Saving the Amazon with PostGIS
Spatial Data Manipulation in the Rain Forest

Luis Fernando Bueno

PGCon 2009 The PostgreSQL Conference

Extractive Reserve of the Cuniã Lake
Porto Velho, Rondônia, Brazil
Photo by Tatiane Emilio Checchia

Overview

🔵 *Spatial data, Spatial analysis and Spatial Database*

🔵 *Using PostGIS*

🔵 *Practical Examples*

🔵 *Why PostGIS?*

🔵 *Opportunities*

Spatial Data?

- Describes ocurrences which is associated with a spatial dimension.

- Geographical Data: related to a location anywhere on the Earth's surface.

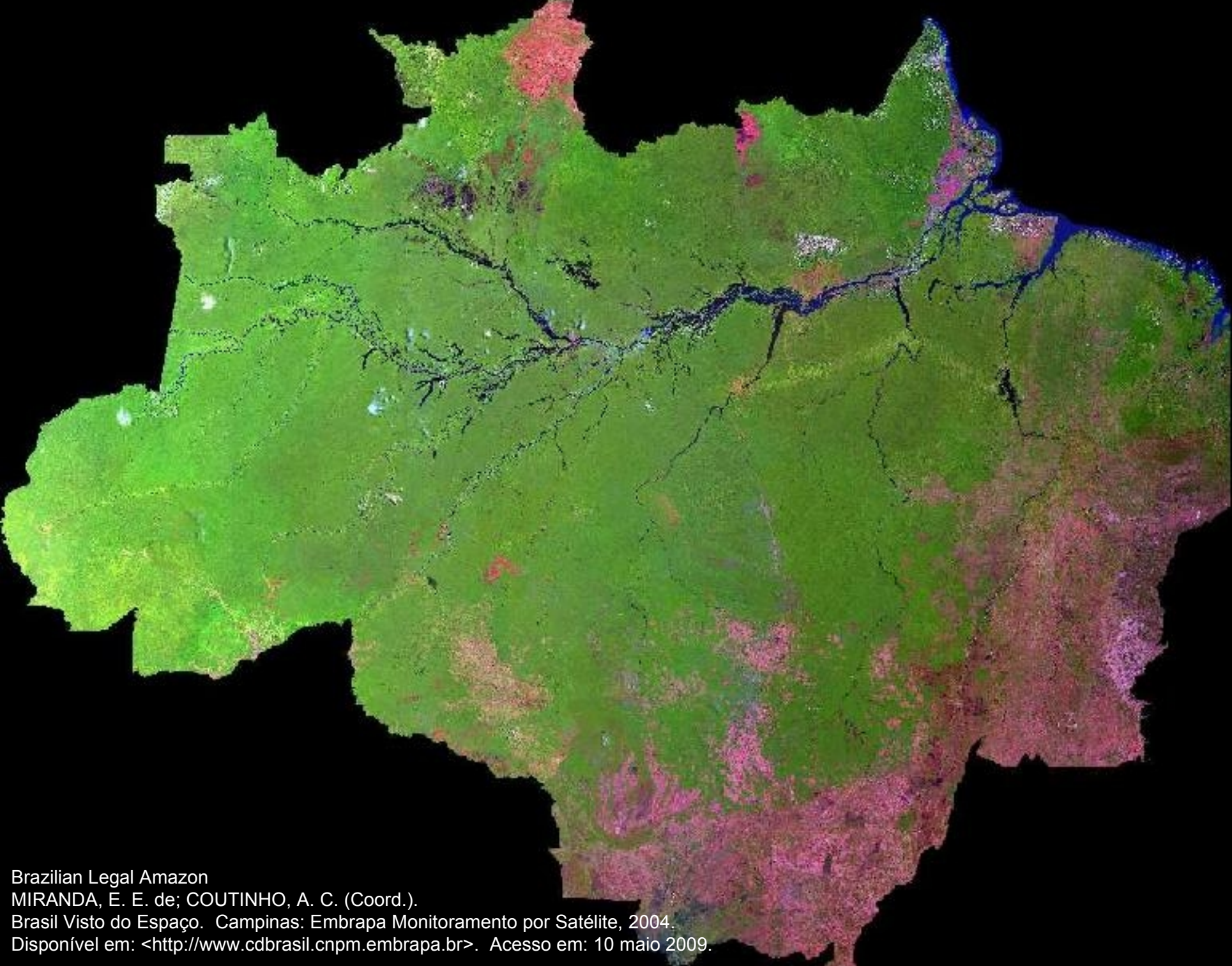- Spatial Data describes both the location of a geographic feature and it's attributes

Brazilian Legal Amazon
MIRANDA, E. E. de; COUTINHO, A. C. (Coord.).
Brasil Visto do Espaço. Campinas: Embrapa Monitoramento por Satélite, 2004.
Disponível em: <http://www.cdbrasil.cnpm.embrapa.br>. Acesso em: 10 maio 2009.

Madeira River
Porto Velho, Rondônia, Brazil
Photo by Wilson Dias/Agência Brasil
http://www.agenciabrasil.gov.br/media/imagens/2007/07/09/1747wd738.jpg

Madeira Mamoré Square   8°45'58.03"S   63°54'31.10"O

8°45'57.67" S   63°54'28.51"O   elev 65 m

Madeira Mamoré Square
Porto Velho, Rondônia, Brazil
Image by Google Earth

Spatial Analysis

Everything is related to everything else, but near things are more related than distant things.

First law of Geography, by Waldo Tobler (1970).

Approach that considers the spatial location of the phenomenon under study.

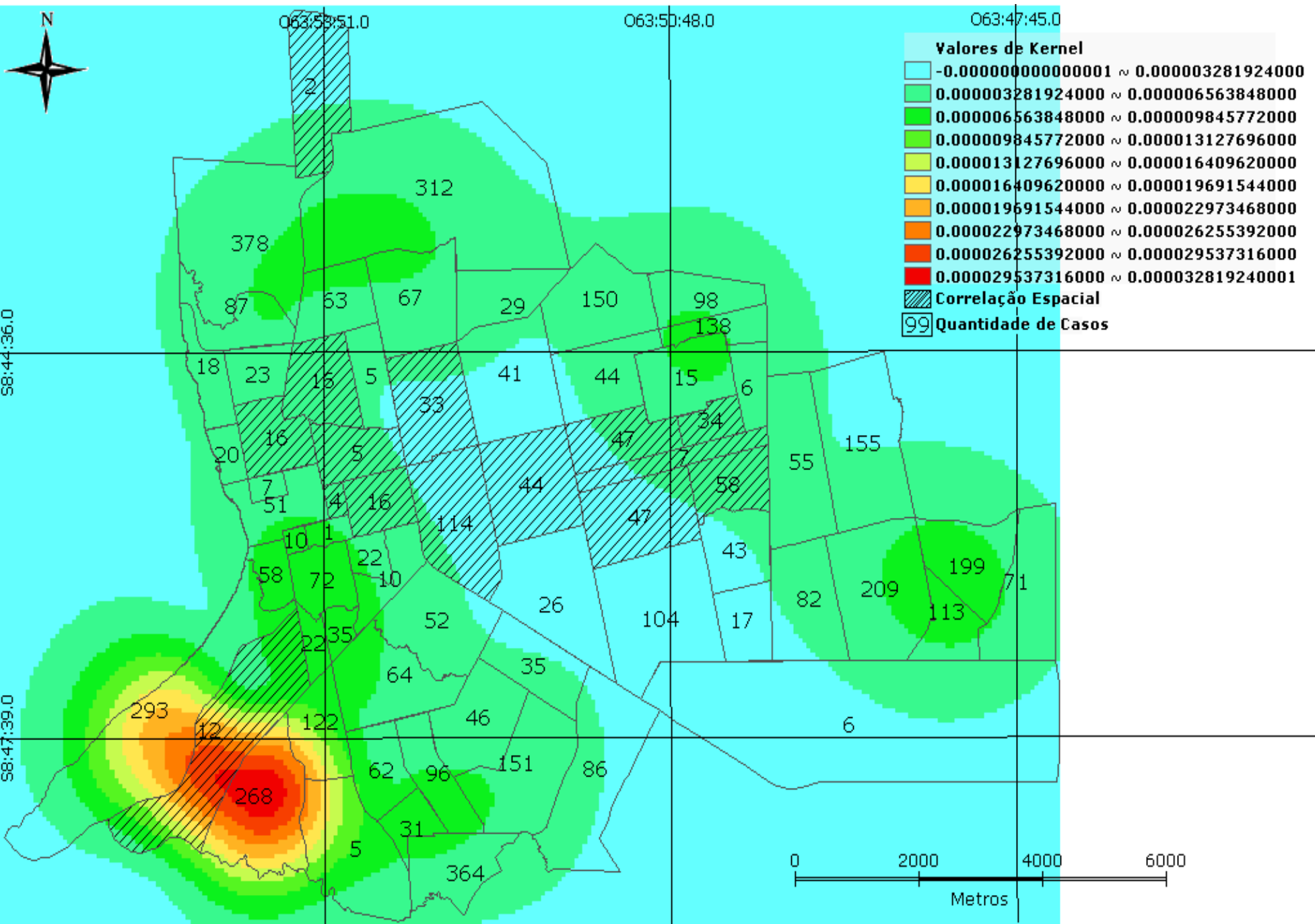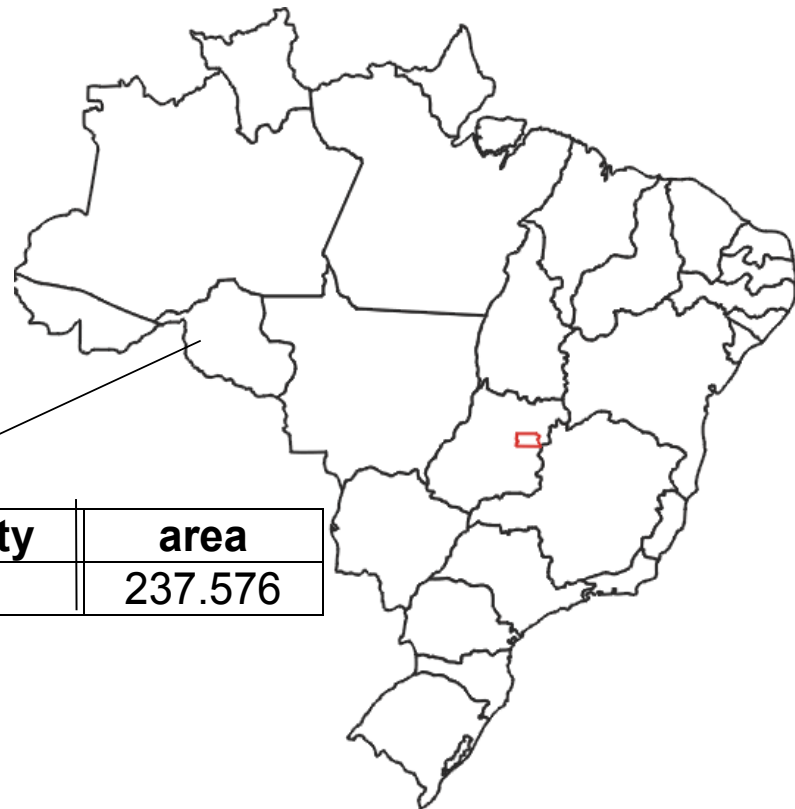Process of looking for patterns and associations, considering the space and time.

