Vol.6 Issue No. 3 December 2005
Print ISSN 2244-4432 • E-ISSN 2984-7125

National Peer Reviewed Journal
DOI: https://doi.org/10.59120/drj.v6i3.572

Basic Statistical Ecology Software

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Abstract

Information technology plays a vital part in various studies in the field of ecology. It opens the way for more concise and more accurate results for ecological research and reduces effort, especially in the manipulation of data. In Davao Oriental State College of Science and Technology, ecologists seek assistance from statisticians for their studies. However, some of these statisticians manually compute their data, which often leads to a waste of time, effort, and resources. This software is designed to be user-friendly. It was developed in a Visual Basic environment, which provides a fast and easy way to calculate basic statistical operations. It has a Graphical User Interface which allows users to just click the desired commands instead of typing command lines. The software first requires the user to define the name of the species, station name, and quadrats used in their study. Then a table is filled with raw data gathered from his study. The list of ecological raw data will then be the basis for calculations. The software automatically calculates basic statistical operations that include summary statistics, spatial pattern indices, diversity indices, and correlation. The development of this software follows the prototyping method that involves the use of interactive prototypes that can be replaced or altered after receiving feedback from evaluations of the clients.

Keywords: Ecological, Graphical user interface, Information technology, Quadrats, Statistician

Introduction

People are always in search of innovation and new advancements that would improve their quality of living and perhaps eliminate flaws that often lead to to waste of time, effort, and resources. The birth of Information Technology has opened the gate towards change and improvements. It is continuously searching for more ideas and discoveries that would cater to the needs of people from all walks of life. Even sciences have also benefited from the usefulness of Information Technology, particularly in research. As society transforms and is transformed by new technology, there are new ways in which researchers collect, analyze, and manipulate their data. There is now a range of software intended for researchers. In response to demand, developers are still adding new features and functions that researchers need to understand. The diversity of software means that there is a need for standards for storing data and analysis. At the same time, new evidence of analytic developments is made possible by the use of new technology.

In this field, science strives for the discovery of significant scientific truth. It is Statistics that takes care of the uncertainty of the scientific method, consisting of design, analysis, interpretation, and even the assessment of significance. The society in which we live in has chosen to fully use Statistics as a decisive instrument to deal with ecological problems and issues While it is exciting that we are living in the age of information, yet, unfortunately, we find ourselves having crisis of our environment, thus it is only bliss to have the opportunity to more effectively and efficiently capture, query, and present data and to provide for security [FREE1999].

Researchers in the field of ecology gather data through the use of sampling procedures on how living and non-living things interact and how major factors affect their existence. With this, the application of statistics plays a vital role. It is needed in storing, generating, computing, and presenting data that are accurate and relevant for their studies. As of now, there is an existing statistical ecology software designed in DOS-Based application. It was made using the QBASIC programming language. Most of the users find this application difficult because it is only applicable for those who have sufficient knowledge of QBASIC. In addition, the application is also prone to mistakes due to the errors that may be made in the code of the program every time a user runs it.

The development of basic statistical ecology software is a gateway to having solutions to the problems of ecologists in terms of their statistical computations being used in the summary, organization, and presentation of data for their studies. In Davao Oriental State College of Science and Technology, ecologists seek assistance from statisticians for their studies. However, some of these statisticians manually manipulate the data with the aid of some applications, such as Microsoft Excel. But most of them find it inefficient, time-consuming, and have a greater possibility of producing inaccurate results since the application requires the user to define the formula every time new data is entered. The general objective of this project was to develop basic statistical ecology software that can be used for environmental and ecological research. Specifically, the project aimed to create a Windows-based, user-friendly application that allows users to input ecological data and store it in a text or flat file for later retrieval or editing. The software will be capable of computing summary statistics, spatial pattern indices, diversity indices, and correlations. It will also provide options for printing outputs in tabular form, as well as printing any data or results required by the user. Additionally, the project sought to produce a detailed and informative user manual to guide users in effectively utilizing the software. Ecological researchers seeking for more accurate and efficient way of computing their data are the targets end users of this study. Most of them are professional researchers, Biology and Environmental Science students of the college. With this software, these researchers need only the basic computer skills to be able to use the software, thereby cutting the cost of hiring statisticians and creating a smoother research flow. Although this project specifically aims to help researchers of this college, researchers outside the college may also benefit from it. This can also serve as a basis for future studies in Information Technology with respect to statistical ecology applications. This study focuses only on the development of basic statistical ecology software that would cater to the needs of ecologists in generating accurate results and eliminating manual transactions. The software covers only the computation of summary statistics, spatial pattern indices, diversity indices, and correlation.

