

Saving the Amazon with PostGIS

Spatial Data Manipulation in the Rain Forest



Luis Fernando Bueno



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 occurrences 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 its attributes



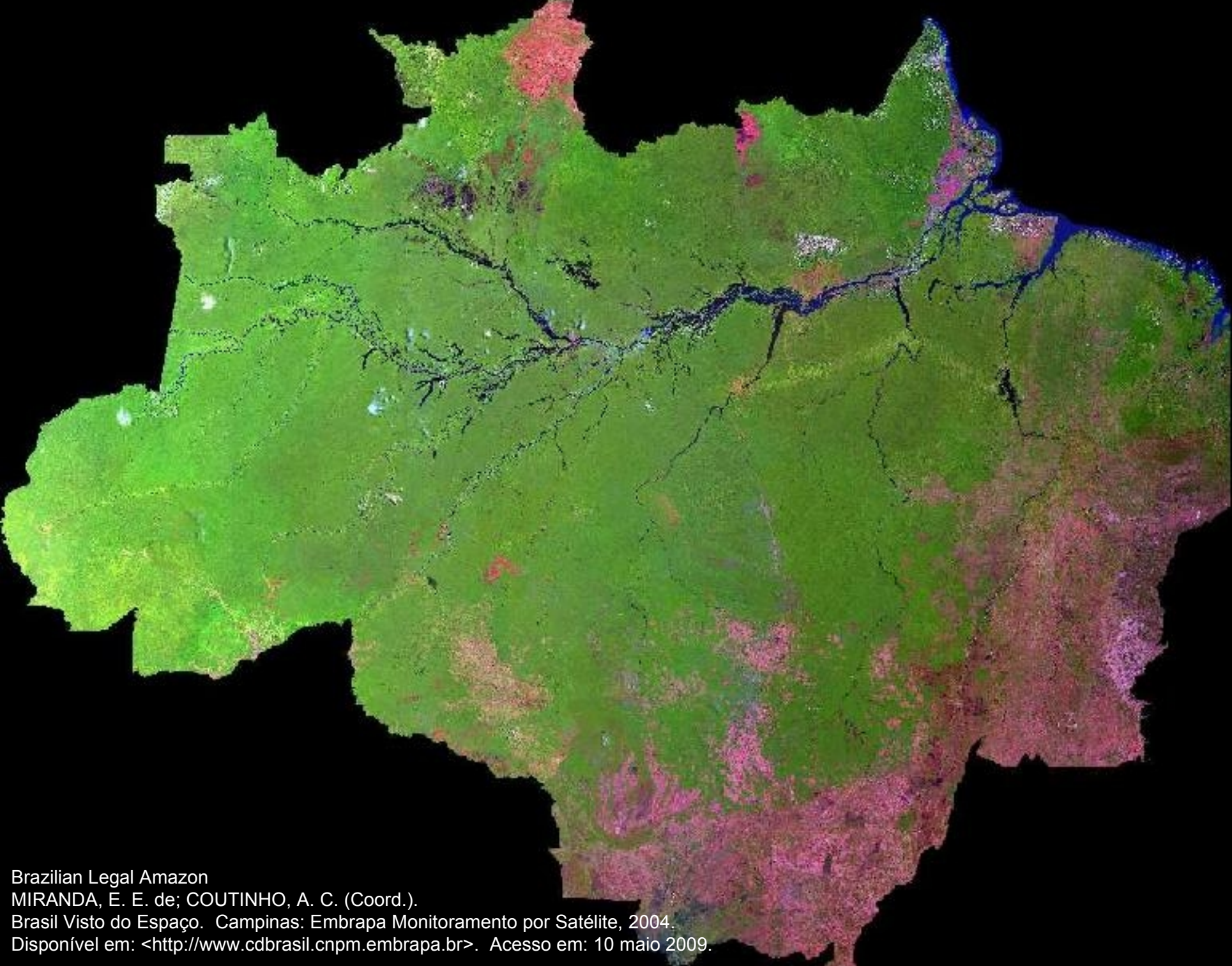
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ILES/ULBRA PORTO VELHO



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

© 2009 Google
Image © 2009 DigitalGlobe

© 2009 MapLink/TeleAtlas

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.



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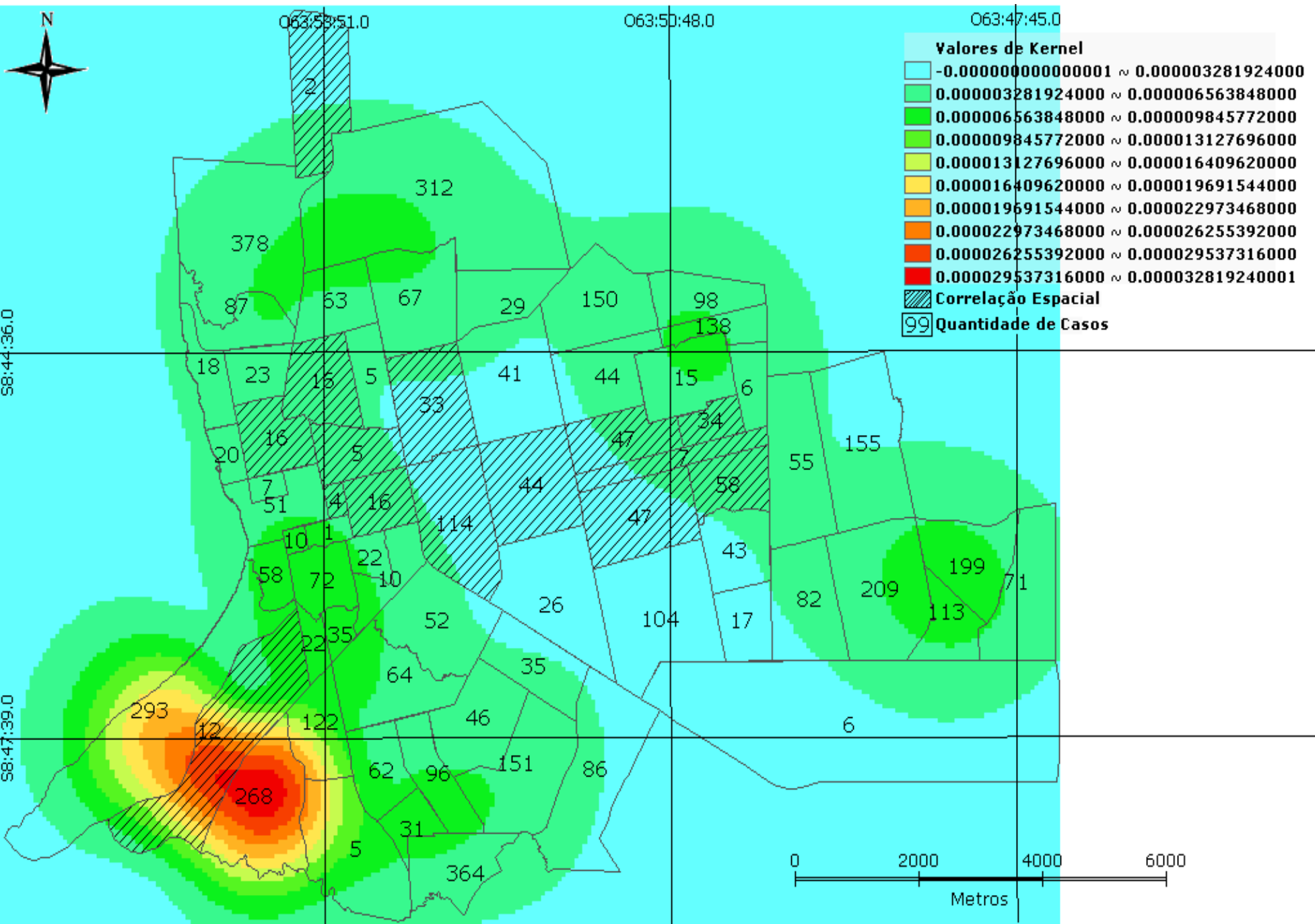
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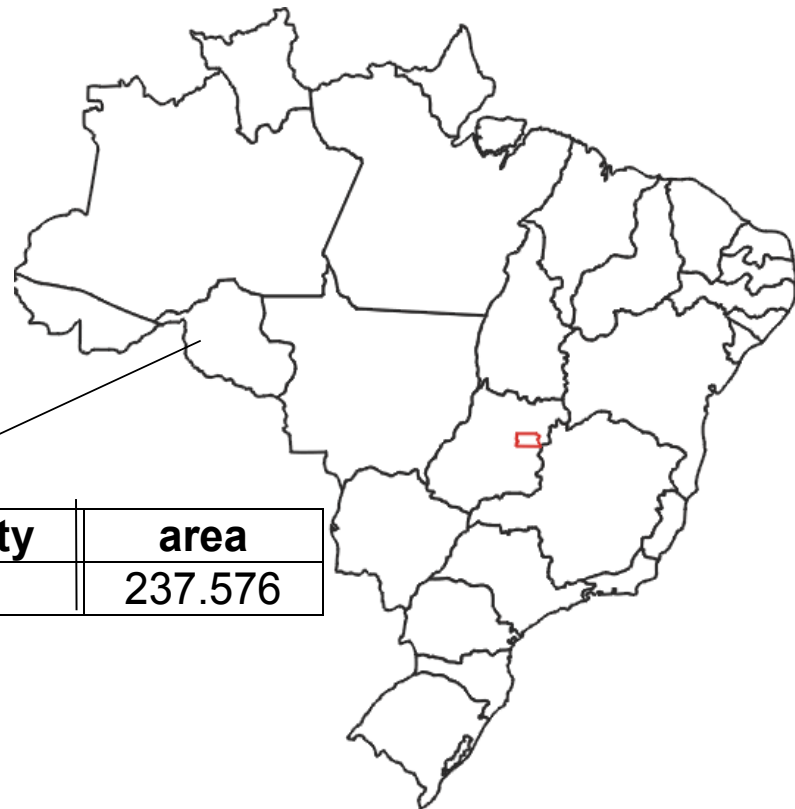
Kernel Estimation of Malaria in Porto Velho (2006)

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



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



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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 Refrations Research Inc.

