Appendix A
Atlas of Groundwater-Dependent Biodiversity and Threats to Groundwater Quantity and Quality Across Oregon

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Leslie Bach and Allison Aldous

This atlas of maps provides spatial information on the distribution and diversity of groundwater-dependent biodiversity across Oregon and the type and location of potential threats to their groundwater supply. It is part of an assessment developed by The Nature Conservancy to help fill data and information gaps in our understanding of groundwater-dependent ecosystems and species and the extent to which their groundwater supplies are impaired. The information will be used to help prioritize areas for conservation of groundwater-dependent biodiversity, and guide the development of targeted conservation strategies to reduce risks to groundwater quantity and quality. For a complete description of the assessment methods and results, please refer to the main text of this report "Groundwater-Dependent Biodiversity and Associated Threats: A Statewide Screening Methodology and Spatial Assessment of Oregon." (available online at http://conserveonline.org).

The maps in this atlas are divided into three sections: (1) base maps; (2) type and location of groundwater-dependent ecosystems and species (GDEs) and associated analysis information; and (3) type and location of potential threats to GDEs from alterations in groundwater quantity and quality. The Atlas consists of 37 maps, which display the data used in the assessment and some of the results. Each map contains a brief overview of the analysis methodology, as applicable. The complete assessment information is contained in the report and Appendix B, "Detailed Methods."

To manage the information and summarize the results at an appropriate scale, we divided the state into regional analysis units, which are based on the administrative basins of Oregon Water Resource Department. We identified 14 regions (Atlas Map 1), in which we expected similar biota and groundwater processes due to the relative homogeneity of hydrogeologic, ecological, and climatic conditions. We then summarized the findings within each region by watershed, using the sixth field Hydrologic Units of the USGS as the boundaries for the watersheds (BLM and USFS, 2006). These watersheds, referred to as HUC6 throughout the report, have a mean size = 8055 ha or 19905 acres (Atlas Map 2). All data maps contain a small inset map in the upper left hand corner that provides the data as summarized at the HUC6 scale.

The analysis relies on existing, coarse-scale datasets. Because limited information exists about both groundwater-dependent biota and the condition of groundwater across the region, we developed new analytical methods for assessing biodiversity and threats based on a suite of surrogate indicators. In general, the indicators provide information on where GDEs may occur and serve to highlight potential threats to groundwater from land use activities. As such, this assessment functions as an inventory of information and a screening tool to identify high-priority areas for the conservation of groundwater-dependent ecosystems rather than a definitive assessment of effects to groundwater quantity and quality.

This Atlas is divided into three sections, containing the following maps:

A. Base maps
1. Analysis Regions and Major Rivers
2. 6th Field Hydrologic Units of Oregon

B. Biodiversity and related analysis information
3. Springs
4. Hot Springs
5. Groundwater-Dependent Wetlands
6. Wetland Data Extent and Gaps
7. Relative Permeability of Geologic Deposits
8. USGS Stream Gages and Assessment of Groundwater-Dependent Streamflow
9. HUC6s with Groundwater-Dependent Rivers
10. Groundwater-Dependent Lakes
11. Obligately Groundwater-Dependent Species and Communities
12. Facultatively Groundwater-Dependent Species
13. Richness of Groundwater-Dependent Ecosystems

C. Risks to groundwater quantity
14. Groundwater Restricted Areas
15. Irrigation, Community or Industrial Wells
16. Domestic or Livestock Wells
17. Construction of New Domestic Wells by Decade
18. Pending Groundwater Right Applications
19. Rural Residential Zoning in High Growth Counties

D. Risks to groundwater quality
20. Draft Groundwater Management Areas
21. Known Groundwater Contamination – Nutrients
22. Known Groundwater Contamination – Pesticides
23. Known Groundwater Contamination – Other Toxic Contaminants
24. Risk of Nitrate Contamination of Shallow Groundwater
25. High Nitrogen Fertilizer Use in Areas Susceptible to Groundwater Contamination
26. High Rural Population Density
27. Concentrated Animal Feeding Operations
28. Class V Underground Injection Control Wells – Nutrients
29. Agricultural Use of Phosphorus Fertilizer
30. Developed Landuse – High and Medium Intensity
31. Threat of Groundwater Contamination from Agricultural Pesticide Use
32. Leaking Underground Storage Tanks (LUSTs) near GDEs
33. Underground Injection Control Wells – Other Toxic Contaminants near GDEs
34. Hazardous Waste Spill Sites near GDEs
35. Landuses that Potentially Impact Groundwater Quality near GDEs
36. Known Geothermal Resource Areas
37. Potential Geothermal Resource Areas

Analysis Regions and Major Rivers

Inset map shows location of assessment.

Project area, analysis regions, and major rivers used throughout this atlas. Analysis regions are derived from the Administrative Basins used by Oregon Water Resources Department.

Analysis Regions
Lakes and Reservoirs
Major Rivers

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N

Miles
0 12.5 25 50
Kilometers
0 25 50 100

Data Sources: USGS, 2006; TNC, 2007d.

North Coast
Columbia Drainages
Columbia Drainages
Northeast OR
John Day
Willamette
Deschutes
Powder / Burnt
Middle Coast
Malheur / Owyhee
South Coast
Umpqua
OR Basin and Range
Klamath
Rogue
South Coast

Nehalem River
Tualatin River
Hood River
Grande Ronde River
Umatilla River
Wallowa River
Minam River
Imnaha River
Nestucca River
Willamette River
Sandy River
Clackamas River
White River
Warm Springs River
Powder River
Middle Fork John Day River
Burnt River
Siletz River
Yaquina River
Metolius River
Crooked River
John Day River
Alsea River
Long Tom River
Calapooia River
McKenzie River
Middle Fork Willamette River
Deschutes River
Malheur River
Siuslaw River
Silvies River
Owyhee River
Umpqua River
Little Deschutes River
North Umpqua River
Coquille River
South Umpqua River
Rogue River
Williamson River
Sycan River
Chehaucan River
Donner und Blitzen River
Elk River
Rogue River
Illinois River
Applegate River
Sprague River
Klamath River
Lost River

Map 1

6th Field Hydrologic Units of Oregon

Inset map shows location of assessment.

6th field hydrologic units or HUC6s used as assessment units. The Hydrologic Unit system is a nested watershed classification based on size, developed by USGS.

Hydrologic Units (6th Field)
Analysis Regions
Major Rivers
Lakes and Reservoirs

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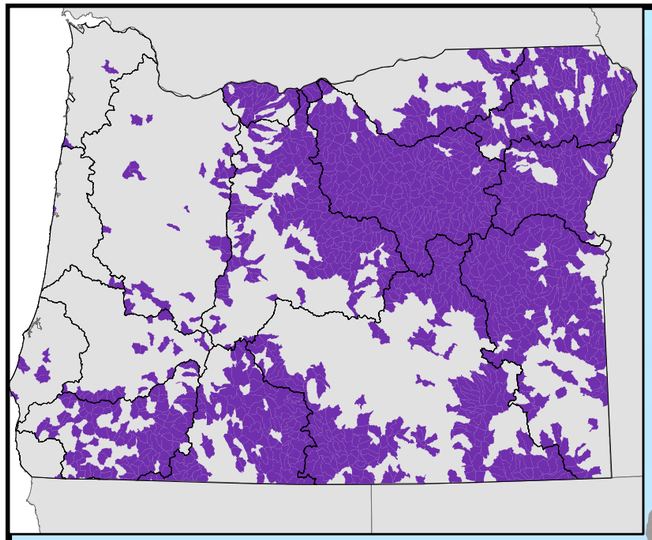
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: BLM-OR and USFS, 2006; USGS, 2006; TNC, 2007d.

Map 2

Springs



HUCs containing more than 1 spring per 2236 ha or 5525 acres

Mapped springs, based on data from USGS (1996); Pacific Northwest Hydrography Framework (2005); and Idaho Experimental Project to Stimulate Competitive Research (EPSCoR) (2006). All springs are considered groundwater dependent.

- Known Springs
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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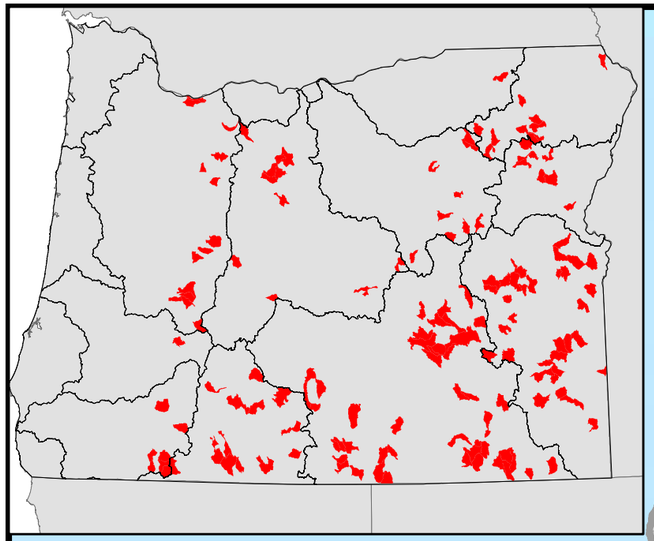
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 1996; PNWHF, 2005; EPSCoR, 2006; USGS, 2006; TNC, 2007d; TNC, 2008.

Map 3

Hot Springs



HUCs with hot springs

Mapped hot springs from Oregon Department of Geology and Mineral Industries.

Hot Springs
Analysis Regions
Lakes and Reservoirs
Major Rivers

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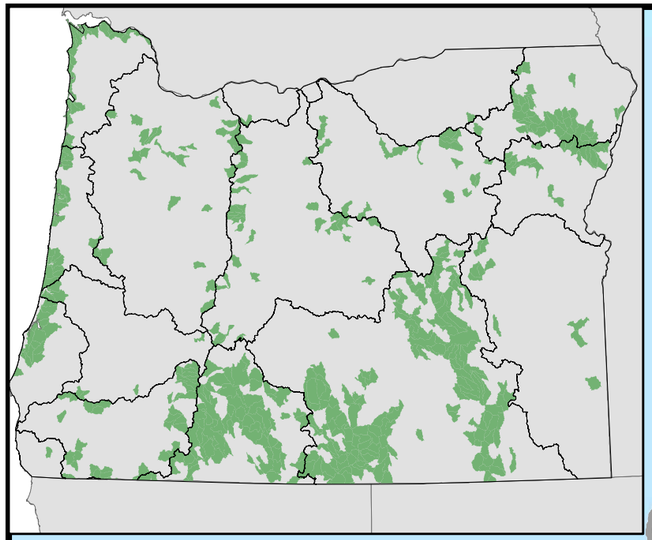
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; Niewendorp et al., 2007; TNC, 2007d; TNC, 2008.

