Practical Introduction to QGIS

ILPÖ Institut für Landschaftsplanung und Ökologie
Universität Stuttgart

Day 1: May 3rd , 2019 9:00 - 16:00
Day 2: May 10th, 2019 9:00 - 16:00

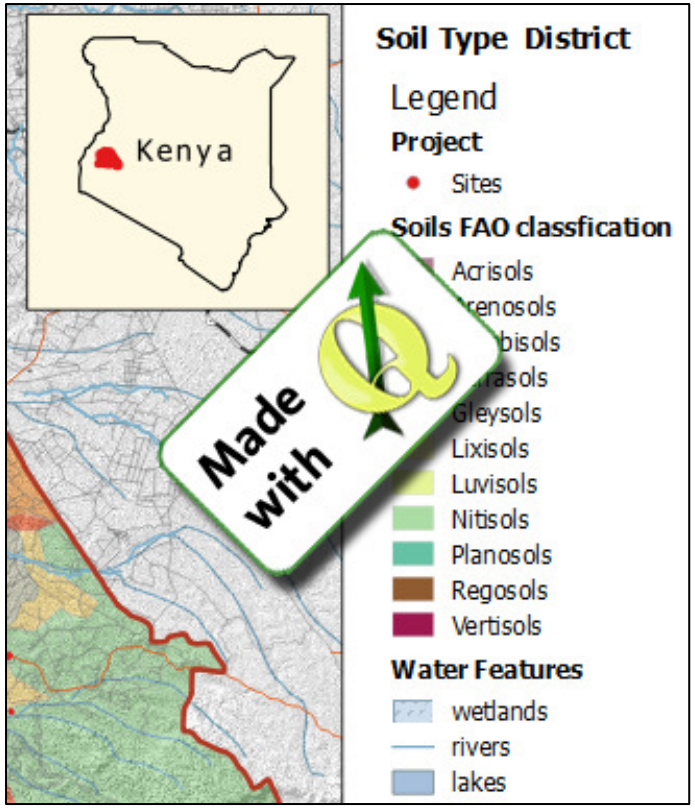
with one hour lunch break

Karsten Vennemann

TERRA GIS
TERRESTRIAL ENVIRONMENT REGIONAL ANALYSIS

QGIS

a very capable and flexible Desktop GIS



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Workshop Schedule

Workshop Schedule - Day 1

- **What is GIS ?**
  - Short Introduction/Overview
  - Use cases for GIS - Examples
- **Overview and Foundations of QGIS**
  - The QGIS project and it’s open source community
- **Practical Introduction**
  - **The QGIS software and spatial data**
    - QGIS Desktop and Browser
    - Spatial Data
    - Data Sources (e.g. Open Street Map)

Workshop Schedule - Day 1

- **Practical Introduction**
  - **QGIS Basics and Interface Overview**
    - Supported data formats
    - Exploring and using vector and raster data
    - Layer + map properties
    - Symbology / Cartography
  - **Exercises - Creating and Printing Maps**
    - Working with tables and layers
    - Using layouts for cartography and printing maps

Workshop Schedule - Day 2

- **Managing Raster Data - Exercises**
  - Hill shade, slope, aspect (from DEM)
  - Raster calculator
- **Spatial Analysis and Tools**
  - **Geospatial Processing in QGIS - Exercises**
    - Using the geo-processing tools and graphical model builder
    - Exercises (e.g. counting trees in Seattle neighborhoods)

Workshop Schedule - Day 2

- Spatial Analysis and Tools
  - QGIS Plug-ins
    - Default Plug-ins: DB Manager, Coordinate capture etc.
    - Topology
    - OpenLayers (Tile layers + OSM data download)
    - Semi Automatic Classification Plug-in (Remote sensing)
    - Integration with external programs
      (Grass, R Statistical Software, SAGA GIS, Lidar tools etc.)
  - QGIS User Resources
    - Manuals, books, articles, workshops
    - Email lists, conferences

What is GIS

- Use cases for GIS - Examples
- Short Introduction/Overview

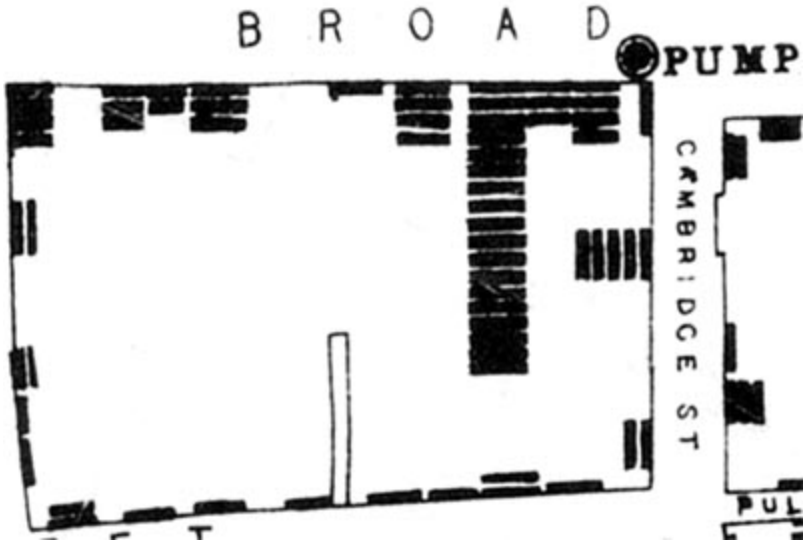
Babylon's view of the world 600 BC - Clay Tablet

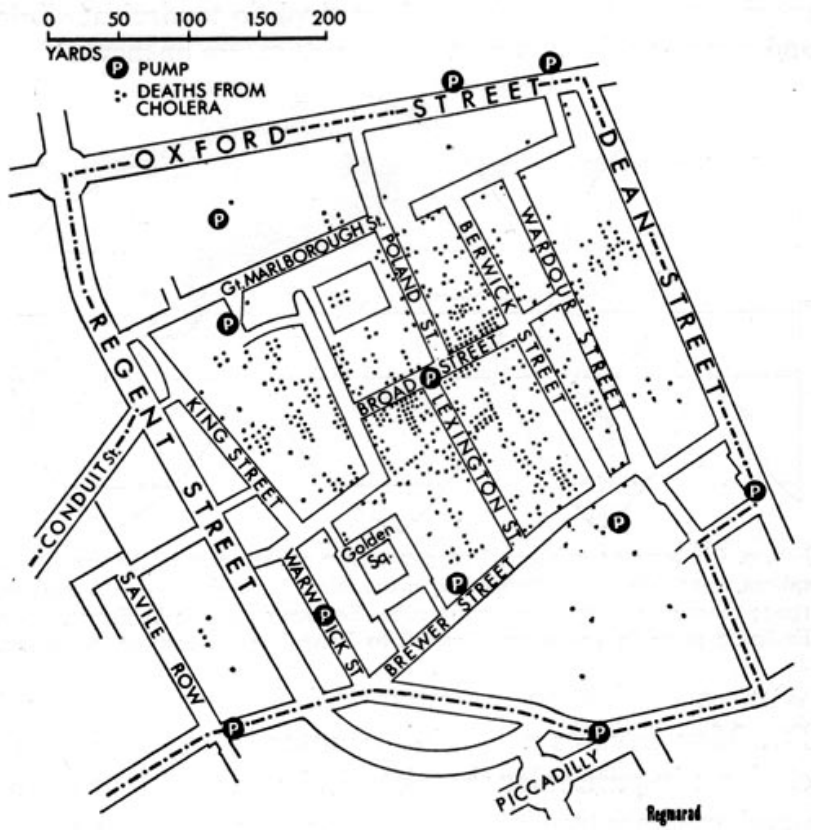
Al-Idrisi's world map 1154

Leonardo Da Vinci's Plan of Imola 1502

Mapping 1854 cholera outbreak in London's Broad Street region

John Snow is viewed by many as a pioneer in disease mapping. For the 1854 cholera outbreak in London's Broad Street region, he presented two maps.





Harry Beck's Iconic London Tube Map – 1932

Set a style for transport maps around the world

1994/95 early web maps

Internet just starting to take off
Tile services and mapping APIs emerge

- Map Quest 1996
- Yahoo maps 2002
- Open Street Map 2004
- Google maps 2005
- Bing maps 2005

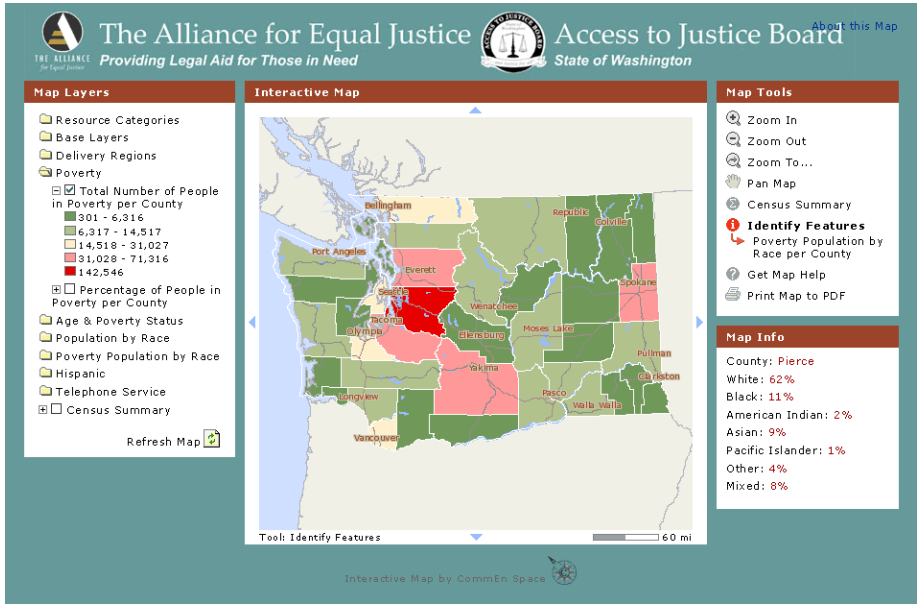
2008 Ubiquitous Google type layers

- How Google ~~enabled~~ automized Web mapping ?

Arnulf Christl at FOSS4G 2010
(2008-2012 President of OSGeo):
„In 2008: All maps have become static and street maps”

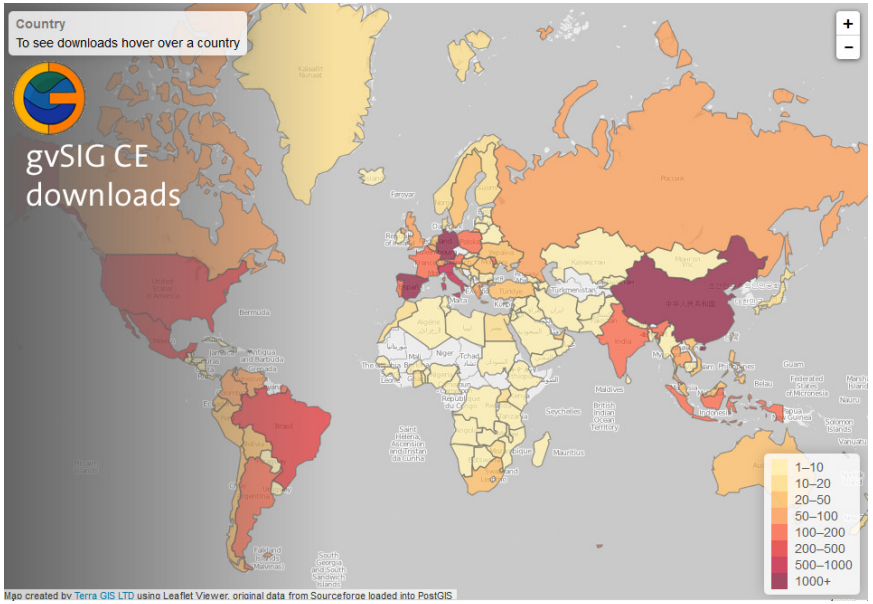
Web map layout types

compartmentalized



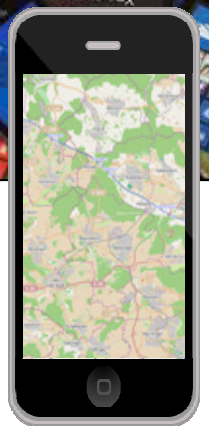
- formal presentation
- separation of maped area and other map elements
- work well on big screens

fluid



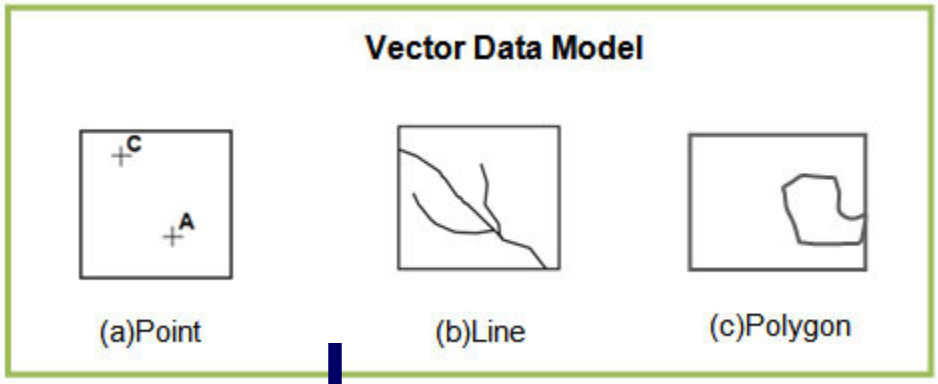
- map elements distributed around the mapped area
- best choice for mobile devices

Over time many different display devices



What is GIS

Vector



Raster

Attributes Table – or data base

Relative pearl millet panicle yield with Boule NPK fertilization compared to the non-fertilized cont...

