Inhaltsverzeichnis

1 Kurseinführung
  1.1 Vorwort ................................................................. 1
      1.1.1 Why QGIS? ....................................................... 1
      1.1.2 Hintergrund .................................................... 2
      1.1.3 Lizenz ............................................................. 2
      1.1.4 Förderer ........................................................... 3
      1.1.5 Autoren ........................................................... 3
      1.1.6 Einzelne Mitwirkende .......................................... 3
      1.1.7 Sponsoren ........................................................ 3
      1.1.8 Source files and Issue reports ............................ 3
      1.1.9 Aktuelle Version ............................................... 3
  1.2 About the exercises ................................................ 4
      1.2.1 How to use this tutorial ................................... 4
      1.2.2 Tiered course objectives ................................... 4
      1.2.3 Data .............................................................. 5

2 Module: Erstellen und Erkunden einer einfachen Karte
  2.1 Lesson: An Overview of the Interface ............................ 7
      2.1.1 Try Yourself: The Basics .................................... 7
      2.1.2 Try Yourself 1 .................................................. 9
      2.1.3 Try Yourself 2 .................................................. 10
      2.1.4 What’s Next? ..................................................... 10
  2.2 Lesson: Adding your first layers .................................. 10
      2.2.1 Follow Along: Prepare a map ................................ 11
      2.2.2 Try Yourself .................................................... 12
      2.2.3 Follow Along: Loading vector data from a GeoPackage Database .................................................. 13
      2.2.4 Follow Along: Loading vector data from a SpatiaLite Database with the Browser .................................. 14
      2.2.5 Try Yourself Load More Vector Data .......................... 15
      2.2.6 Follow Along: Reordering the Layers ....................... 16
      2.2.7 In Conclusion .................................................... 17
      2.2.8 What’s Next? ..................................................... 17
  2.3 Lesson: Navigating the Map Canvas ................................ 17
      2.3.1 Follow Along: Basic Navigation Tools ..................... 17
      2.3.2 In Conclusion .................................................... 21
  2.4 Lesson: Symbologie ................................................... 21
      2.4.1 Follow Along: Changing Colors ................................ 21
      2.4.2 Try Yourself ..................................................... 22
      2.4.3 Follow Along: Changing Symbol Structure .................. 23
      2.4.4 Try Yourself ..................................................... 24
      2.4.5 Follow Along: Scale-Based Visibility ........................ 24
      2.4.6 Follow Along: Adding Symbol Layers ........................ 25
6 Module: Vektoranalyse

6.2 Lesson: Vector Analysis

6.2.1 The GIS Process

6.2.2 The Problem

6.2.3 The Data

6.2.4 Follow Along: Start a Project and get the Data

6.2.5 Try Yourself: Convert Layers' CRS

6.2.6 Follow Along: Analyzing the Problem: Distances From Schools and Roads

6.2.7 Try Yourself: Distance from schools

6.2.8 Follow Along: Overlapping Areas

6.2.9 Follow Along: Extract the Buildings

6.2.10 Try Yourself: Further Filter our Buildings

6.2.11 Follow Along: Select Buildings of the Right Size
8 Module: Fertigstellung der Analyse 241
8.1 Lesson: Raster to Vector Conversion 241
8.1.1 Follow Along: The Raster to Vector Tool 241
8.1.2 Try Yourself 242
14.2.1 Scan the map ................................................. 338
14.2.2 Follow Along: Georeferencing the scanned map ........ 338
14.2.3 In Conclusion ............................................... 342
14.2.4 What’s Next? ............................................... 342
14.3 Lesson: Digitizing Forest Stands .............................. 342
14.3.1 Follow Along: Extracting the Forest Stands Borders .... 342
14.3.2 Try Yourself Georeference the Green Pixels Image .... 345
14.3.3 Follow Along: Creating Supporting Points for Digitizing 346
14.3.4 Follow Along: Digitize the Forest Stands ............... 349
14.3.5 Try Yourself Finish Digitizing the Forest Stands ....... 353
14.3.6 Follow Along: Joining the Forest Stand Data ........... 353
14.3.7 Try Yourself Renaming Attribute Names and Adding Area and Perimeter 356
14.3.8 In Conclusion ............................................... 356
14.3.9 What’s Next? ............................................... 356
14.4 Lesson: Updating Forest Stands ................................ 358
14.4.1 Comparing the Old Forest Stands to Current Aerial Photographs 358
14.4.2 Interpreting the CIR Image ................................ 358
14.4.3 Try Yourself Digitizing Forest Stands from CIR Imagery .... 361
14.4.4 Follow Along: Updating Forest Stands with Conservation Information 361
14.4.5 Try Yourself Updating Forest Stands with Distance to the Stream 364
14.4.6 In Conclusion ............................................... 367
14.4.7 What’s Next? ............................................... 367
14.5 Lesson: Systematic Sampling Design ........................ 367
14.5.1 Inventorying the Forest .................................... 367
14.5.2 Follow Along: Implementing a Systematic Sampling Plot Design 368
14.5.3 Follow Along: Exporting Sample Plots as GPX format .... 371
14.5.4 In Conclusion ............................................... 372
14.5.5 What’s Next? ............................................... 372
14.6 Lesson: Creating Detailed Maps with the Atlas Tool ........ 372
14.6.1 Follow Along: Preparing the Print Layout ................ 372
14.6.2 Follow Along: Adding Background Map ................. 373
14.6.3 Try Yourself Changing the Symbology of the Layers .... 375
14.6.4 Try Yourself Create a Basic Map Template .............. 376
14.6.5 Follow Along: Adding More Elements to the Print Layout 377
14.6.6 Follow Along: Creating an Atlas Coverage ............... 379
14.6.7 Follow Along: Setting Up the Atlas Tool ................. 382
14.6.8 Follow Along: Editing the Coverage Layer ............... 384
14.6.9 Follow Along: Printing the Maps ......................... 386
14.6.10 In Conclusion .............................................. 387
14.6.11 What’s Next? .............................................. 387
14.7 Lesson: Calculating the Forest Parameters .................. 387
14.7.1 Follow Along: Adding the Inventory Results ............ 388
14.7.2 Follow Along: Whole Forest Parameters Estimation .... 388
14.7.3 Follow Along: Estimating Stand Parameters ............. 389
14.7.4 In Conclusion ............................................... 393
14.7.5 What’s Next? ............................................... 393
14.8 Lesson: DEM zu LiDAR-Daten ................................ 393
14.8.1 Follow Along: Installing Lastools ....................... 393
14.8.2 Follow Along: Calculating a DEM with LASTools ....... 395
14.8.3 Follow Along: Creating a Terrain Hillshade .............. 400
14.8.4 In Conclusion ............................................... 402
14.8.5 What’s Next? ............................................... 402
14.9 Lesson: Kartendarstellung .................................... 402
14.9.1 Follow Along: Preparing the Map Data .................. 402
14.9.2 Try Yourself Try Different Blending Modes ............... 403
14.9.3 Try Yourself Using a Layout Template to Create the Map result 403
14.9.4 In Conclusion ............................................... 407
16 Module: Spatial Database Concepts with PostGIS

16.1 Lesson: PostGIS-Einrichtung ........................................ 431
   16.1.1 Installation unter Ubuntu .................................... 431
   16.1.2 Installation unter Windows ................................... 432
   16.1.3 Installation auf anderen Plattformen ......................... 432
   16.1.4 Konfiguration von Datenbanken zur Nutzung von PostGIS .... 432
   16.1.5 Die installierten PostGIS Funktionen ....................... 433
   16.1.6 Räumliche Bezugssysteme .................................... 434
   16.1.7 In Conclusion ................................................ 434
   16.1.8 What’s Next? ................................................ 435

16.2 Simple-Feature-Modell .............................................. 435
   16.2.1 Was ist OGC ................................................ 435
   16.2.2 Was ist das SFS Modell ...................................... 435
   16.2.3 Hinzufügen eines Geometriefeldes zu einer Tabelle ......... 436
   16.2.4 Hinzufügen einer Einschränkung basierend auf dem Geometrietyp . 436
   16.2.5 Try Yourself ................................................ 436
   16.2.6 Füllen der geometry_columns Tabelle ....................... 436
   16.2.7 Hinzufügen eines Geomtrieieieieieiedatensatzes zur Tabelle mit Hilfe von SQL 437
   16.2.8 In Conclusion ................................................ 440
   16.2.9 What’s Next? ................................................ 440

16.3 Lesson: Importieren und Exportieren ............................... 440
   16.3.1 shp2pgsql .................................................. 440
   16.3.2 pgsql2shp .................................................. 440
   16.3.3 ogr2ogr ................................................... 441
   16.3.4 DB Manager ............................................... 441
   16.3.5 In Conclusion ................................................ 441
   16.3.6 What’s Next? ................................................ 441

16.4 Lesson: Räumliche Abfragen ....................................... 441
   16.4.1 Räumliche Operationen ...................................... 441
   16.4.2 Räumliche Indexe .......................................... 442
   16.4.3 Try Yourself ............................................... 442
   16.4.4 Demonstration der räumlichen Funktionen von PostGIS .... 443
   16.4.5 In Conclusion ................................................ 449
   16.4.6 What’s Next? ................................................ 449

16.5 Lesson: Geometrieaufbau ............................................ 449
   16.5.1 Erstellen von Linien ...................................... 449
   16.5.2 Try Yourself ............................................... 449
   16.5.3 Erstellung von Polygonen ................................... 450
   16.5.4 Übersetzung: Anbindung Städte an Personen ................. 450
   16.5.5 Unser Schema .............................................. 451
   16.5.6 Try Yourself ............................................... 451
   16.5.7 Zugriff auf Unter-Objekte .................................. 451
   16.5.8 Datenverarbeitung ........................................... 451
   16.5.9 Ausschneiden .............................................. 452
   16.5.10 Geometrien aus anderen Geometrien erstellen .......... 452
   16.5.11 Geometriebereinigung ................................... 453
   16.5.12 Unterschiede zwischen Tabellen .......................... 453
   16.5.13 Tablespace ............................................... 453
   16.5.14 In Conclusion .............................................. 456

17 Der QGIS-Verarbeitungsleitfaden ................................... 457

17.1 Einleitung .......................................................... 457
17.2 Eine wichtige Warnung zu Beginn .................................. 458
17.3 Einrichtung der Verarbeitungsgröße ................................ 459
17.4 Ausführung unseres ersten Algorithmus. Der Werkzeugkasten .... 461
18.5 Mehr Algorithmen und Datentypen ........................................ 464
17.6 KBS - reprojizieren ....................................................... 469
17.7 Auswahl ................................................................. 473
17.8 Ausführung eines externen Algorithmus .............................. 475
17.9 Das Prozessierungsprotokoll .......................................... 480
17.9.1 Fortgeschritten .................................................... 482
17.10 Der Rasterrechner. Nullwerte ...................................... 482
17.11 Vektorberechner ....................................................... 486
17.12 Definierung von Ausschnitten ...................................... 488
17.13 HTML-Ausgaben ...................................................... 492
17.14 Erstes Analysebeispiel ................................................. 494
17.15 Zuschneiden und Verschmelzen von Rasterlayern ............... 497
17.16 Hydrologische Analyse ............................................... 508
17.17 Einstieg in den Grafischen Modellierer ............................. 518
17.18 Mehr komplexe Modelle .............................................. 527
17.19 Numerische Berechnungen im Modellierer ....................... 534
17.20 Ein Model in einem Modell .......................................... 539
17.21 Erstellung eines Modells mit modellinternen Werkzeugen .... 540
17.22 Interpolation .......................................................... 545
17.23 Noch mehr Interpolation .............................................. 551
17.24 Die iterative Ausführung von Algorithmen ....................... 560
17.25 Noch mehr iterative Ausführung von Algorithmen ............ 564
17.26 Die Schnittstelle zur Stapelverarbeitung ......................... 566
17.27 Modelle innerhalb der Stapelverarbeitung ....................... 569
17.28 Aktionsskripte vor oder nach Ausführung ....................... 570
17.29 Andere Programme .................................................. 571
17.29.1 GRASS .......................................................... 571
17.29.2 R ................................................................. 572
17.29.3 Andere ........................................................... 572
17.29.4 Comparison among backends .................................. 572
17.30 Interpolation und Kontourlinienzeichnung ....................... 573
17.30.1 Interpolation ...................................................... 573
17.30.2 Contour .......................................................... 573
17.31 Vektorvereinfachung und Glättung .................................. 573
17.32 Planung eines Solarparks ............................................. 574
17.33 Nutzung von R-Skripten in der Prozessierung ...................... 574
17.33.1 Hinzufügen von Skripten ...................................... 575
17.33.2 Erstellung von Plots ............................................. 576
17.33.3 Erstellen eines Vektorlayers ................................... 580
17.33.4 Textausgabe und grafische Ausgabe mit der R - Syntax ... 582
17.34 Predicting landslides .................................................. 582
18 Module: Räumliche Datenbanken in QGIS nutzen .......................... 585
18.1 Lesson: Arbeit mit Datenbanken im QGIS Browser .............. 585
18.1.1 Follow Along: Datenbanktabellen mit Hilfe des Browsers zu QGIS hinzufügen . 585
18.1.2 Follow Along: Hinzufügen einer gefilterten Liste von Datensätzen als Layer ... 587
18.1.3 In Conclusion ...................................................... 587
18.1.4 What’s Next? ...................................................... 587
18.2 Lesson: Verwendung der DB-Verwaltung zur Arbeit mit räumlichen Datenbanken in QGIS .......... 587
18.2.1 Follow Along: Managen von PostGIS Datenbanken mit der DB-Verwaltung . 589
18.2.2 Follow Along: Erstellen einer neuen Tabelle .................. 593
18.2.3 Follow Along: Einfache Datenbankadministration ............ 595
18.2.4 Follow Along: Executing SQL Queries with DB Manager .... 595
18.2.5 Importing Data into a Database with DB Manager ........... 596
18.2.6 Exporting Data from a Database with DB Manager .......... 599
18.2.7 In Conclusion ...................................................... 599
18.2.8 What’s Next? ...................................................... 601
18.3 Lesson: Working with SpatiaLite databases in QGIS ............ 601
19 Appendix: Contributing To This Manual

19.1 Downloading Resources .................................................. 605
19.2 Manual Format ................................................................. 605
19.3 Adding a Module .............................................................. 605
19.4 Adding a Lesson ............................................................... 606
19.5 Adding a Section .............................................................. 607
19.5.1 Adding a „follow along“ section ..................................... 607
19.5.2 Adding a „try yourself“ section ..................................... 608
19.6 Add a Conclusion .............................................................. 608
19.7 Add a Further Reading Section ......................................... 608
19.8 Add a What’s Next Section ................................................. 609
19.9 Using Markup ................................................................. 609
19.9.1 New concepts ............................................................. 609
19.9.2 Emphasis .................................................................... 609
19.9.3 Images ....................................................................... 609
19.9.4 Internal links ............................................................... 609
19.9.5 External links .............................................................. 610
19.9.6 Using monospaced text ............................................... 610
19.9.7 Labeling GUI items ...................................................... 610
19.9.8 Menu selections .......................................................... 610
19.9.9 Adding notes ............................................................... 610
19.9.10 Adding a sponsorship/authorship note ......................... 611
19.10 Thank You! ...................................................................... 611

20 Vorbereitung der Übungsdaten ............................................. 613

20.1 Try Yourself Create OSM based vector Files ..................... 613
20.2 Try Yourself Create SRTM DEM tiff Files ......................... 618
20.3 Try Yourself Create imagery tiff Files ............................... 619
20.4 Try Yourself Replace Tokens ............................................. 619

21 Antwortblatt ................................................................ 621

21.1 Results For Eine Übersicht über das Interface ..................... 621
21.1.1 Übersicht (Teil 1) .......................................................... 621
21.1.2 Übersicht (Teil 2) .......................................................... 621
21.2 Results For Adding Your First Layer ................................ 621
21.2.1 Vorbereitung ............................................................... 621
21.2.2 Data loading ............................................................... 622
21.3 Results For Symbology ...................................................... 622
21.3.1 Colors ....................................................................... 622
21.3.2 Symbol Structure ........................................................ 623
21.3.3 Symbol Layers ............................................................ 624
21.3.4 Symbol Levels ............................................................ 625
21.3.5 Symbol Levels ............................................................ 626
21.4 Outline Markers ............................................................... 627
21.4.1 Geometry generator symbology ................................... 627
21.5 Results For Vector Attribute Data .................................... 628
21.5.1 Exploring Vector Data Attributes ................................. 628
21.6 Results For Labels ............................................................ 629
21.6.1 Label Customization (Part 1) ......................................... 629
21.6.2 Label Customization (Part 2) ......................................... 629
21.6.3 Using Data Defined Settings ........................................ 630
21.7 Results For Classification ................................................ 630
21.7.1 Refine the Classification .............................................. 630
21.8 Results For Creating a New Vector Dataset ....................... 633
21.8.1 Digitizing ................................................................. 633
21.8.2 Topology: Add Ring Tool ............................................. 633

xi
21.8.3 Topology: Add Part Tool ........................................... 633
21.8.4 Merge Features ................................................... 636
21.8.5 Forms ............................................................. 636

21.9 Results For Vector Analysis ................................. 638
21.9.1 Distance from High Schools ............................... 638
21.9.2 Distance from Restaurants .................................. 641

21.10 Results For Network Analysis ............................... 641

21.11 Fastest Path ......................................................... 641

21.12 Results For Raster Analysis .............................. 644
21.12.1 Calculate Aspect ............................................. 644
21.12.2 Calculate Slope (less than 2 and 5 degrees) .... 644

21.13 Results For Completing the Analysis .................. 644
21.13.1 Raster to Vector ............................................... 644
21.13.2 Inspecting the Results .................................... 650
21.13.3 Refining the Analysis ...................................... 650

21.14 Results For WMS .................................................. 653
21.14.1 Adding Another WMS Layer ............................... 653
21.14.2 Adding a New WMS Server ............................... 655
21.14.3 Finding a WMS Server .................................... 655

21.15 Results For GRASS Integration ......................... 657
21.15.1 Add Layers to Mapset .................................... 657
21.15.2 Reclassify raster layer ................................... 657

21.16 Results For Database Concepts .......................... 658
21.16.1 Address Table Properties ................................. 658
21.16.2 Normalising the People Table ............................. 659
21.16.3 Further Normalisation of the People Table .... 659
21.16.4 Create a People Table ..................................... 660
21.16.5 The DROP Command .................................... 661
21.16.6 Insert a New Street ....................................... 661
21.16.7 Add a New Person With Foreign Key Relationship ... 661
21.16.8 Return Street Names ................................... 661

21.17 Results For Spatial Queries ................................. 662
21.17.1 The Units Used in Spatial Queries ....................... 662
21.17.2 Creating a Spatial Index .................................. 662

21.18 Results For Geometry Construction ............... 662
21.18.1 Creating Linestrings ...................................... 662
21.18.2 Linking Tables ............................................... 663

21.19 Results For Simple Feature Model ....................... 663
21.19.1 Populating Tables .......................................... 663
21.19.2 Populate the Geometry_Columns Table ............ 664
21.19.3 Adding Geometry ........................................... 664
1.1 Vorwort

Welcome to our course! We will be showing you how to use QGIS easily and efficiently. If you are new to GIS, we will tell you what you need to get started. If you are an experienced user, you will see how QGIS fulfills all the functions you expect from a GIS program, and more!

1.1.1 Why QGIS?

As information becomes increasingly spatially aware, there is no shortage of tools able to fulfill some or all commonly used GIS functions. Why should anyone be using QGIS over some other GIS software package?

Here are only some of the reasons:

- *It's free, as in lunch.* Installing and using the QGIS program costs you a grand total of zero money. No initial fee, no recurring fee, nothing.

- *It's free, as in liberty.* If you need extra functionality in QGIS, you can do more than just hope it will be included in the next release. You can sponsor the development of a feature, or add it yourself if you are familiar with programming.

- *It's constantly developing.* Because anyone can add new features and improve on existing ones, QGIS never stagnates. The development of a new tool can happen as quickly as you need it to.

- *Extensive help and documentation is available.* If you're stuck with anything, you can turn to the extensive documentation, your fellow QGIS users, or even the developers.

- *Cross-platform.* QGIS can be installed on MacOS, Windows and Linux.

Now that you know why you want to use QGIS, these exercises will make you know how.
1.1.2 Hintergrund

In 2008 we launched the Gentle Introduction to GIS, a completely free, open content resource for people who want to learn about GIS without being overloaded with jargon and new terminology. It was sponsored by the South African government and has been a phenomenal success, with people all over the world writing to us to tell us how they are using the materials to run University Training Courses, teach themselves GIS and so on. The Gentle Introduction is not a software tutorial, but rather aims to be a generic text (although we used QGIS in all examples) for someone learning about GIS. There is also the QGIS manual which provides a detailed functional overview of the QGIS application. However, it is not structured as a tutorial, but rather as a reference guide. At Linfiniti Consulting CC, we frequently run training courses and have realised that a third resource is needed - one that leads the reader sequentially through learning the key aspects of QGIS in a trainer-trainee format - which prompted us to produce this work.

Dieses Trainingshandbuch ist dafür vorgesehen alle Materialien bereitzustellen, die für einen Kurs über 5 Tage in QGIS, PostgreSQL und PostQIS nötig sind. Dieser Kurs beinhaltet Inhalte für Anfänger, bereits vertraute und fortgeschrittene Benutzer und besitzte ebenso viele Übungen mit Antworten im Text.

1.1.3 Lizenz

The Free Quantum GIS Training Manual by Linfiniti Consulting CC. is based on an earlier version from Linfiniti and is licensed under a Creative Commons Attribution 4.0 International. Permissions beyond the scope of this license may be available at below.

Wir haben das QGIS Trainingshandbuch unter einer freien Lizenz veröffentlicht, was Ihnen die Freiheit bietet die Inhalte zu kopieren, modifizieren und zu verteilen. In einfachen Worten gesprochen gelten folgende Nutzungsbedingungen:

- Es ist nicht erlaubt die Inhalte als eigene Arbeit darzustellen, urheberrechtlich Texte oder Namensnennungen zu entfernen.
- Sie sind nicht berechtigt diese Arbeit und mehr eingeschränkten Berechtigungen zu verteilen, als wie sie Ihnen zur Verfügung gestellt wurde.
- Falls Sie weitere Inhalte zu dieser Arbeit hinzufügen (zumindest ein komplettes Modul), dann können Sie Ihren Namen am Ende der Autorenliste dieses Dokumentes einfügen (Dieser wird auf der Startseite angezeigt)
- Falls Sie kleinere Änderungen beifügen, dann tragen Sie Ihren Namen bei Einzelne Mitwirkende ein.
- Falls Sie dieses Dokument komplett Übersetzt haben, dann können Sie ihren Namen in der Autorenliste in Form von „Übersetzt von Joe Bloggs” eintragen.
- Falls Sie ein Modul oder eine Lehreinheit gesponsert haben, dann können Sie den Autor bitten eine Anmerkung an den Beginn jeder beigefügten Lehreinheit beizufügen, z.B.:

**Bemerkung:** Diese Lektion wurde von Megacorp gesponsert.

- Falls Sie unsicher sind, wie Sie mit dieser Lizenz arbeiten können, dann kontaktieren Sie uns bitte unter: office@linfiniti.com und wir beraten Sie, ob Ihr vorhaben in Ordnung ist.
- If you publish this work under a self publishing site such as https://www.lulu.com we request that you donate the profits to the QGIS project.
- Sie dürfen diese Arbeit nicht vermarkten, außer mit der Erlaubnis der Autoren. Hierbei ist gemeint, dass die Arbeit nicht zum Profit verkauft werden darf, wie das erstellen eines kommerziell abgeleiteten Werkes (z.B. Inhalt an Magazine verkaufen). Die Ausnahme besteht darin, den gesamten Gewinn an das QGIS-Projekt weiter zu leiten. Sie dürfen (und wir ermutigen Sie dazu) diese Arbeit als Lehrbuch zu verwenden, wen Sie Kurse
anbieten, selbst wenn diese kommerziell sind. Anders gesagt, selbstverständlich dürfen Sie einen kostenpflich-
tigen Kurs anbieten und dieses Lehrbuch verwenden, aber Sie dürfen das Lehrbuch selber nicht verkaufen -
solche Gelder sollten an das QGIS-Projekt gehen.

1.1.4 Förderer

Diese Arbeit umfasst nicht die komplette Abhandlung der Dinge die mit QGIS getan werden können und wir ermuti-
gen euch Inhalte beizutragen, welche diese Lücken schließen. Linfiniti Consulting CC. kann auf kommerzieller Basis
für Sie weitere Inhalte erstellten, diese werden jedoch unter der gleichen Lizenz veröffentlichen.

1.1.5 Autoren

- Rüdiger Thiede (rudi@linfiniti.com) - Rudi verfasste das QGIS Lehr- und Teile des PostGIS-Materials.
- Tim Sutton (tim@linfiniti.com) - Tim beaufsichtigte und leitete das Projekt, ebenso war er Mitverfasser des
  PostgreSQL und PostGIS Abschnittes. Tim erstellte ebenso das Sphinxmotiv, welche für das Handbuch benutzt
  wurde
- Horst Düster (horst.duester@kappasyss.ch ) - Horst war Co-Autor in den Bereichen PostSQL und PostGIS
- Marcelle Sutton (marcelle@linfiniti.com) - Marcelle war Korrekturleser und gab Redaktionstipps während der
  Erstellung.

1.1.6 Einzelne Mitwirkende

Hier könnte Ihr Name stehen!

1.1.7 Sponsoren

- Cape Peninsula University of Technology

1.1.8 Source files and Issue reports

The source of this document is available at GitHub QGIS Documentation repository. Consult GitHub.com for instruc-
tions on how to use the git version control system.

Despite our efforts, you could find some errors or miss some information while following this training. Please report
them at [https://github.com/qgis/QGIS-Documentation/issues](https://github.com/qgis/QGIS-Documentation/issues).

1.1.9 Aktuelle Version

You can always obtain the latest version of this document by visiting the online version which is part of the QGIS
documentation website ([https://docs.qgis.org](https://docs.qgis.org)).

**Bemerkung:** The documentation website contains links to both online and PDF versions of the Training manual
and other parts of the QGIS documentation.
1.2 About the exercises

Now that you know why you want to use QGIS, we can show you how.

| Warnung: | This course includes instructions on adding, deleting and altering GIS datasets. We have provided training datasets for this purpose. Before using the techniques described here on your own data, always ensure you have proper backups! |

1.2.1 How to use this tutorial

Any text that looks like this refers to something that you can see in the QGIS user interface.

Text that looks like this directs you through menus.

This kind of text refers to something you can type, such as a command.

This kind of text refers to a path or filename.

This + That refers to a keyboard shortcut comprised of two buttons.

1.2.2 Tiered course objectives

This course caters to different user experience levels. Depending on which category you consider yourself to be in, you can expect a different set of course outcomes. Each category contains information that is essential for the next one, so it’s important to do all exercises that are at or below your level of experience.

Basic

In this category, the course assumes that you have little or no prior experience with theoretical GIS knowledge or the operation of GIS software.

Limited theoretical background will be provided to explain the purpose of an action you will be performing in the program, but the emphasis is on learning by doing.

When you complete the course, you will have a better concept of the possibilities of GIS, and how to harness their power via QGIS.

Intermediate

In this category, it is assumed that you have working knowledge and experience of the everyday uses of GIS software.

Building on the instructions for the beginner level will provide you with familiar ground, as well as to make you aware of the cases where QGIS does things slightly differently from other software you may be used to. You will also learn how to use analysis functions in QGIS.

When you complete the course, you should be comfortable with using QGIS for all of the functions you usually need for everyday use.
In this category, the assumption is that you are experienced with GIS software, have knowledge of and experience with spatial databases, using data on a remote server, perhaps writing scripts for analysis purposes, etc.

Building on the instructions for the other two levels will familiarize you with the approach that the QGIS interface follows, and will ensure that you know how to access the basic functions that you need. You will also be shown how to make use of the QGIS plugin system, database access, and so on.

When you complete the course, you should be well-acquainted with the everyday operation of QGIS, as well as its more advanced functions.

1.2.3 Data

The sample data that accompanies this resource is freely available and comes from the following sources:

- Streets and Places datasets from OpenStreetMap (https://www.openstreetmap.org/)
- Property boundaries (urban and rural), water bodies from NGI (http://www.ngi.gov.za/)
- SRTM DEM from the CGIAR-CSI (http://srtm.cgiar.org/)

Download the prepared dataset from the Training data repository and unzip the file. All the necessary data are provided in the exercise_data folder.

If you are an instructor, and would like to use more relevant data, you will find instructions for creating local data in the Vorbereitung der Übungsdaten appendix.
Module: Erstellen und Erkunden einer einfachen Karte

In diesem Modul erstellen Sie eine grundlegende Karte, die später als Grundlage für weitere Demonstrationen der QGIS-Funktionalität verwendet wird.

2.1 Lesson: An Overview of the Interface

We will explore the QGIS user interface so that you are familiar with the menus, toolbars, map canvas and layers list that form the basic structure of the interface.

**The goal for this lesson:** To understand the basics of the QGIS user interface.

2.1.1 Try Yourself: The Basics

The elements identified in the figure above are:

1. Layers List / Browser Panel
2. Werkzeugkästen
3. Map canvas
4. Status bar
5. Side Toolbar
6. Locator bar
The Layers List

In the Layers list, you can see a list, at any time, of all the layers available to you. Expanding collapsed items (by clicking the arrow or plus symbol beside them) will provide you with more information on the layer’s current appearance.

Hovering over the layer will give you some basic information: layer name, type of geometry, coordinate reference system and the complete path of the location on your device.

Right-clicking on a layer will give you a menu with lots of extra options. You will be using some of them before long, so take a look around!

**Bemerkung:** A vector layer is a dataset, usually of a specific kind of object, such as roads, trees, etc. A vector layer can consist of either points, lines or polygons.

The Browser Panel

The QGIS Browser is a panel in QGIS that lets you easily navigate in your database. You can have access to common vector files (e.g. ESRI Shapefile or MapInfo files), databases (e.g. PostGIS, Oracle, SpatiaLite, GeoPackage or MSSQL Spatial) and WMS/WFS connections. You can also view your GRASS data.

If you have saved a project, the Browser Panel will also give you quick access to all the layers stored in the same path of the project file under in the **Project Home** item.

Moreover, you can set one or more folder as **Favorites**: search under your path and once you have found the folder, right click on it and click on **Add as a Favorite**. You should then be able to see your folder in the **Favorites** item.

**Tipp:** It can happen that the folders added to Favorite item have a really long name: don’t worry right-click on the path and choose **Rename Favorite**... to set another name.
Toolbars

Your most often used sets of tools can be turned into toolbars for basic access. For example, the File toolbar allows you to save, load, print, and start a new project. You can easily customize the interface to see only the tools you use most often, adding or removing toolbars as necessary via the View > Toolbars menu.

Even if they are not visible in a toolbar, all of your tools will remain accessible via the menus. For example, if you remove the File toolbar (which contains the Save button), you can still save your map by clicking on the Project menu and then clicking on Save.

The Map Canvas

This is where the map itself is displayed and where layers are loaded. In the map canvas you can interact with the visible layers: zoom in/out, move the map, select features and many other operations that we will deeply see in the next sections.

The Status Bar

Shows you information about the current map. Also allows you to adjust the map scale, the map rotation and see the mouse cursor’s coordinates on the map.

The Side Toolbar

By default the Side toolbar contains the buttons to load the layer and all the buttons to create a new layer. But remember that you can move all the toolbars wherever it is more comfortable for you.

The Locator Bar

Within this bar you can access to almost all the objects of QGIS: layers, layer features, algorithms, spatial bookmarks, etc. Check all the different options in the locator_options section of the QGIS User Manual.

Tipp: With the shortcut Ctrl+K you can easily access the bar.

2.1.2 Try Yourself 1

Try to identify the four elements listed above on your own screen, without referring to the diagram above. See if you can identify their names and functions. You will become more familiar with these elements as you use them in the coming days.

Check your results
### 2.1.3 Try Yourself 2

Try to find each of these tools on your screen. What is their purpose?

1. ![Icon]
2. ![Icon]
3. ![Icon]
4. ![Icon]
5. ![Icon]

**Bemerkung:** If any of these tools is not visible on the screen, try enabling some toolbars that are currently hidden. Also keep in mind that if there isn’t enough space on the screen, a toolbar may be shortened by hiding some of its tools. You can see the hidden tools by clicking on the double right arrow button in any such collapsed toolbar. You can see a tooltip with the name of any tool by holding your mouse over the tool for a while.

---

### Check your results

---

### 2.1.4 What’s Next?

Now that you are familiar with the basics of the QGIS interface, in the next lesson we will see how to load some common data types.

---

### 2.2 Lesson: Adding your first layers

We will start the application, and create a basic map to use for examples and exercises.

**The goal for this lesson:** To get started with an example map.

**Bemerkung:** Before starting this exercise, QGIS must be installed on your computer. Also, you should have downloaded the *sample data* to use.

Launch QGIS from its desktop shortcut, menu item, etc., depending on how you configured its installation.

**Bemerkung:** The screenshots for this course were taken in QGIS 3.4 running on Linux. Depending on your setup, the screens you encounter may well appear somewhat different. However, all the same buttons will still be available, and the instructions will work on any OS. You will need QGIS 3.4 (the latest version at time of writing) to use this course.

Let’s get started right away!
2.2.1 Follow Along: Prepare a map

1. Open QGIS. You will have a new, blank map.

2. The Data Source Manager dialog allows you to choose the data to load depending on the data type. We’ll use it to load our dataset: click the Open Data Source Manager button.

   If you can’t find the icon, check that the Data Source Manager toolbar is enabled in the View Toolbars menu.

3. Load the protected_areas.shp vector dataset:

   1. Click on the Vector tab.
2. Enable the File source type.

3. Press the … button next to Vector Dataset(s).

4. Select the exercise_data/shapefile/protected_areas.shp file in your training directory.

5. Click Open. You will see the original dialog, with the file path filled in.

6. Click Add here as well. The data you specified will now load; you can see a protected_areas item in the Layers panel (bottom left) with its features shown in the main map canvas.

Congratulations! You now have a basic map. Now would be a good time to save your work.

1. Click on the Save As button:

2. Save the map under a solution folder next to exercise_data and call it basic_map.qgz.

2.2.2 Try Yourself

Repeat the steps above to add the places.shp and rivers.shp layers from the same folder (exercise_data/shapefile) to the map.

Check your results
Databases allow you to store a large volume of associated data in one file. You may already be familiar with a database management system (DBMS) such as Libreoffice Base or MS Access. GIS applications can also make use of databases. GIS-specific DBMSes (such as PostGIS) have extra functions, because they need to handle spatial data.

The GeoPackage open format is a container that allows you to store GIS data (layers) in a single file. Unlike the ESRI Shapefile format (e.g. the protected_areas.shp dataset you loaded earlier), a single GeoPackage file can contain various data (both vector and raster data) in different coordinate reference systems, as well as tables without spatial information; all these features allow you to share data easily and avoid file duplication.

In order to load a layer from a GeoPackage, you will first need to create the connection to it:

1. Click on the Open Data Source Manager button.
2. On the left click on the GeoPackage tab.
3. Click on the New button and browse to the training_data.gpkg file in the exercise_data folder you downloaded before.
4. Select the file and press Open. The file path is now added to the Geopackage connections list, and appears in the drop-down menu.

You are now ready to add any layer from this GeoPackage to QGIS.

1. Click on the Connect button. In the central part of the window you should now see the list of all the layers contained in the GeoPackage file.
2. Select the roads layer and click on the Add button.
   A roads layer is added to the Layers panel with features displayed on the map canvas.
3. Click on Close.

Congratulations! You have loaded the first layer from a GeoPackage.
Follow Along: Loading vector data from a SpatiaLite Database with the Browser

QGIS provides access to many other database formats. Like GeoPackage, the SpatiaLite database format is an extension of the SQLite library. And adding a layer from a SpatiaLite provider follows the same rules as described above: Create the connection -> Enable it -> Add the layer(s).

While this is one way to add SpatiaLite data to your map, let’s explore another powerful way to add data: the Browser.

1. Click the icon to open the Data Source Manager window.
2. Click on the Browser tab.
3. In this tab you can see all the storage disks connected to your computer as well as entries for most of the tabs in the left. These allow quick access to connected databases or folders.

   For example, click on the drop-down icon next to the GeoPackage entry. You’ll see the training-data.gpkg file we previously connected to (and its layers, if expanded).

4. Right-click the SpatiaLite entry and select New Connection.
5. Navigate to the exercise_data folder, select the landuse.sqlite file and click Open.

   Notice that a landuse.sqlite entry has been added under the SpatiaLite one.
6. Expand the landuse.sqlite entry.
7. Double-click the landuse layer or select and drag-and-drop it onto the map canvas. A new layer is added to the Layers panel and its features are displayed on the map canvas.

Tipp: Enable the Browser panel in View Panels and use it to add your data. It’s a handy shortcut for the Data
Source Manager | Browser tab, with the same functionality.

Bemerkung: Remember to save your project frequently! The project file doesn’t contain any of the data itself, but it remembers which layers you loaded into your map.

2.2.5 Try Yourself Load More Vector Data

Load the following datasets from the exercise_data folder into your map using any of the methods explained above:

- buildings
- water

Check your results
2.2.6 Follow Along: Reordering the Layers

The layers in your Layers list are drawn on the map in a certain order. The layer at the bottom of the list is drawn first, and the layer at the top is drawn last. By changing the order that they are shown on the list, you can change the order they are drawn in.

**Bemerkung:** You can alter this behavior using the Control rendering order checkbox beneath the Layer Order panel. We will however not discuss this feature yet.

The order in which the layers have been loaded into the map is probably not logical at this stage. It's possible that the road layer is completely hidden because other layers are on top of it.

For example, this layer order…

… would result in roads and places being hidden as they run *underneath* the polygons of the landuse layer.

To resolve this problem:

1. Click and drag on a layer in the Layers list.
2. Reorder them to look like this:

You’ll see that the map now makes more sense visually, with roads and buildings appearing above the land use regions.
2.2.7 In Conclusion

Now you've added all the layers you need from several different sources and created a basic map!

2.2.8 What’s Next?

Now you're familiar with the basic function of the Open Data Source Manager button, but what about all the others? How does this interface work? Before we go on, let's take a look at some basic interaction with the QGIS interface. This is the topic of the next lesson.

2.3 Lesson: Navigating the Map Canvas

This section will focus on basic QGIS navigation tools used to navigate within the Map Canvas. These tools will allow you to visually explore the layers at different scales.

The goal for this lesson: Learn how to use Pan and Zoom tools within QGIS and learn about map scale.

2.3.1 Follow Along: Basic Navigation Tools

Before learning how to navigate within the Map Canvas, let's add some layers that we can explore during this tutorial.

1. Open a new blank project and using the steps learnt in Create a Map, load the previously seen protected_areas, roads and buildings layers to the project. The result view should look similar to the snippet in Abb. 2.1 below (colors do not matter):

Let's first learn how to use the Pan Tool.

1. In the Map Navigation Toolbar, make sure the Pan button is activated.
2. Move the mouse to the center of the Map Canvas area.
3. Left-click and hold, and drag the mouse in any direction to pan the map.

Next, let's zoom in and take a closer look at the layers we imported.

1. In the Map Navigation Toolbar, click on the Zoom In button.
2. Move your mouse to approximately the top left area of where there is the highest density of buildings and roads.
3. Left click and hold.
4. Then drag the mouse, which will create a rectangle, and cover the dense area of buildings and roads (Zoom in).
5. Release the left click. This will zoom in to include the area that you selected with your rectangle.

6. To zoom out, select the Zoom Out button and perform the same action as you did for zooming in.

As you pan, zoom in, or zoom out, QGIS saves these views in a history. This allows you to backtrack to a previous view.

1. In the Map Navigation Toolbar, click on Zoom Last button to go to your previous view.
2. Click on Zoom Next button to proceed to move forward in your history.

Sometimes after exploring the data, we need to reset our view to the extent of all the layers. Instead of trying to use the Zoom Out tool multiple times, QGIS provides us with a button to do that action for us.

1. Click on the Zoom Full Extent button.
Abb. 2.1: Protected areas, roads and buildings added
As you zoomed in and out, notice that the *Scale* value in the Status Bar changes. The *Scale* value represents the Map Scale. In general, the number to the right of : represents how many times smaller the object you are seeing in the Map Canvas is to the actual object in the real world.

You can also use this field to set the Map Scale manually.

1. In the Status Bar, click on the *Scale* textfield.
2. Type in 50000 and press Enter. This will redraw the features in the Map Canvas to reflect the scale you typed in.
3. Alternatively, click on the options arrow of the *Scale* field to see the preset map scales.
4. Select 1:5000. This will also update the map scale in the Map Canvas.

Now you know the basics of navigating the Map Canvas. Check out the User Manual on Zooming and Panning to learn about alternative ways of navigating the Map Canvas.
Kapitel 2. Module: Erstellen und Erkunden einer einfachen Karte
2.3.2 In Conclusion

Knowing how to navigate the Map Canvas is important, as it allows one to explore and visually inspect the layers. This could be done for initial data exploration, or to validate output of a spatial analysis.

2.4 Lesson: Symbologie

The symbology of a layer is its visual appearance on the map. The basic strength of GIS over other ways of representing data with spatial aspects is that with GIS, you have a dynamic visual representation of the data you’re working with. Therefore, the visual appearance of the map (which depends on the symbology of the individual layers) is very important. The end user of the maps you produce will need to be able to easily see what the map represents. Equally as important, you need to be able to explore the data as you’re working with it, and good symbology helps a lot.

In other words, having proper symbology is not a luxury or just nice to have. In fact, it’s essential for you to use a GIS properly and produce maps and information that people will be able to use.

The goal for this lesson: To be able to create any symbology you want for any vector layer.

2.4.1 Follow Along: Changing Colors

To change a layer’s symbology, open its Layer Properties. Let’s begin by changing the color of the landuse layer.

1. Right-click on the landuse layer in the layers list.
2. Select the menu item Properties… in the menu that appears.

Bemerkung: By default, you can also access a layer’s properties by double-clicking on the layer in the Layers...
Tipp: The button at the top of the Layers panel will open the Layer Styling panel. You can use this panel to change some properties of the layer: by default, changes will be applied immediately!

3. In the Layer Properties window, select the Symbology tab:

4. Click the color select button next to the Color label. A standard color dialog will appear.
5. Choose a gray color and click OK.
6. Click OK again in the Layer Properties window, and you will see the color change being applied to the layer.

2.4.2 Try Yourself

Change the color of the water layer to light blue. Try to use the Layer Styling panel instead of the Layer Properties menu.

Check your results
2.4.3 Follow Along: Changing Symbol Structure

This is good stuff so far, but there’s more to a layer’s symbology than just its color. Next we want to eliminate the lines between the different land use areas so as to make the map less visually cluttered.

1. Open the Layer Properties window for the landuse layer.

   Under the Symbology tab, you will see the same kind of dialog as before. This time, however, you’re doing more than just quickly changing the color.

2. In the symbol layers tree, expand the Fill dropdown and select the Simple fill option.

3. Click on the Stroke style dropdown. At the moment, it should be showing a short line and the words Solid Line.

4. Change this to No Pen.

5. Click OK.

Now the landuse layer won’t have any lines between areas.
2.4.4  Try Yourself

- Change the water layer’s symbology again so that it has a darker blue outline.
- Change the rivers layer’s symbology to a sensible representation of waterways.

Remember: you can use the Open the Layer Styling panel button and see all the changes instantly. That panel also allows you to undo individual changes while symbolizing a layer.

Check your results

2.4.5  Follow Along: Scale-Based Visibility

Sometimes you will find that a layer is not suitable for a given scale. For example, a dataset of all the continents may have low detail, and not be very accurate at street level. When that happens, you want to be able to hide the dataset at inappropriate scales.

In our case, we may decide to hide the buildings from view at small scales. This map, for example…

… is not very useful. The buildings are hard to distinguish at that scale.

To enable scale-based rendering:

1. Open the Layer Properties dialog for the buildings layer.
2. Activate the Rendering tab.
3. Enable scale-based rendering by clicking on the checkbox labeled Scale dependent visibility.
4. Change the Minimum value to 1:10000.
5. Click OK.

Test the effects of this by zooming in and out in your map, noting when the buildings layer disappears and reappears.

Bemerkung: You can use your mouse wheel to zoom in increments. Alternatively, use the zoom tools to zoom to a window:
Now that you know how to change simple symbology for layers, the next step is to create more complex symbology. QGIS allows you to do this using symbol layers.

1. Go back to the landuse layer’s symbol properties panel (by clicking Simple fill in the symbol layers tree).

   In this example, the current symbol has no outline (i.e., it uses the No Pen border style).

2. Select the Fill level in the tree and click the Add symbol layer button. The dialog will change to look something like this, with a new symbol layer added:

   It may appear somewhat different in color, for example, but you’re going to change that anyway.

Now there’s a second symbol layer. Being a solid color, it will of course completely hide the previous kind of symbol. Plus, it has a Solid Line border style, which we don’t want. Clearly this symbol has to be changed.

**Bemerkung:** It’s important not to get confused between a map layer and a symbol layer. A map layer is a vector (or raster) that has been loaded into the map. A symbol layer is part of the symbol used to represent a map layer. This course will usually refer to a map layer as just a layer, but a symbol layer will always be called a symbol layer, to prevent confusion.

With the new Simple Fill symbol layer selected:

1. Set the border style to No Pen, as before.

2. Change the fill style to something other than Solid or No brush. For example:
Kapitel 2. Module: Erstellen und Erkunden einer einfachen Karte
2.4. Lesson: Symbologie
3. Click **OK**.

Now you can see your results and tweak them as needed. You can even add multiple extra symbol layers and create a kind of texture for your layer that way.

It’s fun! But it probably has too many colors to use in a real map…

---

### 2.4.7 Try Yourself

Remembering to zoom in if necessary, create a simple, but not distracting texture for the *buildings* layer using the methods above.

*Check your results*

---

### 2.4.8 Follow Along: Ordering Symbol Levels

When symbol layers are rendered, they are also rendered in a sequence, similar to the way the different map layers are rendered. This means that in some cases, having many symbol layers in one symbol can cause unexpected results.

1. Give the *roads* layer an extra symbol layer (using the method for adding symbol layers demonstrated above).
2. Give the base line a *Stroke width* of 1.5 and a black color.
3. Give the new, uppermost layer a thickness of 0.8 and a white color.

You’ll notice that this happens:

Well, roads have now a *street* like symbology, but you see that lines are overlapping each others at each cross. That’s not what we want at all!

To prevent this from happening, you can sort the symbol levels and thereby control the order in which the different symbol layers are rendered.

To change the order of the symbol layers:

1. Select the topmost *Line* layer in the symbol layers tree.
2. Click **Advanced Symbol levels**… in the bottom right-hand corner of the window.
   - This will open a dialog like this:
3. Check **Enable symbol levels**. You can then set the layer order of each symbol by entering the corresponding level number. 0 is the bottom layer.
   - In our case, we just want to activate the option, like this:
   - This will render the white line above the thick black line borders:
4. Click **OK** twice to return to the map.

The map will now look like this:
2.4. Lesson: Symbologie
Enable symbol levels

Define the order in which the symbol layers are rendered. The numbers in the cells define in which rendering pass the layer will be drawn.

<table>
<thead>
<tr>
<th>Layer 0</th>
<th>Layer 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
When you’re done, remember to save the symbol itself so as not to lose your work if you change the symbol again in the future. You can save your current symbol style by clicking the Save Style… button at the bottom of the Layer Properties dialog. We will be using the QGIS QML Style File format.

Save your style in the solution/styles/better_roads.qml folder. You can load a previously saved style at any time by clicking the Load Style… button. Before you change a style, keep in mind that any unsaved style you are replacing will be lost.

2.4.9  🕒 Try Yourself

Change the appearance of the roads layer again.

Make the roads narrow and yellow, with a thin, pale gray outline and a thin black line in the middle. Remember that you may need to change the layer rendering order via the Advanced Symbol levels… dialog.

Check your results
2.4.10 **Try Yourself**

Symbol levels also work for classified layers (i.e., layers having multiple symbols). Since we haven’t covered classification yet, you will work with some rudimentary pre-classified data.

1. Create a new map and add only the *roads* dataset.
2. Load the style file `advanced_levels_demo.qml` provided in `exercise_data/styles`.
3. Zoom in to the Swellendam area.
4. Using symbol layers, ensure that the outlines of layers flow into one another as per the image below:

   ![Map Image]

   *Check your results*

2.4.11 **Follow Along: Symbol layer types**

In addition to setting fill colors and using predefined patterns, you can use different symbol layer types entirely. The only type we’ve been using up to now was the *Simple Fill* type. The more advanced symbol layer types allow you to customize your symbols even further.

Each type of vector (point, line and polygon) has its own set of symbol layer types. First we will look at the types available for points.
Point Symbol Layer Types

1. Uncheck all the layers except for places.
2. Change the symbol properties for the places layer:

3. You can access the various symbol layer types by selecting the Simple marker layer in the symbol layers tree, then click the Symbol layer type dropdown:

4. Investigate the various options available to you, and choose a symbol with styling you think is appropriate.

5. If in doubt, use a round Simple marker with a white border and pale green fill, with a Size of 3.00 and a Stroke width of 0.5.
Kapitel 2. Module: Erstellen und Erkunden einer einfachen Karte
Line Symbol Layer Types

To see the various options available for line data:

1. Change the Symbol layer type for the roads layer’s topmost symbol layer to Marker line:

2. Select the Simple marker layer in the symbol layers tree. Change the symbol properties to match this dialog:

3. Select the Marker line layer and change the interval to 1.00:

4. Ensure that the symbol levels are correct (via the Advanced Symbol levels dialog we used earlier) before applying the style.

Once you have applied the style, take a look at its results on the map. As you can see, these symbols change direction along with the road but don’t always bend along with it. This is useful for some purposes, but not for others. If you prefer, you can change the symbol layer in question back to the way it was before.
2.4. Lesson: Symbologie
Polygon Symbol Layer Types

To see the various options available for polygon data:

1. Change the Symbol layer type for the water layer, as before for the other layers.
2. Investigate what the different options on the list can do.
3. Choose one of them that you find suitable.
4. If in doubt, use the Point pattern fill with the following options:

5. Add a new symbol layer with a normal Simple fill.
6. Make it the same light blue with a darker blue border.
7. Move it underneath the point pattern symbol layer with the Move down button:

As a result, you have a textured symbol for the water layer, with the added benefit that you can change the size, shape and distance of the individual dots that make up the texture.
2.4. Lesson: Symbologie
2.4.12 Try Yourself

Apply a green transparent fill color to the protected_areas layer, and change the outline to look like this:

![Protected Areas](image)

Check your results

2.4.13 Follow Along: Geometry generator symbology

You can use the Geometry generator symbology with all layer types (points, lines and polygons). The resulting symbol depends directly on the layer type.

Very briefly, the Geometry generator symbology allows you to run some spatial operations within the symbology itself. For example you can run a real centroid spatial operation on a polygon layer without creating a point layer.

Moreover, you have all the styling options to change the appearance of the resulting symbol.

Let’s give it a try!

1. Select the water layer.
2. Click on Simple fill and change the Symbol layer type to Geometry generator.
3. Before to start writing the spatial query we have to choose the Geometry Type in output. In this example we are going to create centroids for each feature, so change the Geometry Type to Point / Multipoint.
4. Now let’s write the query in the query panel:
   ```sql
   centroid($geometry)
   ```
5. When you click on OK you will see that the water layer is rendered as a point layer! We have just run a spatial operation within the layer symbology itself, isn’t that amazing?

With the Geometry generator symbology you can really go over the edge of normal symbology.
Kapitel 2. Module: Erstellen und Erkunden einer einfachen Karte
2.4. Lesson: Symbologie
Geometry generator are just another symbol level. Try to add another Simple fill underneath the Geometry generator one.

Change also the appearance of the Simple marker of the Geometry generator symbology. The final result should look like this:

Check your results

2.4.14 Follow Along: Creating a Custom SVG Fill

Bemerkung: To do this exercise, you will need to have the free vector editing software Inkscape installed.

1. Start the Inkscape program. You will see the following interface:
   You should find this familiar if you have used other vector image editing programs, like Corel.
   First, we'll change the canvas to a size appropriate for a small texture.

2. Click on the menu item File → Document Properties. This will give you the Document Properties dialog.
3. Change the Units to px.

4. Change the Width and Height to 100.

5. Close the dialog when you are done.

6. Click on the menu item View → Zoom → Page to see the page you are working with.

7. Select the Circle tool:

8. Click and drag on the page to draw an ellipse. To make the ellipse turn into a circle, hold the Ctrl button while you’re drawing it.

9. Right-click on the circle you just created and open its Fill and Stroke options. You can modify its rendering, such as:
   1. Change the Fill color to a somehow pale grey-blue,
   2. Assign to the border a darker color in Stroke paint tab,
   3. And reduce the border thickness under Stroke style tab.

10. Draw a line using the Pencil tool:
    1. Click once to start the line. Hold Ctrl to make it snap to increments of 15 degrees.
    2. Move the pointer horizontally and place a point with a simple click.
    3. Click and snap to the vertex of the line and trace a vertical line, ended by a simple click.
    4. Now join the two end vertices.
    5. Change the color and width of the triangle symbol to match the circle’s stroke and move it around as necessary, so that you end up with a symbol like this one:

11. If the symbol you get satisfies you, then save it as landuse_symbol under the directory that the course is in, under exercise_data/symbols, as SVG file.

2.4. Lesson: Symbologie
Kapitel 2. Module: Erstellen und Erkunden einer einfachen Karte
In QGIS:

1. Open the Layer Properties for the landuse layer.

2. In the Symbology tab, change the symbol structure by changing the Symbol Layer Type to SVG Fill shown below.

3. Click the … button and then Select File… to select your SVG image.

   It’s added to the symbol tree and you can now customize its different characteristics (colors, angle, effects, units…).

Once you validate the dialog, features in landuse layer should now be covered by a set of symbols, showing a texture like the one on the following map. If textures are not visible, you may need to zoom in the map canvas or set in the layer properties a bigger Texture width.
2.4.15 In Conclusion

Changing the symbology for the different layers has transformed a collection of vector files into a legible map. Not only can you see what’s happening, it’s even nice to look at!

2.4.16 Further Reading

Examples of Beautiful Maps

2.4.17 What’s Next?

Changing symbols for whole layers is useful, but the information contained within each layer is not yet available to someone reading these maps. What are the streets called? Which administrative regions do certain areas belong to? What are the relative surface areas of the farms? All of this information is still hidden. The next lesson will explain how to represent this data on your map.

**Bemerkung:** Did you remember to save your map recently?
Kapitel 2. Module: Erstellen und Erkunden einer einfachen Karte
Module: Vektordaten klassifizieren

Das Klassifizieren von Vektordaten ermöglicht es Ihnen, den Elementen (verschiedene Objekte im selben Layer) in Abhängigkeit von ihren Attributen unterschiedliche Symbole zuzuordnen. Auf diese Weise kann jemand, der die Karte benutzt, die Attribute verschiedener Elemente leicht erkennen.

3.1 Lesson: Vector Attribute Data

Vector data is arguably the most common kind of data in the daily use of GIS. The vector model represents the location and shape of geographic features using points, lines and polygons (and for 3D data also surfaces and volumes), while their other properties are included as attributes (often presented as a table in QGIS).

Up to now, none of the changes we have made to the map have been influenced by the objects that are being shown. In other words, all the land use areas look alike, and all the roads look alike. When looking at the map, the viewers don’t know anything about the roads they are seeing; only that there is a road of a certain shape in a certain area.

But the whole strength of GIS is that all the objects that are visible on the map also have attributes. Maps in a GIS aren’t just pictures. They represent not only objects in locations, but also information about those objects.

**The goal for this lesson:** To learn about the structure of vector data and explore the attribute data of an object

3.1.1 Follow Along: Viewing Layer Attributes

It’s important to know that the data you will be working with does not only represent **where** objects are in space, but also tells you **what** those objects are.

From the previous exercise, you should have the protected_areas layer loaded in your map. If it is not loaded, then you can find the protected_areas.shp ESRI Shapefile format dataset in directory exercise_data/shapefile.

The polygons representing the protected areas constitute the **spatial data**, but we can learn more about the protected areas by exploring the **attribute table**.

1. In the **Layers** panel, click on the protected_areas layer to select it.

2. In the **Attributes Toolbar** click the **Open Attribute Table** button. This will open a new window showing the attribute table of the protected_areas layer.
A row is called a **record** and is associated with a **feature** in the Canvas Map, such as a polygon. A column is called a **field** (or an **attribute**), and has a name that helps describe it, such as **name** or **id**. Values in the cells are known as **attribute values**. These definitions are commonly used in GIS, so it is good to become familiar with them.

**In the protected_areas layer**, there are two **features**, which are represented by the two polygons we see on the Map Canvas.

**Bemerkung:** In order to understand what the **fields** and **attribute values** represent, one may need to find documentation (or metadata) describing the meaning of the attribute values. This is usually available from the creator of the data set.

Next, let’s see how a record in the attribute table is linked to a polygon feature that we see on the Map Canvas.

1. Go back to the main QGIS window.
2. In the **Attributes Toolbar**, click on the **Select Feature** button.
3. Make sure the **protected_areas** layer is still selected in the **Layers** panel.
4. Move your mouse to the Map Canvas and left click on the smaller of the two polygons. The polygon will turn yellow indicating it is selected.
5. Go back to the **Attribute Table** window, and you should see a record (row) highlighted. These are the attribute values of the selected polygon.

You can also select a feature using the Attribute Table.

1. In the **Attribute Table** window, on the far left, click on the row number of the record that is currently not selected.
2. Go back to the main QGIS window and look at the Map Canvas. You should see the larger of the two polygons colored yellow.
3. To deselect the feature, go to the **Attribute Table** window and click on **Deselect all features from the layer** button.

Sometimes there are many features shown on the Map Canvas and it might be difficult to see which feature is selected from the Attribute Table. Another way to identify the location of a feature is to use the **Flash Feature** tool.

1. In the **Attribute Table**, right-click on any cell in the row that has the attribute value `r2855697` for the field **full_id**.
2. In the context menu, click on **Flash Feature** and watch the Map Canvas.
   You should see the polygon flash red a few times. If you missed it, try it again.

Another useful tool is the **Zoom to Feature** tool, that tells QGIS to zoom to the feature of interest.

1. In the **Attribute Table**, right-click on any cell in the row that has the attribute value `r2855697` for the field **full_id**.
3.1. Lesson: Vector Attribute Data
### Kapitel 3. Module: Vektordaten klassifizieren

<table>
<thead>
<tr>
<th>full id</th>
<th>osm id</th>
<th>osm type</th>
<th>boundary</th>
<th>is in</th>
<th>leisure</th>
<th>name</th>
<th>type</th>
<th>wikidata</th>
<th>w</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2855697</td>
<td>relation</td>
<td>protected_a_</td>
<td>Western Ca_</td>
<td>nature reser...</td>
<td>Bontebok N...</td>
<td>boundary</td>
<td>Q8928884</td>
<td>en-Si...</td>
</tr>
<tr>
<td>2</td>
<td>187055916</td>
<td>way</td>
<td>protected_a_</td>
<td>Western Ca_</td>
<td>nature_reser...</td>
<td>Marioth Nat...</td>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
</tr>
</tbody>
</table>
2. In the context menu, click on Zoom to Feature

![Image of QGIS context menu with Zoom to Feature selected]

Look at the Map Canvas. The polygon should now occupy the extent of the Map Canvas area.

You may now close the attribute table.

### 3.1.2 Try Yourself Exploring Vector Data Attributes

1. How many fields are available in the rivers layer?
2. Tell us a bit about the town places in your dataset.
3. Open the attribute table for the places layer. Which field would be the most useful to represent in label form, and why?

*Check your results*

### 3.1.3 In Conclusion

You now know how to use the attribute table to see what is actually in the data you’re using. Any dataset will only be useful to you if it has the attributes that you care about. If you know which attributes you need, you can quickly decide if you’re able to use a given dataset, or if you need to look for another one that has the required attribute data.

### 3.1.4 What’s Next?

Different attributes are useful for different purposes. Some of them can be represented directly as text for the map user to see. You’ll learn how to do this in the next lesson.
3.2 Lesson: Labels

Labels can be added to a map to show any information about an object. Any vector layer can have labels associated with it. These labels rely on the attribute data of a layer for their content.

The goal for this lesson: To apply useful and good-looking labels to a layer.

3.2.1 Follow Along: Using Labels

First, ensure that the button is visible in the GUI:

1. Go to the menu item View Toolbars
2. Ensure that the Label Toolbar item has a check mark next to it. If it doesn’t, click on the Label Toolbar item to activate it.
3. Click on the places layer in the Layers panel so that it is highlighted
4. Click on the toolbar button to open the Labels tab of the Layer Styling panel
5. Switch from No Labels to Single Labels

You’ll need to choose which field in the attributes will be used for the labels. In the previous lesson, you decided that the name field was the most suitable one for this purpose.

6. Select name from the Value list:
7. Klicken Sie auf Anwenden

The map should now have labels like this:

3.2.2 Follow Along: Changing Label Options

Depending on the styles you chose for your map in earlier lessons, you might find that the labels are not appropriately formatted and either overlap or are too far away from their point markers.

Bemerkung: Above, you used the button in the Label Toolbar to open the Layer Styling panel. As with Symbolology, the same label options are available via both the Layer Styling panel and the Layer Properties dialog. Here, you’ll use the Layer Properties dialog.

1. Open the Layer Properties dialog by double-clicking on the places layer
2. Select the Labels tab
3. Make sure Text is selected in the left-hand options list, then update the text formatting options to match those shown here:
4. Klicken Sie auf Anwenden

That font may be larger and more familiar to users, but its readability is still dependent on what layers are rendered beneath it. To solve this, let’s take a look at the Buffer option.

5. Select Buffer from the left-hand options list
6. Select the checkbox next to Draw text buffer, then choose options to match those shown here:
7. Klicken Sie auf Anwenden

You’ll see that this adds a colored buffer or border to the place labels, making them easier to pick out on the map:

Now we can address the positioning of the labels in relation to their point markers.
3.2. Lesson: Labels
8. Select Placement from the left-hand options list
9. Select Around point and change the value of Distance to 2.0 Millimeters:
10. Klicken Sie auf Anwenden
   You’ll see that the labels are no longer overlapping their point markers.

### 3.2.3 Follow Along: Using Labels Instead of Layer Symbology

In many cases, the location of a point doesn't need to be very specific. For example, most of the points in the places layer refer to entire towns or suburbs, and the specific point associated with such features is not that specific on a large scale. In fact, giving a point that is too specific is often confusing for someone reading a map.

To name an example: on a map of the world, the point given for the European Union may be somewhere in Poland, for instance. To someone reading the map, seeing a point labeled European Union in Poland, it may seem that the capital of the European Union is therefore in Poland.

So, to prevent this kind of misunderstanding, it’s often useful to deactivate the point symbols and replace them completely with labels.

In QGIS, you can do this by changing the position of the labels to be rendered directly over the points they refer to.

1. Open the Labels tab of the Layer Properties dialog for the places layer
2. Select the Placement option from the options list
3. Click on the Offset from point button
   This will reveal the Quadrant options which you can use to set the position of the label in relation to the point marker. In this case, we want the label to be centered on the point, so choose the center quadrant:
3.2. Lesson: Labels
Lorem Ipsum
4. Hide the point symbols by editing the layer *Symbology* as usual, and setting the size of the *Marker* size to 0.0.

5. Click *Apply* and you'll see this result:

If you were to zoom out on the map, you would see that some of the labels disappear at larger scales to avoid overlapping. Sometimes this is what you want when dealing with datasets that have many points, but at other times you will lose useful information this way. There is another possibility for handling cases like this, which we’ll cover in a later exercise in this lesson. For now, zoom out and click on the button in the toolbar and see what happens.

3.2.4 Try Yourself Customize the Labels

- Reset the label and symbol settings to have a point marker and a label offset of 2.0 Millimeters.

**Check your results**

- Set the map to the scale 1:100000. You can do this by typing it into the *Scale* box in the *Status Bar*. Modify your labels to be suitable for viewing at this scale.

**Check your results**
Kapitel 3. Module: Vektordaten klassifizieren
Lorem Ipsum
Kapitel 3. Module: Vektordaten klassifizieren
3.2.5 Follow Along: Labeling Lines

Now that you know how labeling works, there’s an additional problem. Points and polygons are easy to label, but what about lines? If you label them the same way as the points, your results would look like this:

We will now reformat the roads layer labels so that they are easy to understand.

1. Hide the places layer so that it doesn’t distract you
2. Activate Single Labels for the roads layer as you did above for places
3. Set the font Size to 10 so that you can see more labels
4. Zoom in on the Swellendam town area
5. In the Labels tab’s Placement tab, choose the following settings:
   - You’ll probably find that the text styling has used default values and the labels are consequently very hard to read. Update the Text to use a dark-grey or black Color and the Buffer to use a light-yellow Color.
   - The map will look somewhat like this, depending on scale:
   - You’ll see that some of the road names appear more than once and that’s not always necessary. To prevent this from happening:
6. In the Labels tab of the Layer Properties dialog, choose the Rendering option and select Merge connected lines to avoid duplicate labels as shown:
7. Klicken Sie auf OK

Another useful function is to prevent labels being drawn for features too short to be of notice.
8. In the same Rendering panel, set the value of Suppress labeling of features smaller than ... to \(5.00\) mm and note the results when you click Apply.

Try out different Placement settings as well. As we've seen before, the Horizontal option is not a good idea in this case, so let's try the Curved option instead.

9. Select the Curved option in the Placement panel of the Layers tab.

Here's the result:

As you can see, this hides some labels that were previously visible, because of the difficulty of making some of them follow twisting street lines while still being legible. It makes other labels much more useful since they track the roads rather than float in space between them. You can decide which of these options to use, depending on what you think seems more useful or what looks better.

### 3.2.6 Follow Along: Data Defined Settings

1. Deactivate labeling for the roads layer
2. Reactivate labeling for the places layer
3. Open the attribute table for places via the button.

It has one field which is of interest to us now: place which defines the type of urban area for each record. We can use this data to influence the label styles.

4. Navigate to the Text panel in the places Labels panel.
5. Click the button next to the Italic text button beneath Style and select Edit… to open the Expression String Builder:

6. Under Fields and Values, double click on place and then click All Unique. This will list all unique values of the place field of this layer. Add a = in the text editor and then double click on town.

   Alternatively, you can type: "place" = 'town' directly in the text editor.

7. Click OK twice:

   Notice that the labels for all places whose place field matches town are displayed in italics.

3.2.7 Try Yourself Using Data Defined Settings

*Bemerkung:* We’re jumping ahead a bit here to demonstrate some advanced labeling settings. At the advanced level, it’s assumed that you’ll know what the following means. If you don’t, feel free to leave out this section and come back later when you’ve covered the requisite materials.

1. Open the Attribute Table for places

2. Enter edit mode by clicking the button

3. Add a new column with the button

4. Configure it like this:

5. Use this to set custom font sizes for each different type of place (each key in the place field)
3.2. Lesson: Labels

Lorem Ipsum

Label z-index: 0.00

Data defined:
- Show label
- Always show

Show upside-down labels:
- never
- when rotation defined
- always

Feature options:
- Label every part of multi-part features
- Merge connected lines to avoid duplicate labels
- Limit number of features to be labeled to
  - 2000
- Suppress labeling of features smaller than
  - 5.00 mm
Kapitel 3. Module: Vektordaten klasifizieren
3.2. Lesson: Labels
3.2.8 Further Possibilities With Labeling

We can’t cover every option in this course, but be aware that the *Label* tab has many other useful functions. You can set scale-based rendering, alter the rendering priority for labels in a layer, and set every label option using layer attributes. You can even set the rotation, XY position, and other properties of a label (if you have attribute fields allocated for the purpose), then edit these properties using the tools adjacent to the main *Layer Labeling Options* button:

(These tools will be active if the required attribute fields exist and you are in edit mode.)

Feel free to explore more possibilities of the labeling system.

3.2.9 In Conclusion

You’ve learned how to use layer attributes to create dynamic labels. This can make your map a lot more informative and stylish!

3.2.10 What’s Next?

Now that you know how attributes can make a visual difference for your map, how about using them to change the symbology of objects themselves? That’s the topic for the next lesson!

3.3 Lesson: Klassifikation

Labels are a good way to communicate information such as the names of individual places, but they can’t be used for everything. For example, let us say that someone wants to know what each landuse area is used for. Using labels, you would get this:

This makes the map’s labeling difficult to read and even overwhelming if there are numerous different landuse areas on the map.

**The goal for this lesson:** To learn how to classify vector data effectively.
3.3.1 Follow Along: Classifying Nominal Data

1. Open the Layer Properties dialog for the landuse layer
2. Go to the Symbology tab
3. Click on the dropdown that says Single Symbol and change it to Categorized:

   ![Layer Properties](image)

4. In the new panel, change the Value to landuse and the Color ramp to Random colors
5. Click the button labeled Classify
6. Klicken Sie auf OK
You’ll see something like this:

7. Click the arrow (or plus sign) next to landuse in the Layers panel, you’ll see the categories explained:

Now our landuse polygons are colored and are classified so that areas with the same land use are the same color.

8. If you wish to, you can change the symbol of each landuse area by double-clicking the relevant color block in the Layers panel or in the Layer Properties dialog:

Notice that there is one category that’s empty:

This empty category is used to color any objects which do not have a landuse value defined or which have a NULL value. It can be useful to keep this empty category so that areas with a NULL value are still represented on the map. You may like to change the color to more obviously represent a blank or NULL value.

Remember to save your map now so that you don’t lose all your hard-earned changes!

### 3.3.2 Try Yourself More Classification

Use the knowledge you gained above to classify the buildings layer. Set the categorisation against the building field and use the Spectral color ramp.

**Bemerkung:** Remember to zoom into an urban area to see the results.
### 3.3.3 Follow Along: Ratio Classification

There are four types of classification: *nominal*, *ordinal*, *interval* and *ratio*.

In **nominal** classification, the categories that objects are classified into are name-based; they have no order. For example: town names, district codes, etc. Symbols that are used for nominal data should not imply any order or magnitude.

- For points, we can use symbols of different shape.
- For polygons, we can use different types of hatching or different colours (avoid mixing light and dark colours).
- For lines, we can use different dash patterns, different colours (avoid mixing light and dark colours) and different symbols along the lines.

In **ordinal** classification, the categories are arranged in a certain order. For example, world cities are given a rank depending on their importance for world trade, travel, culture, etc. Symbols that are used for ordinal data should imply order, but not magnitude.

- For points, we can use symbols with light to dark colours.
- For polygons, we can use graduated colours (light to dark).
- For lines, we can use graduated colours (light to dark).

In **interval** classification, the numbers are on a scale with positive, negative and zero values. For example: height above/below sea level, temperature in degrees Celsius. Symbols that are used for interval data should imply order and magnitude.

- For points, we can use symbols with varying size (small to big).
- For polygons, we can use graduated colours (light to dark) or add diagrams of varying size.
- For lines, we can use thickness (thin to thick).

In **ratio** classification, the numbers are on a scale with only positive and zero values. For example: temperature above absolute zero (0 degrees Kelvin), distance from a point, the average amount of traffic on a given street per month,
3.3. Lesson: Klassifikation
etc. Symbols that are used for ratio data should imply order and magnitude.

- For points, we can use symbols with varying size (small to big).
- For polygons, we can use graduated colours (light to dark) or add diagrams of varying size.
- For lines, we can use thickness (thin to thick).

In the example above, we used nominal classification to color each record in the landuse layer based on its landuse attribute. Now we will use ratio classification to classify the records by area.

We are going to reclassify the layer, so existing classes will be lost if not saved. To store the current classification:

1. Open the layer’s properties dialog
2. Click the Save Style … button in the Style drop-down menu.
3. Select Rename Current…, enter land usage and press OK.

   The categories and their symbols are now saved in the layer’s properties.

4. Click now on the Add… entry of the Style drop-down menu and create a new style named ratio. This will store the new classification.

5. Close the Layer Properties dialog

We want to classify the landuse areas by size, but there is a problem: they don’t have a size field, so we’ll have to make one.

1. Open the Attributes Table for the landuse layer.
2. Enter edit mode by clicking the Toggle editing button
3. Add a new column of decimal type, called AREA, using the New field button:

   ![Add Field dialog](image)

   4. Klicken Sie auf OK

   The new field will be added (at the far right of the table; you may need to scroll horizontally to see it). However, at the moment it is not populated, it just has a lot of NULL values.

   To solve this problem, we will need to calculate the areas.

   1. Open the field calculator with the button.

      You will get this dialog:

   2. Check the Update existing fields

   3. Select AREA in the fields drop-down menu

   4. Under the Expression tab, expand the Geometry functions group in the list and find Sarea

   5. Double-click on it so that it appears in the Expression field

   6. Klicken Sie auf OK

   7. Scroll to the AREA field in the attribute table and you will notice that it is populated with values (you may need to click the column header to refresh the data).
3.3. Lesson: Klassifikation
Bemerkung: These areas respect the project’s area unit settings, so they may be in square meters or square degrees.

5. Press to save the edits and exit the edit mode with  
6. Close the attribute table

Now that we have the data, let’s use them to render the landuse layer.

1. Open the Layer properties dialog’s Symbology tab for the landuse layer
2. Change the classification style from Categorized to Graduated
3. Change the Value to AREA
4. Under Color ramp, choose the option Create New Color Ramp…:
5. Choose Gradient (if it’s not selected already) and click OK. You will see this:
   You’ll be using this to denote area, with small areas as Color 1 and large areas as Color 2.
6. Choose appropriate colors
   In the example, the result looks like this:
7. Klicken Sie auf OK
8. You can save the colour ramp by selecting Save Color Ramp… under the Color ramp tab. Choose an appropriate name for the colour ramp and click Save. You will now be able to select the same colour ramp easily under All Color Ramps.
9. Click Classify
   Now you will have something like this:
3.3.4  Try Yourself Refine the Classification

> Change the values of *Mode* and *Classes* until you get a classification that makes sense.

