Forest Stewardship Plan for the Waynesville Watershed

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Executive Summary:

In 2005, the Town of Waynesville placed 7300 acres of their 8600-acre municipal watershed under a working forest conservation easement. The terms of that easement allowed for forest management that would ***"create and maintain a vigorous, healthy, and diverse forest that will ensure the production of high quality drinking water from the Waynesville watershed land area"***. The town also placed 690 acres of this property into a forever-wild conservation easement that precludes most forms of active management. In 2005, the Town entered into an agreement with Western Carolina University and its partners to develop a forest stewardship plan for the entire property.

The Waynesville watershed land area has been heavily impacted during the past 100+ years. Quinlan-Monroe Lumber Company logged the property intensively from 1900 until nearly 1920. They extracted 5 million board feet of timber annually from the property using exploitive timbering practices that were common at that time. During that period, a town (Quinlantown), sawmill, and tannery were established within what is now the watershed boundary. These were subsequently abandoned after the town of Waynesville acquired much of the property in early 1920's.

The watershed was heavily logged again in the 1940's and 50's when the town implemented its first forest management plan. These operations were designed to extract the dead, but still salvageable American chestnut and other merchantable timber. The town developed a major forest road network in association with these operations, and many of those roads remain today. The final large scale timber harvesting activities occurred in the 1980's, when the town harvested timber from about 1200 acres in several large cutting units.

Data collected during the past few years suggest that the quality of the streams and surface waters have recovered almost completely from the past disturbances. Turbidity and sediment levels are very low, and the streams support healthy aquatic ecosystems.

The forests are generally healthy though we believe they are less diverse than they were historically due in large part to (1) the widespread clearcutting that occurred during the past century, (2) the introduction of exotic pests, most notably the chestnut blight and the balsam wooly adelgid, and perhaps (3) a reduction in fire frequency on drier sites. These have affected the forest in the following ways:

- Much of the forest has been converted from multiple-aged stands to even-aged stands.
- The overstory contains a greater percentage of early successional species than were previously present.
- American chestnut and Fraser fir have essentially been lost from the overstory due to insect and disease attacks, though both still persist in the understory.
- In many cases, the next cohort of trees that will occupy the overstory represent more tolerant species than those currently there.
- There is evidence that the production of high quality hard mast will fall well below historical levels due first to the loss of American chestnut, and then to a reduction in the number of oaks.

- The forest is not structured to achieve historical levels of gap phase stand disturbances.
- Overstory trees are entering a stand development stage in which they are competing heavily with each other for limited resources, slowing their growth rates. This reduced vigor may increase their vulnerability to environmental stresses.
- Mountain laurel is becoming increasingly dense on drier sites (perhaps due to a reduction in fire frequency), and is limiting the growth of other species.
- There is significant hemlock mortality in the watershed already, and it appears that the vast majority of the remaining hemlock will succumb to the hemlock wooly adelgid during the next decade.

The fundamental forest stewardship goal for this property is to increase forest diversity by increasing the number of naturally occurring forest types. This diversity will be reflected by differences in species composition, age class distribution, successional stage, and stage of stand development. This overall goal was arrived at following numerous public information sessions and workshops with citizens and officials from the town of Waynesville. We believe this is the appropriate strategy for maintaining a healthy and aggrading forest, and for maximizing the resistance and resilience of this property to future forest stresses, and for protecting water quality.

This forest stewardship plan calls for the careful, and gradual introduction of silvicultural treatments that will mimic natural disturbance patterns and increase forest diversity. Large areas of the watershed will be left untreated and allowed to develop naturally. Some of the principal treatments that will be employed include: creating small gaps to stimulate regeneration, crown thinning to increase stand diversity and promote vigor in residual trees, and crop tree release treatments in younger coppice stands to stimulate crown-class differentiation and increase stand diversity. We propose treating 0.5 to 2% of the land area per year (about 30 to 120 acres per year), though we suggest performing several years worth of treatments at one time, as opposed to operating every year.

This plan suggests that the town continue to collect key base line data for the next 2 years, and in 2010 begin silvicultural treatments in the white pine stands that were planted around the reservoir. These areas are overstocked and becoming increasingly susceptible to pine beetles and other stresses. Removing the pine from the overstory would allow natural hardwoods to become re-established in these areas. The plan suggests silvicultural treatments next be implemented in the Rocky Branch sub-watershed in 2012. This area contains forest and topographic conditions that are more typical of the rest of the property, yet this sub-watershed does not flow into the town’s reservoir.

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http://www.townofwaynesville.org/content/view/374/347/

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Background and Project Overview

The Waynesville Watershed occupies an area of approximately 8600 acres in the Allen Creek area of Haywood County, North Carolina (Maps 1 and 2). The town of Waynesville began acquiring this property around 1913 for the purpose of creating a reservoir that would supply the town with high quality water for residential and commercial needs, and for flood control. Construction on the reservoir began in 1977 and was completed in 1980.

The total reservoir capacity is approximately 1.1 billion gallons (86 acres), though it is typically maintained at around 600 million gallons (50 acres) for flood control. The water treatment process includes flocculation, sedimentation, and dual media filtration. The water treatment plant can treat 8 million gallons per day. Currently, about 3.6 million gallons of treated water are used per day. The minimum release of water to maintain flow in Allen Creek is about 2.5 million gallons per day (3.5 cubic feet per second). The estimated yield of the watershed is 12.8 million gallons per day (19.8 cubic feet per second).

The Waynesville Watershed is classified by the NC Department of Environment and Natural Resources Division of Water Quality as a WS-I watershed, meaning that waters are used as sources of water supply for drinking, culinary or food processing by users desiring maximum protection for their water supplies. WS-I waters are those within essentially natural and undeveloped watersheds with no permitted point source (wastewater) discharges.

Forever wild conservation easement

In 2005, the Town of Waynesville placed approximately 690 acres of their watershed property into a "forever wild" conservation easement (Map 3). The State of North Carolina, acting solely through the North Carolina Clean Water Management Trust Fund is the Grantee for this easement, which expressly prohibits and restricts a number of activities, including the following:

- Agricultural, Timber Harvesting, Grazing and Horticultural Use. Agricultural, timber harvesting, grazing, horticultural and animal husbandry operations are prohibited on the Property.
- Disturbance of Natural Features, Plants and Animals. There shall be no cutting or removal of trees, or the disturbance of other natural features except for the following: (1) as incidental to boundary marking, fencing, signage, construction and maintenance of nature trails and public access allowed hereunder; (2) selective cutting and prescribed burning or clearing of vegetation and the application of mutually approved pesticides for fire containment and protection, disease control, restoration of hydrology, wetlands enhancement and/or control of non-native plants; subject however, to the prior approval of Fund; and (3) fishing pursuant to applicable rules and regulations.

Working forest conservation easement:

Also in 2005, the Town placed the remaining 7340 acres of their property that drains into the Allen Creek reservoir into a "working forest" conservation easement (Map 3). The grantees for this easement are the Conservation Trust of North Carolina, the Southern Appalachians

Highlands Conservancy, and the State of North Carolina, acting solely through the North Carolina Clean Water Management Trust Fund. The purpose of this easement is as follows:

- The principal objective of this Conservation Easement is to maintain high quality water resources on the Property.
- The secondary objectives of this Grant include, in no particular order of priority, the following: (1) to establish and maintain productive forest resources on the Property for the generation of income for the Town of Waynesville; and, in consideration of the contribution forest products make to the economy and communities of the region and the state, to encourage long-term, professional management of the forest resources, and to facilitate the economically sustainable production of forest resources in a manner that minimizes negative impacts and the duration of impacts on surface water quality, and scenic, educational and/or recreational benefits to the public, wildlife habitat, and other Conservation Values; (2) the protection of natural heritage values of the Property; (3) creation of opportunities for environmental education (at the discretion of the Town of Waynesville); (4) the protection of scenic vistas (primarily for visitors on the Blue Ridge Parkway); and (5) the protection of other Conservation Values described in the Baseline Documentation, by ensuring that the Property will forever retain its predominantly natural, scenic, and forested condition, and that native animals, plants, and plant communities on the property will be protected.

A strategic forest management plan was developed as part of the "working forest" conservation easement (Supplemental Document 1). The purpose of the strategic forest management plan was to articulate broad forest management objectives for the property, as well as, to outline general management strategies for achieving those objectives. The forest management objectives from the strategic forest management plan are described below:

The primary forest management goal is to create and maintain a vigorous, healthy, and diverse forest that will ensure the production of high quality drinking water from the Waynesville Watershed land area. Other objectives for the management of this forest will also be pursued, but only in a manner that is consistent with the primary objective stated above. These other objectives include:

- The preservation and protection of biodiversity and of rare and unique plant and animal species.
- The protection of the visual quality of the watershed, particularly as it is viewed from the Blue Ridge Parkway and other surrounding vistas.
- The generation of income through the sale of timber and non-timber forest products.
- The development of a forestry education resource for the surrounding community.

Rocky branch area

In addition to the areas defined by the easements listed above, the town also owns about 570 acres in the Rocky Branch drainage (Map 3). This area drains into Allen Creek north of the reservoir, and thus does not currently contribute to the town's drinking water supply. This area is not included in either of the easements described above, and there are no special management restrictions on this property.

In 2006, the Town of Waynesville entered into an agreement with Western Carolina University, and its partners, to develop a detailed forest assessment of the biophysical resources within the watershed property, and to develop a forest management plan for achieving the objectives described above. This report presents the results of that work.