Kernel Estimation of Malaria in Porto Velho (2006)

Marcelo Vitor Amaral Campos in Exploratory Spatial Analysis of Cases of Malaria

Valores de Kernel

☐	-0.000000000000001 ~ 0.000003281924000
☐	0.000003281924000 ~ 0.000006563848000
☐	0.000006563848000 ~ 0.000009845772000
☐	0.000009845772000 ~ 0.000013127696000
☐	0.000013127696000 ~ 0.000016409620000
☐	0.000016409620000 ~ 0.000019691544000
☐	0.000019691544000 ~ 0.000022973468000
☐	0.000022973468000 ~ 0.000026255392000
☐	0.000026255392000 ~ 0.000029537316000
☐	0.000029537316000 ~ 0.000032819240001
▨	Correlação Espacial
99	Quantidade de Casos

Metros

Spatial Databases

How to integrate the representations of spatial data and not spatial data?

state	region	population	density	area
Rondônia	North	1.377.792	5,02	237.576

What's PostGIS?

Add geographicals entities to PostgreSQL

Spatial data manipulation in accordance with
Simple   Features Implementation
Specification for SQL (SFS) of Open GeoSpatial
Consortium (OGC)
http://www.opengeospatial.org/standards/sfs

Developed by Refractions Research Inc.
http://postgis.refractions.net

What's PostGIS?

Make use of libraries know for geomatic's systems developers:

PROJ4:
Provides support for on-the-fly reprojection of coordinates

GEOS:
Provides support for geometrics functions and spatial predicates

PostGIS for Data Manipulation
Storage of spatial data

The object coordinates are storage in tables,
considering the geometry type
(point, line, polygon, geometric collection)

In geometry column the data are storaged in
Well Known Text (WKT) format

PostGIS for data manipulation
Storage of spatial data - WKT

POINT(-68.799328 -11.105151)

LINESTRING (-51.2185709867611 -30.040603613161,
-51.2048896289546 -30.0473001826066,
-51.195329656248 -30.0540632644352)

POLYGON (-62.9673500061035 -12.4721698760986,
-62.9673500061035 -11.8302621841431,
-62.3219795227051 -11.8302621841431,
-62.3219795227051 -12.4721698760986,
-62.9673500061035 -12.4721698760986)

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PostGIS for data manipulation

Storage of spatial data - WKT

PostGIS for data manipulation
Storage of spatial data - WKT

```
SELECT the_geom
FROM povoado
WHERE gid =1;

 the_geom
----------------------------------------------------------
 01010000200A120000BCB1A030283351C08C48145AD63526C0
(1 registro)
```

```
SELECT ST_AsText(the_geom)
FROM povoado
WHERE gid =1;

 st_astext
---------------------------------
 POINT(-68.799328 -11.105151)
(1 registro)
```

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PostGIS for data manipulation
Storage of spatial data

Basic geometrics types (OGC)
POINT
POLYGON
LINESTRING

Array of geometrics types

MULTIPOINT
MULTIPOLYGON
MULTILINESTRING
GEOMETRYCOLLECTION

PostGIS for data manipulation
Bounding Box Operators

$$A \ \&< \ B$$
$$A \ \&> \ B$$
$$A \ << \ B$$
$$A \ >> \ B$$
$$A \ \&<| \ B$$
$$A \ |\&> \ B$$
$$A \ <<| \ B$$
$$A \ |>> \ B$$
$$A \ \sim= \ B$$
$$A \ @ \ B$$
$$A \ \sim \ B$$
$$A \ \&\& \ B$$

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PostGIS for data manipulation
Some functions

```
ST_Equals(geometry, geometry)
ST_Disjoint(geometry, geometry)
ST_Intersects(geometry, geometry)
ST_Touches(geometry, geometry)
ST_Crosses(geometry, geometry)
ST_Within(geometry, geometry)
ST_Overlaps(geometry, geometry)
ST_Contains(geometry, geometry)
ST_Relate(geometry, geometry)
ST_Buffer(geometry, double, [integer])
ST_Union (geometry, geometry)
ST_Difference(geometry, geometry)
ST_Distance(geometry,geometry)
ST_Area(geometry)
```

PostGIS for data manipulation
Some functions

```
What States are crossed by highway BR-364?
SELECT distinct b.gid, b.the_geom, b.nm_nome
FROM rodovia_pavimentada a,
     limite_politico administrativo b
WHERE a.nm_sigla = 'BR-364' AND
    ST_Crosses(a.the_geom,b.the_geom);

What are the fragments of roads linked to the
bridge President Costa e Silva?
    SELECT b.gid, b.the_geom, b.nm_sigla
    FROM ponte a, rodovia_pavimentada b
    WHERE a.nm_nome = 'Ponte Presidente Costa e
        Silva' AND
        ST_Touches(a.the_geom, b.the_geom);

What the villages are located within a radius of
up to 500 kilometers from the city of Cacoal?
    SELECT b.gid, b.the_geom, b.nm_nome
    FROM cidade a, povoado b
    WHERE a.nm_nome = 'Cacoal' AND
        ST_Distance(ST_Transform(b.the_geom,
    29101), ST_Transform(a.the_geom,29101))
    /1000 <= 500;
```

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Spatial data manipulations

Other examples

Wich cities are neighbouring Ariquemes?
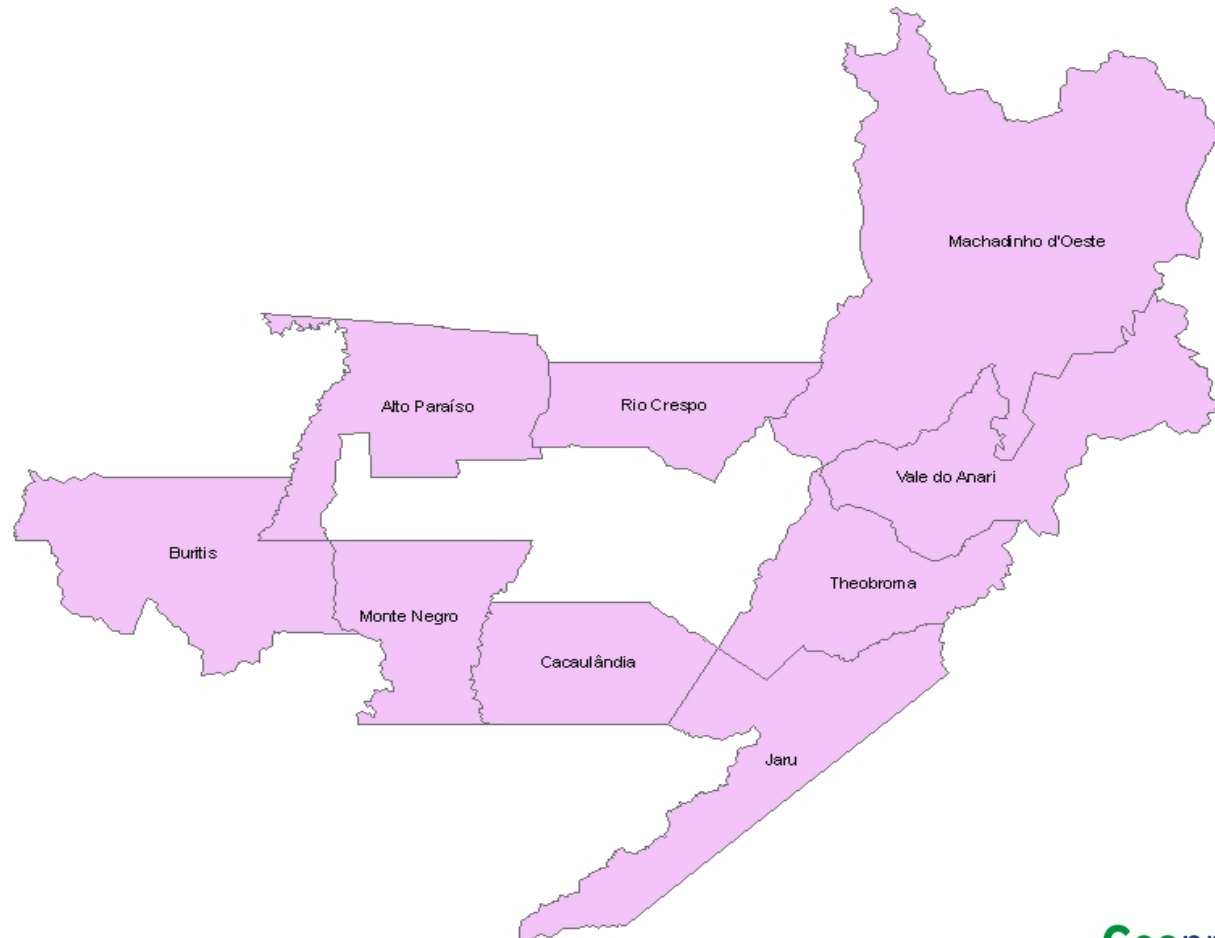
```
SELECT m2.nome as "Nome"
FROM municipio_brasil m1, municipio_brasil m2
WHERE ST_Touches(m1.the_geom,m2.the_geom) AND
        m1.nome_munic='Ariquemes';
```

Spatial data manipulations
Other examples

Wich cities are neighbouring Ariquemes?