*Check your results*

3.3.5  Follow Along: Rule-based Classification

It's often useful to combine multiple criteria for a classification, but unfortunately normal classification only takes one attribute into account. That's where rule-based classification comes in handy.

In this lesson, we will represent the *landuse* layer in a way to easily identify Swellendam city from the other residential area, and from the other types of landuse (based on their area).

1. Open the *Layer Properties* dialog for the *landuse* layer
2. Switch to the *Symbology* tab
3. Switch the classification style to *Rule-based*

   QGIS will automatically show the rules that represent the current classification implemented for this layer. For example, after completing the exercise above, you may see something like this:

4. Click and drag to select all the rules
5. Use the *Remove selected rules* button to remove all of the existing rules

Let's now add our custom rules.
Kapitel 3. Module: Vektordaten klassifizieren

QGIS Training Manual
3.3. Lesson: Klassifikation
Kapitel 3. Module: Vektordaten klassifizieren
1. Click the **Add rule** button
2. The **Edit rule** dialog then appears
3. Enter **Swellendam city** as **Label**
4. Click the **E** button next to the **Filter** text area to open the **Expression String Builder**
5. Enter the criterion "name" = 'Swellendam' and validate
6. Back to the **Edit rule** dialog, assign it a darker grey-blue color in order to indicate the town's importance in the region and remove the border
7. Press **OK**
8. Repeat the steps above to add the following rules:
   1. **Other residential** label with the criterion "landuse" = 'residential' AND "name" <> 'Swellendam' (or "landuse" = 'residential' AND "name" != 'Swellendam'). Choose a pale blue-grey **Fill color**
   2. **Big non residential areas** label with the criterion "landuse" <> 'residential' AND "AREA" >= 605000. Choose a mid-green color.
      These filters are exclusive, in that they exclude areas on the map (non-residential areas which are smaller than 605000 (square meters) are not included in any of the rules).
   3. We will catch the remaining features using a new rule labeled **Small non residential areas**. Instead of a filter expression, Check the **Else**. Give this category a suitable pale green color.

3.3. Lesson: Klassifikation
Kapitel 3. Module: Vektordaten klassifizieren
Your rules should now look like this:

9. Apply this symbology
Your map will look something like this:
Now you have a map with Swellendam the most prominent residential area and other non-residential areas colored according to their size.
3.3.6 In Conclusion

Symbology allows us to represent the attributes of a layer in an easy-to-read way. It allows us as well as the map reader to understand the significance of features, using any relevant attributes that we choose. Depending on the problems you face, you’ll apply different classification techniques to solve them.

3.3.7 What’s Next?

Now we have a nice-looking map, but how are we going to get it out of QGIS and into a format we can print out, or make into an image or PDF? That’s the topic of the next lesson!
Module: Layout der Karten

In diesem Modul lernen Sie, wie Sie das QGIS-Drucklayout verwenden, um qualitativ hochwertige Karten mit allen erforderlichen Kartenkomponenten zu erstellen.

4.1 Lesson: Using Print Layout

Now that you've got a map, you need to be able to print it or to export it to a document. The reason is, a GIS map file is not an image. Rather, it saves the state of the GIS program, with references to all the layers, their labels, colors, etc. So for someone who doesn’t have the data or the same GIS program (such as QGIS), the map file will be useless. Luckily, QGIS can export its map file to a format that anyone’s computer can read, as well as printing out the map if you have a printer connected. Both exporting and printing is handled via the Print Layout.

The goal for this lesson: To use the QGIS Print Layout to create a basic map with all the required settings.

4.1.1 Follow Along: The Layout Manager

QGIS allows you to create multiple maps using the same map file. For this reason, it has a tool called the Layout Manager.

1. Click on the Project Layout Manager menu entry to open this tool. You’ll see a blank Layout manager dialog appear.

2. Under New from Template, select Empty layout, click the Create… button, and give the new layout the name of Swellendam.

3. Click OK.

(You could also close the dialog and navigate to a layout via the Project Layouts menu, as in the image below.) Whichever route you take to get there, you will now see the Print Layout window:
Kapitel 4. Module: Layout der Karten
4.1.2 Follow Along: Basic Map Composition

In this example, the composition was already the way we wanted it. Ensure that yours is as well.

1. Right-click on the sheet in the central part of the layout window and choose Page properties… in the context menu. Check that the values in the Item Properties tab are set to the following:
   - **Size**: A4
   - **Orientation**: Landscape

   Now you’ve got the page layout the way you wanted it, but this page is still blank. It clearly lacks a map. Let’s fix that!

2. Click on the Add New Map button.

   With this tool activated, you will be able to place a map on the page.

3. Click and drag a box on the blank page:

   ![Image of QGIS layout window with a new map added]

   The map will appear on the page.

4. Move the map by clicking and dragging it around:

5. Resize it by clicking and dragging the boxes on the edges:

   **Bemerkung:** Your map may look a lot different, of course! This depends on how your own project is set up. But not to worry! These instructions are general, so they will work the same regardless of what the map itself looks like.

6. Be sure to leave margins along the edges, and a space along the top for the title.

7. Zoom in and out on the page (but not the map!) by using these buttons:

8. Zoom and pan the map in the main QGIS window. You can also pan the map using the Move item content tool.
The map view updates as you zoom in or zoom out.

9. If, for any reason, the map view does not refresh correctly, you can force the map to refresh by clicking this button:

![Refresh button]

Remember that the size and position you’ve given the map doesn’t need to be final. You can always come back and change it later if you’re not satisfied. For now, you need to ensure that you’ve saved your work on this map. Because a Print Layout in QGIS is part of the main map file, you must save your project.

10. Go to the Layout \[Layout\] \[Save Project\]. This is a convenient shortcut to the one in the main dialog.

### 4.1.3 Follow Along: Adding a Title

Now your map is looking good on the page, but your readers/users are not being told what’s going on yet. They need some context, which is what you’ll provide for them by adding map elements. First, let us add a title.

1. Click on the \[Add Label\] button
2. Click on the page, above the map, accept the suggested values in the New Item Properties dialog, and a label will appear at the top of the map.
3. Resize it and place it in the top center of the page. It can be resized and moved in the same way that you resized and moved the map.

   As you move the title, you’ll notice that guidelines appear to help you position the title in the center of the page. However, there is also a tool in the Actions Toolbar to help position the title relative to the map (not the page):

   ![Actions Toolbar]

4. Click the map to select it
5. Hold in Shift on your keyboard and click on the label so that both the map and the label are selected.
6. Look for the \[Align selected items left\] button and click on the dropdown arrow next to it to reveal the positioning options and click \[Align center\]:

![Alignment options]

4.1. Lesson: Using Print Layout 93
Now the label frame is centered on the map, but not the contents. To center the contents of the label:

1. Select the label by clicking on it.
2. Click on the Item Properties tab in the side panel of the layout window.
3. Change the text of the label to „Swellendam“:
4. Use this interface to set the font and alignment options:

5. Choose a large but sensible font (the example will use the default font with a size of 36) and set the Horizontal Alignment to Center.

    You can also change the font color, but it’s probably best to keep it black as per the default.

The default setting is not to add a frame to the title’s text box. However, if you wish to add a frame, you can do so:

1. In the Item Properties tab, scroll down until you see the Frame option.
2. Click the Frame checkbox to enable the frame. You can also change the frame’s color and width.

In this example, we won’t enable the frame, so here is our page so far:

To make sure that you don’t accidentally move these elements around now that you’ve aligned them, you can lock items into place:

- With both the label and map selected, click the Lock Selected Items button in the Actions Toolbar.

Bemerkung: Click the Unlock All Items button in the Actions Toolbar to be able to edit the items again.
4.1.4 Follow Along: Adding a Legend

The map reader also needs to be able to see what various things on the map actually mean. In some cases, like the place names, this is quite obvious. In other cases, it’s more difficult to guess, like the colors of the forests. Let’s add a new legend.

1. Click on this button
2. Click on the page to place the legend, accept the suggested values in the New Item Properties dialog, and then move it to where you want it:

4.1.5 Follow Along: Customizing Legend Items

Not everything on the legend is necessary, so let’s remove some unwanted items.

1. In the Item Properties tab, you’ll find the Legend items panel.
2. Select the entry with buildings (from training_data.gpkg).
3. Delete it from the legend by clicking the button:

You can also rename items.

1. Select a layer from the same list.
2. Click the button.
3. Rename the layers to Places, Roads and Streets, Surface Water, and Rivers.
4. Set landuse to Hidden (right-click to bring up the context menu).

You can also reorder the items:

As the legend will likely be widened by the new layer names, you may wish to move and resize the legend and or map. This is the result:
Kapitel 4. Module: Layout der Karten
4.1.6 Follow Along: Exporting Your Map

**Bemerkung:** Did you remember to save your work often?

Finally the map is ready for export! You'll see the export buttons near the top left corner of the layout window:

- **Print Layout:** interfaces with a printer. Since the printer options will differ depending on the model of printer that you're working with, it's probably better to consult the printer manual or a general guide to printing for more information on this topic.

  The other buttons allow you to export the map page to a file.

- **Export as Image:** gives you a selection of various common image formats to choose from. This is probably the simplest option, but the image it creates is "dead" and difficult to edit.

- **Export as SVG:** If you're sending the map to a cartographer (who may want to edit the map for publication), it's best to export as an SVG. SVG stands for "Scalable Vector Graphic", and can be imported to programs like Inkscape or other vector image editing software.

- **Export as PDF:** If you need to send the map to a client, it's most common to use a PDF, because it's easier to set up printing options for a PDF. Some cartographers may prefer PDF as well, if they have a program that allows them to import and edit this format.

For our purposes, we're going to use PDF.

1. Click the **Export as PDF** button
2. Choose a save location and a file name as usual. The following dialog will show up.
3. You can safely use the default values now and click **Save**.

  QGIS will proceed to the map export and push a message on top of the print layout dialog as soon as it finishes.
4. Click the hyperlink in the message to open the folder in which the PDF has been saved in your system’s file manager.

5. Open it and see how your layout looks. Everything is OK? Congratulations on your first completed QGIS map project!

6. Anything unsatisfying? Go back to the QGIS window, do the appropriate modifications and export again.

7. Remember to save your project file.

4.1.7 In Conclusion

Now you know how to create a basic static map layout. We can go a step further and create a map layout that adapts dynamically, with more layout items.

4.2 Lesson: Creating a Dynamic Print Layout

Now that you have learned to create a basic map layout we go a step further and create a map layout that adapts dynamically to our map extent and to the page properties, e.g. when you change the size of the page. Also, the date of creation will adapt dynamically.

4.2.1 Follow Along: Creating the dynamic map canvas

1. Load the ESRI Shapefile format datasets protected_areas.shp, places.shp, rivers.shp and water.shp into the map canvas and adapt its properties to suit your own convenience.

2. After everything is rendered and symbolized to your liking, click the New Print Layout icon in the toolbar or choose File  New Print Layout. You will be prompted to choose a title for the new print layout.

3. We want to create a map layout consisting of a header and a map of the region near Swellendam, South Africa. The layout should have a margin of 7.5 mm and the header should be 36 mm high.

4. Create a map item called main map on the canvas and go to the Layout panel. Scroll down to the Variables section and find the Layout part. Here we set some variables you can use all over the dynamic print layout. Go to the Layout panel and scroll down to the Variables section. The first variable will define the margin. Press the button and type in the name sw_layout_margin. Set the value to 7.5. Press the button again and type in the name sw_layout_height_header. Set the value to 36.

5. Now you are ready to create the position and the size of the map canvas automatically by means of the variables. Make sure that your map item is selected, go to the Item Properties panel, scroll down to and open the Position and Size section. Click the Data defined override for X and from the Variables entry, choose @sw_layout_margin.

6. Click the Data defined override for Y, choose Edit… and type in the formula:

\[
\text{to\_real}(\text{sw\_layout\_margin}) + \text{to\_real}(\text{sw\_layout\_height\_header})
\]

7. You can create the size of the map item by using the variables for Width and Height. Click the Data defined override for Width and choose Edit … again. Fill in the formula:

\[
\text{layout\_pagewidth} - \text{sw\_layout\_margin} * 2
\]

Click the Data defined override for Height and choose Edit …. Here fill in the formula:
8. We will also create a grid containing the coordinates of the main canvas map extent. Go to Item Properties again and choose the Grids section. Insert a grid by clicking the button. Click on Modify grid … and set the Interval for X, Y and Offset according to the map scale you chose in the QGIS main canvas. The Grid type Cross is very well suited for our purposes.

4.2.2 Follow Along: Creating the dynamic header

1. Insert a rectangle which will contain the header with the Add Shape button. In the Items panel enter the name header.

2. Again, go to the Item Properties and open the Position and Size section. Using Data defined override, choose the sw_layout_margin variable for X as well as for Y. Width shall be defined by the expression:

\[
\text{Width} = \text{@layout_pagewidth} - \text{@sw_layout_margin} \times 2
\]

and Height by the sw_layout_height_header variable.

3. We will insert a horizontal line and two vertical lines to divide the header into different sections using the Add Node Item. Create a horizontal line and two vertical lines and name them Horizontal line, Vertical line 1 Vertical line 2.

1. For the horizontal line:
   1. Set X to the variable sw_layout_margin
   2. Set the expression for Y to:

\[
\text{Y} = \text{sw_layout_margin} + 8
\]

3. Set the expression for Width to:

\[
\text{Width} = \text{@layout_pagewidth} - \text{@sw_layout_margin} \times 3 - 53.5
\]

2. For the first vertical line:
   1. Set the expression for X to:

\[
\text{X} = \text{@layout_pagewidth} - \text{@sw_layout_margin} \times 2 - 53.5
\]

2. Set Y to the variable sw_layout_margin
3. The height must be the same as the header we created, so set Height to the variable sw_layout_height_header.
3. The second vertical line is placed to the left of the first one.
   1. Set the expression for X to:

\[
\text{X} = \text{@layout_pagewidth} - \text{@sw_layout_margin} \times 2 - 83.5
\]

2. Set Y to the variable sw_layout_margin
3. The height shall be the same as the other vertical line, so set Height to the variable sw_layout_height_header.

The figure below shows the structure of our dynamic layout. We will fill the areas created by the lines with some elements.
Follow Along: Creating labels for the dynamic header

1. The title of your QGIS project can be included automatically. The title is set in the Project Properties. Insert a label with the Add Label button and enter the name project title (variable). In the Main Properties of the Items Properties Panel enter the expression:

\[ \%@project\_title\% \]

Set the position of the label.
   1. For X, use the expression:

\[ @sw\_layout\_margin + 3 \]

2. For Y, use the expression:

\[ @sw\_layout\_margin + 0.25 \]

3. For Width, use the expression:

\[ @layout\_pagewidth - @sw\_layout\_margin * 2 - 90 \]

4. Enter 11.25 for Height

Under Appearance set the Font size to 16 pt.

2. The second label will include a description of the map you created. Again, insert a label and name it map description. In the Main Properties enter the text map description. In the Main Properties we will also include:

\[ \% format\_date(now(),'dd.MM.yyyy')\% \]

Here we used two Date and Time functions (now and format_date).

Set the position of the label.
   1. For X, use the expression:
2. For \( Y \), use the expression:
\[
@sw\_layout\_margin + 11.5
\]

3. The third label will include information about your organisation. First we will create some variables in the Variables menu of the Item Properties. Go to the Layout menu, click the \( \text{+} \) button each time and enter the names \( o\_department \), \( o\_name \), \( o\_adress \) and \( o\_postcode \). In the second row enter the information about your organisation. We will use these variables in the Main Properties section.

In Main Properties enter:

\[
[\% o\_name \%]
[\% o\_department \%]
[\% o\_adress \%]
[\% o\_postcode \%]
\]

Set the position of the label.

1. For \( X \), use the expression:
\[
@layout\_pagewidth - @sw\_layout\_margin - 49.5
\]

2. For \( Y \), use the expression:
\[
@sw\_layout\_margin + 15.5
\]

3. For Width, use 49.00

4. For Height, use the expression:
\[
@sw\_layout\_height\_header - 15.5
\]

### 4.2.4 Follow Along: Adding pictures to the dynamic header

1. Use the \( \text{Add Picture} \) button to place a picture above your label organisation information. After entering the name organisation logo define the position and size of the logo:

   1. For \( X \), use the expression:
\[
@layout\_pagewidth - @sw\_layout\_margin \times 2 - 78
\]

   2. For \( Y \), use the expression:
\[
@sw\_layout\_margin + 3.5
\]

   3. For Width, use 39.292

   4. For Height, use 9.583

To include a logo of your organisation you have to save your logo under your home directory and enter the path under Main Properties \( \text{Image Source} \).

2. Our layout still needs a north arrow. This will also be inserted by using \( \text{Add North Arrow} \). We will use the default north arrow. Define the position:

   1. For \( X \), use the expression:
2. For Y, use the expression:

\[ \text{@sw\_layout\_margin} + 9 \]

3. For \textit{Width}, use 21.027

4. For \textit{Height}, use 21.157

### 4.2.5 Follow Along: Creating the scalebar of the dynamic header

1. To insert a scalebar in the header click on \( \text{Add Scale Bar} \) and place it in the rectangle above the north arrow. In \textit{Map} under the \textit{Main Properties} choose your \textit{main map} (\textit{Map 1}). This means that the scale changes automatically according to the extent you choose in the QGIS main canvas. Choose the \textit{Style Numeric}. This means that we insert a simple scale without a scalebar. The scale still needs a position and size.

   1. For \textit{X}, use the expression:

   \[ \text{@layout\_pagewidth} - \text{@sw\_layout\_margin} * 2 - 78 \]

   2. For \textit{Y}, use the expression:

   \[ \text{@sw\_layout\_margin} + 1 \]

   3. For \textit{Width}, use 25

   4. For \textit{Height}, use 8
5. Place the Reference point in the center.

Congratulations! You have created your first dynamic map layout. Take a look at the layout and check if everything looks the way you want it! The dynamic map layout reacts automatically when you change the page properties. For example, if you change the page size from DIN A4 to DIN A3, click the Refresh view button and the page design is adapted.

4.2.6 What’s Next?

On the next page, you will be given an assignment to complete. This will allow you to practice the techniques you have learned so far.

4.3 Zuordnung 1

Open your existing map project and revise it thoroughly. If you have noticed small errors or things you’d have liked to fix earlier, do so now.

While customizing your map, keep asking yourself questions. Is this map easy to read and understand for someone who’s unfamiliar with the data? If I saw this map on the Internet, or on a poster, or in a magazine, would it capture my attention? Would I want to read this map if it wasn’t mine?

If you’re doing this course at a Basic or Intermediate level, read up on techniques from the more advanced sections. If you see something you’d like to do in your map, why not try to implement it?

If this course is being presented to you, the course presenter may require you to submit a final version of your map, exported to PDF, for evaluation. If you’re doing this course by yourself, it’s recommended that you evaluate your own map using the same criteria. Your map will be evaluated on the overall appearance and symbology of the map itself, as well as the appearance and layout of the map page and elements. Remember that the emphasis for evaluating the appearance of maps will always be ease of use. The nicer the map is to look at and the easier it is to understand at a glance, the better.

Happy customizing!
4.3.1 In Conclusion

The first four modules have taught you how to create and style a vector map. In the next four modules, you'll learn how to use QGIS for a complete GIS analysis. This will include creating and editing vector data; analyzing vector data; using and analyzing raster data; and using GIS to solve a problem from start to finish, using both raster and vector data sources.
Die Erstellung von Karten unter Verwendung vorhandener Daten ist nur der Anfang. In diesem Modul lernen Sie, wie Sie bestehende Vektordaten modifizieren und vollständig neue Datensätze erstellen können.

### 5.1 Lesson: Creating a New Vector Dataset

The data that you use has to come from somewhere. For most common applications, the data exists already; but the more particular and specialized the project, the less likely it is that the data will already be available. In such cases, you'll need to create your own new data.

**The goal for this lesson:** To create a new vector dataset.

#### 5.1.1 Follow Along: The Layer Creation Dialog

Before you can add new vector data, you need a vector dataset to add it to. In our case, you'll begin by creating new data entirely, rather than editing an existing dataset. Therefore, you'll need to define your own new dataset first.

1. Open QGIS and create a new blank project.
2. Navigate to and click on the menu entry `Layer ➔ Create Layer ➔ New Shapefile Layer`. You’ll be presented with the `New Shapefile Layer` dialog, which will allow you to define a new layer.
3. Click … for the `File name` field. A save dialog will appear.
4. Navigate to the `exercise_data` directory.
5. Save your new layer as `school_property.shp`.

It's important to decide which kind of dataset you want at this stage. Each different vector layer type is “built differently” in the background, so once you’ve created the layer, you can’t change its type.

For the next exercise, we're going to create new features which describe areas. For such features, you'll need to create a polygon dataset.
6. For `Geometry Type`, select `Polygon` from the drop down menu:

This has no impact on the rest of the dialog, but it will cause the correct type of geometry to be used when the vector dataset is created.
The next field allows you to specify the Coordinate Reference System, or CRS. CRS is a method of associating numerical coordinates with a position on the surface of the Earth. See the User Manual on Working with Projections to learn more.

For this example we will use the default CRS associated with this project, which is WGS84.

```
EPSG:4326 - WGS 84
```

Next there is a collection of fields grouped under New Field. By default, a new layer has only one attribute, the id field (which you should see in the Fields list) below. However, in order for the data you create to be useful, you actually need to say something about the features you’ll be creating in this new layer. For our current purposes, it will be enough to add one field called name that will hold Text data and will be limited to text length of 80 characters.

7. Replicate the setup below, then click the Add to Fields List button:

![New Field Form]

8. Check that your dialog now looks like this:

9. Klicken Sie auf OK

The new layer should appear in your Layers panel.

### 5.1.2 Follow Along: Datenquellen

When you create new data, it obviously has to be about objects that really exist on the ground. Therefore, you’ll need to get your information from somewhere.

There are many different ways to obtain data about objects. For example, you could use a GPS to capture points in the real world, then import the data into QGIS afterwards. Or you could survey points using a theodolite, and enter the coordinates manually to create new features. Or you could use the digitizing process to trace objects from remote sensing data, such as satellite imagery or aerial photography.

For our example, you’ll be using the digitizing approach. Sample raster datasets are provided, so you’ll need to import them as necessary.

1. Click on the DataSourceManager button.
2. Select Raster on the left side.
3. In the Source panel, click on the … button:
4. Navigate to exercise_data/raster/.
5. Select the file 3420C_2010_327_RGB_LATLNG.tif.
6. Click Open to close the dialogue window.
7. Click Add and Close. An image will load into your map.
Kapitel 5. Module: Vektordaten erzeugen

**New Shapefile Layer**

- **File name**: `training-Data-2.0\exercise_data\school_property.shp`
- **File encoding**: UTF-8
- **Geometry type**: Polygon
- **Additional dimensions**: None
- **EPSG**: 4326 - WGS 84

**New Field**

- **Name**
- **Type**: Text data
- **Length**: 80
- **Precision**

**Fields List**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Length</th>
<th>Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>Integer</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>name</td>
<td>String</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>
5.1. Lesson: Creating a New Vector Dataset
Kapitel 5. Module: Vektordaten erzeugen
8. If you don’t see an aerial image appear, select the new layer, right click, and choose **Zoom to Layer** in the context menu.

![QGIS Layers Panel]

9. Click on the **Zoom In** button, and zoom to the area highlighted in blue below:

Now you are ready to digitize these three fields:

Before starting to digitize, let’s move the **school_property** layer above the aerial image.

1. Select **school_property** layer in the **Layers** pane and drag it to the top.

In order to begin digitizing, you’ll need to enter **edit mode**. GIS software commonly requires this to prevent you from accidentally editing or deleting important data. Edit mode is switched on or off individually for each layer.

To enter edit mode for the **school_property** layer:

1. Click on the **school_property** layer in the **Layers** panel to select it.

5.1 Lesson: Creating a New Vector Dataset
5.1. Lesson: Creating a New Vector Dataset
2. Click on the Toggle Editing button.

If you can't find this button, check that the Digitizing toolbar is enabled. There should be a check mark next to the View Toolbars Digitizing menu entry.

As soon as you are in edit mode, you'll see that some digitizing tools have become active:

- Capture Polygon
- Vertex Tool

Other relevant buttons are still inactive, but will become active when we start interacting with our new data.

Notice that the layer school_property in the Layers panel now has the pencil icon, indicating that it is in edit mode.

3. Click on the Capture Polygon button to begin digitizing our school fields.

You'll notice that your mouse cursor has become a crosshair. This allows you to more accurately place the points you'll be digitizing. Remember that even when you're using the digitizing tool, you can zoom in and out on your map by rolling the mouse wheel, and you can pan around by holding down the mouse wheel and dragging around in the map.

The first feature you’ll be digitizing is the athletics field:

4. Start digitizing by clicking on a point somewhere along the edge of the field.
5. Place more points by clicking further along the edge, until the shape you’re drawing completely covers the field.
6. After placing your last point, right click to finish drawing the polygon. This will finalize the feature and show you the Attributes dialog.
7. Fill in the values as below:
8. Click OK, and you have created a new feature!
9. In the Layers panel select the school_property layer.
10. Right click and choose Open Attribute Table in the context menu.

In the table you will see the feature you just added. While in edit mode you can update the attributes data by double click on the cell you want to update.

11. Close the attribute table.
12. To save the new feature we just created, click on Save Edits button.

Remember, if you’ve made a mistake while digitizing a feature, you can always edit it after you’re done creating it. If you’ve made a mistake, continue digitizing until you’re done creating the feature as above. Then:
5.1. Lesson: Creating a New Vector Dataset
5.1. Lesson: Creating a New Vector Dataset
1. Click on the Vertex Tool button.
2. Hover the mouse over a vertex you want to move and left click on the vertex.
3. Move the mouse to the correct location of the vertex, and left click. This will move the vertex to the new location.
   The same procedure can be used to move a line segment, but you will need to hover over the midpoint of the line segment.

If you want to undo a change, you can press the Undo button or Ctrl+Z.

Remember to save your changes by clicking the Save Edits button.

To enable the remaining feature editing tools, one needs to select the feature.

1. Click on the Select Features button in the Attributes Toolbar.
2. Click on the feature that was just created and the remaining buttons will become enabled.
   See User Manual for description of the other buttons in this toolbar.
3. When done editing, click the Toggle Editing button to get out of edit mode, and save your edits.

5.1.3 Try Yourself: Digitizing Polygons

Digitize the school itself and the upper field. Use this image to assist you:

Remember that each new feature needs to have a unique id value!

Bemerkung: When you’re done adding features to a layer, remember to save your edits and then exit edit mode.

Bemerkung: You can style the fill, outline and label placement and formatting of the school_property using techniques learnt in earlier lessons.
5.1. Lesson: Creating a New Vector Dataset
### 5.1.4 Follow Along: Using Vertex Editor Table

Another way to edit a feature is to manually enter the actual coordinate values for each vertex using the **Vertex Editor** table.

1. Make sure you are in edit mode on layer `school_property`.

2. If not already activated, click on the **Vertex Tool** button.

3. Move the mouse over one of the polygon features you created in the `school_property` layer and right click on it. This will select the feature and a **Vertex Editor** pane will appear.

![Vertex Editor Table](image)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20.4456</td>
<td>-34.0225</td>
</tr>
<tr>
<td>1</td>
<td>20.4456</td>
<td>-34.0238</td>
</tr>
<tr>
<td>2</td>
<td>20.4457</td>
<td>-34.0251</td>
</tr>
<tr>
<td>3</td>
<td>20.4453</td>
<td>-34.0247</td>
</tr>
<tr>
<td>4</td>
<td>20.4450</td>
<td>-34.0250</td>
</tr>
<tr>
<td>5</td>
<td>20.4441</td>
<td>-34.0241</td>
</tr>
<tr>
<td>6</td>
<td>20.4456</td>
<td>-34.0225</td>
</tr>
</tbody>
</table>

**Bemerkung:** This table contains the coordinates for the vertices of the feature. Notice there are seven vertices for this feature, but only six are visually identified in the map area. Upon closer inspection, one will notice that row 0 and 6 have identical coordinates. These are the start and end vertices of the feature geometry, and are required in order to create a closed polygon feature.

4. Click and drag a box over a vertex, or multiple vertices, of the selected feature.

   The selected vertices will change to a color blue and the **Vertex Editor** table will have the corresponding rows highlighted, which contain the coordinates of the vertices.

5. To update a coordinate, double left click on the cell in the table that you want to edit and enter the updated value. In this example, the x coordinate of row 4 is updated from `20.4450` to `20.4444`.

6. After entering the updated value, hit the enter key to apply the change. You will see the vertex move to the new location in the map window.

7. When done editing, click the **Toggle Editing** button to get out of edit mode, and save your edits.
Kapitel 5. Module: Vektordaten erzeugen
5.1.5 Try Yourself: Digitizing Lines

We are going to digitize two routes which are not already marked on the roads layer; one is a path, the other is a track. Our path runs along the southern edge of the suburb of Railton, starting and ending at marked roads:

Our track is a little further to the south:

1. Create a new ESRI Shapefile line dataset called `routes.shp`, with attributes `id` and `type` (use the approach above to guide you.)

2. If the roads layer is not in your map, then add it from the GeoPackage file `training-data.gpkg` included in the `exercise_data` folder of the training data you downloaded.

3. Activate edit mode.

4. Since you are working with a line feature, click on the `Add Line` button to initiate line digitizing mode.

5. One at a time, digitize the path and the track on the `routes` layer. Try to follow the routes as accurately as possible, adding additional points along corners or turns.

6. Set the `type` attribute value to `path` or `track`.

7. Use the `Layer Properties` dialog to add styling to your routes. Feel free to use different styles for paths and tracks.

8. Save your edits and toggle off editing mode by pressing the `Toggle Editing` button.

*Check your results*
5.1. Lesson: Creating a New Vector Dataset
5.1.6 In Conclusion

Now you know how to create features! This course doesn't cover adding point features, because that's not really necessary once you've worked with more complicated features (lines and polygons). It works exactly the same, except that you only click once where you want the point to be, give it attributes as usual, and then the feature is created.

Knowing how to digitize is important because it's a very common activity in GIS programs.

5.1.7 What's Next?

Features in a GIS layer aren't just pictures, but objects in space. For example, adjacent polygons know where they are in relation to one another. This is called topology. In the next lesson you'll see an example of why this can be useful.

5.2 Lesson: Funktionstopologie

Topology is a useful aspect of vector data layers, because it minimizes errors such as overlap or gaps.

For example: if two features share a border, and you edit the border using topology, then you won't need to edit first one feature, then another, and carefully line up the borders so that they match. Instead, you can edit their shared border and both features will change at the same time.

The goal for this lesson: To understand topology using examples.

5.2.1 Follow Along: Snapping

Snapping makes topological editing easier. This will allow your mouse cursor to snap to other objects while you digitize. To set snapping options:

1. Navigate to the menu entry Project ➤ Snapping Options….

2. Set up your Snapping options dialog to activate the landuse layer with Type vertex and tolerance 12 pixels:

3. Make sure that the box in the Avoid overlap column is checked.

4. Leave the dialog.

5. Select the landuse layer and enter edit mode (_pen)

6. Check (under View ➤ Toolbars) that the Advanced Digitizing toolbar is enabled.

7. Zoom to this area (enable layers and labels if necessary):

8. Digitize this new (fictional) area:
5.2. Lesson: Funktionstopologie
9. When prompted, give it an OGC_FID of 999, but feel free to leave the other values unchanged.

If you are careful while digitizing, and allow the cursor to snap to the vertices of adjoining areas, you'll notice that there won't be any gaps between your new area and the existing adjacent areas.

10. Note the undo and redo tools in the Advanced Digitizing toolbar.

5.2.2 Follow Along: Correct Topological Features

Topology features can sometimes need to be updated. In our study area, an area has been turned into forest, so the landuse layer need an update. We will therefore expand and join some forest features in this area:

Instead of creating new polygons to join the forest areas, we are going to use the Vertex Tool to edit and join existing polygons.

1. Enter edit mode (if it is not active already)

2. Select the Vertex Tool tool.

3. Choose an area of forest, select a vertex, and move it to an adjoining vertex so that the two forest features meet.

4. Click on the other vertices and snap them into place.

The topologically correct border looks like this:

Go ahead and join a few more areas using the Vertex Tool.

You can also use the Add Polygon Feature tool to fill the gap between the two forest polygons. If you have enabled Avoid overlap, you don’t have to add every single vertex - they will be added automatically if your new polygon overlaps the existing ones.

If you are using our example data, you should have a forest area looking something like this:
5.2. Lesson: Funktionstopologie
Don’t worry if you have joined more, less or different areas of forest.

### 5.2.3 Follow Along: Tool: Simplify Feature

Continuing on the same layer, we will test the Simplify Feature tool:

1. Click on it to activate it.
2. Click on one of the areas which you joined using either the Vertex Tool or Add Feature tool. You will see this dialog:
3. Modify the Tolerance and watch what happens:
   
   This allows you to reduce the number of vertices.
4. Klicken Sie auf OK

The advantage of this tool is that it provides you with a simple and intuitive interface for generalization. But notice what the tool ruins topology. The simplified polygon no longer shares boundaries with its adjacent polygons, as it should. So this tool is better suited for stand-alone features.

Before you go on, set the polygon back to its original state by undoing the last change.
5.2. Lesson: Funktionstopologie
### 5.2.4  Try Yourself Tool: Add Ring

The **Add Ring** tool allows you to add an interior ring to a polygon feature (cut a hole in the polygon), as long as the hole is completely contained within the polygon (touching the boundary is OK). For example, if you have digitized the outer boundaries of South Africa and you need to add a hole for Lesotho, you would use this tool.

If you experiment with the tool, you may notice that the snapping options can prevent you from creating a ring inside a polygon. So you are advised to turn off snapping before cutting a hole.

1. Disable snapping for the *landuse* layer using the **Enable Snapping** button (or use the shortcut `s`).
2. Use the **Add Ring** tool to create a hole in the middle of a polygon geometry.
3. Draw a polygon over the target feature, as if you were using the **Add polygon** tool.
4. When you right-click, the hole will be visible.
5. Remove the hole you just created using the **Delete Ring** tool.

**Bemerkung:** Click inside the hole to delete it.

---

### Check your results

---

### 5.2.5  Try Yourself Tool: Add Part

The **Add Part** tool allows you to add a new part to a feature, that is not directly connected to the main feature. For example, if you have digitized the boundaries of mainland South Africa, but you haven’t yet added the Prince Edward Islands, you would use this tool to create them.

1. Select the polygon to which you wish to add the part by using the **Select Features by area or single click** tool.
2. Use the **Add Part** tool to add an outlying area.
3. Delete the part you just created using the **Delete Part** tool.

**Bemerkung:** Click inside the part to delete it.

---

### Check your results

---

### 5.2.6  Follow Along: Tool: Reshape Features

The **Reshape Features** tool is used to extend a polygon feature or cut away a part of it (along the boundary).

**Extending:**

1. Select the polygon using the **Select Features by area or single click** tool.
2. Left-click inside the polygon to start drawing.
3. Draw a shape outside the polygon. The last vertex should be back inside the polygon.
4. Right-click to finish the shape:

![Image of QGIS interface with polygon and snapping tool highlighted]

This will give a result similar to:

Cut away a part:

1. Select the polygon using the \[\text{Select Features by area or single click}\] tool.
2. Click outside the polygon.
3. Draw a shape inside the polygon. The last vertex must be back outside the polygon.
4. Right-click outside the polygon:
   The result of the above:

5.2.7 Try Yourself Tool: Split Features

The \[\text{Split Features}\] tool is similar to the \[\text{Reshape Features}\] tool, except that it does not delete either of the two parts. Instead, it keeps them both.

We will use the tool to split a corner from a polygon.

1. First, select the landuse layer and re-enable snapping for it.
2. Select the \[\text{Split Features}\] tool and click on a vertex to begin drawing a line.
3. Draw the bounding line.
4. Click a vertex on the „opposite“ side of the polygon you wish to split and right-click to complete the line:
5. At this point, it may seem as if nothing has happened. But remember that the landuse layer is rendered without border lines, so the new division line will not be shown.
6. Use the \[\text{Select Features by area or single click}\] tool to select the part you just split out; the new feature will now be highlighted:
5.2.8 Try Yourself Tool: Merge Features

Now we will re-join the feature you just split out to the remaining part of the polygon:

1. Experiment with the Merge Selected Features and Merge Attributes of Selected Features tools.
2. Note the differences.

*Check your results*

5.2.9 In Conclusion

Topology editing is a powerful tool that allows you to create and modify objects quickly and easily, while ensuring that they remain topologically correct.
5.2.10 What’s Next?

Now you know how to digitize the shape of the objects easily, but adding attributes is still a bit of a headache! Next we will show you how to use forms, making attribute editing simpler and more effective.

5.3 Lesson: Formulare

When you add new data via digitizing, you’re presented with a dialog that lets you fill in the attributes for that feature. However, this dialog is not, by default, very nice to look at. This can cause a usability problem, especially if you have large datasets to create, or if you want other people to help you digitize and they find the default forms to be confusing. Fortunately, QGIS lets you create your own custom dialogs for a layer. This lesson shows you how.

**The goal for this lesson:** To create a form for a layer.

5.3.1 **Follow Along: Using QGIS’ Form Design Functionality**

1. Select the *roads* layer in the **Layers** panel
2. Enter **Edit Mode** as before
3. Open the *roads* layer’s attribute table
4. Right-click on any cell in the table. A short menu will appear, that includes the **Open form** entry.
5. Click on it to see the form that QGIS generates for this layer

Obviously it would be nice to be able to do this while looking at the map, rather than needing to search for a specific street in the **Attribute Table** all the time.

1. Select the *roads* layer in the **Layers** panel
2. Using the **Identify Features** tool, click on any street in the map.
3. The *Identify Results* panel opens and shows a tree view of the fields values and other general information about the clicked feature.

4. At the top of the panel, check the *Auto open form for single feature results* checkbox in the *Identify Settings* menu.

5. Now, click again on any street in the map. Along the previous *Identify Results* dialog, you’ll see the now-familiar form:

![Identify Results Panel](image)

6. Each time you click on a single feature with the *Identify* tool, its form pops up as long as the *Auto open form* is checked.

### 5.3.2 Try Yourself Using the Form to Edit Values

If you are in edit mode, you can use this form to edit a feature’s attributes.

1. Activate edit mode (if it isn’t already activated).

2. Using the *Identify Features* tool, click on the main street running through Swellendam:

3. Edit its *highway* value to be *secondary*

4. Exit edit mode and save your edits

5. Open the *Attribute Table* and note that the value has been updated in the attributes table and therefore in the source data
5.3.3 Follow Along: Setting Form Field Types

It’s nice to edit things using a form, but you still have to enter everything by hand. Fortunately, forms have different kinds of so-called widgets that allow you to edit data in various different ways.

1. Open the roads layer’s Properties…
2. Switch to the Fields tab. You’ll see this:
3. Switch to the Attributes Form tab. You’ll see this:
4. Click on the oneway row and choose Checkbox as Widget Type in the list of options:
5. Klicken Sie auf OK
6. Enter edit mode (if the roads layer is not already in edit mode)
7. Click on the Identify Features tool
8. Click on the same main road you chose earlier

You will now see that the oneway attribute has a checkbox next to it denoting True (checked) or False (unchecked).
5.3.4 Try Yourself

Set a more appropriate form widget for the highway field.

Check your results

5.3.5 Try Yourself Creating Test Data

You can also design your own custom form completely from scratch.

1. Create a simple point layer named test-data with two attributes:
   • name (text)
   • age (text)

2. Capture a few points on your new layer using the digitizing tools so that you have a little data to play with. You should be presented with the default QGIS generated attribute capture form each time you capture a new point.

   Bemerkung: You may need to disable Snapping if still enabled from earlier tasks.
5.3.6 Follow Along: Creating a New Form

Now we want to create our own custom form for the attribute data capture phase. To do this, you need to have QT Designer installed (only needed for the person who creates the forms).

1. Start QT Designer.

2. In the dialog that appears, create a new dialog:

3. Look for the Widget Box along the left of your screen (default). It contains an item called Line Edit.

4. Click and drag this item into your form. This creates a new Line Edit in the form.

5. With the new line edit element selected, you'll see its properties along the side of your screen (on the right by default):

6. Set its name to Name.
Kapitel 5. Module: Vektordaten erzeugen
7. Using the same approach, create a new spinbox and set its name to Age.

8. Add a Label with the text Add a New Person in a bold font (look in the object properties to find out how to set this). Alternatively, you may want to set the title of the dialog itself (rather than adding a label).

9. Click anywhere in your dialog.

10. Find the Lay Out Vertically button (in a toolbar along the top edge of the screen, by default). This lays out your dialog automatically.

11. Set the dialog’s maximum size (in its properties) to 200 (width) by 100 (height).

12. Save your new form as exercise_data/forms/add_people.ui

13. When it’s done saving, you can close Qt Designer

5.3.7 Follow Along: Associating the Form with Your Layer

1. Go back to QGIS

2. Double click the test-data layer in the legend to access its properties.

3. Click on the Attributes Form tab in the Layer Properties dialog

4. In the Attribute editor layout dropdown, select Provide ui-file.

5. Click the ellipsis button and choose the add_people.ui file you just created:

6. Click OK on the Layer Properties dialog

7. Enter edit mode and capture a new point
8. When you do so, you will be presented with your custom dialog (instead of the generic one that QGIS usually creates).

9. If you click on one of your points using the Identify Features tool, you can now bring up the form by right clicking in the identify results window and choosing View Feature Form from the context menu.

10. If you are in edit mode for this layer, that context menu will show Edit Feature Form instead, and you can then adjust the attributes in the new form even after initial capture.

5.3.8 In Conclusion

Using forms, you can make life easier for yourself when editing or creating data. By editing widget types or creating an entirely new form from scratch, you can control the experience of someone who digitizes new data for that layer, thereby minimizing misunderstandings and unnecessary errors.

5.3.9 Further Reading

If you completed the advanced section above and have knowledge of Python, you may want to check out this blog entry about creating custom feature forms with Python logic, which allows advanced functions including data validation, autocompletion, etc.

5.3.10 What’s Next?

Opening a form on identifying a feature is one of the standard actions that QGIS can perform. However, you can also direct it to perform custom actions that you define. This is the subject of the next lesson.

5.4 Lesson: Aktionen

Now that you have seen a default action in the previous lesson, it is time to define your own actions.

An action is something that happens when you click on a feature. It can add a lot of extra functionality to your map, allowing you to retrieve additional information about an object, for example. Assigning actions can add a whole new dimension to your map!

The goal for this lesson: To learn how to add custom actions.

In this lesson you will use the school_property layer you created previously. The sample data include photos of each of the three properties you digitized. What we are going to do is to associate each property with its image. Then we will create an action that will open the image for a property when clicking on the property.

5.4.1 Follow Along: Add a Field for Images

The school_property layer has no way to associate an image with a property yet. First we will create a field for this purpose.

1. Open the Layer Properties dialog.
2. Click on the Fields tab.
3. Toggle editing mode:
4. Add a new column:
5. Enter the values below:
6. After the field has been created, move to the Attributes Form tab and select the image field.
5.4. Lesson: Aktionen
7. Set Widget Type to Attachment:

8. Click OK in the Layer Properties dialog.

9. Use the Identify tool to click on one of the three features in the school_property layer. Since you are still in edit mode, the dialog should be active and look like this:

10. Click on the browse button (the … next to the image field).

11. Select the path for your image. The images are in exercise_data/school_property_photos/ and are named the same as the features they should be associated with.

12. Click OK.

13. Associate all of the images with the correct features using this method.

14. Save your edits and exit edit mode.

5.4.2 Follow Along: Creating an Action

1. Open the Actions tab for the school_property layer, and click on the Add a new action button.

2. In the Add New Action dialog, enter the words Show Image into the Description field:

   What to do next varies according to your operating system, so choose the appropriate course to follow:
   
   - Windows
     
     Click on the Type dropdown and choose Open.
5.4. Lesson: Aktionen
The action text defines what happens if the action is triggered. The content depends on the type.

For the type *Python* the content should be python code.
For other types it should be a file or application with optional parameters.

Execute if notification matches

Enable only when editable
• Ubuntu Linux
  Under *Action*, write `eog` for the *Gnome Image Viewer*, or write `display` to use *ImageMagick*. Remember to put a space after the command!

• MacOS
  1. Click on the *Type* dropdown and choose *Mac*.
  2. Under *Action*, write `open`. Remember to put a space after the command!

Now you can continue writing the command.

You want to open the image, and QGIS knows where the image is. All it needs to do is to tell the *Action* where the image is.

3. Select *image* from the list:

4. Click the *Insert field* button. QGIS will add the phrase `% "image" %` in the *Action Text* field.

5. Click the *OK* button to close the *Add New Action* dialog

6. Click *OK* to close the *Layer Properties* dialog

Now it is time to test the new action:

1. Click on the *school_property* layer in the *Layers* panel so that it is highlighted.

2. Find the button (in the *Attributes Toolbar*).

3. Click on the down arrow to the right of this button. There is only one action defined for this layer so far, which is the one you just created.

4. Click the button itself to activate the tool.

5. Using this tool, click on any of the three school properties.
   The image for that property should open.

### 5.4.3 Follow Along: Searching the Internet

Let’s say we are looking at the map and want to know more about the area that a farm is in. Suppose you know nothing of the area in question and want to find general information about it. Your first impulse, considering that you’re using a computer right now, would probably be to Google the name of the area. So let’s tell QGIS to do that automatically for us!

1. Open the attribute table for the *landuse* layer.
   We will be using the *name* field for each of our landuse areas to search Google.

2. Close the attribute table.

3. Go back to *Actions* in *Layer Properties*.

4. Click on the *Create Default Actions* button to add a number of pre-defined actions.

5. Remove all the actions but the *Open URL* action with the short name *Search Web* using the *Remove the selected action* button below.

6. Double-click on the remaining action to edit it

7. Change the *Description* to *Google Search*, and remove the content of the *Short Name* field.

8. Make sure that *Canvas* is among the checked *Action scopes*.

   What to do next varies according to your operating system, so choose the appropriate course to follow:
The action text defines what happens if the action is triggered. The content depends on the type. For the type *Python* the content should be python code. For other types it should be a file or application with optional parameters.
• Windows
  Under Type, choose Open. This will tell Windows to open an Internet address in your default browser, such as Internet Explorer.

• Ubuntu Linux
  Under Action, write xdg-open. This will tell Ubuntu to open an Internet address in your default browser, such as Chrome or Firefox.

• MacOS
  Under Action, write open. This will tell MacOS to open an Internet address in your default browser, such as Safari.

Now you can continue writing the command

Whichever command you used above, you need to tell it which Internet address to open next. You want it to visit Google, and to search for a phrase automatically.

Usually when you use Google, you enter your search phrase into the Google Search bar. But in this case, you want your computer to do this for you. The way you tell Google to search for something (if you don’t want to use its search bar directly) is by giving your Internet browser the address https://www.google.com/search?q=SEARCH_PHRASE, where SEARCH_PHRASE is what you want to search for. Since we don’t know what phrase to search for yet, we will just enter the first part (without the search phrase).

9. In the Action field, write https://www.google.com/search?q=. Remember to add a space after your initial command before writing this in!

Now you want QGIS to tell the browser to tell Google to search for the value of name for any feature that you could click on.

10. Select the name field.

11. Click Insert button:

  What this means is that QGIS is going to open the browser and send it to the address https://www.google.com/search?q=% "name" %. [% "name" %] tells QGIS to use the contents of the name field as the phrase to search for.

  So if, for example, the landuse area you click on is named Marloth Nature Reserve, QGIS is going to send the browser to https://www.google.com/search?q=Marloth%20Nature%20Reserve, which will cause your browser to visit Google, which will in turn search for „Marloth Nature Reserve“.

12. If you have not done so already, set everything up as explained above.

13. Click the OK button to close the Add New Action dialog

14. Click OK to close the Layer Properties dialog

Now to test the new action.

1. With the landuse layer active in the Layers panel, click on the down arrow to the right of the button, and select the only action (Google Search) defined for this layer.

2. Click on any landuse area you can see on the map. Your browser will now open, and will start a Google search for the place that is recorded as that area’s name value.

**Bemerkung:** If your action doesn’t work, check that everything was entered correctly; typos are common with this kind of work!
Edit Action

**Type**: Generic  
**Capture output**: 

**Description**: Google Search

**Short Name**: Leave empty to use only icon

**Icon**: 

**Action Scopes**
- [ ] Field Scope
- [ ] Layer Scope
- [x] Canvas
- [ ] Feature Scope

**Action Text**

The action text defines what happens if the action is triggered. The content depends on the type. For the type **Python** the content should be python code. For other types it should be a file or application with optional parameters.

```bash
xdg-open http://www.google.com/search?q=%name%
```

**Execute if notification matches**: 

**Enable only when editable**: 

[Help]  [Cancel]  [OK]
5.4.4 Follow Along: Open a Webpage Directly in QGIS

Above, you’ve seen how to open a webpage in an external browser. There are some shortcomings with this approach in that it adds an unknowable dependency – will the end-user have the software required to execute the action on their system? As you’ve seen, they don’t necessarily even have the same kind of base command for the same kind of action, if you don’t know which OS they will be using. With some OS versions, the above commands to open the browser might not work at all. This could be an insurmountable problem.

However, QGIS sits on top of the incredibly powerful and versatile Qt library. Also, QGIS actions can be arbitrary, tokenized (i.e. using variable information based on the contents of a field attribute) Python commands!

Now you will see how to use a python action to show a web page. It is the same general idea as opening a site in an external browser, but it requires no browser on the user’s system since it uses the Qt QWebView class (which is a webkit based html widget) to display the content in a pop-up window.

Let us use Wikipedia this time. So the URL you request will look like this:

https://wikipedia.org/wiki/SEARCH_PHRASE

To create the layer action:

1. Open the Layer Properties dialog and head over to the Actions tab.
2. Set up a new action using the following properties for the action:
   - Type: Python
   - Description: Wikipedia
   - Action Text (all on one line):

```python
from qgis.PyQt.QtCore import QUrl; from qgis.PyQt.QtWebKitWidgets import QWebView; myWV = QWebView(None); myWV.load(QUrl('https://wikipedia.org/wiki/%[name%]')); myWV.show()
```

There are a couple of things going on here:

- All the python code is in a single line with semi-colons separating commands (instead of newlines, the usual way of separating Python commands).
- [%name%] will be replaced by the actual attribute value when the action is invoked (as before).
• The code simply creates a new QWebView instance, sets its URL, and then calls `show()` on it to make it visible as a window on the user’s desktop.

Note that this is a somewhat contrived example. Python works with semantically significant indentation, so separating things with semicolons isn’t the best way to write it. So, in the real world, you’d be more likely to import your logic from a Python module and then call a function with a field attribute as parameter.

You could also use this approach to display an image without requiring that the users have a particular image viewer on their system.

3. Try to use the methods described above to load a Wikipedia page using the Wikipedia action you just created.

5.4.5 In Conclusion

Actions allow you to give your map extra functionality, useful to the end-user who views the same map in QGIS. Due to the fact that you can use shell commands for any operating system, as well as Python, the sky is the limit in terms of the functions you could incorporate!

5.4.6 What’s Next?

Now that you’ve done all kinds of vector data creation, you will learn how to analyze the data to solve problems. That is the topic of the next module.
Nun, da Sie einige Funktionen bearbeitet haben, sollten Sie wissen, was man sonst mit ihnen machen kann. Kennen Sie mitAttributen zu besitzen, ist nett, aber am Ende sagt das nichts anderes aus als eine normale Nicht-GIS-Karte.

Der Hauptvorteil eines GIS ist: *Ein GIS kann Fragen beantworten.*

Für die nächsten drei Module werden wir uns bemühen, eine *Forschungsfrage* mit der Hilfe von GIS-Funktionen zu beantworten. Zum Beispiel sind Sie ein Makler und Sie sind auf der Suche nach einer Wohnimmobilie in |major-UrbanName| Für Kunden mit folgenden Kriterien:

1. Sie muss sich in Swellendam befinden.
2. Sie muss innerhalb einer vernünftigen Fahrstrecke einer Schule (ca. 1km) liegen.
3. Sie muss größer als 100m² sein.
4. Näher als 50m an einer Hauptstraße.
5. Näher als 500m an einem Restaurant.

Innerhalb der nächsten Module werden wir die Leistung von GIS-Analyse-Tools nutzen, um geeignete Flächeneigenschaften für diese neue Wohnsiedlung zu lokalisieren.

### 6.1 Lesson: Reprojecting and Transforming Data

Let us talk about Coordinate Reference Systems (CRSs) again. We have touched on this briefly before, but haven’t discussed what it means practically.

**The goal for this lesson:** To reproject and transform vector datasets.
6.1.1 Follow Along: Projections

The CRS that all the data, as well as the map itself are in right now is called WGS84. This is a very common Geographic Coordinate System (GCS) for representing data. But there’s a problem, as we will see.

1. Save your current map
2. Then open the map of the world which you will find under exercise_data/world/world.qgs
3. Zoom in to South Africa by using the Zoom In tool
4. Try setting a scale in the Scale field, which is in the Statusbar along the bottom of the screen. While over South Africa, set this value to $1:5\,000\,000$ (one to five million).
5. Pan around the map while keeping an eye on the Scale field

Notice the scale changing? That’s because you are moving away from the one point that you zoomed into at $1:5\,000\,000$, which was at the center of your screen. All around that point, the scale is different.

To understand why, think about a globe of the Earth. It has lines running along it from North to South. These longitude lines are far apart at the equator, but they meet at the poles.

In a GCS, you are working on this sphere, but your screen is flat. When you try to represent the sphere on a flat surface, distortion occurs, similar to what would happen if you cut open a tennis ball and tried to flatten it out. What this means on a map is that the longitude lines stay equally far apart from each other, even at the poles (where they are supposed to meet). This means that, as you travel away from the equator on your map, the scale of the objects that you see gets larger and larger. What this means for us, practically, is that there is no constant scale on our map!

To solve this, let’s use a Projected Coordinate System (PCS) instead. A PCS „projects“ or converts the data in a way that makes allowance for the scale change and corrects it. Therefore, to keep the scale constant, we should reproject our data to use a PCS.

6.1.2 Follow Along: „On the Fly“ Reprojection

By default, QGIS reprojects data „on the fly“. What this means is that even if the data itself is in another CRS, QGIS can project it as if it were in a CRS of your choice.

You can change the CRS of the project by clicking on the Current projection button in the bottom right corner of QGIS.

1. In the dialog that appears, type the word global into the Filter field. A few CRSs should appear in the Predefined Reference Systems field below.
2. Select WGS 84 / NSIDC EASE-Grid 2.0 Global | EPSG:6933 entry by clicking on it, and then click OK.
3. Zoom to a scale of $1:5\,000\,000$ again, as before.
4. Pan around the map.

Notice how the scale stays the same!

„On the fly“ reprojection is also used for combining datasets that are in different CRSs.

1. Add another vector layer to your map which has the data for South Africa only. You will find it as exercise_data/world/RSA.shp.
2. Load it. A quick way to see its CRS is by hovering the mouse over the layer in the legend. It is EPSG:3410. What do you notice?

The layer is visible even if it has a different CRS from the continents one.
6.1.3 Follow Along: Saving a Dataset to Another CRS

Sometimes you need to export an existing dataset with another CRS. As we will see in the next lesson, if you need to make distance calculations on layer, it is always better to have the layer in a projected coordinate system.

Be aware that the 'on the fly' reprojection is related to the project and not to single layers. This means that a layer can have a different CRS from the project even if you see it in the correct position.

You can easily export the layer with another CRS.

1. Add the buildings dataset from training_data.gpkg
2. Right-click on the buildings layer in the Layers panel
3. Select Export / Save Features As… in the menu that appears. You will be shown the Save Vector Layer as… dialog.
4. Click on the Browse button next to the File name field
5. Navigate to exercise_data/ and specify the name of the new layer as buildings_reprojected.shp.
6. Change the value of the CRS. Only the recent CRSs used will be shown in the drop-down menu. Click on the Select projection button next to the drop-down menu.
7. The Coordinate Reference System Selector dialog will appear. In its Filter field, search for 34S.
8. Select WGS 84 / UTM zone 34S | EPSG:32734 from the list
9. Leave the other options unchanged. The Save Vector Layer as… dialog now looks like this:
10. Klicken Sie auf OK

You can now compare the old and new projections of the layer and see that they are in two different CRS but they are still overlapping.

6.1.4 Follow Along: Creating Your Own Projection

There are many more projections than just those included in QGIS by default. You can also create your own projections.

1. Start a new map
2. Load the world/oceans.shp dataset
3. Go to Settings † Custom Projections… and you will see this dialog.
4. Click on the † Add new CRS button to create a new projection
5. An interesting projection to use is called Van der Grinten I. Enter its name in the Name field. This projection represents the Earth on a circular field instead of a rectangular one, as most other projections do.
6. Add the following string in the Parameters field:

   `*proj=vandg +lon_0=0 +x_0=0 +y_0=0 +R_A+a=6371000 +b=6371000 +units=m +no_def`n

7. Klicken Sie auf OK
8. Click on the † Current CRS button to change the project CRS
9. Choose your newly defined projection (search for its name in the Filter field)
10. On applying this projection, the map will be reprojected thus:
Select the coordinate reference system for the vector file. The data points will be transformed from the layer coordinate reference system.

Filter: 34S

Recently used coordinate reference systems

<table>
<thead>
<tr>
<th>Coordinate Reference System</th>
<th>Authority ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>WGS 84 / UTM zone 34S</td>
<td>EPSG:32734</td>
</tr>
</tbody>
</table>

Coordinate reference systems of the world

<table>
<thead>
<tr>
<th>Coordinate Reference System</th>
<th>Authority ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGRDC 2005 / UTM zone 34S</td>
<td>EPSG:4062</td>
</tr>
<tr>
<td>WGS 72 / UTM zone 34S</td>
<td>EPSG:32334</td>
</tr>
<tr>
<td>WGS 72BE / UTM zone 34S</td>
<td>EPSG:32534</td>
</tr>
</tbody>
</table>

Selected CRS: WGS 84 / UTM zone 34S

Extent: 18.00. -80.00. 24.00. 0.00
Proj4: +proj=utm +zone=34 +south +datum=WGS84 +units=m +no_defs

Help Cancel OK
Save Vector Layer as...

- **Format**: ESRI Shapefile
- **File name**: ome/matteo/exercise_data/exercise_data/buildings_reprojected.shp
- **Layer name**: [Blank]
- **CRS**: EPSG:32734 - WGS 84 / UTM zone 34S

**Encoding**: UTF-8

- Save only selected features
- Add saved file to map

**Select fields to export and their export options**

**Geometry**

- Geometry type: Automatic
- Force multi-type
- Include z-dimension

**Extent (current: layer)**

**Layer Options**

**Custom Options**
Custom Coordinate Reference System Definition

Define

You can define your own custom Coordinate Reference System (CRS) here. The definition must conform to the proj4 format for specifying a CRS.

Name | Parameters
--- | ---

Name

Parameters

Test

Use the text boxes below to test the CRS definition you are creating. Enter a coordinate where both the lat/long and the transformed result are known (for example by reading off a map). Then press the calculate button to see if the CRS definition you are creating is accurate.

Geographic / WGS84 | Destination CRS
--- | ---
North
East

Calculate

Help | Cancel | OK
6.1. Lesson: Reprojecting and Transforming Data
6.1.5 In Conclusion

Different projections are useful for different purposes. By choosing the correct projection, you can ensure that the features on your map are being represented accurately.

6.1.6 Further Reading

Materials for the Advanced section of this lesson were taken from this article. Further information on Coordinate Reference Systems is available here.

6.1.7 What’s Next?

In the next lesson you will learn how to analyze vector data using QGIS’ various vector analysis tools.

6.2 Lesson: Vector Analysis

Vector data can also be analyzed to reveal how different features interact with each other in space. There are many different analysis-related functions, so we won't go through them all. Rather, we will pose a question and try to solve it using the tools that QGIS provides.

The goal for this lesson: To ask a question and solve it using analysis tools.
6.2.1 The GIS Process

Before we start, it would be useful to give a brief overview of a process that can be used to solve a problem. The way to go about it is:

1. State the Problem
2. Get the Data
3. Analyze the Problem
4. Present the Results

6.2.2 The Problem

Let’s start off the process by deciding on a problem to solve. For example, you are an estate agent and you are looking for a residential property in Swellendam for clients who have the following criteria:

1. It needs to be in Swellendam
2. It must be within reasonable driving distance of a school (say 1km)
3. It must be more than 100m squared in size
4. Closer than 50m to a main road
5. Closer than 500m to a restaurant

6.2.3 The Data

To answer these questions, we are going to need the following data:

1. The residential properties (buildings) in the area
2. The roads in and around the town
3. The location of schools and restaurants
4. The size of buildings

These data are available through OSM, and you should find that the dataset you have been using throughout this manual also can be used for this lesson.

If you want to download data from another area, jump to the Introduction Chapter to read how to do it.

Bemerkung: Although OSM downloads have consistent data fields, the coverage and detail does vary. If you find that your chosen region does not contain information on restaurants, for example, you may need to chose a different region.
6.2.4 Follow Along: Start a Project and get the Data

We first need to load the data to work with.

1. Start a new QGIS project
2. If you want, you can add a background map. Open the *Browser* and load the *OSM* background map from the *XYZ Tiles* menu.

3. In the *training_data.gpkg* Geopackage database, you will find most the datasets we will use in this chapter:
   1. buildings
   2. roads
   3. restaurants
   4. schools
   Load them, and also *landuse.sqlite*.
4. Zoom to the layer extent to see Swellendam, South Africa

   Before proceeding we will filter the *roads* layer, in order to have only some specific road types to work with.

   Some roads in OSM datasets are listed as *unclassified*, *tracks*, *path* and *footway*. We want to exclude these from our dataset and focus on the other road types, more suitable for this exercise.

   Moreover, OSM data might not be updated everywhere, and we will also exclude NULL values.

5. Right click on the *roads* layer and choose *Filter*....

6. In the dialog that pops up we filter these features with the following expression:

   ```sql
   "highway" NOT IN ('footway', 'path', 'unclassified', 'track') AND "highway" != NULL
   ```
The concatenation of the two operators \texttt{NOT} and \texttt{IN} excludes all the features that have these attribute values in the \textit{highway} field.

\texttt{!= NULL} combined with the \textbf{AND} operator excludes roads with no value in the \textit{highway} field.

Note the \text{lock} icon next to the \textit{roads} layer. It helps you remember that this layer has a filter activated, so some features may not be available in the project.

The map with all the data should look like the following one:

![Map with data](image)

### 6.2.5 Try Yourself Convert Layers' CRS

Because we are going to be measuring distances within our layers, we need to change the layers' CRS. To do this, we need to select each layer in turn, save the layer to a new one with our new projection, then import that new layer into our map.

You have many different options, e.g. you can export each layer as an ESRI Shapefile format dataset, you can append the layers to an existing GeoPackage file, or you can create another GeoPackage file and fill it with the new reprojected layers. We will show the last option, so the \texttt{training_data.gpkg} will remain clean. Feel free to choose the best workflow for yourself.

\textbf{Bemerkung:} In this example, we are using the \textit{WGS 84 / UTM zone 34S} CRS, but you should use a UTM CRS which is more appropriate for your region.

1. Right click the \textit{roads} layer in the \textbf{Layers} panel
2. Click \texttt{Export} \rightarrow \texttt{Save Features As…}
3. In the \texttt{Save Vector Layer As} dialog choose \textbf{GeoPackage} as \textit{Format}
4. Click on \texttt{…} for the \textit{File name}, and name the new GeoPackage \texttt{vector_analysis}
5. Change the Layer name to roads_34S
6. Change the CRS to WGS 84 / UTM zone 34S
7. Click on OK:

This will create the new GeoPackage database and add the roads_34S layer.

8. Repeat this process for each layer, creating a new layer in the vector_analysis.gpkg GeoPackage file with _34S appended to the original name and removing each of the old layers from the project.

**Bemerkung:** When you choose to save a layer to an existing GeoPackage, QGIS will append that layer to the GeoPackage.

9. Once you have completed the process for all the layers, right click on any layer and click Zoom to layer extent to focus the map to the area of interest.
Now that we have converted OSM data to a UTM projection, we can begin our calculations.

**6.2.6 Follow Along: Analyzing the Problem: Distances From Schools and Roads**

QGIS allows you to calculate distances between any vector object.

1. Make sure that only the `roads_34S` and `buildings_34S` layers are visible (to simplify the map while you're working)
2. Click on the Processing Toolbox to open the analytical core of QGIS. Basically, all algorithms (for vector and raster analysis) are available in this toolbox.
3. We start by calculating the area around the `roads_34S` by using the Buffer algorithm. You can find it in the Vector Geometry group.
   Or you can type buffer in the search menu in the upper part of the toolbox:
4. Double click on it to open the algorithm dialog
5. Select `roads_34S` as Input layer, set Distance to 50 and use the default values for the rest of the parameters.
6. The default Distance is in meters because our input dataset is in a Projected Coordinate System that uses meter as its basic measurement unit. You can use the combo box to choose other projected units like kilometers, yards, etc.

**Bemerkung:** If you are trying to make a buffer on a layer with a Geographical Coordinate System, Processing will warn you and suggest to reproject the layer to a metric Coordinate System.

7. By default, Processing creates temporary layers and adds them to the Layers panel. You can also append the result to the GeoPackage database by:
   1. Clicking on the … button and choose Save to GeoPackage…
   2. Naming the new layer `roads_buffer_50m`
   3. Saving it in the `vector_analysis.gpkg` file
8. Click on Run, and then close the Buffer dialog

Now your map will look something like this:

If your new layer is at the top of the Layers list, it will probably obscure much of your map, but this gives you all the areas in your region which are within 50m of a road.

Notice that there are distinct areas within your buffer, which correspond to each individual road. To get rid of this problem:

1. Uncheck the `roads_buffer_50m` layer and re-create the buffer with Dissolve results enabled.
2. Save the output as `roads_buffer_50m_dissolved`
3. Click Run and close the Buffer dialog

Once you have added the layer to the Layers panel, it will look like this:

Now there are no unnecessary subdivisions.

**Bemerkung:** The Short Help on the right side of the dialog explains how the algorithm works. If you need more information, just click on the Help button in the bottom part to open a more detailed guide of the algorithm.
6.2. Lesson: Vector Analysis
Buffer

This algorithm computes a buffer area for all the features in an input layer, using a fixed or dynamic distance.

The segments parameter controls the number of line segments to use to approximate a quarter circle when creating rounded offsets.

The end cap style parameter controls how line endings are handled in the buffer.

The join style parameter specifies whether round, miter or beveled joins should be used when offsetting corners in a line.

The miter limit parameter is only applicable for miter join styles, and controls the maximum distance from the offset curve to use when creating a mitered join.
6.2. Lesson: Vector Analysis

This algorithm computes a buffer area for all the features in an input layer, using a fixed or dynamic distance.

The segments parameter controls the number of line segments to use to approximate a quarter circle when creating rounded offsets.

The end cap style parameter controls how line endings are handled in the buffer.

The join style parameter specifies whether round, miter or beveled joins should be used when offsetting corners in a line.

The miter limit parameter is only applicable for miter join styles, and controls the maximum distance from the offset curve to use when creating a mitered join.
Buffer

This algorithm computes a buffer area for all the features in an input layer, using a fixed or dynamic distance.

The segments parameter controls the number of line segments to use to approximate a quarter circle when creating rounded offsets.

The end cap style parameter controls how line endings are handled in the buffer.

The join style parameter specifies whether round, miter or beveled joins should be used when offsetting corners in a line.

The miter limit parameter is only applicable for miter join styles, and controls the maximum distance from the offset curve to use when creating a mitered join.
6.2.7  Try Yourself Distance from schools

Use the same approach as above and create a buffer for your schools.

It shall to be 1 km in radius. Save the new layer in the vector_analysis.gpkg file as schools_buffer_1km_dissolved.

Check your results

6.2.8  Follow Along: Overlapping Areas

Now we have identified areas where the road is less than 50 meters away and areas where there is a school within 1 km (direct line, not by road). But obviously, we only want the areas where both of these criteria are satisfied. To do that, we will need to use the Intersect tool. You can find it in Vector Overlay group in the Processing Toolbox.

1. Use the two buffer layers as Input layer and Overlay layer, choose vector_analysis.gpkg GeoPackage in Intersection with Layer name road_school_buffers_intersect. Leave the rest as suggested (default).

2. Klicken Sie auf Starten.

In the image below, the blue areas are where both of the distance criteria are satisfied.
3. You may remove the two buffer layers and only keep the one that shows where they overlap, since that’s what we really wanted to know in the first place:
6.2.9 Follow Along: Extract the Buildings

Now you’ve got the area that the buildings must overlap. Next, you want to extract the buildings in that area.

1. Look for the menu entry Vector Selection → Extract by location within the Processing Toolbox

2. Select buildings_34S in Extract features from. Check intersect in Where the features (geometric predicate), select the buffer intersection layer in By comparing to the features from. Save to the vector_analysis.gpkg, and name the layer well_located_houses.

3. Click Run and close the dialog

4. You will probably find that not much seems to have changed. If so, move the well_located_houses layer to the top of the layers list, then zoom in.

   The red buildings are those which match our criteria, while the buildings in green are those which do not.

5. Now you have two separated layers and can remove buildings_34S from the layer list.
6.2.10 Try Yourself Further Filter our Buildings

We now have a layer which shows us all the buildings within 1km of a school and within 50m of a road. We now need to reduce that selection to only show buildings which are within 500m of a restaurant.

Using the processes described above, create a new layer called `houses_restaurants_500m` which further filters your `well_located_houses` layer to show only those which are within 500m of a restaurant.

Check your results

6.2.11 Follow Along: Select Buildings of the Right Size

To see which buildings are of the correct size (more than 100 square meters), we need to calculate their size.

1. Select the `houses_restaurants_500m` layer and open the Field Calculator by clicking on the `Open Field Calculator` button in the main toolbar or in the attribute table window.
2. Select Create a new field, set the Output field name to `AREA`, choose Decimal number (real) as Output field type, and choose $area from the Geometry group.

The new field `AREA` will contain the area of each building in square meters.
3. Click OK. The `AREA` field has been added at the end of the attribute table.
4. Click the Toggle Editing button to finish editing, and save your edits when prompted.
5. In the Source tab of the layer properties, set the Provider Feature Filter to "AREA >= 100."
6. Click OK.

Your map should now only show you those buildings which match our starting criteria and which are more than 100 square meters in size.
You are editing information on this layer but the layer is currently not in edit mode. If you click OK, edit mode will automatically be turned on.
Set provider filter on houses_restaurants_500m

**Fields**
- old_name
- address
- internet_access
- level
- sport
- man_made
- layer
- height
- AREA

**Values**
- Search...
- Sample
- All
- Use unfiltered layer

**Operators**
- =
- <
- >
- LIKE
- %
- IN
- NOT IN
- <=
- >=
- !=
- ILIKE
- AND
- OR
- NOT

**Provider specific filter expression**

```
"AREA" >= 100
```
6.2.12 Try Yourself

Save your solution as a new layer, using the approach you learned above for doing so. The file should be saved within the same GeoPackage database, with the name solution.

6.2.13 In Conclusion

Using the GIS problem solving approach together with QGIS vector analysis tools, you were able to solve a problem with multiple criteria quickly and easily.

6.2.14 What’s Next?

In the next lesson, we will look at how to calculate the shortest distance along roads from one point to another.

6.3 Lesson: Netzwerkanalyse

Calculating the shortest distance between two points is a common GIS task. Tools for this can be found in the Processing Toolbox.

The goal for this lesson: learn to use Network analysis algorithms.

6.3.1 Follow Along: The Tools and the Data

You can find all the network analysis algorithms in the Processing Network Analysis menu. You can see that there are many tools available:

Open the project exercise_data/network_analysis/network.qgz. It contains two layers:

• network_points
• network_lines

The network_lines layer has already a style that helps to understand the road network.

The shortest path tools provide ways to calculate either the shortest or the fastest path between two points of a network, given:

• start and end points selected on the map
• start point selected on the map and end points taken from a point layer
• start points taken from a point layer and end point selected on the map

Let’s start.

6.3.2 Calculate the shortest path (point to point)

The Network analysis Shortest path (point to point) allows you to calculate the shortest distance between two manually selected points on the map.

In this example we will calculate the shortest (not fastest) path between two points.

1. Open the Shortest path (point to point) algorithm
2. Select network_lines for Vector layer representing network
### Network analysis

- Service area (from layer)
- Service area (from point)
- Shortest path (layer to point)
- Shortest path (point to layer)

### Raster analysis
- Raster terrain analysis

### Raster tools

### Vector analysis
- Vector creation
- Vector general
- Vector geometry
- Vector overlay
- Vector selection

### Vector table

### GDAL

### GRASS

### SAGA

You can add more algorithms to the toolbox, [enable additional providers.](#)
3. Use **Shortest for Path type** to calculate

Use these two points as starting and ending points for the analysis:

4. Click on the … button next to **Start point (x, y)** and choose the location tagged with **Starting Point** in the picture. The coordinates of the clicked point are added.

5. Do the same thing, but choosing the location tagged with **Ending point for End point (x, y)**

6. Click on the **Run** button:

7. A new line layer is created representing the shortest path between the chosen points. Uncheck the **network_lines** layer to see the result better:

8. Open the attribute table of the output layer. It contains three fields, representing the coordinates of the start and end points and the **cost**.
Kapitel 6. Module: Vektoranalyse

Shortest Path (Point to Point)

Parameters

Vector layer representing network

network_lines [EPSG:3857]

Selected features only

Path type to calculate

Shortest

Start point

-337683.413243,14891795.812691 [EPSG:32734]

End point

-338395.362613,14891385.191690 [EPSG:32734]

Advanced parameters

Shortest path

Create temporary layer

Open output file after running algorithm

0%

Help  Run as Batch Process...  Close  Run

Shortest path (point to point)

This algorithm computes optimal (shortest or fastest) route between given start and end points.
We chose Shortest as *Path type to calculate*, so the *cost* represent the *distance*, in layer units, between the two locations.