Methodology of the study

The development of the basic statistical ecology software follows the prototyping method. The prototyping method involves the use of interactive prototypes that can be replaced or altered after receiving design feedback. A prototype is a working model that is functionally equivalent to a subset of the product [SCHA1999]. Prototyping allows the user to view a working model and provides feedback that will help create a more suitable design for the user base.

Requirements gathering and refinement

During the first two months of the project duration, the group had undergone several sessions. Members had planned and agreed to create a Gantt chart that contains a set of scheduled activities that serves as a guide for the creation of the software. The group then started the first phase of the software engineering process, the analysis phase. Particular things were discussed, such as the requirements needed for the design. Requirements needed in the creation of the software were gathered through a series of interviews and discussions with the target users, project adviser, and an Information Technology expert. To further analyze the whole project with its corresponding problems and possible solutions, the group had constructed different diagrams that serve as basis for designing and building the prototype These diagrams consist of the use case, data flow diagram, and sequence diagram. Particular programming tools to be used were also recognized by the members.

Quick design

This involves the second phase of the software engineering process, the design phase. Before this, the group had reviewed the gathered requirements to better understand their contents and importance in the software development. Class diagram, menu structure, and data description were constructed, and they serve as a guide in designing the software. Things that were discussed in this phase are the design and style of the prototype and the possible output of the project.

Building a prototype

This is the implementation phase of the software engineering process. In here, the construction of the software had started using suitable programming tools (flat file as the data storage and Microsoft Visual Basic 6.0 as the Integrated Development Environment). Discussions within the group are seriously conducted now and then, as they are much needed. Simple results were generated using simple codes. From time to time, further improvements were made to create a partial software subject for evaluation.

Data gathering procedures and output

Prior to and during the development stages of the Basic Statistical Ecology Software, the group has undergone a lot of data gathering techniques. For preliminary action, the group conducted a series of interviews and discussions with the group’s adviser, who is also considered the client of the project. Along with the discussions, the group gathered ideas and opinions regarding the desired outcome of the project and the statistical formulas (see Table 7-6) needed for its implementation. The project would not be prospective without the requirement analysis and system specification. The group sought the assistance of an IT expert concerning the software and the analysis and programming tools to be used. This was also done through several discussions and further interviews.

As the project progresses, the group collected sample reports of ecological data from the students taking up the Bachelor of Science in Environmental Science and the Bachelor of Science in Biology. They were considered as target users of the software, and their reports were used as a basis for the project development. Gradually, the simple software was developed. It had undergone several tests and evaluations from the client and target users. The group provided questionnaires for the user to have their comments and suggestions about the project. The group gathered several research articles from the Internet that helped them with the programming and with the background of their project. Statistical books were also collected as the basis of accurate statistical formulas. With these data gathering procedures, the group came up with enough knowledge on the project to be done, and the requirements needed were also completely gathered.

Documentation of the current system

In Davao Oriental State College of Science and Technology, statisticians do not just manually perform computations using calculators, papers, and a pen, but they also use present software applications such as Microsoft Excel and Statistical Package for the Social Sciences or SPSS.

Hardware setup

A single computer unit is enough to calculate ecologists' data using the said applications.

Software and applications being used

Microsoft Excel is a product manufactured by Microsoft. It has many versions, the MS Excel 95/98/2000/2003, and runs on all Windows operating systems. Using this application for statistical computation is not very easy. No instant statistical formulas are given. Every time the user computes any data, formula is repeatedly set on the formula bar Of course, a mistake in the formula generates wrong answers Yet, if these formulas were appropriately given, accurate results will be produced In Excel, it is very easy for the user to retrieve and print data SPSS on the other hand is a product of SPSS, Inc in Chicago. It is more applicable to small social science datasets. It does not merely focus on certain fields such as Environmental and Biology, but also provides many features such as charts, graphics, lists, general statistical analysis, and accurate results of statistical computations.

SPSS suffers from certain problems since it does not have strong data management tools. It only edits one data file at a time; it cannot support multiple tasks. The number of records is limited by the disk space.

Requirements analysis specification

After the data obtained from the preliminary interviews were gathered, the analysis stage started. The group had undergone a series of meetings and discussions to better understand the gathered data and how these are applied in the creation of the software.

