DATABASE FOR PUBLISHING ECOLOGICAL DATA

GRADUATE PROJECT

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by

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ABSTRACT

The field of Ecological research produces rich, interdisciplinary datasets. Data collected in the research are stored either as flat files or relational databases. These data files or databases are used for analyzing the structure and function of ecosystems. Comparing trends among environments and over time is a critical analysis requiring data sets from multiple investigators. Yet, there are very few tools that allow the data to be published on Web and make it available to other researchers. One reason behind not publishing is because of the complexity of Ecological data. This project defines a tool for publishing the Ecological data to make it available on the Web. Data can be viewed in user required format which can be either in a PDF, Excel sheet or a Web Browser. This tool also allows the users to download the data.

This project also makes it easy to publish the data collected by researchers by simply uploading the Excel sheet or the CSV files. Upload functionality is provided with this tool. This report also describes the design and working of the tool. This report also shows the testing of this tool in various environments and evaluation is done based on the comments given by the users. These comments are taken into consideration for further enhancement.
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1. BACKGROUND AND RATIONALE

The sources of ecological data are mainly fresh water, air, forest, grasslands, marine ecosystems. The sources of biological data are mainly the life sciences data. Depending on the data collected, it can be stored in various formats. It varies from structured data to unstructured data. Data stored in relational databases are structured data and data stored as a textual file is unstructured data. Biological data are often complete and easy to handle in the databases but face many difficulties while querying, Elena Baralis et al 2005 [5].

1.1 Background

Ecological data are complex and have missing values. The format of the ecological data changes among various scientists. Data collected are stored in files or databases and are used for analyzing the structure and function of ecosystem. Due to its complexity, most of the data collected by researchers is not available to others. Hence the data collected will just be stored in proprietary and incomplete ways, and can be used only by the originators who can access the database or the files. This is a major problem with many scientists whose research is accessible to only a specific group of users with an access to the database and understanding of the data structures. Thus, few ecological databases have been built, which makes its data available on the Web.

EMBL, DDBJ, and EBI are three biological databases that are well developed. These data sources allow their data to be shared by other scientists or users through their Web Site. EMBL (European Molecular Biology Laboratory) [6] data source, established in 1980, contains the Nucleotide Sequence Data Library and was the world’s first biological database. EMBL allows the data to be searched by a keyword and the results related to the keyword
appear on the Web Browser. DDBJ (DNA Data Bank of Japan) [1] is a biological database with the DNA samples. It began its work in early 1986 and it is the only nucleotide database in Asia. EBI (European Bioinformatics Institute) is a part of EMBL that contains various biotic and abiotic data, which makes its data available to promote its scientific progress. These three data sources exchange its data on a daily basis. Hence the data from these three sources are the same at any point of time.

The Ecological Society of America (ESA) [4] is nonprofit organization of scientists founded in 1915 used to promote ecological data and improve communication among the ecologists. The National Oceanographic Data Center (NODC) [12] is an environmental data center operated by National Oceanic and Atmospheric Administration (NOAA). It is established in 1962 to store the data permanently and accessible to others. The DataONE (Data Observation Network of Earth) [2] is a foundation for new environmental science data through a distributed framework that meets the needs of science. There are few other ecological database and water database that allow its data to be used by others. They include Deepwater Horizon Support database [3], University of Texas Center in Water Resources (CRWR) [15], water data services and the USGS (U.S. Geoglocial Survey) National Water Information Systems (NWIS) [16].

Functionality provided by these data sources is different from each other. The way the data source allow the user to search the database also differs. The common functionalities provided by these three data sources are:

1. Search
2. Download
The results are displayed in the Web Browser and database can be downloaded easily through the Web Site. The problem with these databases is the availability of the data to the users. Data returned from the database are displayed in a Web Browser but are not available for download. Download functionality for these data sources allow the user to download the whole database but not the specific data that the user is looking for. This will result in wasting of time and space. These data sources also provide a functionality that allows the user to upload his data. Basic steps involved are:

1. Select a Tool to upload the data
2. Make it available for the world
3. Search for the data
4. Download the data

1.2 Ecological Data

The data used in this project is ecological data, which contains the measurement of ecological components in Texas Bays. The data is an outcome of many different studies performed by students and staff working in Ecosystem Studies Laboratory led by Dr. Paul Montagna. Data mainly cover Corpus Christi Bay, Lavaca Bay, Nueces Bay, Laguna Madre Bay, Matagorda Bay, East Matagorda Bay, Rio Grande, Brazos River, Cedar Lakes, South Bay, Mission Aransas Bay, and San Antonio Bay. Each Bay has its own components. Measurements carried out in these bays generate data that is used for further research on estuarine ecology in general and environmental flows specifically.

