RS-GIS with free software

Dr. Ankur Awadhiya, IFS

Indira Gandhi National Forest Academy
Dehradun

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सत्यमेव जयते

FOREWORD

Dr Ankur Awadhiya, IFS Probationer of 2014 batch at the Indira Gandhi National Forest Academy has been an academically and creatively passionate officer trainee and always coming up with interesting pursuits. This documentation "RS-GIS with free software" is one amongst many. I would like to complement his zeal of learning, analysis and outputs as a thinking forest technocrat with his background of education and research.

Remote sensing is the act of obtaining information about something without being in direct contact with it or near it. Field of Remote Sensing and Geographical Information System has become exciting and glamorous with rapidly expanding opportunities. Today, the data obtained is usually stored and manipulated using computers whose use as a device has also been changing from stationary to navigable ones as well as in shape and sizes from desktop to laptop and now as palmtop including powerful tiny ones. The most common software used in remote sensing is ERDAS Imagine, ESRI, MapInfo and ERMapper. Organizations spend large amounts of money on these software besides for GIS hardware to be installed on locations. Limitation of fund like limitation on land and forest resource play very important factor in application of knowledge and skill available with human resources in forestry sector also.

The hardware and software helps foresters meet the needs of their forests, the demands of society, and the pressures of economic efficiency. Foresters are also increasingly turning to GIS for its analytic and visualization tools that allow them to analyze complex situations and make better-informed decisions and is becoming the foundation for new decision support tools used in all business processes of integrated forest management.

This document highlights availability and utilisation of free software from internet world to meet various functions of GIS application in forestry in substitution and additionality of priced software with further cost of annual maintenance. Author has simplified principle and process of such skill for search, download and application through illustrative contents herein.

I would like to elucidate importance of skilful use of GIS software & hardware on growing developmental demands for forest diversions. Forest diversions under the Forest (Conservation) Act 1980 is a binding legal instrument that allows developmental rights but the restrictions on nature of land remaining forestland goes with the diverted land forever. Such diversions help to minimize deforestation sprawl and conserve biodiversity in a working forest environment. Each forest diversion therefore brings the responsibility of monitoring conformance to diversion regulations and restrictions, therefore, the need in achieving the most cost-effective and efficient monitoring protocol. GIS has become the most valid and applicable tool for planning development of forest blocks distributed over large geographical area and with topographical variations on accessibility plus diversities of communities & their behaviour.

I am glad to put my preface to this documentation of Dr Ankur Awadhiya, IFS Probationer (MP, 2014). His work is praiseworthy and commendable. I would also like to complement our faculty member Sri Deepak Mishra, IFS (Kerala, 1996) with his guidance and facilitations for this work.

I am sure the present handbook **"RS_GIS with free software"** would encourage IFS Probationers at IGNFA and through them the forest personnel in field to benefit from ideas & illustrations and to contribute for dynamic forest resources affected by many concurrent ecological processes and direct management intervention for simulation or process modelling by putting their sincere efforts while practicing training for their skills.

Dehradun
The 01 April, 2016.

(Vinod Kumar)

Ph.: 0135 - 2754647 (O), 0135-2757314 (Fax)

इन्दिरा गाँधी राष्ट्रीय वन अकादमी
Indira Gandhi National Forest Academy

सत्यमेव जयते

भारत सरकार, पर्यावरण, वन और
जलवायु परिवर्तन मंत्रालय
Govt. of India, Ministry of
Environment & Forest Climate
Change

02 April 2016

PREFACE

Remote sensing and GIS have emerged as extremely important tools for natural resource management, and as such these technologies are increasingly being used by forest managers. The academy imparts extensive training on these subjects to the probationers, both in theory and practical aspects. The training is being imparted using proprietary softwares such as Erdas Imagine and Arc-GIS. However, due to the heavy costs in procurement and maintenance of these softwares, the field application of these technologies gets limited.

It was felt that the use of open source softwares will place these technologies in the hands of field officers, to facilitate their use in the day-to-day management and decision-making.

Ankur has demonstrated the use of open-source softwares in RS-GIS applications in forestry. This book is intended as a lab manual for the probationers so that they can develop their expertise in the use of open-source softwares. This is a very good attempt by Ankur to spread the use of open-source softwares among the forestry leaders of the future. I wish him all the best.

Deepak Mishra, IFS

Additional Professor

Indira Gandhi National Forest Academy

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AUTHOR'S PREFACE

Remote sensing is a pervasive field; we get our day-to-day information through it. Our eyes and ears are remote sensors that catch light and sound signals, respectively, and the conversion of these signals into information permits us to understand our world. Instrumental remote sensing has also had a very extensive history. It is just an extension of our natural ability of sensing remotely, and began with the advent of photography. Aerial photography using weather balloons was extensively employed during the first world war. And after the second world war, the field literally exploded. Satellite remote sensing that began mostly for military applications has now entered various dimensions of our daily living: from weather forecasting and navigation to disease monitoring, to name just a few.

While nobody can deny the importance and utility of remote sensing and GIS in this modern information age, the discipline is literally indispensable for effective and efficient administrative planning and monitoring. In the field of forestry for instance, we use it to create the biannual maps of forest cover at the country level. At local levels, the data is employed in the creation of working plans for administering the forests. Geotagged maps are being used for granting forest rights to the tribals and other traditional forest dwellers under the Forest Rights Act of 2006. Geotagged revenue maps and forest maps can be used for an expeditious resolution of boundary disputes. And GIS applications are rapidly finding themselves consequential in the variegated realms of human-wildlife conflict, wildlife migrations, forest health and monitoring and control of disease spreads.

While most of our administrative and front-line staff get exposure to remote sensing applications in several courses, the need for the development of a module to provide efficacious and expeditious hands-on experience to them is strongly being felt. Most of the existing modules in this field use expensive proprietary softwares that largely become inaccessible in field situations. We need systems that the field staff can legally possess on their own laptops, not only for usage in field situations, but also to play with in their leisure times to expand the breadth of their knowledge and outlook. Hence, a new module for hands-on experience using free and open-source softwares is being presented. In the module, every chapter begins with a brief theoretical background that explains the whats, whys and hows of the exercise, followed by the procedure to be employed and sample results. The background has been kept succinct and to the point, for the emphasis of the module is only on providing an overview and hands-on experience. For an extremely detailed theoretical understanding, the passionate student may refer to several advanced theoretical textbooks that are widely available.

The target audience for this module is very wide, and might comprise field staff such as beat officers, foresters, range officers, patwaris, students of civil engineering and geography, probationary officers of the Indian Forest Service, the Indian Police Service and the Indian Administrative Service, civil service aspirants, media personnel and people with a general interest in this field.

It is hoped that the book will be useful in the hands of the users. I shall be extremely delighted to receive any comments from the users, who may contact me at mp572@ifs.nic.in.

Before closing, I take the opportunity to express my heartfelt gratitude towards Dr. Rajiv Sinha of IIT Kanpur who first exposed me to the field of remote sensing and GIS. Our faculty Sh. Deepak Mishra, IFS at the Indira Gandhi National Forest Academy, Dehradun motivated me to develop this module to be used for the future batches of IFS probationers at the academy. It was through his prodding that the book in its current form got developed. And he so delightedly agreed to write a preface to the manuscript. Thank you Sir. Sh. Vinod Kumar, IFS and the Director of the Indira Gandhi National Forest Academy, Dehradun was kind enough to draft a foreword for the manuscript. He also took personal interest in getting it published. Thank you so much Sir. I also wish to thank the staff of geomatics lab at the Indira Gandhi National Forest Academy, Dehradun who were extremely helpful in my quest of understanding the RS-GIS proprietary softwares, and Sh. K. Kannan, IFS and course director 2014 batch at the Indira Gandhi National Forest Academy, Dehradun for his guidance and motivation.

Dr. Ankur Awadhiya

04 April 2016, Dehradun

ABOUT THE AUTHOR

Dr. Ankur Awadhiya (b. 1987) is an IFS officer of 2014 batch borne on the Madhya Pradesh cadre. He has been trained as an engineer, and received his B. Tech in Biological Sciences and Bioengineering in 2009 from IIT Kanpur. He earned his Ph.D from IIT Kanpur in 2015, where his doctoral research was titled "Studies in Agarose-based bioplastic material". He got exposed to the field of remote sensing during his IIT days, where he presented a talk on the application of remote sensing in human health, and has since continued taking interest in the field. He developed expertise during his probation days at the Indira Gandhi National Forest Academy, Dehradun. Besides academics, he maintains a passion towards photography, painting, movie-making, and creative literary pursuits.

DEDICATION

To Ushi

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Chapter 1

Introduction

1.1 What is remote sensing (RS)?

Remote sensing is defined as “the process used to acquire and measure the information of some property of objects and phenomena by a recording device (aka sensor) that is not in physical contact with the objects and phenomena under study”. It involves action from a distance (remote) for gathering information about an object or phenomenon (sensing).

There are three components involved in remote sensing:

1. an object
2. a recording device
3. information carrying energy waves.

Remote sensing is an eight-step process involving

1. generation of energy: the device can generate its own energy (active sensor) or use the Sun's emitted energy (passive sensor)
2. transmission of energy from the source to the surface of the object
3. interaction of the transmitted energy with the surface of the object
4. propagation of the reflected / emitted energy through the atmosphere
5. detection of the reflected / emitted energy by the sensor
6. conversion of the received energy into photographic / digital form of data
7. extraction of the information contents from the data
8. conversion of the information into maps or tables for presentation.

1.2 What is GIS?

GIS or Geographic Information System is a system consisting of hardware (equipment), software (code) and humanware (people) that is designed to capture, store, manipulate, analyse, manage and present different kinds of geographical data. Thus it is an integrated system to process and analyse geographical data, including those received through remote sensing.

Modern GIS technologies handle data in a digital format. The data is represented in the form of layered stacks that are inter-connected and can be queried.

We get data for GIS from various sources, including

1. satellite data
2. photographs
3. scanned copies of maps
4. data from old documents
5. toposheets
6. GPS coordinates
7. field surveys
8. transacts and description forms
9. cruises, etc.

For handling geographical data, several platforms, including ArcGIS, QGIS, Grass and Erdas may be employed.

1.3 What is QGIS?

Quantum GIS or QGIS is a cross-platform, FOSS (free and open-source software) GIS application that is licensed under GNU General Public License. It is an official project of the Open Source Geospatial Foundation (OSGeo), and can be accessed at: http://www.qgis.org

1.4 What are we going to do in this module?

In this module, we'll understand how to gather satellite data and perform basic analyses such as layer stacking for the creation of composite images, image enhancement, congregation of information from satellite data in the form of normalised difference vegetation indices, classification of image into categories for land use analysis, detection of changes to an area, downloading and referencing of toposheets, digitisation of maps and querying them, and selection of a site for execution of an operation, based on certain set criteria. We shall perform all these operations using freely available data sources and softwares that are cross-platform in availability.

Chapter 2

Downloading satellite data

2.1 What is a satellite?

In the context of remote sensing, a satellite is any artificial body placed in orbit round the Earth or another planet, for the purposes of collecting information or communication. These artificial satellites are distinct from natural satellites like the Earth's Moon.

The USSR's Sputnik-1 was the first artificial satellite to be launched on 04 October 1957. Since then, around 7000 satellites have been launched till date.

2.2 Kinds of satellites

There are several kinds of satellites. Based on their use, we have

1. weather and atmosphere monitoring satellites: These help observe and predict weather phenomena on the Earth. e.g. Metsat
2. Earth observation and mapping satellites: These observe our planet and the changes occurring in it. e.g. ENVISAT, Landsat
3. astronomical and planetary exploration satellites: These are involved in scientific missions for the study of the Sun, stars or planets. e.g. the Hubble telescope
4. communication satellites: These relay television, telephone, or data conversations through their transponders.
5. navigational satellites: These satellites help in locating a point on the Earth and navigation of vehicles, ships, aircrafts, etc. e.g. the GPS-NAVSTAR series of satellites
6. military satellites: These are involved in intelligence gathering and reconnaissance missions, including nuclear monitoring, observations of enemy movements, early warning of missile launches, photography, etc.

Based on the centre of orbit, satellites can be

1. geocentric satellites: orbiting around the planet Earth
2. heliocentric satellites: orbiting around the Sun
3. areocentric satellites: orbiting around the planet Mars.

Based on their altitudes, geocentric satellites can be

1. low Earth orbit (LEO) satellites: altitude $<$ 2,000 km. Such satellites are generally used for military applications.

2. medium Earth orbit (MEO) satellites: altitude 2,000 km to 35,786 km. Such satellites are generally used for remote sensing applications.

3. geosynchronous orbit (GEO) satellites: altitude 35,786 km. Here the period of rotation coincides with the rotation period of the Earth. Such satellites are generally used for telecommunication and weather monitoring.

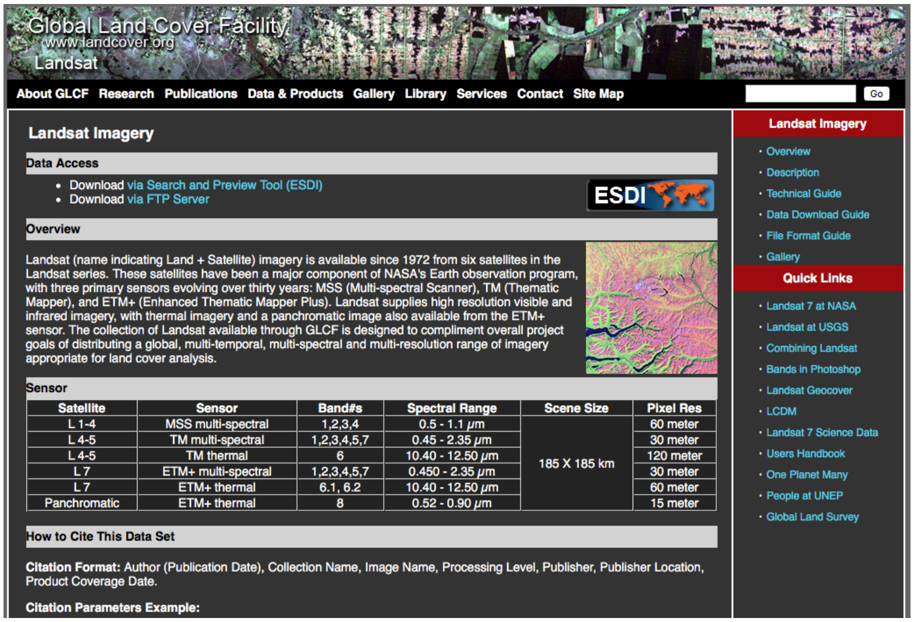
4. high Earth orbit (HEO) satellites: altitude $>$ 35,786 km. Such satellites are generally used for astronomical explorations.

There are several other classifications that are beyond the scope of this module. Here we shall concentrate on the downloading and use of Landsat Earth observation and mapping satellite data for RS-GIS applications.

2.3 Steps to be followed

1. Goto http://glcf.umd.edu/data/landsat/ This is the website of the Global Land Cover Facility that permits downloading of satellite data from the Landsat program (Figure 2.1). The Landsat (the term has been derived from Land + Satellite) imagery is available since 1972

from three primary sensors: MSS (Multi-Spectral Scanner), TM (Thematic Mapper) and ETM+ (Enhanced Thematic Mapper Plus).



Landsat Imagery

Data Access

- Download via Search and Preview Tool (ESDI)
- Download via FTP Server

Overview

Landsat (name indicating Land + Satellite) imagery is available since 1972 from six satellites in the Landsat series. These satellites have been a major component of NASA's Earth observation program, with three primary sensors evolving over thirty years: MSS (Multi-spectral Scanner), TM (Thematic Mapper), and ETM+ (Enhanced Thematic Mapper Plus). Landsat supplies high resolution visible and infrared imagery, with thermal imagery and a panchromatic image also available from the ETM+ sensor. The collection of Landsat available through GLCF is designed to compliment overall project goals of distributing a global, multi-temporal, multi-spectral and multi-resolution range of imagery appropriate for land cover analysis.

Sensor

Satellite	Sensor	Band#s	Spectral Range	Scene Size	Pixel Res
L 1-4	MSS multi-spectral	1,2,3,4	0.5 - 1.1 μm	185 X 185 km	60 meter
L 4-5	TM multi-spectral	1,2,3,4,5,7	0.45 - 2.35 μm		30 meter
L 4-5	TM thermal	6	10.40 - 12.50 μm		120 meter
L 7	ETM+ multi-spectral	1,2,3,4,5,7	0.450 - 2.35 μm		30 meter
L 7	ETM+ thermal	6.1, 6.2	10.40 - 12.50 μm		60 meter
Panchromatic	ETM+ thermal	8	0.52 - 0.90 μm		15 meter

How to Cite This Data Set

Citation Format: Author (Publication Date), Collection Name, Image Name, Processing Level, Publisher, Publisher Location, Product Coverage Date.

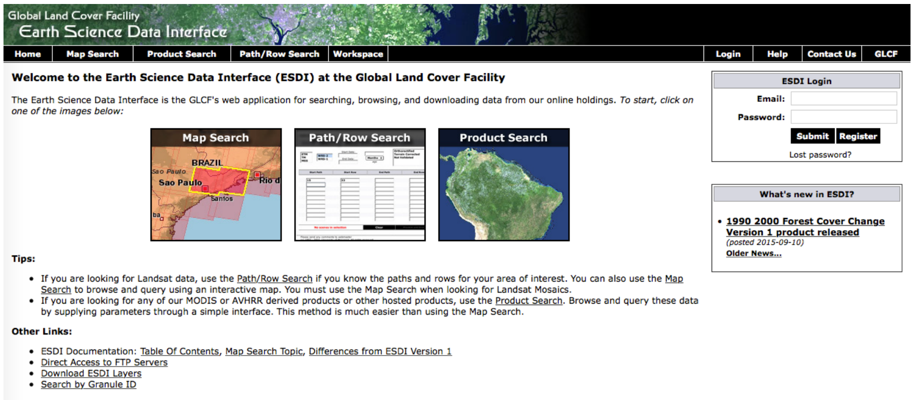
Citation Parameters Example:

Figure 2.1: The homepage of GLCF

2. Click on "Download via Search and Preview Tool (ESDI)." This opens the Earth Science Data Interface (ESDI) where data can be searched, browsed and downloaded using map search, path / row search or product search (Figure 2.2).

3. Click on "Map Search" (Figure 2.3). This window permits selection of several datasets: MSS, TM, ETM+, ALI, ASTER and others, that can be searched with Date / Type, Path / Row, Lat / Long, etc.

4. Select "Landsat Imagery" on the left panel and click "Lat/Long" on



Welcome to the Earth Science Data Interface (ESDI) at the Global Land Cover Facility

The Earth Science Data Interface is the GLCF's web application for searching, browsing, and downloading data from our online holdings. *To start, click on one of the images below:*

Tips:

- If you are looking for Landsat data, use the Path/Row Search if you know the paths and rows for your area of interest. You can also use the Map Search to browse and query using an interactive map. You must use the Map Search when looking for Landsat Mosaics.
- If you are looking for any of our MODIS or AVHRR derived products or other hosted products, use the Product Search. Browse and query these data by supplying parameters through a simple interface. This method is much easier than using the Map Search.

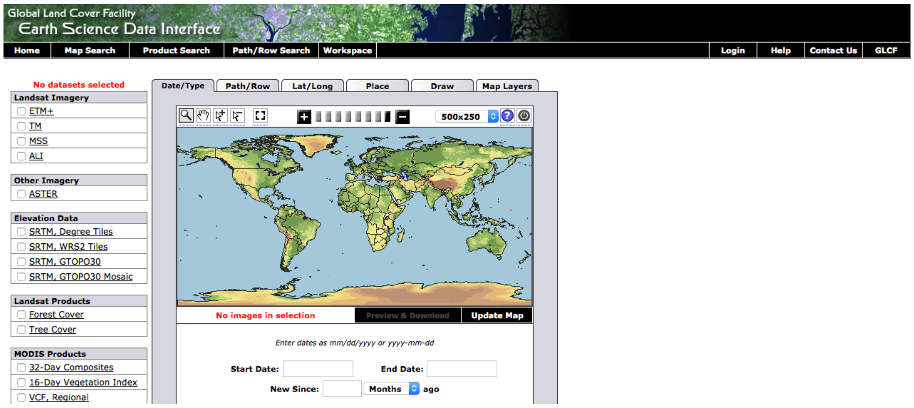
Other Links:

- ESDI Documentation: Table Of Contents, Map Search Topic, Differences from ESDI Version 1
- Direct Access to FTP Servers
- Download ESDI Layers
- Search by Granule ID

What's new in ESDI?

- **1990 2000 Forest Cover Change Version 1 product released**
  (posted 2015-09-10)
  Older News...

Figure 2.2: The Earth Science Data Interface

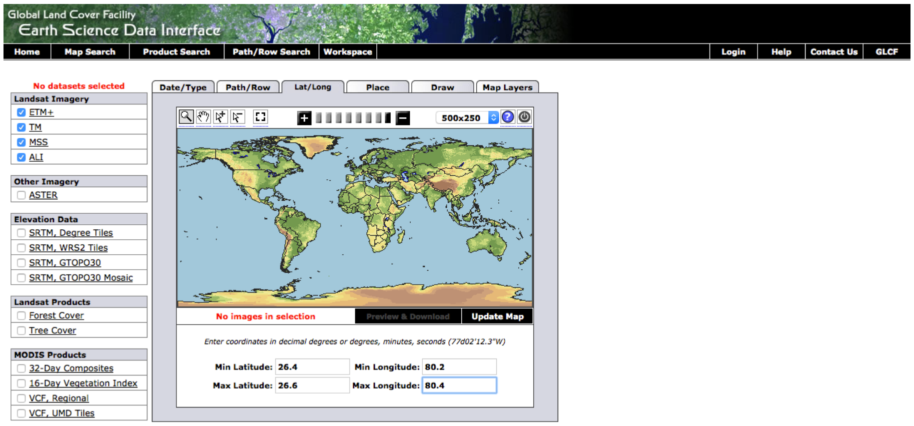


Enter dates as mm/dd/yyyy or yyyy-mm-dd

Figure 2.3: The Map Search window

the right. Enter coordinates of the desired location. For example, to search for the datasets representing Kanpur, we enter Min Latitude: 26.4, Max Latitude: 26.6, Min Longitude: 80.2 and Max Longitude: 80.4. Press Enter (Figure 2.4).

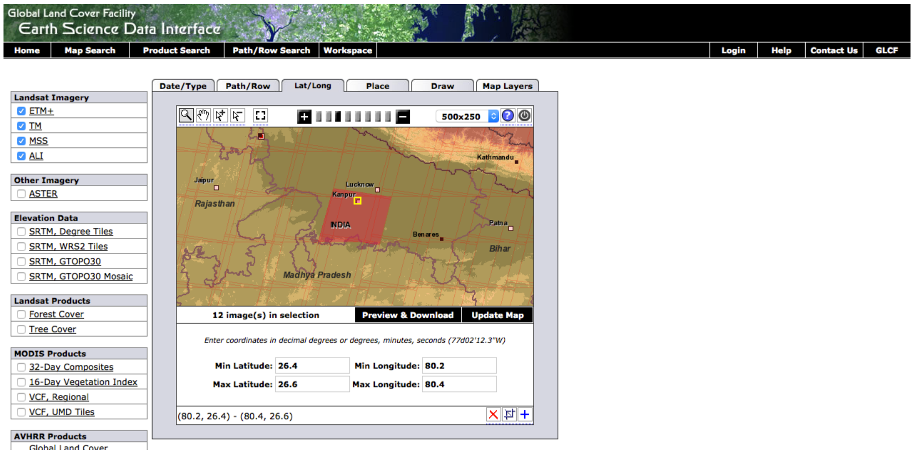
5. The portal locates the region and lists the images present within the coordinate limits (Figure 2.5).



Enter coordinates in decimal degrees or degrees, minutes, seconds (77d02'12.3"W)

Min Latitude: 26.4
Min Longitude: 80.2
Max Latitude: 26.6
Max Longitude: 80.4

Figure 2.4: Entering coordinates



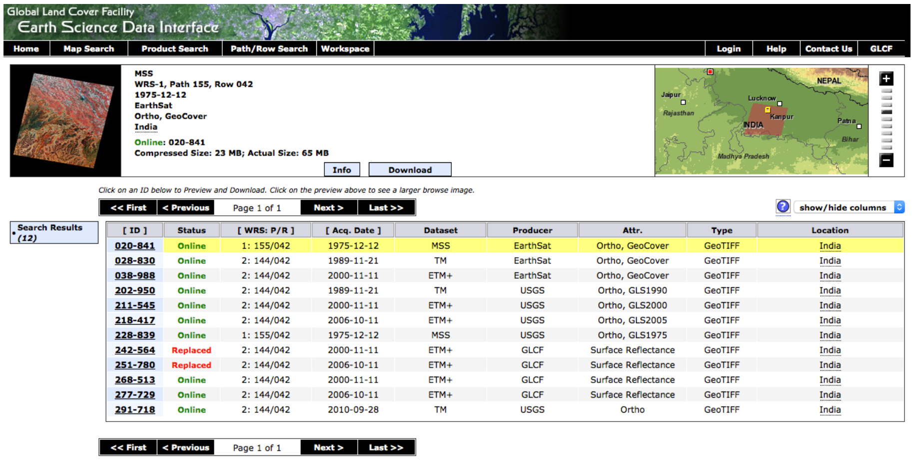
Enter coordinates in decimal degrees or degrees, minutes, seconds (77d02'12.3"W)

Min Latitude: 26.4
Min Longitude: 80.2
Max Latitude: 26.6
Max Longitude: 80.4

(80.2, 26.4) - (80.4, 26.6)

Figure 2.5: Locating the desired region

6. Click on "Preview and Download". The list of images based on the search result is displayed. The page also displays the kind of sensor, path and row of the satellite, date of image acquisition, name of the satellite, kind of image and the country of the image, besides giving the compressed and actual sizes of the files (Figure 2.6).



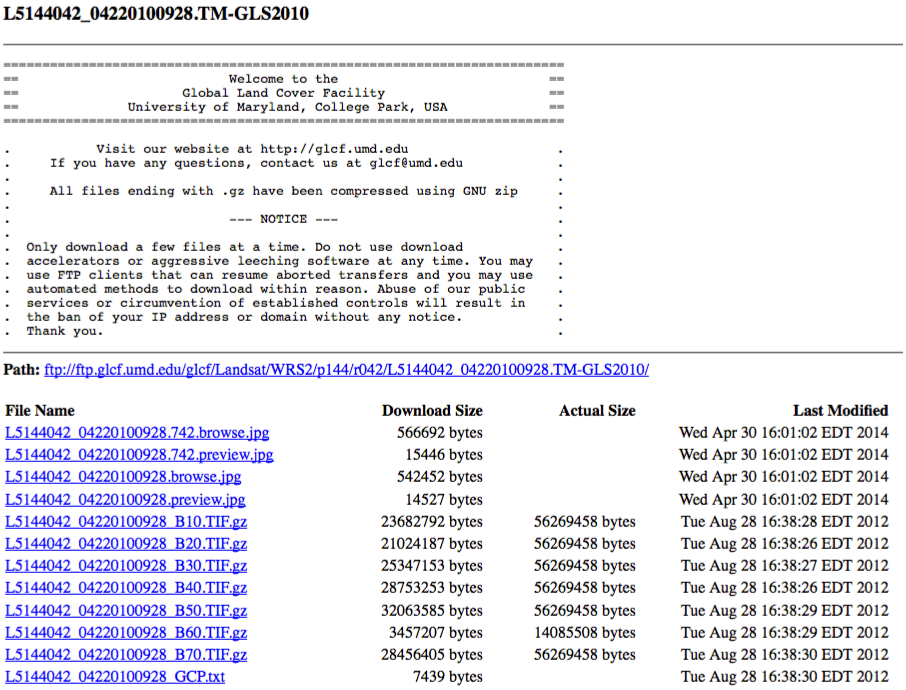
MSS
WRS-1, Path 155, Row 042
1975-12-12
EarthSat
Ortho, GeoCover
India
Online: 020-841
Compressed Size: 23 MB; Actual Size: 65 MB

Click on an ID below to Preview and Download. Click on the preview above to see a larger browse image.

