GLYPHOSATE:

## Risk assessment of Argentina's most widely used Herbicide

Cartographer: Quang Truong

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Overview

Glyphosate is a broad-spectrum herbicide used to eliminate weeds in both industrial farming and domestic gardening. Introduced in the 1970's by Monsanto under the brand name *RoundUp,* glyphosate is widely used by farmers of soy, corn and cotton and attributed with higher yields and easier crop management.
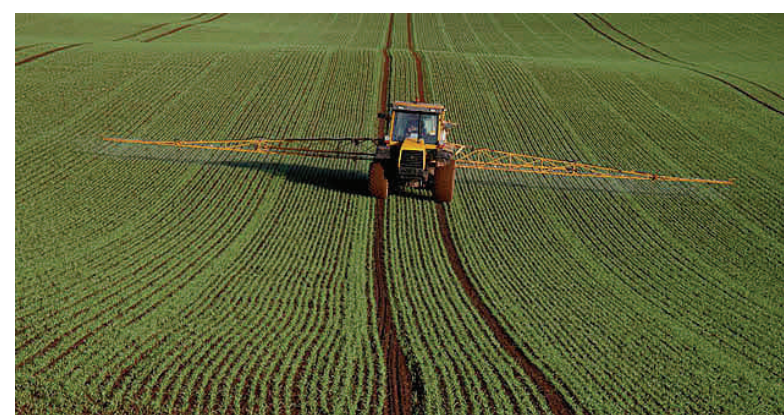
Recently, however, studies have been released raising doubts about the safety of the herbicide. Gasnier et al., 2009 conclude that glyphosate based herbicides are toxic and endo-crine disruptors in human cell lines. An Argentinian team led by Carrasco et al., 2010 conclude that pre-natal glyphosate exposure can lead to birth defects in amphibian em-bryos. Numerous other studies have been published: Yousef et al., 1995; Savitz et al., 1997; Daruich et al., 2001; Beuret et al., 2005; Dallegrave et al., 2007; Oliveira et al., 2007; Cavalcante et al., 2008.

The potential toxicity of glyphosate is especially of interest in Ar-gentina, where 95% of the soy grown is sprayed with glyphosate. Hospitals in the cities of Cordoba and Resistencia, both in soy grow-ing regions, have noted a sharp rise in birth defects. Local municipal-ities and news agencies allege that the chemical is directly responsi-ble for these birth defects. The purpose of this analysis is to identify areas in Argentina where potential exposure to glyphosate is highest. This will allow policy makers to determine which areas are most crit-ical to consider for public health and safety.

Methodology

This analysis relies on geospatial analysis of risk factors that may contribute to glyphosate exposure. Summarily, three broad categories of potential risks factors were examined:

1) *Soy Production Figures:* Because over 95% of the soy grown in Argentina is genetically-modified for use with glyphosate, these fig-ures present a reliable proxy for spraying of the herbicide.

2) *Small Holder Farmers:* Based on interviews with industry experts at Monsanto and Soyatech, farmers face high levels of primary-level exposure risk, due to constant and direct contact with the chemicals.