<http://postgis.refrations.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



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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 stored in
Well Known Text (WKT) format



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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

Edit Data - minha_conexao (localhost:5432) - treinamento - cidade

Arquivo Editar Visualizar Ajuda

Sem limite

	gid [PK] integ	MD_LONG character	MD_LATIT character	GEOCODIC character	ESTADO character	UF character	NM_NOME character	the_geom geometry
1	0	-70:12:40	1:15:54.6				Mitu	01010000200A12000098C3EE3B868D51C0B421FFCC203EF43F
2	1	-67:33:21	2:43:10.7				Maroa	01010000200A120000DD0A613596E350C0CF9F36AAD3C10540
3	2	-67:50:13	3:51:12.8				Pto. Inrida	01010000200A120000B491EBA694F550C0D1E9793716D40E40
4	3	-67:04:55	1:50:47.4				San Felipe	01010000200A120000C2C2499A3FC550C04C6BD3D85E8BF3F
5	4	-67:03:04	1:51:21.4				San Carlos	01010000200A120000FF3C0D1824C350C05A8121AB5BDDF3F
6	5	-50:47:21	1:44:43.5	160055005	AMAP	AP	Pracuba	01010000200A1200007A371614066549C0E3E2A8DC44EDFB3F
7	6	-50:47:44	2:03:09.6	160010505	AMAP	AP	Amap	01010000200A1200006EFB1EF5D76549C0AC1A84B9DD6B0040
8	7	-67:57:18	-9:48:54.	120013805	ACRE	AC	Bujari	01010000200A120000D26EF4311FFD50C0AB5CA8FC6BA123C0
9	8	-67:08:13	-10:16:50	120038505	ACRE	AC	Plcido de Ca	01010000200A120000F48C7DC9C6C850C01DE6C80BB08F24C0
10	9	-70:46:19	-8:09:25.	120060905	ACRE	AC	Tarauac	01010000200A120000705E9CF86AB151C04694F6065F5020C0
11	10	-70:21:03	-8:10:13.	120030205	ACRE	AC	Feij	01010000200A120000DB317557769651C0D1949D7E505720C0
12	11	-61:07:49	1:49:39.5	140020905	RORAIMA	RR	Caracara	01010000200A120000170FEF39B0904EC04DD7135D173EFD3F
13	12	-61:02:29	2:10:58.9	140028205	RORAIMA	RR	Iracema	01010000200A120000CAA31B6151854EC0164F3DD2E0760140
14	13	-60:54:34	2:26:23.9	140030805	RORAIMA	RR	Mucaja	01010000200A120000FD6838656E744EC01FA1664815850340
15	14	-61:18:25	2:59:18.8	140005005	RORAIMA	RR	Alto Alegre	01010000200A12000089B48D3F51A74EC062D68BA19CE80740
16	15	-61:22:09	3:38:44.5	140002705	RORAIMA	RR	Amajari	01010000200A120000139B8F6B43AF4EC0048E041A6C2A0D40
17	16	-60:26:20	0:56:23.8	140047205	RORAIMA	RR	Rorainpolis	01010000200A1200002A3BFD02E384EC02CBAF59A1E14EE3F
18	17	-60:02:30	1:00:36.6	140060505	RORAIMA	RR	So Luiz	01010000200A12000006F357C85C054EC0BB5E9A22C029F03F
19	18	-59:54:47	0:57:05.9	140050605	RORAIMA	RR	So Joo da B	01010000200A1200003755F7C8E6F44DC0C6353E93FD73EE3F
20	19	-59:41:45	0:53:03.1	140023305	RORAIMA	RR	Caroebe	01010000200A1200004DFDDCA12D94DC085CD0017644BEC3F
21	20	-60:36:20	2:36:35.7	140017505	RORAIMA	RR	Cant	01010000200A120000530438BD8B4D4EC08C2D043928E10440
22	21	-59:49:59	3:21:41.8	140015905	RORAIMA	RR	Bonfim	01010000200A120000DFE00B93A9EA4DC0B9347EE195E40A40
23	22	-59:37:13	3:53:07.0	140040705	RORAIMA	RR	Normandia	01010000200A120000BE2F2E5569CF4DC0DAE1AFC91A150F40
24	23	-61:08:51	4:28:47.6	140045605	RORAIMA	RR	Pacaraima	01010000200A120000306475ABE7924EC0410E4A9869EB1140
25	24	-60:10:53	4:36:11.3	140070405	RORAIMA	RR	Uiramut	01010000200A1200005FB35C363A174EC0501DAB949E691240
26	25	-54:05:34	3:39:07.3				Benzdom	01010000200A120000331AF9BCF20B48C0D1CF691668370D40

5755 registros.



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)
```



PostGIS for data manipulation

Storage of spatial data

Basic geometrics types (OGC)

POINT

POLYGON

LINestring

Array of geometrics types

MULTIPOINT

MULTIPOLYGON

MULTILINestring

GEOMETRYCOLLECTION



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PostGIS for data manipulation

Bounding Box Operators

```
A &< B  
A &> B  
A << B  
A >> B  
A &< | B  
A | &> B  
A << | B  
A | >> B  
A ~= B  
A @ B  
A ~ 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;
```



Spatial data manipulations

Other examples

Which cities are neighbouring Ariquemes?

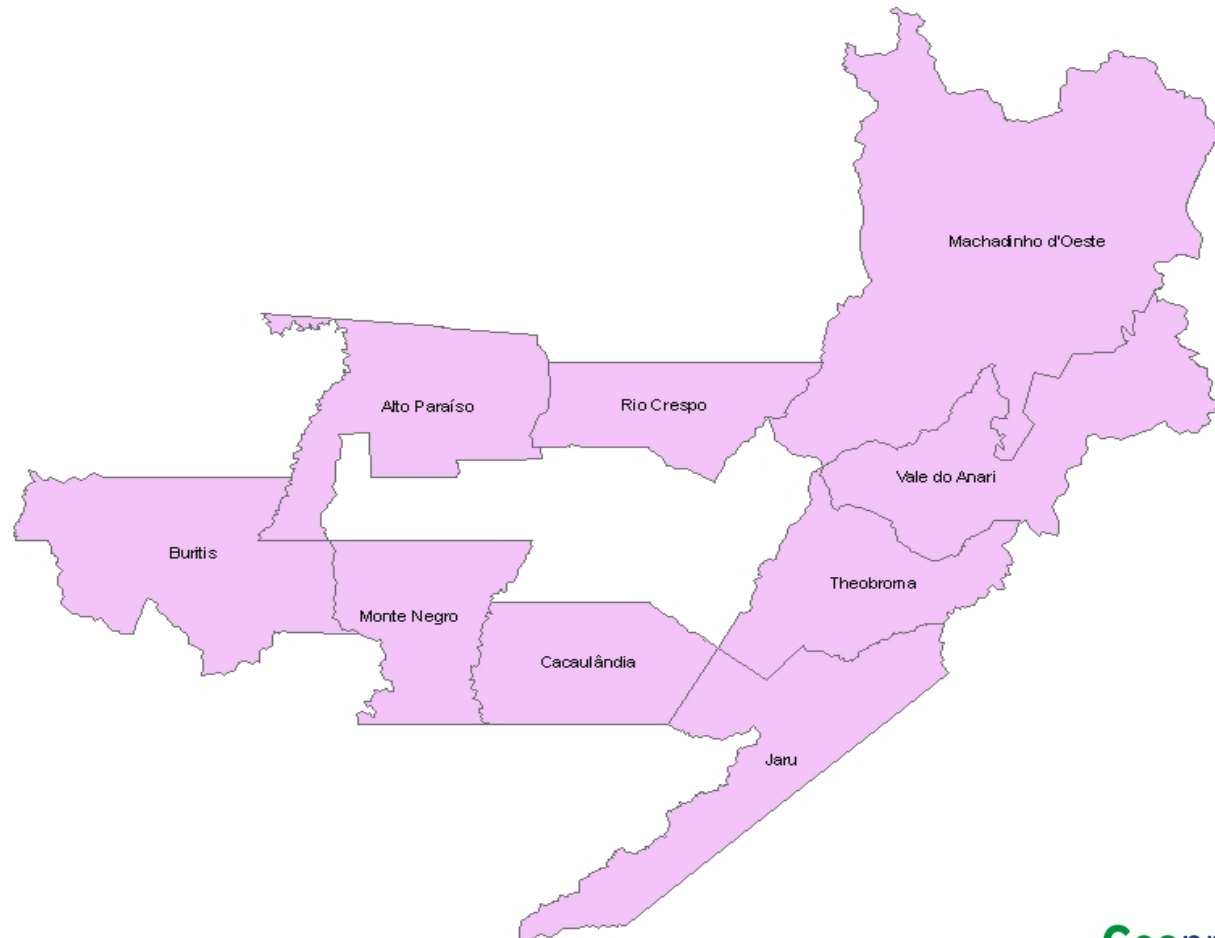
```
SELECT m2.nome as "Nome"  
FROM municipio_brasil m1, municipio_brasil m2  
WHERE ST_Touches(m1.the_geom,m2.the_geom) AND  
      m1.nome_munic='Ariquemes';
```



Spatial data manipulations

Other examples

Which 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';
```



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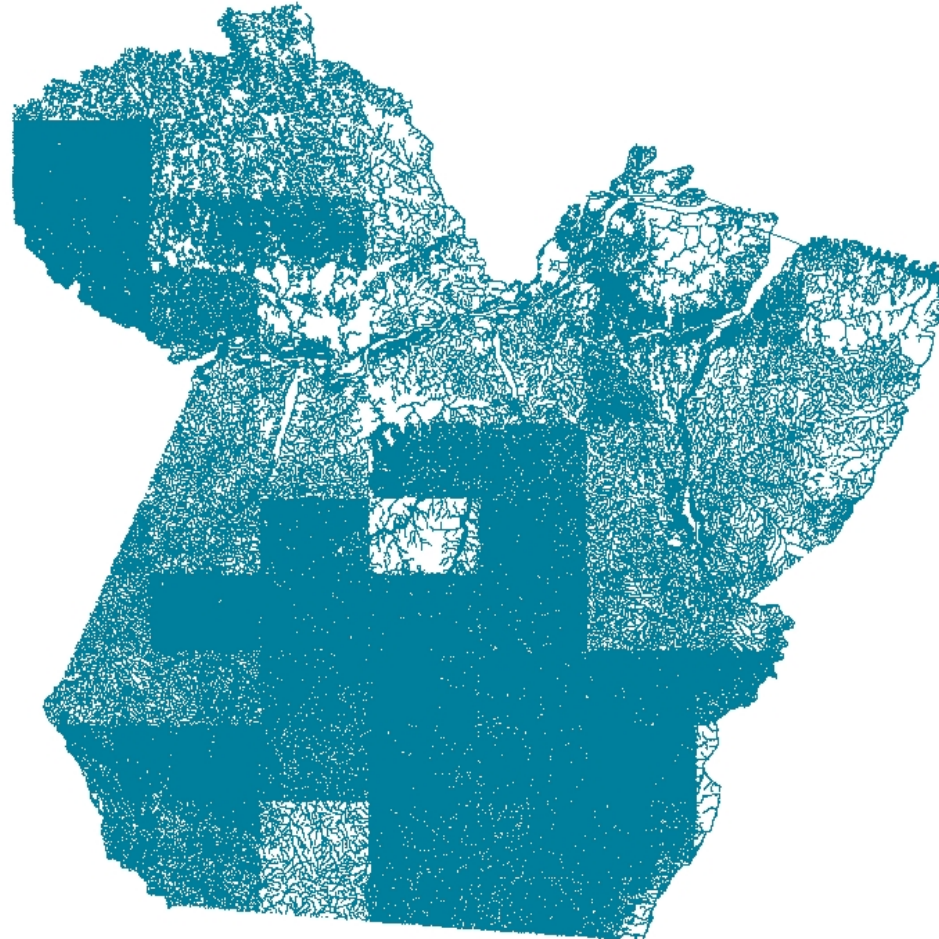


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Spatial data manipulations

Other examples

Which rivers are contained in Pará State?



