:48	Block one burn 0- test
Blaauwberg Nature Reserve	02/04/2012	17:48	18:48	Block one burn 0- test

Figure 39: An example of the management activities list, which records all past, present and future management actions for a site. Each record can be opened to view all the parameters of the activity event.

Since the launching of the Site Calendar at the end of 2012, there are at the time of writing some 10 300 events planned or archived on the Site Calendar function on the biodiversity database (De Jager, pers com).

6.10 Population Management Function

This function is in a development phase, but allows a user to record the population numbers of a specific species that is being managed. This applies to species whose precise numbers on a site need to be precisely known and managed. With this function, a sighting or translocation record made for that particular species will automatically adjust the population total depending on whether there was a net loss or gain of individuals.

The hippopotamus (*Hippopotamus amphibious*) population at Rondevlei is an example of a site specific population of animals whose numbers are being managed. An accurate base line of the number of animals present is set for the site; this is then adjusted by sighting or translocation records. A sighting of record of a hippo logged as “new born” under the Health Status tab on the general sighting page will increase the site total for that species.

A general sighting of a number of hippos will not alter the site total, as these do not influence the number of individual on the site. However a sighting logged of a hippo with its Health Status tab set as “dead” will decrease site total for this species. Likewise, translocation records of hippos on to or off the site will alter the site total for this species respectively.

As in other functions, a total for all the managed populations of hippos could be extracted at an area cluster, regional or city level if needed.

6.11 Gallery Function

The gallery function allows for the inclusion of photos of species for reference by users. These can either be included as pictures attached to the species, or built up from photos attached to actual sighting records. For the sake of speed and uploading, a thumb-nail image is displayed, with the full size version being available for downloading if needed.

When downloading photos, the user, date and title of the photograph are included for future reference and to be able to track the source of the photograph.

6.12 Thresholds of Potential Concern

This is a function for the database that will be introduced in the future and it will be activated when a species reaches a predetermined threshold number, absence or reporting rate. A threshold of potential concern is a point at which the number of organisms of a species may have negative impacts on biodiversity in an ecosystem (Foxcroft, 2009) or where numbers of an indigenous species drop to a pre-determined level (Roger *et al.,* 2013). Management options are evaluated at this point and management protocols may be implemented (Foxcroft, 2009).

In the case of the database, the function that is to be developed has three parameters that can be set to fine tune a threshold of potential concern. This is based upon a species at a particular site, but may be extrapolated to work at the Regional or City wide level. These parameters are species, numbers of individuals and time frame.

In its simplest form, this function can be used by a site manager to set a species of concern at a site, regional, or city level. A threshold number is set against the particular species, with a warning raised if the numbers exceed the predetermined threshold.

Thus the simple option is: species number > or < threshold = warning raised.

Such a warning may however merely be indicative of seasonal variations in populations or migratory species. In order to clarify this, an additional parameter of time can be set along with the species number. This additional parameter is time. Thus if the numbers of a species recorded at a site exceed the predetermined threshold over a predetermined time then a warning is raised.

Thus this option is: species number > or < threshold and > time period = warning.

The warning that is generated would contain any notes created by the author as to what remedial action to take. Thus a new site manager may not be familiar with a particular species on their site but would be automatically informed when a problem may be arising due to a predetermined warning generated by a previous site manager. The warning notification can also be set to duplicate through to other people who may be able to assist the site manager with remedial action for the species in question. It is also hoped that this function can help capture institutional knowledge about specific species management and what remedial actions are needed to reverse a trend.

6.13 Indicator Species

Indicator species are those that can reflect changes in an ecosystem and can provide clues as to the causal factors of these changes (Vos *et al.,* 1999). They can thus give an indication of the health of an ecosystem, provide an early warning system of impending changes or help diagnose environmental problems (Dale, 2001).

In order for a species to be an effective indicator it needs to have a variety of the following characteristics:

- It needs to be easy to monitor, not being a cryptic species or one that is easily confused with other species in the ecosystem (Dale. 2001).
- It needs to be a species that is sensitive to stresses that occur in the ecosystem and must respond to those stresses in a predictable way (Vos *et al.* 1999).
- An indicator species must predict a change that can be linked to a potential management action in order for it to be effective (Dale. 2001).
- An indicator species must be able to reflect a broad range of factors across various components of the ecosystem (Vos *et al.* 1999).
- An indicator species must have a known response to disturbances in an ecosystem that is measurable (Dale, 2001).

The difficulty of using a specific species as a definitive indicator tool to represent the health of an entire ecosystem lies in the species being selected for this task. Species selected are often specialist species that are sensitive to changes in their local ecosystem (Young *et al.* 2013) and can reflect these changes in their health or population (Caro. 1999). Thus the exclusive monitoring of wetland specialist species will only reveal certain aspects of the ecosystem being evaluated and will not reflect for any terrestrial components (Vos *et al.,* 1999).

A potential solution to this is the selection of a suite of indicator species that are weighted according to factors such as degree of specialisation, conservation value and regional representation of a species (Young *et al.,* 2013). Such a technique aims to take in to account the various ecosystems at a site, national conservation priorities and regional species richness (Young *et al.,* 2013). A suite of indicator species can also be drawn up by selection by experts in respective fields; indeed a study by Young found that suites of indicator species drawn up by experts proved as effective as those formulated by a weighted matrix (Young *et al.* 2013).

As a future feature on the biodiversity database, it is envisaged that this tool will function closely linked to the thresholds of potential concern function (6.12 above). A species that has a ‘threshold number’ ascribed to it should preferably be an indicator species which will provide information about a change that is occurring in an ecosystem. The notification that the site manager would receive when an indicator species has reached a threshold number will include a section explaining what this species is indicating and what remedial actions can be taken by the site manager. In so doing, it is hoped to capture institutional knowledge about species and be able to convey it to future site managers without them having to experience negative ecological changes in an ecosystem before learning what individual species may be indicating.

7 The Mobile Application

With the advent of so-called "smart phones" many of the traditional functions restricted to desktop or laptop computers are now available on cellular phones (Williams & Pence. 2011). Coupled to these functions is the additional function of a Global Positioning System (GPS), using either the local cell phone networks or satellite tracking. This allows the user to determine their position with reasonable accuracy in most cases.

The mobile application is branded under the name "Wildlife Heroes" and is separate from www.biodiversity.co.za. This enables this application to interact with other biodiversity related sites such as the Peace Parks Foundation, South African National Parks and various private game reserves. The development of this application falls largely outside the scope of this thesis, but was supported by information provided from this database.

8 Management Cascades and Feedback Systems

In order create relevance to conservation management; information needs to be accurate and as real time as possible. This is particularly true for ecological emergencies such as pollution events, fires or illegal activities. For this a "management cascade" function is being designed and built into the system and is hoped to be launched in the near future.

With the hierarchical nature of the sites on the database, sites can be clustered around management functions, with for example all the sites in the East of the city falling under one person for any illegal activities being reported. This person would characteristically be a law enforcement officer; able to respond to reports of illegal activities which affect biodiversity, for example poaching or illegal hunting.

Given that many observers do not know who the municipal or state conservation officers for an area are, they have to only create a sighting record for what they have seen. Key words in the record will thus activate an automated response to the relevant conservation officer.

For example a record using the key terms in the "Health Status" as dead and "Cause of Death" as illegal hunting will elicit a notification email to not just the site manager for the relevant site, but also to the law enforcement officer responsible for that specific district.

Likewise sighting records using "Health Status" = dead and "Cause of Death" = water pollution will elicit a real time email to the relevant site manager and the water pollution officer for that specific district or catchment.

The management cascade function is thus a means to connect observers with the specific people who manage both the site and deal with environmental disasters or crime without having to intimately know this information. Thus by creating a sighting record of what has been observed information has been recorded and a management response has been created.

9 Maintaining Data Integrity

Whilst the process of verification is outlined in chapter 13 below, where old historical information was evaluated against set criteria, data integrity instead deals with keeping the data consistent over time and between users. When a sighting record it is marked as "pending" as its default value until it has been verified by the relevant site manager. As outlined previously, the site manager can accept, reject or leave the record pending. This acceptance ability is restricted to a site manager or administrator on the system only, reducing the number of people who can change a record. This reduces the chances of the record being tampered with or changed over time. Likewise, the ability to change any information in the record is also restricted to the relevant site manager or an administrator.

If a record is marked as "Rejected" or Pending" by the site manager, the record is not deleted, but continues to reflect against the relevant site in the "Manage Sightings" section. This is functions is designed as such for four reasons, namely:

1) the site manager may need some new information to confirm and hence accept the record
2) the record is erroneous and the site manager needs to keep a record of such records from a specific observer to feed back to them and hopefully improve their identification skills
3) the observer is deliberately creating fake records and the number of rejected records against that observers name will raise a query at the administrators level
4) the site manager is not sure if the specific species has been seen, but would like to keep such doubtful records under the "Rejected" category against their site in case future observations prove that this species has indeed been recorded there. Older rejected records can then be altered to reflect the correct species.

The function to manipulate these records in the above manner is restricted to the site manager and administrators only. The ability to delete a record outright however is restricted to a system administrator to prevent the deletion of records at a site level; only once such records have been examined and are deemed totally erroneous are they deleted

10. Managing Data Safety

The server used for daily transactions of the biodiversity database is hosted in London, which has the best cost/speed balance for South African users. The backing up of the data for safety is however done completely off site in order to protect the information not only from hard drive failure, but also from physical calamities such as theft, fire, flooding and other natural disasters (Johnson, Pers. comm., 2014).

The biodiversity database information is thus secured from hard drive corruption or other loss by being copied and backed up daily as an image and stored on a server in Hong Kong. This is a complete backup that includes all the background programmes that allow the system to run. From this backed up image the entire server could be recreated on any server if needed with information supplied by the internet service provider (Johnson, Pers. comm., 2014).

A second backup of only the Sequel data code is backed up on a server in the United States of America. From this backup the biodiversity database could be recreated once restored with the web server software that allows it to run. In to this daily backup are incremental backups of the most recent changes done every four hours and backed up on the server in the United States (Johnson, Pers. comm., 2014).

Should the numbers of simultaneous online user increase to several thousand, the need for balancing this load will be needed to prevent server down time and loss of short term information. The present volume of user traffic on the biodiversity database precludes the need to load balance at the moment (Johnson, Pers. comm., 2014).

11. Managing Data Security

Being able to access a SQL database, insert data and interact with other sites, makes a database vulnerable to security breaches and a variety of threats (Lam *et al.,* 2008). Coupled to this is the number of data portals where information is exchanged and provided to users outside of the database (Atluri & Avugdor, 2002).

Unauthorised access to a dataset is usually for one of two reasons; to either damage or alter the data or to install malware onto the server (Zuo & Panda, 2004; Buehrer *et al.,* 2005).

In the case of a database, where the system relies on user controlled input to provide information, it becomes open to the possibility of a hacker injecting a sequence in the SQL code (Lam *et al.,* 2008).

Using a legitimate input method, a hacker could deliver a coded sequence into the database that could deliver information, delete information or change the programing in the database itself. This method of attack is one of the top five threats faced by databases worldwide (Buehrer *et al.,* 2005).

The biodiversity server prevents these SQL injection attacks by sanitising all input before it is passed to the database. This is done through the presence of a web server interface between the user and the SQL server. This web server has been programmed with its own unique user proprietary software and will not accept SQL as an input language even though it provides the SQL server with the users information in SQL language (Johnson, Pers. comm., 2014).

An “information portal” is a term referring to web sites which serve as the primary source of information gleaned from other diverse data sources (Atluri & Avugdor, 2002). Both the gathering and dissemination of these data by the information portal website opens the associated database to security risks (Atluri & Avugdor, 2002).

At this stage the biodiversity database does not operate as an information portal in this way and thus this avenue of attack is not present.

Some databases that maintain sensitive information, for example medical health database, deal with security issues by “depersonalising” the information when it leaves the server. This allows researchers to mine health data from a wide variety of sources, providing large number of files without accessing personal information relating to the specific individuals (Agrawal & Johnson, 2007). While this does not stop an attacker, if the intention of such an attack is to illegally harvest data, the data that will be stolen will not be personalised enough to be of any direct use. This approach unfortunately cannot be applied to the biodiversity database, where information records need to be conveyed to the manager as intact and unambiguous as possible. For whereas unlike data mining in for example a health care dataset, where a researcher may be analysing trends involving millions of records, the biodiversity database records are often important as a single record of a single species at a given place and time. Hence “depersonalising” or “anonymizing” such records would reduce their value to a manager.

However the biodiversity database contains no personal information, no bank or other financial information, and no health related information. As such the data itself has little or no commercial value and thus presents a low value target. The information presented by the biodiversity database cannot be "depersonalised" as this would render the information largely unusable to the recipient.

Another form of attack is the "hijacking" of the data stream during a transaction between the web server and the user (Buehrer *et al.,* 2005). In order to ensure that a data stream is not "hijacked" during an information trading session, an authentication protocol is set up between the machines. This was developed for the gambling industry, where online gambling software relies on a random user number generated for a particular log-on sequence, which is encrypted by the server and sent to the user. The reverse is then also done and sent from the user's machine to the server. This is then decrypted by a sequence sent by the server to authenticate the machine from which the player is gambling. This protocol establishes an authentication link between the server and the player's machine (Jorasch & Schneier, 2000).

In order to avoid this threat, the server hosting the biodiversity database hosts proprietary web server software that has been specifically written. Industry standard penetration tests are regularly performed against the server to detect any possible vulnerabilities. In addition the proprietary nature of the server makes common attacks fruitless (Johnson, Pers. comm., 2014).

A penetration test is run on average quarterly, during which +- 50 000 tests which are performed against the web server by creating +- 100 000 requests to the server in order to gain unauthorised access to data. The last test run on 12 March 2014 resulted in a 100% successful resistance to penetration (Johnson, Pers. comm., 2014).

12 Data Validation

The challenge of improving data and maintaining a high standard of data can be achieved through two basic approaches namely error detection (and correction) and error prevention (Dalcin, 2005). Error detection is largely linked with the examination of available data, which in the case of the database was largely historical data of sometimes unknown origin. Steps taken to detect and correct historical data errors are dealt with in this chapter.

Error prevention, where human and technical process can deliver substandard information, has been dealt with through the technical design of the database reporting system (Chapter 7) as well as the development of training standard for observer to reduce human observer error (Chapter 14).

Much of the information obtained to establish a base line of sightings in Cape Town were gleaned from old species lists for sites which themselves came from a wide variety of sources. These old records were mostly loaded in 2006 as a nominative record "created" on the 1 January 1998 and annotated as "Historical Record".

In terms of the system rules, such a record was entered into the "Present" category for the site as there was a record within the previous 10 years. During 2006 – 7 staff on the sites documented new records, superseding the older "Historical Record" and keeping the species in question in the "Present" category for that particular site. On the 1 January 2008 however any species that did not have a new sighting record at a site was automatically mover into the "Previous Recorded at Site" category, which accommodates species that have not had a sighting record for between 10-15 years.

The five year period from 2008 – 2013 allowed a five year period for staff to create further sightings for records those species that had not been sighted for >10 years. These species then moved back into the "Present" category.

On the 1 January 2013, after an absence of 15 years, species that had no new record at a site were automatically moved to the "Lost to Site" category. This category lists those species for which no record has been made for >15years and can be considered as missing from the particular site. For practical purposes the species can be considered locally extinct at the site, although this term has not been used so as not to confuse it with the IUCN "extinct" term (Minter *et al*., 2004).

There are four possible reasons why such a species has not been re-sighted within a 15 year time period. These are:

1) The species has disappeared from the site, or is in a dormant stage of its life cycle
2) The species is a vagrant species and the record was a once-off record
3) The species was misidentified in the original record
4) The species is still present, but no contemporary search (using the correct search methodology) has been conducted to find the species

Using these criteria, the Fauna Management Committee of the City of Cape Town's Biodiversity Management Branch met for three days in December 2012 to analyse all animal records >15 years old. The Fauna Management Committee is a ground of managers and the City's veterinary Officer who determine protocol for fauna management on City of Cape Town nature reserves.

The committee met to examine records of animal species that had been listed as "Lost to Site" across Cape Town. The committee used a combination of field guides, distribution atlases, reference books and combined knowledge to determine whether a historical record was valid or not. In any cases of doubt the "If in doubt leave it out!" principle was used, the consensus being that doubtful records made of vagrants in the past have no impact on the management of sites. Attention was rather made in determining which breeding resident species had disappeared from sites, regions and the city.

In order to deal with records consistently, I created the following flow diagram to explore all the possible options for a species record that had to be adjudicated. The flow diagram is illustrated below and reflects this decision making process used to either accept, delete or recommend a new search for a species at a site which has not had a sighting record within 15 years.

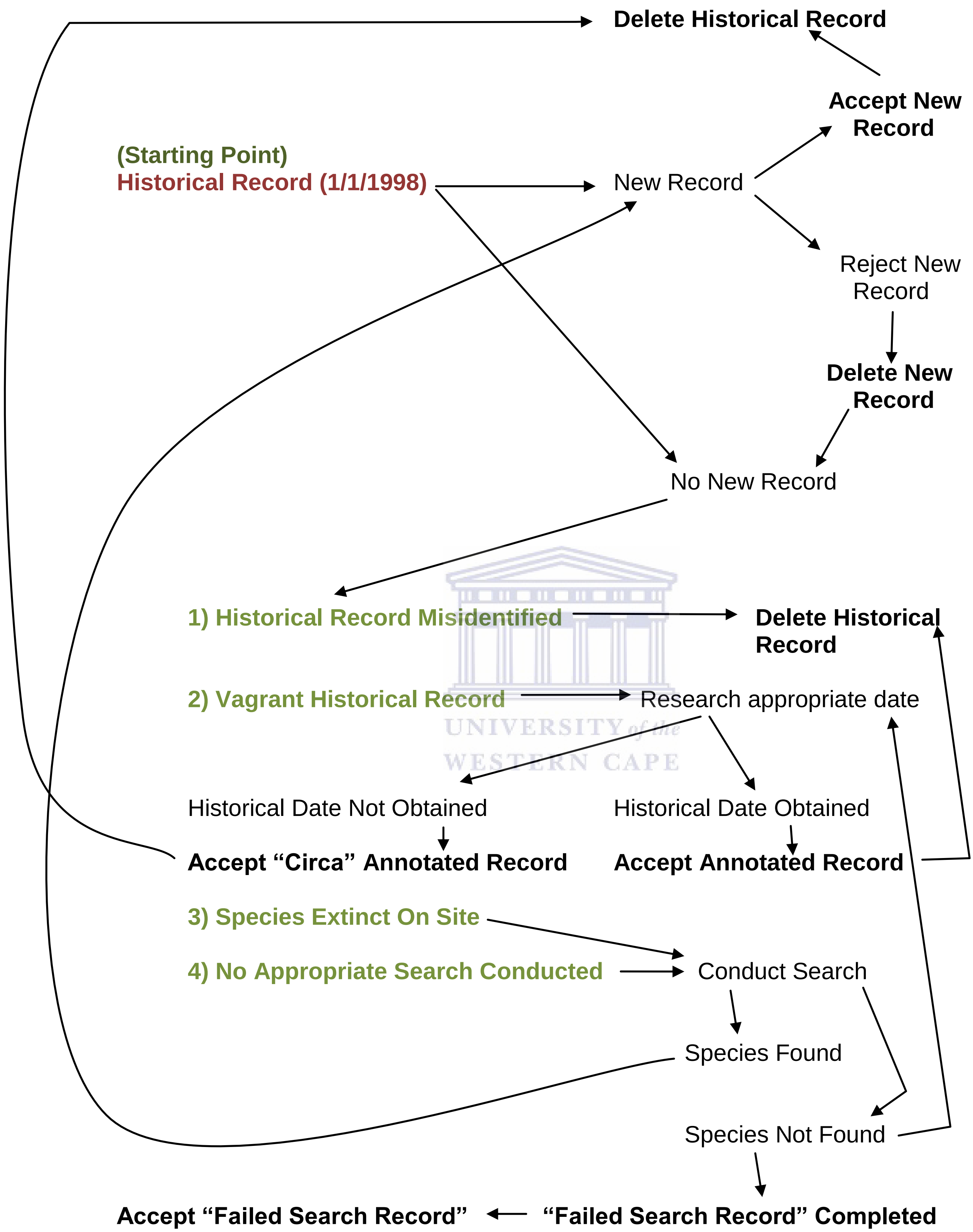


Figure 40: A schematic flow chart showing the decision making tree to verify historical records in the database.

What soon became evident when the data validation began was that there was a batch of old historical data that was being dealt with, but there were also a number of recent records that were inaccurate. These were almost exclusively attributed to observer error and a lack of both experience and diligence on the part of the observer. Of 21 records that were found to be incorrect in 2013, the author found that only one of these could be attributed to a technical error on the database; all others were attributed to observer error. In one case, the observer error was of a species that could not under normal circumstances be found in Cape Town; the observer had read the coloured in portion of a distribution map as where a species would not occur! Hence the wrong species was recorded.

This fact, coupled with information gained in the user survey that the author conducted (see Chapter 14) led to the development of three features, namely; an external verification of new species records, the development of “Observer Standards” for users (Chapter 13 below), and a user manual.

Firstly the verification feature subjects any new species record for a site to verification by the Fauna Management Committee (FMC) before being added to the site’s species list. When a new species for a site is recorded in a sighting record it is submitted to the site manager for acceptance. Upon acceptance, the record is marked “This is a TYPE record” in red lettering and its status is marked as “Referred to FMC”.

The Fauna Management Committee of Cape Town’s Biodiversity Management Branch comprises a regional representative from each of the four regions, the Branch’s veterinarian and the biodiversity co-ordinator. New species sighting records that need verification come to the committee who may accept, reject or ask for more information about a record. Since these records form the basis for a species being entered on to a site’s species list, the principal if in doubt leave it out” is rigorously applied.

The adjudication of the records are done by using available literature, but largely the local knowledge that exists in the Fauna Management Committee regarding the site, species in question and the person who made the sighting. In certain cases where similar species can co-exist, a request may be made for a detailed photograph to be submitted before a sighting record is accepted.

Once accepted the first record of a particular species at a site will be permanently marked “This is a TYPE record” in red; denoting that this record is the basis for listing the species on the site’s species list. All subsequent records for this particular species will not need external verification and can be accepted by the site manager; taking their cue from the original “Type Record”.

The second intervention that the author developed was to address the standard of species identification being made by the observers. This led to the development of a set of “Observer Standards” (Chapter 13 below) for users of the database.

The third intervention was the development of a user manual, with clearly laid out steps to insert records, insert infrastructure records, find site species lists and

download data. Two types of manuals were developed; one for a Site Manager and another for a User who would regularly input data onto the database.
The user manuals are illustrated in Appendix 4 below.

13. Observer Standards

The author analyzed the records lodged during 2013, which had been created after the database had been cleaned up (see Data Validation, Section 12 above) and found 21 records that were obviously erroneous; with species whose distribution ranges were a considerable distance from Cape Town. None of these were vagrant bird species and none had any evidence to substantiate them (Pers. obs., 2013).

Of the 21 records, one record was found to have been caused by a technical error in the reporting format. This was due to the extended lag time in the proxy server in the City of Cape Town processing the information. A correction was built in to the reporting format of the database in order to prevent this for occurring again.

The other 20 erroneous sightings were all caused by observer error, with the group of warblers (*Acrocephalus* sp.) causing the most confusion (six records). From this validation exercise three solutions arose which have been discussed above; the one to be examined here is the development of Observer Standards to train observers in specific identification skills and reduce observer error.

Although never envisaged and not strictly part of a biodiversity database, as detailed above, it became evident through the examination of collected data that a minimum competency standard was needed by observers. To this end the author motivated for, and developed, "Observer Standards" for users contributing data toward the biodiversity database. Although it is not possible to train every user up to this standard, an Observer Standard was adopted as part of a competency standard for a job where this entailed conducting set monitoring programmes that were part of a long term monitoring programme.

Thus the rationale was followed, and users are to be trained to a minimum standard to make observations as part of established monitoring programmes. This however does not preclude users, who are maybe not as well trained, from creating ad hoc sightings. If such observations perhaps faltered in ad hoc sightings, at least the set monitoring programmes at a site would be conducted by observers who had been accredited. Data collected as part of a set monitoring programme is viewed as the backbone of the sites data and is more important, as it can be compared, interpreted and analysed, having been gathered using a comparable protocol.

Users who successfully pass the evaluation for an Observer Standard have an applicable "competency icon" displayed next to their user name. This icon would appear whenever their name is displayed and would be linked to any records that they may have made. A site manager evaluating such records will be able to attribute more value to such a record where he or she can see the observer has attained the applicable observer standard. This is particularly important in the future, when such a site manager can no longer query the observer about the record as they are no longer available or no longer living.

An Observer Standard was developed for each class of fauna and in some cases these were divided into smaller groups with their own qualification. This was done in the case of birds, which was a large group, or in the case of fish which have a large disparity between fresh water and estuarine fish species.

Observer Standards were developed for the following classes of fauna:

1) Water birds of Cape Town
2) Terrestrial birds of Cape Town
3) Coastal birds of Cape Town
4) Fresh water fish of Cape Town
5) Estuary fish of Cape Town
6) Reptiles of Cape Town
7) Amphibians of Cape Town
8) Mammals of Cape Town

Upon successfully completing an Observer Standard, the user will be issued a certificate and have a corresponding icon displayed against their name and profile on the database.

The Observer Standards were developed on the following principles:

Understand how to make an identification.
The layout and design of the Observer Standards were such that the student has to explain to the examiner how he or she arrived at certain identification and not merely to be able to identify the animal of by heart. This is important as in many cases the identification of certain groups of animals relies on identifying and interpreting key characteristics of the animal. Knowing what to look for and how to use applicable tools such a field guide are important, and the student needs to be able to demonstrate this.

Learn the common things first.
In the training, students are only asked to identify the common and most likely to see species in Cape Town. In so doing observers will gain confidence and become aware of vagrant or are species that may then be encountered. Coupled with skills to use field guides and what features to look for, observers will be able to identify rare or vagrant species when these may appear.

Identification not facts.
The Observer Standards aim to teach a learner the identification only and does not at this stage include any peripheral knowledge about the species. Thus the learner will not learn about the species, only how to successfully identify it.