3) *Socioeconomic Indicators:* Factors such as level of wealth, litera-cy, access to plumbing and population density also affect the level of risk.
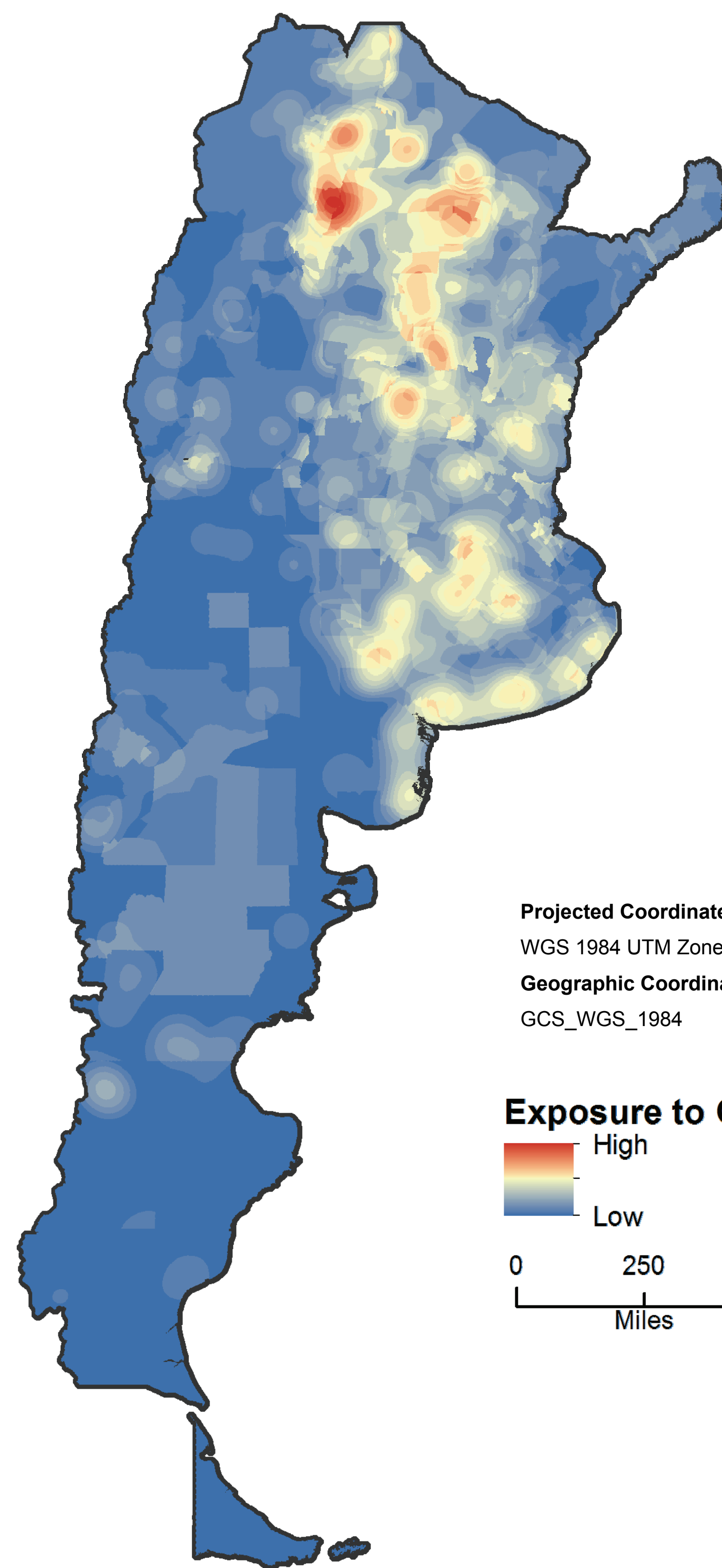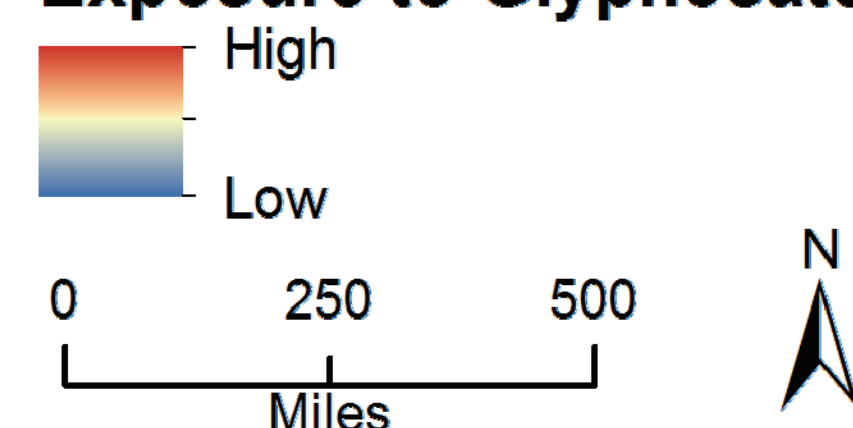
Analysis

