

GIS Proximity Modeling to Prioritize
Sampling for Radon in Well Water
Session Title: Utilizing GIS for
Reporting

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Purpose

- Characterization of acute public health risks using GIS tools plays a key role for defensible decision-making and to implement timely control measures.
- Radon as a public cancer health risk must be further researched to be clearly understood, documented, and communicated.
- This research can benefit from analyses using temporal and spatial domains since Radon fluctuates in the environment.
- GIS buffering and intersecting tools may be used to *prioritize* wells and adjacent structures to measure Radon concentration to study correlation

Proximity Modeling in Radon Assessment

- There is a small but growing evidence that the inhalation and/or ingestion of Radon cause cancer.
- It is believed that the technique of **proximity modeling** to prioritize sampling sites has not been utilized before for Radon concentration measurements and may prove to be a new method for assessing suitable well sites.

The Issue with Radon

- Radon-222 (^{222}Rn) is formed by the decay of uranium-238
- It may be the radionuclide that can present the greatest risk to human health (Komov, 2002).
- ^{222}Rn dissolves in groundwater with activity concentration ranging from a few pCi/L to thousands of pCi/L. Typically, the highest activity concentrations are found in well water (Hopke et al., 2000) since radon is highly soluble in water (Asumadu-Sakyi et al., 2012).
- Radon in drinking water is also of significant concern to human health since uranium soil deposits can contribute significantly to the amounts of radon gas in groundwater (Wedin & Sorensen, 2013). The accumulation of radon gas in confined spaces is usually the result of the radon gas seeping into cracks in the building's foundation or from the use of the well water inside the building.

The Issue with Radon (cont.)

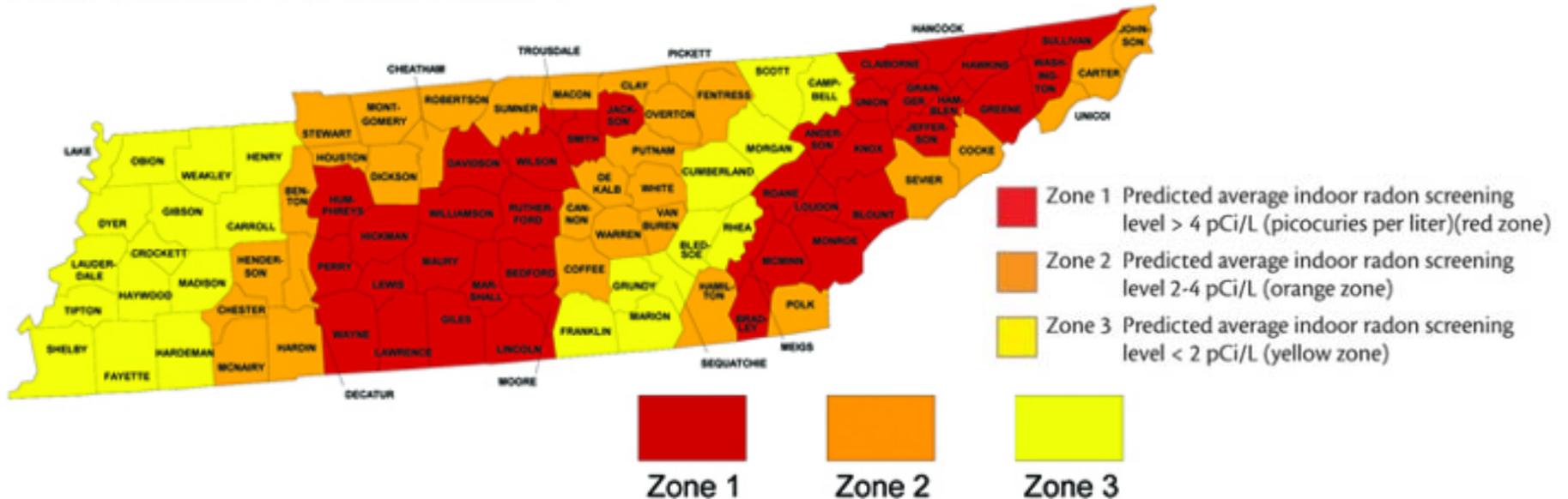
- The alpha emitting radionuclides progenies of ^{222}Rn are capable of damaging cellular DNA (NRC, 1988).
- The Iowa Radon Lung Cancer Study (IRLCS) examined the risk estimates and found a significant relationship between cumulative radon exposures in the residential environment and associated with lung cancer risk (Field et al., 2000).
- Tennessee's radon signature has been noted by both the Environmental Protection Agency (EPA) and Tennessee Department of Health (TDH).
- It is estimated that approximately 15% (or approximately 38,500 homes; based on the 2014 estimates of the number of homes) of the homes in Davidson County, Tennessee have higher than normal levels of radon.