Map 4

Groundwater-Dependent Wetlands



HUCs containing a fen or >1% of HUC area covered by groundwater-dependent wetlands

Mapped wetlands that are likely to be groundwater dependent. Groundwater-dependent wetlands are those i) with organic soils; ii) within 100 m of a mapped spring; or iii) that are known fens.

- Groundwater-Dependent Wetlands
- All Mapped Wetlands
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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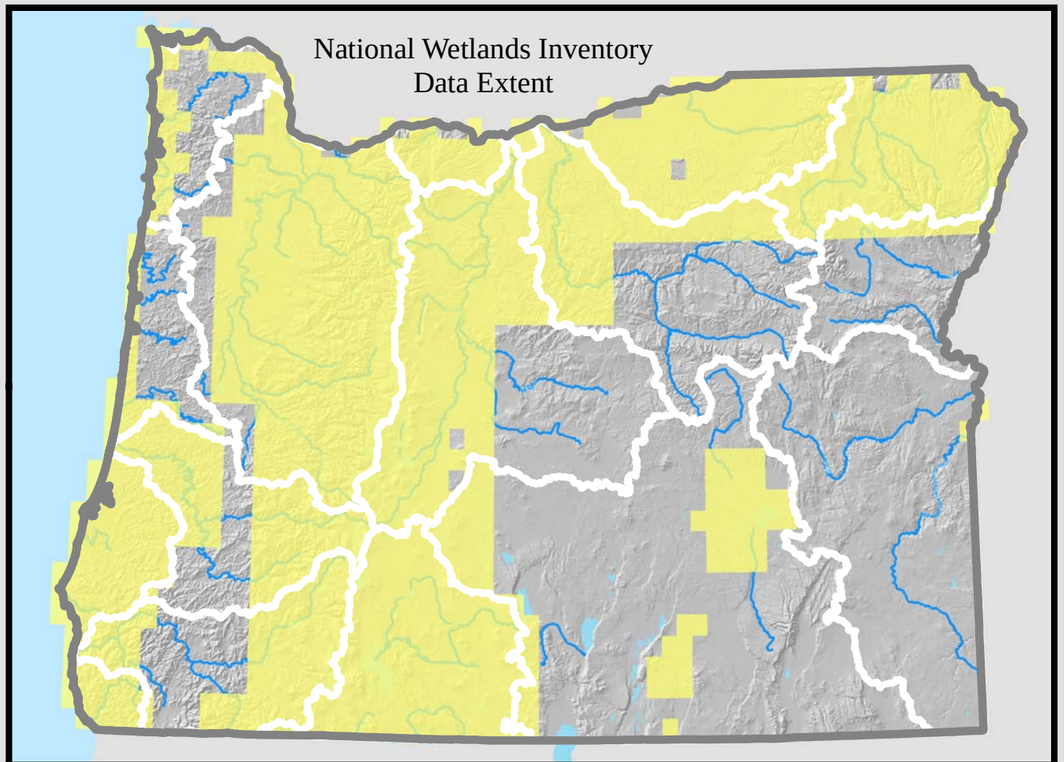
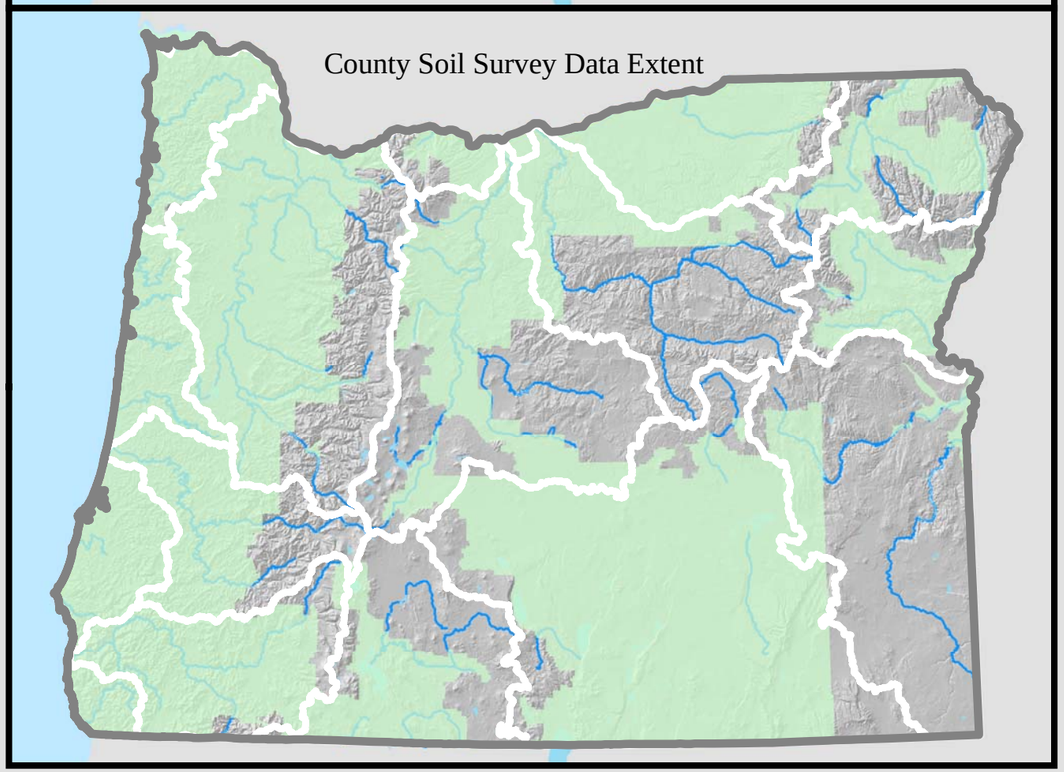
Miles
0 12.5 25 50

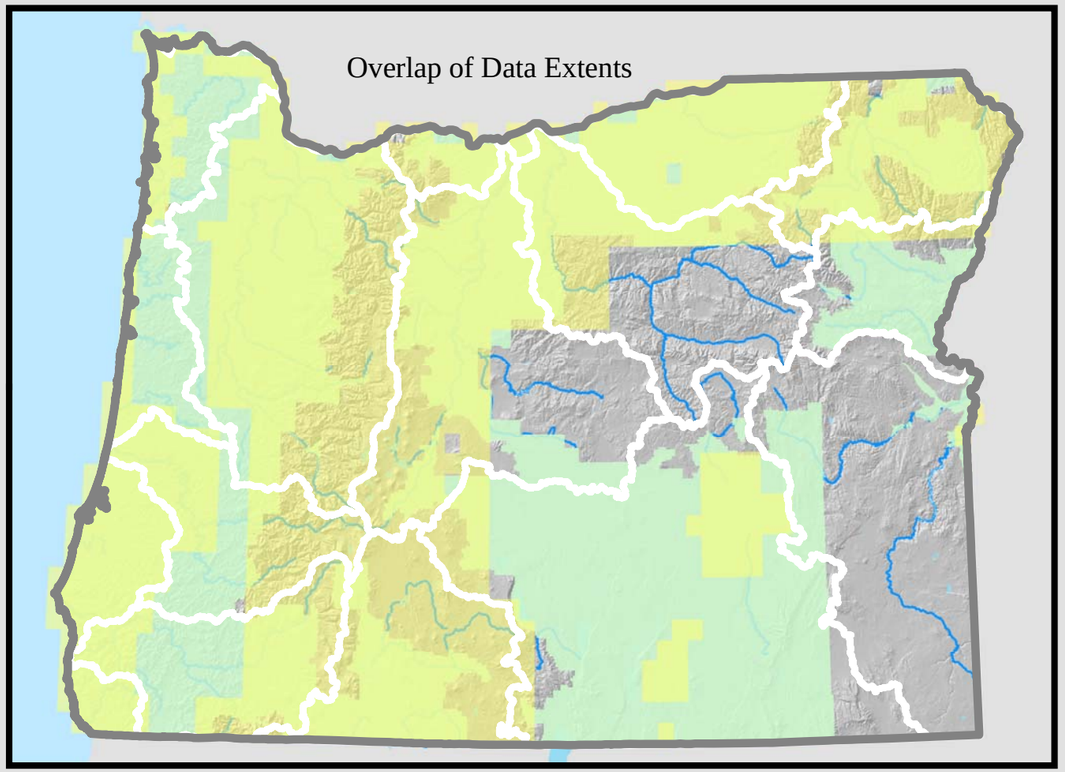
Kilometers
0 25 50 100

Data Sources: Vander Schaaf, 2004; PNWHF, 2005; USDA NRCS, 2006; USGS, 2006; ORNHIC, 2007; TNC, 2007c; TNC, 2007d; TNC eds., 2007; USFWS, 2007; TNC, 2008.

Wetland Data Extent and Gaps







County Soil Survey Data Extent
National Wetlands Inventory Data Extent
Analysis Regions
Lakes and Reservoirs
Major Rivers

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Miles
0 25 50 100

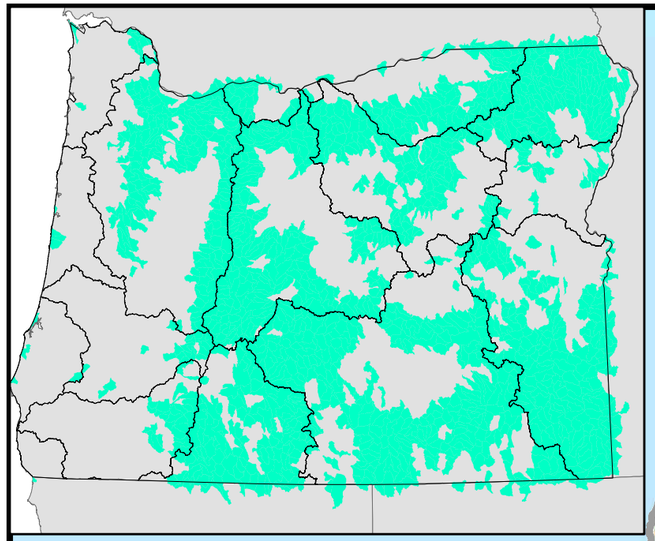
Kilometers
0 50 100 200

Wetland data extent. The two most detailed wetland datasets, the National Wetland Inventory and the County soil survey, both have incomplete coverage in Oregon. Less detailed wetlands data that covered the entire state including wetlands from the Pacific Northwest Hydrography Framework (2005) were also used in the assessment.