A Brief History of the Waynesville Watershed

The following summary was prepared by Ms. Christina Fulcher of the Western Carolina Department of History and the Mountain Heritage Center

Land in the Allen's Creek watershed is extremely rugged and steep. When forester H.B. Ayres and W.W. Ashe surveyed the watershed in 1905 they noted that, "excepting for the narrow alluvial lands along the narrowest streams, there is no level land."[1] Given the steep slopes and sandy nature of most of the land, farming was uncommon in all but a few places near streams. Nevertheless, humans have actively exploited and managed the natural resources in the watershed for thousands of years. American Indians, early Anglo settlers, timber and mining interests, and municipal governments have all spent considerable time cultivating and controlling the natural resources in the watershed.

American Indians most likely used the lower elevations of the watershed to set up semi-permanent base camps for hunting and fishing at higher elevations in the watershed.[2] Archeologists surveying the area have found projectile points and evidence of tool production dating back to the middle archaic period (6000 B.C.E. to 3000 B.C.E.). Such artifacts are indicative of temporary or semi-permanent (seasonal) use and not permanent settlement. Like their Anglo successors, American Indians likely hunted a variety of fauna as well as fished in one of the half a dozen streams in the watershed.

Like the Native Americans before them, early Anglo settlers used the area to hunt and fish. Bear, deer, squirrel, pheasant, and rabbit as well as brook trout were all abundant in the watershed. Additionally, blueberries, huckleberries, ramps and strawberries could provide early settlers with seasonal treats to supplement their modest diets.[3] Unlike their Native American counterparts, these settlers typically set up permanent households. They built grist-mills and harvested timber for household and agricultural uses. However, such activities altered the landscape in minor ways. It was not until the logging boom of the early twentieth century that humans had a more considerable impact in the Allen Creek watershed.

By the late nineteenth century, timber resources in the industrial North were dwindling. Northern timber companies began to move both south and west in search of additional timberlands to harvest. Wider valley regions such as the Shenandoah Valley were logged first and timbering in more rugged regions like the watershed did not begin until the late nineteenth century. The construction of the railroad and the advent of steam-powered skidders and narrow gauge railways that could penetrate steep narrow coves ushered in western North Carolina's timber era.

By the turn of the century, both state and national foresters began surveying the steeper southern Appalachian Mountains for mineral and timber resources. On the highest ridges of the Allen Creek Watershed they found a great deal of black spruce and balsam, but the majority of the

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1 H.B. Ayres and W.W. Ashe, *The Southern Appalachian Forests* (Washington, D.C.: Government Printing Office, 1905), 153.

2 J. Ned Woodal et al. "Archeological Investigations in the Waynesville Water Facilities Improvements Compound." June 9, 1976. (unpublished report)

3 Jim Woods, interview by author, 22 January 2007, Allen's Creek NC, digital audio recording.

watershed was composed of mixed hardwood. Chestnut, hickory, and black, white and red oaks, were ubiquitous on steep, dry slopes; while linn, birch, beech, buckeye, ash, and poplar grew in deeper hollows and north-facing slopes.[4]

Pennsylvanians Edwin E. Quinlan and his son Charles E., who founded the Quinlan-Monroe Lumber Company in 1888, had secured a mutual agreement from Thomas Crary of Haywood Mining and Lumber Company (then Young Lumber Company) by 1900. Quinlan-Monroe agreed to "sell all the merchantable saw timber" on 9000 acres of land in the Allen Creek watershed. [5] Quinlan-Monroe Lumber obtained the right to "cut, remove and skid said timber and bark until all the timber is removed."[6] Under the agreement, Quinlan-Monroe was obliged to remove 5 million board feet of lumber per fiscal year beginning on June 1, 1901. If they did not meet their yearly quota, Quinlan Monroe would pay Haywood Lumber and Mining $1.50 per one thousand board feet difference. To recoup their loss, Quinlan-Monroe could make up the difference by exceeding their quota the following year, during which time Haywood Lumber and Mining Company would reimburse them for the previous year's loss.[7]

Quinlan Monroe Lumber extracted and sold hardwoods to lumber and finished goods companies throughout the South, East, and Midwest. Hardwood from the watershed was used to make pianos in Boston and Cincinnati; egg cases in Indiana; chairs in Georgia; furniture in Morganton; and caskets in Asheville. Quinlan-Monroe also shipped a considerable amount of lumber to middlemen in Connecticut, Pennsylvania, Massachusetts, New York, New Jersey, Delaware, Georgia, Illinois and Missouri.[8] By-products such as the bark from chestnut, hemlock and oak trees, called acid wood, was sold to leather tanneries.[9] In 1905, Quinlan Monroe sold acid wood to nearby tanneries operated in Hazelwood, Waynesville, and Asheville.[10] In 1908 after the Champion Fibre Company opened its pulp mill in Canton in 1908, Quinlan-Monroe made a majority of its money selling pulpwood to the giant mill. This local market for pulpwood made clear-cutting the mixed hardwood tracts in the hollows and coves much more profitable. Additionally, Champion Fibre created a market for cutting by-products. Quinlan-Monroe sold both pulpwood, "acid wood," and bark to Champion's local paper mill in Canton, a little over ten miles away.[11]

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4 Ayers and Ashe, *The Southern Appalachian Forests*, 153. Demand for black walnut, cherry, ash, poplar and oak lumber were in high demand at the turn of the twentieth century. Furthermore, paper mills created a high demand for pulpwood from spruce and chestnut trees while leather tanneries used the tannins from hemlock bark and chestnut to tan their leather. These types of woods were found in abundance in the Waynesville watershed. On the upper ridges, acid wood such as spruce, hemlock, chestnut and balsam could yield between 15,000 and 30,000 board feet of merchantable timber to the acre.4 In the deeper coves, a variety of timber including oak, birch, Maple, Buckeye, poplar, cucumber, ash, cherry, and basswood grew between 5,000and 6,000 feet BM of merchantable timber.

5 Haywood County, North Carolina. Book of Deeds. Book 25 Page 357.

6 North Carolina. Haywood County Record of Deeds. Book 25 Page 358.

7 North Carolina. Haywood County Record of Deeds. Book 25 Page 358.

8 Quinlan-Monroe Lumber Company Papers, 1900-1910. Private Manuscript Collections, North Carolina State Archives, Raleigh, North Carolina.

9 The Quinlan Monroe Lumber Company hired eleven men specifically as bark peelers.

10 Ayres and Ashe, *The Southern Appalachian Forests,* 19. Tanneries also operated in Lenoir, Morganton, Andrews and Murphy. Later CJ Harris would add a tannery in Jackson County. All of these points were on a Southern Railway route, providing a potential Market for local lumber companies.

11 Quinlan-Monroe Lumber Company Papers, 1900-1910. Private Manuscript Collections, North Carolina State Archives, Raleigh, North Carolina; US Department of Interior, US Geological Survey, The Southern

On March 1903 locals Nathan Green, Joseph Harrison, Joseph McClure, R.L. Hendricks and Martha Wyatt went down to the county courthouse in Waynesville to sign Right of Way agreements giving Quinlan-Monroe Lumber Company the right to build a tramway for removing timber from the watershed to the shipping yard in Hazelwood.[12] The landowners agreed to lease their land for five years, receiving five dollars each year in rent. At the time, a common timber laborer, working a ten-hour day, made a dollar a day. In addition to relying on timber and right of way agreements to log on land they did not actually own outright, Quinlan-Monroe depended on well over 100 Haywood County residents to clear, haul, stock, and mill the lumber.[13]

In addition to a flourishing logging community, a mica mining community in began to grow in the Allen's Creek area at this time. At the turn of the century, national demand for mica grew. Mica is a fire resistant mineral typically used for stoves, chimneys, and incandescent lighting.[14] Scrap mica was also ground into powder and used in lubricants and wallpapers. During both World War I and II, mica was an important element in eyeholes of gas masks, road goggles, and armored car peepholes.[15]

The mountains in western North Carolina contained some of the largest mica deposits in the county. Although Mitchell, Yancy, Jackson and Macon Counties had by far the largest most productive deposits, Haywood County boasted a modest vein in the Allen's Creek watershed.[16] The Big Ridge and Shiny Mines provided the majority of commercial mica.[17] The Shiny mine was a two hundred foot long and twenty five foot deep open cut mine located on a steep slope about four hundred and fifty feet from the creek. Workers accessed the mine on a steep trail, which required "several sets of ladders" to navigate. While the quality of mica from this mine was "very good," by 1911, "only small crystals were left exposed from the last operations."[18] The Big Ridge Mine was owned by Haywood Lumber and Mining Company. The timber industry dominated resource extraction and the labor market in the watershed. Most men who were not farming were employed in the timber industry.[19]

Appalachian Forests, by H.B. Ayers and W.W. Ashe, Professional Paper No. 37 (Washinton DC, 1905), 19. See also: Robert S. Lambert. "Logging in the Great Smokies. 1880-1930." Tennessee Historical Quarterly 21 (Dec 1961), 350-63.

12 North Carolina. Haywood County Record of Deeds, Book 25, Page 357; Book 17, Pages 73, 80, 82, 84, 86; Book 28 Page 4. For more on common practices for getting timber to lumber and shipping yards see: Donald Davis. Where there are Mountains: An Environmental History of the Southern Appalachian Mountains. (Athens, GA: University of Georgia Press, 2000.); Ronald Lewis. Transforming the Appalachian Countryside: Railroads, Deforestation and Social Change in West Virginia. (Chapel Hill: University of North Carolina, 1998.); Robert S. Lambert. "Logging in the Great Smokies. 1880-1930." Tennessee Historical Quarterly 21 (Dec 1961), 350-63.