[ID]	Status	[WRS: P/R]	[Acq. Date]	Dataset	Producer	Attr.	Type	Location
020-841	Online	1: 155/042	1975-12-12	MSS	EarthSat	Ortho, GeoCover	GeoTIFF	India
028-830	Online	2: 144/042	1989-11-21	TM	EarthSat	Ortho, GeoCover	GeoTIFF	India
038-988	Online	2: 144/042	2000-11-11	ETM+	EarthSat	Ortho, GeoCover	GeoTIFF	India
202-950	Online	2: 144/042	1989-11-21	TM	USGS	Ortho, GLS1990	GeoTIFF	India
211-545	Online	2: 144/042	2000-11-11	ETM+	USGS	Ortho, GLS2000	GeoTIFF	India
218-417	Online	2: 144/042	2006-10-11	ETM+	USGS	Ortho, GLS2005	GeoTIFF	India
228-839	Online	1: 155/042	1975-12-12	MSS	USGS	Ortho, GLS1975	GeoTIFF	India
242-564	Replaced	2: 144/042	2000-11-11	ETM+	GLCF	Surface Reflectance	GeoTIFF	India
251-780	Replaced	2: 144/042	2006-10-11	ETM+	GLCF	Surface Reflectance	GeoTIFF	India
268-513	Online	2: 144/042	2000-11-11	ETM+	GLCF	Surface Reflectance	GeoTIFF	India
277-729	Online	2: 144/042	2006-10-11	ETM+	GLCF	Surface Reflectance	GeoTIFF	India
291-718	Online	2: 144/042	2010-09-28	TM	USGS	Ortho	GeoTIFF	India

Figure 2.6: Listing images

7. Download the requisite images to your computer (Figure 2.7).



L5144042_04220100928.TM-GLS2010

```
=========================================================================
==                           Welcome to the                            ==
==                     Global Land Cover Facility                      ==
==                University of Maryland, College Park, USA            ==
=========================================================================

.           Visit our website at http://glcf.umd.edu                    .
.     If you have any questions, contact us at glcf@umd.edu             .
.                                                                       .
.     All files ending with .gz have been compressed using GNU zip      .
.                                                                       .
.                           --- NOTICE ---                              .
.                                                                       .
.  Only download a few files at a time. Do not use download             .
.  accelerators or aggressive leeching software at any time. You may    .
.  use FTP clients that can resume aborted transfers and you may use    .
.  automated methods to download within reason. Abuse of our public     .
.  services or circumvention of established controls will result in     .
.  the ban of your IP address or domain without any notice.            .
.  Thank you.                                                           .
```

Path: ftp://ftp.glcf.umd.edu/glcf/Landsat/WRS2/p144/r042/L5144042_04220100928.TM-GLS2010/

File Name	Download Size	Actual Size	Last Modified
L5144042_04220100928.742.browse.jpg	566692 bytes		Wed Apr 30 16:01:02 EDT 2014
L5144042_04220100928.742.preview.jpg	15446 bytes		Wed Apr 30 16:01:02 EDT 2014
L5144042_04220100928.browse.jpg	542452 bytes		Wed Apr 30 16:01:02 EDT 2014
L5144042_04220100928.preview.jpg	14527 bytes		Wed Apr 30 16:01:02 EDT 2014
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L5144042_04220100928_B20.TIF.gz	21024187 bytes	56269458 bytes	Tue Aug 28 16:38:26 EDT 2012
L5144042_04220100928_B30.TIF.gz	25347153 bytes	56269458 bytes	Tue Aug 28 16:38:27 EDT 2012
L5144042_04220100928_B40.TIF.gz	28753253 bytes	56269458 bytes	Tue Aug 28 16:38:26 EDT 2012
L5144042_04220100928_B50.TIF.gz	32063585 bytes	56269458 bytes	Tue Aug 28 16:38:29 EDT 2012
L5144042_04220100928_B60.TIF.gz	3457207 bytes	14085508 bytes	Tue Aug 28 16:38:29 EDT 2012
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L5144042_04220100928_GCP.txt	7439 bytes		Tue Aug 28 16:38:30 EDT 2012

Figure 2.7: Downloading images

Chapter 3

Layer stacking of Landsat data

3.1 The structure of satellite data

Satellites gather data using sensors. A sensor is a device that performs three functions:

1. gathering of electromagnetic radiations
2. conversion of electromagnetic radiations into signals
3. presenting the signals in a form suitable for obtaining information about the object under investigation.

The earliest satellites used analogue sensors. These were in the form of photographic plates, much similar to old film cameras. The image was recorded at the instant of exposure of the photographic plate. Modern satellites, on the other hand, use digital sensors, comparable to those used in modern digital cameras. These sensors, also called scanners, obtain the images in a bit-by-bit form.

The modern satellites transmit information in the form of digital images. A digital image is made up of discrete picture elements called pixels. Each pixel in the image has two attributes: an intensity value and an address in the two-dimensional image space.

The average intensity value of a pixel is called its digital number (DN). This DN value is dependent upon the electromagnetic energy received by the sensor and the intensity levels used to describe its range. The range, also known as the *radiometric range*, represents the number of grey level variations that can be present in a pixel. For an n-bit image, these numbers can be from 0 to 2^n -1. Thus, for example, a one-bit image will have DN values that are either 0 (black) or 2^1 - 1 = 1 (white). On the other hand, an eight-bit image can have values from 0 (black) to 2^8 - 1 = 255 (white). Thus, the eight-bit image will represent 256 shades of grey and will have a greater radiometric range than a one-bit image.

In a digital image, the size of a pixel determines the reproduction of the details of the object under study. More the number of pixels in a sensor, more will be its *spatial resolution.* A smaller-size pixel is better in preserving scene details for digital representation, and the image can be zoomed in without much pixellation.

3.2 Multispectral scanners used in modern remote sensing satellites

The modern remote sensing satellites employ multispectral scanners (MSS). These are designed to obtain images of the objects under study while sweeping across the field of view. The scanner is made up of two components: (1) a reception system consisting of a mirror and (2) detectors. The scanner constructs the scene line-by-line by recording a series of scan lines. In the process, the scanning mirror gets oscillated through the angular field of view of the sensor, determining the length of scan lines (aka the swath).

A scene is comprised of cells that determine the spatial resolution of the image. The mirror reflects the received electromagnetic radiation to the detectors that convert it into electrical signals. These signals get further converted to DN values for recording and transmission.

There are two kinds of multispectral scanners:

1. Whiskbroom Scanners: These have one rotating mirror and one detector. When the mirror completes one rotation, the detector sweeps across the field of view (FOV) between 90° and 120°, obtaining images in a large number of narrow spectral bands. The total extent of the oscillating sensor is called the Total Field of View (TFOV) of the scanner.

2. Pushbroom Scanners: These have numerous detectors. All the detec-

tors are linearly arrayed.

A spectral band is a term used for the range of wavelengths in a continuous spectrum. For instance, the Landsat-5 satellite consists of 7 spectral bands:

1. Band 1 Visible (0.45 - 0.52 μm): 30 m resolution
2. Band 2 Visible (0.52 - 0.60 μm): 30 m resolution
3. Band 3 Visible (0.63 - 0.69 μm): 30 m resolution
4. Band 4 Near-Infrared (0.76 - 0.90 μm): 30 m resolution
5. Band 5 Near-Infrared (1.55 - 1.75 μm): 30 m resolution
6. Band 6 Thermal (10.40 - 12.50 μm): 120 m resolution
7. Band 7 Mid-Infrared (2.08 - 2.35 μm): 30 m resolution

3.3 The resolution of satellite data

There are four terms used to define the resolution of satellite data:

1. temporal resolution: the revisit time of the satellite over the same area of the Earth's surface. With increasing temporal resolution, more frequent monitoring of an area becomes possible.

2. spatial resolution: the capability of a sensor to distinguish two closely spaced objects on the target surface as two different objects. With increasing spatial resolution, smaller objects become discernible.

3. spectral resolution: the sensing and recording power of a sensor in different bands of electromagnetic radiation. With increasing spectral resolution, more frequency bands (or colours) become discernible in the image.

4. radiometric resolution: the capability of a sensor to discern radiance differences. Higher radiometric resolution images have more bits in their DN values.

For instance, the Landsat 7 data has eight spectral bands with spatial resolutions ranging from 15 to 60 meters, and a temporal resolution of 16 days. It provides 8-bit images.

3.4 The Landsat program

The Landsat program is the longest-running program for the acquisition of satellite imagery of the Earth. It began on July 23, 1972, when the Earth Resources Technology Satellite (Landsat-1) was launched with a multispectral sensor comprising four bands: green, red, and two bands of infrared. Landsat 8, the most recent addition, was launched on February 11, 2013.

The Landsat images are accessible through the USGS 'Earth Explorer' website, and have been used in agriculture, map-making, geology, forestry, planning, surveillance, education and other applications.

3.5 Interpretation of satellite imagery

Interpretation refers to the process of extraction of qualitative and quantitative information about the object under study. Satellite imagery can be interpreted through

1. visual interpretation methods
2. digital image processing techniques.

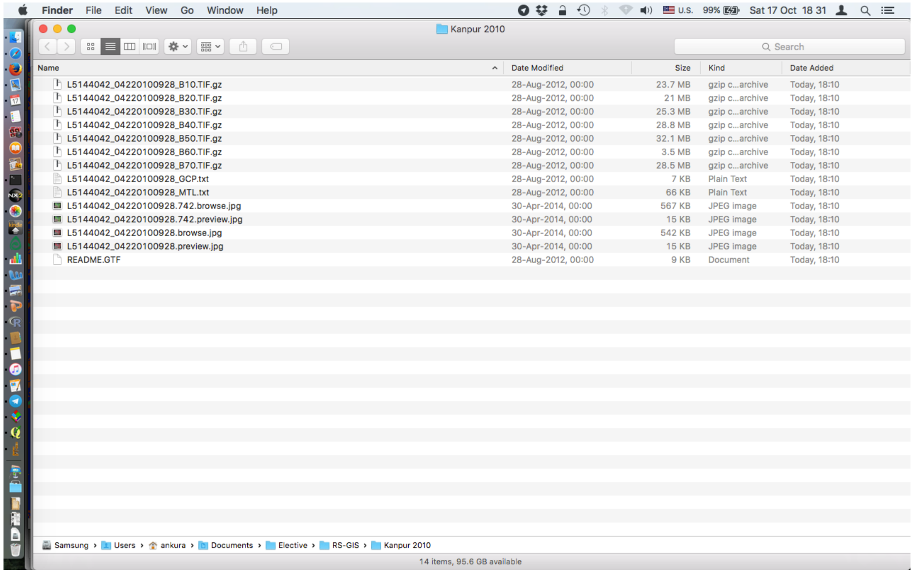
The method of visual interpretation is a manual exercise in which the multi-spectral data from satellites is converted into a human-readable RGB image through the process of layer stacking. Then the objects in the image are discerned and analysed using

1. image characteristics of tone, colour, shape, size, pattern, texture and shadow
2. terrain characteristics of location and association.

In the digital image processing method, a computer analyses the image based on certain algorithms to classify objects into different groups such as forests, agricultural fields, water, habitation, etc. using unsupervised, supervised and semi-supervised classification methods. We shall discuss unsupervised classification in chapter 5.

3.6 Steps to be followed

1. The downloaded items (see chapter 2) consist of several compressed (.gz files) and uncompressed (.txt, .jpg, .GTF) files (Figure 3.1).



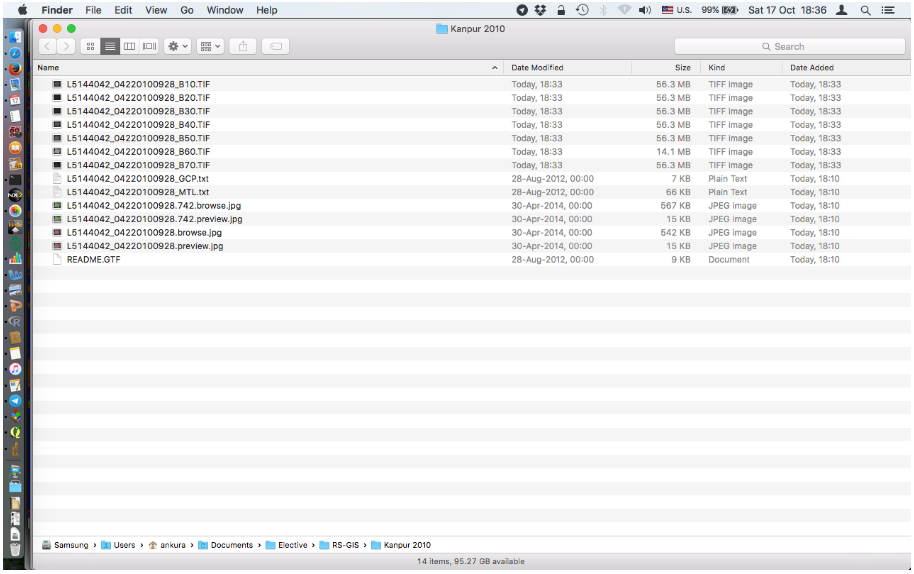
Name	Date Modified	Size	Kind	Date Added
L5144042_04220100928_B10.TIF.gz	28-Aug-2012, 00:00	23.7 MB	gzip c...archive	Today, 18:10
L5144042_04220100928_B20.TIF.gz	28-Aug-2012, 00:00	21 MB	gzip c...archive	Today, 18:10
L5144042_04220100928_B30.TIF.gz	28-Aug-2012, 00:00	25.3 MB	gzip c...archive	Today, 18:10
L5144042_04220100928_B40.TIF.gz	28-Aug-2012, 00:00	28.8 MB	gzip c...archive	Today, 18:10
L5144042_04220100928_B50.TIF.gz	28-Aug-2012, 00:00	32.1 MB	gzip c...archive	Today, 18:10
L5144042_04220100928_B60.TIF.gz	28-Aug-2012, 00:00	3.5 MB	gzip c...archive	Today, 18:10
L5144042_04220100928_B70.TIF.gz	28-Aug-2012, 00:00	28.5 MB	gzip c...archive	Today, 18:10
L5144042_04220100928_GCP.txt	28-Aug-2012, 00:00	7 KB	Plain Text	Today, 18:10
L5144042_04220100928_MTL.txt	28-Aug-2012, 00:00	66 KB	Plain Text	Today, 18:10
L5144042_04220100928.742.browse.jpg	30-Apr-2014, 00:00	567 KB	JPEG image	Today, 18:10
L5144042_04220100928.742.preview.jpg	30-Apr-2014, 00:00	15 KB	JPEG image	Today, 18:10
L5144042_04220100928.browse.jpg	30-Apr-2014, 00:00	542 KB	JPEG image	Today, 18:10
L5144042_04220100928.preview.jpg	30-Apr-2014, 00:00	15 KB	JPEG image	Today, 18:10
README.GTF	28-Aug-2012, 00:00	9 KB	Document	Today, 18:10

14 items, 95.6 GB available

Figure 3.1: The downloaded files

2. Uncompress the compressed files and delete the compressed versions (Figure 3.2). We won't require the compressed files now.

3. Different satellites have carried different sensors. The Landsat 1, 2, and 3 satellites have carried the Multispectral Scanner (MSS) sensor; the Landsat 4 and 5 satellites have carried both the MSS and the Thematic Mapper (TM) sensors; and the Landsat 7 satellites have carried the Enhanced Thematic Mapper Plus (ETM+) sensor.



Name	Date Modified	Size	Kind	Date Added
L5144042_04220100928_B10.TIF	Today, 18:33	56.3 MB	TIFF image	Today, 18:33
L5144042_04220100928_B20.TIF	Today, 18:33	56.3 MB	TIFF image	Today, 18:33
L5144042_04220100928_B30.TIF	Today, 18:33	56.3 MB	TIFF image	Today, 18:33
L5144042_04220100928_B40.TIF	Today, 18:33	56.3 MB	TIFF image	Today, 18:33
L5144042_04220100928_B50.TIF	Today, 18:33	56.3 MB	TIFF image	Today, 18:33
L5144042_04220100928_B60.TIF	Today, 18:33	14.1 MB	TIFF image	Today, 18:33
L5144042_04220100928_B70.TIF	Today, 18:33	56.3 MB	TIFF image	Today, 18:33
L5144042_04220100928_GCP.txt	28-Aug-2012, 00:00	7 KB	Plain Text	Today, 18:10
L5144042_04220100928_MTL.txt	28-Aug-2012, 00:00	66 KB	Plain Text	Today, 18:10
L5144042_04220100928.742.browse.jpg	30-Apr-2014, 00:00	567 KB	JPEG image	Today, 18:10
L5144042_04220100928.742.preview.jpg	30-Apr-2014, 00:00	15 KB	JPEG image	Today, 18:10
L5144042_04220100928.browse.jpg	30-Apr-2014, 00:00	542 KB	JPEG image	Today, 18:10
L5144042_04220100928.preview.jpg	30-Apr-2014, 00:00	15 KB	JPEG image	Today, 18:10
README.GTF	28-Aug-2012, 00:00	9 KB	Document	Today, 18:10

Figure 3.2: The uncompressed files

The Readme file provides a wealth of information, and is worth looking into. The file naming convention for Landsat LPGS-processed GeoTIFF data is as follows:

LLfppprrr_rrrYYYYMMDD_AAA.TIF

where

(a) LL = Landsat sensor (LE for ETM+ data; LT for TM data)

(b) f = ETM+ data format (1, 2, or G) (character omitted from TM file name)

(c) ppp = starting path of the product

(d) rrr_rrr = starting and ending rows of the product

(e) YYYYMMDD = acquisition date of the image

(f) AAA = file type

  i. B10 = band 1
  ii. B20 = band 2
  iii. B30 = band 3
  iv. B40 = band 4
  v. B50 = band 5
  vi. B61 = band 6L (low gain)
  vii. B62 = band 6H (high gain)
  viii. B70 = band 7
  ix. B80 = band 8
  x. MTL = Level-1 metadata
  xi. GCP = ground control points

(g) TIF = GeoTIFF file extension

The file naming convention for Landsat NLAPS-processed GeoTIFF data is as follows:

LLNppprrrOOYYDDDMM_AA.TIF

where

(a) LL = Landsat sensor (LM for MSS data; LT for TM data)

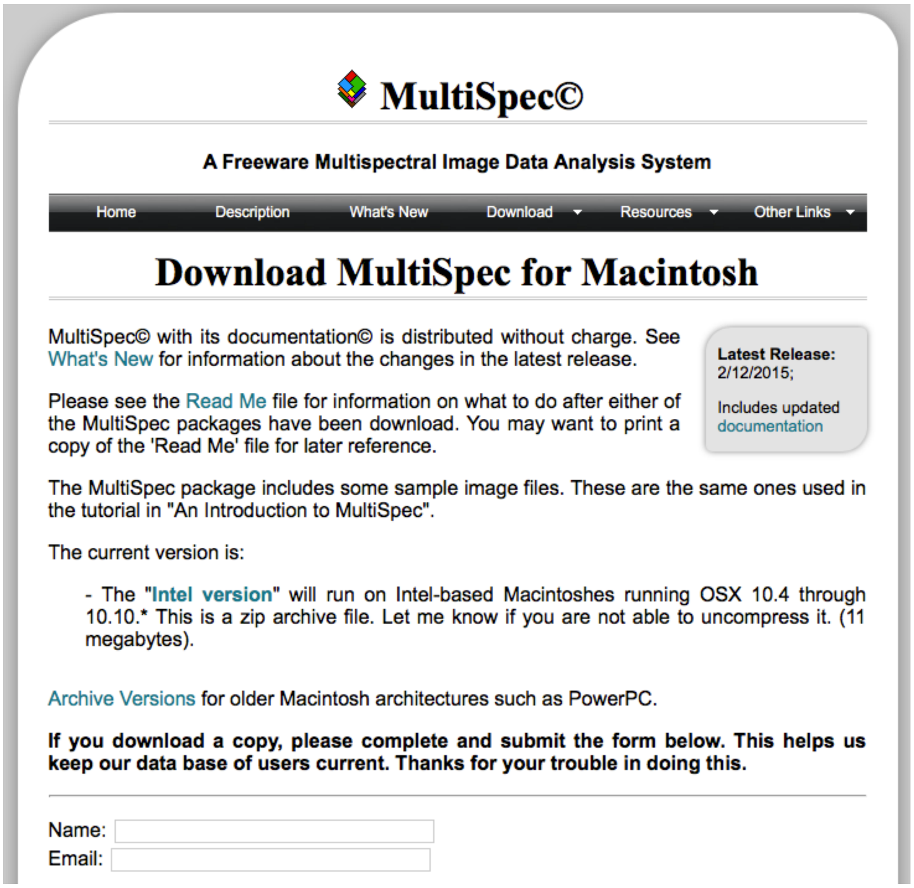
(b) N = satellite number

(c) ppp = starting path of the product

   (d) rrr = starting row of the product
   (e) OO = WRS row offset (set to 00)
   (f) YY = last two digits of the year of acquisition
   (g) DDD = Julian date of acquisition
   (h) MM = instrument mode (10 for MSS; 50 for TM)
   (i) AA = file type:
      i. B1 = band 1
      ii. B2 = band 2
      iii. B3 = band 3
      iv. B4 = band 4
      v. B5 = band 5
      vi. B6 = band 6
      vii. B7 = band 7
      viii. WO = processing history file
   (j) TIF = GeoTIFF file extension

4. Download the Multispec software from https://engineering.purdue.edu/~biehl/MultiSpec/download_mac.html and install it (Figure 3.3).

   MultiSpec is a freely available cross-platform multispectral image data analysis system. This system is hosted by the Laboratory for Applications of Remote Sensing at Purdue University, and funded by NASA grants.



A Freeware Multispectral Image Data Analysis System

Download MultiSpec for Macintosh

MultiSpec© with its documentation© is distributed without charge. See What's New for information about the changes in the latest release.

Please see the Read Me file for information on what to do after either of the MultiSpec packages have been download. You may want to print a copy of the 'Read Me' file for later reference.

Latest Release: 2/12/2015;

Includes updated documentation

The MultiSpec package includes some sample image files. These are the same ones used in the tutorial in "An Introduction to MultiSpec".

The current version is:

- The "**Intel version**" will run on Intel-based Macintoshes running OSX 10.4 through 10.10.* This is a zip archive file. Let me know if you are not able to uncompress it. (11 megabytes).

Archive Versions for older Macintosh architectures such as PowerPC.

If you download a copy, please complete and submit the form below. This helps us keep our data base of users current. Thanks for your trouble in doing this.

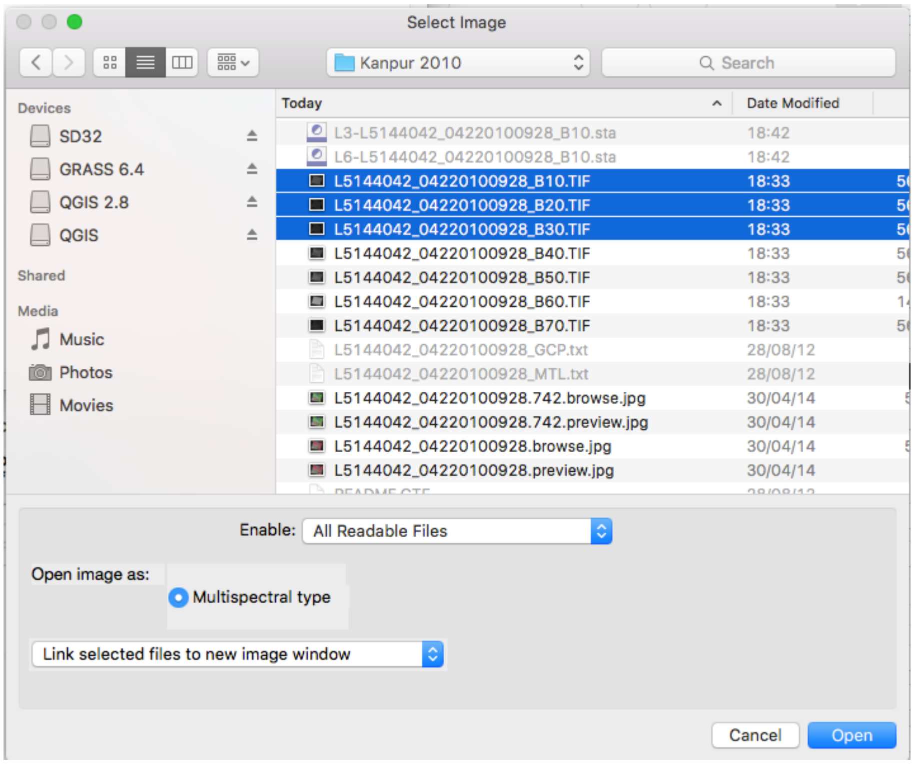
Name:
Email:

Figure 3.3: The homepage of Multispec

5. Launch the app. Open images for bands 1, 2 and 3 by File → Open Image; choosing TIF files ending in B10, B20 and B30 and pressing “Open” (Figure 3.4).

6. The display specifications window opens (Figure 3.5). The window is divided into three parts:

   (a) Area to display: Here we can crop the image



Enable: All Readable Files

Open image as: ● Multispectral type

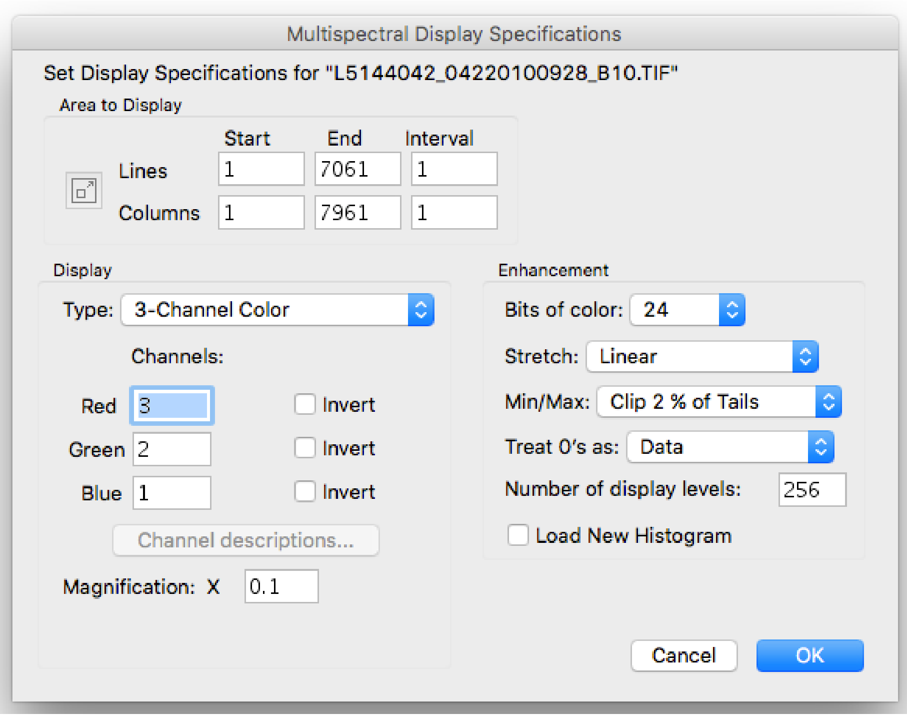
Link selected files to new image window

Figure 3.4: Opening requisite bands

(b) Display: Here we can change the type of display, the channels for R-G-B, and the magnification factor for display

(c) Enhancement: Here we can enhance the image using stretching, clipping and other ways.

7. Keeping default settings, press "OK". This creates a true colour composite image of the location (Figure 3.6). A true colour composite is one where red data is represented in red channel, green data is represented in green channel and blue data is represented in blue channel. Thus, it provides a human-vision-like representation of the satellite data.



Multispectral Display Specifications

Set Display Specifications for "L5144042_04220100928_B10.TIF"

Area to Display

	Start	End	Interval
Lines	1	7061	1
Columns	1	7961	1

Display

Type: 3-Channel Color

Channels:

Red 3 ☐ Invert

Green 2 ☐ Invert

Blue 1 ☐ Invert

Magnification: X 0.1

Enhancement

Bits of color: 24

Stretch: Linear

Min/Max: Clip 2 % of Tails

Treat 0's as: Data

Number of display levels: 256

☐ Load New Histogram

Figure 3.5: The display specifications window

8. To enhance the image, the stretching can be changed from linear (default) to Equal Area or Gaussian using Processor → Display Image... and changing stretch options (Figure 3.7).