Data Sources: USGS, 2006; USDA NRCS, 2006; TNC, 2007d; USFWS, 2007.

Map 6

Relative Permeability of Geologic Deposits



HUCs dominated by more permeable geology as described in document

Relative permeability of geologic deposits (1:500,000) assigned in TNC analysis.

Analysis Regions
High Permeability Deposits
Low Permeability Deposits
Lakes and Reservoirs
Major Rivers

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Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: Miller et al. 2002; USGS, 2006; TNC, 2007d; TNC, 2008.

USGS Stream Gages and Assessment of Groundwater-Dependent Streamflow

Assessment of groundwater-dependent rivers based on USGS Gage Data. We used all stream gage data for both active and inactive gages in Oregon from the USGS National Water Information System (NWIS). Hydrologic experts evaluated data from rivers unaffected by dams or glacial snowmelt that had at least two years of gage data. Of these, rivers with mean monthly low flows more than 15% of the mean monthly flows were identified as receiving significant groundwater inputs.

USGS Gaging Stations Assessed

- Groundwater-Dependent
- Other Gages
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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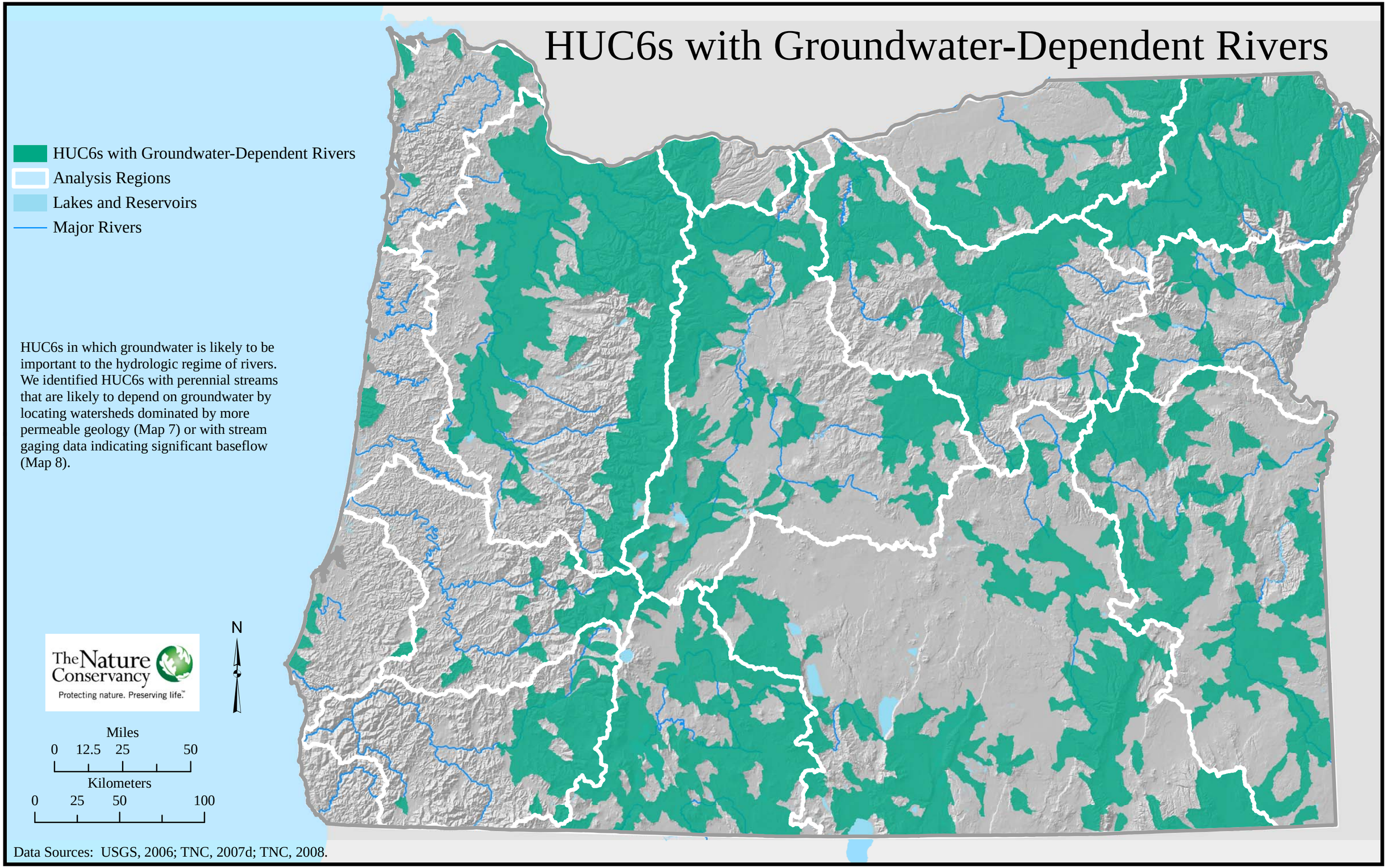
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; TNC, 2007d; USGS, 2007.

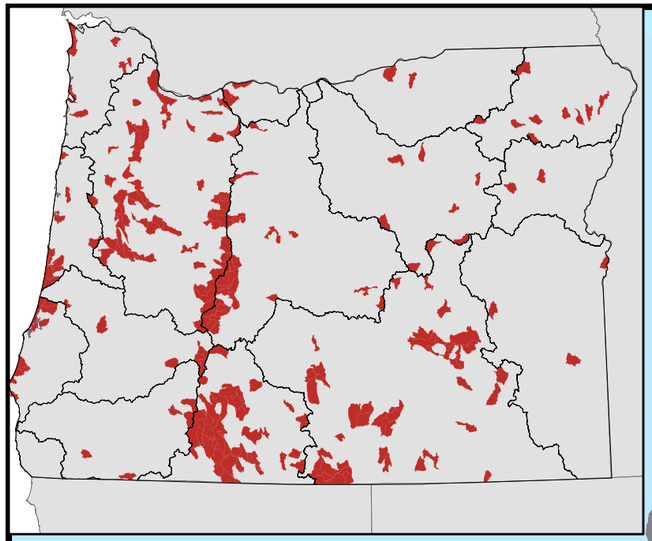
Map 8

HUC6s with Groundwater-Dependent Rivers



Data Sources: USGS, 2006; TNC, 2007d; TNC, 2008.

Groundwater-Dependent Lakes



HUCs containing groundwater-dependent lakes

Lakes in Oregon that occur in landscapes where they are likely groundwater dependent. We defined lakes as water bodies >8.1 ha (20 acres) in size and assumed all perennial lakes, with the exception of reservoirs and a few removed by experts, are groundwater dependent. On the map, only the perennial portion of lakes is shown as groundwater dependent.

- Groundwater-Dependent Lakes
- Analysis Regions
- Major Rivers
- Lakes and Reservoirs

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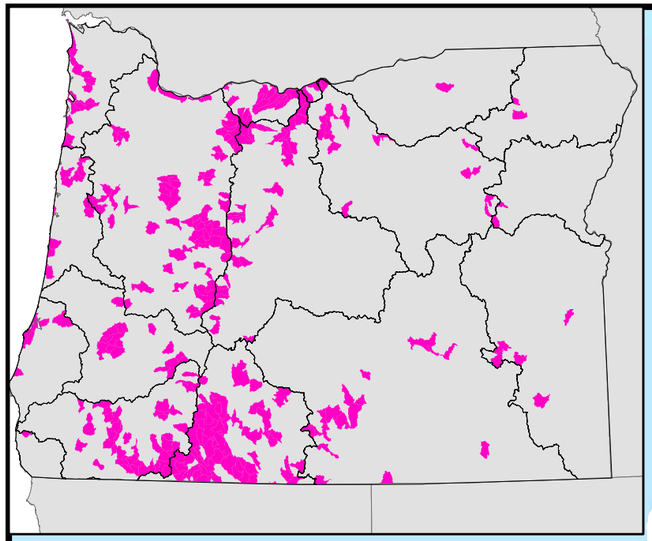
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; TNC, 2007a; TNC, 2007d; TNC, 2008.

Map 10

Obligately Groundwater-Dependent Species and Communities



HUCs containing at least one obligately groundwater-dependent species

Species of conservation concern that are obligately dependent on groundwater based on their habitat requirements as indicated in on-line databases (e.g. NatureServe Explorer and Flora of North America) or in the published and gray literature. Larger dots mean that there is less certainty about the actual location of the species.