13 North Carolina. Haywood County Record of Deeds, Book 25, Page 357; Book 17, Pages 73, 80, 82, 84, 86; Book 28 Page 4.

14 Joseph Hyde Pratt. *The Mining Industry in North Carolina During 1901: The North Carolina Geological Survey Economic Paper, No 6."* (Raleigh, NC: EM Uzzell, Public Printer and Binder, 1902), 44.

15 Timothy Silver, Mount Mitchell and the Black Mountains: An Environmental History of the Highest Peaks in Eastern America (Chapel Hill: University of North Carolina, 2003), 200-201.

16 Joseph Hyde Pratt. *The Mining Industry in North Carolina During 1901: The North Carolina Geological Survey Economic Paper, No 6."* (Raleigh, NC: E.M. Uzzell, Public Printer and Binder, 1902.)

17 Ibid.

18 Ibid, 53-54.

19 US Bureau of Census, 1910.

Because it was difficult to access high, steep elevations with trains and steam-powered skidders, the effective use of gravity was an important part of removing timber. Smaller trees and underbrush were removed to "open up" the area to accommodate the removal of logs by rolling them, "skidding" them with animals, or sliding them down impromptu log chutes. In addition to using oxen to skid the logs down gullies, Quinlan-Monroe employed a combination of "natural flumes," log chutes, splash dams, and wooden flumes to get their timber to the sawmill in Quinlantown. Furthermore, Quinlan-Monroe did not engage in clear cutting. The forest in the Waynesville watershed was mixed hardwood, and not conducive to clear cutting. Rather, Quinlan-Monroe engaged in selective cutting, which was more profitable.[20]

In the Allen's Creek watershed, operations could continue year round as the moist spongy land at the headwaters of creeks and in stream corridors was slippery enough to skid logs down the mountain, and severe snow storms were infrequent. Theses "natural flumes" in the riparian corridors were used to skid and "flume" logs down the mountain. Such operations wreaked havoc on the streams in the watershed. Some efforts to manage and mitigate such damage were in place early on. In their timber agreement with Haywood Mining and Lumber, Quinlan-Monroe Lumber Company agreed "not to open up or cut timber upon" more than three streams or gullies at one time.[21]

Typically, removing timber from high steep slopes in the watershed required loggers to break the job up into parts. The practices that were most damaging to the riparian corridors took place in the most delicate headwater regions, high on the mountain. Quinlan-Monroe also used the highly destructive slash dam method to remove timber. A wooden dam was built on a stream and a pond filled behind it. Logs were skidded into the pond, and, when it was full of timber, the dam was dynamited, sending logs down the mountain in a torrent. Splash dams not only destroyed stream beds, a great deal of timber was also irreparably damaged in the endeavor. Most timber operators tried to avoid such a damaging practice. It is likely Quinlan-Monroe resorted to splash damming during dry seasons and droughts when the rivers and creeks ran too low to "flume" large logs down the streambed.

When the slope eased, wooden log chutes or flumes could be built to transport timber to tramways and railways. Quinlan-Monroe Lumber employed twenty-four flumers, including five carpenters and three foreman charged with specifically working on the flumes.[22] Logs were also transported out of the woods on small cars pulled by the powerful Shay engine. The Shay engine was preferred on steep mountains throughout Appalachia. Its power to climb steep grades and it maneuverability around sharp corners was unmatched at the time.

Either a flume or a log car would usually be the last leg of the journey timber would take before arriving at the sawmill. There was one flume and two narrow gauge railways in Quinlantown. One section of the railway was owned by Quinlan-Monroe and Champion Fibre Company

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[20] Usually, lumber companies would only clear cut uniform, spruce and pine forests at higher elevations and in the West. Once a lumber company extracted all of the merchantable timber, the left over area was referred to as "cut over.

[21] Haywood County, North Carolina. Book of Deeds. Book 25 Page 411.

[22] US Bureau of Census, 1910; Quinlan-Monroe Lumber Company Papers, 1900-1910. Private Manuscript Collections, North Carolina State Archives, Raleigh, North Carolina

owned the other. Champion Fibre also built narrow gauge railways up the principal waterways in the watershed. Soon after Champion Fibre was founded in Haywood, Quinlan-Monroe regularly sold pulpwood to the giant papermill. According to local oral histories, pulpwood would be chopped into cordwood in the lumberyard and hauled away to Champion's plant. Quinlan-Monroe hired twenty-five cord woodchoppers and one cordwood foreman in Quinlantown to supply Champion.[23] The paper mills could consume nearly five hundred cords of wood each day.[24]

Wood not destined for Champion's paper mill was sent to the sawmill in Quinlantown, where the sawyer would cut the wood into lumber on a steam powered saw. The cut lumber was then transported by narrow-gauge rail to the lumberyard in Hazelwood. There it would await shipment to finished goods manufacturers or regional lumber companies, which would then bring the lumber to larger national and international markets.

Quinlan-Monroe enjoyed considerable success as a mid-sized lumber company. The company hired over one hundred workers, and had plans to cut over sixty-five million feet of merchantable hardwood, spruce and hemlock in the Allen's Creek watershed. Nevertheless, the company's account books only go to 1914 and by 1920, the company had completely faded away. Workers found work elsewhere and Quinlantown began to dwindle. While the town continued to be occupied by a handful families. After World War II, the mica mining population grew and freelance loggers continued to live in the old logging town. In the early 1950's the Town of Waynesville condemned the area and the remaining families left.

In 1923, the Town of Waynesville bought two thousand and forty three acres of watershed land from the Haywood Mining and Lumber Company for one dollar an acre, and allowed Haywood Mining and Lumber to retain the mineral rights to the area.[25] Waynesville provided drinking water from Rocky Branch, Shiny Creek and Cold Spring Creek and their tributaries. Several drought cycles in the twenties, prompted the Town to sue Haywood Lumber and Mining in 1926 for use of the remaining waterways to use for "good pure, healthful, wholesome drinking water." Waynesville won the right to purchase "at a reasonable rate," the "five or six thousand acres" that drained Ball Creek, Cherry Cove Creek, Steestachi Creek, and Deep Gap Creek.[26]

In 1945, the Town became interested in harvesting timber from the watershed and in 1946, the North Carolina Department of Conservation and Development and the Tennessee Valley Authority issued a plan for cutting timber in the watershed while maintaining the integrity of

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[23] US Bureau of Census, 1910; Quinlan-Monroe Lumber Company Papers, 1900-1910. Private Manuscript Collections, North Carolina State Archives, Raleigh, North Carolina

[24] W. Clark Medford, *Mountain People, Mountain Times* (Waynesville, N.C.: Miller Publishing Company, 1963,)113.

[25] Haywood County, North Carolina. Book of Deeds. Book 64 Page 380.

[26] Town of Waynesville vs. Haywood Lumber and Mining Company, Haywood County Superior Court, p Book 10 See also a hand written account of watershed history by J.Hardin Howell in the Allen's Creek Watershed Records in the Town of Waynesville Records. Mr. Hardin claims that, in addition to pressures from multiple droughts, the Town decided to sue for the remaining lands after they found agents from the Mayor of Canton's office casing the watershed.

their municipal water supply.[27] The town planned a thirteen-year cutting cycle along Rocky Branch, Cherry Cove, Shiny Creek and Deep Gap Creek.[28] To preserve the quality of its water resource, the town confined its logging to select drainage sites while water was taken from a separate drainage.[29] According to a 1953 progress report, the town successfully avoided the harmful effects of erosion by making sure that logging roads were "laid out in such a way that drainage from them would be dispersed and filtered through natural forest litter rather than concentrated into channels."[30]

In 1948, the town began cutting timber from "600 acres on the eastern side of Old Bald drainage."[31] Between 1948 and 1953 the town harvested over two million board feet of lumber and nearly two thousand cords of pulpwood, generating slightly over fifty two thousand dollars in additional revenue.[32] The town continued to harvest and sell timber from the watershed into the 1980's.

In 1976 the Town built a large dam, interning 86 acres of water. By 1987, The Town of Waynesville received word from Raleigh that the watershed and the municipal treatment facility had received "Class A" certification" (or WS-1 Certification).[33] Timber operations seemed to have ceased by the 1990's. However, building homes on ridge tops and at higher elevations had become increasingly popular in western North Carolina by the 1990s. In order to protect its watershed and retain its high-level WS-1 designation, the town moved to buy the three remaining privately owned tracts of land within the watershed boundary. With $850,000 of financial support from the Environmental Protection Agency, North Carolina's Division of Water Resources, and The Clean Water Management Trust Fund, the Town purchased the remaining six hundred and ninety acres. The final cost came to $1,350,000. Soon after, The Town placed the land in the Allen's Creek Watershed into a conservation easement.

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27 "A Guide for a Conducted Tour, Watershed Management Demonstration: Waynesville Municipal Watershed." Haywood County NC, June 1950. (Unpublished document). See also: "Prospectus for Forest Management on the Waynesville Municipal Watershed" North Carolina Department of Conservation and Development Division of Forests and Parks the Tennessee Valley Authority. Mach 1946 (Unpublished document).

28 "Prospectus for Forest Management on the Waynesville Municipal Watershed," 10.

29 "A Guide for a Conducted Tour, Watershed Management Demonstration," 1.

