Hydrological Deposition Modeling

GIS Water Resource Planning for the Anthropocene

Background Map:

🟩 NCLD Agriculture Designation

▨ DOGAMI LiDAR Availability

This study depended on NLCD class and high resolution GIS surface modeling derived from LiDAR. It also needed to be in an area east of the Cascade Range and dominated by agriculture.

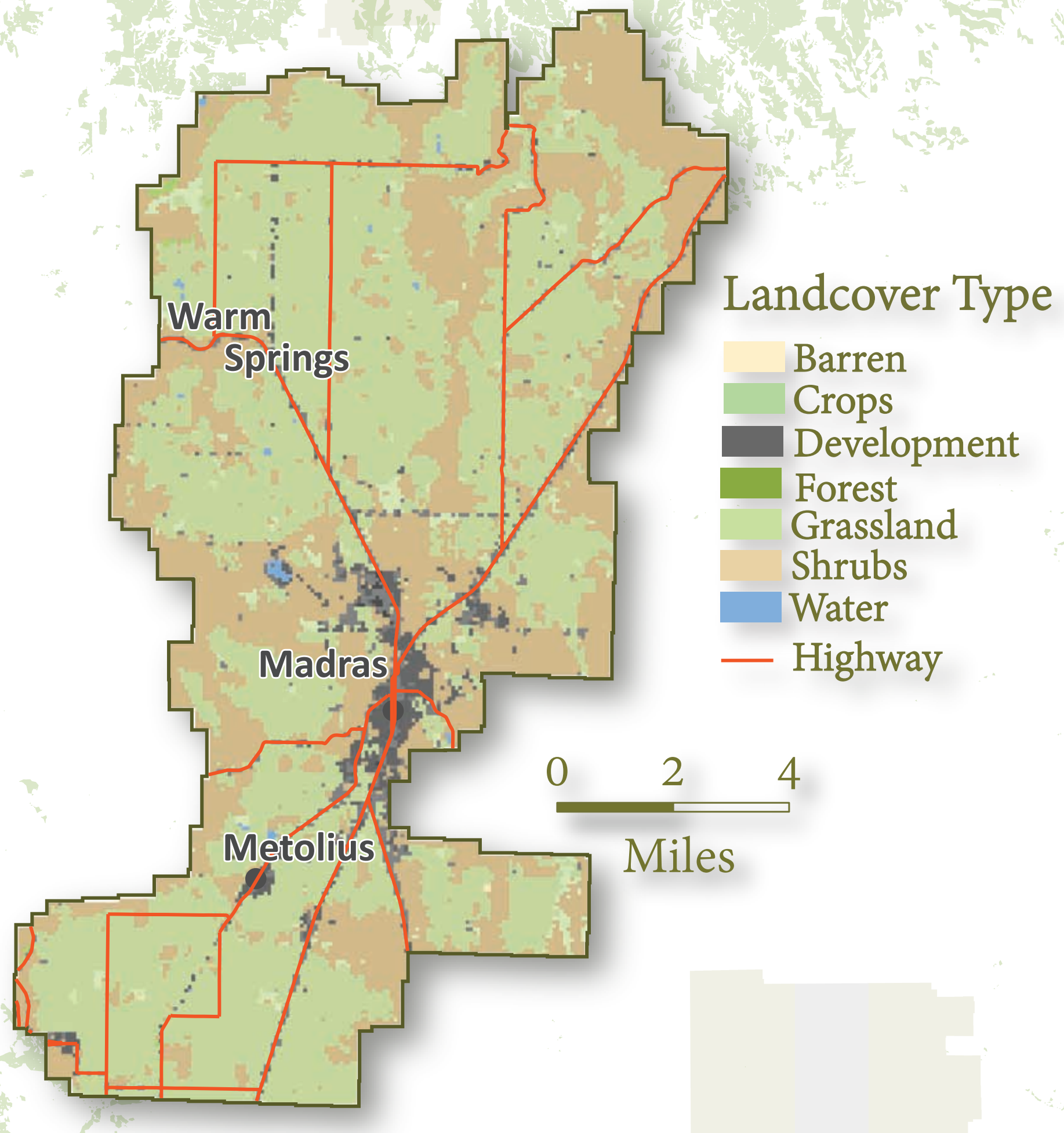
The Madras Agricultural Region

The Madras agricultural region sits in the rain shadow of the Cascade Range in North Central Oregon and is is heavily dependant upon the Deschutes, Metolius and Crooked Rivers (fed by snowpack) for irrigation. Between 1990 and 2014 the average monthly precipitation for the area was .9 inches with an annual average of 10.8 inches. The farms and ranches here are major economic drivers for the towns of Madras, Culver, Metolious and Warm Springs.