Soy Production: Using crop production figures as a proxy for chemical level exposure is not unique. Kettles et al., 1997 use corn production data as a proxy for Triazine exposure in Kentucky. Nuckols et. al, 2004, similarly provides guidance for using crop data on epidemiological surveys. Soy produc-tion figures were obtained at Sistema Integrado de Infor-macion Agropecuaria (SIIA), a statistical division of Argen-tina's Ministry of Agriculture. These data were imported into GIS, creating a map of area of soy harvested, in hectares, at the department level in 2010. This was also combined with Land Cover data from Argen-tina's Geographic Agency (SIG-250) to arrive at a more fine-grained assessment of where soy is grown. Lastly, the maps were converted to a kernel-density raster and given a risk score based on intensity of soy pro-duction.
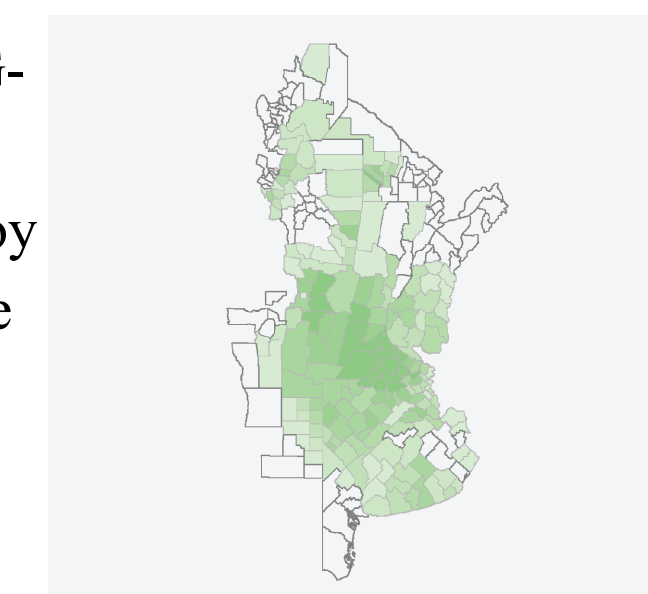
Small Holder Farmers: Calculations for determining the presence of smallholders throughout Argentina were per-formed using 2001 Rural Infrastructure data from the SIG-250 data set. This dataset consisted of 29,215 discreet points labeled by farm type. Points with labels representing small farms (Chacra, Finca) were filtered and then used to create a kernel-density raster map. Scores were then given, with high-er scores associated with areas possessing a higher density of these small farm infrastructures.
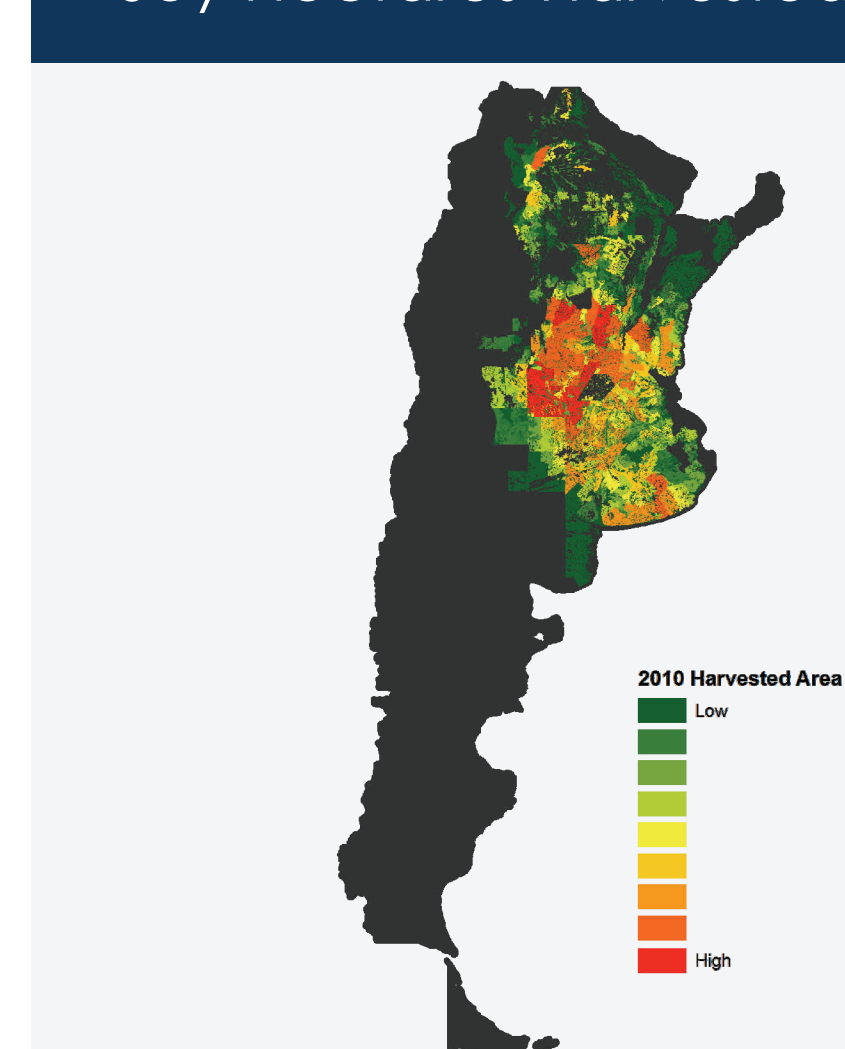
The SIG-250 dataset also provided information on water-courses and elevation. While many exposure assessments use these data as representative risk factors, I chose not to. Ele-vation data in soy growing regions is incredibly consistent, so factoring this into the final risk assessment would not have had a meaningful impact. Additionally, the case for heightened toxic exposure risk due to waterways is quite weak. Current literature suggests that rivers tend to diffuse - more than spread toxins - so the argument for this epidemio-logical pathway is somewhat suspect.