	id	site	village	ɲatricule producteu	ːteu	sex	nom du c
1	18	Chadakori	Makeraoua_maji...	FM-AA 197-D	A...	Femme	Gusum
2	19	Chadakori	Makeraoua_maji...	FM-AA 220-P	M...	Femme	Yama
3	224	Serkin_Haoussa	Dan_Tsuntsu	FM-AK 635-C	H...	Femme	Roumboun
4	245	Tchake	El Tsamiya	FM-AL 373-F	K...	Femme	Kori
5	249	Tchake	Tchake	FM-AL 391-M	S...	Femme	Kila
6	250	Tchake	El Tsamiya	FM-AL 597-S	R...	Femme	Gadambo
7	258	Tchake	Tchake	FM-AL 802-L	B...	Femme	Yamma
8	401	Tessaoua	Tssamiyal_koura	FM-AS 798-T	S...	Femme	Goussoum

Alle Objekte anzeigen

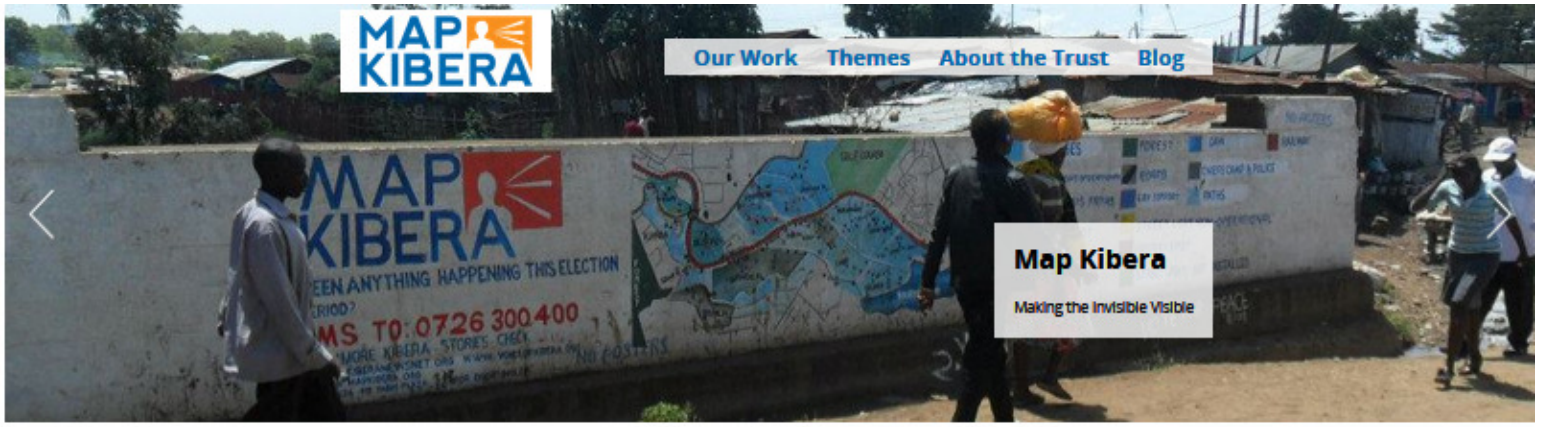
Uses of GIS

- Cartography
  - Visualization – Representation
- Storage and retrieval of spatial data
- Tool to derive new information and to generate knowledge
  - Spatial Analysis
  - Reporting

Major types of GIS

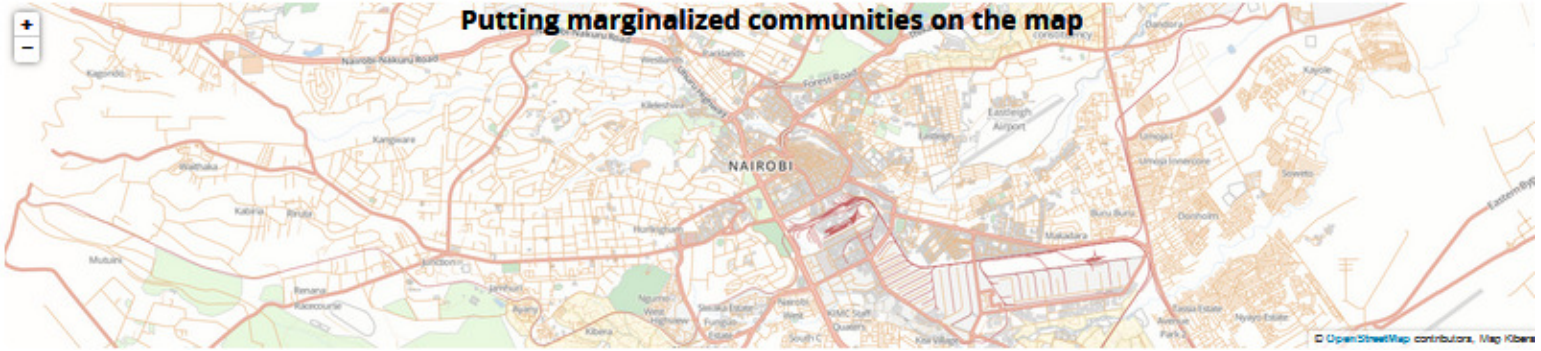
- **Emergency response**
- **Decision support**

Map Kibera – Community project



CITIZEN MAPPING | CITIZEN MEDIA | CITIZEN ADVOCACY

Kibera in Nairobi, Kenya, was a blank spot on the map until November 2009, when young Kiberans created the first free and open digital map of their own community. Map Kibera has now grown into a complete interactive community information project. We work in **Kibera**, **Mathare** and **Mukuru**, use all these **tools**. **Get in touch**!

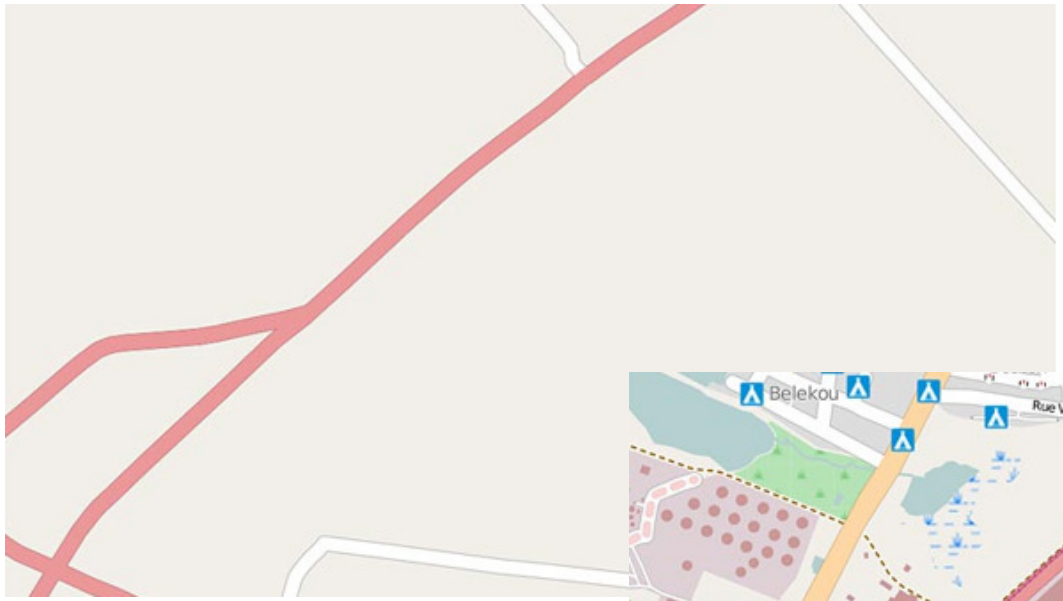


The volunteer mappers who helped Haiti

When a huge earthquake hit Haiti a month ago, the jobs of rescuers and aid workers were made more difficult by the lack of information about the layout of Port au Prince.

AFP

The volunteer mappers who helped Haiti



2-3 weeks

Overview and Foundations of QGIS

- The QGIS project and it's open source community

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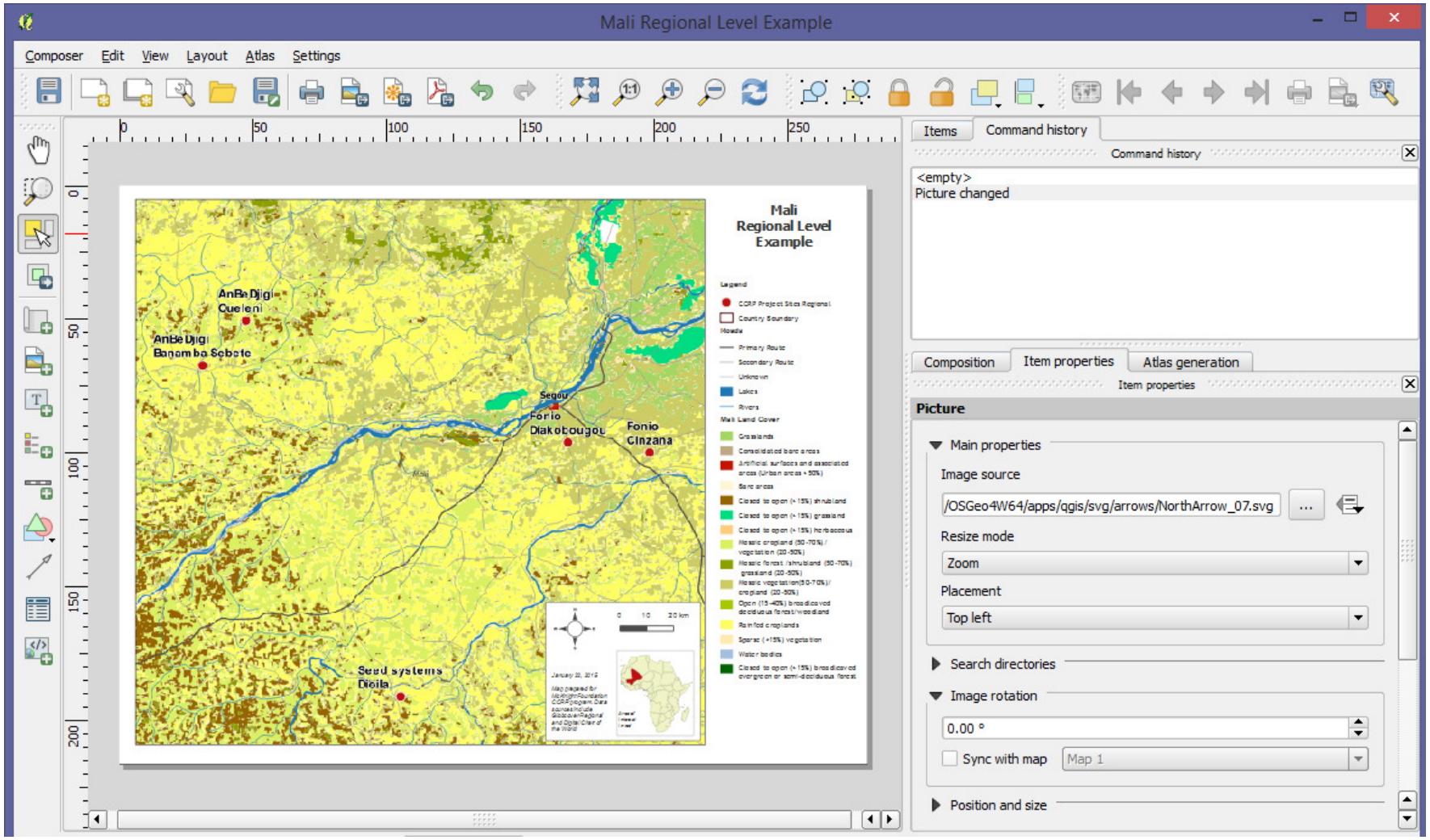
QGIS - Desktop GIS

originally a GIS viewing environment QGIS for the Linux desktop but is available for Solaris, Windows and Mac. Support for many data Formats



QGIS Facts

Main supporter of **Quantum GIS**	Gary Sherman and others
Type	Desktop GIS Viewer
Functionality	Can be used as a UI to GRASS GIS with GRASS Plug-in, Python bindings allow for programmatic interaction
Operating systems	Multi platform
Project started	2002
Implementation	C++, Depends on QT widget
OS libraries	OGR/GDAL
PostGIS support	Yes
License	GPL

QGIS Highlights

- „Intermediate“ Desktop GIS
- all basic and intermediate GIS Functionality
- support for many input formats
- easily extensible and highly customizable
- extended comprehensive Analytic capabilities
  -> Processing Tools and modeler
- automation and custom tool development via
  - Python scripting (Python bindings and pyQT integration)
  - Enables plug-in and user interface development
- Very active User and Developer Community
  - rapid development, good community support

What is Open Source (GIS)?

Open source means that the source code is available to the general public for use, distribution, and modification from its original design free of charge (among a long list of other requirements)

Open Source ≠ Open Standards

While most open source geospatial software is built on the standards of the Open Geospatial Consortium (OGC) the term "Open Source" it is not synonymous with Open Standards because both proprietary and open source software can be compliant with the OGC Open Standards. http://www.opengeospatial.org

OSGeo is the organization that supports the development of the highest quality open source geospatial software. http://www.osgeo.org

The OS Culture

Often the FOSS movement is referred to as not only a model on how to create, distribute and license software but rather a culture. A lot of times business people don't understand why one would create something useful and just give it away instead of selling it. Thus, many times they infer that there must be a catch, something must be wrong with the product, since it is free it must have no value and other misconceptions.

There is much more to it than producing free and open software. It is a way of doing things, of working together, of collaborating, a movement of people around the globe, in short a culture. It is appreciated when people using the software are giving something back to the community. That might be helping others in the user list and online forums, writing documentation about something you learned about using the software in the online wiki pages[6] of the project, writing new source code or customizations and sharing it with the community. The community is working like an organism and the organism does better if all parts are working together.