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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';
```



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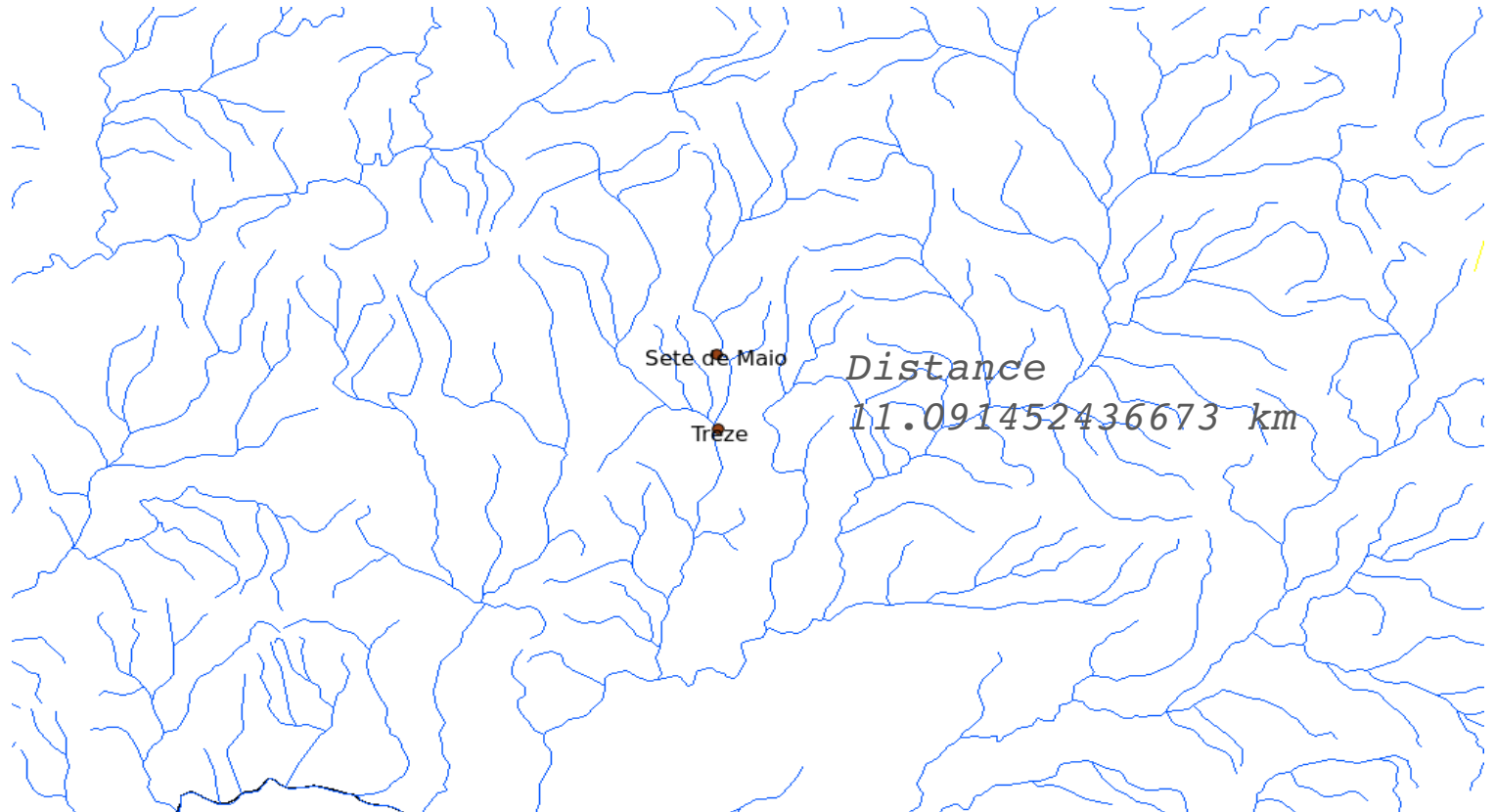


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Spatial data manipulations

Other examples

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



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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
```



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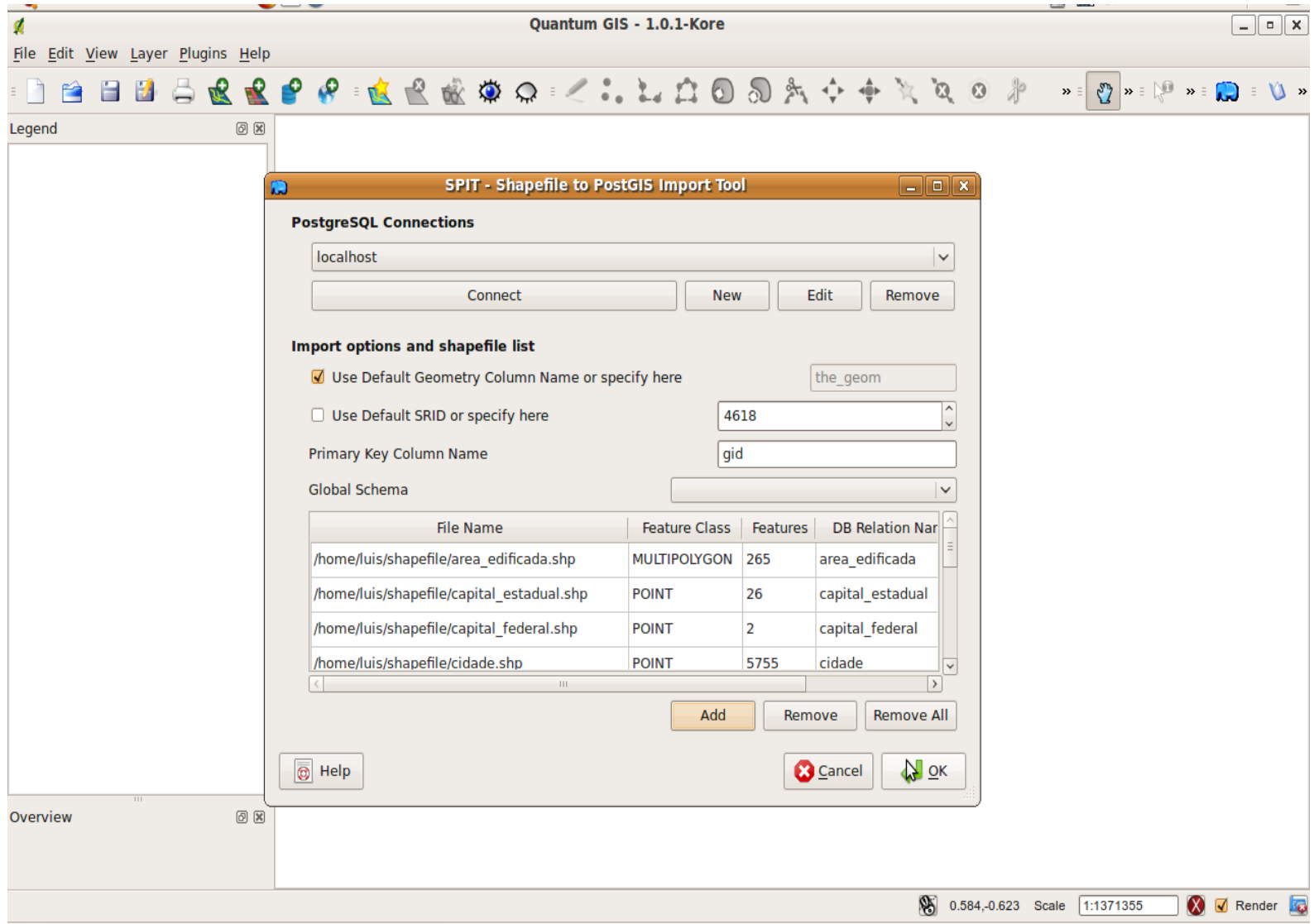
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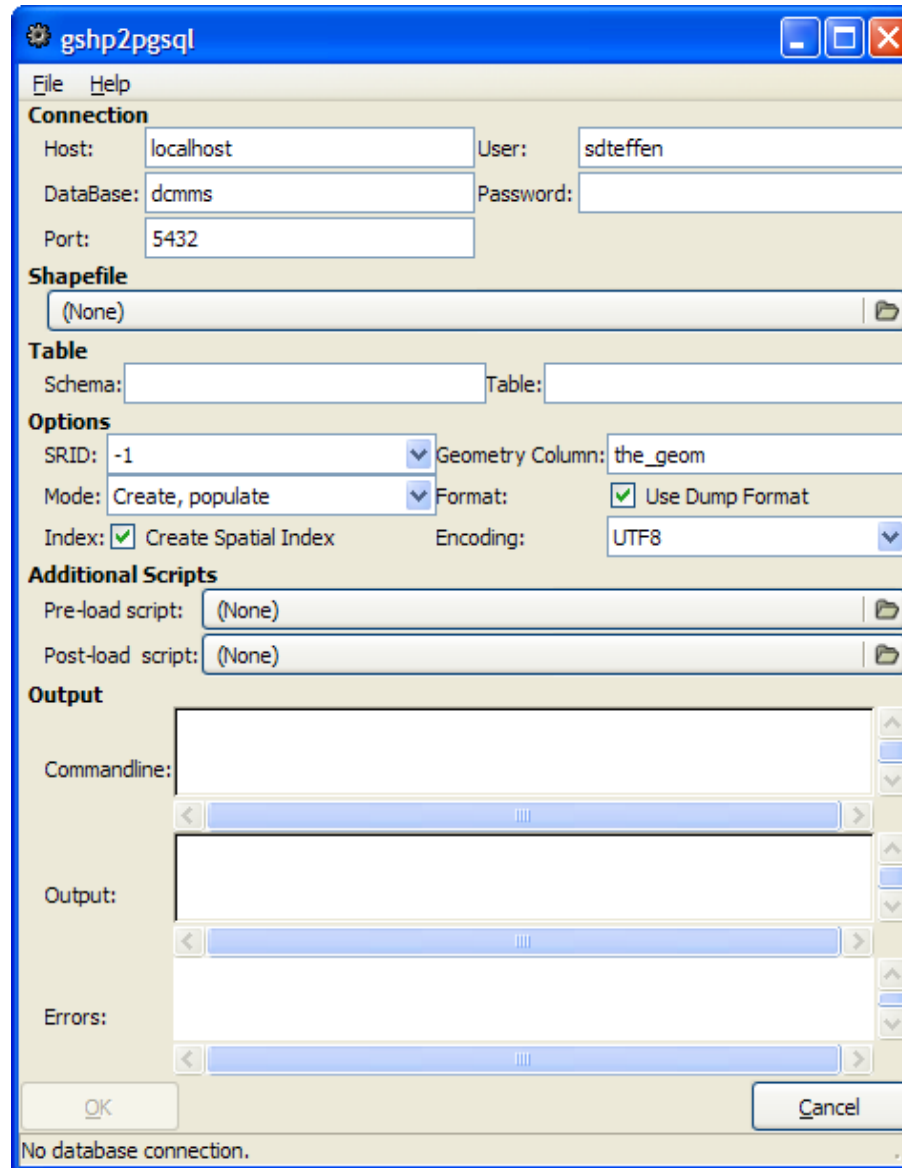
Integration with systems

