Exploration of Nuclear Emergency Preparedness

Introduction

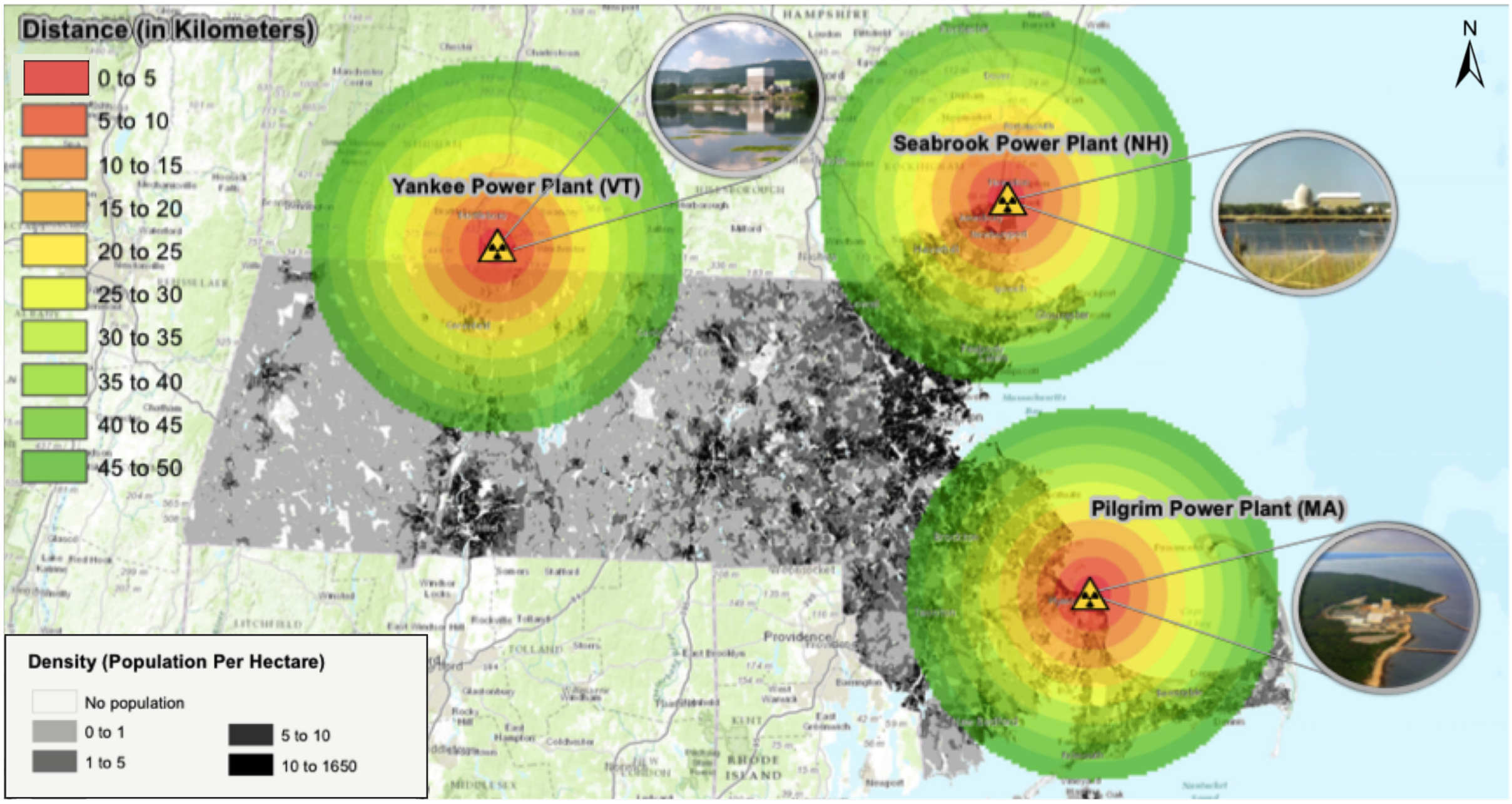
Recent nuclear accidents, such as the Fukushima nuclear catastrophe in 2011, have shown that emergency preparedness and response is essential for protection of the public from health hazards associated with radiation exposure. This project explores and assesses the size of the population in Massachusetts that is potentially at risk of exposure to radioactive materials from an airborne radiation plume in the event of a damaged nuclear plant.

"Nuclear power can *never* be safe. Put the nuclear regime under close public scrutiny." – Greenpeace International

Data and Methodology

Data. This map includes data from the following sources: block population density from the 2010 US Census Bureau, locations of nuclear power plants within 50 km of Massachusetts State from the 2012 Urban Decision Group, and a base map of the world topography from ArcGIS online, which includes hydrography, main roads, transportation, state names, and boundaries. All of the data sets have been projected to the Massachusetts State Plane meters coordinate system.

