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Uptake of Tritiated Groundwater by Black Locust Trees

Abstract

Artificially planted trees have survived for four decades in the very dry climate of south-central Washington without irrigation. It is generally believed that long-time tree survival depends on root contact with groundwater but this assumption had not been critically evaluated. Leafwater from trees growing at a location where groundwater was 7.7 m below the surface had elevated levels of tritium. The well water also had elevated levels of tritium indicating that some of the tritium measured in tree leaf water was obtained from root contact with tritiated groundwater. Tritium concentrations in leaf water were greatest in August when sources of tritium other than groundwater are least abundant, indicating that the trees relied most heavily on groundwater during the hottest and driest season of the year.

Introduction

The climate of the U.S. Department of Energy's Hanford Site in south-central Washington is characterized by low (16 cm) annual precipitation and hot, dry summers (Stone *et al.* 1983). The natural vegetation consists mostly of sagebrush, *Artemisia tridentata,* and several species of drought tolerant grasses. However, introduced deciduous trees will grow when planted and irrigated. In the years prior to the acquisition of the land by the federal government, deciduous trees, especially black locust, *Robinia pseudo-acacia,* had been planted and irrigated in the vicinity of farm buildings to provide shade and wind protection. Following land acquisition in 1943, the farms were abandoned, irrigation ceased, and the land was used as a buffer zone around nuclear material production facilities. Over the past four decades many of the trees have died. The survivors were believed to have root access to groundwater which allowed them to meet their water requirements during the hot, dry, summer months. Although it was generally accepted that tree survival depended upon access to groundwater, this had never been adequately demonstrated because there was no way to distinguish the two major sources of tree water, namely that contributed to the upper meter or so of the root zone by annual rainfall from that contributed from deeper soil strata by root contact with groundwater.

One way to distinguish the two possible sources of tree water is to tag groundwater with tritium and then analyze leaf water. Tritium is present in groundwater on the Hanford Site but it had not been used as an experimental technique (McCormack and Carlile 1984).

Methods

In a preliminary survey conducted during the summer of 1985, leaf water was collected from trees at widely scattered locations across the Hanford Site. The survey indicated that a few black locust trees, growing near the 100 K area, had the greatest concentrations of tritium (Figure 1). However, the depth to groundwater beneath the trees was not known. In April 1986, a well, 16 m deep, was bored near these trees and designated as well K-31.

In May, six black locust trees spaced 10 meters or more apart, but all located within a 50-m radius of well K-31, were selected for leaf water sampling. Leaf water was obtained from small branches clipped from each tree monthly from June through September. Leafy twigs were cut from the freshly severed branches and placed inside translucent plastic bags. Each bag was tightly sealed and then placed in direct sunlight for four to five hours. Water droplets that accumulated on the inside surface of the bags were drained into a bottle. The accumulated water was purified by distillation in the laboratory and the distillate analyzed for tritium (Rickard and Kirby 1987). A sample of groundwater was collected from well K-31 on the same day the leaves were taken from the trees. The groundwater was distilled and analyzed in the same way as leaf water.

One tree from a group of non-irrigated black locust trees located outside the boundaries of the Hanford Site at Horn Rapids Park, near the Yakima River, was used as a control or background