Out the development of the Observer Standards was a request to develop a “Knowledge Standard” as a further and higher level of study and knowledge. This standard would be built upon the Observer Standards, but in addition to successful identification would also include information that the learner would have to learn about the species. This “Knowledge Standard” would be used to train educators and staff giving talks and public information. Although it is beyond the scope of this research, this “Knowledge Standard” was developed as a by-product that was developed as a result of this database.

The development of Observer Standards as a “bench mark” for observational data in the biodiversity database was created for not only conservation staff, but also for volunteers, members of the public in interested parties. Indeed the Observer Standards and the further “Knowledge Standards” will hopefully be a tool to encourage interest and appreciation of species.

Volunteers are an important part of modern conservation areas, reducing management costs and freeing up conservation resources to be used elsewhere (Danielsen *et al.*, 2004). This is significant as the largest cost of a monitoring program is the data collection (Caughlan. 2001). Such volunteer participation is particularly valuable in an urban environment, helping to integrate communities with conservation areas, provide early warning for environmental disasters (Firehock & West, 1995), crime and providing political buy-in for conservation.

A study of 155 wildlife volunteers in the United Kingdom, who were collecting biological data, showed improved data credibility with as little as half a day’s training. The biological data that was being collected was compared to data collected by professional conservation staff at the same time and no sizeable difference could be detected after the training (Newman, Buesching & Macdonald, 2003). In a different study, the establishment of a biodiversity monitoring programme found the use of community groups that share knowledge through group dicussions, produced data of value (Danielsen *et al.,* 2000).

These accounts show that the training of staff and volunteers in basic biological observations can add value to both the data and the conservation area where such people work. It is hoped the development of the Observer Standards and the information rich “Knowledge Stadards” will add value to both the people and the data they collect.

In the short term the Observer Standards are being developed in a paper based and software version as a Power Point presentation that can be given to learners. Longer term the objective is to provide the Observer Standards on an online platform such as provided for on Moodle.com. Moodle supports a learning platform where learners and teachers both contribute toward the learning experience through collaboration, flexible lessons and observing one’s peers (Dougiamas, 2000). This style of online learning is often termed “constructivism” and promises a style that would suite the scattered nature of the learners who need to qualify in Observer Standards in the future.

14. User Survey

I conducted a user survey of the City of Cape Town's Biodiversity Management Branch staff, as well as private users of the database, in 2013. The participants represented a mix of site managers, students who enter data and interested parties. The questionnaire comprised nine questions which covered the areas of the database most used, design and user problems experienced, user constraints and recommendations. Participants were requested to fill in a form with the questions; as such the exercise was entirely paper based. They were very few questions of clarity that people needed in completing the form and it was felt that the exercise was well received judging by participants feedback.

The complete survey is provided as Appendix 2.

There were 31 questionnaire returns, which provided the following results:

1.) This question determined how many of the respondents managed a site on the biodiversity database.
19 were site managers; 12 were not site managers.

2.) Of those respondents that managed sites; how many sites did they manage on the biodiversity database?

The lowest number was 1 and the maximum 6. The average is 2.26 sites managed per site manager.

3.) This question related to the position the person occupied in their organisation. For people outside the employ of the City of Cape Town there was no applicable information given.

4.) Respondents were asked how many times they logged on to the site per month. Users logged on to the site an average of 3.6 times per month.

5.) Respondents were asked how many sightings they created per month.
Users created an average of 11.5 sightings per month.

6.) Of the users, 17 had a student or intern entering information for them and 14 did not. Of the users, six had Friends Groups entering information for them and 25 did not.

7.) Respondents scored the following functions which they most frequently used in the following order:

Site species list: 33.04 %
Site statistics: 18.95%
Species search: 18.5%
Site calendar: 15.86%
Reference documents: 7.5%
Site infrastructure: 6.15%

8.) What additional features would you recommend? The following six suggestions were received:

A visual representation of trends. Access to related publications/documents.
A visual representation of species lists.
A feature to show how many times a species has been recorded at that site in the last year.
City species lists & species lists per veg type.
Rainfall data.
Annual Plan of Operation (APO) & Quarterly report system

9.) Respondents were asked what the biggest constraints were found in using the Biodiversity Database in the following areas:

Line speed: 32.27%
Connectivity: 27.27%
Time: 24.54%
User interface: 10%
Site downtime; 2.72%
Software programme bugs: 2.72%

Results of the user survey

The user survey gave the author an opportunity to engage with users of the database after the initial design and development phase had been completed. During the design and development phase, there had been consultation with a number of conservation managers regarding the features they had wanted to see in the database. These ideas had been developed and further features had also been developed by the IT Company and myself. The user survey was a useful pause in the development of the database to see if it was meeting the needs and expectations of the users.

What was important coming out from the user survey was that the top three constraints to the use of the database were linked to infrastructural issues such as the line speed, connectivity and work time available. These factors account for 84% of the constraints experienced by participants of the survey. It was encouraging to note that these factors were beyond the control of the database itself and reflected the broader working environment of participants.

The next highest constraint was the user interface, constituting 10% of the constraints for usage. This finding resulted in the modification of some front end features of the user interface. These were relatively minor changes but helped users find information easier. The Google Map interface was also developed from this feedback, enabling users to create sighting records in a more streamlined way.

As previously mentioned in Chapter 12, the user survey was conducted during a time of data verification and added to the impetus to develop the Verification Tool, the Observer Standards and the User manual which have been discussed before.

15. Biodiversity Database – Corrections & New Features

The following list of corrections and new features is an accumulation of the concepts, ideas and corrections discussed in the document thus far. This list is the basis for future development of the database and is the central point of discussion with the IT Company going forward. It is useful to have future design features or corrections in one centralized place to work against. This way work can be prioritized and resources allocated to specific items.

Corrections

1) Plant species name updates. Update the plant species list with the most recent SANBI list which is available digitally.

2) Translocations; the site display name in the summary table is wrong.
   Under a site a translocation shows up as having come from a particular site and then always going to the same site. When the record is opened however, it is correct and will show it has having come from another site.
   Thus the display of the record needs to correct origin or end location site.

3) Translocations are not presently contributing toward a site's species total, statistics and are not showing up on the species list. This should happen automatically without the site manager's verification.

New features

1) Add categories of "Immature" and "Unknown" into the sightings report form; these numbers are to automatically add up to the total number of individuals in the sighting record. Thus there should be four categories listed – Males, Females, Immature, Unknown.

2) Create an Area (cluster) boundary level, which is a variable cluster of sites. These sites may be contiguous or not. No records can be made at this level – it is merely a reporting level and different clusters can be made of a different set of sites in a region.
   For example; there are sites 1,2,3,4,5,6,7,8,9,10. Cluster 1 = sites 1,4,5,8
   Cluster 2 = 1,4,7

3) A function is needed to display what new species have been added over a specific period of time at a site, cluster, region and city level.
   The dates to be searched for this feature would be inserted by the user.

4) A function to display the changes that have occurred in the statistics over a specific period of time at a site, cluster, region and city level.
   The dates to be searched for this feature would be inserted by the user.

5) In the statistics, the indigenous and species alien listed at a site needed ot be separated. These could be displayed in the site totals, either by the use of differing colours or in brackets.
For examples “present” = 23 (21)(2) (where green = indigenous and blue = alien).

6) On the site species list page, enable the alien column to be searchable; the two present options in this column are “Yes” and “No”. A searchable option will allow a user to extract the alien/indigenous species out of the species list.

7) Site Endemic. Sometimes a species is endemic to a specific site and is found nowhere else. This is very important from a conservation perspective and something is needed to highlight this on the species list. Site endemics are invariably Red Listed as Endangered or Critically Endangered. The species can either be highlighted by lightly flashing and when moused over a pop up announces “Site Endemic”.

8) Automatically link to SANBI’s PRECIS list to update the master species list with taxonomic and conservation status changes.

9) The function to lock a species list for a site. Any new species that is reported for the site would have to be verified by the site manager **and** a verification panel/committee before being added to the sites’ species list.
This is a once off verification and any subsequent sightings will automatically be added to the site’s records once the site manager had accepted them.

10) The need to “tag” a batch of data records in the Batch Import function with a code to indicate that they belong to a common data set that was collected by means of a set Monitoring Protocol that is linked to a specific site. This would appear in the “Import” function and a batch of records would be tagged with this Monitoring Protocol before being processed. This will separate this batch of data from the general “data pool” attached to the specific site. The Monitoring Protocol would have a unique identifying code that is linked to the site’s code eg ROND01 = the first Monitoring Protocol for the Rondevlei site. This is a unique code and cannot be repeated even if the protocol becomes defunct and is not used into the future as all the data linked to this is set.

This data set that is linked to a specific monitoring Protocol needs to be able to be expressed as:
  a. A graph reflecting total species count
  b. A graph reflecting an individual species count within the data set

Not with standing this unique Monitoring Protocol code, there is still the need to an “Ad Hoc” code to be available for Batch Capture Imports, as some tabulated data will be captured for a site that is purely ad hoc sighting records for the site's species list.

11) The need to be able to lodge a Monitoring Protocol against a specific site. This protocol would be given specific unique identifying code which is linked to the unique four letter site code. For example Rondevlei = ROND. The first Monitoring Protocol for Rondevlei would be ROND1.

The identifying code issued needs to be irrevocable and non-repeatable, even if the Monitoring Protocol falls into disuse in the future. Thus all data tagged using this protocol would be a unique data set with the "data pool" of a specific site and within the overall database.

12) The need to create a "Failed Search Record" which is like a Sighting Record but reflects a zero return. Very similar to a Sighting Record but with the following fields:

Front Page (Required Data) Note: items underlined and marked below with an asterisk * need to be compulsory fields
a. Date *
b. Starting Time *
c. Number of Hours of Search *
d. Site *
e. Species *
f. Quantity * (this defaults to zero and should be automated)
g. Entry added by * (this is automated)
Second Page (General)
a. Habitat Searched (linked to the Site's list)
b. Vegetation Type (linked to the Site's list)
c. Search Technique Used * (linked to a predetermined list under "Look Ups"); this field needs the ability of recording at least three techniques from the predetermined list.
d. Number of People Searching (free field)
Third Page
Remains the same, but change the heading to "Location of Search".
Fourth Page
Remains the same, but change the heading to "GPS of Search".
Fifth, Sixth, Seventh and Eighth Pages
Remain the same.

13) Create a reference filing system for each site, where documents, tables, reports and photographs could be stored. The exact layout of this reference system to be decided; but will follow the general layout of the Annual Plan of Operation (APO) of the Nature Conservation Section.

14) Create the ability to capture a daily rainfall figure linked to a rain gauge linked to a specific site. Rain gauges can be determined in the site's infrastructure

list and have a GPS reference point when profiled here. The rain fall records should reflect and be linked to the rainfall gauge that is listed.

15) Create the ability to "Accept" or "Reject" a Sighting Record on the email receipt. This, linked with the Site Species List Lock Function (see no. 9 above), will make the validation much easier for Site Managers dealing with Sighting Records which may be related to multiple sites that they are managing the information for.

16) Be able to add a small icon against a person's profile indicating if they have been formally trained in the identification and reporting of a specific group of organisms. This needs to be added by an Administrator and then needs to reflect whenever a person's name is listed, for example against a sighting. This indicates a person's level of expertise and familiarity with a group of species and will be an important indicator of the validity of the record if the observer is unknown to the Site Manager who has to accept or reject the record.

The icon will be awarded to the person on passing the necessary identification tests as set by the City's Biodiversity Management Branch and then implemented by an Administrator. This is thus a function that must be linked to Administrator privileges.

17) Create a window for a Google Earth map to display the location of sites as well as being able to select a site from this map.

18) Create a window for a Google Earth map to display sighting records as well as to be able to select a GPS coordinate for the sighting record.

19) In the Site Calendar, be able to have a "Jump To" field to speed up the movement through years without having to scroll through each month individually.

20) In the Site Calendar, have a function to deselected all Activity Type options so as to speed up the ability to highlight just one Activity type field.

21) Be able to automatically generate a quarterly report generated from the sites calendar and reflect the changes in the sites species statistics in the last quarter. These would be produced on the 31st March, 30th June, 30th September and 31st December and emailed to the contacts list attached to the site.
For a full outline of the reporting format please see Appendix 3 below.

CONCLUSION

The development and construction of this biodiversity database system has taken several years and has changed a number of times as ideas have been developed, expanded or scrapped. What started as an exercise to consolidate the old biological data for Cape Town's nature reserve has resulted in the development of a database that has attempted to convert monitoring information into management decisions.

In retrospect the development of the database can be broadly broken down into three phases, namely;

Phase one was the accumulation of old biodiversity data and realising that a coherent on-line database was needed to collect and manage this data. This realisation resulted in the design, development and launching of the on-line system that exists today. Several versions have been launched since then, but broadly speaking the background architecture has remained in place since the database first became active.

Phase two was an analysis of old data that was now centralized and consolidated into workable formats. This analysis revealed errors, which when examined were shown to result primarily of the poor observational skills of observers. This was bluntly put human error. As a result the observer standards were developed which sought to train observers and in so doing bring about a standardised way of ensuring observer reliability. This was a practical means to ensure the ongoing integrity of data into the future.

Phase three has seen the development of tools in which data is automatically analysed to produce management decisions. This is a means of turning data into meaningful management decisions and ensure continuity of management actions into the future.

The greatest challenge I have experienced during this entire process has been the sourcing of funds to pay for both the development of the database as well as the ongoing hosting costs. Given the dire straits that some ecosystems in Cape Town are in, it has been understandably difficult to motivate for funding. This funding would have to be diverted away from practical on the ground management and into a digital resource that is largely intangible. Furthermore this intangible resource would only really start to produce meaningful results in a few years' time. Despite this sufficient funds have been located to get the frame work developed and operating for the past 11 years.

What follows below is a synopsis of what this system makes available to the user at present.

The information system is built around the management of a "Site", which could be any spatially defined area of interest such as a nature reserve, nature area, public park or private garden. Linked to this spatially defined unit are the following functions:

1) Sightings – species records can be logged for a site with numerous attributes (eg, quantity, sex, veg type, health status). Sightings can be viewed on a google map and are displayed in relation to all other sightings made for this species. A future function will filter this by time.

All sighting records are stored against their relevant site and can be searched for by user name, species name, class or date. All sighting records are verified by a site manager before being added to the site records.

2) Early warning – a site record that comes in linked to for eg. "Health status = dead" and "Cause of Death = water pollution" will automatically trigger a notice to the relevant Water Pollution expert for the area in question.

3) Translocation – this function tracks any organisms moved from one point to another (with numerous attributes – eg photos, reference documents, permits, etc).

4) Facilities – this function holds the inventory and placement of all facilities on a site. These are GPS referenced with attributes such as plans, documentation, contact address, photos, etc. The facilities are displayed on a Google map in relation to all other facilities. A future function will filter facilities by type.

5) Site Calendar – this function allows a calendar (for the future) and a diary (for the past) to be kept of all management actions. This produces a monthly work schedule and allows the event to be reported back on.

This function can automatically produce a report of all work done at a site for a selected period of time – this automatically becomes a monthly/weekly/quarterly report.
This function can automatically produce an activity graph showing the number of management actions per category (for eg fire versus law enforcement) for a selected period of time.

The user can draw a report on all management actions for a particular activity (eg all ecological burns) for a selected period of time.

The user can set up a repeat for a certain activity – for e.g. if an ecological burn needs to be conducted every 10 years, the system will alert the future manager of this in 10 years' time. Reminders can be set before the time to any selected group. This function thus records the entire management history for the site.

The site's "Annual Plan of Operation", as determined by the Sites' Management Plan, can be loaded on to the calendar.
6) Statistics - This function creates a daily updated species numbers (per class) for the site in question. The species lists reflects the species that have been seen/not

been seen over a 10; 15 and 15+ year time span. Any new records result in this list being automatically updated.

These statistics are also calculated for a region and higher (district) levels – ie. species lists at higher/multiple layers.

This function alerts managers to any species which has not been seen for a predetermined period of time, thus becoming an “early warning” system for species at a site.

7) Species Lists - This function produces a daily updated species for the site in question. This can be filtered by time, species, class, IUCN or alien status. The list can be downloaded as a “working list” or a “reference list” which is in taxonomic order. Species lists also reflect the IUCN Red Data status of a species.
Species lists also reflect the local “alien organism” status of a species.

Information pertaining to certain species can be locked to unauthorised users.

8) Sites - The system is built around spatially defined sites.

All the important background information pertaining to the site is stored (e.g. erf numbers, proclamation status, documentation, photos, etc).
A Google map displays the site and its boundaries in relation to sites around it.

APPENDICES

APPENDIX 1 – OFFLINE COPY OF THE BIODIVERSITY DATABASE & OBSERVER STANDARDS

An envelope is attached to this document which contains an offline version of the Biodiversity Database as well as the Observer Standards that have been developed.

APPENDIX 2 - USER SURVEY

A user survey was conducted in the Biodiversity Management Branch in September 2013. Thirty one survey forms were completed and received from within the Branch, mainly focusing on the core management component of operational staff.
Several questions were raised in the survey form which had potential multiple choice questions to guide the reply, as well as having some free field queries to be feedback. The following questions were posed with their corresponding answers:

1) **Are you a site manager on the site?**
   19 the respondents surveyed managed a site on the database, with a further 12 not managing a site.
2) **If "Yes", how many sites do you manage?**
   Site managers on the database manage an average of 2.25 each.
3) **Approximately how many times do you log on to use www.biodiversity.co.za per month? Approximately how many sightings do you input per month?**
   Respondents log on 3.6 per month on average uploading on average 11.5 sightings per month.
4) **Do you have a student or intern adding information for you?**
   17 of the 19 site managers utilise either a student or the biodiversity intern to capture information on the system for them.
5) **Do you have a Friends Group or other interest group adding information for you?**
   Only six of the respondents utilise their friends groups to add information for them, whilst 25 do not.

6) **Which functions do you use the most in order 1,2,3)?**

   - **Site species list**
   - **Site statistics**
   - **Site reference documents**
   - **Species search**
   - **Site infrastructure**
   - **Site calendar**

   The most utilised functions in priority are:

   i. Site species lists (75 points)
   ii. Site statistics (43 points)
   iii. Species search (42 points)

iv. Site calendar (38 points)
v. Reference documents (17 points)
vi. Site infrastructure (14 points)

7) **What is the biggest constraint in using the system ordered in importance? (eg Time, connectivity, line speed, user interface).**
Constraints in using the database are in priority as follows:
i. Line speed (36 points)
ii. Internet connectivity (30 points)
iii. Time available (27 points)
iv. User interface (11 points)
v. Site down time (3 points)
vi. Programme bugs (3 points)

8) **Is there any additional function/report back tool that you would like to see added?**
i. A visual representation and maps
ii. A visual representation of species lists
iii. Feature to show how many times a species has been seen at a site in a year/total

a……………………………………………………………………………………………
b……………………………………………………………………………………………
c……………………………………………………………………………………………
d...…………………………………………………………………………………………

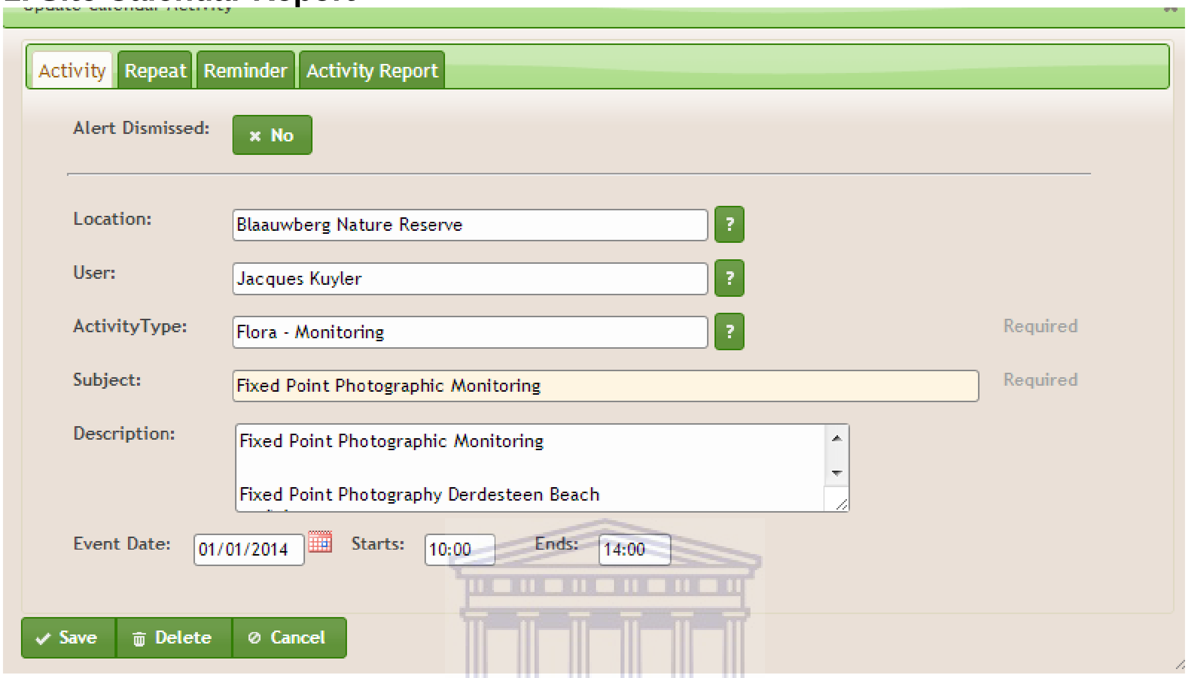
9) **Given that www.biodiversity.co.za will be developing more as a Management Tool do you have suggestions as to its name?**

……………………………………………………………………………………………………

APPENDIX 3 - BIODIVERSITY DATABASE – QUARTERLY REPORT

The Biodiversity Database Quarterly Report would report on two features from each site, namely all calendar events during the quarter and changes in the species statistics for the site during the quarter.

1. Site Calendar Report



The information above is what is presently on an event in the calendar. This example would for eg fall under "1.2 Flora – Monitoring" (see below).

Date: 1/1/2014

Activity: Fixed Point Photographic Monitoring

Description: Fixed Point Photographic Monitoring

Fixed Point Photography Derdesteen Beach
33Ã,Â°46'3.20"S
18Ã,Â°26'41.30"E
Fixed Point Photography Blaauwberg Hill
33Ã,Â°45'24.80"S
18Ã,Â°27'53.40"E
Fixed Point Photography Above Research Plot
33Ã,Â°45'30.90"S
18Ã,Â°28'13.71"E

Fixed Point Photography Research Plot
33Ã,Â°45'31.60"S
18Ã,Â°28'23.11"E
Fixed Point Photography Saddle
33Ã,Â°45'38.61"S
18Ã,Â°28'15.80"E
Fixed Point Friends Patch
33Ã,Â°45'9.61"S
18Ã,Â°29'37.10"E

Person: Jacques Kuyler

References: *Display any document that has been attached as a reference to the calendar event.*

Photos: *Display any photographs that have been attached to the calendar event.*

The next event of "Flora Monitoring (activity type 1) would fall after this event (ie in chronological sequence).

1 FLORA

1.1 Flora – Invasive Flora Management (14)

Actions and activities relating to the management, control and eradication of invasive plant species. This includes both indigenous and alien invasive plant species.

(Note: this is the definition taken from the Activity Type in the "Lookups").

(Note: the Activity Type reference number is given in brackets – ie. "Invasive Flora Management " is activity type reference number 14).

The activities for the quarter relating to this activity type would be listed here in chronological order.

1

2 etc.

1.2 Flora – Monitoring (1)

1.3 Flora – Restoration (15)

2 FAUNA

2.1 Fauna – Invasive Population Management (16)

2.2 Fauna – Capture (13)

2.3 Fauna – Monitoring (2)

3 SOIL

3.1 Soil – Erosion Mapping & Monitoring (17)

3.2 Soil – Erosion Control (4)

4 WATER

4.1 Water – Monitoring (3)

4.2 Water – Water Level Management (12)

4.3 Water – Pollution Event (11)

5 FIRE

5.1 Fire – Preparation (9)

5.2 Fire – Planned Ecological (6)

5.3 Fire – Unplanned Wildfire (5)

6 INFRASTRUCTURE

6.1 Infrastructure – Facility Safety Check (18)

6.2 Infrastructure – New (10)

6.3 Infrastructure – Maintenance (7)

6.4 infrastructure – Demolish (8)

7 ADMINISTRATION

7.1 Administration – Staff Administration (20)

7.2 Administration – Staff Training (19)

7.3 Administration – Vehicles (21)

7.4 Administration – Small Plant & Equipment (22)

7.5 Administration – IT Backup (23)

8 **PUBLIC EVENT** (24)

2 Site Statistics
The Site Statistics display the number of species in the time based categories of "Present", "Previous" and "Lost to Site".
For the quarterly report, display the movement of any species between these categories as follows:
The following species moved between categories
New Species
Anas hottentota (Hottentot Teal) appeared on the species list for XXX Site for the first time on the 20 May 2013.
Present (0-10 years)
Amietophrynus pantherinus (Western Leopard Toad) moved to the Present category from the Previous category on the 14 May 2013.
Anas undulata (Yellow-billed Duck) moved to the Present category from the Lost to Site category on the 18 May 2013.
Previous (10-15 years)
Pandion haliaetus (Osprey) moved into this category from the Present category on the 25 May 2013, with no new record in the past 10 years.
Lost to Site (15 years +)
Pernis apivorus (European Honey Buzzard) moved into this category from the Previous category on the 7 May 2013, with no new record in the past 15 years.