9. Now create a standard false colour composite (fcc) image by opening bands 4, 3, 2 in RGB channels, respectively (Figure 3.8). The standard false colour composite represents near infrared data in red channel, red data in green channel and green data in blue channel. Such processing helps in interpreting certain information regarding vegetation. For instance, since chlorophyll shows strong reflectance in near infrared part

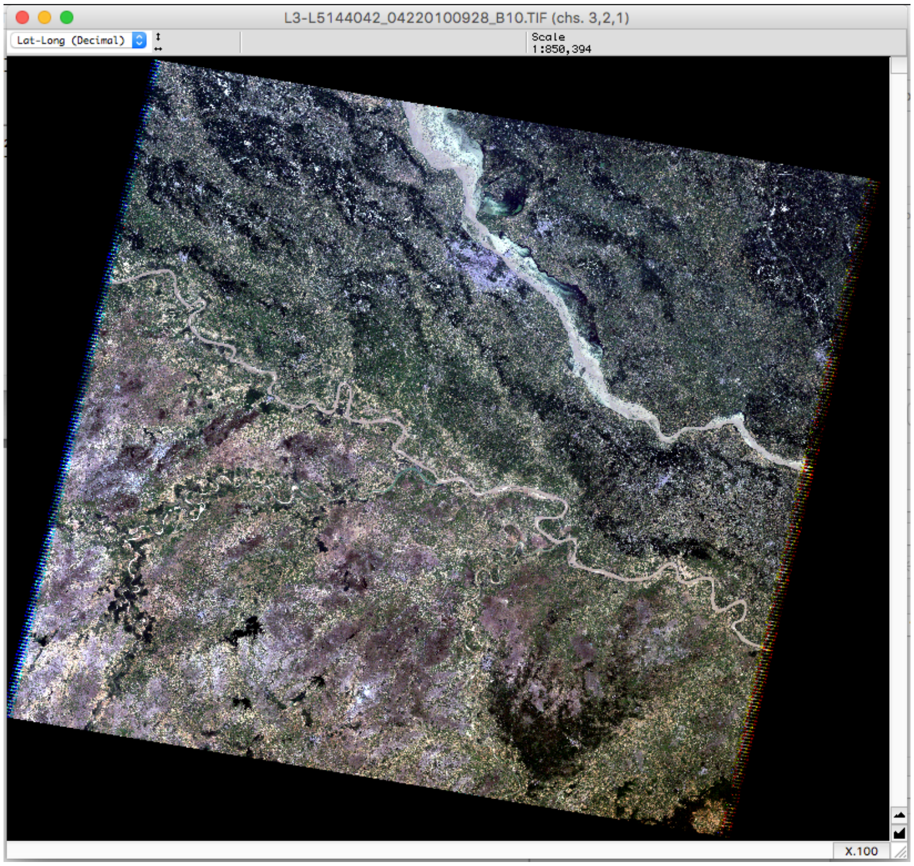
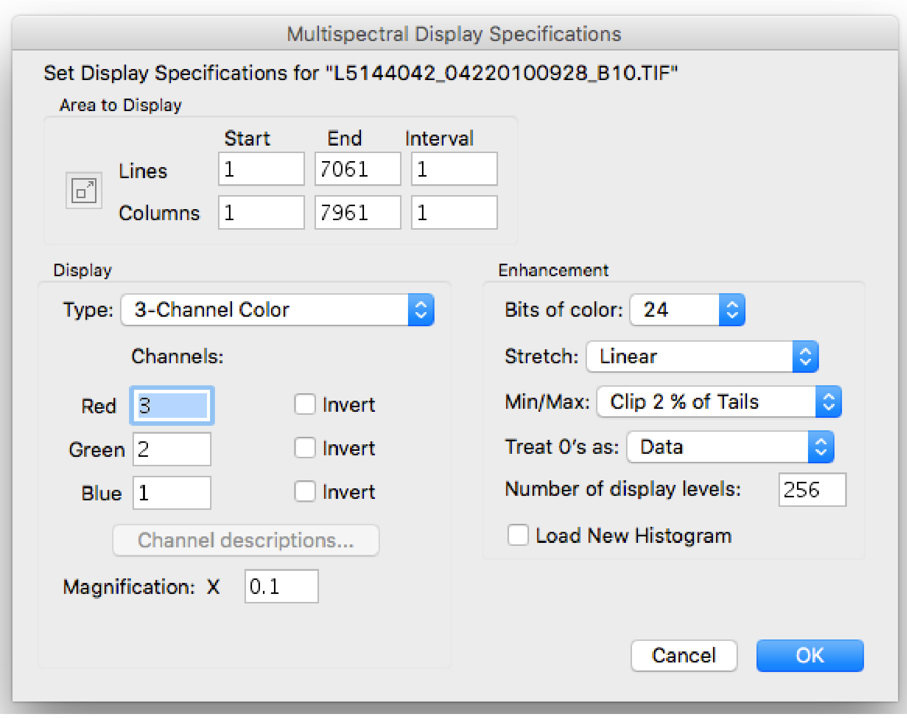


Figure 3.6: True colour composite image

of the spectrum, areas represented by red colour in the standard fcc image are rich in green vegetation. This information would not have been represented in the true colour composite, since it does not display information in the near infrared band which is invisible to the human eye.

10. Save images as composites by File → Save Image to GeoTIFF As... (Figure 3.9).



Multispectral Display Specifications

Set Display Specifications for "L5144042_04220100928_B10.TIF"

Area to Display

	Start	End	Interval
Lines	1	7061	1
Columns	1	7961	1

Display

Type: 3-Channel Color

Channels:

Red 3 ☐ Invert
Green 2 ☐ Invert
Blue 1 ☐ Invert

Magnification: X 0.1

Enhancement

Bits of color: 24
Stretch: Linear
Min/Max: Clip 2 % of Tails
Treat 0's as: Data
Number of display levels: 256
☐ Load New Histogram

Figure 3.7: Altering stretch options

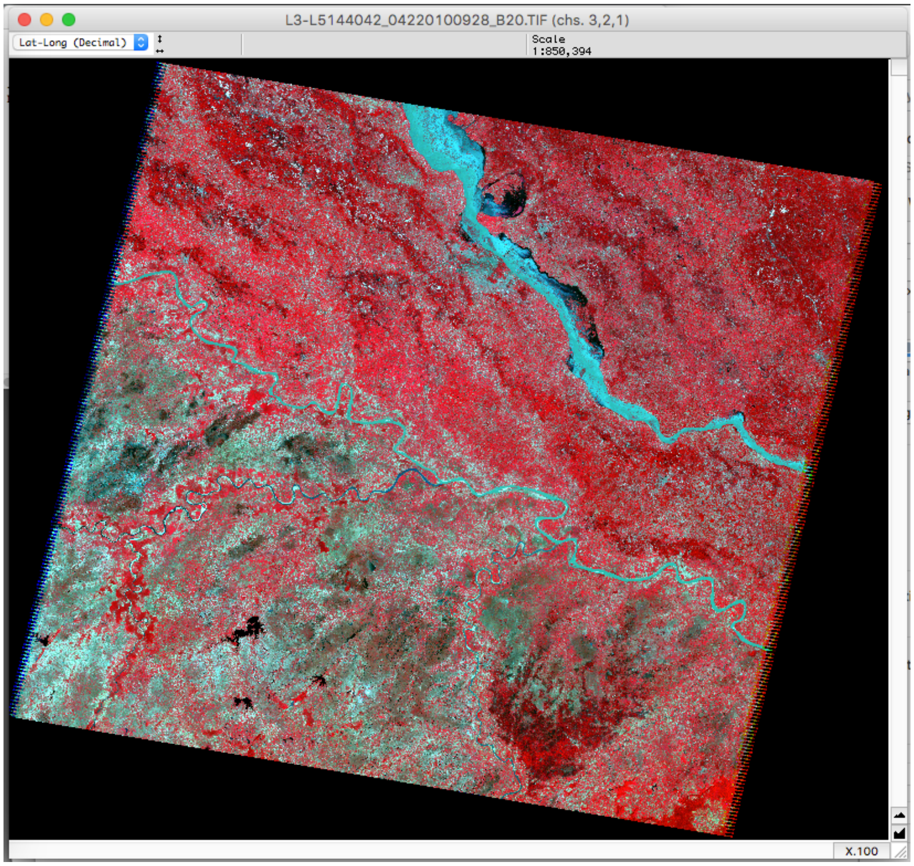
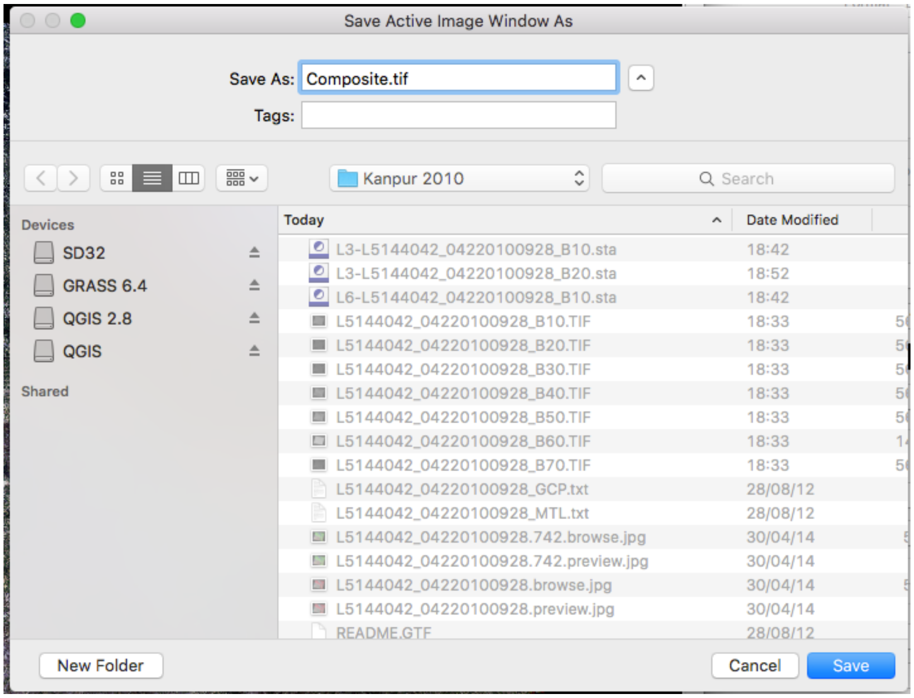


Figure 3.8: False colour composite image



Save As: Composite.tif

Tags:

Today	Date Modified
L3-L5144042_04220100928_B10.sta	18:42
L3-L5144042_04220100928_B20.sta	18:52
L6-L5144042_04220100928_B10.sta	18:42
L5144042_04220100928_B10.TIF	18:33
L5144042_04220100928_B20.TIF	18:33
L5144042_04220100928_B30.TIF	18:33
L5144042_04220100928_B40.TIF	18:33
L5144042_04220100928_B50.TIF	18:33
L5144042_04220100928_B60.TIF	18:33
L5144042_04220100928_B70.TIF	18:33
L5144042_04220100928_GCP.txt	28/08/12
L5144042_04220100928_MTL.txt	28/08/12
L5144042_04220100928.742.browse.jpg	30/04/14
L5144042_04220100928.742.preview.jpg	30/04/14
L5144042_04220100928.browse.jpg	30/04/14
L5144042_04220100928.preview.jpg	30/04/14
README.GTF	28/08/12

Figure 3.9: Saving the composite image

Chapter 4

NDVI

4.1 Introduction

Plants use solar radiation (white light) as part of the photosynthesis reaction to produce food. In this process, the red and blue ends of the spectrum get absorbed, and most of the rest gets reflected. Thus, green plants look green, which is the dominant colour of the reflected radiation. We have also discussed in chapter 3 that green vegetation has a strong reflectance signature in the near infrared band (700 nm to 1,100 nm). NDVI (normalised difference vegetation index) is an index that accentuates this vegetation signature of high reflectance in near infrared band and low reflectance in red band by using a ratio of difference and addition of data in NIR and Red bands. It was first used by Rouse, Haas, Schell, and Deering in 1973 to monitor vegetation systems in the Great Plains with ERTS. The index is defined as:

$$NDVI = \frac{NIR - Red}{NIR + Red} \tag{4.1}$$

where NIR = reflected radiation in near infrared band

and Red = reflected radiation in red band

4.2 Use of NDVI

NDVI provides a measure of vegetation density and condition. The values can, in theory, range between -1 and +1. Vegetation NDVI is typically from 0.1 up to 0.7, with higher values associated with greater canopy density and greenness (health). NDVI decreases under conditions of disease, water stress or death. Bare soil and snow have NDVI values that are close to zero, since they have a much more even reflectance across the light spectrum. Water bodies have negative values of NDVI.

Since NDVI is a ratio of data from two bands, it helps compensate for differences in illumination within an image (due to slope and aspect), and for differences between images (due to time of day or season of image acquisition). Thus, NDVI makes it possible to compare images over time to look for ecologically significant changes in the net primary productivity, canopy cover, bare ground cover and the health of vegetation. In the context of ecology, values less than zero do not have any ecological meaning, and the range of the index is truncated. It varies from 0 to +1.

NDVI has been used in assessing and monitoring various factors, including

1. changes in plant phenology over time
2. vegetation and land use classification
3. biomass production
4. impact of grazing
5. amount of moisture in soil
6. carbon sequestration potential of an area.

4.3 NDVI and Landsat

In the Landsat images, the NIR band is represented by band 4, and the Red band is represented by band 3. This information should be kept in mind while performing the exercise in this chapter.

4.4 Steps to be followed

1. In Multispec, open the FCC image created in Chapter 3. (Figure 4.1).

2. Click on Processor → Reformat → Change Image File Format... (Figure 4.2).

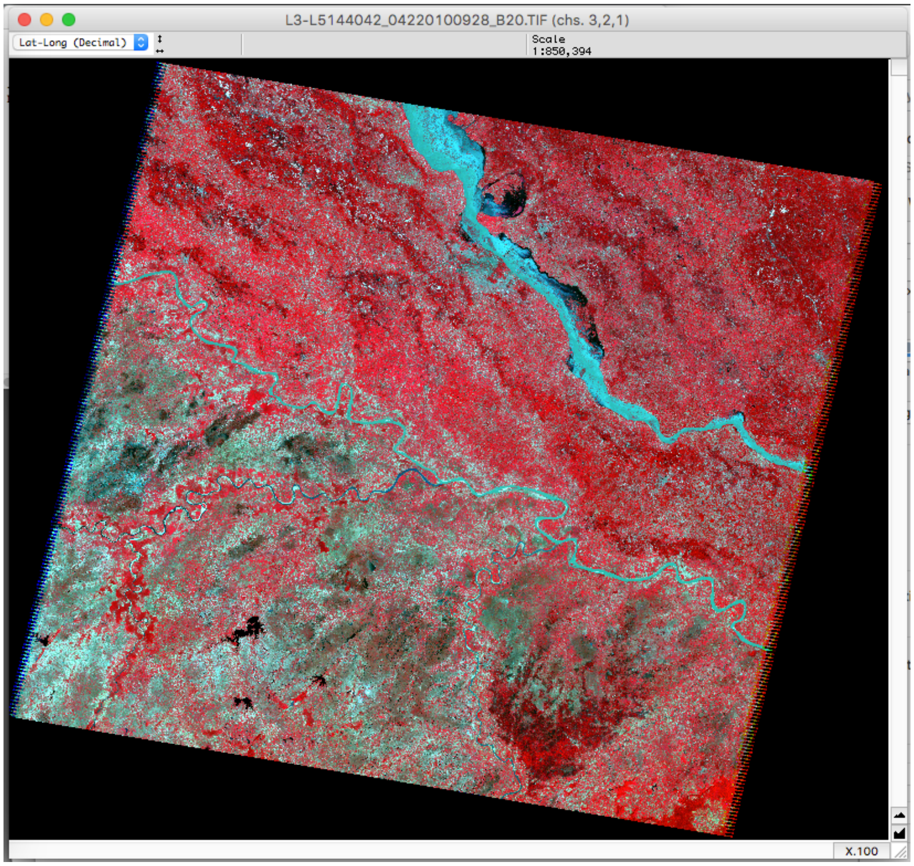


Figure 4.1: False colour composite image

3. Click "Transform Data..." A new window opens that permits setting of the reformat transform parameters (Figure 4.3). In this window, we can adjust selected channels, adjust selected channels by selected (another) channel, generate a new channel from a general algebraic transformation, generate a new channel from a function, or exit without doing any transformations.

4. Select "New Channel from General Algebraic Transformation". The

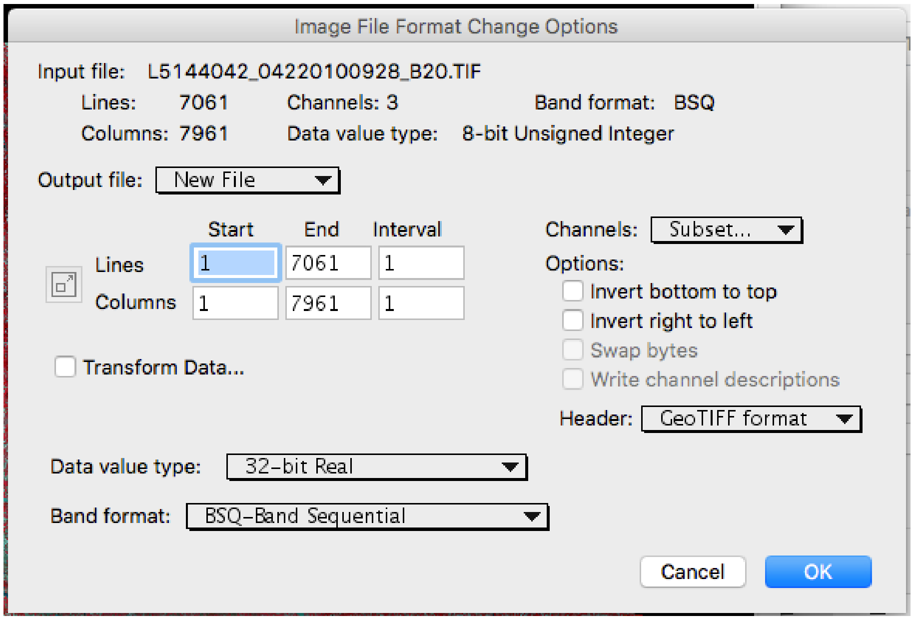


Image File Format Change Options

Input file: L5144042_04220100928_B20.TIF
Lines: 7061 Channels: 3 Band format: BSQ
Columns: 7961 Data value type: 8-bit Unsigned Integer

Output file: New File

	Start	End	Interval
Lines	1	7061	1
Columns	1	7961	1

☐ Transform Data...

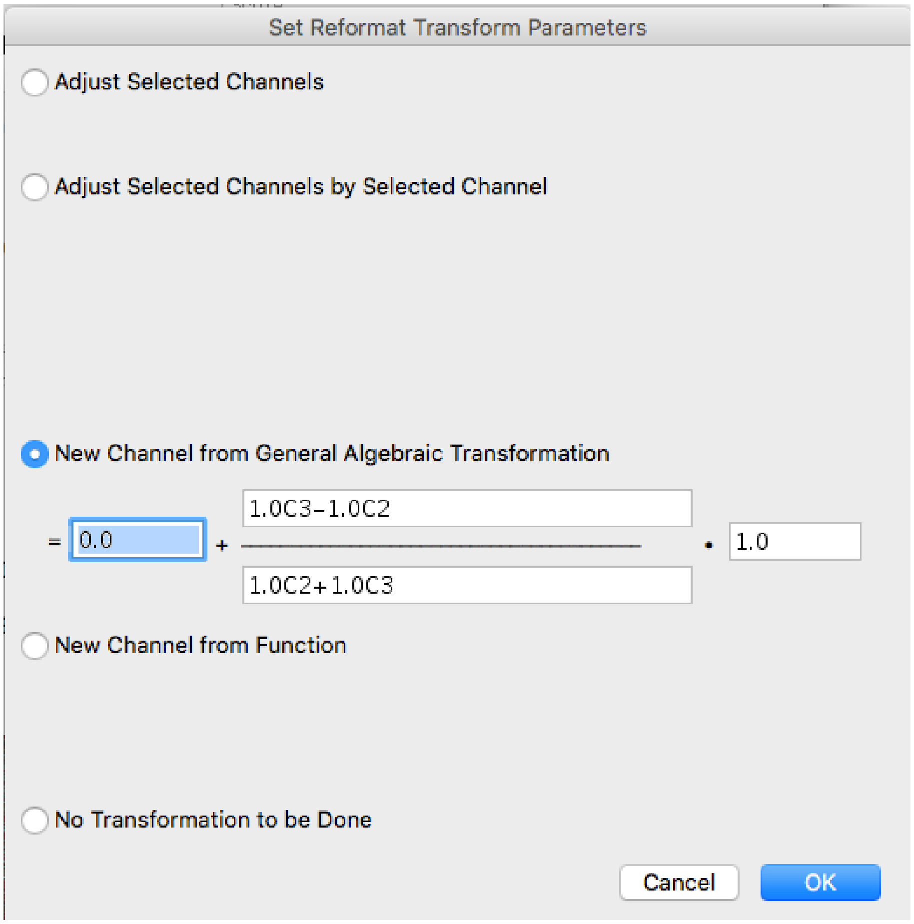
Channels: Subset...
Options:
☐ Invert bottom to top
☐ Invert right to left
☐ Swap bytes
☐ Write channel descriptions
Header: GeoTIFF format

Data value type: 32-bit Real
Band format: BSQ–Band Sequential

Figure 4.2: Reformatting the image

default equation subtracts band 2 (Red) from band 3 (NIR), divides the value so obtained by their sum, multiplies this value with 1 and adds 0. Thus, we can appreciate that it is the NDVI calculator. Click "OK" twice. Next the software would ask to save the new image file; save it as NDVI.tif at some location (Figure 4.4).

The image displays the area as a varying function of vegetation, with NDVI values increasing as we move from 0 (black) to 255 (white). Thus, the regions with no vegetation look black, while those with vegetation are shown as varying shades of grey and white (Figure 4.5).



Set Reformat Transform Parameters

○ Adjust Selected Channels

○ Adjust Selected Channels by Selected Channel

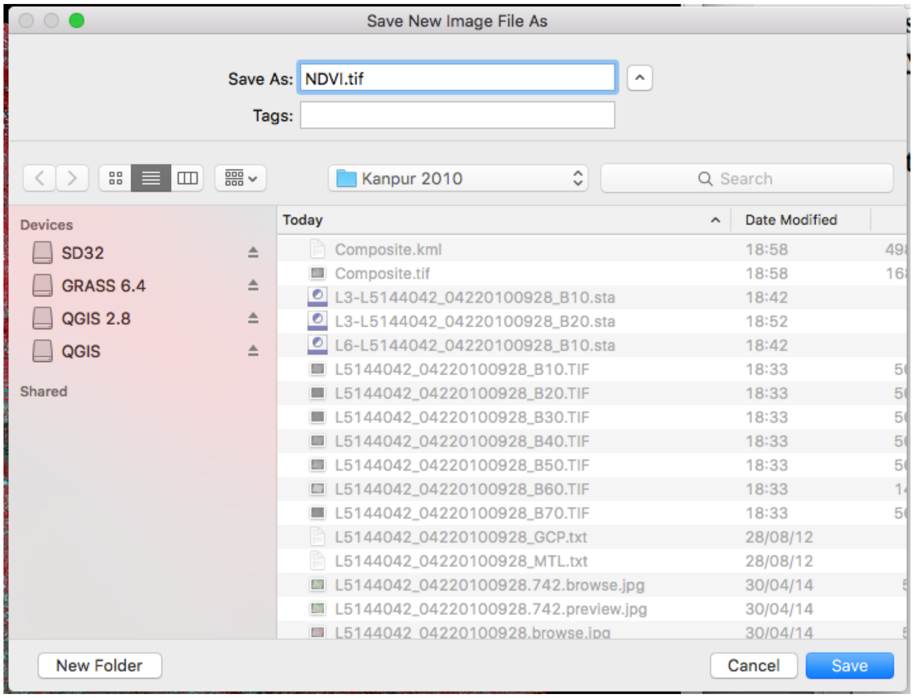
● New Channel from General Algebraic Transformation

$$= 0.0 + \frac{1.0C3-1.0C2}{1.0C2+1.0C3} \cdot 1.0$$

○ New Channel from Function

○ No Transformation to be Done

Figure 4.3: Setting the reformat transform parameters



Save As: NDVI.tif

Tags:

Today	Date Modified
Composite.kml	18:58
Composite.tif	18:58
L3-L5144042_04220100928_B10.sta	18:42
L3-L5144042_04220100928_B20.sta	18:52
L6-L5144042_04220100928_B10.sta	18:42
L5144042_04220100928_B10.TIF	18:33
L5144042_04220100928_B20.TIF	18:33
L5144042_04220100928_B30.TIF	18:33
L5144042_04220100928_B40.TIF	18:33
L5144042_04220100928_B50.TIF	18:33
L5144042_04220100928_B60.TIF	18:33
L5144042_04220100928_B70.TIF	18:33
L5144042_04220100928_GCP.txt	28/08/12
L5144042_04220100928_MTL.txt	28/08/12
L5144042_04220100928.742.browse.jpg	30/04/14
L5144042_04220100928.742.preview.jpg	30/04/14
L5144042_04220100928.browse.jpg	30/04/14

Figure 4.4: Saving the NDVI result

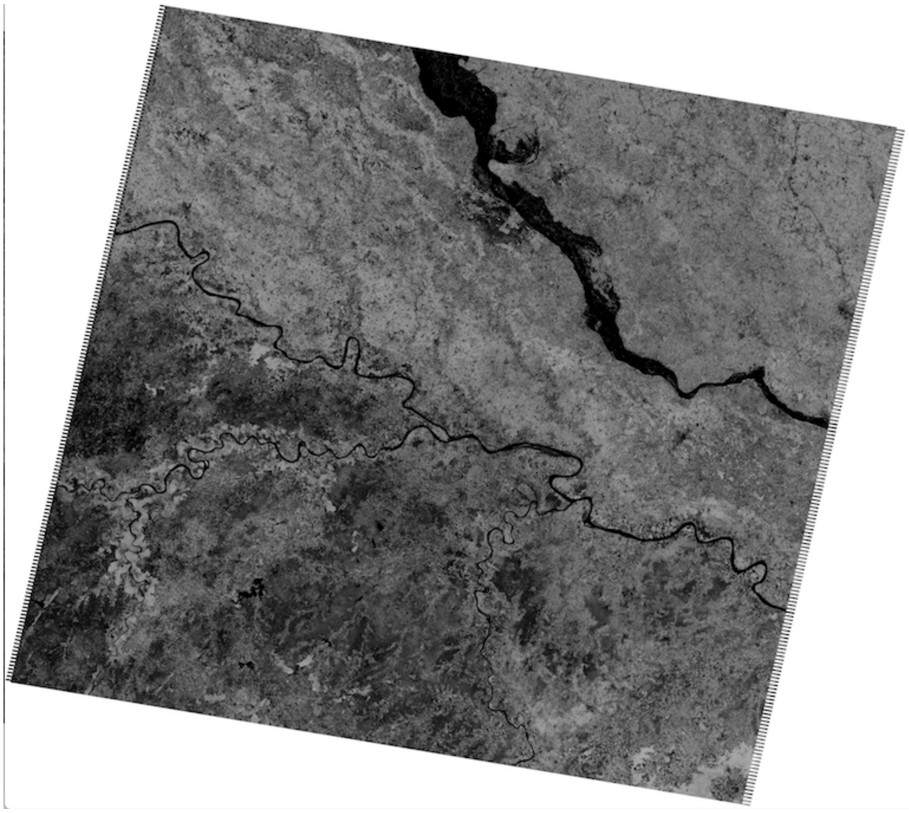


Figure 4.5: The NDVI result

Chapter 5

Unsupervised classification and change detection

5.1 Digital image classification

We use satellite remote sensing to gather data in the form of images, and then interpret those images to identify and classify features as an aid to administration, planning, management and research. Images are built up of several pixels. Image classification is the set of techniques that group individual pixels, based on their reflectance statistics, to identify and represent various land cover features such as forests, agricultural land, water, mountains, urban settlements, bare land, etc. While earlier classifications done on low resolution images were pixel-based and done manually, today the vast amounts of data being processed demand computerised and automated digital image classification of high resolution image data.