Spatial data manipulations
Other examples

Which rivers are contained in Pará State?

```
SELECT b.gid, b.nome, b.the_geom
FROM estado a, hidrografia b
WHERE ST_Contains(a.the_geom, b.the_geom)AND
      a.nm_lim_pol = 'Pará';
```

Spatial data manipulations
Other examples

Which rivers are contained in Pará State?
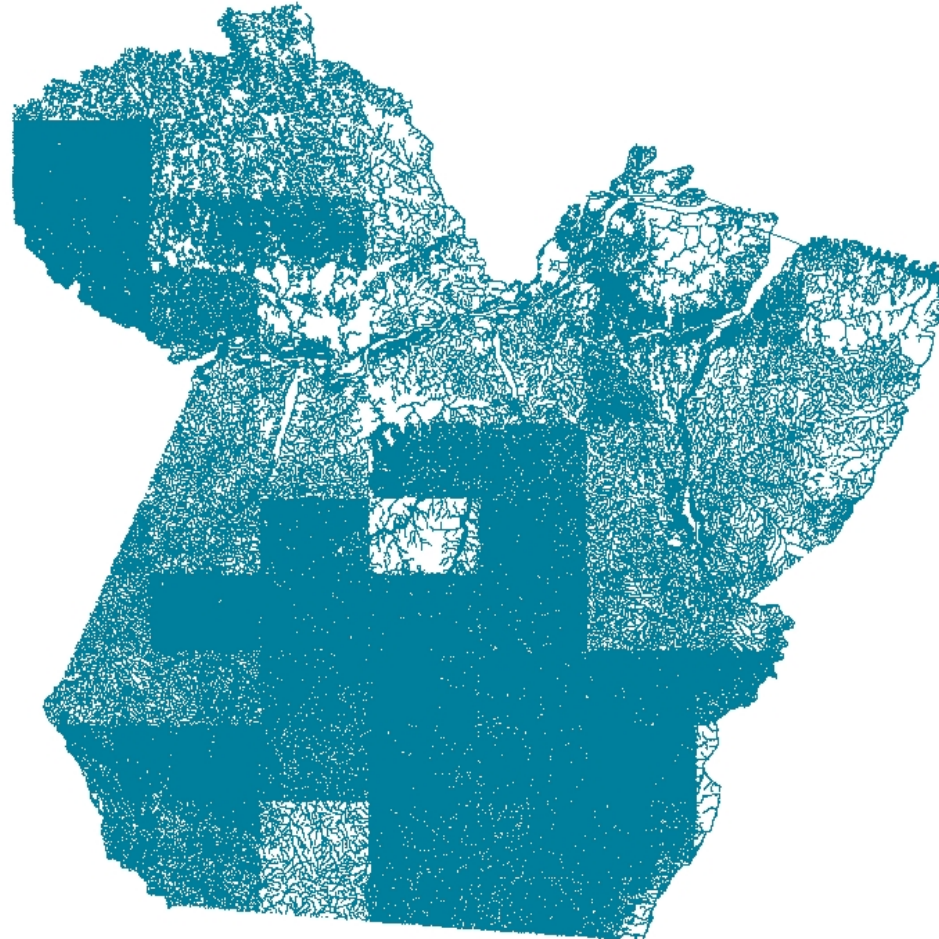
Spatial data manipulations
Other examples

What's the distance between ports Sete de Maio and Treze?

```
SELECT ST_Distance(a.the_geom,b.the_geom)/1000
FROM porto a, porto b
WHERE a.nome = 'Sete de Maio' AND
               b.nome = 'Treze';
```

Spatial data manipulations
Other examples

What's the distance between ports Sete de Maio and Treze?

Sete de Maio

Treze

Distance
11.091452436673 km
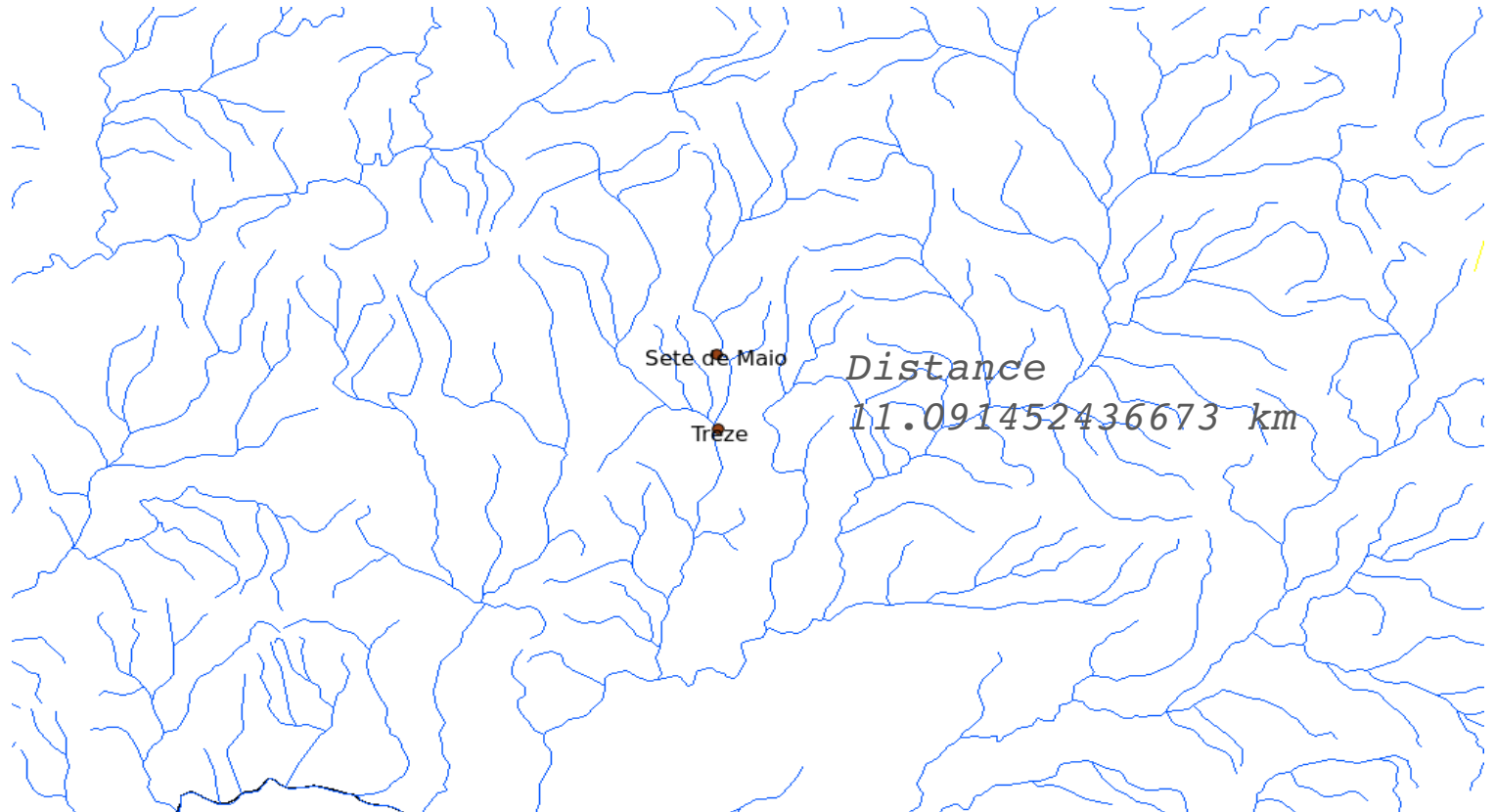
Integration with systems

Storage and recovery of data from Geographical Information Systems (GIS)

shp2pgsql converts ESRI Shapefile into PostGIS tables

```
shp2pgsql   [OPTIONS] shapefile [schema.] table
```

Integration with systems
SPIT plugin - Quantum GIS
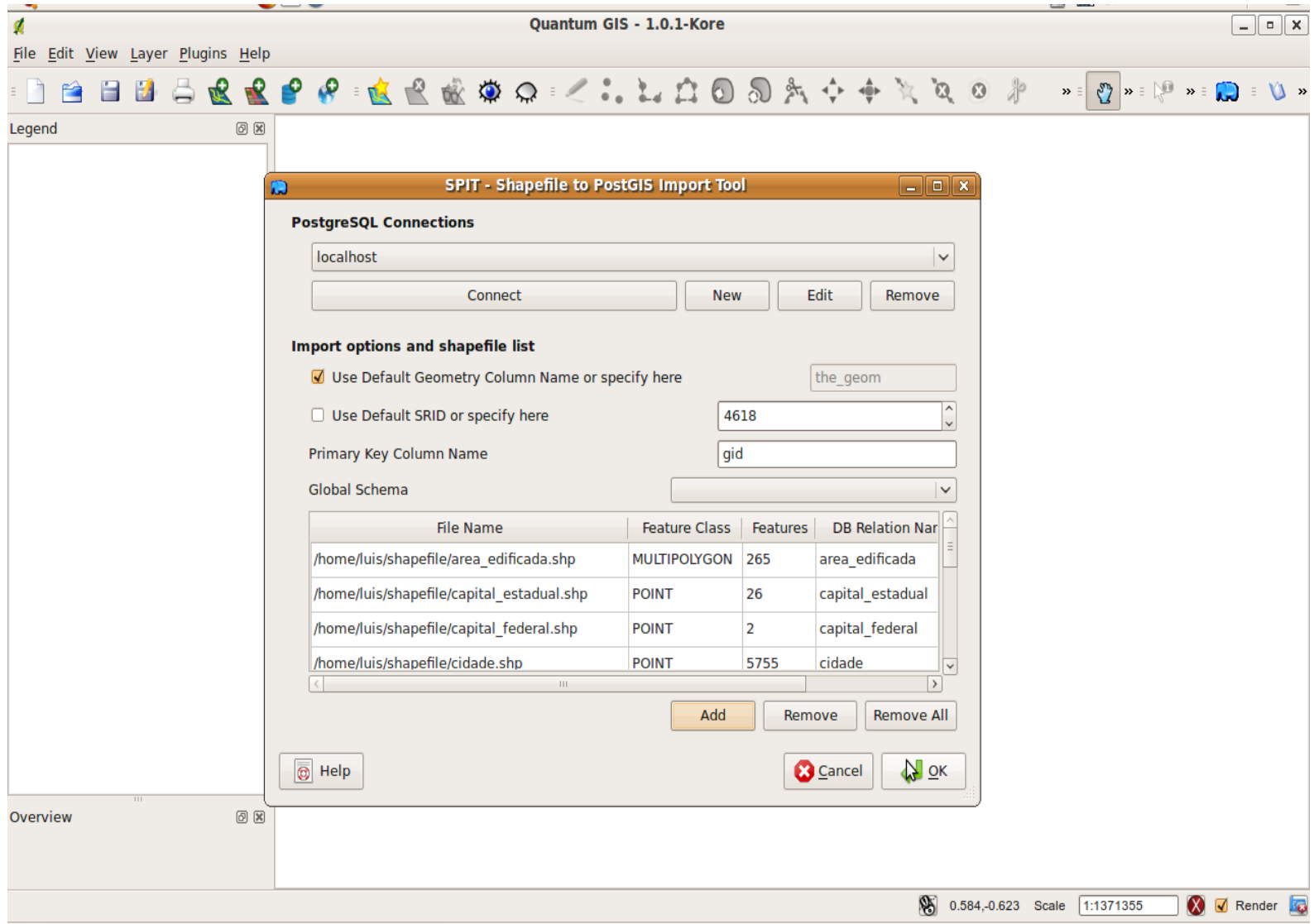
Integration with systems

