A Bitter Legacy: Agent Orange in 21st-Century Vietnam

Project Overview

Between 1961 and 1971, the US military, in an effort to remove vegetation being used for concealment by North Vietnamese and Vietcong forces during the Vietnam War, sprayed an estimated 12 (Schechter et al 1995, 516) to 19 (Stellman et al 2003, 321) million gallons of chemical herbicides—primarily Agent Orange, which contains a toxic chemical compound called dioxin—over approximately 10% of the land surface of the former Republic of Vietnam (South Vietnam). This action was taken at the request of South Vietnam's US-backed government, and at the time it was not seen as an aggressive act by the US and South Vietnamese governments, but today it remains an area of tension between the US and Vietnam and has had significant public health impacts in Vietnam and among American veterans (Stevenson 2014).

The precise impact of Agent Orange on health is still debated among scientists, but studies have indicated a causal relationship between dioxin exposure and a number of diseases (including cancers) in veterans. Agent Orange has been credibly linked to "birth defects, reproductive health problems, endocrine disruption, and neurological damage" (Ngo et al 2012, 956). Effects like spina bifida may manifest in the children of those exposed; a 2012 study found that gestating female rats exposed to dioxin passed mutations to their children (Ornstein and Fresques 2016). The US government has recognized Agent Orange-related health problems in American veterans and their children, but Vietnamese victims of Agent Orange and their children have gone unrecognized; the government has cited studies dismissing a link between Agent Orange and birth defects. Nevertheless, the extent of possible dioxin contamination in Vietnam is extensive enough, and the possibility of debilitating health effects serious enough, to make the use of Agent Orange and its continuing impact worthy of further study. This project attempts to shed more light on the potential effects of Agent Orange in modern-day Vietnam by answering the following questions using ArcGIS:

- **What populations are most vulnerable to the effects of dioxin contamination? Where are populations most vulnerable to the effects of dioxin contamination? Where was Agent Orange sprayed in South Vietnam?**
- **How many vulnerable people live in areas likely to have high rates of contamination?**
- **What type of land experienced high rates of Agent Orange exposure? How much cropland is in high-exposure areas?**

The goal of this study is to inform future Agent Orange-related interventions by highlighting the areas and populations that have the most potential vulnerability to dioxin contamination.

Methodology

This study was conducted at the district level, the second-level administrative unit in Vietnam below the province (using districts as they existed during the 2009 census, the most recent conducted at the time of this study). Before beginning the study, the **environment** was limited to include *only* districts in the former Republic of Vietnam (South Vietnam); Agent Orange was not used in North Vietnam, and including it in the study would only have served to skew the results.

As discussed previously, there is significant evidence that dioxin contamination can be passed from parents to children, and that potential effects of dioxin may be felt most acutely among pregnant women (Kogevinas 2011, 338). In addition to the possibility of birth defects, infants in contaminated areas face increased risk of dioxin contamination through breast milk (Lorber and Phillips 2002, 325), potentially leading to serious health consequences. This led to the creation of a vulnerability index incorporating two variables derived from 2009 Vietnamese census data: **percentage of the population under 5** and **percentage of the population who are women with children**. Persons with disabilities also experience greater difficulty accessing health services in Vietnam and face other barriers to a healthy life, in addition to the possibility that their disabilities themselves are linked to Agent Orange (Ngo et al, 961). Therefore, a third vulnerability factors was added: the **percentage of the population identifying as disabled**. These were added together to create an index of the percentage of the population in each district that fits within a vulnerable category—while not comprehensive, this index provides a reasonable approximation of vulnerability to dioxin by district.