- Analysis Regions
- Obligate Species
- Lakes and Reservoirs
- Major Rivers

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Miles
0 12.5 25 50

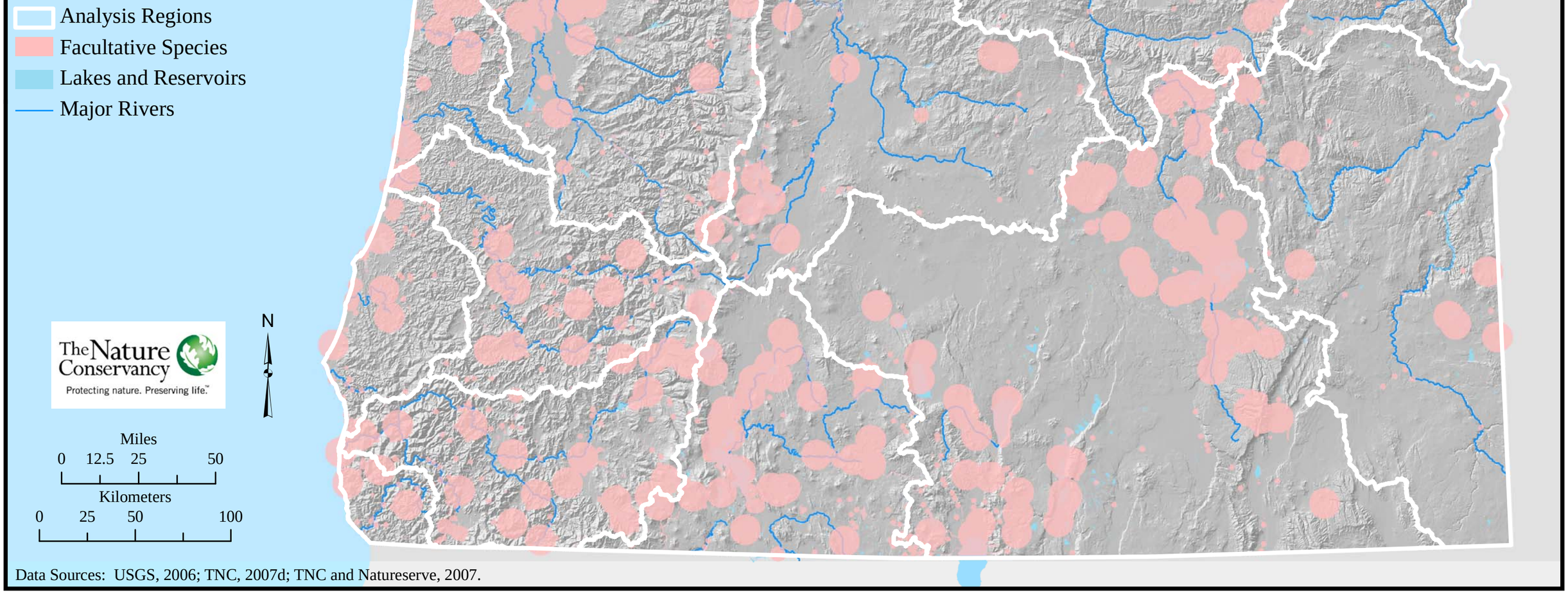
Kilometers
0 25 50 100

Data Sources: USGS, 2006; TNC, 2007d; TNC and Natureserve 2007; TNC, 2008.

Map 11

Facultatively Groundwater-Dependent Species

Species of conservation concern that are facultatively dependent on groundwater based on habitat requirements as indicated in on-line databases (e.g. NatureServe Explorer and Flora of North America) or in the published and gray literature. Larger dots mean that there is less certainty about the actual location of the species.



Data Sources: USGS, 2006; TNC, 2007d; TNC and Natureserve, 2007.

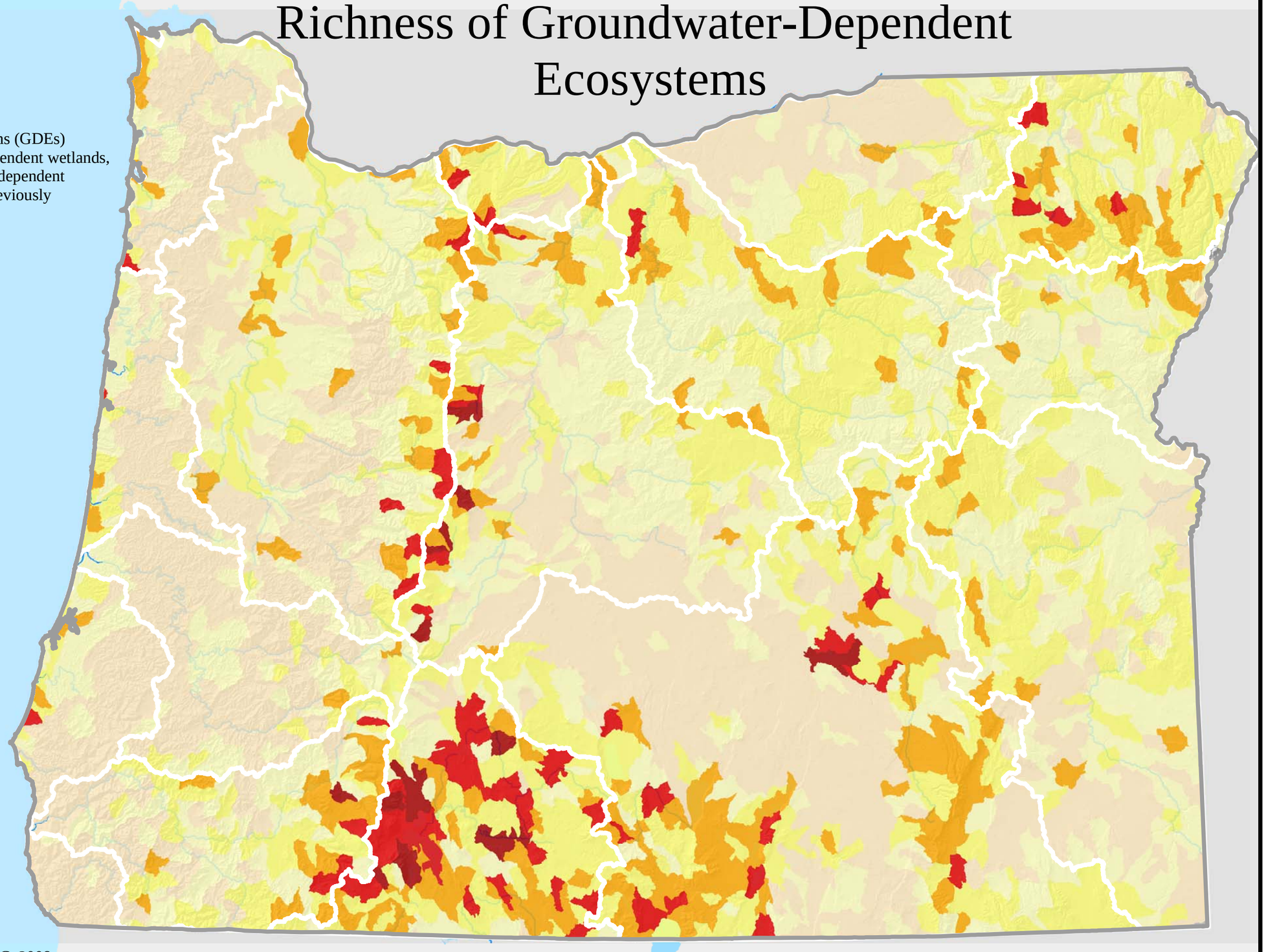
Map 12

Richness of Groundwater-Dependent Ecosystems

Number of groundwater-dependent ecosystems (GDEs) per HUC. Includes springs; groundwater-dependent wetlands, rivers and lakes; and obligately groundwater-dependent species found in each HUC6, based on the previously described mapping rules.

Number of GDEs

- 0
- 1
- 2
- 3
- 4
- 5



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Miles
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Kilometers
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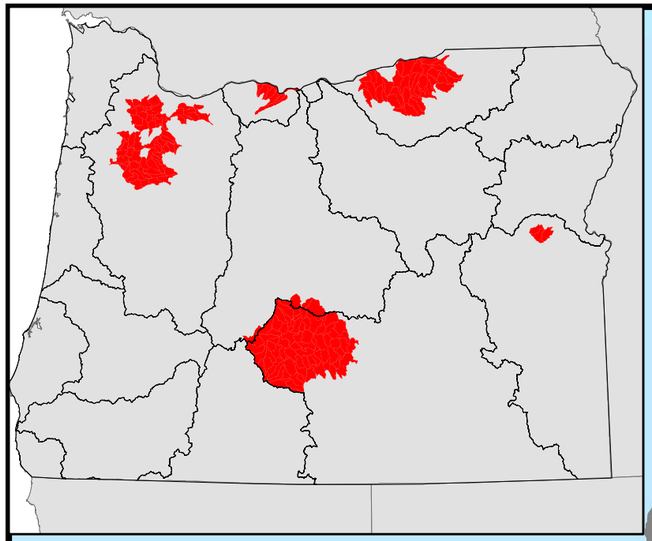
Data Sources: USGS, 2006; TNC, 2007d; TNC, 2008.

Groundwater Restricted Areas



HUCs in groundwater restricted areas

Groundwater Restricted Areas designated by the Oregon Water Resources Department. These are areas where the rate of groundwater pumping exceeds recharge and OWRD has restricted water use.

Groundwater Restricted Areas
Analysis Regions
Lakes and Reservoirs
Major Rivers

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Miles
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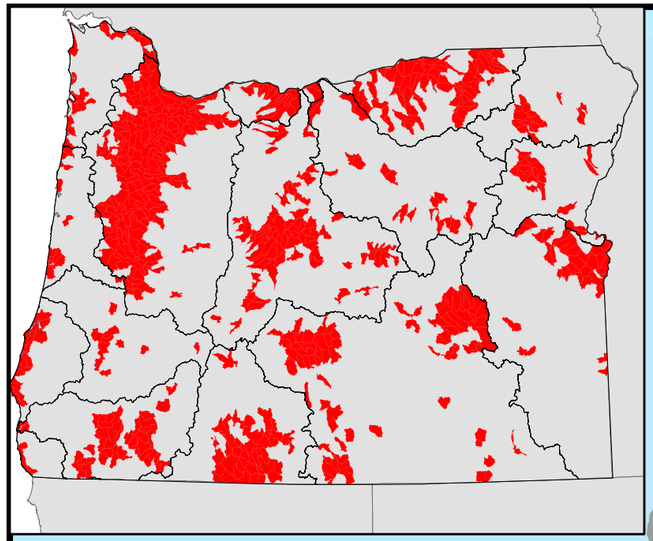
Kilometers
0 25 50 100

Data Sources: USGS, 2006; TNC, 2007d; OWRD, 2007a; TNC, 2008.

Map 14

Irrigation, Community or Industrial Wells



HUCs containing more than 1 well per 2,130 ha (5,263 acres)

Irrigation, community or industrial wells, per the OWRD well logs.

- Irrigation, Community or Industrial Wells
- Analysis Regions
- Major Rivers
- Lakes and Reservoirs

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Miles
0 12.5 25 50

Kilometers
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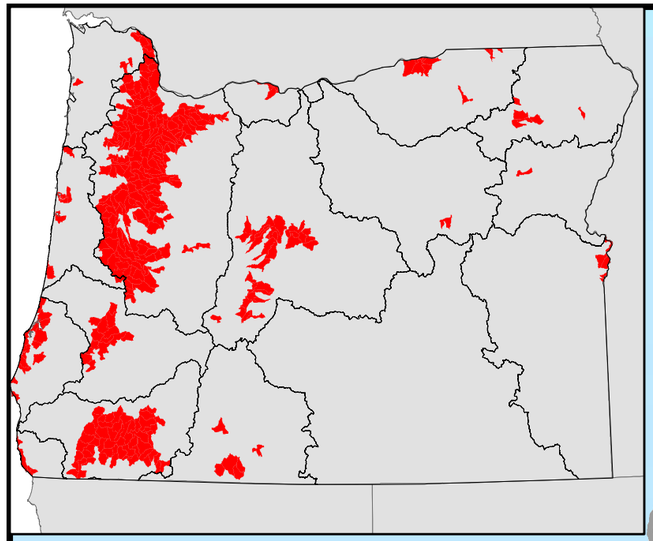
Data Sources: USGS, 2006; TNC, 2007d; OWRD, 2007b; TNC, 2008.