SPIT plugin - Quantum GIS



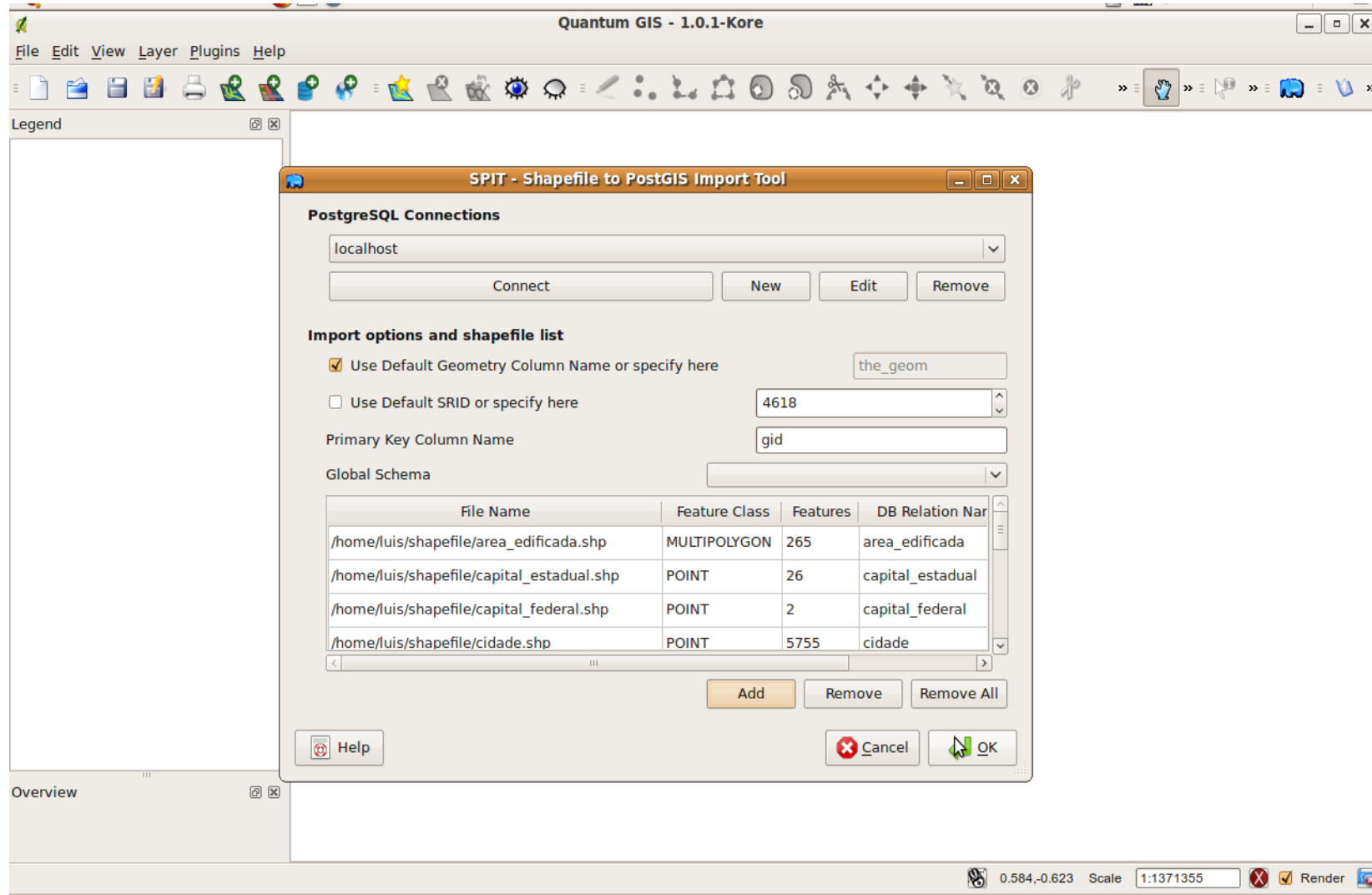
Integration with systems

gshp2pgsql



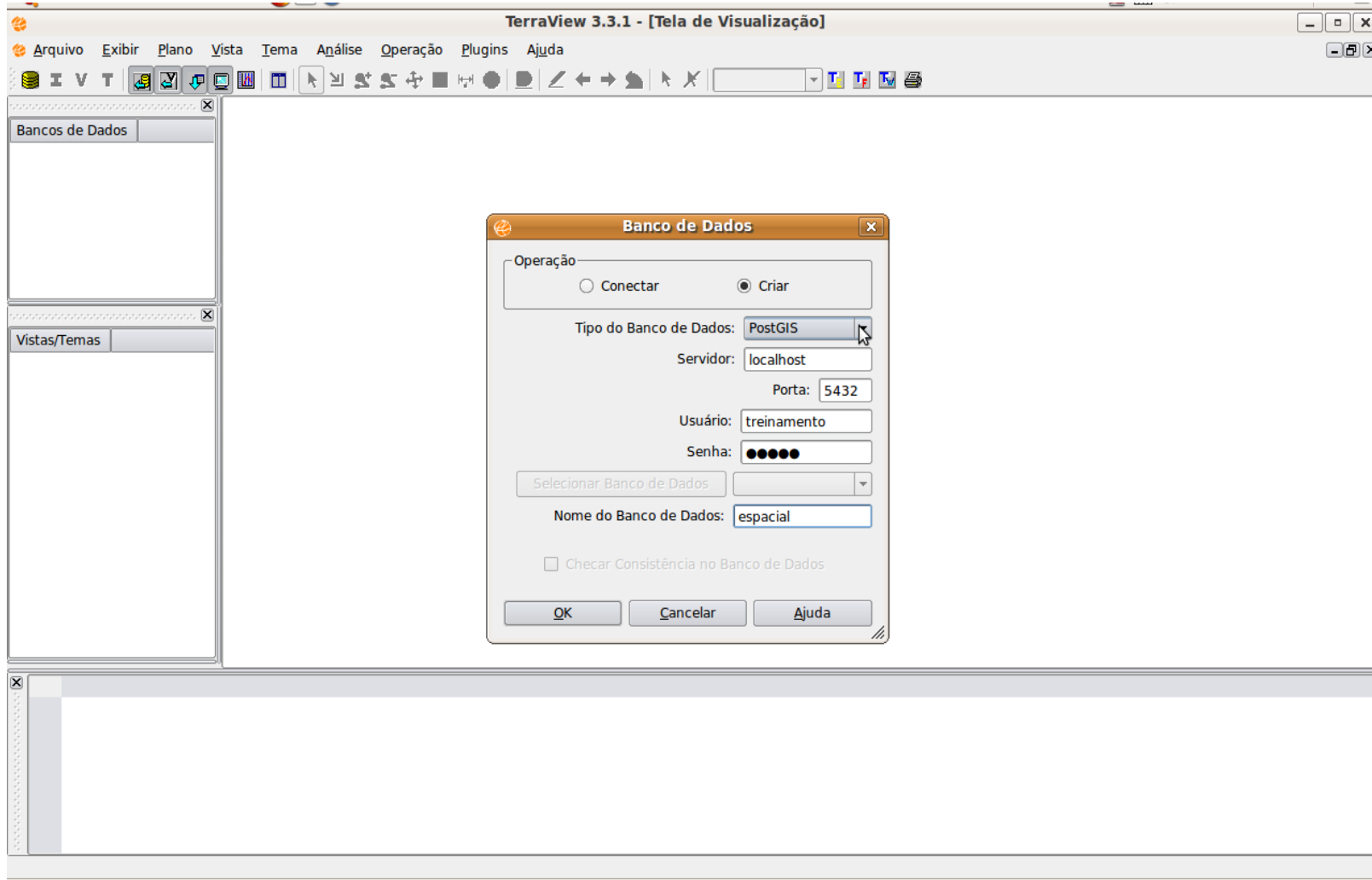
Integration with systems

Quantum GIS



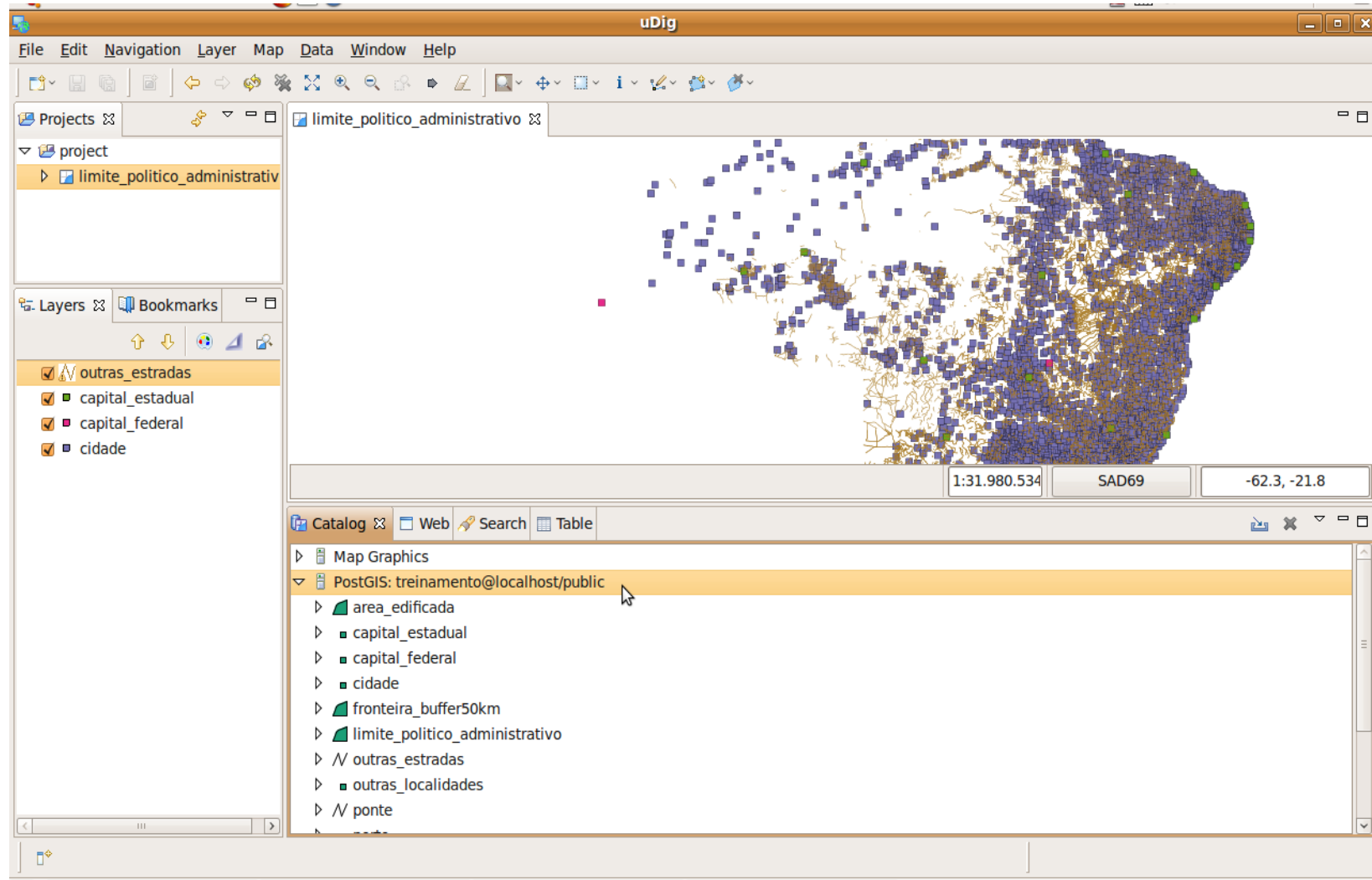
Integration with systems

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.



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Integration with systems

GeoServer

GeoServer ©

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

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

* = Campo necessário



Integration with systems

Mapfile fragment (MapServer)

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

    CONNECTIONTYPE postgis
    CONNECTION "host=localhost dbname=especial
               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
```

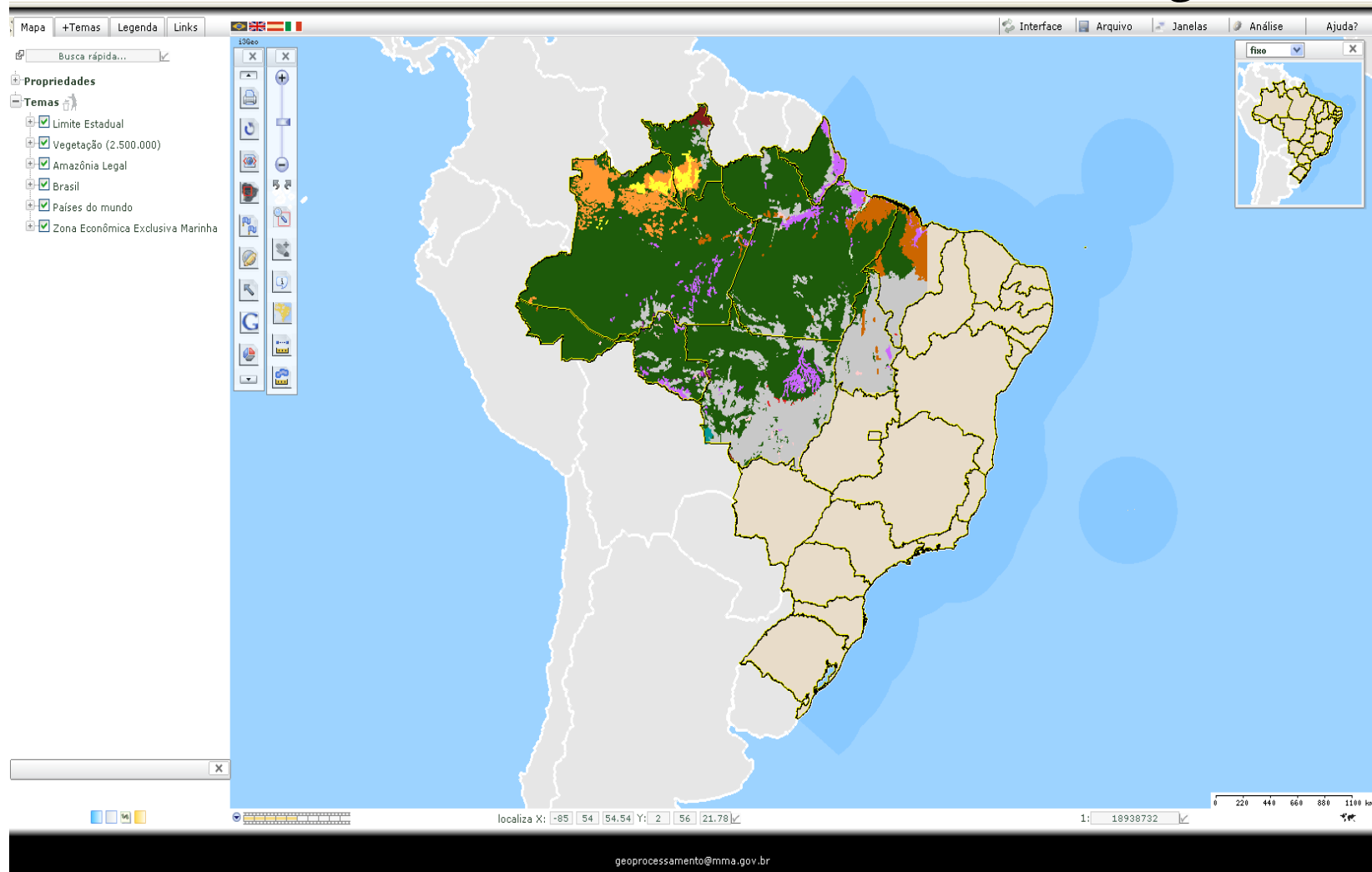
...



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Integration with systems

I3GEO



Integration with systems

InterMap

SISTEMA DE PROTEÇÃO DA AMAZÔNIA

SISTEMA DE PROTEÇÃO DA AMAZÔNIA

JavaScript Tree Menu

Favor, escolha um ou mais map services na lista abaixo

Servidor GeoServer WMS - SIPAM

Sumário A Base SIPAM integra informações atualizadas sobre a Amazônia Legal brasileira. O uso destas informações em projetos desenvolvidos pelo SIPAM e órgão parceiros proporciona a geração de conhecimentos que auxiliam a articulação, o planejamento e a coordenação de ações globais de governo, visando a proteção, a inclusão social e o desenvolvimento sustentável da região. SIPAM - Protegendo e promovendo o desenvolvimento sustentável da nossa Amazônia!

Palavras chave: SIPAM , WFS , GeoServer , Amazônia

Home page: <http://200.140.146.182:80/geoserver/wms>

Contato para informação:
Contato pessoal principal: Luis Fernando Bueno (SIPAM - Sistema de Proteção da Amazônia)
Posição: Analista Gerencial
Endereço Avenida Lauro Sodré, 6500, Porto Velho Rondônia 78903-711 Brasil
Telefone: +55(69)3217-6296
Fax: +55(69)3217-6294
email: luis.bueno@sipam.gov.br

SIPAM - Sistema de Proteção da Amazônia

Servidor GeoServer WMS - SIPAM

- Área de Abrangência do Centro Técnico e Operacional de Porto Velho
- Projeto e Produtos
 - Malha Viária do Estado de Rondônia
 - Perfil Epidemiológico
 - PROAE
 - Primeira Edição - 2007
 - Acre
 - Mato Grosso
 - Desmatamento em Áreas Especiais no Estado do Mato Grosso (Acumulado até o ano de 2005)
 - Limites das Áreas Especiais no Estado do Mato Grosso
 - Rondônia
 - Segunda Edição - 2007
 - SIGIPLAM

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

Cancelar Ok

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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Geoprocessamento
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Integration with systems

phpPgGIS