30 Ibid., 6.

31 Ibid., 2.

32 "Waynesville Watershed Management Demonstration: A 1953 Progress Report." Town of Waynesville, North Carolina Division of Forestry Relations, Tennessee Valley Authority Division of Forestry, N.C. Department of Conservation and Development. (unpublished document,) 4-5.

33 John C. McFadyen, Chairman, North Carolina Water Treatment Facility Operations Certification Board to Robert Dewey Whitner, September 9, 1987, Unpublished Document, Town of Waynesville. While the letter awarded "class A" certification, the actual state regulation is WS-1 Classification and it is the most restrictive of any classification in the state.

Watershed Assessment: Soils

Information in this section is summarized from the Soil Survey of Haywood County Area, North Carolina (NRCS 1997)

The Waynesville Watershed occupies a primarily north-facing valley and occurs at elevations ranging from about 3200 feet near the reservoir to over 6200 feet at Richland Balsam (Map 3). The watershed contains predominantly deep, well-drained soils that formed in felsic to mafic, high-grade metamorphic and igneous rocks that occur on gently sloping to very steep topography. The forest productivity potential for soils within the watershed varies greatly, with the most productive soils occurring on more gentle, north facing slopes and in coves. The least productive soils occur on ridges, south-facing slopes, and at the highest elevations in the watershed. The locations of soils in the watershed are shown in Map 14, and a table describing the characteristics, parent materials, and productivity values are presented in Appendix 1.

The majority of soils in the watershed are considered to have moderate to severe limitations for erosion hazard and equipment operability due to the steepness of the slopes and/or to soil wetness. Moderate limitations generally require management precautions for selected management activities, and severe limitations require precautions for most management practices. The act of removing trees is not the main cause of erosion in forest management. Erosion primarily occurs in areas of access roads and skid trails, in loading areas, and in other areas where the soil surface has been disturbed. Soils with moderate to severe erosion hazard indicate the need for additional care in the construction and maintenance of roads, or the use of special equipment. Moderate and severe limitations for equipment operability indicate a need to choose the best suited equipment and to carefully plan the timing of harvesting and other management activities. The forest management limitations for each soil type are presented in Appendix 2.

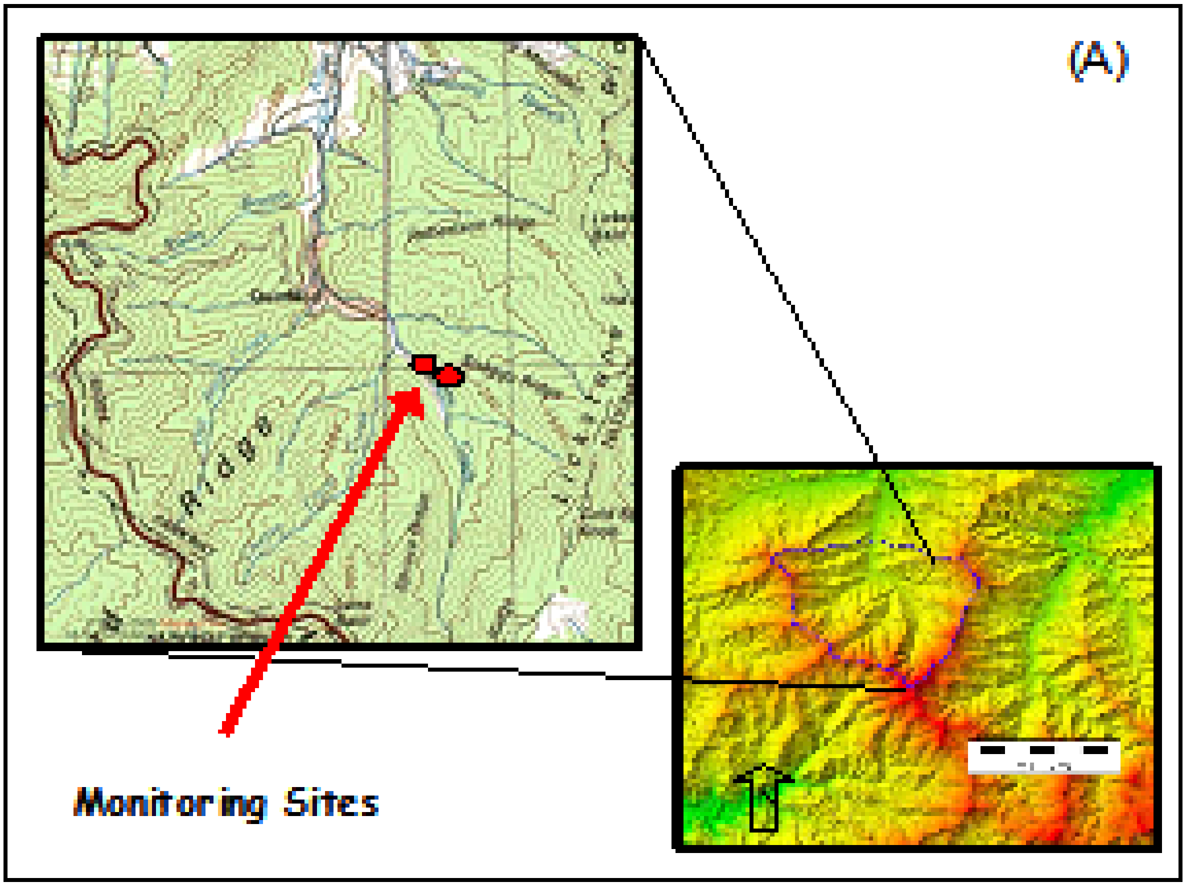
Watershed assessment: Water quality

Drs. Jerry Miller and Mark Lord from Western Carolina University's Department of Geosciences and Natural Resources began assessing water quality in the Waynesville Watershed in 2006. The following information is summarized from their Water Quality Assessment Report completed in March, 2008. Their entire report is included as Supplemental Document 2.

The primary objective of the designed and implemented water quality monitoring program was to gain a thorough understanding of the physical and chemical conditions of stream waters within the Watershed in terms of pH, temperature, turbidity, dissolved oxygen, electrical conductivity and total suspended solids. The analysis was considered necessary to identify changes in water quality that might accompany future management activities. Inherent in this objective was the need to (1)
document variations in selected water quality parameters through time (particularly during floods), (2) gain an understanding of the factors that control parameter values (especially for turbidity and total suspended solids), (3) identify the predominant sources of sediment and suspended material within the watershed, and (4) develop the protocols that allow for the effective characterization of sediment loads and their variations during runoff events when using automated sampling systems.

Data were collected at two sites during the monitoring period. At site 1, pH, electrical conductivity, dissolved oxygen, and temperature were collected from November 6, 2006 through February 10, 2007. Data were then collected for the same parameters plus stage, turbidity, and TSS from the fixed site from March 3, 2007 to the present (Fig. 1). The results from both sites are similar, but because data from the fixed site includes measurements of stream flow (stage) and turbidity, our discussion will focus on the fixed site unless otherwise noted.

During the period of monitoring, there were more than 60,000 measurements made of turbidity, pH, electrical conductivity, stage, and dissolved oxygen at the fixed monitoring site (Site 2). The collected data reveal that water quality within Allen Branch is in very good condition, at least for the parameters measured. None of the parameters regularly fell within a range that would be detrimental to aquatic biota (Table 1). For example, trout are thought to show signs of stress when subjected to waters with a turbidity value in excess of approximately 10 NTU for a period of hours. Maximum turbidity exceeded 10 NTU a total of 14 times, but only for short periods, on average about 1.20 hours (Fig. 2a). In fact, turbidity values were less than 2.5 NTU, and close to the level of detection, for 99 % of the time (Fig. 2b). As an illustration of how clear the water actually is, water with a turbidity of <5 NTU can be used for consumption provided that it is not contaminated by microbes. It is also important to recognize that other streams in the region which lie within developed areas exhibit turbidity values on the order of several thousand NTUs during flood events.



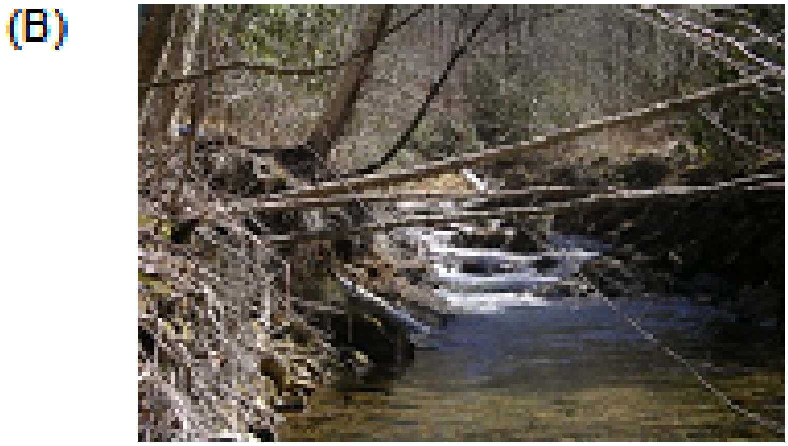


Figure 1. (A) Location of monitoring sites 1 and 2 (fixed site); (B) Fixed sampling site #2. White pipes along left bank lead to recording equipment.

Table 1. Descriptive statistics for selected water quality parameters measured at the fixed monitoring site between March 3, 2007 and February 4, 2008.

