Radon Gas

A Soil Survey Perspective

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Synopsis

- Nuclear science short course
- Human physiological factors
- Distribution of radon in soils
- Sources of Radon in soils
- Factors affecting the radon content of soils
- Modeling the radon content of soils
- Mapping the radon content of soils
- Needs for further work
- Conclusion

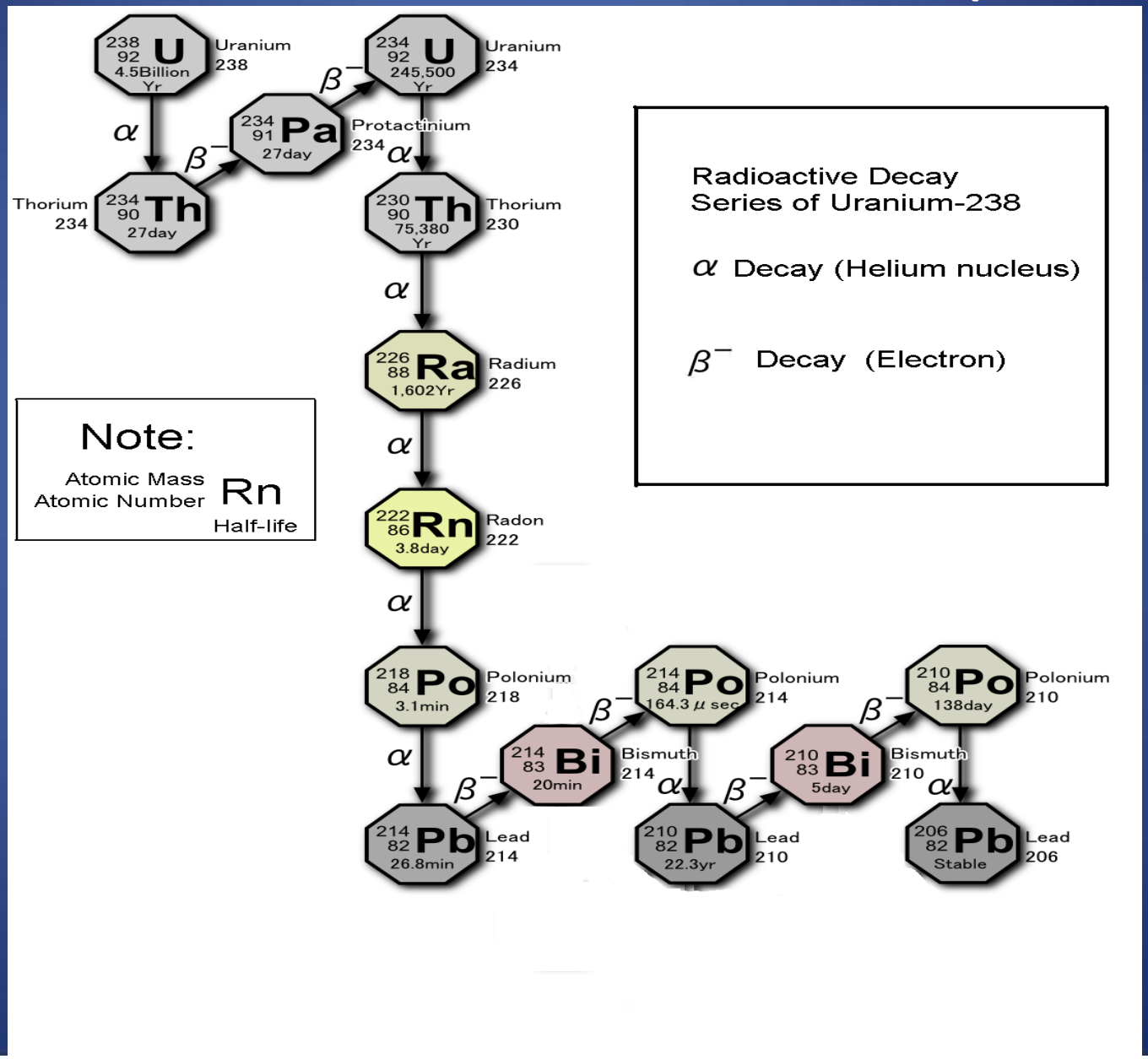
Nuclear Science Short Course

- **Nucleus** of an atom is composed of protons and neutrons
- **Atomic number** is the number of protons in the nucleus (positive charge)
- **Atomic mass** is the number of protons plus the number of neutrons
- Many large atoms (high atomic mass) are unstable
- **Decay chain** – a series of transformations moving an unstable isotope to a stable one
- **Alpha particle** – two protons and two neutrons, decay lowers atomic mass by 4 and atomic number by 2

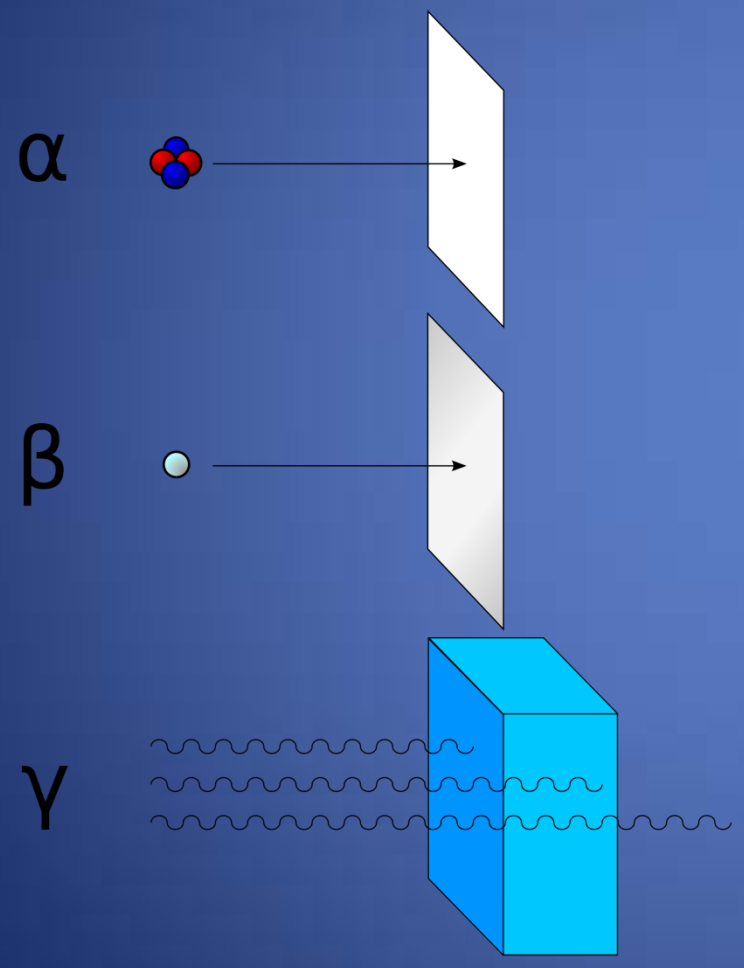
Nuclear Science Short Course (cont)