The screenshot displays the phpPgGIS web interface. On the left, there is a sidebar with a 'Servers' section containing a 'PostgreSQL' connection. The main area shows a data table with columns for actions, IDs, names, types, areas, and geometry. A Mozilla Firefox browser window is overlaid on the table, displaying a map of a region with a red grid overlay. The browser's address bar shows the URL: `http://localhost/phppggis/showmap.php?id_geom=gid&`. A 'Concluído' (Completed) dialog box is visible at the bottom of the browser window.

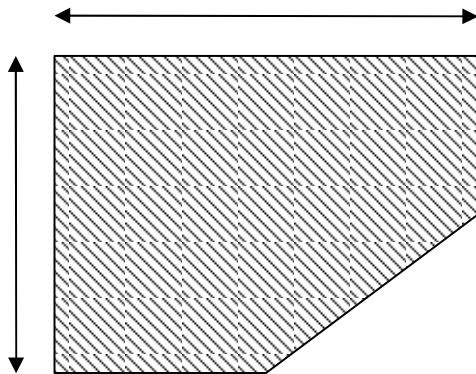
Ações	gid	NM_NOME	CD_TIPO_LI	AREA_OFICI	the_geom
Editar Deletar	0	ESPRITO SANTO	estadual	46077.5	01060000200A120000090000000103000
Editar Deletar	1	BAHIA	estadual	564693	01060000200A1200002A0000000103000
Editar Deletar	2	URUGUAY	internacional	0	01030000200A12000001000000DA0400
Editar Deletar	3	ARGENTINA	internacional	0	01030000200A120000010000006008000
Editar Deletar	4	GUYANA	internacional	0	01060000200A120000020000000103000
Editar Deletar	5	SURINAME	internacional	0	01030000200A120000010000009103000
			estadual	237576	01030000200A12000001000000ED0F00
			estadual	340087	01030000200A120000010000007C1600
			distrito federal	5801.94	01030000200A12000001000000401000
			estadual	586528	01030000200A120000010000003619000
			estadual	277621	01030000200A12000001000000F811000
			lo federal	0.012254	01060000200A120000080000000103000
			estadual	903358	01030000200A12000001000000F314000
			estadual	357125	01030000200A12000001000000050F000
			internacional	0	01030000200A120000010000000F08000
			internacional	0	01030000200A120000010000001D06000
			internacional	0	01030000200A120000010000000E06000
			estadual	1570750	01030000200A12000001000000FD1E000
			internacional	0	01060000200A120000020000000103000
			estadual	224299	01030000200A120000010000009B0D000
			estadual/litigio	2819.26	01060000200A120000030000000103000
			internacional	0	01030000200A120000010000008403000
			federal	9.58235	01030000200A120000010000001E00000
			estadual	281749	01060000200A120000090000000103000
			estadual	95346.2	01060000200A1200001B0000000103000
			estadual	199315	01060000200A1200000E0000000103000
			estadual	248209	01060000200A120000360000000103000
			estadual	27767.7	01060000200A120000020000000103000
			estadual	56439.8	01060000200A1200000A0000000103000
			estadual	251529	01060000200A120000030000000103000
Editar Deletar	26	ALAGOAS	estadual		
Editar Deletar	27	ALAGOAS	estadual	27767.7	01060000200A120000020000000103000
Editar Deletar	28	PARABA	estadual	56439.8	01060000200A1200000A0000000103000
Editar Deletar	29	PIAU	estadual	251529	01060000200A120000030000000103000

Practical Examples

Simple queries... or Frequently Asked Questions

Calculate size of the deforested area

Polygon

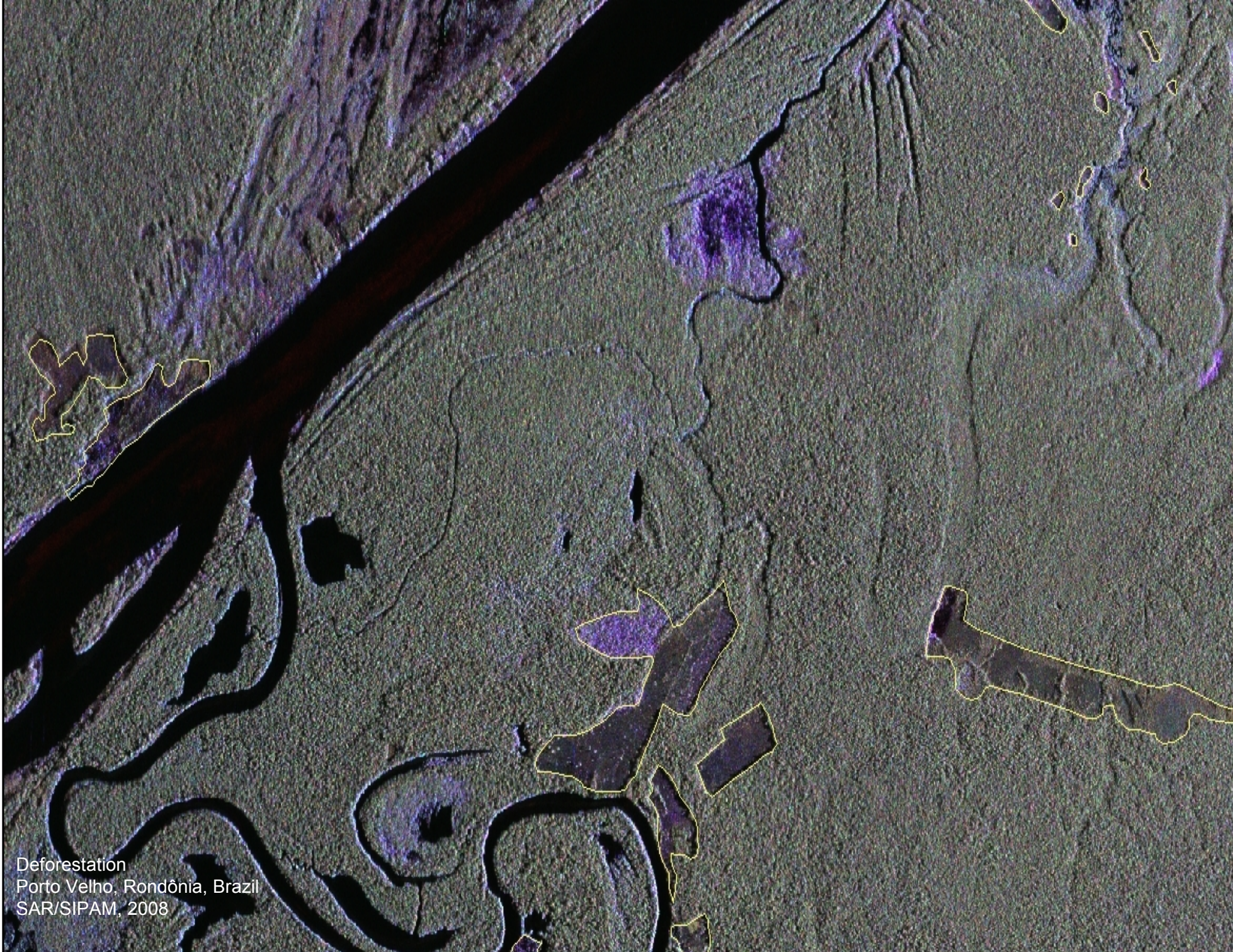


