# Natural Reforestation Reclaims a Watershed:

# A Case History from West Virginia

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## ABSTRACT

Thirteen years of hydrologic data from two contiguous small watersheds in West Virginia were analyzed to determine the effects on streamflow of natural reforestation on abandoned farmlands. During the study period (1958-1970), streamflow on the watersheds was unchanged. The history of land use on the study area helps explain the apparent lack of hydrologic effects of reforestation. Aerial photographs taken in 1933, 1945, 1956, and 1968 documented the rapid advance of reforestation. Observations of streamflow began about 25 years after farming had terminated; any measurable hydrologic effects of natural reforestation probably occurred before these observations.

SUCCESSIVE STAGES of exploitation of indigenous resources—wildlife, plant cover, soil, and water—usually occur when land is occupied by agrarian people. This progressively intensive exploitation always results in the modification of the original environment—and often in the deterioration of the indigenous resources. The exploitation of resources, unless it was drastic, tended to be self-terminating in the Appalachian region of the United States. Where the terrain was steep, the destruction of forest vegetation soon caused soil erosion and stream siltation. In time, human occupancy waned, so the land was subjected to less demanding use, and it reverted to natural forest.

Two small watersheds near Parsons, West Virginia, provide an example of this sequence. Our report examines changes caused by exploitive land use, the natural revegetation that followed, and their interacting effects on watersheds.

# THE STUDY AREA

The watersheds, designated Clover Watershed 8 and 9, are within the Monongahela National Forest, about 15 km northwest of Parsons, in Tucker County, West Virginia (Fig. 1). They are contiguous headwater branches of Clover Run, a small tributary of the Cheat River that is part of the Ohio River system. Strong relief and steep terrain characterize the study area. Watershed 9 is somewhat less steep than Watershed 8 (Table 1), but most of the study area has slopes of 30 percent or greater. Today, such land is considered unsuitable for cultivation because the steep soils are easily eroded (U.S. Soil Conserv. Serv. 1970).

Nearly all of the study area is underlain with alternating strata of Devonian shales and sandstones of the Hampshire and Chemung series. Small patches of a Mississippian