gshp2pgsql

http://polylinie.de/gshp2pgsql/en/index.html
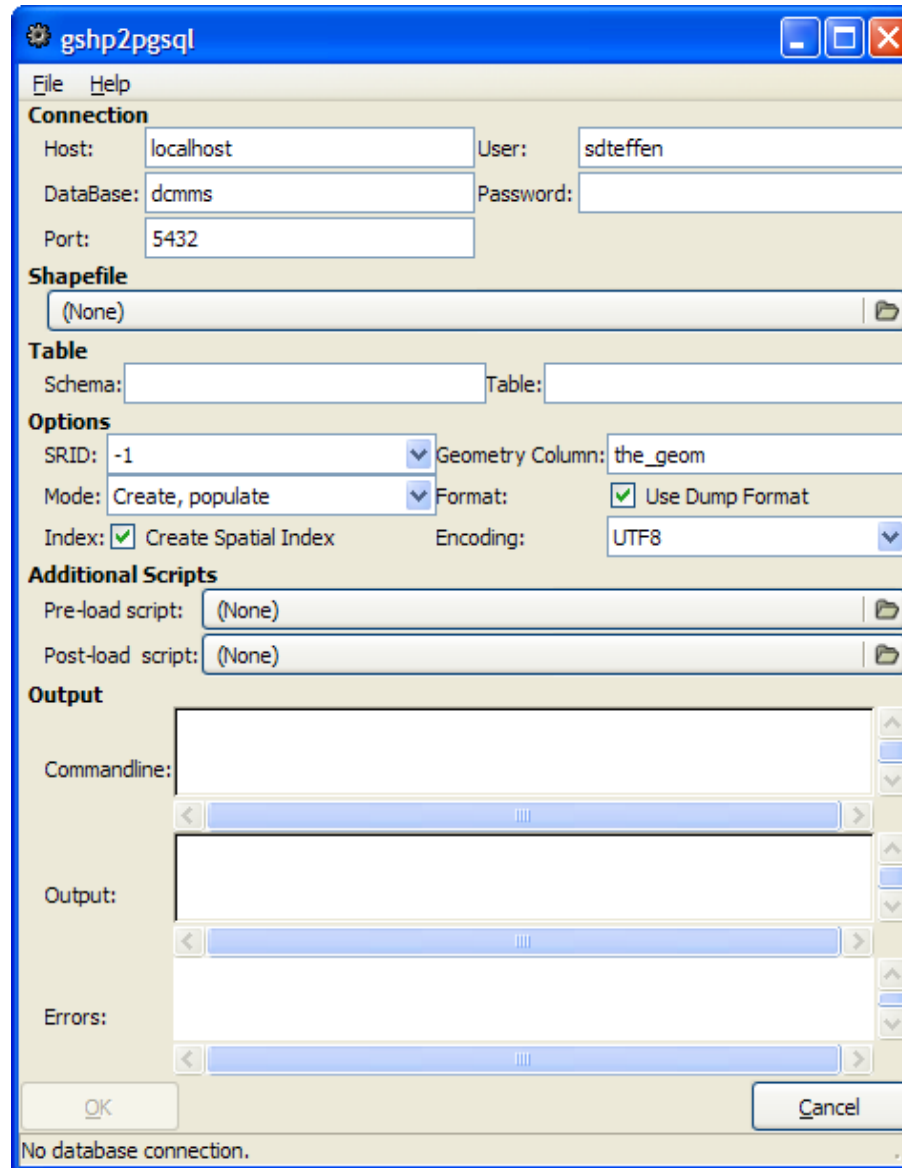
Integration with systems