In order to analyze the concept of the software, the group had created different diagrams, namely, use case, data flow diagram, and sequence. A use case diagram was utilized by the group to discover the requirements of the software and the possible actions that a user

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DOI: https://doi.org/10.59120/drj.v6i3.572

takes in their interaction with the software. The contents of the use case serve as the basis for creating the sequence diagram. With a sequence diagram, the actions of the user while interacting with the software were sequentially defined. The group then created a class diagram in order to picture out the elements that are involved in the software and its relationships to other elements.

Based on the diagrams made, the group had come up with a picture of the software to be developed. The group had delved into deeper analysis and decided on the specific programming tools to be used. Because it was stated in the objectives to develop Windows-based and user-friendly software, the group had agreed to develop the software using an application that would run on Windows. The members of the group had decided to use Microsoft Visual Basics 60 as its Integrated Development Environment because the group finds it easier to program and there are many resources about this application. Tables can easily be manipulated in Microsoft Visual Basic for computations of each row and column. The group can easily program calculations in Visual Basic rather than in other programming languages. In Visual Basic, some methods and functions already exist, and the programmer can use them anytime he wants. An easy way of printing data is also provided by Visual Basic. For data storage, the group had chosen a simple storage or a flat file. Ecological data and computed results fall into this category since they do not require a higher capacity of storage.

With the use of diagrams, the group had come up with a clear analysis regarding the concept of the software. This includes the flow of data and activities that occur With the use of Visual Basic and a flat file, a software was then developed that would cater the needs of the users.

Basic statistical ecology software

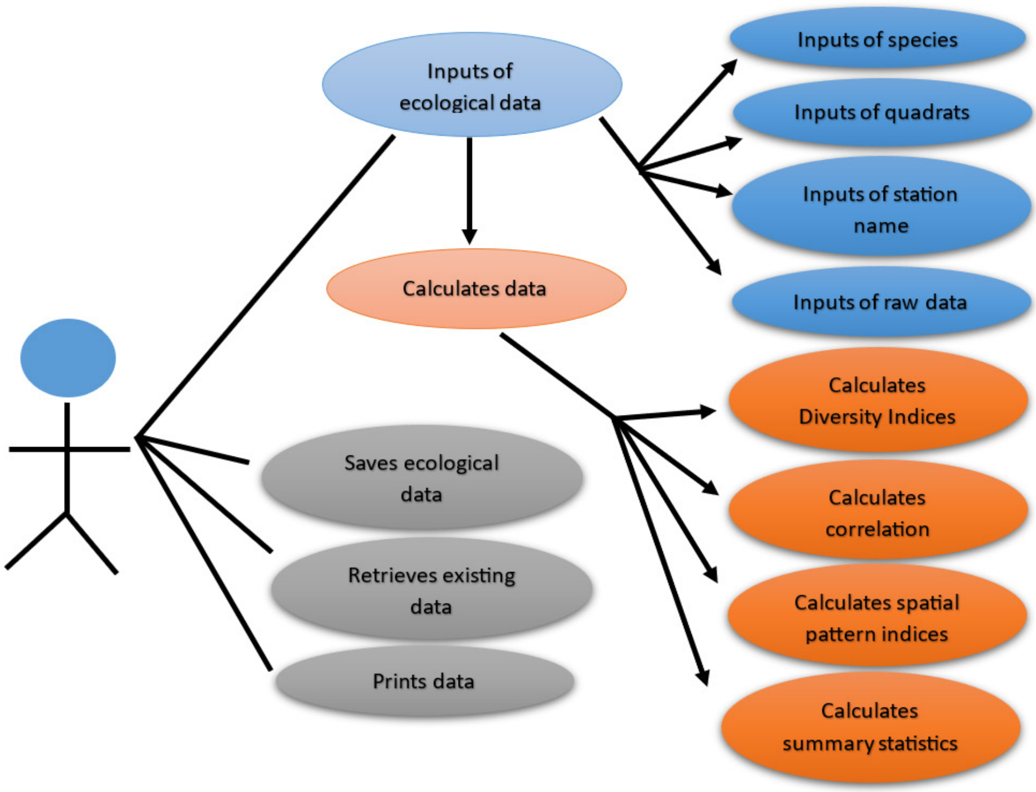

Figure 1. Use case diagram.

Table 1. Description of use case # 1.

Use case #1	Input of ecological data
Goals in context	A user inputs the ecological raw data into the table provided by the software.
Preconditions	The user must have a set of detailed ecological raw data before using the software.
Success end condition	The user has placed the ecological raw data in the table.
Failed end condition	The table is empty because the user did not supply any data.
Primary actor	Ecological researchers, ecologists, and statisticians.
Trigger	The user inputs his ecological raw data.
Main Success Scenario	1. User inputs his ecological data. These include the station name, quadrats, species name, and raw data.