EPA map of Radon zones in Tennessee

The purpose of this map is to assist National, State and local organizations to target their resources and to implement radon-resistant building codes.

This map is not intended to determine if a home in a given zone should be tested for radon. Homes with elevated levels of radon have been found in all three zones.

All homes should be tested, regardless of zone designation.



Dangers of Indoor Radon Exposure; Smokers Among Most At Risk

Indoor radon, particularly when combined with smoking, poses a serious health risk. Radon and smoking appear to have a synergistic effect in promoting lung cancer, even when radon concentrations are relatively low. For example, at 1.3 pCi/L, a person who has never smoked has a 2 in 1,000 chance of dying from lung cancer

reduced by decreasing radon levels in homes. Since radon is a colorless and odorless radioactive gas, humans are unable to detect its presence without specific detection equipment or laboratory testing.

To increase the public's awareness of radon and to promote radon testing and miti-

Conservation (TDEC). If initial test results show an indoor radon level of 4 pCi/L or greater, the EPA recommends a follow-up test. If the average of the first and second test is 4 pCi/L or greater, methods to reduce indoor radon buildup should be considered.

<http://www.elizabethton.com/2015/01/21/tdec-residents-should-test-homes-for-radon/>

Proximity Model Development

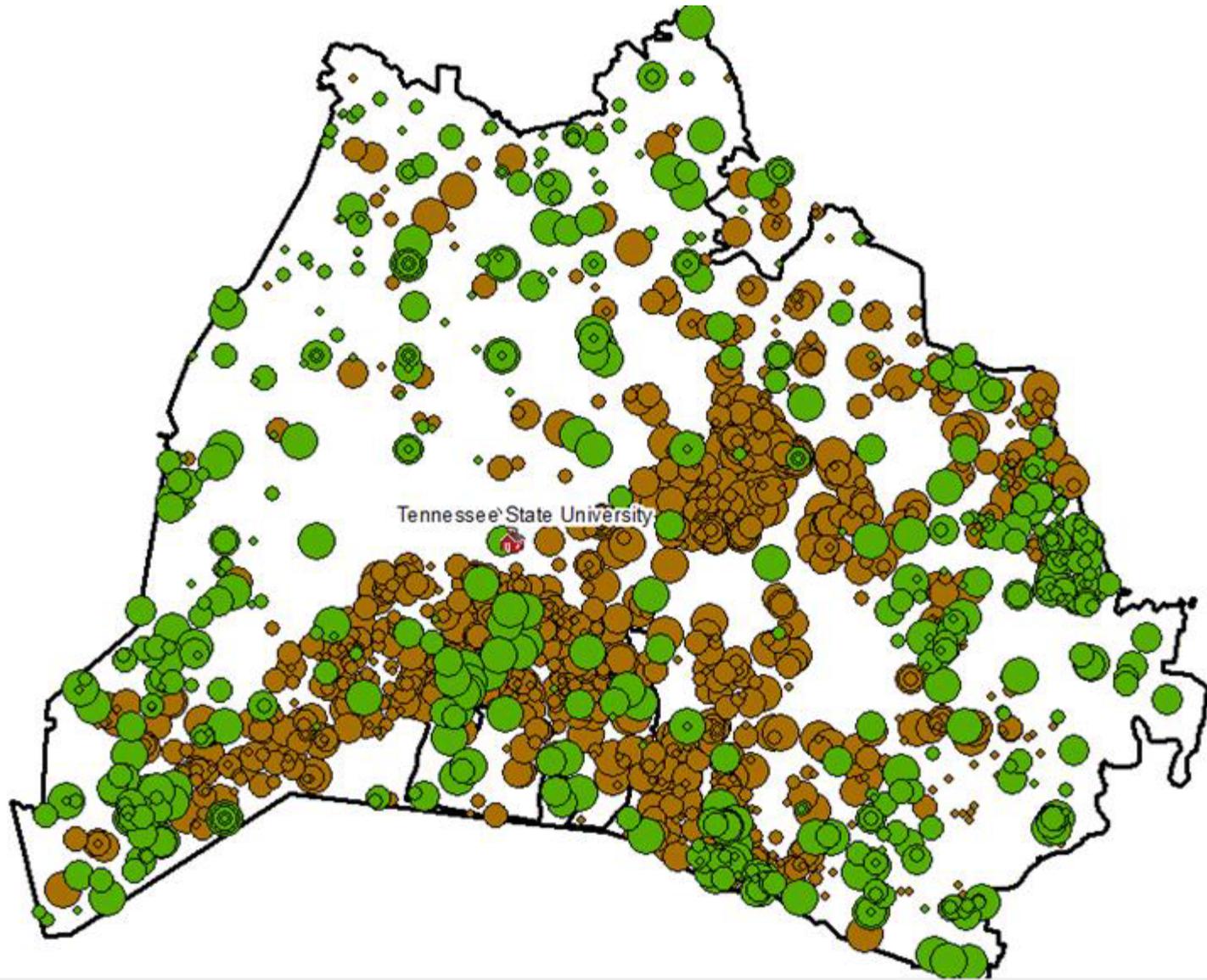
- Reliable data on Rn concentration measurements for wells and indoor air for structures in proximity to the wells
- Determination of criteria for proximity of wells and indoor structures
- Geocoding of data to establish plausible locations
- Use of GIS (ArcGIS in our case) to run the proximity model using geocoding, buffering, and intersecting tools