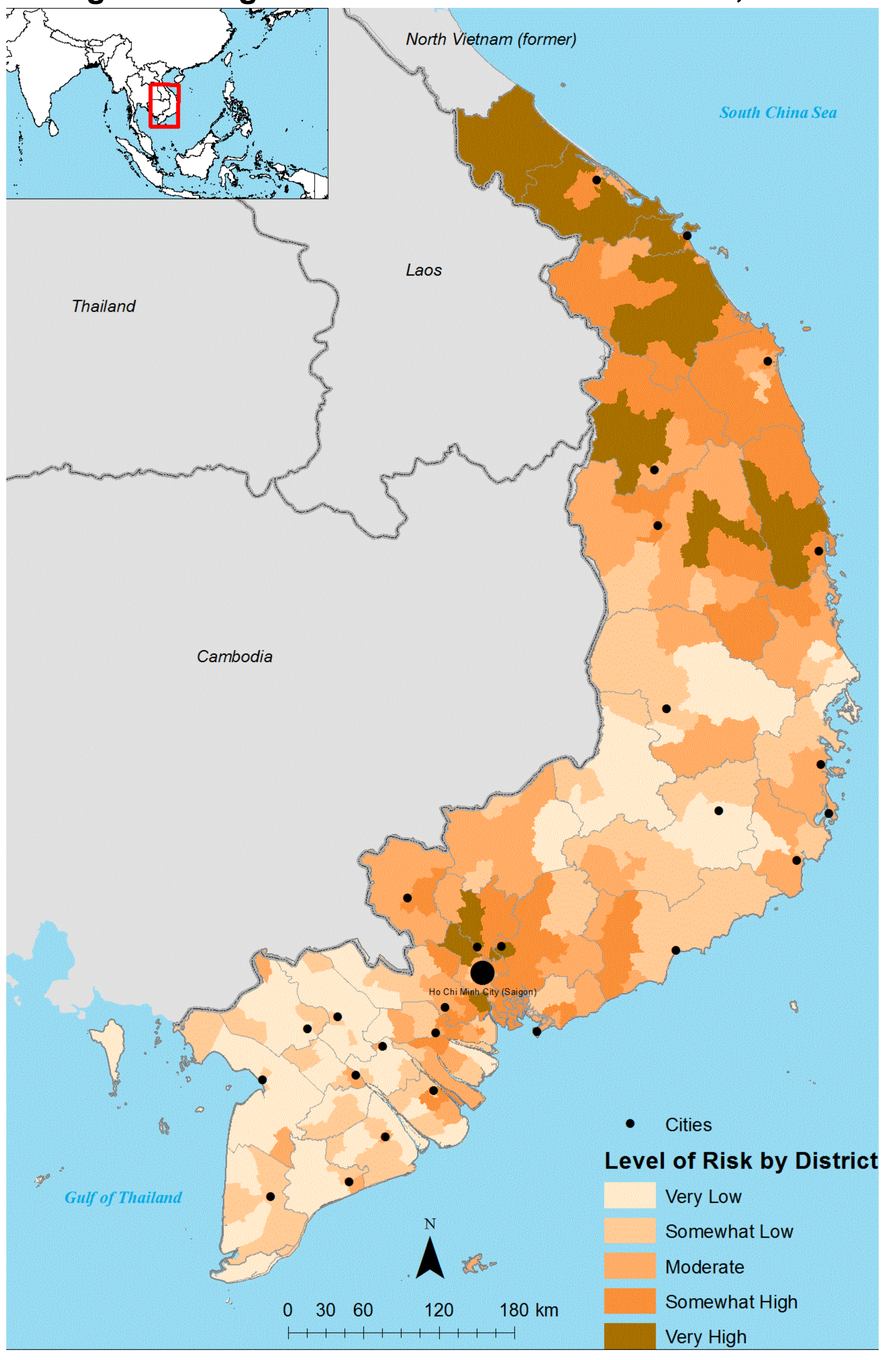
After determining variables to include in the index, the index was created as follows: **ranking data** for each variable, **normalizing** each variable by population and using the **field calculator** to add them up and create a complete index.

After setting the environment and creating the index, the following steps were taken:

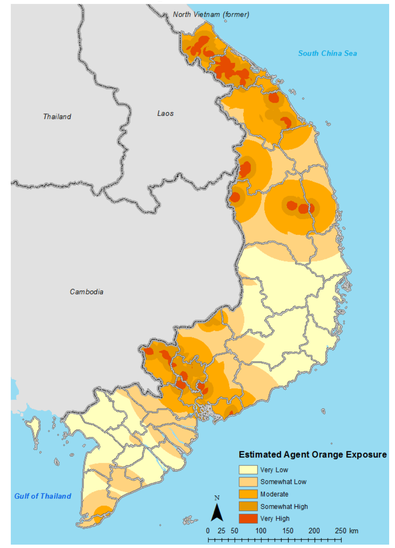
- Mapping Agent Orange data using the *exposure score* developed by Stellman et al based on the HERBS dataset, a comprehensive study by the US military of herbicide spraying missions in South Vietnam. For each location measured, the exposure score determines the likely level of exposure to Agent Orange, "takes into account the number of gallons of herbicide sprayed, the actual distance along the flight path, and continuing exposure over the entire residence time at the location" (Herbicide Exposure Assessment Manual). Two point files were created based on the exposure score, using natural breaks to create two point files reflecting medium- and high-exposure points.
- Two methods were used to determine exposure by district and region. For the first method, **Euclidean distance** was used for each point, which were **reclassified** to rank Euclidean distances—the shorter the distance to an exposure point, the higher the rank. This was done separately for medium- and high-exposure points. The **raster calculator** was used to add these two datasets together, with high-exposure points being weighted more heavily (at 67% of the total). For the second method, a **spatial join** of exposure points to districts was conducted. Agent Orange data was normalized by population, and **zonal statistics as table** was used to create a composite vulnerability score, which was **joined** to districts.
- To measure risk (vulnerability and exposure) by district, new fields were created using the **field calculator** to measure distance and vulnerability with population. **Tabulate area** was used to determine the mean exposure score by district (which was **joined** to previously determined data). A composite risk score was created for each district by using the **field calculator** to add mean exposure by district (indexed from low to high) and the vulnerability index created previously.
- To examine the relationship between land cover and exposure, a worldwide dataset on land cover was added to the existing map. After **projecting** this dataset to match the rest of the project, **tabulate area** was used to find the area of land cover for each district. High-exposure districts could then be selected to find the type of land exposed and the amount of cropland exposed.