Table 2. Description of use case # 2.

Use case #2	Calculates data
Goals in Context	The basic statistical ecology software calculates summary statistics, spatial pattern indices, diversity indices, and correlation.
Preconditions	The set of numeric ecological raw data is placed in a table with the corresponding quadrat and species name.
Success End Condition	The set of ecological data is calculated by row or by column
Failed End Condition	No results were generated because the user encoded a non-numeric set of ecological raw data.
Primary Actor	Ecological researchers, ecologists, and statisticians
Trigger	The user chooses a specific column or row and clicks the button that will calculate the set of data.
Main Success Scenario	1. The user chooses a specific column or row and clicks the button for calculation. 2. The software displays accurate results.
Extensions	Generated results include: a. Summary Statistics b. Diversity Indices c. Spatial Pattern Indices d. Correlation

Table 3. Description of use case # 3.

Use case #3	Saves ecological data
Goals in Context	The Basic Statistical Ecology Software stores the set of ecological raw data in a text or flat file.
Preconditions	The software displays the raw data with the calculated results in a tabular form.
Success End Condition	The raw data are stored in a specific storage area
Failed End Condition	Nothing will be saved if a user failed to encode the set of ecological raw data.
Primary Actor	Ecological researchers or ecologists and statisticians

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Trigger	The user clicks the Save menu from the File Menu Bar or from the toolbar
Main Success Scenario	The set of ecological raw data is stored

Table 4. Description of use case # 4.

Use case #4	**Retrieves existing data**
Goals in Context	The set of ecological raw data is retrieved after it was stored in a text or flat file storage area.
Preconditions	User has existing data.
Success End Condition	The software displays the set of ecological raw data.
Failed End Condition	The user cannot retrieve data if there is no stored data.
Primary Actor	Ecological researchers, or ecologists and statisticians.
Trigger	The user clicks the Open menu from the File Menu Bar or from the toolbar.
Main Success Scenario	1 Ecological raw data are displayed to the user.

Table 5. Description of use case # 5.

Use case #5	**Prints data**
Goals in Context	The set of ecological raw data is printed together with its calculation
Preconditions	The user must supply the table with ecological data
Success End Condition	The data are printed in a tabular form
Failed End Condition	The software could not print any data because no data were supplied in the table.
Primary Actor	Ecological researchers, ecologists, and statisticians.
Trigger	The user clicks the print menu from the file menu bar or toolbar
Main Success Scenario	1. Tabular form of data is printed.
Extensions	la. Printed data can be: lal. Ecological data 1a2. Computed results

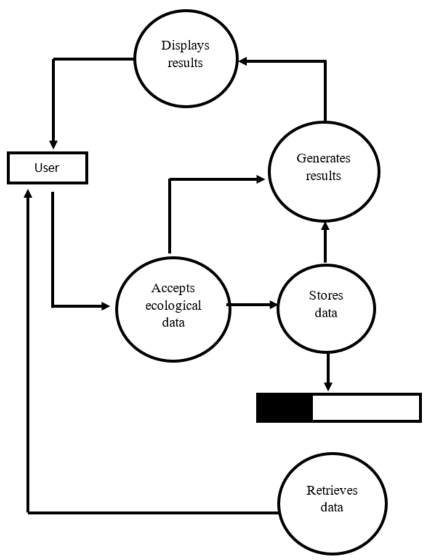

Figure 2. Data flow diagram.