Domestic or Livestock Wells



HUC6s containing more than 1 well per 43.5 ha (108 acres)

Domestic or livestock wells, per OWRD well logs.

- Domestic or Livestock Wells
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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N

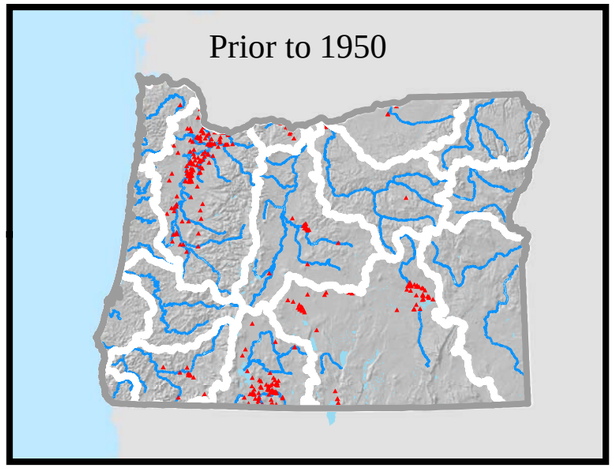
Miles
0 12.5 25 50

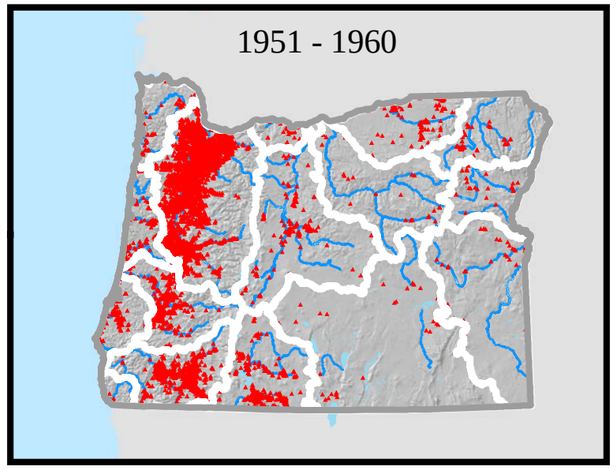
Kilometers
0 25 50 100

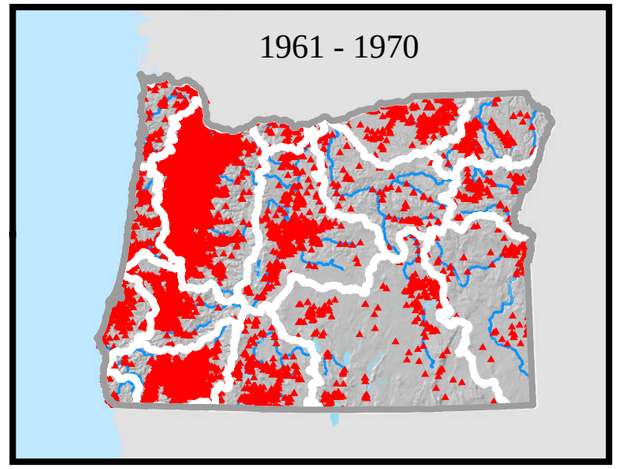
Data Sources: USGS, 2006; OWRD, 2007b; TNC, 2007d; TNC, 2008.

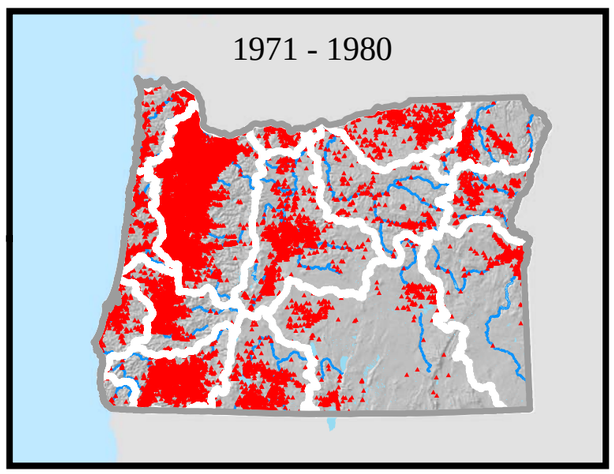
Map 16

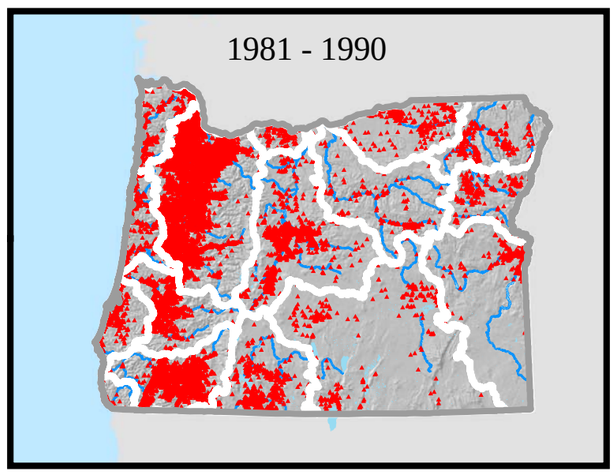
Construction of New Domestic Wells by Decade

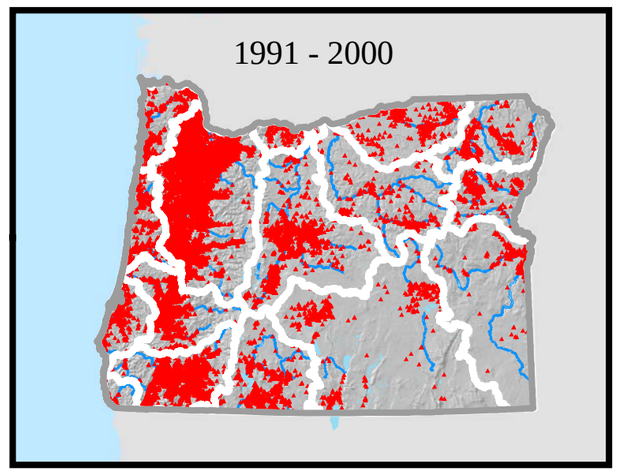


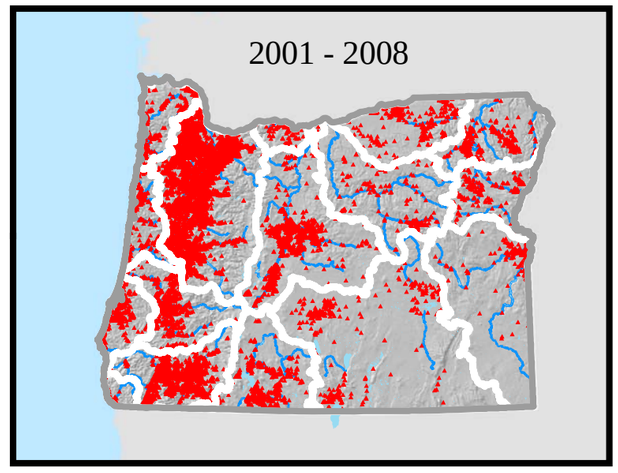












Miles
0 50 100 200

Kilometers
0 100 200 400

N

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New Domestic Wells in Specified Time Period

Analysis Regions

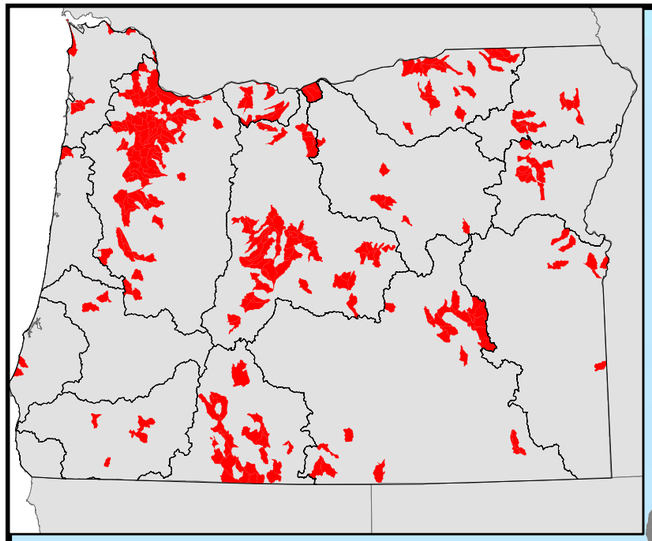
Major Rivers

Lakes and Reservoirs

New domestic wells for each specified time period, per OWRD well logs.

Data Sources: USGS, 2006; TNC, 2007d; OWRD, 2007b.

Pending Groundwater Right Applications



HUCs with pending applications for groundwater rights

Locations of pending applications to OWRD for groundwater rights for irrigation, municipal, and industrial uses.

- Pending Groundwater Right Applications
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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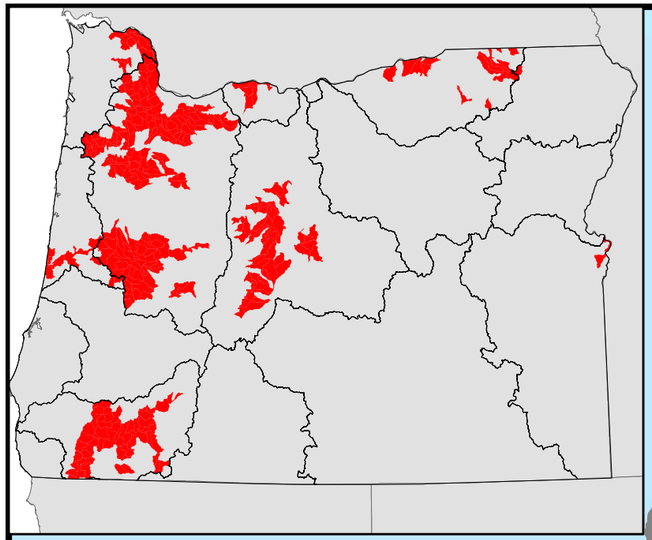
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: OWRD, 2008; USGS, 2006; TNC, 2007d; TNC, 2008.

