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Creating Geologically Based Radon Potential Maps for Kentucky

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Abstract

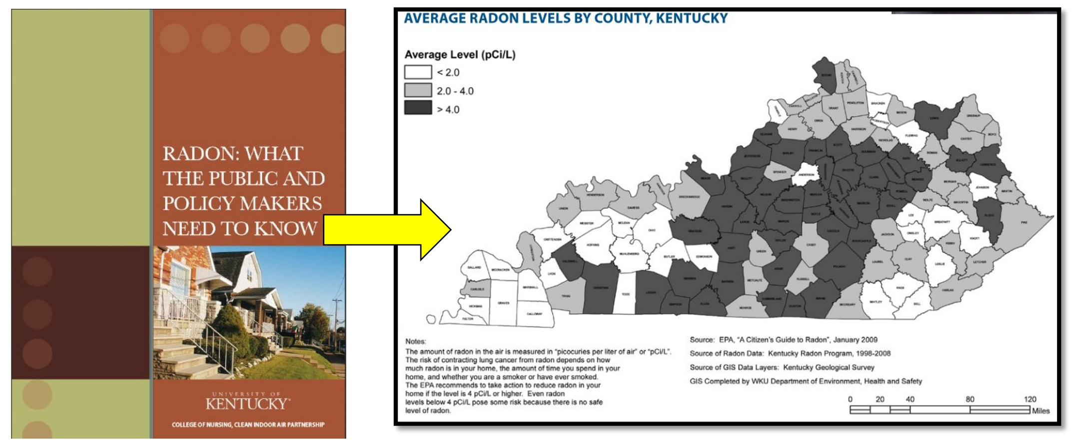
Radon potential in the United States, Kentucky in particular, has historically been communicated using a single hazard level for each county; however, physical phenomena are not controlled by administrative boundaries, so single-value county maps do not reflect the significant variations in radon potential in each county. A more accurate approach uses bedrock geology as a predictive tool. A team of nurses, health educators, statisticians, and geologists partnered to create 120 county maps showing spatial variations in radon potential by intersecting residential radon test kit results (N = 60,000) with a statewide 1:24,000-scale bedrock geology coverage to determine statistically valid radon-potential estimates for each geologic unit. Maps using geology as a predictive tool for radon potential are inherently more detailed than single-value county maps. This mapping project revealed that areas in central and south-central Kentucky with the highest radon potential are underlain by shales and karstic limestones.

Background

Helping the public understand radon risk is extremely important, especially in Kentucky. Kentucky leads the nation in adult smoking and lung cancer incidence and mortality. There is a synergistic affect between radon exposure and smoking—people exposed to both are 10 times more likely to develop lung cancer. Radon is the second leading cause of lung cancer. Portions of the state have been identified as having high radon potential (due to the geology). Additionally, Kentucky has weak smoke-free protections.

The Kentucky Geological Survey (KGS) partnered with researchers in the University of Kentucky BREATHE (Bridging Research Efforts and Advocacy Toward Healthy Environments) Program to better understand the spatial variability of radon incidence by using a geologically referenced radon data set. The primary aim was to identify the potential risk for population-level radon exposure and communicate the level of risk to homeowners in Kentucky.

BREATHE published an informational document, "Radon: What the Public and Policymakers Need to Know" containing a map that categorized average radon levels by county. The map was derived from a previously published EPA publication. KGS initiated a meeting with BREATHE to discuss potential issues with classifying physical phenomena in terms of political boundaries. A collaborative effort to make better informed maps for the public immediately followed.



The county-based radon map (above) inspired the collaboration between KGS and BREATHE.

Radon data is most often analyzed by county and zip code; political boundaries are not, however, optimal for describing the extent of physical phenomena.

What is Radon?