The method used to perform these tests is to first identify the physical characteristics of the bay, Montagna and Kalke, 1995 [9]. Later the salinity and dissolved oxygen is tested if it
directly or indirectly affects the biology. Measurements are made on various components, which include chlorophyll-a, biomass, nutrients etc.

1.2.1 Biomass

This particular component contains the following data.

<table>
<thead>
<tr>
<th>DATE</th>
<th>STA</th>
<th>REP</th>
<th>SEC</th>
<th>TAXA</th>
<th>N</th>
<th>MG</th>
<th>GM2</th>
<th>NM2</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/19/1987</td>
<td>C</td>
<td>1</td>
<td>3</td>
<td>P</td>
<td>14</td>
<td>0.11</td>
<td>0.0312</td>
<td>3970.96</td>
</tr>
<tr>
<td>10/19/1987</td>
<td>C</td>
<td>1</td>
<td>10</td>
<td>N</td>
<td>1</td>
<td>0.24</td>
<td>0.068074</td>
<td>283.64</td>
</tr>
<tr>
<td>10/19/1987</td>
<td>C</td>
<td>1</td>
<td>10</td>
<td>M</td>
<td>1</td>
<td>13.38</td>
<td>3.795103</td>
<td>283.64</td>
</tr>
</tbody>
</table>

Table 1.1 Example of biomass data of Corpus Christi Bay

Date is the day on which the sample was collected. ‘STA’ refers to the station where the experiment was conducted. REP is the replicate of the sample which shows whether a repeated test is conducted or not. TAXA refer to the taxa code of the sample. Codes are defined in the metadata. N and NM2 are the abundance of the sample present in water. MG and GM2 are measures of biomass.

1.2.2 Chlorophyll-a

Table 1.2 shows a sample of the Chlorophyll-a component. Depth of the water where the test is conducted is shown in meters. Sample Bottle is the sample which is tested and the measure of chlorophyll is measured in mg/L. The data also shows the Technician, Machine used and the analysis time and data.

<table>
<thead>
<tr>
<th>Date</th>
<th>Station</th>
<th>Depth(m)</th>
<th>CHL(mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/19/1987</td>
<td>C</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10/19/1987</td>
<td>C</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>10/20/1987</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.2 Chlorophyll data
1.2.3 Mollusca

These are a large number of invertebrate animals. Tests on these are done to know the amount of Mollusc’s present in a particular bay. This also shows the length of each Mollusc shell. Table 1.3 shows the sample data of Mollusc’s.

<table>
<thead>
<tr>
<th>Date</th>
<th>Station</th>
<th>Replicate</th>
<th>Section</th>
<th>SPcode</th>
<th>Len(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/9/2002</td>
<td>A</td>
<td>1</td>
<td>3</td>
<td>162</td>
<td>1.66667</td>
</tr>
<tr>
<td>7/9/2002</td>
<td>A</td>
<td>1</td>
<td>3</td>
<td>180</td>
<td>2.41667</td>
</tr>
<tr>
<td>7/9/2002</td>
<td>A</td>
<td>1</td>
<td>3</td>
<td>510</td>
<td>1.75</td>
</tr>
<tr>
<td>7/9/2002</td>
<td>A</td>
<td>1</td>
<td>3</td>
<td>159</td>
<td>1.08333</td>
</tr>
</tbody>
</table>

Table 1.3 Mollusc data of a Bay

1.2.4 Pore Water

Porosity is the amount of water present in sediment. It is measured in two states, dry and wet sediments. The data gives the proportion (PROPORTION) of water weight in wet sediment, dry sediment, and difference between them and the total proportion of Pore in sediment. Table 1.4 shows a sample data of Pore Water data.