In our case, the *shortest* distance between the chosen points is around 1000 meters:

![Shortest path feature table]

Now that you know how to use the tool, feel free to test other locations.

### 6.3.3 Try Yourself Fastest path

With the same data of the previous exercise, try to calculate the fastest path between the two points.

How much time do you need to go from the start to the end point?

*Check your results*

### 6.3.4 Follow Along: Advanced options

Let us explore some more options of the Network Analysis tools. In the *previous exercise* we calculated the *fastest* route between two points. As you can imagine, the time depends on the travel *speed*.

We will use the same layers and starting and ending points of the previous exercises.

1. Open the *Shortest path (point to point)* algorithm
2. Fill the *Input layer*, *Start point (x, y)* and *End point (x, y)* as we did before
3. Choose *Fastest* as the *Path type to calculate*
4. Open the *Advanced parameter* menu
5. Change the *Default speed (km/h)* from the default 50 value to 4
6. Click on *Run*
7. Once the algorithm is finished, close the dialog and open the attribute table of the output layer.
   
   The *cost* field contains the value according to the speed parameter you have chosen. We can convert the *cost* field from hours with fractions to the more readable *minutes* values.

8. Open the field calculator by clicking on the icon and add the new field *minutes* by multiplying the *cost* field by 60:

That’s it! Now you know how many minutes it will take to get from one point to the other one.
**Shortest Path (Point to Point)**

- Vector layer representing network
  - network_lines [EPSG:3857]
- Selected features only
- Path type to calculate
  - Fastest
- Start point (x, y): -337692.9914418324,14891793.808113473 [EPSG:32734]
- End point (x, y): -339431.3986965991,14891497.742442127 [EPSG:32734]
- **Advanced parameters**
  - Direction field (optional)
  - Value for forward direction (optional)
  - Value for backward direction (optional)
  - Value for both directions (optional)
  - Default direction
  - Speed field (optional)
  - Default speed (km/h): 4.000000
  - Topology tolerance: 0.000000 meters
- Shortest path
  - Create temporary layer
  - Open output file after running algorithm

**Shortest path (point to point)**

This algorithm computes optimal (shortest or fastest) route between given start and end points.
6.3. Lesson: Netzwerkanalyse

Field Calculator

- Only update 0 selected features
- Create a new field
  - Output field name: minutes
  - Output field type: Decimal number (real)
  - Output field length: 10
- Update existing field

Expression Editor

Expression: "cost" * 60

Output preview: 60.32885332564259

Notes

- Double-click to add field name to expression string.
- Right-click on field name to open context menu with sample value loading options.
- Loading field values from WFS layers isn't supported, before the layer is actually inserted, i.e., when building queries.
6.3.5 Shortest path with speed limit

The Network analysis toolbox has other interesting options. Looking at the following map:

we would like to know the fastest route considering the speed limits of each road (the labels represent the speed limits in km/h). The shortest path without considering speed limits would of course be the purple path. But in that road the speed limit is 20 km/h, while in the green road you can go at 100 km/h!

As we did in the first exercise, we will use the Network analysis \textit{Shortest path (point to point)} and we will manually choose the start and end points.

1. Open the Network analysis \textit{Shortest path (point to point)} algorithm
2. Select network_lines for the Vector layer representing network parameter
3. Choose Fastest as the Path type to calculate
4. Click on the … button next to the Start point \((x, y)\) and choose the start point.
5. Do the same thing for End point \((x, y)\)
6. Open the Advanced parameters menu
7. Choose the speed field as the Speed Field parameter. With this option the algorithm will take into account the speed limits for each road.
8. Click on the Run button
9. Turn off the network_lines layer to better see the result

As you can see the fastest route does not correspond to the shortest one.
6.3. Lesson: Netzwerkanalyse
6.3.6 Service area (from layer)

The Network Analysis Service area (from layer) algorithm can answer the question: given a point layer, what are all the reachable areas given a distance or a time value?

**Bemerkung:** The Network Analysis Service area (from point) is the same algorithm, but it allows you to manually choose the point on the map.

Given a distance of 250 meters we want to know how far we can go on the network from each point of the network_points layer.

1. Uncheck all the layers except network_points
2. Open the Network Analysis Service area (from layer) algorithm
3. Choose network_lines for Vector layer representing network
4. Choose network_points for Vector layer with start points
5. Choose Shortest in Path type to calculate
6. Enter 250 for the Travel cost parameter
7. Click on Run and close the dialog

The output layer represents the maximum path you can reach from the point features given a distance of 250 meters:
6.3.7 In Conclusion

Now you know how to use Network analysis algorithm to solve shortest and fastest path problems. We are now ready to perform some spatial statistic on vector layer data. Let’s go!

6.3.8 What’s Next?

Next you’ll see how to run spatial statistics algorithms on vector datasets.

6.4 Lesson: Spatial Statistics

**Bemerkung:** Lesson developed by Linfiniti and S Motala (Cape Peninsula University of Technology)

Spatial statistics allows you to analyze and understand what is going on in a given vector dataset. QGIS includes many useful tools for statistical analysis.

**The goal for this lesson:** To know how to use QGIS’ spatial statistics tools within the Processing Toolbox.
6.4.1 Follow Along: Create a Test Dataset

We will create a random set of points, to get a dataset to work with.

To do so, you will need a polygon dataset to define the area you want to create the points in.

We will use the area covered by streets.

1. Start a new project
2. Add your roads dataset, as well as srtm_41_19 (elevation data) found in exercise_data/raster/SRTM/.

**Bemerkung:** You might find that the SRTM DEM layer has a different CRS to that of the roads layer. QGIS is reprojecting both layers in a single CRS. For the following exercises this difference does not matter, but feel free to reproject (as shown earlier in this module).

3. Open Processing toolbox
4. Use the Vector Geometry Minimum bounding geometry tool to generate an area enclosing all the roads by selecting Convex Hull as the Geometry Type:

As you know, if you don’t specify the output, Processing creates temporary layers. It is up to you to save the layers immediately or at a later stage.

Creating random points

- Create 100 random points in this area using the tool at Vector Creation Random points in layer bounds, with a minimum distance of 0.0:

**Bemerkung:** The yellow warning sign tells you that that parameter concerns distances. The Bounding geometry layer is in a Geographical Coordinate System and the algorithm is just reminding you this. For this example we won’t use this parameter so you can ignore it.

If needed, move the generated random point to the top of the legend to see them better:
6.4. Lesson: Spatial Statistics

This algorithm creates a new point layer with a given number of random points, all of them within the extent of a given layer. A distance factor can be specified, to avoid points being too close to each other.
Sampling the data

To create a sample dataset from the raster, you’ll need to use the *Raster Analysis* Sample raster values algorithm. This tool samples the raster at the locations of the points and adds the raster values in new field(s) depending on the number of bands in the raster.

1. Open the *Sample raster values* algorithm dialog

2. Select Random points as the layer containing sampling points, and the SRTM raster as the band to get values from. The default name of the new field is rvalue\_N, where \( N \) is the number of the raster band. You can change the name of the prefix if you want.

3. Press Run

Now you can check the sampled data from the raster file in the attribute table of the Sampled Points layer. They will be in a new field with the name you have chosen.

A possible sample layer is shown here:

The sample points are classified using the rvalue\_1 field such that red points are at a higher altitude.

You will be using this sample layer for the rest of the statistical exercises.
6.4.2  Follow Along: Basic Statistics

Now get the basic statistics for this layer.

1. Click on the Show statistical summary icon in the Attributes Toolbar. A new panel will pop up.
2. In the dialog that appears, specify the Sampled Points layer as the source.
3. Select the rvalue_1 field in the field combo box. This is the field you will calculate statistics for.
4. The Statistics Panel will be automatically updated with the calculated statistics:

   **Bemerkung**: You can copy the values by clicking on the Copy Statistics To Clipboard button and paste the results into a spreadsheet.

5. Close the Statistics Panel when done

Many different statistics are available:

- **Count** The number of samples/values.
- **Sum** The values added together.
- **Mean** The mean (average) value is simply the sum of the values divided by the number of values.
- **Median** If you arrange all the values from smallest to greatest, the middle value (or the average of the two middle values, if N is an even number) is the median of the values.
- **St Dev (pop)** The standard deviation. Gives an indication of how closely the values are clustered around the mean. The smaller the standard deviation, the closer values tend to be to the mean.
- **Minimum** The minimum value.
- **Maximum** The maximum value.
- **Bereich** The difference between the minimum and maximum values.
- **Q1** First quartile of the data.
- **Q3** Third quartile of the data.
- **Missing (null) values** The number of missing values.
<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>100</td>
</tr>
<tr>
<td>Sum</td>
<td>14148</td>
</tr>
<tr>
<td>Mean</td>
<td>141.48</td>
</tr>
<tr>
<td>Median</td>
<td>122.5</td>
</tr>
<tr>
<td>St dev (pop)</td>
<td>89.4792</td>
</tr>
<tr>
<td>St dev (sample)</td>
<td>89.93</td>
</tr>
<tr>
<td>Minimum</td>
<td>18</td>
</tr>
<tr>
<td>Maximum</td>
<td>737</td>
</tr>
<tr>
<td>Range</td>
<td>719</td>
</tr>
<tr>
<td>Minority</td>
<td>18</td>
</tr>
<tr>
<td>Majority</td>
<td>120</td>
</tr>
<tr>
<td>Variety</td>
<td>78</td>
</tr>
<tr>
<td>Q1</td>
<td>97</td>
</tr>
<tr>
<td>Q3</td>
<td>163.5</td>
</tr>
<tr>
<td>IQR</td>
<td>66.5</td>
</tr>
<tr>
<td>Missing (null) values</td>
<td>0</td>
</tr>
</tbody>
</table>
6.4.3 Follow Along: Compute statistics on distances between points

1. Create a new temporary point layer.
2. Enter edit mode, and digitize three points somewhere among the other points.
   Alternatively, use the same random point generation method as before, but specify only three points.
3. Save your new layer as distance_points in the format you prefer.

To generate statistics on the distances between points in the two layers:

1. Open the Vector Analysis \( \text{Distance matrix} \) tool.
2. Select the distance_points layer as the input layer, and the Sampled Points layer as the target layer.
3. Set it up like this:

   ![Distance Matrix Tool](image)

4. If you want you can save the output layer as a file or just run the algorithm and save the temporary output layer later.
5. Click Run to generate the distance matrix layer.
6. Open the attribute table of the generated layer: values refer to the distances between the distance_points features and their two nearest points in the Sampled Points layer:

With these parameters, the Distance Matrix tool calculates distance statistics for each point of the input layer with respect to the nearest points of the target layer. The fields of the output layer contain the mean, standard deviation, minimum and maximum for the distances to the nearest neighbors of the points in the input layer.
6.4.4 Follow Along: Nearest Neighbor Analysis (within layer)

To do a nearest neighbor analysis of a point layer:

1. Choose Vector analysis Nearest neighbor analysis.
2. In the dialog that appears, select the Random points layer and click Run.
3. The results will appear in the Processing Result Viewer Panel.
4. Click on the blue link to open the html page with the results:

<table>
<thead>
<tr>
<th>InputID</th>
<th>MEAN</th>
<th>STDDEV</th>
<th>MIN</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>401.87013</td>
<td>235.74757</td>
<td>166.12256</td>
<td>637.61770</td>
</tr>
<tr>
<td>2</td>
<td>653.19728</td>
<td>229.72430</td>
<td>423.47299</td>
<td>882.92158</td>
</tr>
<tr>
<td>3</td>
<td>1005.87036</td>
<td>296.03133</td>
<td>709.83903</td>
<td>1301.90169</td>
</tr>
</tbody>
</table>

6.4.5 Follow Along: Mean Coordinates

To get the mean coordinates of a dataset:

1. Start Vector analysis Mean coordinate(s)
2. In the dialog that appears, specify Random points as Input layer, and leave the optional choices unchanged.

Let us compare this to the central coordinate of the polygon that was used to create the random sample.

1. Start Vector geometry Centroids
2. In the dialog that appears, select Bounding geometry as the input layer.

As you can see, the mean coordinates (pink point) and the center of the study area (in green) don't necessarily coincide.

The centroid is the barycenter of the layer (the barycenter of a square is the center of the square) while the mean coordinates represent the average of all node coordinates.
Algorithm: Nearest neighbour
File path: /tmp/processing_MXcuYE/6aa2320aecdf41d4adbe6e45440f23be/OUTPUT_HTML_FILE.html
Observed mean distance: 1408.03338044153
Expected mean distance: 0.01577808561
Nearest neighbour index: 89239.81118148957
Number of points: 100
Z-Score: 1707201.00974689284
6.4.6 Follow Along: Image Histograms

The histogram of a dataset shows the distribution of its values. The simplest way to demonstrate this in QGIS is via the image histogram, available in the Layer Properties dialog of any image layer (raster dataset).

1. In your Layers panel, right-click on the srtm_41_19 layer
2. Select Properties
3. Choose the Histogram tab. You may need to click on the Compute Histogram button to generate the graphic. You will see a graph that shows the frequency distribution for the raster values.

4. The graph can be exported as an image with the Save plot button
5. You can see more detailed information about the layer in the Information tab (the mean and max values are estimated, and may not be exact).

The mean value is 332.8 (estimated to 324.3), and the maximum value is 1699 (estimated to 1548)! You can zoom in to cover everything but the peak at 0, you will see more details:
Kapitel 6. Module: Vektoranalyse
**Bemerkung:** If the mean and maximum values are not the same as above, it can be due to the min/max value calculation. Open the Symbology tab and expand the Min / Max Value Settings menu. Choose Min / max and click on Apply.

Keep in mind that a histogram shows you the distribution of values, and not all values are necessarily visible on the graph.

### 6.4.7 Follow Along: Spatial Interpolation

Let’s say you have a collection of sample points from which you would like to extrapolate data. For example, you might have access to the Sampled points dataset we created earlier, and would like to have some idea of what the terrain looks like.

1. To start, launch the GDAL Raster analysis Grid (IDW with nearest neighbor searching) tool in the Processing Toolbox.
2. For **Point layer** select Sampled points
3. Set **Weighting power** to 5.0
4. In **Advanced parameters**, set **Z value from field** to rvalue_1
5. Finally click on **Run** and wait until the processing ends
6. Close the dialog

Here is a comparison of the original dataset (left) to the one constructed from our sample points (right). Yours may look different due to the random nature of the location of the sample points.

As you can see, 100 sample points aren’t really enough to get a detailed impression of the terrain. It gives a very general idea, but it can be misleading as well.

### 6.4.8 Try Yourself Different interpolation methods

1. Use the processes shown above to create a set of 10 000 random points

   **Bemerkung:** If the number of points is really big, the processing time can take a long time.

2. Use these points to sample the original DEM
3. Use the Grid (IDW with nearest neighbor searching) tool on this dataset.
4. Set *Power* and *Smoothing* to 5.0 and 2.0, respectively.

The results (depending on the positioning of your random points) will look more or less like this:

![Image 1](image1.png) ![Image 2](image2.png)

This is a better representation of the terrain, due to the greater density of sample points. Remember, larger samples give better results.

### 6.4.9 In Conclusion

QGIS has a number of tools for analyzing the spatial statistical properties of datasets.

### 6.4.10 What’s Next?

Now that we have covered vector analysis, why not see what can be done with rasters? That is what we will do in the next module!
Wir haben schon früher Raster für die Digitalisierung verwendet, aber Rasterdaten können auch direkt verwendet werden. In diesem Modul sehen Sie, wie es in QGIS gemacht wird.

7.1 Lesson: Working with Raster Data

Raster data is quite different from vector data. Vector data has discrete features with geometries constructed out of vertices, and perhaps connected with lines and/or areas. Raster data, however, is like any image. Although it may portray various properties of objects in the real world, these objects don’t exist as separate objects. Rather, they are represented using pixels with different values.

During this module you are going to use raster data to supplement your existing GIS analysis.

The goal for this lesson: To learn how to work with raster data in QGIS.

7.1.1 Follow Along: Loading Raster Data

Raster data can be loaded with the same methods we used for vector data. However we suggest to use the Browser Panel.

1. Open the Browser Panel and expand the exercise_data/raster folder.
2. Load all the data in this folder:
   - 3320C_2010_314_RGB_LATLNG.tif
   - 3320D_2010_315_RGB_LATLNG.tif
   - 3420B_2010_328_RGB_LATLNG.tif
   - 3420C_2010_327_RGB_LATLNG.tif

You should see the following map:

There we have it - four aerial images covering our study area.
Now as you can see from this, your solution layer lies across all four images. What this means is that you are going to have to work with four rasters all the time. That's not ideal. It would be better to have one file to work with.

Luckily, QGIS allows you to do exactly this, and without needing to actually create a new raster file. You can create a Virtual Raster. This is also often called a Catalog, which explains its function. It's not really a new raster. Rather, it is a way to organize your existing rasters into one catalog: one file for easy access.

To make a catalog we will use the Processing Toolbox.

1. Open the Build virtual raster algorithm from the GDAL Raster miscellaneous;
2. In the dialog that appears, click on the … button next to the Input layers parameter and check all the layers or use the Select All button;
3. Uncheck Place each input file into a separate band. Notice the text field below. What this dialog is actually doing is that it is writing that text for you. It is a long command that QGIS is going to run.

   **Bemerkung:** Keep in mind that you can copy and paste the text in the OSGeo Shell (Windows user) or Terminal (Linux and OSX users) to run the command. You can also create a script for each GDAL command. This is very handy when the procedure is taking a long time or when you want to schedule specific tasks. Use the Help button to get more help on the syntax of the command.

4. Finally click on Run.

   **Bemerkung:** As you know from the previous modules, Processing creates temporary layers by default. To save the file click on the … button.

You can now remove the original four rasters from the Layers Panel and leave only the output virtual catalog raster.
QGIS Training Manual

7.1. Lesson: Working with Raster Data

![Build Virtual Raster dialog box]

- **Input layers**: 4 elements selected
- **Resolution**: Average
- **Place each input file into a separate band**: checked
- **Allow projection difference**: unchecked
- **Advanced parameters**:
  - Add alpha mask band to VRT when source raster has none
  - Override projection for the output file [optional]
- **Resampling algorithm**: Nearest Neighbour
- **NoData value(s) for input bands (space separated) [optional]**
- **Additional command-line parameters [optional]**

- **Virtual**:
  - [Save to temporary file]
  - Open output file after running algorithm

GDAL/OGR console call:

```
gdalbuildvrt -resolution average -separate -r nearest -input_file_list /tmp/processing_waXvap/9e7960668f424564a9ca71decadc15f9/buildvrtInputFiles.txt /tmp/processing_waXvap/219f32d6606644108251f5ad770a7945/OUTPUT.vrt
```
7.1.3 Transforming Raster Data

The above methods allow you to virtually merge datasets using a catalog, and to reproject them „on the fly“. However, if you are setting up data that you’ll be using for quite a while, it may be more efficient to create new rasters that are already merged and reprojected. This improves performance while using the rasters in a map, but it may take some time to set up initially.

Reprojecting rasters

Open Warp (reproject) from GDAL Raster projections.
You can also reproject virtual rasters (catalogs), enable multithreaded processing, and more.

Merging rasters

If you need to create a new raster layer and save it to disk you can use the merge algorithm.

**Bemerkung:** Depending on how many raster files you are merging and their resolution, the new raster file created can be really big. Consider instead to create a raster catalog as described in the Create a Virtual Raster section.

1. Click on the Merge algorithm from the GDAL Raster miscellaneous menu.
2. As we did for the Create a Virtual raster, use the … button to choose which layers you want to merge.
   You can also specify a Virtual raster as input, and then all of the rasters that it consists of will be processed.
3. If you know the GDAL library, you can also add your own options by opening the Advanced parameters menu.

7.1.4 In Conclusion

QGIS makes it easy to include raster data into your existing projects.

7.1.5 What’s Next?

Next, we’ll use raster data that isn’t aerial imagery, and see how symbolization is useful in the case of rasters as well.

7.2 Lesson: Changing Raster Symbology

Not all raster data are aerial photos. There are many other forms of raster data, and in many of those cases, it is essential to symbolize the them so that they becomes properly visible and useful.

**The goal for this lesson:** To change the symbology for a raster layer.
7.2. Lesson: Changing Raster Symbology
QGIS Training Manual

Kapitel 7. Module: Raster

![Image of the Merge dialog box with parameters set to:
- Input layers: 4 elements selected
- Output data type: Float32
- Advanced parameters: Merged file saved to temporary file
- GDAL/OGR console call:
  
  ```
gdal_merge.py -ot Float32 -of GTiff -o /tmp/processing_E3t0r2/517f150854b344bc9f4588a6e9884e32/OUTPUT.tif --optfile /tmp/processing_E3t0r2/44e87c4b7bdf4453aa9552e0d6695f3b/mergeInputFiles.txt
  ```

- Cancel, Close, Run buttons available.
7.2.1 Try Yourself

1. Use the Browser Panel to load srtm_41_19.tif, found under exercise_data/raster/SRTM/

2. Zoom to the extent of this layer by right-clicking on it in the Layers panel and selecting Zoom to Layer.

This dataset is a Digital Elevation Model (DEM). It is a map of the elevation (altitude) of the terrain, allowing us to see where the mountains and valleys are, for example.

While each pixel of the dataset of the previous section contained color information, in a DEM, each pixel contains elevation values.

Once the DEM is loaded, you will notice that it is a grayscale representation:

QGIS has automatically applied a stretch to the pixel values of the image for visualization purposes, and we will learn more about how this works as we continue.
7.2.2 Follow Along: Changing Raster Layer Symbology

You have two different options to change the raster symbology:

1. Within the **Layer Properties** dialog, by right-clicking on the layer in the Layer tree and selecting the **Properties** option. Then switch to the **Symbology** tab.

2. By clicking on the **Open the Layer Styling panel** button right above the **Layers** panel (shortcut F7). This will open the **Layer Styling** panel, where you can switch to the **Symbology** tab.

Choose the method you prefer to work with.

7.2.3 Follow Along: Singleband gray

When you load a raster file, if it is not a photo image like the ones of the previous section, the default style is set to a grayscale gradient.

Let’s explore some of the features of this renderer.

The default **Color gradient** is set to **Black to white**, meaning that low pixel values are black and while high values are white. Try to invert this setting to **White to black** and see the results.

Very important is the **Contrast enhancement** parameter: by default it is set to **Stretch to MinMax** meaning that the pixel values are stretched to the minimum and maximum values.

Look at the difference with the enhancement (left) and without (right):

But what are the minimum and maximum values that should be used for the stretch? The ones that are currently under **Min / Max Value Settings**. There are many ways to calculate the minimum and maximum values and use them for the stretch:

1. **User Defined**: you enter the **Min** and **Max** values manually
2. **Cumulative count cut**: this is useful when you have some extreme low or high values. It cuts the 2% (or the value you choose) of these values
3. **Min / max**: the **Real or Estimated** minimum and maximum values of the raster
4. **Mean +/- standard deviation**: the values will be calculated according to the mean value and the standard deviation

7.2.4 Follow Along: Singleband pseudocolor

Grayscales are not always great styles for raster layers. Let’s try to make the DEM more colorful.

- Change the **Render type** to **Singleband pseudocolor**. If you don’t like the default colors loaded, select another **Color ramp**
- Click the **Classify** button to generate a new color classification
- If it is not generated automatically click on the **OK** button to apply this classification to the DEM

You’ll see the raster looking like this:

This is an interesting way of looking at the DEM. You will now see that the values of the raster are again properly displayed, going from blue for the lower areas to red for the higher ones.
7.2. Lesson: Changing Raster Symbology

- **Band Rendering**
  - Render type: Singleband gray
  - Gray band: Band 1 (Gray)
  - Color gradient: Black to white
  - Contrast enhancement: Stretch to MinMax
  - Min: 0, Max: 1548

- **Min / Max Value Settings**
  - User defined
  - Cumulative count cut: 2.0, 98.0%
  - Min / Max
  - Mean +/- standard deviation: 2.0
  - Statistics extent: Whole raster
  - Accuracy: Estimate (faster)

- **Color Rendering**
  - Blending mode: Normal
  - Brightness: 0
  - Contrast: 0
  - Saturation: 0
  - Grayscale: Off
  - Hue: Colorize
  - Strength: 100%

- **Resampling**
  - Zoomed in: Nearest neighbour
  - Zoomed out: Nearest neighbour
  - Oversampling: 2.0
Kapitel 7. Module: Raster
7.2.5 Follow Along: Changing the transparency

Sometimes changing the transparency of the whole raster layer can help you to see other layers covered by the raster itself and better understand the study area.

To change the transparency of the whole raster switch to the Transparency tab and use the slider of the Global Opacity to lower the opacity:

More interesting is changing the transparency for some pixel values. For example in the raster we used you can see a homogeneous color at the corners. To set these pixels as transparent, go to Custom Transparency Options in the Transparency tab.

• By clicking on the Add values manually button, you can add a range of values and set their transparency percentage

• For single values the Add values from display button is more useful

• Click on the Add values from display button. The dialog disappears, and you can interact with the map.

• Click on the homogeneous color in a corner of the DEM

• You will see that the transparency table will be filled with the clicked values:

• Click on OK to close the dialog and see the changes.

See? The corners are now 100% transparent.
7.2.6 In Conclusion

These are some the basic functions to get you started with raster symbology. QGIS also gives you many other options, such as symbolizing a layer using paletted/unique values, representing different bands with different colors in a multispectral image, or making an automatic hillshade effect (useful only with DEM raster files).

7.2.7 Referenz

The SRTM dataset was obtained from http://srtm.csi.cgiar.org/

7.2.8 What’s Next?

Now that we can see our data displayed properly, let’s investigate how we can analyze it further.

7.3 Lesson: Terrain Analysis

Certain types of rasters allow you to gain more insight into the terrain that they represent. Digital Elevation Models (DEMs) are particularly useful in this regard. In this lesson you will use terrain analysis tools to find out more about the study area for the proposed residential development from earlier.

The goal for this lesson: To use terrain analysis tools to derive more information about the terrain.
7.3.1 Follow Along: Calculating a Hillshade

We are going to use the same DEM layer as in the previous lesson. If you are starting this chapter from scratch, use the Browser panel and load the `raster/SRTM/srtm_41_19.tif`.

The DEM layer shows you the elevation of the terrain, but it can sometimes seem a little abstract. It contains all the 3D information about the terrain that you need, but it doesn’t look like a 3D object. To get a better impression of the terrain, it is possible to calculate a hillshade, which is a raster that maps the terrain using light and shadow to create a 3D-looking image.

We are going to use algorithms in the Raster terrain analysis menu.

1. Click on the Hillshade menu

2. The algorithm allows you to specify the position of the light source: Azimuth has values from 0 (North) through 90 (East), 180 (South) and 270 (West), while the Vertical angle sets how high the light source is (0 to 90 degrees). We will use the default values:

   ![Diagram of light source with azimuth and vertical angle](image)

3. Save the file in a new folder `raster_analysis` within the folder `exercise_data` with the name `hillshade`

4. Finally click on Run

You will now have a new layer called `hillshade` that looks like this:

That looks nice and 3D, but can we improve on this? On its own, the hillshade looks like a plaster cast. Can’t we use it together with our other, more colorful rasters somehow? Of course we can, by using the hillshade as an overlay.
7.3.2 Follow Along: Using a Hillshade as an Overlay

A hillshade can provide very useful information about the sunlight at a given time of day. But it can also be used for aesthetic purposes, to make the map look better. The key to this is setting the hillshade to being mostly transparent.

1. Change the symbology of the original srtm_41_19 layer to use the Pseudocolor scheme as in the previous exercise.
2. Hide all the layers except the srtm_41_19 and hillshade layers.
3. Click and drag the srtm_41_19 to be beneath the hillshade layer in the Layers panel.
4. Set the hillshade layer to be transparent by clicking on the Transparency tab in the layer properties.
5. Set the Global opacity to 50%.

You’ll get a result like this:

6. Switch the hillshade layer off and back on in the Layers panel to see the difference it makes.

Using a hillshade in this way, it’s possible to enhance the topography of the landscape. If the effect doesn’t seem strong enough to you, you can change the transparency of the hillshade layer; but of course, the brighter the hillshade becomes, the dimmer the colors behind it will be. You will need to find a balance that works for you.

Remember to save the project when you are done.
7.3.3 Follow Along: Calculating the Slope

Another useful thing to know about the terrain is how steep it is. If, for example, you want to build houses on the land there, then you need land that is relatively flat.

To do this, you need to use the Slope algorithm of the Processing Raster terrain analysis.

1. Open the algorithm
2. Choose srtm_41_19 as the Elevation layer
3. Save the output as a file with the name slope in the same folder as the hillshade
4. Click on Run

Now you’ll see the slope of the terrain, with black pixels being flat terrain and white pixels, steep terrain:
7.3.4 Try Yourself Calculating the aspect

Aspect is the compass direction that the slope of the terrain faces. An aspect of 0 means that the slope is North-facing, 90 East-facing, 180 South-facing, and 270 West-facing.

Since this study is taking place in the Southern Hemisphere, properties should ideally be built on a north-facing slope so that they can remain in the sunlight.

Use the Aspect algorithm of the Processing Raster terrain analysis to get the layer.

Check your results

7.3.5 Follow Along: Using the Raster Calculator

Think back to the estate agent problem, which we last addressed in the Vector Analysis lesson. Let us imagine that the buyers now wish to purchase a building and build a smaller cottage on the property. In the Southern Hemisphere, we know that an ideal plot for development needs to have areas on it that are north-facing, and with a slope of less than five degrees. But if the slope is less than 2 degrees, then the aspect doesn’t matter.

Fortunately, you already have rasters showing you the slope as well as the aspect, but you have no way of knowing where both conditions are satisfied at once. How could this analysis be done?

The answer lies with the Raster calculator.

QGIS has different raster calculators available:

- Raster Raster Calculator
- In processing:
  - Raster Analysis Raster calculator
  - GDAL Raster miscellaneous Raster calculator
  - SAGA Raster calculus Raster calculator

Each tool is leading to the same results, but the syntax may be slightly different and the availability of operators may vary.

We will use Raster Analysis Raster calculator in the Processing Toolbox.

1. Open the tool by double clicking on it.

   - The upper left part of the dialog lists all the loaded raster layers as name@N, where name is the name of the layer and N is the band.
   - In the upper right part you will see a lot of different operators. Stop for a moment to think that a raster is an image. You should see it as a 2D matrix filled with numbers.

2. North is at 0 (zero) degrees, so for the terrain to face north, its aspect needs to be greater than 270 degrees and less than 90 degrees. Therefore the formula is:

   \[
   \text{aspect@1} < 90 \text{ OR aspect@1} > 270
   \]

3. Now you have to set up the raster details, like the cell size, extent and CRS. This can be done manually or it can be automatically set by choosing a Reference layer. Choose this last option by clicking on the … button next to the Reference layer(s) parameter.

4. In the dialog, choose the aspect layer, because we want to obtain a layer with the same resolution.

5. Save the layer as aspect_north.

   The dialog should look like:

6. Finally click on Run.
7.3. Lesson: Terrain Analysis
Your result will be this:

The output values are 0 or 1. What does it mean? The formula we wrote contains the conditional operator OR. Therefore the final result will be False (0) and True (1).

7.3.6  🌟 Try Yourself More criteria

Now that you have done the aspect, create two new layers from the DEM.

- The first shall identify areas where the slope is less than or equal to 2 degrees
- The second is similar, but the slope should be less than or equal to 5 degrees.

- Save them under exercise_data/raster_analysis as slope_lte2.tif and slope_lte5.tif.

Check your results
7.3.7 Follow Along: Combining Raster Analysis Results

Now you have generated three raster layers from the DEM:

- `aspect_north`: terrain facing north
- `slope_lte2`: slope equal to or below 2 degrees
- `slope_lte5`: slope equal to or below 5 degrees

Where the conditions are met, the pixel value is 1. Elsewhere, it is 0. Therefore, if you multiply these rasters, the pixels that have a value of 1 for all of them will get a value of 1 (the rest will get 0).

The conditions to be met are:

- at or below 5 degrees of slope, the terrain must face north
- at or below 2 degrees of slope, the direction that the terrain faces does not matter.

Therefore, you need to find areas where the slope is at or below five degrees AND the terrain is facing north, OR the slope is at or below 2 degrees. Such terrain would be suitable for development.

To calculate the areas that satisfy these criteria:

1. Open the Raster calculator again
2. Use this expression in Expression:

   ```
   ( aspect_north @1 = 1 AND slope_lte5 @1 = 1 ) OR slope_lte2 @1 = 1
   ```

3. Set the Reference layer(s) parameter to `aspect_north` (it does not matter if you choose another - they have all been calculated from `srtm_41_19`)
4. Save the output under `exercise_data/raster_analysis/` as `all_conditions.tif`
5. Click Run

Das Ergebnis:

7.3.8 Follow Along: Simplifying the Raster

As you can see from the image above, the combined analysis has left us with many, very small areas where the conditions are met. But these aren’t really useful for our analysis, since they are too small to build anything on. Let us get rid of all these tiny unusable areas.

1. Open the Sieve tool (`GDAL Raster Analysis` in the `Processing Toolbox`)
2. Set the Input file to `all_conditions`, and the Sieved to `all_conditions_sieve.tif` (under `exercise_data/raster_analysis/`).
3. Set the Threshold to 8 (minimum eight contiguous pixels), and check Use 8-connectedness.

   Once processing is done, the new layer will be loaded.

   What is going on? The answer lies in the new raster file’s metadata.

4. View the metadata under the Information tab of the Layer Properties dialog. Look the STATISTICS_MINIMUM value:

   This raster, like the one it is derived from, should only feature the values 1 and 0, but it has also a very large negative number. Investigation of the data shows that this number acts as a null value. Since we are only after areas that weren’t filtered out, let us set these null values to zero.

5. Open the Raster Calculator, and build this expression:
7.3. Lesson: Terrain Analysis
This will maintain all non-negative values, and set the negative numbers to zero, leaving all the areas with value 1 intact.

6. Save the output under `exercise_data/raster_analysis/` as `all_conditions_simple.tif`.

Your output looks like this:

This is what was expected: a simplified version of the earlier results. Remember that if the results you get from a tool aren’t what you expected, viewing the metadata (and vector attributes, if applicable) can prove essential to solving the problem.

### 7.3.9 Follow Along: Reclassifying the Raster

We have used the `Raster calculator` to do calculations on raster layers. There is another powerful tool that we can use to extract information from existing layers.

Back to the `aspect` layer. We know now that it has numerical values within a range from 0 through 360. What we want to do is to reclassify this layer to other discrete values (from 1 to 4), depending on the aspect:

- 1 = North (from 0 to 45 and from 315 to 360);
- 2 = East (from 45 to 135)
- 3 = South (from 135 to 225)
- 4 = West (from 225 to 315)

This operation can be achieved with the raster calculator, but the formula would become very very large.

The alternative tool is the `Reclassify by table` tool in `Raster analysis` in the `Processing Toolbox`.
1. Open the tool
2. Choose aspect as the Input raster layer
3. Click on the … of Reclassification table. A table-like dialog will pop up, where you can choose the minimum, maximum and new values for each class.
4. Click on the Add row button and add 5 rows. Fill in each row as the following picture and click OK:

   ![Fixed table]

   The method used by the algorithm to treat the threshold values of each class is defined by the Range boundaries.
5. Save the layer as file: reclassified.tif in the exercise_data/raster_analysis/ folder
6. Click on Run
Reclassify by Table

Parameters

**Raster layer**
Aspect [EPSG:32733]

**Band number**
Band 1 (Gray)

**Reclassification table**
Fixed table (5x3)

**Advanced parameters**

- **Output no data value**
  -9999.000000

- **Range boundaries**
  min < value <= max

- **Use no data when no range matches value**

- **Output data type**
  Float32

**Reclassified raster**
::rcise_data/raster_analysis/reclassified.sdat

- **Open output file after running algorithm**

0%

[Help][Run as Batch Process...][Close][Run]
If you compare the native *aspect* layer with the *reclassified* one, there are not big differences. But by looking at the legend, you can see that the values go from 1 to 4.

Let us give this layer a better style.

1. Open the *Layer Styling* panel
2. Choose *Paletted/Unique values*, instead of *Singleband gray*
3. Click on the *Classify* button to automatically fetch the values and assign them random colors:

The output should look like this (you can have different colors given that they have been randomly generated):

With this reclassification and the paletted style applied to the layer, you can immediately differentiate the aspect areas.

### 7.3.10 Follow Along: Querying the raster

Unlike vector layers, raster layers don’t have an attribute table. Each pixel contains one or more numerical values (singleband or multiband rasters).

All the raster layers we used in this exercise consist of just one band. Depending on the layer, pixel values may represent elevation, aspect or slope values.

How can we query the raster layer to get the value of a pixel? We can use the *Identify Features* button!

1. Select the tool from the Attributes toolbar.
2. Click on a random location of the `srtm_41_19` layer. *Identify Results* will appear with the value of the band at the clicked location:
3. You can change the output of the *Identify Results* panel from the current *tree* mode to a *table* one by selecting *Table* in the *View* menu at the bottom of the panel:

Clicking each pixel to get the value of the raster could become annoying after a while. We can use the *Value Tool* plugin to solve this problem.

1. Go to *Plugins ➤ Manage/Install Plugins*…
2. In the *All* tab, type *value* t in the search box
3. Select the *Value Tool* plugin, press *Install Plugin* and then *Close* the dialog.
   
   The new *Value Tool* panel will appear.

   **Tipp:** If you close the panel you can reopen it by enabling it in the *View ➤ Panels ➤ Value Tool* or by clicking on the icon in the toolbar.

4. To use the plugin just check the *Enable* checkbox and be sure that the `srtm_41_19` layer is active (checked) in the *Layers* panel.
5. Move the cursor over the map to see the value of the pixels.
6. But there is more. The Value Tool plugin allows you to query **all** the active raster layers in the *Layers* panel.
   
   Set the *aspect* and *slope* layers active again and hover the mouse on the map:

---

**7.3. Lesson: Terrain Analysis** 235
### Identify Results

<table>
<thead>
<tr>
<th>Layer</th>
<th>FID</th>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>srtm_41_19</td>
<td>1</td>
<td>Band 1</td>
<td>592</td>
</tr>
</tbody>
</table>

### Value Tool

**Qgis plugin to display in table or plot values from raster layers (or mesh layers, from version 3.0.5) at the current mouse position**

Qgis plugin to display in table or plot values from raster layers (or mesh layers, from version 3.0.5) at the current mouse position. If this plugin is useful for you, please consider to make a donation of any value to the Maintainer.

- **Tags**: raster, mesh
- **More info**: homepage, bug tracker, code repository
- **Author**: Jorge Almerie (maintainer)
- **Available version**: 3.0.6
7.3. Lesson: Terrain Analysis
7.3.11 In Conclusion

You've seen how to derive all kinds of analysis products from a DEM. These include hillshade, slope and aspect calculations. You've also seen how to use the raster calculator to further analyze and combine these results. Finally you learned how to reclassify a layer and how to query the results.

7.3.12 What's Next?

Now you have two analyses: the vector analysis which shows you the potentially suitable plots, and the raster analysis that shows you the potentially suitable terrain. How can these be combined to arrive at a final result for this problem? That's the topic for the next lesson, starting in the next module.
Module: Fertigstellung der Analyse

Sie haben nun zwei Hälften einer Analyse: einen Vektor- und einen Rasterteil. In diesem Modul sehen Sie, wie Sie sie kombinieren können. Sie werden die Analyse abschließen und die Endergebnisse präsentieren.

8.1 Lesson: Raster to Vector Conversion

Converting between raster and vector formats allows you to make use of both raster and vector data when solving a GIS problem, as well as using the various analysis methods unique to these two forms of geographic data. This increases the flexibility you have when considering data sources and processing methods for solving a GIS problem.

To combine a raster and vector analysis, you need to convert the one type of data to the other. Let’s convert the raster result of the previous lesson to a vector.

The goal for this lesson: To get the raster result into a vector that can be used to complete the analysis.

8.1.1 Follow Along: The Raster to Vector Tool

Start with the map from the last module, raster_analysis.qgs. There you should have the all_conditions_simple.tif calculated during the previous exercises.

- Click on Raster Conversion Polygonize (Raster to Vector). The tool dialog will appear.
- Set it up like this:
  - Change the field name (describing the values of the raster) to suitable.
  - Save the layer under exercise_data/residential_development as allTerrain.shp.

Now you have a vector file which contains all the values of the raster, but the only areas you’re interested in are those that are suitable; i.e., those polygons where the value of suitable is 1. You can change the style of this layer if you want to have a clearer visualization of it.
8.1.2 Try Yourself

Refer back to the module on vector analysis.

- Create a new vector file that contains only the polygons where suitable has the value of 1.
- Save the new file as exercise_data/residential_development/suitable_terrain.shp.

Check your results

8.1.3 Follow Along: The Vector to Raster Tool

Although unnecessary for our current problem, it’s useful to know about the opposite conversion from the one performed above. Convert to raster the suitable_terrain.shp vector file you just created in previous step.

- Click on Raster Conversion Rasterize (Vector to Raster) to start this tool, then set it up as in the screenshot below:
  - Input file is all_terrain.
  - Output file is exercise_data/residential_development/raster_conversion.tif.
  - Width and Height are 837 and 661, respectively.

Bemerkung: The size of the output image is specified here to be the same as the original raster which was vectorized. To view the dimensions of an image, open its metadata (Metadata tab in the Layer Properties).

- Click OK on the dialog to begin the conversion process.
- When it is complete, gauge its success by comparing the new raster with the original one. They should match up exactly, pixel for pixel.
8.1.4 In Conclusion

Converting between raster and vector formats allows you to widen the applicability of data, and need not lead to data degradation.

8.1.5 What’s Next?

Now that we have the results of the terrain analysis available in vector format, they can be used to solve the problem of which buildings we should consider for the residential development.

8.2 Lesson: Combining the Analyses

Using the vectorized results of the raster analysis will allow you to select only those buildings on suitable terrain.

The goal for this lesson: To use the vectorized terrain results to select suitable plots.

8.2.1 Try Yourself

• Save your current map (raster_analysis.qgs).
• Open the map in which you created during the vector analysis earlier (you should have saved the file as analysis.qgs).
• In the Layers panel, enable these layers:
  – hillshade,
  – solution (or buildings_over_100)
• In addition to these layers, which should already be loaded in the map from when you worked on it before, also add the suitableTerrain.shp dataset.
If you are missing some layers, you should find them in `exercise_data/residential_development/`

Use the **Intersect** tool (Vector Geoprocessing Tools) to create a new vector layer called `new_solution.shp` which contains only those buildings which intersect the `suitableTerrain` layer.

You should now have a layer showing certain buildings as your solution, for example:

### 8.2.2 Try Yourself Inspecting the Results

Look at each of the buildings in your `new_solution` layer. Compare them with the `suitableTerrain` layer by changing the symbology for the `new_solution` layer so that it has outlines only. What do you notice about some of the buildings? Are they all suitable just because they intersect with the `suitableTerrain` layer? Why or why not? Which ones would you deem to be unsuitable?

*Check your results*

### 8.2.3 Try Yourself Refining the Analysis

You can see from the results that some buildings which were included were not really suitable, so we can now refine the analysis.

We want to ensure that our analysis returns only those buildings which fall entirely within the `suitableTerrain` layer. How would you achieve this? Use one or more Vector Analysis tools and remember that our buildings are all over 100m squared in size.

*Check your results*
8.2.4 In Conclusion

You have now answered the original research question, and can offer an opinion (with reasons, backed by analysis) for a recommendation regarding which property to develop.

8.2.5 What’s Next?

Next you will present these results as part of your second assignment.

8.3 Zuordnung

Using the print layout, make a new map representing the results of your analysis. Include these layers:

- places (with labels),
- hillshade,
- solution (or new_solution),
- roads and
- either aerial_photos or DEM.

Write a short explanatory text to accompany it. Include in this text the criteria that were used in considering a house for purchase and subsequent development, as well as explaining your recommendations for which buildings are suitable.

8.4 Lesson: Supplementary Exercise

In this lesson, you will be guided through a complete GIS analysis in QGIS.

Bemerkung: Lesson developed by Lininiti Consulting (South Africa) and Siddique Motala (Cape Peninsula University of Technology)

8.4.1 Problem Statement

You are tasked with finding areas in and around the Cape Peninsula that are suitable habitats for a rare fynbos plant species. The extent of your area of investigation covers Cape Town and the Cape Peninsula between Melkbosstrand in the north and Strand in the south. Botanists have provided you with the following preferences exhibited by the species in question:

- It grows on east facing slopes
- It grows on slopes with a gradient between 15% and 60%
- It grows in areas that have a total annual rainfall of > 1000 mm
- It will only be found at least 250 m away from any human settlement
- The area of vegetation in which it occurs should be at least 6000 $m^2$ in area

As a student at the University, you have agreed to search for the plant in four different suitable areas of land. You want those four suitable areas to be the ones that are closest to the University of Cape Town where you live. Use your GIS skills to determine where you should go to look.
8.4.2 Solution Outline

The data for this exercise can be found in the exercise_data/more_analysis folder. You are going to find the four suitable areas that are closest to the University of Cape Town. The solution will involve:

1. Analysing a DEM raster layer to find the east facing slopes and the slopes with the correct gradients
2. Analysing a rainfall raster layer to find the areas with the correct amount of rainfall
3. Analysing a zoning vector layer to find areas that are away from human settlement and are of the correct size

8.4.3 Follow Along: Setting up the Map

1. Click on the Current CRS button in the lower right corner of the screen. Under the CRS tab of the dialog that appears, use the „Filter“ tool to search for „33S“. Select the entry WGS 84 / UTM zone 33S (with EPSG code 32733).
2. Klicken Sie auf OK
3. Save the project file by clicking on the Save Project toolbar button, or use the File Save As... menu item.
   Save it in a new directory called Rasterprac, that you should create somewhere on your computer. You will save whatever layers you create in this directory as well. Save the project as your_name_fynbos.qgs.

8.4.4 Loading Data into the Map

In order to process the data, you will need to load the necessary layers (street names, zones, rainfall, DEM) into the map canvas.

For vectors...

1. Click on the Open Data Source Manager button in the Data Source Manager Toolbar, and enable the Vector tab in the dialog that appears, or use the Layer Add Layer Add Vector Layer... menu item
2. Ensure that File is selected
3. Click on the … button to browse for vector dataset(s)
4. In the dialog that appears, open the exercise_data/more_analysis/Streets directory
5. Select the file Street_Names_UTM33S.shp
6. Click Open.
   The dialog closes and shows the original dialog, with the file path specified in the text field next to Vector dataset(s). This allows you to ensure that the correct file is selected. It is also possible to enter the file path in this field manually, should you wish to do so.
7. Click Add. The vector layer will be loaded into your map. Its color is automatically assigned. You will change it later.
8. Rename the layer to Streets
   1. Right-click on it in the Layers panel (by default, the pane along the left-hand side of the screen)
   2. Click Rename in the dialog that appears and rename it, pressing the Enter key when done
9. Repeat the vector adding process, but this time select the Generalised_Zoning_Dissolve_UTM33S.shp file in the Zoning directory.
10. Rename it to Zoning.
For rasters...

1. Click on the Open Data Source Manager button and enable the Raster tab in the dialog that appears, or use the Layer Add Layer menu item
2. Ensure that File is selected
3. Navigate to the appropriate file, select it, and click Open
4. Do this for each of the following two raster files, DEM/SRTM.tif and rainfall/reprojected/rainfall.tif
5. Rename the SRTM raster to DEM and the rainfall raster to Rainfall (with an initial capital)

8.4.5 Changing the layer order

Click and drag layers up and down in the Layers panel to change the order they appear in on the map so that you can see as many of the layers as possible.

Now that all the data is loaded and properly visible, the analysis can begin. It is best if the clipping operation is done first. This is so that no processing power is wasted on computing values in areas that are not going to be used anyway.

8.4.6 Find the Correct Districts

1. Load the vector layer admin_boundaries/Western_Cape_UTM33S.shp into your map.
2. Rename it to Districts.
3. Right-click on the Districts layer in the Layers panel.
4. In the menu that appears, select the Filter… menu item. The Query Builder dialog appears.

You will now build a query to select only the following districts:

- Bellville
- Cape
- Goodwood
- Kuils River
- Mitchells Plain
- Simon Town
- Wynberg

1. In the Fields list, double-click on the NAME_2 field to make it appear in the SQL where clause text field below
2. Click the = button; an = sign is appended to the SQL query
3. Click the All button below the (currently empty) Values list.

   After a short delay, this will populate the Values list with the values of the selected field (NAME_2).
4. Double-click the value Bellville in the Values list to append it to the SQL query.
   In order to select more than one district, you'll need to use the OR boolean operator.
5. Click the OR button and it will be appended to the SQL query
6. Using a process similar to the above, add the following to the existing SQL query:

   "NAME_2" = 'Cape'
7. Add another OR operator, then work your way through the list of districts above in a similar fashion.

The final query should be:

```
"NAME_2" = 'Bellville' OR "NAME_2" = 'Cape' OR
"NAME_2" = 'Goodwood' OR "NAME_2" = 'Kuils River' OR
"NAME_2" = 'Mitchells Plain' OR "NAME_2" = 'Simon Town' OR
"NAME_2" = 'Wynberg'
```

**Bemerkung:** By using the IN operator, the query would look like this:

```
"NAME_2" in ('Bellville', 'Cape', 'Goodwood', 'Kuils River',
'Mitchells Plain', 'Simon Town', 'Wynberg')
```

8. Click OK.

The districts shown in your map are now limited to those in the list above.

### 8.4.7 Clip the Rasters

Now that you have an area of interest, you can clip the rasters to this area.

1. Ensure that the only layers that are visible are the DEM, Rainfall and Districts layers
2. Districts must be on top to be visible
3. Open the clipping dialog by selecting the menu item Raster Extraction Clip Raster by Mask Layer...
4. In the Input layer dropdown list, select the DEM layer
5. In the Mask layer dropdown list, select the Districts layer
6. Scroll down and specify an output location in the Clipped (mask) text field by clicking the … button and choosing Save to File...
   1. Navigate to the Rasterprac directory
   2. Enter a file name - DEM_clipped.tif
   3. Save
7. Make sure that Open output file after running algorithm is checked
8. Click Run

   After the clipping operation has completed, leave the Clip Raster by Mask Layer dialog open, to be able to reuse the clipping area
9. Select the Rainfall raster layer in the Input layer dropdown list and save your output as Rainfall_clipped.tif
10. Do not change any other options. Leave everything the same and click Run.
11. After the second clipping operation has completed, you may close the Clip Raster by Mask Layer dialog
12. Save the map
Align the rasters

For our analysis we need the rasters to have the same CRS and they have to be aligned.

First we change the resolution of our rainfall data to 30 meters (pixel size):

1. Right-click on the Rainfall_clipped layer and select Export Save As... in the context menu.
2. Set the Horizontal and Vertical resolution to 30 (meters).
3. Save the file as Rainfall30.tif in rainfall/reprojected (File name)

Then we align the DEM:

1. Right-click on the DEM_clipped layer and select Export Save As... in the context menu
2. For CRS, choose WGS 84 / UTM zone 33S (EPSG code 32733)
3. Set the Horizontal and Vertical resolution to 30 (meters)
4. Under Extent, click on Calculate from Layer and choose rainfall30
5. Save the file as DEM30.tif in DEM/reprojected (File name)

In order to properly see what’s going on, the symbology for the layers needs to be changed.

8.4.8 Changing the symbology of vector layers

1. In the Layers panel, right-click on the Streets layer
2. Select Properties from the menu that appears
3. Switch to the Symbology tab in the dialog that appears
4. Click on the Color dropdown
5. Select a new color in the dialog that appears
6. Klicken Sie auf OK
7. Click OK again in the Layer Properties dialog. This will change the color of the Streets layer.
8. Follow a similar process for the Zoning layer and choose an appropriate color for it

8.4.9 Changing the symbology of raster layers

Raster layer symbology is somewhat different.

1. Open the Properties dialog for the Rainfall30 raster layer
2. Switch to the Symbology tab. You’ll notice that this dialog is very different from the version used for vector layers.
3. Expand Min/Max Value Settings
4. Ensure that the button Mean +/- standard deviation is selected
5. Make sure that the value in the associated box is 2.00
6. For Contrast enhancement, make sure it says Stretch to MinMax
7. For Color gradient, change it to White to Black
8. Klicken Sie auf OK

The Rainfall30 raster, if visible, should change colors, allowing you to see different brightness values for each pixel
9. Repeat this process for the DEM30 layer, but set the standard deviations used for stretching to 4.00

8.4. Lesson: Supplementary Exercise
8.4.10 Clean up the map

1. Remove the original Rainfall and DEM layers, as well as Rainfall_clipped and DEM_clipped from the Layers panel:
   - Right-click on these layers and select Remove.

   **Bemerkung:** This will not remove the data from your storage device, it will merely take it out of your map.

2. Save the map
3. You can now hide the vector layers by unchecking the box next to them in the Layers panel. This will make the map render faster and will save you some time.

8.4.11 Create the hillshade

In order to create the hillshade, you will need to use an algorithm that was written for this purpose.

1. In the Layers panel, ensure that DEM30 is the active layer (i.e., it is highlighted by having been clicked on)
2. Click on the Raster Analysis Hillshade... menu item to open the Hillshade dialog
3. Scroll down to Hillshade and save the output in your Rasterprac directory as hillshade.tif
4. Make sure that Open output file after running algorithm is checked
5. Click Run
6. Wait for it to finish processing.

The new hillshade layer has appeared in the Layers panel.

1. Right-click on the hillshade layer in the Layers panel and bring up the Properties dialog
2. Click on the Transparency tab and set the Global Opacity slider to 20%
3. Klicken Sie auf OK
4. Note the effect when the transparent hillshade is superimposed over the clipped DEM. You may have to change the order of your layers, or click off the rainfall30 layer in order to see the effect.

8.4.12 Slope

1. Click on the Raster Analysis Slope... menu item to open the Slope algorithm dialog
2. Select DEM30 as Input layer
3. Check Slope expressed as percent instead of degrees. Slope can be expressed in different units (percent or degrees). Our criteria suggest that the plant of interest grows on slopes with a gradient between 15% and 60%. So we need to make sure our slope data is expressed as a percent.
4. Specify an appropriate file name and location for your output.
5. Make sure that Open output file after running algorithm is checked
6. Click Run

The slope image has been calculated and added to the map. As usual, it is rendered in grayscale. Change the symbology to a more colorful one:

1. Open the layer Properties dialog (as usual, via the right-click menu of the layer)
2. Click on the Symbology tab
3. Where it says Singleband gray (in the Render type dropdown menu), change it to Singleband pseudocolor
4. Choose Mean +/- standard deviation x for Min / Max Value Settings with a value of 2.0
5. Select a suitable Color ramp
6. Click Run

8.4.13 Try Yourself Aspect

Use the same approach as for calculating the slope, choosing Aspect… in the Raster Analysis menu.
Remember to save the project periodically.

8.4.14 Reclassifying rasters

1. Choose Raster calculator…
2. Specify your Rasterprac directory as the location for the Output layer (click on the … button), and save it as slope15_60.tif
3. Ensure that the Open output file after running algorithm box is selected.
   In the Raster bands list on the left, you will see all the raster layers in your Layers panel. If your Slope layer is called slope, it will be listed as slope@1. Indicating band 1 of the slope raster.
4. The slope needs to be between 15 and 60 degrees.
   Using the list items and buttons in the interface, build the following expression:
   \[(slope@1 > 15) \text{ AND } (slope@1 < 60)\]
5. Set the Output layer field to an appropriate location and file name.

Now find the correct aspect (east-facing: between 45 and 135 degrees) using the same approach.

1. Build the following expression:
   \[(aspect@1 > 45) \text{ AND } (aspect@1 < 135)\]

You will know it worked when all of the east-facing slopes are white in the resulting raster (it’s almost as if they are being lit by the morning sunlight).

Find the correct rainfall (greater than 1000 mm) the same way. Use the following expression:

   rainfall30@1 > 1000

Now that you have all three criteria each in separate rasters, you need to combine them to see which areas satisfy all the criteria. To do so, the rasters will be multiplied with each other. When this happens, all overlapping pixels with a value of 1 will retain the value of 1 (i.e. the location meets the criteria), but if a pixel in any of the three rasters has the value of 0 (i.e. the location does not meet the criteria), then it will be 0 in the result. In this way, the result will contain only the overlapping areas that meet all of the appropriate criteria.
8.4.15 Combining rasters

1. Open the Raster Calculator (Raster Calculator…)
2. Build the following expression (with the appropriate names for your layers):
   \[\text{aspect}_45_{-135} \times \text{slope}_{15_{-60}} \times \text{rainfall}_{1000}\]
3. Set the output location to the Rasterprac directory
4. Name the output raster aspect_slope_rainfall.tif
5. Ensure that Open output file after running algorithm is checked
6. Click Run

The new raster now properly displays the areas where all three criteria are satisfied.

The next criterion that needs to be satisfied is that the area must be 250 m away from urban areas. We will satisfy this requirement by ensuring that the areas we compute are inside rural areas, and are 250 m or more from the edge of the area. Hence, we need to find all rural areas first.

8.4.16 Finding rural areas

1. Hide all layers in the Layers panel
2. Unhide the Zoning vector layer
3. Right-click on it and bring up the Attribute Table dialog. Note the many different ways that the land is zoned here. We want to isolate the rural areas. Close the Attribute table.
4. Right-click on the Zoning layer and select Filter… to bring up the Query Builder dialog
5. Build the following query:
   \[\text{"Gen_Zoning"} = \text{"Rural"}\]
   See the earlier instructions if you get stuck.
6. Click OK to close the Query Builder dialog. The query should return one feature.

You should see the rural polygons from the Zoning layer. You will need to save these.

1. In the right-click menu for Zoning, select Export Save Features As….
2. Save your layer under the Rasterprac directory
3. Name the output file rural.shp
4. Klicken Sie auf OK
5. Save the project

Now you need to exclude the areas that are within 250 m from the edge of the rural areas. Do this by creating a negative buffer, as explained below.
8.4.17 Creating a negative buffer

1. Click the menu item Vector \(\text{Geoprocessing Tools} \text{ Buffer…}\)
2. In the dialog that appears, select the rural layer as your input vector layer (Selected features only should not be checked)
3. Set Distance to -250. The negative value means that the buffer will be an internal buffer. Make sure that the units are meters in the dropdown menu.
4. Check Dissolve result
5. In Buffered, place the output file in the Rasterprac directory, and name it rural_buffer.shp
6. Click Save
7. Click Run and wait for the processing to complete
8. Close the Buffer dialog.

Make sure that your buffer worked correctly by noting how the rural_buffer layer is different from the rural layer. You may need to change the drawing order in order to observe the difference.

9. Remove the rural layer
10. Save the project

Now you need to combine your rural_buffer vector layer with the aspect_slope_rainfall raster. To combine them, we will need to change the data format of one of the layers. In this case, you will vectorize the raster, since vector layers are more convenient when we want to calculate areas.

8.4.18 Vectorizing the raster

1. Click on the menu item Raster \(\text{Conversion} \text{ Polygonize (Raster to Vector)}\)
2. Select the aspect_slope_rainfall raster as Input layer
3. Set Name of the field to create to suitable (the default field name is DN - Digital number data)
4. Save the output. Under Vectorized, select Save file as. Set the location to Rasterprac and name the file aspect_slope_rainfall_all.shp.
5. Ensure that Open output file after running algorithm is checked
6. Click Run
7. Close the dialog when processing is complete

All areas of the raster have been vectorized, so you need to select only the areas that have a value of 1 in the suitable field. (Digital Number.

1. Open the Query Builder dialog (right-click - Filter…) for the new vector layer
2. Build this query:

   ```sql
   "suitable" = 1
   ```

3. Klicken Sie auf OK
4. After you are sure the query is complete (and only the areas that meet all three criteria, i.e. with a value of 1 are visible), create a new vector file from the results, using the Export → Save Features As… in the layer’s right-click menu
5. Save the file in the Rasterprac directory
6. Name the file aspect_slope_rainfall_1.shp
7. Remove the aspect_slope_rainfall_all layer from your map
8. Save your project
When we use an algorithm to vectorize a raster, sometimes the algorithm yields what is called „Invalid geometries“, i.e. there are empty polygons, or polygons with mistakes in them, that will be difficult to analyze in the future. So, we need to use the „Fix Geometry“ tool.

8.4.19 Fixing geometry

1. In the Processing Toolbox, search for „Fix geometries“, and Execute… it
2. For the Input layer, select aspect_slope_rainfall_1
3. Under Fixed geometries, select Save file as, and save the output to Rasterprac and name the file fixed_aspect_slope_rainfall.shp.
4. Ensure that ☑ Open output file after running algorithm is checked
5. Click Run
6. Close the dialog when processing is complete

Now that you have vectorized the raster, and fixed the resulting geometry, you can combine the aspect, slope, and rainfall criteria with the distance from human settlement criteria by finding the intersection of the fixed_aspect_slope_rainfall layer and the rural_buffer layer.

8.4.20 Determining the Intersection of vectors

1. Click the menu item Vector ➘ Geoprocessing Tools ➘ Intersection…
2. In the dialog that appears, select the rural_buffer layer as Input layer
3. For the Overlay layer, select the fixed_aspect_slope_rainfall layer
4. In Intersection, place the output file in the Rasterprac directory
5. Name the output file rural_aspect_slope_rainfall.shp
6. Click Save
7. Click Run and wait for the processing to complete
8. Close the Intersection dialog.
   Make sure that your intersection worked correctly by noting that only the overlapping areas remain.
9. Save the project

The next criteria on the list is that the area must be greater than 6000 m². You will now calculate the polygon areas in order to identify the areas that are the appropriate size for this project.

8.4.21 Calculating the area for each polygon

1. Open the new vector layer’s right-click menu
2. Select Open attribute table
3. Click the ☑ Toggle editing button in the top left corner of the table, or press Ctrl+e
4. Click the ☑ Open field calculator button in the toolbar along the top of the table, or press Ctrl+i
5. In the dialog that appears, make sure that ☑ Create new field is checked, and set the Output field name to area.
   The output field type should be a decimal number (real). Set Precision to 1 (one decimal).
6. In the Expression area, type:

   \$area
This means that the field calculator will calculate the area of each polygon in the vector layer and will then populate a new integer column (called `area`) with the computed value.

7. Klicken Sie auf OK

8. Do the same thing for another new field called `id`. In Field calculator expression, type:

   ```
   $id
   ```

   This ensures that each polygon has a unique ID for identification purposes.

9. Click ⬇️ Toggle editing again, and save your edits if prompted to do so

### 8.4.22 Selecting areas of a given size

Now that the areas are known:

1. Build a query (as usual) to select only the polygons that are larger than 6000 m². The query is:

   ```
   "area" > 6000
   ```

2. Save the selection in the Rasterprac directory as a new vector layer called `suitable_areas.shp`.

You now have the suitable areas that meet all of the habitat criteria for the rare fynbos plant, from which you will pick the four areas that are nearest to the University of Cape Town.

### 8.4.23 Digitize the University of Cape Town

1. Create a new vector layer in the Rasterprac directory as before, but this time, use Point as Geometry type and name it `university.shp`

2. Ensure that it is in the correct CRS (Project CRS:EPSG:32733 – WGS 84 / UTM zone 33S)

3. Finish creating the new layer (click OK)

4. Hide all layers except the new university layer and the Streets layer.

5. Add a background map (OSM):

   1. Go to the Browser panel and navigate to XYZ Tiles 🌐 OpenStreetMap

   2. Drag and drop the OpenStreetMap entry to the bottom of the Layers panel

Using your internet browser, look up the location of the University of Cape Town. Given Cape Town’s unique topography, the university is in a very recognizable location. Before you return to QGIS, take note of where the university is located, and what is nearby.

6. Ensure that the Streets layer clicked on, and that the university layer is highlighted in the Layers panel

7. Navigate to the View 🌐 Toolbars menu item and ensure that Digitizing is selected. You should then see a toolbar icon with a pencil on it (Toggle editing). This is the Toggle Editing button.

8. Click the Toggle editing button to enter edit mode. This allows you to edit a vector layer

9. Click the Add Point Feature button, which should be nearby the Toggle editing button

10. With the Add feature tool activated, left-click on your best estimate of the location of the University of Cape Town

11. Supply an arbitrary integer when asked for the id

12. Klicken Sie auf OK

13. Click the Save Layer Edits button

14. Click the Toggle editing button to stop your editing session

15. Save the project

---

**8.4. Lesson: Supplementary Exercise**
8.4.24 Find the locations that are closest to the University of Cape Town

1. Go to the Processing Toolbox, locate the Join Attributes by Nearest algorithm (Vector general Join Attributes by Nearest) and execute it.
2. Input layer should be university, and Input layer 2 suitable_areas.
3. Set an appropriate output location and name (Joined layer).
4. Set the Maximum nearest neighbors to 4.
5. Ensure that Open output file after running algorithm is checked.
6. Leave the rest of the parameters with their default values.
7. Click Run.

The resulting point layer will contain four features - they will all have the location of the university and its attributes, and in addition, the attributes of the nearby suitable areas (including the id), and the distance to that location.

1. Open the attribute table of the result of the join.
2. Note the id of the four nearest suitable areas, and then close the attribute table.
3. Open the attribute table of the suitable_areas layer.
4. Build a query to select the four suitable areas closest to the university (selecting them using the id field).

This is the final answer to the research question.

For your submission, create a fully labeled layout that includes the semi-transparent hillshade layer over an appealing raster of your choice (such as the DEM or the slope raster, for example). Also include the university and the suitable_areas layer, with the four suitable areas that are closest to the university highlighted. Follow all the best practices for cartography in creating your output map.
Module: Erweiterungen

Erweiterungen bieten Ihnen die Möglichkeiten den Funktionsumfang von QGIS zu vergrößern. In diesem Modul wird Ihnen gezeigt, wie Erweiterungen Aktiviert und genutzt werden können.

9.1 Lesson: Installing and Managing Plugins

To begin using plugins, you need to know how to download, install and activate them. To do this, you will learn how to use the Plugin Installer and Plugin Manager.

The goal for this lesson: To understand and use QGIS' plugin system.

9.1.1 Follow Along: Managing Plugins

1. To open the Plugin Manager, click on the menu item Plugins → Manage and Install Plugins.
2. In the dialog that opens, find the Processing plugin:
3. Click in the box next to this plugin and uncheck it to deactivate it.
4. Click Close.
5. Looking at the menu, you will notice that the Processing menu is is now gone. This means that many of the processing functions you have been using before have disappeared! For example look at the Vector and Raster menus. This is because they are part of the Processing plugin, which needs to be activated to use them.
6. Open the Plugin Manager again and reactivate the Processing plugin by clicking in the checkbox next to it.
7. Close the dialog. The Processing menu and functions should be available again.
9.1.2 Follow Along: Installing New Plugins

The list of plugins that you can activate and deactivate draws from the plugins that you currently have installed. To install new plugins:

1. Select the Not Installed option in the Plugin Manager dialog. The plugins available for you to install will be listed here. This list will vary depending on your existing system setup.
2. Find information about the plugin by selecting it in the list
3. Install the one(s) you are interested in by clicking the Install Plugin button below the plugin information panel.

Besprekung: if the plugin has some error it will be listed in the Invalid tab. You can then contact the plugin owner to fix the problem.

9.1.3 Follow Along: Configuring Additional Plugin Repositories

The plugins that are available to you for installation depend on which plugin repositories you are configured to use. QGIS plugins are stored online in repositories. By default, only the official repository is active, meaning that you can only access plugins that are published there. Given the diversity of available tools, this repository should meet most of your needs.

It is possible, however, to try out more plugins than the default ones. First, you want to configure additional repositories. To do this:

1. Open the Settings tab in the Plugin Manager dialog
2. Click Add to find and add a new repository.
3. Provide a Name and URL for the new repository you want to configure and make sure the Enabled checkbox is selected.
9.1. Lesson: Installing and Managing Plugins

Not installed plugins

Here you see the list of all plugins available in the repositories, but which are not yet installed.
Click on the name to see details.
A plugin can be downloaded and installed by clicking on its name, and then click the 'Install plugin' button.

Data Plotly

D3 Plots for QGIS

Draw D3 plots in QGIS

Tags plots, graphs, d3, python, vector
More info homepage, bug tracker, code repository
Author Matteo Ghetta (Faunalia)
Available version 1.5
Kapitel 9. Module: Erweiterungen

QGIS Training Manual

Plugins | Settings

- Check for updates on startup
  every time QGIS starts
  Note: If this function is enabled, QGIS will inform you whenever a new plugin or plugin update is available. Otherwise, fetching repositories will be performed during opening of the Plugin Manager window.

- Show also experimental plugins
  Note: Experimental plugins are generally unsuitable for production use. These plugins are in early stages of development, and should be considered 'incomplete' or 'proof of concept' tools. QGIS does not recommend installing these plugins unless you intend to use them for testing purposes.

- Show also deprecated plugins
  Note: Deprecated plugins are generally unsuitable for production use. These plugins are unmaintained, and should be considered 'obsolete' tools. QGIS does not recommend installing these plugins unless you still need it and there are no other alternatives available.

Plugin repositories

<table>
<thead>
<tr>
<th>Status</th>
<th>Name</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>connected</td>
<td>QGIS Official Plugin Repository</td>
<td><a href="https://plugins.qgis.org/plugins/plugins.xml?qgis=3.2">https://plugins.qgis.org/plugins/plugins.xml?qgis=3.2</a></td>
</tr>
</tbody>
</table>

Reload all repositories

Repository details

Name: Faunalia
URL: https://www.faunalia.eu/qgis/plugins.xml
Parameters: ?qgis=3.2
Authentication
Enabled: ✓
4. You will now see the new plugin repo listed in the list of configured Plugin Repositories.

5. You can also select the option to display Experimental Plugins by selecting the *Show also experimental plugins* checkbox.

6. If you now switch back to the *Not Installed* tab, you will see that additional plugins are available for installation.

7. To install a plugin, click on it in the list and then on the *Install plugin* button.

**9.1.4 In Conclusion**

Installing plugins in QGIS should be straightforward and effective!

**9.1.5 What’s Next?**

Next we’ll introduce you to some useful plugins as examples.

**9.2 Lesson: Nützliche QGIS Erweiterungen**

Now that you can install, enable and disable plugins, let’s see how this can help you in practice by looking at some examples of useful plugins.

**The goal for this lesson:** To familiarize yourself with the plugin interface and get acquainted with some useful plugins.
9.2.1 Follow Along: The QuickMapServices Plugin

The QuickMapServices plugin is a simple and easy to use plugin that adds base maps to your QGIS project. It has many different options and settings, let's start to explore some of its features.

1. Start a new map and add the roads layer from the training_data Geopackage.
2. Install the QuickMapServices plugin.
3. Open the plugin's search tab by clicking on Web QuickMapServices Search QMS. This option of the plugin allows you to filter the available base maps by the current extent of the map canvas.
4. Click on the Filter by extent and you should see one service available.
5. Click on the Add button next to the map to load it.
6. The base map will be loaded and you will have a satellite background for the map.

The QuickMapServices plugin makes a lot of base maps available.

1. Close the Search QMS panel we opened before
2. Click again on Web QuickMapServices. The first menu lists different map providers with available maps:

But there is more.

If the default maps are not enough for you, you can add other map providers.
1. Click on Web QuickMapServices Settings and go to the More services tab.

2. Read carefully the message of this tab and if you agree click on the Get Contributed pack button.

If you now open the Web QuickMapServices menu you will see that more providers are available. Choose the one that best fits your needs!

### 9.2.2 Follow Along: The QuickOSM Plugin

With an incredible simple interface, the QuickOSM plugin allows you to download OpenStreetMap data.

1. Start a new empty project and add the roads layer from the training_data GeoPackage.

2. Install the QuickOSM plugin. The plugin adds two new buttons in the QGIS Toolbar and is accessible in the Vector QuickOSM menu.

3. Open the QuickOSM dialog. The plugin has many different tabs: we will use the Quick Query one.

4. You can download specific features by selecting a generic Key or be more specific and choose a specific Key and Value pair.

**Tipp:** if you are not familiar with the Key and Value system, click on the Help with key/value button. It will open a web page with a complete description of this concept of OpenStreetMap.

5. Look for railway in the Key menu and let the Value be empty: so we are downloading all the railway features without specifying any values.

6. Select Layer Extent in the next drop-down menu and choose roads.

7. Click on the Run query button.

After some seconds the plugin will download all the features tagged in OpenStreetMap as railway and load them directly into the map.

Nothing more! All the layers are loaded in the legend and are shown in the map canvas.

**Warnung:** QuickOSM creates temporary layer when downloading the data. If you want to save them permanently, click on the icon next to the layer and choose the options you prefer. Alternatively you can open the Advanced menu in QuickOSM and choose where to save the data in the Directory menu.
Follow Along: The QuickOSM Query engine

The quickest way to download data from QuickOSM plugin is using the Quick query tab and set some small parameters. But if you need some more specific data?

If you are an OpenStreetMap query master you can use QuickOSM plugin also with your personal queries.

QuickOSM has an incredible data parser that, together with the amazing query engine of Overpass, lets you download data with your specific needs.

For example: we want to download the mountain peaks that belongs into a specific mountain area known as Dolomites.

You cannot achieve this task with the Quick query tab, you have to be more specific and write your own query. Let’s try to do this.

1. Start a new project.
2. Open the QuickOSM plugin and click on the Query tab.
3. Copy and paste the following code into the query canvas:

```
<!--
This shows all mountains (peaks) in the Dolomites.
You may want to use the "zoom onto data" button. -->
<osm-script output="json">
  <!-- search the area of the Dolomites -->
  <query type="area">
    <has-kv k="place" v="region"/>
    <has-kv k="region:type" v="mountain_area"/>
    <has-kv k="name:en" v="Dolomites"/>
  </query>
  <print mode="body" order="quadtile"/>
  <!-- get all peaks in the area -->
  <query type="node">
    <area-query/>
    <has-kv k="natural" v="peak"/>
  </query>
  <print mode="body" order="quadtile"/>
  <!-- additionally, show the outline of the area -->
  <query type="relation">
    <has-kv k="place" v="region"/>
    <has-kv k="region:type" v="mountain_area"/>
    <has-kv k="name:en" v="Dolomites"/>
  </query>
  <print mode="body" order="quadtile"/>
  <recurse type="down"/>
  <print mode="skeleton" order="quadtile"/>
</osm-script>
```
4. And click on **Run Query**:

![](image)

The mountain peaks layer will be downloaded and shown in QGIS:

![](image)

You can write complex queries using the **Overpass Query language**. Take a look at some example and try to explore the query language.
9.2.4 Follow Along: The DataPlotly Plugin

The DataPlotly plugin allows you to create D3 plots of vector attributes data thanks to the plotly library.

