



LOWER WATER TEMPERATURES WITHIN A STREAMSIDE BUFFER STRIP

Abstract.--The removal of streamside vegetation increases the water temperature in mountain streams. Clearcutting and farming have been found to raise temperatures beyond the tolerance level for trout (68° F.). Within the sale area of a commercial clearcut in the mountains of North Carolina, a narrow buffer strip of uncut trees and shrubs was left beside a stream. Although water temperatures within the sale area may have exceeded 68° F., the stream immediately below the sale area was never warmer than 62° F.

Logging and other land uses which result in removal of all vegetation around a stream have been shown to increase water temperatures. In a review by Swift and Messer,¹ several examples were reported of increased temperatures which degraded the aquatic habitat by exceeding the accepted thermal tolerance level for brook trout--68° F.² Seven of these studies suggest that a buffer strip of vegetation left next to a stream can prevent excessive heating of the water or allow a warmed stream to cool down. The purpose of the present study was to document the effect of a buffer strip on stream temperatures in an operational timber sale. The effects of such strips have not been reported for any Appalachian Mountain streams.

TIMBER SALE AREA

Stream temperatures were measured from June through September 1971 and again in June 1972 along Brushy Ridge Branch near Brevard, North Carolina. This stream passes through compartments of a regeneration cut in the Stone Mountain timber sale on the Pisgah Ranger District. Before logging, the timber stand was classified as mature red oak-white oak-hickory. Some yellow-poplars and maples grew in the stream bottom. An extensive understory of mountain-laurel and rhododendron occurred on the steep west-facing slope and in patches along the stream.

¹Swift, L. W., Jr., and Messer, J. B. Forest cuttings raise temperatures of small streams in the southern Appalachians. *J. Soil & Water Conserv.* 26: 111-116. 1971.

²Stroud, R. H. Water quality criteria to protect aquatic life--a summary. *Am. Fish. Soc.*, Washington, D. C., Spec. Publ. 4, pp. 33-37. 1967.

Most of the 135 acres of the sale area within the watershed was logged between June 1970 and November 1971. Except for the shrubs and some unmerchantable stems, the watershed was clearcut around a buffer of forest averaging 40 feet in width along either side of the lower stream channel. Because of low timber volume, very little logging was done on the steep west-facing slope and considerable shrub vegetation remained there during the study. The photograph in figure 1, taken in July 1972 from the north boundary, shows the upper edge of the streamside buffer strip and the regeneration cut on the east-facing slope. The map (fig. 2) shows the vegetation distribution during the late summer of 1971, the topography around Brushy Ridge Branch, and the location of the various stations for measuring stream temperatures.

The main prong of Brushy Ridge Branch originates on a steep west-facing slope and flows as a thin sheet of water over a rock face for about 450 feet. Below the slope, the stream meanders over a sand or mud bottom through flat terrain for about 1,800 feet. The gradient increases as the stream leaves the sale area and flows over large boulders in a series of small falls and pools. Within the sale area, the stream is too small to be classed as trout habitat.



Figure 1. --Upper end of the streamside buffer strip in the regeneration cut (July 1972).