<table>
<thead>
<tr>
<th>DATE</th>
<th>STA</th>
<th>REP</th>
<th>SEC</th>
<th>PROPORTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/2/1994</td>
<td>A</td>
<td>1</td>
<td>1</td>
<td>0.613779</td>
</tr>
<tr>
<td>11/2/1994</td>
<td>A</td>
<td>1</td>
<td>3</td>
<td>0.522316</td>
</tr>
<tr>
<td>11/2/1994</td>
<td>A</td>
<td>1</td>
<td>6</td>
<td>0.575488</td>
</tr>
<tr>
<td>11/2/1994</td>
<td>A</td>
<td>1</td>
<td>11</td>
<td>0.587887</td>
</tr>
</tbody>
</table>

Table 1.4 Sample of Pore data

1.2.5 TOC

TOC is the measure of total organic carbon in sediments. This data set also includes other sediment characteristics such as the carbon and nitrogen isotope values and percentage of carbon and nitrogen content of sediments. Table 1.5 shows the sample data of TOC.
<table>
<thead>
<tr>
<th>DATE</th>
<th>STA</th>
<th>REP</th>
<th>SEC</th>
<th>del N ppt</th>
<th>N content %</th>
<th>del C ppt</th>
<th>C content %</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/5/2000</td>
<td>C</td>
<td>1</td>
<td>1</td>
<td>6.7</td>
<td>0.07</td>
<td>-17.61</td>
<td>0.67</td>
</tr>
<tr>
<td>10/5/2000</td>
<td>C</td>
<td>1</td>
<td>3</td>
<td>7.05</td>
<td>0.11</td>
<td>-19.41</td>
<td>0.95</td>
</tr>
<tr>
<td>10/5/2000</td>
<td>C</td>
<td>2</td>
<td>3</td>
<td>7.05</td>
<td>0.11</td>
<td>-19.41</td>
<td>0.95</td>
</tr>
<tr>
<td>10/5/2000</td>
<td>A</td>
<td>1</td>
<td>1</td>
<td>8.19</td>
<td>0.05</td>
<td>-19.48</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Table 1.5 Sample TOC Data

1.3 Rationale

The tool in this project is similar to these online data sources, but is mostly used by an organization (Harte Research Institute, Texas A&M Corpus Christi). This tool helps the organization to store its data in the database, retrieve the data from database and download the data. Unlike the three data sources discussed earlier, this tool allows the user to search and retrieve the data which are displayed in user specified format. It can be a PDF, an Excel sheet or a Web Browser. The results viewed in a PDF or an Excel sheet can be downloaded to the user’s disk and can be used by for their purpose. By this only the required data can be downloaded but not the whole database as the three other online data sources do.

1.3.1. Objective

The objectives of this project are:

- Generate report in a user defined format
- Make the data available for download
- Search the data based on the year
- Upload functionality where the user can upload the files directly to the database
Due to the increase and advancement of data storage, data is stored in large databases. This will increase the complexity of the publishing the Ecological data. PathCase tool developed by Krishnamurthy L, et al., 2003 [8] is a tool that deals with large databases and uses an integrated approach to analyze the data sets. It has a good database design and graphical tools for analyzing but does not support download and upload of data. Tool in this project also provides the upload functionality by which the users can upload Excel files or CSV files to the database, which is reflected in the next search.

The remainder of this report discusses the Narrative of this project in section 2. The System design and Approach in section 3 deals with the analysis, implementation and working of the project. This section also deals with the requirements, database tables and other technical details. Section 4 is the Evaluation and Results, where the project is tested under various environments and evaluation of this project is shown in this section. Future work in section 5 discusses if any additional features are to be added and if it can be continued. Finally the project is concluded briefly in section 6.
2. PUBLISHING ECOLOGICAL DATA

Publishing the Ecological data and making it available to the users is the main aim of this project. There are few previous works done for publishing data but as mentioned in section 1.1, it does not allow the users to download the specific data. In this section, the description of the tool is given by which the users can easily work with the tool.

2.1 Use of Ecological Data

The data collected during these tests are used for further research. The Ecological data is mainly used for

- Role of freshwater inflows in bays, rivers, and lagoons- Freshwater inflow have major impact on salinities. Reduction in freshwater inflow increases salinity, William M Longley 1994 [17], allows intrusion of predators, intrusion into groundwater, decrease in nutrient and organic inputs, and increase in erosion.