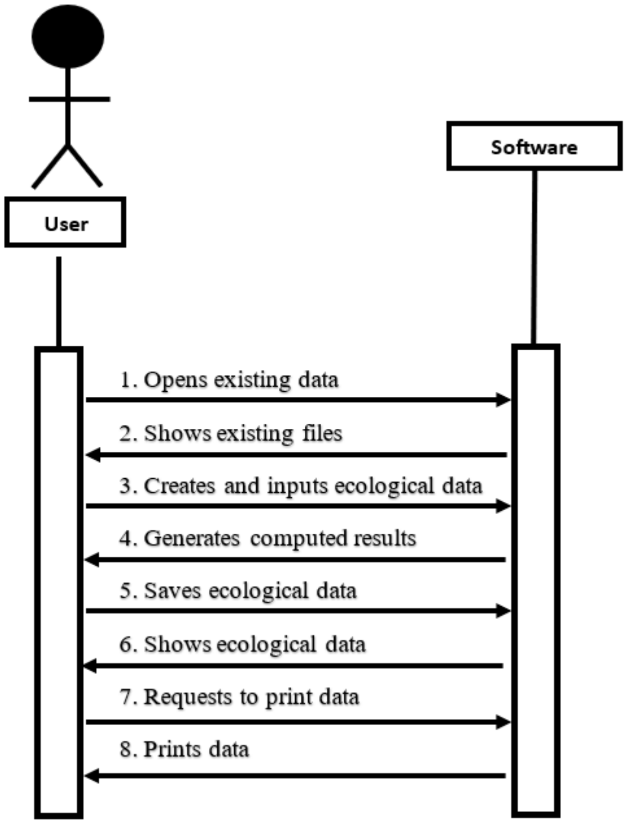

Figure 3. Sequence Diagram.

In Basic Statistical Ecology Software, the user's main action is to open an existing file or creates a new file using his ecological data. When the user opens his existing data, automatically the software will give these Behind the scene, the interface grabs the data from the storage or flat file. On the other hand, if the user creates a new file, he has to input his ecological data and gives the software some commands like computations. In return, the software generates the computed results and let the user view them. After creating a new file, the user may save his data in the software in order for him to retrieve his file later. When he wants to use that file again, the software shows it, ready for any modifications from the user. For hard copies of data, user can print them as long as they exist in the software.

Table 6. Statistical Formulas.

Mean	$\overline{x} = \sum_{i=1}^{n} x_i$
Median	$\mathrm{Md} = \frac{n+1}{2}$, if index is even $\mathrm{Md} = \frac{n}{2}$, if index is odd
Sample Variance	$s^2 = \frac{(x_i - \overline{x})^2}{n-1}$
Coefficient of Variance	$\mathrm{Cv} = \frac{s}{\overline{x}}(100\%)$
Skewness	$\mathrm{Sk} = \frac{3(\overline{x} - median)}{s}$

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Simpson's Index	$SI = \sum_{i=1}^{s} \left(\frac{n_i}{N} \right)^2$
Shannon's Index	$H = 1\sum_{i=1}^{s} \left[\left(\frac{n_i}{N} \right) 1n \left(\frac{n_i}{N} \right) \right]$
Pileous Index	$\mathrm{P} = \frac{H}{1n\ (\ s\ )}$
	$\mathrm{HR} = \frac{\frac{1}{\lambda}}{\mathrm{e}^{H}}$
Index of Dispersion	$\mathrm{ID} = \frac{S^2}{\bar{x}}$
Index of Clumping	$\mathrm{IC} = \frac{S^2}{\bar{x}} - 1$
Green's Index	$\mathrm{GI} = \frac{\left(\frac{S^2}{\bar{x}} \right) - 1}{n-1}$
Coefficient of Correlation	$= \frac{^{\mathrm{N}} (\sum xy) - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2}\ \sqrt{n(\sum y^2) - (\sum y)^2}}$

Shown in Table 6 are the statistical formulas which were used as basis for the Basic Statistical Ecology Software to create accurate results The mean as one of the measurements of central location refers to the average of a set of data. To fully understand its manipulation, the symbol ∑ is a capital sigma, the Greek letter for S, x, refers to raw data, and n refers to its index By adding set of data and divided by the index, one can generate the mean value in like manner, median is also manipulated through hierarchical arrangement in order to determine the middle value of a set of data. If the number of data is odd, the value in its center point is the value of median, otherwise if the number of data is even, it is required to add 1 in order to get its central point value [RAMO2001].

However, in a variance manipulation, the data are enclosed in a parenthesis raised to the power of two (2). Data are subtracted by the mean divided by the index deducted to one (1) The square root of the variance is the standard deviation. If the standard deviation is small, the measurements are tightly clustered around the mean, if it is large, they are widely scattered. The coefficient of variance measures the real variability, which expresses the standard deviation as a percentage of what is being measured at least on the average Skewness is calculated by subtracting the mean and median multiplied by three. The result will be divided by the standard deviation. The calculated results follow data distribution symmetrical, positive and negative distribution. For a symmetrical distribution, the median line divides the box into equal halves. It is moved to the left of center when a distribution is positively skewed, that is Skewness is greater than zero and to the right of center when a distribution is negatively skewed, that is Skewness is less than zero [RAMO2001].

To measure the symmetrical distribution, the values of the median and the mean should coincide Since the presence of some relatively high values that are not offset by corresponding low values will tend to make the mean greater than the median and the presence of some relatively low values that are not offset by corresponding high values will tend to make the mean less than the median, this will result to positive and negative distributions.