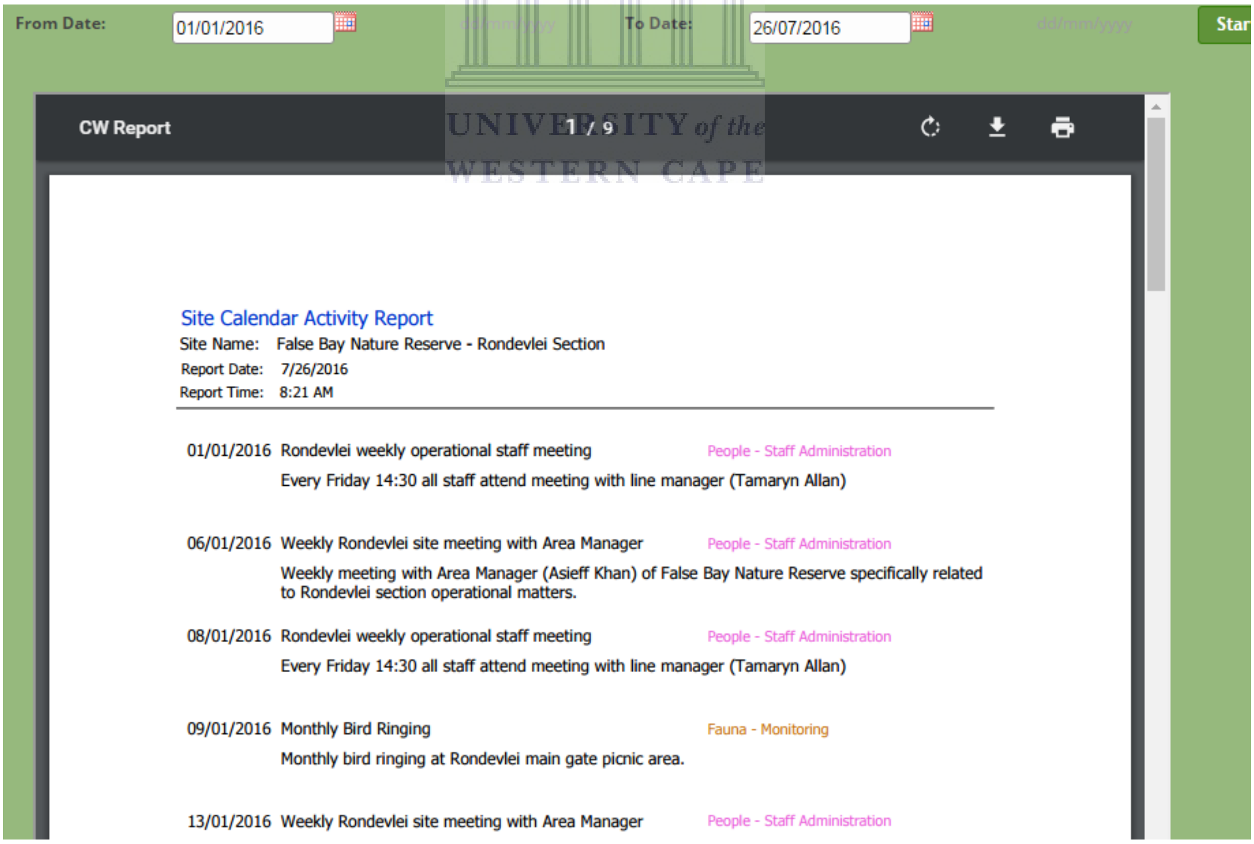
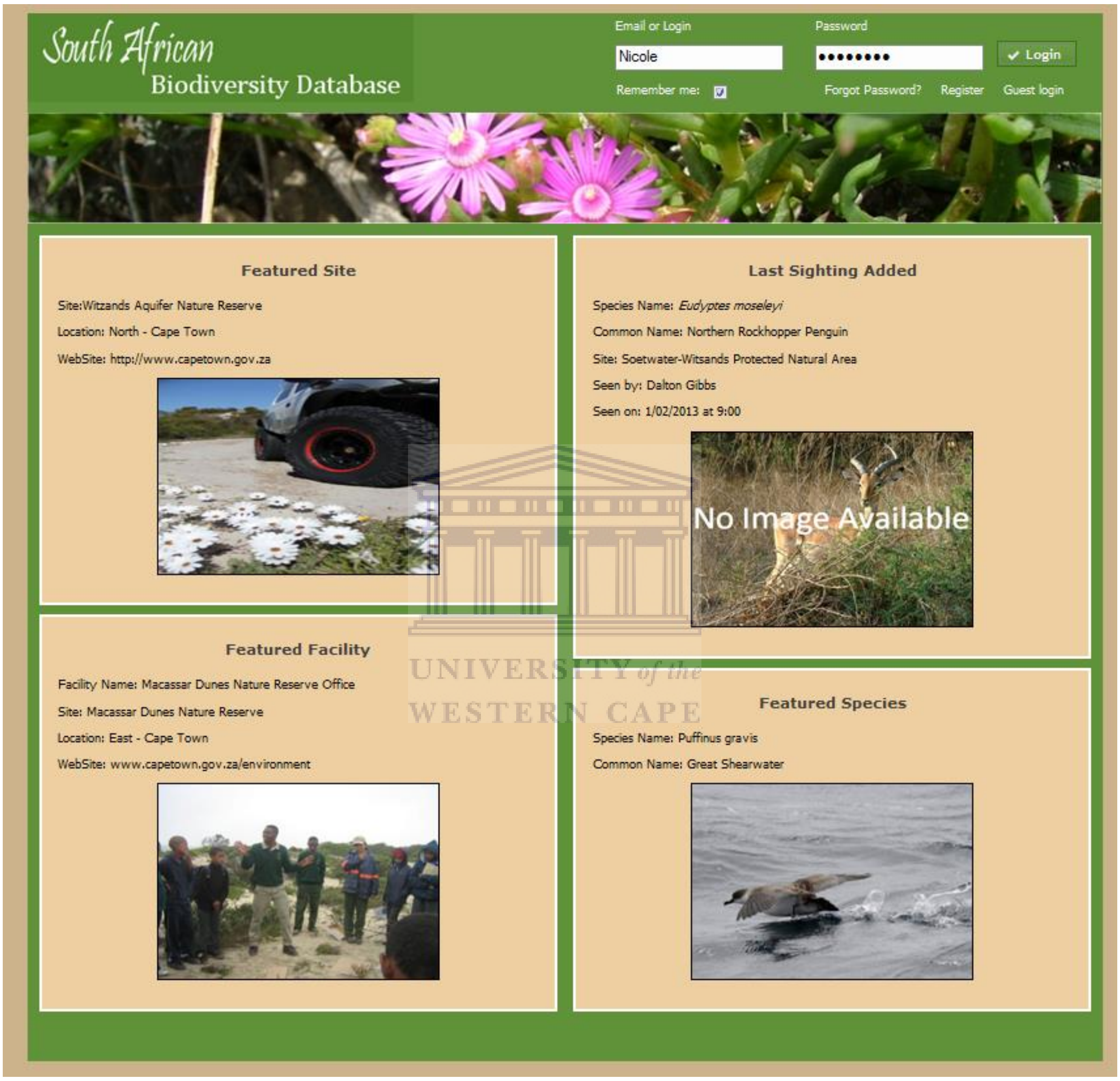


Figure 41: An example of a report automatically generated from a site calendar; in this case False Bay Nature Reserve (Rondevlei Section).

APPENDIX 4 – USER MANUALS

The user manual developed for a Site Manager using the Biodiversity Database.

BIODIVERSITY DATABASE – www.biodiversity.co.za



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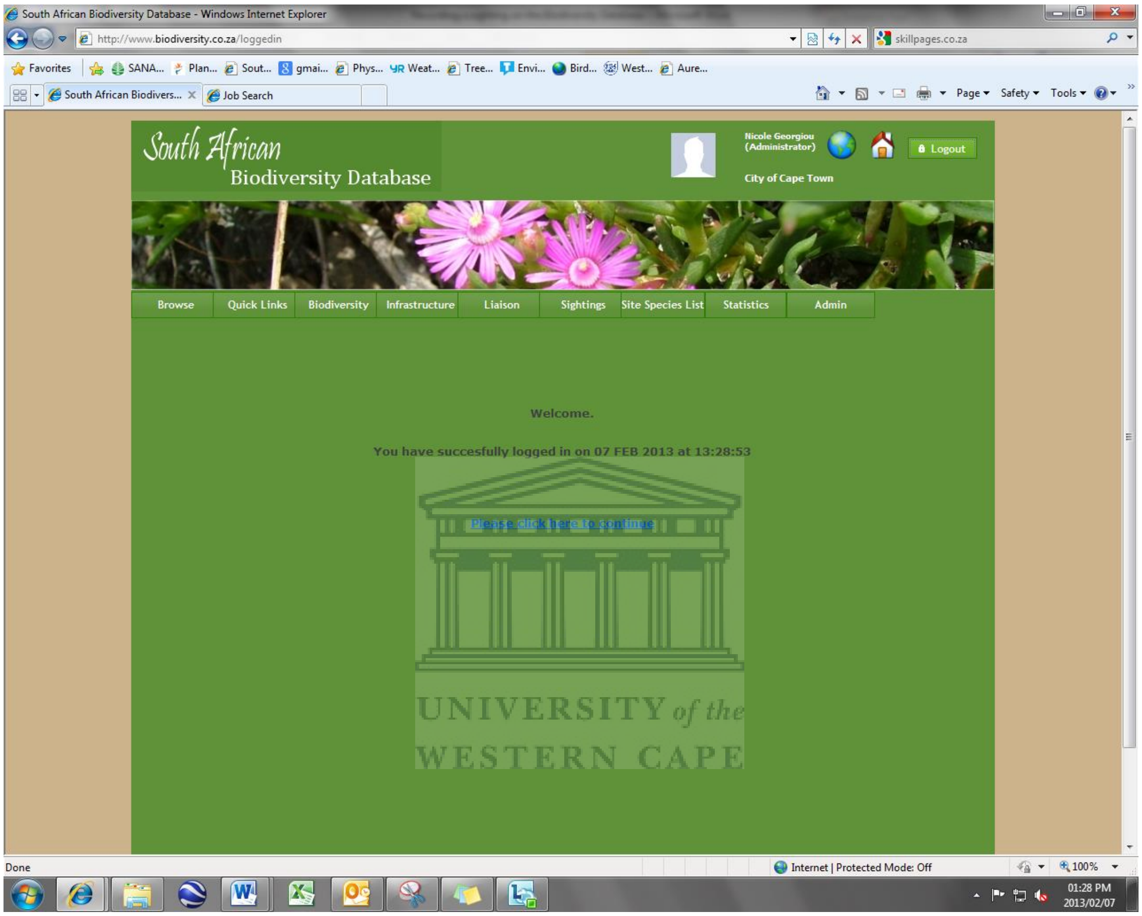
Intro:

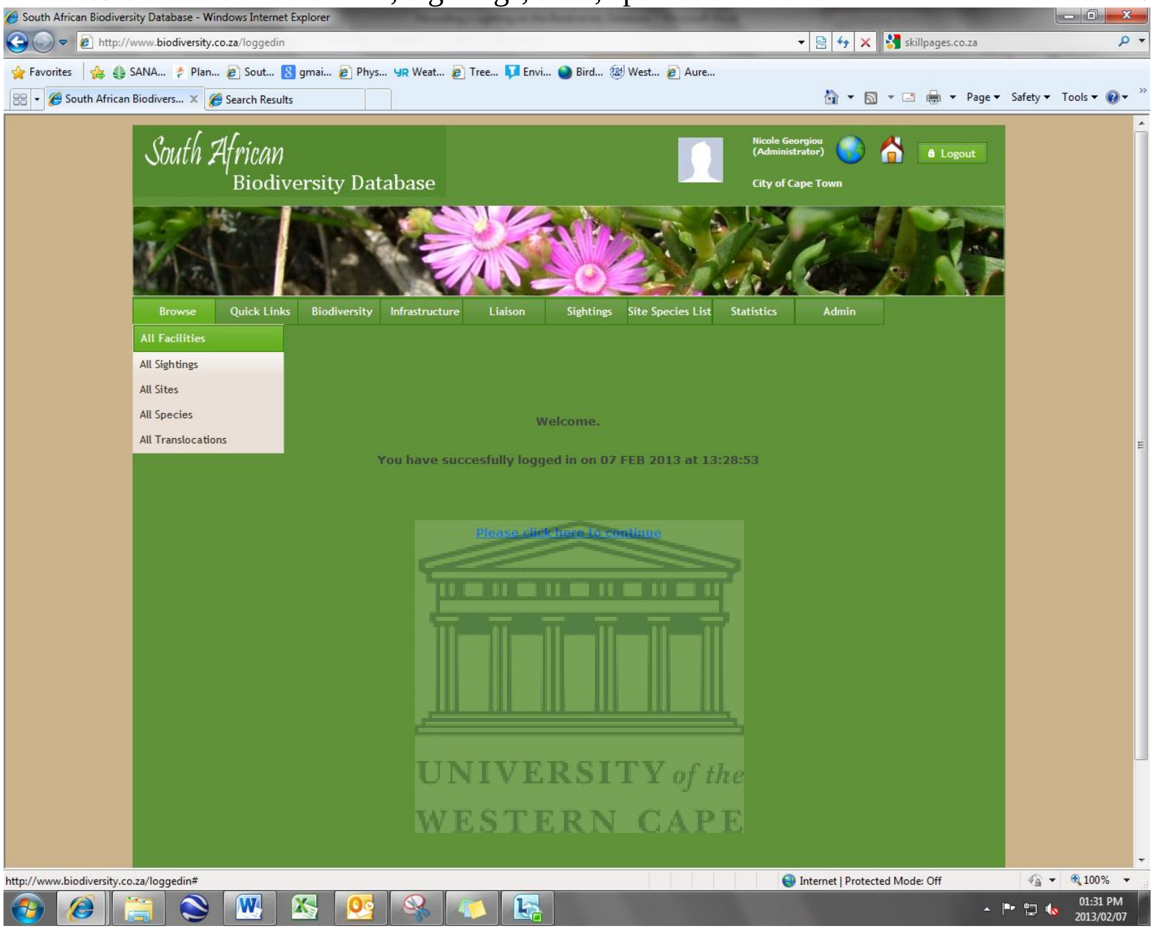
To Login: Type in username and password, and click 

Welcome Screen:

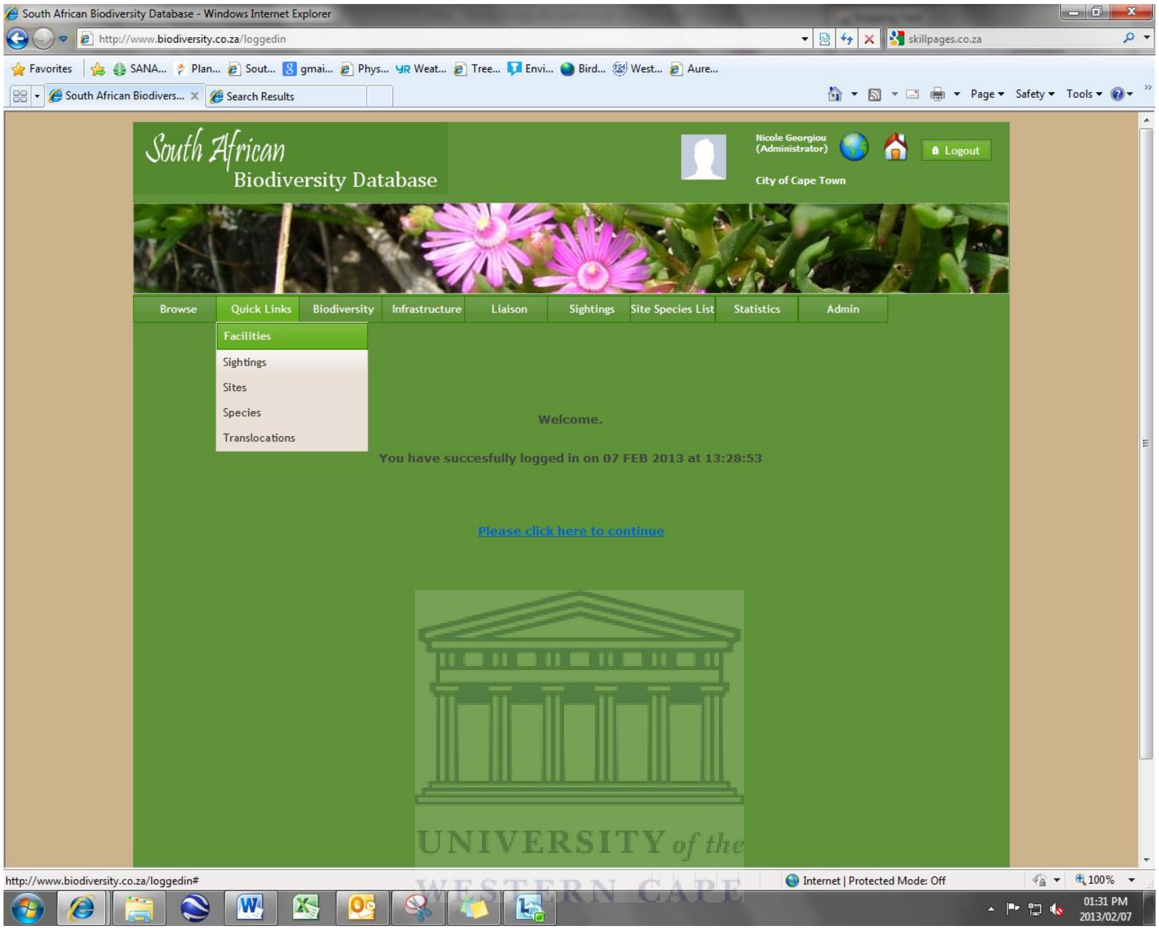


The screenshots below show the tabs and what each tab contains.

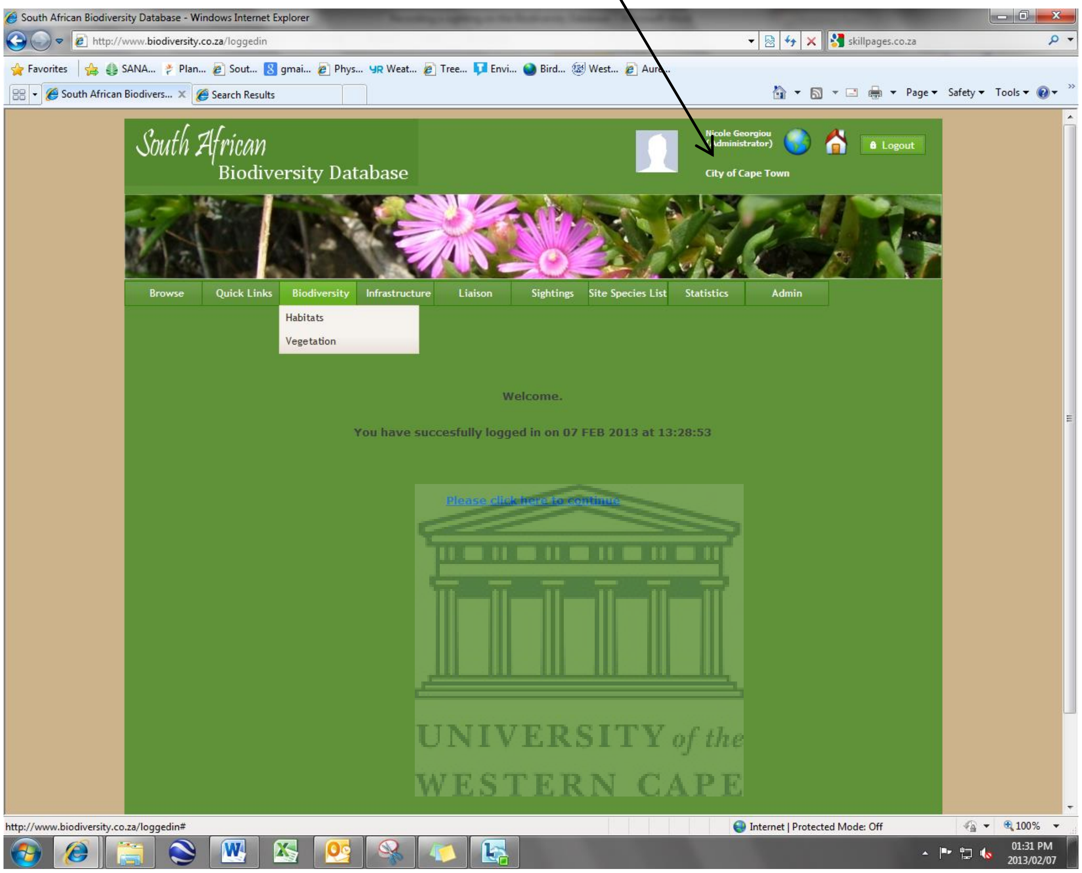
Browse: Contains all facilities, sightings, sites, species and translocations in the database.



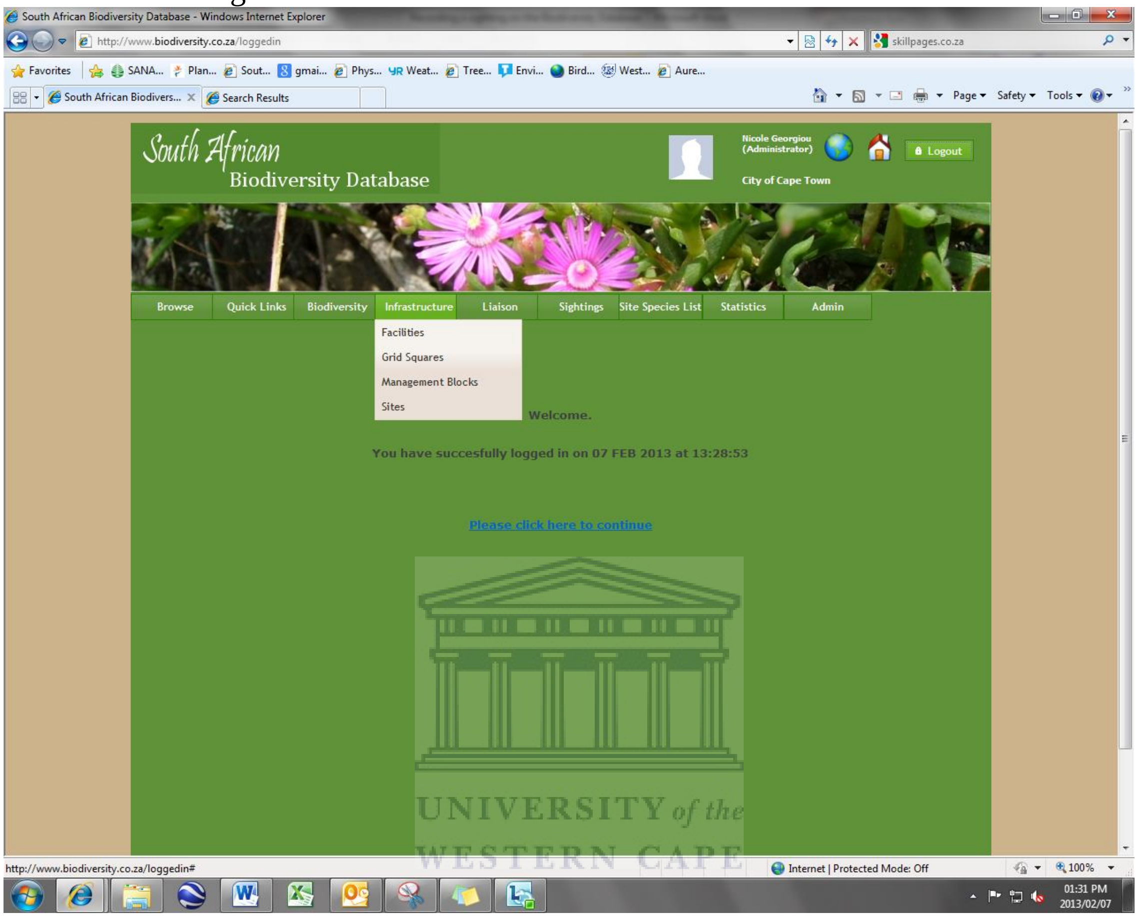
Quick Links: Same as above.



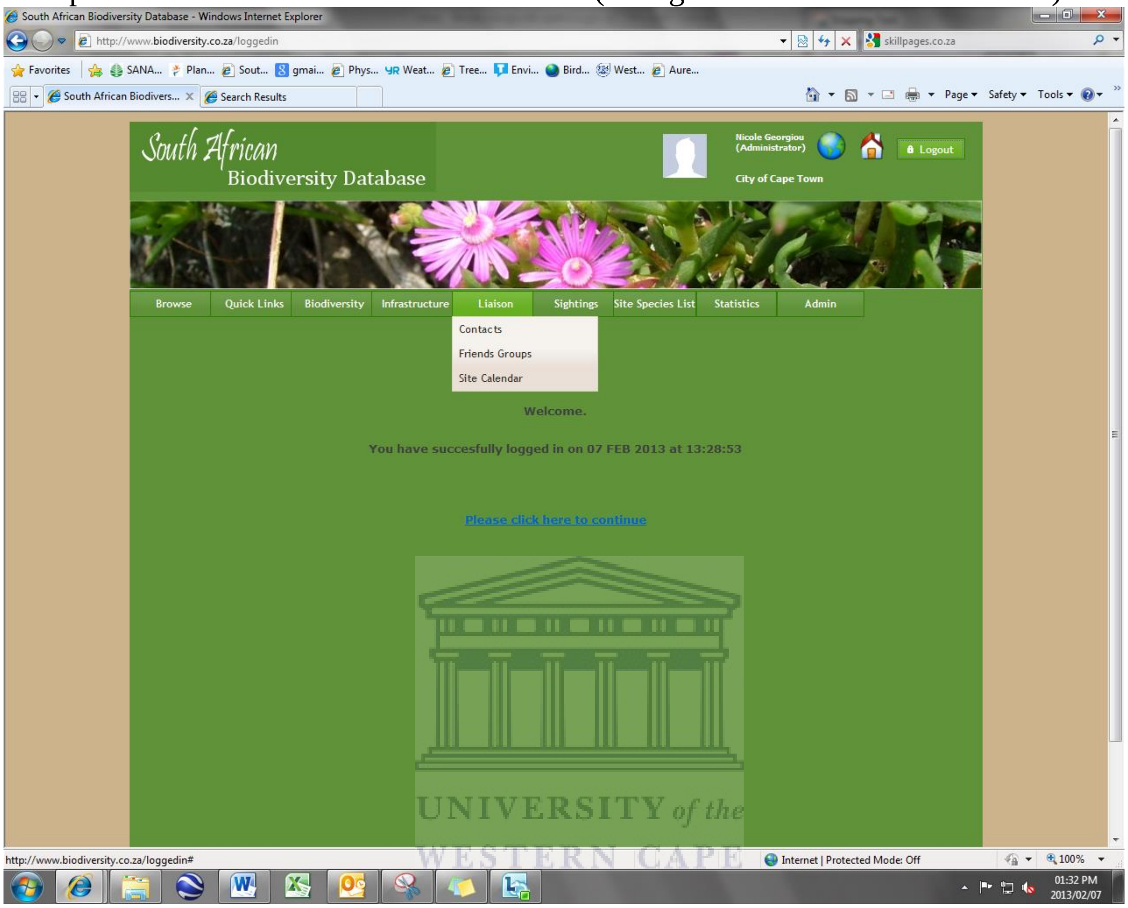
Biodiversity: Links to Habitat and Vegetation. This lists the habitats and vegetation found at the site listed on the top right, next to your profile picture (in this case City of Cape Town). From Biodiversity to Statistics the tabs relate to the site on the right.