GIS is a tool that will help populations all over the globe plan for Anthropogenic Climate Change. Agriculture in semi-arid regions such as this one will perhaps be the first to experience the worst affects of Global Warming. Consequently, it is imperative that GIS modeling in conjuction with other technologies such as Light Detection & Ranging (LiDAR) be utilized for optimal surface and ground-water resource management.

Study Area

NLCD Cover Typology

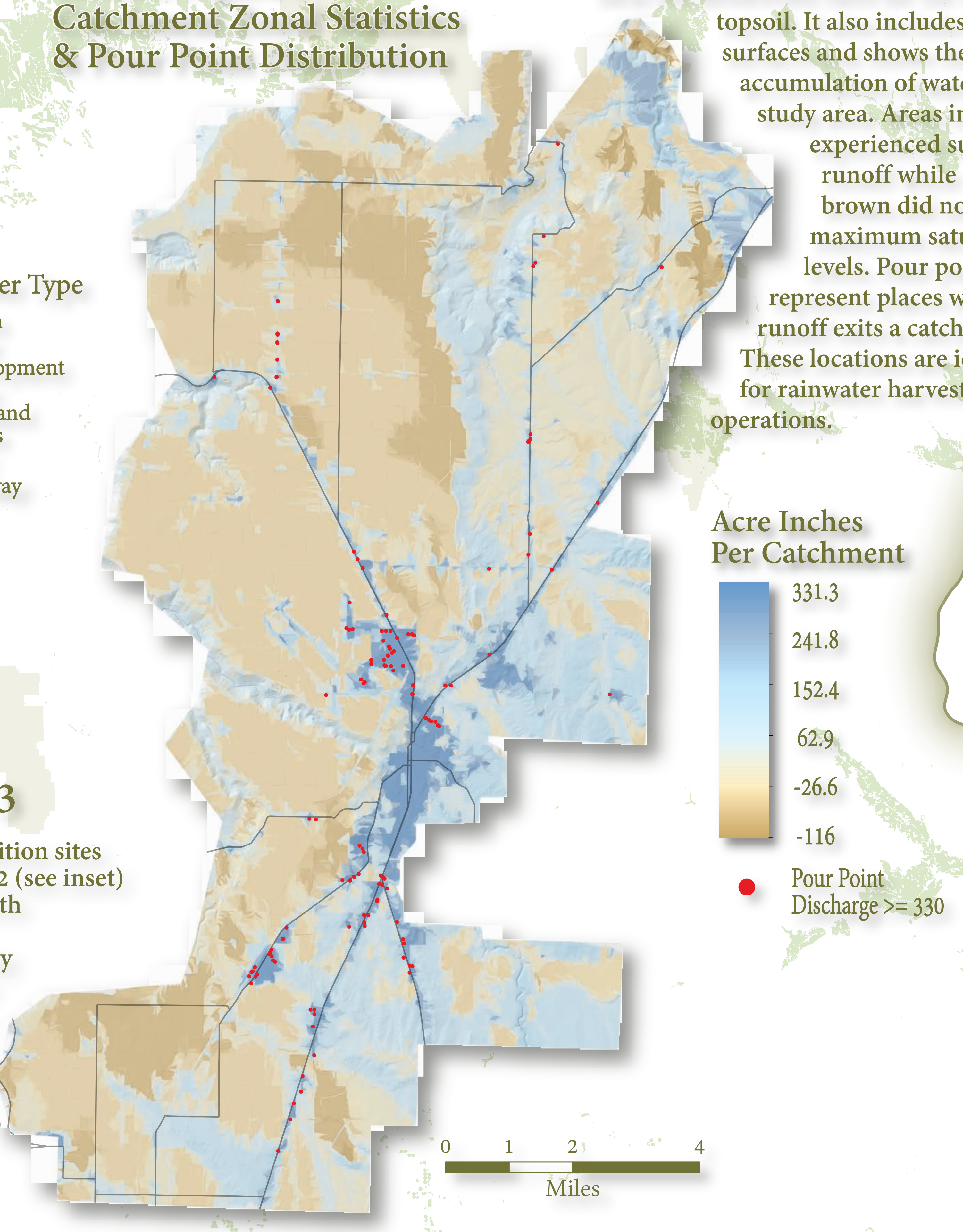


Landcover Type

- Barren
- Crops
- Development
- Forest
- Grassland
- Shrubs
- Water
- Highway

Results: Figure 1

Catchment Zonal Statistics & Pour Point Distribution



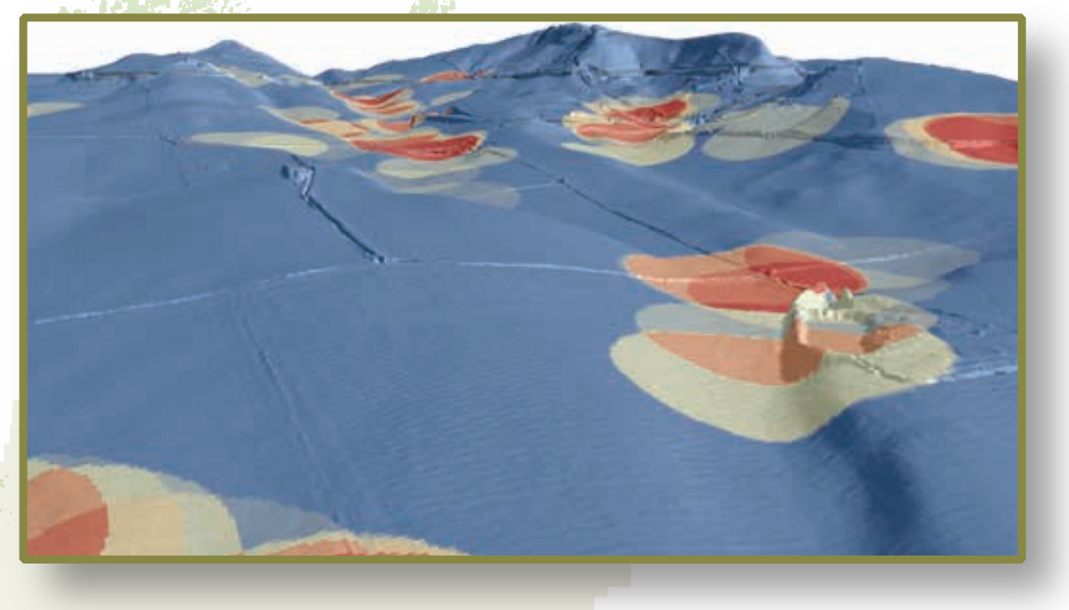
Acre Inches Per Catchment

331.3
241.8
152.4
62.9
-26.6
-116