Radon is a naturally occurring radioactive gas that is tasteless, odorless, and colorless

It is measured in picocuries per liter (pCi/L)

It's the heaviest known gas (9x denser than air)

Radon comes from the breakdown of uranium in rocks and soil

All rocks contain varying amounts of uranium

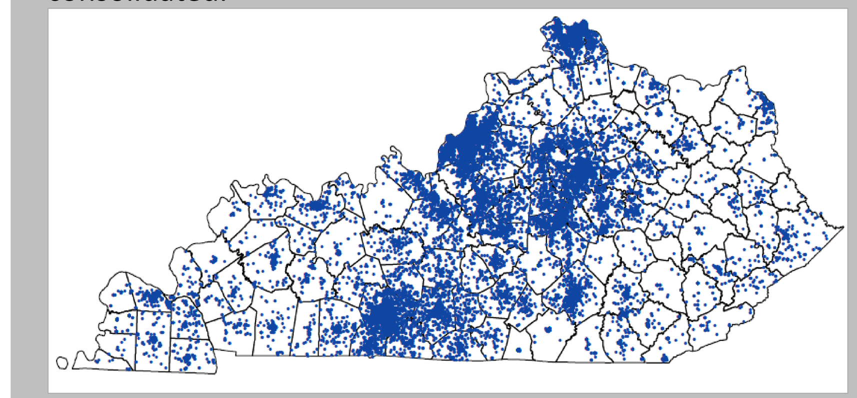
Radon exposure is the second leading cause of lung cancer

Methodology

A residential radon data set with more than 60,000 values was combined with mapped near-surface geologic rock formation units in order to assess typical radon values by rock type. This was done using ArcMap by intersecting radon data with geology. Values were then classified by geologic formation so statewide and county-level maps could be created.

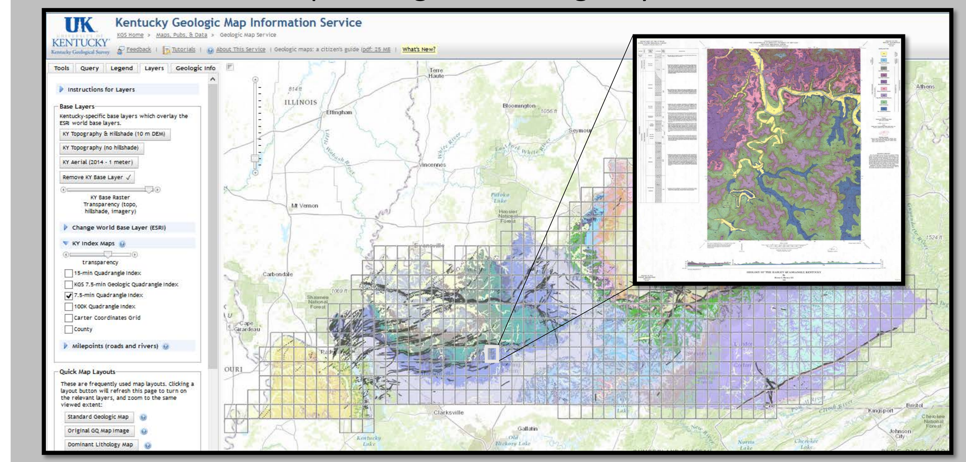
Radon Data (N > 60K)

- Data from short-term residential test kits (sponge tests)
- Addresses converted to lat/long coordinates by a third party
- If a geologic unit had less than 10 radon measurements in it, the unit was either not analyzed or consolidated.



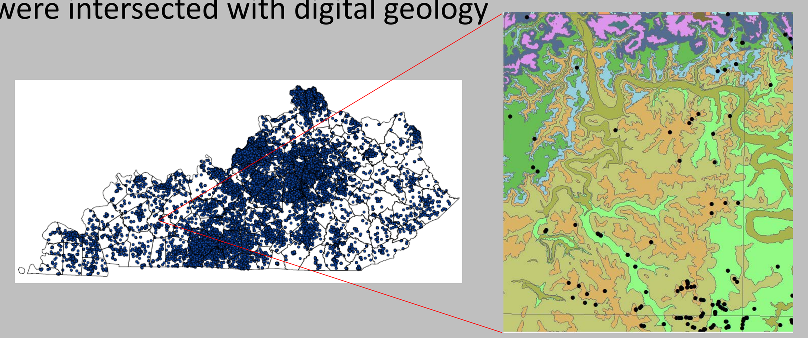
Digital Geologic Data in Kentucky

The near-surface bedrock geology is mapped at a very detailed scale (1:24,000, 1 inch = 2000 ft.). All 707 7.5-minute quadrangles were digitally vectorized and can be used for derivative mapping.