Methods. As the preliminary step, the Euclidean Distance spatial analyst tool was used to create a raster that shows various colored rings in an intuitive color scale that represent incremental 5-km distances from 0 to 50 km away from the nuclear power plants to the Massachusetts population. Using the "Select Layer by Location" function, the relationship of "Having Center In" was examined. With this methodology, it is an overestimate of the number of people who reside within this radius of the plants because it incorporates the entire population of a block, if the center of that block is within 50-km proximity to a nuclear plant. Next, the census blocks were converted to centroids with the "Feature to Point" tool and a spatial join was carried out between buffers, which model the plumes, and the block centroids. This new table provided information about the population within each ring of the 50-km radii.



Sources
Map: Katherine Howe
NUTR 213 | Fundamentals of GIS | December 2014

Block Population Density: US Census Bureau, 2010
Nuclear Power Plants: Urban Decision Group, 2012
Base Map: ESRI, etc, 2014

Kilometers
0 12.5 25 50 75 100
Massachuestts State Plane Projection

Planning Recommendations for the Airborne Radiation Plume Exposure Pathway

Discussion, Critical Analysis, and Limitations

According to this model, **1,163,793** people around the Pilgrim Nuclear Power Plant, **191,036** individuals surrounding the Yankee Power Plant, and **984,556** people near the Seabrook Power Plant could be potentially exposed to radiation from an airborne plume following a nuclear emergency.

Limitations. While this model is a useful tool for examining the population density around nuclear power plants and assessing estimates of the number of people who live nearby and could be exposed to radiation through plumes, there is ample room for improvement. A main limitation of this model is that it does not incorporate wind speed or direction that would affect the plume's range and movement. In addition, the frequency and methodology used to collect census data does not take into account the fluctuating population size from births and deaths and mobility into and out of the region for jobs or seasonal housing. The census also does not count people with secondary residences in the area.

Emergency Preparedness. The U.S. Nuclear Regulatory Commission (NRC) recommends evacuation of high-risk populations within 10 miles (~15 km) of stricken nuclear reactors that are directly exposed to airborne radiation. An estimated **62,004**, **50,957**, and **5,479 people** from the areas surrounding Pilgrim, Seabrook, and Yankee Power Plants, respectively, would need to be evacuated. For people 10 to 30 miles (~15 to 50 km) away, the NRC recommends shelter (staying indoors with the windows closed) until the plume has passed overhead. Potassium iodide pills that block radioactive iodine are required for people living within 30 miles (~50 km).

Distance (Kilometers)	Pilgrim (Population)	Seabrook (Population)	Yankee (Population)	MA State (Population)
0 to 5	6441	2902	0	9343
5 to 10	22666	27525	1267	51458
10 to 15	32897	20530	4212	57639
15 to 20	48243	13807	8874	70924
20 to 25	62828	68405	23528	154761
25 to 30	69648	42079	14983	126710
30 to 35	126752	165757	21160	313669
35 to 40	200001	137321	16931	354253
40 to 45	320797	155111	36134	512042
45 to 50	273520	351119	63947	688586
Total	**1163793**	**984556**	**191036**	**2339385**

1,163,793, **984,556**, and **191,036 people** from the areas surrounding Pilgrim, Seabrook, and Yankee Power Plants, respectively, are estimated to need these pills readily available on an emergency basis

Conclusions. These measures should be implemented due to the increased risk of cancer through radiation exposure. However, it remains unclear how far radiation emissions might reach in the case of a nuclear disaster. According to computer modeling of catastrophic nuclear meltdowns, the guidelines could be exceeded well beyond 50 kilometers in the worst-case scenario. Evacuation and shelter plans for adequate protection for public health and safety of Massachusetts' residents. These emergency preparedness recommendations should be integrated into the public policy agenda-setting at the state and local level in the event of a nuclear power plant accident.

Distance (Kilometers)	Pilgrim (Population)	Seabrook (Population)	Yankee (Population)	Emergency Recommendations
0 to 15	62004	50957	5479	Evacuation and Potassium Iodide Pills
15 to 50	1101789	933599	185557	Shelter and Potassium Iodide Pills

Future Directions

This model drastically oversimplifies how airborne plumes would travel and expose populations to nuclear radiation. The next step for this project is to incorporate wind speed and direction, in which focal statistics would be carried out with the utilization of wedge-shaped neighborhoods. With evacuation planning, unpredictable wind direction and speed are very complex factors to incorporate, as the plume could shift downwind and move at varying speeds. Ongoing assessment and analysis of the movement of radiation hot spots from airborne plumes would more accurately target and identify at-risk populations near the power plants at the time of a nuclear emergency. Another step is to conduct an assessment that estimates the average number of people at any given time of day, week, and season around the three sites to inform first-wave recommendations for state-level emergency preparedness.

References

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