**Figure 1.—Watersheds 8 and 9 in Tucker County, West Virginia.**

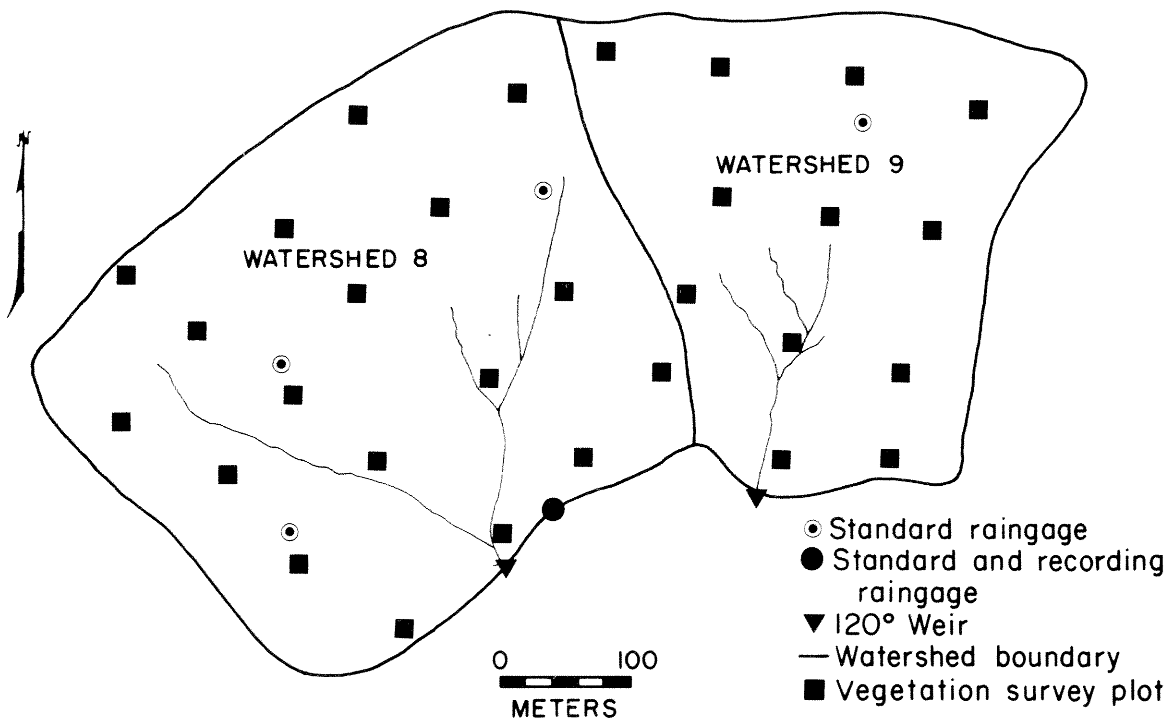


**Table 1.—Physical characteristics of the Clover watersheds**

| Characteristic | Watershed 8 | Watershed 9 |
|---|---|---|
| Area (ha) | 19.1 | 11.6 |
| Relief (m) | 147 | 85 |
| Mean elevation (m) | 795 | 784 |
| Percent of land in: | | |
| 10 - 20% slopes | 16 | 45 |
| 30 - 40% slopes | 56 | 48 |
| 40 - 75% slopes | 28 | 7 |

sandstone (Pocono series) occur on higher portions of the divides (Reger 1923).

## Climate

The climate of the study area is humid-temperate; the seasonal distribution of precipitation is fairly even. The relief and the striking differences in elevation, however, influence both temperature and precipitation (Losche and Beverage 1967). At Parsons (elevation: 515 m), the mean annual precipitation and temperature are 1,120 mm and 17.8°C, respectively; at Canaan in Tucker County (elevation: 970 m), these values are 1,360 mm and 14.4°C. The influence of elevation is reflected in the annual frost-free period; the average frost-free period is 150 days at Parsons and 90 days at Canaan.

Snowfall is common; 10 years of data indicate a yearly average of 37 and 70 days with snow cover at Parsons and Canaan, respectively. Losche and Beverage (1967) stated that "Rainfall . . . is adequate for the needs of most crops . . . Rainfall heavy enough to cause local floods occurs occasionally, usually accompanying a thunderstorm. Totals of more than 5 inches (127 mm) in a 24-hour period have been recorded."

Weather information was recorded on the study watersheds from 1958 to 1970. These data (Lima 1971) show a mean annual precipitation of 1,480 mm distributed evenly throughout the year. The mean temperature was −4.0°C for January, 18.9°C for July, and 8.4°C for the entire year. These data differ little from those for the other stations in the Central Climatological Division of West Virginia (U.S. Environ. Data Serv. 1958-1970). The calculated potential evapotranspiration (Black 1967) averaged 609 mm per year; there was no season of soil moisture deficit.

## Soils

The watershed soils are acid, moderately thick, and medium textured. They have formed in materials derived from the shale and sandstone bedrock; the bedrock is usually within 0.6 to 1.2 m of the surface. Rock fragments are common in the subsoil and they are especially abundant in Dekalb soil. All of the watershed soils are moderately permeable, low to moderate in fertility. The soils include 3 series—Calvin, Dekalb, and Gilpin—of which Calvin is the most extensive.

The Calvin and Dekalb series are classified as Typic Dystrochrepts, loamy skeletal, mixed mesic; the Gilpin series as Typic Hapluudults, fine loamy, mixed mesic (U.S. Soil Conserv. Serv. 1972). These soils series are given the hydrologic classification of "C". Soils in this classification are those "having slow infiltration rates when thoroughly wetted. They consist chiefly of soils with a layer that impedes downward movement of water, soils with moderately fine to fine texture, or soils with moderately high water tables" (U.S. Soil Conserv. Serv. 1970). The presence of bedrock, especially shale, impedes the downward movement of water, even though these soils are moderately permeable.