Map 18

Rural Residential Zoning in High Growth Counties



HUCs with rural residential zoning in high growth counties

Counties with expected population growth rates >15% between 2005 and 2020 and areas zoned rural residential that are outside urban growth boundaries in these counties. Domestic water demand in these areas will most likely be supplied by "new" domestic exempt wells.

- Rural Residential Zoning
- Counties Expected to Grow> 15% by 2020
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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N

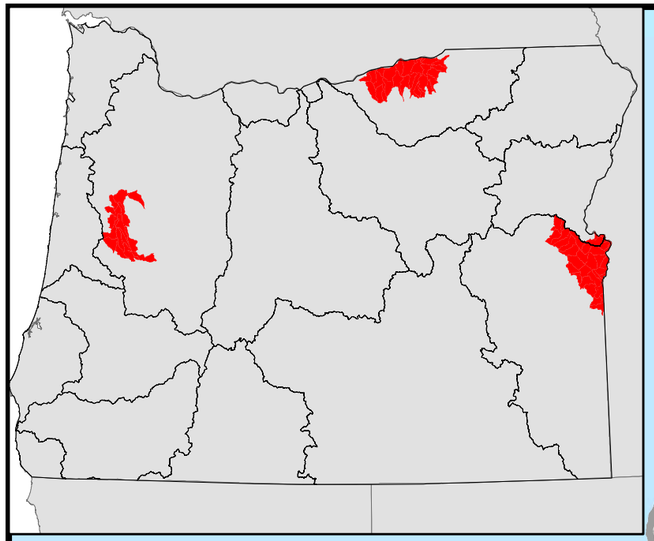
Miles
0 12.5 25 50

Kilometers
0 25 50 100

COLUMBIA
WASHINGTON
HOOD RIVER
UMATILLA
MORROW
YAMHILL
CLACKAMAS
POLK
MARION
JEFFERSON
CROOK
LANE
DESCHUTES
MALHEUR
JOSEPHINE
JACKSON

Data Sources: ODOT, 1995; OOEA, 2004; USGS, 2006; ODLCD, 2007; TNC, 2007d; TNC, 2008.

Draft Groundwater Management Areas



HUCs with draft groundwater management areas

Draft Groundwater Management Areas designated by the Oregon Department of Environmental Quality (ODEQ) due to groundwater contamination by nitrates from nonpoint sources.

Draft Groundwater Management Areas
Analysis Regions
Lakes and Reservoirs
Major Rivers

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N

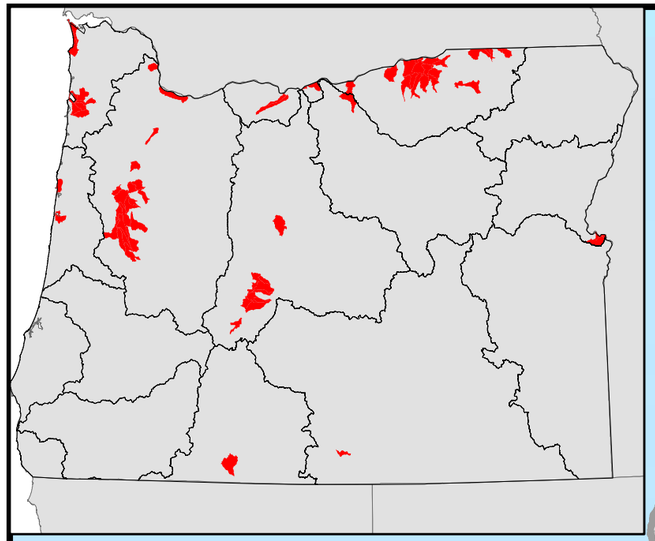
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: ODEQ, 2003; USGS, 2006; TNC, 2008.

Map 20

Known Groundwater Contamination - Nutrients



HUCs with known nutrient contamination of groundwater

Locations of groundwater samples contaminated with nutrients (nitrates and phosphorus) from ODEQ LASAR and USGS NWIS databases.

Known Nutrient Contamination

Analysis Regions

Lakes and Reservoirs

Major Rivers

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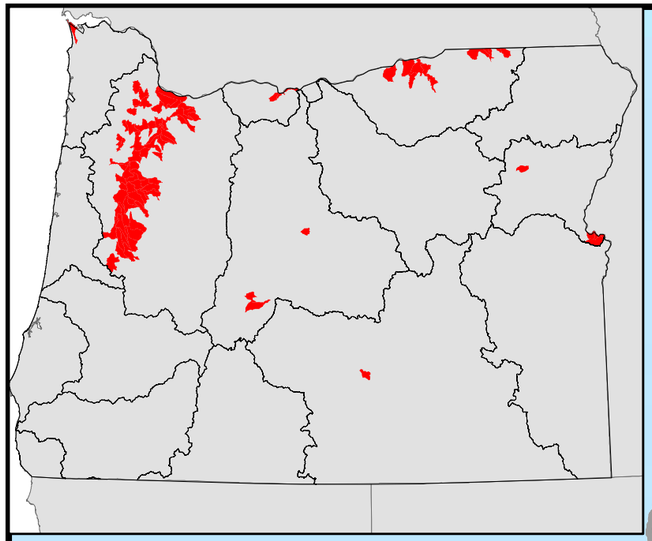
N

Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; ODEQ, 2007e; USGS, 2007; TNC, 2008.

Known Groundwater Contamination - Pesticides



HUCs with known pesticide contamination of groundwater

Locations of groundwater samples contaminated with pesticides from ODEQ LASAR and USGS NWIS databases.

- Known Pesticide Contamination
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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N

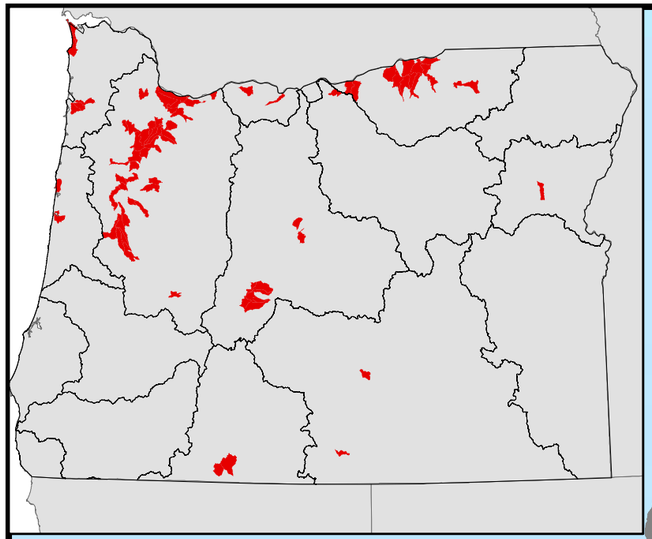
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: ODEQ, 2007e; USGS, 2006; USGS, 2007; TNC, 2008.

Map 22

Known Groundwater Contamination - Other Toxic Contaminants



HUCs with known chemical contamination of groundwater

Groundwater samples contaminated with chemicals other than pesticides or nutrients, per ODEQ LASAR and USGS NWIS databases.

- Known Groundwater Contamination
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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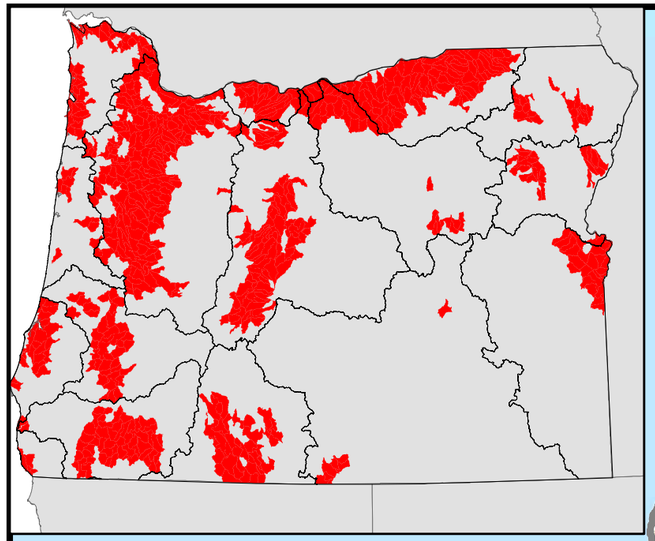
N

Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; ODEQ, 2007e; TNC, 2007d; USGS, 2007; TNC, 2008.

Risk of Nitrate Contamination of Shallow Groundwater



HUCs with medium to high risk of nitrate contamination

Logistic regression model of risk of nitrate contamination of shallow (<5 m) groundwater based on vulnerability and sensitivity. Areas most vulnerable to nitrate contamination are determined based on i) nitrogen fertilizer use rates; ii) % of crop land; and iii) population density. Most sensitive areas are those with i) well drained soils and ii) a seasonally high water table. High risk areas are both vulnerable and sensitive.

Groundwater Risk

Low

High

Analysis Regions

Lakes and Reservoirs

Major Rivers

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N

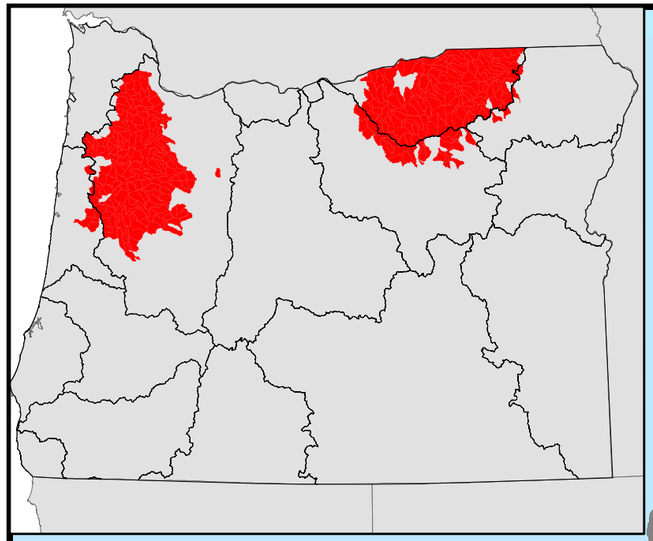
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: Nolan et al., 2002; USGS, 2006; TNC, 2008.