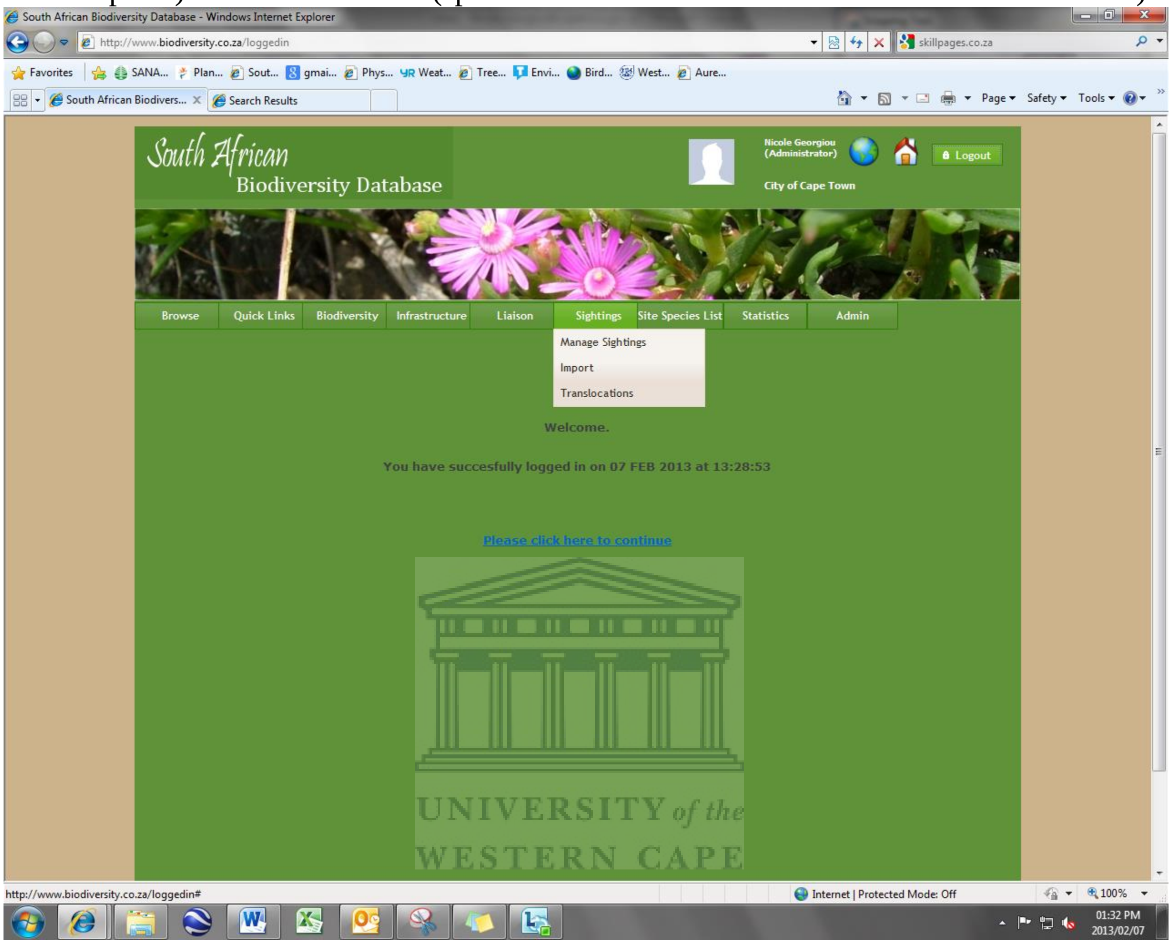
Infrastructure: Lists links to Facilities, Grid Squares, Management Blocks and Sights related to the indicated sight.



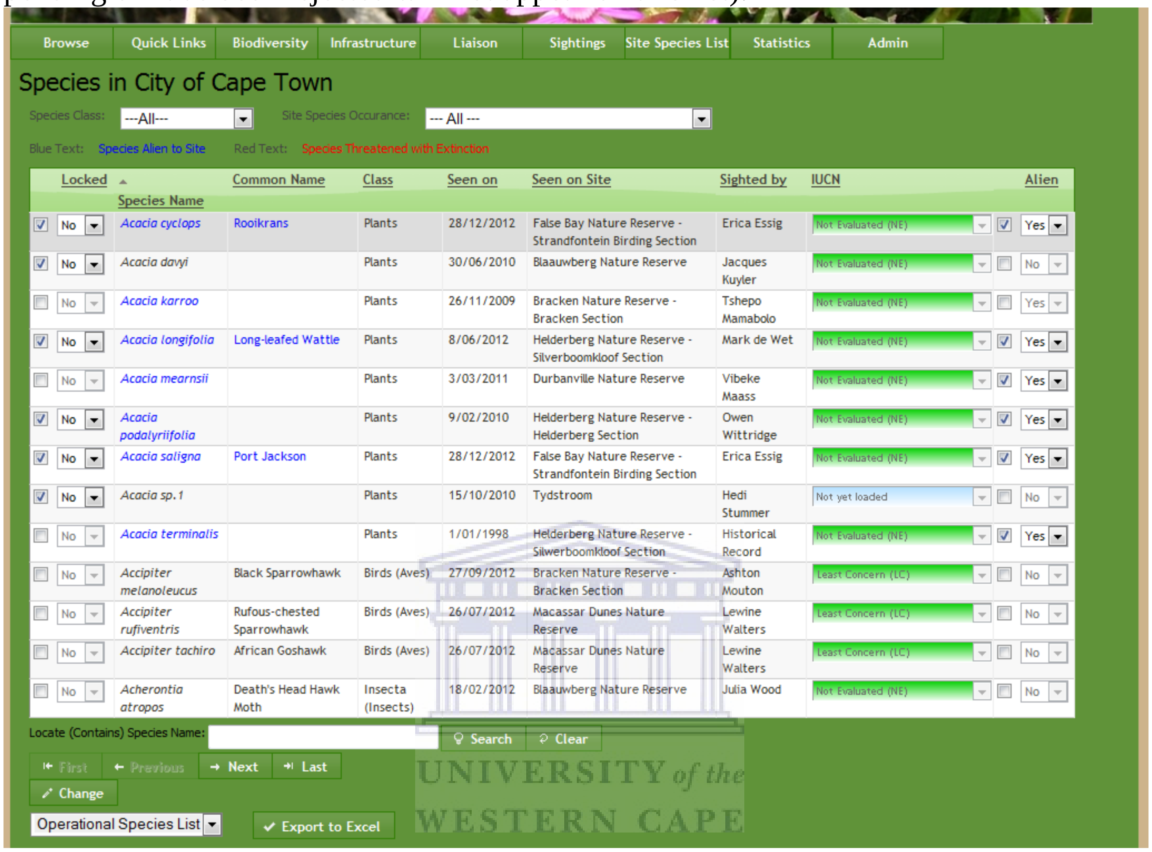
Liaison: Links to Contacts (site manager, biodiversity manager, etc.) for the site, any Friends Groups that the site has and the Site Calendar (listing all activities on the calendar).



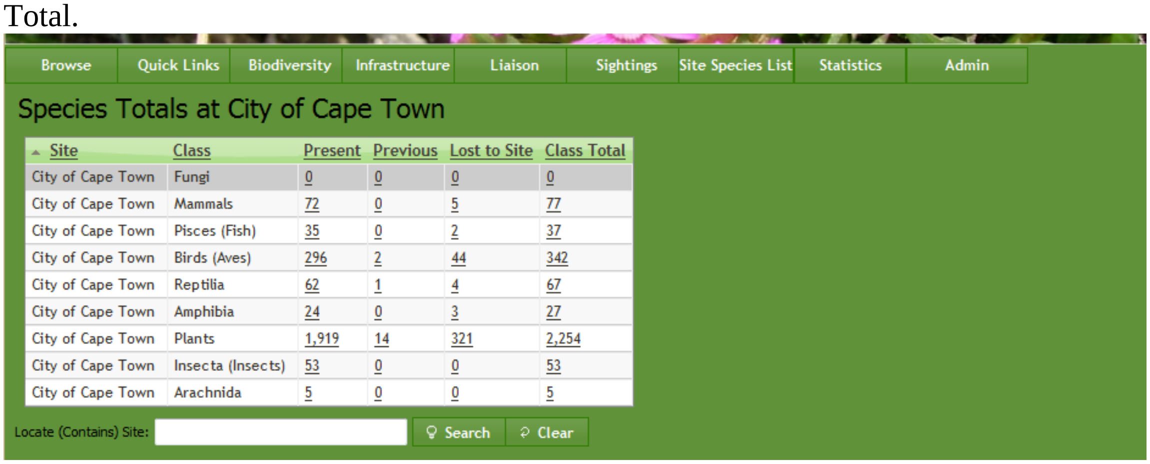
Sightings: Links to Manage Sightings (this is where sightings are made for a site), Import (for batch capture) and Translocation (species that have been moved from one site to another).



Site Species List: Shows all the sightings for the site (only the sightings that have been accepted by the site manager will appear on the Site Species List, the sightings that are still pending or have been rejected will not appear on this list).

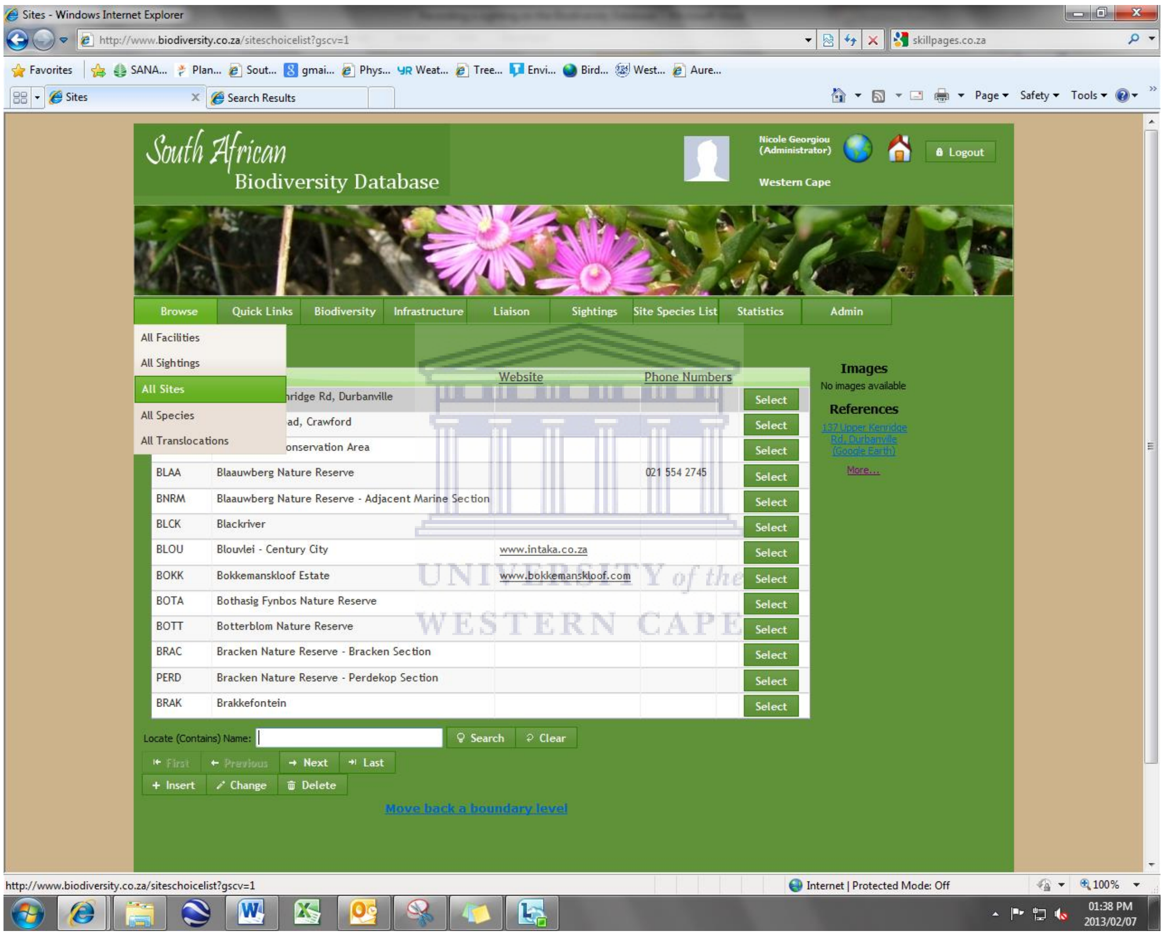


Statistics: Shows the stats for the site – Present, Previous and Lost to Site, as well as a Class Total.

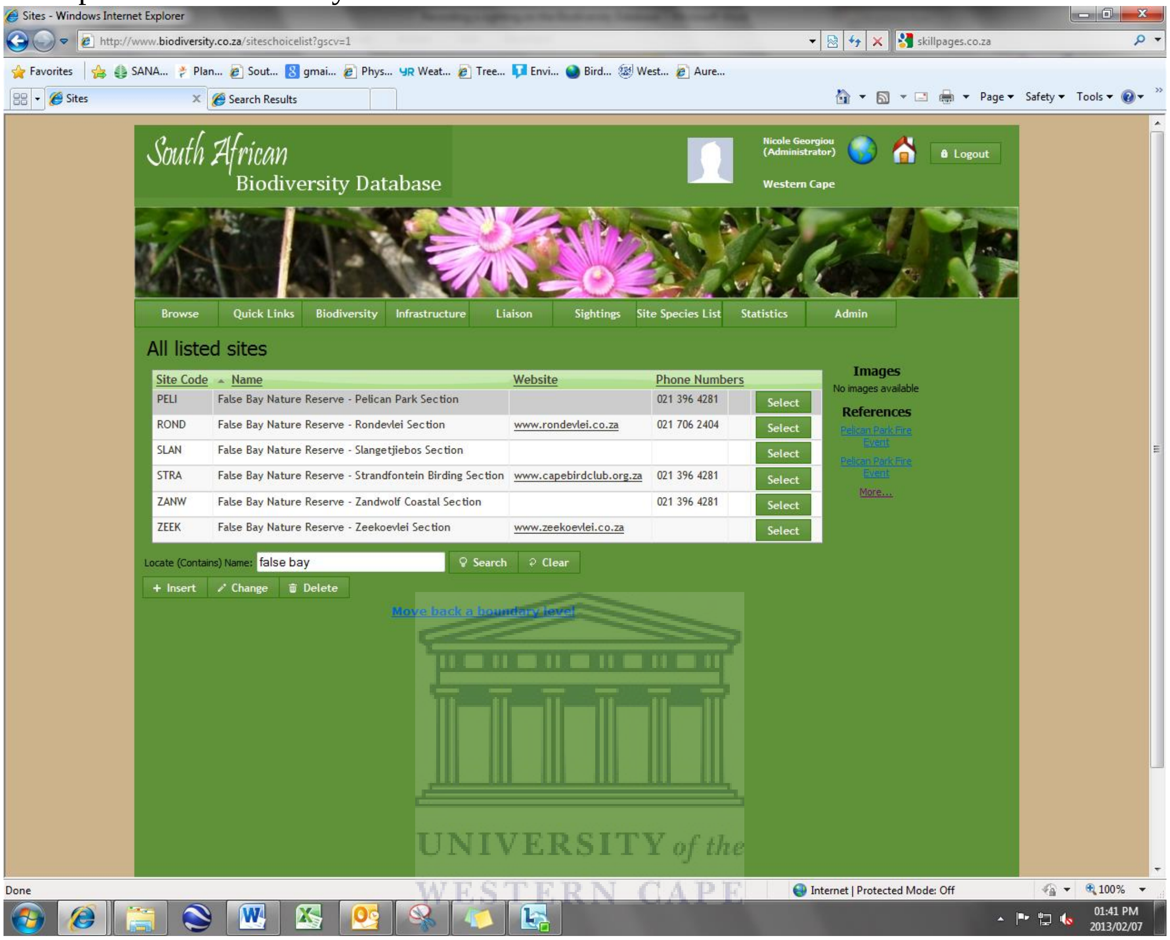


Getting to a site:

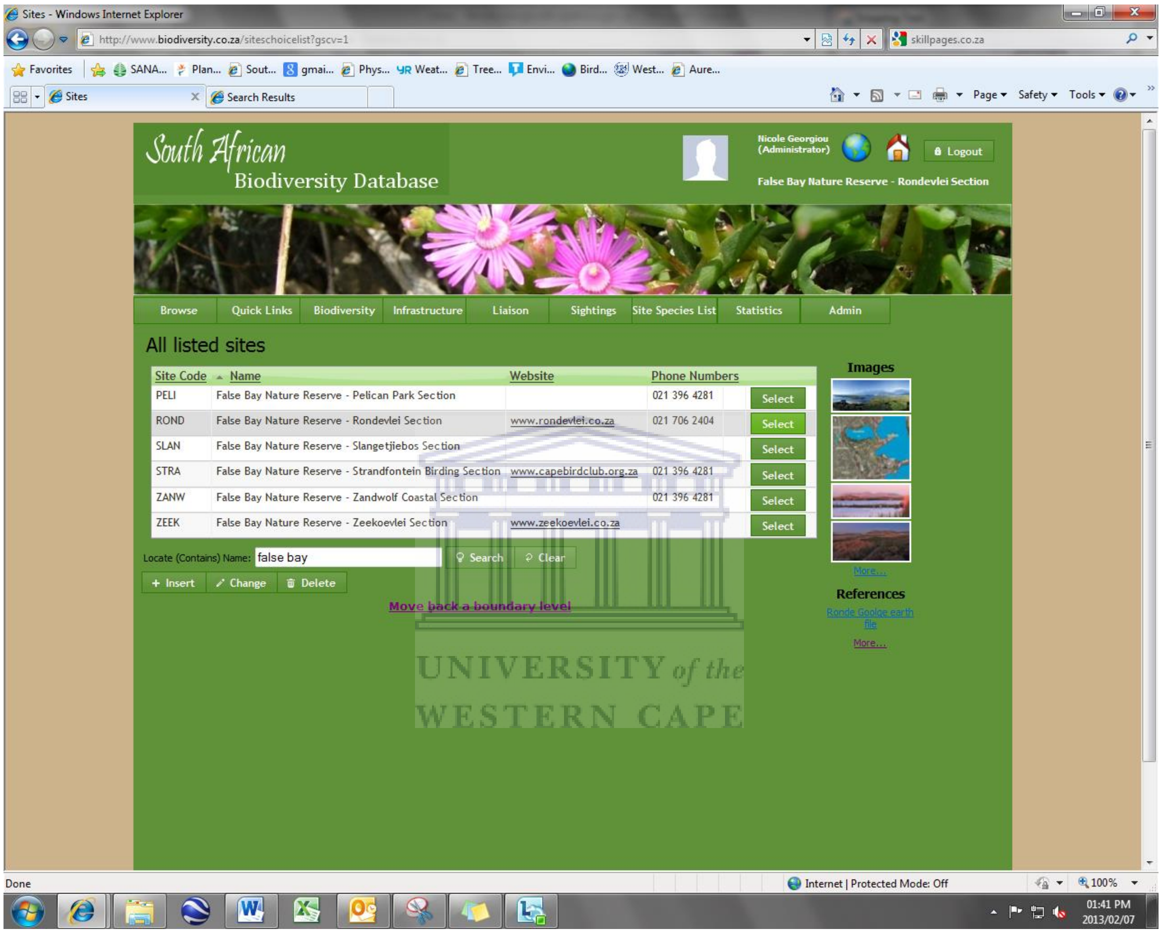
- Click on All Sites under Browse.
- You will see a list of sites appear alphabetically.
- In the search box at the bottom type in the site that is required (make sure you get the spelling right as there is no predictive text for this database), otherwise, you can manually search for the required site by clicking Next.



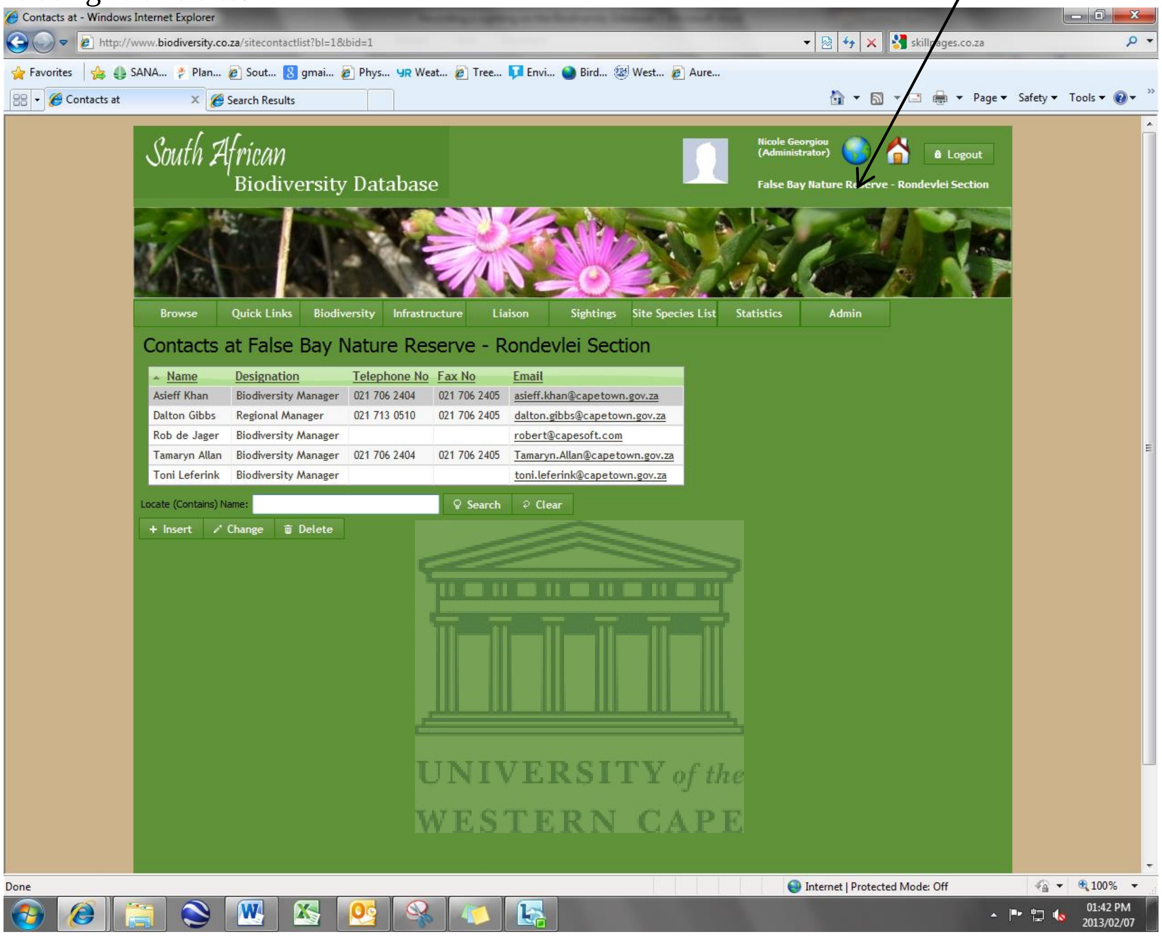
Example below: False Bay Nature Reserve – Rondevlei Section



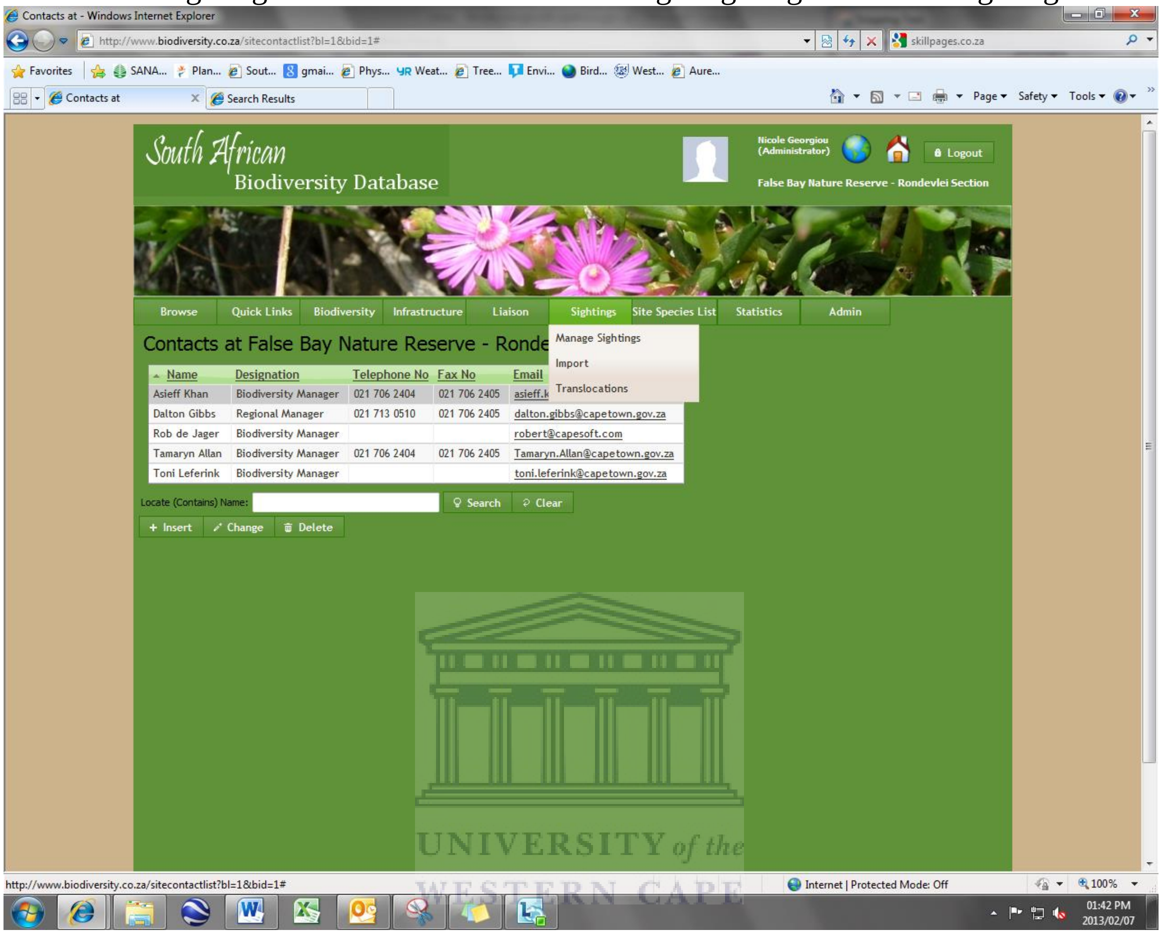
- Click on the reserve you require and make sure the block is highlighted grey (as below).
- On the right you can see the photos that have been loaded against the site as well as any reference material.
- To go into the menu for the site, click on Select.
- The Contacts for the site will be loaded (see next screenshot).