The spatial pattern indices refer to the row calculation where data are measured through patterns clumping, uniform, and random. If the variance is equal to the mean, the pattern of data is randomized, if the variance is greater than the mean, the pattern is clumped, and if it is less than then the pattern is uniform. These indices are divided into three parts indexes of dispersion, the index of clumping, and Green's index. The index of dispersion is manipulated by dividing the variance by the mean. However, the result of the index of dispersion is subtracted by one, and that is the index of clumping. The result of the second index of the spatial pattern is divided by the total number, also known as the index of set data - Green's index [RAMO2001].

The diversity indices refer to the column calculation. The Simpson's, Shannon's, Pielou's indices and hills ratio are the main points of these indices. The Simpson's index is denoted by a lambda symbol, the rows are added and divided by the total number. In Shannon's index, the data are expressed in a natural logarithm form where the base is approximately equal to 2 718282. Pielou's index and Hill's ratio are dependent on Shannon's index to generate output. It is calculated by dividing Shannon's index by the natural logarithm of the total number of data Pielou's indices and the result of Simpson's index are inverse and divided by the Exponent of Shannon's index [FREU1986].

The coefficient of correlation is a quantity that gives the quality of the least squares fitting to the original data It expresses the proportion of the total variation in the value of the variable y than can be accounted for or explained by the linear relationship with the values of the variable x. It was denoted by a small letter r. The two columns specified are denoted by two variables x and y. To correlate the two variables, each column holds ecological data. The generated results are interpreted according to their relationship.

Systems Design specification

Figure 4 shows that the user, ecological data, data storage, and the generated results are the class of the Basic Statistical Ecology Software. Below, the class names are the entities of each class. These entities describe the class to which it belongs. At the bottom part of each box are the methods that will be used in the manipulation of each class. These three parts of the class diagrams are involved in the development of the software.

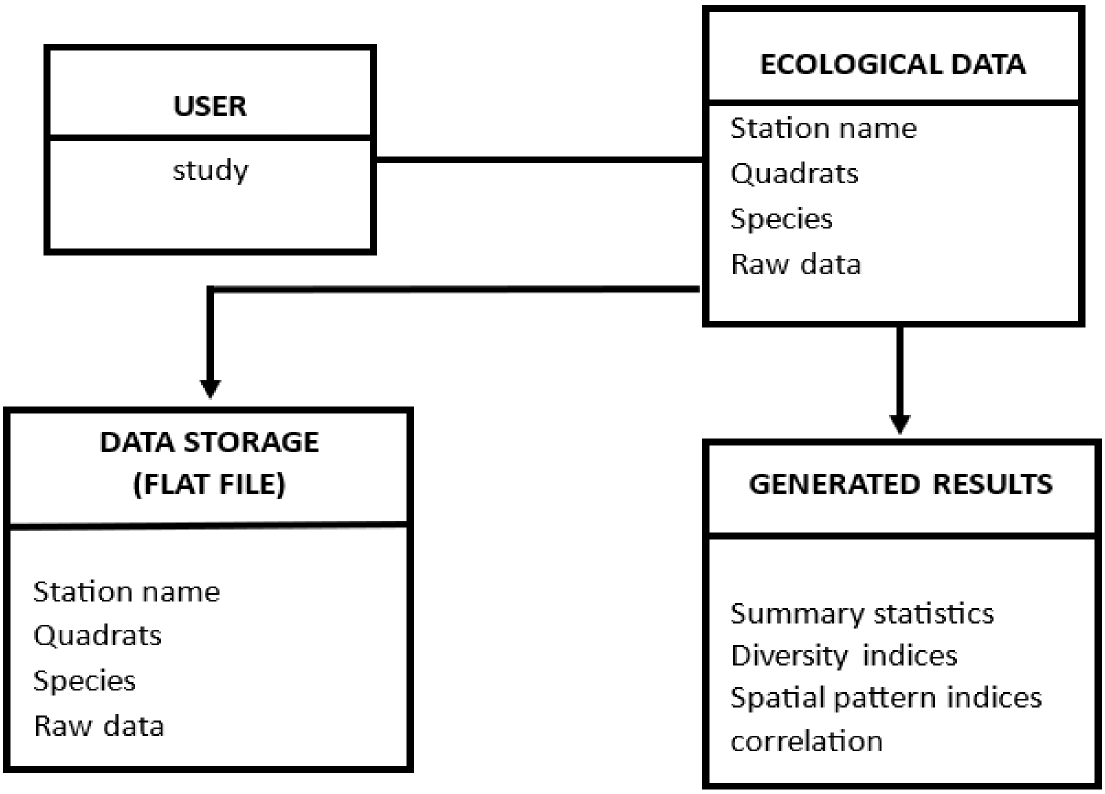

Figure 4. Class diagram.