```
SELECT ST_area(ST_Transform(a.the_geom,29101))/10000  
FROM desmatamento a  
WHERE a.gid = 990;
```



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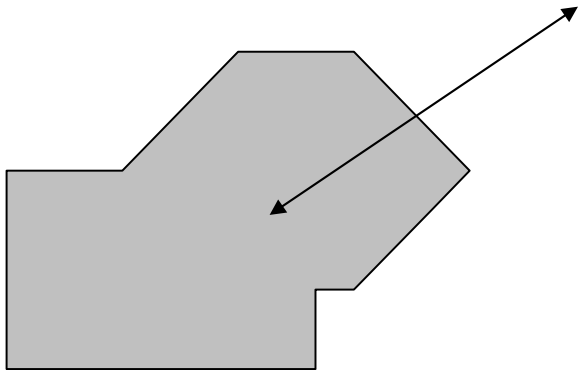


Deforestation
Porto Velho, Rondônia, Brazil
SAR/SIPAM, 2008

Practical Examples

Simple queries... or Frequently Asked Questions

Identify routes of access to protected areas



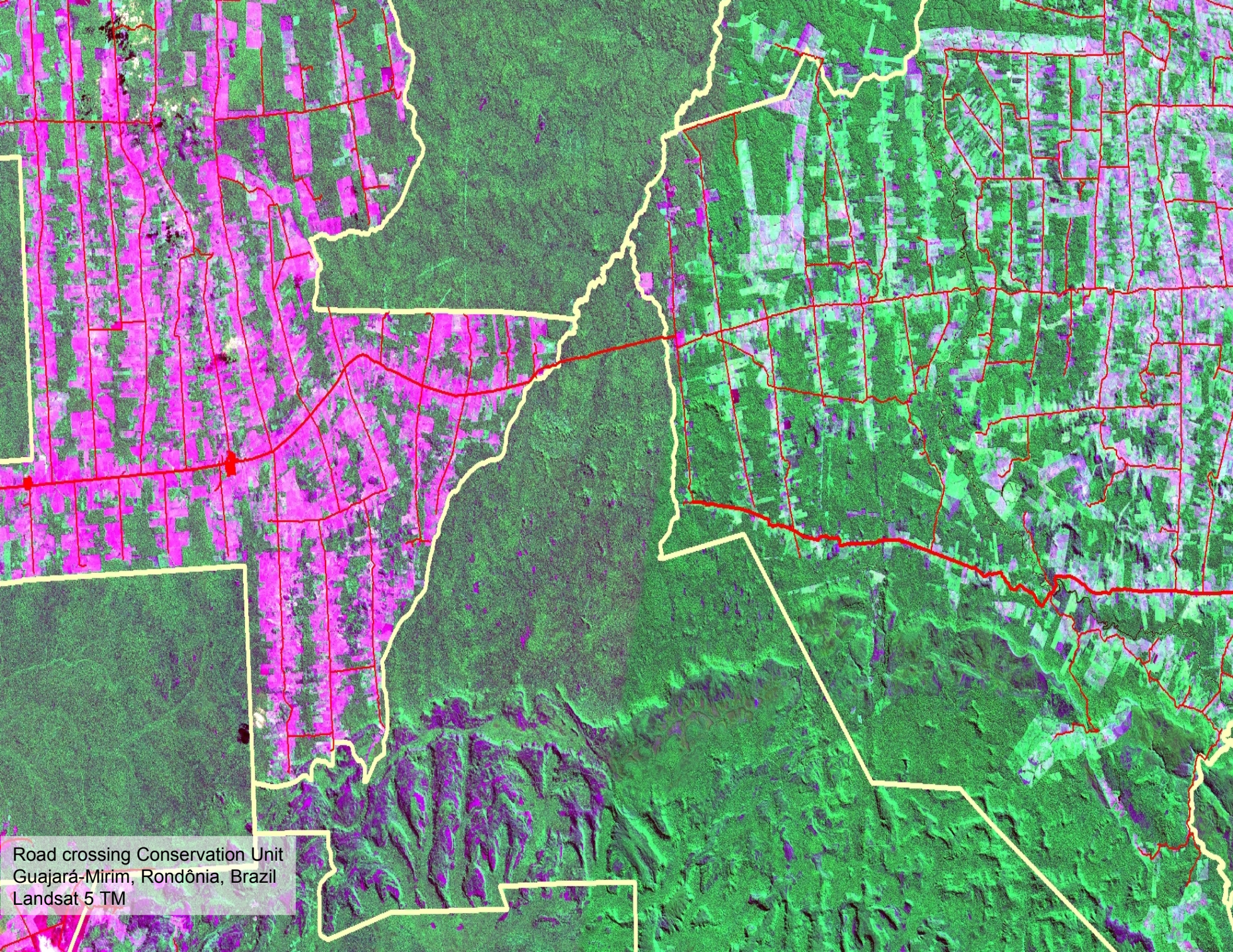
Polygon/Line

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



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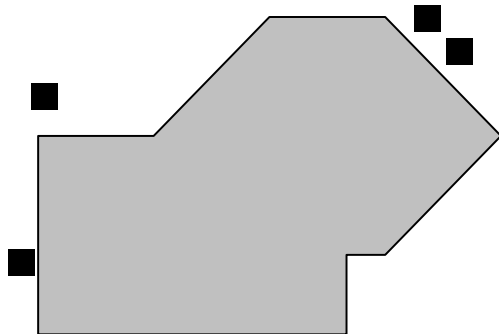
Road crossing Conservation Unit
Guajará-Mirim, Rondônia, Brazil
Landsat 5 TM

Practical Examples

Simple queries... or Frequently Asked Questions

Identify buildings near the protected areas

Point/Polygon

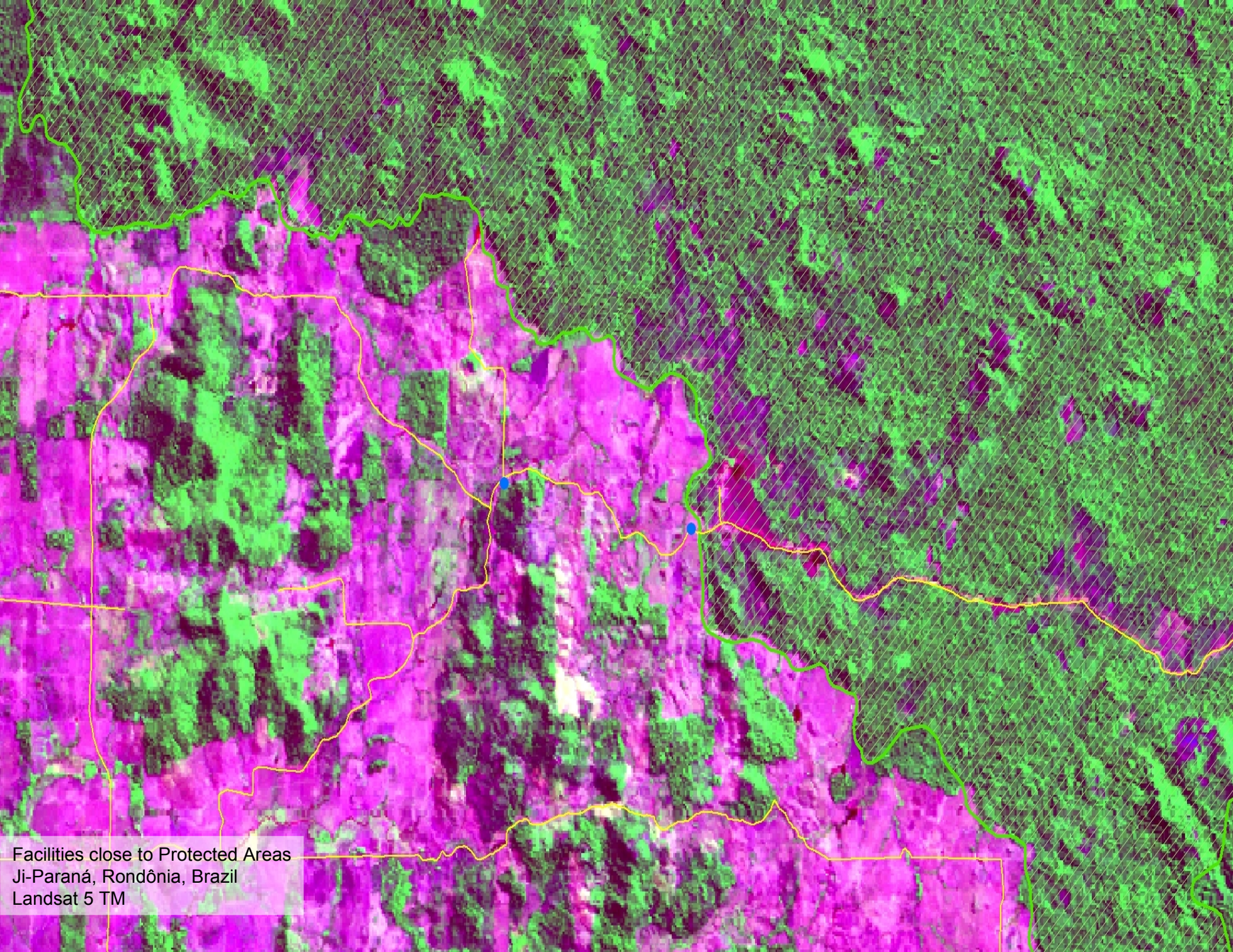