Socioeconomic Indicators: Lastly, 2010 data provided by the Instituto Nacional de Estadísticas y Censos (INDEC), was used to assess general department level risk. Of the possible census indicators, I chose population density, literacy rate, and access to tap water. Population density is typically used in epidemiological surveys, simply because there is a higher chance for health ailments in larger populations. Literacy rate is used as a proxy for wealth in some studies, but also of im-portance in relation to glyphosate: farmers who are illiterate will be unable to read warning labels or directions on proper use of the chemical. They are also more likely to be undered-ucated, increasing potential risks. Finally, access to piped-water is crucial in the context of glyphosate. Households without access to water infra-structure are more likely to use well water, or exterior sources of water that may be contami-nated with toxins.

Conclusions

The results of this analysis may come as a surprise to some: areas in Argentina that are at highest risk of glyphosate exposure are not in the regions where soy is most heavily grown. Though the Pampas "breadbasket" of the nation has the most acres under cultivation, the center north of the country, in prov-inces such as Santiago del Estro, Chaco, Tucamao and Salta face greater risks. Specifically, the depart-ments of Burruyacu, Nuevo de Julio (Chaco) and General Belgrano (Chaco) fall entirely in the high risk zone. The reasons for this have to do with the greater concentration of smallholder farmers and