5.2 Kinds of digital image classification techniques

The digital image classification techniques in use today fall under two broad categories:

1. unsupervised image classification (calculated by the computer)
2. supervised (human-guided) image classification.

At times, a combination of these techniques may also be employed, which is referred to as semi-supervised image classification.

5.2.1 Unsupervised image classification

The unsupervised image classification requires two steps of operation:

1. generation of clusters
2. assignment of classes to different clusters.

It is called an unsupervised image classification because the first step, generation of clusters is done automatically by the computer without any human involvement. At the outset, we lay down the number of clusters to be created, and the computer creates those clusters based on differences in reflectance values of different channels across the image. After that, all the individual pixels in the image are compared to each discrete cluster in the image to identify the cluster to which the pixels are the closest. They then become a part of those clusters. K-means and ISODATA are two commonly employed clustering algorithms. The success of clustering is measured by comparing the "between cluster" variability with the "within cluster" variability; greater success emanates from maximising the former and minimising the latter.

After clustering, the program generates a map of all the pixels in the image as classified into different clusters. These clusters are then interpreted by the human user to identify the meaning of different colour patterns in the map, thus designating various classes. Several clusters may be part of a single class; however, all the pixels in one cluster must be in one class only, not more. The identification of classes requires a knowledge and understanding of the features and material constitution of different objects in the scene, from general experience or personal familiarity with the area imaged. For instance, a pond may appear to be land during lean season, but the human user, through an understanding of the climatic seasonality of the region, may manually designate it as a water body.

The objective of the exercise is to group the reflectance response patterns of a multi-band spectral image into statistically separable clusters, and to relate these clusters to meaningful ground categories. At times ground truthing may be required to validate the assigned categories. Unsupervised image classification technique is generally employed when adequate sample sites are unavailable for the application of a supervised image classification technique.

5.2.2 Supervised image classification

The supervised image classification requires three steps of operation:

1. selection of training areas
2. generation of signature files
3. classification of the image.

In supervised classification, the human user has adequate number of known pixels for each land cover class. He begins by selecting representative samples for each land cover class in the digital image by digitising a vector layer over the raster scene. These polygon samples are known as "training sites". Several polygons are created for each land use category. This ensures that the software has sufficient data available to create the representative spectral signatures of various land use classes.

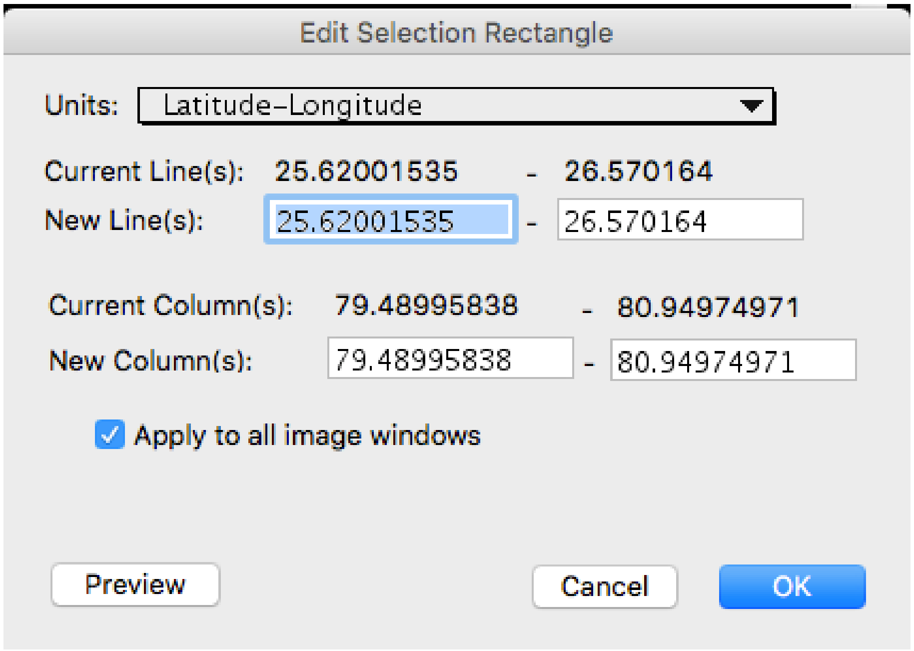
The software then utilises the spectral signatures of the training sites to identify and classify various land cover classes in the entire image. Maximum likelihood classification (MLC), minimum-distance classification (MDC), iso cluster classification, class probability and principal components analysis (PCA) algorithms are commonly employed in supervised image classifications. The MLC algorithm, for instance, describes each spectral class by a multivariate normal distribution, and uses mean vectors and multivariate spreads of each class to identify the elongated classes.

The supervised image classification technique is employed when adequate training sites are known through *a priori* field observations. We shall not be using this classification technique in the current module.

5.3 Steps to be followed

1. Open two images from the same area, but of different times.

2. Select the area of interest (AoI) by Edit → Selection Rectangle... (Figure 5.1).



Edit Selection Rectangle

Units: Latitude–Longitude

Current Line(s): 25.62001535 - 26.570164

New Line(s): 25.62001535 - 26.570164

Current Column(s): 79.48995838 - 80.94974971

New Column(s): 79.48995838 - 80.94974971

☑ Apply to all image windows

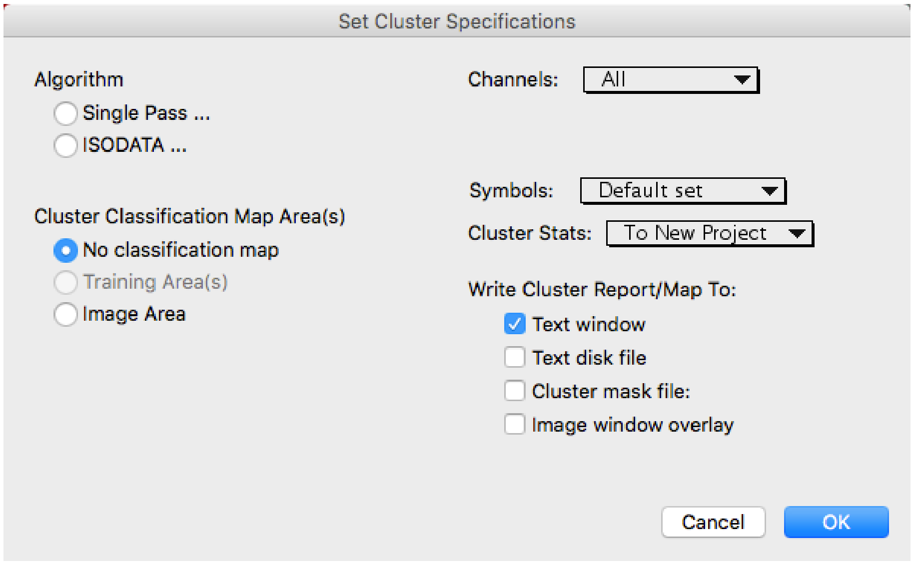
Figure 5.1: Selecting the area of interest (AoI)

3. Change units to "Latitude-Longitude". Enter values and select "Apply to all image windows". Press OK. The same area of interest is selected on both the images.

4. Subset the images by Processor → Reformat → Change Image File Format. Press OK in the dialog box and save the image. Do this for both the images.

5. Now open both the images.

6. To perform unsupervised classification, click Processor → Cluster (Figure 5.2).



Set Cluster Specifications

Algorithm
○ Single Pass ...
○ ISODATA ...

Cluster Classification Map Area(s)
● No classification map
○ Training Area(s)
○ Image Area

Channels: All

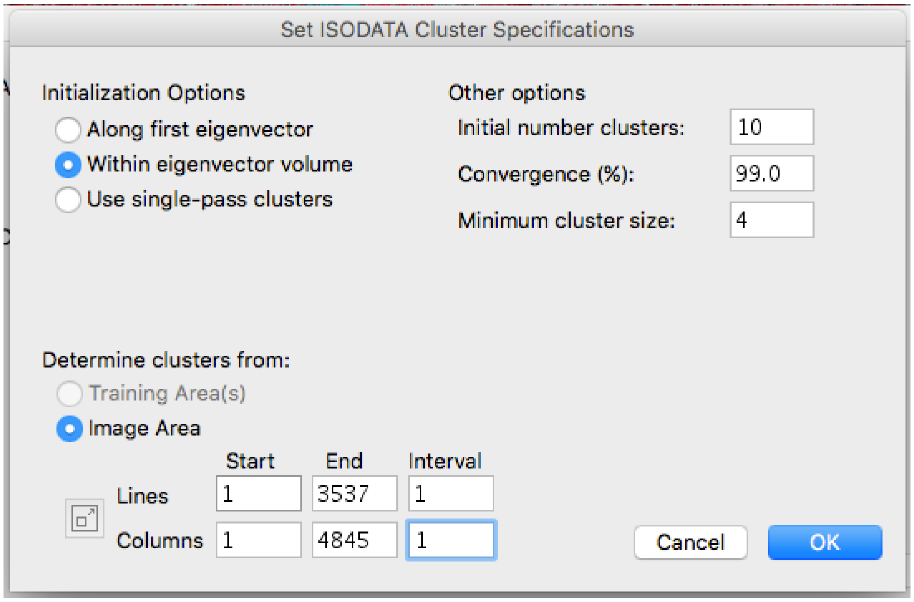
Symbols: Default set

Cluster Stats: To New Project

Write Cluster Report/Map To:
☑ Text window
☐ Text disk file
☐ Cluster mask file:
☐ Image window overlay

Figure 5.2: Setting cluster specifications

7. Select ISODATA algorithm. Change Lines and Columns interval to 1. Press OK (Figure 5.3).



Set ISODATA Cluster Specifications

Initialization Options

○ Along first eigenvector
● Within eigenvector volume
○ Use single-pass clusters

Other options

Initial number clusters: 10
Convergence (%): 99.0
Minimum cluster size: 4

Determine clusters from:

○ Training Area(s)
● Image Area

	Start	End	Interval
Lines	1	3537	1
Columns	1	4845	1

Figure 5.3: Setting ISODATA cluster specifications

8. Change Cluster Stats to "Do Not Save". Select Cluster mask file and Image window overlay. Press OK (Figure 5.4).

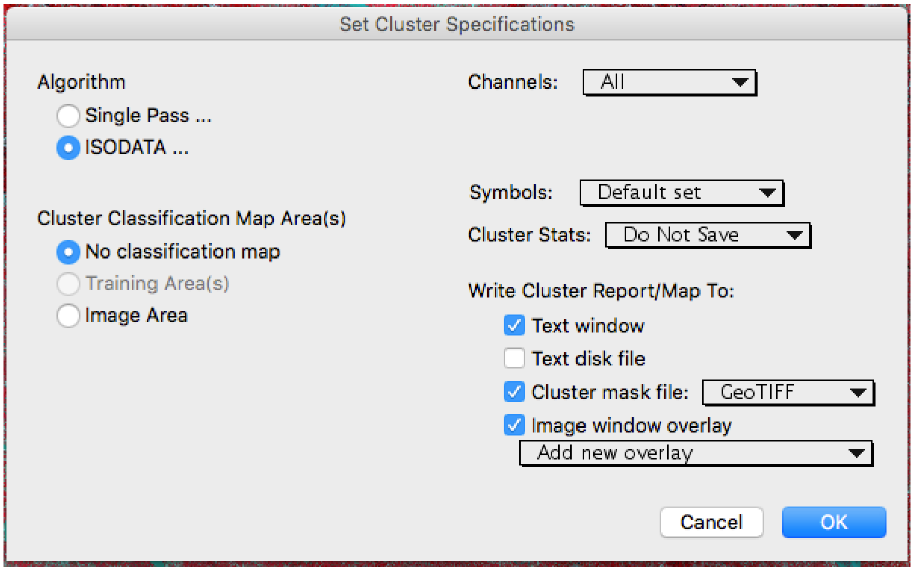
9. Save the result.

10. After the processing has finished, close the images.

11. Now open the subset image and the classified image together. For the original image, change channels by Processor → Display Image, and selecting channels as 1, 2 and 3.

12. In the classified image, change Classes to Groups/Classes on the top left of the window. (Figure 5.5).

13. To view a classified area, place the mouse pointer on a colour brick,



Set Cluster Specifications

Algorithm
○ Single Pass ...
● ISODATA ...

Cluster Classification Map Area(s)
● No classification map
○ Training Area(s)
○ Image Area

Channels: All
Symbols: Default set
Cluster Stats: Do Not Save

Write Cluster Report/Map To:
☑ Text window
☐ Text disk file
☑ Cluster mask file: GeoTIFF
☑ Image window overlay
Add new overlay

Figure 5.4: Setting cluster specifications

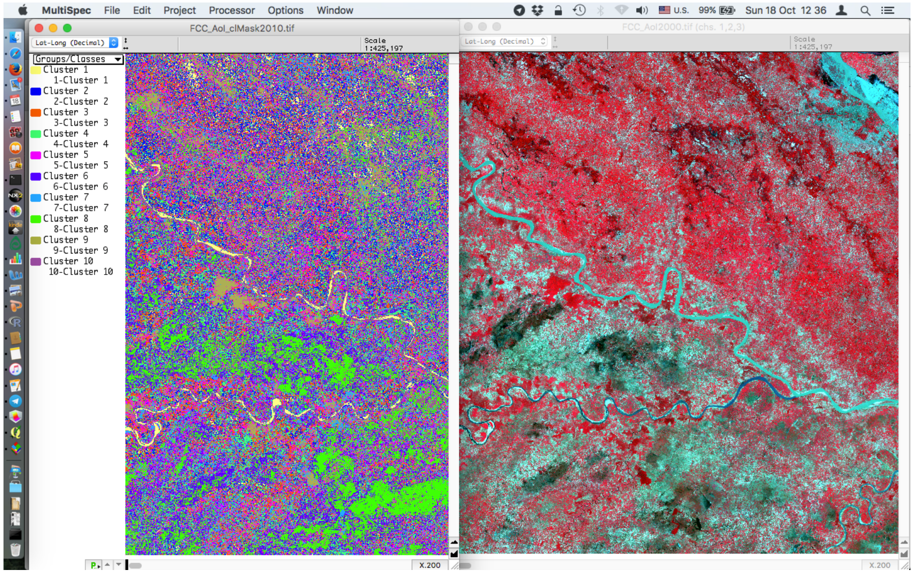


Figure 5.5: The classified image

and press the Shift key. The pointer changes to an eye. Click on the brick. This causes the selected area to blink. Compare with the original image to classify the land use as forest, agriculture, water, etc. In case two areas belong to the same group, drag and drop a class into its new group. The names and colours can be changed by double clicking on them (Figure 5.6). We traditionally depict forests in green, agricultural fields in yellow, water in blue and habitation and bare lands in cyan colours.

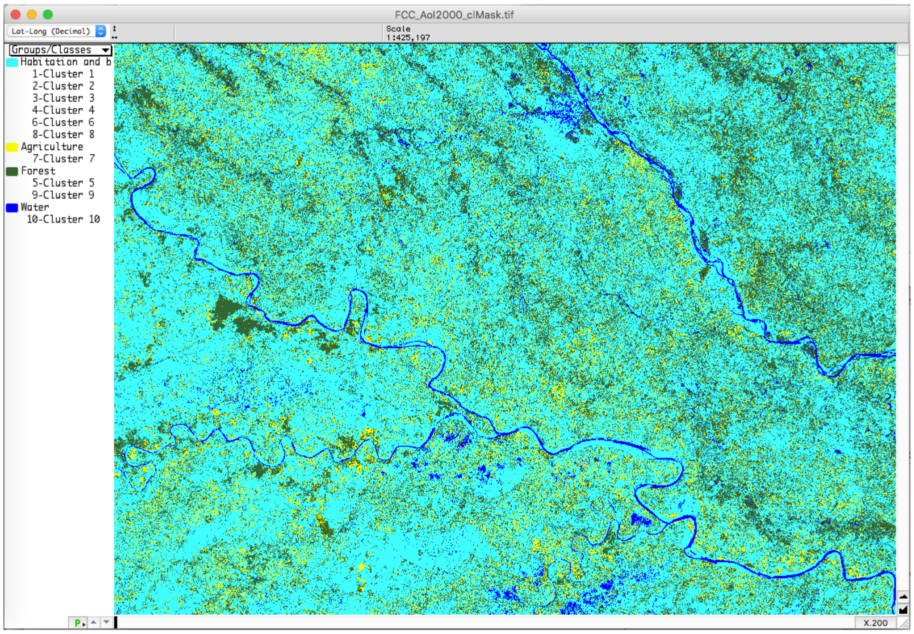


Figure 5.6: Grouping classes

14. View distribution of the areas into different groups by clicking Processor → List results... (Table 5.1).

15. Repeat for the image from another time to view the changes (Table 5.2).

Table 5.1: Output Information for the year 2000: Group distribution for the selected area

	Thematic Image Group	Number Samples	Percent	Area (Hectares)
1	Habitation and bare land	11,149,630	65.1	1,003,466.700
2	Agriculture	1,358,053	7.9	122,224.770
3	Forest	4,200,807	24.5	378,072.630
4	Water	428,275	2.5	38,544.750
	Total	17,136,765	100.0	1,542,308.850

Table 5.2: Output Information for the year 2010: Group distribution for the selected area

	Thematic Image Group	Number Samples	Percent	Area (Hectares)
1	Habitation and bare land	7,706,196	45.0	693,557.640
2	Agriculture	5,945,230	34.7	535,070.700
3	Forest	2,849,960	16.6	256,496.400
4	Water	635,379	3.7	57,184.110
	Total	17,136,765	100.0	1,542,308.850

In the example case, we can observe that the area under forests has decreased over time. The areas under habitation and bare land have also reduced, while those under agriculture have increased. While this might indicate a change in the land use pattern, it may also be due to the difference in the months when the images were acquired; with the year 2010 image having been acquired during the Kharif season of agriculture, while the year 2000 image having been acquired after the end of the Kharif season of agriculture. Thus, any information derived from the image classification techniques needs to be correlated with other empirical sources of information to reach logical conclusions.

Chapter 6

Georeferencing

6.1 What is georeferencing?

The ESRI GIS dictionary defines georeferencing as:

> "Aligning geographic data to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting, or orthorectifying the data."

In essence, georeferencing is the process of assigning real-world coordinates (latitude and longitude) to each pixel of a raster image, such as an aerial photograph, a scanned copy of a map or a toposheet.

The coordinates can be collected through field surveys by collecting the coordinates of a few identifiable features (called ground control points or

GCPs for short) in the image using a GPS device, or from already existing markings on the scanned copy of maps or toposheets. Using the coordinates, the entire image is warped and transformed to fit within the chosen coordinate system.

The relevant coordinate transforms applied to the image are stored within the image file, as in a GeoTIFF image used in these exercises, or in a separate file.

6.2 Uses of georeferencing

Georeferencing of a digital image enhances its utility for several purposes, such as:

1. Mapping operations: Georeferencing allocates GPS coordinates to aerial and satellite imageries, after which they can readily be transformed into maps.

2. Studies of temporal variations at sites: By allocating GPS coordinates to scanned copies of old maps and toposheets, we can overlap them and study the changes that have come about with the passage of time.

3. Rationalisation of maps with different projection systems: Georeferencing performs several geometrical operations on an image: shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting, or orthorectification. After these operations, combination and overlay-

ing of maps made with different projection systems (such as conical, cylindrical equal area projection, Mercator's projection, etc.) becomes possible with minimum distortion.

4. Georeferencing permits the identification of points of reference from total station surveys in the existing maps.
5. Social and epidemiological studies: Various surveys collect data regarding family sizes, political orientations, gender ratios, or the incidence of diseases from different locations. These locations may be noted as GPS coordinates, postal codes, street addresses, *mohalla* names, etc. Such information can readily be depicted on a georeferenced map, facilitating their analysis for administrative, planning, research or epistemological purposes.

In this module, we shall use the QGIS platform to georeference toposheets.

6.3 Steps to be followed

1. Download a toposheet for Dehradun from http://www.lib.utexas.edu/maps/ams/india/ by searching (Cmd + F on a Mac, Ctrl + F on a PC) for Dehradun.
2. Save it on your system.
3. Download and install QGIS from https://www.qgis.org/en/site/forusers/download.html

4. Launch QGIS. When we launch the QGIS application, we are presented with a window depicted in figure 6.1.

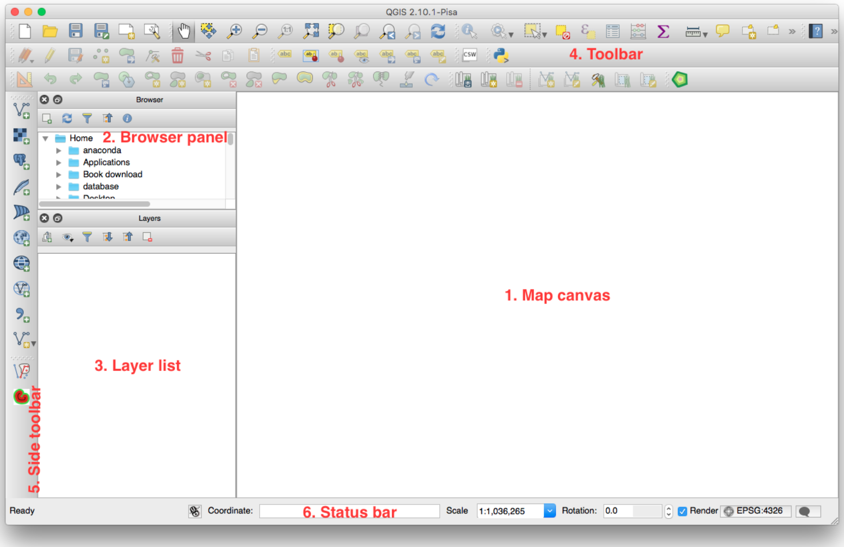


Figure 6.1: The basic interface of QGIS

This window is divided into 5 parts:

(a) Map canvas: This is the largest vacant space, where the map itself gets rendered.

(b) Browser panel: This panel, to the left, permits easy navigation in the database. Files can be loaded from the browser panel by double clicking the file or by dragging them onto the map canvas.

(c) Layer list: The layer list on the left displays the layers available at any point of time. Ticking the checkbox next to a layer switches its visibility on and off.

   (d) Toolbar: The toolbar on the top houses the most often used tools. The interface of the toolbar can be customised via View → Toolbars menu.

   (e) Side toolbar: The side toolbar on the left can similarly be customised. By default, it houses the "add layer" tools.

   (f) Status bar: The status bar at the bottom depicts the information about the current map, besides facilitating the user to adjust the map scale and to locate the coordinates of the mouse cursor on the map.

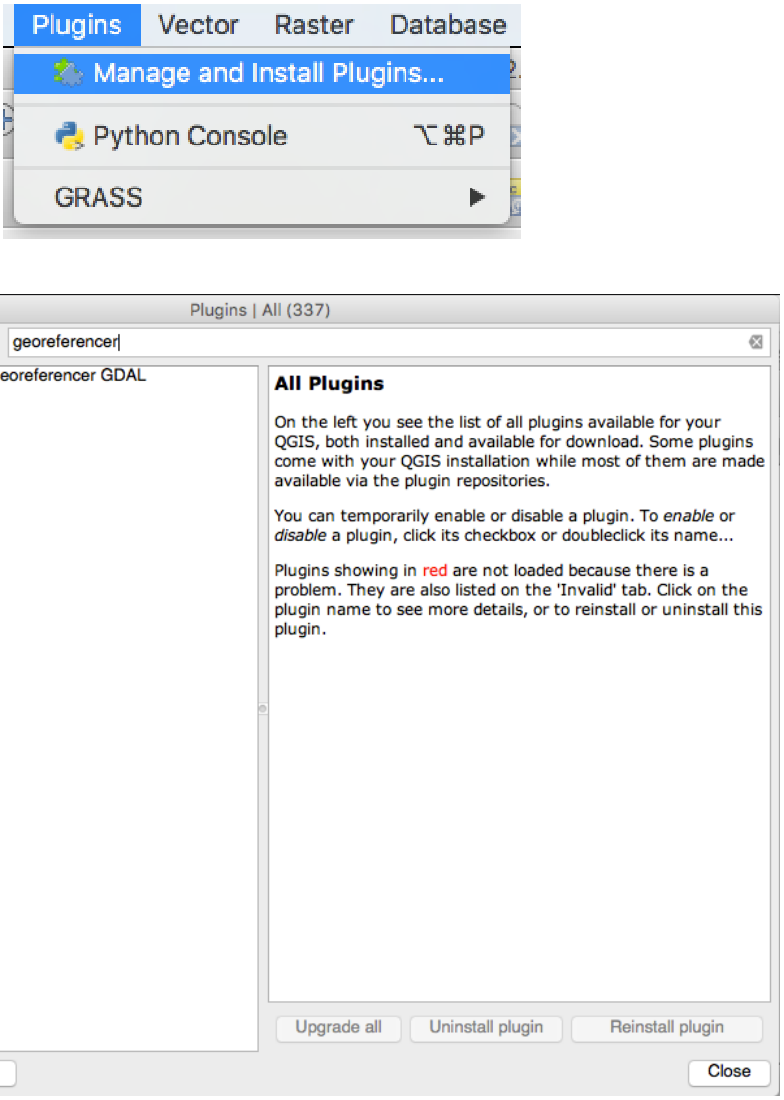
5. Install Georeferencer GDAL plugin from Plugins → Manage and Install Plugins... (Figure 6.2a) by searching for "georeferencer" (Figure 6.2b).

6. The plugin gets installed in the Raster menu on the toolbar at the top. Launch it through Raster → Georeferencer → Geroreferencer... (Figure 6.3).

7. Open the downloaded image through File → Open Raster... (Figure 6.4).

8. Zoom to the four corners of the map using the zoom tool (Figure 6.5) and set the GCPs at the four corners using the "Add point" tool (Figure 6.6).

9. Enter the map coordinates (Figure 6.7).



All Plugins

On the left you see the list of all plugins available for your QGIS, both installed and available for download. Some plugins come with your QGIS installation while most of them are made available via the plugin repositories.

You can temporarily enable or disable a plugin. To *enable* or *disable* a plugin, click its checkbox or doubleclick its name...

Plugins showing in red are not loaded because there is a problem. They are also listed on the 'Invalid' tab. Click on the plugin name to see more details, or to reinstall or uninstall this plugin.

(a)

(b)

Figure 6.2: Installation of the Georeferencer GDAL plugin by opening the Manage and Install Plugins window (a) and searching for georeferencer (b).

10. After all the four corners are done, set the transformation settings by Settings → Transformation Settings... (Figure 6.8).