```
SELECT b.gid, b.the_geom, b.nome
FROM area_especial a, edificacao b
WHERE a.nome = 'TI Uru-Eu-Wau-Wau' AND
      ST_Distance(ST_Transform(b.the_geom, 29101),
                  ST_Transform(a.the_geom, 29101))/1000 <= 10;
```



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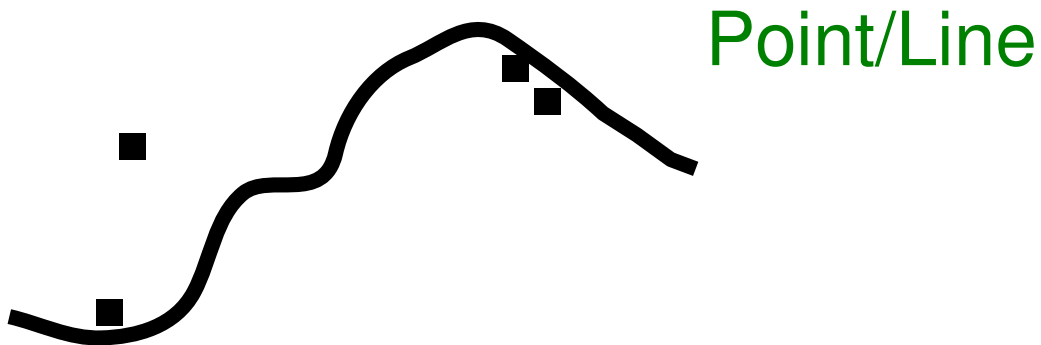


Facilities close to Protected Areas
Ji-Paraná, Rondônia, Brazil
Landsat 5 TM

Practical Examples

Simple queries... or Frequently Asked Questions

Identify schools near the principal roads

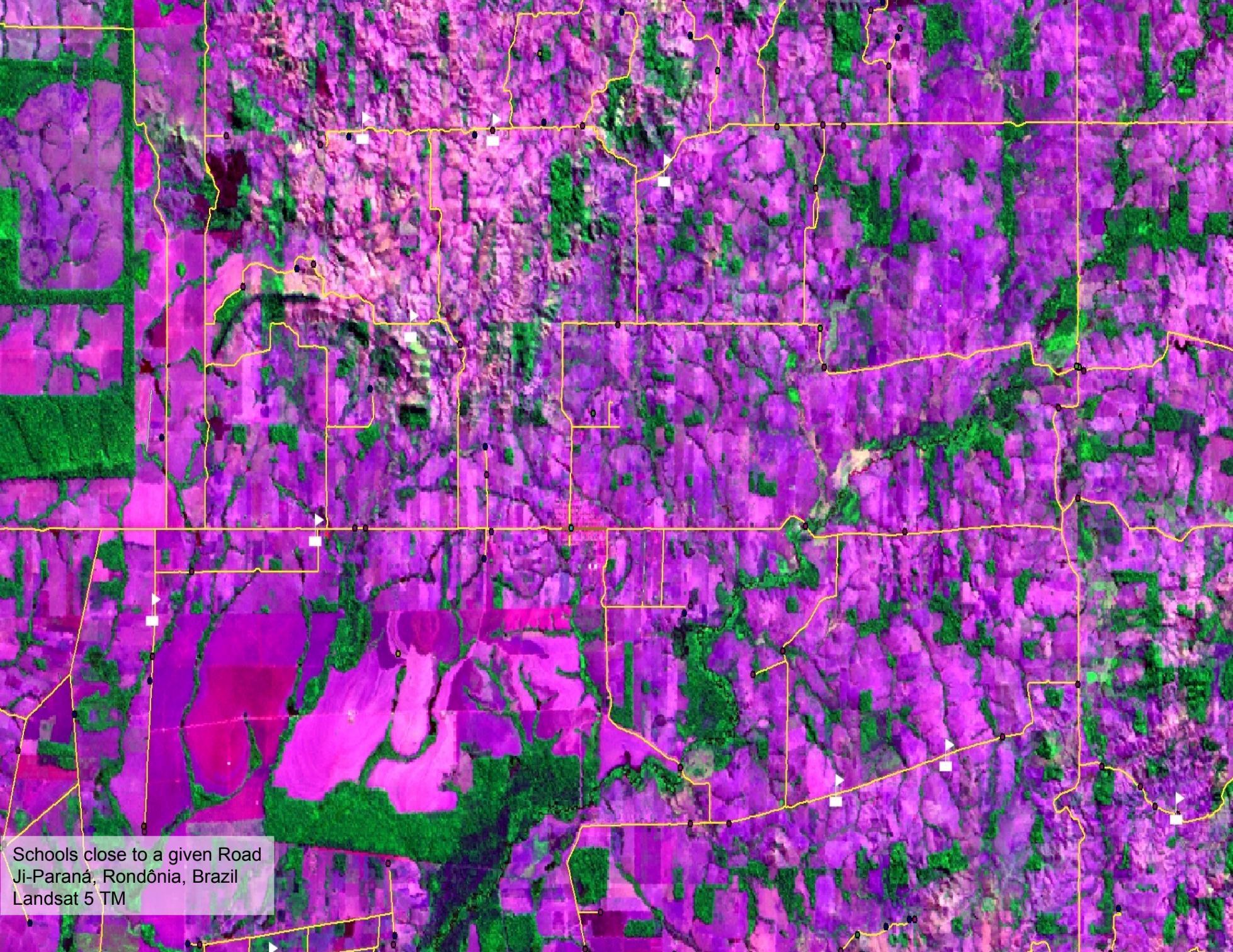