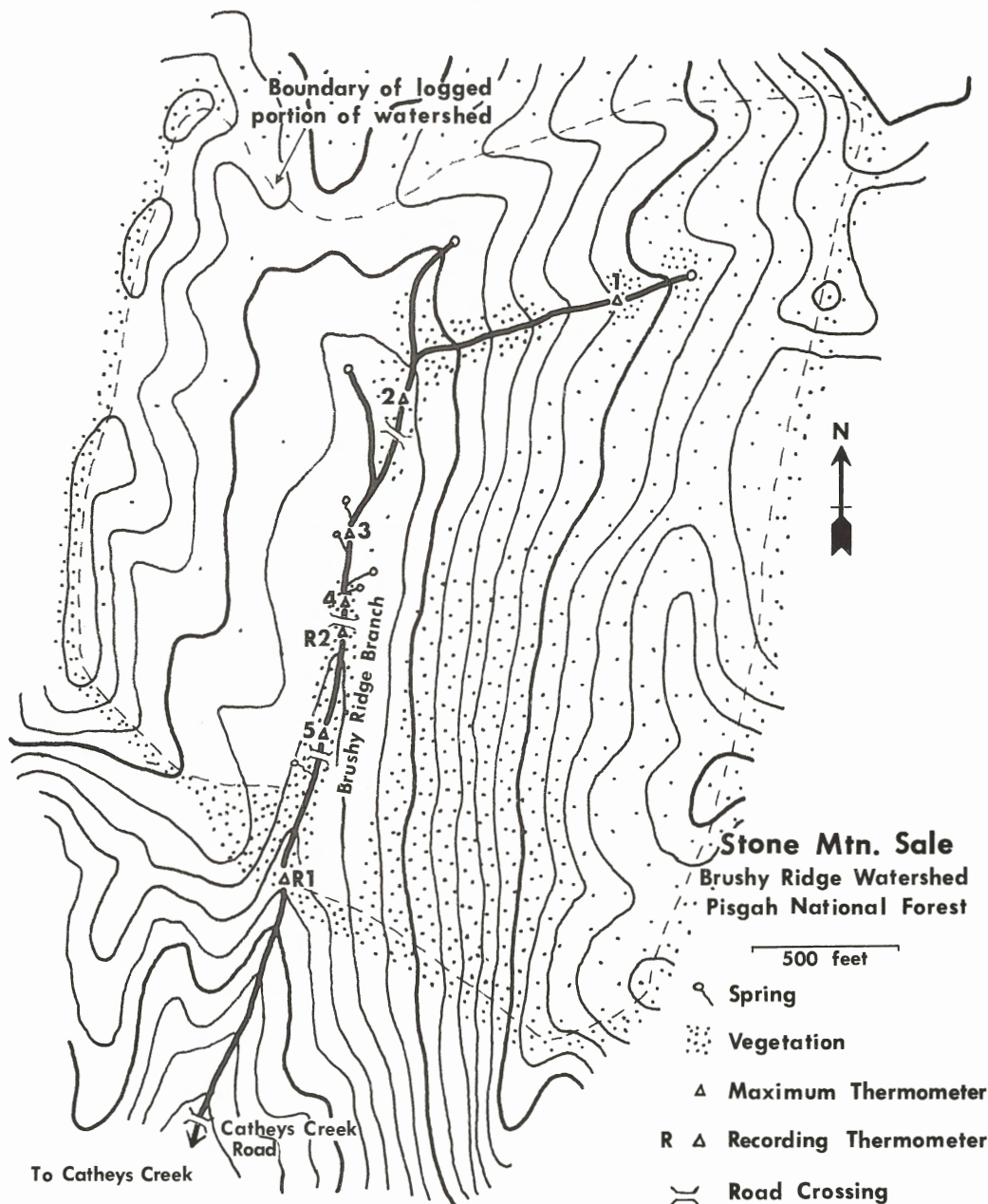


Figure 2. --Distribution of vegetation in the regeneration cut, topography of the logged portion of the watershed, and location of stations for measuring temperature of Brushy Ridge Branch in the summer of 1971.

Sections of the first 1,970 feet of streambed were exposed to direct sunlight. On the upper slope, portions of the stream were shaded by patches of rhododendron and mountain-laurel remaining after the merchantable forest had been cut. At the base of the slope above Station 2, part of the forest vegetation was left uncut next to the stream. Station 3 was in an area of almost total clearcut. Station 4 was at the head of a buffer strip of uncut forest with a dense shrub understory. The buffer

strip contained some tops and slash from adjacent cutting and was crossed below Station 4 by two skid roads. The stream ponded behind the log culverts at these two road crossings. The clearcut zone and buffer strip ended at Station R1 on the south boundary of the sale area.