- Determine oyster populations in flood and drought conditions, Pollack JB et al., 2011 [7]. Oysters were sampled to test the impact of change in environment on its population. This response to environmental change in a short term is helpful for long term effects of changing climate.

- Analyze relationship between molluscs and salinity, P A Montagna et al., 2008 [13].

- Effect of FWI (Freshwater Inflow) on ecosystem metabolism. “Ecosystems depend on FWI to maintain the gradients in environmental characteristics”, Russell MJ et al., 2006 [11].
• Examine the relation between freshwater inflow and the distribution, abundance, physiology and production of fish and shellfish. The study showed that the production of shellfish is higher at low salinity, which is due to the increase in freshwater inflow.

• Effects of hypoxia in a Bay, Froeschke J et al, 2009 [10]. The benthic community is degraded in hypoxia zone in a long term. This mainly occurred at the surface rather in the deep.

• Identify the biomass structure and carbon flow in the deep, Rowe Gilbert T, 2008 [14].

2.2 Related Work

2.2.1 NODC

The NODC is one of the environmental data centers operated by NOAA. The main NODC source is from Silver Spring, Maryland and is one of five divisions. It has offices in other parts of the country including Austin, TX; Miami, FL; Seattle, WA etc. NOAA also operates National Climatic Data Center and National Geophysical Data Center. These sources provide data of Earth’s changing environment and support research and operational applications. NOAA and NCCDC are integrated to provide to allow access to the worlds environmental data and information. This data source allows users to upload their data and can be shared with other users. NODC updates data from the local and foreign activists which can be used to monitor global environmental changes. NODC manages the world’s largest collection of oceanographic data. These data are collected by a variety of operations and research by U.S federal agencies including Navy.
NODC allows users to submit data to its database. This should be done by submitting the data and the metadata. The metadata should be mailed to NODC, by submitting it by SIF (Submission Information Form), or in EDDF (Electronic Data Description Format) format. The submitted data is now sent to NODC via ftp or email which is further prepared for archive and these are converted into protected digital archive such that they can be accessible by others. This data source also allows the users to find their submitted data by following a sequence of steps.

2.2.2 USGS

The U.S Geographical Survey NWIS is a distributed application that supports storage and processing of long term water data. This data is made available to the world through WWW. This data source provides water data access to 1.2 million sites from 50 states and few neighboring states. The data available in this data source are a part of data investigated on occurrence, quality and movement of surface and underground water. This data source also allows users and projects to submit their data and share them with other researchers. USGS allows users to search for data in six simple steps, which when followed correctly displays the desired output.

2.2.3 Advantages

The two databases NODC and USGS are used by people from various countries. They have a common functionality for uploading the data and accessing the data. The advantages of NODC and USGS are:
• Provides access to the database on Web by which the data can be used by other researchers
• Allow the researchers to share their data with other researchers
• Large projects data is available to the users
• Download the whole database if required
• Uploading individuals data via email or a tool

2.2.4 Problems

As these two databases have common functionalities and advantages, there are few situations where it becomes a problem for the users and the database managers. They are:

• As the data can be uploaded by any user of the database, it becomes a scope for unnecessary data. User can upload junk or false data to the database. This will result wasting time of the database managers to check the data.
• The required data accessed can be viewed in the Web Browser but cannot be downloaded
• Downloading the whole database to the users disk and searching for the required data will waste the time and space of the users
3. DESIGN AND IMPLEMENTATION

This project’s design and implementation is discussed in this section. The basic steps involved in building this tool are:

- Build Database from the Excel files
- Select a tool for importing data
- Create forms for user interface
- Establishing a database connection
- Querying the database according to the user’s requirements

3.1 Requirements

This tool require some basic requirements which include

- A standard Web Browser with java script enabled
- 128 MB RAM
- Acrobat Reader
- MS-Excel

Technologies and Software used to build this project are:

- Technologies- Strut 1.29, J2EE (JDBC and JSP), POI Library for reading and publishing excel files, Itext jar files for publishing in a PDF document.
- Software- Apache Tomcat 6.0.26, NetBeans IDE 6.9, MySql Work Bench 5.6, Java, Navcat Premium tool for importing the Excel files to the database.
3.2 Java Class Description

The database is configured in “DBconnection.java”. This java file connects the front end and with the database. The parameters used to connect are:

- Database name
- User name
- Password
- Port number

DBconnection() constructor is used to connect to the database which loads the connection drive into memory and establish connection.