Intersection of Radon Data with Geology

60K+ data point locations were intersected with digital geology



Resulting example data set:

Geologic Formation	n	Min	Max	Mean	Median	q3	% > 4
Renfro Member of the Slade Formation, undivided	24	0.35	36.3	4.74	2.1	3.75	20.83333
Salem Limestone	63	0.3	112.3	8.78	4.5	7.8	52.38095
Ste. Genevieve Limestone and St. Louis Limestone, Upper Member	84	0.6	41	6.68	3.2	8.85	39.28571
Ste. Genevieve Limestone Member of Slade Formation	23	0.4	19.1	3.77	2.7	5	30.43478
Ste. Genevieve Limestone	6338	0.1	489	14.05	6.8	16.4	65.74629
Ste. Genevieve Limestone Member, Monteagle Limestone	154	0.3	74.4	9.37	5.7	11.7	61.68831
Alluvium	2073	0.1	170	4.016305	1.9	4	24.9397
Artificial fill	26	0.6	19.5	4.038462	2.8	4.9	30.76923
Sand deposits	17	0.6	5.1	2.247059	2.2	2.6	11.76471
Continental deposits	296	0.1	13.4	1.673649	1	1.9	7.432432
Glacial drift	177	0.4	24	3.60565	2.6	4.6	29.9435
High-level fluvial deposits	180	0.4	47.6	4.076667	1.85	3.5	20

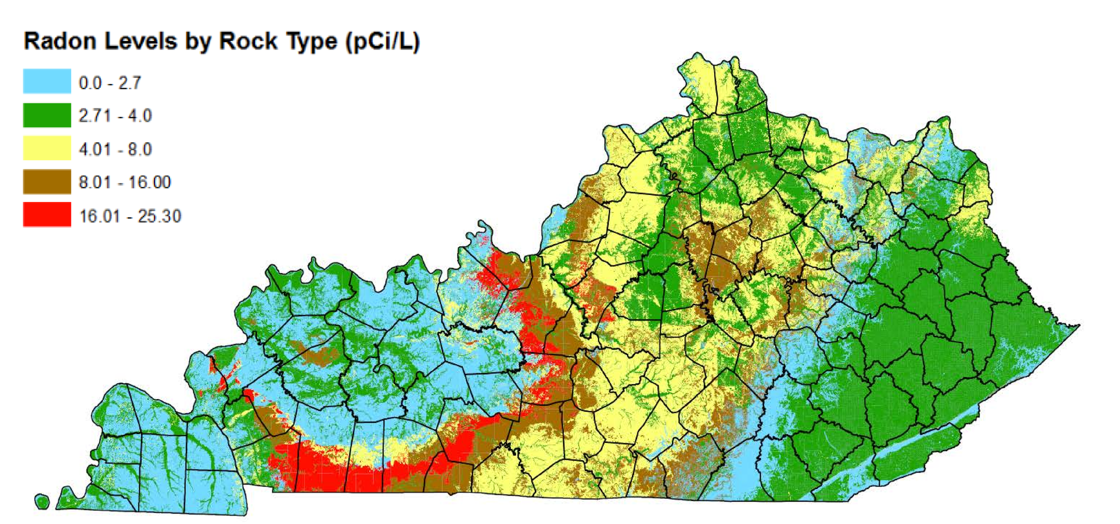
Geologic formations were assigned a radon value based on data points within the formation

Results

A statewide radon potential map was created based on radon levels summarized by geologic formations.

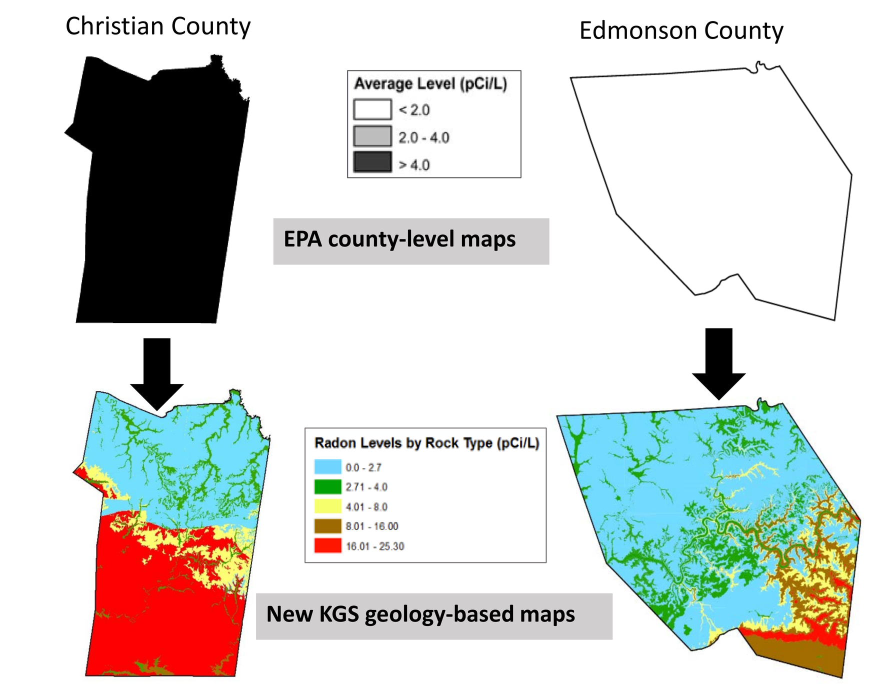
County maps were derived from the statewide map and subsequently placed in infographics.