Quantum GIS
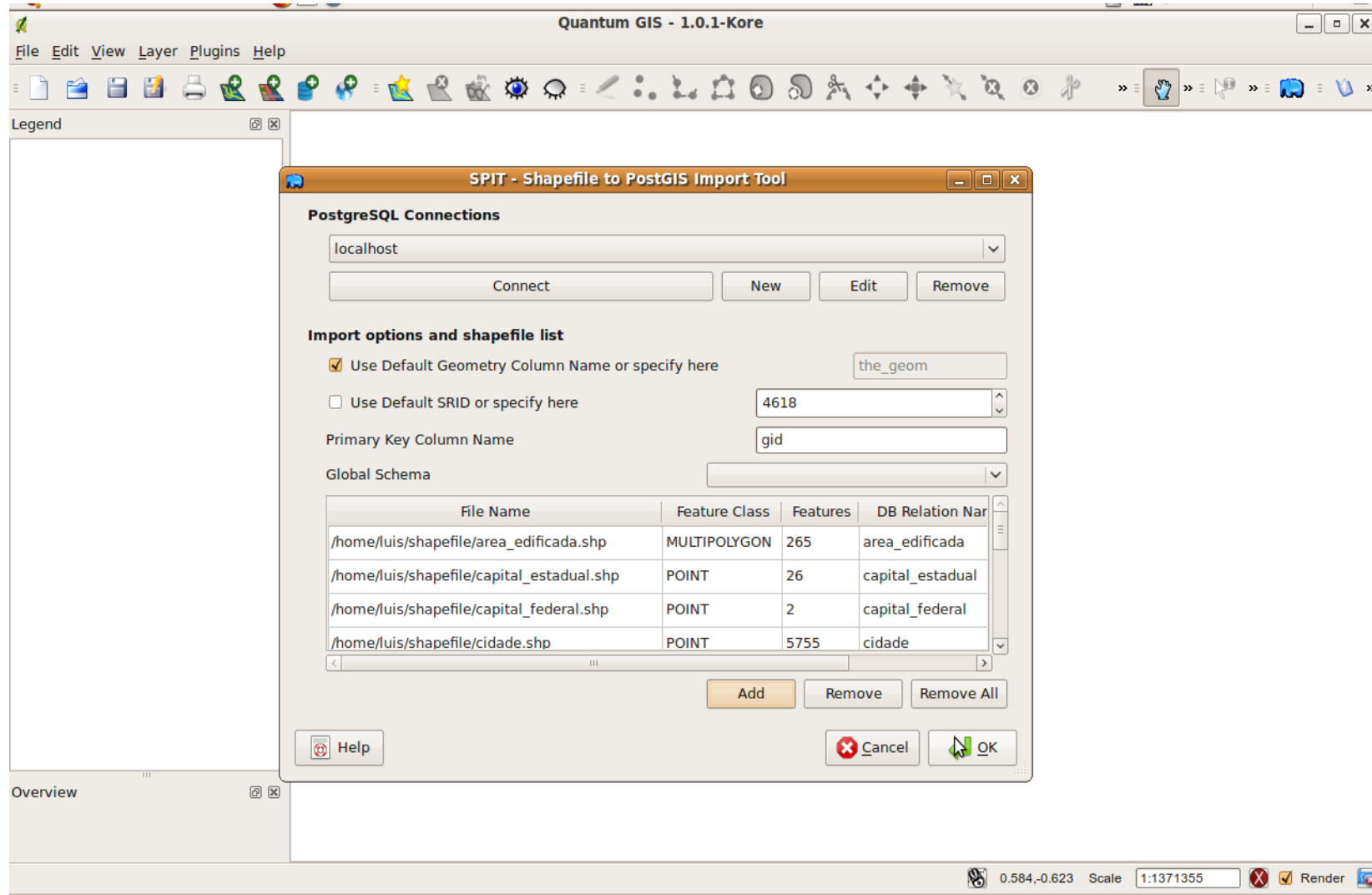
Integration with systems

TerraView
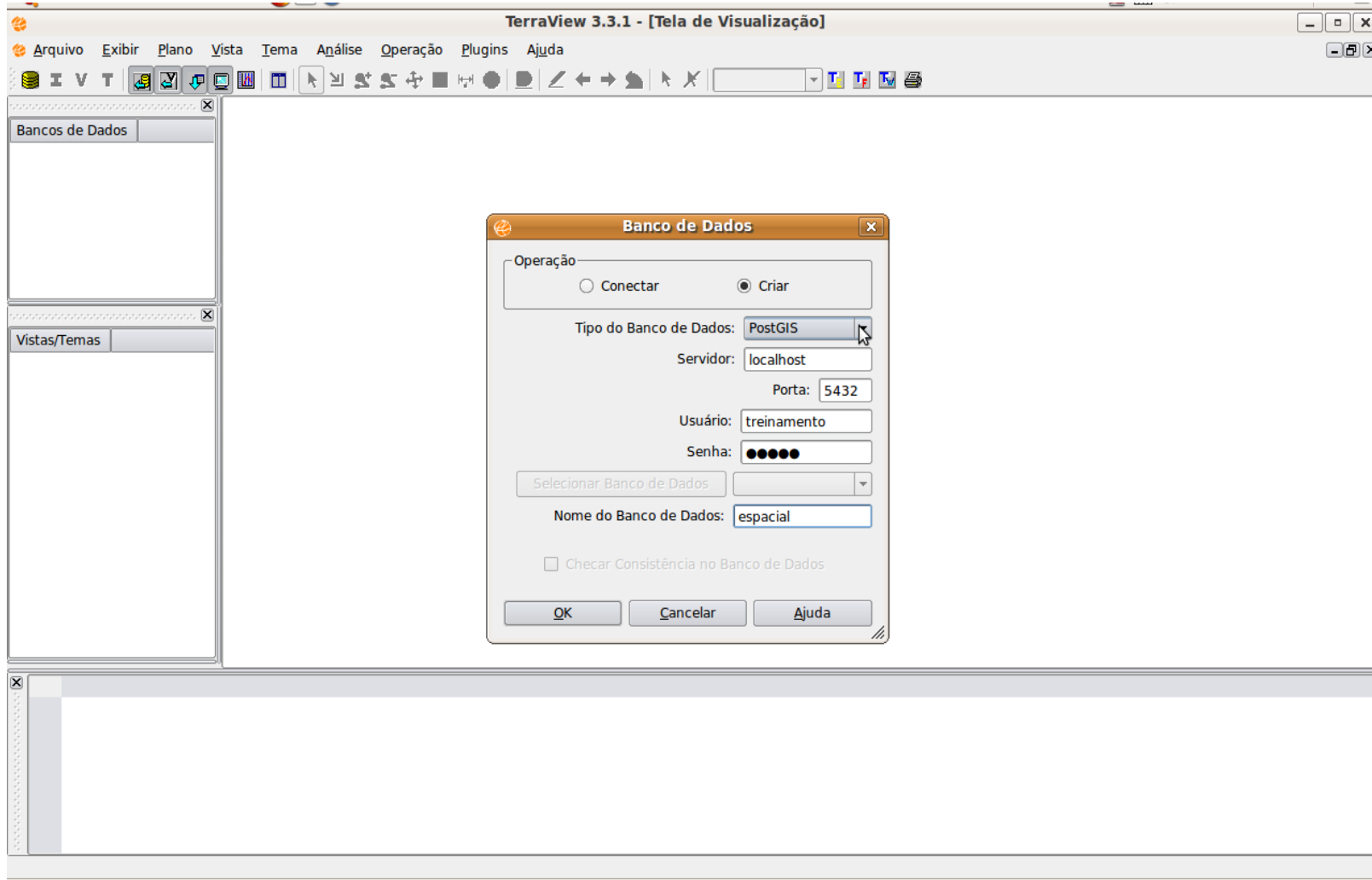
Integration with systems

uDIG
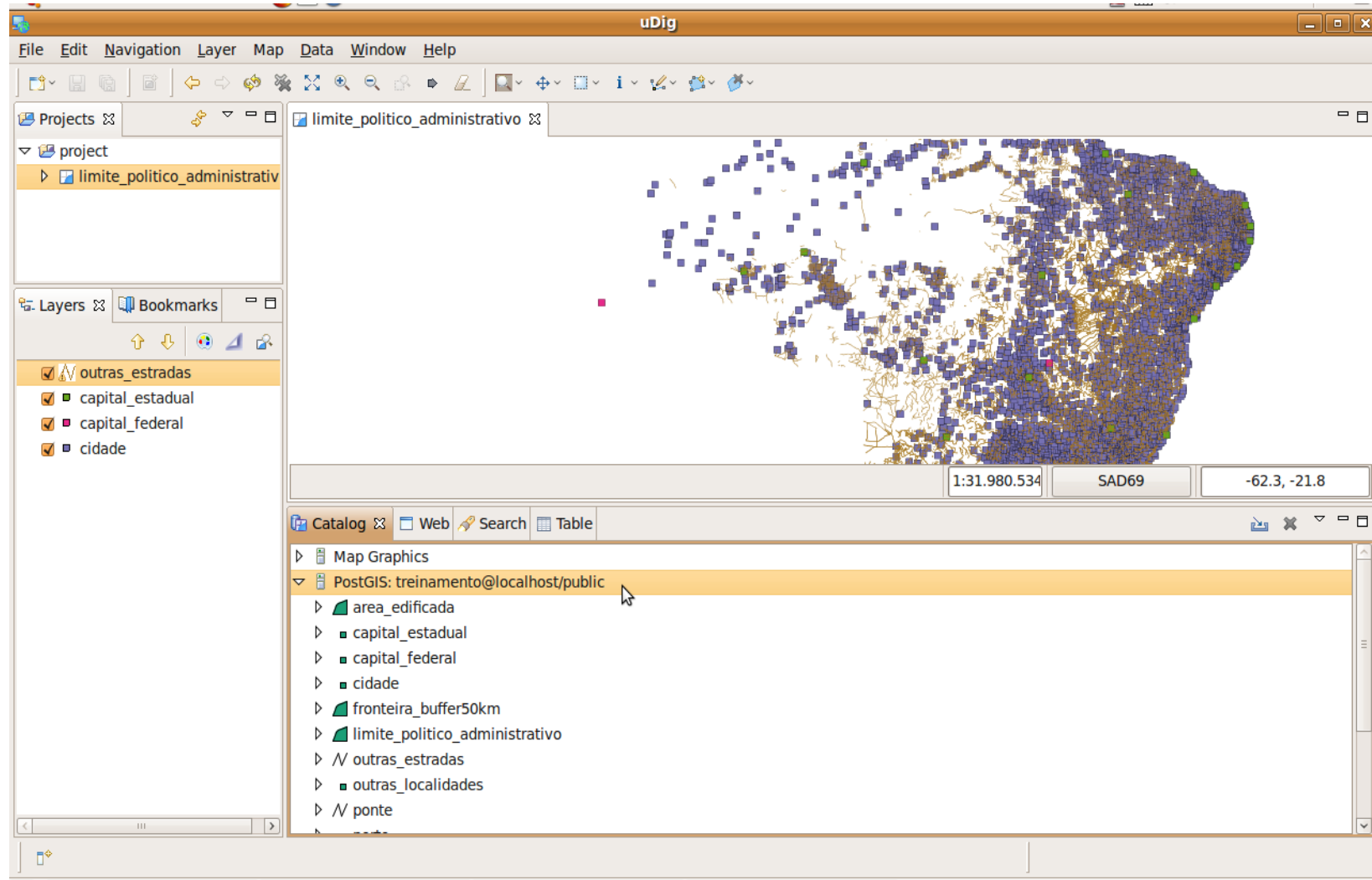
Integration with systems

Map servers provide support to PostGIS, like MapServer and GeoServer

Desktop GIS can read PostGIS database, directly or through Web Map Servicer (WMS) and Web Feature Service (WFS) protocols of OGC.

Integration with systems

GeoServer

GeoServer ©

Dados: ▇▇▇▇▇▇▇▇▇

GeoServer	Jan 24, 5:46 AM
Configuration *	Mai 16, 8:20 PM
XML	Jan 24, 5:46 AM

Aplicar | Salvar | Carregar

Meu GeoServer

Créditos

Bem-vindo | Config | Dados | Stores | Editar

Logout

Editor de DataStore

Editar uma fonte de informação geoespacial

ID do DataStore: spatial_postgis

Ativado: ☑

NameSpace: amazon ⌄

Descrição: PostGIS connection

* host: localhost

* port: 5432

schema: postgis_schema

* database: spatial

* user: treinamento

passwd: ●●●●●●

wkb enabled: true ⌄

loose bbox: true ⌄

estimated extent: false ⌄

Enviar | Limpar

* = Campo necessário

Integration with systems

Mapfile fragment (MapServer)

```
SYMBOLSET ../symbols/simbolos.sym
FONTSET    "../symbols/fontes.txt"
LAYER

      CONNECTIONTYPE postgis
      CONNECTION "host=localhost dbname=espacial
         user=treinamento password= ****** port=5432"
      DATA "the_geom from zsee_ro_carto_ae20"
      NAME "zsee_ro_carto_ae20"
      STATUS OFF
      TYPE POINT
      UNITS METERS
      CLASS
          NAME "zsee_ro_carto_ae20"
          STYLE
              COLOR 0 0 0
              SYMBOL "pt2"
              SIZE 5
          END
...
```

Integration with systems

I3GEO

http://mapas.mma.gov.br/i3geo

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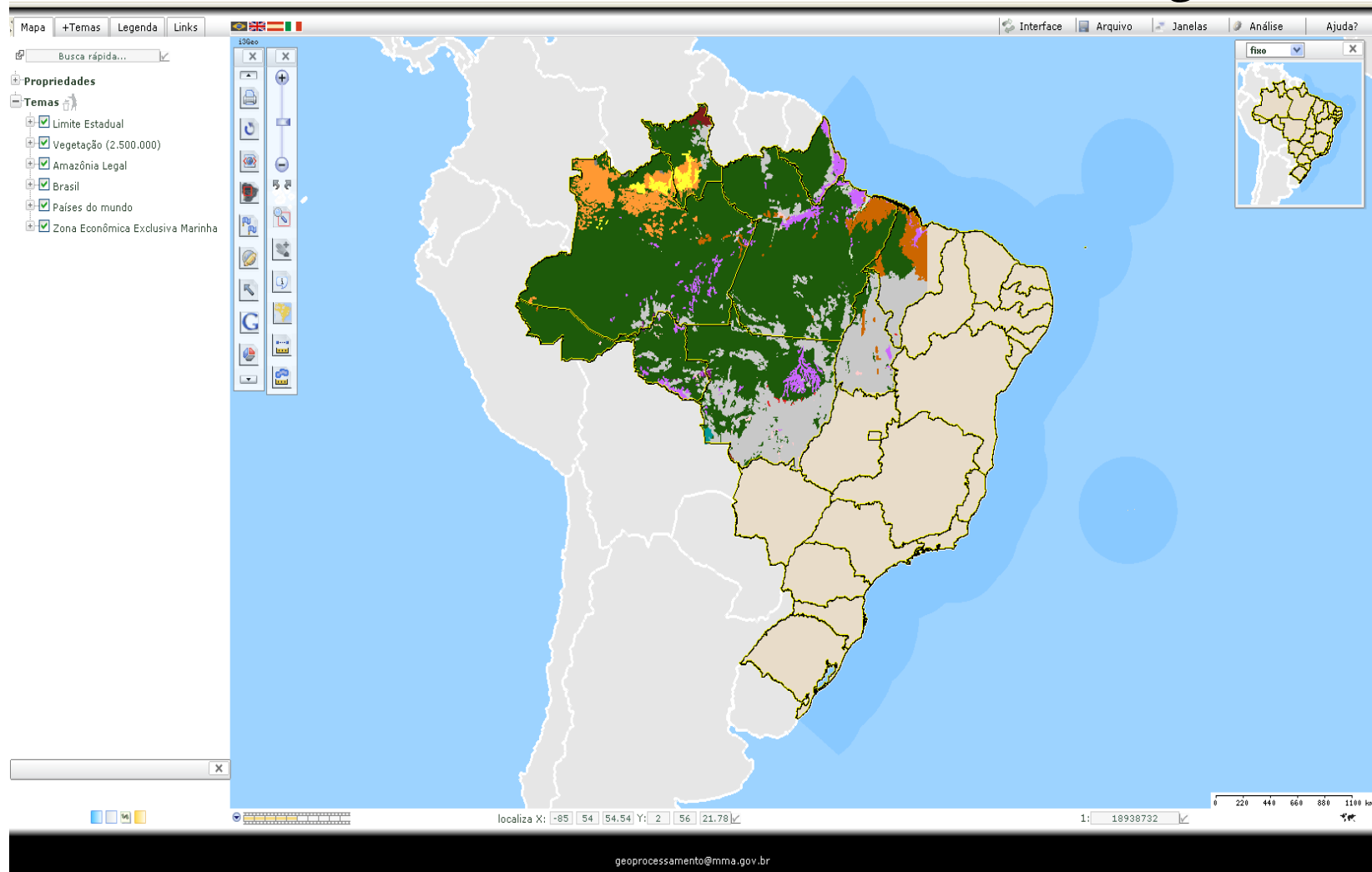
Integration with systems