Statistic	Stage (m)	Temp (C)	Specific Conductivity (µS/cm)	pH	Turbidity (NTU)
Mean	0.44	10.73	17.73	7.13	1.05
Standard Dev.	0.06	5.06	3.12	0.13	1.76
Minimum	0.34	0.04	<1.00	4.31	<1.00
Maximum	0.97	21.61	39.00	7.43	93.20
(# of measurements)	60764	60752	60764	60764	60732
NC Guidelines*	---	<29	---	<~6; >~9	<10

* - North Carolina State Water Quality Guidelines for Class C Waters (trout water designation)

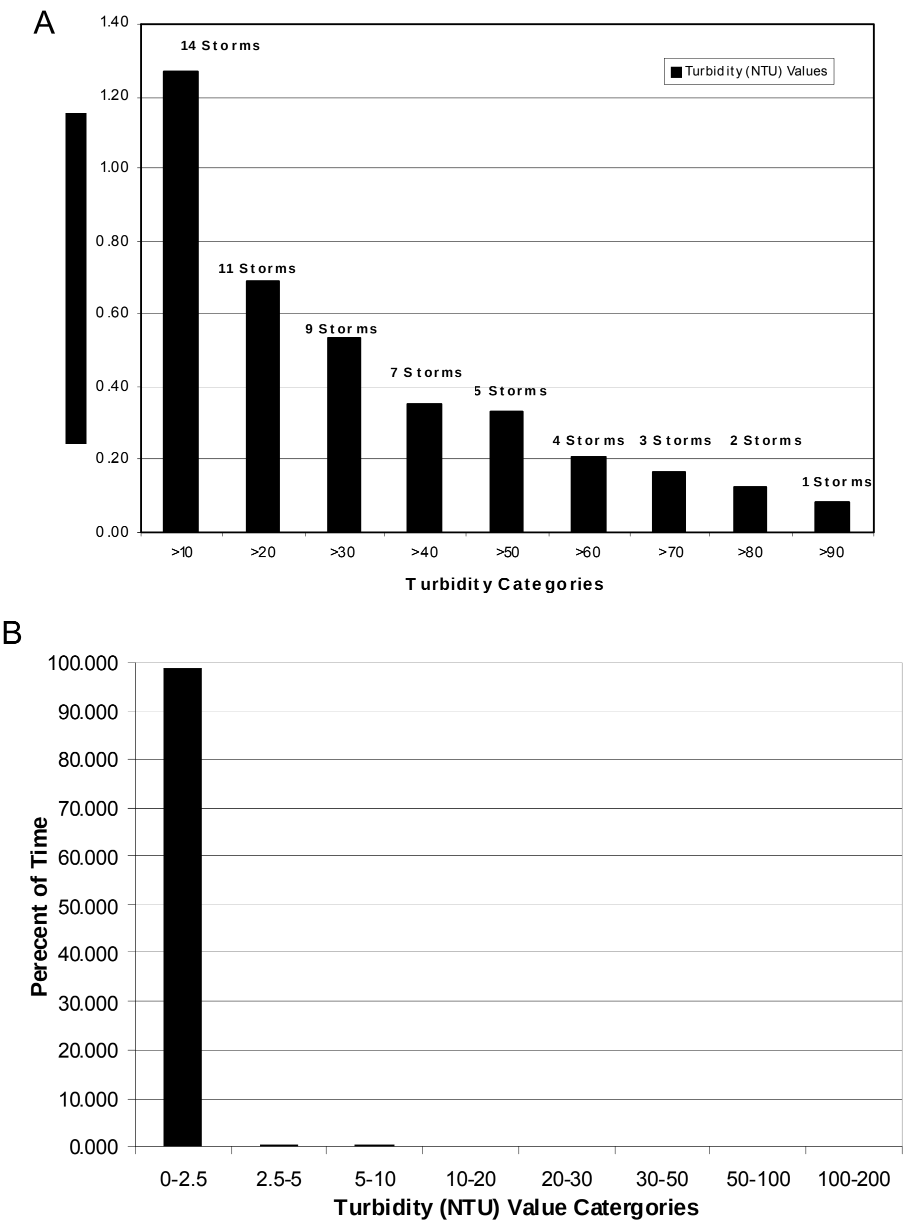


Figure 2. (A) Average time during which turbidity exceeded specified values during floods; (B) frequency of turbidity measurements during the monitoring period.

Turbidity is a measure of the degree to which substances in the water (both dissolved and suspended with the water column) attenuate or scatter a beam of light. It is often used in regulations because it is easier to measure than the total suspended solids content of the water. However, turbidity values are affected by more than just the concentration of suspended particles. Dissolved constituents can dramatically influence turbidity, as can the size and shape of the particles that are present. As a result, many scientists prefer to rely on TSS measurements when quantifying water quality. TSS refers to the total mass of solid material in the water (included mineral matter, algae, and plant debris) that can be separated by means of filtration. Unlike turbidity, regulations related to TSS values are typically based on comparisons with background or reference values measured for the region. Unfortunately, quantitative data for this area are lacking. Nevertheless, toxic effects to trout are likely to be on the order of a hundred to a few hundred mg/L.

Of the 292 samples which were collected and analyzed, nearly 70 % exhibited TSS values of less than 2 mg/L (Fig. 3). The highest values occurred during flood events, but none of the collected samples exceeded 90 mg/L. The TSS data, like the turbidity data, indicate that suspended sediment loads are very low within Allen Branch.

The exceedingly clean water may come as a surprise given the basin's previous history and the extent of roads which remain. The low TSS and turbidity values are likely to result from a combination of factors, including (1) gullies and ditches along the margins of the roads have largely healed, are vegetated, and do not transmit large amounts of water and sediment, (2) roads and other sources of upland sediment are not well integrated with the drainage network, inhibiting the influx of large amounts of sediment to the channel, (3) although the channel is locally incised and locally characterized by vertical banks, the exposed bank materials are largely composed of bedrock and coarse debris which forms relative stable banks and is hard to transport once bank failure occurs, and (4) the vast majority of the watershed maintains healthy soils with high infiltration capacities, so that very little storm runoff (especially overland flow) is generated.

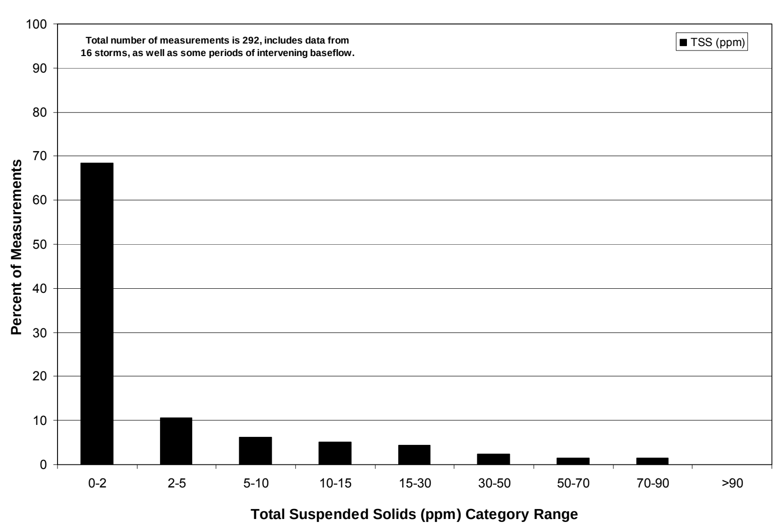


Figure 3. Percent of samples for specific TSS ranges.

Discussion and Summary of Results

Stream waters within the downstream reaches of Allen Branch were found to be of exceptionally quality for the parameters evaluated. Given the watershed's past history, the findings are a somewhat surprising, and attest to the region's ability to rapidly recover from intense disturbances. The highest measurements of turbidity and TSS were associated with floods, but typically developed relationships between discharge (stage) and sediment load (TSS, turbidity) were weak. The high degree of variability is most likely due to (1) the limited range of values that were measured, (2) differences in the influx of sediment during storm events as a result of varying precipitation intensities, duration, antecedent moisture conditions, and season, (3) hysteresis affects, and (4) differences in the type and source of sediment that comprise the total suspended solids and which causes increases in turbidity. The absence of strong statistical relationships between stage and turbidity or stage and TSS reduces our ability to determine changes in water quality as a result of watershed disturbance. However, other approaches can be used to identify changes in water quality, such as an analysis of the frequency of which turbidity of a given value (e.g., 10 NTU) occur during or following a management activity (discussed in more detail below).

It is also important to recognize that the high quality of the water, and the sensitivity of our instrumentation, should allow the system to detect even minor inputs of sediment to the channel. Thus, the question that may arise is not whether we will be able to detect a change in water quality, but rather, what level of change is considered acceptable. We argue that criteria (or guidelines) regarding what is acceptable should be developed before any management activity is undertaken to avoid confusion as to what is considered a successful management operation.

Watershed Assessment: Aquatic health

Dr. Thomas Martin from Western Carolina University's Department of Biology began assessing aquatic health in the Waynesville Watershed in 2006. The following information is summarized from his Aquatic Life Assessment Report completed in March, 2008. The entire report is included as Supplemental Document 3.

The tributaries to the Allen Creek reservoir are designated as WS-I streams in reference to their water quality. A NCDENR (1998) macroinvertebrate study of Shiny Creek in 1997 rated the stream as Excellent. Further, Cherry Cove Creek, Shiny Creek, and Old Bald Creek were recently (2001) found to meet trout waters regulation criteria (Tracy 2001).

The primary objectives of this study were to provide a current assessment of the water quality as indicated by stream fishes and macroinvertebrates, to expand on previous sampling to other stream reaches, and to assess the quality of the brook trout population in the watershed. The protocols employed, and the data generated may then be used as baseline information for any future monitoring.