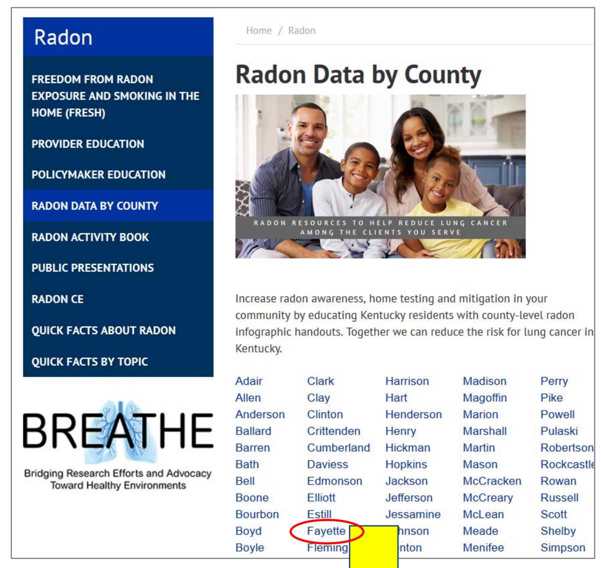
Radon Potential Map



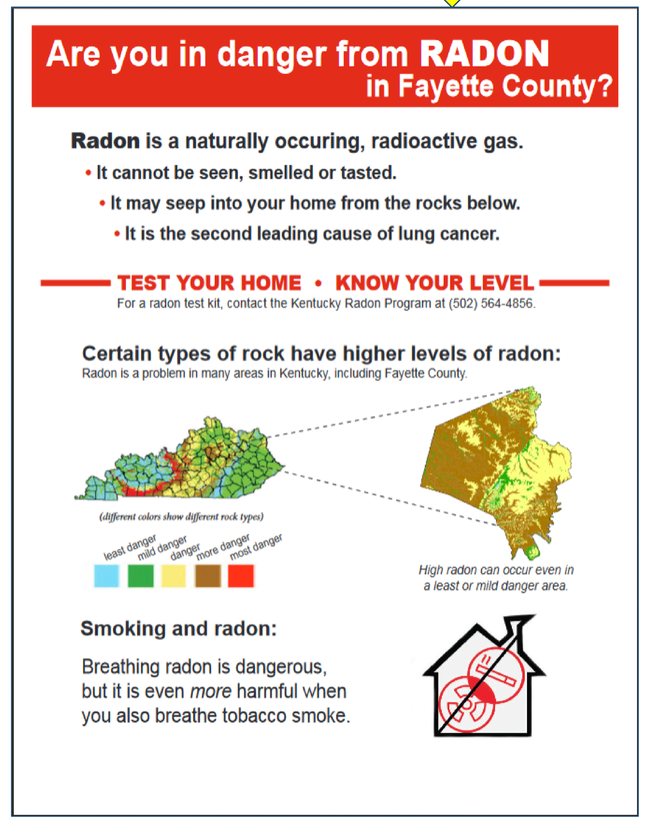
To prevent statistical anomalies from interfering with a more accurate representation of the data, the upper quartile (also called 75th percentile or third quartile) was used to represent the data.