InterMap

http://www2.sipam.gov.br/geonetwork/intermap

Integration with systems

PhpPgGIS is a friendly tool for
spatial data management storage in PostgreSQL/
PostGIS

http://sourceforge.net/projects/phppggis/
http://www.opengeo.com.br/br/index.php

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Integration with systems

phpPgGIS

Practical Examples
Simple queries... or Frequently Asked Questions

Calculate size of the deforested area

Polygon
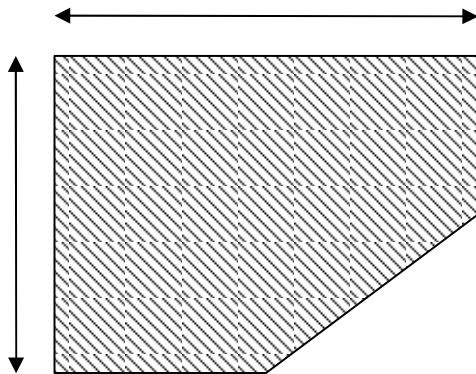
```
SELECT ST_area(ST_Transform(a.the_geom,29101))/10000
FROM desmatamento a
WHERE a.gid = 990;
```
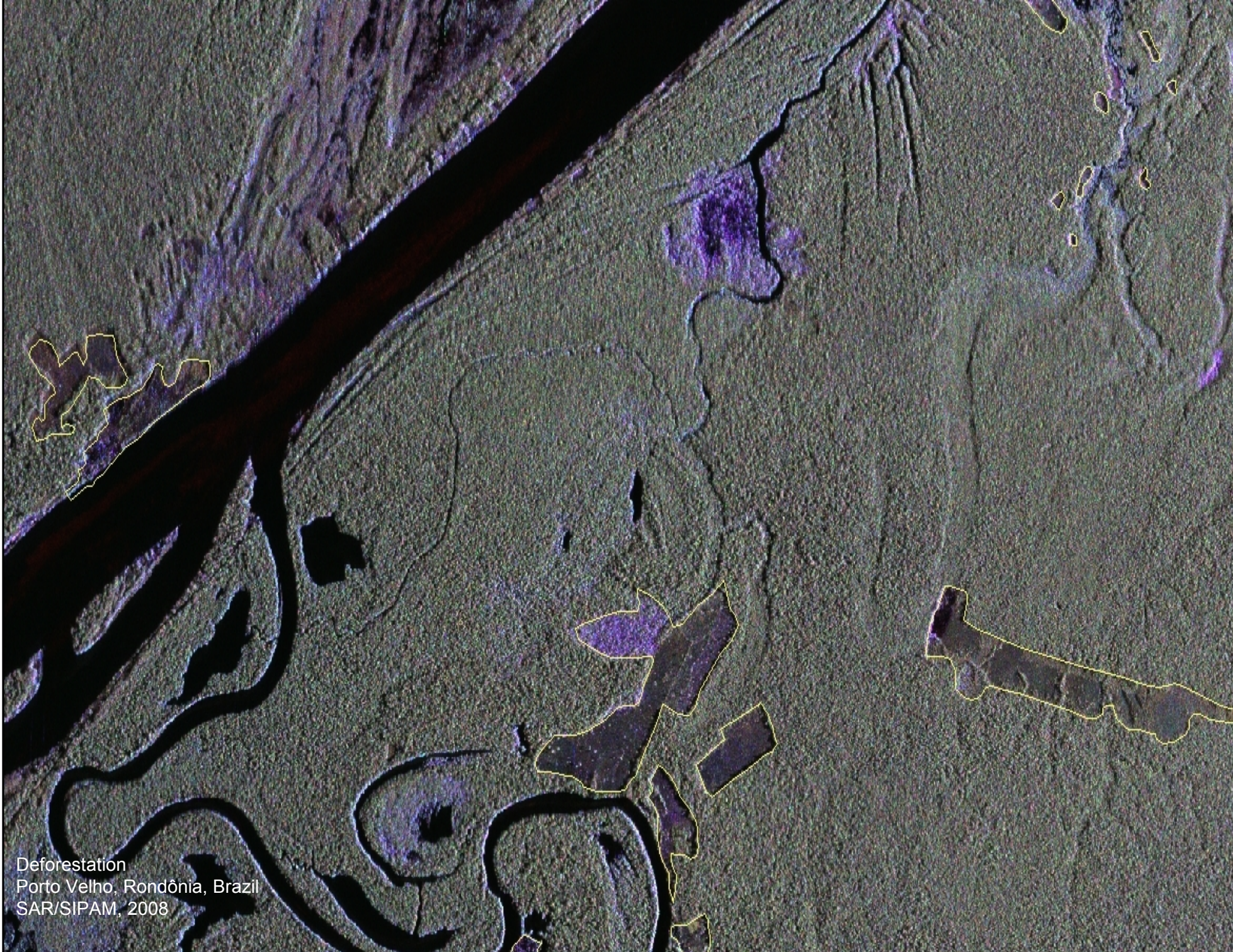
Deforestation
Porto Velho, Rondônia, Brazil
SAR/SIPAM, 2008

Practical Examples
Simple queries... or Frequently Asked Questions

Identify routes of access to protected areas
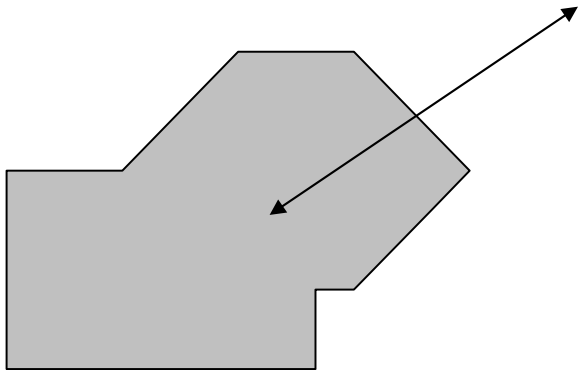
Polygon/Line

```
SELECT via.sigla as "Acesso"
FROM via, area_especial as ae
WHERE ae.nome='FLONA Jamari' and
              via.the_geom && ae.the_geom;
```

Luis Fernando Bueno – May 2009

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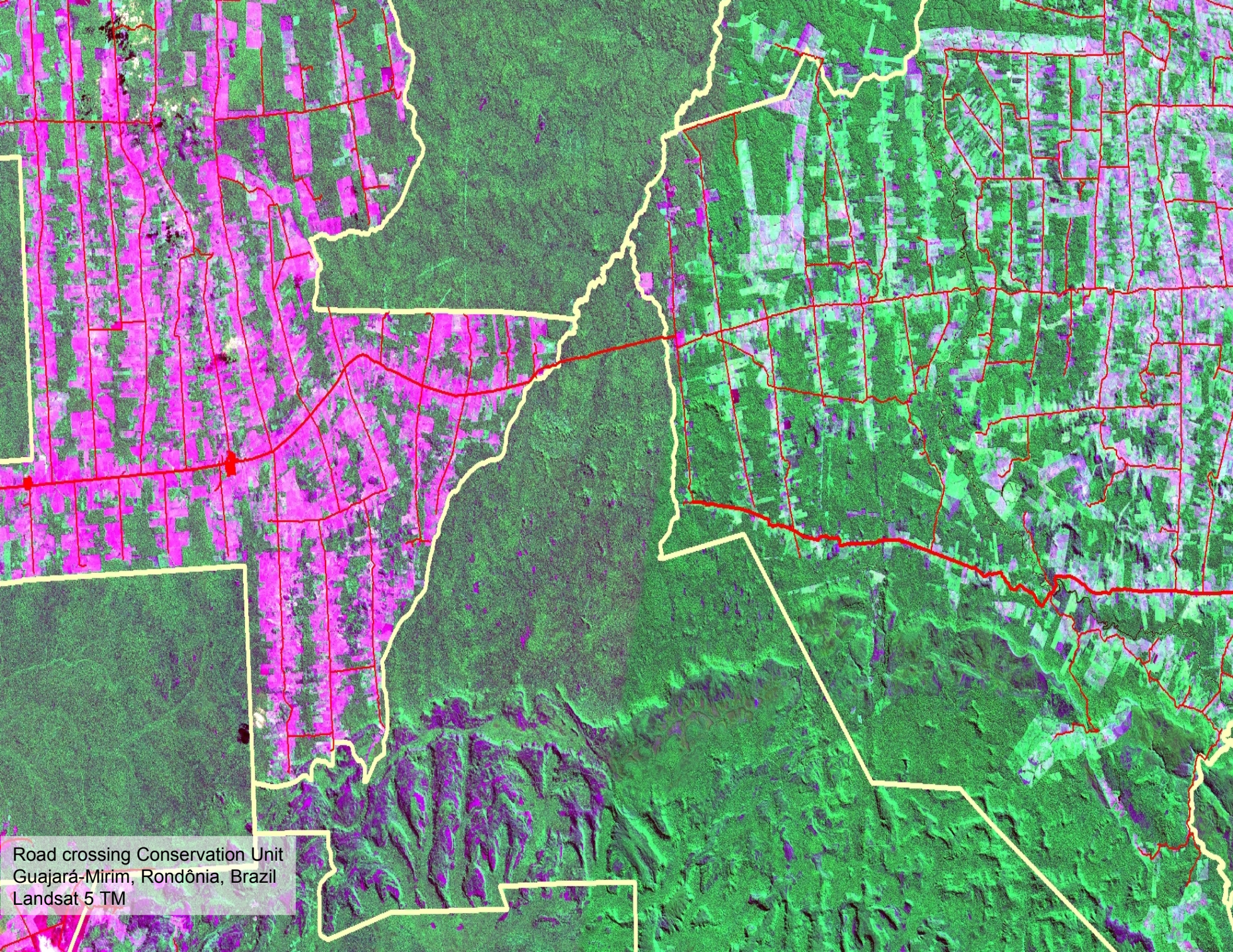
Road crossing Conservation Unit
Guajará-Mirim, Rondônia, Brazil
Landsat 5 TM

