# The Influence of Hillside Springs on Subalpine Streamwater


## Chuck Rhoades, Natalie Quiet, Kathleen Dwire & Kendra Brewer

Rocky Mountain Research Station
& Fraser Experimental Forest
crhoades@fs.fed.us


## Overview

In high-elevation watersheds, more than 90% of snowmelt water passes through near-surface flowpaths before entering the stream channel. Groundwater discharges from isolated and clustered springs generating ephemeral, intermittent and permanent flow in headwater stream channels. At the Fraser Experimental Forest, 157 hillside springs are distributed throughout the 290-hectare Fool Creek watershed. This preliminary report describes results from synoptic sampling of 39 randomly selected springs in alpine and subalpine portions of the catchment.

## Historic Context of Current Research



### Historic Characterization of Fool Creek Springs

In 1950 and 1953, several years prior to harvesting of the Fool Creek watershed, RMRS soil scientist John Retzer surveyed and characterized wetland communities throughout the basin. Retzer's groundwork and preliminary recommendations have not been revisited for a half-century.

### Retzer's Objectives

"To locate and plot … all seeps and springs in the watershed.

To classify the water-yielding ability at the surface of each spring …

To relate the emergence of springs to geologic structures or other features that may have influence on their surface emergence.

To collect water samples from the more vigorously flowing springs for analysis of salts present.

To evaluate the [forest harvest] treatment program on the occurrence and water yield of springs."

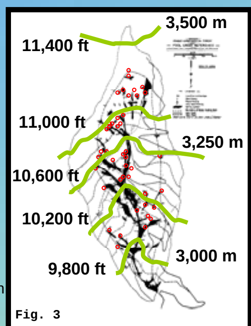



Fig. 3

### Historic Recommendations / Current Objectives

1. Select a number of the rapidly and very rapidly flowing springs and measure their rates of flow at intervals throughout the season. The intervals would be selected after a study of the hydrograph to locate in time the critical periods. It is suggested that the seasonal variations in spring flow may coincide with flow in the main channel. If it does to any appreciable extent then water yields (surface flow) may be approximately predicted by gauging key springs in watersheds of similar nature to Fool Creek. The springs selected must be those in perimeter positions and not those in the systems or along the main channel.

   It is suggested that a high percentage of the water passing over the two weirs is the sum of the yields from the flowing perimeter springs. This study should be started in 1954.

2. The rate of ground water movement through the regolith can be measured here. By inserting the proper substance in the perimeter springs its location and rate of movement through the soil can be readily traced. This will relate springs at low elevations with those along the perimeter. It will give a measure of the time required for precipitation in the upper part of the watershed to contribute to stream flow. It will assist in tracing waters along faults.

   Some of these studies should be made in 1954 previous to logging.

3. Waters for chemical analysis should be collected from more springs than reported herein. This will give a basis for any changes that may occur due to logging operations. Suspended and bedloads are already being measured.

   These samples should be taken previous to logging and the first and fifth years following operations.

   It is not anticipated that changes will occur but they may if appreciably more water moves through the soil.

4. Data available from climatic and soil installations in Fool Creek should be analysed to shed some light on possible causes of the low temperatures of the springs. It is important to management to know whether low temperatures are primarily related to air temperatures or to melting ground ice. If the latter, then what is the significance of high altitude burns and logging on the hydrologic cycle?

J. Retzer. 1953. Characteristics of Springs in Fool Creek. Rocky Mtn. For. & Range Expt. Sta.

## Plant Associations & Soil Conditions

| Elevational Zone | Wetland Plant Association[1] | Species Name/ Occurrence (# springs) | Mean Cover (%) | Cover-Range (%) |
|---|---|---|---|---|
| Treeline Zone (3375 – 3500 m) | Willow shrubland *Salix planifolia* *Caltha leptosepala* | *Salix planifolia* (3) | 47 | 10 – 100 |
| | | *Caltha leptosepala* (3) | 18 | 5 – 40 |
| | | *Senecio triangularis* (3) | 21 | 5 – 45 |
| | | *Saxafraga odontoloma* (3) | 20 | 5 – 25 |
| | | Moss spp. (3) | 70 | 35 – 90 |
| Subalpine Forest (3000 – 3375 m) | Herb dominated *Senecio triangularis* *Cardimine cordifolia* | *Senecio triangularis* (12) | 21 | 5 – 90 |
| | | *Saxifraga odontoloma* (12) | 20 | 5 – 65 |
| | | *Cardimine cordifolia* (10) | 14 | 1 – 65 |
| | | *Mitella petandra* (11) | 10 | 1 – 25 |
| | | *Luzula parviflora* (10) | 3 | 1 – 5 |
| | | *Carex aquatilis* (7) | 16 | 5 – 85 |
| | | Moss spp. (12) | 73 | 5 – 100 |

[1] Carsey, K., G. Kittel, K. Decker, D.J. Cooper, and D. Culver. 2003. *Field Guide to the Wetland and Riparian Plant Associations of Colorado*. Colorado Natural Heritage Program, Fort Collins, CO.