- **Beta particle** – an electron or positron, decay increases atomic number by 1 (a neutron is converted to a proton by emitting the electron)
- **Gamma radiation** – very short wavelength electromagnetic radiation
- **Half-life** - the period of time it takes for a substance undergoing decay to decrease by half

Nuclear Science Short Course (cont)

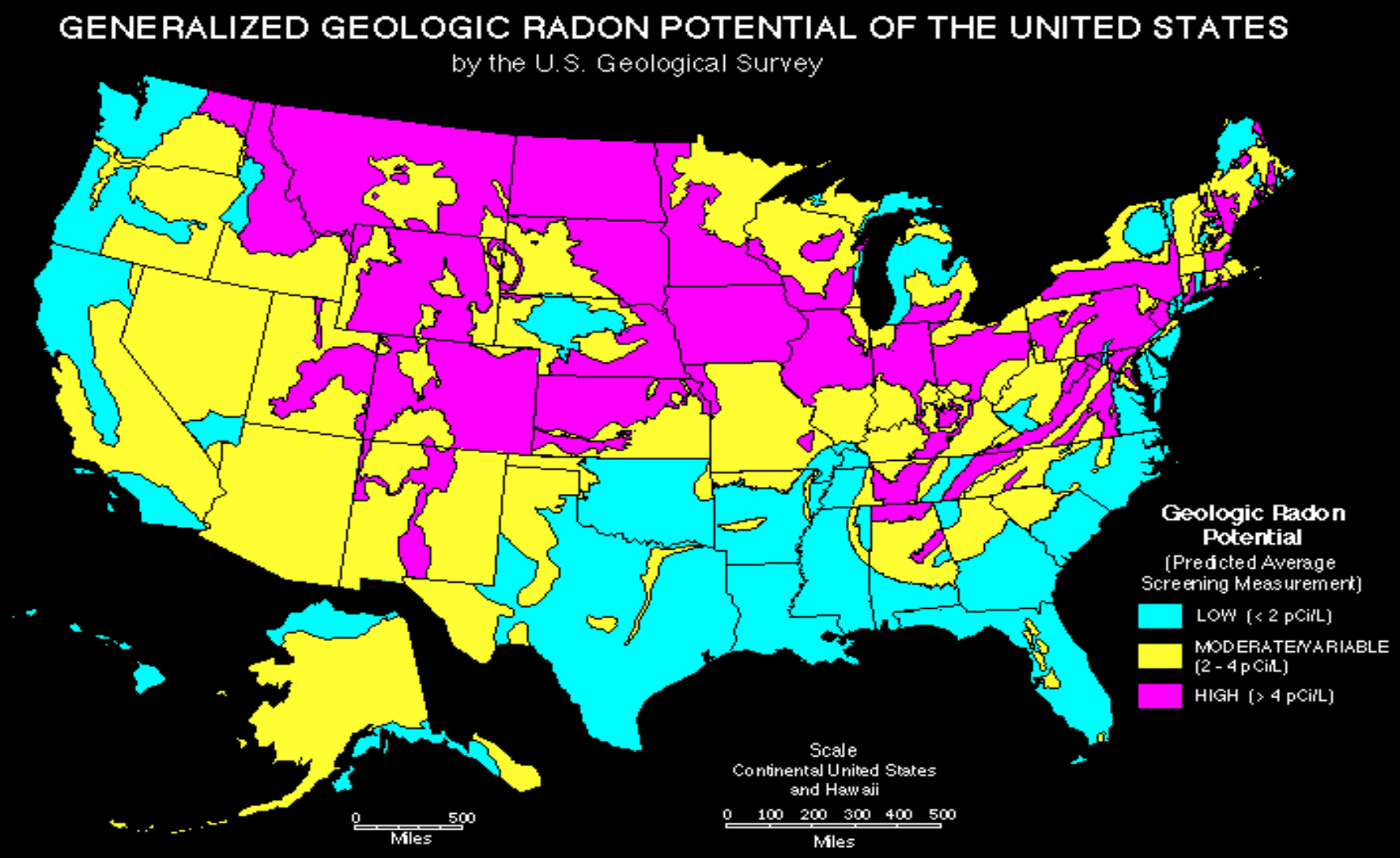


Human physiological factors

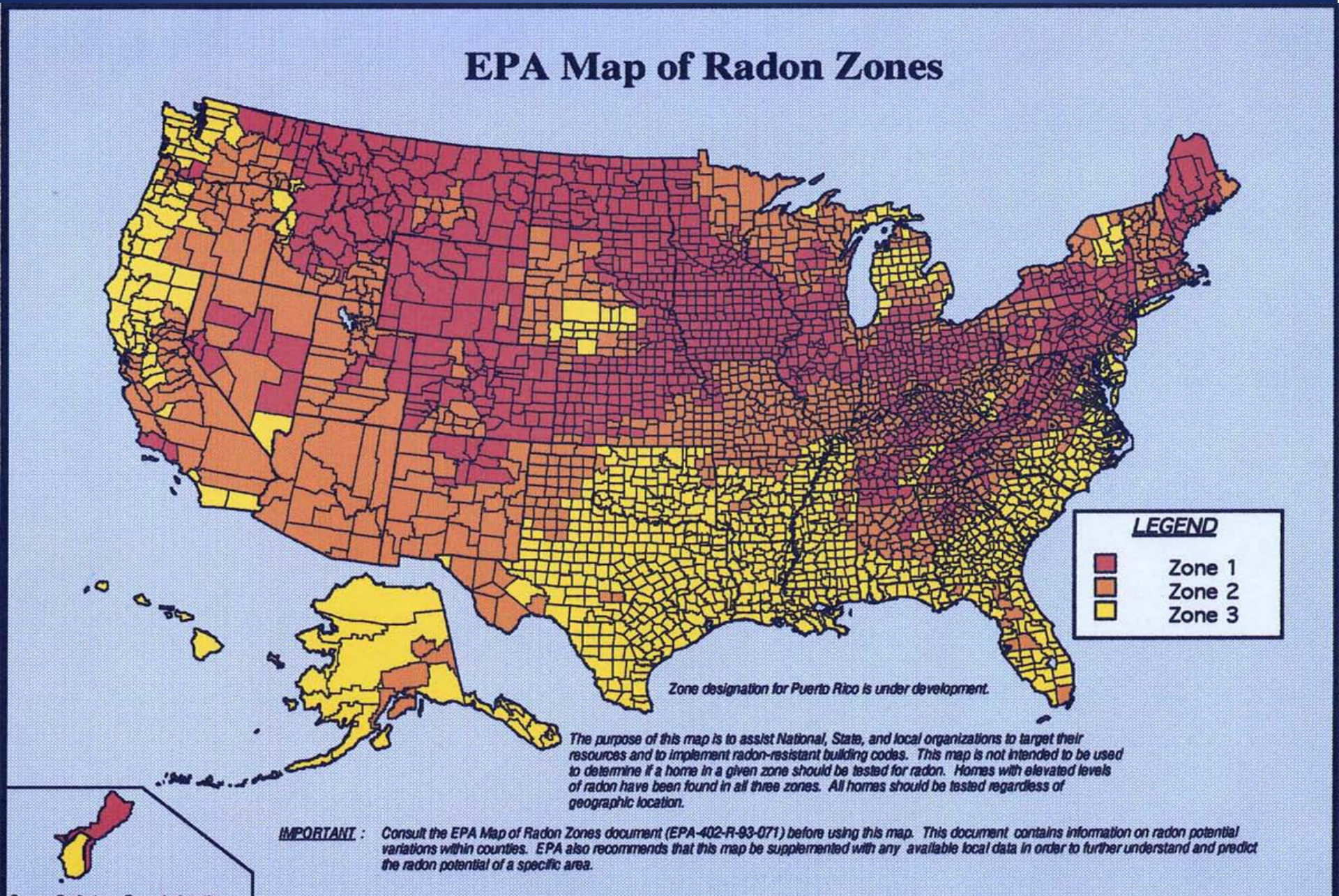


- **Alpha particles** are charged, highly ionizing and cause chromosome damage
- **Beta particles** can penetrate tissue and damage the molecules they hit
- **Gamma rays** penetrate deeply and cause molecular changes (DNA)