```
SELECT b.gid, b.the_geom, b.nome  
FROM estrada a, escola b  
WHERE a.sigla = 'RO-010' AND  
ST_Distance(a.the_geom, b.the_geom) <= 2000;
```



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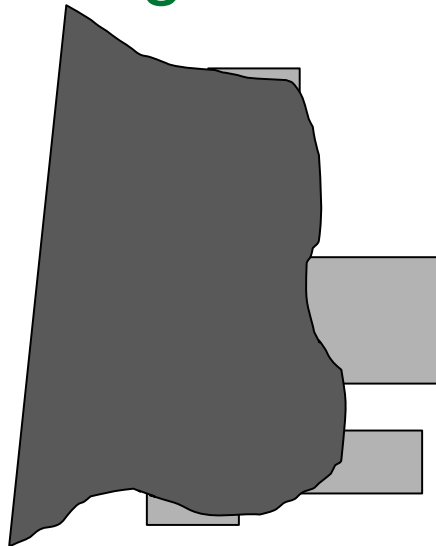


Schools close to a given Road
Ji-Paraná, Rondônia, Brazil
Landsat 5 TM

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);
```



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



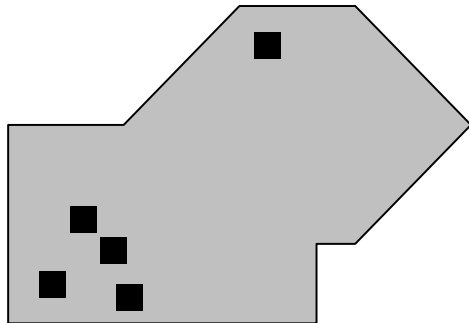
2007 5 17

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);
```

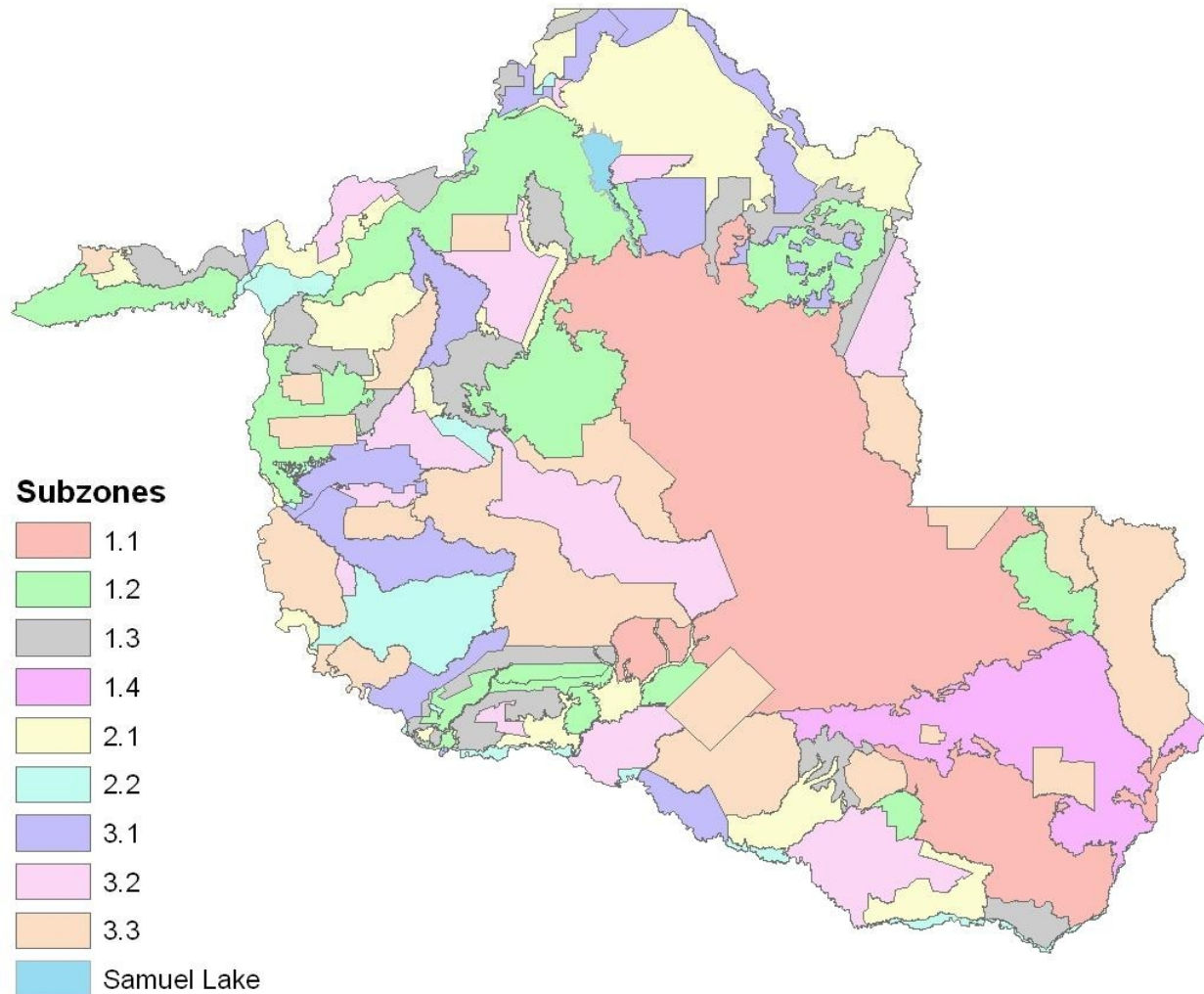




Heat sources
Colniza, Mato Grosso, Brazil
Alberto Setzer – INPE, 2007
<http://www.obt.inpe.br/fototeca/managefoto.php?ID=7291&ANO=2007&proj=CPTEC&>

Practical Examples

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



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?



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.



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Opportunities

We can do it!

Client
Applications



uDig

Interfaces

Direct
Access

WMS
(GIF, PNG,
JPG, KML)

WFS
(GML,
Shapefile)

CSW
(FGDC,
ISO19115/
19119/19139)

Servers



THE **GeoServer** PROJECT
the open Internet gateway for geographic data

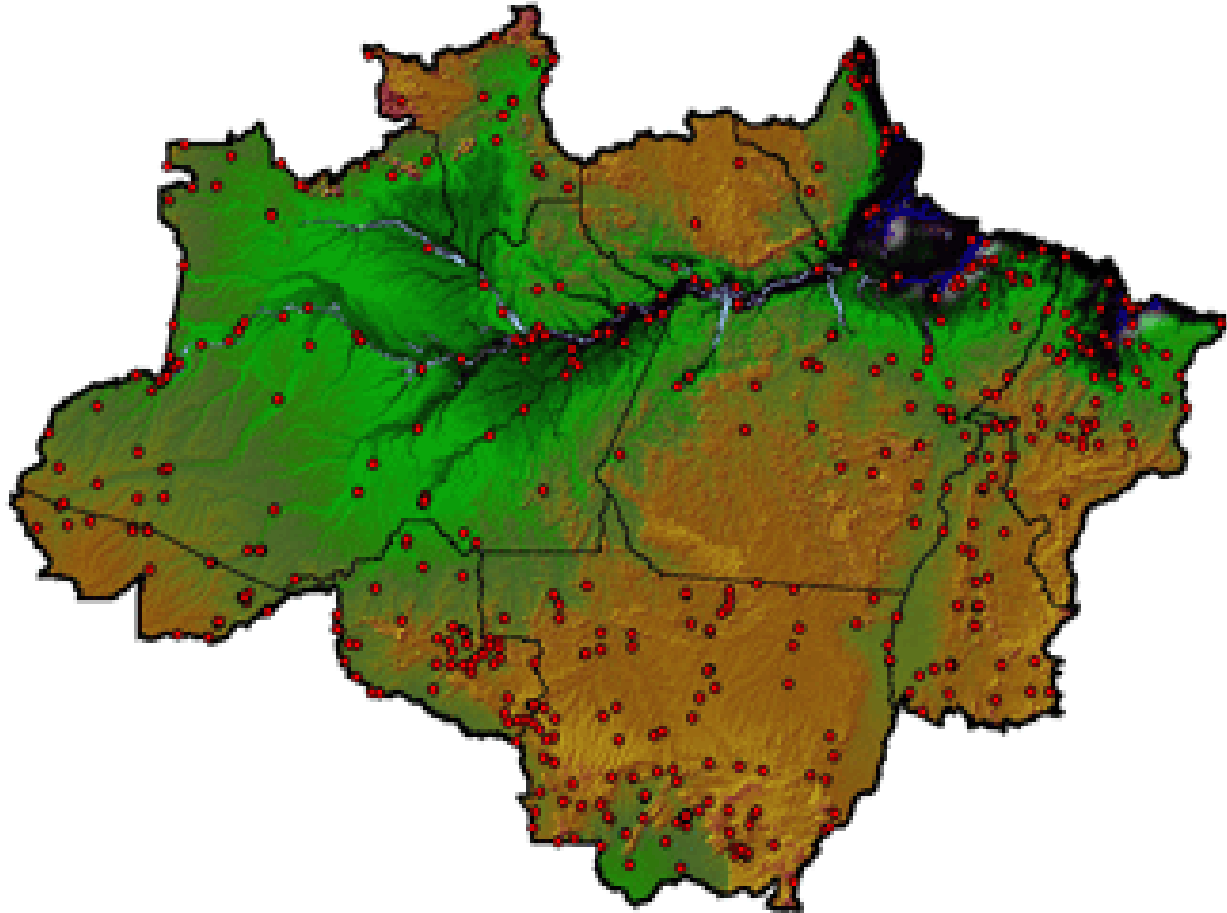
Database



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!

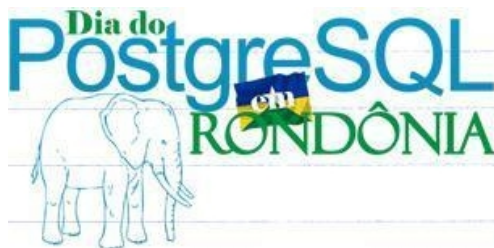
First event of PostgreSQL in north Brazil



PGDay Porto Velho – April, 29
85 participants



PGDay Ji-Paraná – April, 30
103 participants



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especially Daniel Langille*

***Thanks so much for this unforgettable
experience!!!!***



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Luis Fernando Bueno – May 2009



Geoprocessamento
ILES/ULBRA PORTO VELHO

Saving the Amazon with PostGIS

Spatial Data Manipulation in the Rain Forest

Thanks for the attention (and patience!)

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www.geoprocessamento.com

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