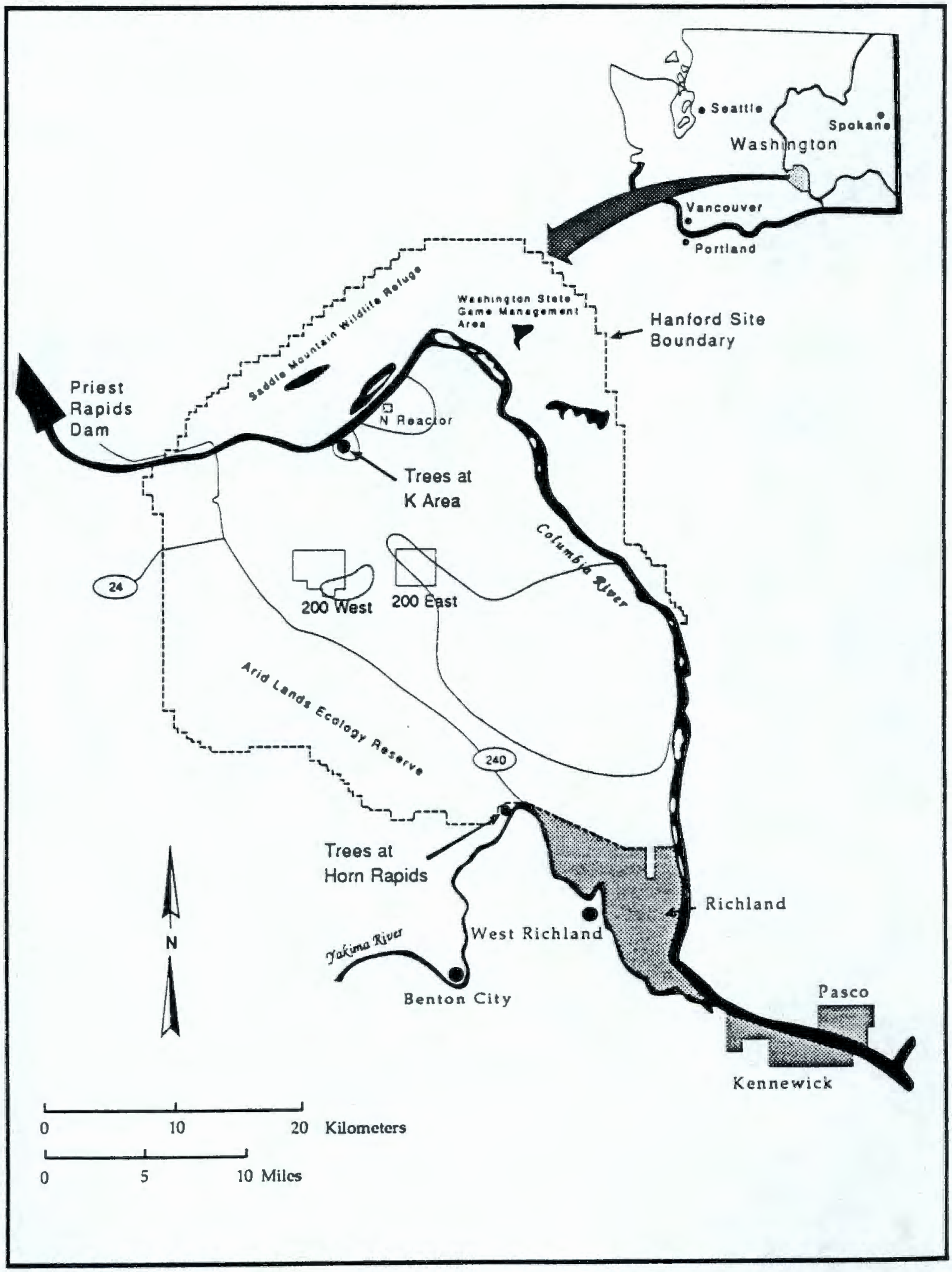

Figure 1. Map of the Hanford Site and Adjacent Areas Showing the Location of Black Locust Trees Sampled for Tritium and the Approximate Extent of Tritiated Groundwater (lightly stippled).

sample (Figure 1). Tritium concentrations are reported as picocuries (10^{-12} curies) per liter of water.

Results and Discussion

The water level in well K-31 stood at 7.7 m below the ground surface. The tritium concentration of the well water was relatively stable throughout the summer and averaged 4500 pCi per liter (Table 1). All the trees sampled near well K-31 had leaf water concentrations of tritium greater than 3000 pCi per liter, and as high as 12,000, indicating root contact with tritiated groundwater (Table 1). In contrast, the tree at Horn Rapids Park, beyond the boundaries of groundwater contamination, had background tritium concentrations ranging between 200 and 800 pCi per liter of leaf water.

It was thought that tritium concentrations in leaf water would be less than those measured in groundwater at all times because the trees also have root access to water introduced to the ground in rainfall, which characteristically contains low levels of tritium. Therefore, the tritiated groundwater, when it appeared in leaf water, would be expected to be somewhat diluted by rain water input. However, at times tritium concentrations in leaf water were greater than those in groundwater (Table 1). This suggested to us that the root systems of the trees had access to zones of groundwater with higher tritium concentrations than those measured in the well water.

On the average, the highest concentrations of tritium were measured in the leaf water samples collected in August when water sources other than groundwater were least plentiful, indicating that trees relied most heavily on groundwater late in the summer (Table 1). Similar findings were obtained during a similar survey conducted in a natural oak-hickory forest in eastern Kentucky (Kalisz *et al.* 1988).

A conclusion is that black locust trees rely on groundwater throughout the leaf-bearing season but most heavily in late summer.

Acknowledgments

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TABLE 1. Tritium concentrations (pCi/L of leaf water) extracted from six black locust trees growing near well K-31 on the Hanford Site in the summer of 1986. Values are rounded to 2 significant figures. Counting errors ($\pm 1\sigma$) were within 10% of the reported values.

	Tree Identification Numbers							
	tree 1	tree 2	tree 3	tree 4	tree 5	tree 6	Mean	groundwater
June	4600	5500	7000	5900	6600	7600	6200	4500
July	3300	5800	10000	5300	3600	9500	6200	4400
August	5200	7400	12000	4700	5300	10000	7400	4400
September	3000	5400	4500	3600	4000	6400	4500	4600
Mean	4000	6000	8400	4900	4900	8400	6100	4500

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