3.2.1 Database Schema

Figure 1: BayData Schema
The database schema in Figure 1 shows the relationship between the data and the metadata. The schema in Figure 1 gives relationship with only three tables in the database which has a metadata in it. Similar relationship is followed for the remaining tables which has metadata in it. The metadata is merged with its actual data.

### 3.2.2 Flow between Bay Data and its Class

![Flow diagram](image)

**Figure 2: Flow between ‘BayData’ and its class**

The input parameters are given in the ‘Baydata’ page where the user can select the bay name and the bay components, these parameters are passed to the ‘Baylist’ class which talk with the database and give the results back in ‘BayResult’ page.

### 3.2.3 Flow between Search and its Class

The list box values in Search form are loaded through the ‘SearchForm Bay’ class. The user can give search parameters in the Search page, which are passed to the ‘Baylist’ action class, which connects to the database, search the database and the results are displayed back to the ‘BayResult’ page. Figure 3 shows the flow of the event.
### 3.2.4 File Uploading

This page allows authenticated users to upload files directly to the database. The user has to login with an authorized username and password. The username and the password are stored in the database. Failure to login redirects to the same page, successful login takes to the upload page where the user can upload Excel files directly to the database. Few constraints must be followed while uploading.

- A valid username and password
- The file must be an Excel file with an extension “.xls” or “.xlsx”
- The name of the file should be same as the previous Excel files.
- Column name must remain the same
- Number of columns should not be less than the previous files.
3.2.5 Flow of Feedback

Feedback page is used to provide feedback about the project from the users. The feedback given in Feedback page is passed to the Feedback action class. The parameters are processed here and the content which has to be sent through email are passed to the Sendmail action class.
action class. A SendMail( ) method used here stores the parameters from the Feedback action
class. Also, the SMPT server and email to which the feedback has to send are passed here.
These parameters are send to the postmail() method where the host’s SMPT address is set,
which are passed to the Authentication method where a simple authentication is done when
the SMPT server requires it.

3.3 User Interface

3.3.1 Home Page

Figure 6 shows the home page of this project which has a menu that navigates to the
other pages of the project. A login link is present on the home page where the user can login
to upload the files to the database.

Figure 6: Home Page

3.3.2 Bay Data Page

This page allows the user to search the bay data. It has three drop down menus, Bay,
Components and Report Type. Bay menu contain Bay names, Components menu has the
particular bay components and the Report Type contain the type of report the user want the results to be displayed on. The user can select Bay name, the component required and the format of the results. Figure 7 shows the search by Bay page and Figure 8, Figure 9, Figure 10 shows the display of results in a Web Browser, in a PDF and in an Excel sheet respectively.
Figure 8: Results displayed in Web Browser

Figure 9: Output in a PDF
The users are provided with functionality where the data can be searched by date. This page has four fields, the first two fields are related to date, third field is the Bay field and the fourth field is the Components. Two buttons, reset and submit are used to submit the query or to reset the entries in the field. User can specify the period in which the data is collected in the first two fields, select the Bay name and Components in the next two fields. This will display the results of a particular bay component in the specified period of days. Figure 11 and figure 12 show the entry to the fields and results to those entries respectively.
Figure 11: Specific Period Entry

Figure 12: Results for the specified period
3.3.4 Feedback Page

This project is used by novice users and also experts. This page allows the users to give feedback of this project. Figure 13 shows the feedback page where the user has to give Name, Email ID, subject and comments. These comments are sent to the administrator and a copy to the user. These comments are considered for further enhancement.

![Ecological Database Management System](image)

**Figure 13: Feedback Page**

3.3.5 Login Page

Figure 14 shows the login page, where an authorized user can login and upload the data to the database. Figure 15 shows the upload page where the user can browse the file from disk and upload it. As the data is uploaded, a successful upload message is shown. Few file constraints must be followed while uploading.
Figure 14: Login Page

Figure 15: Upload Page
This page is visible only to the authorized users of this tool. This page can also navigate the users other pages of this project by the menu at the left. Metadata menu item open a PDF document which contains the units used to measure the components, how the components are measured and the Bay code with the Bay names.