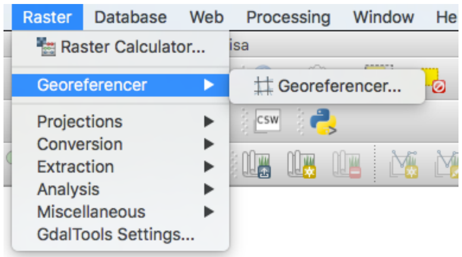


Figure 6.3: Launching the Georeferencer plugin

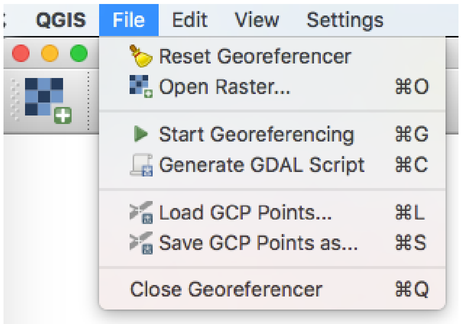


Figure 6.4: Opening the downloaded image

Figure 6.5: The zoom tool

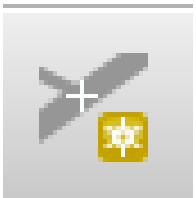
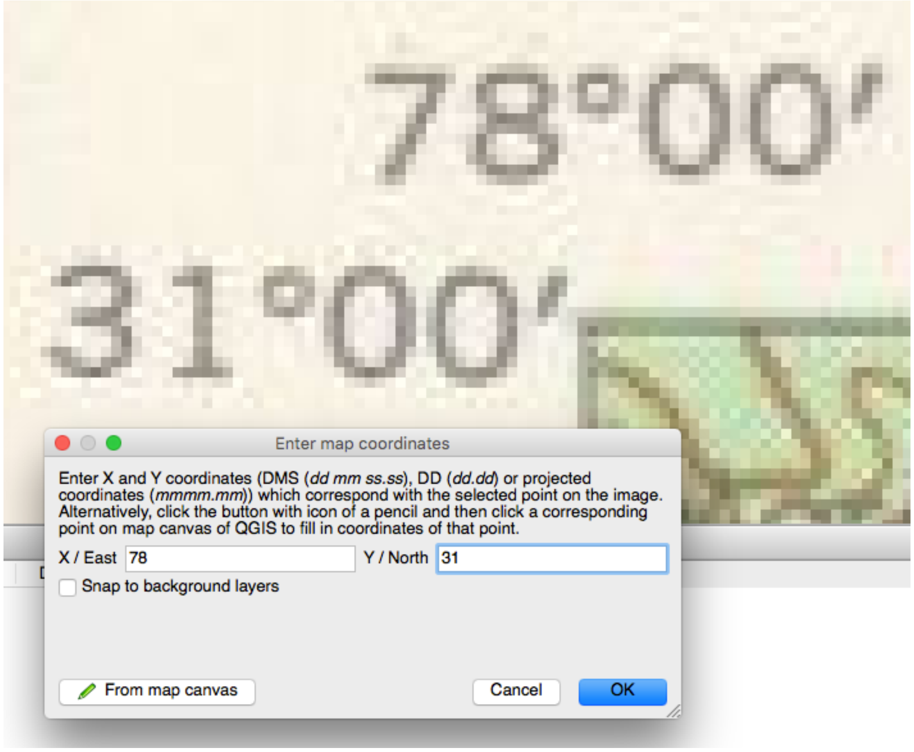


Figure 6.6: The add point tool



Enter X and Y coordinates (DMS (*dd mm ss.ss*), DD (*dd.dd*) or projected coordinates (*mmmm.mm*)) which correspond with the selected point on the image. Alternatively, click the button with icon of a pencil and then click a corresponding point on map canvas of QGIS to fill in coordinates of that point.

X / East 78 Y / North 31

☐ Snap to background layers

Figure 6.7: Entering the map coordinates

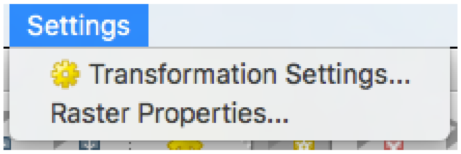
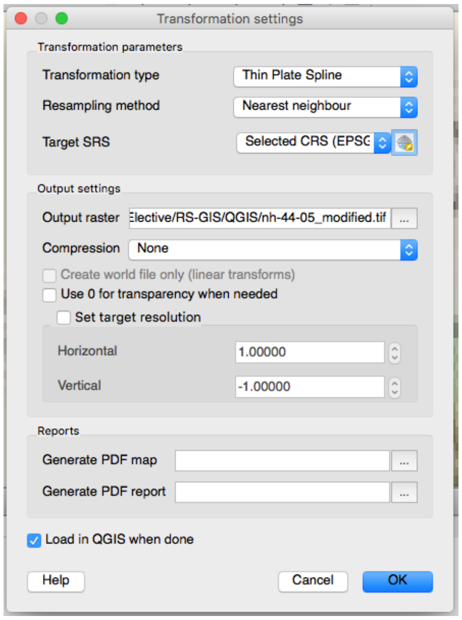


Figure 6.8: Accessing transformation settings

11. Set the transformation type as “Thin Plate Spline”, target SRS as WGS 84 / UTM zone 44N and give a filename to the output raster file. Select “Load in QGIS when done” (Figure 6.9).

12. Press OK and close the window. The georeferenced toposheet is loaded into QGIS, with the coordinates of the mouse pointer shown in the



Transformation parameters

Transformation type: Thin Plate Spline
Resampling method: Nearest neighbour
Target SRS: Selected CRS (EPSG

Output settings

Output raster: Elective/RS-GIS/QGIS/nh-44-05_modified.tif
Compression: None
☐ Create world file only (linear transforms)
☐ Use 0 for transparency when needed
☐ Set target resolution
Horizontal: 1.00000
Vertical: -1.00000

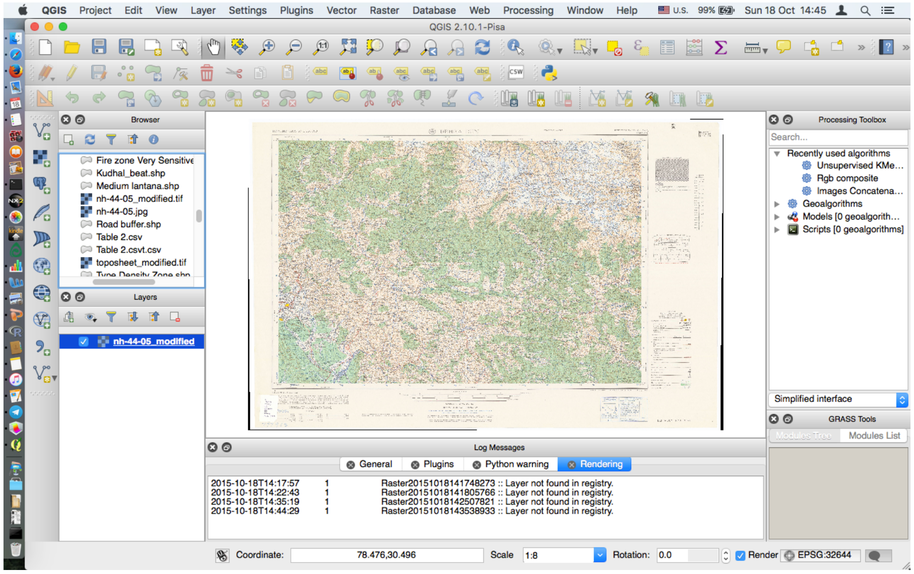
Reports

Generate PDF map:
Generate PDF report:

☑ Load in QGIS when done

Figure 6.9: Transformation settings

bottom status bar panel (Figure 6.10).



Browser:
- Fire zone Very Sensitive
- Kudhal_beat.shp
- Medium lantana.shp
- nh-44-05_modified.tif
- nh-44-05.jpg
- Road buffer.shp
- Table 2.csv
- Table 2.csvt.csv
- toposheet_modified.tif
- Type Density Zone.shp

Layers: ☑ nh-44-05_modified

```
2015-10-18T14:17:57    1    Raster20151018141748273 :: Layer not found in registry.
2015-10-18T14:22:43    1    Raster20151018141805766 :: Layer not found in registry.
2015-10-18T14:35:19    1    Raster20151018142507821 :: Layer not found in registry.
2015-10-18T14:44:29    1    Raster20151018143538933 :: Layer not found in registry.
```

Coordinate: 78.476,30.496 Scale 1:8 Rotation: 0.0 ☑ Render EPSG:32644

Figure 6.10: The georeferenced toposheet

Chapter 7

Digitising and querying a map

7.1 Introduction

GIS is an extremely powerful tool in the hands of administrators and policy makers, since it can be profitably employed for functions such as

1. finding and selecting locations with a specific set of attributes
2. relating several sets of attribute data simultaneously
3. depicting the numerical data in the form of thematic maps.

However, to do these, we need to convert the raster data into a vector format that can be given attributes and then queried. In this module, we shall investigate the method of digitising and querying a map on the QGIS platform.

7.2 Steps to be followed

1. Launch QGIS and click Layer → Add Layer → Add Raster Layer... (Figure 7.1).

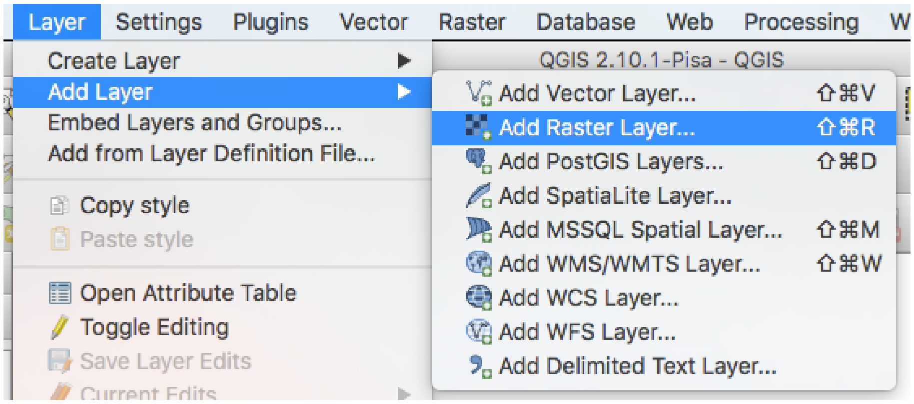


Figure 7.1: Adding a new raster layer

2. Select the scanned map file and load it.

3. Georeference the map file (See chapter 6).

4. Create a new shapefile layer through Layer → Create Layer → New Shapefile Layer... (Figure 7.2).

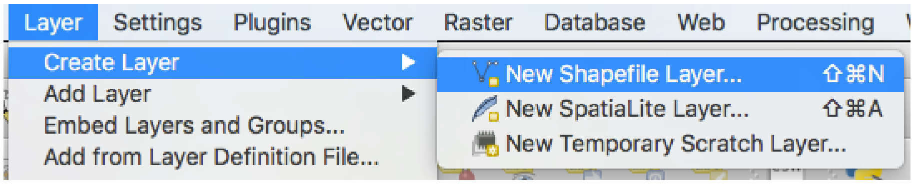


Figure 7.2: Creation of a new shapefile layer

5. Set the type as Polygon, File encoding as UTF-8, CRS as WGS 84 / UTM zone 44N and add the attributes, taking care of the type and width of the data (Figure 7.3).

6. Save the layer.

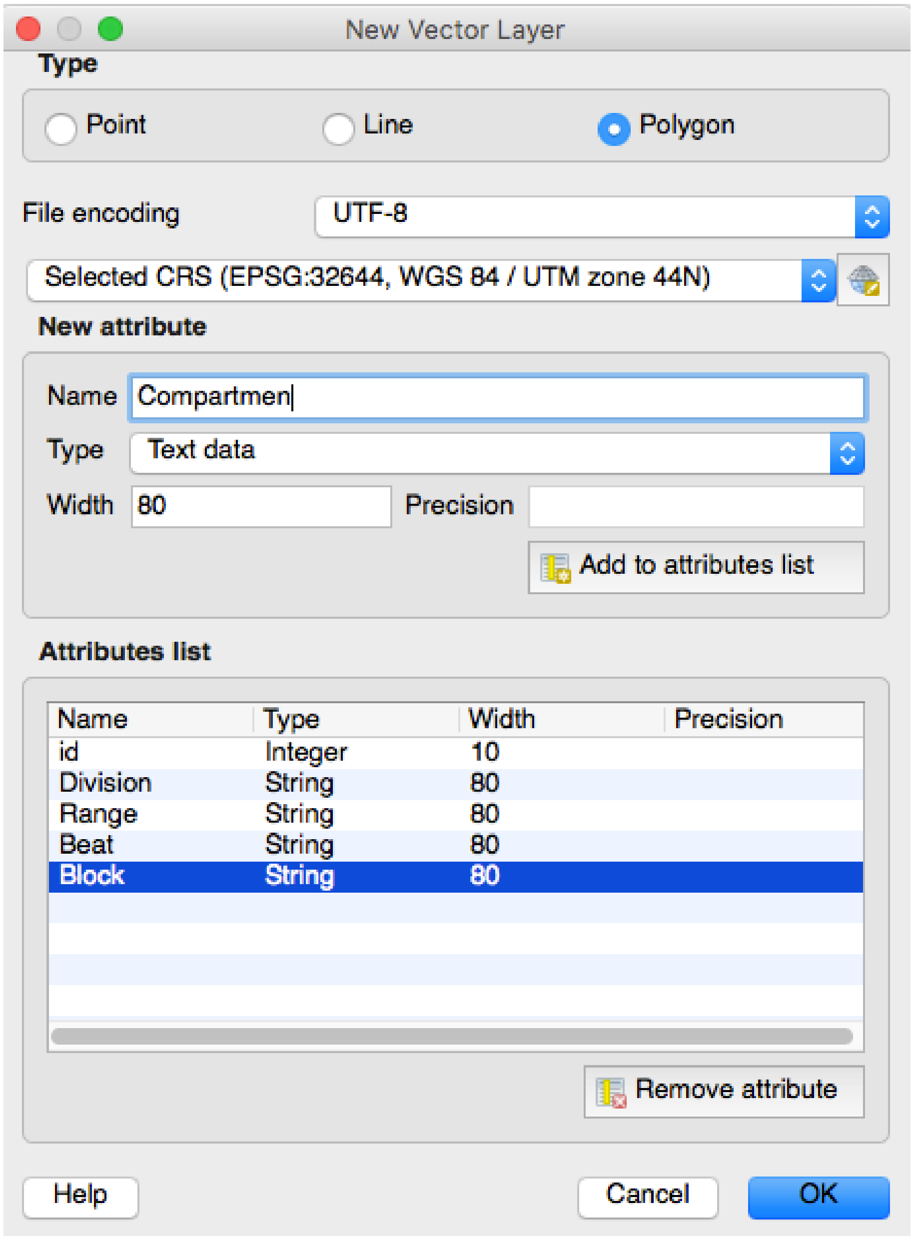
7. Begin digitisation by toggling the editing mode (Figure 7.4) and adding the features using the add feature tool (Figure 7.5). Left click along the boundaries to be digitised. End with a right click (Figure 7.6).

8. If required, the boundary can be adjusted with the node tool (Figure 7.7).

9. After digitisation of the outer boundary is done, increase the layer's transparency by double-clicking its name to open layer properties and increasing the transparency (Figure 7.8).

10. Now digitise the inner boundaries by selecting the outer boundary with the selection tool (Figure 7.9) and splitting the feature with the split tool (Figure 7.10). Start from the outer boundary, and click along the inner boundaries. End by right clicking outside the outer boundary (Figure 7.11).

11. Click the attribute table button (Figure 7.12) to open the attribute table (Figure 7.13) and fill in the details after toggling the edit mode (Figure 7.4).



New Vector Layer

Type

○ Point ○ Line ● Polygon

File encoding: UTF-8

Selected CRS (EPSG:32644, WGS 84 / UTM zone 44N)

New attribute

Name: Compartmen

Type: Text data

Width: 80

Precision:

Attributes list

Name	Type	Width	Precision
id	Integer	10	
Division	String	80	
Range	String	80	
Beat	String	80	
Block	String	80	

Figure 7.3: Formatting the new shapefile layer

12. To add details from another table, save it as a .csv file, and open it by double-clicking its name in the browser panel on the left.

Figure 7.4: Toggle edit mode tool

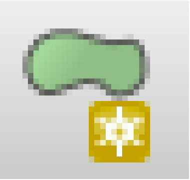


Figure 7.5: Add feature tool

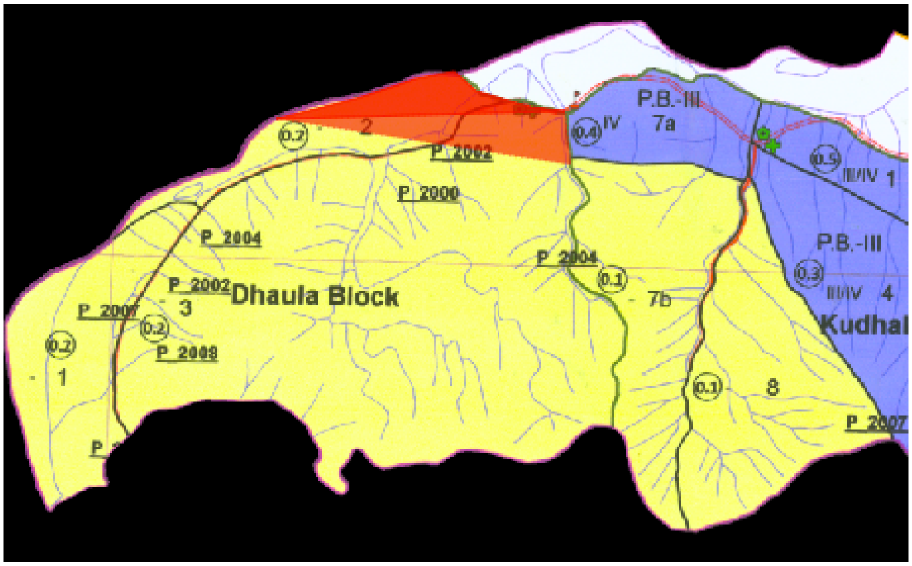
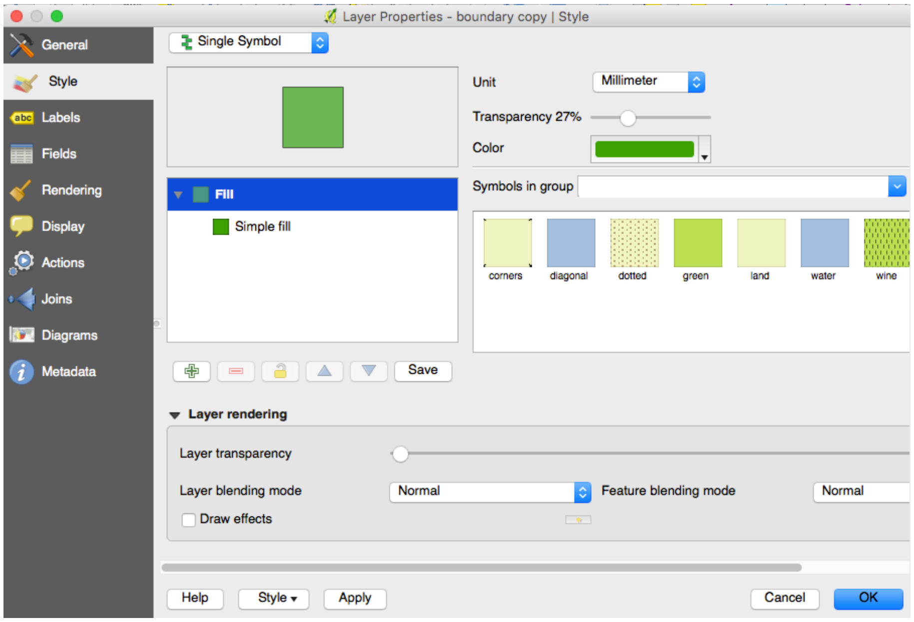


Figure 7.6: The digitisation process

13. Select file layer properties by double-clicking the layer's name. Goto Joins and click on the joins button (Figure 7.14). Set the Join layer,

Figure 7.7: The node tool



Layer Properties - boundary copy | Style

Single Symbol

Unit: Millimeter

Transparency 27%

Layer blending mode: Normal

Feature blending mode: Normal

☐ Draw effects

Figure 7.8: Increasing the transparency of a layer

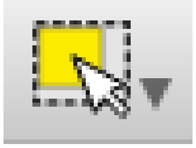


Figure 7.9: The selection tool

the Join field and the Target field (Figure 7.15).

14. Click OK and OK. Check the attribute table to confirm the joining procedure (Figure 7.16).

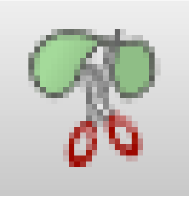


Figure 7.10: The split tool

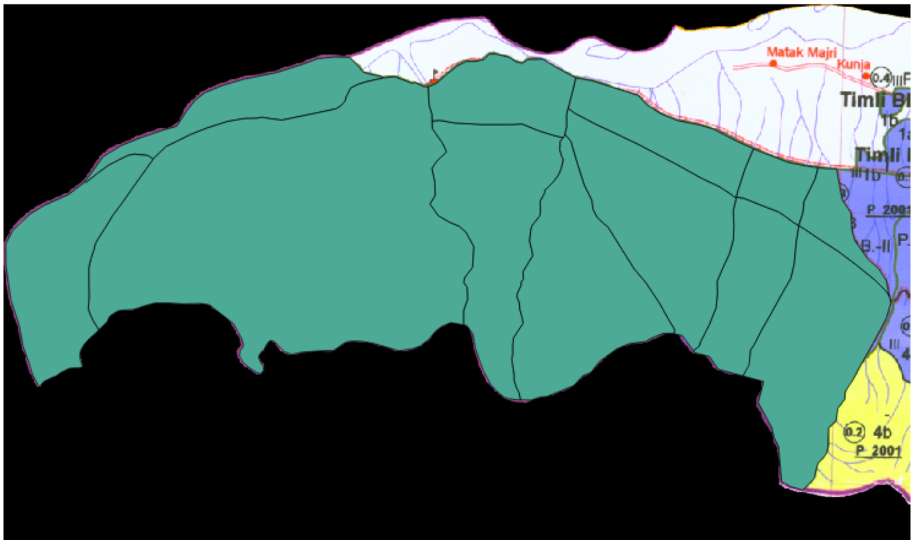
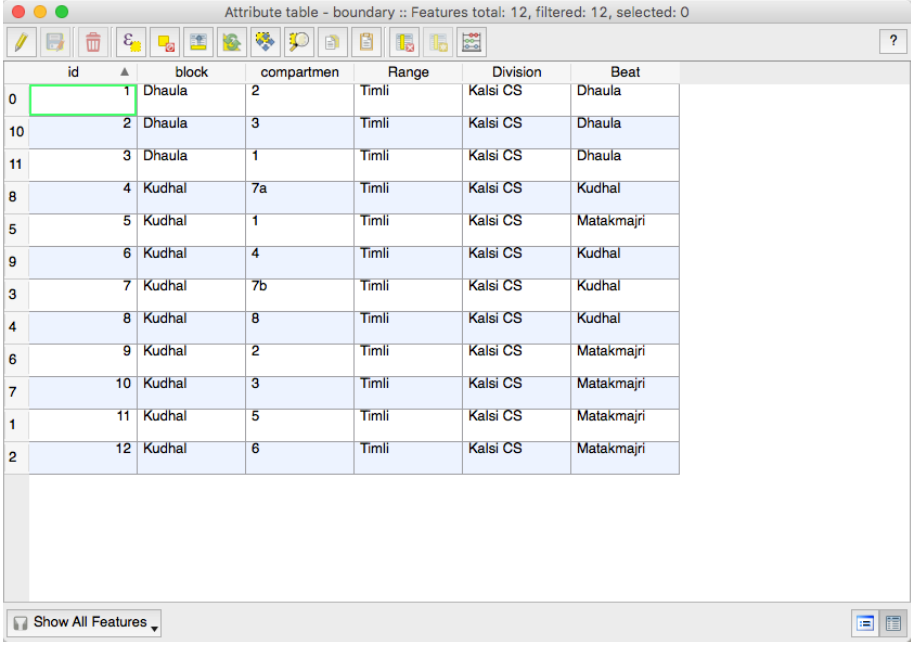


Figure 7.11: Digitising the inner boundaries

Figure 7.12: The attribute table button

15. Now we have a digitised map with the attributes filled in.

16. To query the map and select features using an expression, click the query tool (Figure 7.17) to open the query window (Figure 7.18).



Attribute table - boundary :: Features total: 12, filtered: 12, selected: 0

	id	block	compartmen	Range	Division	Beat
0	1	Dhaula	2	Timli	Kalsi CS	Dhaula
10	2	Dhaula	3	Timli	Kalsi CS	Dhaula
11	3	Dhaula	1	Timli	Kalsi CS	Dhaula
8	4	Kudhal	7a	Timli	Kalsi CS	Kudhal
5	5	Kudhal	1	Timli	Kalsi CS	Matakmajri
9	6	Kudhal	4	Timli	Kalsi CS	Kudhal
3	7	Kudhal	7b	Timli	Kalsi CS	Kudhal
4	8	Kudhal	8	Timli	Kalsi CS	Kudhal
6	9	Kudhal	2	Timli	Kalsi CS	Matakmajri
7	10	Kudhal	3	Timli	Kalsi CS	Matakmajri
1	11	Kudhal	5	Timli	Kalsi CS	Matakmajri
2	12	Kudhal	6	Timli	Kalsi CS	Matakmajri

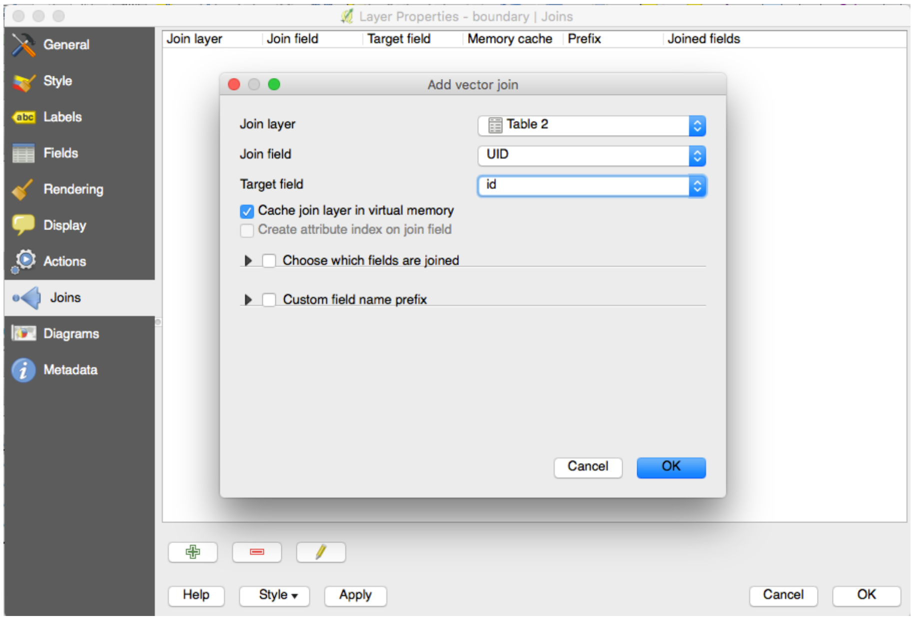
Figure 7.13: The attribute table

Figure 7.14: The joins button

17. To take an example, for selecting the compartments with Forest type 5B/CIa with density more than or equal to 0.3 and the fire zone as most sensitive, we type the following in the expression field:

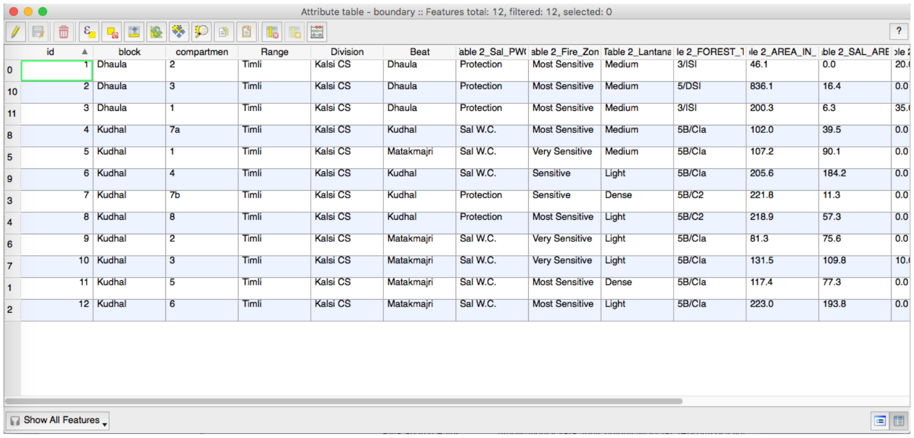
    "Table 2_FOREST_TYP" = '5B/CIa' AND "Table 2_Density" >= '0.3' AND "Table 2_Fire_Zone" = 'Most Sensitive'