List of common FOSS software licenses

Name	Style	software
GNU-GPL	strong copyleft license, derived works have to be available under the same copyleft	GRASS, QGIS, gvSIG, Mapbender, PostGIS, GeoServer, AveiN!
LPGL	compromise between copyleft and more permissive licenses, has copy-left restrictions on the program itself, but not on other software linking with the program.	Mapnik, MapGuide
MIT	permissive license, permits reuse within proprietary software (license has to be distributed with that software)	MapServer, GDAL/OGR, Proj4
BSD	permissive license, little restriction, close to the public domain	FeatureServer, TileCache, OpenLayers
Mozilla (MPL)	hybrid of modified BSD and GPL.	MapWindow, Mozilla Firefox

The „Tribes“ of FOSS4G

Tribe	FOSS4G Projects
C/C++	MapServer, GRASS, MapGuide, QGIS, PostGIS, OGR/GDAL, PROJ4, GEOS, FDO
Java	GeoTools, GeoServer, uDig, DeeGree, JUMP, gvSIG
Web	MapBender, OpenLayers
.Net	SharpMap, WorldWind, MapWindow

Some of the Foundations of OS Software (Tools)

A few libraries that are the foundation of many
Open Source and commercial Geospatial Software Packages

- GDAL (Raster) and OGR (Vector)
  Geospatial Data Abstraction Library / OpenGIS Simple Features Reference Implementation
  - Tools for reading, writing and processing of raster and vector data sets -> formats
  - Important base for many Desktop GIS systems e.g. ArcGIS
  - OGR extends Mapserver formats
    Oracle Spatial, ESRI Geodatabase (MDB), TIGER, MapInfo…
- PROJ4 is a library for cartographic projection routines
  - stand alone projection utility "proj"
  - libraries for more than 2500 projections (e.g. EPSG list)
- GeoTools is an open source Java GIS toolkit is a library for cartographic projection routines
  - Similar usage as OGR and GDAL for Java based projects
  - Udig and GeoServer are based on GeoTools

Examples for practical use of GDAL/OGR

- **Raster / Image processing**
  - run automatically from server side scripts on server bash shell
  - image mosaicing, reprojection
  - custom scripts to process 3 band tiff images e.g. vegetation vigor classification (Landsat 7+ 8)
  - assemble *synthetic* map images , grayscale for background + color classified raster map

Practical Introduction

The QGIS software and spatial data

- **QGIS Desktop and Browser (show)**
- **Spatial Data (workshop)**
- **Data Sources Examples**

volunteer efforts	Open Street Map
	Natural Earth Data
data portals	NRW (North Rhine Westphalia)
	USGS Earth Explorer

Practical Introduction

The map document

open the Kenya Map

data/kenya/kenya_exercises.qgs

Using workshop maps and data

- Tour of the Interface
  including but not limited to
  - Adding data
  - Changing cartographic style/ representation
  - Displaying and arranging map layers
  - Attribute tables and indentifying attributes
  - Feature selections and filters
  - Data conversions / export
  - Using tool bars

Quick Tour

- **Menu Bar** provides access to all the main functions and plugins
- **Toolbars** provide one-click common functions, and task-specific functions
- **Layer List** shows all data layers currently added to the project
- **Status Bar** provides some vital information about the current project settings
- **Python Console** allows you to script Python code within QGIS
- **Map View** provides a dynamic visualization of the *active* data layers that can be mapped

QGIS Basics and Interface Overview

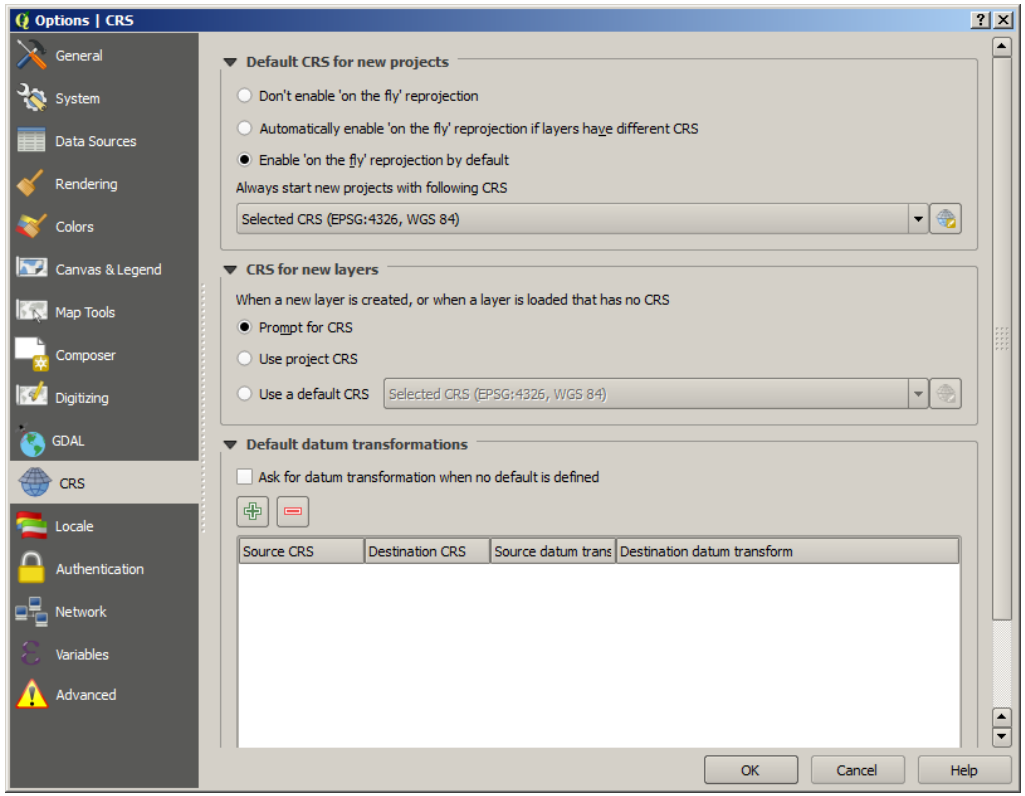
- Supported Data Formats
- Exploring and using vector and raster data
- Layer + map properties
- Symbology / Cartography

Exercises - Basic Functionalities

Using workshop maps and data

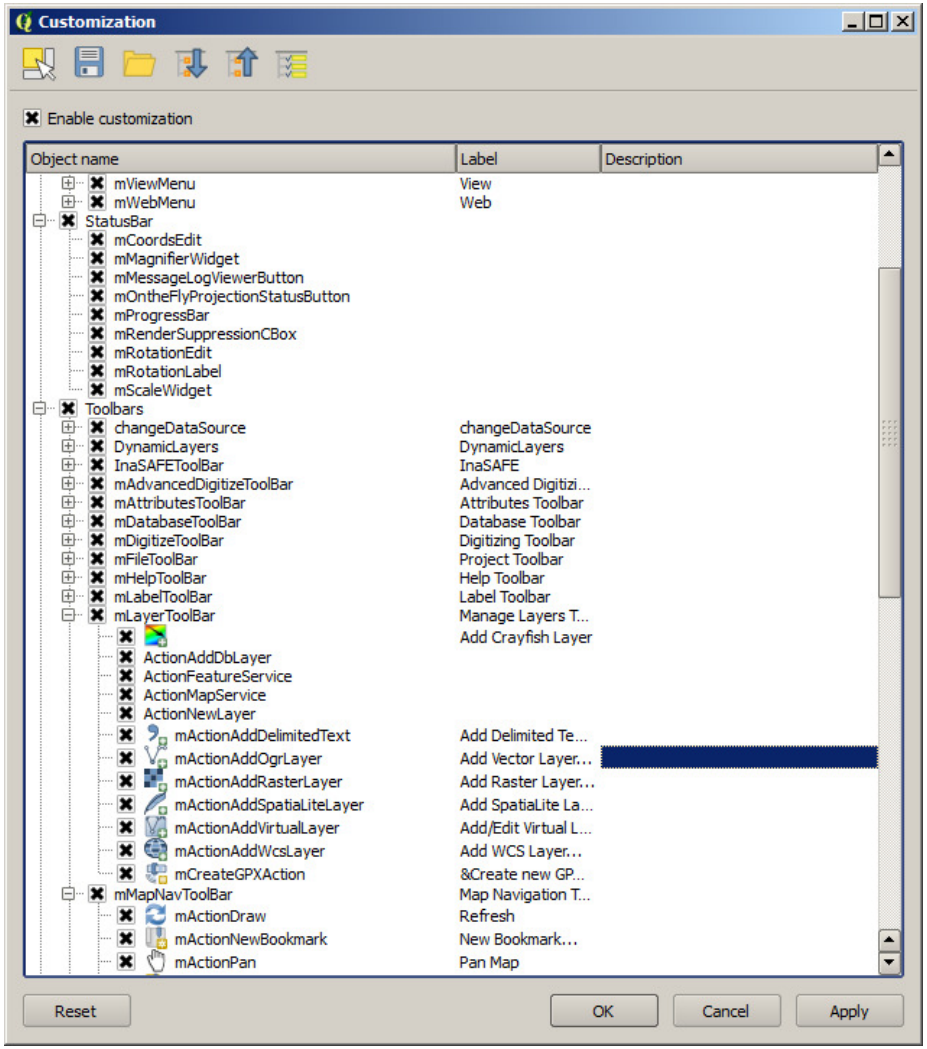
Settings - Options - user interface (Task 1)

- CRS (Task 1.1)
  - enable "on the fly reprojection"
  - set default CRS
- Digitizing (Task 1.2)
  - enable snapping
- Canvas and Legend (Task 1.3)
  - change selection color



Settings - Customization - user interface (Task 2)

- Customize Toolbar (Task 2.1)
  - disable one tool bar of your choice and review the user interface
  - enable that tool bar again



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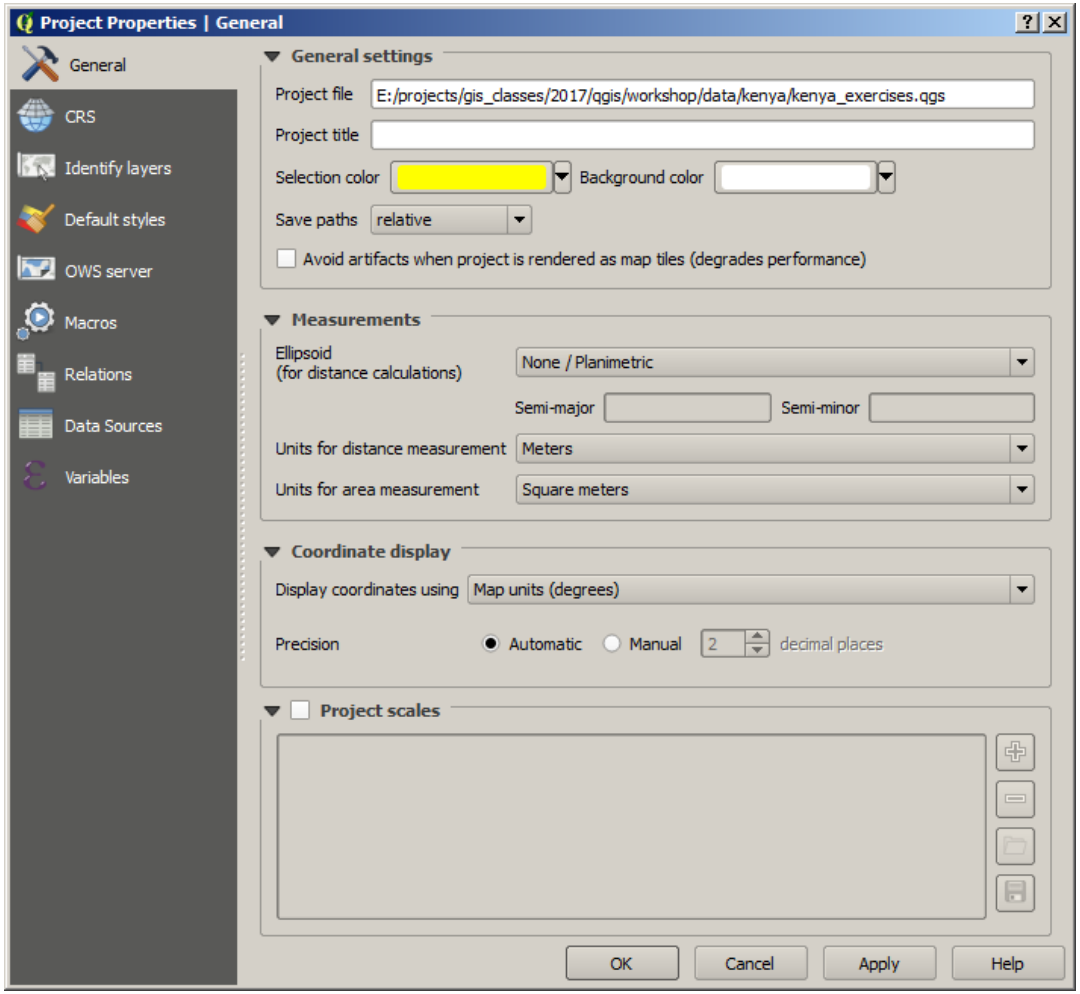
Project Settings (Task 3)

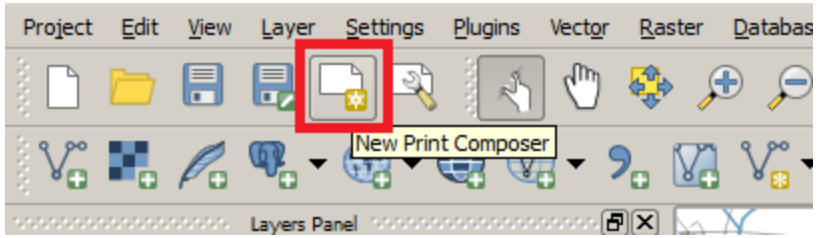
- General settings
  - Set “Save paths” to “relative”

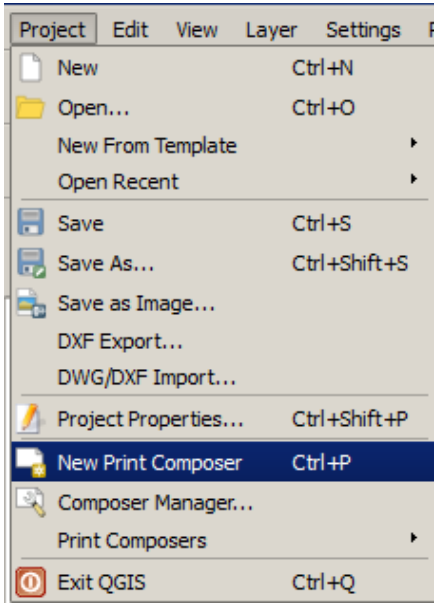


Exercises - Creating Maps

Creating Maps (Task 4)