Data

- Indoor radon data were obtained from two sources:
 - TDEC Office of Sustainable Practices
 - Tennessee Department of Health (via AirCheck; AccuStar; Radon Testing Corporation of America).
- The database for the wells in Davidson County was supplied by TDEC Division of Water Resources.
- The indoor data and the well data is at the core of this study; the culled data for these variables totaled **1,221 indoor air data** and **638 well data**.

Data (cont.)

- Shapefiles for Davidson County was extracted from the U.S. Census Bureau's Tiger Products website (<https://www.census.gov/geo/maps-data/data/tiger.html>) for the State of Tennessee.
- Roads (primary, secondary, and local) were also obtained from Tiger Products.
- These were trimmed for Davidson County, Tennessee using the clipping function in the Geoprocessing function in ArcGIS 10.3.
- Trimming was also done for the well data and the indoor air data.



Locations of well sites (represented by **green well-depth graduated symbols**) and indoor air radon sites (**represented by brown graduated circles for concentration levels greater than 4.0 pCi/L**)

Observations on the Data

- The well data have longitude and latitude and/or address and types of uses attributes
- The indoor air data had to be batched geocoded using the comma delimited file for the indoor air data at the website
http://www.findlatitudeandlongitude.com/batch-geocode/#.Vbgc0_IVikr .
- The indoor radon data have not been validated by TDEC since they were self-reported data from do-it-yourself kits reported by homeowners and other radon measurement professionals.

Observations on the Data (cont.)

- Not all the TDEC indoor data could be used as several attributes were missing and were deleted from the analysis.
- The data from THD only had the street names (no street numbers), the radon concentration values, and zip codes.
- The accuracy of the geocoding was lessened, and it was decided not to use THD data in for the proximity model analysis.

Selection Criteria

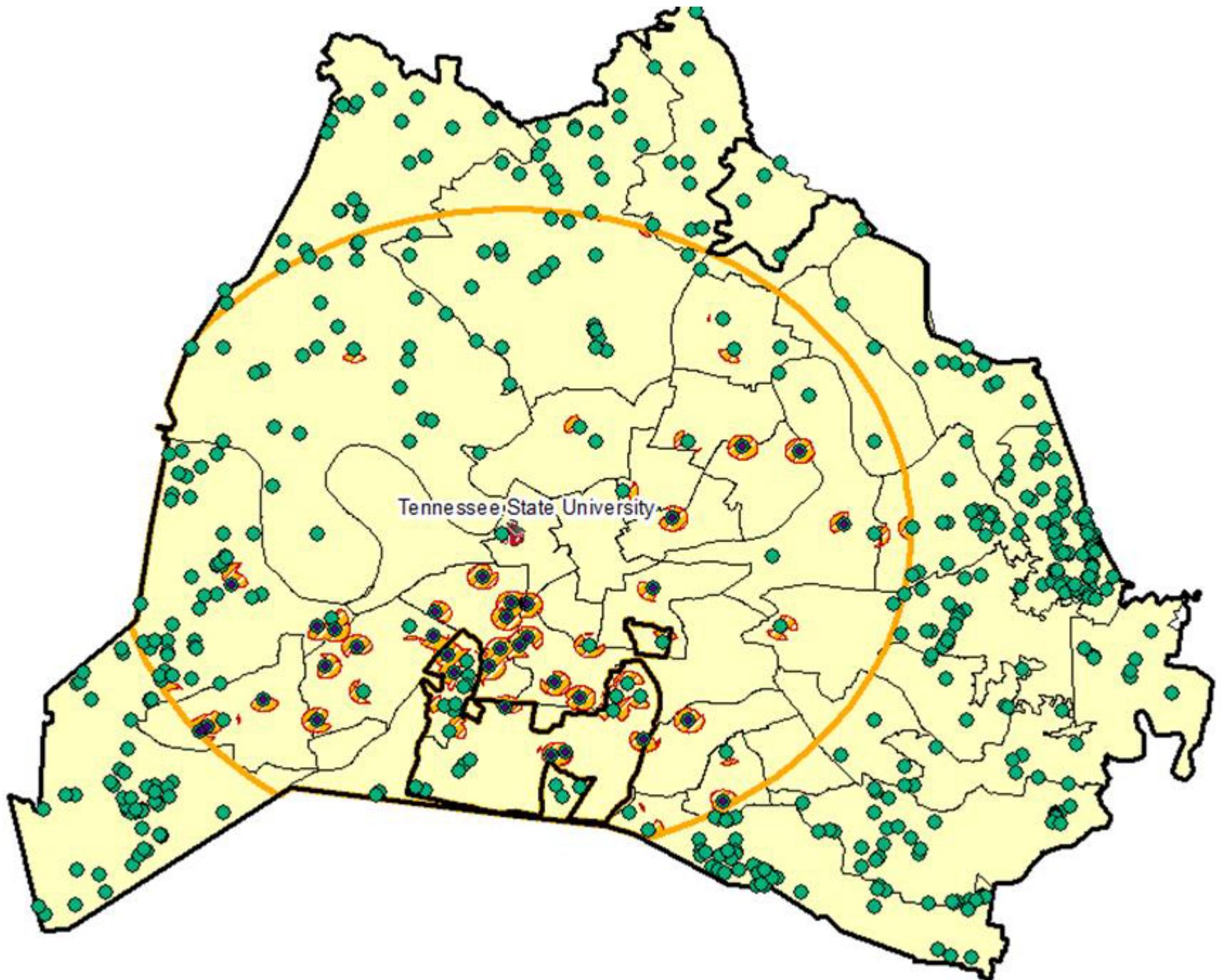
- Sampling sites were to be within a radius of 10 miles of the main campus of TSU to facilitate a measurement schedule that is compatible with funding for the project and the university's schedules for the measurement specialists.
- Wells were selected based on a distance of 2000 feet from an indoor site where the indoor radon concentration was greater than the MCL of 4.0 pCi/L.
- Similarly, homes for which the MCL > 4.0 pCi/L were selected based on a distance of 2000 feet from a given well.