18. Now press select. The objects matching these properties get selected (Figure 7.19).



Join layer: Table 2
Join field: UID
Target field: id
☑ Cache join layer in virtual memory
☐ Create attribute index on join field
☐ Choose which fields are joined
☐ Custom field name prefix

Figure 7.15: Setting the joining attributes



Attribute table - boundary :: Features total: 12, filtered: 12, selected: 0

	id	block	compartmen	Range	Division	Beat	able 2_Sal_PW	able 2_Fire_Zon	Table 2_Lantana	le 2_FOREST_T	le 2_AREA_IN_	ble 2_SAL_ARE	le 2
0	1	Dhaula	2	Timli	Kalsi CS	Dhaula	Protection	Most Sensitive	Medium	3/ISI	46.1	0.0	20.
10	2	Dhaula	3	Timli	Kalsi CS	Dhaula	Protection	Most Sensitive	Medium	5/DSI	836.1	16.4	0.0
11	3	Dhaula	1	Timli	Kalsi CS	Dhaula	Protection	Most Sensitive	Medium	3/ISI	200.3	6.3	35.
8	4	Kudhal	7a	Timli	Kalsi CS	Kudhal	Sal W.C.	Most Sensitive	Medium	5B/Cla	102.0	39.5	0.0
5	5	Kudhal	1	Timli	Kalsi CS	Matakmajri	Sal W.C.	Very Sensitive	Medium	5B/Cla	107.2	90.1	0.0
9	6	Kudhal	4	Timli	Kalsi CS	Kudhal	Sal W.C.	Sensitive	Light	5B/Cla	205.6	184.2	0.0
3	7	Kudhal	7b	Timli	Kalsi CS	Kudhal	Protection	Sensitive	Dense	5B/C2	221.8	11.3	0.0
4	8	Kudhal	8	Timli	Kalsi CS	Kudhal	Protection	Most Sensitive	Light	5B/C2	218.9	57.3	0.0
6	9	Kudhal	2	Timli	Kalsi CS	Matakmajri	Sal W.C.	Very Sensitive	Light	5B/Cla	81.3	75.6	0.0
7	10	Kudhal	3	Timli	Kalsi CS	Matakmajri	Sal W.C.	Very Sensitive	Light	5B/Cla	131.5	109.8	10.
1	11	Kudhal	5	Timli	Kalsi CS	Matakmajri	Sal W.C.	Most Sensitive	Dense	5B/Cla	117.4	77.3	0.0
2	12	Kudhal	6	Timli	Kalsi CS	Matakmajri	Sal W.C.	Most Sensitive	Light	5B/Cla	223.0	193.8	0.0

Figure 7.16: The joined table

19. Export by right-clicking the layer's name and clicking "Save As..." (Figure 7.20).

20. Give a name to the output file and select "Save only selected features".

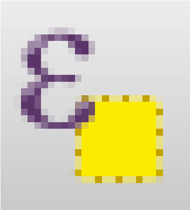


Figure 7.17: The query tool

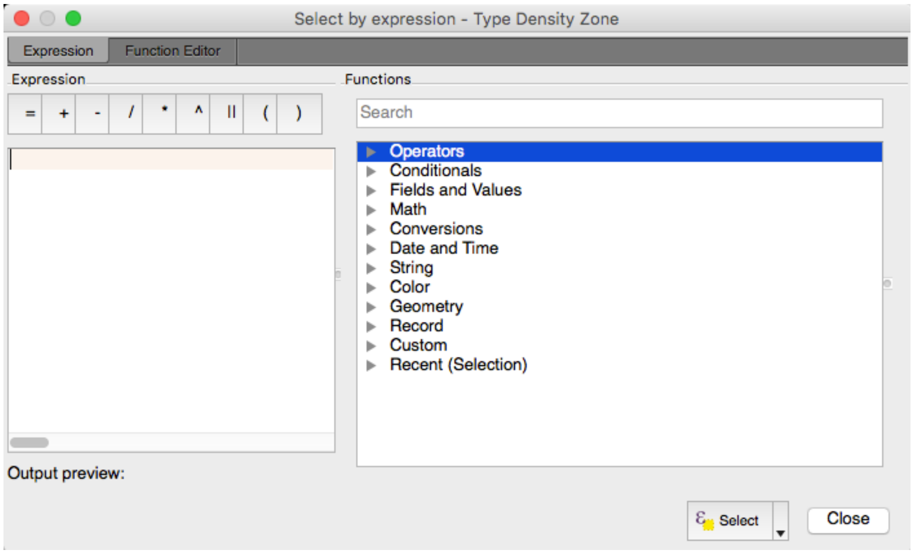


Figure 7.18: The query window

Press OK. The new shapefile gets saved.

21. Confirm the properties of the layer by perusing its attribute table.

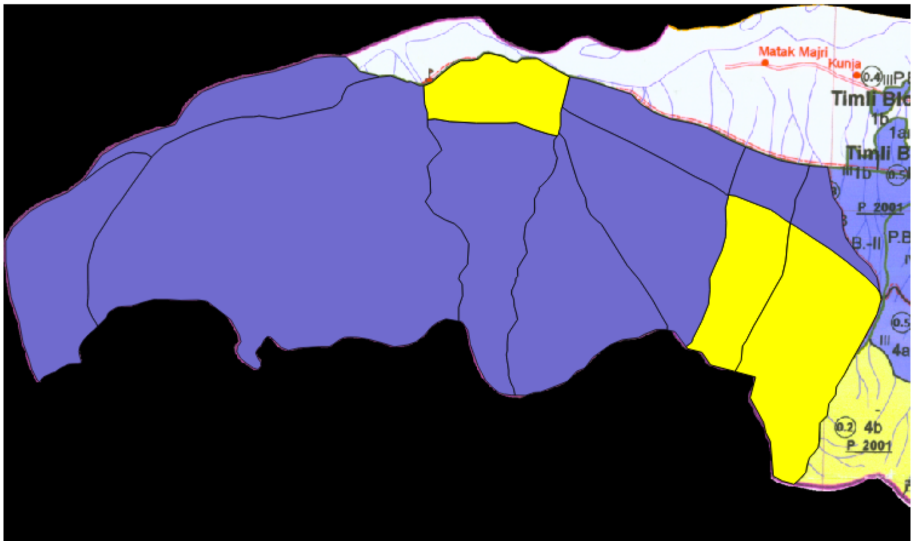
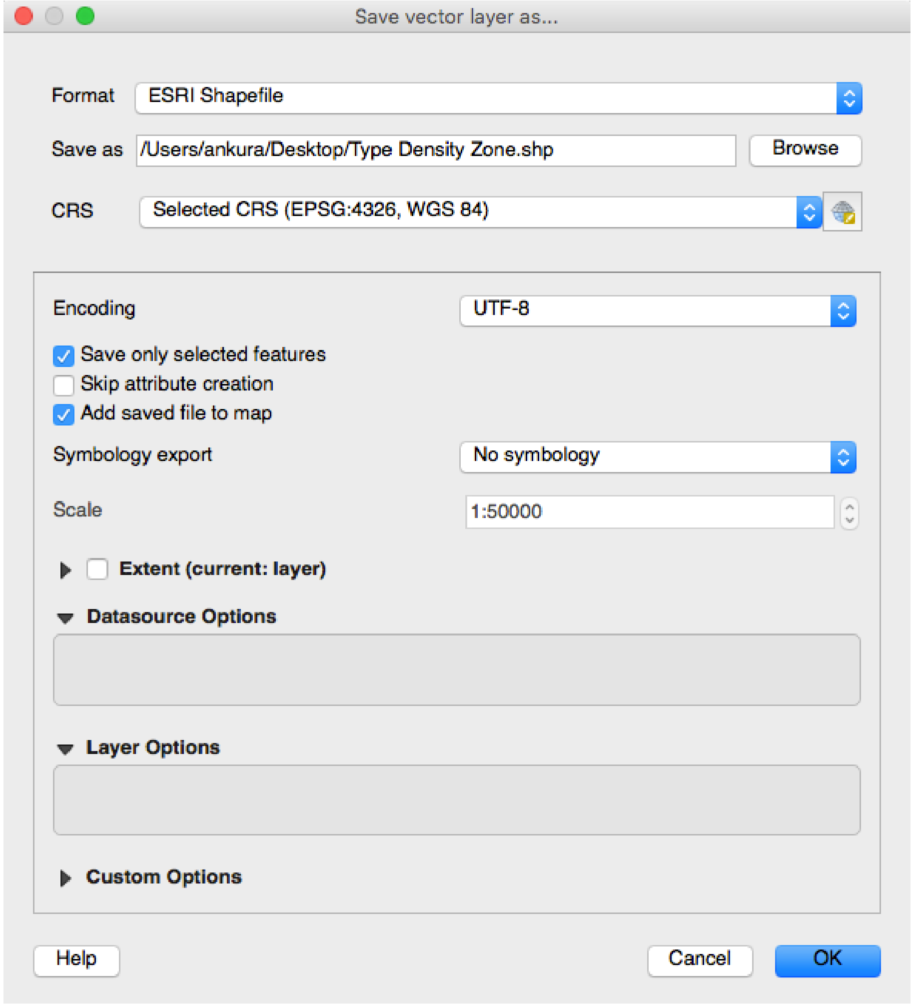


Figure 7.19: Objects matching query properties are selected (yellow)



Format: ESRI Shapefile

Save as: /Users/ankura/Desktop/Type Density Zone.shp

CRS: Selected CRS (EPSG:4326, WGS 84)

Encoding: UTF-8

☑ Save only selected features
☐ Skip attribute creation
☑ Add saved file to map

Symbology export: No symbology

Scale: 1:50000

☐ Extent (current: layer)

Figure 7.20: Saving the selection

Chapter 8

Site Selection

8.1 Introduction

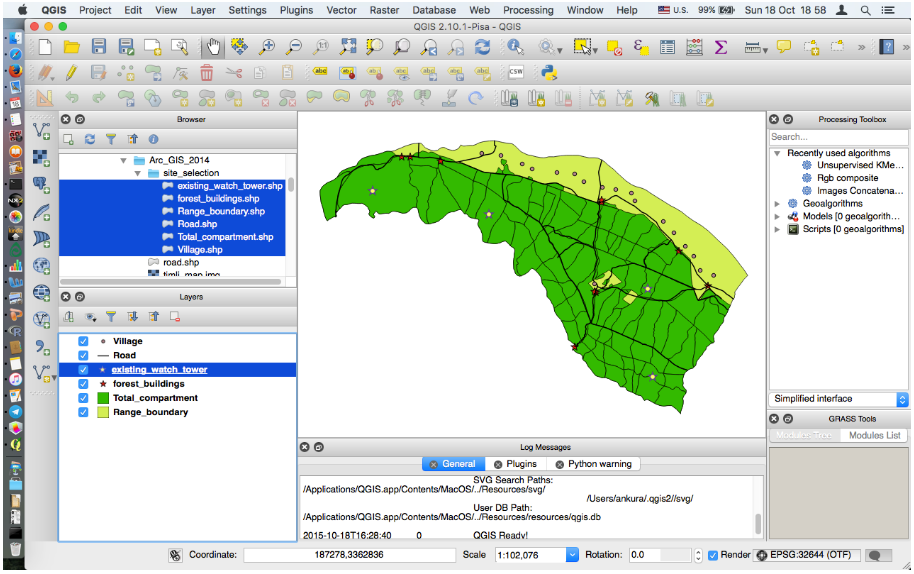
This chapter demonstrates the use of GIS techniques in practical problem-solving. At times, we need to discern locations with particular attributes to build or manage a feature. An example could be the construction of a watch tower, for which the potential location should be:

1. at a distance of more than 1,500 metres from the existing watch towers
2. at a distance of 500-1,500 metres from other forest buildings
3. at least 500 metres away from the main roads
4. only in those compartments that are included in joint forest management (JFM), where the JFM compartments are those that are comprised within, or touch the 1,500 meters buffers of villages.

We shall now try to find all the locations in our forest range that satisfy these conditions for the construction of a watch tower.

8.2 Steps to be followed

1. Load the input files: locations of villages, roads, existing watch towers, forest buildings, compartments and the range boundary (Figure 8.1).



```
                              SVG Search Paths:
/Applications/QGIS.app/Contents/MacOS/../Resources/svg/
                                                       /Users/ankura/.qgis2//svg/
                              User DB Path:
/Applications/QGIS.app/Contents/MacOS/../Resources/resources/qgis.db

2015-10-18T16:28:40      0      QGIS Ready!
```

Figure 8.1: Loading the input files

2. To create a 1,500m buffer around the existing watch towers, select the buffer tool from Vector → Geoprocessing Tools → Buffer(s)... (Figure 8.2).

3. Fill in the parameters. Input vector layer: existing watch tower, buffer distance: 1500 (m). Give a location for the output shapefile, and select

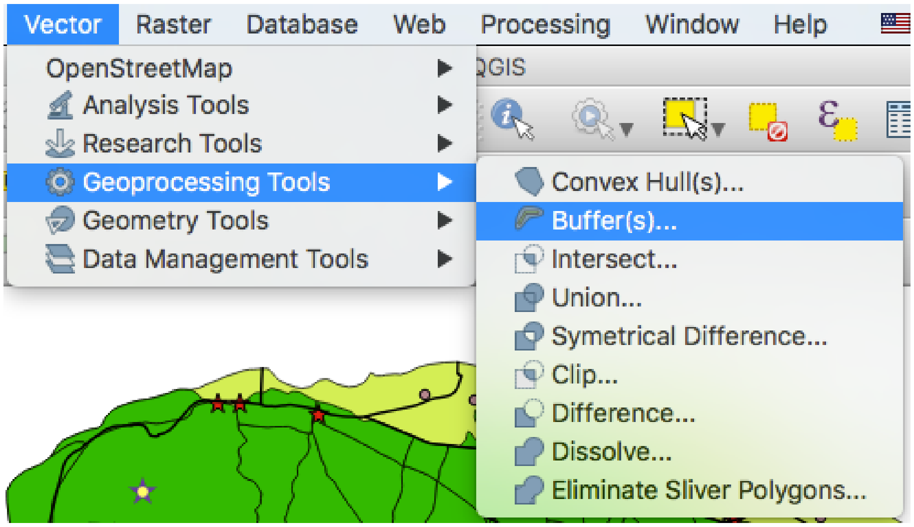


Figure 8.2: Accessing the buffer tool

“Add result to canvas” (Figure 8.3). Press OK.

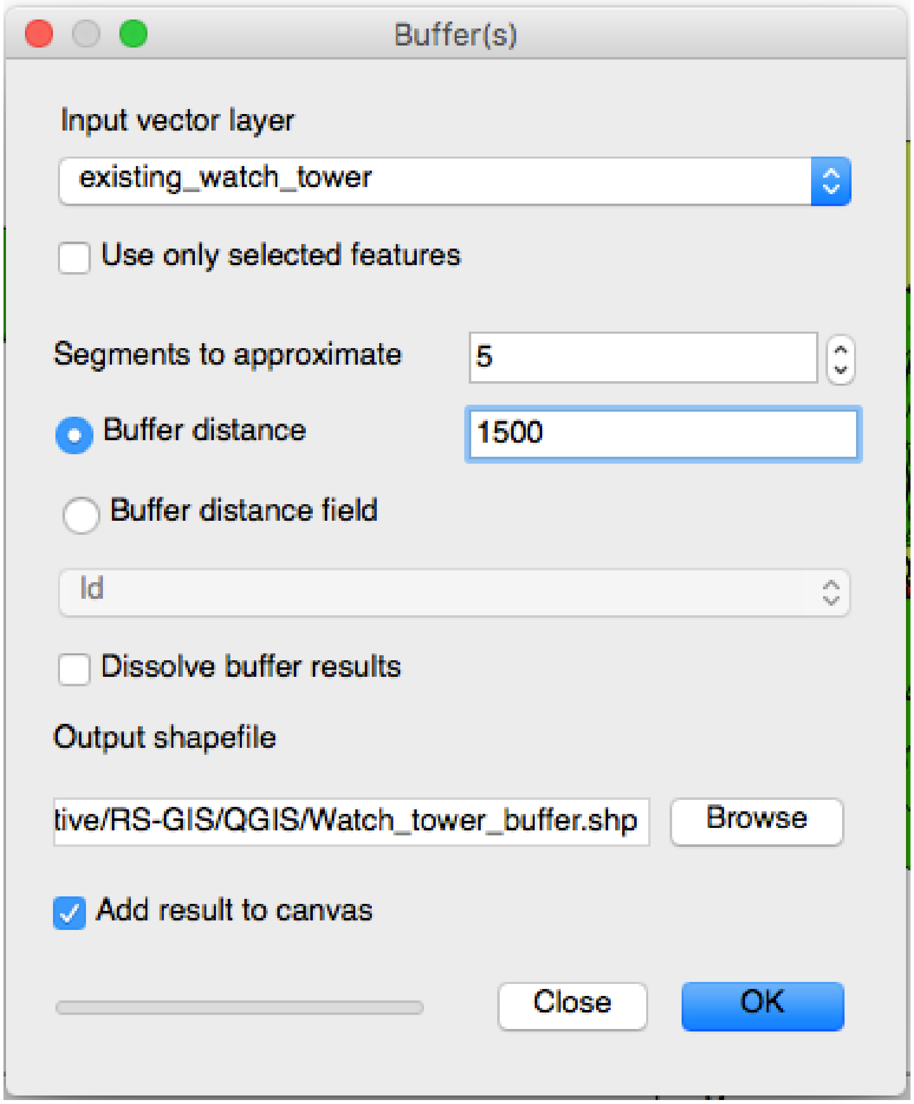
4. The application the generates the circular buffers (Figure 8.4).

5. To find the locations at a distance of 500-1,500 metres from other forest buildings, we need to install the Multi-distance buffer plugin. Install the plugin from Plugins → Manage and Install Plugins... (Figure 8.5).

6. Search for “multiple” and install the multi-distance buffer plugin (Figure 8.6).

7. The multi-distance buffer tool can be accessed from Vector → Multiple Distance Buffer → MultiDistanceBuffer (Figure 8.7).

8. Input the parameters: Input layer is forest buildings; and there are two



Buffer(s)

Input vector layer

existing_watch_tower

☐ Use only selected features

Segments to approximate 5

● Buffer distance 1500

○ Buffer distance field

Id

☐ Dissolve buffer results

Output shapefile

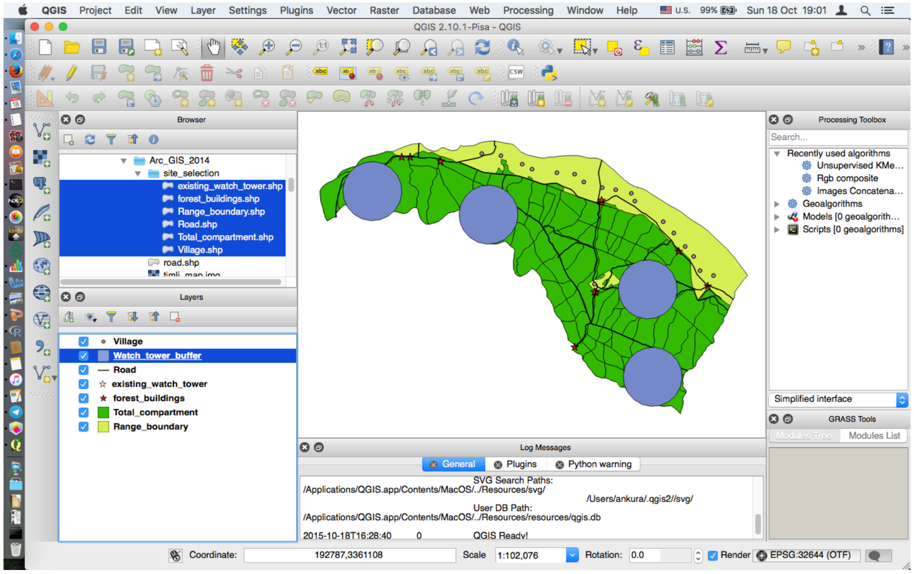
tive/RS-GIS/QGIS/Watch_tower_buffer.shp

☑ Add result to canvas

Figure 8.3: Inputting parameters for buffer

buffer distances, 500 and 1500 (m). Give a name to the output (buffer) layer. Press OK (Figure 8.8).

9. The application then generates the ring-shaped buffers (Figure 8.9).



```
SVG Search Paths:
/Applications/QGIS.app/Contents/MacOS/../Resources/svg/
                                   /Users/ankura/.qgis2//svg/
User DB Path:
/Applications/QGIS.app/Contents/MacOS/../Resources/resources/qgis.db
2015-10-18T16:28:40    0    QGIS Ready!
```

Coordinate: 192787,3361108 Scale 1:102,076 Rotation: 0.0

Figure 8.4: Generation of circular buffers around existing watch towers

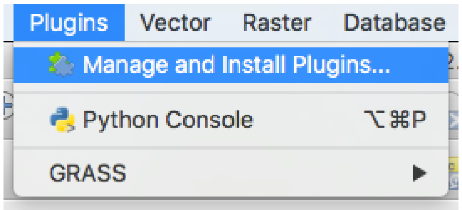
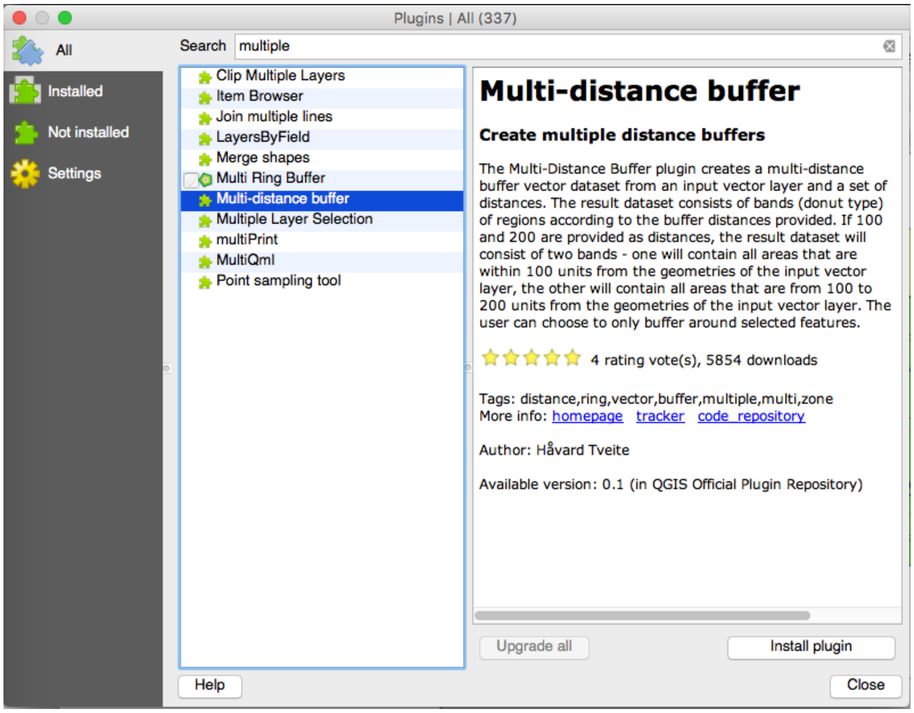


Figure 8.5: Installation of a new plugin

10. To select the outer rings, toggle the editing mode (Figure 7.4) and then click on the select features tool (Figure 7.9). Select the outer rings by left-clicking on them (Figure 8.10).

11. Export the selection by right-clicking on the layer name and saving the vector layer. Give a file name to the output file and select "Save only selected features". Press OK (Figure 8.11).

12. To create the road buffer, select the buffer tool from Vector → Geo-



Multi-distance buffer

Create multiple distance buffers

The Multi-Distance Buffer plugin creates a multi-distance buffer vector dataset from an input vector layer and a set of distances. The result dataset consists of bands (donut type) of regions according to the buffer distances provided. If 100 and 200 are provided as distances, the result dataset will consist of two bands - one will contain all areas that are within 100 units from the geometries of the input vector layer, the other will contain all areas that are from 100 to 200 units from the geometries of the input vector layer. The user can choose to only buffer around selected features.

★★★★★ 4 rating vote(s), 5854 downloads

Tags: distance,ring,vector,buffer,multiple,multi,zone
More info: homepage tracker code repository

Author: Håvard Tveite

Available version: 0.1 (in QGIS Official Plugin Repository)

Figure 8.6: Installation of the multi-distance buffer plugin

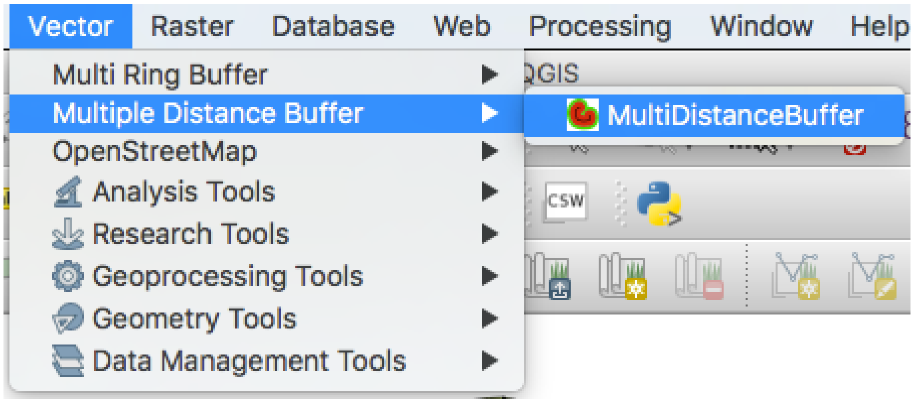
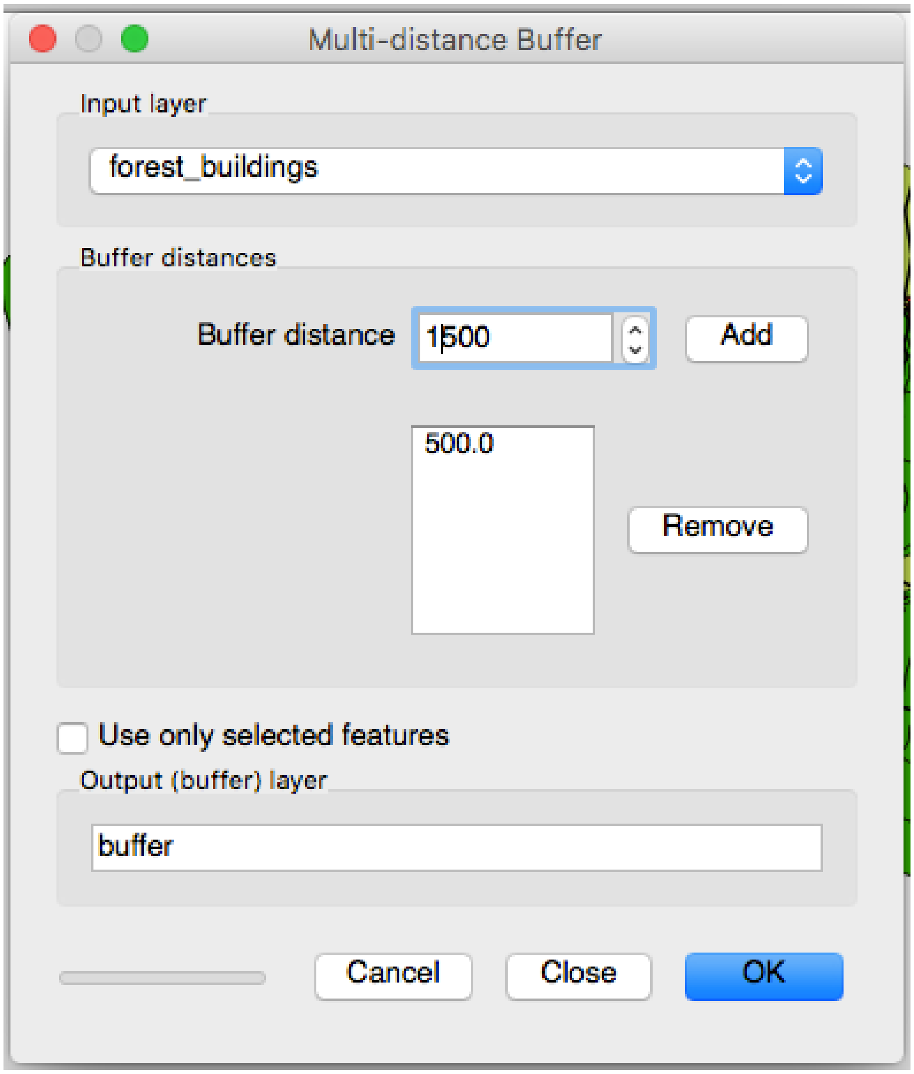


Figure 8.7: Accessing the multi-distance buffer plugin

processing Tools → Buffer(s)... (Figure 8.12).