● Pour Point Discharge >= 330

Results: Figure 1

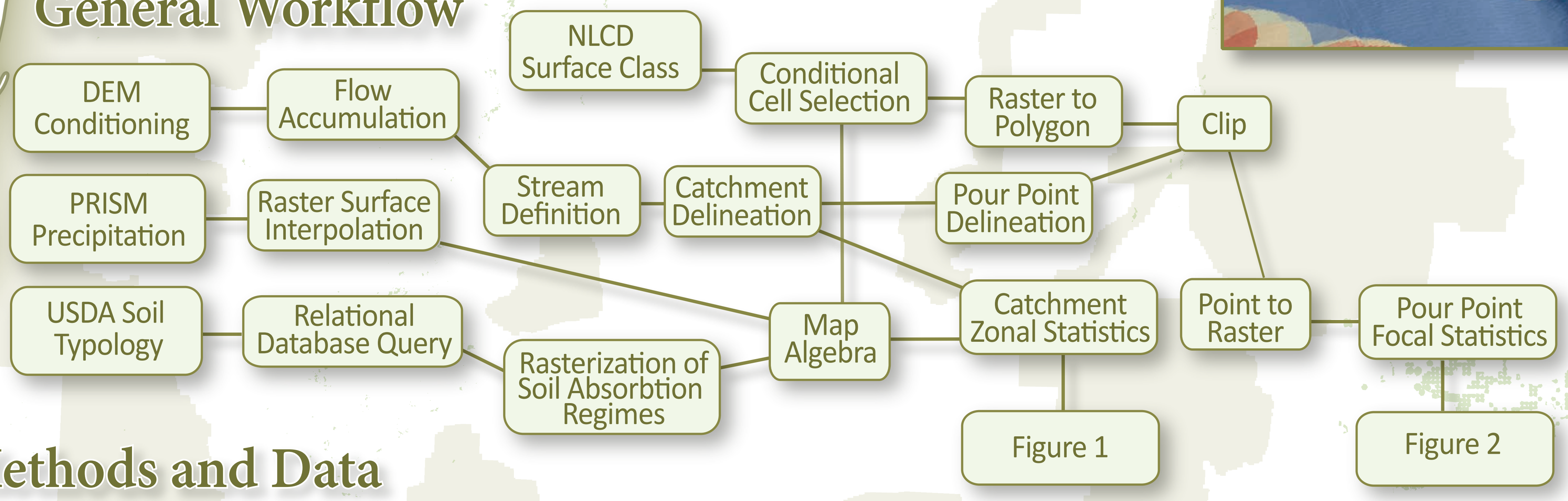
This map models the distribution of precipitation on 11/19/1996 when estimating local soil absorbtion rates for the top 50 cm of topsoil. It also includes impervious surfaces and shows the modelled accumulation of water over the study area. Areas in blue experienced surface runoff while areas in brown did not reach maximum saturation levels. Pour points represent places where runoff exits a catchment. These locations are ideal for rainwater harvesting operations.



Results: Figure 3

Left: Primary water deposition sites southward view of Figure 2 (see inset) Developed in ArcScene with 5X vertical exageration. These are areas that display localized pooling under a large precipitation event.