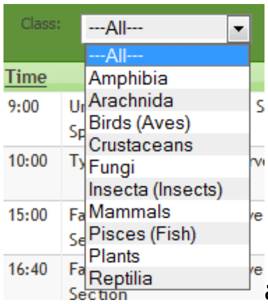


When you are on this page the site you are working in will appear on the top right. The tabs (Biodiversity, Infrastructure, Liaison, Sightings, Site Species List and Statistics) will now be relating to this site.

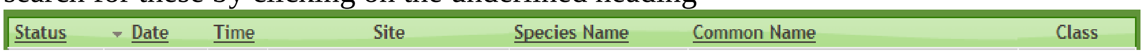


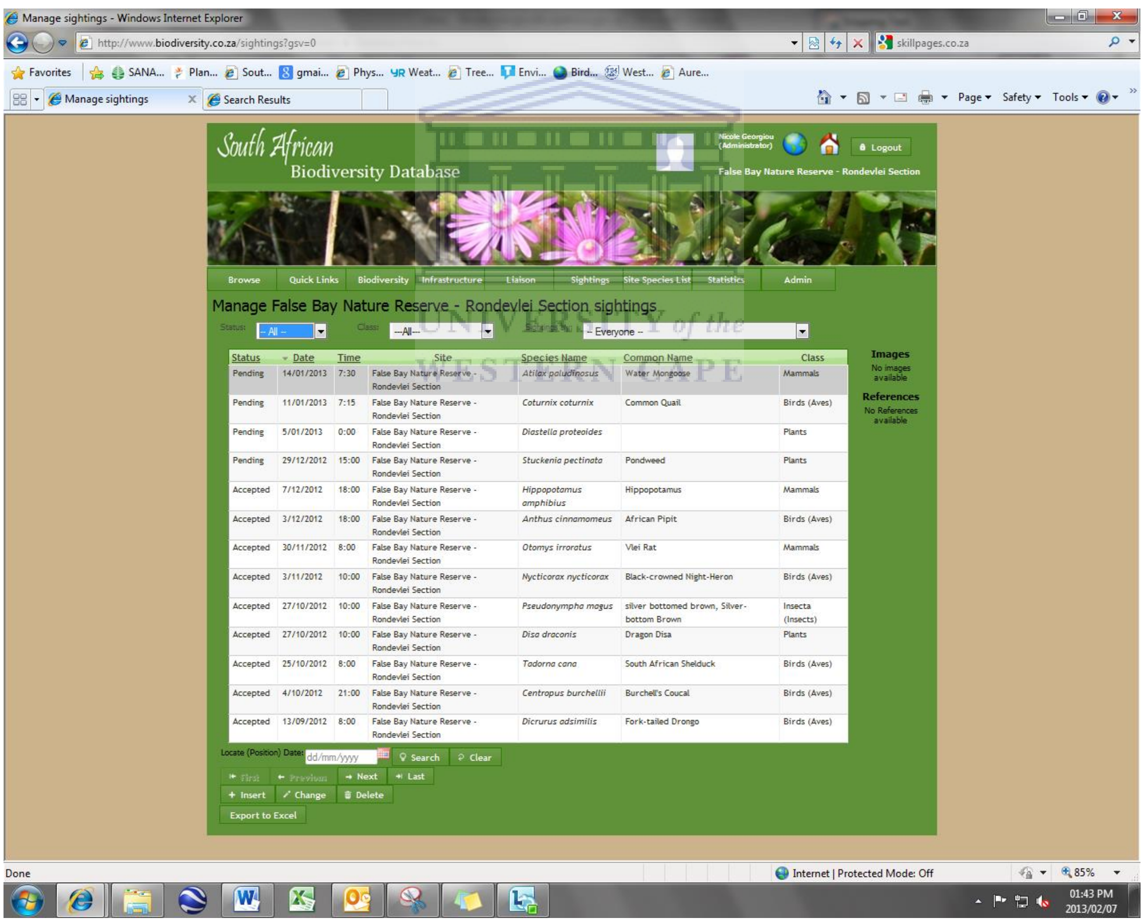
To view the sightings for Rondevlei click on Manage Sightings under the Sightings tab:



All the sightings for Rondevlei are listed in this section (Accepted, Pending and Rejected). You can view sightings with specific conditions: Status (Accepted, Pending, and Rejected), Class 

and/or Sightings By. You can also search the sightings by Date, Time, Species Name or Common Name (again, please make sure the spelling is correct). You can search for these by clicking on the underlined heading –



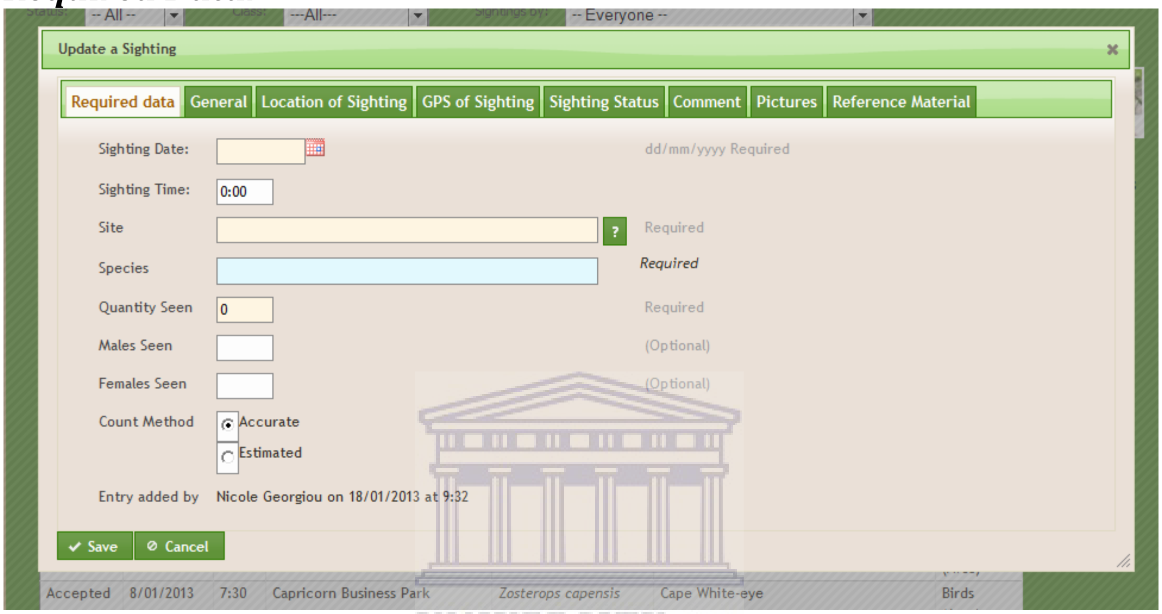


Recording a sighting:

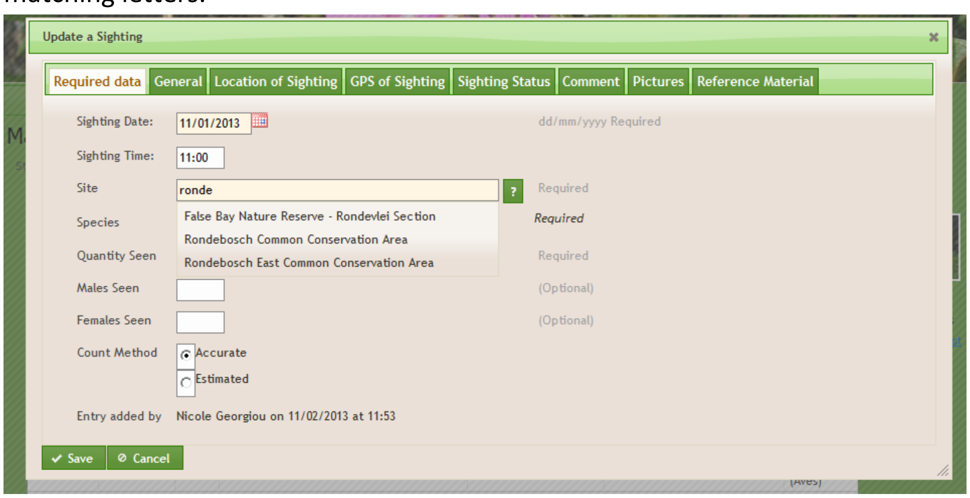
Click on 

at the bottom of the Manage Sightings page. The page below will appear.

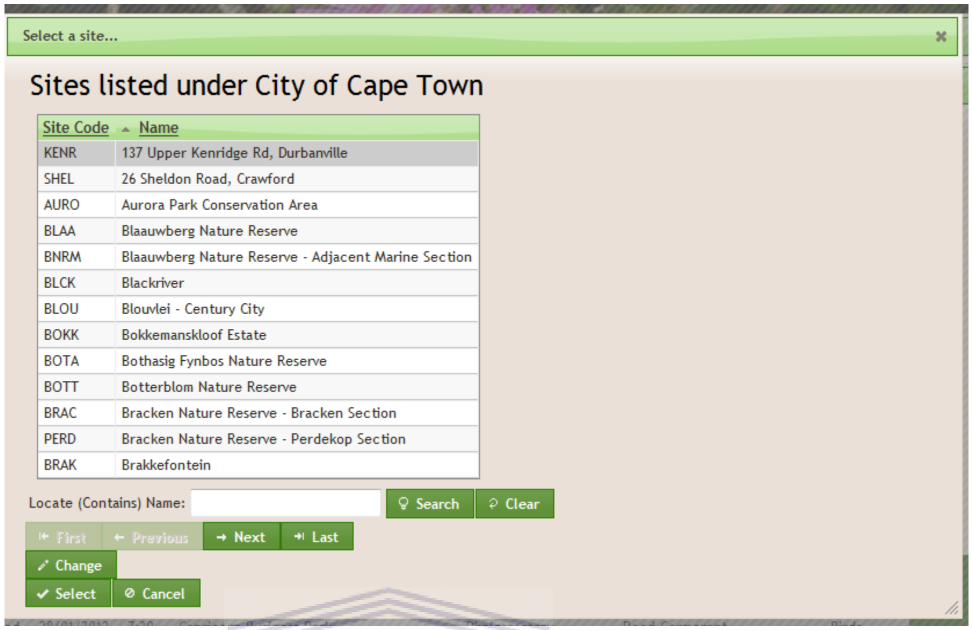
Required Data:



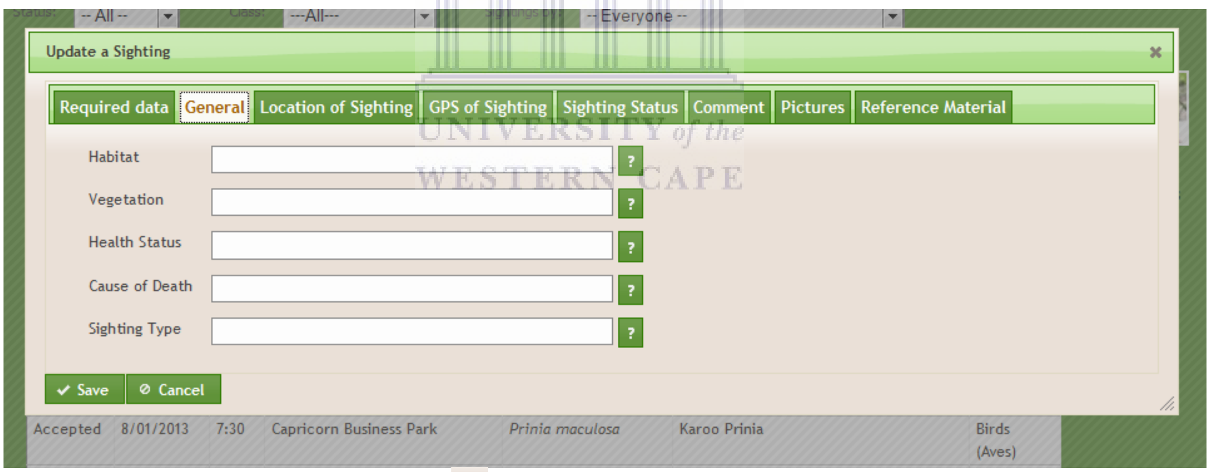
- You will need to fill in all the *required* details above.
- When filling in the site, there are two (2) ways of doing it
    - You can start to type the required site; the database will find the sites with the matching letters.



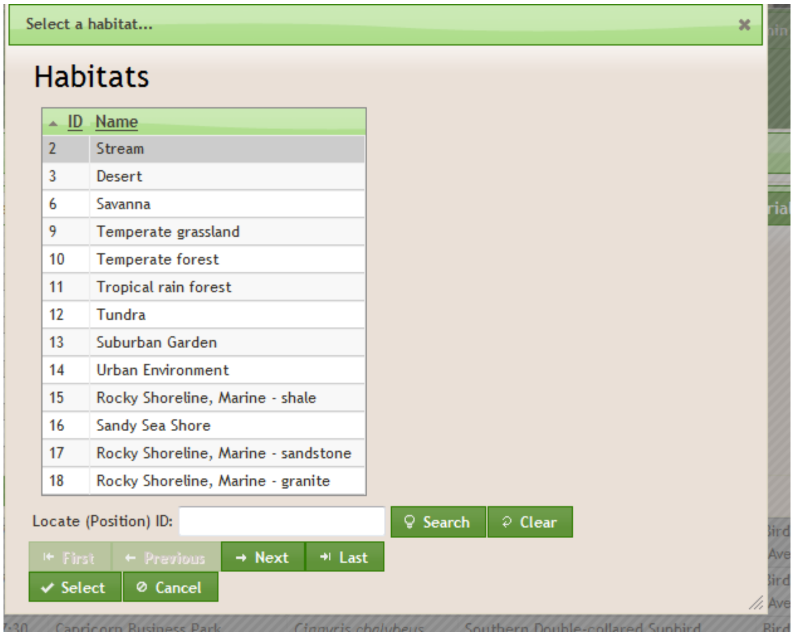
- Click and a list of sites will appear. You can then search for the required site.



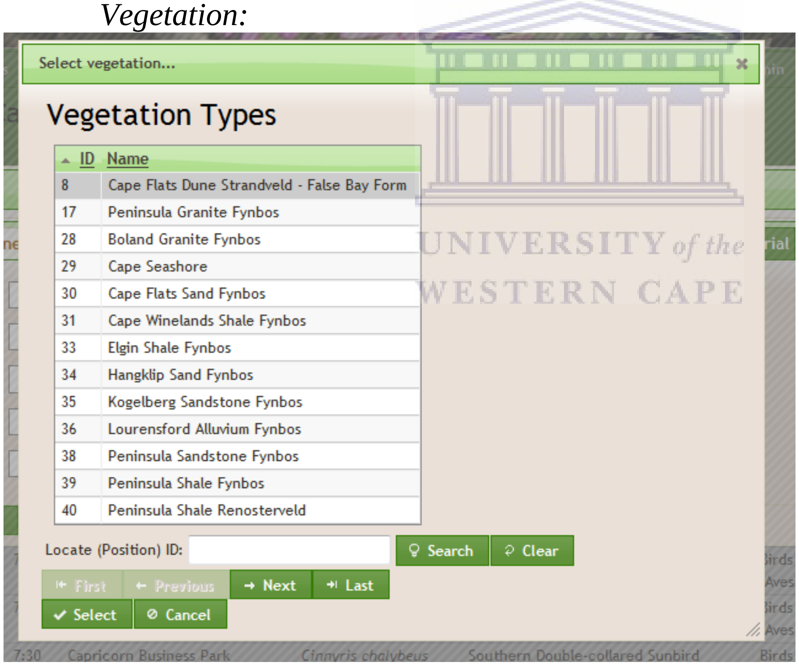
General:



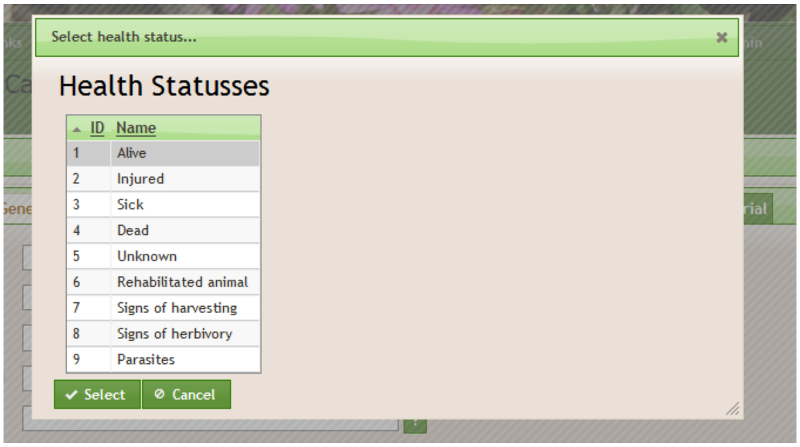
Habitat examples (click on):


Select a habitat...
Habitats
ID Name
2 Stream
3 Desert
6 Savanna
9 Temperate grassland
10 Temperate forest
11 Tropical rain forest
12 Tundra
13 Suburban Garden
14 Urban Environment
15 Rocky Shoreline, Marine - shale
16 Sandy Sea Shore
17 Rocky Shoreline, Marine - sandstone
18 Rocky Shoreline, Marine - granite
Locate (Position) ID:
Search
Clear
First
Previous
Next
Last
Select
Cancel

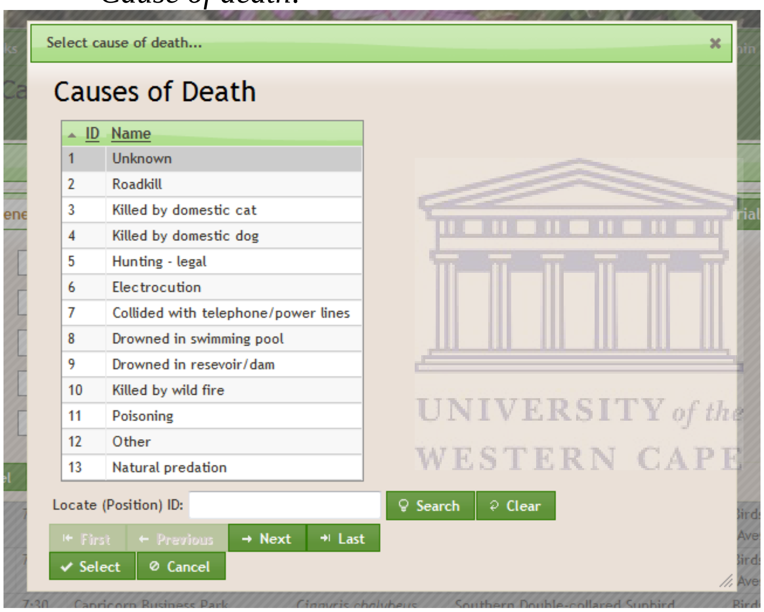
Vegetation:


Select vegetation...
Vegetation Types
ID Name
8 Cape Flats Dune Strandveld - False Bay Form
17 Peninsula Granite Fynbos
28 Boland Granite Fynbos
29 Cape Seashore
30 Cape Flats Sand Fynbos
31 Cape Winelands Shale Fynbos
33 Elgin Shale Fynbos
34 Hangklip Sand Fynbos
35 Kogelberg Sandstone Fynbos
36 Lourensford Alluvium Fynbos
38 Peninsula Sandstone Fynbos
39 Peninsula Shale Fynbos
40 Peninsula Shale Renosterveld
Locate (Position) ID:
Search
Clear
First
Previous
Next
Last
Select
Cancel

Health Status:

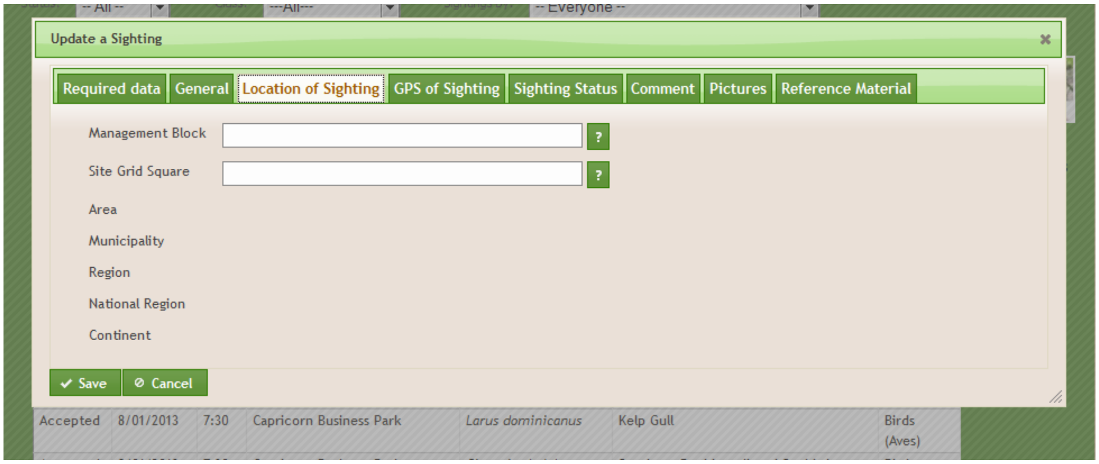


Cause of death:



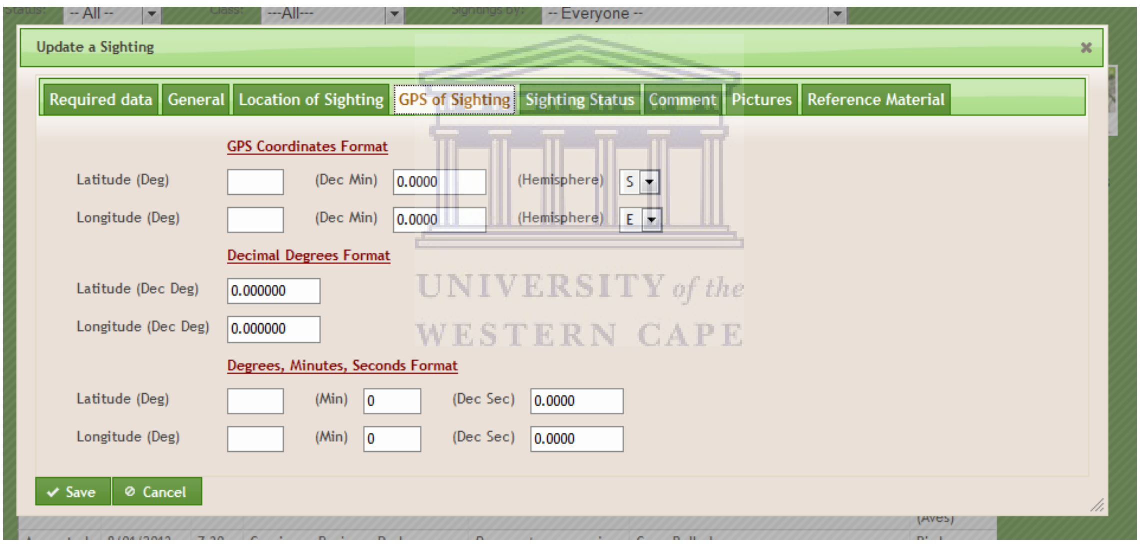
Sighting Type:

Location of Sighting:



You can select the management block of the site if you know it and the blocks have been loaded onto the database.

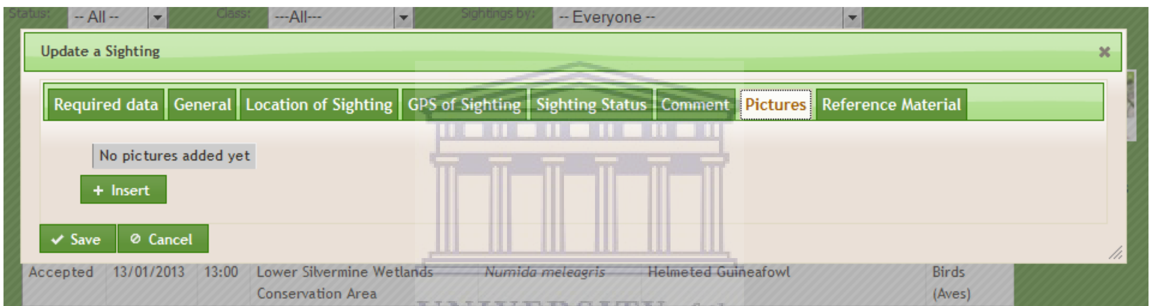
GPS of Sighting:



You do not need to fill in all three (3) formats. By filling in one (1), the database will automatically calculate the other two (2).