Distribution of radon in soils



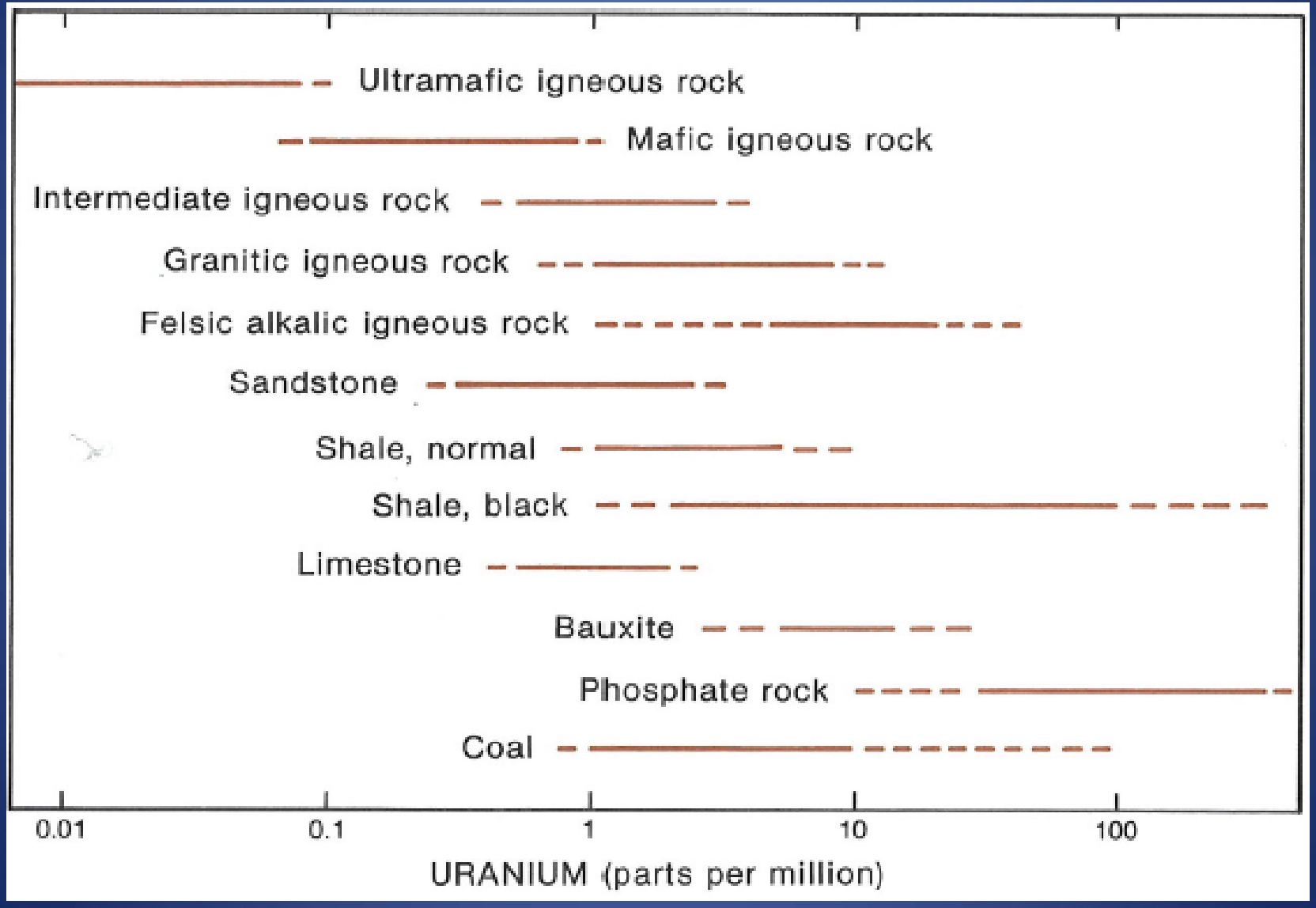
Distribution of radon in soils



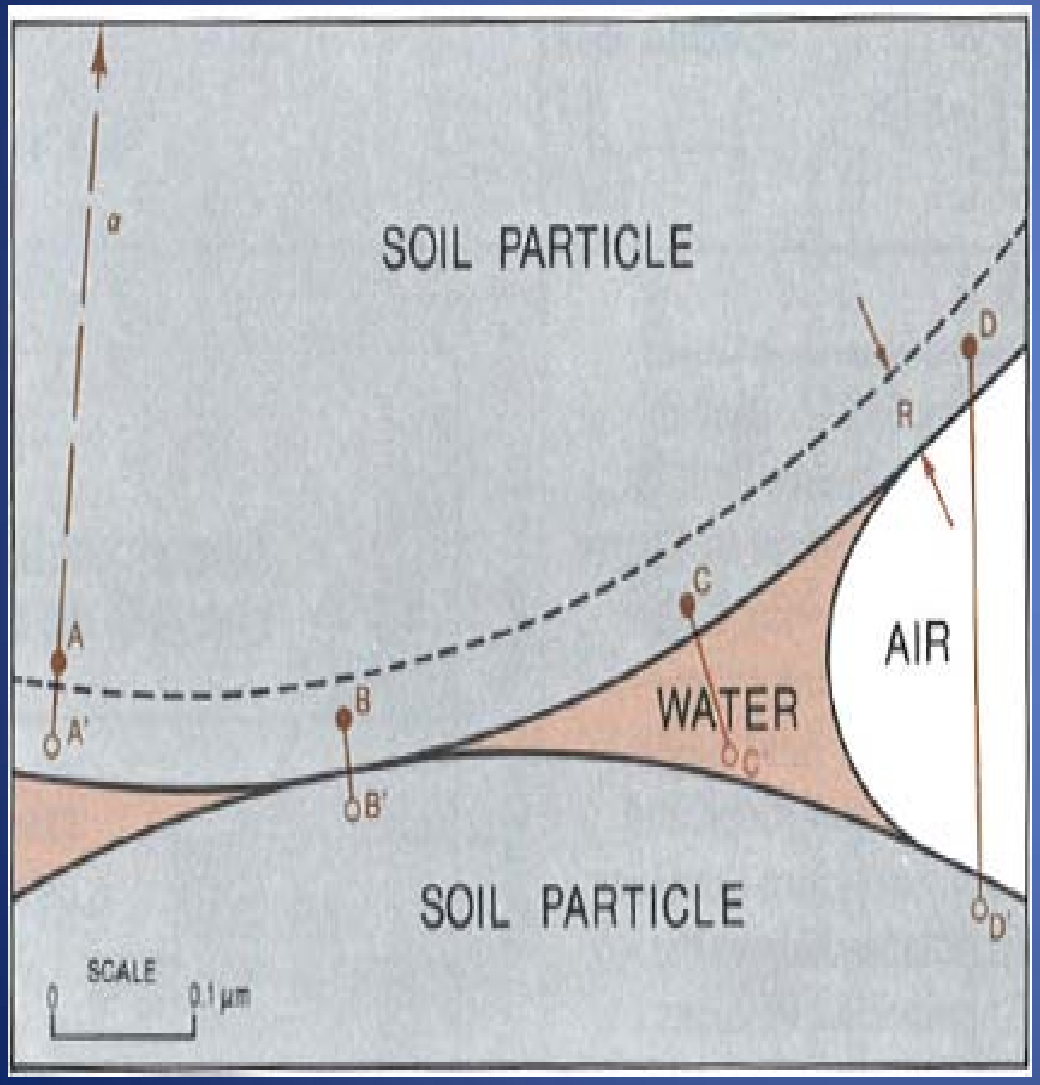
Sources of Radon in Soils

- Radon is a radioactive noble gas that is produced from the radioactive decay of radium-226
- The distribution of radon in soils is correlated with the distribution of radium-226 and uranium in the bedrock and parent material

Sources of Radium in Soils



Factors Affecting Soil Radon: Emanation



- The distance R represents how far an atom recoils as an alpha particle is emitted
- Daughter A' does not escape the mineral