Fig. 4

The floral communities surrounding the spring openings are typical of central Rocky Mountain forested and riparian wetlands underlain by Precambrian bedrock.

Dense willow shrublands differentiate the seep communities found on flatter topography and sparse forest canopy of the treeline zone from forb-dominated herb strata of springs that emerge within closed-canopy subalpine forest, often on steeper slopes.

The organic horizon averages 20 cm deep and extends to > 60 cm in 20% of sampled seeps (Fig. 4). Total soil depth (organic + mineral) to gravel or bedrock averaged 40 cm and was >120 cm for several seeps.

## Landscape Controls on Spring Chemistry

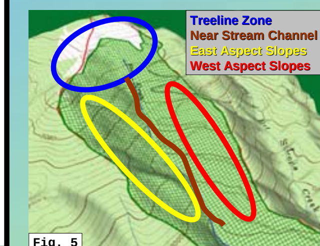



Fig. 5

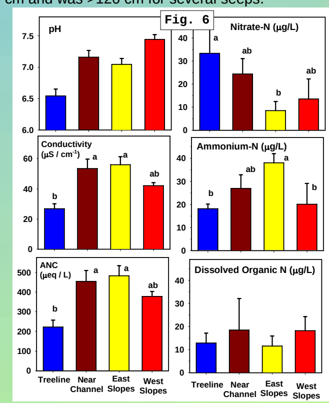


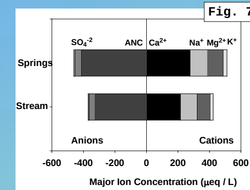

Fig. 6

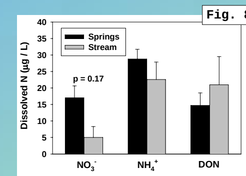
In general, the chemistry of springs emerging within the Treeline zone is distinct from subalpine & Near Channel springs (Fig. 6). Concentrations of most dissolved ions are significantly lower in the upper elevation springs.

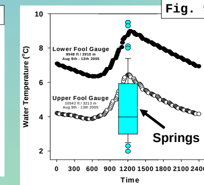
The similar ionic composition of East Slope & Near Channel springs combined with greater density & higher discharge of East Slope springs (Fig. 3 & 11) suggests that springs originating on this aspect may have a predominant influence on basin-scale aqueous chemistry.

High nitrate & low ammonium concentrations of Treeline springwater agrees with greater nitrification & nitrate leaching measured in alpine soils at Fraser & elsewhere (See Adjacent Poster). Similar Treeline & Near Channel springwater nitrate suggests that groundwater flowpaths link these landscapes.

## Springwater versus Streamwater



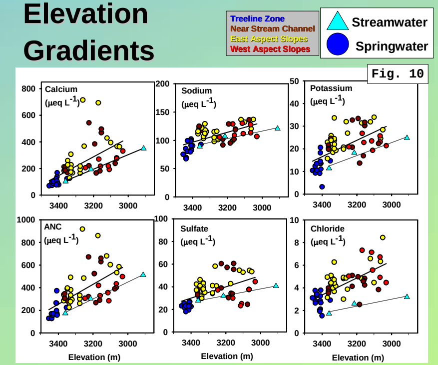




Concentrations of dominant cationic & anionic constituents of springwater exceed Fool Creek streamwater (Fig. 7).

Springwater nitrate was higher, but organic N did not differ from streams (Fig. 8).

The average mid-day temperature of water emerging at springs was equal to the daily minimum streamwater temperature at the upper Fool Creek gauge (Fig. 9).

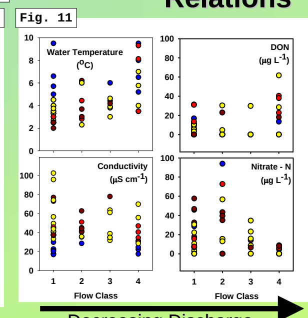
## Elevation Gradients




The ionic concentration of springwater increases with decreasing elevation as does streamwater.

On the East aspect springs, the high variability of elements released by mineral weathering may correspond to zones of geologic faulting.

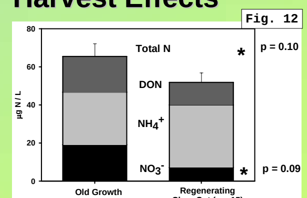
## Discharge Relations

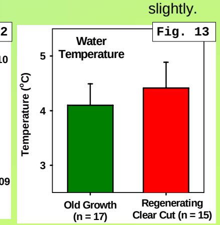



Springwater temperature increased as discharge declined.

At low flow springs nitrate declined dramatically & organic N increased slightly.

## Harvest Effects




50 years after harvesting, dissolved inorganic & organic N concentrations are lower in springs emerging within recovering stands than in uncut forest.

Spring water temperature is no different between forest conditions.

## Future Directions

Identify seasonal patterns & linkages among springs and between springs & streamwater

Assess long-term effect of harvesting on edaphic, vegetation, snowpack & hydrochemical conditions of spring network