Comment:

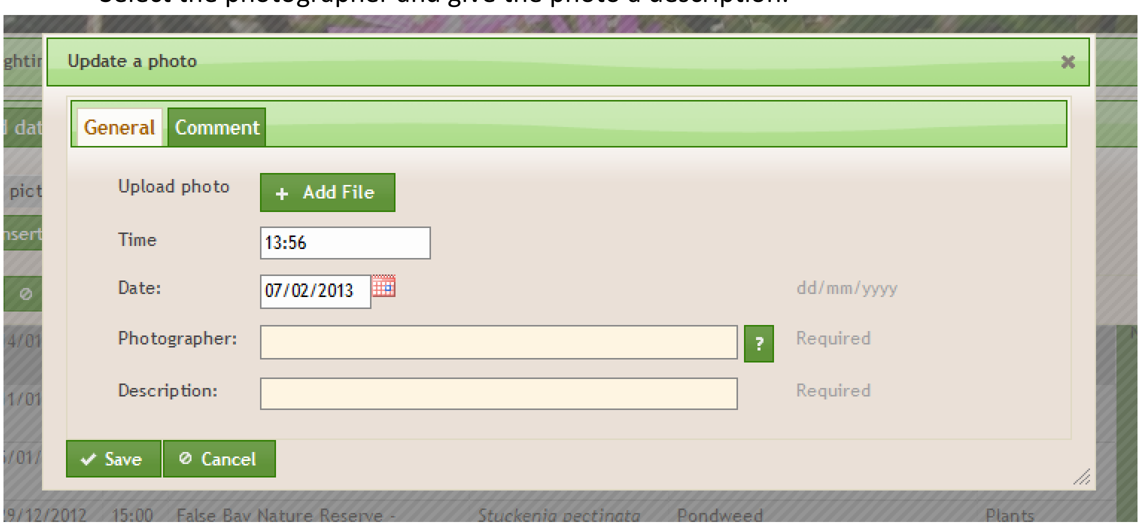
Pictures:



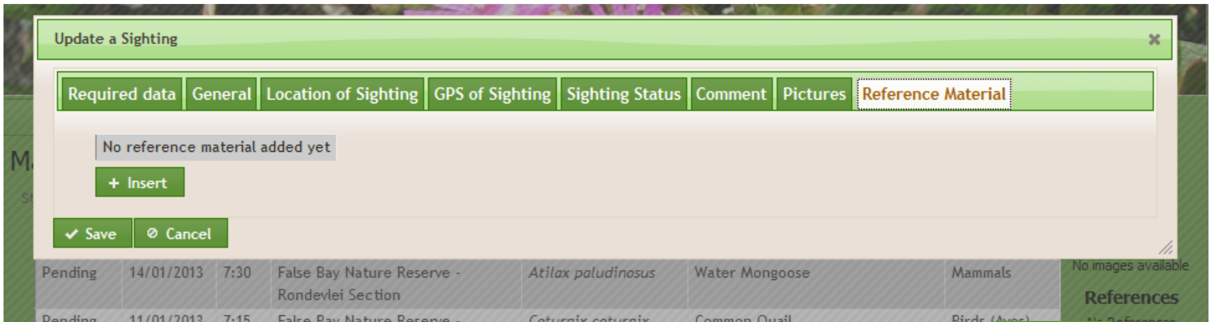
- To add a photo, click on 

 and the screen below will load.
- Click on 

 and select the photo from your PC.
- Select the photographer and give the photo a description.

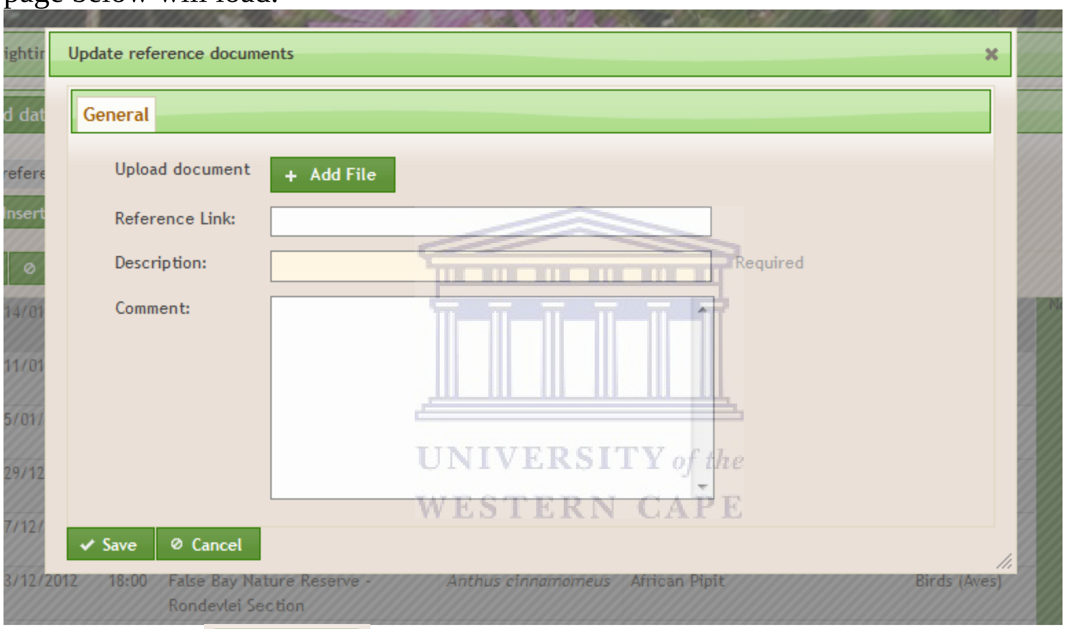


Reference material:



To add reference material (documents, Google Earth images etc.) click on 

and the page below will load.



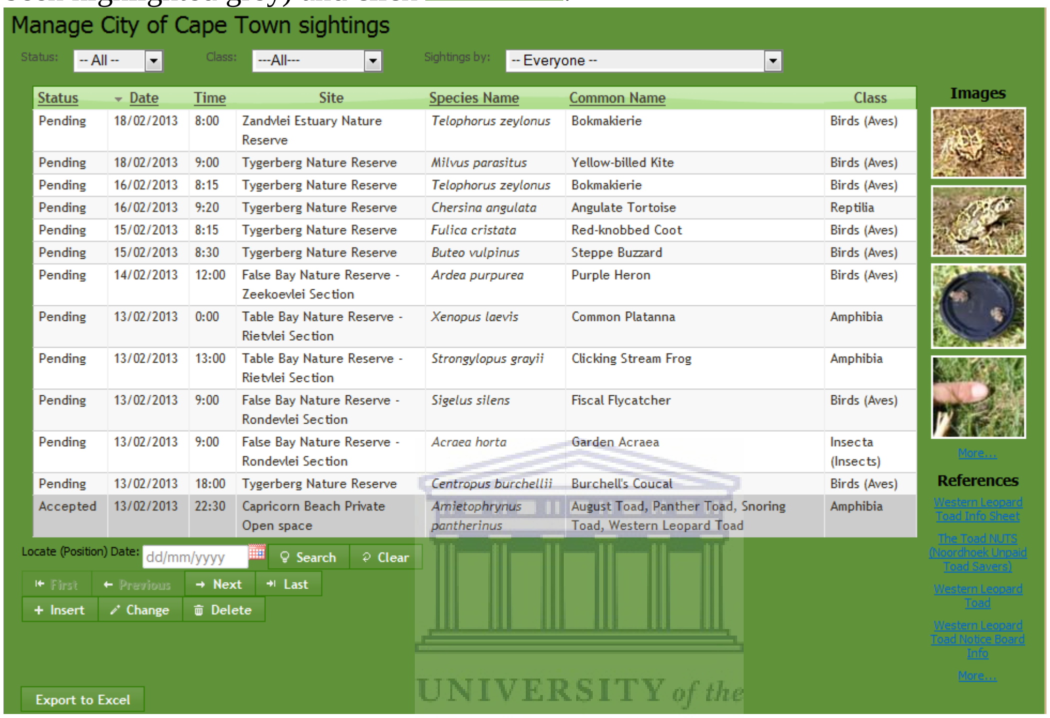
- Click on 

and select the document etc. from your PC. Do not worry about the 'Reference Link', as the database will create that.
- Add a description and there is a space if further information is required.

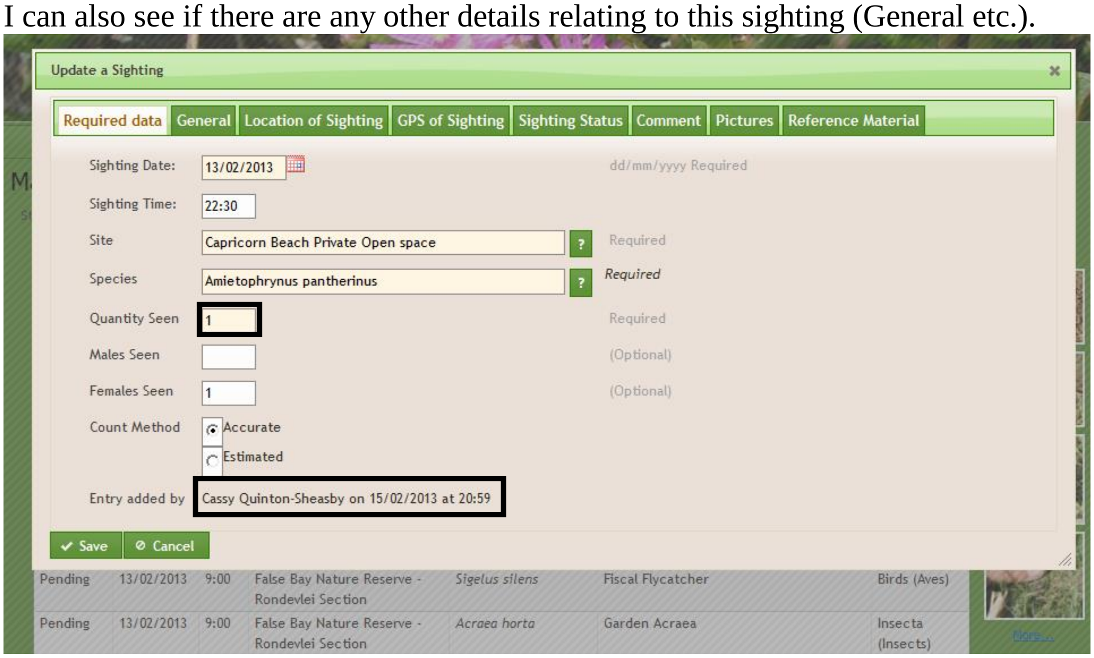
Viewing an existing record:

To view an existing record, click on the record you wish to view (make sure the record has been highlighted grey) and click 

.

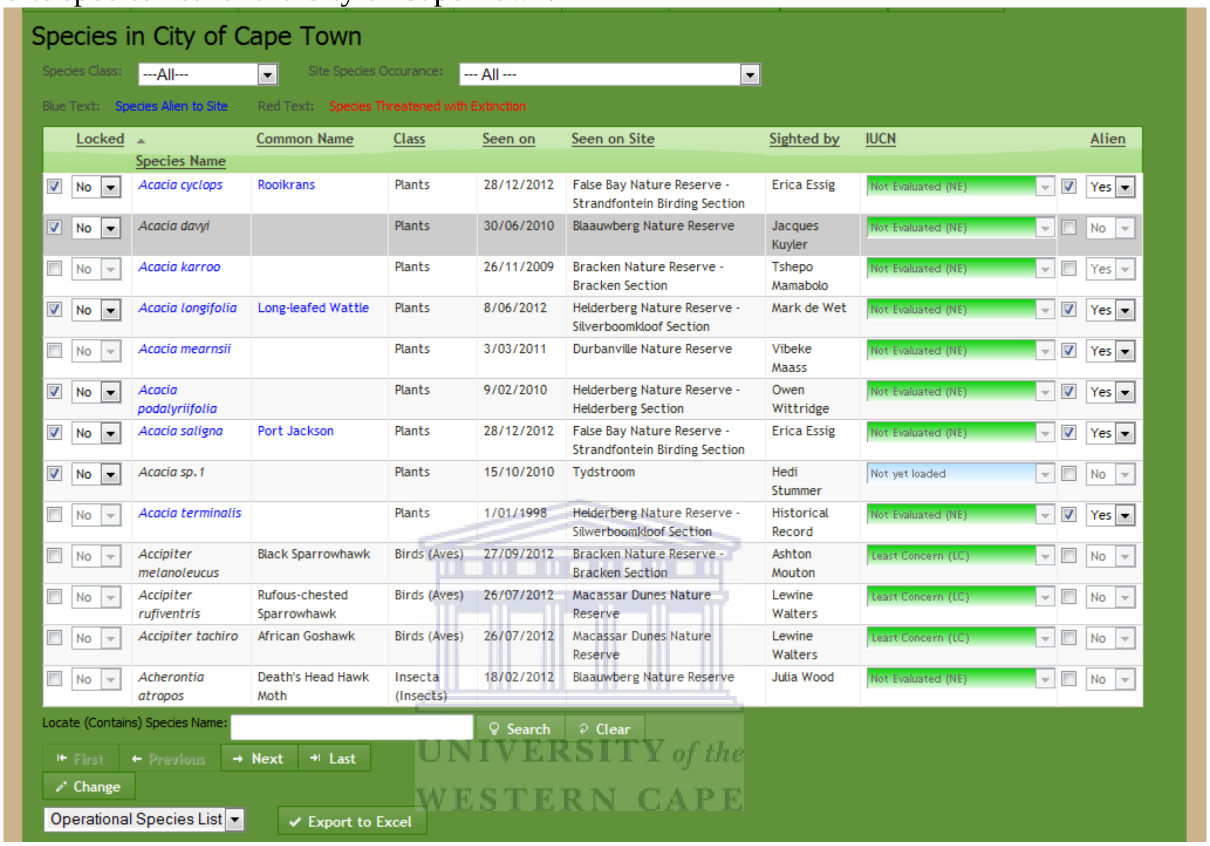


I have selected the Western Leopard Toad on 13/02/2013. By viewing the record I can see how many were recorded, who made the sighting and the date and time the sighting was made. I can also see if there are any other details relating to this sighting (General etc.).



Site Species List:

Site species list for the City of Cape Town:



Species in City of Cape Town

Species Class: ---All---   Site Species Occurance: --- All ---

Blue Text: Species Alien to Site   Red Text: Species Threatened with Extinction

	Locked	Species Name	Common Name	Class	Seen on	Seen on Site	Sighted by	IUCN		Alien
☑	No	*Acacia cyclops*	Rooikrans	Plants	28/12/2012	False Bay Nature Reserve - Strandfontein Birding Section	Erica Essig	Not Evaluated (NE)	☑	Yes
☑	No	*Acacia davyi*		Plants	30/06/2010	Blaauwberg Nature Reserve	Jacques Kuyler	Not Evaluated (NE)	☐	No
☐	No	*Acacia karroo*		Plants	26/11/2009	Bracken Nature Reserve - Bracken Section	Tshepo Mamabolo	Not Evaluated (NE)	☐	Yes
☑	No	*Acacia longifolia*	Long-leafed Wattle	Plants	8/06/2012	Helderberg Nature Reserve - Silverboomkloof Section	Mark de Wet	Not Evaluated (NE)	☑	Yes
☐	No	*Acacia mearnsii*		Plants	3/03/2011	Durbanville Nature Reserve	Vibeke Maass	Not Evaluated (NE)	☑	Yes
☑	No	*Acacia podalyriifolia*		Plants	9/02/2010	Helderberg Nature Reserve - Helderberg Section	Owen Wittridge	Not Evaluated (NE)	☑	Yes
☑	No	*Acacia saligna*	Port Jackson	Plants	28/12/2012	False Bay Nature Reserve - Strandfontein Birding Section	Erica Essig	Not Evaluated (NE)	☑	Yes
☑	No	*Acacia sp.1*		Plants	15/10/2010	Tydstroom	Hedi Stummer	Not yet loaded	☐	No
☐	No	*Acacia terminalis*		Plants	1/01/1998	Helderberg Nature Reserve - Silverboomkloof Section	Historical Record	Not Evaluated (NE)	☑	Yes
☐	No	*Accipiter melanoleucus*	Black Sparrowhawk	Birds (Aves)	27/09/2012	Bracken Nature Reserve - Bracken Section	Ashton Mouton	Least Concern (LC)	☐	No
☐	No	*Accipiter rufiventris*	Rufous-chested Sparrowhawk	Birds (Aves)	26/07/2012	Macassar Dunes Nature Reserve	Lewine Walters	Least Concern (LC)	☐	No
☐	No	*Accipiter tachiro*	African Goshawk	Birds (Aves)	26/07/2012	Macassar Dunes Nature Reserve	Lewine Walters	Least Concern (LC)	☐	No
☐	No	*Acherontia atropos*	Death's Head Hawk Moth	Insecta (Insects)	18/02/2012	Blaauwberg Nature Reserve	Julia Wood	Not Evaluated (NE)	☐	No

Locate (Contains) Species Name: Search Clear

First Previous Next Last

Change

Operational Species List   Export to Excel

A site species list will show the most recent sighting for a species. A sighting list (sightings) will show you all sightings made for a species.

The site species list can be downloaded and used to create a batch capture.

Batch Capture:

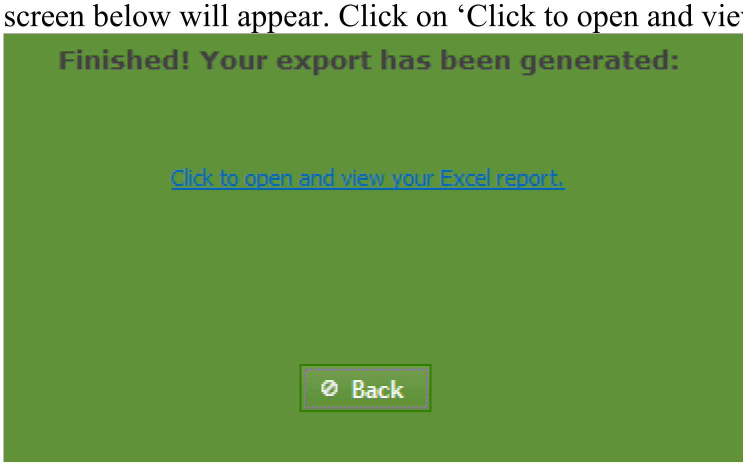
A batch capture is used when there are multiple sightings for one day e.g. Bird count. You can download the full species list (all species and classes) or download a certain class, see example below: Birds (Aves) has been selected.

Locked	Species Name	Common Name	Class	Seen on	Seen on Site	Sighted by	IUCN	Alien
No	*Accipiter melanoleucus*	Black Sparrowhawk	Birds (Aves)	27/09/2012	Bracken Nature Reserve - Bracken Section	Ashton Mouton	Least Concern (LC)	No
No	*Accipiter rufiventris*	Rufous-chested Sparrowhawk	Birds (Aves)	26/07/2012	Macassar Dunes Nature Reserve	Lewine Walters	Least Concern (LC)	No
No	*Accipiter tachiro*	African Goshawk	Birds (Aves)	26/07/2012	Macassar Dunes Nature Reserve	Lewine Walters	Least Concern (LC)	No
No	*Acrocephalus baeticatus*	African Reed-Warbler	Birds (Aves)	9/10/2012	False Bay Nature Reserve - Strandfontein Birding Section	Erica Essig	Not Evaluated (NE)	No
No	*Acrocephalus gracilirostris*	Lesser Swamp-Warbler	Birds (Aves)	28/01/2013	Capricorn Business Park	Cassy Quinton-Sheasby	Least Concern (LC)	No
No	*Acrocephalus palustris*	Marsh Warbler	Birds (Aves)	4/05/2009	Steenbras Nature Reserve	Hayley-May Wittridge	Least Concern (LC)	No
No	*Acrocephalus schoenobaenus*	Sedge Warbler	Birds (Aves)	7/05/2011	False Bay Nature Reserve - Strandfontein Birding Section	Victoria Day	Least Concern (LC)	No
No	*Actitis hypoleucos*	Common Sandpiper	Birds (Aves)	26/07/2012	Macassar Dunes Nature Reserve	Lewine Walters	Least Concern (LC)	No
No	*Actophilornis africanus*	African Jacana	Birds (Aves)	21/04/2012	Zandvlei Estuary Nature Reserve	Cassy Quinton-Sheasby	Least Concern (LC)	No
No	*Afrotis afra*	Southern Black Korhaan	Birds (Aves)	1/01/1998	Wolfgat Nature Reserve	Historic Record	Not Evaluated (NE)	No
No	*Alcedo cristata*	Malachite Kingfisher	Birds (Aves)	22/11/2012	Psoralea Park (Soralia Village)	Cassy Quinton-Sheasby	Least Concern (LC)	No
No	*Alcedo semitorquata*	Half-collared Kingfisher	Birds (Aves)	1/01/1998	False Bay Nature Reserve - Rondevlei Section	Dalton Gibbs	Near Threatened (NT)	No
No	*Alopochen aegyptiaca*	Egyptian Goose, Kolgans	Birds (Aves)	28/01/2013	Capricorn Business Park	Cassy Quinton-Sheasby	Least Concern (LC)	No

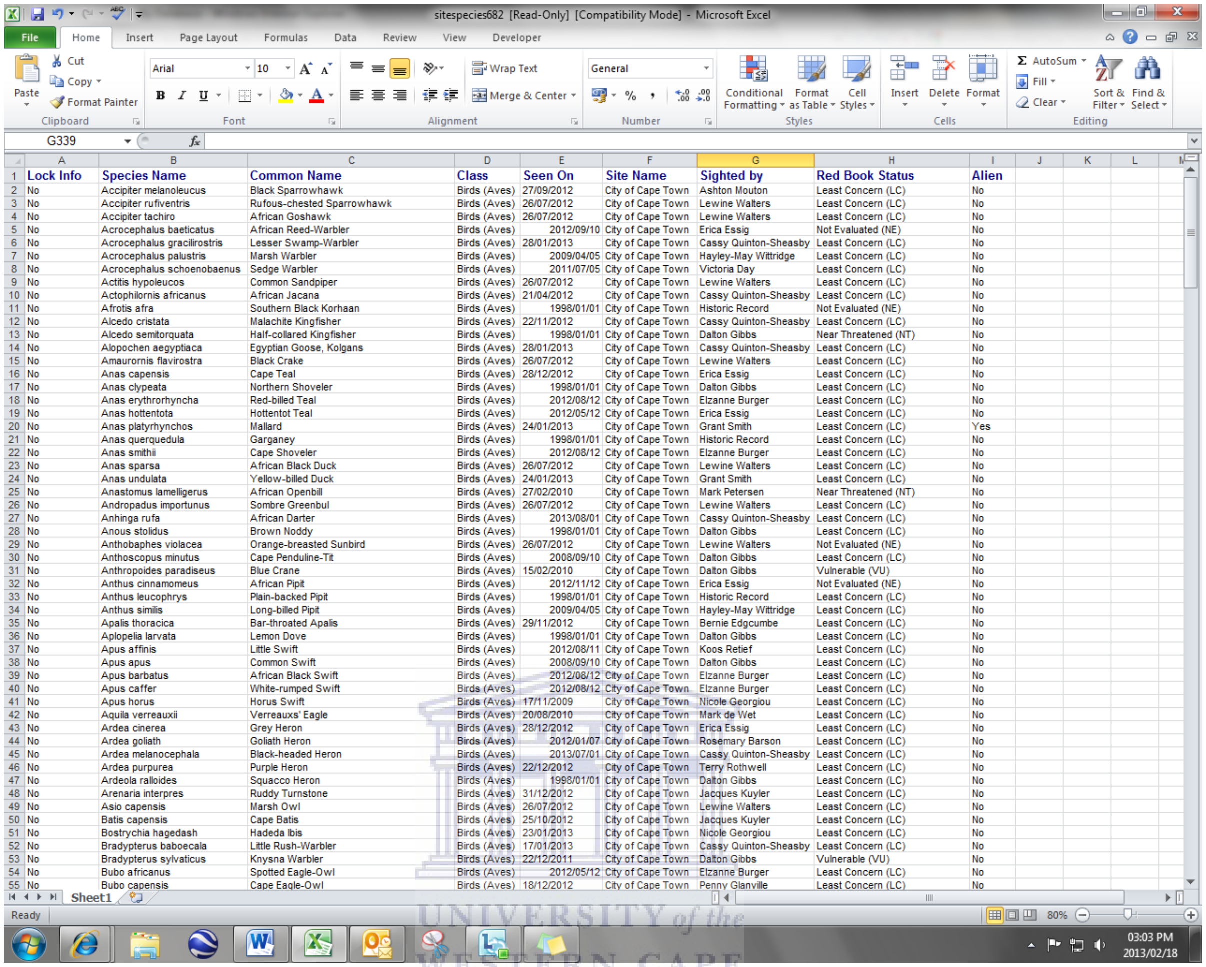
Once you are happy with the list, you can download it to Excel. This will allow you to work with the list.

Click on 

. Make sure you are downloading the Operational Species List. The screen below will appear. Click on 'Click to open and view your Excel report.'