3.4 Advantages

The tool built in this project has its own advantages when compared to other tools previously built. The advantages over other tools are:

- Easy access to the data
- Can be used even by novice users
- Feedback helps the user to comment the project which can improve its functionality
- Get only the required data in user defined format
- Easy to download data
- Saves time to search for required data in the database
- Saves space as only the required data is downloaded
4. EVALUATION AND RESULTS

This project is tested and evaluation under various operating system environments and different Web Browsers. This tool is used by many novice users and experts. The user operability of this tool is made such a way that it can be used by any kind of users in different environments.

4.1 Testing

This tool is designed in such a way that it works in different Web Browsers and in different operating system environments. This is tested under standard Web Browsers and by users ranging from novice computer users to experts.

4.1.1 Testing in Internet Explorer

This tool works in every standard Web Browser. Figure 16 shows the working in Internet Explorer.
Figure 16: Bay Data in Internet Explorer

Figure 17 shows the results of the Figure 16 fields. The same Bay and components are tested in different Web Browsers.

Figure 17: Results of BR and Molluse in IE
4.1.2 Testing in Google Chrome

The data searched here is same as the data searched for testing Internet Explorer. Figures 18 and 19 show the results in Google Chrome.

Figure 18: Testing in Google Chrome
4.1.3 Testing in Mozilla Firefox

This is one of the most widely used Web Browser these days. The same data is tested as in Internet Explorer and Google Chrome.
Figure 20: Testing in Mozilla Firefox

Figure 21: Results in Mozilla Firefox
4.2 Evaluation

This project is evaluated by the users of this tool. Users working on the bay data and users who require bay data for their research are provided with a feedback option where they can give their feedback on this project. These comments are send to the administrator and a copy to the user. These are considered for further improvement of the project. This project is evaluated by the bay data users and their comments are:

“This database management strategy seems efficient in performing different types of analysis – Bhanu Paudel (July 18, 2011)”

“This Application is good, have good features for searching the data both by Bay and component, and also by date. The upload option provided also adds to this project. Searching the Bay data by Station can be included, so that users can search the data by station – Akshara Uppaluri (July 18, 2011)”

“add units. looks good – Terry Palmer (July 18, 2011)”

“Sai, the application seems to work. I think the label for Bay should be "Bay/Project". And you might want to have a legend where someone who doesn't know what NC means can find out.- Kevin Nelson (July 19, 2011)”

A comment to add units is considered and a Metadata page is added to the menu item which has the units of the components and also the bay names. Also, the name of the first
The drop down menu in the Bay Data page is changed from Bay to Bay/Project. The outcome of evaluation adding a PDF and changing the name of the drop down menu is shown in Figure 22 and Figure 23 respectively.

![Units](image)

**Figure 22: Units**
Figure 23: Changed Bay to Bay/Project
5. FUTURE WORK

Publishing ecological data and surveying various ecological components is the main goal of this project. Based on the comments in the evaluation section 4, this project can be further worked on the search option provided, by which the users should be able to search every components. Now, the data components can be searched by date where the user can search from specific date another. Future work will provide search option where the users will be able search by station, component and bay which will give that specific station’s data. This can be further extended to the Texas Parks and Wildlife Department (TPWD) data.
6. CONCLUSION

The tool developed in this project allows the users of the Ecological data access the data. Data published can be used for further research and the user will be able to survey the ecological components. This project accomplishes the following:

1. Creating a tool for data management
2. Publish ecological data
3. Survey ecological components

These three functions of this project are done by few other tools mentioned in Section 1. But the problems with those tools are

1. The required data can only be viewed in a Web Browser but cannot be downloaded
2. The whole database can be downloaded which is a waste of time and space

These problems are resolved by this tool which allows only the required data to be downloaded. The data searched is displayed in a PDF, an Excel sheet or in a Web Browser, where the PDF or the Excel sheet can be saved to the disk.
BIBLIOGRAPHY AND REFERENCES