Map 24

High Nitrogen Fertilizer Use in Areas Susceptible to Groundwater Contamination



HUCs with risk of groundwater contamination from agricultural fertilizer use

Agricultural land use or irrigated areas in counties with high use of nitrogen fertilizer. Potential nitrate contamination of groundwater increases when high nitrogen fertilizer use (defined as >4 tons/sq. mile) coincides with agricultural land use or irrigated areas (per OWRD place of use data) on permeable deposits.

- Counties using >4 tons/sq.mile Nitrogen Fertilizer
- Irrigated Areas on Permeable Deposits
- Agriculture Lands on Permeable Deposits
- Analysis Regions
- Lakes and Reservoirs

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N

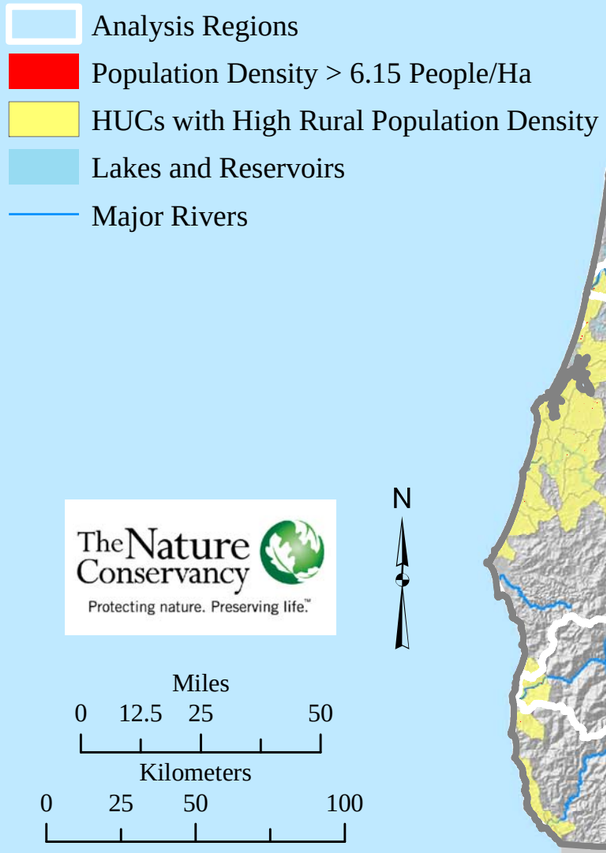
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: Battaglin and Goolsby, 1994; Miller et al. 2002; OWRD, 2005; USGS, 2003; USGS, 2006.

High Rural Population Density

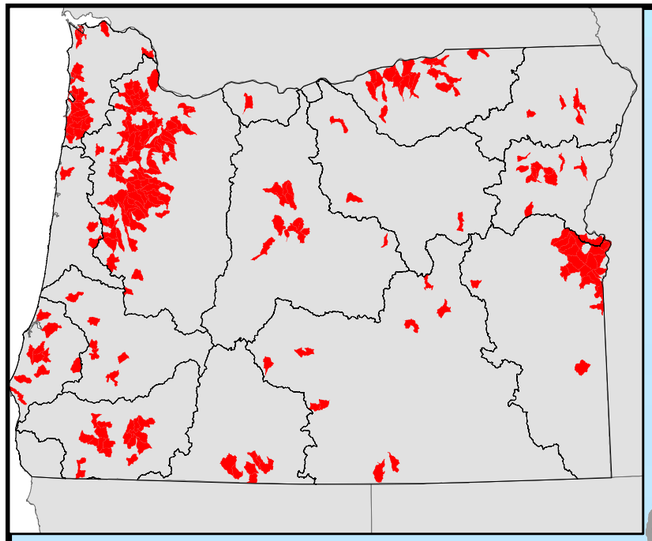
Population density used as a surrogate for septic system density. Census block areas with population densities greater than 6.15 people/ha (2.46 people/acre), the equivalent of 2.5 septic systems/ha (1 system/acre) based on average Oregon household size. HUCs with high rural population density are shown under census blocks.



Data Sources: US Census Bureau, 2000; USGS, 2006; TNC, 2008.

Map 26

Concentrated Animal Feeding Operations



HUCs with CAFOs

Active Concentrated Animal Feeding Operations (CAFOs), according to the Oregon Department of Agriculture database.

- CAFOs
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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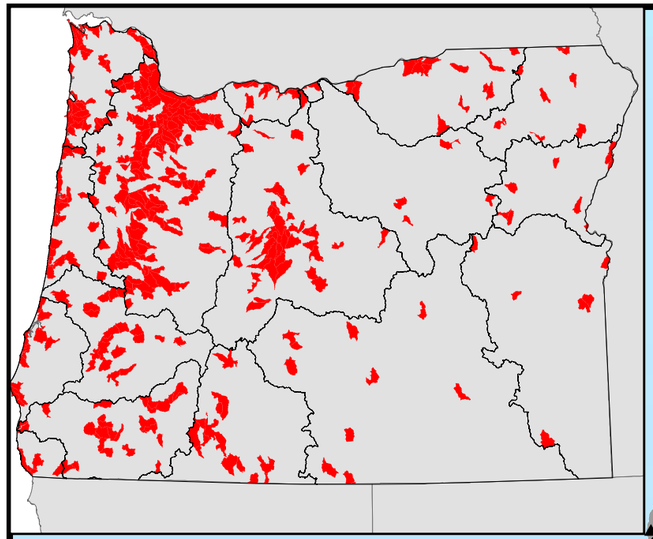
N

Miles
0 37.5 75 150

Kilometers
0 75 150 300

Data Sources: USGS, 2006; ODA, 2007; TNC, 2008.

Class V Underground Injection Control Wells - Nutrients



HUCs with UIC wells associated with nutrients

Class V Underground Injection Control (UIC) wells associated with nutrient inputs.

Nutrient UIC
Analysis Regions
Lakes and Reservoirs
Major Rivers

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N

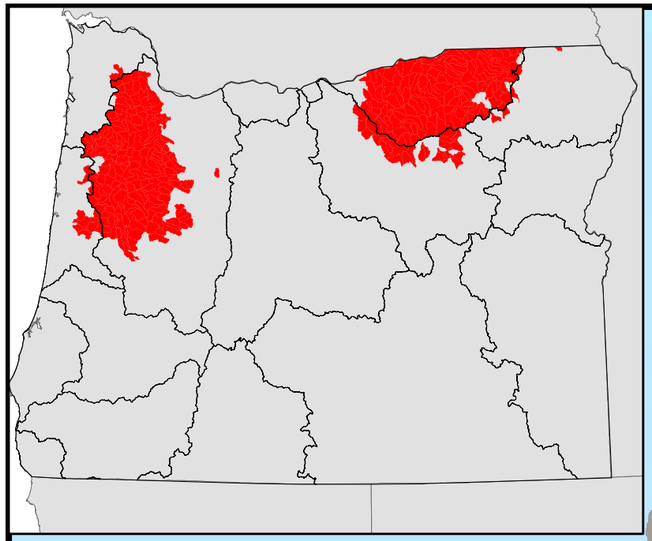
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; ODEQ, 2007b; TNC, 2008.

Map 28

Agricultural Use of Phosphorus Fertilizer



HUCs with agricultural landuse and high phosphorus fertilizer use

Agricultural land use in counties with high phosphorous fertilizer use.

- Agricultural Landuse
- Phosphorus Fertilizer Use
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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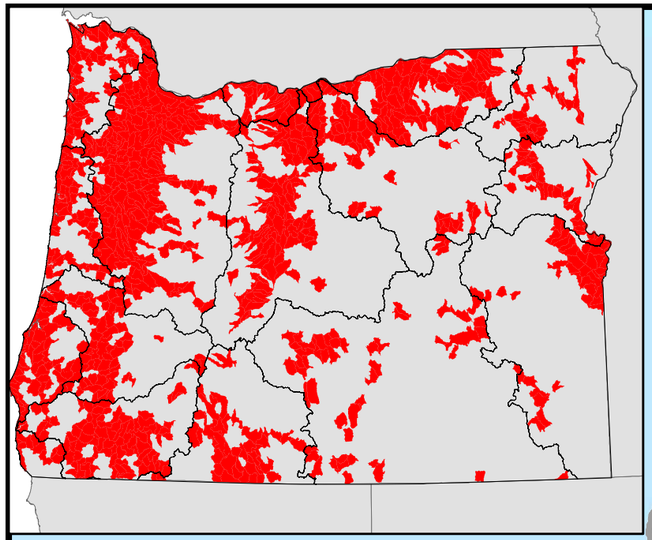
N

Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: Battaglin and Goolsby, 1994; USGS, 2003; USGS, 2006; TNC, 2008.

Developed Landuse - High and Medium Intensity



HUCs with high and medium intensity developed landuse

Urban landuse (high and medium intensity developed landuse) per the National Land Cover Dataset (NLCD).

Urban Landuse

Analysis Regions

Lakes and Reservoirs

Major Rivers

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N

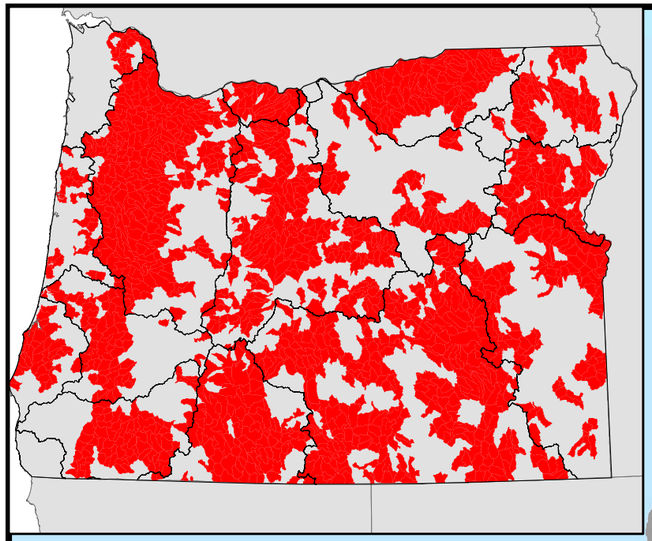
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2003; USGS, 2006; TNC, 2008.

Map 30

Threat of Groundwater Contamination from Agricultural Pesticide Use



HUCs with estimated use of 2 or more pesticides

1997 estimated use of 10 agricultural pesticides toxic to aquatic life and likely to contaminate groundwater. Colors indicate the number of these pesticides estimated to be used in each HUC6.