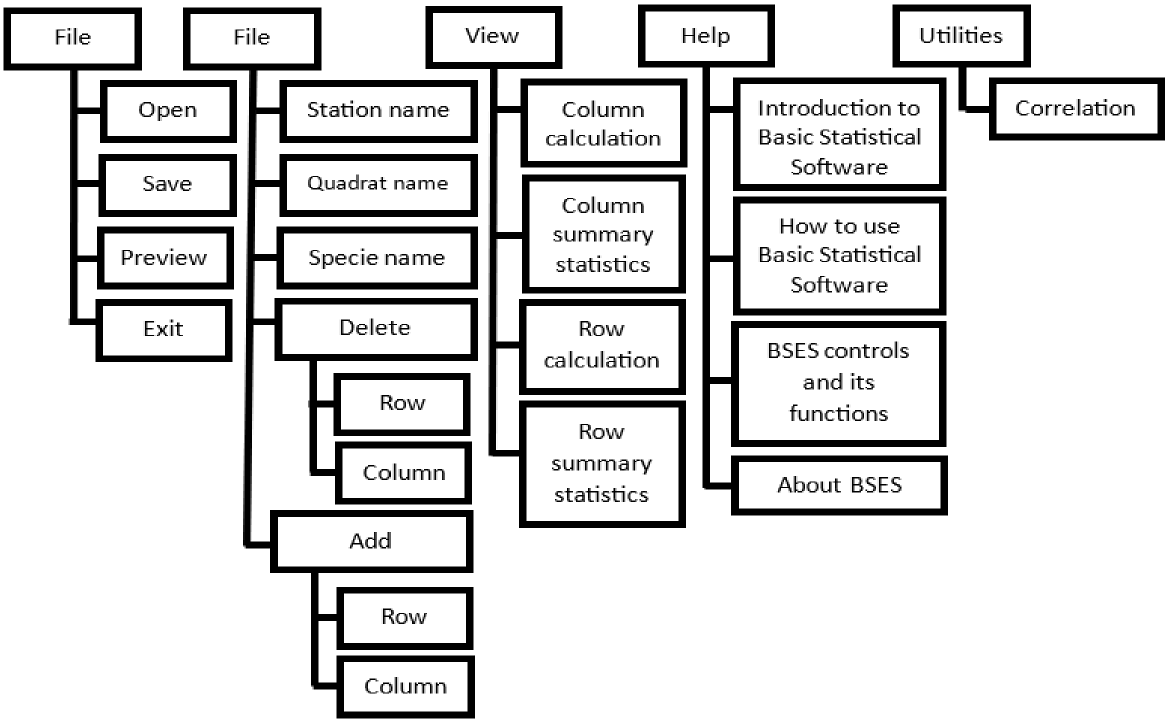

Figure 5. Menu Structure.

Table 7. Data Description.

Object Name	**Type**	**Data Type**	**Description**
frminterface	Form		First window of the software
cmdStart	Command button		A button that starts the software
cmdCreateNew	Command button		Allows user to create a new file
cmdEditExisting	Command button		Allows user to open an existing file
frmFlex	Form		Window for entering and manipulating ecological data
MSFlexGrid1	MSFlexGrid		A table where the user enters his ecological data
txtDataEntry	Textbox		variant Allows entry and editing of raw data
cmdSummaryStat	Command button		Calculates summary statistics of row and columns
cmdSpatial	Command button		Calculates spatial pattern of a selected row
cmdDiversity	Command button		Calculates diversity indices of a selected column
cmdAll	Command button		Shows all calculations of each row and column
cmdAddQuadrat	Command button		Adds columns
cmdAddRow	Command button		Adds rows
cmdDeleteColumn	Command button		Delete selected column
cmdDeleteRow	Command button		Delete selected row
cmdCorrelation	Command button		Opens another window for calculations of

			correlation
mnuFileOpen	Menu		Opens existing file
mnuFileSave	Menu		Saves data
mnuFilePrint	Menu		Prints data
mnuFilePreview	Menu		Previews the table ready for printing
mnuEditStation	Menu		Edits name of station
mnuHelp	Menu		Shows a help facility
frmColCalculation	Form		Window that displays calculations of a selected column
frmRowCalculation	Form		Window that displays calculations of a selected row
frmSpatial	Form		Window that displays spatial pattern indices of a selected row
frmDiversity	Form		Window that displays diversity indices of a selected column
frmCorrelation	Form		Window that displays correlations of two variables
MsgBox (quad)	Message box	string	Accepts quadrat name
MsgBox (station name)	Message box	string	Accepts station name
MsgBox (specie)	Message box	string	Accepts species name