1. Start a new project
2. Load the sample_points layer from the exercise_data/plugins folder
3. Install the plugin following the guidelines described in Follow Along: Installing New Plugins searching Data Plotly
4. Open the plugin by clicking on the new icon in the toolbar or in the Plugins → Data Plotly menu

In the following example we are creating a simple Scatter Plot of two fields of the sample_points layer. In the DataPlotly Panel:

1. Choose sample_points in the Layer filter, cl for the X Field and mg for the Y Field:
2. If you want you can change the colors, the marker type, the transparency and many other settings: try to change some parameters to create the plot below.
3. Once you have set all the parameters, click on the Create Plot button to create the plot.

The plot is interactive: this means you can use all the upper buttons to resize, move, or zoom in/out the plot canvas. Moreover, each element of the plot is interactive: by clicking or selecting one or more point on the plot, the corresponding point(s) will be selected in the plot canvas.

You can save the plot as a png static image or as an html file by clicking on the button or on the button in the lower right corner of the plot.

There is more. Sometimes it can be useful to have two (or more) plots showing different plot types with different variables on the same page. Let's do this!

1. Go back to the main plot settings tab by clicking on the button in the upper left corner of the plugin panel
2. Change the Plot Type to Box Plot
3. Choose group as Grouping Field and ph as Y Field
4. In the lower part of the panel, change the Type of Plot from SinglePlot to SubPlots and let the default option Plot in Rows selected.
5. Once done click on the Create Plot button to draw the plot

Now both scatter plot and box plot are shown in the same plot page. You still have the chance to click on each plot item and select the corresponding features in the map canvas.

Tipp: Each plot has its own manual page available in the tab. Try to explore all the plot types and see all the other settings available.

9.2.5 In Conclusion

There are many useful plugins available for QGIS. Using the built-in tools for installing and managing these plugins, you can find new plugins and make optimum use of them.
9.2. Lesson: Nützliche QGIS Erweiterungen

DataPlotly

Plot Type: Scatter Plot

Plot Parameters:
- Layer: sample_points
- Use only selected features
- X Field: 1.2 cl
- Y Field: 1.2 mg

Properties:
- Marker Color
- Marker Size: 10
- Stroke Color
- Stroke Width: 1
- Marker type: Points
- Point Type
- Transparency: 0

Type of Plot: SinglePlot

Clean Plot Canvas  Update Plot  Create Plot
9.2. Lesson: Nützliche QGIS Erweiterungen
Kapitel 9. Module: Erweiterungen
9.2.6 What’s Next?

Next we’ll look at how to use layers that are hosted on remote servers in real time.
Module: Online Resources

When considering data sources for a map, there is no need to be restricted to data which you have saved on the computer you’re working on. There are online data sources which you can load data from as long as you are connected to the Internet.

In this module, we’ll cover two kinds of web-based GIS services: Web Mapping Services (WMS) and Web Feature Services (WFS).

10.1 Lesson: Web Mapping Services

A Web Mapping Service (WMS) is a service hosted on a remote server. Similar to a website, you can access it as long as you have a connection to the server. Using QGIS, you can load a WMS directly into your existing map.

From the lesson on plugins, you will remember that it’s possible to load a new raster image from Google, for example. However, this is a once-off transaction: once you have downloaded the image, it doesn’t change. A WMS is different in that it’s a live service that will automatically refresh its view if you pan or zoom on the map.

**The goal for this lesson:** To use a WMS and understand its limitations.

10.1.1 Follow Along: Loading a WMS Layer

For this exercise, you can either use the basic map you made at the start of the course, or just start a new map and load some existing layers into it. For this example, we used a new map and loaded the original places, landuse and protected_areas layers and adjusted the symbology:

1. Load these layers into a new map, or use your original map with only these layers visible.

2. Before starting to add the WMS layer, deactivate „on the fly“ projection (Project Properties… CRS tab, check No projection (or unknown/non-Earth projection). This may cause the layers to no longer overlap properly, but don’t worry: we’ll fix that later.

3. To add WMS layers, click on the button to open the Data Source Manager dialog and enable the WMS/WMTS tab.

Remember how you connected to a SpatiaLite or GeoPackage database at the beginning of the course. The landuse, buildings, and roads layers are stored in a database. To use those layers, you first needed to connect to the database. Using a WMS is similar, with the exception that the layers are on a remote server.
4. To create a new connection to a WMS, click on the New button.

   You’ll need a WMS address to continue. There are several free WMS servers available on the Internet. One of these is terrestris, which makes use of the OpenStreetMap dataset.

5. To make use of this WMS, set it up in your current dialog, like this:

   ![Create a New WMS/WMTS Connection dialog](image)

   - The value of the Name field should be terrestris.
   - The value of the URL field should be https://ows.terrestris.de/osm/service.

6. Click OK. You should see the new WMS server listed:

7. Click Connect. In the list below, you should now see these new entries loaded:

   These are all the layers hosted by this WMS server.

8. Click once on the OSM-WMS layer. This will display its Coordinate Reference System:

   Since we’re not using WGS 84 for our map, let’s see all the CRSs we have to choose from.

   1. Click the Change… button. You will see a standard Coordinate Reference System Selector dialog.
   2. We want a projected CRS, so let’s choose WGS 84 / Pseudo Mercator.
      1. Enter the value pseudo in the Filter field:
      2. Choose WGS 84 / Pseudo Mercator from the list.
      3. Click OK. The Coordinate Reference System associated with the entry has changed.

9. Click Add and the new layer will appear in your map as OpenStreetMap WMS - by terrestris.

10. Close the Data Source Manager dialog if not done automatically

11. In the Layers panel, click and drag it to the bottom of the list.
10.1. Lesson: Web Mapping Services
12. Zoom out in order to get a global view of the layers. You will notice that your layers aren’t located correctly (near west of Africa). This is because „on the fly“ projection is disabled.

13. Let’s enable the reprojection again, but using the same projection as the OpenStreetMap WMS layer, which is WGS 84 / Pseudo Mercator.

1. Open the Project Properties… CRS tab
2. Uncheck No projection (or unknown/non-Earth projection)
3. Choose WGS 84 / Pseudo Mercator from the list.
4. Click OK.

14. Now right-click on one of your own layers in the Layers panel and click Zoom to layer extent. You should see the Swellendam area:

Note how the WMS layer’s streets and our own streets overlap. That’s a good sign!

The nature and limitations of WMS

By now you may have noticed that this WMS layer actually has many features in it. It has streets, rivers, nature reserves, and so on. What’s more, even though it looks like it’s made up of vectors, it seems to be a raster, but you can’t change its symbology. Why is that?

This is how a WMS works: it’s a map, similar to a normal map on paper, that you receive as an image. What usually happens is that you have vector layers, which QGIS renders as a map. But using a WMS, those vector layers are on the WMS server, which renders it as a map and sends that map to you as an image. QGIS can display this image, but can’t change its symbology, because all that is handled on the server.

This has several advantages, because you don’t need to worry about the symbology. It’s already worked out, and should be nice to look at on any competently designed WMS.

On the other hand, you can’t change the symbology if you don’t like it, and if things change on the WMS server, then they’ll change on your map as well. This is why you sometimes want to use a Web Feature Service (WFS) instead,
10.1. Lesson: Web Mapping Services
which gives you vector layers separately, and not as part of a WMS-style map. 
This will be covered in the next lesson, however. First, let’s add another WMS layer from the terrestris WMS server.

### 10.1.2 Try Yourself

1. Hide the OSM-WSM layer in the Layers panel.
2. Add the „ZAF CGS 1M Bedrock Lithostratigraphy“ WMS server at this URL: \[http://196.33.85.22/cgi-bin/ZAF_CGS_Bedrock_Geology/wms\]
3. Load the BEDROCKGEOLOGY layer into the map (you can also use the Layer \[Add Layer \[Add WMS/WMTS Layer…\] button to open the Data Source Manager dialog). Remember to check that it’s in the same WGS 84 / World Mercator projection as the rest of your map!
4. You might want to set its Encoding to JPEG and its Tile size option to 200 by 200, so that it loads faster:

   **Check your results**

### 10.1.3 Try Yourself

1. Hide all other WMS layers to prevent them from rendering unnecessarily in the background.
2. Add the „OGC“ WMS server at this URL: \[http://ogc.gbif.org:80/wms\]
3. Add the bluemarble layer.

   **Check your results**
Try Yourself

Part of the difficulty of using WMS is finding a good (free) server.

- Find a new WMS at directory.spatineo.com (or elsewhere online). It must not have associated fees or restrictions, and must have coverage over the Swellendam study area.

Remember that what you need in order to use a WMS is only its URL (and preferably some sort of description).

Check your results

In Conclusion

Using a WMS, you can add inactive maps as backdrops for your existing map data.

Further Reading

- Spatineo Directory
- OpenStreetMap.org list of WMS servers

What’s Next?

Now that you’ve added an inactive map as a backdrop, you’ll be glad to know that it’s also possible to add features (such as the other vector layers you added before). Adding features from remote servers is possible by using a Web Feature Service (WFS). That’s the topic of the next lesson.
10.2 Lesson: Web Feature Services

A Web Feature Service (WFS) provides its users with GIS data in formats that can be loaded directly in QGIS. Unlike a WMS, which provides you only with a map which you can’t edit, a WFS gives you access to the features themselves.

The goal for this lesson: To use a WFS and understand how it differs from a WMS.

10.2.1 Follow Along: Loading a WFS Layer

- Start a new map. This is for demo purposes and won’t be saved.
- Ensure that „on the fly“ re-projection is switched off.
- Click the Add WFS Layer button:
  - Click the New button.
  - In the dialog that appears, enter the Name as nsidc.org and the URL as https://nsidc.org/cgi-bin/atlas_south?version=1.1.0.

![Create a new WFS connection](image)

- Click OK, and the new connection will appear in your Server connections.
- Click the Connect. A list of the available layers will appear:
  - Find the layer south_poles_wfs.
  - Click on the layer to select it:
  - Click Add.

It may take a while to load the layer. When it has loaded, it will appear in the map. Here it is over the outlines of Antarctica (available on the same server, and by the name of antarctica_country_border):

How is this different from having a WMS layer? That will become obvious when you see the layers’ attributes.

- Open the south_poles_wfs layer’s attribute table. You should see this:

Since the points have attributes, we are able to label them, as well as change their symbology. Here’s an example:

- Add labels to your layer to take advantage of the attribute data in this layer.
## 10.2. Lesson: Web Feature Services

### Add WFS Layer from a Server

**Server connections**

- mskic.org

**Filter**

- Use title for layer name
- Coordinate reference system

**Table:**

<table>
<thead>
<tr>
<th>Title</th>
<th>Name</th>
<th>Abstract</th>
<th>Cache Feature</th>
<th>Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antarctic ice shelves</td>
<td>antarctic_ice_shelves_fill</td>
<td>Bohlander, J. and T. S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctic continent</td>
<td>antarctic_continent</td>
<td>Bohlander, J. and T. S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctic islands</td>
<td>antarctic_islands</td>
<td>Bohlander, J. and T. S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctica (excluding Antarctica)</td>
<td>land_excluding_antarctica</td>
<td>Center for International Mapping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctic surface elevation contours</td>
<td>antarctica_surface_elevation</td>
<td>Lu, H., K. Jezek, B. L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Countries (excluding Antarctica)</td>
<td>country_borders_excluding_antarctica</td>
<td>Center for International Mapping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctic coastline</td>
<td>antarctic_coastline</td>
<td>Bohlander, J. and T. S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctic island coastlines</td>
<td>antarctic_islands_coastlines</td>
<td>Bohlander, J. and T. S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctic megadunes</td>
<td>antarctic_megadunes</td>
<td>Bohlander, J. and T. S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctic research stations</td>
<td>antarctic_research_stations</td>
<td>Wikipedia contributor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctic ice core locations</td>
<td>antarctic_ice_cores</td>
<td>Maurer, J. compiler, 2...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Pole, Geographical</td>
<td>south_pole_geographic</td>
<td>Labels the location of...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Pole, Magnetic</td>
<td>south_pole_magnetic</td>
<td>McClean, S. 24 Janu...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Pole, Geomagnetic</td>
<td>south_pole_geomagnetic</td>
<td>McClean, S. 24 Janu...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Pole of Inaccessibility</td>
<td>south_pole_inaccessibility</td>
<td>Wikipedia contributor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Pole of Cold</td>
<td>south_pole_cold</td>
<td>Wikipedia contributor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Use title for layer name**

**Coordinate reference system**

- EPSG:3031

**Help** | **Add** | **Build query**
Attribute table – south_poles_wfs :: Features total: 5, filtered: 5, selected: 0

<table>
<thead>
<tr>
<th>Id</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Geographic South Pole</td>
</tr>
<tr>
<td>1</td>
<td>Magnetic South Pole (2005)</td>
</tr>
<tr>
<td>2</td>
<td>Geomagnetic South Pole (2005)</td>
</tr>
<tr>
<td>3</td>
<td>South Pole of Inaccessibility</td>
</tr>
<tr>
<td>4</td>
<td>South Pole of Cold</td>
</tr>
</tbody>
</table>
Differences from WMS layers

A Web Feature Service returns the layer itself, not just a map rendered from it. This gives you direct access to the data, meaning that you can change its symbology and run analysis functions on it. However, this is at the cost of much more data being transmitted. This will be especially obvious if the layers you're loading have complicated shapes, a lot of attributes, or many features; or even if you're just loading a lot of layers. WFS layers typically take a very long time to load because of this.

10.2.2 Follow Along: Querying a WFS Layer

Although it is of possible to query a WFS layer after having loaded it, it's often more efficient to query it before you load it. That way, you're only requesting the features you want, meaning that you use far less bandwidth.

For example, on the WFS server we're currently using, there is a layer called countries (excluding Antarctica). Let's say that we want to know where South Africa is relative to the south_poles_wfs layer (and perhaps also the antarctica_country_border layer) that's already been loaded.

There are two ways to do this. You can load the whole countries … layer, and then build a query as usual once it's loaded. However, transmitting the data for all the countries in the world and then only using the data for South Africa seems a bit wasteful of bandwidth. Depending on your connection, this dataset can take several minutes to load.

The alternative is to build the query as a filter before even loading the layer from the server.

- In the Add WFS Layer … dialog, connect to the server we used before and you should see the list of available layers.
- Double-click next to the countries … layer in the Filter field, or click Build query:
- In the dialog that appears, build the query "Countryeng" = 'South Africa':
- It will appear as the Filter value:
- Click Add with the countries layer selected as above. Only the country with the Countryeng value of South Africa will load from that layer:

You don’t have to, but if you tried both methods, you’ll notice that this is a lot faster than loading all the countries before filtering them!
Notes on WFS availability

It is rare to find a WFS hosting features you need, if your needs are very specific. The reason why Web Feature Services are relatively rare is because of the large amounts of data that must be transmitted to describe a whole feature. It is therefore not very cost-effective to host a WFS rather than a WMS, which sends only images.

The most common type of WFS you’ll encounter will therefore probably be on a local network or even on your own computer, rather than on the Internet.

10.2.3 In Conclusion

WFS layers are preferable over WMS layers if you need direct access to the attributes and geometries of the layers. However, considering the amount of data that needs to be downloaded (which leads to speed problems and also a lack of easily available public WFS servers) it’s not always possible to use a WFS instead of a WMS.

10.2.4 What’s Next?

Next, you’ll see how to use QGIS Server to provide OGC services.
10.2. Lesson: Web Feature Services

Example of using the expression string builder to create a condition for a query:

```
"CountryEng" = 'South Africa'
```

Note:
Loading field values from WFS layers isn't supported, before the layer is actually inserted, i.e., when building queries.
Kapitel 10. Module: Online Resources
Module: QGIS Server

Module contributed by Tudor Bărăscu.

In this module, we'll cover how to install and use QGIS Server.

For an introduction to what QGIS Server is (see the label_qgisserver section)

11.1 Lesson: Install QGIS Server

The goal for this lesson: To learn how to install QGIS Server on Debian Stretch. With negligible variations you can also follow it for any Debian based distribution like Ubuntu and its derivatives.

Bemerkung: In Ubuntu you can use your regular user, prepending sudo to commands requiring admin permissions. In Debian you can work as admin (root), without using sudo.

11.1.1 Follow Along: Install from packages

In this lesson we’re going to do only the install from packages as shown here.

Install QGIS Server with:

```
apt install qgis-server
# if you want to install server plugins, also:
apt install python-qgis
```

QGIS Server should be used in production without QGIS Desktop (with the accompanying X Server) installed on the same machine.
11.1.2 Follow Along: QGIS Server Executable

The QGIS Server executable is `qgis_mapserv.fcgi`. You can check where it has been installed by running `find / -name 'qgis_mapserv.fcgi'` which should output something like `/usr/lib/cgi-bin/qgis_mapserv.fcgi`.

Optionally, if you want to do a command line test at this time you can run the `/usr/lib/cgi-bin/qgis_mapserv.fcgi` command which should output something like:

```
QFSFileEngine::open: No file name specified
Warning 1: Unable to find driver ECW to unload from GDAL_SKIP environment variable.
Warning 1: Unable to find driver ECW to unload from GDAL_SKIP environment variable.
Warning 1: Unable to find driver JP2ECW to unload from GDAL_SKIP environment...
--variable.
Warning 1: Unable to find driver ECW to unload from GDAL_SKIP environment variable.
Warning 1: Unable to find driver JP2ECW to unload from GDAL_SKIP environment...
--variable.
```

Content-Length: 206
Content-Type: text/xml; charset=utf-8

```
<ServiceExceptionReport version="1.3.0" xmlns="https://www.opengis.net/ogc">
 <ServiceException code="Service configuration error">
  Service unknown or unsupported</ServiceException>
</ServiceExceptionReport>
```

This is a good thing, it tells you we’re on the right track as the server is saying that we haven’t asked for a supported service. We’ll see later on how to make WMS requests.

11.1.3 Follow Along: HTTP Server Configuration

In order to access on the installed QGIS server from an Internet Browser we need to use an HTTP server.

In this lesson we’re going to use the Apache HTTP server, colloquially called Apache.

First we need to install Apache by running the following command in a terminal:

```
apt install apache2 libapache2-mod-fcgid
```

You can run QGIS server on your default website, or configure a virtualhost specifically for this, as follows.

In the `/etc/apache2/sites-available` directory let's create a file called `qgis.demo.conf`, with this content:

```
<VirtualHost *:80>
  ServerAdmin webmaster@localhost
  ServerName qgis.demo
  DocumentRoot /var/www/html

  # Apache logs (different than QGIS Server log)
  ErrorLog ${APACHE_LOG_DIR}/qgis.demo.error.log
  CustomLog ${APACHE_LOG_DIR}/qgis.demo.access.log combined

  # Longer timeout for WPS... default = 40
  FcgidIOTimeout 120

  FcgidInitialEnv LC_ALL "en_US.UTF-8"
  FcgidInitialEnv PYTHONIOENCODING "UTF-8"
  FcgidInitialEnv LANG "en_US.UTF-8"

  # QGIS log (different from apache logs) see https://docs.qgis.org/testing/en/...
</VirtualHost>
```

This is a good thing, it tells you we’re on the right track as the server is saying that we haven’t asked for a supported service. We’ll see later on how to make WMS requests.

(Forsetzung auf der nächsten Seite)
You can do the above in a linux Desktop system by pasting and saving the above configuration after doing `nano /etc/apache2/sites-available/qgis.demo.conf`.

**Bemerkung:** Siehe einige der Konfigurationsoptionen werden in der Server server_env_variables-Sektion erklärt.

Let's now create the directories that will store the QGIS Server logs and the authentication database:

```bash
echo 'mkdir /var/log/qgis/
chown www-data:www-data /var/log/qgis

echo 'mkdir /home/qgis/qgisserverdb
chown www-data:www-data /home/qgis/qgisserverdb
```

**Bemerkung:** `www-data` ist der Apache-User auf Debian-basierten Systemen und wir benötigen Apache, um Zugriff auf diese Orte oder Dateien zu haben. Die `chown www-data...` Befehle ändern den Besitzer der entsprechenden Verzeichnisse und Dateien auf `www-data`.

We can now enable the virtual host, enable the `fcgid` mod if it's not already enabled and restart the `apache2` service.
**QGIS Training Manual**

**service:**

```
a2enmod fcgid
a2ensite qgis.demo
systemctl restart apache2
```

**Bemerkung:** If you installed QGIS Server without running an X Server (included in Linux Desktop) and if you also want to use the GetPrint command then you should install a fake X Server and tell QGIS Server to use it. You can do that by running the following commands.

Install xvfb:

```
apt install xvfb
```

Create the service file:

```
sh -c \
"echo \n'[Unit]
Description=X Virtual Frame Buffer Service
After=network.target

[Service]
ExecStart=/usr/bin/Xvfb :99 -screen 0 1024x768x24 -ac +extension GLX +render -
→noreset

[Install]
WantedBy=multi-user.target' \n> /etc/systemd/system/xvfb.service"
```

Enable, start and check the status of the xvfb.service:

```
systemctl enable xvfb.service
systemctl start xvfb.service
systemctl status xvfb.service
```

In the above configuration file there's a FcgidInitialEnv DISPLAY ":99" that tells QGIS Server instances to use display no. 99. If you're running the Server in Desktop then there's no need to install xvfb and you should simply comment with # this specific setting in the configuration file. More info at [https://www.itopen.it/qgis-server-setup-notes/](https://www.itopen.it/qgis-server-setup-notes/).

Now that Apache knows that he should answer requests to `http://qgis.demo` we also need to setup the client system so that it knows who qgis.demo is. We do that by adding `127.0.0.1 qgis.demo` in the hosts file. We can do it with `sh -c "echo '127.0.0.1 qgis.demo' >> /etc/hosts"`. Replace `127.0.0.1` with the IP of your server.

**Bemerkung:** Remember that both the myhost.conf and /etc/hosts files should be configured for our setup to work. You can also test the access to your QGIS Server from other clients on the network (e.g. Windows or macOS machines) by going to their /etc/hosts file and point the myhost name to whatever IP the server machine has on the network. You can be sure that that specific IP is not 127.0.0.1 as that's the local IP, only accessible from the local machine. On *nix machines the hosts file is located in /etc, while on Windows it's under the C:\Windows\System32\drivers\etc directory. Under Windows you need to start your text editor with administrator privileges before opening the hosts file.

We can test one of the installed qgis servers with a http request from command line with `curl http://qgis.demo/cgi-bin/qgis_mapserv.fcgi` which should output:
Apache is now configured.

Also, from your web browser you can check the capabilities of the server:

http://qgis.demo/cgi-bin/qgis_mapserv.fcgi?SERVICE=WMS&VERSION=1.3.0&REQUEST=GetCapabilities

11.1.4 Follow Along: Create another virtual host

Let’s create another Apache virtual host pointing to QGIS Server. You can choose whatever name you like (coco, bango, super.duper.training, example.com, etc.) but for simplicity sake we’re going to use myhost.

- Let’s set up the myhost name to point to the localhost IP by adding 127.0.0.1 x to the /etc/hosts with the following command: sh -c "echo '127.0.0.1 myhost' > /etc/hosts" or by manually editing the file with gedit /etc/hosts.

- We can check that myhost points to the localhost by running in the terminal the ping myhost command which should output:

```
qgis@qgis:~$ ping myhost
PING myhost (127.0.0.1) 56(84) bytes of data.
64 bytes from localhost (127.0.0.1): icmp_seq=1 ttl=64 time=0.024 ms
64 bytes from localhost (127.0.0.1): icmp_seq=2 ttl=64 time=0.029 ms
```

- Let’s try if we can access QGIS Server from the myhost site by doing: curl http://myhost/cgi-bin/qgis_mapserv.fcgi or by accessing the url from your Debian box browser. You will probably get:

```
<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html><head></head><body><h1>404 Not Found</h1><p>The requested URL /cgi-bin/qgis_mapserv.fcgi was not found on this server.</p><hr><address>Apache/2.4.25 (Debian) Server at myhost Port 80</address></body></html>
```

- Apache doesn’t know that he’s supposed to answer requests pointing to the server named myhost. In order to setup the virtual host the simplest way would be to make a myhost.conf file in the /etc/apache2/sites-available directory that has the same content as qgis.demo.conf except for the Server-Name line that should be ServerName myhost. You could also change where the logs go as otherwise the logs for the two virtual hosts would be shared but this is optional.

- Let’s now enable the virtual host with a2ensite myhost.conf and then reload the Apache service with service apache2 reload.

- If you try again to access the http://myhost/cgi-bin/qgis_mapserv.fcgi url you’ll notice everything is working now!
11.1.5 In Conclusion

You learned how to install different QGIS Server versions from packages, how to configure Apache with QGIS Server, on Debian based Linux distros.

11.1.6 What’s Next?

Now that you’ve installed QGIS Server and it’s accessible through the HTTP protocol, we need to learn how to access some of the services it can offer. The topic of the next lesson is to learn how to access QGIS Server WMS services.

11.2 Lesson: Serving WMS

Let’s download the Training demo data and unzip the files in the qgis-server-tutorial-data subdirectory to any directory. We recommend that you simply create a /home/qgis/projects directory and put your files there in order to avoid possible permissions problems.

The demo data contains a QGIS project named world.qgs that is already prepared to be served with QGIS Server. If you want to use your own project or you want to learn how a project is prepared see the Creating wms from project section.

Bemerkung: This module presents the URLs so that the audience can easily distinguish the parameters and parameter values. While the normal format is:

```
...&field1=value1&field2=value2&field3=value3
```

this tutorial uses:

```
&field1=value1
&field2=value2
&field3=value3
```

Pasting them into Mozilla Firefox works properly but other web browsers like Chrome may add unwanted spaces between the field:parameter pairs. So, if you encounter this issue you can either use Firefox or modify the URLs so that they’re in one line format.

Let’s make a WMS GetCapabilities request in the web browser or with curl:

```
http://qgisplatform.demo/cgi-bin/qgis_mapserv.fcgi
?SERVICE=WMS
&VERSION=1.3.0
&REQUEST=GetCapabilities
&map=/home/qgis/projects/world.qgs
```

In the Apache config from the previous lesson the QGIS_PROJECT_FILE variable sets the default project to /home/qgis/projects/world.qgs. However, in the above request we made use of the map parameter to be explicit and to show it can be used to point at any project. If you delete the map parameter from the above request QGIS Server will output the same response.

By pointing any WMS client to the GetCapabilities URL, the client gets in response an XML document with metadata of the Web Map Server’s information, e.g. what layers does it serve, the geographical coverage, in what format, what version of WMS etc.

As QGIS is also a ogc-wms you can create a new WMS server connection with the help of the above GetCapabilities url. See the Lesson: Web Mapping Services or the ogc-wms-servers section on how to do it.

By adding the countries WMS layer to your QGIS project you should get an image like the one below:
Abb. 11.1: QGIS Desktop consuming the QGIS Server countries layer WMS service

11.2. Lesson: Serving WMS
Bemerkung: QGIS Server serves layers that are defined in the `world.qgs` project. By opening the project with QGIS you can see there are multiple styles for the countries layer. QGIS Server is also aware of this and you can choose the style you want in your request. The `classified_by_population` style was chosen in the above image.

### 11.2.1 Logging

When you’re setting up a server, the logs are always important as they show you what’s going on. We have setup in the `*.conf` file the following logs:

- QGIS Server log at `/logs/qgisserver.log`
- qgisplatform.demo Apache access log at `qgisplatform.demo.access.log`
- qgisplatform.demo Apache error log at `qgisplatform.demo.error.log`

The log files are simply text files so you can use a text editor to check them out. You can also use the `tail` command in a terminal: `sudo tail -f /logs/qgisserver.log`.

This will continuously output in the terminal what’s written in that log file. You can also have three terminals opened for each of the log files like so:

When you use QGIS Desktop to consume the QGIS Server WMS services you will see all the requests QGIS sends to the Server in the access log, the errors of QGIS Server in the QGIS Server log etc.

Bemerkung:

- If you look at the logs in the following sections you should get a better understanding on what’s happening.
- By restarting Apache while looking in the QGIS Server log you can find some extra pointers on how things work.

### 11.2.2 GetMap requests

In order to display the `countries` layer, QGIS Desktop, like any other WMS client, is using `GetMap` requests.

A simple request looks like:

```
http://qgisplatform.demo/cgi-bin/qgis_mapserv.fcgi
?MAP=/home/qgis/projects/world.qgs
&SERVICE=WMS
&VERSION=1.3.0
&REQUEST=GetMap
&BBOX=-432786,4372992,3358959,7513746
&SRS=EPSG:3857
&WIDTH=665
&HEIGHT=551
&LAYERS=countries
&FORMAT=image/jpeg
```

The above request should output the following image:

**Figure: simple GetMap request to QGIS Server**
Abb. 11.2: Using the `tail` command to visualise QGIS Server logs output

```
qqis@qqis:~

qqis@qqis:~$ sudo tail -f /var/log/apache2/qqisplatform.demo.error.log
```

```
qqis@qqis:~$ sudo tail -f /var/log/apache2/qqisplatform.demo.error.log
```

```
qqis@qqis:~

200 11378 "" ""curl/7.52.1"
127.0.0.1 - - [17/Mar/2017:04:09:41 -0400] "GET /cgi-bin/qgis_mapserve.fcgi?SERVICE=WMS&VERSION=1.3.0&REQUEST=GetCapabilities&map=home/qgis/projects/world.qgs HTTP/1.1" 200 11378 "" ""curl/7.52.1"
127.0.0.1 - - [17/Mar/2017:04:09:42 -0400] "GET /cgi-bin/qgis_mapserve.fcgi?SERVICE=WMS&VERSION=1.3.0&REQUEST=GetCapabilities&map=home/qgis/projects/world.qgs HTTP/1.1" 200 11378 "" ""curl/7.52.1"
```

```
qqis@qqis:~

[1732][04:09:42] Sent 1 blocks of 11205 bytes
[1732][04:09:42] Request finished in 3 ms
```

```
qqis@qqis:~$ sudo tail -f /logs/qgisserver.log
```

```
[1732][04:09:42] MAP:home/qgis/projects/world.qgs
[1732][04:09:42] REQUEST:GetCapabilities
[1732][04:09:42] SERVICE=WMS
[1732][04:09:42] VERSION:1.3.0
[1732][04:09:42] Found capabilities document in cache
[1732][04:09:42] Checking byte array is ok to set...
[1732][04:09:42] Byte array looks good, setting response...
[1732][04:09:42] Sending HTTP response
[1732][04:09:42] Sent 1 blocks of 11205 bytes
[1732][04:09:42] Request finished in 3 ms
```
Abb. 11.3: Qgis Server response after a simple GetMap request
11.2.3 Try Yourself Change the Image and Layers parameters

Based on the request above, let’s replace the countries layer with another.

In order to see what other layers are available you could open up the world.qgs project in QGIS and look at its contents. Keep in mind though that the WMS clients don’t have access to the QGIS project, they just look at the capabilities document contents.

Also, there’s a configuration option so that some of the layers existing in the QGIS project are ignored by QGIS when serving the WMS service.

So, you could look at the layer list when you point QGIS Desktop to the GetCapabilities URL or you could try yourself finding other layer names in the GetCapabilities XML response.

One of the layer names that you could find and works is countries_shapeburst. You may find others but keep in mind some may not be visible at such a small scale so you could get a blank image as response.

You can also play around with others parameters from above, like changing the returned image type to image/png.

11.2.4 Follow Along: Use Filter, Opacities and Styles parameters

Let’s do another request that adds another layer, some of the extra-getmap-parameters, FILTER and OPACITIES, but also uses the standard STYLES parameter.

http://qgisplatform.demo/cgi-bin/qgis_mapserv.fcgi
?MAP=/home/qgis/projects/world.qgs
&SERVICE=WMS
&VERSION=1.3.0
&REQUEST=GetMap
&BBOX=-432786,4372992,3358959,7513746
&SRS=EPSG:3857
&WIDTH=665
&HEIGHT=551
&FORMAT=image/jpeg
&LAYERS=countries,countries_shapeburst
&STYLES=classified_by_name,blue
&OPACITIES=255,30
&FILTER=countries:"name" IN ('Germany', 'Italy')

The above request should output the following image:

As you can see from the above image, among other things, we told QGIS Server to render only Germany and Italy from the countries layer.

11.2.5 Follow Along: Use Redlining

Let’s do another GetMap request that makes use of the qgisserver-redlining feature and of the SELECTION parameter detailed in the extra-getmap-parameters section:

http://qgisplatform.demo/cgi-bin/qgis_mapserv.fcgi
?MAP=/home/qgis/projects/world.qgs
&SERVICE=WMS
&VERSION=1.3.0
&REQUEST=GetMap
&BBOX=-432786,4372992,3358959,7513746
&SRS=EPSG:3857
&WIDTH=665

(Fortsetzung auf der nächsten Seite)
Abb. 11.4: Response to a GetMap request with FILTER and OPACITIES parameters
Pasting the above request in your web browser should output the following image:

Abb. 11.5: Response to a request with the REDLINING feature and SELECTION parameter

You can see from the above image that the countries with the 171 and 65 ids were highlighted in yellow (Romania and France) by using the SELECTION parameter and we used the REDLINING feature to overlay a rectangle with the QGIS Tutorial label.
11.2.6 GetPrint requests

One very nice feature of QGIS Server is that it makes use of the QGIS Desktop print layouts. You can learn about it in the server_getprint section.

If you open the world.qgs project with QGIS Desktop you will find a print layout named Population distribution. A simplified GetPrint request that exemplifies this amazing feature is:

```
http://qgisplatform.demo/cgi-bin/qgis_mapserv.fcgi
?map=/home/qgis/projects/world.qgs
&SERVICE=WMS
&VERSION=1.3.0
&REQUEST=GetPrint
&FORMAT=pdf
&TRANSPARENT=true
&SRS=EPSG:3857
&DPI=300
&TEMPLATE=Population distribution
&map0:extent=-432786,4372992,3358959,7513746
&LAYERS=countries
```

Abb. 11.6: Shows the pdf resulted from the above GetPrint request

Naturally, it's hard to write your GetMap, GetPrint etc. requests. QGIS Web Client or QWC is a Web client project that can work alongside QGIS Server so that you can publish your projects on the Web or help you create QGIS Server requests for a better understanding about the possibilities.

You can install it like this:

- As user qgis go to the home directory with cd /home/qgis.
- Download the QWC project from here and unzip it.
- Make a symbolic link to the /var/www/html directory as it's the DocumentRoot that we've setup in the virtual host configuration. If you unzipped the archive under /home/qgis/Downloads/QGIS-Web-Client-master we can do that with sudo ln -s /home/qgis/Downloads/QGIS-Web-Client-master /var/www/html/.

Now you should be able to see the Map as in the following figure:

If you click the Print button in QWC you can interactively create GetPrint requests. You can also click the ? icon in the QWC to access the available help so that you can better discover the QWC possibilities.
Abb. 11.7: QGIS Web Client consuming the world.qgs project
11.2.7 In Conclusion

You learned how use QGIS Server to provide WMS Services.

11.2.8 What’s Next?

Next, you’ll see how to use QGIS as a frontend for the famous GRASS GIS.
GRASS (Geographic Resources Analysis Support System) ist ein bekanntes Open Source GIS mit einem breiten Feld an GIS Funktionen. Es wurde zuerst 1984 veröffentlicht und wurde seit dem vielfältig verbessert und in der Funktionalität erweitert. QGIS erlaubt es, die mächtigen GRASS Werkzeuge direkt einzusetzen.

12.1 Lesson: GRASS-Einrichtung

Die Nutzung von GRASS in QGIS erfordert etwas Umdenken in Bezug auf die Benutzeroberfläche. Man arbeitet nicht direkt in QGIS sondern in GRASS über QGIS. Stellen Sie daher sicher, dass QGIS Desktop mit GRASS Unterstützung installiert ist.

1. Öffnen Sie zuerst ein neues QGIS Projekt.
2. Schalten Sie dann im Plugin Manager die Erweiterung GRASS ein:

   Die GRASS Werkzeugleiste und das GRASS Bedienfeld werden nun angezeigt.

Ziel dieser Übung: Erstellung eines GRASS Projektes in QGIS.

12.1.1 Follow Along: Start einer neuen GRASS Sitzung

To launch GRASS from within QGIS, you need to activate it as with any other plugin:

1. Öffne zuerst ein neues QGIS Projekt.
2. Wir schalten dazu im Plugin Manager die Erweiterung GRASS ein:

   Das GRASS Bedienfeld ist noch nicht aktiv. Vorher muss ein Mapset erstellt werden. GRASS arbeitet immer in einer Datenbankumgebung. Das bedeutet, dass die Daten die verwendet werden sollen, in die Datenbank importiert werden müssen.

   Die GRASS Datenbank hat eine überschaubare Struktur, selbst wenn sie auf den ersten Blick sehr kompliziert wirkt. Am Wichtigsten ist es zu verstehen, dass die oberste Ebene der Datenbank die Location ist. Jede Location kann mehrere verschiedene Mapset enthalten: in jedem Mapset ist das PERMANENT Mapset enthalten. Es wird standardmäßig von GRASS erstellt. Jedes Mapset enthält die Daten (Raster, Vektor usw.) in einer bestimmten Struktur, aber keine Sorge, darum kümmert sich GRASS.

   Just remember: Location contains Mapset that contains the data. For more information visit the GRASS website.
Abb. 12.1: GRASS Werkzeugleiste
Abb. 12.2: GRASS Bedienfeld
12.1.2 Follow Along: Starten eines neuen GRASS Projektes

1. Klicke im Menü auf Erweiterungen –> GRASS –> Neues Mapset:
   Du wirst nun nach dem GRASS Datenbankverzeichnis gefragt.
2. Wir geben das Verzeichnis ein, das GRASS für die Einrichtung seiner Datenbank verwenden wird.

GRASS muss eine Location erstellen, die die maximale Ausdehnung des Arbeitsgebietes beschreibt und auch GRASS Region genannt wird.


1. Wir nennen die neue location SouthAfrica:
2. Klicke auf Weiter.
3. Wir werden mit WGS 84 arbeiten, d.h. wir suchen und wählen dieses KBS:
4. Klicke auf Weiter.
5. Wähle nun die Region South Africa aus dem dropdown Menü und klicke auf Setzen:
6. Klicke auf Weiter.
7. Wir erstellen ein mapset, d.h. die Kartendatei in der wir arbeiten.
   Wenn wir fertig sind, wird ein Dialogfenster mit einer Zusammenfassung der eingegebenen Informationen angezeigt.
8. Klicke auf Abschließen.
9. Klicke in der Erfolgsmeldung auf OK.
Das GRASS Bedienfeld wird jetzt aktiviert und wir können alle GRASS Werkzeuge nutzen.

12.1.3 Follow Along: Vektordaten in GRASS laden

Wir haben jetzt eine leere Karte. Bevor wir die GRASS Werkzeuge nutzen können, müssen wir Daten in die GRASS Datenbank laden, d.h. in das Mapset. Man kann GRASS Werkzeuge nicht mit Layern verwenden, die nicht in einem GRASS Mapset geladen sind.

Es gibt verschiedene Möglichkeiten, Daten in die GRASS Datenbank zu laden. Wir beginnen mit der Ersten.

Follow Along: Daten mit Hilfe des QGIS Browsers laden

Im Kapitel The Browser Panel sahen wir, dass das Browser Bedienfeld der einfachste Weg ist, um Daten in QGIS zu laden.

GRASS Daten werden vom QGIS Browser als echte GRASS Daten erkannt. Dies erkennt man am GRASS Icon neben dem GRASS Mapset. Außerdem wird das Icon neben einem geöffneten Mapset angezeigt.

Bemerkung: Man sieht eine Kopie der GRASS Location als normalen Ordner: die GRASS Mapset Daten liegen im Ordner

Layer aus einem Ordner können mit drag and drop einfach in das GRASS Mapset gezogen werden.

Let’s try to import the roads layer into the grass_mapset Mapset of the SouthAfrica Location.

Go to the Browser, and simply drag the roads layer from the training_data.gpkg GeoPackage file into the grass_mapset Mapset.

GRASS data are stored in tree directory structure. The GRASS database is the top-level directory in this tree structure.
The GRASS location is a collection of maps for a particular territory or project.
New Mapset

Projection

- Not defined
- Projection

Filter 4326

Recently used coordinate reference systems

<table>
<thead>
<tr>
<th>Coordinate Reference System</th>
<th>Authority ID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Coordinate reference systems of the world

- Geographic Coordinate System
  - WGS 84
    - EPSG:4326

Selected CRS WGS 84

Extent: -180.00, -90.00, 180.00, 90.00

Proj4: +proj=longlat +datum=WGS84 +no_defs

< Back  Next >  Cancel
The GRASS region defines a workspace for raster modules. The default region is valid for one location. It is possible to set a different region in each mapset. It is possible to change the default location region later.
New Mapset

Mapset

New mapset

grass_mapset

The GRASS mapset is a collection of maps used by one user. A user can read maps from all mapsets in the location but he can open for writing only his mapset (owned by user).
Create New Mapset

Database: /home/matteo/exercise_data/grassdata
Location: SouthAfrica
Mapset: grass_mapset
✔ Open new mapset
**Tipp:** Man kann außerdem Layer direkt aus dem Layerinhaltverzeichnis in ein Mapset im Browser Bedienfeld ziehen. Damit wird der Workflow stark vereinfacht!

### Follow Along: Daten mit Hilfe des GRASS Bedienfeldes laden

Wir werden nun die *lange* Methode zum laden des Layers `rivers.shp` in das Mapset nutzen.

1. Wir laden wie gewohnt Daten in QGIS und verwenden den Datensatz `rivers.shp` (zu finden im Ordner `exercise_data/shapefile/`).

2. Sobald die Daten in QGIS geladen sind, klicken wir auf den Filter Kasten im GRASS Bedienfeld und suchen das Vektorimportwerkzeug indem wir `v.in.ogr.qgis` im Filterkasten eingeben:

   **Warnung:** Es werden 2 ähnliche Werkzeuge angezeigt: `v.in.ogr.qgis` und `v.in.ogr.qgis.loc`. Wir verwenden das *erste* Werkzeug.

   Das `v` steht für *Vektor*, `in` steht für die Funktion Daten in die GRASS Datenbank zu importieren, `ogr` ist die Softwarebibliothek die zum Laden von Vektordaten verwendet wird und `qgis` bedeutet, dass das Werkzeug nach bereits in QGIS geladenen Layern sucht.

3. Nachdem wir das Werkzeug gefunden haben, klicken wir darauf, um es zu öffnen. Wählen Sie den Layer `rivers` aus der Auswahlliste `Geladener Layer` und vergeben für die Ausgabe den Namen `g_rivers`, um Verwechslungen vorzubeugen:

   **Bemerkung:** Beachten Sie, dass mit dem Knopf *Fortgeschrittene Optionen einblenden* weitere Optionen verfügbar sind. Hier ist Möglichkeit der Einschränkung des Datenimports mit Hilfe einer *WHERE*
Klausel in der zum Import genutzten SQL Abfrage vorhanden.

4. Klicken Sie auf **Starten** um den Import zu beginnen.
6. Schließen Sie zuerst das Importwerkzeug (Klick auf den Knopf *Schließen* im rechten Bereich neben dem Knopf *Ergebnis visualisieren*) und danach das *GRASS Werkzeuge* Fenster.
7. Entfernen Sie das Original des Layers *rivers*.

In unserer QGIS Karte wird jetzt nur noch der in GRASS importierte Layer angezeigt.

**12.1.4 Follow Along: Rasterdaten in GRASS laden**

Rasterdaten importiert man auf dieselbe Weise wie Vektordaten.
Wir werden in das GRASS Mapset den Layer *srtm_41_19_4326.tif* importieren.

**Bemerkung:** Der Rasterlayer liegt schon im richtigen KBS **WGS 84** vor. Layer mit abweichendem KBS müssen vorher in das KBS des GRASS Mapsets reprojiziert werden.

1. Laden Sie den Layer *srtm_41_19_4326.tif* in QGIS
2. Öffnen Sie erneut das Fenster *GRASS Werkzeuge*.
4. Suchen Sie nach *r.in.gdal.qgis* und klicken doppelt auf das Werkzeug, um sein Dialogfenster zu öffnen.
5. Geben Sie für den Eingabefayer *srtm_41_19_4326.tif* und für den Ausgabefayer *g_dem* vor.
6. Klicken Sie auf *Starten*.
7. Klicken Sie nach dem Abschluss des Prozesses auf *Ergebnis visualisieren*.
8. *Schließen* Sie den Reiter und nochmal mit *Schließen* den gesamten Dialog.
Module: v.in.ogr.qgis

**Loaded layer**

- rivers

**Name for output vector map**

- g_rivers

Show advanced options >>
12.1.5  **Try Yourself Layer zum Mapset hinzufügen**

Versuchen Sie die Vektorlayer `water.shp` und `places.shp` aus dem Ordner `exercise_data/shapefile/` in das GRASS Mapset zu importieren. Benennen Sie die Layer wie beim vorherigen Import mit `g_water` und `g_places` um eine Verwechslung vorzubeugen.

Überprüfen Sie Ihre Resultate

12.1.6  **Öffnen eines vorhandenen Mapsets**

Wenn bereits ein GRASS Mapset vorliegt, können Sie es einfach in einer anderen QGIS-Sitzung öffnen. Es gibt verschiedene Methoden, ein GRASS Mapset zu öffnen. Wir werden nun einige untersuchen. Wir schließen zuerst das Mapset durch Klick auf die Schaltfläche *Schließe Mapset* im Fenster *GRASS-Werkzeuge*.

---

**Follow Along: Benutzung des GRASS Plugins**


2. Gehen Sie zum Ordner mit der GRASS Datenbank: Seien Sie vorsichtig! Man muss den übergeordneten Ordner auswählen, nicht den Ordner mit dem GRASS Mapset. GRASS liest alle Locations der Datenbank und alle Mapsets einer Location ein:

3. Wählen Sie die Location *SouthAfrica* und das Mapset *grass_mapset* das wir vorher erstellt haben.

Das war's. Das GRASS Bedienfeld wird aktiv, was bedeutet, dass das Mapset korrekt geladen wurde.
Follow Along: Verwendung des QGIS Browsers

Noch einfacher kann ein Mapset mit Hilfe des QGIS Browsers geöffnet werden:

1. Schließen Sie das Mapset (wenn es noch geöffnet ist) durch Klick auf die Schaltfläche Schließe Mapset im GRASS-Werkzeuge Fenster.

2. Gehen Sie im QGIS Browser zum Ordner der GRASS Datenbank.


4. Klicke Sie auf Mapset öffnen:

Das Mapset ist nun geöffnet und kann verwendet werden!

**Tipp:** Nach Klick mit rechten Maustaste auf ein Mapset werden viele verschiedene Optionen abgeboten. Untersuchen Sie auch die anderen Optionen.

12.1.7 In Conclusion

Der Arbeitslauf zum Hinzufügen von Daten in GRASS ist etwas abweichend von der QGIS Methode, weil GRASS seine Daten in eine räumliche Datenbank lädt. Trotzdem kann QGIS als Frontend die Verwaltung eines GRASS Mapsets durch die Verwendung von QGIS Layern als Datenquellen für QGIS vereinfachen.

12.1.8 What’s Next?

Jetzt wo die Daten in GRASS importiert sind, können wir uns die erweiterten Analysemöglichkeiten ansehen, die GRASS bietet.
12.2 Lesson: GRASS-Werkzeuge

In dieser Übung werden wir eine Auswahl an Werkzeugen vorstellen, um einen Eindruck der Fähigkeiten von GRASS zu erhalten.

12.2.1 Follow Along: Erstellung einer Karte der Exposition

1. Öffnen Sie das Dialogfenster GRASS-Werkzeuge
2. Laden Sie den Rasterlayer g_dem aus dem Mapset grass_mapset.
3. Suchen Sie das Modul r.aspect durch Eingabe in das Filter Feld im Module Reiter.
4. Öffnen Sie das Werkzeug, tragen sie die Werte wie hier dargestellt ein und klicken Sie auf die Schaltfläche Starten:
5. Klicken Sie nach Abschluss des Prozesses auf Ergebnis visualisieren um den erzeugten Layer im Arbeitsbereich anzuzeigen:

Der Layer g_aspect wird im Mapset grass_mapset gespeichert, so dass man den Layer aus der Karte entfernen und neu einladen kann, wann immer er benötigt wird.

12.2.2 Follow Along: Eine einfache Statistik über den Rasterlayer erstellen

Wir möchten einige einfache Statistiken über den Rasterlayer g_dem erstellen.

1. Öffnen Sie das Dialogfenster GRASS-Werkzeuge
2. Laden Sie den Rasterlayer g_dem aus dem Mapset grass_mapset.
3. Suchen Sie nach dem Modul r.info durch Eingabe in das Filter Feld im Module Reiter.
4. Tragen Sie die Werte wie hier dargestellt ein klicken auf Starten:
5. Im Ergebnis Reiter sehen wir einige Informationen zum Rasterlayer wie z.B. der Pfad der Datei, die Anzahl an Spalten und Zeilen und andere nützliche Informationen:

12.2.3 Follow Along: Das Reklassifizierungswerkzeug

Die Reklassifizierung eines Rasterlayers kann sehr nützlich sein. Wir haben gerade den Layer g_aspect aus dem Layer g_dem erstellt. Der Wertebereich geht von 0 (Nord) über 90 (Ost), 180 (Süd), 270 (West) bis zu 360 (wieder Nord). Wir können den Layer g_aspect reklassifizieren, so dass er nur noch 4 Kategorien entsprechend folgender Regeln enthält: (Nord = 1, Ost = 2, Süd = 3 und West = 4).

Das Grass Werkzeug zur Reklassifizierung verwendet eine txt Datei mit vorgegebenen Regeln. Das Schreiben der Regeln ist sehr einfach und im GRASS Handbuch ist eine sehr gute Beschreibung dazu enthalten.

Tipp: Jedes GRASS Werkzeug hat seinen eigenen Handbuch Reiter. Nehmen Sie sich die Zeit, die Beschreibung des Werkzeuges zu lesen, um nicht einige nützliche Parameter zu übersehen.

1. Laden Sie den Layer g_aspect oder falls Sie ihn noch nicht erstellt haben, gehen Sie zum Abschnitt Follow Along: Erstellung einer Karte der Exposition.
2. Suchen Sie nach dem Modul r.reclass durch Eingabe in das Filter Feld im Module Reiter.

4. Klicken Sie auf **Starten** und warten bis der Prozess abgeschlossen ist:

5. Klicken Sie auf **Ergebnis visualisieren**, um den reklassifizierten Rasterlayer im Arbeitsbereich anzuzeigen.

Der neue Layer enthält nur 4 Werte (1, 2, 3 und 4) und ist einfacher handzuhaben und zu verarbeiten.

**Tipp:** Öffnen Sie die Datei `reclass_aspect.txt` mit einem Texteditor, um sich mit den Regeln vertraut zu machen. Schauen Sie sich auch das GRASS Handbuch an. Hier sind viele verschiedene Beispiele tiefgehend erklärt.

### 12.2.4 Try Yourself Reklassifizieren mit eigenen Regeln

Versuchen Sie den Layer `g_dem` in 3 neue Kategorien zu reklassifizieren:

- von 0 bis 1000: neuer Wert = 1
- von 1000 bis 1400: neuer Wert = 2
- von 1400 bis zum maximalen Rasterwert: neuer Wert = 3

*Überprüfen Sie Ihr Ergebnis*
GRASS Tools: SouthAfrica/grass_mapset

Module: r.info

Options  Output  Manual

r.info map=g_dem@grass_mapset

Map:  g_dem@grass_mapset  Date: Mon Aug 6 10:48:55 2018
Mapset: grass_mapset  Login of Creator: matteo
Location: SouthAfrica
DataBase: /home/mattee/exercise_data/grass/grassdata
Title:  g_dem
Timestamp: none

Type of Map: raster  Number of Categories: 0
Data Type: FCELL
Rows: 619
Columns: 919
Total Cells: 568801
Projection: Latitude-Longitude
N: 33:45:02.790925S  S: 34:16:12.038772S
E: 26:50:22.830235E  W: 29:04:05.845095E
Res: 0:00:03.81978  Res: 0:00:03.81978
Range of data: min = 0  max = 1699

Data Description:
generated by r.in.gdal

Comments:
r.in.gdal input="/home/mattee/exercise_data/raster/SRTM/srtm_41_19_4326.tif" output="g_dem.m" memory=300 offset=0 num_digits=0

Successfully finished
Module: r.reclass

Name of raster map to be reclassified

`g_aspect`

File containing reclass rules

`/home/matteo/exercise_data/grass/reclass_aspect.txt`

Name for output raster map

`g_reclassified`
12.2.5  Follow Along: Das Mapcalc Werkzeug

Das Mapcalc Werkzeug ist vergleichbar mit dem Rasterrechner in QGIS. Man führt mathematische Operationen auf einem oder mehreren Rasterlayer aus und erhält im Ergebnis einen neuen Layer mit den berechneten Werten.

Das Ziel der nächsten Übung ist es, Werte größer als 1000 aus dem Rasterlayer g_dem zu extrahieren.

1. Suchen Sie nach dem Modul `r.mapcalc` durch Eingabe in das Filter Feld des Reiters Module.

2. Starten Sie das Werkzeug.

   Der `Mapcalc` Dialog erlaubt es, eine Abfolge von Analysen für ein Raster oder mehrere Raster zu erstellen. Wir verwenden dazu folgende Werkzeuge:

   Dies sind in geordneter Form:

   - **Add map**: Eine Rasterdatei aus dem aktuellen GRASS Mapset hinzufügen.
   - **Add constant value**: Eine Kostante für die Nutzung in Funktionen hinzufügen, in diesem Fall 1000.
   - **Add operator or function**: Eine Operation oder Funktion hinzufügen, die mit Eingaben und Ausgaben verbunden ist; wir werden den Operator `greater equals than` verwenden.
   - **Add connection**: Verbindet Elemente. Das Werkzeug wird verwendet, indem man den roten Punkt eines Elements mit dem roten Punkt eines anderen Elements durch klicken und ziehen verbindet. Punkte die korrekt mit einer Linie verbunden sind, ändern ihre Farbe zu grau. Wenn die Linie oder ein Punkt rot ist, so ist die Verbindung nicht korrekt!
   - **Select item**: Auswahl eines Elements und Verschieben eines ausgewählten Elements.
   - **Delete selected item**: Entfernt das ausgewählte Element aus dem aktuellen Mapcalc Blatt, aber nicht aus dem Mapset (wenn es ein vorhandenes Raster ist).
   - **Open**: Öffnet eine vorhandene Datei mit der vorgegebenen Operation.
• Save: Sichert alle Verarbeitungsoperationen in einer Datei.
• Save as: Sichert alle Verarbeitungsoperationen in einer neuen lokalen Datei.

3. Erstellen Sie mit Hilfe dieser Werkzeuge den folgenden Algorithmus:

4. Klicken Sie auf Starten und dann auf Ergebnis visualisieren, um die Ausgabe in der Karte anzuzeigen:

Es werden Flächen dargestellt, in denen das Gelände eine Höhe größer als 1000 Meter erreicht.

Tipp: Sie können die Formel, die Sie erstellt haben auch durch Klick auf die letzte Schaltfläche speichern und in einem anderen QGIS Projekt laden.
In dieser Lektion haben wir nur einige der vielen Werkzeuge behandelt, die GRASS bietet. Um die Möglichkeiten von GRASS selbst zu erkunden, öffnen Sie den Dialog GRASS Werkzeuge und scrollen Sie in der Modulliste nach unten. Oder für eine strukturiertere Herangehensweise schauen Sie unter dem Reiter Modulbaum nach, in dem die Werkzeuge nach Typ geordnet sind.

12.2.6 In Conclusion

In dieser Lektion haben wir nur einige der vielen Werkzeuge behandelt, die GRASS bietet. Um die Möglichkeiten von GRASS selbst zu erkunden, öffnen Sie den Dialog GRASS Werkzeuge und scrollen Sie in der Modulliste nach unten. Oder für eine strukturiertere Herangehensweise schauen Sie unter dem Reiter Modulbaum nach, in dem die Werkzeuge nach Typ geordnet sind.
Verwenden Sie Ihre eigenen Daten für diesen Abschnitt. Sie benötigen:

- ein Vektordataset von Punkten der Interesse, mit Namen und mehreren Kategorien
- ein Vektordataset von Straßen
- ein Vektordataset von Bodenverwendung (mit Grundstücksgrenzen)
- ein visuell-spektralbild (wie eine Luftaufnahme)
- ein DEM (herunterladebar von the CGIAR-CSI, wenn Sie nicht Ihren haben)

13.1 Create a base map

Bevor Sie eine Datenanalyse durchführen, benötigen Sie eine Grundkarte, die Ihre Analyseergebnisse in einem Kontext präsentiert.

13.1.1 Add the point layer

- Fügen Sie die Punkt-Layer hinzu. Basiert auf dem Level, auf dem Sie das Kurs machen, tun Sie nur, was in der unten angegebenen Abschnitt aufgeführt ist:

  - Labeln Sie die Punkte gemäß einem einzigartigen Attribut, wie z.B. Ortsnamen. Verwenden Sie ein kleines Schriftbild und halten Sie die Beschriftungen diskret. Die Information sollte verfügbar sein, aber nicht der Hauptfokus der Karte sein.

  - Klassifizieren Sie die Punkte in verschiedene Farben basierend auf einer Kategorie. Zum Beispiel, Kategorien könnten einschließen „tourist destination“, „police station“, und „town center“. 
• Do the same as the previous section.
• Classify the point size by importance: the more significant a feature, the larger its point. However, don't exceed the point size of 2.00.
• For features that aren't located at a single point (for example, provincial/regional names, or town names at a large scale), don't assign any point at all.

• Don't use point symbols to symbolize the layer at all. Instead, use labels centered over the points; the point symbols themselves should have no size.
• Use Data defined settings to style the labels into meaningful categories.
• Add appropriate columns to the attribute data if necessary. When doing so, don't create fictional data - rather, use the Field Calculator to populate the new columns, based on appropriate existing values in the dataset.

13.1.2 Add the line layer

• Add the road layer and then change its symbology. Don't label the roads.

• Change the road symbology to a light color with a broad line. Make it somewhat transparent as well.

• Create a symbol with multiple symbol layers. The resulting symbol should look like a real road. You can use a simple symbol for this; for example, a black line with a thin white solid line running down the center. It can be more elaborate as well, but the resulting map should not look too busy.
• If your dataset has a high density of roads at the scale you want to show the map at, you should have two road layers: the elaborate road-like symbol, and a simpler symbol at smaller scales. (Use scale-based visibility to make them switch out at appropriate scales.)
• All symbols should have multiple symbol layers. Use symbols to make them display correctly.

• Do the same as in the previous section above.
• In addition, roads should be classified. When using realistic road-like symbols, each type of road should have an appropriate symbol; for example, a highway should appear to have two lanes in either direction.
13.1.3 Add the polygon layer

- Add the land use layer and change its symbology.
- Classify the layer according to land use. Use solid colors.
- Classify the layer according to land use. Where appropriate, incorporate symbol layers, different symbol types, etc. Keep the results looking subdued and uniform, however. Keep in mind that this will be part of a backdrop!
- Use rule-based classification to classify the land use into general categories, such as „urban“, „rural“, „nature reserve“, etc.

13.1.4 Create the raster backdrop

- Create a hillshade from the DEM, and use it as an overlay for a classified version of the DEM itself. You could also use the Relief plugin (as shown in the lesson on plugins).

13.1.5 Finalize the base map

- Using the resources above, create a base map using some or all of the layers. This map should include all the basic information needed to orient the user, as well as being visually unified / „simple“.

13.2 Analyze the data

- You are looking for a property that satisfies certain criteria.
- You can decide on your own criteria, which you must document.
- There are some guidelines for these criteria:
  - the target property should be of (a) certain type(s) of land use
  - it should be within a given distance from roads, or be crossed by a road
  - it should be within a given distance from some category of points, like a hospital for example
13.2.1 • Include raster analysis in your results. Consider at least one derived property of the raster, such as its aspect or slope.

13.3 Final Map

• Use the Print Layout to create a final map, which incorporates your analysis results.
• Include this map in a document along with your documented criteria. If the map has become too visually busy due to the added layer(s), deselect the layers which you feel are the least necessary.
• Your map must include a title and a legend.
In modules 1 through 13, you have already learned quite a lot about QGIS and how to work with it. If you are interested in learning about some basic forestry applications of GIS, following this module will give you the ability to apply what you have learned and will show you some new useful tools.

The development of this module has been sponsored by the European Union.

14.1 Lesson: Forestry Module Presentation

Following this module about a forestry application requires the knowledge you have learned through the modules 1 to 11 of this training manual. The exercises in the following lessons assume you are already capable of doing many of the basic operations in QGIS and only tools that have not been used before are presented in more detail.

Nevertheless, the module follows a basic level throughout the lessons so that if you have previous experience with QGIS, you can probably follow the instructions without problems.

Note that you need to download an additional data package for this module.

14.1.1 Forestry Sample Data

Bemerkung: The sample data used in this module is part of the training manual data set and can be downloaded here. Download the zip file and extract the forestry\ folder into your exercise_data\ folder.

The forestry related sample data (forestry map, forest data), has been provided by the EVO-HAMK forestry school. The datasets have been modified to adapt to the lessons needs.
The general sample data (aerial images, LiDAR data, basic maps) has been obtained from the National Land Survey of Finland open data service, and adapted for the purposes of the exercises. The open data file download service can be accessed in English here.

**Warnung:** As for the rest of the training manual, this module includes instructions on adding, deleting and altering GIS datasets. We have provided training datasets for this purpose. Before using the techniques described here on your own data, always ensure you have proper backups!

### 14.2 Lesson: Georeferencing a Map

A common forestry task would be the update of the information for a forestry area. It is possible that the previous information for that area dates several years back and was collected analogically (that is, in paper) or perhaps it was digitized but all you have left is the paper version of that inventory data.

Most likely you would like to use that information in your GIS to, for example, compare later with later inventories. This means that you will need to digitize the information at hand using your GIS software. But before you can start the digitizing, there is an important first step to be done, scanning and georeferencing your paper map.

**The goal for this lesson:** To learn to use the Georeferencer tool in QGIS.

#### 14.2.1 Scan the map

The first task you will have to do is to scan your map. If your map is too big, then you can scan it in different parts but keep in mind that you will have to repeat preprocessing and georeferencing tasks for each part. So if possible, scan the map in as few parts as possible.

If you are going to use a different map that the one provided with this manual, use your own scanner to scan the map as an image file, a resolution of 300 DPI will do. If your map has colors, scan the image in color so that you can later use those colors to separate information from your map into different layers (for ex., forest stands, contour lines, roads...).

For this exercise you will use a previously scanned map, you can find it as rautjarvi_map.tif in the data folder exercise_data/forestry

#### 14.2.2 Follow Along: Georeferencing the scanned map

Open QGIS and set the project’s CRS to ETRS89 / ETRS-TM35FIN in Project ➔ Properties ➔ CRS, which is the currently used CRS in Finland.

Save the QGIS project as map_digitizing.qgs.

You will use the georeferencing plugin from QGIS, the plugin is already installed in QGIS. Activate the plugin using the plugin manager as you have done in previous modules. The plugin is named Georeferencer GDAL.

To georeference the map:

- Open the georeferencer tool, Raster ➔ Georeferencer ➔ Georeferencer.
- Add the map image file, rautjarvi_map.tif, as the image to georeference, File ➔ Open raster.
- When prompted find and select the KKJ / Finland zone 2 CRS, it is the CRS that was used in Finland back in 1994 when this map was created.
- Click OK.

Next you should define the transformation settings for georeferencing the map:
• Open Settings ➤ Transformation settings.

• Click the icon next to the Output raster box, go to the folder and create the folder exercise_data\forestry\digitizing and name the file as rautjarvi_georef.tif.

• Set the rest of parameters as shown below.

• Click OK.

The map contains several cross-hairs marking the coordinates in the map, we will use those to georeference this image. You can use the zooming and panning tools as you usually do in QGIS to inspect the image in the Georeferencer’s window.

• Zoom in to the left lower corner of the map and note that there is a cross-hair with a coordinate pair, X and Y, that as mentioned before are in KKJ / Finland zone 2 CRS. You will use this point as the first ground control point for the georeferencing your map.

• Select the Add point tool and click in the intersection of the cross-hairs (pan and zoom as needed).

• In the Enter map coordinates dialogue write the coordinates that appear in the map (X: 2557000 and Y: 6786000).

• Click OK.

The first coordinate for the georeferencing is now ready.

Look for other cross-hairs in the black lines image, they are separated 1000 meters from each other both in North and East direction. You should be able to calculate the coordinates of those points in relation to the first one.

Zoom out in the image and move to the right until you find other cross-hair, and estimate how many kilometres you have moved. Try to get ground control points as far from each other as possible. Digitize at least three more ground control points in the same way you did the first one. You should end up with something similar to this:

With already three digitized ground control points you will be able to see the georeferencing error as a red line coming out of the points. The error in pixels can be seen also in the GCP table in the dX[pixels] and dY[pixels] columns. The
14.2. Lesson: Georeferencing a Map
error in pixels should not be higher than 10 pixels, if it is you should review the points you have digitized and the coordinates you have entered to find what the problem is. You can use the image above as a guide.

Once you are happy with your control points, you can save them for later use:

- File \[Save GCP points as…\]
- In the folder exercise_data\forestry\digitizing, name the file rautjarvi_map.tif.

Finally, georeference you map:

- File \[Start georeferencing\].
- Note that you named the file already as rautjarvi_georef.tif when you edited the Georeferencer settings.

Now you can see the map in QGIS project as a georeferenced raster. Note that the raster seems to be slightly rotated, but that is simply because the data is KKJ / Finland zone 2 and your project is in ETRS89 / ETRS-TM35FIN.

To check that your data is properly georeferenced you can open the aerial image in the exercise_data\forestry folder, named rautjarvi_aerial.tif. Your map and this image should match quite well. Set the map transparency to 50% and compare it to the aerial image.

Save the changes to your QGIS project, you will continue from this point for the next lesson.

14.2.3 In Conclusion

You have now georeferenced a paper map, making it possible to use it as a map layer in QGIS.

14.2.4 What’s Next?

In the next lesson, you will digitize the forest stands in your map as polygons and add the inventory data to them.

14.3 Lesson: Digitizing Forest Stands

Unless you are going to use your georeferenced map as a simple background image, the next natural step is to digitize elements from it. You have already done so in the exercises about creating vector data in Lesson: Creating a New Vector Dataset, when you digitized the school fields. In this lesson, you are going to digitize the forest stands' borders that appear in the map as green lines but instead of doing it using an aerial image, you will use your georeferenced map.

The goal for this lesson: Learn a technique to help the digitizing task, digitizing forest stands and finally adding the inventory data to them.

14.3.1 Follow Along: Extracting the Forest Stands Borders

Open your map_digitizing.qgs project in QGIS, that you saved from the previous lesson.

Once you have scanned and georeferenced your map you could start to digitize directly by looking at the image as a guide. That would most likely be the way to go if the image you are going to digitize from is, for example, an aerial photograph.

If what you are using to digitize is a good map, as it is in our case, it is likely that the information is clearly displayed as lines with different colors for each type of element. Those colors can be relatively easy extracted as individual images using an image processing software like GIMP. Such separate images can be used to assist the digitizing, as you will see below.
The first step will be to use GIMP to obtain an image that contains only the forest stands, that is, all those greenish lines that you could see in the original scanned map:

- Open GIMP (if you don’t have it installed yet, download it from the internet or ask your teacher).
- Open the original map image, File ➤ Open, `rautjarvi_map.tif` in the `exercise_data/forestry` folder. Note that the forest stands are represented as green lines (with the number of the stand also in green inside each polygon).

Now you can select the pixels in the image that are making up the forest stands’ borders (the greenish pixels):

- Open the tool Select ➤ By color.
- With the tool active, zoom into the image (Ctrl + mouse wheel) so that a forest stand line is close enough to differentiate the pixels forming the line. See the left image below.
- Click and drag the mouse cursor in the middle of the line so that the tool will collect several pixel color values.
- Release the mouse click and wait a few seconds. The pixels matching the colors collected by the tool will be selected through the whole image.
- Zoom out to see how the greenish pixels have been selected throughout the image.
- If you are not happy with the result, repeat the click and drag operation.
- Your pixel selection should look something like the right image below.

Once you are done with the selection you need to copy this selection as a new layer and then save it as separate image file:

- Copy (Ctrl+C) the selected pixels.
- And paste the pixels directly (Ctrl+V), GIMP will display the pasted pixels as a new temporary layer in the Layers - Brushes panel as a Floating Selection (Pasted Layer).
• Right click that temporary layer and select To New Layer.

• Click the „eye“ icon next to the original image layer to switch it off, so that only the Pasted Layer is visible:

• Finally, select File  Export…, set Select File Type (By Extension) as a TIFF image, select the digitizing folder and name it rautjarvi_map_green.tif. Select no compression when asked.

You could do the same process with other elements in the image, for example extracting the black lines that represent roads or the brown ones that represent the terrain' contour lines. But for us, the forest stands is enough.

### 14.3.2 Try Yourself Georeference the Green Pixels Image

As you did in the previous lesson, you need to georeference this new image to be able to use it with the rest of your data.

Note that you don’t need to digitize the ground control points any more because this image is basically the same image as the original map image, as far as the Georeferencer tool is concerned. Here are some things you should remember:

• This image is also, of course, in KKJ / Finland zone 2 CRS.

• You should use the ground control points you saved, File  Load GCP points.

• Remember to review the Transformation settings.

• Name the output raster as rautjarvi_green_georef.tif in the digitizing folder.

Check that the new raster is fitting nicely with the original map.
Having in mind the digitizing tools in QGIS, you might already be thinking that it would be helpful to snap to those green pixels while digitizing. That is precisely what you are going to do next create points from those pixels to use them later to help you follow the forest stands' borders when digitizing, by using the snapping tools available in QGIS.

- Use the Raster Conversion Polygonize (Raster to Vector) tool to vectorize your green lines to polygons. If you don’t remember how, you can review it in Lesson: Raster to Vector Conversion.
- Save as rautjarvi_green_polygon.shp inside the digitizing folder.

Zoom in and see what the polygons look like. You will get something like this:

Next one option to get points out of those polygons is to get their centroids:

- Open Vector Geometry tools Polygon centroids.
- Set the polygon layer you just got as the input file for the tool.
- Name the output as green_centroids.shp inside the digitizing folder.
- Check Add result to canvas.
- Run the tool to calculate the centroids for the polygons.

Now you can remove the rautjarvi_green_polygon layer from the TOC.

Change the symbology of the centroids layer as:

- Open the Layer Properties for green_centroids.
- Go to the Symbology tab.
- Set the Unit to Map unit.
- Set the Size to 1.

It is not necessary to differentiate points from each other, you just need them to be there for the snapping tools to use them. You can use those points now to follow the original lines much easily than without them.
14.3.4 Follow Along: Digitize the Forest Stands

Now you are ready to start with the actual digitizing work. You would start by creating a vector file of *polygon type*, but for this exercise, there is a shapefile with part of the area of interest already digitized. You will just finish digitizing the half of the forest stands that are left between the main roads (wide pink lines) and the lake:

- Go to the digitizing folder using your file manager browser.
- Drag and drop the `forest_stands.shp` vector file to your map.

Change the new layer’s symbology so that it will be easier to see what polygons have already been digitized:

- The filling of the polygon to green.
- The polygons’ borders to 1 mm.
- and set the transparency to 50%.

Now, if you remember past modules, we have to set up and activate the snapping options:

- Go to `Project Snapping options…`
- Activate the snapping for the `green_centroids` and the `forest_stands` layers.
- Set their `Tolerance` to 5 map units.
- Check the `Avoid Int.` box for the `forest_stands` layer.
- Check `Enable topological editing`.
- Click `Apply`.

With these snapping settings, whenever you are digitizing and get close enough to one of the points in the centroids layer or any vertex of your digitized polygons, a pink cross will appear on the point that will be snapped to.

Finally, turn off the visibility of all the layers except `forest_stands` and `rautjarvi_georef`. Make sure that the map image has not transparency any more.

A couple of important things to note before you start digitizing:

- Don’t try to be too accurate with the digitizing of the borders.
- If a border is a straight line, digitize it with just two nodes. In general, digitize using as few nodes as possible.
- Zoom in to close ranges only if you feel that you need to be accurate, for example, at some corners or when you want a polygon to connect with another polygon at a certain node.
- Use the mouse’s middle button to zoom in/out and to pan as you digitize.
- Digitize only one polygon at a time.
- After digitizing one polygon, write the forest stand id that you can see from the map.

Now you can start digitizing:

- Locate the forest stand number 357 in the map window.
- Enable editing for the `forest_stands.shp` layer.
- Select the `Add feature` tool.
- Start digitizing the stand 357 by connecting some of the dots.
- Note the pink crosses indicating the snapping.
- When you are done, right click to end digitizing that polygon.
- Enter the forest stand id (in this case 357).
- Click `OK`. 
If you were not prompted for the polygon id when you finished digitizing it, go to Settings → Options → Digitizing and make sure that the Suppress attribute form pop-up after feature creation is not checked.

Your digitized polygon will look like this:

Now for the second polygon, pick up the stand number 358. Make sure that the Avoid int. is checked for the forest_stands layer. This option does not allow intersecting polygons at digitizing, so that if you digitize over an existing polygon, the new polygon will be trimmed to meet the border of the already existing polygons. You can use this characteristic to automatically obtain a common border.