There is considerable evidence of severe erosion on about 90 percent of the area (Losche and Beverage 1967). A few small patches of soil are still eroding, and there are stable accumulations of sediment along streams, healed gullies, and plow lines. Natural revegetation has effectively halted erosion; gullies have been stabilized by grass, brush, and small trees. Most of the soil is now permeated with roots, and it has acquired appreciable organic matter, indicated by a dark brown or a dark grey color. The surface soil is somewhat granular and absorbs rain readily.

## Land use

The first recorded settlement on Clover Run was a cabin built in 1836 (Maxwell 1884). The population must have increased rapidly because Clover Run became a voting district in 1876; by 1900, Clover Run boasted schools, churches, a store, and a post office (Fansler 1962).

The history of land use on the Clover watersheds begins with Maxwell's (1884) description of farms owned by the Phillips brothers; one farm was 59 ha with 16 ha improved, the other was 32 ha with 14 ha improved. A portion of the larger farm became Watershed 8, and a portion of the smaller became Watershed 9. Wade Phillips, a son of one of the pioneer owners, still lives in Parsons. He once operated a portion of the original farm that now includes Watershed 9. His recollections outline a fairly detailed history of land use.

One of Mr. Phillips's earliest memories is of a primitive water-powered sawmill on his father's farm. The sawmill was later replaced by a steam-powered mill. Some of the lumber sawed at the older mill was used to add rooms to the original log house. Commercial logging probably began about 1890 because by 1910, only 1.4 ha of woodland remained on the farm.

During World War I, Mr. Phillips farmed about 16 ha; more than half of this land provided hay and pasture for livestock. The remainder, cropped with a rotation of corn, oats, and buckwheat, provided adequately for a family of five children. For about the first two decades of this century, the Clover Run District was considered a prosperous farming community. But despite the conscientious use of then-current conservation practices, Mr. Phillips felt that the plowed fields had been subjected to serious erosion. The farm was sold to a Mr. Wilfong in 1920. An aerial photograph taken in 1933 indicates that once-cultivated fields were predominantly in grass; they also contained small trees and other pioneer vegetation. Apparently, this farm had been abandoned before 1930.

Phillips (1925) suggests that land use on the Clover watersheds must have been typical of agriculture throughout the vicinity:

> "The pioneers . . . were attracted by the level, well-drained bottoms, which they rapidly cleared and put in corn. For meat they depended chiefly upon game in the surrounding forests . . . Other crops, such as wheat and oats, were introduced but corn remained the chief cultivated crop. Gradually, the smaller valleys were settled and adjacent hill slopes were cleared. Much of the steeper land after a few years of cultivation failed to give profitable yields and was turned into pasture or allowed to grow up in brush . . ".

In 1941, the study area was purchased by the Forest Service from Mrs. Wilfong, then the absentee owner. Notes from the purchase documents (on file at the Ranger's Office, Cheat District, Monongahela National Forest) suggest that many sad events must have preceded the sale:

> "This was formerly a hill farm but has been abandoned for several years . . . All buildings are in very poor condition. A considerable area was at one time cleared but several of the fields are in various stages of restocking from brush, briers, and reproduction to pole size. Other fields more recently abandoned bear sedge and briers, in some instances sassafras and locust. It is doubtful if this farm will ever be reoccupied because of its location and worn-out fields and poor buildings."

After the land was purchased, natural revegetation continued without incident or interruption. In 1956, this area was selected for a study on how streamflow is influenced by natural reforestation of abandoned farmland. Two contiguous catchments—Watersheds 8 and 9—were deemed typical of much of the abandoned farmland in the central Appalachian region. Soil and vegetation were surveyed, and measurements of precipitation, streamflow, temperature, and humidity began on November 1, 1957. The use of these records to interpret watershed behavior was described at length by Reinhart et al. (1963).