Habitat Survey: The habitat survey was completed by having a team of 2 people walk up the thalweg of each stream, classifying habitat unit types and measuring the length of each habitat unit to the nearest 10^{th} of a meter using a surveying rope. The average width of each habitat unit was visually estimated. Further, dominant substrate was recorded, as was incidence of woody debris. Presence of large woody debris was noted by counting the incidences of individual pieces, numbers of root wads, or presence of complexes producing debris dams following the recommendations of Dolloff et al. (1993). Before beginning the habitat survey for each stream a random number generator was used to determine which habitat units would be selected for fish sampling. Our intent was to electrofish no more than 20% of each stream section, so we randomly chose which of the first 5 habitat units of each type would be electrofished, then we marked that habitat unit and every 5^{th} habitat unit of that type in a systematic fashion for later fish sampling.

Habitat units were classified as belonged to one of 4 categories: Units with a steep slope, small pockets of water interspersed among exposed boulders, or steep runs of water over a single large boulder or bedrock were classified as cascades. Units with an obvious deep spot and little surface disturbance were classified as pools. Units with little surface disturbance, but no obvious deep spot (more homogeneous depth throughout) were classified as glides. Units with a more gradual slope than that of cascades, of more or less homogenous depth, but with considerable surface disturbance, were classified as riffles. In situations where there were split channels, each channel was surveyed separately. Clearly, this process relies heavily on the subjective opinion of the habitat surveyor, so care was taken to have the same person do the habitat classification on all streams.

Fish Survey: Fish were sampled using a single battery powered backpack electrofishing unit. The three-pass depletion method was used to estimate fish number in each sampled habitat unit. All estimates were calculated using the maximum likelihood routines employed in MicroFish (MicroFish Software, Moscow, ID). Upon capture, each fish was anesthetized using clove oil, and then length and wet weight were measured. Fish were then placed in a recovery container for later release back into the habitat unit from which they were removed after the third electrofishing pass. We saw no sampling mortality.

After each habitat unit was electrofished, the width of the habitat unit was measured at three evenly spaced locations along the unit. The average width from these three measures was later regressed against the visual estimates for those same units to provide a correction for any systematic errors in the visual estimates made during the habitat survey for similar habitat units not included in the fish sampling.

Population estimates for each stream section were constructed by converting the estimates for each habitat unit into density estimates using the estimated surface area of the habitat unit (unit length X average width). These densities were then average within habitat type. The area of each habitat type within the stream reach was then used to construct weighted averages of the fish density for the stream reach.

Macroinvertebrate Sampling: Stream invertebrates are typically monitored as surrogates for more specific water quality analysis. Because our primary water quality concern in the Waynesville watershed is sediment, and we have a strong program to monitor changes in sediment load (discussed elsewhere in this document), we placed less emphasis on the macroinvertebrate sampling. Our approach was to replicate and expand upon the invertebrate sampling conducted by NCDENR in 1997. In 1997, NCDENR sampled Shiny Creek at one location using their standard EPT sampling protocol. We used the same EPT sample protocol as described in the NCDENR Standard Operating Procedure manual (NCDENR 2006), but sampled each of the four major tributaries to the reservoir (Old Bald Creek, Cherry Cove Creek, Shiny Creek, and Deep Gap Creek). The EPT method focuses just on three orders of aquatic insects, the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). But, in small headwater streams these three orders account for the overwhelming majority of stream macroinvertebrates found. The sample protocol involves collecting three samples at each sample site: a single "kick" sample, a single "leaf-pack" sample, a single "sweep" sample, and a visual inspection of larger cobble/boulders and woody debris. The kick sample is conducted by holding a sample net downstream and disturbing the substrate upstream of the net, allowing the current of the stream to carry any disturbed invertebrates into the sample net. Leaf-packs are sampled by selecting larger grouping of leaves and other small detritus that have collected on rocks or snags and washing the invertebrates from them into a mesh collector. Sweep samples are collected by using a triangular sample net dragged over the surface of the substrate along or under banks. Visual inspections are to look for invertebrates that may strongly attach themselves to larger substrate so that they are not sampled adequately with the other techniques. While NCDENR standard protocol calls for removing no more than 10 individuals of each species, we returned all individuals so sampled to the laboratory for identification and enumeration.

Discussion and Conclusions:

Habitat: The stream habitat currently found in Waynesville watershed streams is very well suited for coldwater macroinvertebrates and fish. The substrate is largely cobble relatively free of fine sediments. There appears to be sufficient gravel of appropriate sizes for brook trout spawning. The many cascades often lead to plunge pools, a favored habitat for brook trout. Large woody debris loads are similar to that for other headwater steep-gradient streams in second-growth forest. But, due to past land-use and/or the access road restricting LWD recruitment from upstream, the section of each stream between the access road and the reservoir has reduced abundances of larger pieces of LWD. Lower amounts of LWD can result in higher velocities, thus shorter retention rates for the course particulate matter that forms the basis for most biological production in forested streams. Higher velocities may also result in increased erosion of bank material. In these particular streams, given the abundance of large boulders, the retention of material by LWD may be relatively insignificant. But, differences in recruitment and retention of course particulate matter among streams and stream reaches may be an area that we want to investigate further.

Fish: Fish diversity in the watershed is low, but low fish diversity is expected in headwater streams. The streams contain healthy, reproducing populations of brook trout. Multiple age classes were found in each stream with a maximum age of perhaps 3 to 4 years. This longevity is consistent with that normally found in the southern Appalachians. The condition of the fish (as compared to standard weight) was near the average for populations across North America. We expect slower growth and lower weight at length for fish living in headwater free-stone streams due to the lower nutrient levels typically found there. Thus the lower condition compared to the published average is expected for these habitats.

Previous studies have found that the brook trout inhabiting Cherry Cove Creek are southern strain brook trout (Jim Borawa, NCWRC, personal communication). Given the lack of barriers to movement among Shiny Creek, Cherry Cove Creek, and Deep Gap Creek, there is a strong likelihood that the brook trout in those streams are also native brook trout. Old Bald Creek is isolated from the others by the reservoir and by a concrete culvert that connects the stream to the reservoir. The genetic identity (hatchery versus southern strain) of the brook trout residing in the other streams as well as the genetic distance among the various subpopulations is an area for future consideration.

Given the limitations of a representative reach approach to fish population surveys (even after our modifications to expand reach length); we cannot extrapolate with confidence outside the study areas. Even if we were to venture to extrapolate, we currently do not know the upstream extent of the brook trout distribution. If at some time in the future acidification becomes a problem in the watershed, we would expect to see a contraction of brook trout habitat to lower altitudes. Given that, it is important that we consider a study to determine the upstream extent of brook trout in the near future.

Macroinvertebrates: Our invertebrate samples are indicative of excellent water quality. However, EPT monitoring is relatively insensitive to sediment pollution. As sediment pollution is the most likely future water quality problem, future EPT monitoring should be given less emphasis than direct monitoring and monitoring of brook trout population structure. Brook trout reproduction is very sensitive to fine sediment deposition, so declines in population density, or frequent year-class failure may indicate sedimentation in portions of the watershed not under direct sediment monitoring.

Table 2. Habitat type abundance (surface area in m^2) among stream sample reaches.

Habitat Unit Type	Old Bald Creek		Cherry Cove Creek		Shiny Creek		Deep Gap Creek
	Lower	Upper	Lower	Upper	Lower	Upper	
Cascade	615	1112	923	1380	716	1100	892
Glide	24	117	183	318	140	290	96
Pool	701	699	536	719	646	701	463
Riffle	445	132					
Reach length (m)	643	666	468	638	381	642	439

Table 3. Large woody debris density (number per km of stream) among stream study sections. Debris classes are: II – length 1-5 m, diameter 11-50 cm; III – length 1-5 m, diameter >50 cm; V – length >5 m, diameter 11-50 cm; VI – length >5 m, diameter >50 cm; VII – root wad from living or dead trees; and DD – debris dam.

Stream Section	Large Woody Debris Class					
	II	III	V	VI	VII	DD
Lower Old Bald Creek	115	24	3	5	47	29
Upper Old Bald Creek	240	67	11	8	34	19
Lower Cherry Cove Creek	81	4	17	9	24	26
Upper Cherry Cove Creek	85	17	13	8	16	6
Lower Shiny Creek	34	0	9	0	13	4
Upper Shiny Creek	53	11	9	2	6	5
Deep Gap Creek	67	7	13	6	17	12

Table 4. Fish caught over a 600' sample reach in July of 2001, using two backpack electrofishing units. Excerpted from Table 8., Richland Creek Reclassification Study. Numbers in parenthesis represent density estimates (number per hectare, assuming average width of 3 m for each stream as reported in the memorandum).

Species	Common Name	Shiny Creek	Old Bald Creek	Cherry Cove Creek
Salvelinus fontinalis	Brook Trout	23 (419)	42 (766)	61 (1112)
Campostoma anomalum	Central Stoneroller		5 (91)	
Rhinichthys atratulus	Blacknose Dace		4 (73)	
Rhinichthys cataractae	Longnose Dace	68 (1239)	35 (638)	7 (128)
Hypentelium nigricans	Northern Hogsucker		6 (109)	

Table 5. Weighted average fish densities (number per hectare) for the four study streams. Density estimates were based on a systematic-stratified sample design based on 3-pass depletion estimates from individual habitat units.