MEASUREMENTS

Temperature measurements began in June 1971 as the loggers' activity on the sale area was ending. Two recording thermometers (R1 and R2) and five stem thermometers which indicated maximum temperature were installed in the flowing stream (fig. 2). Readings were taken weekly from mid-June to mid-September. Water temperature was also recorded on an unlogged watershed of Catheys Creek, about 0.75 mile NNW. of Station R1. These measurements, used as a comparison, were made at a point where stream size and drainage area were equivalent to those at Station R1 on Brushy Ridge Branch.

In June 1972, after a succession of several warm, sunny days, a series of water temperatures were taken one afternoon along the entire length of Brushy Ridge Branch from the main spring to Catheys Creek Road. Intensive measurements were made every 100 feet below Station 2 to locate points of rapid temperature change within the buffer strip. By then, much of the shrub vegetation along the upper 900 feet of the stream had been cut for timber stand regeneration. Many of these branches had fallen across the stream and were shading the water.

RESULTS

Profiles of weekly maximum stream temperatures through the sale area were plotted for each measurement week in 1971. Figure 3 shows the profiles for the two weeks in July which were the warmest of the summer. The temperature stations could not detail all the effects of the patchwork of clearcut and shaded areas, but the profiles did show that, during each week throughout the summer, maximum water temperature increased as the stream passed through the regeneration cut and rapidly decreased by 3° to 4° F. after the stream entered the lower buffer strip. There appeared to be a further gradual decrease in temperature as the stream flowed through the buffer strip. The lowest maximum temperature in Brushy Ridge Branch was always recorded in the buffer strip at Station R1. Corresponding temperatures in Catheys Creek in the adjacent unlogged watershed were always cooler by 3° to 5° F. than at R1. Preliminary measurements in 1970 indicated that, if the watershed had not been logged, the weekly maximum water temperatures of Brushy Ridge Branch (Station R1) would have been similar to those of Catheys Creek. These measurements in conjunction with those shown in figure 3 indicate that logging raised temperatures at least 10° F. in the upper section of Brushy Ridge Branch on at least two occasions.

The maximum water temperature of 68° F. for the 1971 season was recorded at the lower end of the clearcut zone (Station 3) during the week of July 15 to 21. Although heating of the stream by direct solar radiation