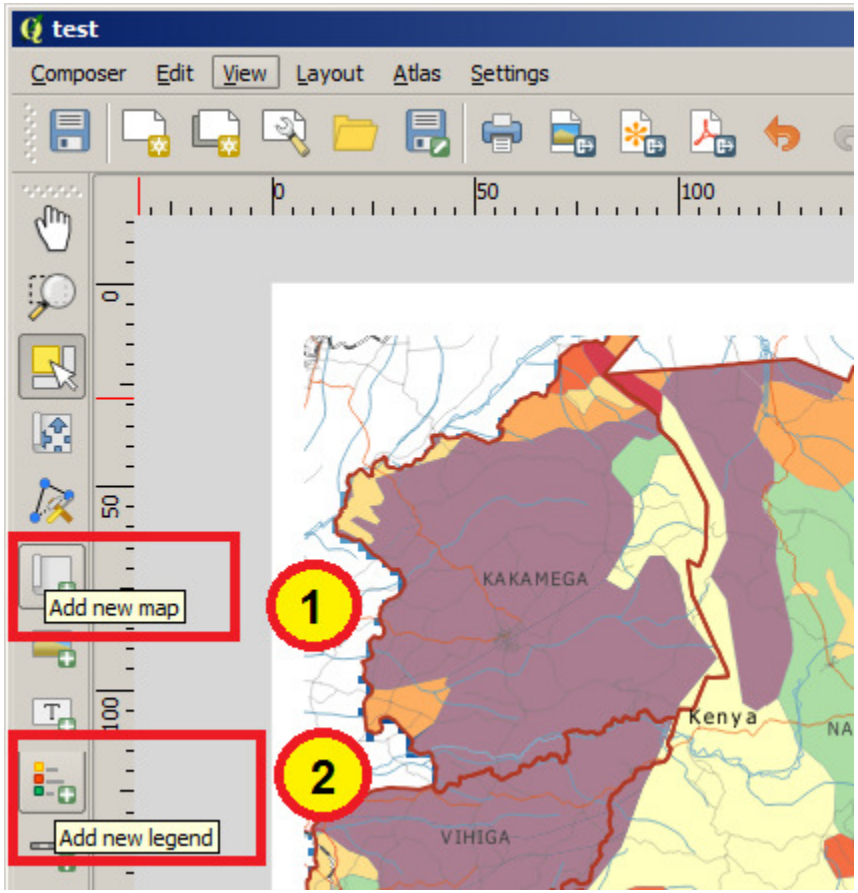
- create a new, empty project (Task 4.1)
- add at least two vector layers (Task 4.2)
  - add two Seattle data set layers
  - open layer properties – style
  - change color and outline (use “single symbol” for one layer and “categorized” for the other layers as options)
  - note the advanced option of rule based classification
- create a new “print composer” (layout) (Task 4.3)





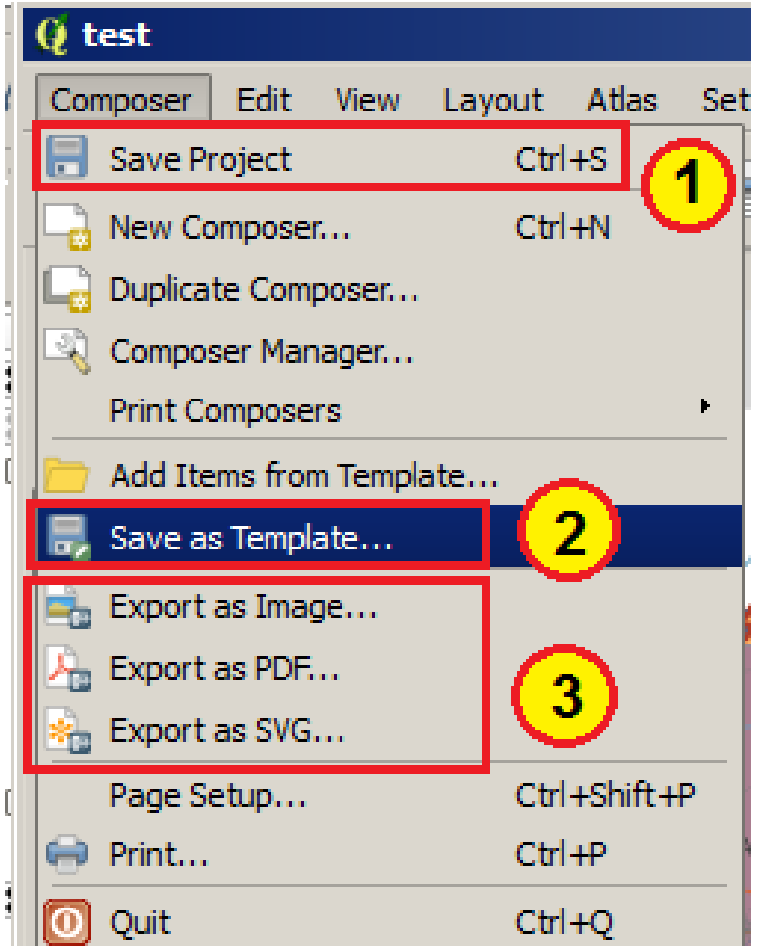
Creating Maps (Task 4.4)

- add map item (Task 4.4.1)
- add legend item (Task 4.4.2)



Creating Maps (Task 4.4)

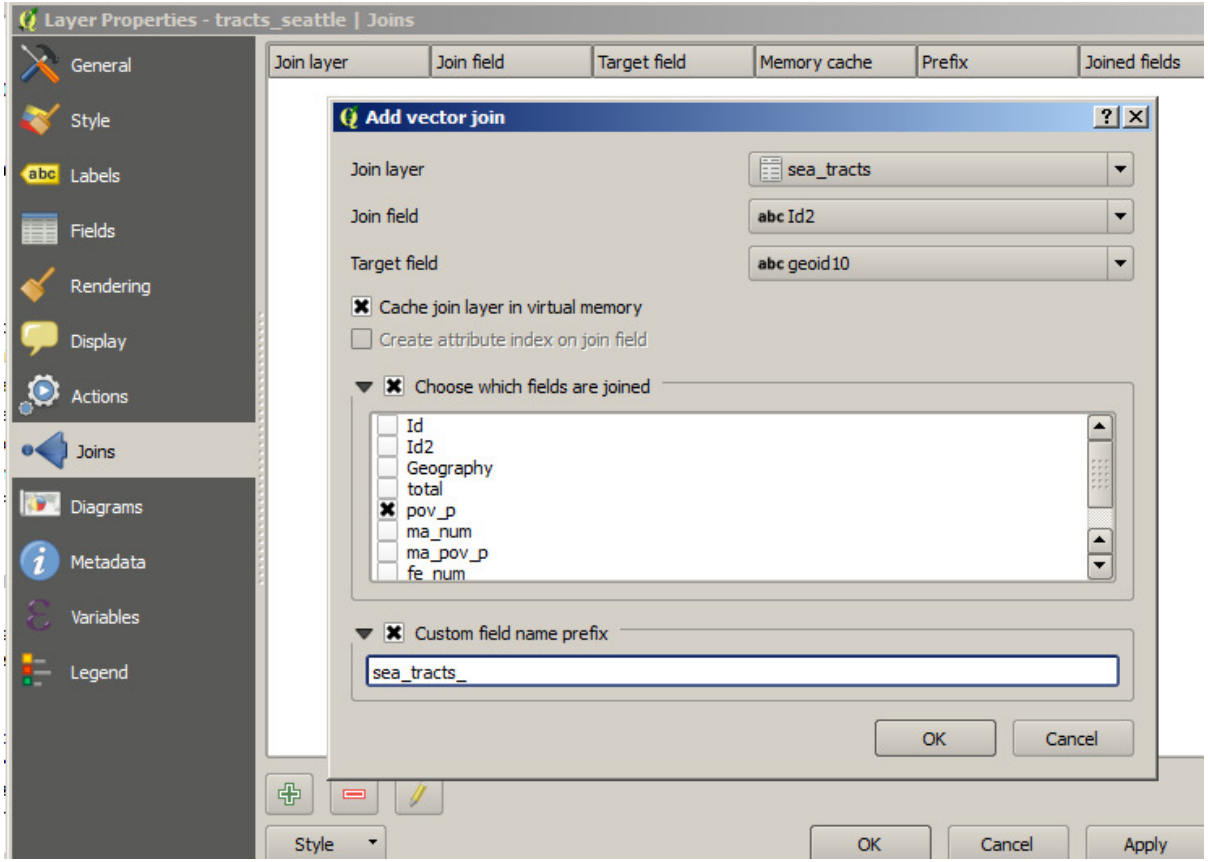
- review options in print composer (Task 4.4.3)
  - add scale bar map item
  - add north arrow
- save project (*.qgs) (Task 4.4.4)
- save work as template (*.qgt) (Task 4.4.5)
- export map as image (Task 4.4.6)
- close print composer and create new project from your template (Task 4.4.7)



Exercises
Working with tables and layers

Working with tables and layers (Task 5)

- open existing QGIS map document data/seattle/seattle_exercises.qgs
- add census tracts layer data/seattle/census/tracts_seattle.sqlite and /seattle/census/sea_tracts.csv + review attribute data tables
- join information for people in poverty using fields geoid10 and Id2



Workshop Day 2

QGIS - Managing Raster Data

QGIS Workshop

Practical QGIS

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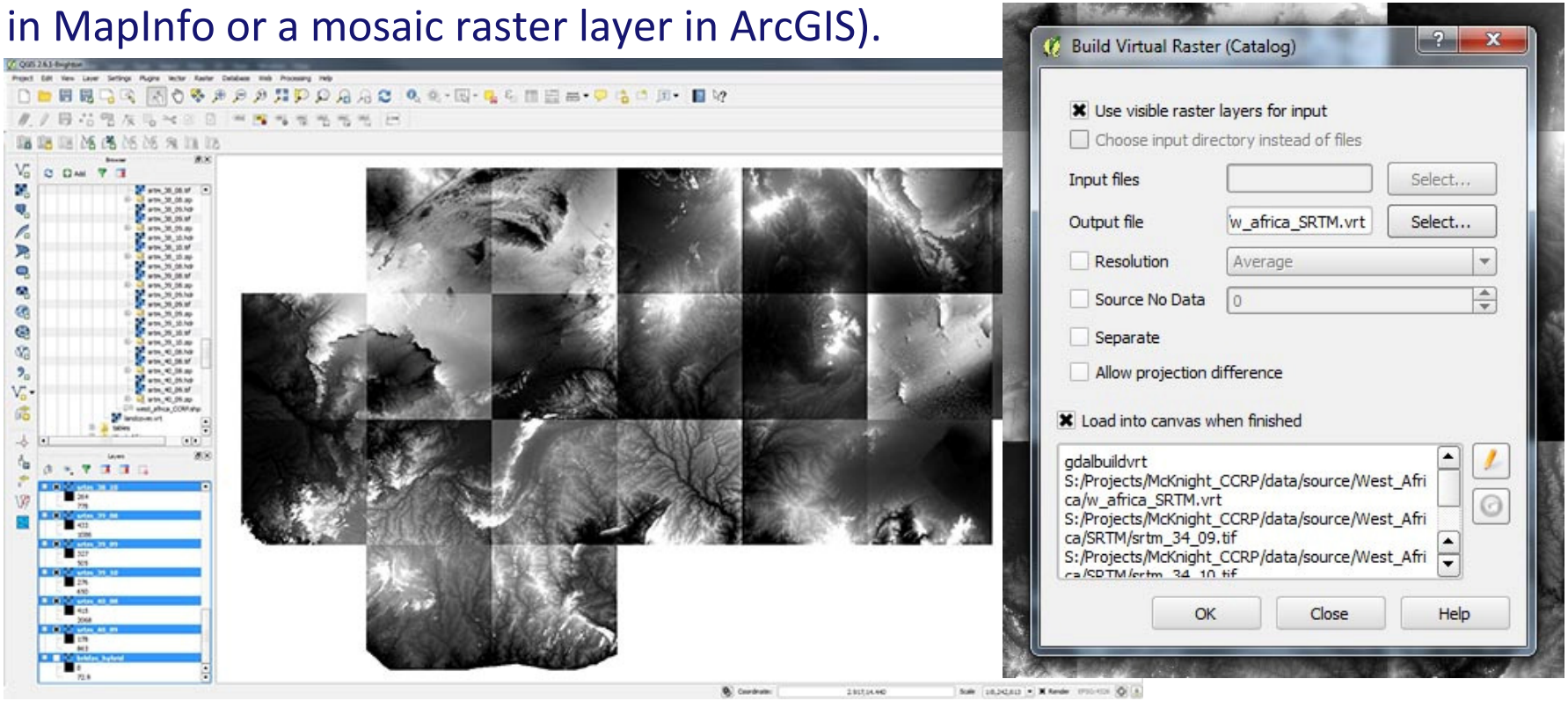
QGIS - Managing Raster Data

Virtual Raster

You can deal with multiple files like they are one file by creating a virtual raster. This can be done by selecting the Raster > Miscellaneous > Build Virtual Raster (Catalog) menu option. This creates a mosaic of the images (like a seamless layer in MapInfo or a mosaic raster layer in ArcGIS).