- Begin digitizing the stand 358 at one of the common corners with the stand 357.
- Then continue normally until you get to the other common corner for both stands.
- Finally, digitize a few points inside polygon 357 making sure that the common border is not intersected. See left image below.
- Right click to finish editing the forest stand 358.
- Enter the id as 358.
- Click OK, your new polygon should show a common border with the stand 357 as you can see in the image on the right.

The part of the polygon that was overlapping the existing polygon has been automatically trimmed out and you are left with a common border, as you intended it to be.
14.3.5 Try Yourself Finish Digitizing the Forest Stands

Now you have two forest stands ready. And a good idea on how to proceed. Continue digitizing on your own until you have digitized all the forest stands that are limited by the main road and the lake.

It might look like a lot of work, but you will soon get used to digitizing the forest stands. It should take you about 15 minutes.

During the digitizing you might need to edit or delete nodes, split or merge polygons. You learned about the necessary tools in Lesson: Funktionstopologie, now is probably a good moment to go read about them again.

Remember that having Enable topological editing activated, allows you to move nodes common to two polygons so that the common border is edited at the same time for both polygons.

Your result will look like this:

14.3.6 Follow Along: Joining the Forest Stand Data

It is possible that the forest inventory data you have for your map is also written in paper. In that case, you would have to first write that data to a text file or a spreadsheet. For this exercise, the information from the inventory for 1994 (the same inventory as the map) is ready as a comma separated text (csv) file.

Open the rautjarvi_1994.csv file from the exercise_data\forestry directory in a text editor and note that the inventory data file has an attribute called ID that has the numbers of the forest stands. Those numbers are the same as the forest stands ids you have entered for your polygons and can be used to link the data from the text file to your vector file. You can see the metadata for this inventory data in the file rautjarvi_1994_legend.txt in the same folder.

- Open the .csv in QGIS with the Layer Add Delimited Text Layer... tool. In the dialog, set it as follows:

To add the data from the .csv file:

- Open the Layer Properties for the forest_stands layer.
- Go to the Joins tab.
- Click the plus sign on the bottom of the dialog box.
- Select rautjarvi_1994.csv as the Join layer and ID as the Join field.
- Make sure that the Target field is also set to id.
- Click OK two times.
Create a Layer from a Delimited Text File

File Name: C:/gis_forestry/exercise_data/forestry/rautjarvi_1994.csv
Layer name: rautjarvi_1994
File format: CSV (comma separated values)
Encoding: UTF-8

Record options:
- Number of header lines to discard: 0
- First record has field names

Field options:
- Trim fields
- Discard empty fields
- Decimal separator is comma

Geometry definition:
- Point coordinates
- Well known text (WKT)
- No geometry (attribute only table)

Layer settings:
- Use spatial index
- Use subset index
- Watch file

<table>
<thead>
<tr>
<th>ID</th>
<th>Hab</th>
<th>Devi</th>
<th>Age</th>
<th>BA</th>
<th>Vol</th>
<th>ManSo</th>
<th>MainPerc</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>376</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>334</td>
<td>4</td>
<td>Y1</td>
<td>15</td>
<td>7.4</td>
<td>54</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>336</td>
<td>4</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
The data from the text file should be now linked to your vector file. To see what has happened, open the attribute table for the `forest_stands` layer. You can see that all the attributes from the inventory data file are now linked to your digitized vector layer.

### 14.3.7 Try Yourself Renaming Attribute Names and Adding Area and Perimeter

The data from the `.csv` file is just linked to your vector file. To make this link permanent, so that the data is actually recorded to the vector file you need to save the `forest_stands` layer as a new vector file. Close the attribute table and right click the `forest_stands` layer to save it as `forest_stands_1994.shp`.

Open your new `forest_stands_1994.shp` in your map if you did not added yet. Then open the attribute table. You notice that the names of the columns that you just added are no very useful. To solve this:

- Add the plugin `Table Manager` as you have done with other plugins before.
- Make sure the plugin is activated.
- In the TOC select the layer `forest_stands_1994.shp`.
- Then, go to `Vector ▶ Table Manager ▶ Table manager`.
- Use the dialogue box to edit the names of the columns to match the ones in the `.csv` file.
- Click on `Save`.
- Select `Yes` to keep the layer style.
- Close the `Table Manager` dialogue.

To finish gathering the information related to these forest stands, you might calculate the area and the perimeter of the stands. You calculated areas for polygons in *Lesson: Supplementary Exercise*. Go back to that lesson if you need to and calculate the areas for the forest stands, name the new attribute `Area` and make sure that the values calculated are in hectares.

Now your `forest_stands_1994.shp` layer is ready and packed with all the available information.

Save your project to keep the current map presentation in case you need to come back later to it.

### 14.3.8 In Conclusion

It has taken a few clicks of the mouse but you now have your old inventory data in digital format and ready for use in QGIS.

### 14.3.9 What’s Next?

You could start doing different analysis with your brand new dataset, but you might be more interested in performing analysis in a dataset more up to date. The topic of the next lesson will be the creation of forest stands using current aerial photos and the addition of some relevant information to your dataset.
14.4 Lesson: Updating Forest Stands

Now that you have digitized the information from the old inventory maps and added the corresponding information to the forest stands, the next step would be to create the inventory of the current state of the forest.

You will digitize new forest stands from scratch following an aerial photo from that forest area. The forestry map you digitized in the previous lesson was created from an aerial Color Infrared (CIR) photograph. This type of imagery, where the infrared light is recorded instead of the blue light, are widely used to study vegetated areas. You will also use a CIR photograph in this lesson.

After digitizing the forest stands, you will add information such as new constraints given by conservation regulations.

**The goal for this lesson:** To digitize a new set of forest stands from CIR aerial photographs and add information from other data-sets.

14.4.1 Comparing the Old Forest Stands to Current Aerial Photographs

The National Land Survey of Finland has an open data policy that allows you downloading a variety of geographical data like aerial imagery, traditional topographic maps, DEM, LiDAR data, etc. The service can be accessed also in English [here](#). The aerial image used in this exercise has been created from two orthorectified CIR images downloaded from that service (M4134F_21062012 and M4143E_21062012).

- Open QGIS and set the project’s CRS to **ETRS89 / ETRS-TM35FIN** in **Project Properties… CRS**.
- From the **exercise_data\forestry\** folder, add the CIR image **rautjarvi_aerial.tif** that is containing the digitized lakes.
- Then save the QGIS project as **digitizing_2012.qgs**.

The CIR images are from 2012. You can compare the stands that were created in 1994 with the situation almost 20 years later.

- Add your **forest_stands_1994.shp** layer.
- Set its styling so that you can see through your polygons.
- Review how the old forest stands follow (or not) what you might visually interpret as an homogeneous forest.

Zoom and pan around the area. You probably will notice that some of the old forest stands might be still corresponding with the image but others are not.

This is a normal situation, as some 20 years have passed by and different forest operations have been done (harvesting, thinning…). It is also possible that the forest stands looked homogeneous back in 1992 to the person who digitized them but as time has passed some forest has developed in different ways. Or simply the priorities for the forest inventory were different that they are today.

Next, you will create new forest stands for this image without using the old ones. Later you can compare them to see the differences.

14.4.2 Interpreting the CIR Image

Let’s digitize the same area that was covered by the old inventory, limited by the roads and the lake. You don’t have to digitize the whole area, as in the previous exercise you can start with a vector file that already contains most of the forest stands.

- Remove the **forest_stands_1994.shp** layer.
- Add the **forest_stands_2012.shp** layer, located in the **exercise_data\forestry\** folder.
- Set the styling of this layer so that the polygons have no fill and the borders are visible.
You can see that a region to the North of the inventory area is still missing. That will be your task, digitizing the missing forest stands.

But before you start, spend some time reviewing the forest stands already digitized and the corresponding forest in the image. Try to get an idea about how the stands borders are decided, it helps if you have some forestry knowledge.

Some ideas about what you could identify from the images:

- What forests are deciduous species (in Finland mostly birch forests) and which ones are conifers (in this region pine or spruce). In CIR images, deciduous species will often come as bright red color whereas conifers present dark green colors.
- When a forest stand age changes, by looking at the sizes of the tree crowns that can be identified in the imagery.
- The different forest stands' densities, for example forest stand were a thinning operation has recently been done would clearly show spaces between the tree crowns and should be easy to differentiate from other forest stands around it.
- Blueish areas indicate barren terrain, roads and urban areas, crops that have not started to grow etc.
- Don't use zooms too close to the image when trying to identify forest stands. A scale between 1:3 000 and 1:5 000 should be enough for this imagery. See the image below (1:4000 scale):
14.4.3 Try Yourself Digitizing Forest Stands from CIR Imagery

When digitizing the forest stands, you should try to get forest areas that are as homogeneous as possible in terms of tree species, forest age, stand density… Don’t be too detailed though, or you will end up making hundreds of small forest stands that would not be useful at all. You should try to get stands that are meaningful in the context of forestry, not too small (at least 0.5 ha) but not too big either (no more than 3 ha).

With this indications in mind, you can now digitize the missing forest stands.

- Enable editing for forest_stands_2012.shp.
- Set up the snapping and topology options as in the image.
- Remember to click Apply or OK.

Start digitizing as you did in the previous lesson, with the only difference that you don’t have any point layer that you are snapping to. For this area you should get around 14 new forest stands. While digitizing, fill in the Stand_id field with numbers starting at 901.

When you are finished your layer should look something like:

Now you have a new set of polygons defining the different forest stands for the current situation as can interpreted from the CIR images. But you are obviously still missing the forest inventory data, right? For that you will still need to visit the forest and get some sample data that you will use to estimate the forest attributes for each of the forest stands. You will see how to do that in the next lesson.

For the moment, you still can improve your vector layer with some extra information that you have about conservation regulation that should be taken into account for this area.

14.4.4 Follow Along: Updating Forest Stands with Conservation Information

For the area you are working with, it has been researched that the following conservation regulations must be taken into account while doing the forest planning:

- Two locations of a protected species of Siberian flying squirrel (Pteromys volans) have been identified. According to the regulation, an area of 15 meters around the spots must be left untouched.
- A riparian forest of special interest growing along a stream in the area must be protected. In a visit to the field, it was found that 20 meters to both sides of the stream must be protected.

You have one vector file containing the information about the squirrel locations and another containing the digitized stream running in the North area towards the lake. From the exercise_data\forestry\ folder, add the vector files squirrel.shp and stream.shp.

For the protection of the squirrels locations, you are going to add a new attribute (column) to your new forest stands that will contain information about point locations that have to be protected. That information will later be available whenever a forest operation is planned, and the field team will be able to mark the area that has to be left untouched before the work starts.
• Open the attribute table for the squirrel layer.
• You can see that there are two locations that are defined as Siberian flying squirrel, and that the area to be protected is indicated by a distance of 15 meters from the locations.

To join the information about the squirrels to your forest stands, you can use the Join attributes by location:

• Open Vector ▶ Data Management Tools ▶ Join attributes by location.
• Set the forest_stands_2012.shp layer as the Target vector layer.
• As Join vector layer select the squirrel.shp point layer.
• Name the output file as stands_squirrel.shp.
• In Output table select Keep all records (including non-matching target records). So that you keep all the forest stands in the layer instead of only keeping those that are spatially related to the squirrel locations.
• Click OK.
• Select Yes when prompted to add the layer to the TOC.
• Close the dialogue box.

Now you have a new forest stands layer, stands_squirrel where there are new attributes corresponding to the protection information related to the Siberian flying squirrel.
Open the table of the new layer and order it so that the forest stands with information for the *Protection* attribute are on top. You should have now two forest stands where the squirrel has been located:

![Attribute table](image)

Although this information might be enough, look at what areas related to the squirrels should be protected. You know that you have to leave a buffer of 15 meters around the squirrels location:

- Open Vector ➔ Geoprocessing Tools ➔ Buffer.
- Make a buffer of 15 meters for the *squirrel* layer.
- Name the result *squirrel_15m.shp*.

You will notice that if you zoom in to the location in the Northern part of the area, the buffer area extends to the neighbouring stand as well. This means that whenever a forest operation would take place in that stand, the protected location should also be taken into account.

From your previous analysis, you did not get that stand to register information about the protection status. To solve this problem:

- Run the *Join attributes by location* tool again.
- But this time use the *squirrel_15m* layer as join layer.
- Name the output file as *stands_squirrel_15m.shp*.

Open the attribute table for the this new layer and note that now you have three forest stands that have the information about the protection locations. The information in the forest stands data will indicate to the forest manager that there are protection considerations to be taken into account. Then he or she can get the location from the *squirrel* dataset, and visit the area to mark the corresponding buffer around the location so that the operators in the field can avoid disturbing the squirrels environment.

### 14.4.5 Try Yourself Updating Forest Stands with Distance to the Stream

Following the same approach as indicated for the protected squirrel locations you can now update your forest stands with protection information related to the stream identified in the field:

- Remember that the buffer in this case is 20 meters around it.
- You want to have all the protection information in the same vector file, so use the *stands_squirrel_15m* layer as the target.
- Name your output as *forest_stands_2012_protect.shp*.
14.4. Lesson: Updating Forest Stands
Open the attributes table for the new vector layer and confirm that you now have all the protection information for the stands that are affected by the protection measures to protect the riparian forest associated with the stream. Save your QGIS project.

14.4.6 In Conclusion

You have seen how to interpret CIR images to digitize forest stands. Of course it would take some practice to make more accurate stands and usually using other information like soil maps would give better results, but you know now the basis for this type of task. And adding information from other datasets resulted to be quite a trivial task.

14.4.7 What’s Next?

The forest stands you digitized will be used for planning forestry operations in the future, but you still need to get more information about the forest. In the next lesson, you will see how to plan a set of sampling plots to inventory the forest area you just digitized, and get the overall estimate of forest parameters.

14.5 Lesson: Systematic Sampling Design

You have already digitized a set of polygons that represent the forest stands, but you don’t have information about the forest just yet. For that purpose you can design a survey to inventory the whole forest area and then estimate its parameters. In this lesson you will create a systematic set of sampling plots.

When you start planning your forest inventory it is important to clearly define the objectives, the types of sample plots that will be used, and the data that will be collected to achieve the objectives. For each individual case, those will depend on the type of forest and the management purpose; and should be carefully planned by someone with forestry knowledge. In this lesson, you will implement a theoretical inventory based on a systematic sampling plot design.

The goal for this lesson: To create a systematic sampling plot design to survey the forest area.

14.5.1 Inventoring the Forest

There are several methods to inventory forests, each of them suiting different purposes and conditions. For example, one very accurate way to inventory a forest (if you consider only tree species) would be to visit the forest and make a list of every tree and their characteristics. As you can imagine this is not commonly applicable except for some small areas or some special situations.

The most common way to find out about a forest is by sampling it, that is, taking measurements in different locations at the forest and generalizing that information to the whole forest. These measurements are often made in sample plots that are smaller forest areas that can be easily measured. The sample plots can be of any size (for ex. 50 m², 0.5 ha) and form (for ex. circular, rectangular, variable size), and can be located in the forest in different ways (for ex. randomly, systematically, along lines). The size, form and location of the sample plots are usually decided following statistical, economical and practical considerations. If you have no forestry knowledge, you might be interested in reading this Wikipedia article.
14.5.2 Follow Along: Implementing a Systematic Sampling Plot Design

For the forest you are working with, the manager has decided that a systematic sampling design is the most appropriate for this forest and has decided that a fixed distance of 80 meters between the sample plots and sampling lines will yield reliable results (for this case, +/− 5% average error at a probability of 68%). Variable size plots has been decided to be the most effective method for this inventory, for growing and mature stands, but a 4 meters fixed radius plots will be used for seedling stands.

In practice, you simply need to represented the sample plots as points that will be used by the field teams later:

- Open your digitizing_2012.qgs project from the previous lesson.
- Remove all the layers except for forest_stands_2012.
- Save your project now as forest_inventory.qgs

Now you need to create a rectangular grid of points separated 80 meters from each other:

- Open Vector  Research Tools  Regular points.
- In the Area definitions select Input Boundary Layer.
- And as input layer set the forest_stands_2012 layer.
- In the Grid Spacing settings, select Use this point spacing and set it to 80.
- Save the output as systematic_plots.shp in the forestry\sampling\ folder.
- Check Add result to canvas.
- Click OK.

Bemerkung: The suggested Regular points creates the systematic points starting in the corner upper-left corner of the extent of the selected polygon layer. If you want to add some randomness to this regular points, you could use a randomly calculated number between 0 and 80 (80 is the distance between our points), and then write it as the Initial inset from corner (LH side) parameter in the tool’s dialog.

You notice that the tool has used the whole extent of your stands layer to generate a rectangular grid of points. But you are only interested on those points that are actually inside your forest area (see the images below):

- Open Vector  Geoprocessing Tools  Clip.
- Select systematic_plots as Input vector layer.
- Set forest_stands_2012 as the Clip layer.
- Save the result as systematic_plots_clip.shp.
- Check Add result to canvas.
- Click OK.

You have now the points that the field teams will use to navigate to the designed sample plots locations. You can still prepare these points so that they are more useful for the field work. At the least you will have to add meaningful names for the points and export them to a format that can be used in their GPS devices.

Let’s start with the naming of the sample plots. If you check the Attribute table for the plots inside the forest area, you can see that you have the default id field automatically generated by the Regular points tool. Label the points to see them in the map and consider if you could use those numbers as part of your sample plot naming:

- Open the Layer Properties  Labels for your systematic_plots_clip.
- Check Label this layer with and select the field ID.
- Go to the Buffer options and check the Draw text buffer, set the Size to 1.
- Click OK.
Now look at the labels on your map. You can see that the points have been created and numbered first West to East and then North to South. If you look at the attribute table again, you will notice that the order in the table is following also that pattern. Unless you would have a reason to name the sample plots in a different way, naming them in a West-East/North-South fashion follows a logical order and is a good option.

**Bemerkung:** If you would like to order or name them in a different way, you could use a spreadsheet to be able to order and combine rows and columns in any different way.

Nevertheless, the number values in the *id* field are not so good. It would be better if the naming would be something like *p_1, p_2,...*. You can create a new column for the `systematic_plots_clip` layer:

- Go to the *Attribute table* for `systematic_plots_clip`.
- Enable the edit mode.
- Open the *Field calculator* and name the new column *Plot_id*.
- Set the *Output field type* to *Text (string)*.
- In the *Expression* field, write, copy or construct this formula `concat('P_', $rownum )`. Remember that you can also double click on the elements inside the *Function list*. The `concat` function can be found under *String* and the `$rownum` parameter can be found under *Record*.
- Click *OK*.
- Disable the edit mode and save your changes.

Now you have a new column with plot names that are meaningful to you. For the `systematic_plots_clip` layer, change the field used for labeling to your new *Plot_id* field.
14.5.3 Follow Along: Exporting Sample Plots as GPX format

The field teams will be probably using a GPS device to locate the sample plots you planned. The next step is to export the points you created to a format that your GPS can read. QGIS allows you to save your point and line vector data in GPS eXchange Format (GPX)<https://en.wikipedia.org/wiki/GPS_Exchange_Format>, which is an standard GPS data format that can be read by most of the specialized software. You need to be careful with selecting the CRS when you save your data:

- Right click systematic_plots_clip and select Save as.
- In Format select GPS eXchange Format [GPX].
- Save the output as plots_wgs84.gpx.
- In CRS select Selected CRS.
- Browse for WGS 84 (EPSG:4326).

Bemerkung: The GPX format accepts only this CRS, if you select a different one, QGIS will give no error but you will get an empty file.

- Click OK.
- In the dialog that opens, select only the waypoints layer (the rest of the layers are empty).
The inventory sample plots are now in a standard format that can be managed by most of the GPS software. The field teams can now upload the locations of the sample plots to their devices. That would be done by using the specific devices own software and the plots_wgs84.gpx file you just saved. Other option would be to use the GPS Tools plugin but it would most likely involve setting the tool to work with your specific GPS device. If you are working with your own data and want to see how the tool works you can find out information about it in the section working_gps in the QGIS User Manual.

Save your QGIS project now.

14.5.4 In Conclusion

You just saw how easily you can create a systematic sampling design to be used in a forest inventory. Creating other types of sampling designs will involve the use of different tools within QGIS, spreadsheets or scripting to calculate the coordinates of the sample plots, but the general idea remains the same.

14.5.5 What’s Next?

In the next lesson you will see how to use the Atlas capabilities in QGIS to automatically generate detailed maps that the field teams will be using to navigate to the sample plots assigned to them.

14.6 Lesson: Creating Detailed Maps with the Atlas Tool

The systematic sampling design is ready and the field teams have loaded the GPS coordinates in their navigation devices. They also have a field data form where they will collect the information measured at every sample plot. To easier find their way to every sample plot, they have requested a number of detail maps where some ground information can be clearly seen along with a smaller subset of sample plots and some information about the map area. You can use the Atlas tool to automatically generate a number of maps with a common format.

The goal for this lesson: Learn to use the Atlas tool in QGIS to generate detailed printable maps to assist in the field inventory work.

14.6.1 Follow Along: Preparing the Print Layout

Before we can automate the detailed maps of the forest area and our sampling plots, we need to create a map template with all the elements we consider useful for the field work. Of course the most important will be a properly styled but, as you have seen before, you will also need to add lots of other elements that complete the printed map.

Open the QGIS project from the previous lesson forest_inventory.qgs. You should have at least the following layers:

• forest_stands_2012 (with a 50% transparency, green fill and darker green border lines).
• systematic_plots_clip.
• rautjarvi_aerial.

Save the project with a new name, map_creation.qgs.

To create a printable map, remember that you use the Layout Manager:

• Open Project ➤ Layout Manager…
• In the Layout manager dialog.
• Click the Add button and name your print layout forest_map.
• Click OK.
• Click the Show button.
Set up the printer options so that your maps will suit your paper and margins, for an A4 paper:

- Open menu selection: Layout -> Page Setup…
- **Size** is A4 (217 x 297 mm).
- **Orientation** is Landscape.
- **Margins (millimeters)** are all set to 5.

In the Print Layout window, go to the Composition tab (on the right panel) and make sure that these settings for Paper and quality are the same you defined for the printer:

- **Size**: A4 (210x297mm).
- **Orientation**: Landscape.
- **Quality**: 300dpi.

Composing a map is easier if you make use of the canvas grid to position the different elements. Review the settings for the layout grid:

- In the Composition tab expand the Grid region.
- Check that Spacing is set to 10 mm.
- And that Tolerance is set to 2 mm.

You need to activate the use of the grid:

- Open the View menu.
- Check Show grid.
- Check Snap to grid.

Notice that options for using guides are checked by default, which allows you to see red guiding lines when you are moving elements in the layout.

Now you can start to add elements to your map canvas. Add first a map element so you can review how it looks as you will be making changes in the layers symbology:

- Click on the Add New Map button: 📦.
- Click and drag a box on the canvas so that the map occupies most of it.

Notice how the mouse cursor snaps to the canvas grid. Use this function when you add other elements. If you want to have more accuracy, change the grid Spacing setting. If for some reason you don’t want to snap to the grid at some point, you can always check or uncheck it in the View menu.

### 14.6.2 Follow Along: Adding Background Map

Leave the layout open but go back to the map. Lets add some background data and create some styling so that the map content is as clear as possible.

- Add the background raster `basic_map.tif` that you can find in the `exercise_data\forestry\` folder.
- When prompted select the ETRS89 / ETRS-TM35FIN CRS for the raster.

As you can see the background map is already styled. This type of ready to use cartography raster is very common. It is created from vector data, styled in a standard format and stored as a raster so that you don’t have to bother styling several vector layers and worrying about getting a good result.

- Now zoom to your sample plots, so that you can see only about four or five lines of plots.
The current styling of the sample plots is not the best, but how does it look in the print layout?:

While during the last exercises, the white buffer was OK on top of the aerial image, now that the background image is mostly white you barely can see the labels. You can also check how it looks like on the layout:

- Go to the Print Layout window.
- Use the button to select the map element in the layout.
- Go to the Item properties tab.
- Under Extents click on Set to map canvas extent.
- If you need to refresh the element, under Main properties click on the Update preview.

Obviously this is not good enough, you want to make the plot numbers as clearly visible as possible for the field teams.

### 14.6.3 Try Yourself Changing the Symbology of the Layers

You have been working in Module: Erstellen und Erkunden einer einfachen Karte with symbology and in Module: Vektor Daten klassifizieren with labeling. Go back to those modules if you need to refresh about some of the available options and tools. Your goal is to get the plots locations and their name to be as clearly visible as possible but always allowing to see the background map elements. You can take some guidance from this image:

You will use later the the green styling of the forest_stands_2012 layer. In order to keep it, and have a visualization of it that shows only the stand borders:

- Right click on forest_stands_2012 and select Duplicate
- you get a new layer named forest_stands_2012 copy that you can use to define a different style, for example with no filling and red borders.

Now you have two different visualizations of the forest stands and you can decide which one to display for your detail map.

Go back to the Print Layout window often to see what the map would look like. For the purposes of creating detailed maps, you are looking for a symbology that looks good not at the scale of the whole forest area (left image below) but at a closer scale (right image below). Remember to use Update preview and Set to map canvas extent whenever you change the zoom in your map or the layout.

14.6. Lesson: Creating Detailed Maps with the Atlas Tool
14.6.4 Try Yourself Create a Basic Map Template

Once you have a symbology you are happy with, you are ready to add some more information to your printed map. Add at least the following elements:

- Title.
- A scale bar.
- Grid frame for your map.
- Coordinates on the sides of the grid.

You have created a similar composition already in Module: Layout der Karten. Go back to that module as you need. You can look at this example image for reference:

Export your map as an image and look at it.
14.6.5 Follow Along: Adding More Elements to the Print Layout

As you probably noticed in the suggested map template images, there are plenty of room on the right side of the canvas. Let's see what else could go in there. For the purposes of our map, a legend is not really necessary, but an overview map and some text boxes could add value to the map.

The overview map will help the field teams place the detail map inside the general forest area:

- Add another map element to the canvas, right under the title text.
- In the Item properties tab, open the Overview dropdown.
- Set the Overview frame to Map 0. This creates a shadowed rectangle over the smaller map representing the extent visible in the bigger map.
- Check also the Frame option with a black color and a Thickness of 0.30.

Notice that your overview map is not really giving an overview of the forest area which is what you want. You want this map to represent the whole forest area and you want it to show only the background map and the forest_stands_2012 layer, and not display the sample plots. And also you want to lock its view so it does not change anymore whenever you change the visibility or order of the layers.

- Go back to the map, but don’t close the Print Layout.
- Right click the forest_stands_2012 layer and click on Zoom to Layer Extent.
- Deactivate all layers except for basic_map and forest_stands_2012.
- Go back to the Print Layout.
• With the small map selected, click the *Set to map canvas extent* to set its extents to what you can see in the map window.

• Lock the view for the overview map by checking *Lock layers for map item* under *Main properties*.

Now your overview map is more what you expected and its view will not change anymore. But, of course, now your detail map is not showing anymore the stand borders nor the sample plots. Lets fix that:

• Go to the map window again and select the layers you want to be visible (*systematic_plots_clip, forest_stands_2012* copy and *Basic_map*).

• Zoom again to have only a few lines of sample plots visible.

• Go back to the *Print Layout* window.

• Select the bigger map in your layout.

• In *Item properties* click on *Update preview* and *Set to map canvas extent*.

Notice that only the bigger map is displaying the current map view, and the small overview map is keeping the same view you had when you locked it.

Note also that the overview is showing a shaded frame for the extent shown in the detail map.

Your template map is almost ready. Add now two text boxes below the map, one containing the text *Detailed map zone:* , and the other one *Remarks:* , Place them as you can see in the image above.

You can also add a North arrow to the overview map:

• Use the *Add image* tool ,

• Click at the upper right corner of the overview map.

• In *Item properties* open *Search directories* and browse for an arrow image.
Under Image rotation, check the Sync with map and select Map 1 (the overview map).

Uncheck Background.

Resize the arrow image to a size that looks good on the small map.

The basic map layout is ready, now you want to make use of the Atlas tool to generate as many detail maps in this format as you consider necessary.

### 14.6.6 Follow Along: Creating an Atlas Coverage

The Atlas coverage is just a vector layer that will be used to generate the detail maps, one map for every feature in the coverage. To get an idea of what you will do next, here is a full set of detail maps for the forest area:

The coverage could be any existing layer, but usually it makes more sense to create one for the specific purpose. Let’s create a grid of polygons covering the forest area:

- In the QGIS map view, open Vector ➤ Research Tools ➤ Vector grid.
- Set the tool as shown in this image:
- Save the output as atlas_coverage.shp.
- Style the new atlas_coverage layer so that the polygons have no filling.

The new polygons are covering the whole forest area and they give you an idea of what each map (created from each polygon) will contain.
14.6. Lesson: Creating Detailed Maps with the Atlas Tool
14.6.7  Follow Along: Setting Up the Atlas Tool

The last step is to set up the Atlas tool:

- Go back to the Print Layout.
- In the panel on the right, go to the Atlas generation tab.
- Set the options as follows:

That tells the Atlas tool to use the features (polygons) inside atlas_coverage as the focus for every detail map. It will output one map for every feature in the layer. The Hidden coverage layer tells the Atlas to not show the polygons in the output maps.

One more thing needs to be done. You need to tell the Atlas tool what map element is going to be updated for every output map. By now, you probably can guess that the map to be changed for every feature is the one you have prepared to contain detail views of the sample plots, that is the bigger map element in your canvas:

- Select the bigger map element.
- Go to the Item properties tab.
- In the list, check Controlled by atlas.
- And set the Marging around feature to 10%. The view extent will be 10% bigger than the polygons, which means that your detail maps will have a 10% overlap.

Now you can use the preview tool for Atlas maps to review what your maps will look like:
14.6. Lesson: Creating Detailed Maps with the Atlas Tool
• Activate the Atlas previews using the button or if your Atlas toolbar is not visible, via Atlas Preview Atlas.

• You can use the arrows in the Atlas tool bar or in the Atlas menu to move through maps that will be created.

Note that some of them cover areas that are not interesting. Let's do something about it and save some trees by not printing those useless maps.

14.6.8 Follow Along: Editing the Coverage Layer

Besides removing the polygons for those areas that are not interesting, you can also customize the text labels in your map to be generated with content from the Attribute table of your coverage layer:

• Go back to the map view.
• Enable editing for the atlas_coverage layer.
• Select the polygons that are selected (in yellow) in the image below.
• Remove the selected polygons.
• Disable editing and save the edits.

You can go back to the Print Layout and check that the previews of the Atlas use only the polygons you left in the layer.

The coverage layer you are using does not yet have useful information that you could use to customize the content of the labels in your map. The first step is to create them, you can add for example a zone code for the polygon areas and a field with some remarks for the field teams to have into account:

• Open the Attribute table for the atlas_coverage layer.
• Enable editing.

• Use the calculator to create and populate the following two fields.
• Create a field named Zone and type Whole number (integer).
• In the Expression box write/copy/construct $rownum.
• Create another field named Remarks, of type Text (string) and a width of 255.
• In the Expression box write 'No remarks.' This will set all the default value for all the polygons.

The forest manager will have some information about the area that might be useful when visiting the area. For example, the existence of a bridge, a swamp or the location of a protected species. The atlas_coverage layer is probably in edit mode still, add the following text in the Remarks field to the corresponding polygons (double click the cell to edit it):

• For the Zone 2: Bridge to the North of plot 19. Siberian squirrel between p_13 and p_14.
• For the Zone 6: Difficult to transit in swamp to the North of the lake.
• For the Zone 7: Siberian squirrel to the South East of p_94.
• Disable editing and save your edits.

Almost ready, now you have to tell the Atlas tool that you want some of the text labels to use the information from the atlas_coverage layer’s attribute table.

• Go back to the Print Layout.
• Select the text label containing Detailed map....
• Set the Font size to 12.
• Set the cursor at the end of the text in the label.
In the Item properties tab, inside the Main properties click on Insert an expression.

In the Function list double click on the field Zone under Field and Values.

Click OK.

The text inside the box in the Item properties should show Detail map inventory zone: [% "Zone" %]. Note that the [% "Zone" %] will be substituted by the value of the field Zone for the corresponding feature from the layer atlas_coverage.

Test the contents of the label by looking at the different Atlas preview maps.
Do the same for the labels with the text Remarks: using the field with the zone information. You can leave a break line before you enter the expression. You can see the result for the preview of zone 2 in the image below:

Use the Atlas preview to browse through all the maps you will be creating soon and enjoy!

**Follow Along: Printing the Maps**

Last but not least, printing or exporting your maps to image files or PDF files. You can use the Atlas Export Atlas as Images... or Atlas Export Atlas as PDF.... Currently the SVG export format is not working properly and will give a poor result.

Let's print the maps as a single PDF that you can send to the field office for printing:

- Go to the Atlas generation tab on the right panel.
- Under the Output check the Single file export when possible. This will put all the maps together into a PDF file, if this option is not checked you will get one file for every map.
- Open Layout Export as PDF....
- Save the PDF file as inventory_2012_maps.pdf in your exercise_data\forestry\samplig\map_creation\ folder.
Open the PDF file to check that everything went as expected.

You could just as easily create separate images for every map (remember to uncheck the single file creation), here you can see the thumbnails of the images that would be created:

In the Print Layout, save your map as a layout template as forestry_atlas.qpt in your exercise_data\forestry\map_creation\ folder. Use Layout → Save as Template. You will be able to use this template again and again.

Close the Print Layout and save your QGIS project.

14.6.10 In Conclusion

You have managed to create a template map that can be used to automatically generate detail maps to be used in the field to help navigate to the different plots. As you noticed, this was not an easy task but the benefit will come when you need to create similar maps for other regions and you can use the template you just saved.

14.6.11 What’s Next?

In the next lesson, you will see how you can use LiDAR data to create a DEM and then use it to your enhance your data and maps visibility.

14.7 Lesson: Calculating the Forest Parameters

Estimating the parameters of the forest is the goal of the forest inventory. Continuing the example from previous lesson, you will use the inventory information gathered in the field to calculate the forest parameters, for the whole forest first, and then for the stands you digitized before.

The goal for this lesson: Calculate forest parameters at general and stand level.
14.7.1 Follow Along: Adding the Inventory Results

The field teams visited the forest and with the help of the information you provided, gathered information about the forest at every sample plot.

Most often the information will be collected into paper forms in the field, then typed to a spreadsheet. The sample plots information has been condensed into a .csv file that can be easily open in QGIS.

Continue with the QGIS project from the lesson about designing the inventory, you probably named it forest_inventory.qgs.

First, add the sample plots measurements to your QGIS project:

1. Go to Layer Add Delimited Text Layer…
2. Browse to the file systematic_inventory_results.csv located in exercise_data/forestry/results/
3. Make sure that the Point coordinates option is checked.
4. Set the fields for the coordinates to the X and Y fields.
5. Click OK.
6. When prompted, select ETRS89 / ETRS-TM35FIN as the CRS.
7. Open the new layer’s Attribute table and have a look at the data.

You can read the type of data that is contained in the sample plots measurements in the text file legend_2012_inventorydata.txt located in the exercise_data/forestry/results/ folder.

The systematic_inventory_results layer you just added is actually just a virtual representation of the text information in the .csv file. Before you continue, convert the inventory results to a real spatial dataset:

1. Right click on the systematic_inventory_results layer.
2. Browse to exercise_data/forestry/results/ folder.
3. Name the file sample_plots_results.shp.
4. Check Add saved file to map.
5. Remove the systematic_inventory_results layer from your project.

14.7.2 Follow Along: Whole Forest Parameters Estimation

You can calculate the averages for this whole forest area from the inventory results for the some interesting parameters, like the volume and the number of stems per hectare. Since the systematic sample plots represent equal areas, you can directly calculate the averages of the volumes and number of stems per hectare from the sample_plots_results layer.

You can calculate the average of a field in a vector layer using the Basic statistics tool:

2. Select sample_plots_results as the Input Vector Layer.
3. Select Vol as Target field.
4. Click OK.

The average volume in the forest is 135.2 m³/ha.

You can calculate the average for the number of stems in the same way, 2745 stems/ha.
Follow Along: Estimating Stand Parameters

You can make use of those same systematic sample plots to calculate estimates for the different forest stands you digitized previously. Some of the forest stands did not get any sample plot and for those you will not get information. You could have planned some extra sample plots when you planned the systematic inventory, so that the field teams would have measured a few extra sample plots for this purpose. Or you could send a field team later to get estimates of the missing forest stands to complete the stand inventory. Nevertheless, you will get information for a good number of stands just using the planned plots.

What you need is to get the averages of the sample plots that are falling within each of the forest stands. When you want to combine information based on their relative locations, you perform a spatial join:

1. Open the Vector  Data Management  Join attributes by location tool.
2. Set forest_stands_2012 as the Target vector layer. The layer you want the results for.
3. Set sample_plots_results as the Join vector layer. The layer you want to calculate estimates from.
4. Check Take summary of intersecting features.
5. Check to calculate only the Mean.
6. Name the result as forest_stands_2012_results.shp and save it in the exercise_data/forestry/results/ folder.
7. Finally select Keep all records…, so you can check later what stands did not get information.
8. Click OK.
9. Accept adding the new layer to your project when prompted.
10. Close the Join attributes by location tool.

Open the Attribute table for forest_stands_2012_results and review the results you got. Note that a number of forest stands have NULL as the value for the calculations, those are the ones having no sample plots. Select them all and view them in the map, they are some of the smaller stands:

Let's calculate now the same averages for the whole forest as you did before, only this time you will use the averages you got for the stands as the bases for the calculation. Remember that in the previous situation, each sample plot represented a theoretical stand of 80x80 m. Now you have to consider the area of each of the stands individually instead. That way, again, the average values of the parameters that are in, for example, m3/ha for the volumes are converted to total volumes for the stands.
You need to first calculate the areas for the stands and then calculate total volumes and stem numbers for each of them:

1. In the Attribute table enable editing.
2. Open the Field calculator.
3. Create a new field called area.
4. Set the Output field type to Decimal number (real).
5. Set the Precision to 2.
6. In the Expression box, write $area / 10000. This will calculate the area of the forest stands in ha.
7. Click OK.

Now calculate a field with the total volumes and number of stems estimated for every stand:

1. Name the fields s_vol and s_stem.
2. The fields can be integer numbers or you can use real numbers also.
3. Use the expressions "area" * "MEANVol" and "area" * "MEANStems" for total volumes and total stems respectively.
4. Save the edits when you are finished.
5. Disable editing.

In the previous situation, the areas represented by every sample plot were the same, so it was enough to calculate the average of the sample plots. Now to calculate the estimates, you need to divide the sum of the stands volumes or number of stems by the sum of the areas of the stands containing information.

1. In the Attribute table for the forest_stands_2012_results layer, select all the stands containing information.
2. Open Vector Analysis Tools Basic statistics for fields.
3. Select the forest_stands_2012_results as the Input layer.
4. Select area as Field to calculate statistics on.
5. Check the Selected features only
6. Click OK.

As you can see, the total sum of the stands’ areas is 66.04 ha. Note that the area of the missing forest stands is only about 7 ha.

In the same way, you can calculate that the total volume for these stands is 8908 m³/ha and the total number of stems is 179594 stems.

Using the information from the forest stands, instead of directly using that from the sample plots, gives the following average estimates:

• 184.9 m³/ha and
• 2719 stems/ha.

Save your QGIS project, forest_inventory.qgs.
Basics statistics

Input Vector Layer
- forest_stands_2012_results

Use only selected features

Target field
- area

Statistics output

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.971161764706</td>
</tr>
<tr>
<td>StdDev</td>
<td>0.688308297253</td>
</tr>
<tr>
<td>Sum</td>
<td>66.039</td>
</tr>
<tr>
<td>Min</td>
<td>0.181</td>
</tr>
<tr>
<td>Max</td>
<td>3.726</td>
</tr>
</tbody>
</table>

Press Ctrl+C to copy results to the clipboard

0%
14.7.4 In Conclusion

You managed to calculate forest estimates for the whole forest using the information from your systematic sample plots, first without considering the forest characteristics and also using the interpretation of the aerial image into forest stands. And you also got some valuable information about the particular stands, which could be used to plan the management of the forest in the coming years.

14.7.5 What’s Next?

In the following lesson, you will first create a hillshade background from a LiDAR dataset which you will use to prepare a map presentation with the forest results you just calculated.

14.8 Lesson: DEM zu LiDAR-Daten

You can improve the look of your maps by using different background images. You could use the basic map or the aerial image you have been using before, but a hillshade raster of the terrain will look nicer in some situations.

You will use LAStools to extract a DEM from a LiDAR dataset and then create a hillshade raster to use in your map presentation later.

The goal for this lesson: Install LAStools and calculate a DEM from LiDAR data and a hillshade raster.

14.8.1 Follow Along: Installing Lastools

Managing LiDAR data within QGIS is possible using the Processing framework and the algorithms provided by LAStools.

You can obtain a digital elevation model (DEM) from a LiDAR point cloud and then create a hillshade raster that is visually more intuitive for presentation purposes. First you will have to set up the Processing framework settings to properly work with LAStools:

• Close QGIS, if you have already started it.
• An old lidar plugin might be installed by default in your system in the folder C:/Program Files/QGIS Valmiera/apps/qgis/python/plugins/processing/.
• If you have a folder named lidar, delete it. This is valid for some installations of QGIS 2.2 and 2.4.
• Go to the exercise_data\forestry\lidar\ folder, there you can find the file QGIS_2_2_toolbox.zip. Open it and extract the lidar folder to replace the one you just deleted.
• If you are using a different QGIS version, you can see more installation instructions in this tutorial.

Now you need to install the LAStools to your computer. Get the newest lastools version here and extract the content of the lastools.zip file into a folder in your system, for example C:\lastools\.
The path to the lastools folder cannot have spaces or special characters.

Bemerkung: Read the LICENSE.txt file inside the lastools folder. Some of the LAStools are open source and other are closed source and require licensing for most commercial and governmental use. For education and evaluation purposes you can use and test LAStools as much as you need to.

The plugin and the actual algorithms are now installed in your computer and almost ready to use, you just need to set up the Processing framework to start using them:

• Open a new project in QGIS.
• Set the project’s CRS to ETRS89 / ETRS-TM35FIN.
• Save the project as forest_lidar.qgs.

To setup the LAStools in QGIS:

• Go to Processing Options and configuration.
• In the Processing options dialog, go to Providers and then to Tools for LiDAR data.
• Check Activate.
• For LAStools folder set c:\lastools\ (or the folder you extracted LAStools to).

![Processing options](image)

### 14.8.2 Follow Along: Calculating a DEM with LAStools

You have already used the Processing toolbox in Lesson: Spatial Statistics to run some SAGA algorithms. Now you are going to use it to run LAStools programs:

• Open Processing Toolbox.
• In the dropdown menu at the bottom, select Advanced interface.
• You should see the Tools for LiDAR data category.
• Expand it to see the tools available, and expand also the LAStools category (the number of algorithms may vary).
• Scroll down until you find the lasview algorithm, double click it to open.
• At Input LAS/LAZ file, browse to exercise_data\forestry\lidar\ and select the rautjarvi_lidar.laz file.
• Klicken Sie auf Starten.

Now you can see the LiDAR data in the *just a little LAS and LAZ viewer* dialog window:

![LAS and LAZ viewer](image)

There are many things you can do within this viewer, but for now you can just click and drag on the viewer to pan the LiDAR point cloud to see what it looks like.

_Bemerkung:_ If you want to know further details on how the LAS tools work, you can read the README text files about each of the tools, in the C:\lastools\bin\ folder. Tutorials and other materials are available at the Rapidlasso webpage.

• Close the viewer when you are ready.

Creating a DEM with LASTools can be done in two steps, first one to classify the point cloud into ground and no ground points and then calculating a DEM using only the ground points.

• Go back to the Processing Toolbox.
• Note the Search… box, write lasground.
• Double click to open the lasground tool and set it as shown in this image:

![lasground tool](image)

• The output file is saved to the same folder where the rautjarvi_lidar.laz is located and it is named rautjarvi_lidar_1.las.

You can open it with lasview if you want to check it.

The brown points are the points classified as ground and the gray ones are the rest, you can click the letter g to visualize only the ground points or the letter u to see only the unclassified points. Click the letter a to see all the points again. Check the lasview_README.txt file for more commands. If you are interested, also this tutorial about editing LiDAR points manually will show you different operations within the viewer.
• Close the viewer again.
• In the Processing Toolbox, search for las2dem.
• Open the las2dem tool and set it as shown in this image:

The result DEM is added to your map with the generic name Output raster file.

Bemerkung: The lasground and las2dem tools require licensing. You can use the unlicensed tool as indicated in the license file, but you get the diagonals you can appreciate in the image results.
14.8.3  Follow Along: Creating a Terrain Hillshade

For visualization purposes, a hillshade generated from a DEM gives a better visualization of the terrain:

- Open Raster → Terrain analysis → Hillshade.
- As the Output layer, browse to exercise_data\forestry\lidar\ and name the file hillshade.tif.
- Leave the rest of parameters with the default settings.

Despite the diagonal lines remaining in the hillshade raster result, you can clearly see an accurate relief of the area. You can even see the different soil drains that have been dug in the forests.
14.8. Lesson: DEM zu LiDAR-Daten
14.8.4 In Conclusion

Using LiDAR data to get a DEM, specially in forested areas, gives good results with not much effort. You could also use ready LiDAR derived DEMs or other sources like the SRTM 9m resolution DEMs. Either way, you can use them to create a hillshade raster to use in your map presentations.

14.8.5 What’s Next?

In the next, and final step in this module, lesson you will use the hillshade raster and the forest inventory results to create a map presentation of the results.

14.9 Lesson: Kartendarstellung

In the previous lessons you have imported an old forest inventor as a GIS project, updated it to the current situation, designed a forest inventory, created maps for the field work and calculated forest parameters from the field measurements.

It is often important to create maps with the results of a GIS project. A map presenting the results of the forest inventory will make it easier for anyone to have a good idea of what the results are in a quick glance, without looking at the specific numbers.

The goal for this lesson: Create a map to present the inventory results using a hillshade raster as background.

14.9.1 Follow Along: Preparing the Map Data

Open the QGIS project from the parameters calculations lesson, forest_inventory.qgs. Keep at least the following layers:

- forest_stands_2012_results.
- basic_map.
- rautjarvi_aerial.
- lakes (if you don’t have it, add it from the exercise_data\forestry\ folder).

You are going to present the average volumes of your forest stands in a map. If you open the Attribute table for the forest_stands_2012_results layer, you can see the NULL values for the stands without information. To be able to get also those stands into your symbology you should change the NULL values to, for example, -999, knowing that those negative numbers mean there is no data for those polygons.

For the forest_stands_2012_results layer:

- Open the Attribute table and enable editing.
- Select the polygons with NULL values.
- Use the calculator to update the values of the MEANVol field to -999 only for the selected features.
- Disable editing and save the changes.

Now you can use a saved style for this layer:

- Go to the Symbology tab.
- Click on Style [Load Style…]
- Select the forest_stands_2012_results.qml from the exercise_data\forestry\results\ folder.
- Click OK.
Your map will look something like this:

### 14.9.2 Try Yourself Try Different Blending Modes

The style you loaded:

is using the **Hard light** mode for the *Layer blending mode*. Note that the different modes apply different filters combining the underlying and overlying layers, in this case the hillshade raster and your forest stands are used. You can read about these modes in the User Guide.

Try with different modes and see the differences in your map. Then choose the one you like better for your final map.

### 14.9.3 Try Yourself Using a Layout Template to Create the Map result

Use a template prepared in advance to present the results. The template `forest_map.qpt` is located in the `exercise_data\forestry\results\` folder. Load it using the *Project Layout Manager*… dialog.

Open the print layout and edit the final map to get a result you are happy with.

The map template you are using will give a map similar to this one:

Save your QGIS project for future references.
14.9. Lesson: Kartendarstellung

QGIS Training Manual
RAUTJÄRVI FOREST
- INVENTORY RESULTS 2012 -

- Results for the whole forest area -

Using Systematic Sample Plots

<table>
<thead>
<tr>
<th>Total area: 72.9</th>
<th>Total volume (m³): 9856</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average volume (m³/ha): 135.2</td>
<td></td>
</tr>
</tbody>
</table>

Using Stand Sample Plots Averages

<table>
<thead>
<tr>
<th>Total area: 72.9</th>
<th>Total volume (m³): 13479</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average volume (m³/ha): 184.9</td>
<td></td>
</tr>
</tbody>
</table>
14.9.4 In Conclusion

Through this module you have seen how a basic forest inventory can be planned and presented with QGIS. Many more forest analysis are possible with the variety of tools that you can access, but hopefully this manual has given you a good starting point to explore how you could achieve the specific results you need.
Relationale Datenbanken sind ein wichtiger Bestandteil eines jeden GIS-Systems. In diesem Modul lernen Sie die Konzepte eines relationalen Datenbankmanagementsystems (RDBMS) kennen und Sie werden PostgreSQL verwenden, um eine neue Datenbank zum Speichern von Daten zu erstellen, sowie andere typische RDBMS-Funktionen kennen lernen.

15.1 Lesson: Einführung in Datenbanken

Bevor wir PostgreSQL verwenden, gehen wir einige Grundlagen der allgemeinen Datenbanktheorie durch. Sie müssen die hier verwendeten Beispielcodes nicht abtippen. Sie dienen nur zur Illustration.

Ziel dieser Übung: Verständnis der grundlegenden Datenbankkonzepte.

15.1.1 Was ist eine Datenbank?


Ein Datenbankmanagementsystem (DBMS) ist ein Programm, das Datenbanken verwaltet, für die Speicherung von Daten, den Zugriff auf Daten, die Sicherheit, Rettungskopien und weitere Dinge sorgt. - Wikipedia

15.1.2 Tabellen

In relationalen Datenbanken und Flat-File-Datenbanken versteht man unter einer Tabelle eine Menge von Datenelementen (Werte), die in vertikalen Spalten (die durch einen Spaltennamen identifiziert sind) und horizontalen Zeilen organisiert sind. Eine Tabelle hat eine bestimmte Anzahl an Spalten und eine unbegrenzte Anzahl an Zeilen. Jede Zeile wird durch die Werte einer Teilmenge der Spalten, die als Schlüsselkandidat gekennzeichnet sind, identifiziert. - Wikipedia

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tim</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Horst</td>
<td>88</td>
</tr>
</tbody>
</table>

(2 rows)

In SQL-Datenbanken wird eine Tabelle auch als Relation bezeichnet.
15.1.3 Spalten / Felder


Eine Spalte:

<table>
<thead>
<tr>
<th>name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tim</td>
<td></td>
</tr>
<tr>
<td>Horst</td>
<td></td>
</tr>
</tbody>
</table>

Ein Feld:

| Horst |

15.1.4 Datensätze

Ein Datensatz ist die in einer Tabellenzeile gespeicherte Information. Jeder Datensatz enthält für jede Spalte der Tabelle ein Feld.

| 2   | Horst | 88 | <== one record |

15.1.5 Datentypen

Datentypen schränken die Art der Information ein, die in einer Spalte gespeichert werden kann. - *Tim und Horst*

Es viele verschiedene Datentypen. Hier sind die am weitesten verbreiteten:

- **String** - zur Speicherung von freiem Text
- **Integer** - um ganzzahlige Zahlen zu speichern
- **Real** - zur Speicherung reeller Zahlen
- **Date** - um den Geburtstag von Horst zu speichern, so dass niemand ihn vergisst
- **Boolean** - um einfache wahr/falsch Werte zu speichern

Man kann der Datenbank auch erlauben gar nichts in einem Feld zu speichern. Wenn ein Feld keinen Wert enthält, wird der Inhalt des Feldes als **Null Wert** bezeichnet:

```
insert into person (age) values (40);

select * from person;
```

Ergebnis:

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>age</th>
</tr>
</thead>
<tbody>
<tr>
<td>---</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>1</td>
<td>Tim</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Horst</td>
<td>88</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

(3 rows)

Es gibt noch viele weitere Datentypen, die man nutzen kann - *check the PostgreSQL manual!*

410 Kapitel 15. Module: Datenbank-Konzepte mit PostgreSQL
15.1.6 Modellierung einer Adressendatenbank

Wir werden ein einfaches Fallbeispiel betrachten, um zu sehen wie eine Datenbank konstruiert ist. Wir werden eine Adressendatenbank erstellen.

Try Yourself

Schreiben Sie die Eigenschaften einer einfachen Adresse auf, die wir in der Datenbank speichern wollen.

Überprüfen Sie Ihre Ergebnisse

Struktur einer Adresse

Die Bestandteile, die zu einer Adresse gehören entsprechen den Spalten. Die Art der Information, die in jeder Spalte gespeichert ist, ist der Datentyp. Im nächsten Abschnitt werden wir unseren Entwurf der Adressentabelle analysieren und verbessern.

15.1.7 Datenbanktheorie

Der Prozess der Erstellung einer Datenbank beinhaltet die Erstellung eines Modells der Wirklichkeit; man repräsentiert Konzepte aus der Wirklichkeit durch Objekte in der Datenbank.

15.1.8 Normalisierung


Normalisierung ist ein systematischer Weg, um sicher zu stellen, dass die Datenbankstruktur für allgemeine Abfragen passend und frei von bestimmten ungewollten Eigenschaften - Unregelmäßigkeiten beim einfügen, aktualisieren und löschen von Daten - die zum Verlust der Datenintegrität führen können. - Wikipedia

Es gibt verschiedene Arten der Normalisierung.

Schauen wir uns ein einfaches Beispiel an:

<table>
<thead>
<tr>
<th>Table &quot;public.people&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>id</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>name</td>
</tr>
<tr>
<td>address</td>
</tr>
<tr>
<td>phone_no</td>
</tr>
</tbody>
</table>

Indexes:
"people_pkey" PRIMARY KEY, btree (id)

```sql
select * from people;
```

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>address</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tim Sutton</td>
<td>3 Buirski Plein, Swellendam</td>
<td>071 123 123</td>
</tr>
<tr>
<td>2</td>
<td>Horst Duester</td>
<td>4 Avenue du Roix, Geneva</td>
<td>072 121 122</td>
</tr>
</tbody>
</table>
(2 rows)
Stellen Sie sich vor, Sie haben viele Freunde die in einer Straße mit demselben Namen oder derselben Stadt leben. Bei jeder Duplizierung der Daten wird Speicherplatz verbraucht. Noch schlimmer ist, dass wenn sich der Name einer Stadt ändert, viele Einträge in der Datenbank korrigiert werden müssen.

15.1.9 Try Yourself

Verändern sie die obige people Tabelle, um Dopplungen zu verringern und die Datenstruktur zu normalisieren.

Unter dem folgendem Link erfährt man mehr über die Datenbanknormalisierung: here

Überprüfen sie Ihr Ergebnis

15.1.10 Indexe

Ein Datenbankindex ist eine Datenstruktur, die die Geschwindigkeit von Abfrageoperationen auf einer Datenbank-tabelle erhöht. - Wikipedia

Stellen Sie sich vor, Sie lesen ein Fachbuch und suchen nach der Erklärung eines Begriffes, aber das Buch hat keinen Index! Sie müssten beginnend mit dem ersten Kapitel das ganze Buch durcharbeiten, bis Sie die gesuchte Information finden. Der Index im Buch hilft, schnell zu der Seite im Buch mit der relevanten Information zu springen:

```
create index person_name_idx on people (name);
```

Jetzt ist die Suche nach Namen schneller:

```
<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>not null default</td>
</tr>
<tr>
<td>name</td>
<td>character varying(50)</td>
<td>nextval('people_id_seq'::regclass)</td>
</tr>
<tr>
<td>address</td>
<td>character varying(200)</td>
<td>not null</td>
</tr>
<tr>
<td>phone_no</td>
<td>character varying</td>
<td></td>
</tr>
</tbody>
</table>
```

Indexes:
"people_pkey" PRIMARY KEY, btree (id)
"person_name_idx" btree (name)

15.1.11 Sequenzen

Eine Sequenz ist eine Folge eindeutiger Zahlen. Sie wird normalerweise als eindeutiger Identifikator in einer Spalte einer Tabelle verwendet.

In diesem Beispiel ist id eine Sequenz - die Zahl wird mit jeder Aufnahme eines neuen Datensatzes in die Tabelle erhöht:

```
<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>address</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tim Sutton</td>
<td>3 Buirski Plein, Swellendam</td>
<td>071 123 123</td>
</tr>
<tr>
<td>2</td>
<td>Horst Duster</td>
<td>4 Avenue du Roix, Geneva</td>
<td>072 121 122</td>
</tr>
</tbody>
</table>
```
15.1.12 Entity Relationship Diagramme

In einer normalisierten Datenbank hat man normalerweise viele Relationen (Tabellen). Das Entity-Relationship-Diagramm (ER-Diagramm) wird verwendet, um die logischen Beziehungen zwischen den Relationen zu entwerfen. Denken Sie an unsere nicht normalisierte Tabelle `people` am Anfang der Lektion:

```
select * from people;
```

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>address</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tim Sutton</td>
<td>3 Buirski Plein, Swellendam</td>
<td>071 123 123</td>
</tr>
<tr>
<td>2</td>
<td>Horst Duster</td>
<td>4 Avenue du Roix, Geneva</td>
<td>072 121 122</td>
</tr>
</tbody>
</table>

Mit etwas Arbeit können wir sie in zwei Tabellen teilen. Der Straßenname von Personen die in derselben Straße wohnen, muss dadurch nicht wiederholt werden:

```
select * from streets;
```

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plein Street</td>
</tr>
</tbody>
</table>

```
select * from people;
```

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>house_no</th>
<th>street_id</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Horst Duster</td>
<td>4</td>
<td>1</td>
<td>072 121 122</td>
</tr>
</tbody>
</table>

Wir können nun die beiden Tabellen mit Hilfe der ‚Schlüssel‘ `streets.id` und `people.streets_id` verbinden.

Wenn wir ein ER-Diagramm für diese beiden Tabellen entwerfen, sieht es in etwa so aus:

![ER-Diagramm](image)

Das ER-Diagramm hilft uns ‚eins zu viele‘ Beziehungen auszudrücken. In diesem Fall zeigt das Pfeilsymbol, dass in einer Straße viele Personen leben können.

**Try Yourself**

Unser Modell `people` hat immer noch einige Probleme bezüglich der Normalisierung - versuchen Sie es weiter mit Hilfe eines ER-Diagramms zu normalisieren.

Überprüfen Sie Ihre Ergebnisse
15.1.13 Einschränkungen, Primärschlüssel und Fremdschlüssel

Eine Datenbankeinschränkung wird verwendet, um sicherzustellen, dass die Daten in einer Relation so gespeichert werden, wie es der Modellierer vorgesehen hat. Zum Beispiel kann eine Einschränkung der Postleitzahl darin bestehen, dass die Zahl zwischen 1000 und 9999 liegt.

Ein Primärschlüssel besteht aus einem oder mehreren Feldwerten, die einen Datensatz eindeutig machen. Oftmals wird der Primärschlüssel id genannt und ist eine ideale Zahlenfolge.

Ein Fremdschlüssel ist eine Referenz zu einem eindeutigen Datensatz in einer anderen Tabelle (Nutzung des Primärschlüssels dieser Tabelle).

In ER-Diagrammen basiert die Verbindung zwischen Tabellen normalerweise auf Fremdschlüsseln die auf Primärschlüssel verweisen.

In unserem Beispiel, zeigt die Definition der Tabelle, dass die Spalte Straße ein Fremdschlüssel ist. Er verweist auf den Primärschlüssel der Tabelle Straßen:

<table>
<thead>
<tr>
<th>Table &quot;public.people&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>id</td>
</tr>
<tr>
<td>name</td>
</tr>
<tr>
<td>house_no</td>
</tr>
<tr>
<td>street_id</td>
</tr>
<tr>
<td>phone_no</td>
</tr>
</tbody>
</table>

Indexes:
"people_pkey" PRIMARY KEY, btree (id)

Foreign key constraints:
"people_street_id_fkey" FOREIGN KEY (street_id) REFERENCES streets(id)

15.1.14 Transaktionen

Wenn beim hinzufügen, ändern oder löschen von Daten in einer Datenbank etwas schief geht, sollte die Datenbank immer in einem konsistenten Zustand bleiben. Die meisten Datenbanken enthalten eine sogenannte Transaktionsunterstützung. Transaktionen erlauben es einen Rollback zu erstellen, d.h. einen Zustand vor Ausführung der Transaktion in den bei Problemen zurück gekehrt werden kann.

Ein Beispiel wäre ein Abrechnungssystem in dem man Mittel von einem Konto auf ein anderes Konto transferieren möchte. Es ergibt sich folgende Schritttfolge:

- entferne R20 von Joe
- Füge R20 bei Anne hinzu

Wenn etwas während des Prozesses schief geht (z.B. Stromausfall), wird ein Rollback der Transaktion ausgeführt.

15.1.15 In Conclusion

Datenbanken erlauben es, Daten in einer strukturierten Weise mit Hilfe von einfachem Programierkode zu managen.
15.1.16 What’s Next?

Nachdem wir gesehen haben, wie Datenbanken in der Theorie arbeiten, wollen wir nun eine neue Datenbank erstellen und die behandelte Theorie umsetzen.

15.2 Lesson: Implementierung des Datenmodells

Nachdem wir die ganze Theorie behandelt haben, wollen wir nun eine neue Datenbank erstellen. Diese Datenbank wird für unsere Übungen in den folgenden Lektionen verwendet.

Das Ziel dieser Lektion: Die Installation der benötigten Software und deren Verwendung, um unsere Beispieldata-

tenbank zu erstellen.

15.2.1 Installation von PostgreSQL

Bemerkung: Although outside the scope of this document, Mac users can install PostgreSQL using Homebrew. Windows users can use the graphical installer. Please note that the documentation will assume users are running QGIS under Ubuntu.

Unter Ubuntu:

```
sudo apt install postgresql-9.1
```

Sie sollten folgende Nachricht erhalten:

```
[sudo] password for qgis:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following extra packages will be installed:
postgresql-client-9.1 postgresql-client-common postgresql-common
Suggested packages:
oidentd ident-server postgresql-doc-9.1
The following NEW packages will be installed:
postgresql-9.1 postgresql-client-9.1 postgresql-client-common postgresql-common
0 upgraded, 4 newly installed, 0 to remove and 5 not upgraded.
Need to get 5,012kB of archives.
After this operation, 19.0MB of additional disk space will be used.
Do you want to continue [Y/n]? 
```

Drücken Sie Y und Enter und warten bis der Download und die Installation abgeschlossen sind.

15.2.2 Hilfe

PostgreSQL hat eine sehr gute online Dokumentation.
15.2.3 Erstellen eines Datenbankbenutzers

Unter Ubuntu:

Starten Sie nach dem Abschluss der Installation das folgende Kommando, um Postgres Nutzer zu werden. Erstellen Sie dann einen neuen Datenbanknutzer:

```
sudo su - postgres
```

Geben Sie bei der Abfrage Ihr normales login Passwort ein (Sie benötigen dazu sudo Rechte).

Erstellen Sie nun in der Postgres bash Eingabeaufforderung den Datenbanknutzer. Stellen Sie sicher, dass der Benutzername Ihrem Unix login Namen entspricht. Die Vereinfachung besteht darin, dass Postgres Sie automatisch authentifiziert, wenn Sie als dieser Nutzer eingeloggt sind:

```
createuser -d -E -i -l -P -r -s qgis
```

Geben Sie ein Passwort ein, wenn Sie danach gefragt werden. Sie sollten ein anderes Passwort als Ihr login Passwort verwenden.

Was bedeutet diese Optionen?

- `-d`, `--createdb` role can create new databases
- `-E`, `--encrypted` encrypt stored password
- `-i`, `--inherit` role inherits privileges of roles it is a member of (default)
- `-l`, `--login` role can login (default)
- `-P`, `--pwprompt` assign a password to new role
- `-r`, `--createrole` role can create new roles
- `-s`, `--superuser` role will be superuser

Jetzt können Sie die Postgres Nutzer bash shell Umgebung durch folgende Eingabe verlassen:

```
exit
```

15.2.4 Überprüfen Sie das neue Konto:

```
psql -l
```

Die Ausgabe sollte ähnlich dem folgendem aussehen:

<table>
<thead>
<tr>
<th>Name</th>
<th>Owner</th>
<th>Encoding</th>
<th>Collation</th>
<th>Ctype</th>
</tr>
</thead>
<tbody>
<tr>
<td>postgres</td>
<td>postgres</td>
<td>UTF8</td>
<td>en_ZA.utf8</td>
<td>en_ZA.utf8</td>
</tr>
<tr>
<td>template0</td>
<td>postgres</td>
<td>UTF8</td>
<td>en_ZA.utf8</td>
<td>en_ZA.utf8</td>
</tr>
<tr>
<td>template1</td>
<td>postgres</td>
<td>UTF8</td>
<td>en_ZA.utf8</td>
<td>en_ZA.utf8</td>
</tr>
</tbody>
</table>

Drücken sie zum Verlassen Q.

15.2.5 Eine Datenbank erstellen

Das Kommando `createdb` wird zum Erstellen einer neuen Datenbank verwendet. Es sollte von der Eingabeaufforderung der bash shell aus gestartet werden:

```
createdb address -O qgis
```

Sie können sich durch folgendes Kommando vergewissern, dass Ihre neue Datenbank erstellt wurde:

```
psql -l
```
Die Ausgabe sollte in etwa so aussehen:

<table>
<thead>
<tr>
<th>Name</th>
<th>Owner</th>
<th>Encoding</th>
<th>Collation</th>
<th>Ctype</th>
<th>Access privileges</th>
</tr>
</thead>
<tbody>
<tr>
<td>address</td>
<td>qgis</td>
<td>UTF8</td>
<td>en_ZA.utf8</td>
<td>en_ZA.utf8</td>
<td></td>
</tr>
<tr>
<td>postgres</td>
<td>postgres</td>
<td>UTF8</td>
<td>en_ZA.utf8</td>
<td>en_ZA.utf8</td>
<td></td>
</tr>
<tr>
<td>template0</td>
<td>postgres</td>
<td>UTF8</td>
<td>en_ZA.utf8</td>
<td>en_ZA.utf8</td>
<td></td>
</tr>
<tr>
<td>template1</td>
<td>postgres</td>
<td>UTF8</td>
<td>en_ZA.utf8</td>
<td>en_ZA.utf8</td>
<td></td>
</tr>
<tr>
<td>template1</td>
<td>postgres</td>
<td>UTF8</td>
<td>en_ZA.utf8</td>
<td>en_ZA.utf8</td>
<td></td>
</tr>
</tbody>
</table>

(4 rows)

Drücken sie zum Verlassen `q`.

### 15.2.6 Start einer Datenbank shell Sitzung

Sie können sich ganz einfach mit Ihrer Datenbank verbinden:

```bash
psql address
```

Geben Sie zum Verlassen der `psql` Datenbank shell folgendes ein:

```
\q
```

Hilfe zur shell erhalten Sie durch Eingabe von:

```
\?
```

Hilfe zur Benutzung von SQL Kommandos erhalten Sie durch:

```
\help
```

Um Hilfe für ein bestimmtes Kommando zu erhalten, geben Sie (beispielsweise) das Folgende ein:

```
\help create table
```

Siehe auch `Psq!L cheat sheet`.

### 15.2.7 Erstellen von Tabellen in SQL

Wir erstellen nun einige Tabellen! Dazu verwenden wir unser ER-Diagramm als Vorlage. Stellen Sie zuerst die Verbindung zur Adressdatenbank her:

```bash
psql address
```

Erstellen Sie dann eine Tabelle `streets`:

```sql
create table streets (id serial not null primary key, name varchar(50));
```

Serial und varchar sind Datentypen. Serial teilt PostgreSQL mit, dass eine ganzzahlige Reihe (automatisch vergebene Zahlen) zur Füllung des Feldes id für jeden neuen Datensatz erstellt werden soll. VARCHAR(50) teilt PostgreSQL mit, dass ein Zeichenkettenfeld mit einer Länge von 50 Zeichen erstellt werden soll.

Wir bemerken, dass das Kommando mit einem `;` endet - alle SQL Kommandos sollten so enden. Wenn Sie Enter drücken, wird `psql` eine ähnliche Meldung wie folgt ausgeben:

```
NOTICE: CREATE TABLE will create implicit sequence "streets_id_seq"
for serial column "streets.id"
NOTICE: CREATE TABLE / PRIMARY KEY will create implicit index
```

(Fortsetzung auf der nächsten Seite)
Das bedeutet, dass Ihre Tabelle mit dem Primärschlüssel streets_pkey für streets.id erfolgreich erstellt wurde.

Achtung: Wenn Sie die Eingabe ohne ; beenden, erhalten Sie eine Meldung wie: address-#. Dies geschieht, weil PG noch eine weitere Eingabe erwartet. Geben Sie zum Abschließen des Kommandos ; ein.

Um die Tabelleneigenschaften anzuzeigen, können wir das Folgende eingeben:

```
\d streets
```

Als Ausgabe erhalten wir in etwa das Folgende:

```
<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>not null default</td>
</tr>
<tr>
<td>name</td>
<td>character varying(50)</td>
<td>nextval('streets_id_seq'::regclass)</td>
</tr>
</tbody>
</table>
```

So zeigen Sie den Inhalt Ihrer Tabellen an:

```
select * from streets;
```

Als Ausgabe erhalten wir in etwa das Folgende:

```
<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>rows</td>
</tr>
</tbody>
</table>
```

Wir sehen, dass unsere Tabelle momentan leer ist.

**Try Yourself**

Erstellen Sie analog zum obigen Vorgehen eine Tabelle personen:

Fügen Sie Felder wie Telefonnummer, Adresse, Name usw. hinzu (achten Sie darauf, dass die Feldnamen gültig sind). Stellen Sie sicher, dass die Tabelle eine ID Spalte mit demselben Datentyp wie Beispiel oben erhält.

**Überprüfen Sie Ihre Ergebnisse**

### 15.2.8 Erstellen von Schlüsseln in SQL

Das Problem der obigen Lösung ist, dass die Datenbank nicht weiß, dass Personen und Straßen in einer logischen Beziehung stehen. Um diese Beziehung auszudrücken, müssen wir einen Fremdschlüssel erstellen, der auf den Primärschlüssel der Tabelle streets zeigt.

Es gibt zwei Wege, dies zu erreichen:
• Hinzufügen des Schlüssels nachdem die Datenbank erstellt wurde
• Definition des Schlüssels bei Erstellung der Tabelle

Unsere Tabelle wurde schon erstellt, wir verwenden also den ersten Weg:

```sql
alter table people
add constraint people_streets_fk foreign key (street_id) references streets(id);
```

Damit teilen wir der Tabelle `people` mit, dass ihr Feld `street_id` einen gültigen Wert aus der Spalte `id` der Tabelle `streets` enthalten muss.

Es ist der gebräuchlichere Weg, eine Einschränkung bei der Erstellung einer Tabelle vorzugeben:

```sql
create table people (id serial not null primary key,
name varchar(50),
house_no int not null,
street_id int references streets(id) not null,
phone_no varchar null);
```

Nach Hinzufügen der Einschränkung sieht unser Tabellenschema wie folgt aus:

```
<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>not null default</td>
</tr>
<tr>
<td>name</td>
<td>character varying(50)</td>
<td>nextval('people_id_seq'::regclass)</td>
</tr>
<tr>
<td>house_no</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>street_id</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>phone_no</td>
<td>character varying</td>
<td></td>
</tr>
</tbody>
</table>

Indexes:
- "people_pkey" PRIMARY KEY, btree (id)
- "people_streets_fk" FOREIGN KEY (id) REFERENCES streets(id)
```

### 15.2.9 Indexe mit SQL erstellen

Wir möchten blitzschnelle Suchen nach Namen von Personen. Um dies zu erreichen, können wir einen Index über die Namensspalte unserer Tabelle der Personen erstellen:

```sql
create index people_name_idx on people(name);
```

Das Ergebnis ist:

```
<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
</tr>
<tr>
<td>name</td>
<td>character varying(50)</td>
</tr>
<tr>
<td>house_no</td>
<td>integer</td>
</tr>
<tr>
<td>street_id</td>
<td>integer</td>
</tr>
<tr>
<td>phone_no</td>
<td>character varying</td>
</tr>
</tbody>
</table>

Indexes:
- "people_pkey" PRIMARY KEY, btree (id)
- "people_streets_fk" FOREIGN KEY (id) REFERENCES streets(id)
```

(Fortsetzung auf der nächsten Seite)
"people_pkey" PRIMARY KEY, btree (id)
"people_name_idx" btree (name)  "new index added!"

Foreign key constraints:
"people_streets_fk" FOREIGN KEY (id) REFERENCES streets(id)

15.2.10 Löschen von Tabellen mit SQL

Wenn man Tabellen los werden möchte, kann man das Kommando drop verwenden:

```sql
drop table streets;
```

**Bemerkung:** In unserem aktuellen Beispiel, würde das obige Beispiel nicht funktionieren. Warum nicht? See why

Wenn man dasselbe Kommando `drop table` mit der Tabelle `people` verwendeten würde, wäre es erfolgreich:

```sql
drop table people;
```

**Bemerkung:** Wenn Sie das Kommando eingegeben haben und die Tabelle `people` gelöscht wurde, ist es ein guter Zeitpunkt, um die Tabelle neu zu erstellen. Wir werden sie für die nächsten Übungen benötigen.

15.2.11 Ein Wort zu pgAdmin III

Wir zeigen die SQL Kommandos in der `psql` Kommandozeile, da dies ein sehr nützlicher Weg ist, um etwas über Datenbanken zu lernen. Es gibt aber auch schnellere und einfachere Wege, um eine Menge der hier gezeigten Dinge zu tun. Installieren Sie pgAdmin III und Sie können Tabellen mit Hilfe der Maus in einer grafischen Oberfläche erstellen, löschen oder ändern.

Unter Ubuntu installieren Sie es in etwa so:

```bash
sudo apt install pgadmin3
```

pgAdmin III wird in einem anderen Modul noch ausführlicher behandelt.

15.2.12 In Conclusion

Sie haben jetzt gesehen, wie man eine brandneue Datenbank komplett von null ausgehend erstellen kann.

