Phytoforensics—Using Trees to Find Contamination

The water we drink, air we breathe, and soil we come into contact with have the potential to adversely affect our health because of the presence of contaminants in the environment. Environmental samples can characterize the extent of potential contamination, but traditional methods for collecting water, air, and soil samples below the ground (for example, well drilling or direct-push soil sampling) are expensive and time consuming. Trees are closely connected to the subsurface, and sampling tree trunks can indicate subsurface pollutants through a process called phytoforensics. Scientists at the U.S. Geological Survey Missouri Water Science Center were among the first to use phytoforensics to screen sites for contamination before using traditional sampling methods, to guide additional sampling, and to show the large cost savings associated with tree sampling compared to traditional methods (Schumacher and others, 2004, 2005).

Phytoforensics is a low cost, rapid sampling method that collects tree-core samples from the tree trunk (fig. 1) to map the extent of contamination below the ground (figs. 2 and 3; Larsen and others, 2008; Limmer and others, 2011; Vroblesky, 2008). Below-ground contaminants in water, air, and soil move into tree roots and upward (fig. 2) through a system of small, water-filled tubes called xylem tissue. Phytoforensics uses existing trees in the vicinity of contaminant plumes and reduces the time, cost, and potential landscape disruption associated with drilling wells and other traditional methods. Tree-core samples may cause local scarring to tree trunks, but trees are able to repair any scarring within 2 to 3 years (Vroblesky, 2008). One- or two-person teams can collect as many as 100 tree-core samples per day. Tree cores are analyzed for contaminants in a laboratory, and results are typically provided within 2 weeks. A user's guide to tree coring was published in 2008 by the U.S. Geological Survey in cooperation with the U.S. Environmental Protection Agency and acknowledged phytoforensics as a viable tool (Vroblesky, 2008).

Trees have many characteristics that are beneficial in mapping subsurface contamination. Contaminant concentrations in tree-core samples are representative of a large subsurface volume because of the horizontal extent of tree roots (fig. 2;

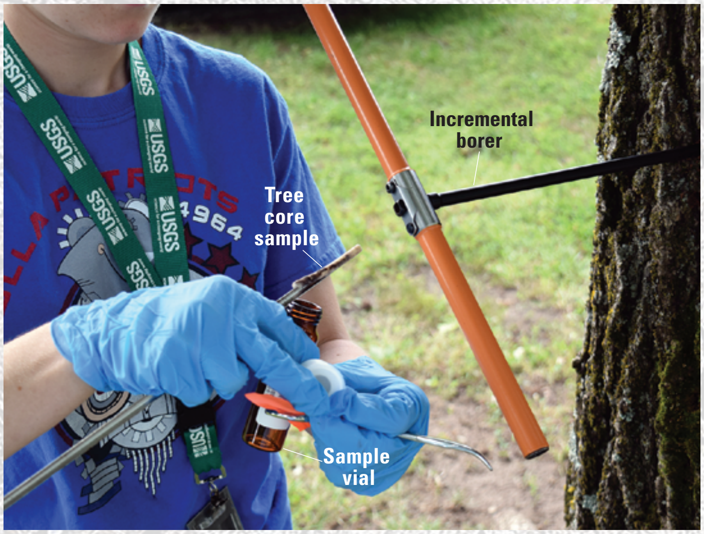

Figure 1. Collection of a tree-core sample with necessary sampling equipment including an incremental borer, forceps, a sample vial, and gloves. Samples are collected at about 3 feet above ground surface, placed into vials, and analyzed at the U.S. Geological Survey Missouri Water Science Center or the Center for Research in Energy and Environment at the Missouri University of Science and Technology.

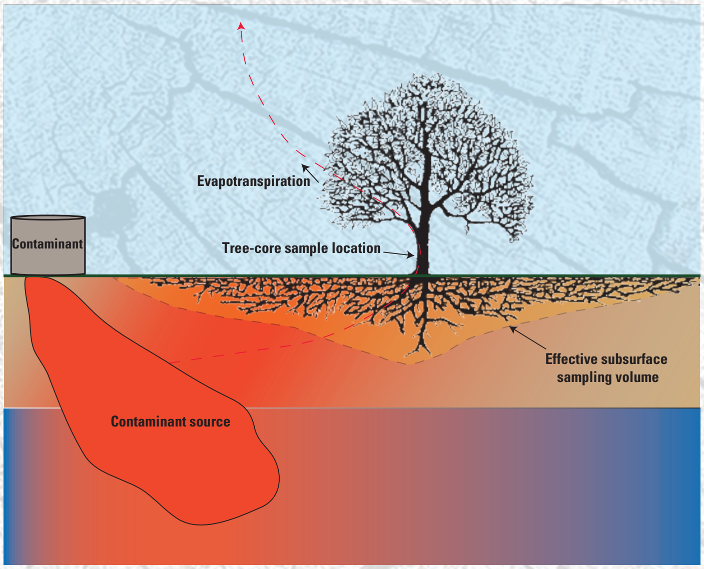

Figure 2. Illustration showing how contaminants move through the subsurface and are collected by trees over a large subsurface extent called the effective subsurface sampling volume.