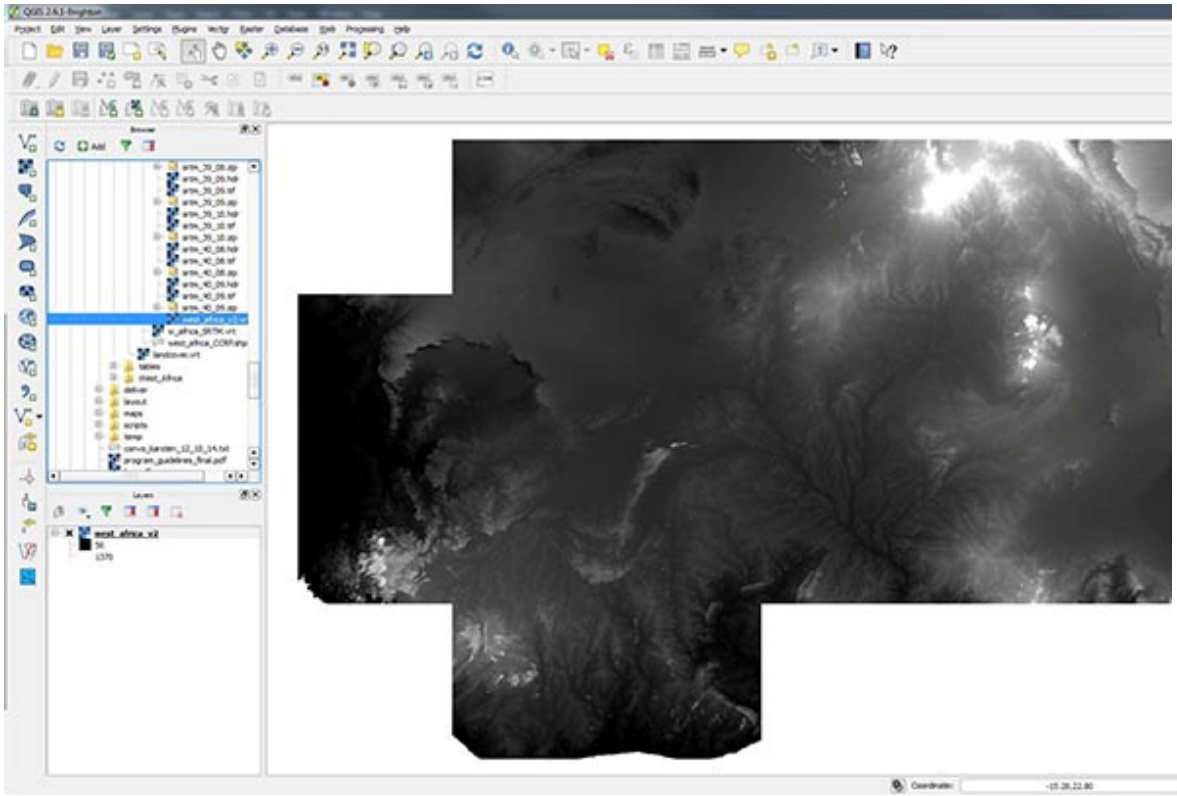


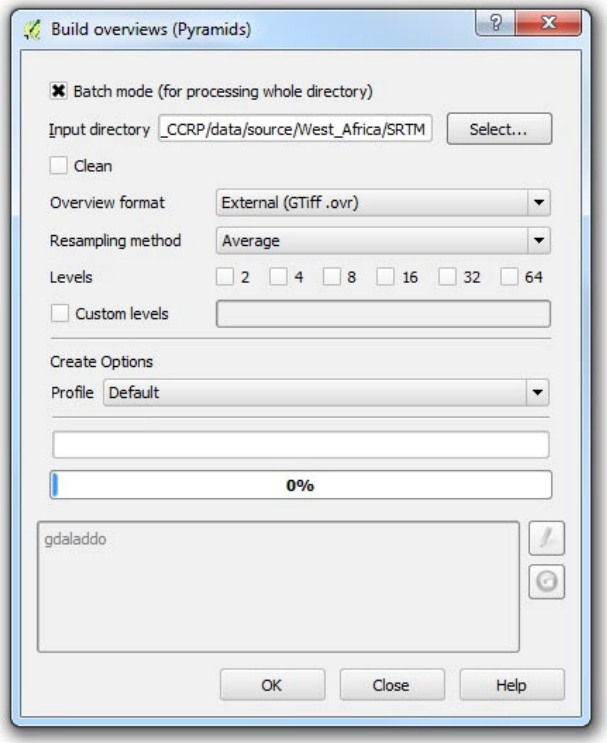
QGIS - Managing Raster Data

Build Overviews (Pyramids in ArcGIS)

You can also create pyramids on multiple datasets in one go by using the Raster > Miscellaneous > Build Overviews menu option.

This allows for a batch mode. It has more advanced options, and its best to read this webpage to understand them

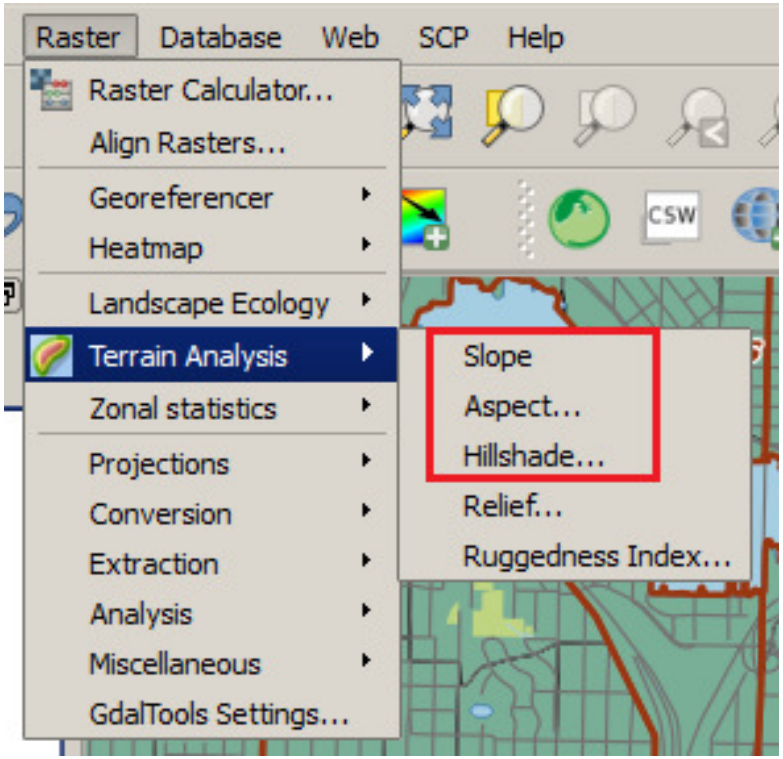




Exercises – Raster data

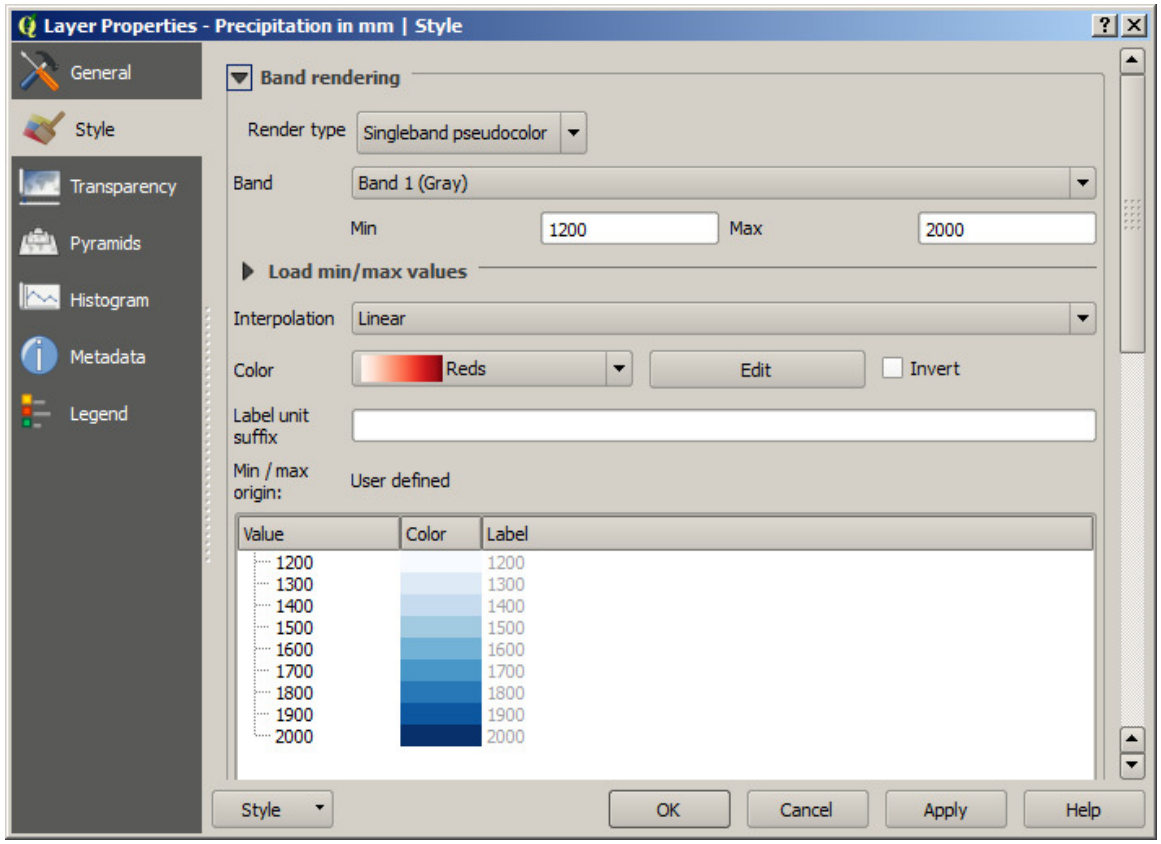
Managing Raster Data (Task 6)

- load Seattle DEM raster layer
  to your project (Task 6.1)
  /data/seattle/seattle_hs30m.tif
- create hill shade,
  slope,
  and aspect layers
  from DEM (Task 6.2)



Managing Raster Data (Task 7)

- open existing QGIS map document **/data/kenya/kenya_exercises.qgs**
- open layer properties for "Precipitation in mm" /data/kenya/newrain.tif
- review the existing Rendering type and the other types available
- review the existing classification
- change to show only 5 classes



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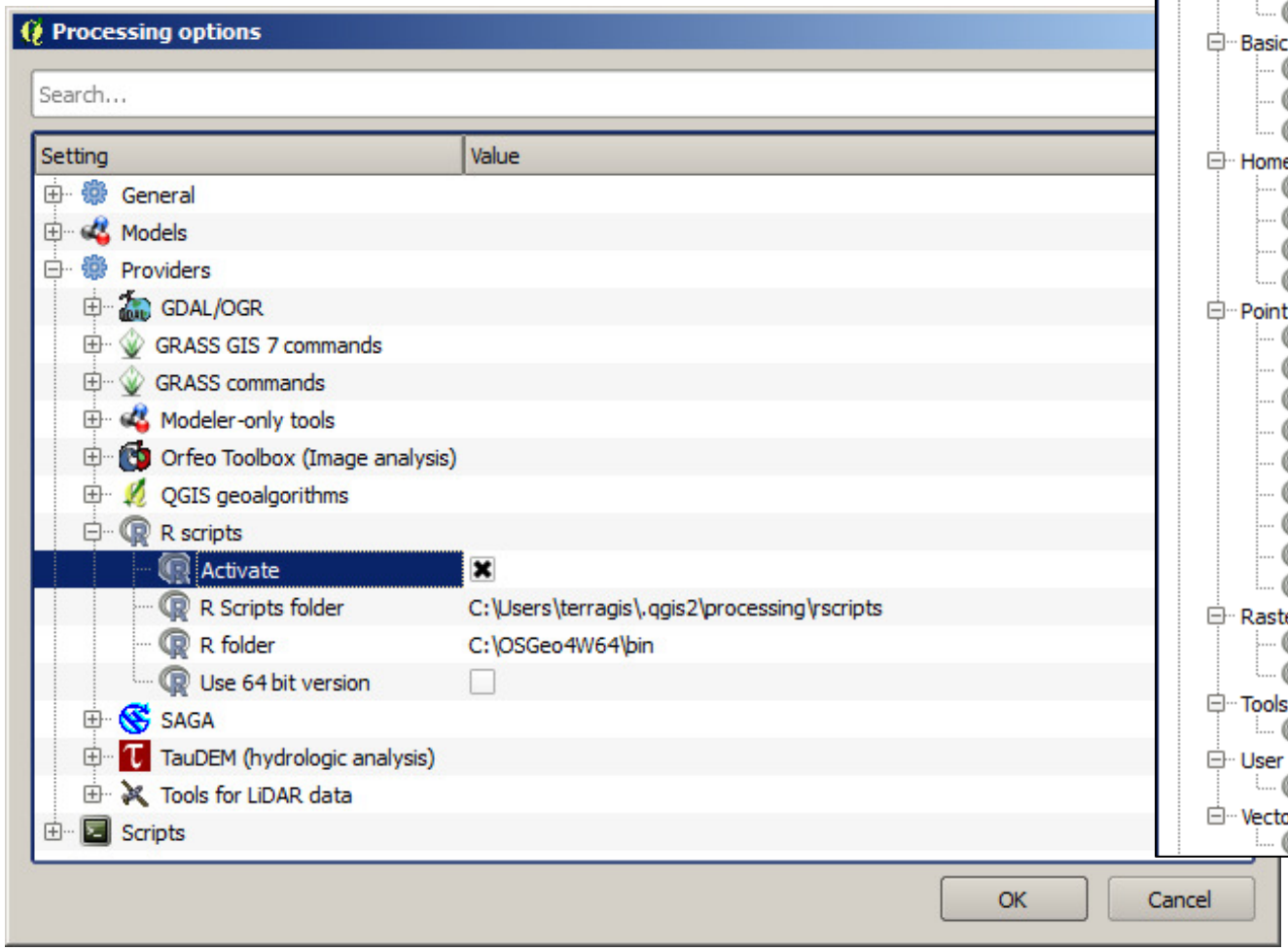
Spatial Analysis and Tools