15.2.13 What’s Next?

Als nächstes lernen Sie, wie man das DBMS nutzt, um neue Daten hinzuzufügen.
15.3 Lesson: Daten in das Modell einfügen

Das Modell, das wir erstellt haben, soll jetzt mit den vorgesehenen Daten gefüllt werden.

**Ziel dieser Lektion:** Das Erlernen des Einfügens neuer Daten in ein Datenbankmodell.

### 15.3.1 Die Einfügeanweisung

Wie fügen Sie Daten zu einer Tabelle hinzu? Das SQL Kommando `INSERT` stellt die erforderliche Funktionalität dazu bereit:

```sql
insert into streets (name) values ('High street');
```

Einige Sachen müssen beachtet werden:

- Nach dem Tabellenname (`streets`) werden die zu füllenden Spaltenamen aufgeführt (in diesem Fall nur die Spalte `name`).
- Fügen Sie nach dem Schlüsselwort `values` die Liste der Feldwerte ein.
- Zeichenketten müssen von einfachen Anführungszeichen umgeben werden.
- Beachten Sie, dass wir keinen Wert für die Spalte `id` einfügen, weil die Spalte automatisch mit einer Sequenz gefüllt wird.
- Wenn man die `id` manuell verändert, riskiert man schwerwiegende Probleme bezüglich der Integrität der Datenbank.

Wir sollten nach erfolgreichen Abschluss die Meldung `INSERT 0 1` sehen.

Wir können das Ergebnis unserer Einfügeaktion durch Auswahl aller in der Tabelle enthaltenden Daten sehen:

```sql
select * from streets;
```

**Ergebnis:**

```
select * from streets;
 id    | name
-------|-------
 1     | High street

(1 row)
```

**Try Yourself**

Nutzen Sie das Kommando `INSERT`, um neue Straßen zur Tabelle `streets` hinzuzufügen.

**Prüfen Sie Ihre Ergebnisse**

### 15.3.2 Aneinanderreihen von Einfügeaktionen aufgrund von Beschränkungen

### 15.3.3 Try Yourself

Versuchen ein Objekt Person zu der Tabelle `people` mit den folgenden Details hinzuzufügen:

<table>
<thead>
<tr>
<th>Name: Joe Smith</th>
</tr>
</thead>
<tbody>
<tr>
<td>House Number: 55</td>
</tr>
<tr>
<td>Street: Main Street</td>
</tr>
<tr>
<td>Phone: 072 882 33 21</td>
</tr>
</tbody>
</table>
**Bemerkung:** Denken Sie daran, dass wir die Telefonnummern als Zeichenketten, nicht als Ganzzahlen definiert haben.

In diesem Fall erhalten wir eine Fehlermeldung, wenn wir vorher noch keinen Datensatz für Main Street in der Tabelle `streets` erstellt haben.

Wir bemerken auch:

- Man kann keine Straße unter Nutzung ihres Namens hinzufügen
- Man kann vor dem Anlegen des Datensatzes für die Straße in der Tabelle `streets` keine Straße mit Hilfe der `id` hinzufügen

Denken Sie daran, dass unsere zwei Tabellen mit Hilfe eines Erst-/Fremdschlüsselpaares verbunden sind. Das bedeutet, dass keine zulässige Person ohne zulässigen dazugehörenden Datensatz für eine Straße erstellt werden kann.

Fügen Sie unter Nutzung dieses Wissens eine neue Person zur Datenbank hinzu.

*Prüfen Sie Ihre Ergebnisse*

### 15.3.4 Auswahl von Daten

Wir haben die Syntax zur Selektion von Datensätzen schon demonstriert. Lassen Sie uns einige weitere Beispiele ansehen:

```sql
select name from streets;
```

```sql
select * from streets;
```

```sql
select * from streets where name='Main Road';
```

In späteren Abschnitten gehen wir detaillierter darauf ein, wie man Daten auswählt und filtert.

### 15.3.5 Aktualisierung von Daten

Was ist, wenn man bereits existierende Daten verändern möchte? Z.B. einen Straßenamen der sich geändert hat:

```sql
update streets set name='New Main Road' where name='Main Road';
```

Seien Sie mit solchen Aktualisierungsanweisungen sehr vorsichtig - wenn mehr als ein Datensatz Ihrer WHERE Bedingung entspricht, werden alle aktualisiert!

Eine bessere Lösung ist die Verwendung des Primärschlüssels der Tabelle um den zu ändernden Datensatz anzusprechen:

```sql
update streets set name='New Main Road' where id=2;
```

Die Ausgabe sollte lauten `UPDATE 1`.

**Bemerkung:** Die Kriterien der WHERE Anweisung unterscheidet zwischen Groß- und Kleinschreibung `Main Road` ist nicht dasselbe wie `Main road`
15.3.6 Löschen von Daten

Nutzen Sie das DELETE Kommando, um ein Objekt aus einer Tabelle zu löschen:

```sql
delete from people where name = 'Joe Smith';
```

Sehen wir uns nun die Tabelle der Personen an:

```sql
address=#
select * from people;

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>house_no</th>
<th>street_id</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(0 rows)
```

15.3.7 Try Yourself

Nutzen Sie das Gelernte, um einige neue Freunde in Ihre Datenbank einzutragen:

```sql
<table>
<thead>
<tr>
<th>name</th>
<th>house_no</th>
<th>street_id</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe Bloggs</td>
<td>3</td>
<td>2</td>
<td>072 887 23 45</td>
</tr>
<tr>
<td>Jane Smith</td>
<td>55</td>
<td>3</td>
<td>072 837 33 35</td>
</tr>
<tr>
<td>Roger Jones</td>
<td>33</td>
<td>1</td>
<td>072 832 31 38</td>
</tr>
<tr>
<td>Sally Norman</td>
<td>83</td>
<td>1</td>
<td>072 932 31 32</td>
</tr>
</tbody>
</table>
```

15.3.8 In Conclusion

Sie wissen nun, wie man neue Daten zu vorhandenen schon erstellten Modellen hinzufügt. Denken Sie daran, dass wenn Sie neue Datenarten hinzufügen, sie unter Umständen auch neue Datenmodelle erstellen müssen.

15.3.9 What’s Next?

Nachdem wir nun einige Daten hinzugefügt haben, werden wir die Nutzung von Abfragen zum Zugriff auf die Daten lernen.

15.4 Lesson: Abfragen

Wenn Sie ein Kommando wie SELECT ... schreiben, wird es in der Regel als Abfrage bezeichnet - Sie befragen die Datenbank nach Informationen.

Ziel dieser Lektion: Zu lernen, wie man Abfragen erstellt, die nützliche Informationen zurückgeben.

Bemerkung: Wenn Sie es noch nicht in der letzten Lektion gemacht haben, fügen Sie die folgenden Personen zur Tabelle people hinzu. Wenn Sie Fehlermeldungen zu Einschränkungen des Fremdschlüssels erhalten, müssen Sie zuerst das Objekt 'Main Road' in die streets Tabelle einfügen

```sql
insert into people (name,house_no, street_id, phone_no) values ('Joe Bloggs',3,2,'072 887 23 45');
insert into people (name,house_no, street_id, phone_no) values ('Jane Smith',55,3,'072 837 33 35');
insert into people (name,house_no, street_id, phone_no) values ('Roger Jones',33,1,'072 832 31 38');
```

(Fortsetzung auf der nächsten Seite)

15.4. Lesson: Abfragen
15.4.1 Ordnung der Ergebnisse

Lassen Sie uns eine Personenliste geordnet nach ihrer Hausnummer abrufen:

```sql
select name, house_no from people order by house_no;
```

Ergebnis:

```
<table>
<thead>
<tr>
<th>name</th>
<th>house_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe Bloggs</td>
<td>3</td>
</tr>
<tr>
<td>Roger Jones</td>
<td>33</td>
</tr>
<tr>
<td>Jane Smith</td>
<td>55</td>
</tr>
<tr>
<td>Sally Norman</td>
<td>83</td>
</tr>
</tbody>
</table>
```

(4 rows)

Sie können die Ergebnisse nach den Werten von mehreren Spalten sortieren lassen:

```sql
select name, house_no from people order by name, house_no;
```

Ergebnis:

```
<table>
<thead>
<tr>
<th>name</th>
<th>house_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane Smith</td>
<td>55</td>
</tr>
<tr>
<td>Joe Bloggs</td>
<td>3</td>
</tr>
<tr>
<td>Roger Jones</td>
<td>33</td>
</tr>
<tr>
<td>Sally Norman</td>
<td>83</td>
</tr>
</tbody>
</table>
```

(4 rows)

15.4.2 Filtern

Oftmals will man nicht jeden einzelnen Datensatz der Datenbank sehen, besonders wenn tausende von Einträgen enthalten sind und man nur einen oder zwei sehen möchte.

Es folgt ein Beispiel eines numerischen Filters, der nur Objekte zurück gibt, deren house_no kleiner ist als 50:

```sql
select name, house_no from people where house_no < 50;
```

Ergebnis:

```
<table>
<thead>
<tr>
<th>name</th>
<th>house_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe Bloggs</td>
<td>3</td>
</tr>
<tr>
<td>Roger Jones</td>
<td>33</td>
</tr>
</tbody>
</table>
```

(2 rows)

Man kann Filter (Benutzung der WHERE-Klausel) und Sortierung kombinieren (Benutzung der ORDER BY-Klausel):

```sql
select name, house_no from people where house_no < 50 order by house_no;
```

Ergebnis:

```
<table>
<thead>
<tr>
<th>name</th>
<th>house_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe Bloggs</td>
<td>3</td>
</tr>
<tr>
<td>Roger Jones</td>
<td>33</td>
</tr>
</tbody>
</table>
```

(2 rows)
Man kann auch auf Basis von Textdaten filtern:

```sql
SELECT name, house_no FROM people WHERE name LIKE '%s%';
```

<table>
<thead>
<tr>
<th>name</th>
<th>house_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe Bloggs</td>
<td>3</td>
</tr>
<tr>
<td>Roger Jones</td>
<td>33</td>
</tr>
</tbody>
</table>

Hier wurde die Klausel LIKE verwendet, um alle Namen, die s enthalten zu finden. Man sieht, dass die Abfrage zwischen Groß- und Kleinschreibung unterscheidet, so dass der Eintrag Sally Norman nicht zurückgegeben wurde.

Wenn man eine Zeichenkette ohne Unterscheidung zwischen Groß- und Kleinschreibung suchen möchte, kann man die Klausel ILIKE verwenden:

```sql
SELECT name, house_no FROM people WHERE name ILIKE '%r%';
```

<table>
<thead>
<tr>
<th>name</th>
<th>house_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roger Jones</td>
<td>33</td>
</tr>
<tr>
<td>Sally Norman</td>
<td>83</td>
</tr>
</tbody>
</table>

Diese Abfrage gab alle Objekte people zurück, die ein r oder R in ihrem Namen enthalten.

### 15.4.3 Verbindungen

Und wenn man die Details zu einer Person und ihre Adresse anstatt der ID sehen möchte? Um das zu erreichen, muss man die zwei Tabellen mit einer einzelnen Abfrage verbinden. Lassen Sie uns ein Beispiel ansehen:

```sql
SELECT people.name, house_no, streets.name
FROM people, streets
WHERE people.street_id = streets.id;
```

**Bemerkung:** Bei Verbindungen müssen immer die zwei Tabellen angegeben werden, aus denen die Informationen stammen, in diesem Fall people und streets. Man muss außerdem angeben, welche Schlüssel miteinander verbunden werden (Fremd- und Primärschlüssel). Ohne diese Angabe erhält man eine Liste aller möglichen Kombinationen an Personen und Straßen, ohne zu wissen, welche Person in welcher Straße wohnt!

Die richtige Ausgabe sieht wie folgt aus:

<table>
<thead>
<tr>
<th>name</th>
<th>house_no</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe Bloggs</td>
<td>3</td>
<td>Low Street</td>
</tr>
<tr>
<td>Roger Jones</td>
<td>33</td>
<td>High street</td>
</tr>
<tr>
<td>Sally Norman</td>
<td>83</td>
<td>High street</td>
</tr>
<tr>
<td>Jane Smith</td>
<td>55</td>
<td>Main Road</td>
</tr>
</tbody>
</table>

Wir werden uns Verbindungen später im Zusammenhang mit komplexeren Abfragen noch einmal ansehen. Vorerst müssen wir uns nur merken, dass sie einen einfachen Weg zur Kombination von Informationen aus zwei oder mehr Tabellen darstellen.
15.4.4 Unterauswahl

Unterauswahlen erlauben es, Objekte aus einer Tabelle basierend auf den Daten einer anderen Tabelle auszuwählen, die über eine Fremdschlüsselverbindung angebunden ist. In unserem Fall wollen wir Personen finden, die in einer bestimmten Straße wohnen.

Lassen Sie uns zuerst unsere Daten etwas optimieren:

```
insert into streets (name) values('QGIS Road');
insert into streets (name) values('OGR Corner');
insert into streets (name) values('Goodle Square');
update people set street_id = 2 where id=2;
update people set street_id = 3 where id=3;
```

Schauen wir uns die Daten nach den Veränderungen an: wir können unsere Abfrage aus dem vorherigen Kapitel wieder verwenden:

```
select people.name, house_no, streets.name
from people,streets
where people.street_id = streets.id;
```

Ergebnis:

<table>
<thead>
<tr>
<th>name</th>
<th>house_no</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roger Jones</td>
<td>33</td>
<td>High street</td>
</tr>
<tr>
<td>Sally Norman</td>
<td>83</td>
<td>High street</td>
</tr>
<tr>
<td>Jane Smith</td>
<td>55</td>
<td>Main Road</td>
</tr>
<tr>
<td>Joe Bloggs</td>
<td>3</td>
<td>Low Street</td>
</tr>
</tbody>
</table>

Nun erstellen wir eine Unterauswahl basierend auf diesen Daten. Wir wollen nur die Personen ausgeben, die in der Straße mit street_id 1 leben:

```
select people.name
from people, ( 
  select * 
  from streets 
  where id=1 
) as streets_subset
where people.street_id = streets_subset.id;
```

Ergebnis:

<table>
<thead>
<tr>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roger Jones</td>
</tr>
<tr>
<td>Sally Norman</td>
</tr>
</tbody>
</table>

Auch wenn es ein sehr einfaches Beispiel und unmöglich für unseren kleinen Datensatz ist, so zeigt es doch wie nützlich und wichtig Unterauswahlen beim Abfragen großer und komplexer Datensätze sind.
15.4.5 Abfragen zur Aggregierung

Eine der mächtigsten Merkmale einer Datenbank ist die Fähigkeit, die Daten in den Tabellen der Datenbank zusammenzufassen. Diese Zusammenfassungen werden Aggregierungs-Abfragen genannt. Es folgt ein typisches Beispiel solch einer Abfrage, die ermittelt, wie viele Personen-Objekte sich in unserer Personentabelle befinden:

```sql
select count(*) from people;
```

Ergebnis:

```
count
-------
  4
(1 row)
```

Wir können die Anzahl auch über den Straßennamen zusammenfassen:

```sql
select count(name), street_id
from people
group by street_id;
```

Ergebnis:

```
count | street_id
-------+-----------
  2 |      1
  1 |      3
  1 |      2
(3 rows)
```

**Bemerkung:** Da wir keine ORDER BY Klausel verwendet haben, weicht die Reihenfolge der Ergebnisse unter Umständen von der hier dargestellten ab.

### Try Yourself

Fassen Sie die Personen nach Straßen zusammen und geben Sie die richtigen Straßen anstatt der street_ids aus.

*Überprüfen Sie Ihre Ergebnisse*

15.4.6 In Conclusion

Wir haben gesehen, wie man Abfragen zur Ausgabe von Daten nutzt, um sinnvolle Information aus unserer Datenbank zu erhalten.

15.4.7 What’s Next?

Als Nächstes werden wir sehen, wie man Sichten aus den erstellten Abfragen erstellt.
15.5 Lesson: Ansichten

Das Schreiben einer Abfrage erfordert viel Zeit und Aufwand. Mit Hilfe von Sichten kann man die Formulierung einer SQL Abfrage in Form einer wiederverwendbaren 'virtuellen Tabelle' speichern.

Ziel dieser Lektion: Das Speichern einer Abfrage als Sicht.

15.5.1 Erstellen einer Sicht

Man kann eine Sicht wie eine Tabelle behandeln, die Daten stammen aber aus einer Abfrage. Sehen wir uns eine einfache Sicht an:

```sql
create view roads_count_v as
    select count(people.name), streets.name
    from people, streets
    where people.street_id = streets.id
    group by people.street_id, streets.name;
```

Wie man sieht, ist der einzige Unterschied der Teil `create view roads_count_v as` am Anfang. Wir können nun Daten aus der Sicht auswählen:

```sql
select * from roads_count_v;
```

Ergebnis:

```
count | name
-------+-------------
 1 | Main Road
 2 | High street
 1 | Low Street
```

(3 rows)

15.5.2 Veränderung einer Sicht

Eine Sicht ist nicht unveränderlich und enthält auch keine 'echten Daten'. Das bedeutet, dass sie leicht verändert werden kann, ohne die eigentlichen Daten in der Datenbank zu beeinflussen:

```sql
CREATE OR REPLACE VIEW roads_count_v AS
    SELECT count(people.name), streets.name
    FROM people, streets
    WHERE people.street_id = streets.id
    GROUP BY people.street_id, streets.name
    ORDER BY streets.name;
```

(Dieses Beispiel zeigt die empfohlene Praxis zur Nutzung von GROSSSCHREIBUNG für alle SQL Schlüsselwörter.)

Wir haben eine `ORDER BY` Klausel hinzugefügt, so dass die Zeilen der Sicht nun schön geordnet sind:

```sql
select * from roads_count_v;
```

```
count | name
-------+-------------
 2 | High street
 1 | Low Street
 1 | Main Road
```

(3 rows)
15.5.3 Verwerfen einer Sicht

Wenn man eine Sicht nicht länger benötigt, kann sie wie folgt gelöscht werden:

```
drop view roads_count_v;
```

15.5.4 In Conclusion

Mit Hilfe von Sichten kann man Abfragen speichern. Auf die Ausgabe der Abfragen kann man dann wie auf eine Tabelle zugreifen.

15.5.5 What’s Next?

Manchmal möchte man, dass die Änderung von bestimmten Daten auch Auswirkungen auf andere Teile der Datenbank hat. In der nächsten Lektion sehen wir, wie man das macht.

15.6 Lesson: Regeln


Ziel dieser Lektion: Zu lernen, wie man neue Regeln für eine Datenbank erstellt.

15.6.1 Erstellen einer Regel zum protokollieren

Angenommen man möchte alle Änderungen des Feldes phone_no in der Tabelle people in einer anderen Tabelle people_log aufzeichnen. Dann müsste man eine neue Tabelle erstellen:

```
create table people_log (name text, time timestamp default NOW());
```

Im nächsten Schritt erstellt man eine Regel, die alle Änderungen des Feldes phone_no in der Tabelle people in die Tabelle people_log protokolliert:

```
create rule people_log as on update to people
where NEW.phone_no <> OLD.phone_no
do insert into people_log values (OLD.name);
```

Um die Regel zu testen, ändern wir eine Telefonnummer:

```
update people set phone_no = '082 555 1234' where id = 2;
```

Überprüfen Sie, ob die Tabelle people richtig aktualisiert wurde:

```
select * from people where id=2;
```

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>house_no</th>
<th>street_id</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Joe Bloggs</td>
<td>3</td>
<td>2</td>
<td>082 555 1234</td>
</tr>
</tbody>
</table>

(1 row)

Mit Hilfe der Regel die wir erstellt haben, sieht die Tabelle people_log nun wie folgt aus:
**select * from people_log;**

<table>
<thead>
<tr>
<th>name</th>
<th>time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe Bloggs</td>
<td>2014-01-11 14:15:11.953141</td>
</tr>
</tbody>
</table>

(1 row)

**Bemerkung:** Der Wert des Feldes `time` wird entsprechend des aktuellen Datums und der Zeit vergeben.

### 15.6.2 In Conclusion

Regeln erlauben es, Daten automatisch hinzuzufügen oder zu ändern basierend auf Änderungen in anderen Teilen der Datenbank.

### 15.6.3 What’s Next?

Das nächste Modul enthält eine Einführung in räumliche Datenbanken mit PostGIS. Die behandelten Datenbankkonzepte werden mit GIS Daten angewendet.
Spatial Databases allow the storage of the geometries of records inside a Database as well as providing functionality for querying and retrieving the records using these Geometries. In this module we will use PostGIS, an extension to PostgreSQL, to learn how to setup a spatial database, import data into the database and make use of the geographic functions that PostGIS offers.

While working through this section, you may want to keep a copy of the PostGIS cheat sheet available from Boston GIS user group. Another useful resource is the online PostGIS documentation.

There are also some more extensive tutorials on PostGIS and Spatial Databases available from Boundless Geo:

- Introduction to PostGIS
- Spatial Database Tips and Tricks

See also PostGIS In Action.

### 16.1 Lesson: PostGIS-Einrichtung

Die Einrichtung von PostGIS Funktionen erlaubt den Zugriff auf räumliche Funktionen innerhalb von PostgreSQL.

**Ziel dieser Lektion:** Die Installation von räumlichen Funktionen und eine kurze Demonstration der Auswirkungen.

**Bemerkung:** Wir gehen in dieser Übung von der PostGIS Version 2.1 aus. Die Installation und Konfiguration der Datenbank weicht für ältere Versionen ab, aber der Rest des hier vorgestellten funktioniert trotzdem. Sehen Sie sich zur Hilfe bei der Installation und zur Konfiguration der Datenbank die Dokumentation für Ihre Plattform an.
16.1.1 Installation unter Ubuntu

Postgis kann leicht mit Hilfe von apt installiert werden.

```
$ sudo apt install postgis
$ sudo apt install postgresql-9.1-postgis
```

Wirklich, es ist nicht schwer…

**Bemerkung:** In Abhängigkeit von der Version Ubuntus und den eingestellten Repositories wird mit diesen Kommandos PostGIS 1.5 oder 2.x installiert. Sie können die installierte Version mit Hilfe der Abfrage `select PostGIS_full_version();` unter psql oder einem anderen Tool herausfinden.

Um die aktuellste Version von PostGIS zu installieren, nutzen Sie die folgenden Kommandos.

```
$ sudo apt-add-repository ppa:sharpie/for-science
$ sudo apt-add-repository ppa:sharpie/postgis-nightly
$ sudo apt update
$ sudo apt install postgresql-9.1-postgis-nightly
```

16.1.2 Installation unter Windows

Die Installation unter Windows ist etwas komplizierter aber nicht schwer. Beachten Sie, dass Sie online sein müssen, um das Postgis Paket zu installieren.

Besuchen Sie zuerst die Seite [the download page](#).

Folgen Sie dann dieser Anleitung: [this guide](#).

Weitere Informationen zur Installation unter Windows finden Sie hier: [PostGIS website](#).

16.1.3 Installation auf anderen Plattformen

Unter [PostGIS website download](#) findet man Informationen zur Installation auf anderen Plattformen darunter MacOS und andere Linux-Distributionen.

16.1.4 Konfiguration von Datenbanken zur Nutzung von PostGIS

Nachdem PostGIS installiert wurde, muss Ihre Datenbank zur Nutzung der Erweiterungen konfiguriert werden. Wenn Sie PostGIS in der Version > 2.0 installiert haben, ist das mit dem folgenden Kommando, hier für die Adressendatenbank aus der vorherigen Übung, ganz einfach.

```
$ psql -d address -c "CREATE EXTENSION postgis;"
```

**Bemerkung:** Wenn Sie PostGIS 1.5 und eine Version von PostgreSQL kleiner als 9.1 verwenden, müssen Sie eine andere Vorgehensweise wählen, um die Postgis-Erweiterungen für Ihre Datenbank zu installieren. Bitte beachten Sie die [PostGIS-Dokumentation](#) für Anweisungen, wie dies zu tun ist.
16.1.5 Die installierten PostGIS Funktionen

PostGIS kann man als eine Sammlung von in der Datenbank integrierten Funktionen sehen, die die Kernfunktionalität von PostgreSQL für den Umgang mit räumlichen Daten erweitern. Unter 'Umgang mit räumlichen Daten' verstehen wir das speichern, abrufen, abfragen und verändern von Daten. Um das zu erreichen, werden eine Reihe von Funktionen in der Datenbank installiert.

Unsere PostgreSQL address Datenbank ist jetzt dank PostGIS für räumliche Daten vorbereitet. Wir werden das in den kommenden Kapiteln noch vertiefen, aber hier erst einmal eine kleine Kostprobe. Sagen wir, wir wollen einen Punkt aus einem Text erstellen. Wir verwenden zuerst das psql Kommando, um Funktionen mit Bezug zu Punkten zu finden. Wenn Sie noch nicht mit der Datenbank address verbunden sind, stellen Sie die Verbindung jetzt her. Starten sie dann:

```
\df *point*
```


Probieren Sie dieses Kommando:

```
select st_pointfromtext('POINT(1 1)');
```

Ergebnis:

```
st_pointfromtext
---------------------
010100000000000000000000F03F00000000000F03F
(1 row)
```

Drei wichtige Dinge:

- Mit Hilfe von POINT(1 1) haben wir einen Punkt an der Position 1,1 (Annahme: EPSG:4326) definiert,
- Wir haben eine SQL Anweisung ausgeführt, aber nicht an einer Tabelle, sondern nur über Daten, die in der Kommandozeile eingegeben wurden,
- Die Ausgabezeile ergibt nicht viel Sinn.

Die Ausgabe erfolgte im OGC Format 'Well Known Binary' (WKB). Wir werden uns dieses Format im nächsten Kapitel genauer ansehen.

Um die Ergebnisse in Textform zu sehen, durchsuchen wir kurz die Funktionsliste nach etwas, das Text ausgibt:

```
\df *text*
```

Die Abfrage nach der wir suchen ist st_astext. Wir kombinieren sie mit der vorherigen Abfrage:

```
select st_astext(st_pointfromtext('POINT(1 1)'));
```

Ergebnis:

```
st_astext
----------
POINT(1 1)
(1 row)
```

Wir gaben die Zeichenkette POINT(1,1) ein, wandelten sie mit Hilfe von st_pointfromtext() in einen Punkt, um sie anschließend mit Hilfe von st_astext() zurück in eine vom Menschen lesbare Form zu bringen, d.h. in unsere anfängliche Zeichenkette.

Ein letztes Beispiel bevor wir uns eingehend mit PostGIS beschäftigen:

```
select st_astext(st_buffer(st_pointfromtext('POINT(1 1)'),1.0));
```

Was passiert hier? Es wird ein Puffer von 1 Grad um unseren Punkt erstellt und das Ergebnis als Text ausgegeben.
16.1.6 Räumliche Bezugssysteme


Wir können die RBS Definitionen untersuchen. Sie sind in normalen Datenbanktabellen gespeichert.

Lassen Sie uns zuerst das Schema der Tabelle mit Hilfe des folgenden Kommandos am psql Prompt ansehen:

```
\d spatial_ref_sys
```

Das Ergebnis sollte wie folgt aussehen:

<table>
<thead>
<tr>
<th>Table</th>
<th>&quot;public.spatial_ref_sys&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column</td>
<td>Type</td>
</tr>
<tr>
<td>srid</td>
<td>integer</td>
</tr>
<tr>
<td>auth_name</td>
<td>character varying(256)</td>
</tr>
<tr>
<td>auth_srid</td>
<td>integer</td>
</tr>
<tr>
<td>srtext</td>
<td>character varying(2048)</td>
</tr>
<tr>
<td>proj4text</td>
<td>character varying(2048)</td>
</tr>
</tbody>
</table>

Indexes:

"spatial_ref_sys_pkey" PRIMARY KEY, btree (srid)

Man kann normale SQL Abfragen (die wir in den einleitenden Kapiteln gelernt haben) verwenden, um die Tabelle anzusehen oder zu verändern. Es ist allerdings keine gute Idee Datensätze in der Tabelle zu verändern oder zu löschen, außer man weiß genau was man tut.

Eine interessante SRID ist EPSG:4326 - das geographische Referenzsystem mit Längen- und Breitengraden, das den WGS 84 Ellipsoid verwendet. Sehen wir es uns genauer an:

```
select * from spatial_ref_sys where srid=4326;
```

Ergebnis:

<table>
<thead>
<tr>
<th>srid</th>
<th>auth_name</th>
<th>auth_srid</th>
<th>srtext</th>
<th>proj4text</th>
</tr>
</thead>
</table>
| 4326    | EPSG      | 4326      | GEOGCS["WGS 84",DATUM["WGS_1984",SPHEROID["WGS 84",6378137,298.257223563,AUTHORITY["EPSG","7030"]],TOWGS84[0, 0,0,0,0,0,0[AUTHORITY["EPSG","6326"],PRIMEM["Greenwich",0, AUTHORITY["EPSG","8901"]],UNIT["degree",0.01745329251994328, AUTHORITY["EPSG","9122"]],AUTHORITY["EPSG","4326"]]
|         |           |           | proj=longlat +ellps=WGS84 +datum=WGS84 +no_defs |

srtext enthält die Definition der Projektion im well known text format (ähnlich der .prj Datei bei shape-Dateien).

16.1.7 In Conclusion

16.1.8 What’s Next?

Als nächstes lernen wir, wie räumliche Objekte in einer Datenbank abgebildet werden.

16.2 Simple-Feature-Modell


**Ziel dieser Lektion:** Das SFS Modell kennen und nutzen lernen.

16.2.1 Was ist OGC


16.2.2 Was ist das SFS Modell

Das Simple-Feature-Modell für SQL (SFS) ist ein *nicht-topologischer* Weg, um räumliche Daten in einer Datenbank zu speichern. Es definiert Funktionen zum Zugriff, zur Verarbeitung und zum Aufbau solcher Daten.

Das Modell definiert räumliche Daten des Typs Punkt, Linie und Polygon (und deren Aggregation zu zusammengesetzten Objekten).

Weitergehende Information findet man unter folgendem Link: [OGC Simple Feature for SQL](https://www.opengeospatial.org/standards/sfgs).

![Diagramm des Simple Feature Models](image-url)
16.2.3 Hinzufügen eines Geometriefeldes zu einer Tabelle

Wir fügen ein Punktfeld in unsere people Tabelle ein:

```sql
alter table people add column the_geom geometry;
```

16.2.4 Hinzufügen einer Einschränkung basierend auf dem Geometrietyp

Wir sehen, dass das Geometriefeld nicht automatisch den Typ der Geometrie bestimmt. Dies wird mit einer Einschränkung festgelegt:

```sql
alter table people
add constraint people_geom_point_chk
check(st_geometrytype(the_geom) = 'ST_Point'::text
OR the_geom IS NULL);
```

Damit wird der Inhalt der Tabelle eingeschränkt, so dass nur noch eine Punktgeometrie oder der NULL Wert akzeptiert werden.

16.2.5 Try Yourself

Erstellen Sie eine neue Tabelle cities und fügen Sie einige passende Felder und ein Geomtriefeld für Polygone (die Stadtgrenzen) hinzu. Stellen Sie sicher, dass die Geometrien auf Polygone eingeschränkt sind.

Überprüfen Sie Ihre Ergebnisse

16.2.6 Füllen der geometry_columns Tabelle

An dieser Stelle sollten wir einen Eintrag in geometry_columns Tabelle machen:

```sql
insert into geometry_columns values
(NULL,'public','people','the_geom',2,4326,'POINT');
```

Warum? geometry_columns wird von einigen Anwendungen genutzt, um zu erkennen, welche Tabellen einer Datenbank räumliche Daten enthalten.

**Bemerkung:** Wenn die obige INSERT Anweisung einen Fehler zurück gibt, starten Sie zuerst die folgende Abfrage:

```sql
select * from geometry_columns;
```

Wenn die Spalte f_table_name den Wert people enthält, wurde die Tabelle schon registriert und man muss nichts weiter tun.

Der Wert 2 bezieht sich auf die Anzahl der räumlichen Dimensionen, in diesem Fall zwei: X und Y.
Der Wert 4326 bezieht sich auf die genutzte Projektion. In diesem Fall ist das WGS 84, auf die sich die Nummer 4326 bezieht (wurde vorher unter dem Stichwort EPSG diskutiert).
Hinzufügen eines passenden Eintrags `geometry_columns` für unseren neuen cities Layer

Überprüfen Sie Ihre Ergebnisse

**16.2.7 Hinzufügen eines Geomtriedatensatzes zur Tabelle mit Hilfe von SQL**

Jetzt sind unsere Tabelle für räumliche Daten vorbereitet und wir können Geometrien darin ablegen:

```
insert into people (name, house_no, street_id, phone_no, the_geom)
values ('Fault Towers',
        34,
        3,
        '072 812 31 28',
        'SRID=4326;POINT(33 -33)');
```

**Bemerkung:** In dem obigen Eintrag müssen Sie angeben, welche Projektion (SRID) genutzt werden soll. Das liegt daran, dass wir die Geometrie des neuen Punktes als reinen Text eingegeben haben. Dadurch wurde nicht automatisch die richtige Projektion hinzugefügt. Offensichtlich benötigt der neue Punkt dieselbe SRID wie der Datensatz zu dem er hinzugefügt wird. Wir müssen die SRID daher vorgeben.

Wenn man an dieser Stelle eine graphische Benutzeroberfläche verwendet, würde z.B. die Projektion für jeden Punkt automatisch vergeben werden. Man braucht sich in diesem Fall keine Gedanken über die richtige Projektion für jeden einzelnen hinzuzufügenden Punkt machen, wenn man die Projektion, wie wir es gemacht haben, vorher für den Datensatz festgelegt hat.

Jetzt ist ein guter Zeitpunkt, um QGIS zu öffnen und zu versuchen unsere `people` anzuzeigen. Wir sollten auch versuchen Datensätze zu editieren, hinzuzufügen und zu löschen und dann Auswahlabfragen erstellen, um zu sehen wie sich die Datensätze ändern.

Um einen PostGIS Layer in QGIS zu laden, wählt man im Menü Layer ▶️ PostGIS-Layer hinzufügen oder drückt den entsprechenden Knopf auf der Werkzeugleiste:

Es öffnet sich der folgende Dialog:

Klicken Sie auf die Schaltfläche Neu, um den folgenden Dialog zu öffnen:

Erstellen Sie dann eine neue Verbindung, z.B.:

```
Name: myPG
Service: 
Host: localhost
Port: 5432
Database: address
User: 
Password: 
```

Klicken Sie auf Test Connect, um zu testen, ob QGIS die Datenbank `address` gefunden hat und Benutzername und Passwort richtig sind. Wenn es funktioniert, Setzen einen Haken bei Benutzername speichern und Passwort speichern. Klicken Sie danach zum Erstellen der Verbindung auf OK.

Zurück im Dialog PostGIS-Layer hinzufügen klicken Sie auf Verbinden und fügen wie gewohnt Layer zu Ihrem Projekt hinzu.

---

**16.2. Simple-Feature-Modell** 437
16.2. Simple-Feature-Modell
Try Yourself

Formulieren Sie eine Abfrage, die Personennamen, Straßennamen und Lage (aus der the_geom Spalte) als reinen Text anzeigt.

Überprüfen Sie Ihre Ergebnisse

16.2.8 In Conclusion

Wir haben gesehen, wie man räumliche Objekte zu unserer Datenbank hinzufügt und sie in einem GIS anzeigt.

16.2.9 What’s Next?

Als nächstes werden wir sehen, wie man Daten in unsere Datenbank importiert und exportiert.

16.3 Lesson: Importieren und Exportieren

Of course, a database with no easy way to migrate data into it and out of it would not be of much use. Fortunately, there are a number of tools that will let you easily move data into and out of PostGIS.

16.3.1 shp2pgsql

shp2pgsql is a commandline tool to import ESRI Shapefile to the database. Under Unix, you can use the following command for importing a new PostGIS table:

```
shp2pgsql -s <SRID> -c -D -I <path to shapefile> <schema>.<table> | \ 
psql -d <databasename> -h <hostname> -U <username>
```

Under Windows, you have to perform the import process in two steps:

```
shp2pgsql -s <SRID> -c -D -I <path to shapefile> <schema>.<table> > import.sql
psql psql -d <databasename> -h <hostname> -U <username> -f import.sql
```

You may encounter this error:

```
ERROR: operator class "gist_geometry_ops" does not exist for access method "gist"
```

This is a known issue regarding the creation in situ of a spatial index for the data you're importing. To avoid the error, exclude the -I parameter. This will mean that no spatial index is being created directly, and you'll need to create it in the database after the data have been imported. (The creation of a spatial index will be covered in the next lesson.)

16.3.2 pgsql2shp

pgsql2shp is a commandline tool to export PostGIS Tables, Views or SQL select queries. To do this under Unix:

```
pgsql2shp -f <path to new shapefile> -g <geometry column name> \ 
-h <hostname> -U <username> <databasename> <table | view>
```

To export the data using a query:

```
pgsql2shp -f <path to new shapefile> -g <geometry column name> \ 
-h <hostname> -U <username> "<query>"
```
16.3.3 ogr2ogr

ogr2ogr is a very powerful tool to convert data into and from postgis to many data formats. ogr2ogr is part of the GDAL/OGR Software and has to be installed separately. To export a table from PostGIS to GML, you can use this command:

```
ogr2ogr -f GML export.gml PG:'dbname=<databasename> user=<username>
host=<hostname>' <Name of PostGIS-Table>
```

16.3.4 DB Manager

You may have noticed another option in the Database menu labeled DB Manager. This is a tool that provides a unified interface for interacting with spatial databases including PostGIS. It also allows you to import and export from databases to other formats. Since the next module is largely devoted to using this tool, we will only briefly mention it here.

16.3.5 In Conclusion

Importing and exporting data to and from the database can be done in many various ways. Especially when using disparate data sources, you will probably use these functions (or others like them) on a regular basis.

16.3.6 What’s Next?

Next we’ll look at how to query the data we’ve created before.

16.4 Lesson: Räumliche Abfragen


16.4.1 Räumliche Operationen

Wenn man wissen möchte, welche Punkte innerhalb eines Abstandes von 2 Grad zu einem Punkt (X,Y) sind, kann man folgende Abfrage verwenden:

```
select * from people
where st_distance(the_geom, 'SRID=4326;POINT(33 -34)') < 2;
```

Ergebnis:

```
id | name      | house_no | street_id | phone_no | the_geom
------------------------------
6  | Fault Towers | 34      | 3         | 072 812 31 28 | 01010008040C0
(1 row)
```
Bemerkung: Der obige Wert von the_geom wurde aus Platzgründen abgeschnitten. Wenn man den Punkt in vom Menschen lesbaren Koordinaten sehen möchte, kann man so ähnlich vorgehen wie oben unter „Einen Punkt als WKT anzeigen“.

Woher wissen wir, dass die obige Abfrage alle Punkte inhaltv. von 2 Grad ausgibt? Warum nicht 2 Meter oder irgend-eine andere Einheit?

Überprüfen Sie Ihre Ergebnisse

16.4.2 Räumliche Indexe

Wir können auch räumliche Indexe definieren. Ein räumlicher Index beschleunigt Ihre räumlichen Abfragen stark. Um einen räumlichen Index über eine Geometriespalte zu erstellen, geht man wie folgt vor:

```
CREATE INDEX people_geo_idx
ON people
USING gist
(the_geom);
```

Ergebnis:

```
Table "public.people"
Column | Type                  | Modifiers
-----------+-----------------------+----------------------------------------
id       | integer               | not null default
 name     | character varying(50) | nextval('people_id_seq'::regclass)
 house_no | integer               | not null
 street_id | integer               | not null
 phone_no | character varying     | |
 the_geom | geometry              | |

Indexes:
"people_pkey" PRIMARY KEY, btree (id)
"people_geo_idx" gist (the_geom) <-- new spatial key added
"people_name_idx" btree (name)

Check constraints:
"people_geom_point_chk" CHECK (st_geometrytype(the_geom) = 'ST_Point'::text OR the_geom IS NULL)

Foreign-key constraints:
"people_street_id_fkey" FOREIGN KEY (street_id) REFERENCES streets(id)
```

16.4.3 Try Yourself 🌟

Verändern Sie die Tabelle cities, so dass die Geometriespalte einen räumlichen Index erhält.

Überprüfen Sie Ihre Ergebnisse
16.4.4 Demonstration der räumlichen Funktionen von PostGIS

Um die räumlichen Funktionen von PostGIS zu demonstrieren, werden wir eine neue Datenbank mit (fiktionalen) Daten erstellen.

Erstellen Sie zu Beginn eine neue Datenbank (verlassen Sie die `psql` Konsole zuerst):

```
createdb postgis_demo
```

Denken Sie daran, die PostGIS Erweiterungen zu installieren:

```
psql -d postgis_demo -c "CREATE EXTENSION postgis;"
```

Importieren Sie als Nächstes die Daten aus dem Verzeichnis `exercise_data/postgis/`. Sehen Sie sich dazu die Anleitung in der vorherigen Lektion an, aber denken Sie daran, dass Sie eine neue PostGIS Verbindung zu der neuen Datenbank erstellen müssen. Sie können mit Hilfe des Terminals oder des DB Managers importieren.

Importieren Sie die Dateien in die folgenden Datenbanktabellen:

- `points.shp` nach `building`
- `lines.shp` nach `road`
- `polygons.shp` nach `region`

Laden Sie diese drei Datenbanklayer wie gewohnt mit Hilfe des `PostGIS-Layer hinzufügen` Dialogs in QGIS ein. Beim Öffnen der Attributtabellen sehen wir, dass beide ein Feld `id` und ein Feld `gid` haben, die beim PostGIS Import erzeugt wurden.

Nachdem die Tabellen importiert wurden, können wir PostGIS zur Abfrage der Daten verwenden. Gehen Sie zurück zur Konsole (Kommandozeile) und geben folgendes Kommando ein:

```
psql postgis_demo
```

Wir werden einige dieser Auswahlanweisungen durch die Erstellung von Sichten demonstrieren, so dass Sie sie in QGIS öffnen und die Ergebnisse sehen können.

**Auswahl nach der Lage**

Wir erhalten alle Bauwerke in der Region KwaZulu:

```
SELECT a.id, a.name, st_astext(a.the_geom) AS point
FROM building a, region b
WHERE st_within(a.the_geom, b.the_geom)
AND b.name = 'KwaZulu';
```

Ergebnis:

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>York</td>
<td>POINT(1622345.23785063 6940490.65844485)</td>
</tr>
<tr>
<td>33</td>
<td>York</td>
<td>POINT(1622495.65620524 6940403.87862489)</td>
</tr>
<tr>
<td>35</td>
<td>York</td>
<td>POINT(1622403.09106394 6940212.96302097)</td>
</tr>
<tr>
<td>36</td>
<td>York</td>
<td>POINT(1622287.38463732 6940357.56905424)</td>
</tr>
<tr>
<td>40</td>
<td>York</td>
<td>POINT(1621888.19746548 6940508.01440885)</td>
</tr>
</tbody>
</table>

(5 rows)

Oder wir erstellen eine Sicht daraus:

```
CREATE VIEW vw_select_location AS
SELECT a.gid, a.name, a.the_geom
FROM building a, region b
WHERE st_within(a.the_geom, b.the_geom)
AND b.name = 'KwaZulu';
```
Fügen Sie die Sicht als Layer in QGIS ein:

Nachbarn auswählen

Geben Sie eine Liste aller Namen von Regionen aus, die an die Hokkaido Region angrenzen:

```sql
SELECT b.name
FROM region a, region b
WHERE stTouches(a.the_geom, b.the_geom)
AND a.name = 'Hokkaido';
```

Ergebnis:

<table>
<thead>
<tr>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missouri</td>
</tr>
<tr>
<td>Saskatchewan</td>
</tr>
<tr>
<td>Wales</td>
</tr>
</tbody>
</table>

Als Sicht:

```sql
CREATE VIEW vw_regions_adjoining_hokkaido AS
SELECT b.gid, b.name, b.the_geom
FROM region a, region b
WHERE TOUCHES(a.the_geom, b.the_geom)
AND a.name = 'Hokkaido';
```

In QGIS:

Achten Sie auf die fehlende Region (Queensland). Das kann an einem Topologiefehler liegen. Solche Artefakte können auf potentielle Fehler in den Daten hinweisen. Um das Problem zu lösen ohne sich in möglichen Problemen des Datensatzes zu verzetteln, können wir einen Puffer verwenden:
Damit wird ein Puffer von 100 Metern um die Region Hokkaido erstellt.

Die dunklere Fläche ist der Puffer:

Auswahl mit Hilfe des Puffers:

```
CREATE VIEW vw_hokkaido_buffer AS
  SELECT gid, ST_BUFFER(the_geom, 100) as the_geom
  FROM region
  WHERE name = 'Hokkaido';
```

In dieser Abfrage wird die Sicht mit Puffer genauso wie eine normale Tabelle verwendet. Die Sicht erhält den Alias `a` und ihr Geometriefeld `a.the_geom` wird verwendet, um alle Polygone in der Tabelle `region` (Alias `b`) zu selektieren, die sie überschneiden. Hokkaido ist dagegen aus der Auswahl ausgeschlossen, da wir nur die angrenzenden Regionen selektieren wollen.

In QGIS:

Es ist auch möglich, alle Objekte innerhalb eines vorgegebenen Abstandes auszuwählen, ohne vorher einen Puffer zu erstellen:

```
CREATE VIEW vw_hokkaido_distance_select AS
  SELECT b.gid, b.name, b.the_geom
  FROM region a, region b
  WHERE ST_DISTANCE (a.the_geom, b.the_geom) < 100
```

(Fortsetzung auf der nächsten Seite)
Das Ergebnis ist dasselbe und der Zwischenschritt der Pufferbildung entfällt:

Auswahl eindeutiger Werte

Anzeige einer Liste der eindeutigen Stadtnamen für alle Gebäude in der Region Queensland:

```sql
SELECT DISTINCT a.name
FROM building a, region b
WHERE st_within(a.the_geom, b.the_geom)
AND b.name = 'Queensland';
```

Ergebnis:

```
name
Beijing
Berlin
Atlanta
(3 rows)
```
Weitere Beispiele ...

```sql
CREATE VIEW vw_shortestline AS
SELECT b.gid AS gid,
       ST_ASTEXT(ST_SHORTESTLINE(a.the_geom, b.the_geom)) as text,
       ST_SHORTESTLINE(a.the_geom, b.the_geom) AS the_geom
FROM road a, building b
WHERE a.id=5 AND b.id=22;

CREATE VIEW vw_longestline AS
SELECT b.gid AS gid,
       ST_ASTEXT(ST_LONGESTLINE(a.the_geom, b.the_geom)) as text,
       ST_LONGESTLINE(a.the_geom, b.the_geom) AS the_geom
FROM road a, building b
WHERE a.id=5 AND b.id=22;

CREATE VIEW vw_road_centroid AS
SELECT a.gid as gid, ST_CENTROID(a.the_geom) as the_geom
FROM road a
WHERE a.id = 1;

CREATE VIEW vw_region_centroid AS
SELECT a.gid as gid, ST_CENTROID(a.the_geom) as the_geom
FROM region a
WHERE a.name = 'Saskatchewan';

SELECT ST_PERIMETER(a.the_geom)
FROM region a
WHERE a.name='Queensland';

SELECT ST_AREA(a.the_geom)
FROM region a
WHERE a.name='Queensland';

CREATE VIEW vw_simplify AS
SELECT gid, ST_Simplify(the_geom, 20) AS the_geom
FROM road;

CREATE VIEW vw_simplify_more AS
SELECT gid, ST_Simplify(the_geom, 50) AS the_geom
FROM road;

CREATE VIEW vw_convex_hull AS
SELECT ROW_NUMBER() over (order by a.name) as id,
       a.name as town,
       ST_CONVEXHULL(ST_COLLECT(a.the_geom)) AS the_geom
FROM building a
GROUP BY a.name;
```
16.4.5 In Conclusion

Wir haben gesehen, wie man räumliche Objekte mit Hilfe der neuen Datenbankfunktionen in QGIS abfragen kann.

16.4.6 What’s Next?

Als Nächstes werden wir die Strukturen komplexerer Geometrien untersuchen und wie man sie mit Hilfe von PostGIS erstellt.

16.5 Lesson: Geometrieaufbau

In diesem Kapitel gehen wir näher darauf ein, wie einfach Geometrien in SQL erstellt werden. In der Realität wird man wahrscheinlich ein GIS wie QGIS mit seinen Digitalisierungshilfen verwenden, um komplexe Geometrien zu erstellen; trotzdem ist das Verständnis für die Erstellung von Abfragen und für die Nachvollziehbarkeit wie die Daten aufgebaut ist nützlich.

Ziel dieser Lektion: Ein besseres Verständnis wie man räumliche Objekte direkt in PostgreSQL/PostGIS erstellt.

16.5.1 Erstellen von Linien

Lassen Sie uns unsere address Datenbank an die anderen Datenbanken anpassen; sie soll eine Einschränkung bezüglich der Geometrie, einen Index und einen Eintrag in der geometry_columns Tabelle erhalten.

16.5.2 Try Yourself

• Verändern Sie die Tabelle streets so, dass sie eine Geometriespalte des Typs ST_LineString enthält.
• Vergessen Sie dabei nicht, die geometry_columns Tabelle zu aktualisieren!
• Fügen Sie auch eine Einschränkung ein, die verhindert, dass andere Geometrien als Linien oder NULL hinzugefügt werden.
• Erstellen Sie einen räumlichen Index über die neue Geometriespalte

Überprüfen Sie Ihre Ergebnisse

Lassen Sie uns nun eine Linie in unsere Tabelle streets einfügen. In diesem Fall aktualisieren wir einen vorhandenen Straßen-Datensatz:

```sql
update streets
set the_geom = 'SRID=4326;LINESTRING(20 -33, 21 -34, 24 -33)'
where streets.id = 2;
```

Sehen Sie sich die Ergebnisse in QGIS an. (Sie müssen unter Umständen mit der rechten Maustaste auf den streets-Layer im 'Layer' Bereich klicken und dann 'Auf den Layer zoomen' auswählen.)

Erstellen Sie noch ein Paar Einträge für Straßen - einige in QGIS und einige aus der Kommandozeile.
16.5.3 Erstellung von Polygone

Die Erstellung von Polygonen ist genauso einfach. Dabei muss man daran denken, dass Polygone definitionsgemäß mindestens vier Stützpunkte haben, wobei der erste und letzte übereinander liegen:

```
insert into cities (name, the_geom)
values ('Tokyo', 'SRID=4326;POLYGON((10 -10, 5 -32, 30 -27, 10 -10)))
```

*Bemerkung:* Ein Polygon erfordert doppelte Klammern um seine Koordinatenliste. Dies erlaubt es, komplexe Polygone mit mehreren unverbundenen Flächen einzufügen. Zum Beispiel

```
insert into cities (name, the_geom)
values ('Tokyo Outer Wards',
  'SRID=4326;POLYGON((20 10, 20 20, 35 20, 20 10),
   (-10 -30, -5 0, -15 -15, -10 -30))')
```

Nach dem Abschluss dieses Schrittes, können Sie die Städte in QGIS einladen und nachvollziehen, was sich verändert hat. Öffnen Sie dazu die Attributabelle und wählen den neuen Eintrag aus. Beachten Sie, wie die neuen Polygone sich wie ein einziges Polygon verhalten.

16.5.4 Überprüfung: Anbindung Städte an Personen

Gehen Sie für diese Übung wie folgt vor:

- Löschen Sie alle Daten aus der Tabelle people.
- Fügen Sie eine Spalte mit einem Fremdschlüssel in der Tabelle people ein, der eine Referenz zum Primär schlüssel der Tabelle cities herstellt.
- Nutzen Sie QGIS, um einige Städte zu erfassen.
- Verwenden Sie SQL um einige neue Datensätze zu people hinzuzufügen. stellen Sie sicher, dass jeder Datensatz eine zugehörige Straße und Stadt enthält.

Ihr aktualisiertes Schema zu people sollte in etwa so aussehen:

```
\d people
Table "public.people"
Column | Type | Modifiers
-----------+-----------------------+--------------------------------------------
id | integer | not null | default nextval('people_id_seq '::regclass)
name | character varying(50) | |
house_no | integer | not null |
street_id | integer | not null |
phone_no | character varying | |
the_geom | geometry | |
city_id | integer | not null |
Indexes:
"people_pkey" PRIMARY KEY, btree (id)
"people_name_idx" btree (name)
Check constraints:
"people_geom_point_chk" CHECK (st_geometrytype(the_geom) = 'ST_Point '::text OR the_geom IS NULL)
Foreign-key constraints:
"people_city_id_fkey" FOREIGN KEY (city_id) REFERENCES cities(id)
"people_street_id_fkey" FOREIGN KEY (street_id) REFERENCES streets(id)
```

Überprüfen Sie Ihre Ergebnisse
16.5.5 Unser Schema

Aktuell sollte unser Schema wie folgt aussehen:

![Schema Diagramm]

16.5.6 Try Yourself

Erstellen Sie Stadtgrenzen indem Sie die minimale konvexe Hülle um alle Adressen einer Stadt und einen Puffer darum ermitteln.

16.5.7 Zugriff auf Unter-Objekte

Die SFS-Model Funktionen bieten eine große Bandbreite an Optionen zum Zugriff auf Sub-Objekte der SFS Geometrien. Wenn man den ersten Stützpunkt aller Polygone in der Tabelle myPolygonTable selektieren möchte, geht man wie folgt vor:

- Umwandeln der Polygongrenze in eine Linie:

  ```sql
  select st_boundary(geometry) from myPolygonTable;
  ```

- Auswahl des ersten Stützpunktes der resultierenden Linie:

  ```sql
  select st_startpoint(myGeometry) from (select st_boundary(geometry) as myGeometry from myPolygonTable) as foo;
  ```

16.5.8 Datenverarbeitung

16.5.9 Ausschneiden

Um einen Teil unserer Daten auszuschneiden, können wir die `ST_INTERSECT()` Funktion verwenden. To avoid empty geometries, use:

```sql
where not st_isempty(st_intersection(a.the_geom, b.the_geom))
```

16.5.10 Geometrien aus anderen Geometrien erstellen


Um eine Linie aus einem neuen Punktlayer 'points' zu erstellen, kann man das folgende Kommando ausführen:

```sql
select ST_LineFromMultiPoint(st_collect(the_geom)), i as id
from (select the_geom
      from points
      order by id
    ) as foo;
```

Um die Arbeitsweise zu testen ohne einen neuen Layer zu erstellen, kann man das Kommando auf den 'people' Layer anwenden, obwohl das kein wirklich sinnvolles Ergebnis liefert.
16.5.11 Geometriebereinigung

Man kann in dem folgenden Blogeintrag weitere Informationen zu diesem Thema erhalten: this blog entry.

16.5.12 Unterschiede zwischen Tabellen

Um den Unterschied zwischen zwei Tabellen mit derselben Struktur herauszufinden, kann man das PostgreSQL Schlüsselwort EXCEPT verwenden:

```
select * from table_a
except
select * from table_b;
```

Im Ergebnis erhält man alle Datensätze aus table_a die nicht in table_b gespeichert sind.

16.5.13 Tablespaces

Man kann durch die Erstellung von Tablespaces vorgeben, wo Postgres seine Daten speichern soll:

```
CREATE TABLESPACE homespace LOCATION '/home/pg';
```

Wenn man eine Datenbank erstellt, kann man vorgeben welcher Tablespace genutzt werden soll, z.B.:

```
createdb --tablespace=homespace t4a
```
16.5.14 In Conclusion

Dieses Modul wurde von Victor Olaya und Paolo Cavallini beigetragen.

Inhalt:

17.1 Einleitung


Dieser Leitfaden ist für das Selbststudium oder zur Durchführung eines Workshops zur Verarbeitung konzipiert.

Die Beispiele in dieser Anleitung beziehen sich auf QGIS 3.4. Sie funktionieren unter Umständen nicht mit anderen Versionen von QGIS.


Um eine systematischere Beschreibung aller Komponenten des Frameworks zu erhalten, ist es empfehlenswert, sich die entsprechenden Kapitel im Benutzerhandbuch anzusehen. Nutzen Sie es als Unterstützung zusammen mit dieser Anleitung.


Viel Spaß!
17.2 Eine wichtige Warnung zu Beginn


Lassen Sie uns das an einem Beispiel demonstrieren.


![Ordinary Kriging Dialogfenster](image)

Das sieht komplex aus, oder?

Mit dem Lesen dieses Handbuchs, lernen Sie, wie man dieses Modul benutzt, wie man es innerhalb einer Stapelverarbeitung verwendet, um Raster Layer aus hunderten von Punkten in einem Durchlauf zu erstellen oder was passiert, wenn im Eingabelayer einige Punkte ausgewählt sind. Die Parameter an sich werden aber nicht erklärt. Ein erfahrener Analyst mit guter Kenntnis der Geostatistik wird keine Probleme haben, die Parameter zu verstehen. Wenn Sie keine Erfahrung damit haben und mit Begriffen wie sill, range oder nugget nicht vertraut sind, sollten Sie das Modul "Kriging"
nicht verwenden. Es beinhaltet weitere Konzepte wie räumliche Autokorrelation oder Semivariogramme, die Ihnen dann vermutlich auch nicht bekannt oder nicht vertraut genug sind. Sie sollten diese zuerst studieren, um sie danach in QGIS anzuwenden. Wenn man dies ignoriert, erhält man falsche Ergebnisse und dürftige (und wahrscheinlich nutzlose) Analyseergebnisse.

Auch wenn nicht alle Algorithmen so komplex sind wie kriging (andererseits gibt es auch noch komplexere!), erfordern doch fast alle, die zu Grunde liegenden Ideen der verwendeten Analysen zu verstehen. Die Anwendung ohne dieses Wissen führt sehr wahrscheinlich zu schlechten Ergebnissen.

Geoalgorithmen ohne eine gutes Grundlagenwissen über räumliche Analysen einzusetzen, ist wie der Versuch eines Romans zu schreiben ohne irgendwelche Kenntnisse zu Grammatik, Rechtschreibung oder Geschichtenerzählungen zu haben. Sie erhalten vielleicht kein Ergebnis, aber es wird vermutlich wertlos sein. Täuschen Sie sich bitte nicht selbst, indem Sie denken, dass Sie nur nach dem Lesen dieser Anleitung bereit sind, räumliche Analysen durchzuführen und korrekte Ergebnisse zu erhalten.

Hier ist ein guter Literaturhinweis, um mehr über die Analyse räumlicher Daten zu lernen.

Michael John De Smith, Michael F. Goodchild, Paul A. Longley

Die online Quelle ist: [here](#)

### 17.3 Einrichtung der Verarbeitungsumgebung

Als Erstes muss die Verarbeitungsumgebung konfiguriert werden. Da nicht viele Sachen einzustellen sind, ist das ganz einfach.

Später werden wir sehen, wie man externe Anwendungen zur Erweiterung der vorhandenen Algorithmen konfiguriert. Zuerst arbeiten wir aber nur mit der Umgebung.


Wenn Sie dieses Menü nicht sehen, müssen Sie die Erweiterung im Erweiterungsmanager aktivieren.


Wenn Sie bis hier gekommen sind, können Sie mit der Nutzung der Geoalgorithmen beginnen. Es muss nichts weiter konfiguriert werden. Wir werden unseren ersten Algorithmus in der nächsten Lektion starten.
17.4 Ausführung unseres ersten Algorithmus. Der Werkzeugkasten

**Bemerkung:** In dieser Lektion werden wir unseren ersten Algorithmus starten und schon erste Ergebnisse erhalten.


Öffnen Sie zuerst das QGIS-Projekt für diese Lektion. Es enthält nur einen Layer mit zwei Polygonen


Geben Sie *centroids* ein und Sie sollten in etwa das Folgende sehen.

Das Suchfeld ist ein praktischer Weg, um einen gesuchten Algorithmus zu finden. Im unteren Teil des Dialogfensters zeigt eine zusätzliche Beschriftung, dass Algorithmen zu Ihrer Suche passen aber zu einem inaktiven Anbieter gehören. Wenn Sie auf den Link in der Beschriftung klicken, werden die Algorithmen der inaktiven Anbieter hellgrau hinterlegt angezeigt. Außerdem wird ein Link zur Aktivierung der inaktiven Anbieter angezeigt. Wir werden später sehen, wie man andere Anbieter aktiviert.

Um einen Algorithmus auszuführen, muss man nur doppelt auf den Eintrag in den Verarbeitungswerkzeugen klicken. Wenn Sie doppelt auf den Algorithmus *Polygon centroids* klicken, sehen Sie das folgende Dialogfenster.

Alle Algorithmen verwenden eine vergleichbare Benutzerschnittstelle mit Eingabeparametern, die man ausfüllen muss und einer Ausgabe für die der Speicherort gewählt werden muss. In diesem Fall ist die einzige Eingabe ein Vektorlayer mit Polygonen.

Wählen Sie den Layer *Polygons* als Eingabefenster. Es gibt zwei Optionen zur Speicherung des Ergebnisses: als Datei auf einem Laufwerk oder als temporäre Datei.
Kapitel 17. Der QGIS-Verarbeitungsleitfaden
Wenn Sie eine Ausgabe vorgeben wollen und das Resultat nicht in einer temporären Datei speichern wollen, wird das Dateiformat durch den Dateityp der Ausgabedatei vorgegeben. Um ein Format zu auszuwählen, wählt man einfach den zugehörigen Dateityp (oder Sie fügen ihn bei der Eingabe des Pfades per Hand ein). Wenn der angegebene Dateityp zu keinem bekannten Dateityp passt, wird ein Standardtyp vergeben (normalerweise .dbf für Tabellen, .tif für Rasterlayer und .shp für Vektorlayer) und der Layer dann im dazu gehörenden Dateiformat gespeichert.

In allen Übungen in dieser Anleitung speichern wir die Ergebnisse nur temporär ab, da sie später nicht mehr benötigt werden. Sie können die Ergebnisse natürlich auch zusätzlich als Datei auf einem Laufwerk speichern.

**Warnung:** Temporäre Dateien werden gelöscht, wenn man QGIS beendet. Wenn Sie ein Projekt erstellen, das eine temporäre Ausgabe enthält, wird QGIS sich beim erneuten Öffnen des Projektes beschweren, da die Ausgabedatei nicht mehr existiert.

Nachdem Sie die Einstellung im Dialogfenster des Algorithmus vorgenommen haben, klicken Sie zum Starten auf **Starte**.

Sie erhalten die folgende Ausgabe.

Die Ausgabe hat dasselbe KBS wie die Eingabe. Die Geoalgorithmen gehen davon aus, dass alle Eingabelayer dasselbe KBS verwenden. Sie führen keine Reprojektion durch. Bis auf einige wenige Algorithmen (z.B. zur Reprojizierung) haben die Ausgaben dasselbe KBS. Wir werden bald mehr dazu erfahren.

Versuchen Sie selbst, andere Dateiformate zu verwenden (z.B. **shp** und **geojson** als Dateitypen). Wenn Sie nicht wollen, dass der Layer nach Abschluss der Verarbeitung in QGIS geladen wird, können Sie den Haken unterhalb des Ausgabepfades entfernen.

17.4. Ausführung unseres ersten Algorithmus. Der Werkzeugkasten 463
17.5 Mehr Algorithmen und Datentypen

**Bemerkung:** In dieser Lektion werden wir noch drei weitere Algorithmen ausführen. Wir werden lernen wie man andere Eingabetypen verwendet und Ausgaben so konfiguriert, dass sie automatisch in einen vorgegebenen Ordner gespeichert werden.


Als Erstes werden wir mit Hilfe des Algorithmus *Punktlayer aus Tabelle erzeugen* einen Punktlayer aus den Koordinaten in der Tabelle erzeugen. Sie wissen schon wie man das Suchfeld benutzt, es sollte also nicht schwer sein, den Algorithmus zu finden. Klicken Sie doppelt darauf und es erscheint der folgende Dialog.

Der Algorithmus generiert, ähnlich wie in der letzten Lektion, genau eine Ausgabedatei. Er benötigt drei Eingaben:

- **Eingabelayer:** die Tabelle mit den Koordinaten. Sie sollten hier die Tabelle aus dem Übungsordner verwenden.
- **X und Y Felder:** diese zwei Parameter gehören zum ersten Eintrag. Das Auswahlfeld zeigt die Felder an, die in der gewählten Tabelle vorhanden sind. Wählen Sie das Feld *XCOORD* für den Parameter *X-Feld* und das Feld *YCOORD* für den Parameter *Y-Feld*.

Der Dialog sollte in etwa so aussehen.

Klicken Sie jetzt auf die *Starte* Schaltfläche, um den folgenden Layer zu erhalten (Sie müssen unter Umständen die Zoomstufe ändern, um alle neu erstellten Punkte zu sehen):

Als nächstes benötigen wir den Polygonlayer. Wir werden mit dem Algorithmus *Gitter erzeugen* ein regelmäßiges Polygonsgitter erzeugen. Im folgenden Dialog sind die Algorithmus Parameter enthalten.
17.5. Mehr Algorithmen und Datentypen
Warnung: Die Optionen sind in neueren Versionen von QGIS einfacher; man muss nur die Minimal- und Maximalwerte für X und Y eingeben (vorgeschlagene Werte: -5.696226,-5.695122,40.24742,40.248171)


Der Dialog enthält einen einfachen Rechner, mit dem Sie Ausdrücke wie 11 * 34, 7 + 4, 6 eingeben können, das Ergebnis wird berechnet und in das zugehörige Feld des Parameter Dialogs eingetragen. Es sind außerdem Konstanten und Werte aus anderen Layer verfügbar, die verwendet werden können.

In diesem Fall wollen wir ein Gitter erstellen, das die Ausdehnung des Eingabepunkt layers umfasst. Wir müssen die Koordinaten des Punktlayers verwenden, um die Koordinaten des Zentrums des Gitters und seine Breite und Höhe zu bestimmen. Versuchen Sie es selbst, mit ein bisschen Mathematik, der Hilfe des Rechners und der Konstanten aus dem Eingabepunkt layer.

Wählen Sie Rechteck (Polygon) im Feld Gittertyp.

Wie beim letzten Algorithmus müssen wir auch das KBS angeben. Wählen sie wie vorher EPSG:4326 als Ziel KBS aus.

Am Ende sollte der Parameterdialog in etwa so aussehen:

(Es ist besser einen Abstand bei Breite und Höhe hinzuzufügen: Horizontaler Abstand: 0,0001, Vertikaler Abstand: 0,0001, Breite: 0,001004, Höhe: 0,000651, Zentrum X: -5,695674, Zentrum Y: 40,2477955) Das X Zentrum ist ein bisschen knifflig: -5,696126+((-5,695222+5,696126)/2)

Drücken Sie Starte und Sie erhalten den Gitterlayer.

Der letzte Schritt ist das Zählen der Punkte in jedem Rechteck des Gitternetzes. Wir werden dazu den Algorithmus Punkte in Polygon zählen verwenden.

Damit haben wir das gewünschte Ergebnis erreicht.

Bevor Sie die Lektion beenden, folgt noch ein kleiner Tipp, der das dauerhafte Speichern von Daten vereinfacht. Wenn Sie alle Ausgabedateien in einem gegebenen Ordner speichern wollen, müssen Sie den Ordernamen nicht

17.5. Mehr Algorithmen und Datentypen
Kapitel 17. Der QGIS-Verarbeitungsleitfaden

In der Gruppe Allgemein finden Sie den Eintrag Ausgabeverzeichnis. Geben Sie hier den Ordner Ihrer Ausgabedateien an.

Wenn Sie nun einen Algorithmus starten, reicht der Dateiname anstelle des gesamten Pfades aus. Im obigen Beispiel würde die Eingabe von graticule.shp als Ausgabepfad dazu führen, dass das Ergebnis unter D:\processing_output\graticule.shp gespeichert werden würde. Man kann weiterhin einen vollständigen Pfad verwenden, wenn man das Ergebnis in einem anderen Ordner speichern möchte.


### 17.6 KBS - reprojizieren

**Bemerkung:** In dieser Lektion werden wir diskutieren, wie die Verarbeitungswerkzeuge KBS verwenden. Wir werden auch einen sehr nützlichen Algorithmus kennenlernen: reprojizieren.


Kapitel 17. Der QGIS-Verarbeitungsleitfaden
• Wenn kein Eingabelayer vorhanden ist, wird das KBS des Projektes verwendet, es sei denn der Algorithmus enthält ein explizites KBS Feld (so wie in der letzten Lektion beim Algorithmus zur Erzeugung des Gitternetzes)


Öffnen Sie den Algorithmus Geometrieattribute hinzufügen.

Dieser Algorithmus fügt neue Spalten in die Attributtabelle eines Vektorlayers ein. Der Inhalt der Spalten hängt vom Geometrietyp des Layers ab. Im Fall von Punkten, werden neue Spalten mit den X- und Y-Koordinaten jedes Punktes hinzugefügt.

In der Liste der verfügbaren Layer unter Eingabelayer werden beide Layer mit ihren jeweiligen KBS angezeigt. Das bedeutet, dass die Layer verschieden behandelt werden, obwohl sie an derselben Stelle angezeigt werden. Wählen Sie den 4326 Layer.


17.6. KBS - reprojizieren
Beim Öffnen der Attributabelle des neuen Layers sehen wir zwei neue Felder, die die X- und Y-Koordinaten für jeden Punkt enthalten.

<table>
<thead>
<tr>
<th>ID</th>
<th>PT_NUM_A</th>
<th>PT_ST_A</th>
<th>coord_x</th>
<th>coord_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>a</td>
<td>-5.695426</td>
<td>40.248071</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>b</td>
<td>-5.695885</td>
<td>40.247622</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>c</td>
<td>-5.695946</td>
<td>40.247520</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>a</td>
<td>-5.695222</td>
<td>40.247684</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>b</td>
<td>-5.695642</td>
<td>40.248030</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>a</td>
<td>-5.695855</td>
<td>40.248067</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>b</td>
<td>-5.696049</td>
<td>40.248028</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>c</td>
<td>-5.696126</td>
<td>40.247629</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>a</td>
<td>-5.695961</td>
<td>40.247786</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>b</td>
<td>-5.695353</td>
<td>40.247929</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>a</td>
<td>-5.695955</td>
<td>40.247739</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>b</td>
<td>-5.695779</td>
<td>40.247896</td>
</tr>
</tbody>
</table>


Wenn Sie sich seine Attributabelle ansehen, bemerken Sie, dass die Werte von denen des ersten Layers abweichen.

<table>
<thead>
<tr>
<th>ID</th>
<th>PT_NUM_A</th>
<th>PT_ST_A</th>
<th>coord_x</th>
<th>coord_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>a</td>
<td>270839.65869</td>
<td>4458983.162670</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>b</td>
<td>270799.116425</td>
<td>4458934.552874</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>c</td>
<td>270839.468187</td>
<td>4458921.978139</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>a</td>
<td>270855.745301</td>
<td>4458940.799487</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>b</td>
<td>270821.164389</td>
<td>4458979.173980</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>a</td>
<td>270803.157564</td>
<td>4458983.848803</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>b</td>
<td>270786.542791</td>
<td>4458980.047841</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>c</td>
<td>270776.601980</td>
<td>4458935.968837</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>a</td>
<td>270793.142411</td>
<td>4458952.931700</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>b</td>
<td>270845.414756</td>
<td>4458967.311298</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>a</td>
<td>270824.166376</td>
<td>4458944.764250</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>b</td>
<td>270809.035643</td>
<td>4458964.649799</td>
</tr>
</tbody>
</table>

Das liegt daran, dass die Originaldaten voneinander abweichen (sie nutzen verschiedene KBS) und die Koordinaten von dort stammen.

Wass sollte man daraus lernen? Der Hauptgedanke hinter diesen Beispielen ist, dass die Geoalgorithmen Layer so verwenden wie sie sind. Sie ignorieren vollständig die Reprojektion die QGIS unter Umständen zur Darstellung benutzt. Mit anderen Worten: vertrauen Sie nicht dem, was Sie in der QGIS Karte sehen. Denken Sie immer daran, dass die Originaldaten verwendet werden. Das ist in diesem Fall nicht so wichtig, da wir jeweils nur einen Layer gleichzeitig verwenden. Bei Algorithmen, die mehrere Layer benutzen (z.B. der Zuschneiden Algorithmus) kann es so aussehen, als ob sie übereinander liegen. In Wirklichkeit sind sie aber weit voneinander entfernt, da sie verschiedene KBS verwenden.
Algorithmen führen keine Reprojektion durch (mit Ausnahme des reprojizieren Algorithmus wie wir gleich sehen werden). Sie müssen darauf achten, dass die Layer dasselbe KBS haben.

Ein interessantes Modul, das sich mit KBS befasst, ist die Reprojektion. Es stellt einen Sonderfall dar, da es einen Eingabelayer entgegen nimmt (den zu reprojizierenden) aber sein KBS nicht für den Ausgabelayer verwendet.

Öffnen Sie den Algorithmus *Layer reprojizieren*.


### 17.7 Auswahl

**Bemerkung:** In dieser Lektion werden wir sehen, wie die Verarbeitungsalgorithmen Auswahlen in Vektorlayern behandeln, die zur Eingabe verwendet werden. Wir werden lernen, wie man eine Auswahl mit einem bestimmten Typ eines Algorithmus erstellt.

Anders als in anderen QGIS Erweiterungen, finden wir in den Verarbeitungswerkzeugen keine Auswahlmöglichkeit wie „nur ausgewählte Objekte benutzen“. Das Verhalten bezüglich der Auswahl wird für die gesamte Erweiterung und alle dazu gehörenden Algorithmen vorgegeben, nicht für jede Ausführung eines Algorithmus. Es gilt für Algorithmen die folgende einfache Regel für Vektorlayer.

- Wenn Teile des Layer ausgewählt sind, werden nur die selektierten Objekte verwendet.
- Wenn keine Auswahl vorhanden ist, werden alle Objekte verwendet.
Bitte beachten Sie, dass sie dieses Verhalten unter Optionen Verarbeitung Allgemein anpassen können.

Sie können das selbst durch Auswahl einiger Punkte aus der letzten Übung und Start der Reprojektion testen. Der reprojierte Layer enthält dann nur die Punkte die ausgewählt waren. Wenn Sie keine Auswahl getroffen hatten, enthält der reprojierte Layer alle Punkte des Originallayers.