Photos courtesy Wikimedia Commons

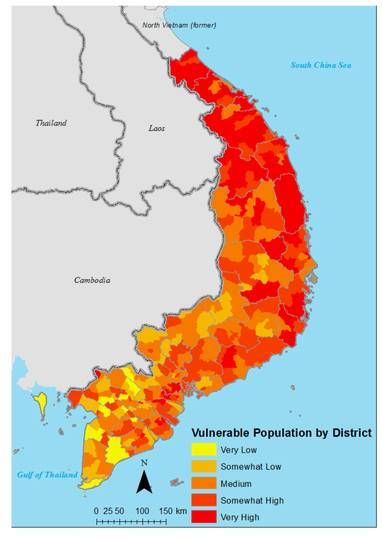
Agent Orange Risk in former South Vietnam, 2009



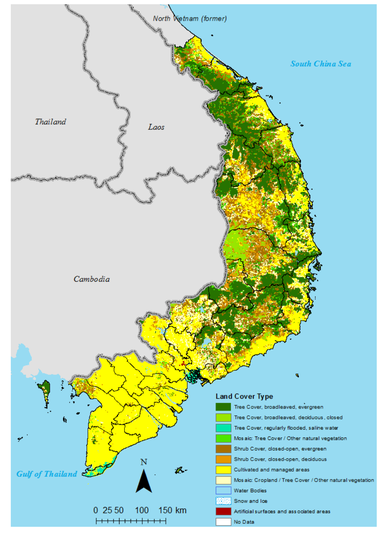
Exposure



Vulnerability



Land Cover



Sources

Projection: WGS 1984 UTM Zone 48N

Data: Agent Orange Herbicide Exposure Assessment (courtesy Jeanne Stellman), 2009 Vietnam Population and Housing Census (courtesy Integrated Public Use Microdata Series, University of Minnesota), Global Land Cover Dataset (courtesy European Commission), Natural Earth

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Analysis

According to this model, 116 of the 346 districts in former South Vietnam can be classified as at least somewhat high-risk, meaning that they have both a high rate of Agent Orange contamination and a large percentage of vulnerable people in the population; of these districts, 50 are "very high-risk." As of 2009, 954,754 people live in very high-risk districts, including 88,060 children under 5; an additional 1,423,167 people and 123,568 children under 5 live in somewhat high-risk districts. The entirety of Quang Tri Province directly south of the former demilitarized zone (with a population of 597,985 as of 2009) is classified as high-risk; other provinces with multiple high-risk districts include Thua Tien Hue and Quang Nam in northern South Vietnam amd Binh Dinh in the center of the country. These areas would presumably be strong targets for Agent Orange-related health interventions .

As would be expected given that Agent Orange is an herbicide, contamination appears to be most prevalent in rural areas. Over 13 million square kilometers of cultivated land are in high-risk areas—this represents over 20% of all cropland in former South Vietnam, and raises concerns about public health and food safety in these areas.

These results do not include people exposed to Agent Orange outside of the areas they now live, such as migrants and former Vietnamese or US soldiers. They also do not take into account other factors such as income level and preexisting health conditions that might affect vulnerability to dioxin-related health effects. Data availability on health problems such as birth defects is limited, but the prevalence of such effects within high-risk areas merits further study.

	Very high risk	Somewhat high risk	Total high risk	Total S. Vietnam
Number of districts	50	66	116	346
Total population	954,754	1,423,167	2,377,921	7,240,188
Children under 5	88,060	123,568	211,268	637,064
Women with children	491,565	732,199	1,223,764	3,675,180
Persons with disabilities	18,612	23,743	42,355	104,803
Amount of cropland (in sq. km)	6,094,489	7,652,548	13,747,037	64,811,494

Conclusion

The impact of Agent Orange on human health remains ambiguous, but assuming that research linking dioxin contamination to serious health problems is valid, the results of this study are cause for grave concern. As of 2009, over two million people live in areas found by the model to be at least somewhat high-risk, around a third of the population of former South Vietnam, which includes over 200,000 children under five. Many more outside these areas may suffer some negative health effects.

Over 40 years after the Fall of Saigon, Agent Orange continues to be a sensitive subject in bilateral relations between Vietnam and the US, with the question of Agent Orange's effect on human health a particular point of contention. These results demonstrate the need for continuing research, awareness, and dialogue on this issue.

Cartographer: Jacob Cohn

P207: GIS for International Applications

May 8, 2018

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