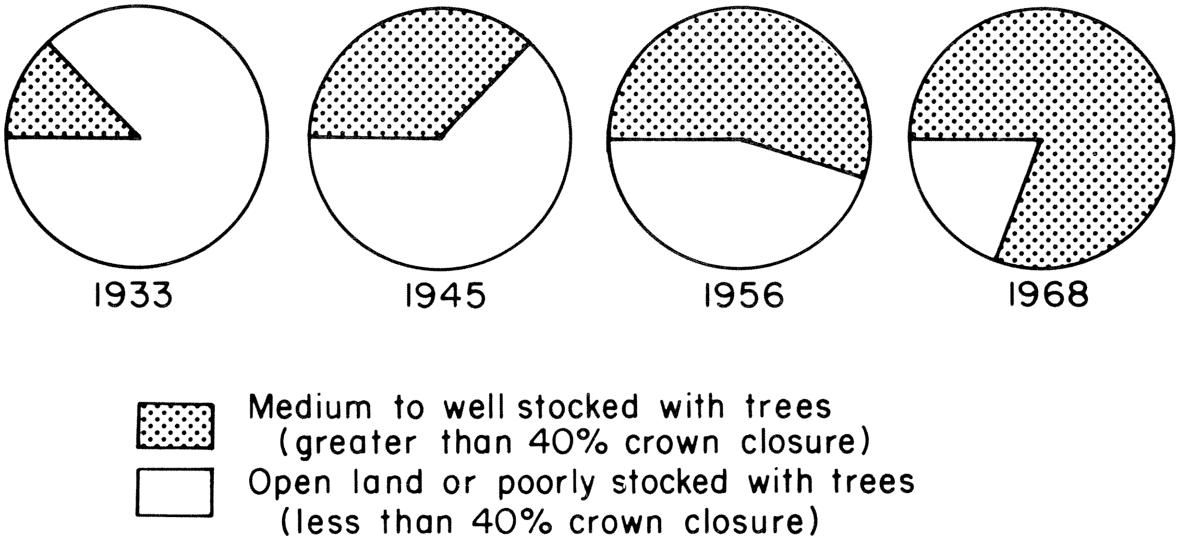
Similar agricultural use of hill country extended far beyond this small area of West Virginia. In fact, during the Depression, problems stemming from such use were endemic to much mountain land in the Eastern United States (Barnes 1938). Thus natural reversion of the Clover watersheds to forest is relevent to current environmental concern throughout the Appalachian region.

## Changes in vegetation

The old-growth vegetative cover was lush oak-chestnut forest; there also were white pine and considerable eastern hemlock. Little is known of early changes in vegetation after initial settlement. No doubt the more desirable and accessible trees were harvested first; this was followed by more extensive logging and, later still, by clearing for farm land.

An aerial photograph of the watersheds taken in 1933 shows many newly abandoned fields, most of them with hedgerows, and some containing isolated small trees and brush patches. Aerial photographs taken in 1945, 1956, and

**Figure 2.—Changes in tree and brush cover and in open space from 1933 to 1968 on Watersheds 8 and 9.**




1968 show expanding tree and brush cover and a corresponding decrease in open land. Measurements of this tree and brush cover by photo interpretation (Fig. 2) indicate that this natural reforestation covered about 80 percent of the watershed areas by 1968.

In addition to the photographic record, ground surveys of the vegetation were made, one in 1959 and the other in 1971. These surveys, based on plot inventories (Fig. 1), showed that the open areas were largely in grass, and that tree and brush stands contained a wide range of species. The number and relative abundance of tree species larger than 2.5 cm in diameter at breast height (dbh) indicate that a profusion of species had invaded the watersheds quickly (Table 2).