Species	Common Name	Shiny Creek		Old Bald Creek		Cherry Cove Creek		Deep Gap Creek
		Lower	Upper	Lower	Upper	Lower	Upper	
Salvelinus fontinalis	Brook Trout	895	546	755	1742	928	180	59
Campostoma anomalum	Central Stoneroller			14				
Rhinichthys atratulus	Blacknose Dace			93				
Rhinichthys cataractae	Longnose Dace	193	186	820	1109	34	21	10
Hypentelium nigricans	Northern Hogsucker			55				

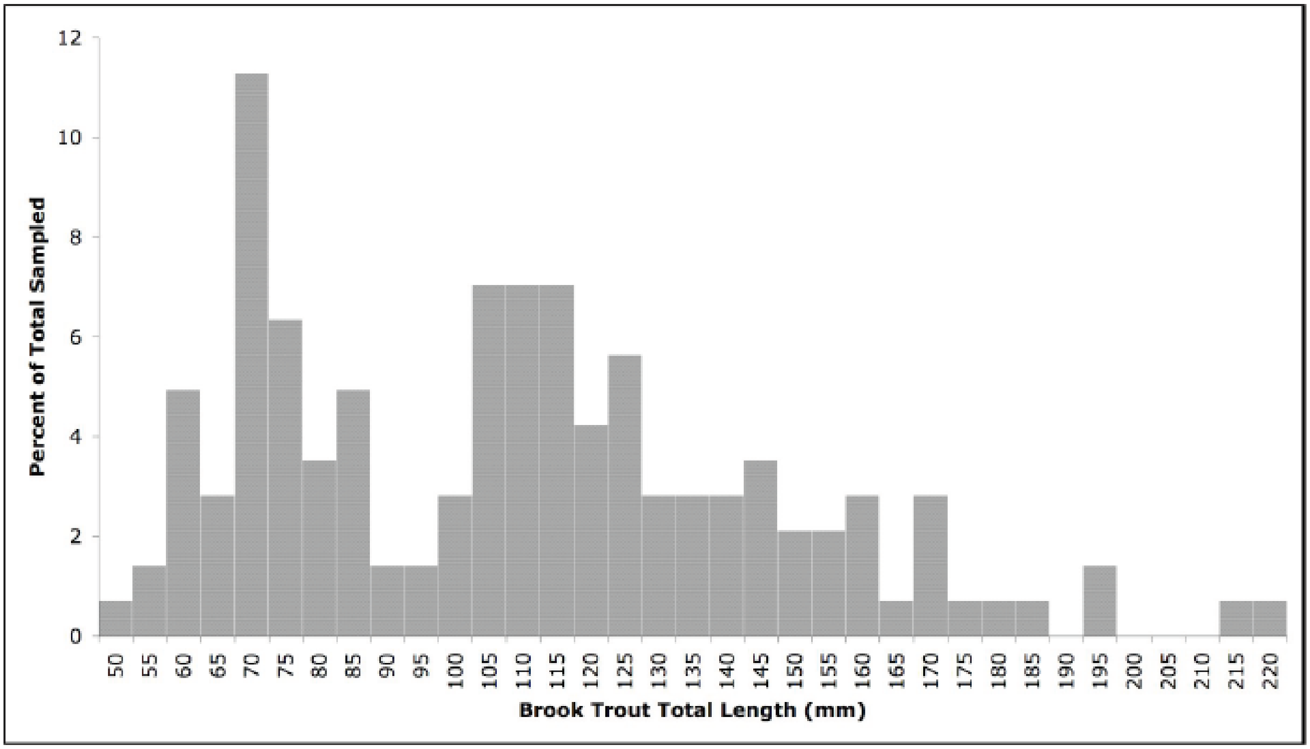


Figure 4. Brook trout length distribution for streams in the Waynesville watershed.

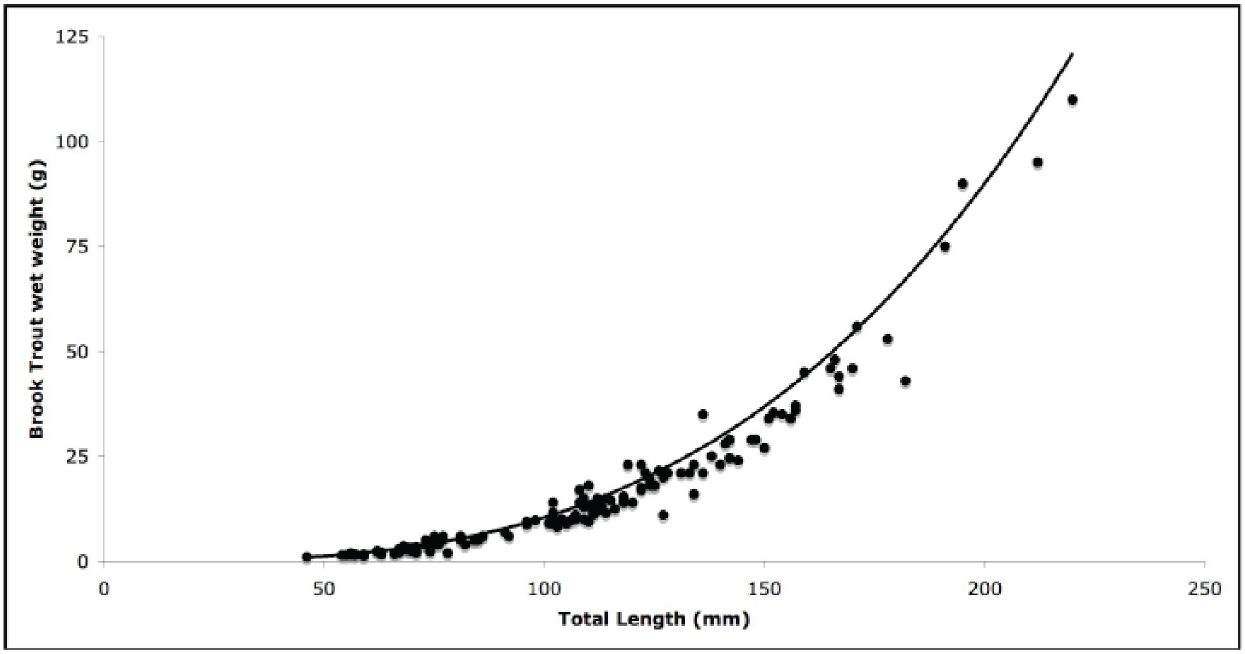


Figure 5. Length-Weight relationship for brook trout sampled in the Waynesville Watershed in 2006. The solid line represents the standard-weight reference for brook trout reported by Hyatt and Hubert (2001).

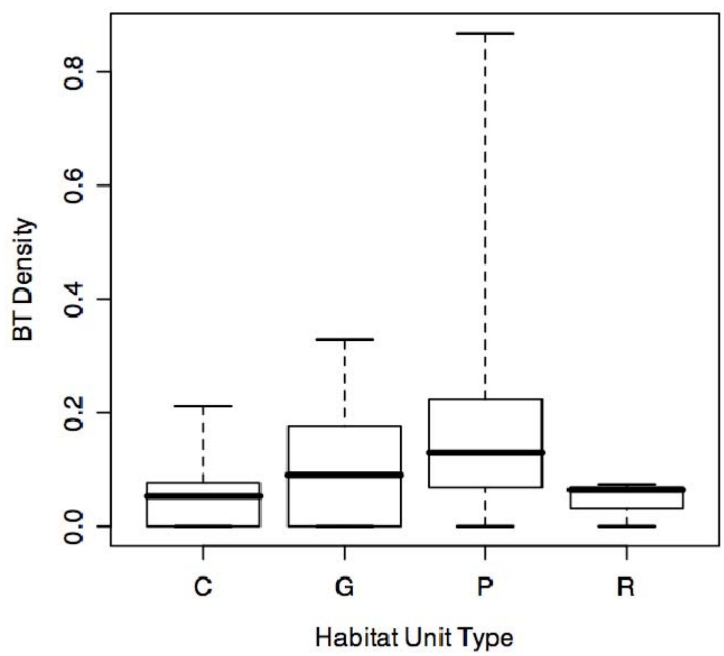


Figure 6. Boxplots of brook trout density estimates (number per m^2) among individual habitat units. Note that horizontal bar denotes median, box represents interquartile range, and whisker is total range of estimates. The habitat types considered were cascades (C), glides (G), pools (P), and riffles (R).

Watershed Assessment: Forest Resources

Students and staff from the Western Carolina Forest Sustainability Initiative conducted a forest inventory of the Waynesville watershed over the past several years. The following information highlights some of the major findings of that inventory. Complete stand descriptions are presented in the Forest Resource Assessment (Supplemental Document 4).

The forests in the Waynesville watershed were heavily cut over during the past century (see History section of this document). This began with Quinlan-Monroe Lumber Company, which harvested 5 million board feet of timber per year from the Allen Creek watershed between 1900 and about 1920. Historical records indicate they utilized harvest and removal methods typical of the times. Most harvesting was complete clearcutting or select cutting (removing all trees with commercial value). After trees were felled, logs were transported to staging areas using the most cost effective means available, regardless of the environmental consequences. These included rolling logs down side slopes; dragging logs down the moist, slick soils of creeks and drainageways (referred to as natural flumes); and piling logs in ponds created behind temporary dams, and then dynamiting the dams to release the logs and water down the mountain in a destructive torrent (splashdams).