Number of Pesticides

- 1
- 2 - 5
- 6 - 7
- 8 - 10
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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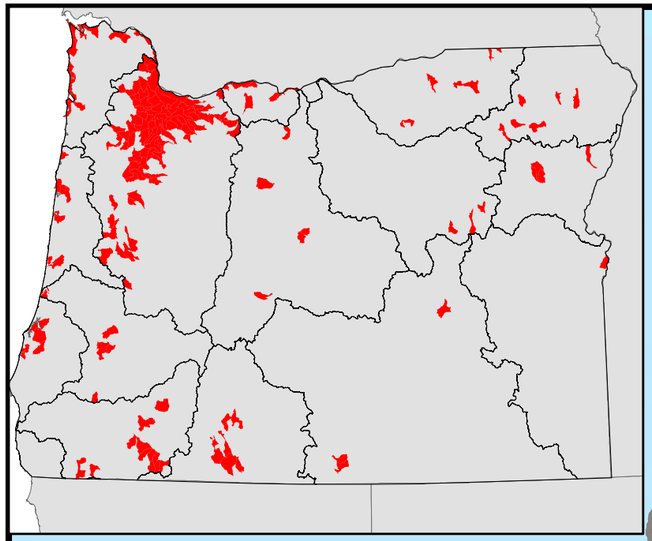
N

Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: Nakagaki and Wolock, 2005; USDA NRCS, 2006; USGS, 2006; TNC, 2008.

Leaking Underground Storage Tanks (LUSTs) near GDEs



HUCs with LUSTs within .8 km (.5 miles) of GDEs

Leaking underground storage tanks (LUSTs) in the ODEQ Facility Profiler database that are unregulated or have confirmed leaks and are within .8 km (.5 miles) of groundwater-dependent ecosystems or species (GDEs).

- LUSTs within .8 km (.5 miles) of GDEs
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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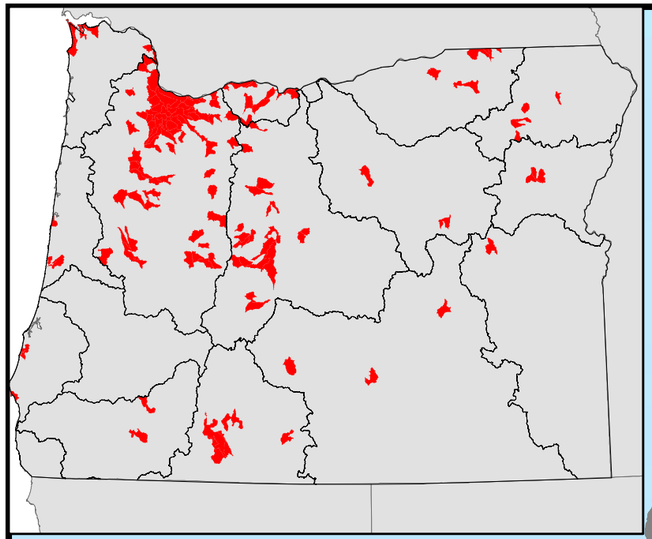
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; ODEQ, 2007a; TNC, 2007d; TNC, 2008.

Map 32

Underground Injection Control Wells - Other Toxic Contaminants near GDEs



HUCs with UICs within .8 km (.5 miles) of GDEs

Class V Underground Injection Control (UIC) wells in the ODEQ database that are i) not used for gray water or drinking water disposal; ii) not associated with nutrients, pesticides, or thermal inputs; and iii) are within .8 km (.5 miles) of groundwater-dependent ecosystems or species (GDEs).

- UIC within .8 km (.5 miles) of GDEs
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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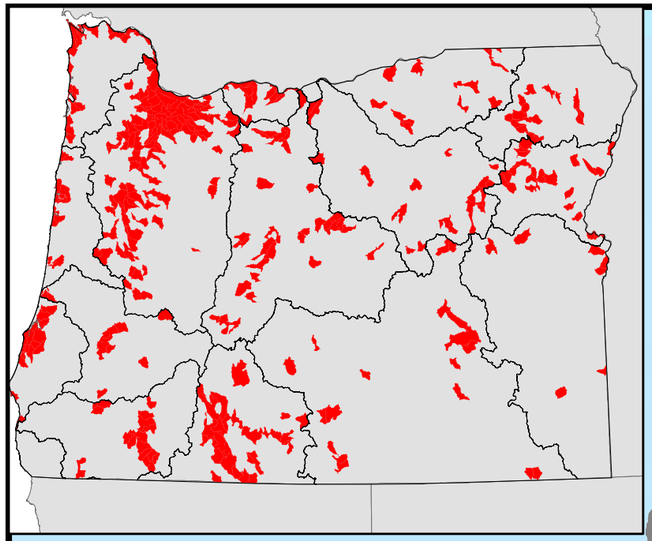
N

Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; ODEQ, 2007b; TNC, 2007d; TNC, 2008.

Hazardous Waste Spill Sites near GDEs



HUCs with hazardous waste spills within .8 km (.5 miles) of GDEs

Hazardous waste spills listed in the ODEQ profiler database that have not been cleaned up and that are within .8 km (.5 miles) of groundwater-dependent ecosystems or species (GDEs).

- Spills within .8 km (.5 miles) of GDE
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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N

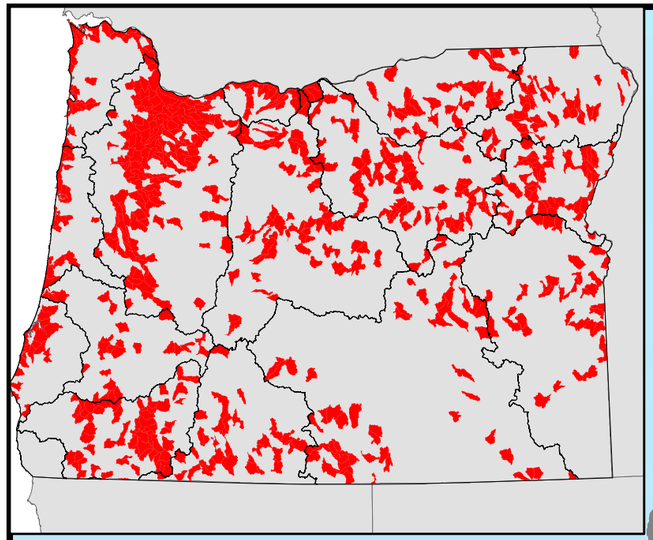
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; ODEQ, 2007c; TNC, 2007d; TNC, 2008.

Map 34

Landuses that Potentially Impact Groundwater Quality near GDEs



HUCs with specific landuses within .8 km (.5 miles) of GDEs

Landuses associated with an increased likelihood of spills that could impact groundwater quality, occurring within .8 km (.5 miles) of groundwater-dependent ecosystems or species (GDEs).

- Dry Cleaners near GDEs
- Airports near GDEs
- Gas Stations near GDEs
- Mines near GDEs
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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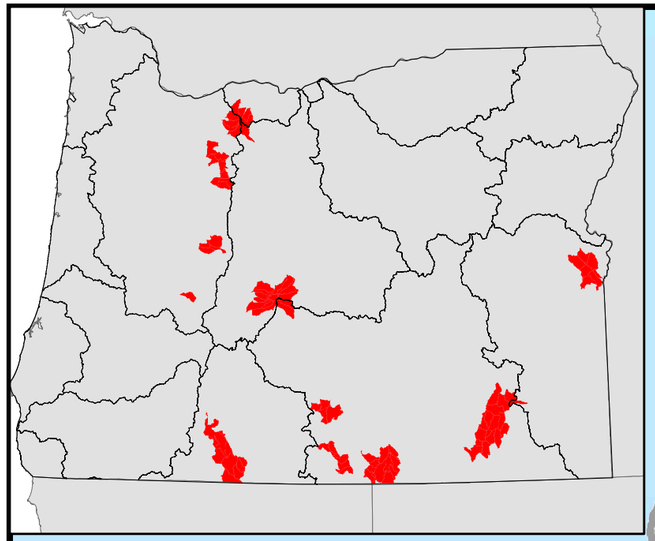
N

Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 1996; USGS, 2006; ODEQ, 2007a; ODEQ, 2007d; ODGAMI, 2007; TNC, 2007d; TNC, 2008.

Known Geothermal Resource Areas



HUCs with known geothermal resource areas

Known geothermal resource areas, per Oregon Department of Geology and Mineral Industries (ODGAMI). These are areas identified by the presence of thermal springs, thermal wells, and geohydrologic settings generally favorable for recovery of thermal water.

- Known Geothermal Resource Areas
- Analysis Regions
- Lakes and Reservoirs
- Major Rivers

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N

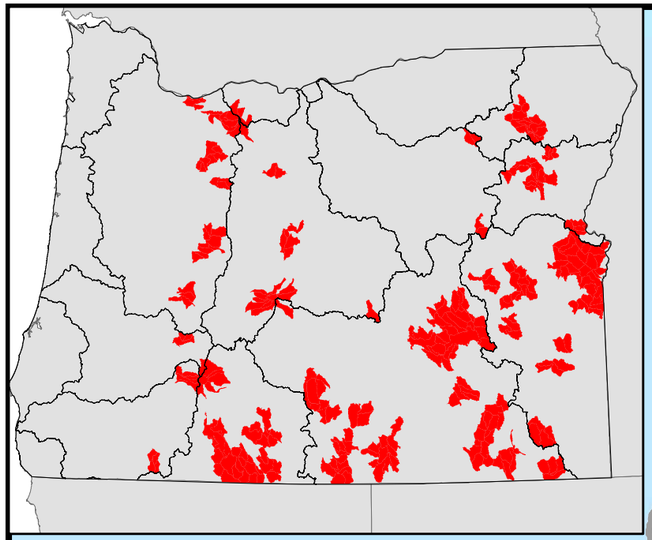
Miles
0 12.5 25 50

Kilometers
0 25 50 100

Data Sources: USGS, 2006; Niewendorp, et al. 2007; TNC, 2008.

Map 36

Potential Geothermal Resource Areas



HUCs with potential geothermal resources

Potential geothermal areas are those that are likely to contain geothermal resources, due to their geologic similarity to known geothermal areas.

Potential Geothermal Resources
Analysis Regions
Lakes and Reservoirs
Major Rivers

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N

Miles
0 12.5 25 50
Kilometers
0 25 50 100

Data Sources: USGS, 2006; Niewendorp, et al. 2007; TNC, 2008.

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