## Hydrology

The first 8 years (1958-1965) of streamflow data showed a slight but statistically nonsignificant decrease in water yield (Hornbeck and Troendle 1969). Lima (1971) reached the same conclusion after analyzing 13 years (1958-1971) of streamflow data. Flow decrease for the entire period was 86 mm for Watershed 8, 30 mm for Watershed 9. Multiple regression analysis also showed a consistent but statistically nonsignificant relationship of natural revegetation to reduced streamflow. As reforestation progressed, the soil was depleted of moisture to progressively greater depths, and greater precipitation was required to replenish the soils before water became available for streamflow.

Specific conductance, pH, methyl orange alkalinity, turbidity, and temperature were measured routinely during the observation period. During most of this period, the turbidity of streams draining the Clover watersheds (Table 3) was near the 5 JTU (Jackson Turbidity Unit) ceiling established for drinking water (U.S. Public Health Serv. 1962). Maximum turbidity (from a June thunderstorm) was only slightly higher than turbidity in a stream draining a nearby watershed forested with old-growth hardwood. These measurements provide a subtle yardstick of environmental quality. Streams draining the Clover watersheds differed little in quality from the stream on undisturbed forest land.

# DISCUSSION

Aerial photography and ground surveys present indisputable evidence of slow but persistent reforestation. Not only is an adequate forest developing, but the area probably is near a peak of wildlife productivity. As Larson (1967) stated: "It was soon realized that optimum forest game habitat existed at a point somewhere in the middle of the area between bare land and climax forest." Neither completely clear nor forested,

**Table 2.—Relative abundance of trees more than 2.5 cm in dbh on Clover watersheds; data from vegetation survey plots**

| Species | Watershed 8 | | Watershed 9 | |
|---|---|---|---|---|
| | 1959 | 1971 | 1959 | 1971 |
| | *Percent of basal area* | | | |
| Apple | 1 | p [a] | 1 | p |
| White ash | 4 | 3 | 11 | 2 |
| Bigtooth aspen | -- | -- [b] | 2 | -- |
| Quaking aspen | -- | p | -- | -- |
| American beech | -- | 1 | 1 | p |
| Sweet birch | 6 | 1 | 7 | 4 |
| Black cherry | 4 | 7 | 5 | 7 |
| Cucumbertree | -- | -- | -- | p |
| Dogwood | 5 | 2 | 2 | p |
| American elm | -- | -- | -- | p |
| Shagbark hickory | 20 | 16 | 8 | 12 |
| Black locust | 6 | 14 | 11 | 11 |
| Red maple | 11 | 17 | 8 | 12 |
| Sugar maple | 8 | 5 | 1 | 1 |
| Chestnut oak | 1 | 4 | -- | 2 |
| Northern red oak | 6 | 5 | 3 | 5 |
| Scarlet oak | -- | -- | -- | p |
| White oak | 3 | 2 | 1 | 3 |
| Sassafras | 15 | 10 | 15 | 26 |
| Downy serviceberry | 6 | 1 | 2 | p |
| Sourwood | 1 | 7 | 2 | 5 |
| Staghorn sumac | -- | p | p | p |
| Black tupelo | 4 | p | 7 | 2 |
| Witch hazel | p | 1 | p | p |
| Yellow-poplar | 2 | 3 | 11 | 7 |
| Species present (no.) | 18 | 21 | 20 | 23 |
| Basal area ($m^2$/ha) | 9.59 | 18.34 | 5.44 | 15.56 |

[a] Present in stands but not common.
[b] Not tallied on plots.

**Table 3.—Water quality values for Clover watersheds, and for a nearby permanently forested watershed**

| Parameter | Long term mean | | Maximum observed | |
|---|---|---|---|---|
| | Clover | Forested | Clover | Forested |
| Turbidity (JTU) | 5 | 5 | 210 | 15 |
| Temperature ( °F) | | | | |
| Average maximum | 54.1 | 52.8 | 63.5 | 61.8 |
| Average minimum | 43.3 | 43.3 | 34.6 | 35.0 |
| pH | 5.9 | 5.9 | 6.3 | 6.3 |
| Alkalinity | 7.0 | 5.4 | 10.3 | 7.7 |
| Specific conductance (mmho) | 19.2 | 16.2 | 27.0 | 19.5 |

the watersheds provide a mixture of trees, brush, and grassy openings that is nearly optimal for wildlife. Crab apples, berries, and treebrier are but a few of the abundant food-bearing species.