Um eine Auswahl zu erstellen, können Sie alle verfügbaren Methoden und Tools in QGIS benutzen. Sie können sogar einen Geoalgorithmus dazu verwenden. Algorithmen zur Erstellung einer Auswahl findet man unter Vektorauswahl

Öffnen Sie den Algorithmus Zufällige Auswahl.

Wenn man die Vorgabeinstellungen so belässt, werden 10 Punkte des aktuellen Layers ausgewählt.

Wir sehen, dass der Algorithmus keine Ausgabe erstellt, er modifiziert den Eingabelayer (nicht den Layer an sich, aber die Auswahl der Objekte des Layers). Das ist ein unübliches Verhalten, da alle anderen Algorithmen neue Layer erzeugen und die Eingabelayer nicht verändern.
Die Auswahl ist nicht Teil der Daten an sich, sondern nur etwas das in QGIS existiert. Daher können diese Auswahl Algorithmen nur für in QGIS geöffnete Layer verwendet werden. Die Dateiauswahl, die als Parameter enthalten ist, kann daher nicht verwendet werden.


17.8 Ausführung eines externen Algorithmus

Bemerkung: In dieser Lektion werden wir lernen, wie man Algorithmen von Drittherstellern, insbesondere SAGA einem der Hauptanbieter von Algorithmen, verwendet.


Wenn Sie unter Windows arbeiten, ist es am besten den QGIS-Installer zu verwenden. Er sorgt dafür, dass die erforderlichen Abhängigkeiten einschließlich SAGA installiert werden. Wenn Sie ihn verwendet haben, ist nichts weiter zu tun. Sie können den Einstellungdialog öffnen und zur Gruppe Datenanbieter/SAGA wechseln.

Der SAGA Pfad sollte schon eingerichtet sein und auf den Ordner zeigen, in dem SAGA installiert ist.

Wenn Sie Linux verwenden, brauchen Sie den Pfad zu Ihrer SAGA Installation nicht in den Verarbeitungsoptionen ändern. Stattdessen müssen Sie SAGA installieren und dabei sicher stellen, dass der SAGA Ordner in der PATH Variable enthalten ist, so dass das Programm von der Kommandozeile aus gestartet werden kann (öffnen Sie eine Konsole und geben Sie `saga_cmd` zum Test ein). Unter Linux ist die Sollversion für SAGA ebenfalls 2.1 aber in einigen Installationen (wie z.B. der OSGeo Live DVD) ist unter Umständen nur die Version 2.0.8 verfügbar. Es kann sein, dass in diesen Fällen auch Paktete in der Version 2.1 verfügbar sind. Sie werden häufig nicht verwendet, da sie noch nicht so stabil laufen. Wenn Sie lieber die verbreiterte und stabile Version 2.0.8 verwenden möchten, können Sie das in den Verarbeitungsoptionen in der SAGA Gruppe einstellen.

Nachdem SAGA installiert ist, können Sie einen SAGA Algorithmus wie jeden anderen Algorithmus durch Doppelklick starten. Da wir eine vereinfachte Schnittstelle benutzen, wissen wir nicht, welche Algorithmen auf SAGA oder eine andere externe Anwendung aufsetzen. Wenn eine zugehörige Anwendung nicht installiert ist, erhalten wir nach Doppelklick auf den Algorithmus in etwa die folgende Meldung.

Wir gehen davon aus, dass SAGA korrekt installiert ist. Es öffnet sich dann an Stelle des Fensters mit der Fehlermeldung der Parametertabellen.

Wir testen einen SAGA–basierten Algorithmus: Split shapes layer randomly.

Benutzen Sie den Punktlayer im zur Lektion gehörenden Projekt. Wenn Sie die Vorgabeparameter verwenden, erhalten Sie in etwa die folgende Ausgabe (die Teilung erfolgt zufällig, d.h. es wird ggf. eine abweichende Ausgabe erzeugt).

Der Eingabelayer wurde in zwei Layer mit jeweils derselben Anzahl an Punkten geteilt. Das Ergebnis wurde von SAGA berechnet und nachfolgend von QGIS übernommen und ins QGIS Projekt eingefügt.

Wenn alles klappt, werden Sie keinen Unterschied zwischen diesem SAGA-basierten Algorithmus und den anderen vorher verwendeten merken. Es kann allerdings passieren, dass SAGA nicht in der Lage ist, die von QGIS erwartete Ergebnisse zu berechnen.
17.8. Ausführung eines externen Algorithmus

**QGIS Training Manual**

![Processing options dialog](image1)

![Missing dependency dialog](image2)

---

This algorithm requires SAGA to be run. Unfortunately, it seems that SAGA is not installed in your system, or it is not correctly configured to be used from QGIS.

[Click here](#) to know more about how to install and configure SAGA to be used with QGIS.
Kapitel 17. Der QGIS-Verarbeitungsleitfaden

![Split shapes layer randomly dialog box](image)

- **Shapes**: 
  - points: EFSG:452G
  - Relation B / A
  - Group A: 50
- **Open output file after running algorithm**
- **Group B**: 
  - Save to temporary file
- **Open output file after running algorithm**

Control panel:
- 0%
- Run
- Close
- Cancel
Datei zu erstellen. In diesem Fall kommt es zu Problemen bei der Übernahme des Ergebnisses in das QGIS Projekt und es erscheint eine Fehlermeldung ähnlich der folgenden.

Diese Art von Fehler kann selbst dann auftreten, wenn SAGA (oder jede andere Anwendung, die man aus den Verarbeitungswerkzeugen aufruft) korrekt installiert ist. Es ist wichtig zu lernen, wie man dieser Fehlerart umgeht. Wir werden diese Art von Fehler nun erzeugen.

Öffnen Sie den Algorithmus Create graticule und verwenden dabei die folgenden Werte.

Wir nutzen Werte für Breite und Höhe, die größer als die vorgegebene Ausdehnung des Gitters sind, so dass SAGA keine Ausgabe erzeugen kann. Mit anderen Worten: die Werte der Parameter sind falsch vergeben, werden aber vor der Übergabe an SAGA nicht geprüft. Da SAGA das Gitter nicht erzeugen kann, wird es den erwarteten Layer nicht erzeugen und man erhält die obige Fehlermeldung.

**Bemerkung:** Ab SAGA >= 2.2.3 werden falsche Eingabewerte automatisch korrigiert, so dass man in diesem Fall keine Fehlermeldung erhält. Um einen Fehler zu provozieren, kann man statt dessen negative Werte für die Parameter Divison verwenden.

Das Verständnis dieser Art von Problemen hilft dabei, zu verstehen was vorschücht und wie man eine Lösung findet. Man erkennt aus der Fehlermeldung, dass ein Test ausgeführt wird, ob die Verbindung mit SAGA richtig funktioniert bzw. ob der Algorithmus in der erwarteten Weise ausgeführt wird. Das gilt nicht nur für SAGA, sondern auch für alle anderen externen Anwendungen.

In der nächsten Lektion lernen wir das Verarbeitungsprotokoll kennen. Hier werden Informationen über die Ausführung von Geoalgorithmen aufgezeichnet. Wir werden sehen, wie man weitere Details zu Problemen dieser Art erhält.

17.8. Ausführung eines externen Algorithmus 479
17.9 Das Prozessierungsprotokoll

**Bemerkung:** Diese Lektion beschreibt das Verarbeitungsprotokoll.

Alle Analysen, die in der Verarbeitungsumgebung ausgeführt werden, werden von QGIS protokolliert. Damit erhält man zusätzliche Informationen, was bei der Ausführung der Verarbeitungswerkzeuge getan wurde. Es erleichtert die Lösung von auftretenden Problemen und erlaubt die Wiederholung vorhergehender Operationen, da die Protokollierung auch interaktive Elemente einschließt.

Öffnen Sie das Protokoll durch Klick auf den Ballon auf der rechten Seite der Statusleiste in QGIS. Einige Algorithmen hinterlassen hier Nachrichten zu ihrer Ausführung. Algorithmen, die eine externe Anwendung aufrufen, hinterlassen in der Regel ein Protokoll der Konsolenausgabe der Anwendung und damit Informationen über deren Ausführung. Beim Betrachten des Protokolls sehen wir die Ausgabe des SAGA Algorithmus, den wir vorher gestartet hatten (und der nicht funktionierte, da die Eingabedaten nicht korrekt waren).

Das hilft uns zu verstehen, was passiert ist. Erfahrene Benutzer sind in der Lage, die Ausgabe zu analysieren und herauszufinden, warum der Algorithmus mit einem Fehler beendet wurde. Wenn Sie kein erfahrener Nutzer sind, kann die Ausgabe durch andere zur Fehlerdiagnose verwendet werden. Es könnte sich um ein Problem bezüglich der Installation von externer Software oder um ein Problem mit den verwendeten Daten handeln.


Im Menü **Verarbeitung** unter **Protokoll** finden wir den Punkt **Algorithm**. Jeder Aufruf eines Algorithmus, egal ob von der Konsole (wird später in dieser Anleitung beschrieben) oder der grafischen Oberfläche, wird hier als Konsolenauftrag aufgezeichnet. Man erhält damit eine komplette Historie aller Aufrufe von Algorithmen der aktuellen...
Arbeitssitzung. Die Historie sieht in etwa wie folgt aus:


Die Historie ist interaktiv, d.h. man kann jeden vorher ausgeführten Algorithmus durch Doppelklick auf den Eintrag in der Historie erneut starten. Damit kann man ganz einfach bereits ausgeführte Arbeitsschritte wiederholen.

17.9.1 Fortgeschritten

Sie können den Algorithmus auch modifizieren. Kopieren Sie ihn einfach, öffnen Sie die Erweiterungen \( \text{Python-Konsole} \), klicken Sie auf \text{Import Klasse} \( \text{Import Verarbeitungsklasse} \), dann fügen Sie ihn ein, um die Analyse erneut auszuführen; ändern Sie den Text nach Belieben. Um die resultierende Datei anzuzeigen, geben Sie `iface. addVectorLayer('/Pfad/Dateiname.shp', 'Layername in der Legende', 'ogr')` ein. Andernfalls können Sie `\text{kdb: processing.runAndLoad}` verwenden.

17.10 Der Rasterrechner. Nullwerte

\textbf{Bemerkung:} In dieser Lektion werden wir lernen, wie man den Rasterrechner verwendet, um Operationen mit Rasterlayern auszuführen. Wir werden außerdem erläutern, worum es sich bei Leerwerten handelt und wie der Rechner und andere Algorithmen damit umgehen.

Der Rasterrechner ist einer der mächtigsten Algorithmen, die zur Verfügung stehen. Er ist sehr flexibel und vielseitig und kann für viele verschiedene Berechnungen verwendet werden. Er wird sehr schnell ein wichtiger Teil Ihrer Werkzeugkiste werden.

In dieser Lektion werden wir einige Berechnungen mit dem Rasterrechner ausführen. Die meisten davon sind eher einfach. Wir erfahren wie er verwendet wird und wie er sich in einigen speziellen Situationen verhält. Das Verständnis hierzu ist wichtig, um später die erwarteten Ergebnisse bei der Verwendung des Rechners zu erhalten und bestimmte Techniken, die in der Regel mit dem Rechner verwendet werden, zu verstehen.

Öffnen Sie das zu dieser Lektion gehörende QGIS Projekt. Sie werden sehen, dass es mehrere Rasterlayer enthält. Öffnen Sie nun die Verarbeitungswerkzeuge und dort den Raster calculator.
**Bemerkung:** Die Schnittstelle unterscheidet sich in neueren Versionen.

Der Dialog enthält 2 Parameter.

- Die für die Analyse genutzten Layer. Hierbei handelt es sich um eine Mehrfacheingabe, d.h. man kann so viele Layer auswählen, wie man möchte. Klicken Sie auf den Knopf auf der rechten Seite und wählen die Layer aus, die Sie verwenden möchten.

- Die anzuwendende Formel. Die Formel verwendet die ausgewählten Layer, die mit Buchstaben als Variablen benannt werden \((a, b, c\ldots)\) oder \(g_1, g_2, g_3\ldots\). Das bedeutet, die Formel \(a + 2 \times b\) ist dasselbe wie \(g_1 + 2 \times g_2\), sie berechnet die Summe der Werte des ersten Layers und dem zweifachen der Werte des zweiten Layers. Die Ordnung der Layer ist dieselbe wie im Auswahldialog.

**Warnung:** Der Rechner unterscheidet zwischen Groß- und Kleinschreibung.

Am Anfang ändern wir die Einheit des DEM von Meter auf Fuß. Wir benötigen die folgende Formel:

\[ h' = h \times 3.28084 \]

Wählen Sie das DEM im Layer Feld und geben als Formel \(a \times 3.28084\) ein.

**Warnung:** Für Benutzer, die nicht englisch verwenden: nutzen Sie immer „,” und nicht „.„.

Klicken Sie auf **Starte** um den Algorithmus zu starten. Wir erhalten einen mit der Quelle vergleichbaren Layer aber mit abweichenden Werten. Der Eingabelayer hat für alle Zellen gültige Werte, so dass der letzte Parameter keine Auswirkung hat.


Öffnen Sie den Dialog des Algorithmus noch einmal, wählen den Layer `accflow` als Eingabelayer und geben die folgende Formel vor: \(\log(a)\).

Wir erhalten den folgenden Layer.

Wir können die Werte des Layers mit Hilfe des **Abfrage** Werkzeuges an jedem Punkt ermitteln. Wenn wir außerhalb des Layers klicken, sehen wir, das der Layer nur Leerwerte enthält.

Für die nächste Übung werden wir zwei Layer statt einem verwenden. Wir werden ein DEM erhalten, das nur gültige Höhenwerte innerhalb des mit dem zweiten Layer vorgegebenen Einzugsgebietes enthält. Öffnen Sie den Dialog des Rasterrechners und wählen beide Layer als Eingabe aus. Geben Sie die folgende Formel vor:

\[ a/a \times b \]

\(a\) bezieht sich auf den Layer des akkumulierten Abflusses (er erscheint als erster in der Liste) und \(b\) bezieht sich auf das DEM. Im ersten Teil der Formel teilen wir den Layer des akkumulierten Abflusses mit sich selbst. Dabei erhalten wir einen Wert von 1 innerhalb und einen Leerwert außerhalb des Einzugsgebietes. Dieser Wert wird anschließend mit dem DEM multipliziert, um den Höhenwert innerhalb des Einzugsgebietes \((\text{DEM} \times 1 = \text{DEM})\) und einen Leerwert außerhalb \((\text{DEM} \times \text{no_data} = \text{no_data})\) zu erhalten.

Das ist der sich ergebene Layer.

Diese Technik wird häufig zur **Maskierung** von Werten eines Rasterlayers verwendet. Sie ist immer dann nützlich, wenn man Berechnungen auf Regionen durchführen möchte, die von der willkürlichen rechteckigen Form abweichen. Wenn man z.B. das Histogramm der Höhenwerte eines Rasterlayers bestimmt, macht das erst mal nicht so viel Sinn.

17.10. **Der Rasterrechner. Nullwerte**
Kapitel 17. Der QGIS-Verarbeitungsleitfaden
Wenn man dagegen nur die Werte eines Einzugsgebietes berücksichtigt (wie im obigen Beispiel), erhält man ein sinnvolles Resultat mit Informationen über die Struktur des Einzugsgebietes.

Neben der Behandlung der Leerwerte gibt es weitere interessante Dinge an dem Algorithmus. Wenn wir uns die Ausdehnung der Layer ansehen, die wir multipliziert haben (man kann sich die Eigenschaften der Layer durch Doppelklick auf einen Layer im Inhaltsverzeichnis ansehen), sehen wir, dass sie nicht identisch sind. Das liegt daran, dass die Ausdehnung des Layers des akkumulierten Abflusses kleiner als die Ausdehnung des DEM ist.


In diesem Fall (wie in den meisten Fällen) erhalten wir das gewünschte Ergebnis. Man sollte die im Hintergrundablaufenden Operationen immer bedenken, da sie unter Umständen das Ergebnis beeinflussen können. Wenn dieses Verhalten ausgeschlossen werden soll, kann im Vorfeld eine manuelle Anpassung der Eingabelayer erfolgen. In späteren Kapiteln werden wir mehr über das Verhalten von Algorithmen bei Verwendung mehrerer Rasterlayer lernen.

Wir beenden diese Lektion mit einer weiteren Übung zur Maskierung. Wir werden die Hangneigung für alle Flächen in einer Höhe zwischen 1000 und 1500 Metern berechnen.

In diesem Fall haben wir keinen Layer, den wir als Maske verwenden können. Wir erstellen diesen Layer mit Hilfe des Rasterrechners.

Starten Sie den Rasterrechner mit dem DEM als Eingabelayer und der folgenden Formel

```plaintext
ifelse(abs(a-1250) < 250, 1, 0/0)
```

Wie man sieht, kann der Rasterrechner nicht nur für einfache Rechenoperationen sondern auch für bedingte Berechnungen wie im Beispiel verwendet werden.

Als Ergebnis erhalten wir eine 1 für Zellen, die im Wertebereich liegen und einen Leerwert für Zellen außerhalb des Wertebereiches.

Der Leerwert entsteht aus dem Ausdruck 0/0. Da es sich um einen unbestimmten Wert handelt, fügt SAGA einen NaN Wert ein (Not a Number), der wie ein Leerwert behandelt wird. Mit diesem Trick können wir einen Leerwert für Zellen vergeben, ohne zu wissen, welchem Wert der Leerwert für eine Zelle entspricht.

Der Layer muss nun nur noch mit dem Neigungslayer multipliziert werden und wir erhalten unser Ergebnis.

Das kann alles in einer einzigen Operation im Rasterrechner erfolgen. Wir belassen die Ausführung als Übung für den Leser.
17.11 Vektorberechner

**Bemerkung:** In dieser Lektion lernen wir, wie man neue Attribute zu einem Vektorlayer basierend auf einem mathematischen Ausdruck mit Hilfe des Vektorrechners hinzufügt.


**Bemerkung:** In neueren Versionen hat sich die Eingabeschnittstelle stark verändert. Sie ist umfangreicher und einfacher zu nutzen.

Es folgen einige Beispiele zur Nutzung des Algorithmus.

Wir werden zuerst den Anteil der weißen Menschen in jedem Polygon, d.h. in einem Zensusgebiet, bestimmen. Wir können dazu die Felder *WHITE* und *SHAPE_AREA* aus der Attributtabelle verwenden. Wir dividieren die Werte und multiplizieren sie anschließend mit einer Million (um auf die Dichte je Quadratkilometer zu kommen). Wir können die folgende Formel verwenden.

\[
\left( \frac{\text{WHITE}}{\text{SHAPE_AREA}} \right) \times 1000000
\]

Der Dialog zur Parametereingabe sollte wie folgt ausgefüllt sein.

Dadurch wird ein neues Feld *WHITE_DENS* erstellt.

Als nächstes berechnen wir das Verhältnis von *MALES* zu *FEMALES* in einem neuen Feld. Wir ermitteln damit inwieweit die männliche Bevölkerung gegenüber der weiblichen vorwiegt.

Geben Sie die folgende Formel ein

\[
\text{"MALES" / "FEMALES"
\]

Dieses Mal sollte das Parameterfenster wie folgt aussehen. Drücken Sie nun auf die *OK* Schaltfläche.
17.11. Vektorberechner
In früheren Versionen wurde das Ergebnis nur als Ganzzahl ausgegeben, da beide Eingabefelder ganzzahlig sind. In diesem Fall muss man folgende Formel verwenden: \(1.0 \times \text{"MALES"} / \text{"FEMALES"}\). Damit wird angezeigt, dass das Ergebnis eine Fließkommazahl sein soll.

Wir können bedingte Funktionen verwenden, um ein neues Feld zu erzeugen, das anstelle des Verhältnisses mit \text{male} oder \text{female} gefüllt wird. Das kann mit der folgenden Formel erfolgen:

\[
\text{CASE WHEN } \text{"MALES"} > \text{"FEMALES"} \text{ THEN } \text{"male"} \text{ ELSE } \text{"female"} \text{ END}
\]

Das Parameterfenster sollte wie folgt aussehen.

Unter \text{Funktionseditor} steht ein Feldrechner mit Python zur Verfügung. Hierauf gehen wir jetzt nicht näher ein.

### 17.12 Definierung von Ausschnitten

**Bemerkung:** In dieser Lektion werden wir sehen, wie man Ausdehnungen definiert, die von einigen Algorithmen, v.a. den Rasteralgorithmen benötigt werden.

Einige Algorithmen benötigen eine Ausdehnung, um die Fläche zu definieren, die von der Analyse berücksichtigt wird und auch die Ausdehnung des Ausgabelayers bestimmt.

Wenn eine Ausdehnung erforderlich ist, kann sie manuell mit Hilfe der vier Werte die sie definieren vorgegeben werden (min X, min Y, max X, max Y). Es gibt aber auch andere praktikablere und interessantere Möglichkeiten, dies zu tun. Wir werden sie in dieser Lektion kennenlernen.

Als Erstes öffnen wir einen Algorithmus, der die Definition einer Ausdehnung voraussetzt. Öffnen Sie den Algorithmus \text{Rastern}, der einen Rasterlayer aus einem Vektorlayer erstellt.
Alle Parameter bis auf die letzten beiden werden benutzt, um zu bestimmen, welcher Layer gerastert werden soll und wie der Prozess der Rasterung ablaufen soll. Die letzten beiden Paramter bestimmen dagegen die Charakteristik des Ausgabelayers. Sie bestimmen die bedeckte Fläche (die unter Umständen von der Fläche des Eingabevektorlayers abweicht) und die Auflösung/Zellengröße (wird nicht vom Vektorlayer beeinflusst, da Vektorlayer keine Zellengröße verwenden).


Sehen wir uns an, welche Möglichkeiten es gibt.

Die erste Option lautet Use layer/canvas extent, wie im Auswahl Dialog unten zu sehen ist.

Hiermit wird die Ausdehnung des Arbeitsbereiches (die Ausdehnung die der aktuellen Zoomstufe entspricht) oder eines beliebigen verfügbaren Layers gewählt. Wählen Sie den Eintrag, klicken auf OK und das Textfeld wird automatisch mit den zugehörigen Werten gefüllt.

Die zweite Option lautet Ausdehnung auf Kartenausschnitt wählen. In diesem Fall verschwindet das Auswahlfeld und man kann den gewünschten Ausschnitt im QGIS Arbeitsbereich aufziehen.

Nachdem man den Ausschnitt aufgezogen hat, erscheint erneut das Dialogfenster und das Textfeld ist mit den zum Ausschnitt gehörenden Werten gefüllt.

Die letzte Option und Standardvorgabe lautet Use min covering extent from input layers. Damit wird die minimale Ausdehnung aller Eingabelayer verwendet, eine händische Eingabe in das Textfeld muss nicht mehr erfolgen. Im Fall eines einzelnen Eingabelayers, wie in unserem Beispiel, wird hiermit dasselbe Ergebnis erzielt wie mit Use layer/canvas extent, das wir schon beschrieben haben. Wenn dagegen mehrere Eingabelayer verwendet werden, entspricht die Ausdehnung keinem einzelnen Layer. Die Ausdehnung wird dann aus allen Eingabelayer berechnet.

Wir werden für unseren Rasterungsalgorithmus diese letzte Möglichkeit verwenden.

17.12. Definierung von Ausschnitten
Kapitel 17. Der QGIS-Verarbeitungsleitfaden
17.12. Definierung von Ausschnitten
Füllen Sie die Parameter im Dialog wie gezeigt aus und drücken auf Starte.

**Bemerkung:** In diesem Fall ist es besser, *Integer (1 byte)* anstelle von *Floating point (4 byte)* zu verwenden, da NAME ganzzahlig mit einem Maximalwert=64 ist. Die Berechnung läuft dann schneller ab und die Ergebnisdatei ist kleiner.

Wir erhalten einen gerasterten Layer, der exakt die Fläche des originalen Vektorlayers abdeckt.

In manchen Fällen ist die letzte Option *Use min covering extent from input layers* nicht verfügbar. Das passiert, wenn der Algorithmus keine Eingabelayer sondern nur Parameter mit anderem Typ verwendet. In diesem Fall müssen Sie die Werte händisch eingeben oder eine der anderen Möglichkeiten verwenden.

Beachten Sie, dass eine Auswahl nicht bei der Berechnung der Ausdehnung berücksichtigt wird auch wenn die Rasterung nur mit den gewählten Objekten erfolgt. Die Ausdehnung bezieht sich auf alle Objekte des Layers. In so einem Fall, ist es günstiger einen Layer aus der Auswahl zu erstellen.

### 17.13 HTML-Ausgaben

**Bemerkung:** In dieser Lektion lernen wir, wie QGIS mit Ausgaben im HTML Format umgeht, die zur Produktion von Textausgaben und Grafiken verwendet wird.

Alle Ausgaben, die wir bisher erzeugt haben, waren Layer (Raster- oder Vektorlayer). Es gibt aber auch Algorithmen, die Ausgaben in Form von Text und Grafiken erzeugen. Alle diese Ausgaben erfolgen in HTML-Dateien, die in der sogenannten Ergebnisanzeige, einem weiteren Teil der Verarbeitungsumgebung, angezeigt werden.

Sehen wir uns einige dieser Algorithmen an, um zu verstehen wie sie arbeiten.

Öffnen Sie das Projekt, dass die Daten für diese Lektion enthält. Öffnen Sie dann den Algorithmus *Grundstatistik für Felder*.

Der Algorithmus ist relativ einfach, man muss nur den zu verwendenden Layer und ein Feld (ein numerisches) auswählen. Die Ausgabe hat den Typ HTML aber die zugehörige Box arbeitet auf dieselbe Art wie bei der Ausgabe von Vektor- oder Rasterlayer. Sie können einen Dateipfad eingeben oder das Feld freilassen, um in eine temporäre Datei zu speichern. In diesem Fall sind nur die Dateierweiterungen *html* und *htm* erlaubt, so dass man das Ausgabeformat nicht ändern kann.


Das ist die Ergebnisanzeige. Alle HTML Resultate die in der aktuellen Sitzung generiert wurden sind so leicht verfügbar und man kann sie bei Bedarf immer schnell aufrufen. Genauso wie bei temporären Layern werden die Resultate
**Shapes to grid**

Shapes
- watersheds [EPSG:23030]

Attribute
- ID

Method for Multiple Values
- [0] first

Method for Lines
- [0] thin

Preferred Target Grid Type
- [3] Floating Point (4 byte)

Output extent (xmin, xmax, ymin, ymax)
- Leave blank to use min covering extent

Cellsize
- 2

Grid
- [Save to temporary file]

- Open output file after running algorithm

---

17.13. HTML-Ausgaben 493
bei Schließen von QGIS gelöscht. Wenn Sie in einem Pfad gespeichert haben, wird die Datei nicht gelöscht. Sie wird aber beim nächsten Start von QGIS nicht in der Ergebnisanzeige angezeigt.

Einige Algorithmen erstellen Text, der nicht weiter in detailliertere Ausgabedateien unterteilt werden kann. Das ist z.B. der Fall wenn ein Algorithmus die Textausgabe eines externen Prozesses entgegennimmt. In anderen Fällen wird die Ausgabe in Form eines Textes präsentiert, die Daten liegen aber intern in Form mehrerer kleinerer Ausgaben vor - in der Regel in Form numerischer Werte. Der Algorithmus den wir eben verwendet haben, ist ein solcher. Jeder der Werte wird als einzelne Ausgabe behandelt und in einer Variable gespeichert. Das hat momentan keine Bedeutung. Wenn wir jedoch die grafische Modellierung verwenden, können wir diese Werte als Eingabe für andere Algorithmen verwenden.

17.14 Erstes Analysebeispiel

_Bemerkung:_ In dieser Lektion werden wir einige echte Analysen ausführen. Wir benutzen die Werkzeugkiste, so dass wir uns noch mehr mit der Verarbeitungsumgebung vertraut machen.

Da jetzt alles richtig konfiguriert ist und wir externe Algorithmen verwenden können, steht uns ein mächtiges Werkzeug zur Durchführung räumlicher Analysen zur Verfügung. Es ist an der Zeit ein echtes Beispiel mit echten Daten zu bearbeiten.


Der Datensatz enthält shape-Dateien mit den Todesfällen an Cholera und der Lage von Pumpen sowie eine nach OSM...
Count: 485
Unique values: 403
Minimum value: 0.0
Maximum value: 3198.0
Range: 3198.0
Sum: 554636.0
Mean value: 1143.57938144
Median value: 1074.0
Standard deviation: 527.408287222
Coefficient of Variation: 0.481190797753
Der erste Schritt ist die Erstellung eines Voronoi Diagramms (bzw. Thiessen-Polygone) für den Layer der Pumpen, um die Einflusszone für jede Pumpe zu ermitteln. Der Algorithmus Voronoi-Polygone kann dazu verwendet werden.

Ganz einfach - aber wir erhalten schon erste interessante Informationen.

Die meisten Fälle liegen offensichtlich innerhalb eines der Polygone.

Um ein genaueres Ergebnis zu erhalten, zählen wir die Todesfälle in jedem Polygon. Jeder Punkt steht für ein Gebäude in dem Todesfälle auftraten. Da die Anzahl der Todesfälle in der Attributabelle gespeichert ist, reicht es nicht, nur die Punkte zu zählen. Wir benötigen eine gewichtete Zählung. Dazu können wir das Werkzeug Punkte in Polygon zählen verwenden.

Das neue Feld wird DEATHS genannt und wir nutzen das Feld COUNT als Wichtungsfeld. Die Ergebnistabelle zeigt eindeutig, dass die Anzahl der Todesfälle im zur ersten Pumpe gehörenden Polygon größer ist, als in den anderen Polygone.

Ein anderer guter Weg zur Visualisierung der Abhängigkeit jedes Punktes aus dem Layer Cholera_deaths zu den Punkten im Layer Pumps ist die Erstellung einer Linie zu der am nächsten gelegenden Pumpe. Dies kann mit Hilfe des Werkzeuges Abstand zum nächsten Knoten (Linie zu Knoten) und der unten aufgeführten Konfiguration erfolgen.

Das Ergebnis sieht wie folgt aus:

Obwohl die Anzahl der Linien zur zentralen Pumpe größer ist, dürfen wir nicht vergessen, dass die Anzahl der Linien nicht der Anzahl der Todesfälle sondern der Anzahl der Orte an denen Todesfälle auftraten, entspricht. Es ist zwar ein repräsentativer Parameter, allerdings ohne Berücksichtigung der mehrfachen Todesfälle an einigen Orten.
Ein Dichtelayer kann das ebenfalls sehr gut verdeutlichen. Wir können ihn mit Hilfe des Algorithmus Heatmap (Kerndichtenschätzung) erstellen. Wenn wir den Layer Cholera_deaths, das COUNT Feld als Wichtungsfeld mit einem Radius von 100 und die Ausdehnung des Rasterlayers der Straßen verwenden, erhalten wir in etwa die folgende Ausgabe.

Denken Sie daran, dass Sie die Ausdehnung der Ausgabe nicht eintippen müssen. Klicken Sie auf die Schaltfläche auf der rechten Seite und wählen Use layer/canvas extent.

Wählen Sie den Rasterlayer der Straßen, seine Ausdehnung wird dann automatisch in das Textfeld übernommen. Mit der Zellgröße können wir genauso vorgehen, d.h. wir wählen diesen Layer erneut.

Zusammen mit dem Layer der Pumpen erkennen wir, dass sich eindeutig eine Pumpe im Zentrum der höchsten Dichte der Todesfälle befindet.

17.15 Zuschneiden und Verschmelzen von Rasterlayern

**Bemerkung:** In dieser Lektion lernen wir ein weiteres Beispiel zur Vorbereitung realer räumlicher Daten mit Hilfe von Geoalgorithmen.

In dieser Lektion werden wir einen Gefällelayer für das Umland eines Stadtgebietes bestimmen. Das Stadtgebiet liegt als einzelnes Polygon in einem Vektorlayer vor. Das Basis DEM ist in zwei Rasterlayer unterteilt, die ein viel größeres Gebiet abdecken, als unser Arbeitsgebiet im Umland der Stadt. Nach dem Öffnen des zur Lektion gehörenden Projektes, sehen wir in etwa das Folgende.

Bei diesen Layern gibt es zwei Probleme:

- Sie überdecken ein für unsere Zwecke zu großes Gebiet (uns interessiert nur eine kleine Region um das Stadtzentrum herum)
17.15. Zuschneiden und Verschmelzen von Rasterlayern

QGIS Training Manual
Sie liegen in zwei verschiedenen Dateien vor (die Stadtgrenze liegt nur in einem Rasterlayer, wir benötigen aber eine etwas größere Fläche außerhalb der Stadt).

Beide Probleme lassen sich leicht mit dem passenden Geoalgorithmus beheben.

Als Erstes erstellen wir ein Rechteck, das unser Untersuchungsgebiet bestimmt. Wir erstellen dazu einen Layer, der den Begrenzungsrahmen der Stadtfläche darstellt. Um diesen Layer erstellen wir einen Puffer, damit wir einen Rasterlayer erhalten, der etwas mehr als die erforderliche Fläche abdeckt.

Um den Begrenzungsrahmen zu erstellen, können wir den Algorithmus *Layerausdehnung extrahieren* verwenden.

Zur Erstellung des Puffers verwenden wir den Algorithmus *Puffer* mit den folgenden Parametern.

**Warnung:** Syntax in neueren Versionen geändert; sowohl Abstand als auch Bogen-Eckpunkt auf .25 setzen

Hier sehen Sie den Begrenzungsrahmen, der mit den gegebenen Parametern erzeugt wird.

Es ist ein abgerundeter Rahmen. Wenn wir den Algorithmus *Layerausdehnung extrahieren* auf ihn anwenden, erzeugen wir daraus einen rechteckigen Rahmen. Wir hätten auch zuerst die Stadtgrenzen puffern und darauf basierend den Begrenzungsrahmen erstellen können. Dadurch hätten wir einen Schritt gespart.

Die Rasterlayer verwenden eine andere Projektion als der Vektorlayer. Wir müssen sie bevor wir fortfahren mit Hilfe des Werkzeuges *Transformieren (reprojizieren)* transformieren.

**Bemerkung:** Neuere Versionen verwenden eine komplexere Schnittstelle. Stellen Sie sicher, dass mindestens eine Komprimierungsmethode gewählt wurde.

Mit Hilfe des Layers des Begrenzungsrahmens schneiden wir beide Rasterlayer zu. Wir verwenden dazu das Werkzeug *Raster auf Layermaske zuschneiden.*
17.15. Zuschneiden und Verschmelzen von Rasterlayern

Soho
QGIS Training Manual

17.15. Zuschneiden und Verschmelzen von Rasterlayern

![Kernel density estimation window](image)

![Output result](image)
Kapitel 17. Der QGIS-Verarbeitungsleitfaden

Polygone aus Layer-Auflage

Eingabe-Layer: mcdford_citylimits

Berechne Bereich für jedes Feature getrennt: Nein

Ausschnitt-Layer:

[Speichern als temporäre Datei]

Öffne Ausschnitt-Datei nach Ausführung des Algorithmus

0%

OK  Close  Cancel

Festen Entfernungswert

Eingabe-Layer: mcdford_citylimits [EPSG:1326]

Abstand: 0.25

Segmente: 5

Verbinden Ergebnis: Nein

Buffer:

[Speichern als temporäre Datei]

Öffne Bufferring-Datei nach Ausführung des Algorithmus

0%

Run  Close  Cancel
17.15. Zuschneiden und Verschmelzen von Rasterlayern
QGIS Training Manual

Kapitel 17. Der QGIS-Verarbeitungsleitfaden
Nachdem die Layer zugeschnitten sind, können sie mit Hilfe des Algorithmus Verschmelzen zusammengeführt werden.

**Bemerkung:** Man kann Zeit sparen, wenn man zuerst verschmilzt und danach zuschneidet. Der Zuschneidealgorithmus muss dann nicht zweimal aufgerufen werden. Wenn man mehrere große Layer zusammenfügen möchte, kann allerdings ein ziemlich großer Layer entstehen, der später schwer zu verarbeiten ist. In diesem Fall ist es günstiger, den Zuschneidealgorithmus mehrmals aufzurufen. Das ist zeitaufwendig, aber wir werden bald weitere Werkzeuge kennenlernen, die die Automatisierung solcher Operationen erlaubt. In diesem Beispiel haben wir nur zwei Layer, so dass das jetzt nicht so wichtig ist.

Wir haben jetzt unser finales DEM wie wir es wollten. 
Jetzt ist es an der Zeit, den Layer mit dem Gefälle zu berechnen.


Mit dem neuen DEM kann nun die Hangneigung berechnet werden.
Hier ist der resultierende Layer mit der Hangneigung.

Die Hangneigung, die durch den Algorithmus *Slope, Aspect, Curvature* berechnet wird, kann in Grad oder Radiant ausgegeben werden. Die verbreitertere und auch praktikablere Einheit ist Grad. Falls Sie die Neigung in Radiant berechnet haben, kann man die Einheit mit Hilfe des Algorithmus *Metric conversions* umrechnen (für den Fall, dass man diesen Algorithmus nicht kennen würde, hätte man auch den Rasterrechner verwenden können, den wir schon benutzt haben).

Nach dem erneuten Reprojizieren des konvertierten Neigungsayers mit *Transformieren (reprojizieren)* zurück zum Ausgangs KBS erhalten wir den Ergebnislayer, den wir uns vorgestellt haben.

17.16 Hydrologische Analyse

**Warnung:** todo: Bild einfügen


**Bemerkung:** In dieser Lektion werden wir einige hydrologische Untersuchungen durchführen. Diese werden in einigen der anderen Übungen gebraucht, da diese ein sehr gutes Beispiel für einen analytischen Workflow darstellt und diese für einige erweiterte Funktionen genutzt werden.

In dieser Übung werden wir einige hydrologische Analysen durchführen. Zu Beginn werden wir aus einem DGM bzw. DEM ein Kanalnetz extrahieren, dann ein Einzugsgebiet erstellt und schlussendlich ein paar statistische Werte berechnet.

Zu Beginn müssen die Übungsdaten in das Projekt geladen werden, welche lediglich ein DGM bzw. DEM ist.

Das erste Modul, dass wir ausführen lautet *Catchment area* (in einigen SAGA Versionen wird es *Flow accumulation (Top Down)* genannt). Sie können auch die anderen Algorithmen, die mit *Catchment area* bezeichnet sind, verwenden. Die zu Grunde liegenden Algorithmen unterscheiden sich zwar, die Ergebnisse sind aber praktisch dieselben.

Wählen Sie das DGM bzw. DEM im Feld *Elevation* aus, die restlichen Parameter bleiben unverändert.

Einige Algorithmen erstellen mehrere Layer, jedoch benutzen wir nur *Catchment Area*.

Die Anderen können gelöscht werden.

Der erstellte Layer ist nicht sonderlich informativ.
Kapitel 17. Der QGIS-Verarbeitungsleitfaden

Der Einzugsbereich (auch bekannt als Ablussakkumulation), kann auch als Grenzwert für Kanaleinleitung genutzt werden. Dies kann über den Algorithmus Channel network erreicht werden. Hier sind die Einstellungen zu sehen (beachte das Initiation threshold, sprich der Einleitungsschwellenwert, größer als 10.000.000 sein muss).

Verwende den originalen Einzugsbereich, nicht den logarithmischen. Dieser war lediglich zu Anschauungszwecken.


Das obere Bild zeigt den entstandene Vector Layer und das DGM, aber es sollte ebenso ein Raster mit dem gleichen Kanalnetz existieren. Den schlussendlich ist es dieses, was von uns weiter benutzt wird.

Nun benutzen wir den Watersheds basins Algorithmus um die Teileinzugsgebiete entsprechend des Kanalnetzes abzugrenzen, wobei die „Austrittsstellen“ als Übergänge genutzt werden. So müssen die entsprechenden Parameter gewählt werden.

Somit entsteht folgendes.

Dies ist ein Raster-Ergebnis. Es kann durch den Vectorising grid classes Algorithmus vektorisiert werden.

Nun versuchen wir statistische Höhenwerte in einem unsere Teileinzugsgebiete zu berechnen. Der Gedanke ist einen Layer zu haben, welche stellvertretend für die Höhen im Teileinzugsgebiet steht um dieses an das Modul zu übergeben, welches diese Statistiken berechnet.

Als Erstes schneiden wir das DEM mit dem Polygon eines Teileinzugsgebietes zu. Wir nutzen dafür den Algorithmus Clip raster with polygon. Wenn wir ein einzelnes Teileinzugsgebiet auswählen und dann den Zuschneidealgorithmus aufrufen, wird das DEM auf das selektierte Teileinzugsgebiet zugeschnitten. Der Algorithmus berücksichtigt die Selektion.

Wähle ein Polygon aus

und führe den „Clipping-Algorithmus“ mit folgenden Parametern aus:
Kapitel 17. Der QGIS-Verarbeitungsleitfaden
Das Element im Input-Feld ist natürlich das DGM was wird clippen wollen.
Dies sollte dann in etwa so aussehen.
Dieser Layer ist nun bereit um im „Raster layer statistics“ Algorithmus genutzt zu werden.
Die resultierende Statistik ist folgende.
Wir werden die Einzugsgebietserkennung und die statistischen Werte in einer anderen Übung nochmals verwenden, um herauszufinden wie andere Elemente uns helfen, automatisiert dies durchzuführen und effektiver zu arbeiten.

### 17.17 Einstieg in den Grafischen Modellierer

**Bemerkung:** In dieser Lektion werden wir die grafische Modellierung verwenden. Es handelt sich um eine mächtige Komponente mit deren Hilfe man einen Arbeitsablauf definieren und mehrere Algorithmen verkettet ausführen kann.

Bei der Arbeit mit der Verarbeitungsumgebung führt man in der Regel mehr als einen Algorithmus aus. Das Erreichen des Ergebnisses erfordert es meistens, mehrere Algorithmen zu starten, wobei die Ausgabe eines Algorithmus als Eingabe für einen anderen Algorithmus verwendet wird.

Wenn man die grafische Modellierung verwendet, kann der Arbeitsablauf in ein Modell überführt werden. Das Modell führt alle erforderlichen Algorithmen auf einmal aus und vereinfacht und automatisiert so den Arbeitsprozess.

Zu Beginn dieser Lektion werden wir den Topographic Wetness Index berechnen. Der zur Berechnung verwendete Algorithmus ist *Topographic wetness index (twi)*.

Wir sehen zwei Eingaben, die ausgefüllt werden müssen: *Slope* und *Catchment area*. Es gibt noch weitere optionale Eingabefelder, die wir außer Acht lassen können.
17.17. Einstieg in den Grafischen Modellierer
Valid cells: 24155
No-data cells: 14573
Minimum value: 771.0
Maximum value: 2080.0
Sum: 29923203.3423
Mean value: 1238.79955878
Standard deviation: 271.406236765

Topographic wetness index (twi)

Slope
demZS [EPSG:23030]

Catchment Area
demZS [EPSG:23030]

Transmissivity
[Not selected]

Area Conversion
[0] no conversion (areas already given as specific catchment area)

Method (TWI)
[0] Standard

Topographic Wetness Index
[Save to temporary file]

Open output file after running algorithm
Die Daten für diese Lektion bestehen nur aus dem DEM, wir haben noch keine der benötigten Eingangsdaten. Wir wissen aber bereits, mit welchen Algorithmen man Hangneigung und Einzugsgebiete berechnen kann. Wir können diese Layer also zuerst berechnen und sie dann als Eingangsdaten für den TWI Algorithmus verwenden.

Es folgen die Paramter, die wir für die Berechnung der 2 Layer des Zwischenstandes benutzen.

**Bemerkung:** Die Hangneigung muss in Radiant und nicht in Grad berechnet werden.

Und so setzen wir die Paramter im Dialog des TWI Algorithmus.

Unten ist das Ergebnis der Berechnung dargestellt (als Darstellung wurde die invertierte Standardpalette der Einkanalpseudofarbe verwendet). Sie können auch den bereit gestellten Stil twi.qml nutzen.


Öffnen Sie die Modellierung über den Eintrag im VerarbeitungsMenü.

Zur Erstellung eines Modells sind zwei Dinge erforderlich: die Festlegung der benötigten Eingabedaten und der zu verwendenden Algorithmen. Beides erfolgt durch die zwei Reiter auf der linken Seite des Fensters der Verarbeitungsmodellierung: **Eingaben** und **Algorithmen**

Wir beginnen mit den Eingabedaten. In diesem Fall muss nicht viel hinzugefügt werden. Wir brauchen als Eingabe nur den Rasterlayer mit dem DEM.

Klicken Sie auf die Eingabe *Rasterlayer*. Wir sehen nun den folgenden Dialog.

Wir müssen hier die Eingabe definieren. Da wir für den Rasterlayer als Eingabe ein DEM erwarten, nennen wir den Paramter *DEM*. Diese Bezeichnung sieht der Nutzer, wenn er das Modell startet. Da wir den Layer unbedingt brauchen, setzen wir bei zwingend einen Haken.
Kapitel 17. Der QGIS-Verarbeitungsleitfaden
Der Dialog sollte wie folgt aussehen.

Klicken Sie auf OK und die Eingabe erscheint im Arbeitsbereich der Verarbeitungsmodellierung.

Kommen wir nun zum Reiter **Algorithmen**. Den Algorithmus *Slope, aspect, curvature* müssen wir als Erstes starten. Suchen Sie den Algorithmus und klicken dann doppelt darauf. Sie sehen jetzt den folgenden Dialog.


Wenn ein Layer kein dauerhaftes Ergebnis darstellt, sollte man das zugehörige Feld leer lassen. Ansonsten muss ein Name vergeben werden, der dann zur Identifikation im Parameter Dialog verwendet und später beim Aufruf des Modells angezeigt wird.

Im Dialogfenster ist nicht viel auszuwählen, da wir nur einen Layer (den vorher erstellten DEM Eingabelayer) im Modell haben. Der Dialog kann auf der Voreinstellung verbleiben. Klicken sie auf OK. Der Arbeitsbereich in der Verarbeitungsmodellierung sieht dann wie folgt aus.


Ihr Modell sollte nun wie folgt aussehen.

Im letzten Schritt muss noch der Algorithmus \textit{Topographic wetness index} mit den folgenden Einstellungen in das Modell eingefügt werden.


Diesmal soll für den Layer TWI ein dauerhafter Layer erstellt werden. Das müssen wir einstellen. Geben Sie im zugehörigen Textfeld den Namen ein, der für die Ausgabe angezeigt werden soll.

Unser Modell ist nun fertig und sollte in etwa so aussehen.

Geben Sie einen Namen und einen Gruppennamen im oberen Teil des Modellfensters ein und klicken dann auf die \textit{Speichern} Schaltfläche.

Sie können das Modell in jedem gewünschten Pfad speichern und von dort später auch wieder öffnen. Wenn Sie das Modell im Modellordner (das ist der Ordner, der im Dialog zum Speichern des Modells geöffnet wird) speichern, wird das Modell auch in der Werkzeugkiste angezeigt. Von daher ist es vorteilhaft, diesen Ordner beizubehalten und den gewünschten Dateinamen zu vergeben.
Schließen Sie nun den Dialog des Modells und gehen zur Werkzeugkiste. Unter dem Eintrag **Modelle** finden wir unser Modell.

Man kann es ganz normal wie jeden anderen Algorithmus durch Doppelklick starten.

Wie man sieht enthält der Parameterdialog die vorgebenen Eingabe- und Ausgabewerte.

Beim Starten des Modells wird das DEM als Eingabe genutzt und der TWI Layer in einem einzigen Schritt erstellt.

### 17.18 Mehr komplexe Modelle

**Bemerkung:** In dieser Lektion werden wir mit einem komplexeren Modell und der graphischen Modellierung arbeiten.


Diese Lektion enthält keine Anleitung, wie man das Modell erstellt. Wir kennen die notwendigen Schritte schon (wir haben sie in vorangehenden Lektionen behandelt) und Sie sind mit den grundlegenden Ideen der Verarbeitungsmodellierung vertraut. Versuchen Sie es also selbst. Nehmen sich einige Minuten Zeit, um Ihr Modell zu erstellen. Machen Sie sich keine Sorgen, dass Sie etwas falsch machen. Denken Sie daran: fügen Sie zuerst die Eingabedaten ein und danach die Algorithmen, die den Arbeitsablauf bestimmen.

Wenn Sie etwas Hilfe benötigen und es nicht schaffen, dass vollständige Modell zu erstellen, finden sie im Ordner zu dieser Lektion eine fast fertige Version des Modells. Öffnen Sie die Verarbeitungsmodellierung und anschließend die Modelldatei im Datenordner. Sie sollten in etwa das Folgende sehen.
17.18. Mehr komplexe Modelle
Das Modell enthält alle erforderlichen Schritte zur Fertigstellung der Berechnung. Es verwendet nur eine Eingabe: das DEM. Das Modell verwendet einen festen Schwellenwert, was nicht ganz den Zweck erfüllt. Das ist aber nicht schlimm, wir werden das Modell noch verändern.


![Parameter definition Dialog](image)

Ihr Modell sollte jetzt in etwa wie folgt aussehen.

![Modell mit Eingabe](image)

Die gerade hinzugefügte Eingabe wird noch nicht verwendet, das Modell hat sich nicht verändert. Wir müssen die Eingabe mit dem Algorithmus verbinden, der sie nutzen wird. In diesem Fall ist das der Algorithmus *Channel network*. Um einen bereits vorhandenen Algorithmus zu verändern, klicken man auf das Stift Symbol in der Box. Wenn Sie auf den Algorithmus *Channel network* klicken, sehen Sie in etwa das Folgende.

Der Dialog enthält die aktuell vom Algorithmus verwendeten Werte. Wir sehen, das der Schwellenwert einen festen Wert von 1.000.000 hat (der voreingestellte Wert für den Algorithmus, es kann ein beliebiger anderer Wert verwendet werden). Wir erkennen, dass der Paramter nicht im Textfeld sondern über ein Menü eingetragen werden kann. Wenn wir das Menü aufklappen, sehen wir in etwa das Folgende.
17.18. Mehr komplexe Modelle
Den ins Modell eingefügten numerischen Parameter können wir hier auswählen. Immer wenn ein Modell eine numerische Eingabe erwartet, kann man einen festen Wert verwenden oder man nutzt eine der vorhandenen Eingabemöglichkeiten (denken sie daran, dass einige Algorithmen einzelne numerische Werte generieren. Wir werden bald mehr darüber lernen.) Im Fall von Parametern im Format Zeichenkette können ebenfalls EingabevARIABLEN im Format Zeichenkette oder feste Werte verwendet werden.

Wählen Sie die Eingabe Threshold für den Parameter Threshold und klicken auf OK, um die Änderung im Modell anzuwenden. Der Entwurf des Modells sollte nun wie folgt aussehen.


Threshold = 100.000
Threshold = 1.0000.000

17.19 Nummerische Berechnungen im Modellierer


Bemerkung: In dieser Lektion lernen wir, wie man numerische Ausgaben in der Verarbeitungsmodellierung verwendet.

In dieser Lektion werden wir das hydologische Modell aus der letzten Lektion (öffnen Sie es bevor Sie beginnen) so verändern, dass der Schwellenwert automatisch gefüllt wird und nicht mehr vom Nutzer vorgegeben werden muss. Da sich der Wert auf die Variable im Rasterlayer Schwellenwert bezieht, werden wir ihn aus diesem Layer mit Hilfe einiger einfacher statistischer Analysen extrahieren.

Wir nehmen am oben genannten Modell die folgenden Änderungen vor:
17.19. Nummerische Berechnungen im Modellierer
Berechnen Sie als Erstes Statistiken des Layers flow accumulation mit Hilfe des Algorithmus Raster layer statistics.

Damit wird eine Menge von statistischen Werten erstellt, die dann für die numerischen Felder in allen Algorithmen verfügbar sind.

Wenn wir den Algorithmus Channel network wie in der letzten Lektion bearbeiten, sehen wir nun weitere Optionen außer der numerischen Eingabe, die wir hinzugefügt hatten.

Allerdings ist keiner der Werte wirklich als Schwellenwert nutzbar. Die entstehenden Abflussnetzwerke wären nicht sehr realistisch. Wir können aber basierend auf diesen Werten einige neue Parameter ableiten. Wir können z.B. den Mittelwert plus 2 mal der Standardabweichung verwenden.

Um diese Rechenoperation zu ergänzen, können wir den Rechner aus der Gruppe Geoalgorithms/modeler/modeler-tools verwenden. Diese Gruppe enthält Algorithmen, die außerhalb der Verarbeitungsmodellierung nicht sehr nützlich sind. Sie stellen aber nützliche Funktionalitäten für die Erstellung eines Modells bereit.

Der Parameter Dialog des Rechner Algorithmus sieht wie folgt aus:

Der Dialog weicht von den anderen vorher verwendeten Dialogen ab. Es sind aber dieselben Variablen verfügbar wie im Feld Threshold im Algorithmus Channel network. Geben Sie die obige Formel ein und klicken auf OK, um den Algorithmus hinzuzufügen.

Wenn Sie den Ausgabeeintrag wie oben gezeigt erweitern, sehen Sie, dass das Modell eine Verbindung zu zwei der Werte hergestellt hat, dem Mittelwert und der Standardabweichung. Das sind die Werte, die wir in der Formel verwendet haben.

Nach dem Hinzufügen des Algorithmus steht ein neuer numerischer Wert zur Verfügung. Wenn Sie noch einmal den Algorithmus Channel network öffnen, können Sie diesen Wert als Parameter für Threshold auswählen.

Klicken Sie auf OK und Ihr Modell sollte wie folgt aussehen.

Wir nutzen die numerische Eingabe, die wir hinzugefügt hatten nicht mehr. Wir können Sie nun durch Klick mit der rechten Maustaste und Auswahl von Remove löschen.
17.19. Nummerische Berechnungen im Modellierer

Der Bildschirm zeigt die Einstellungen für den Modellierer mit einer Übersicht über die Parameter. Die Einstellungen beinhalten:

- **Elevation**: DEM
- **Flow Direction**: [Not selected]
- **Initiation Grid**: Catchment Area from algorithm 1 (Catchment area (parallel))
- **Initiation Type**: [2] Greater than
- **Initiation Threshold**
  - **Threshold for channel definition**
  - **Minimum value from algorithm 5 (Raster layer statistics)**
  - **Maximum value from algorithm 5 (Raster layer statistics)**
  - **Sum from algorithm 5 (Raster layer statistics)**
  - **Mean value from algorithm 5 (Raster layer statistics)**
  - **Valid cells count from algorithm 5 (Raster layer statistics)**
  - **No-data cells count from algorithm 5 (Raster layer statistics)**
  - **Standard deviation from algorithm 5 (Raster layer statistics)**
- **Min. Segment Length**: 10

Im unteren Bildschirm wird der **Calculator** gezeigt. Die Berechnung erlaubt die Verwendung von Variablen in der Formel, wie folgt:

- a: Threshold for channel definition
- b: Minimum value from algorithm 5 (Raster layer statistics)
- c: Maximum value from algorithm 5 (Raster layer statistics)
- d: Sum from algorithm 5 (Raster layer statistics)
- e: Mean value from algorithm 5 (Raster layer statistics)
- f: Valid cells count from algorithm 5 (Raster layer statistics)
- g: No-data cells count from algorithm 5 (Raster layer statistics)
- h: Standard deviation from algorithm 5 (Raster layer statistics)

Die Formel lautet: 

\[ e + 2^h \]
Unser neues Modell ist nun fertig gestellt.

17.20 Ein Model in einem Modell


Wir haben bereits einige Modelle erstellt. In dieser Lektion lernen wir, wie man ein Modell innerhalb eines größeren Modells verwendet.

Wir beginnen mit dem Modell, das unser Ausgangspunkt in der vorherigen Lektion war.


Hier ist der dazu gehörende Paramter Dialog:

Wir haben nun einen TWI Layer, den wir nebem unserem Vektorlayer der Wasserscheiden verwenden können. Wir erstellen damit einen neuen Layer der den zu jeder Wasserscheide gehörenden TWI Wert ermittelt.


Das fertig gestellte Modell sollte in etwa wie folgt aussehen:

Wie man sieht ist das Einfügen eines anderen Modells in ein Modell nichts besonderes. Man kann es wie einen Algorithmus in das Modell einfügen. Man muss nur darauf achten, dass das Modell im Vorgabepfad der Modelle gespeichert und in der Werkzeugkiste verfügbar ist.

**17.21 Erstellung eines Modells mit modellinternen Werkzeugen**

**Bemerkung:** Diese Lektion zeigt, wie man einige Algorithmen nutzt, die nur in der Verarbeitungsmodellierung verfügbar sind. Sie stellen zusätzliche Funktionalitäten für Modelle bereit.

Das Ziel dieser Lektion ist es, mit Hilfe der Verarbeitungsmodellierung einen Algorithmus zur Interpolation zu erstellen. Er soll dabei die aktuelle Selektion berücksichtigen, d.h. nicht nur die selektierten Objekte sondern auch deren räumliche Ausdehnung. Auf Grundlage der Ausdehnung soll ein interpolierter Rasterlayer erstellt werden.

Der Prozess der Interpolation beinhaltet zwei Prozesse, die schon in vorherigen Lektionen beschrieben wurden: die Rasterung von Punktdaten und das Füllen von Leerwerten in gerasterten Layern. Im Fall von Punkten die eine Auswahl enthalten, werden nur diese Punkte verwendet. Wenn die Ausdehnung so eingestellt ist, dass sie automatisch
angepasst wird, wird aber die gesamte Ausdehnung des Layers verwendet und nicht nur die, die sich aus der Selektion ergibt. Wir werden versuchen, das mit Hilfe weiterer Werkzeuge zu beheben.

Öffnen Sie die Verarbeitungsmodellierung und fügen die benötigten Eingabedaten hinzu. Wir benötigen einen Vektorlayer (nur Punkte) und ein Attribut des Layers, das wir für die Rasterung verwenden werden.


Ein einfacher Weg zur Erstellung eines Layers mit der Ausdehnung der selektierten Objekte ist die Berechnung einer konvexen Hüle für den Punktlayer. Dabei werden nur die gewählten Punkte verwendet, so dass die konvexe Hüle dieselbe Ausdehnung wie der Begrenzungsrahmen der Auswahl hat. Wir nutzen dann den Algorithmus *Layerausdehnung extrahieren* mit der konvexen Hüle als Eingabe. Unser Arbeitsbereich sollte nun in etwa wie folgt aussehen:

Das Ergebnis von *Layerausdehnung extrahieren* ist eine Menge von vier Zahlen und ein Ausdehnungsobjekt. Wir werden beides in dieser Übung verwenden.

Wir können nun den Algorithmus zur Rasterung unter Nutzung der Ausdehnung aus dem Algorithmus *Layerausdehnung extrahieren* einfügen.

Füllen Sie die Parameter des Algorithmus wie folgt:

Der Arbeitsbereich sollte jetzt so aussehen:

Füllen Sie zum Schluss die Leerwerte des Rasterlayers mit Hilfe des Algorithmus *Close gaps*.

Der Algorithmus kann nun gespeichert werden und ist dann in der Werkzeugkiste verfügbar. Sie können ihn starten und er wird aus der Interpolation der selektierten Punkte des Eingablayers ein Raster erstellen. Das Rasterlayer wird dieselbe Ausdehnung wie die selektierten Punkte im Eingablayer haben.


Wir können den modellinternen Rechner verwenden und den Wert aus den Koordinaten der Ausdehnung berechnen. Um z.B. einen Layer mit einer festen Breite von 100 Pixeln zu erstellen können wir die folgenden Formel im Rechner verwenden.
17.21. Erstellung eines Modells mit modellinternen Werkzeugen
Wir müssen nun noch den Rasterungsalgorithmus anpassen, so dass er die Ausgabe des Rechners anstelle eines festen Wertes als Eingabe verwendet.

Der fertige Algorithmus sollte wie folgt aussehen:

**17.22 Interpolation**

*Bemerkung:* In diesem Kapitel lernen wir, wie man Punktdaten interpoliert. Wir werden auch ein weiteres reales Beispiel zur räumlichen Analyse kennenlernen.

In dieser Lektion werden wir Punktdaten interpolieren, um einen Rasterlayer zu erhalten. Bevor wir beginnen, müssen wir die Daten vorbereiten. Nach dem Interpolation werden wir den resultierenden Layer noch weiter verarbeiten, so dass sich eine vollständige Analyseroutine ergeben wird.

Öffnen Sie die Beispiel Daten für diese Lektion, die wie folgt aussehen sollten.

Der Datensatz enthält Daten zum Ernteertrag, so wie er von modernen Erntemaschinen erstellt wird. Wir werden aus diesen Daten einen Rasterlayer des Ernteertrages erstellen. Wir wollen keine weiteren Analysen mit diesem Layer ausführen. Er soll als Hintergrundlayer dienen, der die produktivsten Bereiche und die weniger produktiven Bereiche einfach kennzeichnet.


Verwenden Sie bei der ersten Ausführung die folgenden Parameter.

Übernehmen Sie bei der zweiten Ausführung die unten dargestellten Einstellungen.

Beachten Sie, dass wir als Eingabe nicht den Ausgangslayer sondern die Ausgabe des ersten Durchlaufs verwenden.
17.22. Interpolation
Kapitel 17. Der QGIS-Verarbeitungsleitfaden
Der Ergebnislayer sollte dem Ausgangslayer ähneln. Er enthält nur weniger Punkte. Wir können das anhand der Attributtabellen überprüfen.

Wir werden den Layer jetzt mit Hilfe des Algorithmus *Rasterize* rastern.

Der Layer *Filtered points* bezieht sich auf das Ergebnis des zweiten Filters. Er hat denselben Namen wie das Ergebnis des ersten Filters, da der Name vom Algorithmus vergeben wird. Sie sollten das erste Ergebnis nicht verwenden. Da wir den Layer nicht mehr benötigen, können wir das Ergebnis des ersten Filters aus dem Projekt löschen und nur das Ergebnis des zweiten Filters behalten. Wir vermeiden damit weitere Verwechslungen.

Der sich ergebene Rasterlayer sieht wie folgt aus.


Der Layer ohne Leerwerte sieht wie folgt aus.

Um die Fläche des Layers genau auf die Region der Messung der Erntemenge zu beschränken, können wir den Layer mit Hilfe des Layer limits zuschneiden.

Um eine geglättetes Ergebnis (weniger akkurat aber besser für die Darstellung als Hintergrundlayer geeignet) zu erhalten, können wir den *Gaussian filter* auf den Layer anwenden.

Bei Verwendung der oben aufgeführten Parameter erhalten wir das folgende Ergebnis.
17.23 Noch mehr Interpolation

Bemerkung: Dieses Kapitel behandelt ein weiteres praktisches Beispiel zur Nutzung von Algorithmen zur Interpolation.

Interpolation ist eine verbreitete Methode. Sie kann auch zur Demonstration verschiedener Techniken in Zusammenhang mit der QGIS Verarbeitungsanwendung verwendet werden. Diese Lektion zeigt einige schon bekannte Algorithmen zur Interpolation, verfolgt aber ein andere Herangehensweise.

Die Daten für diese Lektion enthalten auch Punktdaten, in diesem Fall Höhenwerte. Wir werden die Daten in ähnlicher Weise wie in der vorherigen Lektion interpolieren. Dieses Mal werden wir Teile der Ausgangsdaten speichern und zur Bewertung des Interpolationsprozesses verwenden.


Damit werden 90% der Punkte des Layer für die Rasterung ausgewählt

Die Auswahl ist zufällig, so dass Ihre Auswahl vermutlich von der hier gezeigten Auswahl abweicht.

Starten Sie nun den Algorithmus Rastern, um den ersten Rasterlayer zu erhalten. Füllen Sie anschließend die Leerwerte mit Hilfe des Algorithmus Close gaps [Cell resolution: 100 m].

Um die Qualität der Interpolation zu überprüfen, verwenden wir nun die nicht selektierten Punkte. An diesen Punkten
17.23. Noch mehr Interpolation
17.23. Noch mehr Interpolation
kennen wir die tatsächliche Geländehöhe (der Wert im Punktlayer) und die interpolierte Geländehöhe (der Wert im interpolierten Rasterlayer). Wir können die beiden durch Berechnung der Differenz der Werte vergleichen.

Da wir die nicht selektierten Punkte nutzen möchten, müssen wir als Erstes die Selektion umkehren.

Die Punkte enthalten die Ausgangswerte aber nicht die interpolierten. Um sie in einem neuen Feld hinzuzufügen, können wir den Algorithmus *Add Raster values to points* verwenden.

Der zu wähelnde Rasterlayer (der Algorithmus unterstützt mehrere Raster, wir benötigen nur eins) ist das Ergebnis der Interpolation. Wir haben den Layer in *interpolate* umbenannt. Dieser Layernamen wird auch als Name für das hinzugefügte Feld verwendet.

Wir haben nun einen Vektorlayer, der für Punkte die nicht für die Interpolation verwendet wurden, beide Werte enthält.

Wir werden für die nächste Aufgabe den Feldrechner verwenden. Öffnen Sie den Algorithmus *Feldrechner* und starten ihn mit den folgenden Parametern.

Wenn Ihr Feld mit den Werten aus dem Rasterlayer einen anderen Namen hat, müssen Sie die Formel entsprechend anpassen. Nach dem Ausführen des Algorithmus erhalten Sie einen Layer der nicht für die Interpolation verwendeten Punkte mit der Differenz zwischen den zwei Höhenwerten.

Die Darstellung des Layer entsprechend dieses Wertes gibt uns einen ersten Hinweis, wo die größten Abweichungen liegen.

Die Interpolation dieses Layers liefert einen Rasterlayer mit dem zu erwartenden Fehler für alle Punkte in der interpolierten Fläche.

Sie können dieselbe Information (Differenz zwischen den Ausgangspunktdaten und den interpolierten Werten) auch direkt über *GRASS v.sample* erhalten.

Ihre Resultate weichen unter Umständen von den hier ermittelten ab. Dies liegt an der Zufallskomponente, die wir mit der anfänglichen zufälligen Auswahl eingeführt hatten.
17.23. Noch mehr Interpolation
17.23. Noch mehr Interpolation
17.24 Die iterative Ausführung von Algorithmen

**Bemerkung:** Diese Lektion zeigt einen anderen Weg, Algorithmen für Vektorlayer wiederholt zu starten. Dabei wird über Objekte des Eingabevektorlayers iteriert.

Wir kennen schon die grafische Modellierung, die eine Möglichkeit der automatischen Aufgabenverarbeitung darstellt. In manchen Situationen ist die Verarbeitungsmodellierung aber nicht das richtige Werkzeug zur Automatisierung. Sehen wir uns so ein Beispiel näher an. Die Lösung ist in diesem Fall eine abweichende Funktionalität: die iterative Ausführung von Algorithmen.

Öffnen Sie die zu diesem Kapitel gehörenden Daten. Sie sollten in etwa wie folgt aussehen.

Wir erkennen unser wohlbekanntes DEM aus früheren Lektionen und einige daraus extrahierte Wasserscheiden. Stellen Sie sich vor, Sie müssen das DEM in mehrere kleinere Layer zerteilen, die jeweils das zu einer Wasserscheide gehörende Gebiet enthalten. Das ist nützlich, wenn man später für jedes Einzugsgebiet bestimmte Parameter wie z.B. die mittlere Höhe oder die hypsografische Kurve bestimmen möchte.

Das kann ein langwieriger und ermüdender Prozess sein, besonders wenn die Anzahl der Wasserscheiden hoch ist. Die Aufgabe kann aber einfach automatisiert werden, wie wir gleich sehen.

Der Algorithmus, der zum Zuschneiden eines Rasterlayers mit einem Polygonlayer verwendet wird, nennt sich *Clip raster with polygons*. Er beinhaltet den folgenden Parameter Dialog.

Wenn Sie ihn mit dem Layer der Wasserscheiden und dem DEM als Eingabe starten, erhalten Sie das folgende Ergebnis.

Wir sehen, dass die Fläche aller Polygone von Wasserscheiden für den Zuschmitt verwendet wird.

Man hätte auch das Polygon einer Wasserscheide auswählen und anschließend den Algorithmus zum Zuschneiden starten können.

Da nur gewählte Objekte verwendet werden, wird nur das ausgewählte Polygon zum Zuschneiden des Rasterlayers genutzt.
17.24. Die iterative Ausführung von Algorithmen

QGIS Training Manual

Clip grid with polygon

Parameters Log Help

Input
dem25 [EPSG:23030] ...

Polygons
watersheds [EPSG:23030] ...

Output
[Save to temporary file] ...

Open output file after running algorithm

Run Close Cancel

0%

Map of a geographical area with a polygon overlay, showing the result of a grid clipping algorithm.
Wenn man so für alle Polygone vorgeht, erhält man das gewünschte Ergebnis. Allerdings ist das kein sehr praktikables Vorgehen. Wir werden stattdessen sehen, wie man die select and crop Routine automatisiert.

Entfernen Sie als Erstes die vorherige Auswahl, so dass wieder alle Polygone genutzt werden. Öffnen Sie nun den Algorithmus Clip raster with polygon und wählen dieselben Eingabewerte wie vorher. Klicken Sie dann auf die Schaltfläche auf der rechten Seite des Eingabefeldes in dem der Vektorlayer ausgewählt wurde.

![Clip raster with polygon Dialogfenster](image)


Hier ist das Ergebnis, dass Sie erhalten wenn Sie den Algorithmus wie beschrieben ausführen.


Wenn Sie einen Ausgabedateinamen angeben, werden die ausgegebenen Dateien mit diesem Namen und einem Suffix für die jeweilige Iteration benannt.
17.25 Noch mehr iterative Ausführung von Algorithmen

**Bemerkung:** In dieser Lektion lernen wir, wie man die Ausführung mehrerer iterativer Algorithmen mit Hilfe der grafischen Modellierung kombiniert.


Die Daten, die wir in dieser Lektion verwenden sind dieselben wie in der letzten Lektion. Diesmal werden wir nicht nur das DEM auf die Einzugsgebiete zuschneiden, sondern zusätzlich für jedes Gebiet eine hypsografische Kurve erstellen und die Verteilung der Höhenwerte auswerten.

Da wir einen Arbeitsablauf mit mehreren Schritten verwenden (zuschneiden + berechnen der hypsografischen Kurve), öffnen wir die grafische Modellierung und erstellen ein Modell.

Sie finden das fertige Modell im Datenordner zu dieser Lektion. Es wäre aber gut, wenn Sie zuerst selbst versuchen, das Modell zu erstellen. Der zugeschnittene Layer ist hier kein endgültiges Ergebnis, da wir nur an den Kurven interessiert sind. Das Modell wir daher keine Layer erstellen sondern nur eine Tabelle mit den Daten der Kurven.

Das Modell sollte in etwa so aussehen:

Add the model to you models folder, so it is available in the toolbox, and execute it.

Select the DEM and watersheds basins.

The algorithm will generate tables for all the basins and place them in the output directory.

We can make this example more complex by extending the model and computing some slope statistics. Add the Slope algorithm to the model, and then the Raster statistics algorithm, which should use the slope output as its only input.

Wenn Sie das Modell nun starten, erhalten Sie außer den Tabellen einige Seiten mit Statistiken. Die Seiten sind in der Ergebnisanzeige verfügbar.
17.25. Noch mehr iterative Ausführung von Algorithmen
17.26 Die Schnittstelle zur Stapelverarbeitung

**Bemerkung:** In dieser Lektion lernen wir die Schnittstelle zur Stapelverarbeitung kennen. Mit ihrer Hilfe können wir einen einzelnen Algorithmus mit mehreren Eingabewerten starten.

Manchmal ist es erforderlich, einen Algorithmus mehrmals mit verschiedenen Eingaben auszuführen. Das ist z.B. der Fall, wenn mehrere Eingabedateien von einem Format in ein anderes konvertiert werden sollen oder wenn Dateien von einer Projektion in eine andere umgewandelt werden müssen.

In diesem Fall ist der wiederholte Aufruf des Algorithmus aus der Werkzeugkiste nicht der optimale Weg. Stattdessen kann man die Stapelverarbeitung verwenden, die die wiederholte Ausführung eines Algorithmus stark vereinfacht. Um einen Algorithmus aus der Werkzeugkiste im Rahmen der Stapelverarbeitung zu starten, klickt man nicht wie sonst doppelt auf den Algorithmus sonder mit der rechten Maustaste und wählt dann *Als Stapelprozess ausführen*....

In diesem Beispiel verwenden wir den Algorithmus *Reprojizieren*. Finden Sie ihn und gehen Sie dann wie beschrieben vor. Wir sehen nun den folgenden Dialog.

Wenn wir uns die Daten dieser Lektion ansehen, bemerken wir drei shape-Dateien aber keine QGIS Projektdatei. Wenn ein Algorithmus als Stapelprozess aufgerufen wird, können die Layer sowohl aus dem QGIS Projekt als auch aus einer Datei gewählt werden. Das macht es einfacher, eine große Anzahl an Layern zu verarbeiten, z.B. alle Layer unter einem bestimmten Dateipfad.

Die Definition des Stapelverarbeitungsprozesses besteht darin, die Tabelle auszufüllen. Der Dialog enthält dazu einige Hilfsmittel.


Als Voreinstellung werden 3 Zeilen angezeigt, genau so viele wie wir benötigen. Wenn Sie mehr Layer auswählen werden zusätzliche Zeilen angelegt. Wenn Sie die Einträge manuell füllen möchten, können Sie neue Zeilen mit Hilfe der Schaltfläche Zeile hinzufügen einfügen.


Nachdem Sie auf die OK Schaltfläche gedrückt haben, erscheint ein neues Fenster wie dieses.


In der letzten Spalte wird eingestellt, ob der Ergebnislayer im aktuellen QGIS Projekt geladen werden soll. Belassen Sie die Einstellung bei Ja, um die Ergebnisse anzuzeigen.
### Kapitel 17. Der QGIS-Verarbeitungsleitfaden

#### Bild 568: Batch Processing - Reproject layer

<table>
<thead>
<tr>
<th>Input layer</th>
<th>Target CRS</th>
<th>Reprojected layer</th>
<th>Load in QGIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>D:\batch_conversion\pt1.shp</td>
<td>EPSG:23030</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>D:\batch_conversion\pt2.shp</td>
<td>EPSG:23030</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>D:\batch_conversion\pt3.shp</td>
<td>EPSG:23030</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

#### Bild 568a: qgis-dev-bin

- **Autofill mode**: Do not autofill
- **Parameter to use**: Input layer

[OK] [Cancel]
Klicken Sie auf Starte, um die Stapelverarbeitung zu beginnen. Wenn alles klappt, werden alle Ihrer Layer verarbeitet und 3 neue Layer erstellt.