Analytical Methods

- Analytical techniques used for selecting the suitable wells for testing for radon is based on the process outlined in Gorr and Kurland's, *GIS tutorial 1: Basic Workbook*.
- The geocoded well data, indoor air data, and TSU location were displayed on the Davidson County map and buffers were created for them; 2000 feet, and 10 miles respectively. The buffers were then intersected, two buffers per intersection, and the results were displayed on the map.

The Suitability Map

- The locations for the potential wells in Davidson County are represented by the **green dots**.
- The **47 selected wells** are represented by **blue dots** in the suitability areas (the hashed marked areas).
- The **gold circle** is the 10-mile radius centered on Tennessee State University



Portion of the suitability site map for the most likely areas to sample wells for radon within a ten-mile radius of the campus of Tennessee State University.

Wells (designated by the graduated green circles representing their depths) and within the hashed areas are the most suitable candidates.

Notice the location of TSU designated by the school house image. The red triangles represent sites where the indoor air exceeds the 4.0 pCi/L.

Table of Partial Listing of Potential Wells for Measuring

Table 1. Portion of the database created in ArcGIS 10.3 displaying the location coordinates of the suitable wells.

County	Latitude	Longitude	Well Depth	Type of Well	City	State	Zip Code
DAVIDSON	36.0466670	-86.7347220	868	Residential	Nashville	TN	37211
DAVIDSON	36.0677780	-86.8113890	260	Residential	Nashville	TN	37220
DAVIDSON	36.0688890	-86.8047220	500	Residential	Nashville	TN	37220
DAVIDSON	36.0747220	-86.7697220	82	Residential	Nashville	TN	37220

Results

The suitability analysis determined that 47 of the 638 wells fitted the buffering and intersecting criteria and were considered candidates to be tested for Radon.

Conclusions

- The targeted region for this project is within Davidson County which is rated as Zone 1 by the EPA and a high zone by TDH.
- This data will contribute to the state's database thereby expanding the State of Tennessee's radon awareness campaign using quantitative data to show correlation between high radon concentration and cancer risk from human radon intake.

Conclusions (cont.)

- This research has shown a GIS-applicable technique (buffering with intersecting) that may be used in the future to prioritize where to select as suitable sites for the measurement of Radon in water, soil, and indoor air.
- It is believed that this technique has not been utilized before and may prove to be a new method for assessing suitable sites for making measurements. Additionally, the latitude and longitude values for these sites may be extracted and used to find addresses.
- From these measurements, analyses and radiation dosage risk assessments for human radon intake based on ingestion and inhalation of Radon may be ascertained.

Acknowledgements

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References

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