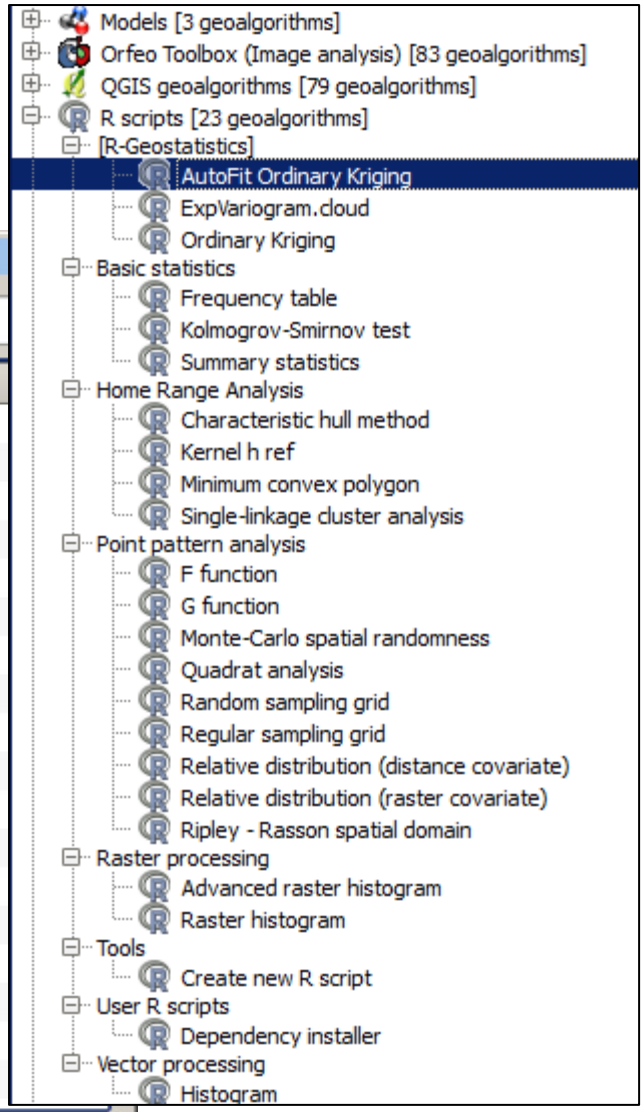
Geospatial Processing in QGIS - Exercises

- Using the geo-processing tools and graphical model builder
- Exercises (e.g. counting trees in Seattle neighborhoods)

QGIS – Processing Toolbox

Enabling R Package (Statistical Software)





QGIS + R Package (Statistical Software)

- Official R webpage and download links
- R Studio

Articles AND Scripts - R + Geospatial use

- Geospatial data in R and Beyond R, an Integrated Statistical Programming
- Environment and GIS Spatial data and R
- QGIS-R-Geostatistics scripts contribution

R scripts and GIS integration

- R-scripts in Processing "Spatial data processing framework for QGIS" Plug-in (formerly Sextante plug-in)
  Needs to be enabled in Processing menu / providers:
- After R is enabled (and installed on your operating system) you can run the scripts from the Processing Toolbox – see next page

Exercises - Analysis

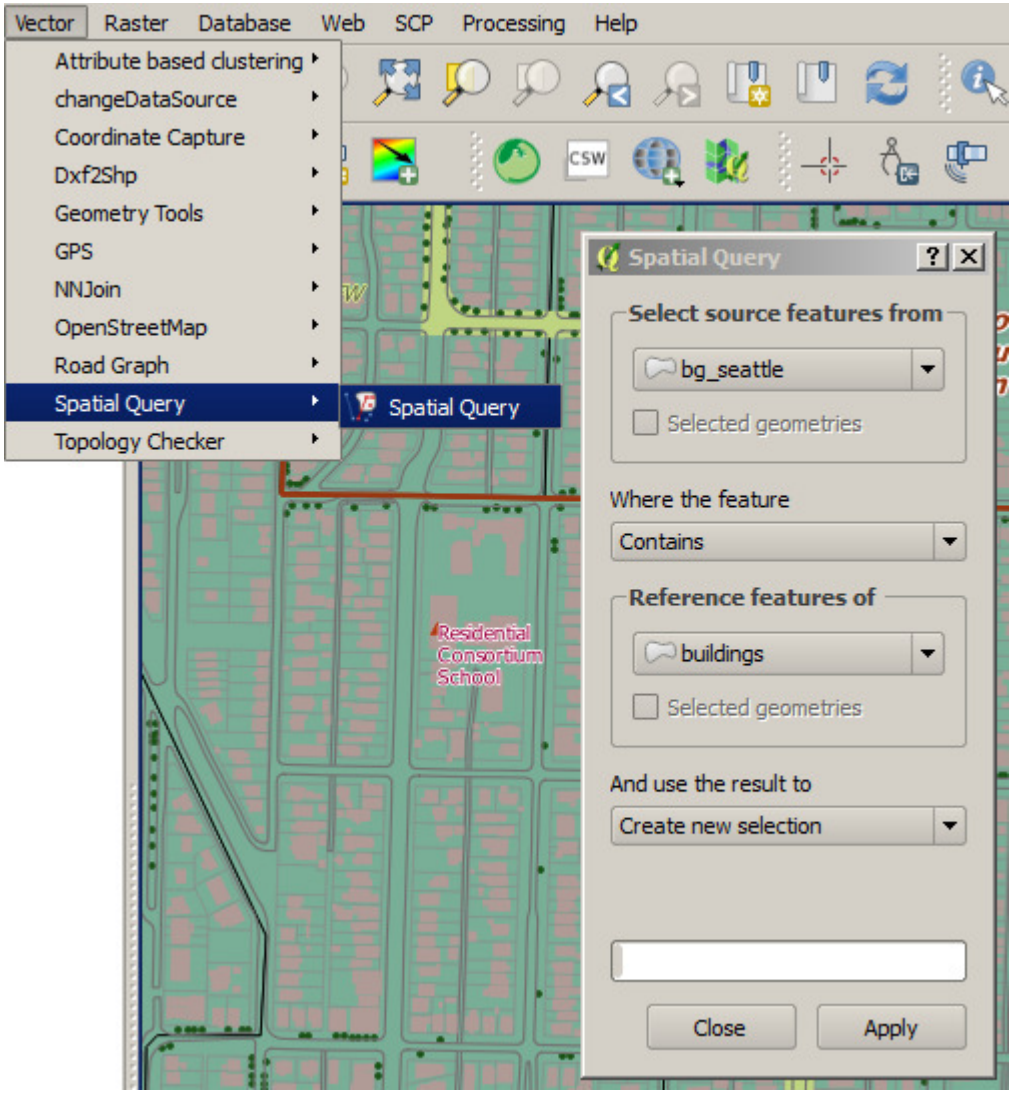
Analysis (Task 8)

- open existing QGIS map document
  data/seattle/seattle_exercises.qgs
- make a map of the neighborhoods colored based on the number of trees in each neighborhood.
- label the neighborhoods including the total count of trees.

Hint: You'll need a spatial join.

Analysis (Task 8)

Creating a selection



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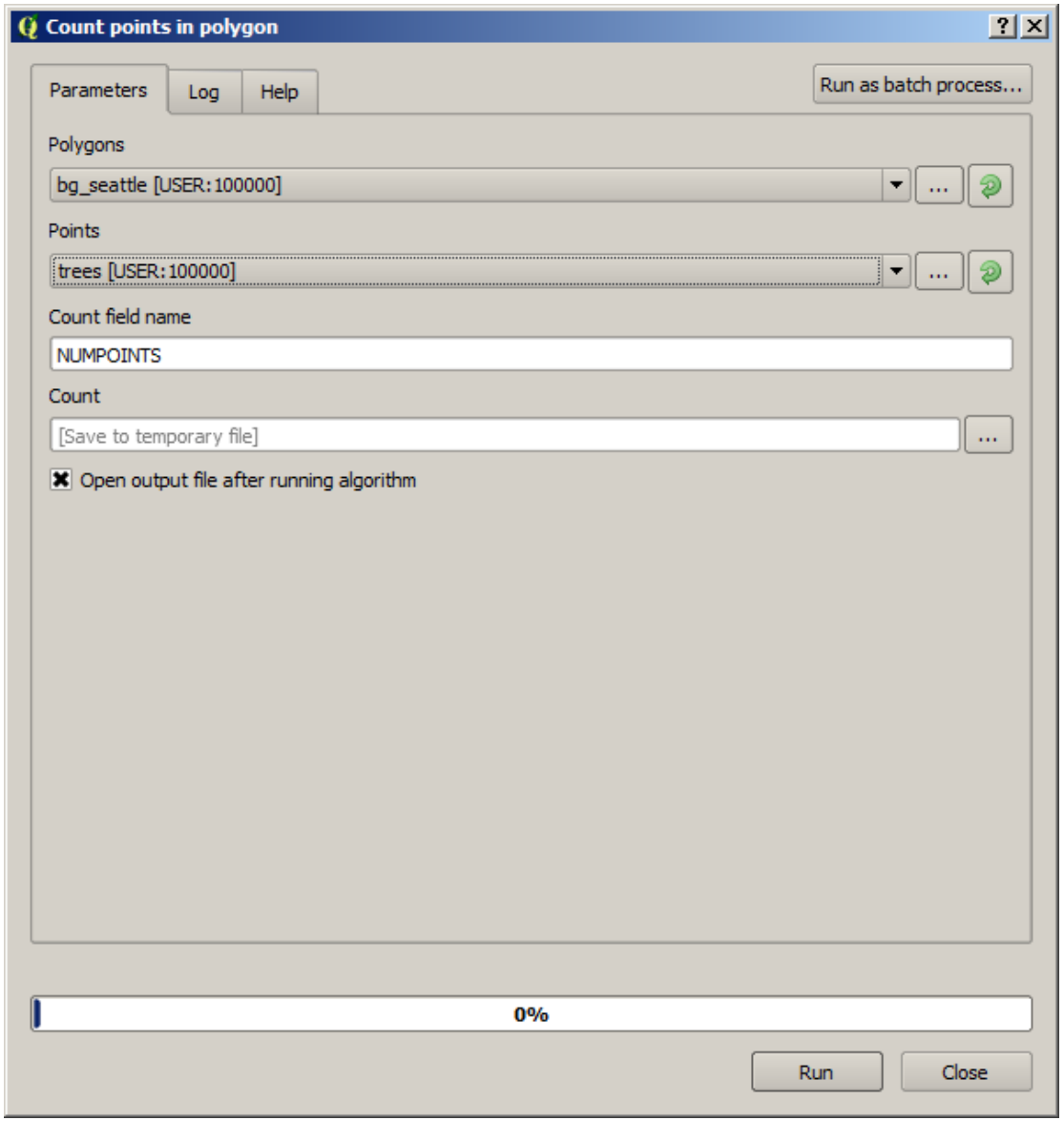
Analysis (Task 8)

Calculating numbers

“count points in polygon”



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Analysis (Task 9)

– Make a map of the number of trees per capita

Hint: You'll need population data from tracts and a field calculation.

Analysis (Task 10)

- Use the data provided and geoprocessing tools to locate areas where the city should plant more trees.
- The manner in which you define/determine this is up to you.

Hints:

- You could set a threshold on the number of trees per area (or capita)
- You could use "Rule based" classification

Spatial Analysis and Tools

- **QGIS Plug-ins**
  - Default Plug-ins: DB Manager, Coordinate capture etc.
  - Topology
  - OpenLayers (Tile layers + OSM data download)
  - Semi Automatic Classification Plug-in (Remote sensing)
  - Integration with external programs
    (Grass, R Statistical Software, SAGA GIS, Lidar tools etc.)

Resources

Documents

Creating Maps in QGIS: A Quick Guide

How do I do that in Quantum GIS: illustrating classic GIS tasks

QGIS 2.18 User Guide

QGIS 2.18 QGIS Training Manual

PyQGIS 2.18 developer cookbook

Building Mapping Applications with QGIS (can be bought at the Packt web site)

Learning QGIS (third edition) – (can be bought at the Packt web site)

Other resources for learning QGIS

OSGEO Foundation

- Conferences
- Email lists
- User groups
- OSGEO Planet blog aggregator

Geo For All is dedicated to to promote the adoption of free and open source software for geospatial technology through education, research and public awareness.

- GeoAcademy
  - Class videos on youtube
  - Class materials download

Additional Resources

QGIS - Best Practices and Settings

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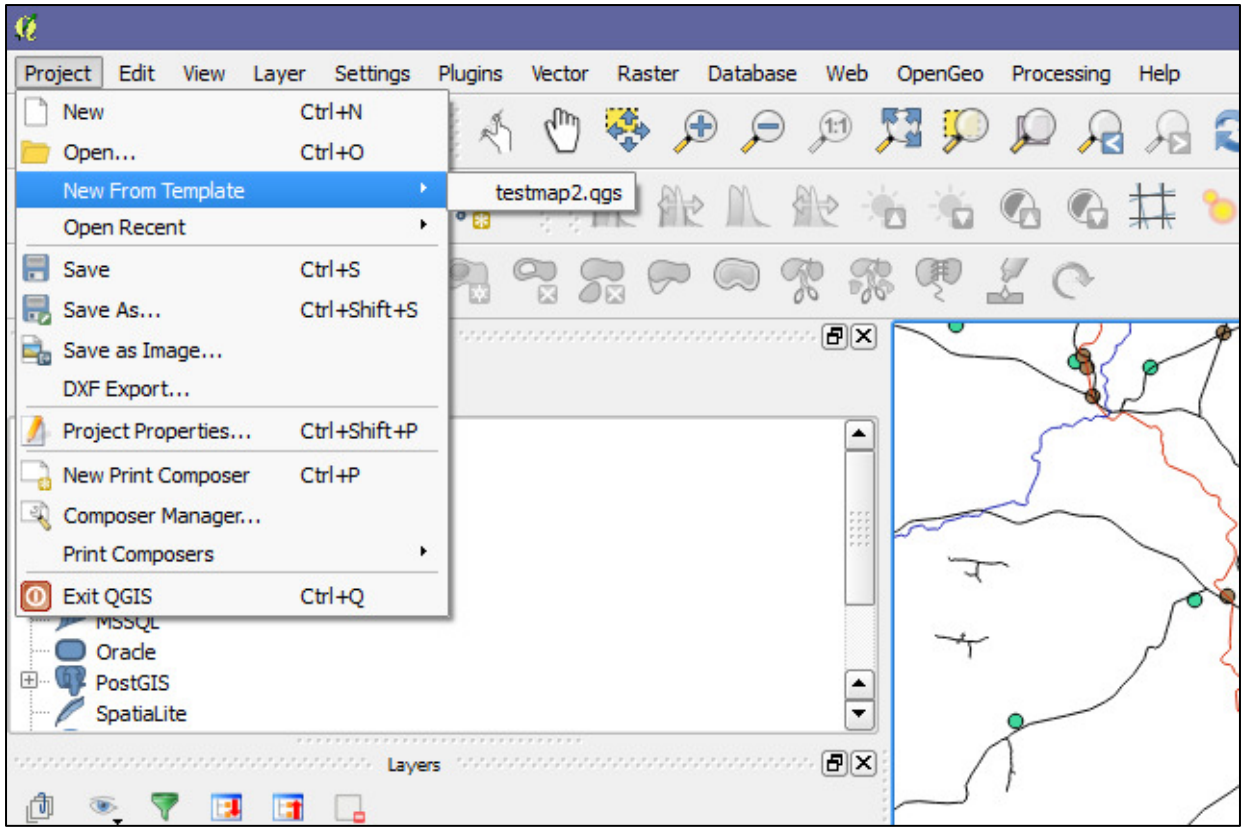
QGIS - Best Practices and Settings