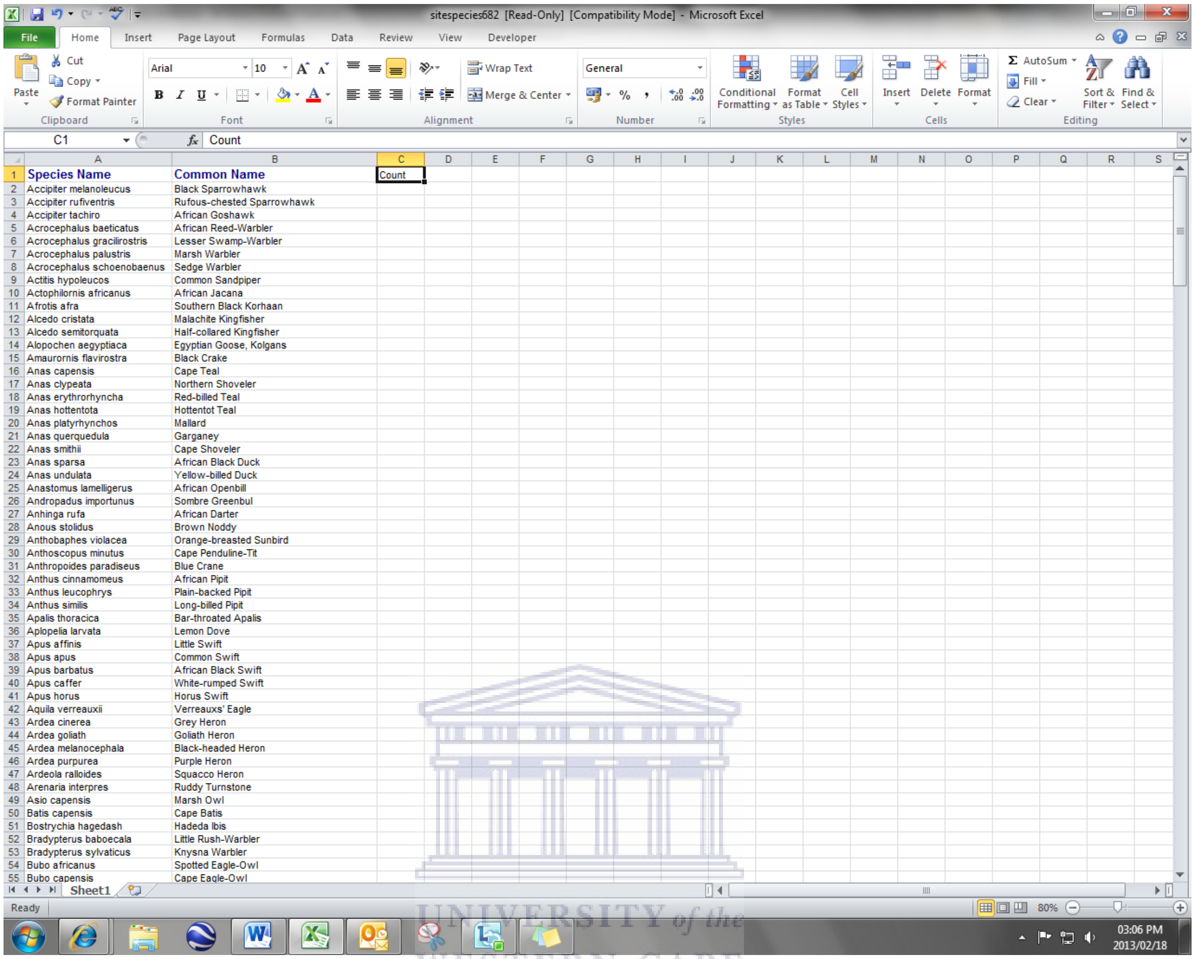
The list will appear in Excel, see below.



	Lock Info	Species Name	Common Name	Class	Seen On	Site Name	Sighted by	Red Book Status	Alien
2	No	Accipiter melanoleucus	Black Sparrowhawk	Birds (Aves)	27/09/2012	City of Cape Town	Ashton Mouton	Least Concern (LC)	No
3	No	Accipiter rufiventris	Rufous-chested Sparrowhawk	Birds (Aves)	26/07/2012	City of Cape Town	Lewine Walters	Least Concern (LC)	No
4	No	Accipiter tachiro	African Goshawk	Birds (Aves)	26/07/2012	City of Cape Town	Lewine Walters	Least Concern (LC)	No
5	No	Acrocephalus baeticatus	African Reed-Warbler	Birds (Aves)	2012/09/10	City of Cape Town	Erica Essig	Not Evaluated (NE)	No
6	No	Acrocephalus gracilirostris	Lesser Swamp-Warbler	Birds (Aves)	28/01/2013	City of Cape Town	Cassy Quinton-Sheasby	Least Concern (LC)	No
7	No	Acrocephalus palustris	Marsh Warbler	Birds (Aves)	2009/04/05	City of Cape Town	Hayley-May Wittridge	Least Concern (LC)	No
8	No	Acrocephalus schoenobaenus	Sedge Warbler	Birds (Aves)	2011/07/05	City of Cape Town	Victoria Day	Least Concern (LC)	No
9	No	Actitis hypoleucos	Common Sandpiper	Birds (Aves)	26/07/2012	City of Cape Town	Lewine Walters	Least Concern (LC)	No
10	No	Actophilornis africanus	African Jacana	Birds (Aves)	21/04/2012	City of Cape Town	Cassy Quinton-Sheasby	Least Concern (LC)	No
11	No	Afrotis afra	Southern Black Korhaan	Birds (Aves)	1998/01/01	City of Cape Town	Historic Record	Not Evaluated (NE)	No
12	No	Alcedo cristata	Malachite Kingfisher	Birds (Aves)	22/11/2012	City of Cape Town	Cassy Quinton-Sheasby	Least Concern (LC)	No
13	No	Alcedo semitorquata	Half-collared Kingfisher	Birds (Aves)	1998/01/01	City of Cape Town	Dalton Gibbs	Near Threatened (NT)	No
14	No	Alopochen aegyptiaca	Egyptian Goose, Kolgans	Birds (Aves)	28/01/2013	City of Cape Town	Cassy Quinton-Sheasby	Least Concern (LC)	No
15	No	Amaurornis flavirostra	Black Crake	Birds (Aves)	26/07/2012	City of Cape Town	Lewine Walters	Least Concern (LC)	No
16	No	Anas capensis	Cape Teal	Birds (Aves)	28/12/2012	City of Cape Town	Erica Essig	Least Concern (LC)	No
17	No	Anas clypeata	Northern Shoveler	Birds (Aves)	1998/01/01	City of Cape Town	Dalton Gibbs	Least Concern (LC)	No
18	No	Anas erythrorhyncha	Red-billed Teal	Birds (Aves)	2012/08/12	City of Cape Town	Elzanne Burger	Least Concern (LC)	No
19	No	Anas hottentota	Hottentot Teal	Birds (Aves)	2012/05/12	City of Cape Town	Erica Essig	Least Concern (LC)	No
20	No	Anas platyrhynchos	Mallard	Birds (Aves)	24/01/2013	City of Cape Town	Grant Smith	Least Concern (LC)	Yes
21	No	Anas querquedula	Garganey	Birds (Aves)	1998/01/01	City of Cape Town	Historic Record	Least Concern (LC)	No
22	No	Anas smithii	Cape Shoveler	Birds (Aves)	2012/08/12	City of Cape Town	Elzanne Burger	Least Concern (LC)	No
23	No	Anas sparsa	African Black Duck	Birds (Aves)	26/07/2012	City of Cape Town	Lewine Walters	Least Concern (LC)	No
24	No	Anas undulata	Yellow-billed Duck	Birds (Aves)	24/01/2013	City of Cape Town	Grant Smith	Least Concern (LC)	No
25	No	Anastomus lamelligerus	African Openbill	Birds (Aves)	27/02/2010	City of Cape Town	Mark Petersen	Near Threatened (NT)	No
26	No	Andropadus importunus	Sombre Greenbul	Birds (Aves)	26/07/2012	City of Cape Town	Lewine Walters	Least Concern (LC)	No
27	No	Anhinga rufa	African Darter	Birds (Aves)	2013/08/01	City of Cape Town	Cassy Quinton-Sheasby	Least Concern (LC)	No
28	No	Anous stolidus	Brown Noddy	Birds (Aves)	1998/01/01	City of Cape Town	Dalton Gibbs	Least Concern (LC)	No
29	No	Anthobaphes violacea	Orange-breasted Sunbird	Birds (Aves)	26/07/2012	City of Cape Town	Lewine Walters	Not Evaluated (NE)	No
30	No	Anthoscopus minutus	Cape Penduline-Tit	Birds (Aves)	2008/09/10	City of Cape Town	Dalton Gibbs	Least Concern (LC)	No
31	No	Anthropoides paradiseus	Blue Crane	Birds (Aves)	15/02/2010	City of Cape Town	Dalton Gibbs	Vulnerable (VU)	No
32	No	Anthus cinnamomeus	African Pipit	Birds (Aves)	2012/11/12	City of Cape Town	Erica Essig	Not Evaluated (NE)	No
33	No	Anthus leucophrys	Plain-backed Pipit	Birds (Aves)	1998/01/01	City of Cape Town	Historic Record	Least Concern (LC)	No
34	No	Anthus similis	Long-billed Pipit	Birds (Aves)	2009/04/05	City of Cape Town	Hayley-May Wittridge	Least Concern (LC)	No
35	No	Apalis thoracica	Bar-throated Apalis	Birds (Aves)	29/11/2012	City of Cape Town	Bernie Edgcumbe	Least Concern (LC)	No
36	No	Aplopelia larvata	Lemon Dove	Birds (Aves)	1998/01/01	City of Cape Town	Dalton Gibbs	Least Concern (LC)	No
37	No	Apus affinis	Little Swift	Birds (Aves)	2012/08/11	City of Cape Town	Koos Retief	Least Concern (LC)	No
38	No	Apus apus	Common Swift	Birds (Aves)	2008/09/10	City of Cape Town	Dalton Gibbs	Least Concern (LC)	No
39	No	Apus barbatus	African Black Swift	Birds (Aves)	2012/08/12	City of Cape Town	Elzanne Burger	Least Concern (LC)	No
40	No	Apus caffer	White-rumped Swift	Birds (Aves)	2012/08/12	City of Cape Town	Elzanne Burger	Least Concern (LC)	No
41	No	Apus horus	Horus Swift	Birds (Aves)	17/11/2009	City of Cape Town	Nicole Georgiou	Least Concern (LC)	No
42	No	Aquila verreauxii	Verreauxs' Eagle	Birds (Aves)	20/08/2010	City of Cape Town	Mark de Wet	Least Concern (LC)	No
43	No	Ardea cinerea	Grey Heron	Birds (Aves)	28/12/2012	City of Cape Town	Erica Essig	Least Concern (LC)	No
44	No	Ardea goliath	Goliath Heron	Birds (Aves)	2012/01/07	City of Cape Town	Rosemary Barson	Least Concern (LC)	No
45	No	Ardea melanocephala	Black-headed Heron	Birds (Aves)	2013/07/01	City of Cape Town	Cassy Quinton-Sheasby	Least Concern (LC)	No
46	No	Ardea purpurea	Purple Heron	Birds (Aves)	22/12/2012	City of Cape Town	Terry Rothwell	Least Concern (LC)	No
47	No	Ardeola ralloides	Squacco Heron	Birds (Aves)	1998/01/01	City of Cape Town	Dalton Gibbs	Least Concern (LC)	No
48	No	Arenaria interpres	Ruddy Turnstone	Birds (Aves)	31/12/2012	City of Cape Town	Jacques Kuyler	Least Concern (LC)	No
49	No	Asio capensis	Marsh Owl	Birds (Aves)	26/07/2012	City of Cape Town	Lewine Walters	Least Concern (LC)	No
50	No	Batis capensis	Cape Batis	Birds (Aves)	25/10/2012	City of Cape Town	Jacques Kuyler	Least Concern (LC)	No
51	No	Bostrychia hagedash	Hadeda Ibis	Birds (Aves)	23/01/2013	City of Cape Town	Nicole Georgiou	Least Concern (LC)	No
52	No	Bradypterus baboecala	Little Rush-Warbler	Birds (Aves)	17/01/2013	City of Cape Town	Cassy Quinton-Sheasby	Least Concern (LC)	No
53	No	Bradypterus sylvaticus	Knysna Warbler	Birds (Aves)	22/12/2011	City of Cape Town	Dalton Gibbs	Vulnerable (VU)	No
54	No	Bubo africanus	Spotted Eagle-Owl	Birds (Aves)	2012/05/12	City of Cape Town	Elzanne Burger	Least Concern (LC)	No
55	No	Bubo capensis	Cape Eagle-Owl	Birds (Aves)	18/12/2012	City of Cape Town	Penny Glanville	Least Concern (LC)	No

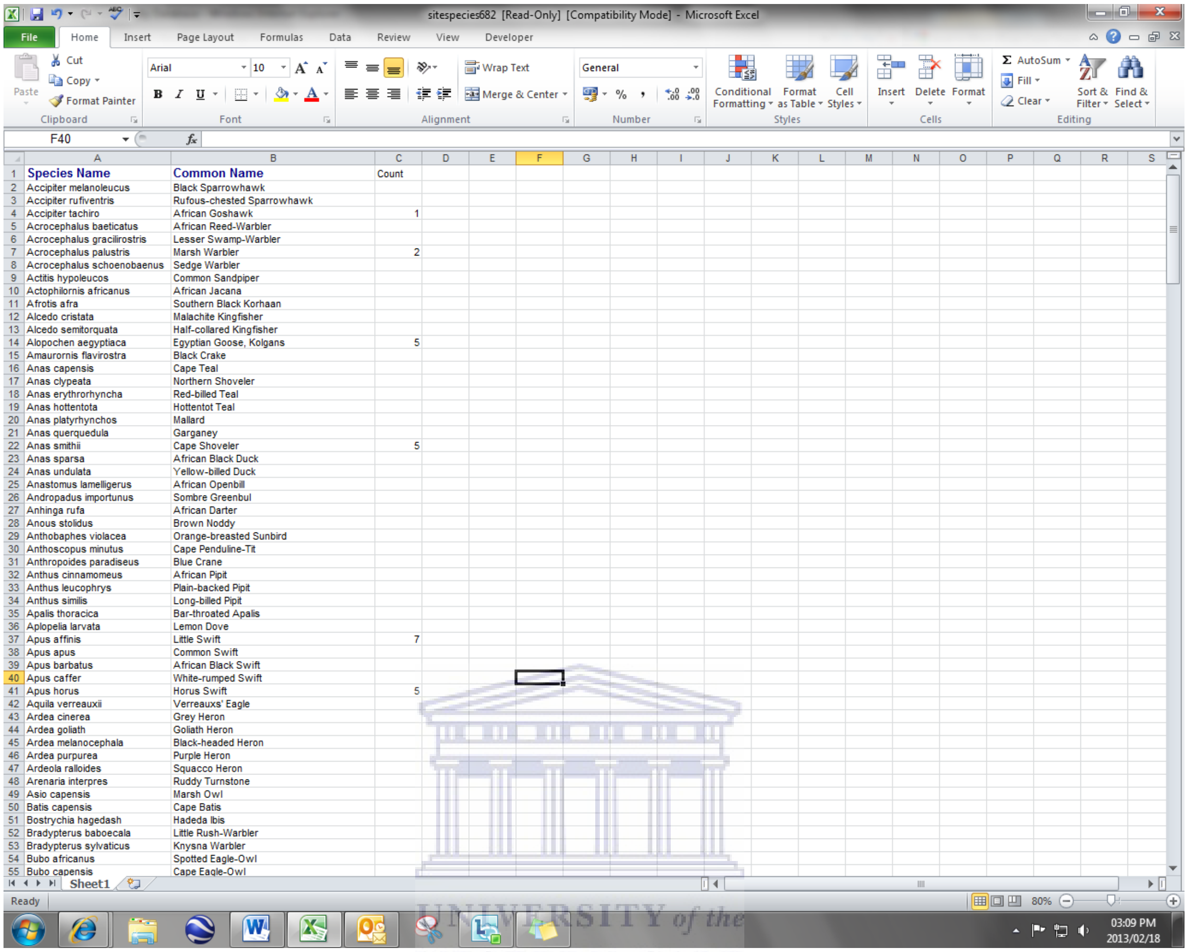
You can now use the list as needed.

When doing a batch capture, the only columns you need is Species Name and Common Name. You can delete the rest. Once you have deleted the unnecessary columns, type 'Count' to column C. See below:



	Species Name	Common Name	Count
2	Accipiter melanoleucus	Black Sparrowhawk	
3	Accipiter rufiventris	Rufous-chested Sparrowhawk	
4	Accipiter tachiro	African Goshawk	
5	Acrocephalus baeticatus	African Reed-Warbler	
6	Acrocephalus gracilirostris	Lesser Swamp-Warbler	
7	Acrocephalus palustris	Marsh Warbler	
8	Acrocephalus schoenobaenus	Sedge Warbler	
9	Actitis hypoleucos	Common Sandpiper	
10	Actophilornis africanus	African Jacana	
11	Afrotis afra	Southern Black Korhaan	
12	Alcedo cristata	Malachite Kingfisher	
13	Alcedo semitorquata	Half-collared Kingfisher	
14	Alopochen aegyptiaca	Egyptian Goose, Kolgans	
15	Amaurornis flavirostra	Black Crake	
16	Anas capensis	Cape Teal	
17	Anas clypeata	Northern Shoveler	
18	Anas erythrorhyncha	Red-billed Teal	
19	Anas hottentota	Hottentot Teal	
20	Anas platyrhynchos	Mallard	
21	Anas querquedula	Garganey	
22	Anas smithii	Cape Shoveler	
23	Anas sparsa	African Black Duck	
24	Anas undulata	Yellow-billed Duck	
25	Anastomus lamelligerus	African Openbill	
26	Andropadus importunus	Sombre Greenbul	
27	Anhinga rufa	African Darter	
28	Anous stolidus	Brown Noddy	
29	Anthobaphes violacea	Orange-breasted Sunbird	
30	Anthoscopus minutus	Cape Penduline-Tit	
31	Anthropoides paradiseus	Blue Crane	
32	Anthus cinnamomeus	African Pipit	
33	Anthus leucophrys	Plain-backed Pipit	
34	Anthus similis	Long-billed Pipit	
35	Apalis thoracica	Bar-throated Apalis	
36	Aplopelia larvata	Lemon Dove	
37	Apus affinis	Little Swift	
38	Apus apus	Common Swift	
39	Apus barbatus	African Black Swift	
40	Apus caffer	White-rumped Swift	
41	Apus horus	Horus Swift	
42	Aquila verreauxii	Verreauxs' Eagle	
43	Ardea cinerea	Grey Heron	
44	Ardea goliath	Goliath Heron	
45	Ardea melanocephala	Black-headed Heron	
46	Ardea purpurea	Purple Heron	
47	Ardeola ralloides	Squacco Heron	
48	Arenaria interpres	Ruddy Turnstone	
49	Asio capensis	Marsh Owl	
50	Batis capensis	Cape Batis	
51	Bostrychia hagedash	Hadeda Ibis	
52	Bradypterus baboecala	Little Rush-Warbler	
53	Bradypterus sylvaticus	Knysna Warbler	
54	Bubo africanus	Spotted Eagle-Owl	
55	Bubo capensis	Cape Eagle-Owl	

Input the values in the ‘Count’ column (you do not need to add values to each species). Find the correct species and input the number you counted for that species. See below:



	Species Name	Common Name	Count
2	Accipiter melanoleucus	Black Sparrowhawk	
3	Accipiter rufiventris	Rufous-chested Sparrowhawk	
4	Accipiter tachiro	African Goshawk	1
5	Acrocephalus baeticatus	African Reed-Warbler	
6	Acrocephalus gracilirostris	Lesser Swamp-Warbler	
7	Acrocephalus palustris	Marsh Warbler	2
8	Acrocephalus schoenobaenus	Sedge Warbler	
9	Actitis hypoleucos	Common Sandpiper	
10	Actophilornis africanus	African Jacana	
11	Afrotis afra	Southern Black Korhaan	
12	Alcedo cristata	Malachite Kingfisher	
13	Alcedo semitorquata	Half-collared Kingfisher	
14	Alopochen aegyptiaca	Egyptian Goose, Kolgans	5
15	Amaurornis flavirostra	Black Crake	
16	Anas capensis	Cape Teal	
17	Anas clypeata	Northern Shoveler	
18	Anas erythrorhyncha	Red-billed Teal	
19	Anas hottentota	Hottentot Teal	
20	Anas platyrhynchos	Mallard	
21	Anas querquedula	Garganey	
22	Anas smithii	Cape Shoveler	5
23	Anas sparsa	African Black Duck	
24	Anas undulata	Yellow-billed Duck	
25	Anastomus lamelligerus	African Openbill	
26	Andropadus importunus	Sombre Greenbul	
27	Anhinga rufa	African Darter	
28	Anous stolidus	Brown Noddy	
29	Anthobaphes violacea	Orange-breasted Sunbird	
30	Anthoscopus minutus	Cape Penduline-Tit	
31	Anthropoides paradiseus	Blue Crane	
32	Anthus cinnamomeus	African Pipit	
33	Anthus leucophrys	Plain-backed Pipit	
34	Anthus similis	Long-billed Pipit	
35	Apalis thoracica	Bar-throated Apalis	
36	Aplopelia larvata	Lemon Dove	
37	Apus affinis	Little Swift	7
38	Apus apus	Common Swift	
39	Apus barbatus	African Black Swift	
40	Apus caffer	White-rumped Swift	
41	Apus horus	Horus Swift	5
42	Aquila verreauxii	Verreauxs' Eagle	
43	Ardea cinerea	Grey Heron	
44	Ardea goliath	Goliath Heron	
45	Ardea melanocephala	Black-headed Heron	
46	Ardea purpurea	Purple Heron	
47	Ardeola ralloides	Squacco Heron	
48	Arenaria interpres	Ruddy Turnstone	
49	Asio capensis	Marsh Owl	
50	Batis capensis	Cape Batis	
51	Bostrychia hagedash	Hadeda Ibis	
52	Bradypterus baboecala	Little Rush-Warbler	
53	Bradypterus sylvaticus	Knysna Warbler	
54	Bubo africanus	Spotted Eagle-Owl	
55	Bubo capensis	Cape Eagle-Owl	

Save the document with a relevant file name (e.g. type of count and date) and send it to the reserve manager, only they can load the batch capture.

Statistics:

The Statistics tab on the database is a very useful tool as it shows you the number of species per site. It shows you the present species (sightings made in the last 0-10 years) as well as previous species (sightings made in the last 10-15 years) and those that have been lost to the site - ‘extinct’ (sightings made in the last 15+ years).

Statistics for City of Cape Town:

Species Totals at City of Cape Town

Site	Class	Present	Previous	Lost to Site	Class Total
City of Cape Town	Fungi	0	0	0	0
City of Cape Town	Mammals	72	0	5	77
City of Cape Town	Pisces (Fish)	35	0	2	37
City of Cape Town	Birds (Aves)	296	2	44	342
City of Cape Town	Reptilia	62	1	4	67
City of Cape Town	Amphibia	24	0	3	27
City of Cape Town	Plants	1,919	14	321	2,254
City of Cape Town	Insecta (Insects)	53	0	0	53
City of Cape Town	Arachnida	5	0	0	5

Locate (Contains) Site: Search Clear

By looking at the table above one can see immediately what species are still occurring in the City. By clicking on the number of species, one can see the species list.

There are 72 present mammal species for the City.

Species Name	Common Name	Seen on	Seen at	Sighted by	IUCN Red List Status	Site Species Status	Alien
Acomys subspinosus	Cape Spiny Mouse	15/10/2008	21:00	Victoria Day	Least Concern (LC)	Not Assessed	No
Aethomys namaquensis	Namaqua Rock Mouse	4/03/2011	11:59	Dalton Gibbs	Least Concern (LC)	Not Assessed	No
Amblysomus hottentotus	Hottentot Golden Mole	24/07/2012	11:59	Lewine Walters	Not yet loaded	Not Assessed	No
Aonyx capensis	Cape Clawless Otter	23/12/2012	5:15	Terry Rothwell	Least Concern (LC)	Not Assessed	No
Arctocephalus pusillus	Cape Fur Seal	31/12/2012	11:59	Jacques Kuyler	Least Concern (LC)	Not Assessed	No
Atilax paludinosus	Water Mongoose	7/01/2013	7:30	Cassy Quinton-Sheasby	Least Concern (LC)	Not Assessed	No
Bathyergus suillus	Cape Dune Molerat	8/01/2013	7:30	Cassy Quinton-Sheasby	Least Concern (LC)	Not Assessed	No
Canis lupus familiaris	Domestic dog	30/10/2012	12:00	Koos Retief	Not yet loaded	Not Assessed	Yes
Canis mesomelas	Blackbacked Jackal	18/03/2011	6:30	Owen Wittridge	Least Concern (LC)	Not Assessed	No
Cephalorhynchus heavisidii	Benguela Dolphin, Heaviside's Dolphin	31/12/2006	11:59	Jacques Kuyler	Data Deficient (DDD)	Not Assessed	No
Connochaetes gnou	Black Wildebeest	1/08/2006	11:59	Dalton Gibbs	Not yet loaded	Not Assessed	Yes
Crocidura cyanea	Reddish-grey Musk Shrew	24/07/2012	11:59	Lewine Walters	Data Deficient (DDD)	Not Assessed	No
Cryptochloris asiatica	Cape Golden Mole	5/12/2012	11:59	Cassy Quinton-Sheasby	Data Deficient (DDD)	Not Assessed	No

First Previous Next Last

Close

There are 5 species that have been lost to the City:

Species Name	Common Name	Seen on	Seen at	Sighted by	IUCN Red List Status	Site Species Status	Alien
Crocidura flavescens	Greater Musk Shrew	1/01/1998	11:59	Historic Record	Data Deficient (DDD)	Not Assessed	No
Dasymus incomtus	Water Rat	1/01/1998	11:59	Historic Record	Not yet loaded	Not Assessed	No
Felis lybica	African Wild Cat	1/01/1998	11:59	Historic Record	Least Concern (LC)	Not Assessed	No
Megaptera novaeangliae	Humpback Whale	1/01/1998	11:59	Historic Record	Near Threatened (NT)	Not Assessed	No
Otomys saundersiae	Saunder's Vlei Rat	1/01/1998	11:59	Historic Record	Least Concern (LC)	Not Assessed	No

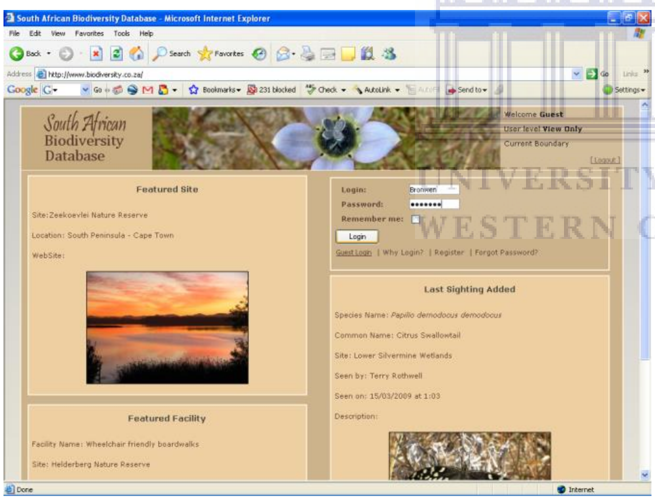
✓ Close

Each site will have statistics and the site manager can have an overall look at what is happening at his/her site.