A quick, non-invasive, and cost-effective method

- Quickly screen sites for subsurface contamination
- Cost- and time-effective approach that uses pre-existing trees
- Non-invasive method: no drill rigs or heavy equipment
- Representative of large subsurface volumes

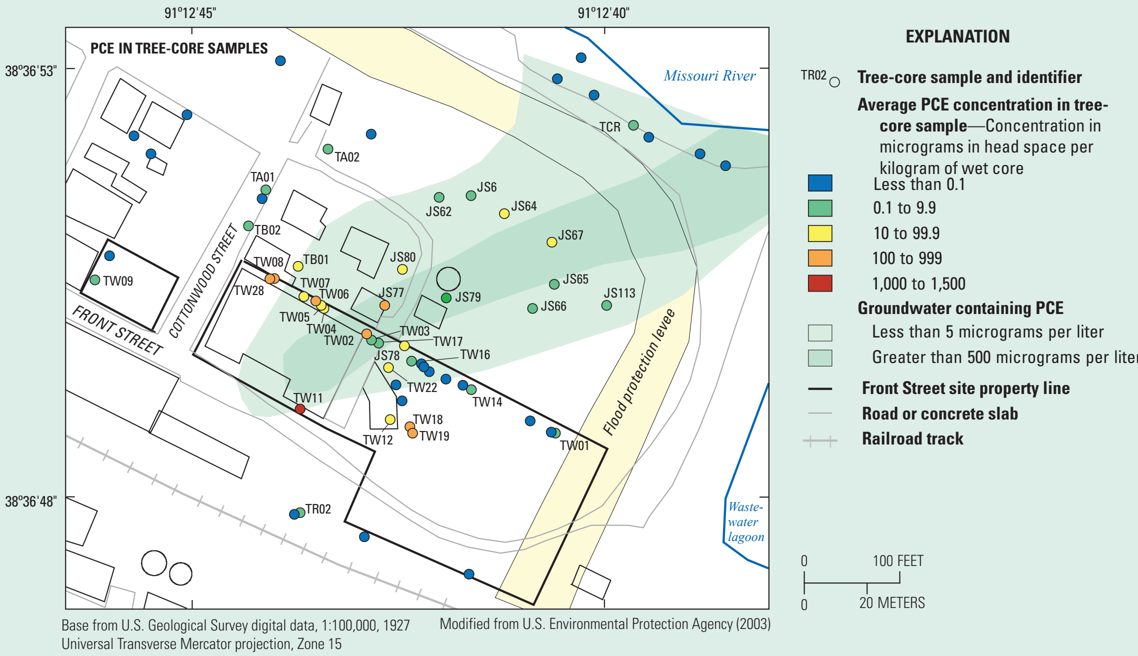

Figure 3. Tetrachloroethylene (PCE) in tree-core samples, and estimated extent of PCE in groundwater. Figure modified from Schumacher and others, 2004.

Dobson and Moffat, 1995; Sorek and others, 2007), which is typically proportional to trunk diameter. Contaminant concentrations in tree-core samples also are representative of subsurface contaminant concentrations averaged over long periods of time because the xylem tissue holds contaminants for a long period (MacKay and Gschwend, 2000; Trapp and others, 2001). Trees also indicate shallow subsurface contamination because most tree roots exist primarily in the shallow subsurface (fig. 2). Lastly, contaminant concentrations can vary around the tree trunk because tree roots generally connect to xylem tissue on the same side of the tree (Orians and others, 2002; Schulte and Brooks, 2003). The side of the trunk with the largest concentrations often indicates the direction of greatest concentrations in the subsurface (fig. 4). Collecting multiple tree cores from around the tree, called directional tree coring, can provide information about the direction of greatest subsurface contamination relative to the tree (Limmer and others, 2013).

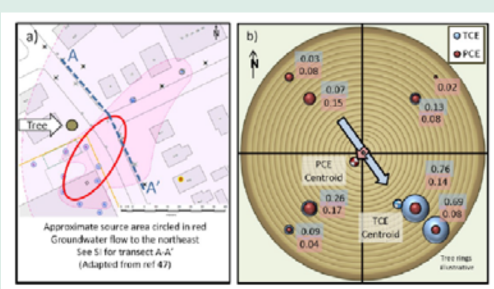

Figure 4. Screen shot showing *A*, the location of tetrachloroethylene (PCE) contamination at a field site and *B*, the direction from the tree center to the PCE and trichloroethylene (TCE) contaminant centroid indicating the general direction from the tree to the below-ground contaminant source in *A*. Figure modified from Limmer and others, 2013.

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