- Daughters B' and D' are shot into the adjacent mineral
- Daughter C' is shot into the water film and can diffuse away

Factors Affecting Soil Radon Content and Transport

- Soil and bedrock → porosity
- Soil moisture film → thickness
- Grain size →

- The larger and more continuous the pores, the more rapid the transport
- Water-filled porosity slows transport, but water is needed to slow recoiling atoms
- Smaller, less crystalline material allows more emanation

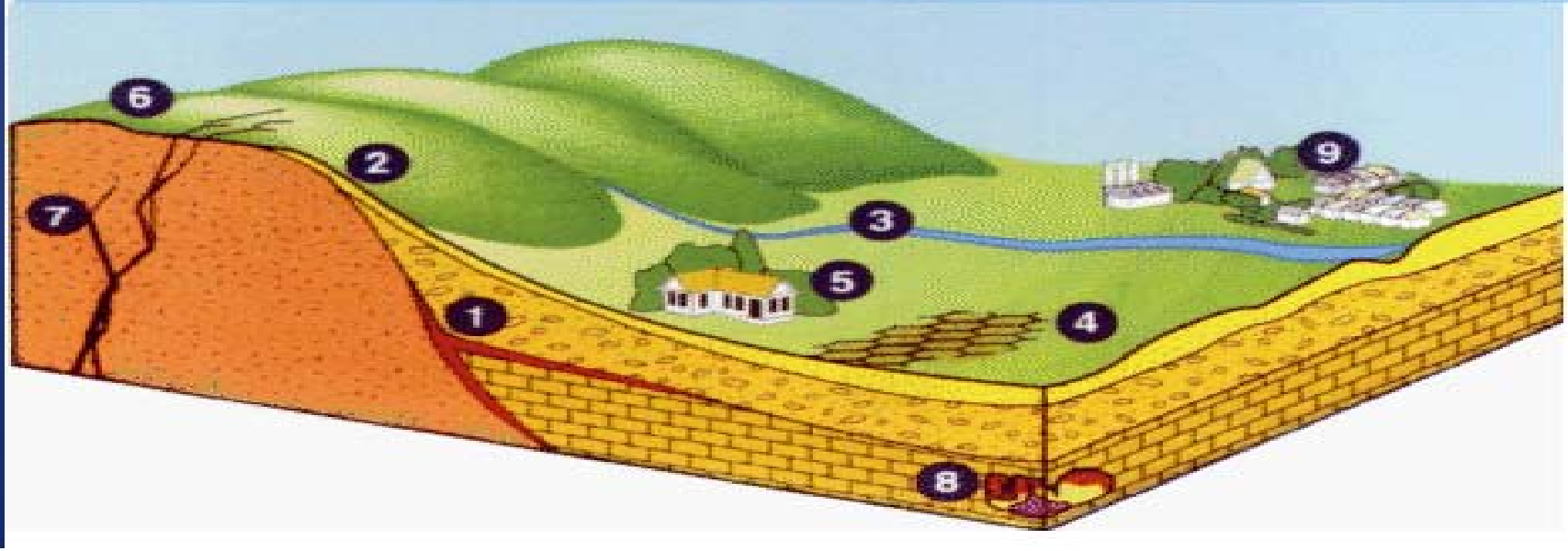
Factors Affecting Soil Radon Content and Transport