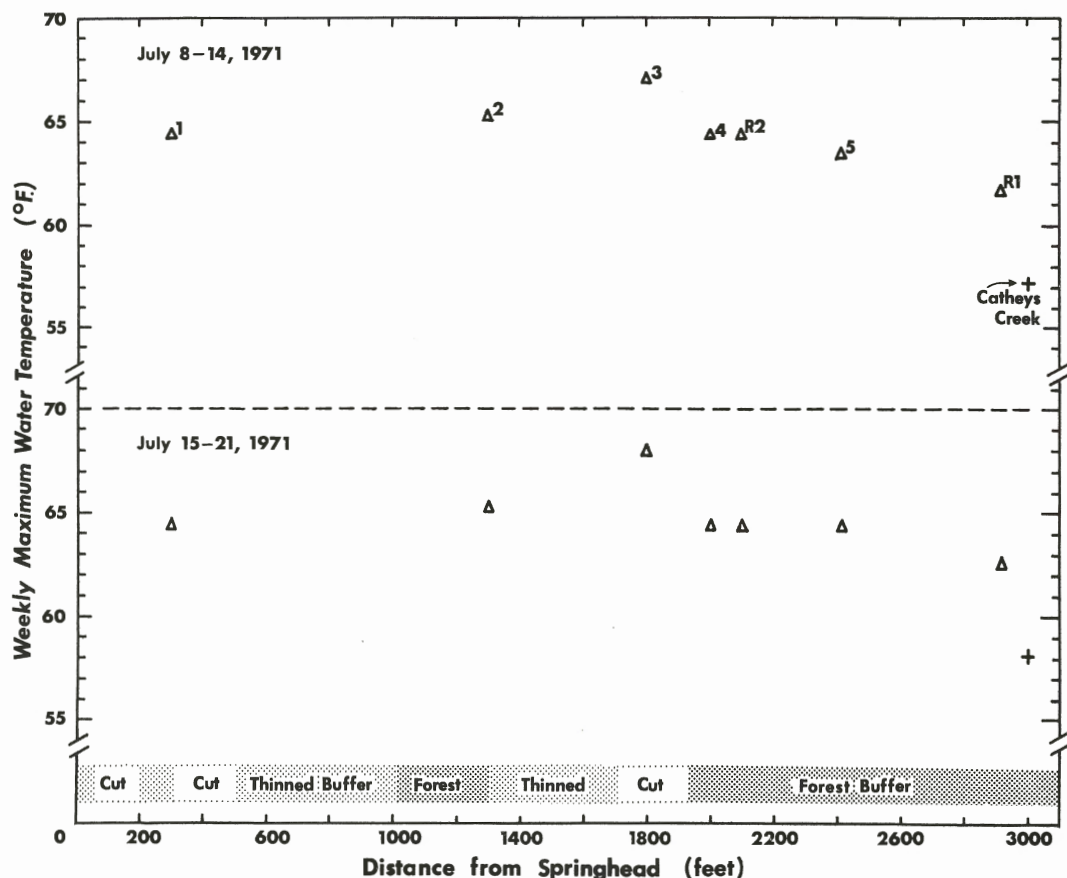


Figure 3.--Profiles of the maximum water temperatures of Brushy Ridge Branch for the two warmest weeks in 1971. (Shaded strip represents the distribution of streamside vegetation at the time of temperature measurement. Δ = temperature in main stream, + = temperature in stream in unlogged watershed.)

was inhibited in the shade of the forest, air temperatures in the buffer strip were raised by heated air from the adjacent logged areas. During this week, the maximum air temperature near the ground within the shade of the buffer strip was 89° F. The maximum air temperature in the shade near Catheys Creek was 74° F. Monthly mean air temperatures indicate that solar heating was below normal in western North Carolina in 1971. Summer temperatures averaged 1° to 2° F. below normal, with July air temperatures at Hendersonville being 3.4° F. below normal. Minimum water flow in Brushy Ridge Branch during this period was about 0.5 cubic foot per second at Station R1.

Figure 4 shows the profile of water temperatures taken between 12:30 p.m. and 3:30 p.m. on June 14, 1972. As the water flowed over the rock and through the upper regeneration cut, the temperature rose 13° F. (from 53° F. at the main spring to 66° F. above the junction with the first side stream). The side stream also flowed through the regeneration cut but not over exposed rock. Its temperature above the junction was 59° F. Mixing reduced the temperature in the main stream nearly