13. Input the parameters: Input vector layer is road, buffer distance is 500



Input layer: forest_buildings

Buffer distance: 1500

500.0

☐ Use only selected features

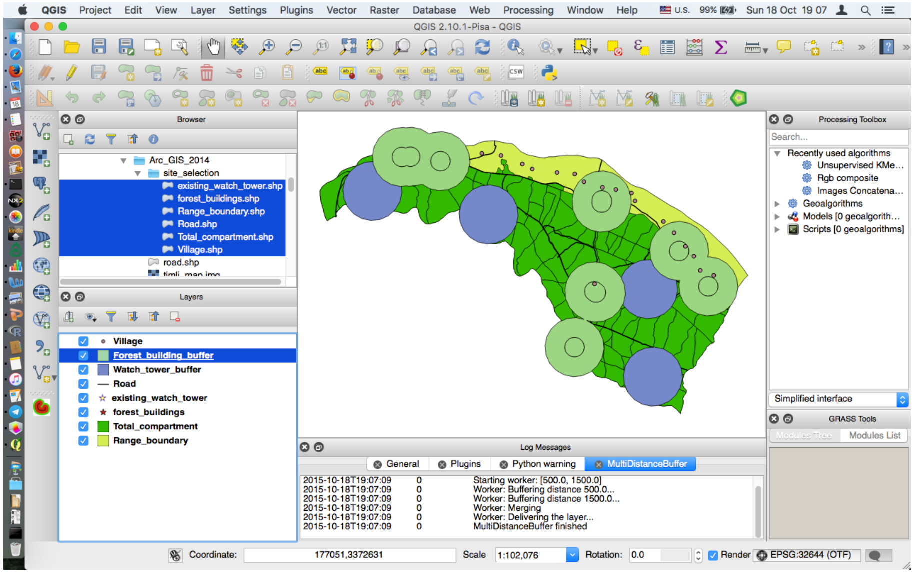
Output (buffer) layer: buffer

Figure 8.8: Inputting parameters to the multi-distance buffer

(m). Select "Dissolve buffer results" and give a filename to the output shapefile. Press OK (Figure 8.13).

14. The application then generates the road buffer (Figure 8.14).

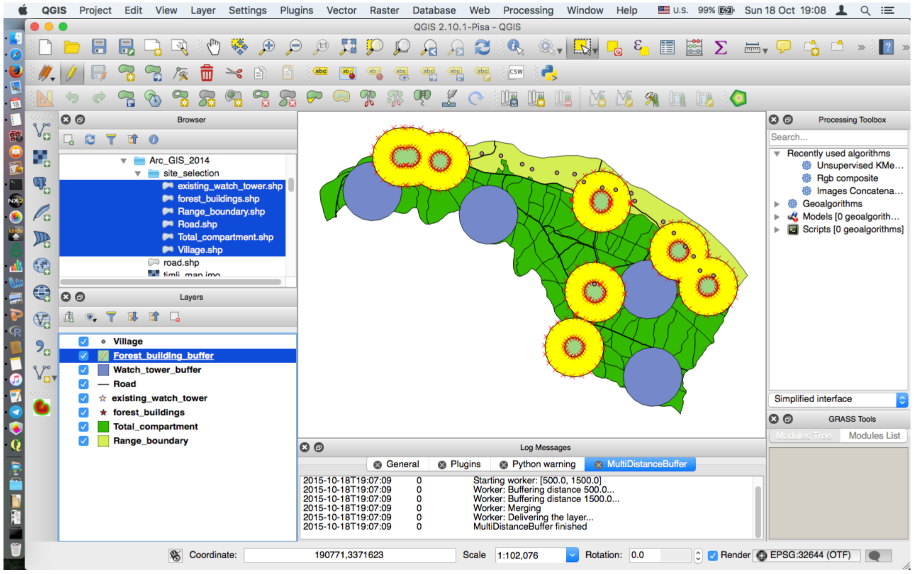
15. To create the village buffer, select the buffer tool from Vector → Geo-



```
2015-10-18T19:07:09   0   Starting worker: [500.0, 1500.0]
2015-10-18T19:07:09   0   Worker: Buffering distance 500.0...
2015-10-18T19:07:09   0   Worker: Buffering distance 1500.0...
2015-10-18T19:07:09   0   Worker: Merging
2015-10-18T19:07:09   0   Worker: Delivering the layer...
2015-10-18T19:07:09   0   MultiDistanceBuffer finished
```

Coordinate: 177051,3372631 Scale 1:102,076 Rotation: 0.0 ☑ Render EPSG:32644 (OTF)

Figure 8.9: Ring-shaped buffers around the existing forest buildings

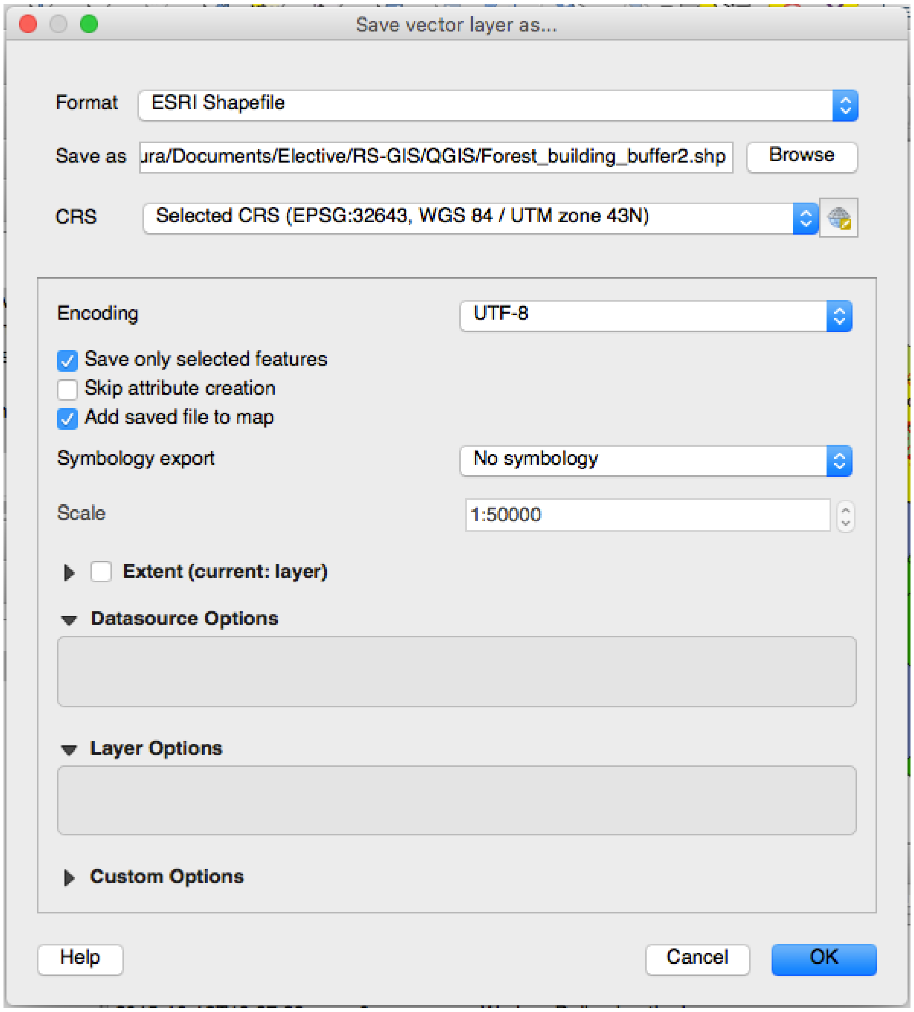


```
2015-10-18T19:07:09   0   Starting worker: [500.0, 1500.0]
2015-10-18T19:07:09   0   Worker: Buffering distance 500.0...
2015-10-18T19:07:09   0   Worker: Buffering distance 1500.0...
2015-10-18T19:07:09   0   Worker: Merging
2015-10-18T19:07:09   0   Worker: Delivering the layer...
2015-10-18T19:07:09   0   MultiDistanceBuffer finished
```

Coordinate: 190771,3371623 Scale 1:102,076 Rotation: 0.0 ☑ Render EPSG:32644 (OTF)

Figure 8.10: Selecting the outer rings

processing Tools → Buffer(s)... (Figure 8.12).



Format: ESRI Shapefile

Save as: ura/Documents/Elective/RS-GIS/QGIS/Forest_building_buffer2.shp

CRS: Selected CRS (EPSG:32643, WGS 84 / UTM zone 43N)

Encoding: UTF-8

☑ Save only selected features
☐ Skip attribute creation
☑ Add saved file to map

Symbology export: No symbology

Scale: 1:50000

☐ **Extent (current: layer)**

Datasource Options

Layer Options

Custom Options

Figure 8.11: Exporting outer rings to a new layer

16. Input the parameters: Input vector layer is Village, buffer distance is 1500 (m). Select "Dissolve buffer results" and give a filename to the output shapefile. Press OK (Figure 8.15).

17. The application the generates the circular buffers around the villages (Figure 8.16).

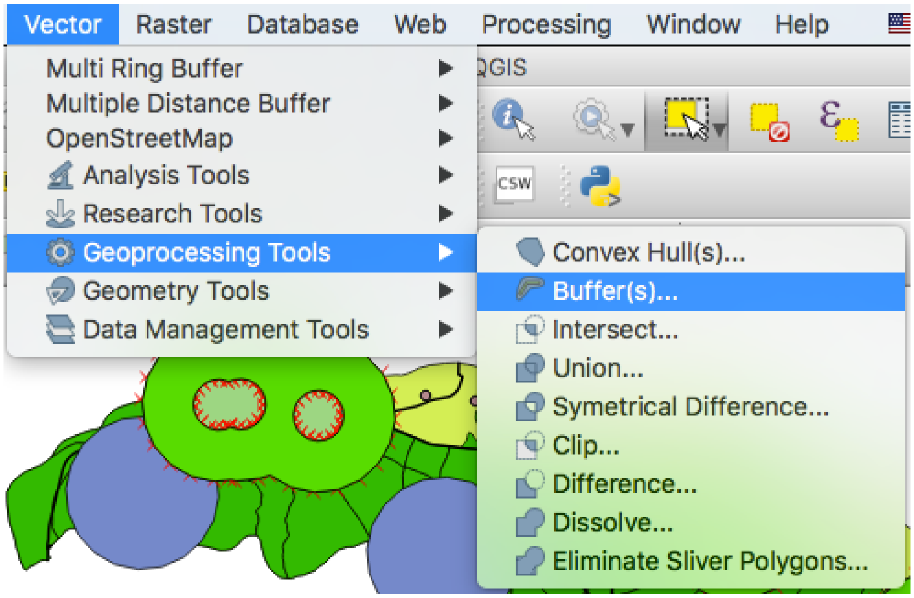


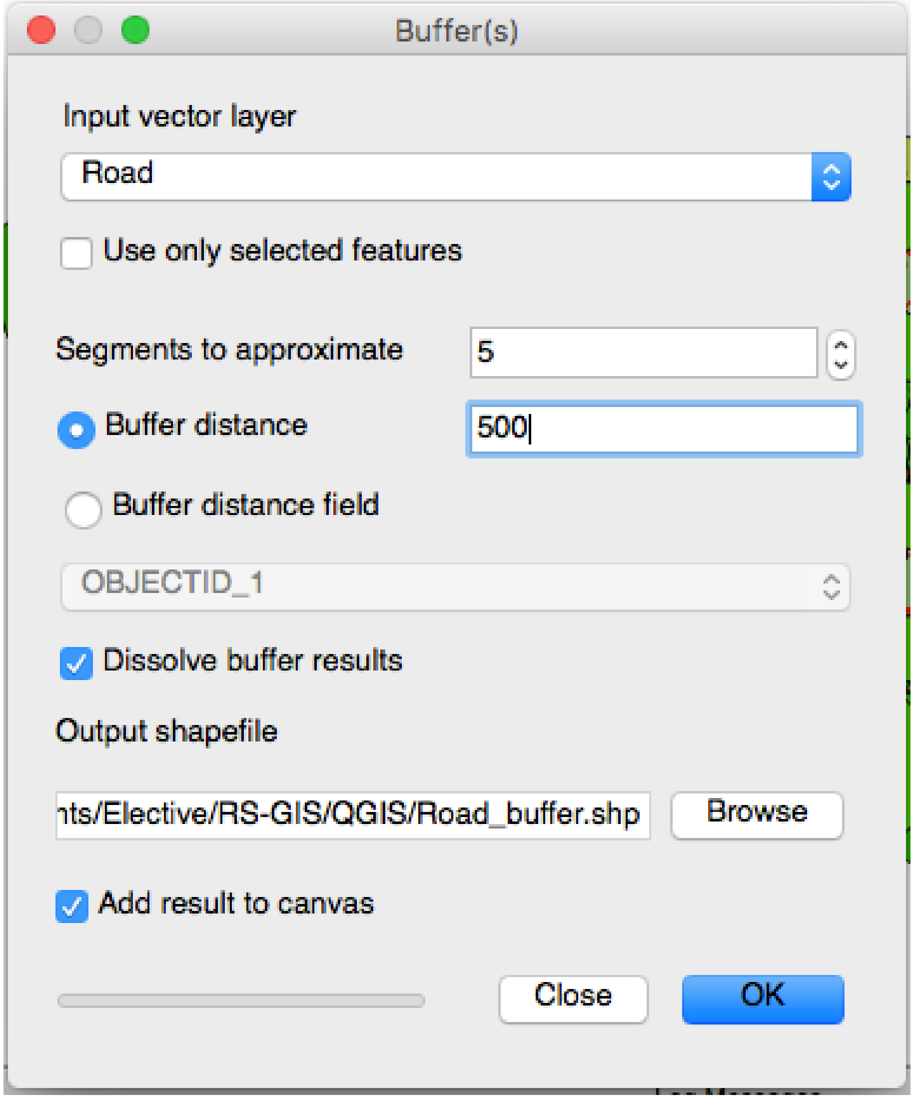
Figure 8.12: Selection of the buffer tool

18. To select by location, we need to install the Spatial query plugin. Install the plugin from Plugins → Manage and Install Plugins... (Figure 8.5).

19. Search for "spatial" and install the Spatial query plugin (Figure 8.17).

20. The plugin can be accessed from Vector → Spatial Query → Spatial Query (Figure 8.18).

21. We can now select the JFM compartments by setting the query. We need to select the source features from the Total compartment layer where the feature overlaps the village buffer. This would give the compartments that come under "JFM compartments". Click "Apply" (Figure 8.19).



Buffer(s)

Input vector layer: Road

☐ Use only selected features

Segments to approximate: 5

● Buffer distance: 500

○ Buffer distance field

OBJECTID_1

☑ Dissolve buffer results

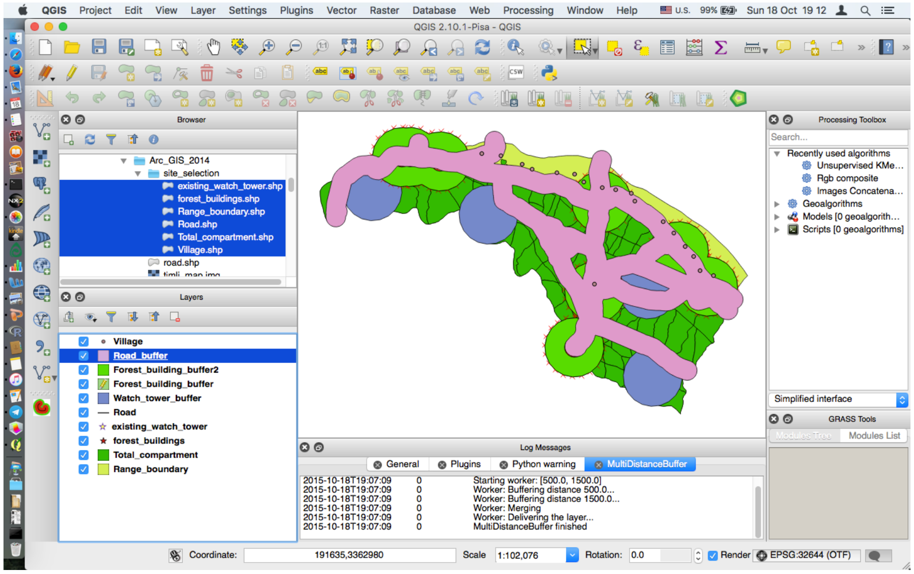
Output shapefile: ıts/Elective/RS-GIS/QGIS/Road_buffer.shp

☑ Add result to canvas

Figure 8.13: Inputting the parameters for the generation of road buffer

22. The requisite compartments get selected (Figure 8.20).

23. Save the selection by right-clicking the Total compartment layer and selecting “Save As...”. Give a file name to the output, and select “Save



```
2015-10-18T19:07:09    0    Starting worker: [500.0, 1500.0]
2015-10-18T19:07:09    0    Worker: Buffering distance 500.0...
2015-10-18T19:07:09    0    Worker: Buffering distance 1500.0...
2015-10-18T19:07:09    0    Worker: Merging
2015-10-18T19:07:09    0    Worker: Delivering the layer...
2015-10-18T19:07:09    0    MultiDistanceBuffer finished
```

Coordinate: 191635,3362980 Scale 1:102,076 Rotation: 0.0 ☑ Render EPSG:32644 (OTF)

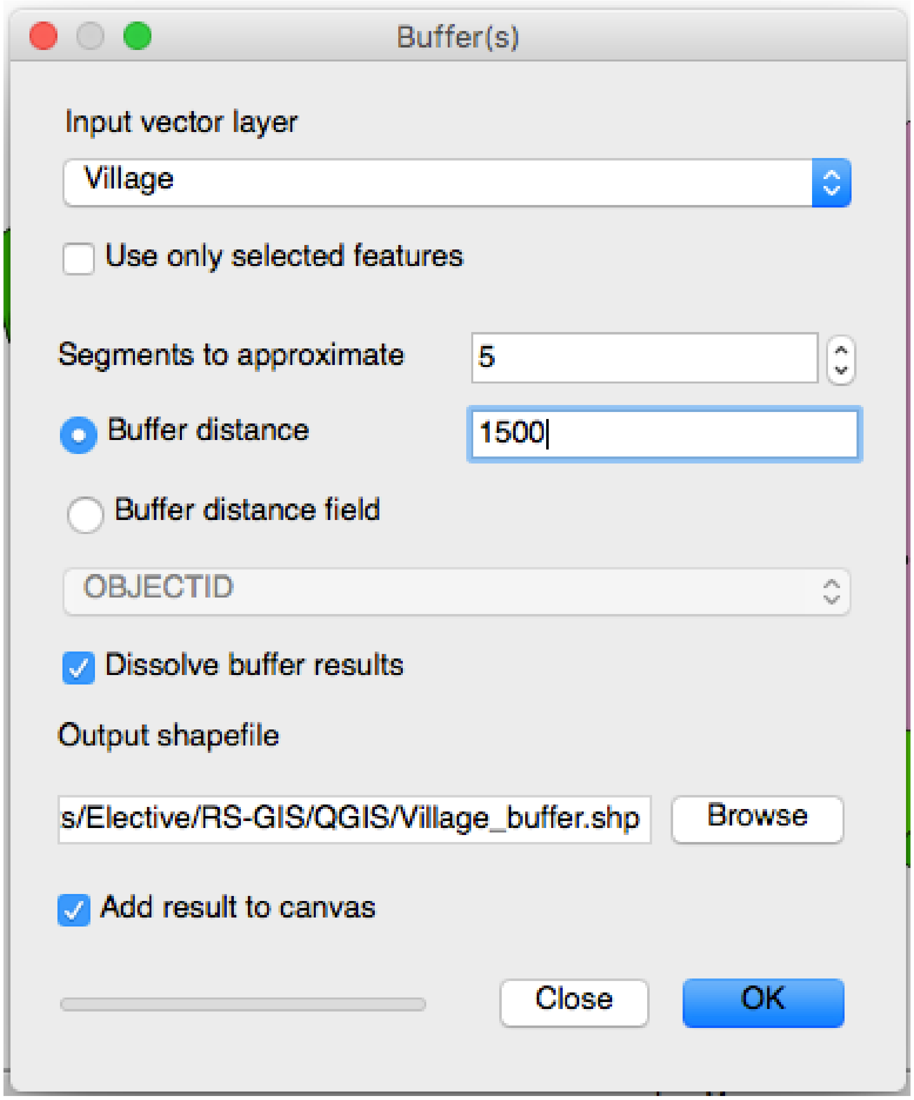
Figure 8.14: The road buffer generated by the application

only selected features" and "Add saved file to map". Click OK (Figure 8.21).

24. The result is a layer depicting the JFM compartments (Figure 8.22).

25. Since the potential locations should lie in JFM compartments and at a distance of 500 - 1,500 m from other forest buildings, we need to intersect the JFM compartment layer with the forest building buffer layer. Select the intersection tool from Vector → Geoprocessing Tools → Intersect... (Figure 8.23).

26. Input the parameters: Input vector layer is JFM compartments, and the intersect layer is Forest building buffer (outer ring only). Give a name to the output shapefile, and select "Add result to canvas". Press



Buffer(s)

Input vector layer: Village

☐ Use only selected features

Segments to approximate: 5

● Buffer distance: 1500

○ Buffer distance field: OBJECTID

☑ Dissolve buffer results

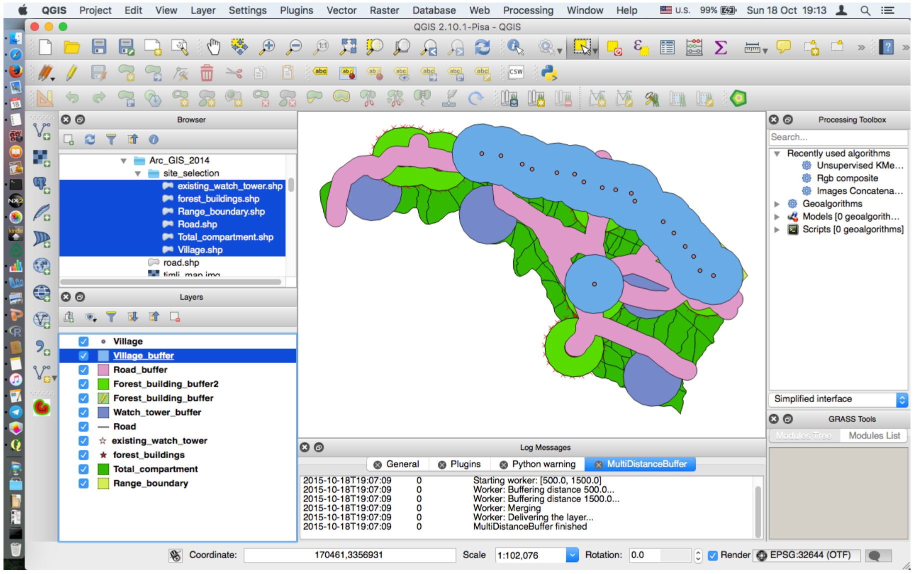
Output shapefile: s/Elective/RS-GIS/QGIS/Village_buffer.shp

☑ Add result to canvas

Figure 8.15: Inputting the parameters for generation of the village buffer

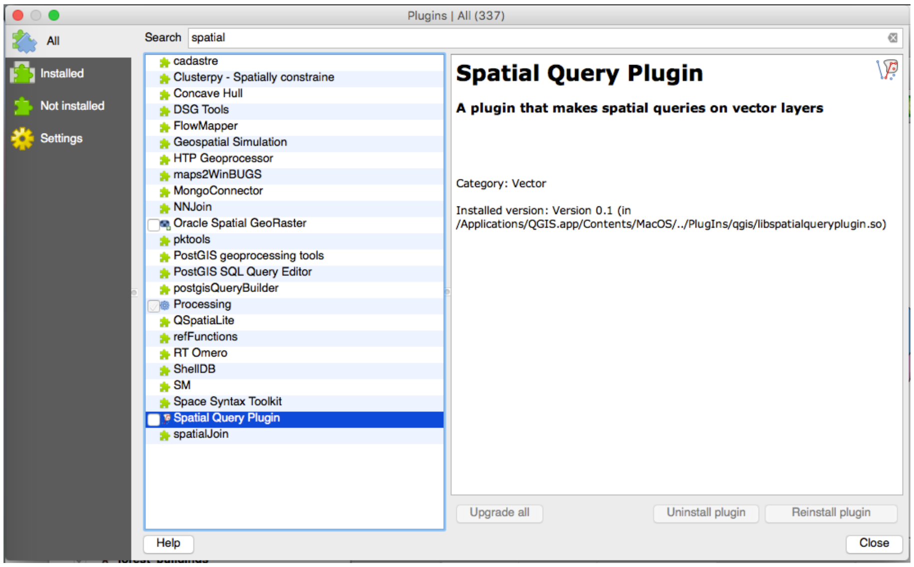
OK (Figure 8.24).

27. The application then outputs those areas in the JFM compartments that are at a distance of 500 - 1,500 metres from the existing forest



```
2015-10-18T19:07:09    0    Starting worker: [500.0, 1500.0]
2015-10-18T19:07:09    0    Worker: Buffering distance 500.0...
2015-10-18T19:07:09    0    Worker: Buffering distance 1500.0...
2015-10-18T19:07:09    0    Worker: Merging
2015-10-18T19:07:09    0    Worker: Delivering the layer...
2015-10-18T19:07:09    0    MultiDistanceBuffer finished
```

Figure 8.16: The village buffers generated by the application



Spatial Query Plugin

A plugin that makes spatial queries on vector layers

Category: Vector

Installed version: Version 0.1 (in /Applications/QGIS.app/Contents/MacOS/../PlugIns/qgis/libspatialqueryplugin.so)

Figure 8.17: Installation of spatial query plugin

buildings (Figure 8.25).