Practical Examples
Simple queries... or Frequently Asked Questions

Identify buildings near the protected areas

Point/Polygon
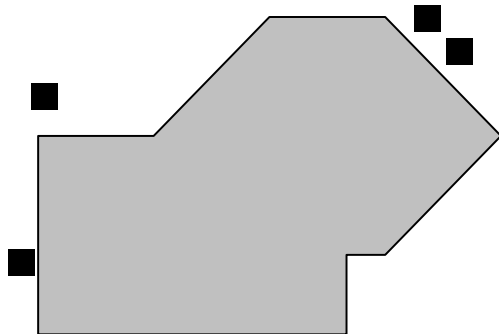
```
SELECT b.gid, b.the_geom, b.nome
FROM   area_especial a, edificacao b
WHERE a.nome = 'TI Uru-Eu-Wau-Wau' AND
    ST_Distance(ST_Transform(b.the_geom, 29101),
    ST_Transform(a.the_geom,29101))/1000 <= 10;
```
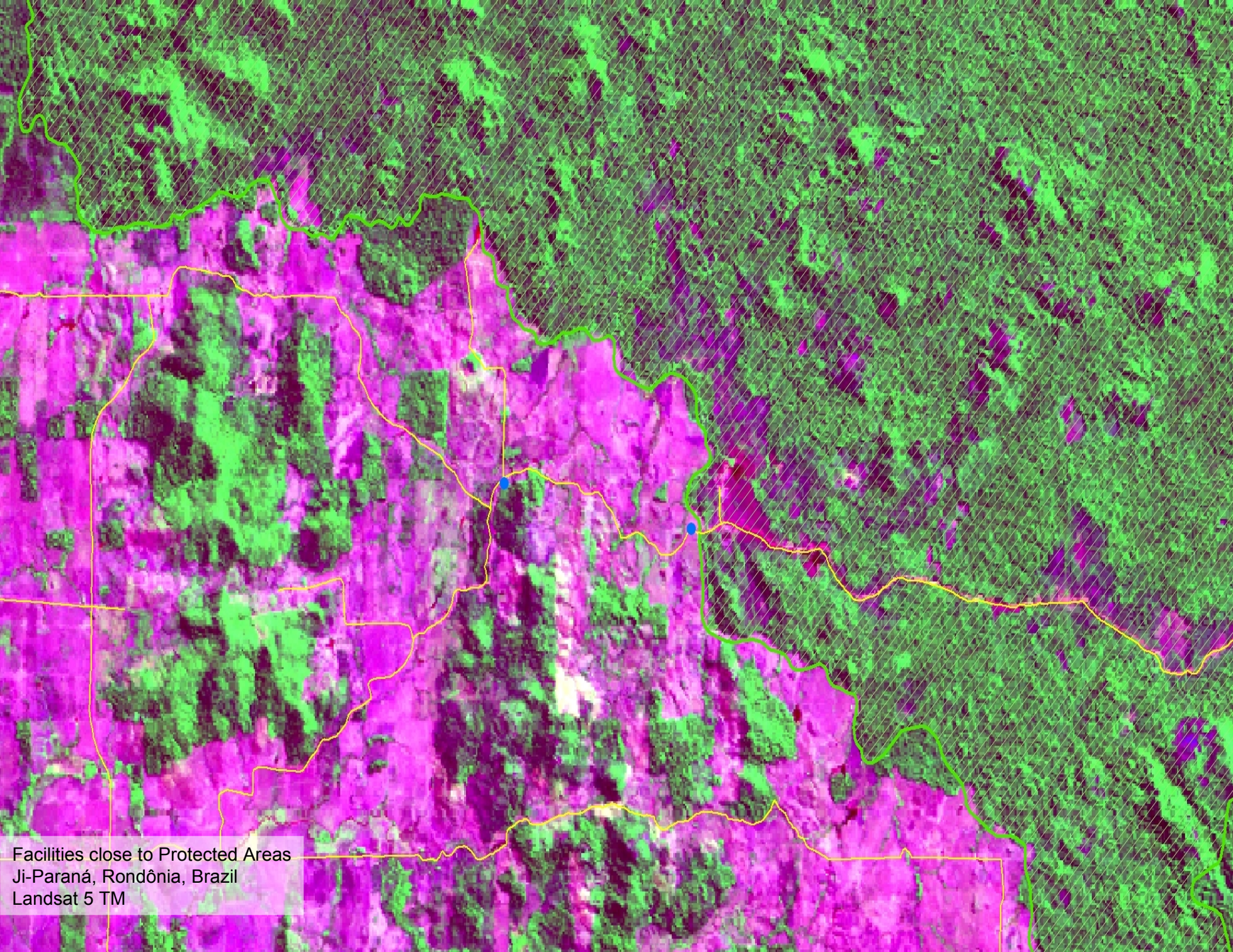
Facilities close to Protected Areas
Ji-Paraná, Rondônia, Brazil
Landsat 5 TM

Practical Examples

Simple queries... or Frequently Asked Questions

Identify schools near the principal roads

Point/Line
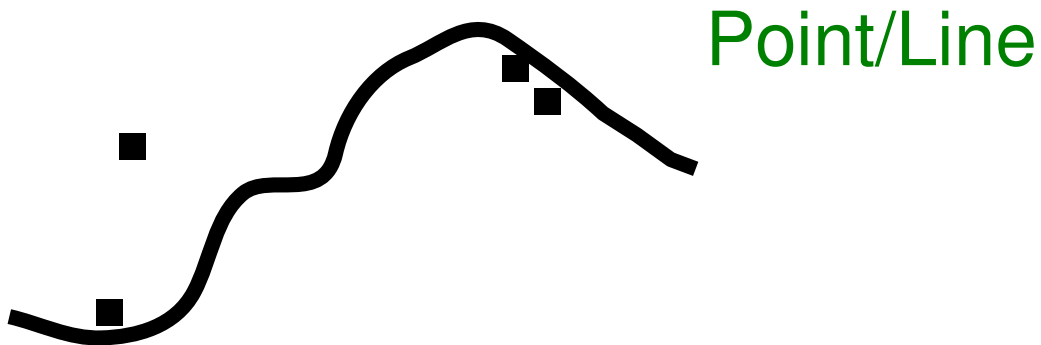
```
SELECT b.gid, b.the_geom, b.nome
FROM estrada a, escola b
WHERE a.sigla = 'RO-010' AND
    ST_Distance(a.the_geom, b.the_geom) <= 2000;
```
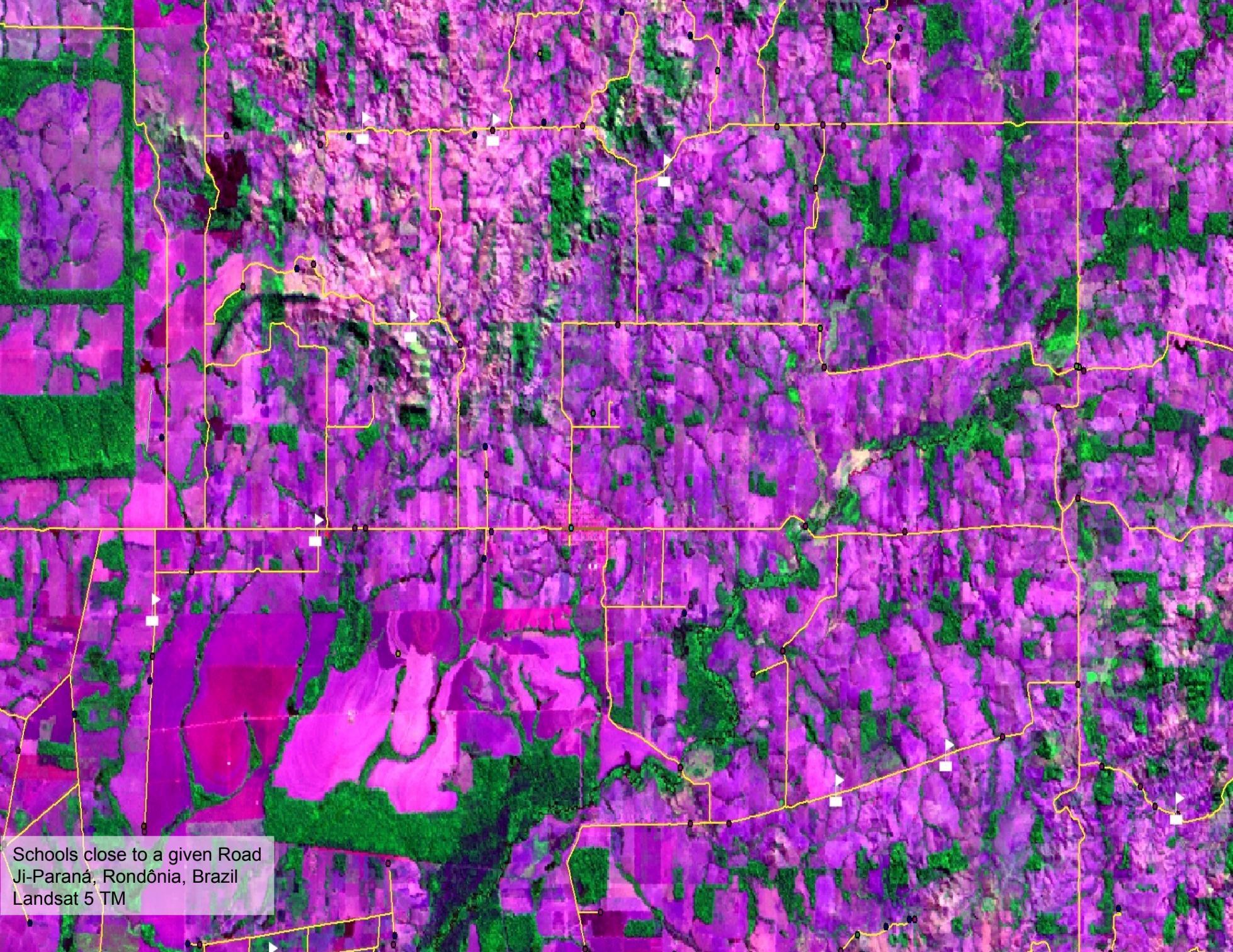
Schools close to a given Road
Ji-Paraná, Rondônia, Brazil
Landsat 5 TM

Practical Examples

Simple queries... or Frequently Asked Questions

Determine areas that may be affected by flooding
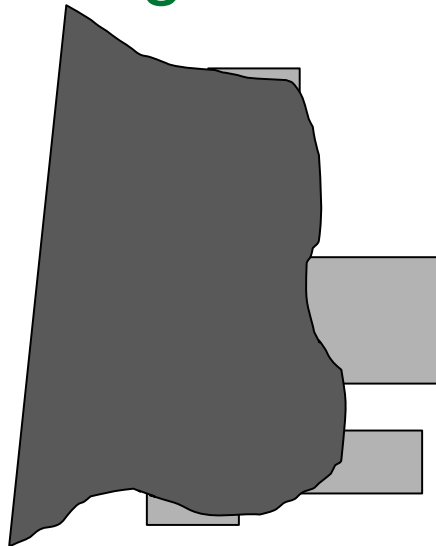
Polygon/Polygon


```
SELECT b.gid, b.the_geom, b.endereco
FROM cota a, edificacao b
WHERE ST_Intersects(a.the_geom, b.the_geom);
```

Flood
Alta Floresta D'Oeste, Rondônia, Brazil
Photo by Hallanfrank Caetano
http://www.rondoniaovivo.com/news.php?news=48300

River Ruler
Porto Velho, Rondônia, Brazil
Photo by Tatiane Emilio Checchia

Practical Examples
Simple queries... or Frequently Asked Questions

Where are heat sources occurring in the protected areas?
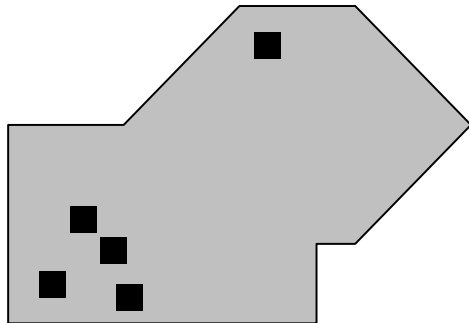
Point/Polygon

```
SELECT b.gid, b.nome, b.the_geom
        AS geom
FROM area_especial a, foco b
WHERE a.nome = 'RESEX Rio Pacaas Novos' AND
            ST_Contains(a.the_geom,b.the_geom);
```

Heat sources
Colniza, Mato Grosso, Brazil
Alberto Setzer – INPE, 2007
http://www.obt.inpe.br/fototeca/managefoto.php?ID=7291&ANO=2007&proj=CPTEC&