SYSTEMS IMPLEMENTATION

Programming considerations, issues, and tools

The Basic Statistical Ecology Software is developed using the Visual Basic 6.0 environment and with Windows 98 and XP as the operating system. The development of Basic Statistical Ecology Software needs only a single computer unit However, the group utilized two computers to increase the software's productivity of work and to assure that it runs on different Windows environment.

At first, the group considered using Microsoft Access as data storage. But during implementation, the group realized that a database isn't necessary since there will be just a simple storage format that varies and changes depending on the user's need. So, the group decided to use a Flat or Text file instead. The group also has to decide the Visual Basic control that will accept user's data and does not require a database. That specific control must be in a table form where the user populates his ecological data. The group at first used DBGrid a control in unbound mode. But programming with DBGrid caused the group real difficulty. After months of coding, the group still wasn't able to make even half of the objectives; thus, the decision using MSFlexGrid a good control for tables in unbound mode. It was really a risk, but then after just a few days of coding, the group has accomplished more than what had been done with DBGnd.

System requirements specification

Hardware requirements

The Basic Statistical Ecology Software is a stand-alone program so it doesn't need a any applications or software to run on the computer. Other Hardware requirements include Pentium III Processor, 20 GB Hard Disk Drive, 14° Colored Monitor, ASUS P3V133 Motherboard, 256 MB SDRAM Memory Card, 128 MB Video Card, 1.44 Floppy Disk Drive, 108 keys Keyboard, 500 watts AVR, Mouse with Mouse Pad and Printer.

National Peer Reviewed Journal
DOI: https://doi.org/10.59120/drj.v6i3.572

Software requirements

This software needs a Windows 98 or higher Operating Systems in order to run.

Human resource requirements

Environmental and ecological researchers, including students and professionals are the target end users of this study. In using the software, a researcher must have the basic computer skills such as the use of mouse and keyboard and familiarity on different controls commonly found on Windows environment.

Testing Activities

Unit/Function testing

Several testing activities were done to test the functionality of the software and to determine if it meets, even partially, the objectives of the study It is done every end of the prototyping cycle after the implementation stage. To test the functionality is to test the accuracy of the displayed outputs. So the group asked their thesis adviser, also a statistician, to prepare a set of data along with its statistical computations (see Appendix 1). Computing the said set of data was done manually with the aid of an electronic calculator. It is however assumed that the calculations done were accurate. That same set of data was then inputted to the Basic Statistical Ecology Software. Afterwards, a comparison was made to see if the software generates same results with that of the calculations done manually.

System testing

The software was installed on computers with different processors and on different version of Windows Operating System.

User's acceptance testing

To further test the functionality of the software and to assure that it meets users' needs, the group recruited a range of target users within the campus. They were students taking up environmental science and biology curricula of this college. After a short introduction of the basic steps of using the software and its functionality, they were asked to test the software using their own set of data gathered from their respective studies. Afterwards, they were asked to fill up a test questionnaire. Their responses to the questions will determine their views about the software, including the problems they met and other possible suggestions. These allow the group to evaluate their work and thus produce a more accurate and functional software that will satisfy the user base.

Conclusion

Due to the problems of ecologists particularly the students taking the courses of Bachelor of Science in Environmental Science and Bachelor of Science in Biology of Davao Oriental State College of Science and Technology, it is therefore concluded that a more capable software must replace Microsoft Excel as the tool for their research analysis. The proposed Basic Statistical Ecology Software is also capable of producing computed results that Microsoft Excel does but of doing it in a manner with less effort and less time spent. This software provides accurate results such as summary statistics, diversity indices, spatial pattern indices, and correlation of any given data without asking or requiring any formulas from the users. It can also generate tabular form of results ready for printing purposes and can open any data that a user had stored. Like Microsoft Excel, it has a graphical interface that interacts to user's demand. With the above-mentioned features, it is guaranteed that the research analysis of ecologist is secured against errors and thus, has the greater possibility of ending into successful research.

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