Evaluation of the water quality data shows that streams draining the Clover watersheds since 1957 almost always have met drinking water standards (U.S. Public Health Serv. 1962). The exception has been turbidity, but even on fully forested watersheds, channel scour during storms occasionally causes turbidity to exceed 5 JTU. It is inconceivable that water quality could be maintained at these levels unless erosion was prevented. Examination of the soils reinforced our opinion that revegetation had controlled erosion and stream sedimentation.

With little reason to dispute that erosion has halted, a more intriguing question remains: When was it controlled? The 1971 soil and vegetation surveys imply merely that erosion was unlikely under existing conditions. The history of land use suggests that farming ceased and that revegetation began about 1930. The extent of trees and brush on the 1945 aerial photograph and their growth in gullies by 1956 strongly suggest that serious erosion halted before 1945. Though the evidence over a 40-year period is not conclusive, decreases in streamflow—nonsignificant from the statistician's viewpoint—provide our best clue.

Significant decreases would indicate a more rapid reversion to forest than actually occurred during the period of measurement. So the nonsignificant decreases in annual streamflow from 1958 to 1971 are important; they indicate that the most rapid reversion to forest occurred in premeasurement years. Although Hibbert's (1967) review shows only that decreases in streamflow accompany reforestation, other evidence (Lull and Reinhart 1967) shows that most of the decrease occurs early in the reforestation process. Thus reforestation was well advanced before hydrologic observation began; water yields had peaked perhaps 20 years earlier, and most of the decreases in streamflow that had been sought occurred before 1958. On the basis of this indirect evidence, we conclude that erosion probably was inconsequential after 1935.

The Clover study has important implications today because concern for the quality of the environment has increased. During this brief history of land use, the environment underwent a nearly full circle of change. The primeval forest afforded maximum protection to soil and water; when the forest was gone and organic remains disappeared from the soil, erosion began. Reduced fertility and, more important, lowered infiltration, led to the deterioration of both soil and water. The food production demanded of the land overtaxed the soil's capacity to resist erosion.

The signs of dangerously depleted organic matter, erosion and sedimentation, must have been as obvious then as they are now, but they were not—indeed, they could not—be heeded. The economy of that time and place provided no means other than agriculture for human sustenance; and the farmers hung on until they were forced out by crop yields too meager even for marginal sustenance. When erosion decreased about 1935, the land was under grass and probably was near a peak of water productivity. Thirty years later, the land is near a peak of wildlife productivity. And in a few decades, the Clover watersheds will again be covered with useful hardwood forest.

As has proven true many times, when disturbing elements are removed, damaged watersheds in humid climates revegetate rapidly; soils are stabilized and stream sedimentation is prevented. For example, a badly eroded farm in North Carolina returned to its prefarming hydrologic condition within 2 years after farming ceased (Dils 1953). Erosion from logging roads was rapidly reduced in West Virginia merely by halting road use (Hornbeck 1967). Infiltration rates nearly doubled and soil erosion virtually halted after farmland purchased by the Tennessee Valley Authority was allowed to revegetate naturally (Rothacker 1953). But tillage, fertilization, and seeding were needed to revegetate more severely gullied soils in South Carolina (Metz 1958), and no amount of reclamation has halted soil loss on portions of the spectacularly eroded Copper Basin of Tennessee (Hursh 1948).

These examples indicate that rapid and complete hydrologic recovery of the farmed-out Clover watersheds was not unique to the Appalachian region. They also suggest that environmental quality has been adequately protected whenever erosion has not prevented natural revegetation on abandoned farmland.

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