17.27 Modelle innerhalb der Stapelverarbeitung

**Warnung:** Achtung, dieses Kapitel wurde nicht weiter getestet. Bitte melden Sie auftretende Probleme. Es sind keine Bilder enthalten.

**Bemerkung:** Diese Lektion zeigt eine weiteres Beispiel für die Stapelverarbeitung. Dieses Mal wird ein Modell anstelle eines integrierten Algorithmus verwendet.

Modelle funktionieren genauso wie andere Algorithmen. Sie können innerhalb der Stapelverarbeitung verwendet werden. Um das zu demonstrieren, folgt ein kurzes Beispiel, das unser schon gut bekanntes hyrologisches Modell verwendet.

Stellen Sie sicher, dass das Modell in Ihrer Werkzeugkiste enthalten ist und starten es dann als Stapelprozess. Der Dialog der Stapelverarbeitung sollte wie folgt aussehen.

**Warnung:** todo: Bild einfügen

Fügen Sie weitere Zeilen ein, so dass insgesamt 5 Zeilen enthalten sind. Wählen Sie das zu dieser Lektion gehörende DEM als Eingabe für alle Zeilen. Geben Sie dann 5 verschiedene Schwellenwerte wie hier gezeigt ein.

**Warnung:** todo: Bild einfügen
Wie man sieht, kann die Stapelverarbeitung nicht nur mit demselben Prozess und verschiedenen Eingabedaten sondern auch mit denselben Daten aber verschiedenen Parametern gestartet werden.

Nach dem Bestätigen mit OK sollten wir 5 neue Layer mit Wasserscheiden entsprechend der 5 vergebenen Schwellenwerte erhalten.

### 17.28 Aktionsskripte vor oder nach Ausführung

Bemerkung: Diese Lektion zieht die Ausführung von Aktionsskripten die die Ausführung weiterer Operationen vor oder nach der Verarbeitung eines Algorithmus erlauben.

Aktionsskript sind Verarbeitungsskript die direkt vor oder nach einer Prozessierung laufen. Sie können verwendet werden, um Aufgaben die in Verbindung mit einem Algorithmus abgearbeitet werden, zu automatisieren.


Hier ist ein Beispiel eines Aktionsskriptes, das nachfolgend ausgeführt wird. In der Voreinstellung wird bei der Verarbeitung nur temporär gespeichert. Dieses Skript kopiert die Ausgaben in ein bestimmtes Verzeichnis, so dass die Dateien beim Beenden von QGIS nicht verlorengehen.

```python
import os
import shutil
from processing.core.outputs import OutputVector, OutputRaster, OutputFile

MY_DIRECTORY = '/home/alex/outputs'

for output in alg.outputs:
    if isinstance(output, (OutputVector, OutputRaster, OutputFile)):
        dirname = os.path.split(output.value)[0]
        shutil.copytree(dirname, MY_DIRECTORY)
```

In den ersten beiden Zeilen werden die benötigten Python Pakete importiert: os — für den Umgang mit Dateipfaden, wie z.B. die Gewinnung eines Dateinamens und shutil — für verschiedene Dateioperationen wie z.B. das Kopieren von Dateien. In der dritten Zeile importieren wir die Verarbeitungsausgaben. Was das bedeutet wird später in dieser Lektion erklärt.

Als Nächstes definieren die Konstante MY_DIRECTORY. Dabei handelt es sich um den Pfad zum Verzeichnis, in das wir die Ergebnisse unserer Analyse ablegen möchten.


To activate this hook we need to open the Processing options, find the entry named *Post-execution script file* in the *General* group, and specify the filename of the hook script there: the specified hook will be executed after each Processing algorithm.

Auf ähnliche Weise können wir Aktionsskripte implementieren, die vor der Ausführung eines Algorithmus gestartet werden. Lassen Sie uns als Beispiel ein Aktionsskript erstellen, das Eingabevectorlayer auf Geometriefehler prüft.

```python
from qgis.core import QgsGeometry, QgsFeatureRequest
from processing.core.parameters import ParameterVector

for param in alg.parameters:
    if isinstance(param, ParameterVector):
```

(Fortsetzung auf der nächsten Seite)
layer = processing.getObject(param.value)
for f in layer.getFeatures(QgsFeatureRequest().setSubsetOfAttributes([])):
    errors = f.geometry().validateGeometry()
    if len(errors) > 0:
        progress.setInfo('One of the input vectors contains invalid geometries!')

Wie im vorherigen Beispiel werden zuerst die benötigten QGIS- und Prozessierungspakete importiert.

To activate this hook we need enter its filename in the Pre-execution script file option in the Processing configuration dialog. The hook will be executed before running any Processing algorithm.

17.29 Andere Programme

Module contributed by Paolo Cavallini - Faunalia

**Bemerkung:** Dieses Kapitel zeigt wie man zusätzliche Programme innerhalb der Verarbeitungsumgebung verwenden kann. Die für dieses Kapitel relevanten Pakete müssen vorher mit Hilfe des verwendeten Betriebssystems installiert worden sein.

17.29.1 GRASS

GRASS ist eine frei verfügbare Open Source GIS Anwendung für Datenmanagement, Analyse, Bildverarbeitung, Bild- und Kartenerstellung, räumliche Modellierung und Visualisierung.

Unter Windows wir die Anwendung mit Hilfe des OSGeo4W Installationsprogrammes (32 und 64 bit) in der Vor-einstellung installiert. Für Linux ist das Programm für alle bedeutenden Distributionen paketiert.

17.29.2 R

R ist eine freie Open Source Anwendung für statistische Berechnungen und Grafiken.

Es muss separat zusammen mit einigen erforderlichen Bibliotheken (LIST) installiert werden. Um R in QGIS nutzen zu können, muss zusätzlich die Erweiterung Processing R Provider installiert sein.

Das schöne an der Umsetzung der Verarbeitungsumgebung ist, dass Sie eigene Skripte - einfache oder komplizierte - in die Umgebung eingeben können. Sie können dann wie jedes andere Modul, z.B. innerhalb komplexer Arbeitsabläufe, genutzt werden.

Testen Sie einige der vorinstallierten Beispiele, wenn Sie R schon installiert haben (denken Sie daran die R Module in den Verarbeitungseinstellungen zu aktivieren).
17.29.3 Andere

Die für mehrere Betriebssystem verfügbaren LASTools sind eine Zusammenstellung verschiedener Programme zur Verarbeitung und Analyse von LiDAR Daten.

Weitere Werkzeuge sind als Erweiterung verfügbar, z.B.:

- **LecoS**: eine Umgebung für Landbedeckungsstatistik und Lanschaftsökologie
- **lwgeom**: die früher zu PostGIS gehörende Bibliothek enthält einige nützliche Werkzeuge zur Geometriebereinigung
- **Animove**: Werkzeuge zur Analyse des Lebensraumes von Tieren.

Weitere werden folgen.

17.29.4 Comparison among backends

Buffers and distances

Let’s load `points.shp` and type `buf` in the filter of the Toolbox, then double click on:

- **Fixed distance buffer**: Distance 10000
- **Variable distance buffer**: Distance field `SIZE`
- **v.buffer.distance**: distance 10000
- **v.buffer.column**: bufcolumn `SIZE`
- **Shapes Buffer**: fixed value 10000 (dissolve and not), attribute field (with scaling)

See how speed is quite different, and different options are available.

**Exercise for the reader**: find the differences in geometry output between different methods.

Now, raster buffers and distances:

- first, load and rasterize the vector `rivers.shp` with GRASS `v.to.rast.value`; **beware**: cell size must be set to 100 m, otherwise the computation time will be enormous; resulting map will have 1 and NULLs
- same, with SAGA `Shapes to Grid COUNT` (resulting map: 6 to 60)
- then, `proximity` (value= 1 for GRASS, a list of rivers ID for SAGA), `r.buffer` with parameters 1000,2000,3000, `r.grow.distance` (the first of the two maps; the second will show the areas pertaining to each river, if done on the SAGA raster).

Dissolve

Dissolve features based on a common attribute:

- **GRASS v.dissolve municipalities.shp on PROVINCIA**
- **QGIS Dissolve municipalities.shp on PROVINCIA**
- **OGR Dissolve municipalities.shp on PROVINCIA**
- **SAGA Polygon Dissolve municipalities.shp on PROVINCIA (NB: Keep inner boundaries must be unselected)**

**Bemerkung**: The last one is broken in SAGA <=2.10

**Exercise for the reader**: find the differences (geometry and attributes) between different methods.
17.30 Interpolation und Kontourlinienerzeugung

Module contributed by Paolo Cavallini - Faunalia

Bemerkung: This chapter shows how to use different backends to calculate different interpolations.

17.30.1 Interpolation

The project shows a gradient in rainfall, from south to north. Let’s use different methods for interpolation, all based on vector points.shp, parameter RAIN:

Warnung: Set cell size to 500 for all analyses.

- GRASS \(\text{v.surf.rst}\)
- SAGA \(\text{Multilevel B-Spline Interpolation}\)
- SAGA \(\text{Inverse Distance Weighted}\) [Inverse distance to a power; Power: 4; Search radius: Global; Search range: all points]
- GDAL \(\text{Grid (Inverse Distance to a power)}\) [Power: 4]
- GDAL \(\text{Grid (Moving average)}\) [Radius1&2: 50000]

Then measure variation among methods and correlate it with distance to points:

- GRASS \(\text{r.series}\) [Unselect Propagate NULLs, Aggregate operation: stddev]
- GRASS \(\text{v.to.rast.value}\) on points.shp
- GDAL \(\text{Proximity}\)
- GRASS \(\text{r.covar}\) to show the correlation matrix; check the significance of the correlation e.g. with http://vassarstats.net/rsig.html.

Thus, areas far from points will have less accurate interpolation.

17.30.2 Contour

Various methods to draw contour lines [always step= 10] on the stddev raster:

- GRASS \(\text{r.contour.step}\)
- GDAL \(\text{Contour}\)
- SAGA \(\text{Contour lines from grid}\) [NB: in some older SAGA versions, output shp is not valid, known bug]

17.31 Vektorvereinfachung und Glättung

Module contributed by Paolo Cavallini - Faunalia

Bemerkung: This chapter shows how simplify vectors, and smooth out sharp corners.

Sometimes we need a simplified version of a vector, to have a smaller file size and get rid of unnecessary details. Many tools do this in a very rough way, and miss the adjacency and sometimes the topological correctness of polygons. GRASS is the ideal tool for this: being a topological GIS, adjacency and correctness are preserved even at very high
simplification levels. In our case, we have a vector resulting from a raster, thus showing a „saw“ pattern at borders. Applying a simplification results in straight lines:

- **GRASS v.generalize** [Maximal tolerance value: 30 m]

We can also do the reverse, and make a layer more complex, smoothing out sharp corners:

- **GRASS v.generalize** [method: chaiken]

Try to apply this second command both to original vector and to the one from the first analysis, and see the difference. Note that adjacency is not lost.

This second option can be applied e.g. to contour lines resulting from a coarse raster, to GPS tracks with sparse vertices, etc.

### 17.32 Planung eines Solarparks

Module contributed by Paolo Cavallini - [Faunalia](#)

**Bemerkung:** This chapter shows how to use several criteria to locate the areas suitable for installing a photovoltaic power station

First of all, create an aspect map from DTM:

- **GRASS r.aspect** [Data type: int; cell size:100]

In GRASS, aspect is calculated in degrees, counterclockwise starting from East. To extract only South facing slopes (270 degrees + 45), we can reclassify it:

- **GRASS r.reclass**

with the following rules:

```
225 thru 315 = 1 south
* = NULL
```

You can use the text file `reclass_south.txt` provided. Note that with these simple text files we can create also very complex reclassifications.

We want to build a large farm, so we select only large (> 100 ha) contiguous areas:

- **GRASS r.reclass.greater**

Finally, we convert to a vector:

- **GRASS r.to.vect** [Feature type: area; Smooth corners: yes]

**Exercise for the reader:** repeat the analysis, replacing GRASS commands with analogous from other programs.

### 17.33 Nutzung von R-Skripten in der Prozessierung

Modul erstellt von Matteo Ghetta - finanziert von der [Scuola Superiore Sant’Anna](#)

Die Verarbeitungsumgebung (mit der Erweiterung Processing R Provider) macht das Schreiben und Ausführen von R Skripten innerhalb von QGIS möglich.

**Warnung:** R muss auf Ihrem Rechner installiert und die PATH-Variable korrekt gesetzt sein. Die Verarbeitungsumgebung ruft die externen R Packete nur auf. Sie kann sie nicht selbst installieren. Stellen Sie daher sicher, dass die externen Pakete direkt in R installiert werden. Im Benutzerhandbuch Kapitel findet man dazu weitere Informationen.
17.33.1 Hinzufügen von Skripten


Bemerkung: Wenn Sie R nicht in der Verarbeitungsumgebung finden, müssen Sie es unter Optionen Verarbeitung Datenanbieter aktivieren.

Es öffnet sich ein Fenster R Script Editor. Hier müssen einige Parameter definiert werden, bevor das Skript an sich erstellt werden kann.
17.33.2 Erstellung von Plots

In dieser Anleitung erstellen wir einen Box-Plot für ein Feld eines Vektorlayers.

Öffnen das QGIS Projekt r_intro.qgs im Ordner exercise_data/processing/r_intro/.

Skript Parameter

Öffnen Sie den Editor und beginnen mit dem Schreiben am Anfang.

Sie müssen einige Parameter vor dem Hauptteil des Skripts festlegen:

1. Der Name der Gruppe (plots in diesem Fall) in der Sie Ihr Skript stellen wollen (wenn die Gruppe nicht existiert, wird sie erstellt):

```
##plots=group
```

Sie finden Ihr Skript in der plots R Gruppe in den Verarbeitungswerkzeugen.

2. Sie müssen der Verarbeitung mitteilen, dass Sie ein Plot (in diesem Beispiel) darstellen möchten:

```
##showplots
```

Sie erhalten dann in der Ergebnisanzeige einen Link zum Plot (das kann unter Ansicht Bedienfelder und mit Verarbeitung Ergebnisanzeige ein- oder ausgeschaltet werden).

3. Sie müssen der Verarbeitung auch die Eingabedaten vorgeben. In diesem Beispiel wollen wir ein Plot für ein Feld eines Vektorlayers erstellen:

```
##Layer=vector
```

Die Verarbeitung weiß nun, dass die Eingabe eine Vektordatei ist. Der Name Layer ist nicht wichtig, entscheidend ist der Parameter vector.


```
##X=Field Layer
```

Die Verarbeitung weiß nun, dass Sie ein Feld Layer benötigen und es X nennen.

5. Man kann den Namen des Skriptes auch mit Hilfe von name definieren:

```
##My box plot script=name
```

Wenn nichts vorgegeben ist, wird der Dateiname als Name des Skriptes verwendet.

Skript Hauptteil

Nachdem wir den Kopf des Skriptes festgelegt haben, können wir die Funktionalität hinzufügen:

```
boxplot(Layer[[X]])
```

boxplot ist der Name der R Funktion. Der Parameter Layer ist der Name, den wir für den Eingabedatensatz vorgegeben haben. X ist der vorgegebene Name des Feldes im Datensatz.

**Warnung:** Der Parameter X muss innerhalb doppelter eckiger Klammern stehen ([ [ ] ]).

Das fertige Skript sollte wie folgt aussehen:
Speichern Sie das Skript im voreingestellten Pfad entsprechend des Vorschlags der Verarbeitung (processing/rscripts). Wenn Sie `name` im Kopf des Skriptes nicht definiert haben, wird das Skript in der Verarbeitungsumgebung mit dem Dateinamen bezeichnet.

**Bemerkung:** Sie können das Skript an einem beliebigen Ort speichern. Die Verarbeitung übernimmt das Skript dann nicht automatisch in die Verarbeitungsumgebung und es muss manuell hinzugefügt werden.

Starten Sie jetzt das Skript durch Drücken auf die ausführen Schaltfläche im Editorfenster:

Nutzen Sie nach dem Schließen des Editorfensters dieTextbox der Verarbeitung, um Ihr Skript zu finden:

Sie können nun die erforderlichen Parameter im Fenster des Verarbeitungsalgorithmus eintragen:

- wählen Sie `sample_points` als **Layer**
- wählen Sie `value` als X Feld

Klicken Sie auf **Starte**.

Die **Ergebnisanzeige** sollte sich automatisch öffnen. Falls das nicht geschieht, klicken Sie auf **Verarbeitung Ergeb-nisanzeige**.

Wenn Sie auf den Link in der Ergebnisanzeige klicken, sehen Sie das Folgende:
17.33. Nutzung von R-Skripten in der Prozessierung
**17.33.3 Erstellen eines Vektorlayers**

Sie können außerdem einen Vektorlayer erstellen und ihn automatisch in QGIS laden.

The following example has been taken from the Random sampling grid script that can be found in the online collection of R scripts (the scripts in this online collection can be found in https://github.com/qgis/QGIS-Processing/tree/master/rscripts).

Das Ziel dieser Übung ist die Erstellung eines zufälligen Punktlayers mit Hilfe der `spsample` Funktion aus dem `sp` Paket. Dabei soll die Ausdehnung über einen Eingabevektorlayer begrenzt werden.

**Skript Parameter**

Wie vorhin müssen wir zuerst einige Parameter oberhalb des Hauptteiles des Skriptes vorgeben:

1. Geben Sie den Namen der Gruppe vor, in die das Skript soll. In diesem Fall ist das *Point pattern analysis*:

   ```
   ##Point pattern analysis=group
   ```

2. Define an input parameter (a vector layer) that will constrain the placement of the random points:

   ```
   ##Layer=vector
   ```

3. Geben Sie einen Eingabeparameter für die Anzahl der zu erzeugenden Punkte vor (`Size`, der Vorgabewert ist 10):

   ```
   ##Size=number 10
   ```

   **Bemerkung:** Da ein Vorgabewert (10) vorhanden ist, kann der Nutzer den Parameter so belassen oder einen eigenen Wert eingeben.

4. Geben Sie vor, dass ein Ausgabevektorlayer erzeugt wird (bezeichnet mit `Output`):

   ```
   ##Output=output vector
   ```

**Skript Hauptteil**

Sie können jetzt den Hauptteil der Funktion hinzufügen:

1. Verwenden Sie die Funktion `spsample`:

   ```
   pts=spsample(Layer, Size, type="random")
   ```

   Die Funktion verwendet den `Layer`, um die Platzierung der Punkte zu beschränken (wenn der Layer eine Linie ist, müssen die Punkte auf der Linie liegen; wenn es ein Polygon ist, müssen die Punkte innerhalb des Polygons liegen). Die Anzahl der Punkte entspricht der Vorgabe im Parameter `Size`. Das Stichprobenverfahren ist `random`.

2. Erstellen Sie die Ausgabe (der Parameter `Output`):

   ```
   Output=SpatialPointsDataFrame(pts, as.data.frame(pts))
   ```

Das fertige Skript sollte wie folgt aussehen:
Speichern Sie es und klicken Sie auf die Schaltfläche zum Starten.

Geben Sie in dem neu geöffneten Fenster die richtigen Parameter ein:

```
#Point pattern analysis=group
#Layer=vector
#Size=number 10
#Output=output vector
pts=spsample(Layer, Size, type="random")
Output=SpatialPointsDataFrame(pts, as.data.frame(pts))
```

und klicken Sie auf Starte.
Der Ergebnislayer wird im Inhaltsverzeichnis eingefügt und die Punkte werden im Kartenfenster angezeigt:

17.33.4 Textausgabe und grafische Ausgabe mit der R - Syntax

Die Verarbeitung (mit dem Processing R Provider plugin) nutzt eine spezielle Syntax, um die Ergebnisse aus R zu erhalten:

- > vor einem Kommando, wie in >lillie.test(Layer[[Field]]) bedeutet, dass das Ergebnis an die R Ausgabe gesendet wird (Ergebnisanzeige)
- + nach einem Plot erlaubt sich überlagernde Plots. Zum Beispiel plot(Layer[[X]], Layer[[Y]]) + abline(h=mean(Layer[[X]]))

17.34 Predicting landslides

Module contributed by Paolo Cavallini - Faunalia

**Bemerkung:** This chapter shows how to create an oversimplified model to predict the probability of landslides.

First, we calculate slope (choose among various backends; the interested reader can calculate the difference between the outputs):

- GRASS r.slope
- SAGA Slope, Aspect, Curvature
- GDAL Slope

Then we create a model of predicted rainfall, based on the interpolation of rainfall values at meteo stations:

- GRASS v.surf.rst (resolution: 500 m)

The probability of a landslide will be very roughly related to both rainfall and slope (of course a real model will use more layers, and appropriate parameters), let’s say (rainfall * slope )/100:

- SAGA Raster calculator rain, slope: (a*b)/100 (or: GRASS r.mapcalc)
then let’s calculate what are the municipalities with the greatest predicted risk of rainfall: SAGA Raster statistics with polygons (the parameters of interest are Maximum and Mean)
Module: Räumliche Datenbanken in QGIS nutzen

In diesem Modul lernen Sie, wie Sie räumliche Datenbanken mit QGIS verwenden, um Daten in der Datenbank zu verwalten, anzuzeigen und zu manipulieren sowie Analysen durch Abfragen durchzuführen. Wir werden in erster Linie PostgreSQL und PostGIS verwenden (die in den vorherigen Abschnitten behandelt wurden), aber die gleichen Konzepte sind auch auf andere räumliche Datenbankimplementierungen einschließlich SpatialLite anwendbar.

18.1 Lesson: Arbeit mit Datenbanken im QGIS Browser


Ziel dieser Lektion: Erlernen des Umgangs mit räumlichen Datenbanken unter Nutzung des QGIS Browsers.

18.1.1 Follow Along: Datenbanktabellen mit Hilfe des Browsers zu QGIS hinzufügen

Wir haben schon behandelt, wie man Tabellen aus einer Datenbank als QGIS Layer hinzufügt. Wir gehen jetzt detaillierter darauf ein und werden noch andere Wege kennenlernen, wie man das in QGIS erledigen kann. Sehen wir uns zuerst die neue Browserschnittstelle an.

- Erstellen Sie einen neue leere Karte in QGIS.
- Öffnen Sie den Browser durch Klick auf den Reiter Browser unten im Layer Bedienfeld
- Öffnen Sie den PostGIS Bereich im Baum des Browsers. Hier sollte Ihre vorher konfigurierte Verbindung verfügbar sein (Sie müssen unter Umständen auf die Aktualisieren Schaltfläche oben im Browserfenster drücken).
- Ein Doppellklick auf eine beliebige Tabelle oder Layer fügt ihn in den Kartenbereich ein.
Kapitel 18. Module: Räumliche Datenbanken in QGIS nutzen
18.1.2 Follow Along: Hinzufügen einer gefilterten Liste von Datensätzen als Layer


- Erstellen Sie eine neue Karte ohne Layer
- Klicken Sie auf die Schaltfläche Add PostGIS Layers oder wählen Layer µ Add PostGIS Layers aus dem Menü.
- Verbinden Sie sich im Dialog Add PostGIS Table(s) mit der postgis_demo Verbindung.
- Durch Erweitern von public schema sollten Sie drei Tabellen finden, mit denen wir schon vorher gearbeitet hatten.
- Klicken sie auf den Layer lines, um ihn auszuwählen. Führen Sie einen Doppelklick auf den Layer aus sondern klicken auf die Schaltfläche Set Filter um den Query Builder Dialog zu öffnen.
- Erstellen Sie den folgenden Ausdruck mit Hilfe der Schaltflächen oder durch direkte Eingabe:

```
"roadtype" = 'major'
```
- Klicken Sie auf OK um die Bearbeitung des Filters abzuschließen. Klicken sie auf Add um den gefilterten Layer in die Karte einzufügen.
- Benennen Sie den Layer lines in roads_primary um.

Wir sehen, dass nur die Hauptstraßen anstelle des kompletten Layers in unsere Karte übernommen wurden.

18.1.3 In Conclusion

Wir haben gesehen, wie man den QGIS Browser zum Umgang mit räumlichen Datenbanken verwendet und wie man mit einem Abfragefilter versehene Layer in die Karte einfügt.

18.1.4 What’s Next?

Als nächstes sehen wir, wie man mit der DB-Verwaltung in QGIS umfangreichere Aufgaben zur Datenbankverwaltung erledigen kann.

18.2 Lesson: Verwendung der DB-Verwaltung zur Arbeit mit räumlichen Datenbanken in QGIS


**Ziel dieser Lektion:** Zu erlernen, wie mit Hilfe der QGIS DB-Verwaltung mit räumlichen Datenbanken interagiert.
Kapitel 18. Module: Räumliche Datenbanken in QGIS nutzen

Eine Query Builder-Fenster mit den Feldern `id_0`, `id`, `roadtype`, sowie den Werten `major`, `minor`, `NULL`. Der operator `roadtype” = 'major'` wird angezeigt.
18.2.1  Follow Along: Managen von PostGIS Datenbanken mit der DB-Verwaltung

Öffnen Sie als Erstes die DB-Verwaltung durch Auswahl von Datenbank -> DB-Verwaltung im Menü durch Auswahl der Schaltfläche DB-Verwaltung in der Werkzeugleiste.

You should already see the previous connections we have configured and be able to expand the myFG section and its public schema to see the tables we have worked with in previous sections.

Als Erstes fällt uns vielleicht auf, dass einige Metadaten über die in der Datenbank enthaltenen Schemas angezeigt werden.


Als Erstes ist es nützlich, sich die Metadaten einer Tabelle anzusehen. Man klickt dazu im Baum auf den Namen der Tabelle und schaut sich den Info Reiter an.

In diesem Bedienfeld sehen wie die Allgemeinen Informationen über die Tabelle als auch die Informationen über die Geometrie und das räumliche Bezugsystem, die von der PostGIS Erweiterung bereitgestellt werden.

Wenn man im Info Reiter weiter nach unten scrollt, sieht man weitere Informationen zu Felder, Constraints und Indexes bezüglich der aktuellen Tabelle.
Kapitel 18. Module: Räumliche Datenbanken in QGIS nutzen
Der DB-Manager ist außerdem sehr nützlich, um sich Datensätze anzusehen - ähnlich der Attributtabelle eines Layers im Layerbaum. Sie können die Daten im Reiter Tabelle durchsehen.

Ergibt auch einen Vorschau Reiter, der die Layerdaten als Kartenvorschau zeigt.

Mit Rechtsklick auf den Layer im Baum und Klick auf Zur Karte hinzufügen wird der Layer in Ihre Karte eingefügt.

Bis hierher haben wir nur die Datenbank, ihre Schemas, Tabellen und Metadaten angezeigt. Was ist nun, wenn man Tabellen ändern möchte und z.B. eine neue Spalte hinzufügen möchte? Die DB-Verwaltung erlaubt uns, dass direkt zu machen.

1. Wählen Sie die Tabelle, die sie bearbeiten möchten im Baum

2. Select Table Edit Table from the menu, to open the Table Properties dialog.

Sie können der Dialog verwenden, um Spalten oder Geometriespalten hinzuzufügen, vorhandene Spalten zu bearbeiten oder Spalten komplett zu entfernen.

Mit Hilfe des Reiters Restriktionen können Sie verwalten, welche Felder als Primärschlüssel verwendet werden oder um vorhandene Einschränkungen zu entfernen.

Im Reiter Indizes können normale oder räumliche Indizes hinzugefügt oder gelöscht werden.
Kapitel 18. Module: Räumliche Datenbanken in QGIS nutzen

![Table properties](image1)

Table columns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Null</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>id_0</td>
<td>int4</td>
<td>True</td>
<td>nextval('lines_id_0_seq')::regclass</td>
</tr>
<tr>
<td>geom</td>
<td>geometry (MultiLineString, 32733)</td>
<td>True</td>
<td></td>
</tr>
<tr>
<td>id</td>
<td>int4</td>
<td>True</td>
<td></td>
</tr>
<tr>
<td>roadtype</td>
<td>varchar (5)</td>
<td>True</td>
<td></td>
</tr>
</tbody>
</table>

![Table properties](image2)

Primary, foreign keys, unique and check constraints:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Column(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>lines_pkey</td>
<td>Primary key</td>
<td>id_0</td>
</tr>
</tbody>
</table>
 Folgeanleitung: Erstellen einer neuen Tabelle

Nachdem wir den Prozess zur Arbeit mit vorhandenen Tabellen durchgegangen sind, nutzen wir die DB-Verwaltung jetzt zur Erstellung einer neuen Tabelle.

1. If it is not already open, open the DB Manager window, and expand the tree until you see the list of tables already in your database.
2. Wählen Sie Tabelle –> Tabelle erzeugen um den Dialog zu öffnen.
3. Use the default Public schema and name the table places.
4. Add the id, place_name, and elevation fields as shown below
5. Make sure the id field is set as the primary key.
6. Click the checkbox to Create geometry column and make sure it is set to a POINT type and leave it named geom and specify 4326 as the SRID.
7. Setzen Sie den Haken bei Räumlichen Index erzeugen und klicken dann auf Erzeugen, um die Tabelle zu erstellen.
8. Dismiss the dialog letting you know that the table was created and click Close to close the Create Table Dialog.

You can now inspect your table in the DB Manager and you will of course find that there is no data in it. From here you can Toggle Editing on the layer menu and begin to add places to your table.

18.2. Lesson: Verwendung der DB-Verwaltung zur Arbeit mit räumlichen Datenbanken in QGIS
Kapitel 18. Module: Räumliche Datenbanken in QGIS nutzen
18.2.3 Follow Along: Einfache Datenbankadministration

The DB Manager will also let you do some basic database administration tasks. It is certainly not a substitute for a more complete database administration tool, but it does provide some functionality that you can use to maintain your database.


Let us take a look at how we can perform a VACUUM ANALYZE command from within DB Manager.

1. Select one of your tables in the DB Manager Tree
2. Select Table [Run Vacuum Analyze] from the menu

PostgreSQL will now perform the operation. Depending on how big your table is, this may take some time to complete.

Weitere Informationen zum Prozess VACUUM ANALYZE finden Sie unter PostgreSQL Documentation on VACUUM ANALYZE.

18.2.4 Follow Along: Executing SQL Queries with DB Manager

DB Manager also provides a way for you to write queries against your database tables and to view the results. We have already seen this type of functionality in the Browser panel, but let’s look at it again here with DB Manager.

1. Select the lines table in the tree.
2. Select the SQL window button in the DB Manager toolbar.

3. Compose the following SQL query in the space provided:

   \[
   \text{SELECT * FROM lines WHERE roadtype = 'major';}
   \]

4. Click the Execute (F5) button to run the query.
5. You should now see the records that match in the Result panel.
6. Click the checkbox for Load as new layer to add the results to your map.
7. Select the id column as the Column with unique integer values and the geom column as the Geometry column.
8. Enter roads_primary as the Layer name (prefix).
9. Click Load now! to load the results as a new layer into your map.

The layers that matched your query are now displayed on your map. You can of course use this query tool to execute any arbitrary SQL command including many of the ones we looked at in previous modules and sections.
18.2.5 Importing Data into a Database with DB Manager

We have already looked at how to import data into a spatial database using command line tools, so now let’s learn how to use DB Manager to do imports.

1. Click the *Import layer/file* button on the toolbar in the DB Manager dialog.
2. Select the *urban_33S.shp* file from *exercise_data/projected_data* as the input dataset.
3. Click the *Update Options* button to pre-fill some of the form values.
4. Make sure that the *Create new table* option is selected.
5. Specify the *Source SRID* as 32722 and the *Target SRID* as 4326.
6. Enable the checkbox to *Create Spatial Index*.
7. Click *OK* to perform the import.
8. Dismiss the dialog letting you know that the import was successful.
9. Click the *Refresh* button on the DB Manager Toolbar.

You can now inspect the table in your database by clicking on it in the Tree. Verify that the data has been reprojected by checking that the *Spatial ref:* is listed as *WGS 84 (4326)*.

Right clicking on the table in the Tree and selecting *Add to Canvas* will add the table as a layer in your map.
18.2. Lesson: Verwendung der DB-Verwaltung zur Arbeit mit räumlichen Datenbanken in QGIS
Kapitel 18. Module: Räumliche Datenbanken in QGIS nutzen

Import vector layer

Input: `xl/exercise_data/projected_data/urban_33S.shp`

Output table

Schema: `public`
Table: `urban_33S`

Action

- Create new table
- Drop existing one
- Append data to table

Options

- Primary key
- Geometry column
- Source SRID: 32722
- Target SRID: 4326
- Encoding: UTF-8
- Create single-part geometries instead of multi-part
- Create spatial index

Cancel  OK
18.2.6 Exporting Data from a Database with DB Manager

Of course DB Manager can also be used to export data from your spatial databases, so let's take a look at how that is done.

1. Select the lines layer in the Tree and click the Export to File button on the toolbar to open the Export to vector file dialog.

2. Click the … button to select the Output file and save the data to your exercise_data directory as urban_4326.

3. Set the Target SRID as 4326.

4. Click OK to initialize the export.

5. Dismiss the dialog letting you know the export was successful and close the DB Manager.

You can now inspect the shapefile you created with the Browser panel.

18.2.7 In Conclusion

You have now seen how to use the DB Manager interface in QGIS to manage your spatial databases, to execute SQL queries against your data and how to import and export data.
Kapitel 18. Module: Räumliche Datenbanken in QGIS nutzen
18.2.8 What’s Next?

Next, we will look at how to use many of these same techniques with SpatiaLite databases.

18.3 Lesson: Working with SpatiaLite databases in QGIS

While PostGIS is generally used on a server to provide spatial database capabilities to multiple users at the same time, QGIS also supports the use of a file format called SpatiaLite that is a lightweight, portable way to store an entire spatial database in a single file. Obviously, these 2 types of spatial databases should be used for different purposes, but the same basic principles and techniques apply to both. Let’s create a new SpatiaLite database and explore the functionality provided to work with these databases in QGIS.

The goal for this lesson: To learn how to interact with SpatiaLite databases using the QGIS Browser interface.

18.3.1 Follow Along: Creating a SpatiaLite database with the Browser

Using the Browser panel, we can create a new SpatiaLite database and get it setup for use in QGIS.

1. Right click on the SpatiaLite entry in the Browser tree and select Create Database.
2. Specify where on your filesystem you want to store the file and name it qgis-sl.db.
3. Again right click on the SpatiaLite entry in the Browser tree and now select the New Connection item. Find the file you created in the last step and open it.

Now that you have configured your new database you will find that the entry in Browser tree has nothing underneath it and the only thing you can do at this point is to delete the connection. This is of course because we haven’t added any tables to this database. Let’s go ahead and do that.

1. Find the button to create a new layer and use the dropdown to create a new SpatiaLite layer, or select Layer ➢ New ➢ New SpatiaLite Layer.
2. Select the database we created in the previous steps in the drop down.
3. Give the layer the name places.
4. Tick the checkbox next to Create an auto-incrementing primary key.
5. Add two attributes as shown in below
6. Click OK to create the table.
7. Click the refresh button at the top of the Browser and you should now see your places table listed.

You can right click on the table and view its properties as we did in the previous exercise.

From here you can start an editing session and start adding data to your new database directly.

We also learned about how to import data into a database using the DB Manager and you can use this same technique to import data into your new SpatiaLite DB.
QGIS Training Manual

Kapitel 18. Module: Räumliche Datenbanken in QGIS nutzen

[Image of a window showing the process of creating a new Spatialite Layer in QGIS, including the database path, layer name, geometry column, EPSG code, and attribute list.]
18.3. Lesson: Working with SpatiaLite databases in QGIS
18.3.2 In Conclusion

You have seen how to create SpatiaLite databases, add tables to them and use these tables as layers in QGIS.
Appendix: Contributing To This Manual

To add materials to this course, you must follow the guidelines in this Appendix. You are not to alter the conditions in this Appendix except for clarification. This is to ensure that the quality and consistency of this manual can be maintained.

19.1 Downloading Resources

The source of this document is available at GitHub. Consult GitHub.com for instructions on how to use the git version control system.

19.2 Manual Format

This manual is written using Sphinx, a Python document generator using the reStructuredText markup language. Instructions on how to use these tools are available on their respective sites.

19.3 Adding a Module

- To add a new module, first create a new directory (directly under the top-level of the qgis-training-manual directory) with the name of the new module.
- Under this new directory, create a file called index.rst. Leave this file blank for now.
- Open the index.rst file under the top-level directory. Its first lines are:

```
.. toctree::
:maxdepth: 2

foreword/index
introduction/index
```

You will note that this is a list of directory names, followed by the name index. This directs the top-level index file to the index files in each directory. The order in which they are listed determines the order they will have in the document.
• Add the name of your new module (i.e., the name you gave the new directory), followed by /index, to this list, wherever you want your module to appear.

• Remember to keep the order of the modules logical, such that later modules build on the knowledge presented in earlier modules.

• Open your new module’s own index file ([module name]/index.rst).

• Along the top of the page, write a line of 80 asterisks (*). This represents a module heading.

• Follow this with a line containing the markup phrase |MOD| (which stands for „module“), followed by the name of your module.

• End this off with another line of 80 asterisks.

• Leave a line open beneath this.

• Write a short paragraph explaining the purpose and content of the module.

• Leave one line open, then add the following text:

```ini
.. toctree::
:maxdepth: 2

lesson1
lesson2
```

... where lesson1, lesson2, etc., are the names of your planned lessons.

The module-level index file will look like this:

```
|MOD| Module Name

Short paragraph describing the module.

.. toctree::
:maxdepth: 2

lesson1
lesson2
```

### 19.4 Adding a Lesson

To add a lesson to a new or existing module:

• Open the module directory.

• Open the index.rst file (created above in the case of new modules).

• Ensure that the name of the planned lesson is listed underneath the toctree directive, as shown above.

• Create a new file under the module directory.

• Name this file exactly the same as the name you provided in the module’s index.rst file, and add the extension .rst.

**Bemerkung:** For editing purposes, a .rst file works exactly like a normal text file (.txt).

• To begin writing the lesson, write the markup phrase |LS|, followed by the lesson name.
• In the next line, write a line of 80 equal signs (=).
• Leave a line open after this.
• Write a short description of the lesson’s intended purpose.
• Include a general introduction to the subject matter. See the existing lessons in this manual for examples.
• Beneath this, start a new paragraph, beginning with this phrase:

**The goal for this lesson:**

• Briefly explain the intended outcome of completing this lesson.
• If you can’t describe the goal of the lesson in one or two sentences, consider breaking the subject matter up into multiple lessons.

Each lesson will be subdivided into multiple sections, which will be addressed next.

### 19.5 Adding a Section

There are two types of sections: „follow along“ and „try yourself“.

• A „follow along“ section is a detailed set of directions intended to teach the reader how to use a given aspect of QGIS. This is typically done by giving click-by-click directions as clearly as possible, interspersed with screenshots.

• A „try yourself“ section gives the reader a short assignment to try by themselves. It is usually associated with an entry in the answer sheet at the end of the documentation, which will show or explain how to complete the assignment, and will show the expected outcome if possible.

Every section comes with a difficulty level. An easy section is denoted by |basic|, moderate by |moderate|, and advanced by |hard|.

#### 19.5.1 Adding a „follow along“ section

• To start this section, write the markup phrase of the intended difficulty level (as shown above).
• Leave a space and then write |FA| (for „follow along“).
• Leave another space and write the name of the section (use only an initial capital letter, as well as capitals for proper nouns).
• In the next line, write a line of 80 minuses/dashes (–). Ensure that your text editor does not replace the default minus/dash character with a long dash or other character.
• Write a short introduction to the section, explaining its purpose. Then give detailed (click-by-click) instructions on the procedure to be demonstrated.
• In each section, include internal links, external links and screenshots as needed.
• Try to end each section with a short paragraph that concludes it and leads naturally to the next section, if possible.
19.5.2 Adding a „try yourself“ section

- To start this section, write the markup phrase of the intended difficulty level (as shown above).
- Leave a space and then write \|TY\| (for „try yourself“).
- In the next line, write a line of 80 minuses/dashes (-). Ensure that your text editor does not replace the default minus/dash character with a long dash or other character.
- Explain the exercise that you want the reader to complete. Refer to previous sections, lessons or modules if necessary.
- Include screenshots to clarify the requirements if a plain textual description is not clear.

In most cases, you will want to provide an answer regarding how to complete the assignment given in this section. To do so, you will need to add an entry in the answer sheet.

- First, decide on a unique name for the answer. Ideally, this name will include the name of the lesson and an incrementing number.
- Create a link for this answer:
  
  :ref:`Check your results <answer-name>`

- Open the answer sheet (answers/answers.rst).
- Create a link to the „try yourself“ section by writing this line:

  .. _answer-name:

- Write the instructions on how to complete the assignment, using links and images where needed.
- To end it off, include a link back to the „try yourself“ section by writing this line:

  :ref:`Back to text <backlink-answer-name>`

- To make this link work, add the following line above the heading to the „try yourself“ section:

  .. _backlink-answer-name:

Remember that each of these lines shown above must have a blank line above and below it, otherwise it could cause errors while creating the document.

19.6 Add a Conclusion

- To end a lesson, write the phrase \|IC\| for „in conclusion“, followed by a new line of 80 minuses/dashes (-).
  Write a conclusion for the lesson, explaining which concepts have been covered in the lesson.

19.7 Add a Further Reading Section

- This section is optional.
- Write the phrase \|FR\| for „further reading“, followed by a new line of 80 minuses/dashes (-).
- Include links to appropriate external websites.
19.8 Add a What’s Next Section

- Write the phrase |WN| for „what’s next“, followed by a new line of 80 minuses/dashes (—).
- Explain how this lesson has prepared students for the next lesson or module.
- Remember to change the „what’s next“ section of the previous lesson if necessary, so that it refers to your new lesson. This will be necessary if you have inserted a new lesson among existing lessons, or after an existing lesson.

19.9 Using Markup

To adhere to the standards of this document, you will need to add standard markup to your text.

19.9.1 New concepts

- If you are explaining a new concept, you will need to write the new concept’s name in italics by enclosing it in asterisks (*).

This sample text shows how to introduce a “new concept”.

19.9.2 Emphasis

- To emphasize a crucial term which is not a new concept, write the term in bold by enclosing it in double asterisks (**).
- Use this sparingly! If used too much, it can seem to the reader that you are shouting or being condescending.

This sample text shows how to use “emphasis” in a sentence. Include the punctuation mark if it is followed by a ”comma,“ or at the ”end of the sentence.”

19.9.3 Images

- When adding an image, save it to the folder _static/lesson_name/.
- Include it in the document like this:

```
.. figure:: img/image_file.extension
   :align: center
```

- Remember to leave a line open above and below the image markup.

19.9.4 Internal links

- To create an anchor for a link, write the following line above the place where you want the link to point to:

```
.. _link-name:
```

- To create a link, add this line:

```
:ref:`Descriptive link text <link-name>`
```

- Remember to leave a line open above and below this line.
19.9.5 External links

- To create an external link, write it out like this:

```
`Descriptive link text <link-url>`
```

- Remember to leave a line open above and below this line.

19.9.6 Using monospaced text

- When you are writing text that the user needs to enter, a path name, or the name of a database element such as a table or column name, you must write it in monospaced text. For example:

```
Enter the following path in the text box: :kbd:`path/to/file`.
```

19.9.7 Labeling GUI items

- If you are referring to a GUI item, such as a button, you must write its name in the GUI label format. For example:

```
To access this tool, click on the :guilabel:`Tool Name` button.
```

- This also applies if you are mentioning the name of a tool without requiring the user to click a button.

19.9.8 Menu selections

- If you are guiding a user through menus, you must use the menu selection format. For example:

```
To use the :guilabel:`Tool Name` tool, go to :menuselection:`Plugins --> Tool Type --> Tool Name`.
```

19.9.9 Adding notes

- You might need to add a note in the text, which explains extra details that can’t easily be made part of the flow of the lesson. This is the markup:

```
[Normal paragraph.]
.. note:: Note text.
   New line within note.
   New paragraph within note.

[Unindented text resumes normal paragraph.]
```
19.9.10 Adding a sponsorship/authorship note

If you are writing a new module, lesson or section on behalf of a sponsor, you must include a short sponsor message of their choice. This must notify the reader of the name of the sponsor and must appear below the heading of the module, lesson or section that they sponsored. However, it may not be an advertisement for their company. 

If you have volunteered to write a module, lesson or section in your own capacity, and not on behalf of a sponsor, you may include an authorship note below the heading of the module, lesson or section that you authored. This must take the form This [module/lesson/section] contributed by [author name]. Do not add further text, contact details, etc. Such details are to be added in the „Contributors“ section of the Foreword, along with the name(s) of the part(s) you added. If you only made enhancements, corrections and/or additions, list yourself as an editor.

19.10 Thank You!

Thank you for contributing to this project! By so doing, you are making QGIS more accessible to users and adding value to the QGIS project as a whole.
KAPITEL 20

Vorbereitung der Übungsdaten


Jeder kann diese Datenbank ohne Schwierigkeiten verwenden, aber Sie mag es bevorzugen, Daten aus Ihrem Land oder Ihren Heimatort zu verwenden. Wenn Sie so machen, werden Ihre lokalen Daten in allen Lektionen von Modul 3 bis Modul 7.2 eingesetzt. Spätere Module verwenden komplexere Datensätze, die in Ihrem Bereich verfügbar sein oder nicht verfügbar sein können.

Bemerkung: Diese Anweisungen voraussetzen, dass Sie eine gute Kenntnis von QGIS haben und nicht als Unterrichtsmaterial gedacht sind.

20.1 Try Yourself Create OSM based vector Files

Wenn Sie die voreingestellte Datensammlung durch lokale Daten für Ihren Kurs ersetzen möchten, kann dies mit den in QGIS eingebauten Werkzeugen einfach ausgeführt werden. Die Region, die Sie verwenden möchten, sollte eine gute Mischung aus städtischen und ländlichen Gebieten enthalten, die von unterschiedlicher Bedeutung sind, mit Gebietsgrenzen (wie Naturreservaten oder Farmen) und Oberflächenwasser, wie Bäche und Flüsse.

1. Öffne ein neues QGIS-Projekt
2. Wählen Sie Layer ➤ Data Source Manager, um das Data Source Manager-Dialogfeld zu öffnen.
3. Im Browser-Tab, expandieren Sie das Drop-down-Menü für XYZ Tiles und doppelklicken Sie auf die OpenStreetMap-Einheit. Ein Karte des Weltansichts ist nun sichtbar auf dem Kartenbereich.
4. Schließen Sie das Data Source Manager-Dialogfeld
5. Bewegen Sie sich ins Gebiet, das Sie als Lernbereich verwenden möchten

Jetzt, dass wir das Gebiet haben, werden wir die Daten auswählen, lasst uns die Extraktionswerkzeuge aktivieren.
1. Go to Plugins Manage/Install Plugins...

2. In the All tab, type QuickOSM in the search box

3. Select the QuickOSM plugin, press Install Plugin and then Close the dialog.

4. Execute the new plugin from Vector QuickOSM QuickOSM... menu

5. In the Quick query tab, select building in the Key drop-down menu

6. Leave the Value field empty, meaning that you are querying all buildings.

7. Select Canvas Extent in the next drop-down menu

8. Expand the Advanced group below and uncheck all geometry types on the right except Multipolygons.

9. Press Run query

A new building layer is added to the Layers panel, showing buildings in the selected extent.

10. Proceed as above to extract other data:

   1. Key = landuse and Multipolygons geometry type.
2. Key = boundary, Value = protected_area and Multipolygons geometry type.
3. Key = natural, Value = water and Multipolygons geometry type.
4. Key = highway and check Lines and Multilines geometry types.
5. Key = waterway, Value = river and check Lines and Multilines geometry types.
6. Key = place and Points geometry type.

This process adds the layers as temporary files (indicated by the icon next to their name).

![QGIS Layers Panel]

You can sample the data your region contains in order to see what kind of results your region will yield.

We now need to save the resulting data to use during your course. We’ll be using ESRI Shapefile, GeoPackage and SpatiaLite formats depending on the data.

To convert the place temporary layer to another format:

1. Click the icon next to the place layer to open the Save Scratch Layer dialog.

   **Bemerkung:** If you need to change any of the temporary layer’s properties (CRS, extent, fields…), use the Export Save Features as… contextual menu instead, and ensure the Add saved file to map option is checked. This adds a new layer.

2. Select the ESRI Shapefile format
3. Use the … button to browse to the exercise_data/shapefile/ folder and save the file as places.shp.
4. Press OK

   In the Layers panel, the temporary place layer is replaced with the saved places shapefile layer and the temporary icon next to it removed.

5. Double-click the layer to open its Layer Properties Source tab and update the Layer name property to match the file name.

6. Repeat the process for other layers, renaming them as follows:
   - natural_water into water
   - waterway_river into rivers
   - boundary_protected_area into protected_areas
Each resulting data set should be saved in the `exercise_data/shapefile/` directory. The next step is to create a GeoPackage file from the `building` layer to use during the course:

1. Click the icon next to the `building` layer
2. Select the GeoPackage format
3. Save the file as `training_data.gpkg` under the `exercise_data/` folder
4. By default, the *Layer name* is filled as the file name. Replace it with `buildings`.

5. Press *OK*
6. Rename the layer in its properties dialog
7. Repeat the process with the `highway` layer, saving it as `roads` in the same GeoPackage database.

The last step is to save the remaining temporary file as a SpatiaLite file.

1. Click the icon next to the `landuse` layer
2. Select the SpatiaLite format
3. Save the file as landuse.sqlite under the exercise_data/ folder. By default, the Layer name is filled as the file name. Do not change it.

![Save Scratch Layer](image)

4. Press OK

You should now have a map which looks something like this (the symbology will certainly be very different, because QGIS randomly assigns colors when layers are added to the map):

The important thing is that you have 7 vector layers matching those shown above and that all those layers have some data.

### 20.2 Try Yourself Create SRTM DEM tiff Files

For modules Module: Vektordaten erzeugen and Module: Raster, you’ll also need raster images (SRTM DEM) which cover the region you have selected for your course.

The CGIAR-CGI provides some SRTM DEM you can download from [http://srtm.csi.cgiar.org/srtmdata/](http://srtm.csi.cgiar.org/srtmdata/).

You'll need images which cover the entire region you have chosen to use. To find the extent coordinates, in QGIS, zoom to the extent of the largest layer and pick the values in the Extents box of the status bar. Keep the GeoTiff format. Once the form is filled, click on the Click here to Begin Search >> button and download the file(s).

Once you have downloaded the required file(s), they should be saved in the exercise_data directory, under raster/SRTM subfolders.
20.3 Try Yourself Create imagery tiff Files

In Module Module: Vektordaten erzeugen, Follow Along: Datenquellen lesson shows close-up images of three school sports fields which students are asked to digitize. You’ll therefore need to reproduce these images using your new SRTM DEM tiff file(s). There is no obligation to use school sports fields: any three school land-use types can be used (e.g. different school buildings, playgrounds or car parks).

For reference, the image in the example data is:

20.4 Try Yourself Replace Tokens

Having created your localised dataset, the final step is to replace the tokens in the substitutions.txt file so that the appropriate names will appear in your localised version of the Training Manual.

The tokens you need to replace are as follows:

- majorUrbanName: this defaults to „Swellendam“. Replace with the name of the major town in your region.
- schoolAreaType1: this defaults to „athletics field“. Replace with the name of the largest school area type in your region.
- largeLandUseArea: this defaults to „Bontebok National Park“. Replace with the name of a large landuse polygon in your region.
- srtmFileName: this defaults to srtm_41_19.tif. Replace this with the filename of your SRTM DEM file.
- localCRS: this defaults to WGS 84 / UTM 34S. You should replace this with the correct CRS for your region.
Kapitel 20. Vorbereitung der Übungsdaten
21.1 Results For Eine Übersicht über das Interface

21.1.1 Übersicht (Teil 1)

Refer back to the image showing the interface layout and check that you remember the names and functions of the screen elements.

21.1.2 Übersicht (Teil 2)

1. Save as
2. Zoom to layer
3. Invert selection
4. Rendering on/off
5. Measure line

21.2 Results For Adding Your First Layer

21.2.1 Vorbereitung

In the main area of the dialog you should see many shapes with different colors. Each shape belongs to a layer you can identify by its color in the left panel (your colors may be different from the ones below):
21.2.2 **Data loading**

Your map should have seven layers:

- protected_areas
- places
- rivers
- roads
- landuse
- buildings (taken from training_data.gpkg) and
- water (taken from exercise_data/shapefile).

Back to text

21.3 **Results For Symbology**

21.3.1 **Colors**

- Verify that the colors are changing as you expect them to change.
- It is enough to select the water layer in the legend and then click on the Open the Layer Styling panel button. Change the color to one that fits the water layer.

**Bemerkung:** If you want to work on only one layer at a time and don’t want the other layers to distract you, you can hide a layer by clicking in the checkbox next to its name in the layers list. If the box is blank, then the layer is hidden.

Back to text
21.3.2 **Symbol Structure**

Ihre Karte sollte nun folgendermaßen aussehen:

Falls Sie ein Benutzer auf Einsteigerniveau sind, können Sie hier stoppen.

- Benutzen Sie die oben genannte Methode um die Farben und Stile für die übrigen Layer anzupassen.
- Versuchen Sie möglichst den Objekten entsprechende Farben zu verwenden. So sollte beispielsweise eine Straße nicht Rot oder Blau sein, sondern eher Grau oder Schwarz.
- Also feel free to experiment with different Fill style and Stroke style settings for the polygons.

*Back to text*
21.3.3 Symbol Layers

Passen Sie den buildings Layer nach Ihrem Ermessen an, aber bedenken Sie dabei, dass es möglichst leicht sein sollte, unterschiedliche Layer unterscheiden zu können.

Im Folgenden ein Beispiel:
21.3.4 Symbol Levels

To make the required symbol, you need three symbol layers:

The lowest symbol layer is a broad, solid gray line. On top of it there is a slightly thinner solid yellow line and finally another thinner solid black line.

If your symbol layers resemble the above but you’re not getting the result you want:

1. Check that your symbol levels look something like this:

2. Inzwischen sollte Ihre Karte folgendermaßen aussehen:

Back to text
21.3.5 Symbol Levels

1. Passen Sie Ihre Symbollevel entsprechend den folgenden Werten an:

2. Experimentieren Sie mit verschiedenen Werten um unterschiedliche Ergebnisse zu erhalten.

3. Öffnen Sie Ihre ursprüngliche Karte abermals bevor Sie mit der nächsten Übung fortsetzen.

Back to text
21.4 Outline Markers

Here are examples of the symbol structure:

21.4.1 Geometry generator symbology

- Click on the button to add another Symbol level.
- Move the new symbol at the bottom of the list clicking the button.
- Choose a good color to fill the water polygons.
- Click on Marker of the Geometry generator symbology and change the circle with another shape as your wish.
- Try experimenting other options to get more useful results.
21.5 Results For Vector Attribute Data

21.5.1 Exploring Vector Data Attributes

- There should be 9 fields in the rivers layer:
  1. Select the layer in the Layers panel.
  2. Right-click and choose Open Attribute Table, or press the button on the Attributes Toolbar.
  3. Count the number of columns.

  **Tipp:** A quicker approach could be to double-click the rivers layer, open the Layer properties Fields tab, where you will find a numbered list of the table’s fields.

- Information about towns is available in the places layer. Open its attribute table as you did with the rivers layer: there are two features whose place attribute is set to town: Swellendam and Buffeljagsrivier. You can add comment on other fields from these two records, if you like.

- The name field is the most useful to show as labels. This is because all its values are unique for every object and are very unlikely to contain NULL values. If your data contains some NULL values, do not worry as long as most of your places have names.

*Back to text*
21.6 Results For *Labels*

21.6.1 *Label Customization (Part 1)*

Your map should now show the marker points and the labels should be offset by 2mm. The style of the markers and labels should allow both to be clearly visible on the map:

![Map with marker points and labels](image)

21.6.2 *Label Customization (Part 2)*

One possible solution has this final product:

To arrive at this result:

- Use a font size of 10
- Use an around point placement distance of 1.5 mm
- Use a marker size of 3.0 mm
- In addition, this example uses the *Wrap on character* option:
  - Enter a space in this field and click *Apply* to achieve the same effect. In our case, some of the place names are very long, resulting in names with multiple lines which is not very user friendly. You might find this setting to be more appropriate for your map.
21.6.3 Using Data Defined Settings

1. Still in edit mode, set the FONT_SIZE values to whatever you prefer. The example uses 16 for towns, 14 for suburbs, 12 for localities, and 10 for hamlets.

2. Remember to save changes and exit edit mode

3. Return to the Text formatting options for the places layer and select FONT_SIZE in the Attribute field of the font size data defined override dropdown:

Your results, if using the above values, should be this:

Back to text

21.7 Results For Classification

21.7.1 Refine the Classification

The settings you used might not be the same, but with the values Classes = 6 and Mode = Natural Breaks (Jenks) (and using the same colors, of course), the map will look like this:

Back to text
21.7. Results For Classification
Kapitel 21. Antwortblatt

QGIS Training Manual
21.8 Results For Creating a New Vector Dataset

21.8.1 Digitizing

The symbology doesn’t matter, but the results should look more or less like this:

Back to text

21.8.2 Topology: Add Ring Tool

The exact shape doesn’t matter, but you should be getting a hole in the middle of your feature, like this one:

• Undo your edit before continuing with the exercise for the next tool.

Back to text

21.8.3 Topology: Add Part Tool

• First select the Bontebok National Park:

• Now add your new part:

• Undo your edit before continuing with the exercise for the next tool.

Back to text
21.8. Results For Creating a New Vector Dataset
21.8.4 Merge Features

- Use the Merge Selected Features tool, making sure to first select both of the polygons you wish to merge.
- Use the feature with the OGC_FID of 1 as the source of your attributes (click on its entry in the dialog, then click the Take attributes from selected feature button):

**Bemerkung:**

If you're using a different dataset, it is highly likely that your original polygon's OGC_FID will not be 1. Just choose the feature which has an OGC_FID.

---

**Bemerkung:** Using the Merge Attributes of Selected Features tool will keep the geometries distinct, but give them the same attributes.

21.8.5 Forms

For the TYPE, there is obviously a limited amount of types that a road can be, and if you check the attribute table for this layer, you'll see that they are predefined.

- Set the widget to Value Map and click Load Data from Layer.
- Select roads in the Label dropdown and highway for both the Value and Description options:
- Click OK three times.
- If you use the Identify tool on a street now while edit mode is active, the dialog you get should look like this:
21.8. Results For Creating a New Vector Dataset
21.9 Results For Vector Analysis

21.9.1 Distance from High Schools

- Your buffer dialog should look like this:

The **Buffer distance** is 1 kilometer.

- The **Segments to approximate** value is set to 20. This is optional, but it’s recommended, because it makes the output buffers look smoother. Compare this:

To this:

The first image shows the buffer with the **Segments to approximate** value set to 5 and the second shows the value set to 20. In our example, the difference is subtle, but you can see that the buffer’s edges are smoother with the higher value.

*Back to text*
21.9. Results For Vector Analysis
21.9.2 Distance from Restaurants

To create the new *houses_restaurants_500m* layer, we go through a two step process:

- First, create a buffer of 500m around the restaurants and add the layer to the map:

![Buffer dialog](image)

- Next, extract buildings within that buffer area:

Your map should now show only those buildings which are within 50m of a road, 1km of a school and 500m of a restaurant:

*Back to text*

21.10 Results For Network Analysis

21.11 Fastest path

Open *Network Analysis* `Shortest Path (Point to Point)` and fill the dialog as:

Make sure that the *Path type to calculate* is *Fastest*.

Click on *Run* and close the dialog.

Open now the attribute table of the output layer. The *cost* field contains the travel time between the two points (as fraction of hours):

*Back to text*
Extract by location

This algorithm creates a new vector layer that only contains matching features from an input layer. The criteria for adding features to the resulting layer is defined based on the spatial relationship between each feature and the features in an additional layer.

Parameters

Extract features from

- well located houses [EPSG:32734]

Where the features (geometric predicate)

- intersect
- touch
- contain
- overlap
- disjoint
- are within
- equal
- cross

By comparing to the features from

- restaurants_buffer_500m [EPSG:32734]

- Selected features only

- Extracted (location)

- latteo/vector_analysis.qgs' table="restaurants_buffer_500m" (geom) sql=

- Open output file after running algorithm

0%
21.11. Fastest path

This algorithm computes optimal (shortest or fastest) route between given start and end points.
21.12 Results For *Raster Analysis*

21.12.1 *Calculate Aspect*

Set your *Aspect* dialog up like this:

Your result:

*Back to text*

21.12.2 *Calculate Slope (less than 2 and 5 degrees)*

Set your *Raster calculator* dialog up like this:

- For the 5 degree version, replace the 2 in the expression and file name with 5.

Your results:

- 2 degrees:
- 5 degrees:

*Back to text*

21.13 Results For *Completing the Analysis*

21.13.1 *Raster to Vector*

Open the *Query Builder* by right-clicking on the *all_terrain* layer in the *Layers* panel, and selecting the *Properties* tab.

Then build the query "suitable" = 1.

Click *OK* to filter out all the polygons where this condition isn’t met.

When viewed over the original raster, the areas should overlap perfectly:

- You can save this layer by right-clicking on the *all_terrain* layer in the *Layers* panel and choosing *Save As…*, then continue as per the instructions.
21.13. Results For Completing the Analysis

The image shows the Aspect window in QGIS with the following settings:

- **Elevation layer**: srtm_41_19 [EPSG:32733]
- **Z factor**: 1.000000
- **Aspect**: /home/matteo/exercise_data/exercise_data/raster_analysis/aspect.tif

There is a checkbox for **Open output file after running algorithm**.

The progress bar shows 0% progress.

Options include Help, Run as Batch Process, Close, and Run.
21.13. Results For Completing the Analysis

QGIS Training Manual
21.13.2 Inspecting the Results

You may notice that some of the buildings in your new_solution layer have been “sliced” by the Intersect tool. This shows that only part of the building - and therefore only part of the property - lies on suitable terrain. We can therefore sensibly eliminate those buildings from our dataset.

21.13.3 Refining the Analysis

At the moment, your analysis should look something like this:

Consider a circular area, continuous for 100 meters in all directions.

If it is greater than 100 meters in radius, then subtracting 100 meters from its size (from all directions) will result in a part of it being left in the middle.

Therefore, you can run an interior buffer of 100 meters on your existing suitableTerrain vector layer. In the output of the buffer function, whatever remains of the original layer will represent areas where there is suitable terrain for 100 meters beyond.

To demonstrate:

- Go to Vector Geoprocessing Tools Buffer(s) to open the Buffer(s) dialog.
- Set it up like this:
  - Use the suitableTerrain layer with 10 segments and a buffer distance of -100. (The distance is automatically in meters because your map is using a projected CRS.)
- Save the output in exercise_data/residential_development/ as suitableTerrain_continuous100m.shp.
- If necessary, move the new layer above your original suitableTerrain layer.

Your results will look like something like this:
21.13. Results For Completing the Analysis
Input vector layer

suitableTerrain_34S

Use only selected features

Segments to approximate 10

Buffer distance -100

Buffer distance field

suitable

Dissolve buffer results

Output shapefile

suitableTerrain_continuous_100m.shp

Add result to canvas

Close OK
• Now use the Select by Location tool (Vector ➥ Research Tools ➥ Select by location).

• Set up like this:

• Select features in new_solution that intersect features in suitable_terrain_continuous100m.shp.

This is the result:

The yellow buildings are selected. Although some of the buildings fall partly outside the new suitable_terrain_continuous100m layer, they lie well within the original suitable_terrain layer and therefore meet all of our requirements.

• Save the selection under exercise_data/residential_development/ as final_answer.shp.

21.14 Results For WMS

21.14.1 Adding Another WMS Layer

Your map should look like this (you may need to re-order the layers):

Back to text
Select by location

Select features in:
new_solution

that intersect features in:
suitableTerrain_continuous_100m

Use selected features only
Modify current selection by:
creating new selection

Add result to canvas

Close  OK
21.14.2 Adding a New WMS Server

- Use the same approach as before to add the new server and the appropriate layer as hosted on that server:
  - If you zoom into the Swellendam area, you’ll notice that this dataset has a low resolution:

Therefore, it’s better not to use this data for the current map. The Blue Marble data is more suitable at global or national scales.

Back to text

21.14.3 Finding a WMS Server

You may notice that many WMS servers are not always available. Sometimes this is temporary, sometimes it is permanent. An example of a WMS server that worked at the time of writing is the World Mineral Deposits WMS at http://apps1.gdr.nrcan.gc.ca/cgi-bin/worldmin_en-ca_ows. It does not require fees or have access constraints, and it is global. Therefore, it does satisfy the requirements. Keep in mind, however, that this is merely an example. There are many other WMS servers to choose from.

Back to text
21.15 Results For GRASS Integration

21.15.1 Add Layers to Mapset

You can add layers (both vector and raster) into a GRASS Mapset by drag and drop them in the Browser (see Follow Along: Daten mit Hilfe des QGIS Browsers laden) or by using the v.in.gdal.qgis for vector and r.in.gdal.qgis for raster layers.

Back to text

21.15.2 Reclassify raster layer

To discover the maximum value of the raster run the r.info tool: in the console you will see that the maximum value is 1699.

You are now ready to write the rules. Open a text editor and add the following rules:

```
0 thru 1000 = 1
1000 thru 1400 = 2
1400 thru 1699 = 3
```

save the file as a my_rules.txt file and close the text editor.

Run the r.reclass tool, choose the g_dem layer and load the file containing the rules you just have saved.

Click on Run and then on View Output. You can change the colors and the final result should look like the following picture:

Back to text
21.16 Results For Database Concepts

21.16.1 Address Table Properties

For our theoretical address table, we might want to store the following properties:

<table>
<thead>
<tr>
<th>House Number</th>
<th>Street Name</th>
<th>Suburb Name</th>
<th>City Name</th>
<th>Postcode</th>
<th>Country</th>
</tr>
</thead>
</table>

When creating the table to represent an address object, we would create columns to represent each of these properties and we would name them with SQL-compliant and possibly shortened names:

```sql
house_number
street_name
suburb
city
postcode
country
```

Back to text
21.16.2 Normalising the People Table

The major problem with the `people` table is that there is a single address field which contains a person’s entire address. Thinking about our theoretical `address` table earlier in this lesson, we know that an address is made up of many different properties. By storing all these properties in one field, we make it much harder to update and query our data. We therefore need to split the address field into the various properties. This would give us a table which has the following structure:

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>house_no</th>
<th>street_name</th>
<th>city</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tim Sutton</td>
<td>3</td>
<td>Buirski Plein</td>
<td>Swellendam</td>
<td>071 123 123</td>
</tr>
<tr>
<td>2</td>
<td>Horst Duester</td>
<td>4</td>
<td>Avenue du Roix</td>
<td>Geneva</td>
<td>072 121 122</td>
</tr>
</tbody>
</table>

*Bemerkung:* In the next section, you will learn about Foreign Key relationships which could be used in this example to further improve our database’s structure.

21.16.3 Further Normalisation of the People Table

Our `people` table currently looks like this:

<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
<th>house_no</th>
<th>street_id</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Horst Duster</td>
<td>4</td>
<td>1</td>
<td>072 121 122</td>
</tr>
</tbody>
</table>

The `street_id` column represents a ‘one to many’ relationship between the `people` object and the related `street` object, which is in the `streets` table.

One way to further normalise the table is to split the name field into `first_name` and `last_name`:

<table>
<thead>
<tr>
<th>id</th>
<th>first_name</th>
<th>last_name</th>
<th>house_no</th>
<th>street_id</th>
<th>phone_no</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Horst</td>
<td>Duster</td>
<td>4</td>
<td>1</td>
<td>072 121 122</td>
</tr>
</tbody>
</table>

We can also create separate tables for the town or city name and country, linking them to our `people` table via ‘one to many’ relationships:

<table>
<thead>
<tr>
<th>id</th>
<th>first_name</th>
<th>last_name</th>
<th>house_no</th>
<th>street_id</th>
<th>town_id</th>
<th>country_id</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Horst</td>
<td>Duster</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

An ER Diagram to represent this would look like this:
21.16.4 Create a People Table

The SQL required to create the correct people table is:

```sql
create table people (
    id serial not null primary key,
    name varchar(50),
    house_no int not null,
    street_id int not null,
    phone_no varchar null);
```

The schema for the table (enter `\d people`) looks like this:

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>integer</td>
<td>not null default</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nextval('people_id_seq':regclass)</td>
</tr>
<tr>
<td>name</td>
<td>character varying(50)</td>
<td></td>
</tr>
<tr>
<td>house_no</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>street_id</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>phone_no</td>
<td>character varying</td>
<td></td>
</tr>
</tbody>
</table>

Indexes:
- "people_pkey" PRIMARY KEY, btree (id)

**Bemerkung**: For illustration purposes, we have purposely omitted the fkey constraint.
21.16.5  **The DROP Command**

The reason the DROP command would not work in this case is because the *people* table has a Foreign Key constraint to the *streets* table. This means that dropping (or deleting) the *streets* table would leave the *people* table with references to non-existent *streets* data.

**Bemerkung:** It is possible to 'force' the *streets* table to be deleted by using the *CASCADE* command, but this would also delete the *people* and any other table which had a relationship to the *streets* table. Use with caution!

21.16.6  **Insert a New Street**

The SQL command you should use looks like this (you can replace the street name with a name of your choice):

```
insert into streets (name) values ('Low Road');
```

21.16.7  **Add a New Person With Foreign Key Relationship**

Here is the correct SQL statement:

```
insert into streets (name) values('Main Road');
insert into people (name,house_no, street_id, phone_no)
    values ('Joe Smith',55,2,'072 882 33 21');
```

If you look at the streets table again (using a select statement as before), you'll see that the *id* for the *Main Road* entry is 2.

That's why we could merely enter the number 2 above. Even though we're not seeing *Main Road* written out fully in the entry above, the database will be able to associate that with the *street_id* value of 2.

**Bemerkung:** If you have already added a new *street* object, you might find that the new *Main Road* has an *id* of 3 not 2.

21.16.8  **Return Street Names**

Here is the correct SQL statement you should use:

```
select count(people.name), streets.name
from people, streets
where people.street_id=streets.id
group by streets.name;
```

Result:
<table>
<thead>
<tr>
<th>count</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low Street</td>
</tr>
<tr>
<td>2</td>
<td>High street</td>
</tr>
<tr>
<td>1</td>
<td>Main Road</td>
</tr>
</tbody>
</table>

**Bemerkung:** You will notice that we have prefixed field names with table names (e.g. people.name and streets.name). This needs to be done whenever the field name is ambiguous (i.e. not unique across all tables in the database).

### 21.17 Results For Spatial Queries

#### 21.17.1 The Units Used in Spatial Queries

The units being used by the example query are degrees, because the CRS that the layer is using is WGS 84. This is a Geographic CRS, which means that its units are in degrees. A Projected CRS, like the UTM projections, is in meters.

Remember that when you write a query, you need to know which units the layer’s CRS is in. This will allow you to write a query that will return the results that you expect.

### 21.18 Results For Geometry Construction

#### 21.18.1 Creating Linestrings

```
alter table streets add column the_geom geometry;
alter table streets add constraint streets_geom_point_chk check
    (st_geometrytype(the_geom) = 'ST_LineString':text OR the_geom IS NULL);
insert into geometry_columns values ('','public','streets','the_geom',2,4326,
    'LINESTRING');
create index streets_geo_idx
    on streets using gist (the_geom);
```
21.18.2 Linking Tables

delete from people;
alter table people add column city_id int not null references cities(id);
(capture cities in QGIS)

insert into people (name,house_no, street_id, phone_no, city_id, the_geom)
values ('Faulty Towers',
  34,
  3,
  '072 812 31 28',
  1,
  'SRID=4326;POINT(33 33)');

insert into people (name,house_no, street_id, phone_no, city_id, the_geom)
values ('IP Knightly',
  32,
  1,
  '071 812 31 28',
  1,F
  'SRID=4326;POINT(32 -34)');

insert into people (name,house_no, street_id, phone_no, city_id, the_geom)
values ('Rusty Bedsprings',
  39,
  1,
  '071 822 31 28',
  1,
  'SRID=4326;POINT(34 -34)');

If you’re getting the following error message:

ERROR: insert or update on table "people" violates foreign key constraint "people_city_id_fkey"
DETAIL: Key (city_id)=1 is not present in table "cities".

then it means that while experimenting with creating polygons for the cities table, you must have deleted some of them and started over. Just check the entries in your cities table and use any id which exists.

Back to text

21.19 Results For Simple Feature Model

21.19.1 Populating Tables

create table cities (id serial not null primary key,
  name varchar(50),
  the_geom geometry not null);
alter table cities
add constraint cities_geom_point_chk
check (st_geometrytype(the_geom) = 'ST_Polygon':text );

Back to text
### Populate the Geometry_Columns Table

```sql
insert into geometry_columns values
('','public','cities','the_geom',2,4326,'POLYGON');
```

### Adding Geometry

```sql
select people.name, streets.name as street_name,
       st_astext(people.the_geom) as geometry
from streets, people
where people.street_id=streets.id;
```

Result:

<table>
<thead>
<tr>
<th>name</th>
<th>street_name</th>
<th>geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roger Jones</td>
<td>High street</td>
<td></td>
</tr>
<tr>
<td>Sally Norman</td>
<td>High street</td>
<td></td>
</tr>
<tr>
<td>Jane Smith</td>
<td>Main Road</td>
<td></td>
</tr>
<tr>
<td>Joe Bloggs</td>
<td>Low Street</td>
<td></td>
</tr>
<tr>
<td>Fault Towers</td>
<td>Main Road</td>
<td>POINT(33 -33)</td>
</tr>
</tbody>
</table>

As you can see, our constraint allows nulls to be added into the database.