- Organic material → content
- Plants seem to concentrate radium, both a soil and bedrock phenomenon
- Iron oxide content →
- Redder soils have a higher radium content if the original parent material is a source

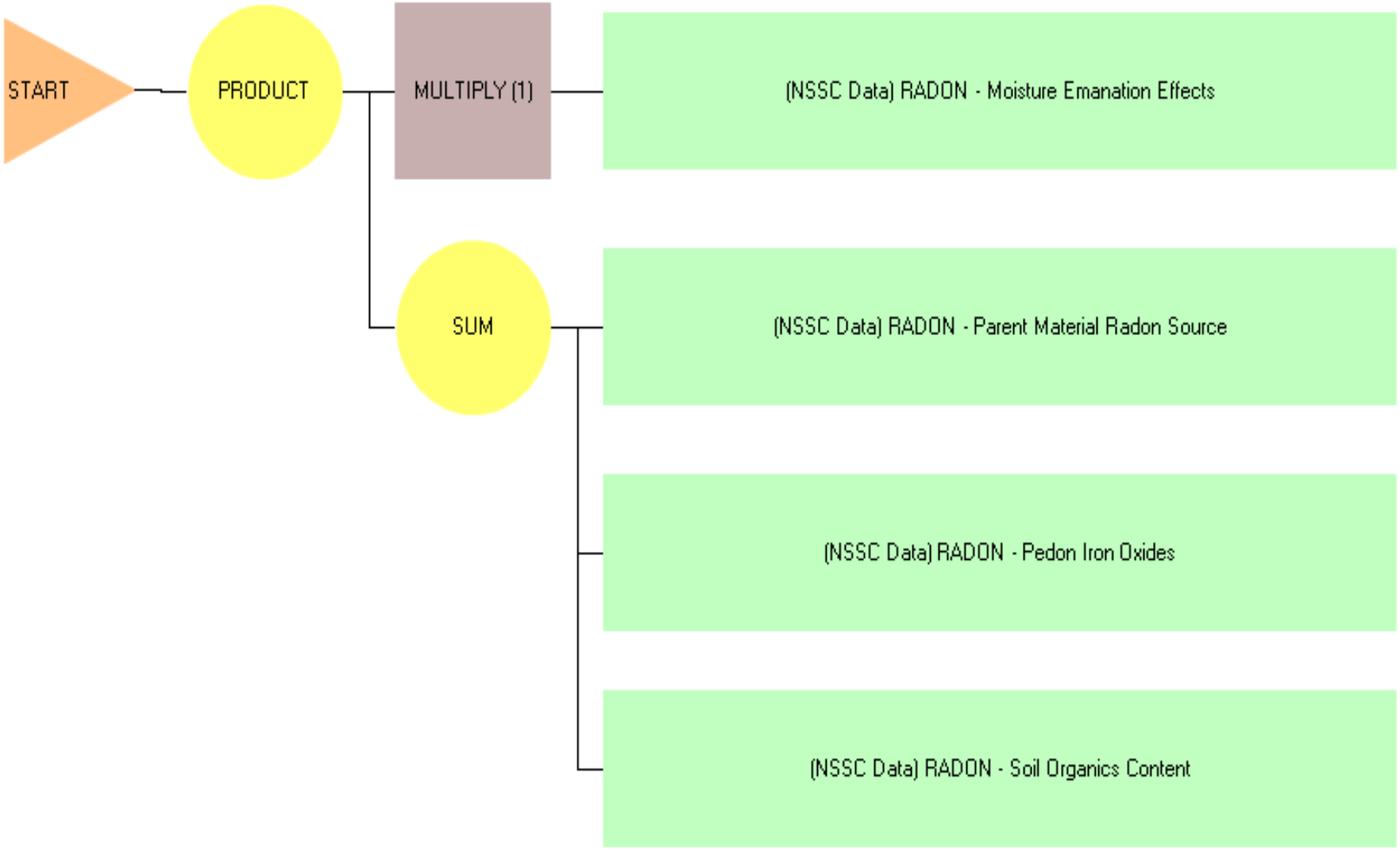
Evaluating radon potential

By knowing something about the geology and soils of the area, scientists can evaluate the radon potential for the rocks and soils of housing sites or areas of interest. These factors can increase the probability that an area will have above-average levels of radon.

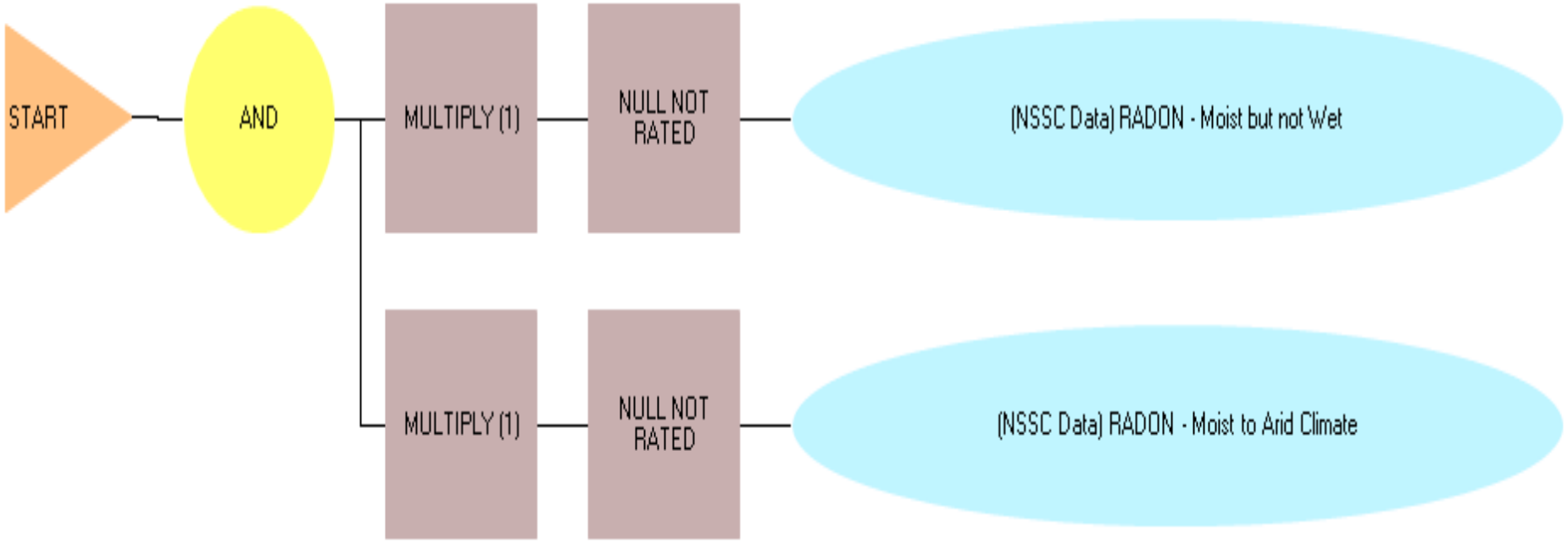
1. Uranium-rich rocks occur in the area.
2. Highly permeable soils are present.
3. Soils are well-drained or dry most of the time.
4. Soils form deep cracks during dry times of the year.
5. The site is located on a hill or slope.
6. The soils are thin and bedrock is close to the surface.
7. Underlying rocks are fractured.
8. The underlying rock contains limestone caverns.
9. High levels of indoor radon have been reported in the county or neighborhood.