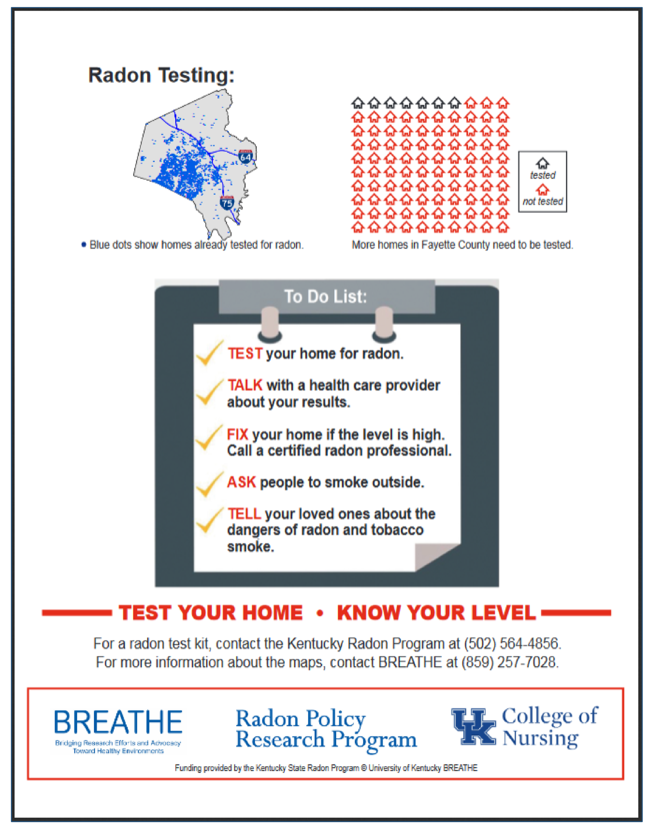
Radon levels have the potential to be extremely variable within a county based on the context of geology.





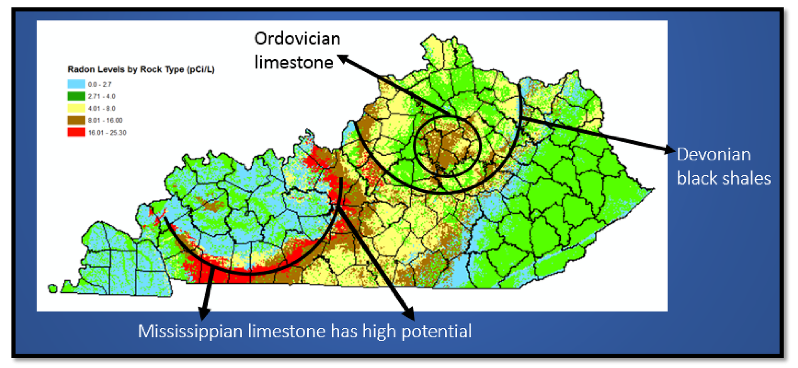
Infographics for all 120 Kentucky counties are available on the web. These communicate radon risk to the general public using language for all audiences. For example, picocuries per liter were not used; more general terms were used to communicate risk. The primary focus was to create awareness and to encourage people to test their homes for radon exposure.





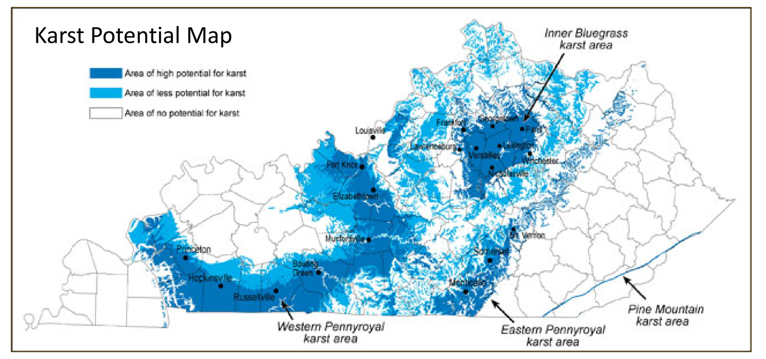
Conclusions

This mapping project revealed that areas in central and south-central Kentucky with the highest radon potential are underlain by shales and karstic limestones. A comparison of the radon potential map to a karst potential map indicates a correlation between karst and radon potential in Kentucky.



Research assessing the geologic controls of radon potential as well as the life cycle of radon as it pertains to geology is underway.

Additionally, research focusing on climate and seasonal influences on radon migration is underway.



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