General Workflow

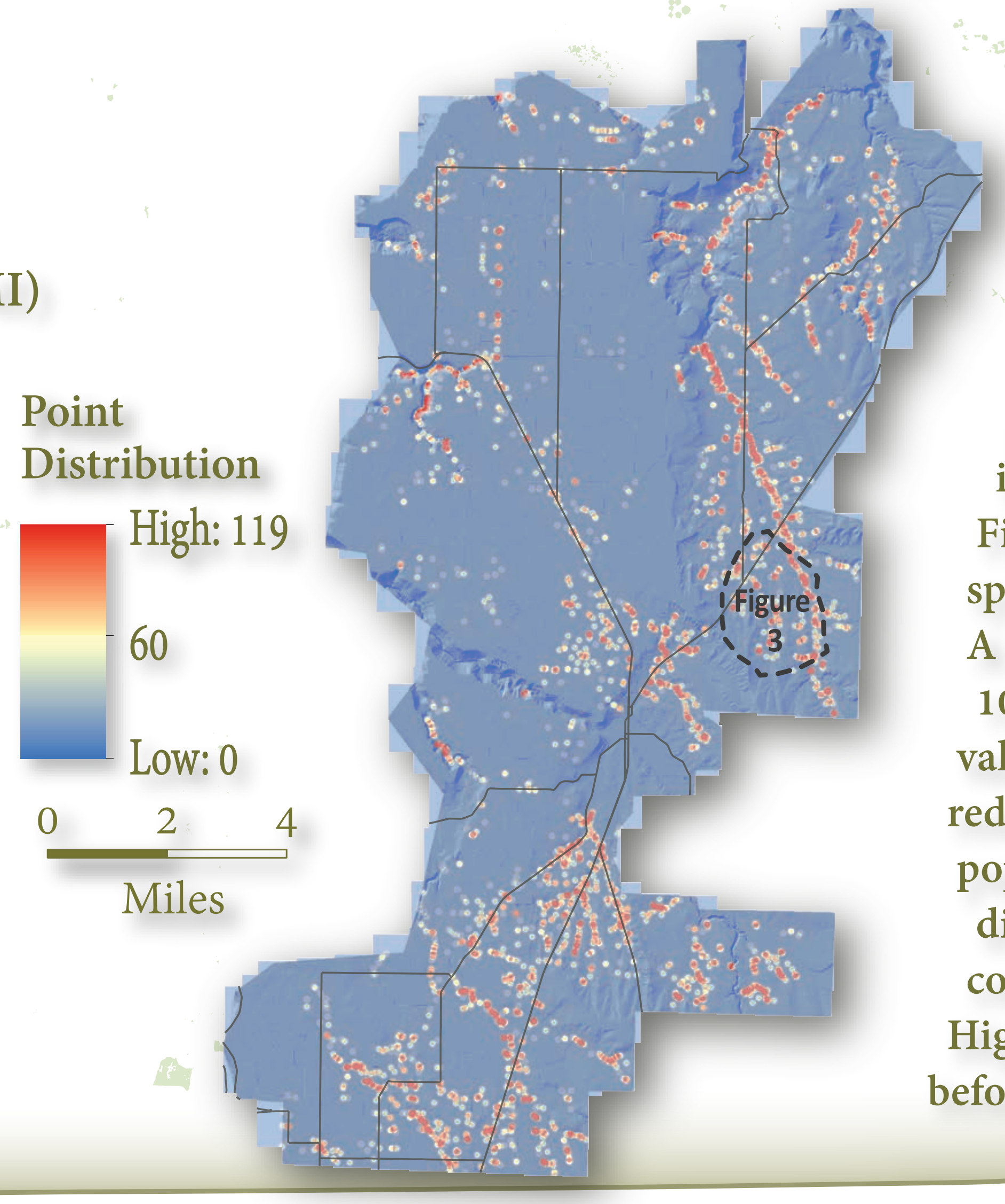


DEM Conditioning
Flow Accumulation
NLCD Surface Class
Conditional Cell Selection
Raster to Polygon
Clip
PRISM Precipitation
Raster Surface Interpolation
Stream Definition
Catchment Delineation
Pour Point Delineation
USDA Soil Typology
Relational Database Query
Rasterization of Soil Absorbtion Regimes
Map Algebra
Catchment Zonal Statistics
Point to Raster
Pour Point Focal Statistics
Figure 1
Figure 2

Methods and Data

This study utilized a 1-meter resolution DEM acquired from the Oregon Department of Geology and Mineral Industries (DOGAMI) in conjunction with interpolated precipitation data provided by the PRISM Climate Group/Oregon State University and, an estimated 50 cm available water storage (AWS) layer derived from the USDA/NRCS National Soils Database.

This study employed the traditional workflows associated with watershed delineation and flow network analysis as are used by the USGS. Because this study aimed to model localized hydrologic pooling, the stream definition threshold was designated at 2 acres. This yielded complex stream channel networks and catchment systems. Precipitation values were interpolated from data recorded on November 19th of 1996 in which the study area received 2.77 inches of rain, Madras area's largest precipitation event between 1990 and 2014. This value was then added to the estimated holding capacity of the top 50 cm of soil plus NLCD areas designated as "Developed" such as towns and roads. In some places the soil was capable of absorbing all precipitation, while in others, it was not. To find out which catchments experienced surface runoff Zonal Statistics was performed (Figure 1) with delineated catchments as specified zones. At this scale many pour points (locations where a stream exits a catchment) are in close proximity and may contribute to a mutual pooling area. To find out which areas have an aggregation of pour points, focal statistics were performed (Figure 2).



Point Distribution

High: 119
60
Low: 0

Results: Figure 2

Pour Point Focal Statistics

This surface model shows relative distribution of pour points across the study area. To be included in the model, point locations needed to have a positive runoff value assigned from bilinear interpolation extracted from the surface created in Figure 1. Similarly, they also needed to occupy space designated as agricultural by the NLCD. A focal statistics search radius was assigned at 100 radial feet; this produced a surface where blue values have zero pour points within that distance and red values have up to 119 pour points. Regions populated with higher focal values are generally distributed along roadways or where terrain displays concave characteristics (see figure 3). High focal values model where water collects locally before it chanelizes and heads downstream.

N

About the Author:
Gabriel Rousseau earned his Graduate Certificate in GIS in 2015
He is a M.S.Candidate in Urban and Regional Planning at Portland State