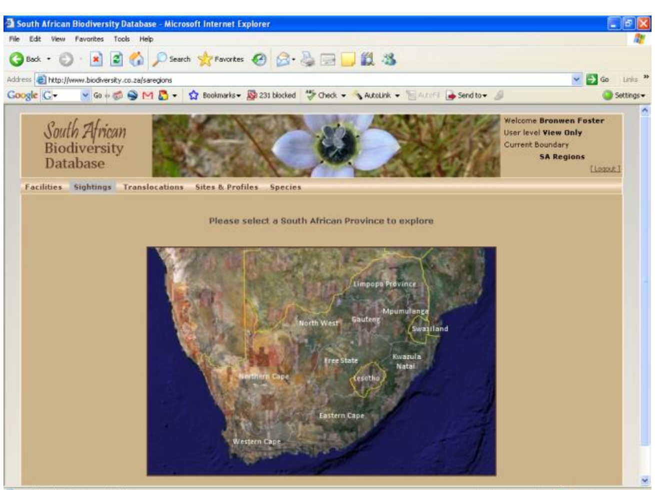
A user manual developed for an Operator to enter information into the Biodiversity Database.

1. How to insert a sighting on the Biodiversity Database:

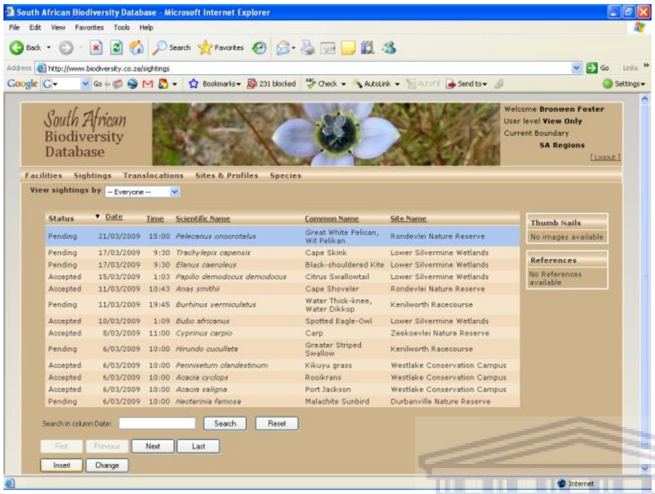
→ Log on to: www.biodiversity.co.za



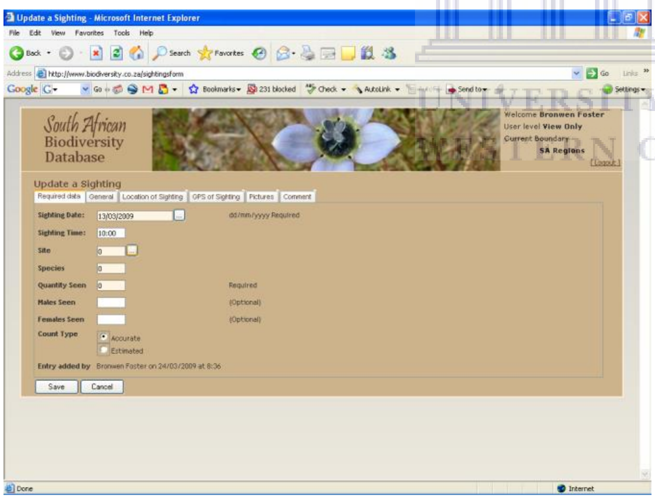
→ Enter username and password
→ Click on login



→Click on the sightings icon

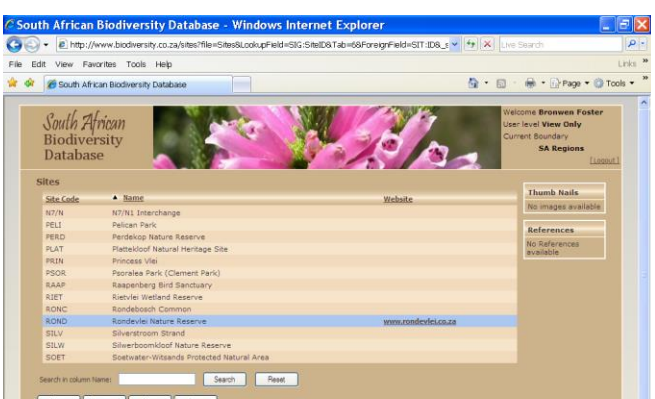


→Click on Insert

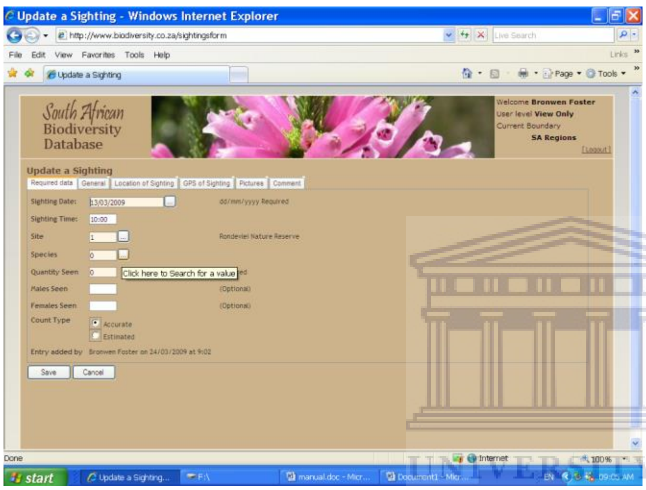


Required Information:

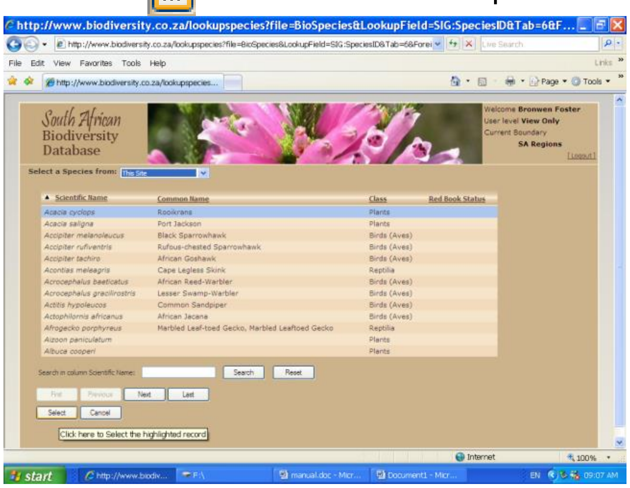
→Type in sighting date and sighting time
→Click the  button next to the Site field



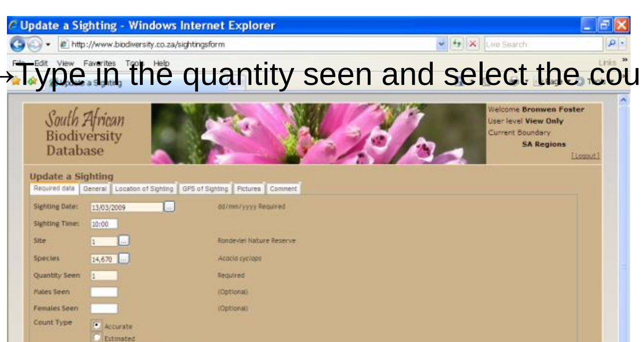
→Highlight site and click select



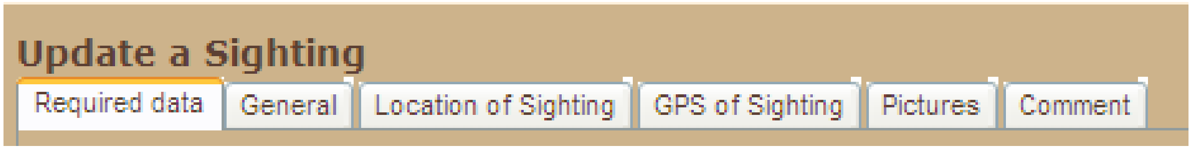
→Click the ... button next to the Species field



→Highlight species and click select



→Type in the quantity seen and select the count type (accurate/estimate)



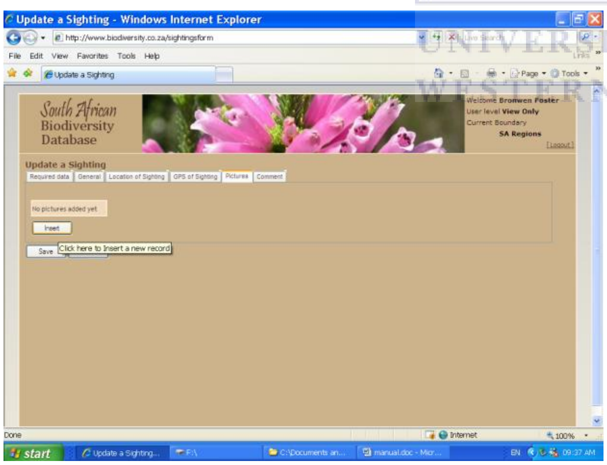
Optional Extra Information:

→Click "General" to add any general information
→Click "Location of sighting" to add the sighting location
→Click "GPS of sighting" to add the GPS of the sighting
→Click "Picture" to add a picture (see section 2 of manual for guidelines)
→Click "Comment" to add a comment

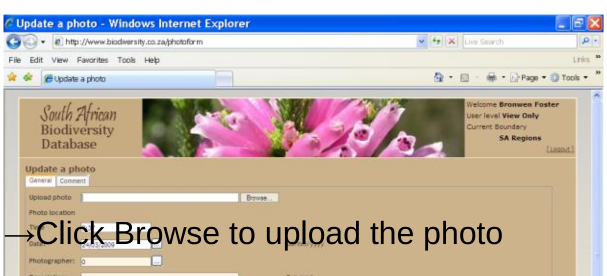
→Once the required data and optional extra data have been filled in press save to save the sighting onto the database.

2. How to add a picture to your sighting:

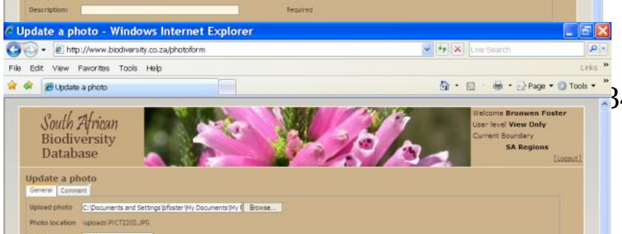
→When inserting a sighting click on "Picture" to add a picture



→Click on Insert



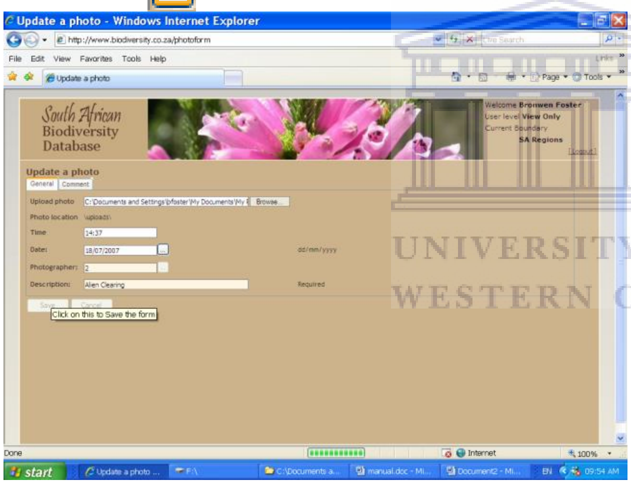
→Click Browse to upload the photo



Required Information:

→Type in the time and date that the photo was taken

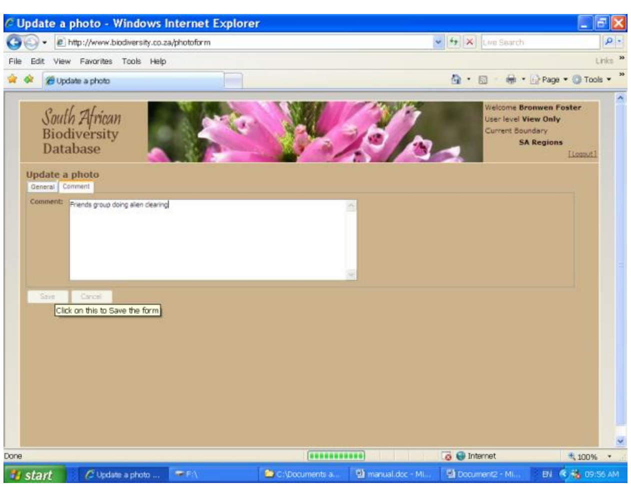
→Click the  button next to the Photographer field to select the photographer



→Highlight the photographer on the list and click select
→Type in a description of the photo

Optional Information:

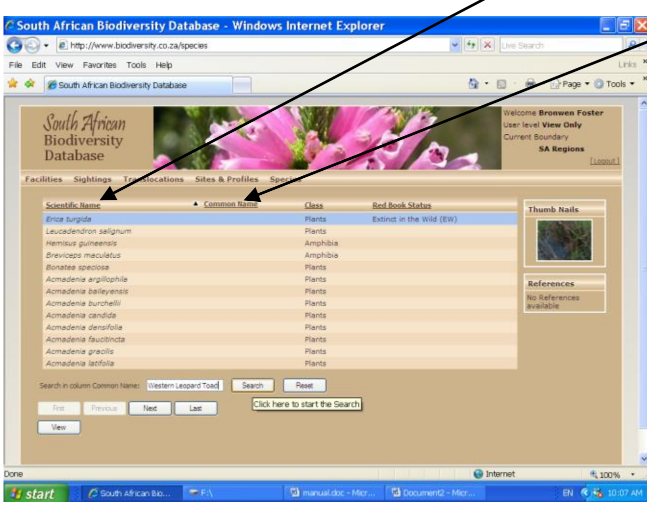
→Add a comment to the photo



→Click on Save to add the picture to the sighting.

3. How to search for a species:

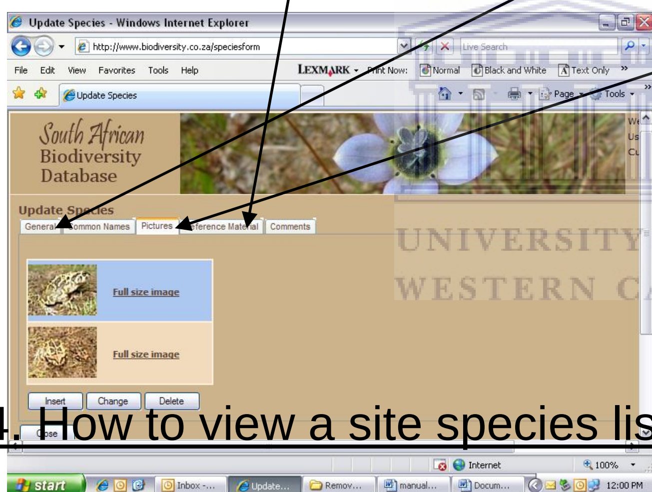
One can search for a species using the scientific name or the common name



→Type the name of the species in and click search

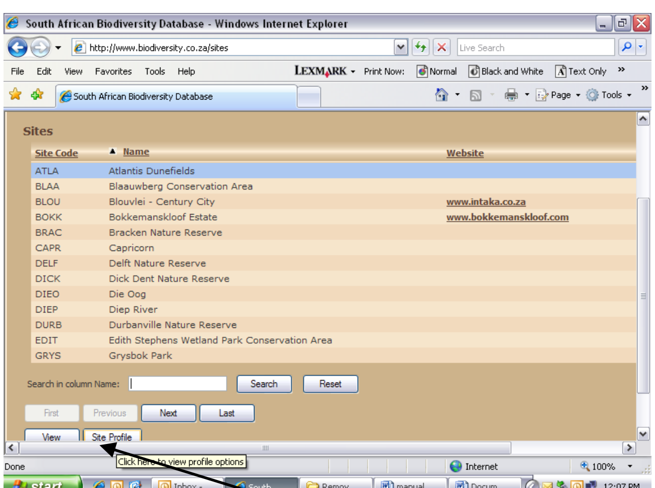
→ Highlight the species and click View

→Once inside the species page one can view information about the species, pictures of the species and reference material by clicking on the appropriate item

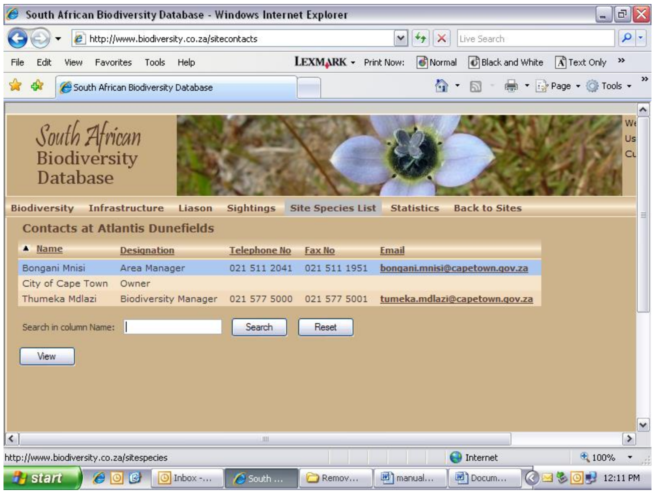


4. How to view a site species list:

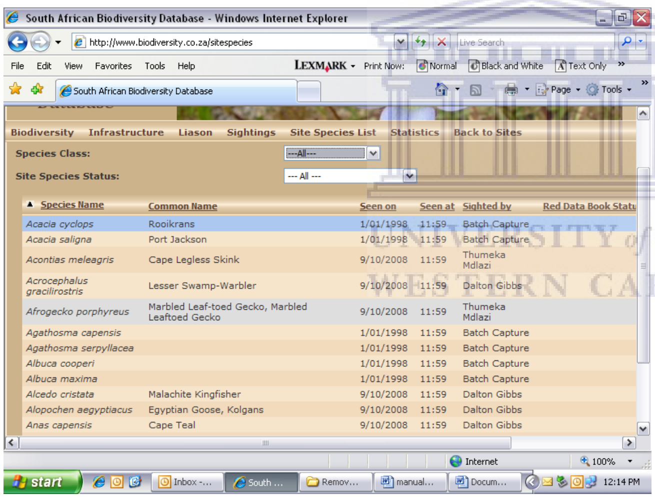
→ Select Sites and Profiles



→ Highlight the site and click Site Profile

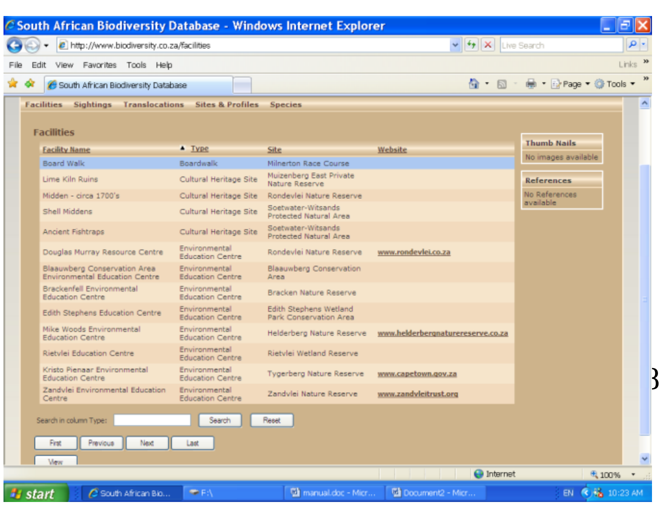


→Click Site Species List



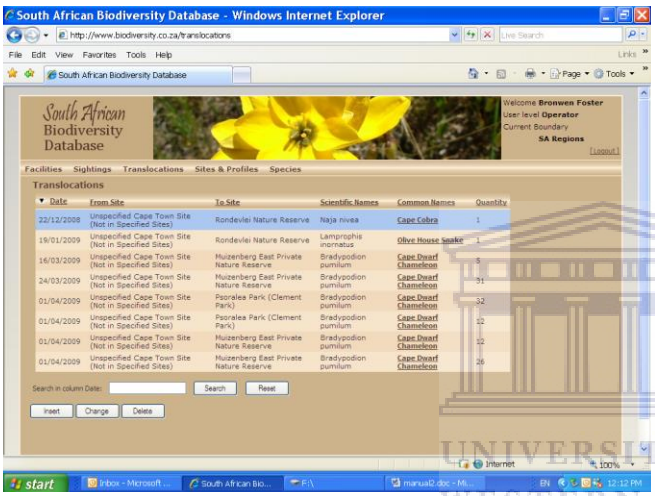
→ View species for the sites

5. How to view facilities:



→ Select Facilities
→ Highlight the facility and click view

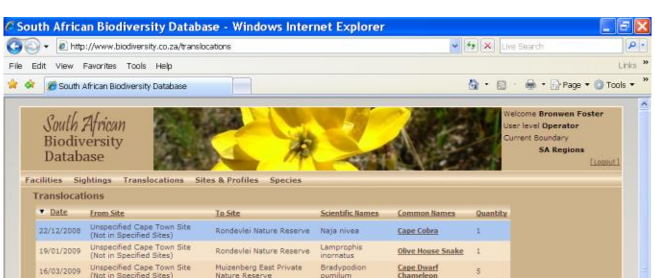
6. How to view translocations:



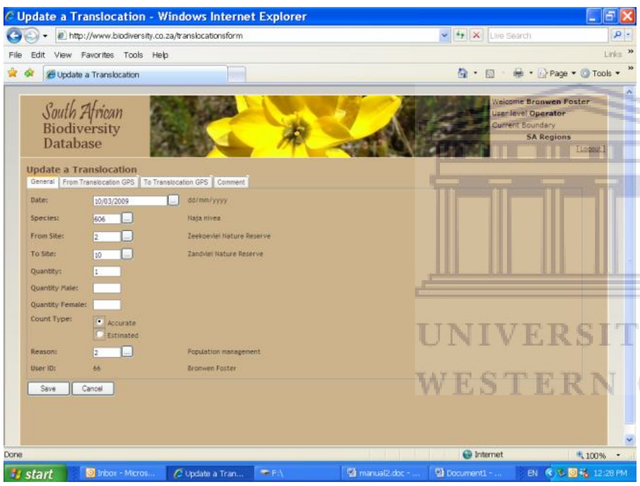
→ Select Translocations
→ Highlight the translocation and click view

7. How to add translocations:

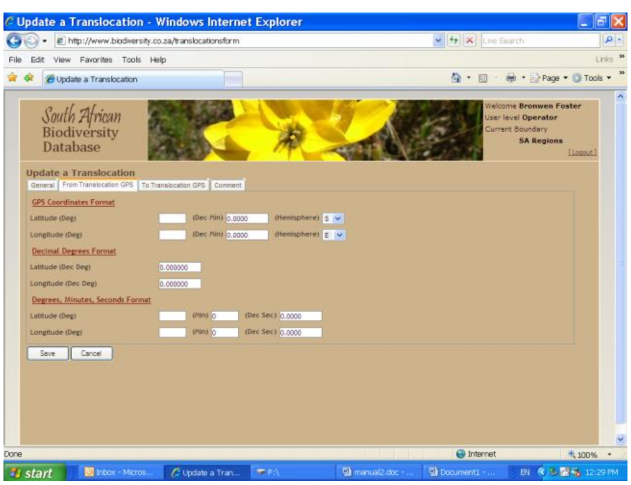
→ Select Translocations



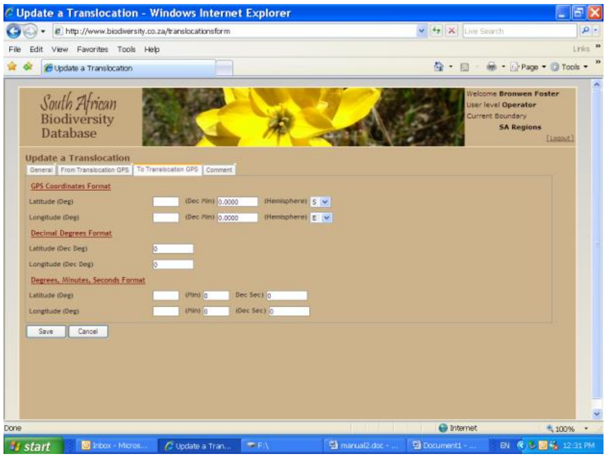
→ Click Insert
→ Type in the required information



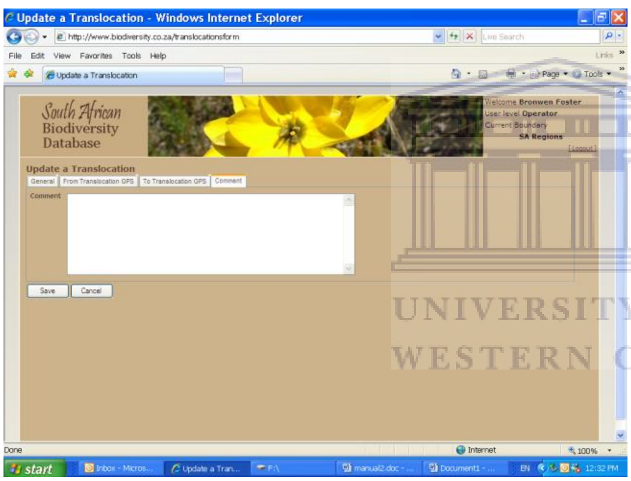
→ Type in the GPS location from where the individual is being moved



→ Type in the GPS location from where the individual is released



→ Type in a comment and click save



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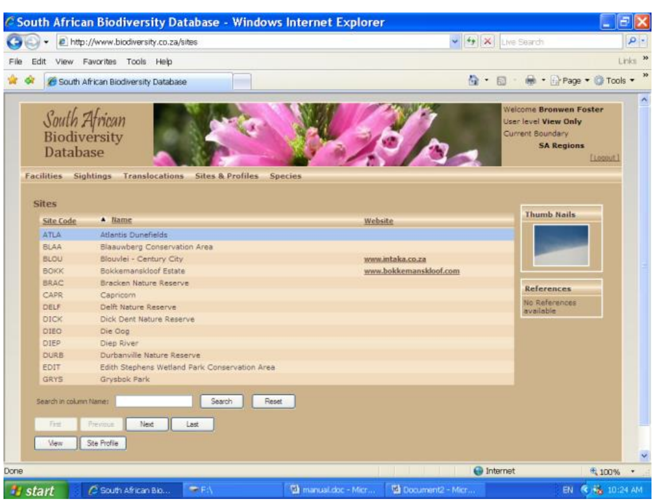

→ Select Sites and Profiles
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