poorer economic conditions which may lead to lower safety and sustainability standards. However, it is important to point out that other ways for combining production data, economic data and farm data exist, and different methods may have varied results.
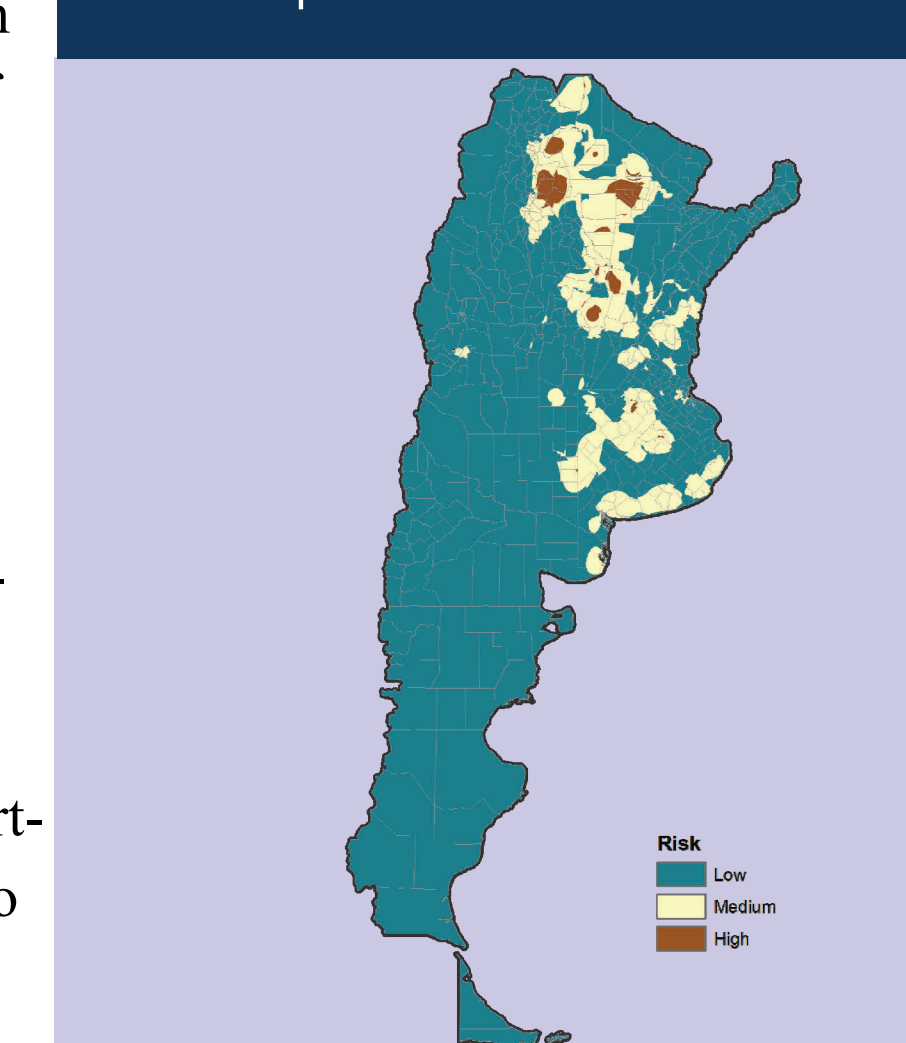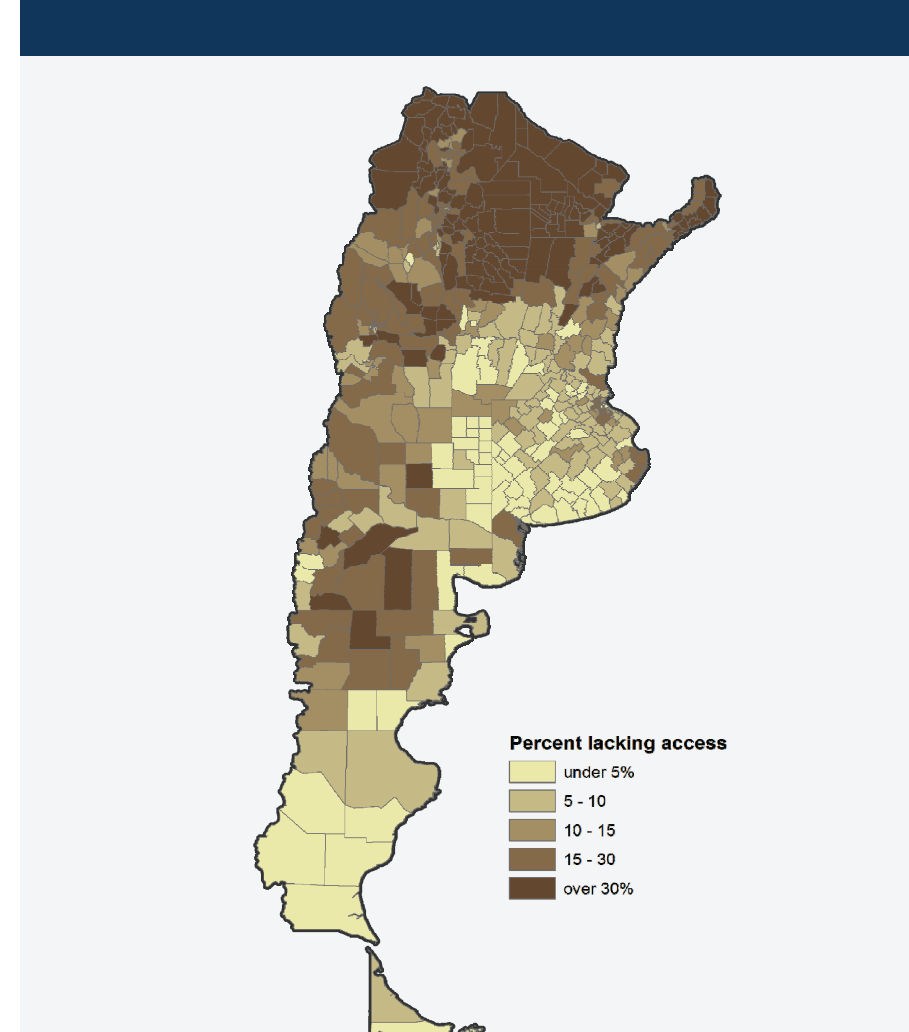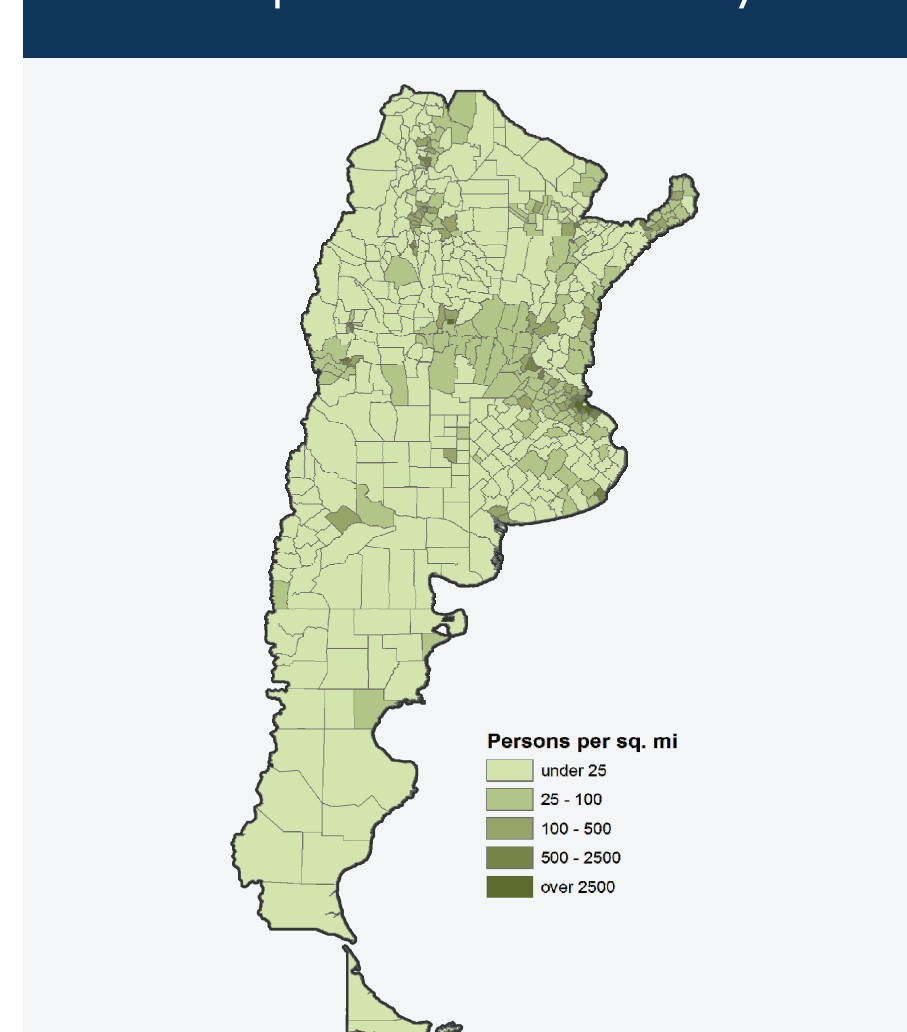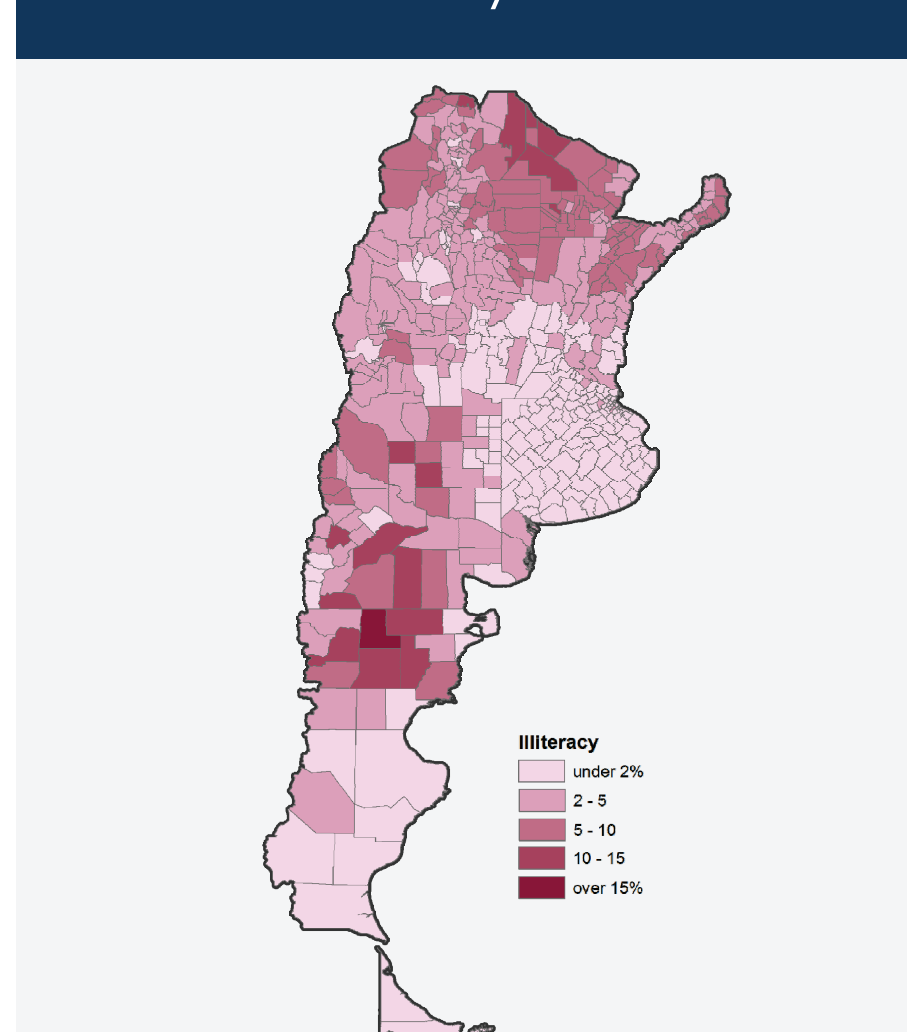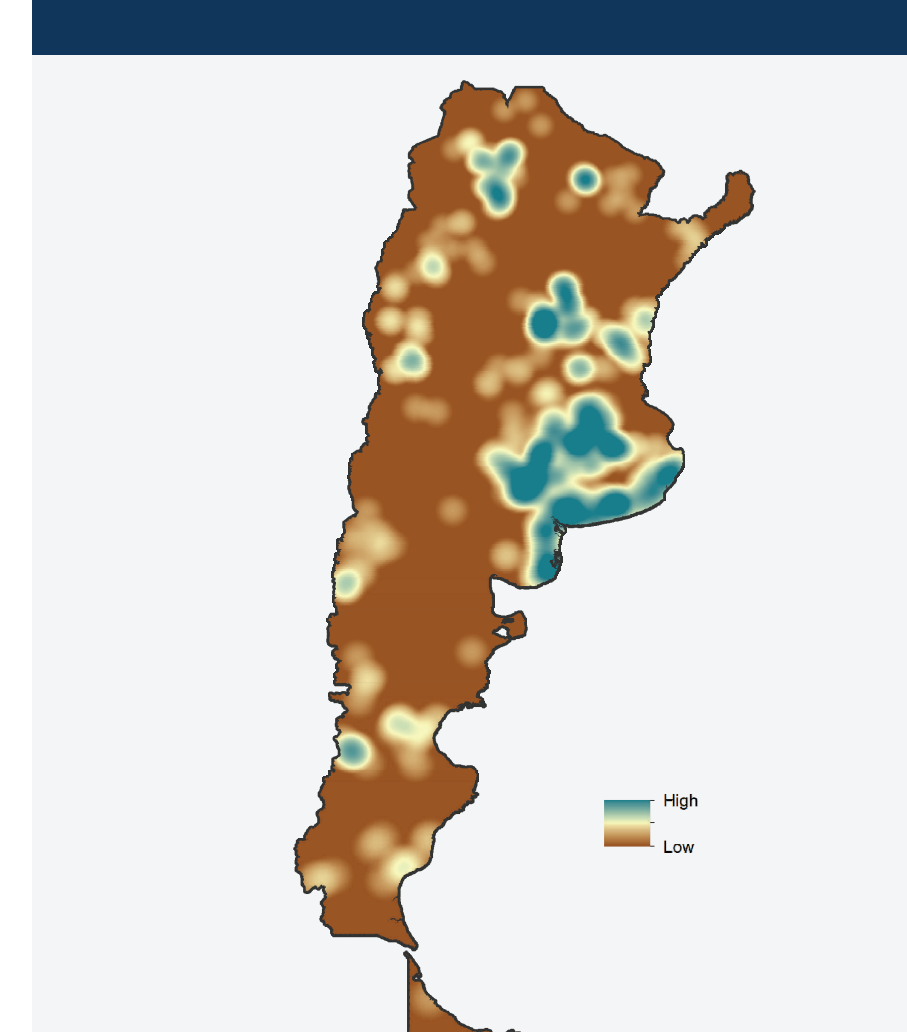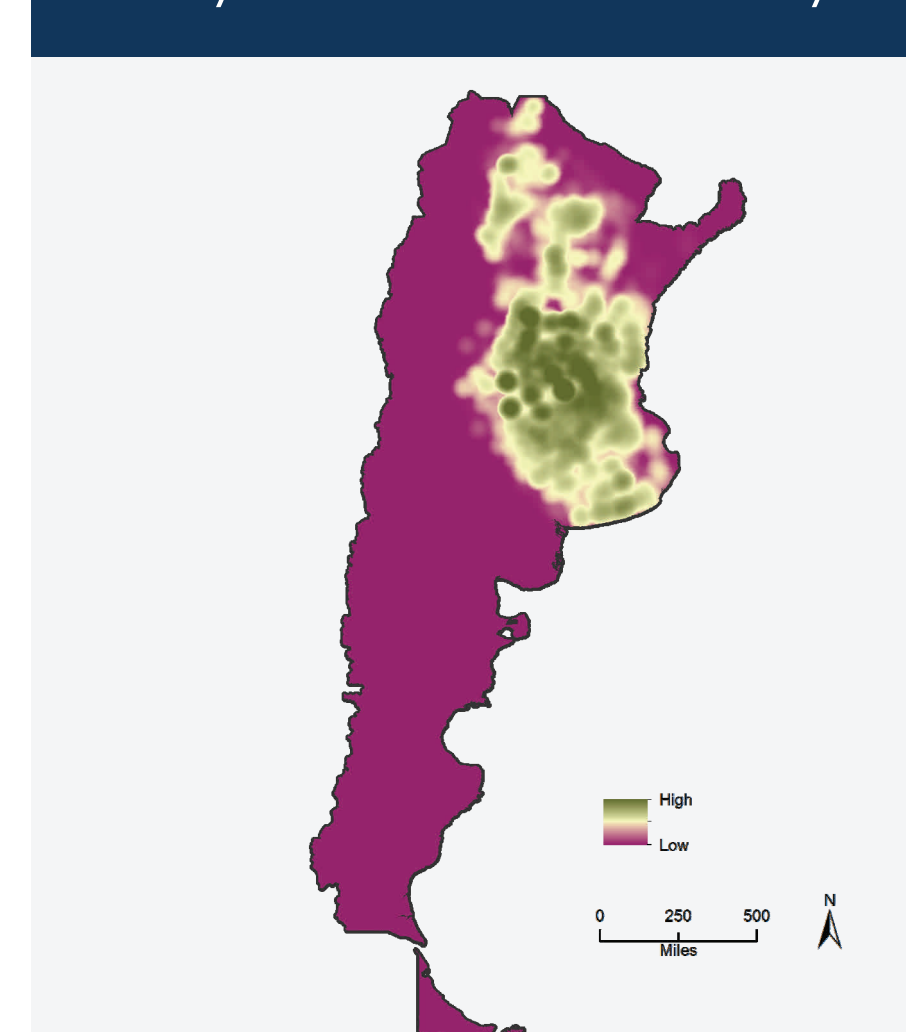
Sources and Citations:

1)"Setsistema de Información Geográfica 250", Argentina Mapping Agency. 2001. <http://www.ign.gob.ar/sig250 >

2)"SIIA Database", Sistema Integrado de Informacion Agropecuaria. Argentina Ministry of Agriculture. 2010. <http://www.siia.gov.ar/index.php/series-por-tema/agricultura >

3)"Census Data", Instituto Nacional de Estadística y Censos (INDEC). 2010. <http://www.sig.indec.gov.ar/censo2010/>

4)"Administrative Boundaries", Global Administrative Database. 2000. <http://www.gadm.org/country>

5)Additional research not cited above: Stellman, Jeanne M., et al. "A Geographic Information System for Characterizing Exposure to Agent Or-ange and Other Herbicides in Vietnam." Environmental Health Perspectives 111.3 (2003)...Nhu, Dang, et al. "A GIS study of dioxin contamina-tion in a Vietnamese region sprayed with herbicide." Environ Health Prev Med (2009)...Reynolds, Peggy, et al. "Childhood Cancer and Agricul-tural Pesticide Use: An Ecologic Study in California." Environmental Health Perspectives 110.3 (2002)

Projected Coordinate System:
WGS 1984 UTM Zone 20S
Geographic Coordinate System:
GCS_WGS_1984

Exposure to Glyphosate
High
Low

0   250   500
Miles
N

Soy Hectares Harvested

2010 Harvested Area
Low
High

Departments at Risk

Risk
Low
Medium
High

Water Infrastructure

Percent lacking access
under 5%
5 - 10
10 - 15
15 - 30
over 30%

Population Density

Persons per sq. mi
under 20
25 - 100
100 - 500
500 - 2500
over 2500

Illiteracy Rate

Illiteracy
under 2%
2 - 5
5 - 10
10 - 15
over 15%

Small Holder Farmers

High
Low

Soy Production Density

High
Low

0   250   500
Miles
N