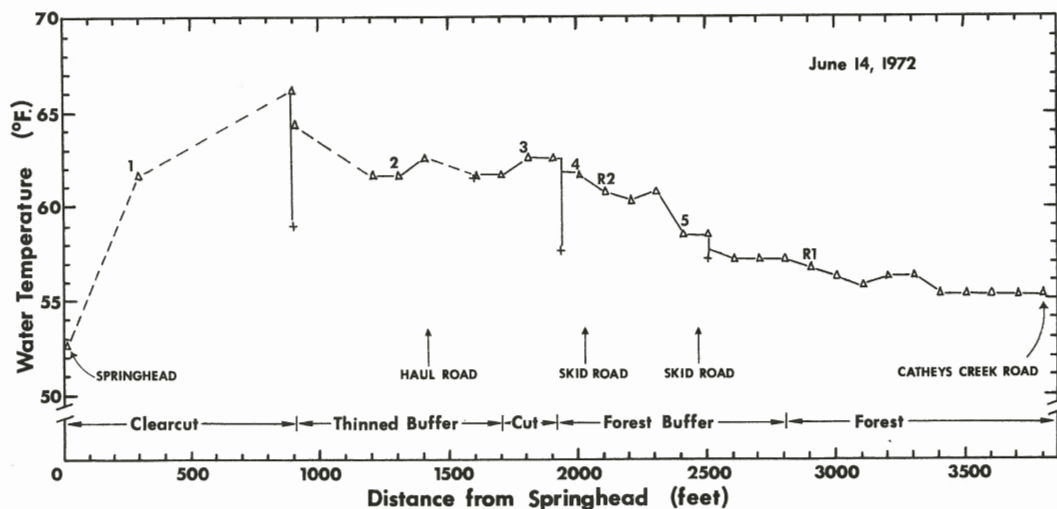


Figure 4.--Profile of water temperatures of Brushy Ridge Branch between 12:30 p.m. and 3:30 p.m. on June 14, 1972. Location of stations for recording maximum temperatures during the previous summer is shown for comparison. (Δ = temperature in main stream, + = temperature in spring or side stream.)

2° F., and further cooling occurred within the heavily thinned forest downstream from the junction. The next side stream, also draining the regeneration cut, entered with the same temperature as the main stream, 62° F. at that point. Several springs fed into the main stream. Two springs within the buffer strip were both cooler than the main stream and caused further temperature reductions. The profile shows other temperature decreases which also may have been caused by springs, but these inflow points were not found.

CONCLUSIONS

These observations confirm that forest cutting next to a small mountain stream will increase maximum water temperatures during the summer. Measured temperatures did not exceed the habitat standard for trout of 68° F. However, if 1971 had been an exceptionally warm year, stream temperatures in Brushy Ridge Branch might have been greater.

The detailed temperature profile made in 1972 (fig. 4) shows that the stations set up in 1971 (fig. 3) to measure the weekly maximum temperatures failed to demonstrate the full range of conditions, such as the low temperature at the springhead and a possibly higher temperature at the foot of the first slope. Furthermore, this detailed profile shows that most of the temperature reduction which occurred below the regeneration cut was completed inside the sale area and within the buffer strip above the final measurement point (Station R1). Thus, the water temperatures in some parts of Brushy Ridge Branch may have exceeded 68° F. during the summer of 1971, but the effects of these increases were modified within the buffer strip by shading and dilution from side streams and springs before the water joined a stream large enough to support trout.

The important finding of this study is the rapid reduction of water temperature within the protection of the buffer zone. The large temperature drop immediately after the stream entered the buffer zone (fig. 3) actually occurred over a much shorter distance than the 400 to 1,000 feet reported by Greene,³ Levno and Rothacher,⁴ or Gray and Edington.⁵ Brown et al.⁶ concluded that the influx of cool ground water was more responsible for the reduction of stream temperature than was shading of the stream channel below the logged area. Our detailed temperature profile supports their view.

This study confirms that a narrow buffer strip of uncut trees or shrubs on either side of a small mountain stream will moderate those increases in water temperature which might be caused by forest cutting. A shaded zone downstream from a clearcut area reduces the solar radiation received at the stream surface and allows the cool water contributed by side streams and springs to reduce the stream temperature. In the Appalachian Mountains, most streams will gain water from subsurface sources all along the channel, and temperature reduction appears to be rapid once the stream is shaded from the sun. However, the farther the buffer strip extends upstream to shelter the smaller channels and prevent an initial temperature increase, the less the need for heat dissipation by dilution or shading within the buffer strip before a small stream reaches trout water.

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³Greene, G. E. Land use and trout streams. J. Soil & Water Conserv. 5: 125-126. 1950.

⁴Levno, A., and Rothacher, J. Increases in maximum stream temperatures after logging in old-growth Douglas-fir watersheds. Pac. Northwest For. & Range Exp. Stn., U. S. For. Serv. Res. Note PNW-65, 12 pp. 1967.

⁵Gray, J. R. A., and Edington, J. M. Effect of woodland clearance on stream temperature. J. Fish. Res. Board Can. 26: 399-403. 1969.

⁶Brown, G. W., Swank, G. W., and Rothacher, J. Water temperature in the Steamboat Drainage. Pac. Northwest For. & Range Exp. Stn., USDA For. Serv. Res. Pap. PNW-119, 17 pp. 1971.

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