- Project settings – Data Browser - Favorites
- Layer settings
- GUI Customization
- Using templates or default project to start

How do we get a list of templates to show up



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QGIS - Best Practices and Settings

Using templates or default project to start

How do we get
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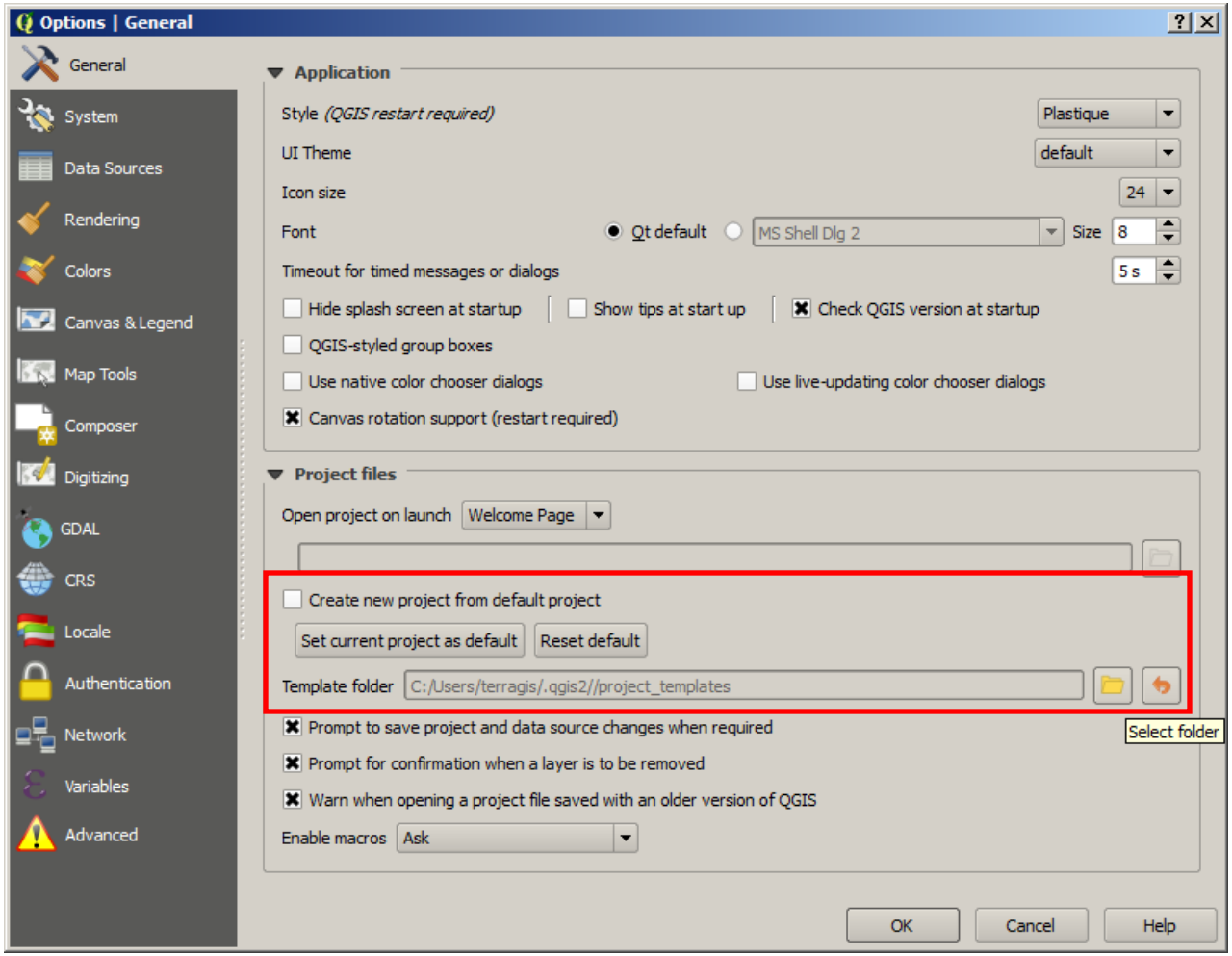
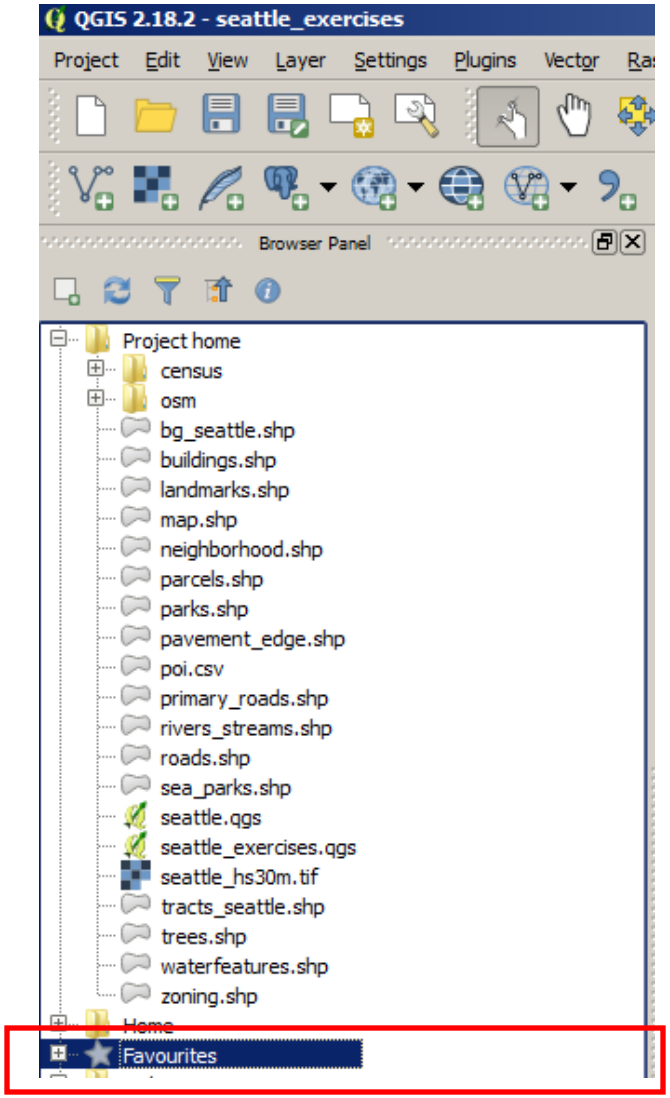


QGIS - Best Practices and Settings

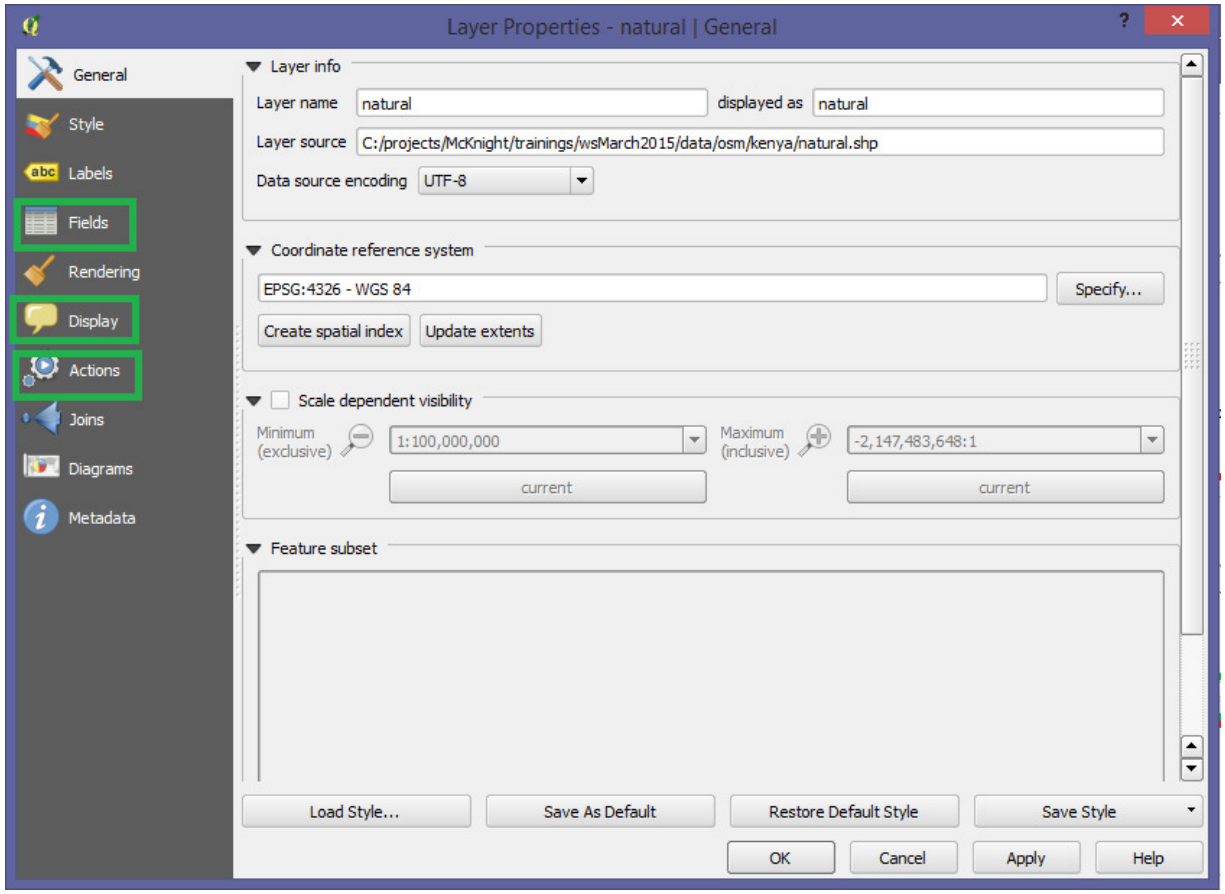
- Adding data
  - Using the Browser panel
  - adding favorites



QGIS - Layer Properties

Lots of settings - note 3 that have unusual / interesting options – including :

- Flexible UI Attribute tables
- Configurable Display Map Tips
- Custom Actions of a Layer Python console



Spatial Data Bases

Extending GIS Capabilities

file based vs. server based

Karsten Vennemann, Seattle

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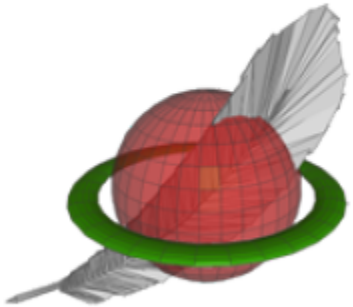
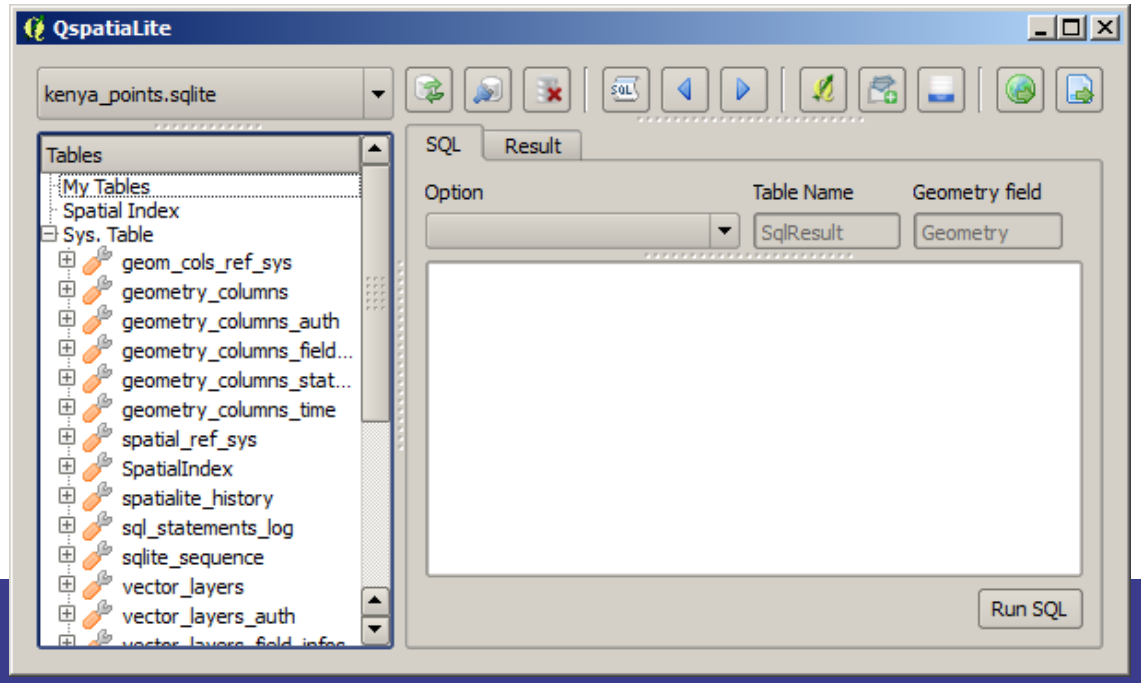
Spatialite – file based Spatial Database