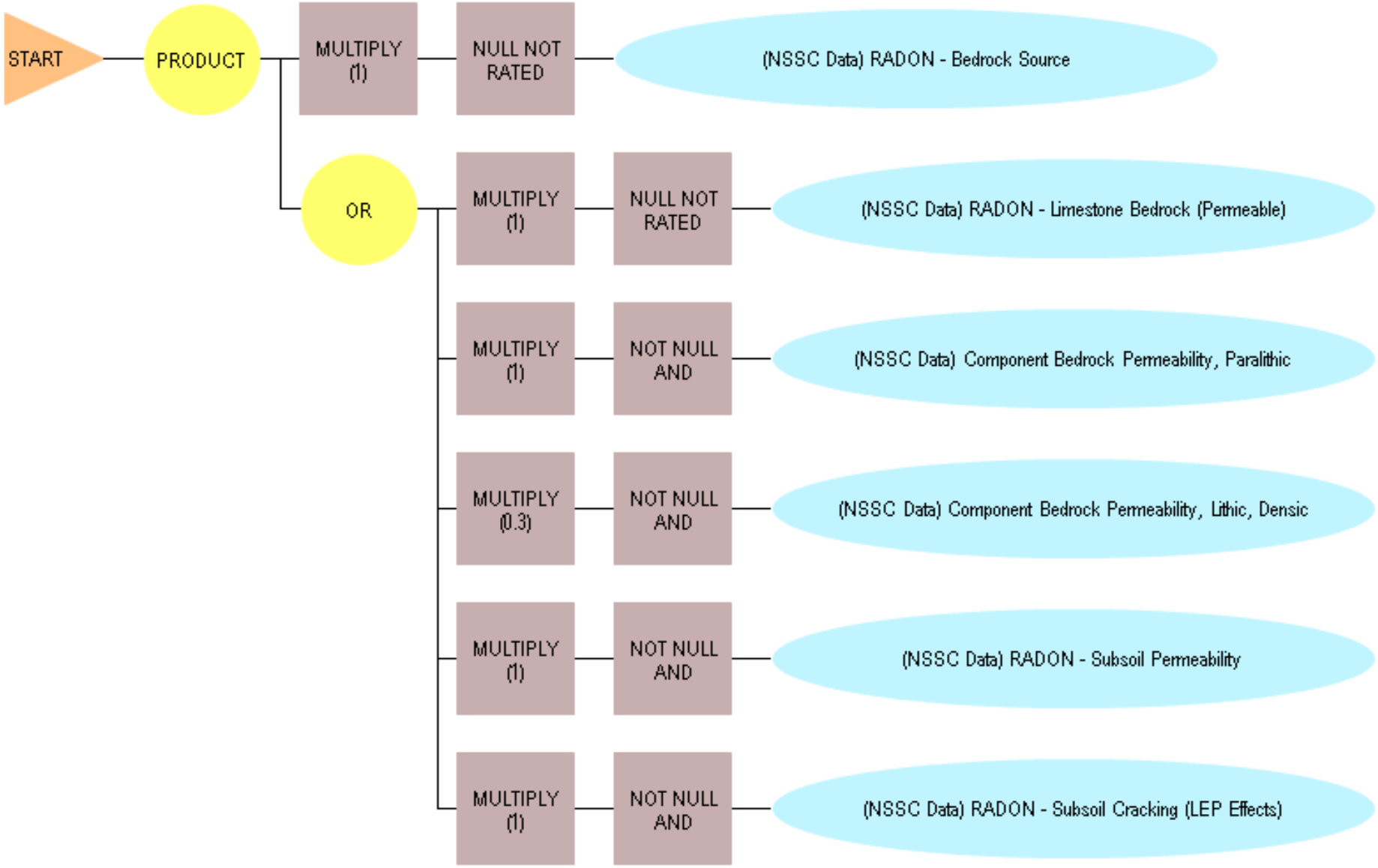
Modeling the radon content of soils



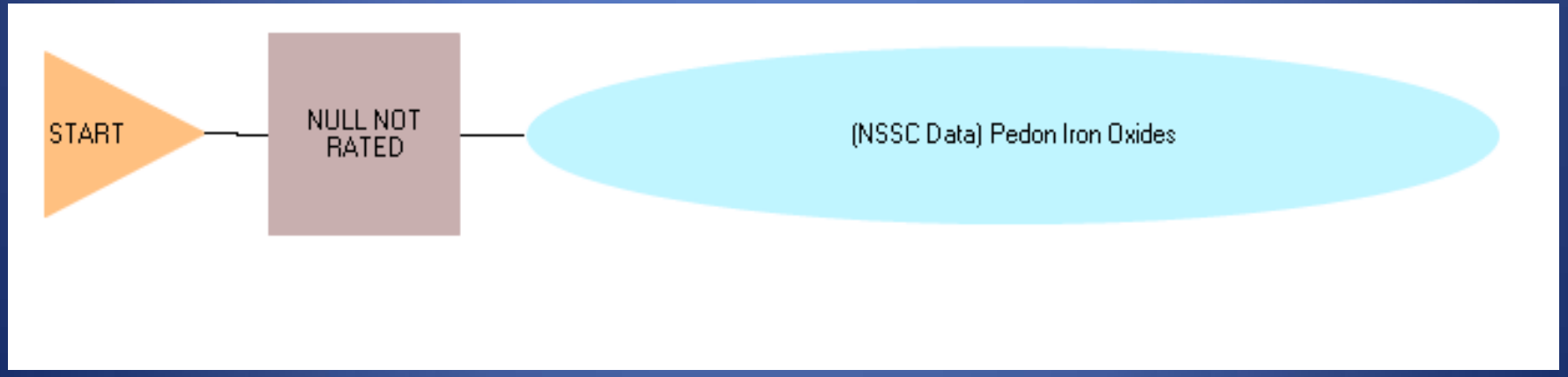
Moisture Emanation Effects



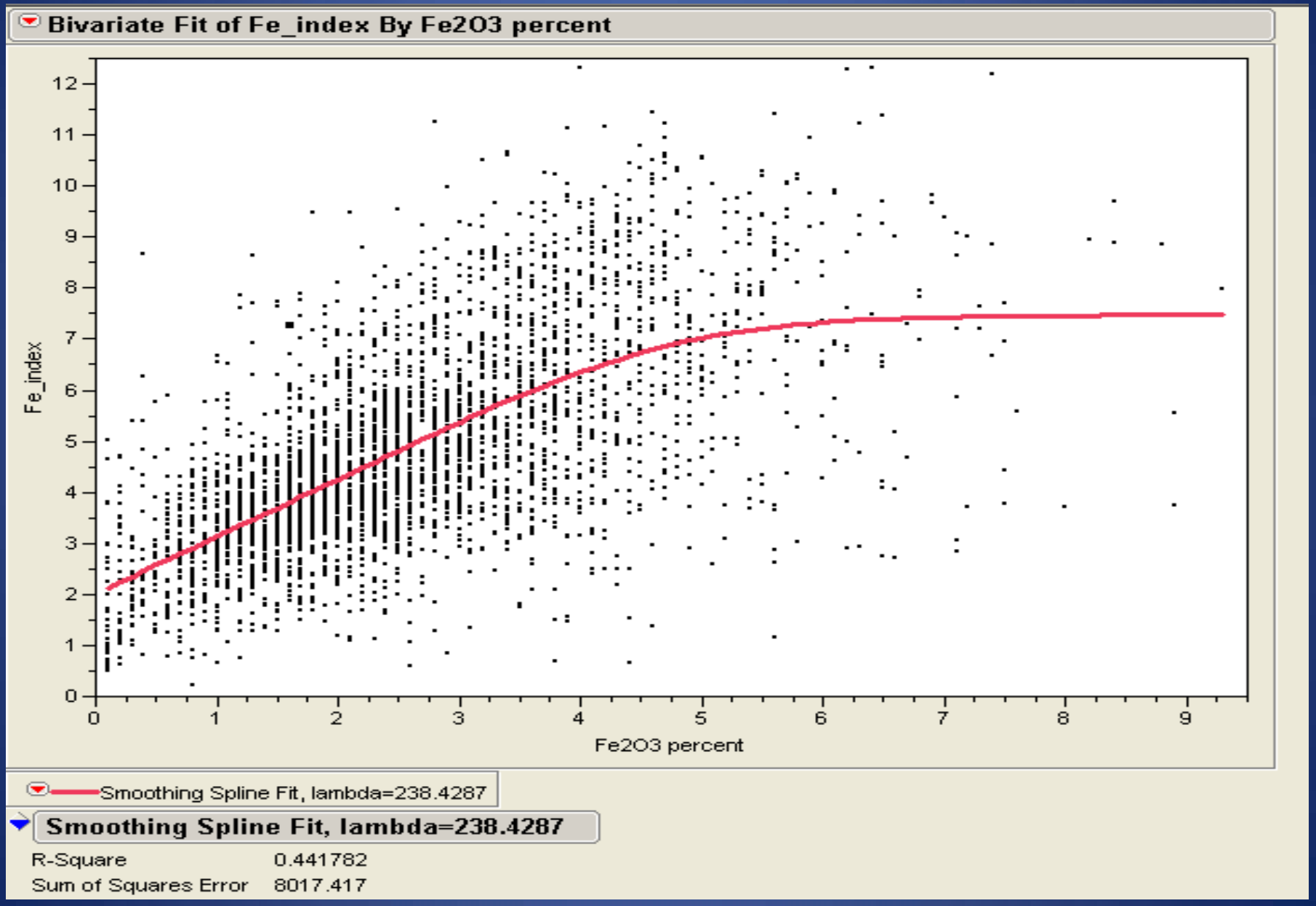
Parent Material Radon Source



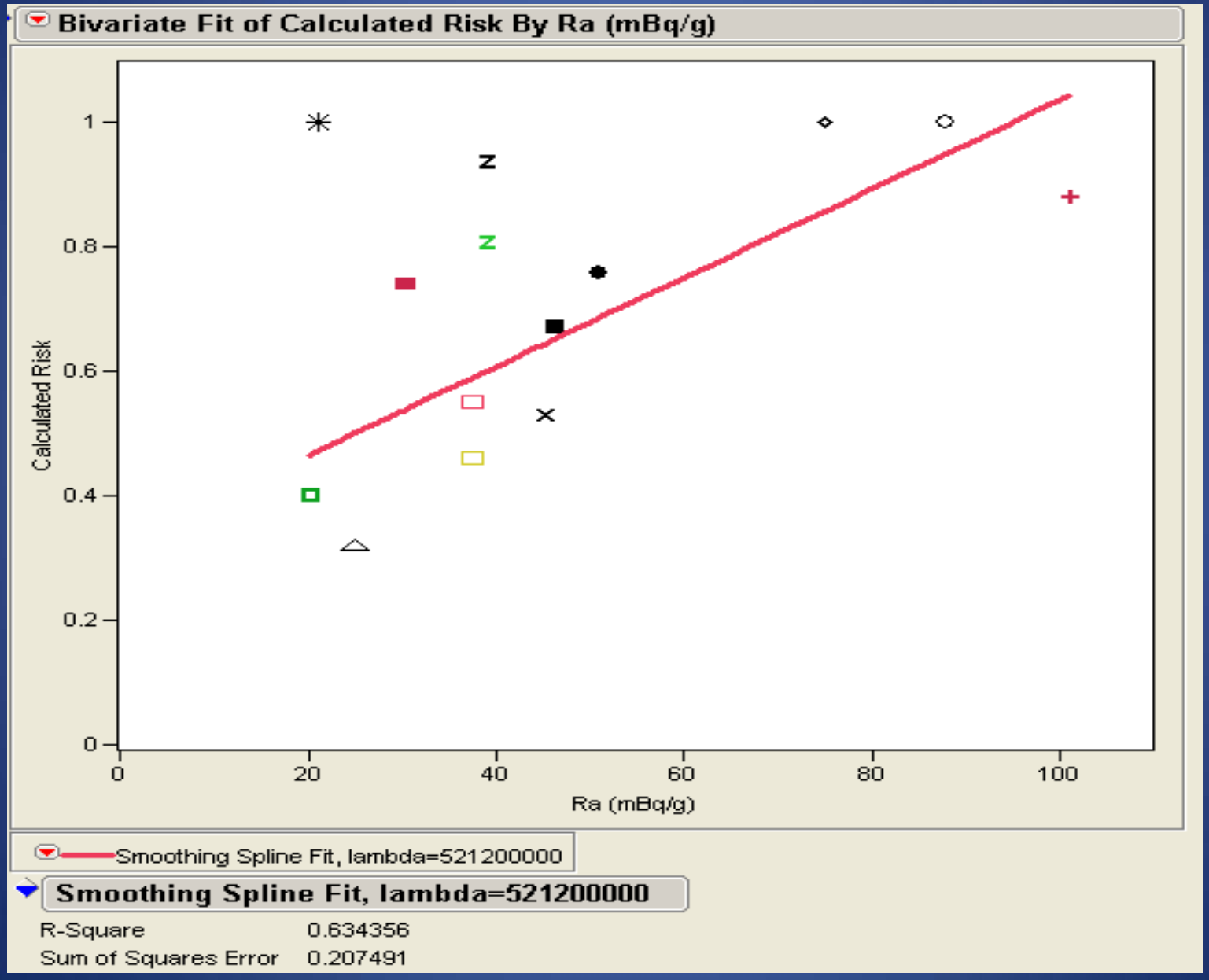
Pedogenic Sources



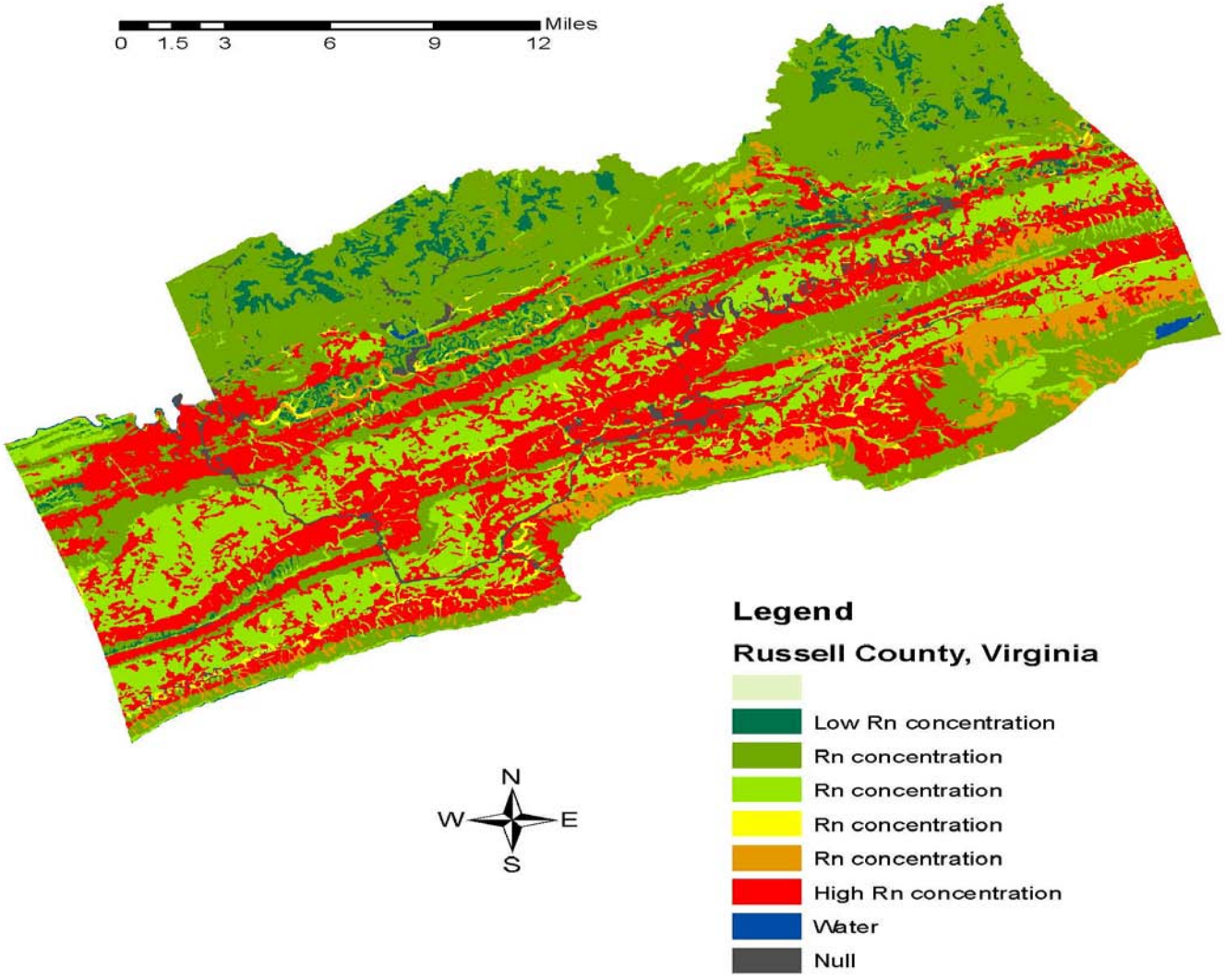
Iron Oxides and Color



Calculated Risk vs Radium



Relative Radon Gas Concentration



Needs for Further Work

- Identify other sources and/or interactions
- Validate with output from georeferenced sources
- Develop lookup table of uranium/radium contents of geologic materials
- Data Need – Component pedons to get the color data for estimating iron oxides

Conclusion

- The radon content of soils is a soil related issue and should be able to be modeled from a soils perspective
- The soil survey database is the logical data to use to develop a large scale (SSURGO) map of soil radon content