Practical Examples

Social Economical-Ecological Zoning of Rondonia
Database Migration for PostgreSQL/PostGIS

Subzones

- 1.1
- 1.2
- 1.3
- 1.4
- 2.1
- 2.2
- 3.1
- 3.2
- 3.3
- Samuel Lake

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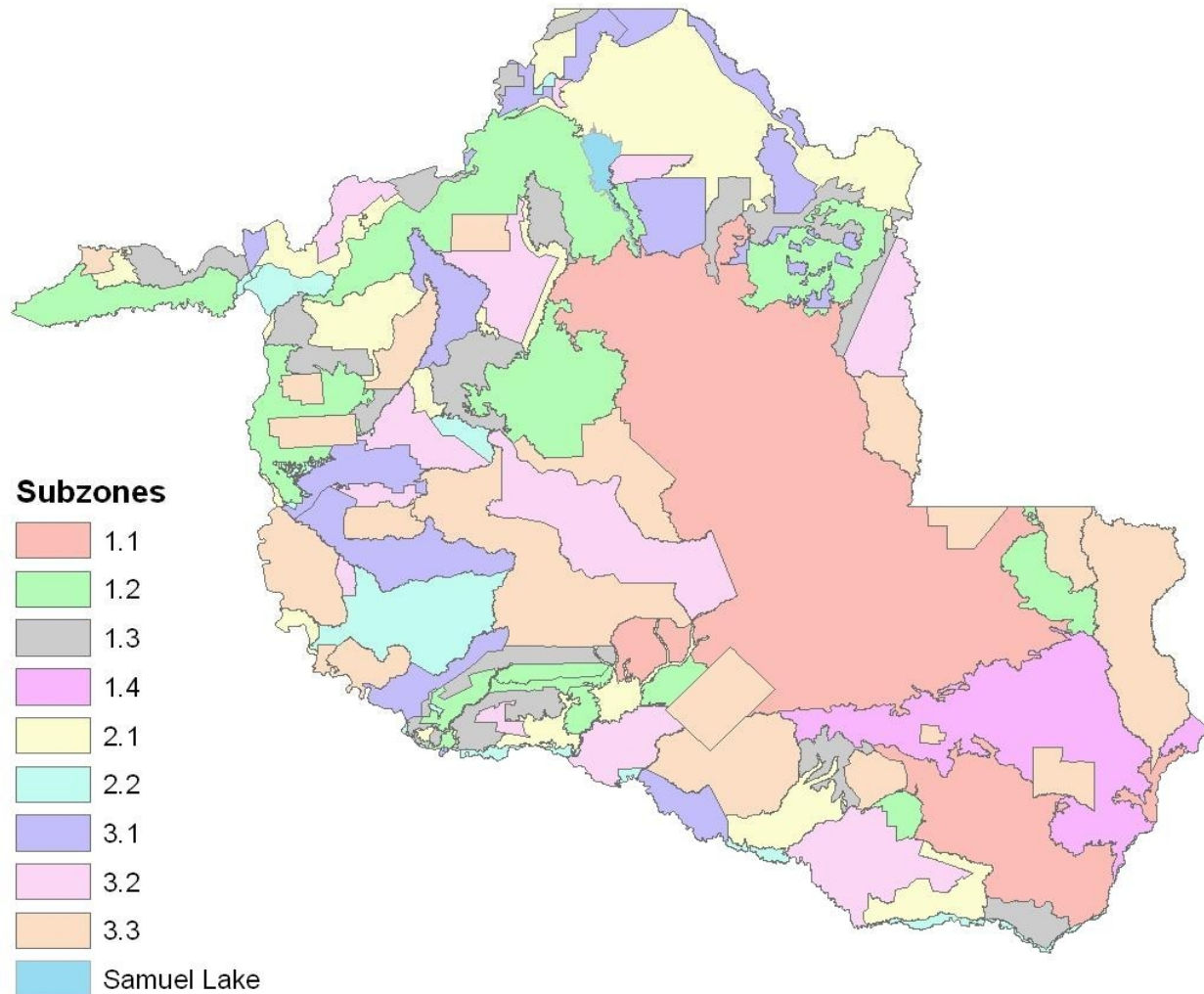
Practical Examples

Social Economical-Ecological Zoning of Rondonia
Database Migration for PostgreSQL/PostGIS

- The economic and social development of Rondônia are consistent with the zoning?

- The proposed environmental restrictions are being met by zoning?

- The advance of deforestation compromises the protected areas defined?

- The agricultural activities developed in the various zones are suitable?

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Geoprocessamento
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Why PostGIS?

The world's most advanced open source database!

Guaranteed interoperability

Conformance with OGC standards

Without licensing costs

Opportunities

We can do it!

- Two scenarios for spatial data manipulation in Brazilian Amazon:

  – PostgreSQL and PostGIS for Spatial Data Infrastructure based in free and open source software;

  – Server-Side Programming for Spatial Analysis.

Opportunities

We can do it!

Client Aplications	i³Geo	QGIS	gvSIG	uDig

Interfaces

Direct Access		WMS (GIF, PNG, JPG, KML)	WFS (GML, Shapefile)	CSW (FGDC, ISO19115/ 19119/19139)

Servers

Powered by Map Server — GeoNetwork Opensource — THE GeoServer PROJECT — the open Internet gateway for geographic data

Database

PostgreSQL POWERED — PostGIS Spatial PostgreSQL

Information flow

Opportunities

We can do it!
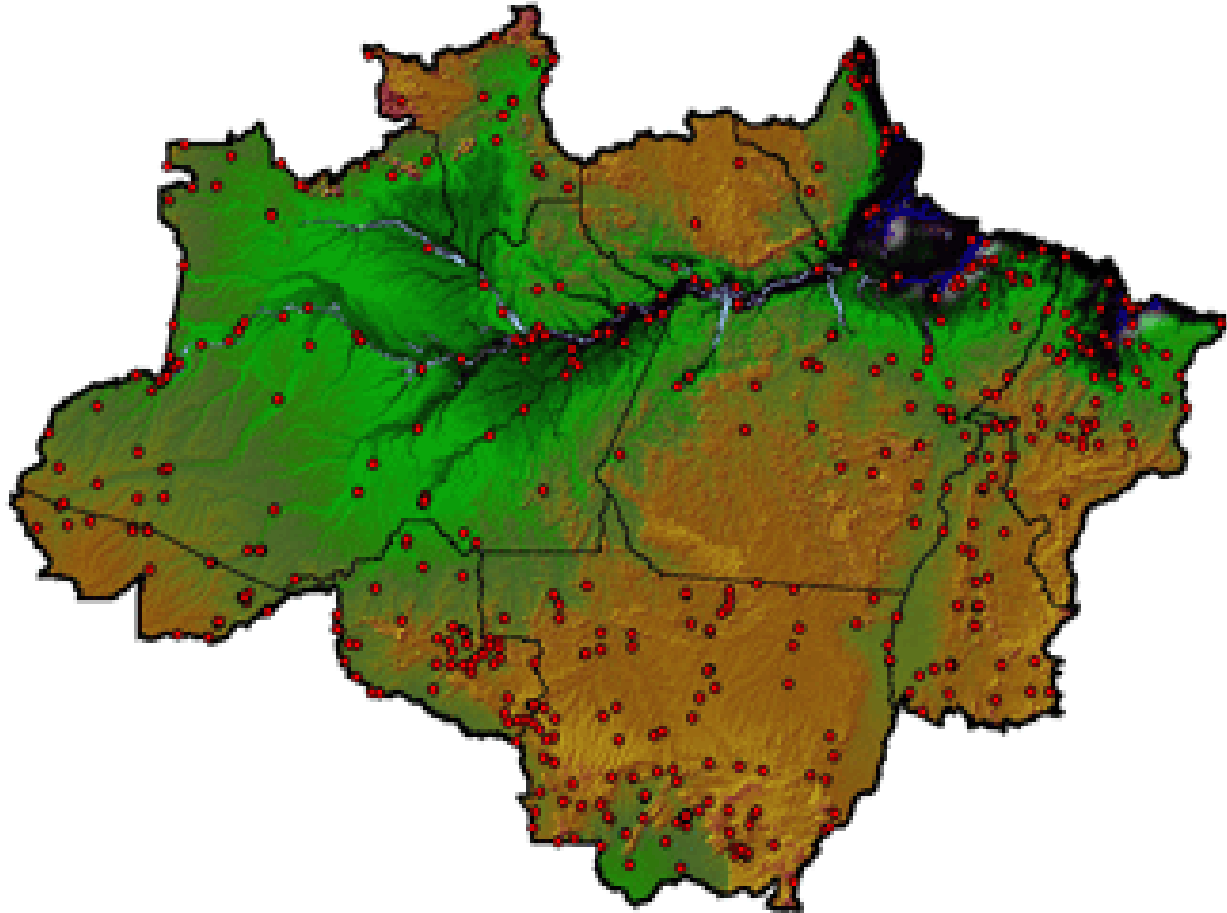
Terminals of Remote Users in Brazilian Amazon
Amazonian Protection System - SIPAM
http://www.sipam.gov.br/content/view/42/51/
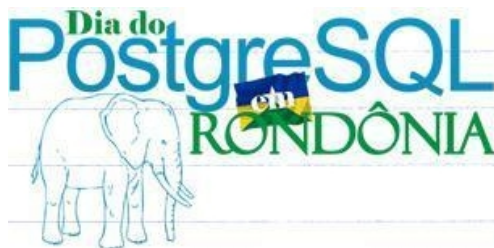
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Opportunities?
Oh yes! PostgreSQL in the Amazon!

First event of PostgreSQL in north Brazil

PGDay Porto Velho – April, 29
85 participants

PGDay Ji-Paraná – April, 30
103 participants

Dia do PostgreSQL em RONDÔNIA

http://www.postgresro.com

References

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   http://www.dpi.inpe.br/geopro/referencias/karla_tese.pdf

Câmara, Gilberto; Casanova, Marco A.; Hemerly, Andrea S.; Magalhães, Geovane C.; Medeiros, Claudia M. B. Anatomia de Sistemas de Informações Geográficas.
   http://mtc-m12.sid.inpe.br/col/sid.inpe.br/sergio/2004/10.07.13.36/doc/anatomia.pdf

Carvalho, Marilia Sá; SANTOS, Reinaldo Souza. Análise de dados espaciais em saúde pública: métodos, problemas, perspectivas.
   http://www.scielo.br/pdf/csp/v21n2/03.pdf

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    http://www.postgresql.org/docs/8.3/static/index.html

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    http://postgis.refractions.net/

Samet, Hanan; Aref, Walid G. Spatial Data Models and Query Processing.
    https://eprints.kfupm.edu.sa/66098/1/66098.pdf

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Spatial Data Manipulation in the Rain Forest

Thanks for the attention (and patience!)

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Sunset in Madeira River
Porto Velho, Rondônia, Brazil
Photo by Euler Taveira

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