SpatiaLite is a spatial DBMS built on top of **SQLite** . Both formats are file based and thus are light weight and portable. The spatial components depend on the PROJ and GEOS libraries. Related tools include the **RasterLite** library to handle Raster data and **spatialite-gis** (a minimalistic GIS tool). SpatiaLite has the potential to replace shapefiles as a simple data exchange format. Starting with version 1.1 QGIS can read the format, support by OGR/GDAL was included since version 1.7.0.

file based
DBMS
light weight
portable



QspatiaLite Plugin



Spatialite GUI

http://www.gaia-gis.it/spatialite-2.3/

PostGIS – Spatial Database

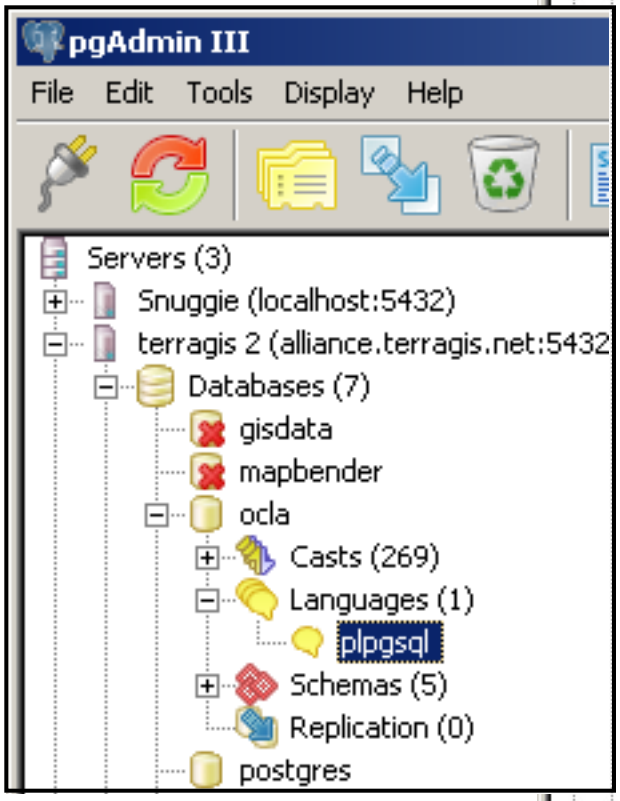
PostGIS PostgreSQL

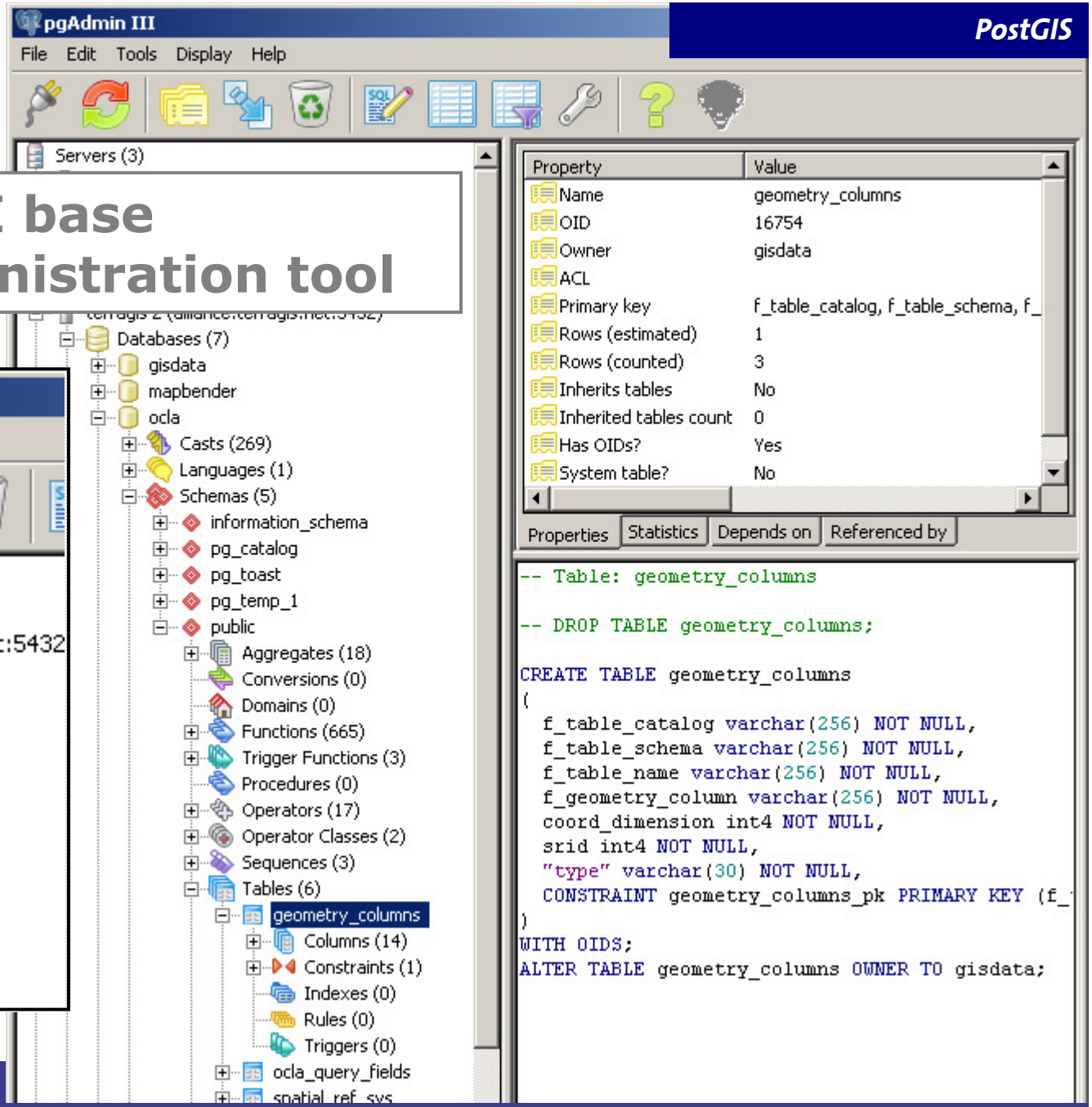
- PostGIS is an extension for PostgreSQL
- adds support for geographic objects to PostgreSQL
- enables PostgreSQL server to be used as a backend spatial database for GIS
- Spatial operations and analysis simply mean running a (spatial) SQL query in the database
- Similar functions to ESRI Arc SDE but also much more ….

PostGIS Functions

- Spatial SQL

pgAdmin – GUI base Database administration tool





Example for practical use of the PostGIS Database

- **Unified data storage and retrieval**
- **GIS functionalities**
  - Find nearest spatial features
    - Nearest road (reverse geocoding)
    - Nearest *conspecific* plant species (Whippet model)
  - Buffer, locate within another feature, and calculate distances (modeling)
  - Model calculations of attributes (leading to prioritization scores)
- **Extension of Web GIS capabilities**
  - Data queries for dynamic data display

pgAdmin III Edit Data - terragis 2 (alliance.terragis.net:5432) - ocla - geometry_columns

	oid	le_ca | varc	_table_schem [PK] varchar	f_table_name [PK] varchar	_geometry_colum [PK] varchar	d_dimer int4	srid int4	type varchar
1	63153	"	public	wa_counties	the_geom	2	2285	MULTIPOLYGON
2	63206	"	public	wa_counties_we	the_geom	2	2285	MULTIPOLYGON
3	63226	"	public	wa_tracts	the_geom	2	2285	MULTIPOLYGON
*								

PostGIS tables — **geometry columns**

spatial reference table

pgAdmin III Edit Data - terragis 2 (alliance.terragis.net:5432) - ocla - spatial_ref_sys

	srid [PK] int4	auth_name varchar	auth_srid int4	srtext varchar	proj4text varchar
1614	4324	EPSG	4324	GEOGCS["WGS 72BE",DATUM["WGS_1972_	+proj=longlat +ellps=WGS72 +t
1615	4326	EPSG	4326	GEOGCS["WGS 84",DATUM["WGS_1984",SP	+proj=longlat +ellps=WGS84 +d
1616	4600	EPSG	4600	GEOGCS["Anguilla 1957",DATUM["Anguilla_1	+proj=longlat +ellps=clrk80 +no
1617	4601	EPSG	4601	GEOGCS["Antigua 1943",DATUM["Antigua_1	+proj=longlat +ellps=clrk80 +no
1618	4602	EPSG	4602	GEOGCS["Dominica 1945",DATUM["Dominica	+proj=longlat +ellps=clrk80 +to
1619	4603	EPSG	4603	GEOGCS["Grenada 1953",DATUM["Grenada_	+proj=longlat +ellps=clrk80 +to
1620	4604	EPSG	4604	GEOGCS["Montserrat 1958",DATUM["Montse	+proj=longlat +ellps=clrk80 +to

QGIS – Advanced Topics

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QGIS - Metadata viewing, editing, exporting, etc

What are our options for documenting database or shape files with metadata?

- QGIS browser allows for viewing metadata, previewing layers, looking at attributes, etc. Not possible to edit/import/export metadata here, and does not display existing XML metadata files.
- There is an experimental metadata plugin called Metatools hasn't been updated in over a year , BETA version
- Within QGIS, it is possible to edit metadata as follows:
  - Right click layer, choose Metadata tab
  - Add Title, abstract, etc. Not clear yet if there is anyway to import XML data.
  - These entries do not appear to persist outside of the project in which they were entered

-->UPSHOT: metadata support in QGIS appears to be really weak, and the few plugin efforts are stalled

QGIS - Joining Tables

- tutorial
  http://www.qgistutorials.com/en/docs/performing_table_joins.html

QGIS - Building a Map Atlas

- tutorial
  https://docs.qgis.org/2.18/en/docs/training_manual/forestry/forest_maps.html

QGIS – Topology

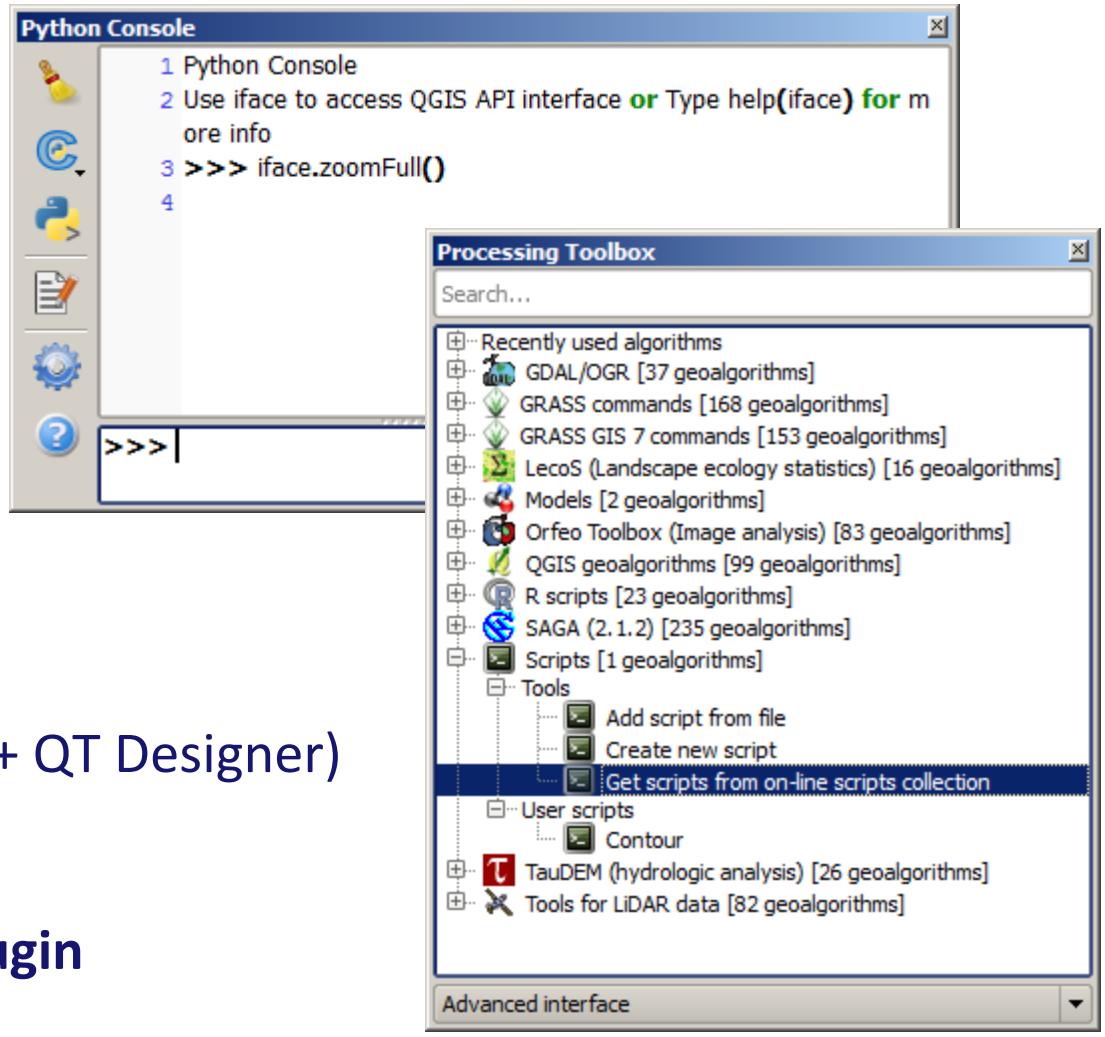
- step-by-step tutorial:
  https://docs.qgis.org/2.18/en/docs/training_manual/create_vector_data/topo_editing.html

QGIS - Grass integration - two options:

- Using the Processing plug-in (Spatial data processing framework for QGIS) is easy to use
- Using the Grass plug-in - has more functions but is more difficult to use

QGIS - Python Interface

- **Three Options**
  - Python console
  - Processing tools
  - Plugins



- **Tools such as**
  - WinPython (IDE + QT Designer)
  - QT Designer
  - *Plugin-Builder* **Plugin**