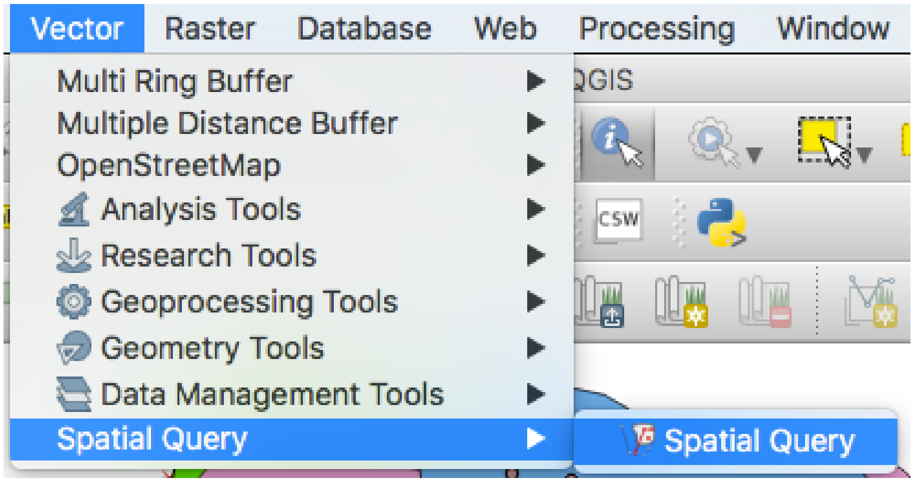
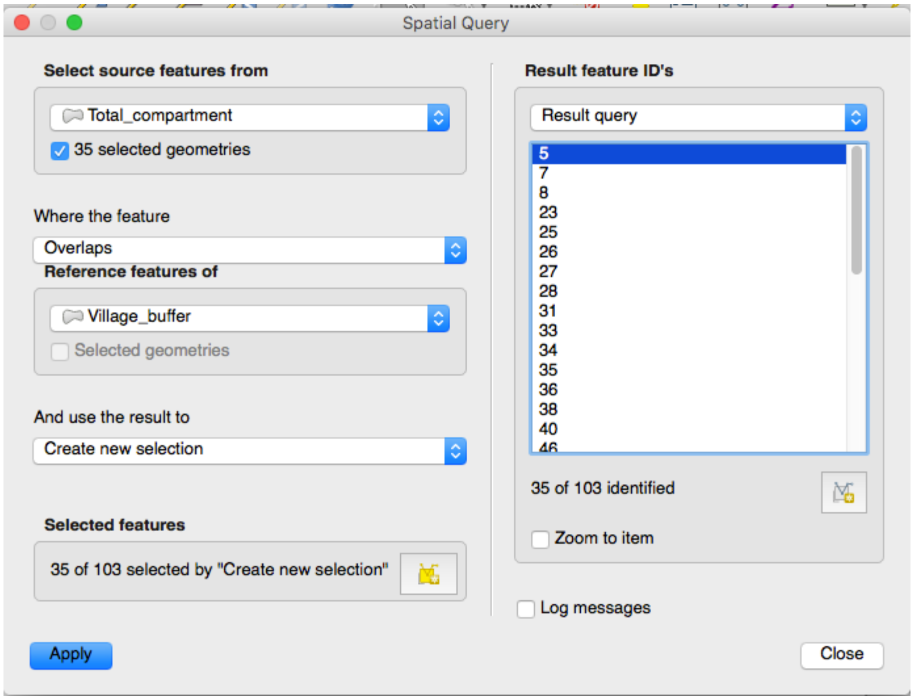


Figure 8.18: Accessing the spatial query plugin


Spatial Query

Select source features from

Total_compartment

☑ 35 selected geometries

Where the feature

Overlaps

Reference features of

Village_buffer

☐ Selected geometries

And use the result to

Create new selection

Selected features

35 of 103 selected by "Create new selection"

Result feature ID's

Result query

5
7
8
23
25
26
27
28
31
33
34
35
36
38
40
46

35 of 103 identified

☐ Zoom to item

☐ Log messages

Figure 8.19: Inputting parameters into the spatial query plugin

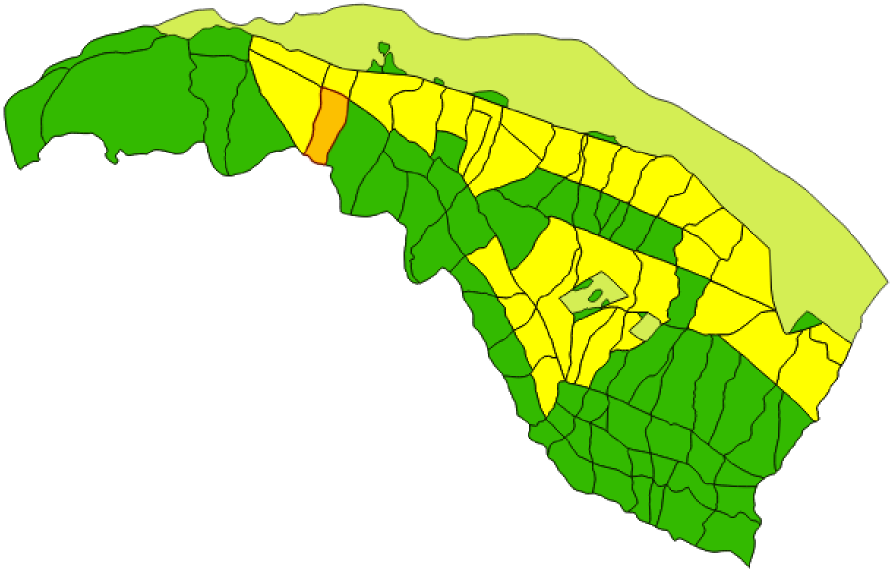


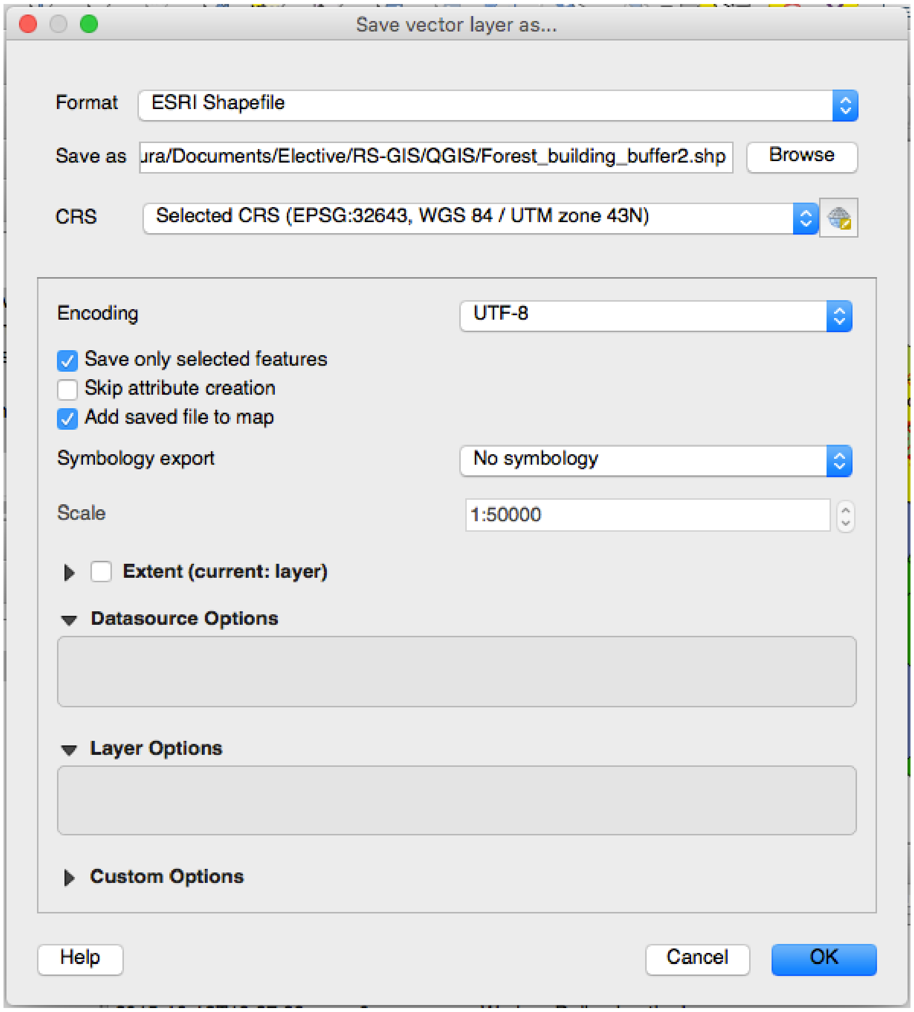
Figure 8.20: Compartments selected through the spatial query plugin

28. Next we need to exclude those areas that are within 500 m of the main roads, or within 1,500 m of the existing watch towers. We discern these excludible areas by performing a union of the road buffer and the watchtower buffer. Select Union tool from Vector → Geoprocessing Tools → Union... (Figure 8.26).

29. Input the parameters: the input vector layer is Road buffer, and the union layer is Watch tower buffer. Give a name to the output shapefile, and select "Add result to canvas". Press OK (Figure 8.27).

30. The result is depicted in figure 8.28.

31. Next we need to subtract these areas in the union layer from the intersection layer. Select the Difference tool from Vector → Geoprocessing



Save vector layer as...

Format: ESRI Shapefile

Save as: ıra/Documents/Elective/RS-GIS/QGIS/Forest_building_buffer2.shp

CRS: Selected CRS (EPSG:32643, WGS 84 / UTM zone 43N)

Encoding: UTF-8

☑ Save only selected features

☐ Skip attribute creation

☑ Add saved file to map

Symbology export: No symbology

Scale: 1:50000

☐ Extent (current: layer)

Figure 8.21: Exporting the selection to a new layer

Tools → Difference... (Figure 8.29).

32. Input the parameters: Input vector layer is the intersection layer, and the difference layer is the union layer. Give a name to the output shapefile, and select “Add result to canvas”. Press OK (Figure 8.30).

33. The final result, depicting the requisite potential locations for the con-

Figure 8.22: The JFM compartments layer

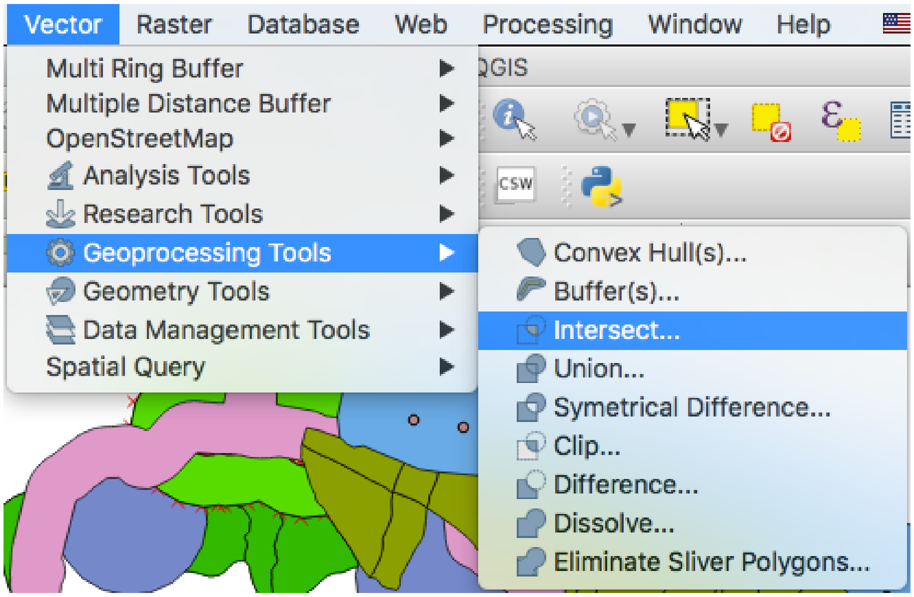
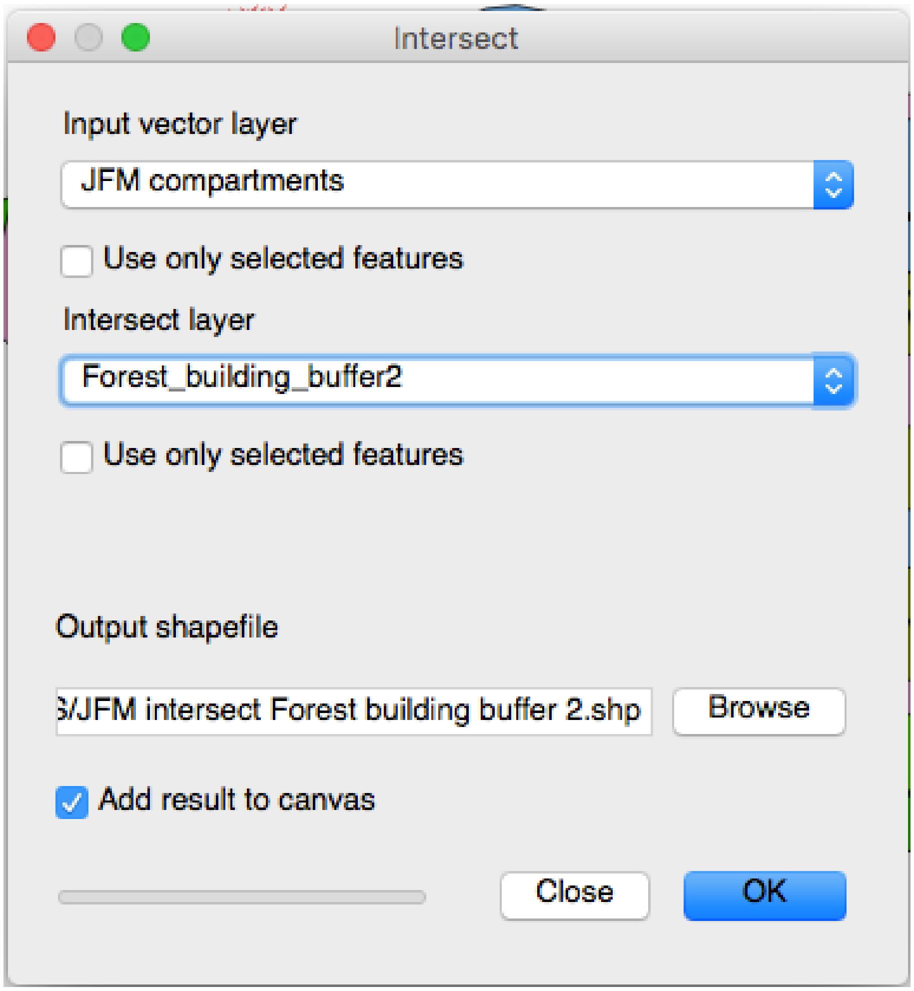


Figure 8.23: Accessing the intersection tool



Input vector layer

JFM compartments

☐ Use only selected features

Intersect layer

Forest_building_buffer2

☐ Use only selected features

Output shapefile

S/JFM intersect Forest building buffer 2.shp

☑ Add result to canvas

Figure 8.24: Inputting the parameters for the intersect tool

struction of watch tower(s) is depicted in figure 8.31.

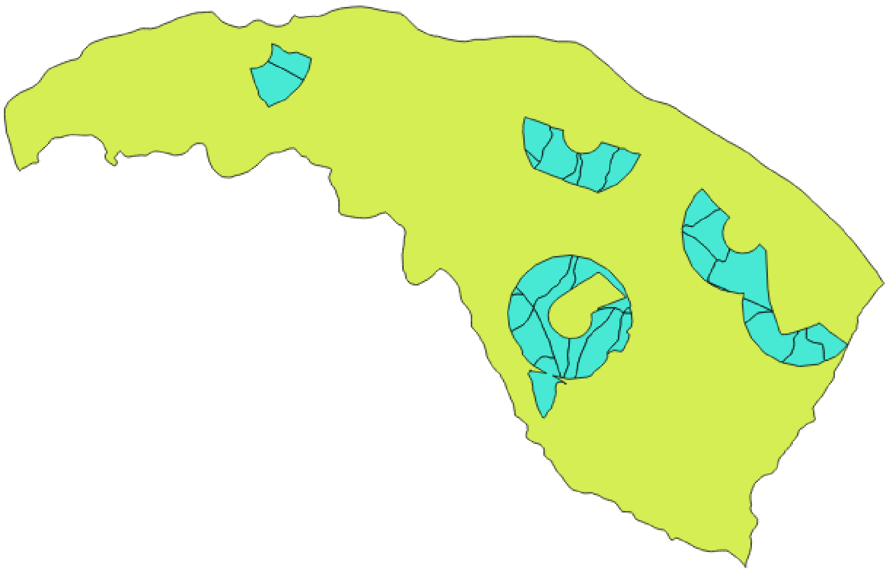


Figure 8.25: Areas in the JFM compartments that are at a distance of 500 - 1,500 metres from the existing forest buildings

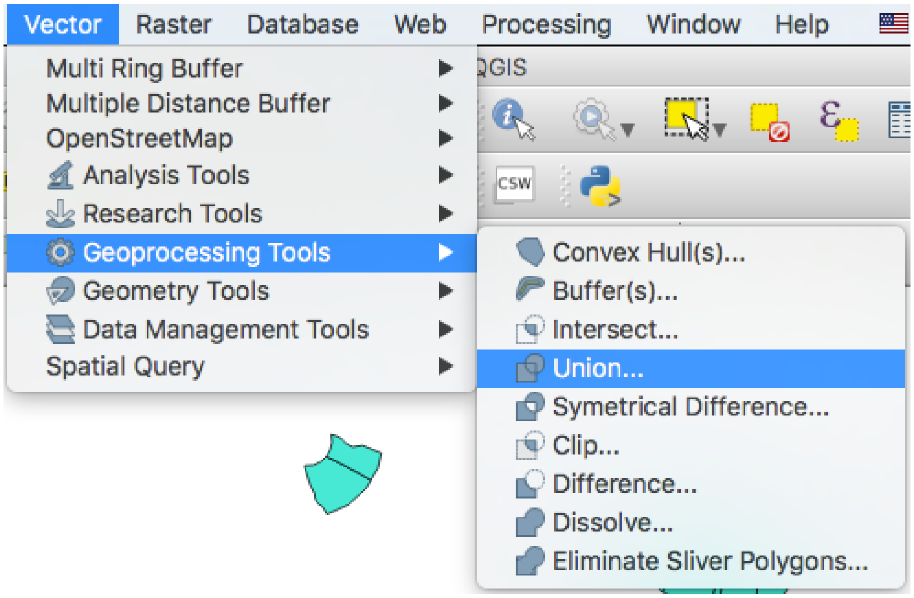
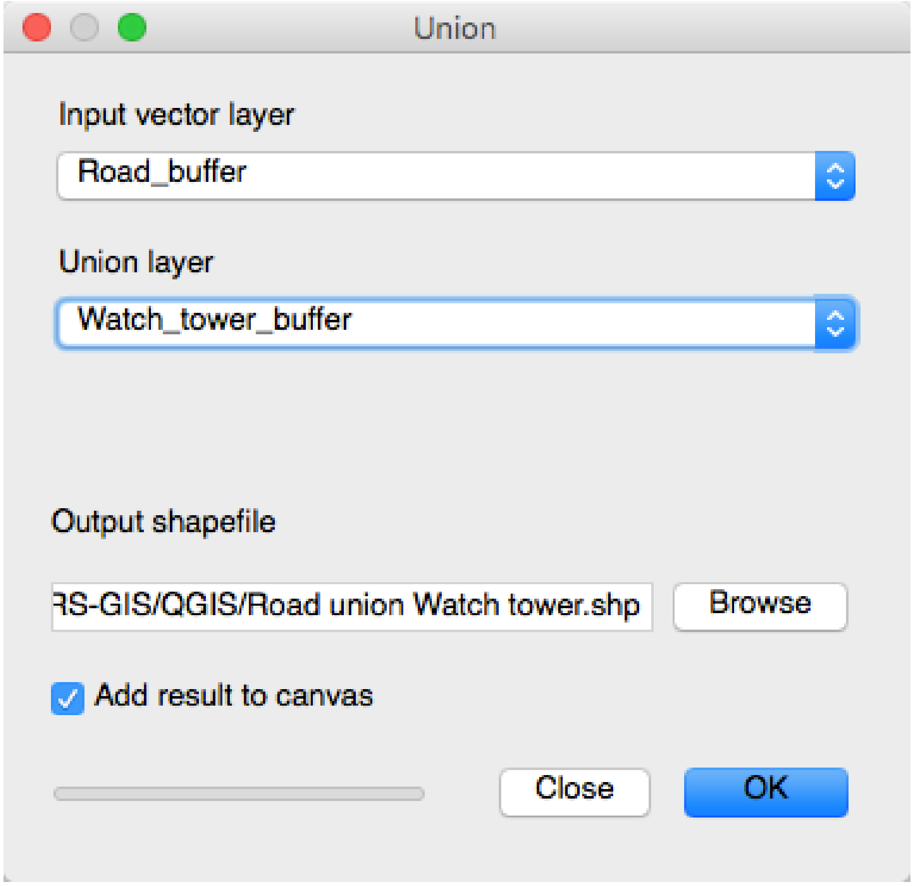


Figure 8.26: Accessing the Union tool



Input vector layer: Road_buffer

Union layer: Watch_tower_buffer

Output shapefile: RS-GIS/QGIS/Road union Watch tower.shp

☑ Add result to canvas

Figure 8.27: Inputting the parameters for the Union tool

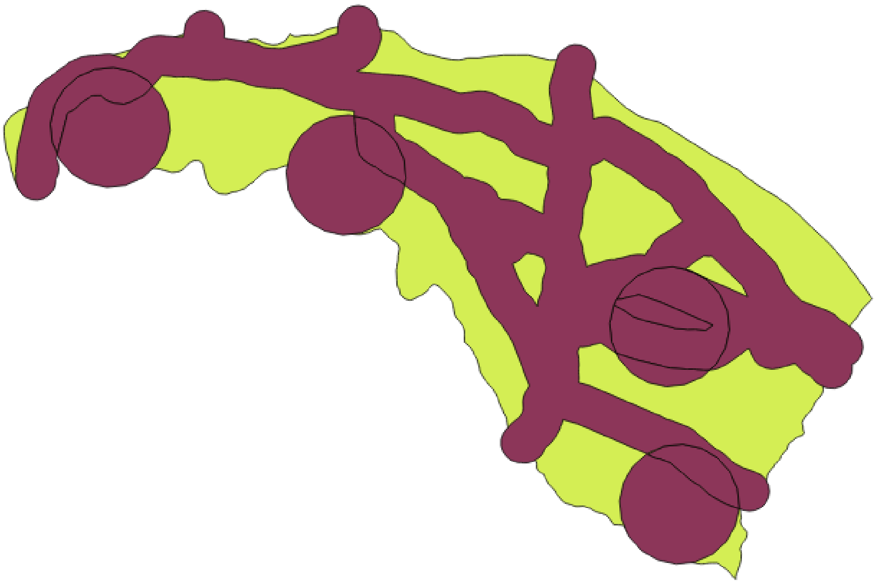


Figure 8.28: The result of the union operation

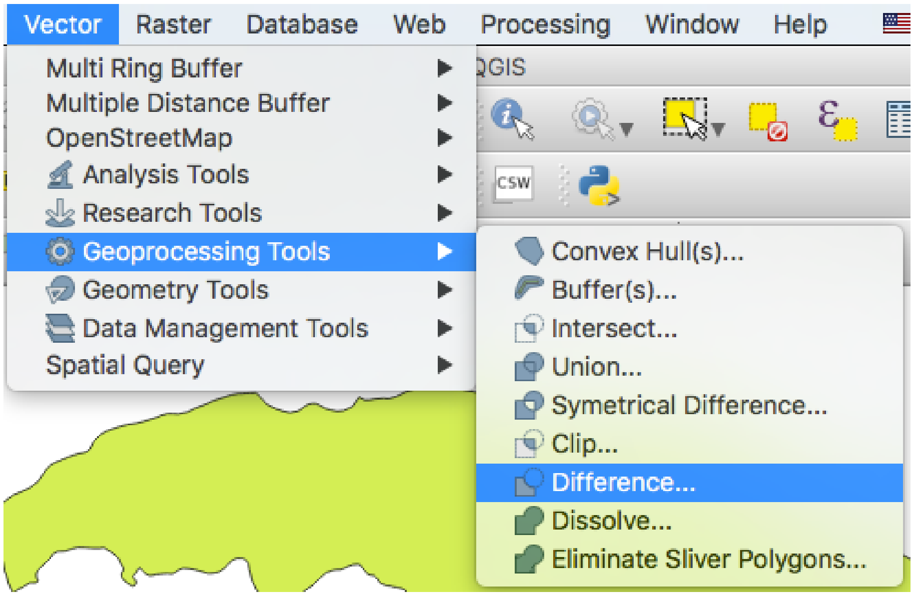
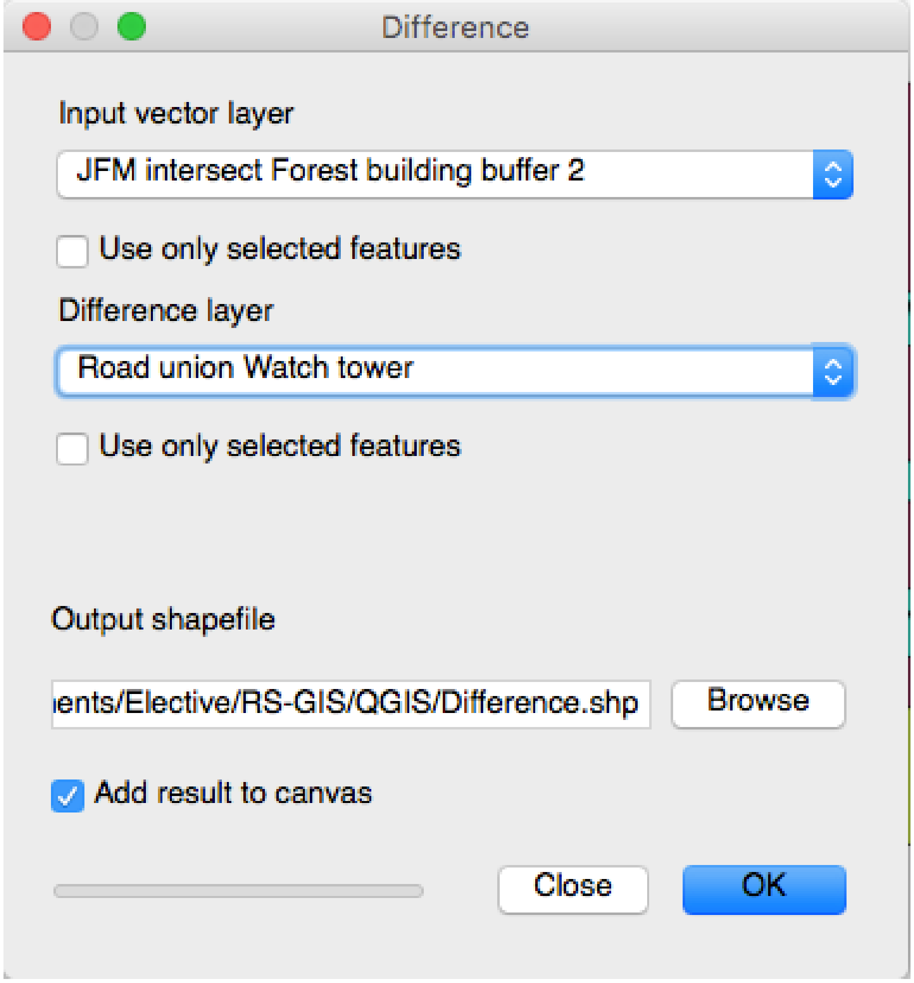


Figure 8.29: Accessing the Difference tool



Input vector layer

JFM intersect Forest building buffer 2

☐ Use only selected features

Difference layer

Road union Watch tower

☐ Use only selected features

Output shapefile

ents/Elective/RS-GIS/QGIS/Difference.shp

☑ Add result to canvas

Figure 8.30: Inputting the parameters for the Difference tool

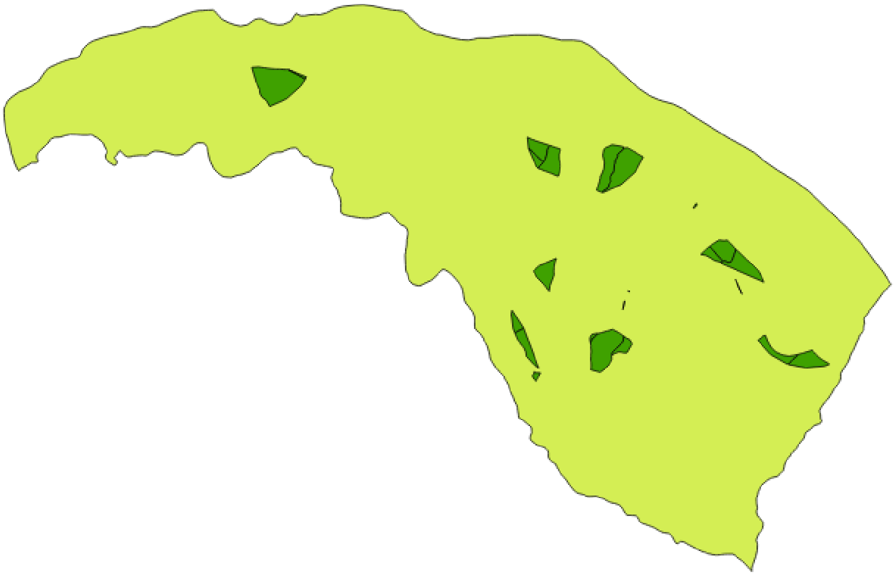


Figure 8.31: Final result depicting the requisite potential locations for the construction of watch tower(s)

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