The next period of intensive harvesting occurred during the late 1940's through the 1950's. This harvesting was initiated to salvage the remains of the now dead American chestnut, as well as, to liquidate other mature timber. This was the first time that the watershed was harvested under the guidance of a forest management plan (Tennessee Valley Authority 1946), which identified a series of timber sale units – each coinciding with a sub-watershed (Fig. 7). This plan also required the construction of an extensive network of access roads and skid trails using some of the first techniques designed to minimize soil erosion and sedimentation.

The final period of major timber harvesting took place in the 1980's when about 1200 acres were harvested using a combination of clearcutting and select cutting or thinning (Fig. 8).

The purpose of the forest resource assessment was to map and describe the current forest condition throughout the watershed. Field data were collected between 2002 and 2006 from a total of 402 randomly located plots. Plot types varied, and included both fixed area plots ($1/10^{th}$ acre) and 20 BAF variable radius plots. Overstory (species diameter, merchantable height, and grade), advanced regeneration density, stand structure, and tree growth rates were quantified at each plot.

Forest stands were classified and mapped using the ecological classification system developed by NatureServe, and currently being utilized by the Great Smoky Mountains National Park (http://www.dlia.org/atbi/grsmnp_habitats/index.shtml). In addition, each stand was classified based on its stage of stand development (Oliver and Larson 1990).

The locations of different forest cover types (and other land cover classes) are presented in Maps 4 through 6. Summaries of selected stand attributes are presented in Tables 7 through 9.

Current Forest Condition

The Waynesville watershed forests reflect their management history. The forest is generally healthy, though we believe it contains less overall diversity than was present in historic times. We define diversity to include a watershed scale consideration of species composition (both overstory and understory), age class distribution, and successional stage. We attribute the loss of diversity to (1) the widespread use of clearcutting throughout much of the forest during the past century, (2) the introduction of non-native pests (most notably the chestnut blight and the balsam wooly adelgid), and (3) a reduction fire frequency on some of the drier sites. These factors, alone or in combination, have led to the following:

- Much of the forest has been converted from multiple-aged stands to even-aged stands that develop following clearcutting, and many of these stands are between 60 and 80 years old.
- The overstory contains a greater percentage of early successional species than were previously present due to the ability of these species to aggressively regenerate sites following clearcutting.
- American chestnut and Fraser fir have essentially been lost from the overstory due to insect and disease attacks, though both still persist in the understory.
- A large percentage of the forest is entering into the understory reinitiation stage of stand development, and in many cases, the next cohort of trees that will occupy the overstory represent more shade tolerant species than those currently there.
- Overstory trees in the many stands that are entering the understory reinitiation phase of stand development are competing heavily for limited resources, which slows their growth rates. This reduced vigor may increase their vulnerability to environmental stresses. The even-aged nature of the forest compounds this problem by making it difficult for trees to differentiate into dominant, co-dominant, intermediate and suppressed crown classes.
- For the most part, the forest is not structured to achieve historical levels of gap phase (endogenous) stand disturbances. This is due both to the loss of large American chestnut from the overstory, and the lack of very old (and very large) trees. The lack of large gaps favors the succession of shade tolerant species.
- There is evidence that the production of high quality hard mast will fall well below historical levels due first to the loss of American chestnut, and then to the loss of oaks that will be replaced in many areas by shade tolerant species, such as birch and maple.
- In some productive areas, a large percentage of the overstory trees are being strangled by native vines (most commonly Dutchman’s pipe and wild grape vine).
- Mountain laurel is becoming increasingly dense on drier sites (perhaps due to a reduction in fire frequency), and is limiting the growth of other species.
- Rhododendron may be expanding its range, and is limiting the growth of other species where that occurs.

Present and Future Concerns

- Hemlock wooly adelgid: The Hemlock wooly adelgid is common throughout the forest, and is starting to cause significant mortality of eastern Hemlock. Based on patterns of mortality that have occurred in other regions, it is likely that more than 90% of the hemlock will die within the next decade. At this point there is no cost-effective means to save large stands of hemlock trees.

- Oak decline: Oak decline is attributed to a complex of environmental, insect, and disease factors that lead to the dieback or death of oak. It is often associated with dry soil conditions which can leave trees stressed and susceptible to other pests. Isolated evidence of oak decline was observed in some areas, but it was not widespread.

- Other insect and disease issues: We did not observe outbreaks of other insects or diseases; however, there is a continual threat that various insects and diseases may become established in the watershed. Maintaining a diversity of forest conditions across the watershed is the best strategy to maximize the resistance and resilience of the watershed forest to unknown future insect and disease problems.

- Air pollution and global climate change: We do not have evidence to document direct effects associated with either of these factors, though there is evidence from other regions that high-elevation, spruce/fir forests have suffered from acidic deposition. It is possible that both of these factors could significantly stress forest vegetation in the future. Maintaining a diversity of forest conditions across the watershed is the best strategy to maximize the resistance and resilience of the watershed forest to unknown future forest stresses.

In summary, while there are no known, imminent threats to the watershed forest (other than the Hemlock Wooly Adelgid), we believe that the overall condition of the forest can be improved by increasing, and in some cases restoring forest diversity.

Table 7. Area of Each Cover Type	
Type	**Acres**
Southern Appalachian Northern Hardwood Forest (Red Oak Type)	**1,254**
Southern Appalachian Northern Hardwood Forest (Typic Type)	**1,174**
High-Elevation Red Oak Forest (Deciduous Shrub Type)	**1,022**
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	**800**
Southern Appalachian Acid Cove Forest (Typic Type)	**788**
Red Spruce - Northern Hardwood Forest (Shrub Type)	**663**
Chestnut Oak Forest (Xeric Ridge Type)	**632**
Southern Appalachian Cove Forest (Typic Montane Type)	**500**
Red Spruce - Northern Hardwood Forest (Herb Type)	**290**
Southern Appalachian Northern Hardwood Forest (Rich Type)	**277**
Early Successional Montane Oak Hickory/White Pine Forest	**239**
Blue Ridge Hemlock - Northern Hardwood Forest	**211**
Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type)	**174**
Early Successional Cove Forest	**130**
Early Successional Northern Hardwood Forest	**111**
Eastern White Pine Successional Forest	**79**
Reservoir	**51**
Grassy Bald (Southern Grass Type)	**44**
Southern Appalachian Boulderfield Forest (Typic Type)	**34**
Appalachian Montane Alluvial Forest	**33**
Appalachian Felsic Cliff	**21**
Meadow	**17**
Cove Forest/White Pine Successional Forest	**17**
Artificial Lake Drawdown Zone	**13**
Rocky Bar and Shore (Alder - Yellowroot Type)	**11**

Table 8. Sum of Board Feet per Acre by Cover Type and Grade					
Type	**0**	**1**	**2**	**3**	**Total**
Southern Appalachian Cove Forest (Typic Montane Type)	58	3101	2063	1939	**11,335**
Southern Appalachian Northern Hardwood Forest (Red Oak Type)	112	4346	2001	1326	**7,785**
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	65	2964	2545	1633	**7,206**
Southern Appalachian Acid Cove Forest (Typic Type)	47	3056	2147	1850	**7,100**
Eastern White Pine Successional Forest	224	2127	1070	3671	**7,093**
Southern Appalachian Northern Hardwood Forest (Rich Type)	80	2631	1913	1370	**5,994**
Red Spruce - Northern Hardwood Forest (Herb Type)	225	1925	1762	1345	**5,257**
Blue Ridge Hemlock - Northern Hardwood Forest	0	1584	0	2586	**4,170**
High-Elevation Red Oak Forest (Deciduous Shrub Type)	116	1019	1026	1600	**3,761**
Chestnut Oak Forest (Xeric Ridge Type)	50	1022	825	1204	**3,101**
Southern Appalachian Northern Hardwood Forest (Typic Type)	55	919	725	896	**2,596**
Red Spruce - Northern Hardwood Forest (Shrub Type)	62	1134	228	356	**1,781**
Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type)	169	633	233	251	**1,286**

Table 9. Basal Area (square feet per Acre) by Cover Type and Diameter Class						
Habitat Type	**<12**	**12-16**	**16-20**	**20-24**	**>24**	**Total**
Eastern White Pine Successional Forest	109	54	28	5	3	**198**
Blue Ridge Hemlock - Northern Hardwood Forest	73	27	20	13	33	**167**
Red Spruce - Northern Hardwood Forest (Herb Type)	67	29	27	18	12	**153**
Southern Appalachian Northern Hardwood Forest (Red Oak Type)	41	33	31	24	21	**150**
Southern Appalachian Acid Cove Forest (Typic Type)	43	30	28	27	15	**144**
Southern Appalachian Northern Hardwood Forest (Rich Type)	39	35	34	14	16	**139**
Southern Appalachian Cove Forest (Typic Montane Type)	27	25	32	28	25	**136**
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	46	27	27	22	16	**136**
High-Elevation Red Oak Forest (Deciduous Shrub Type)	48	34	21	12	12	**127**
Southern Appalachian Northern Hardwood Forest (Typic Type)	52	29	20	15	8	**124**
Chestnut Oak Forest (Xeric Ridge Type)	45	28	22	6	2	**104**
Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type)	82	15	7	1	1	**106**
Red Spruce - Northern Hardwood Forest (Shrub Type)	65	13	10	4	3	**95**
Early Successional Northern Hardwood Forest	86	0	0	0	0	**86**
Early Successional Cove Forest	79	0	0	3	0	**82**
Early Successional Montane Oak Hickory/White Pine Forest	78	3	0	0	0	**81**

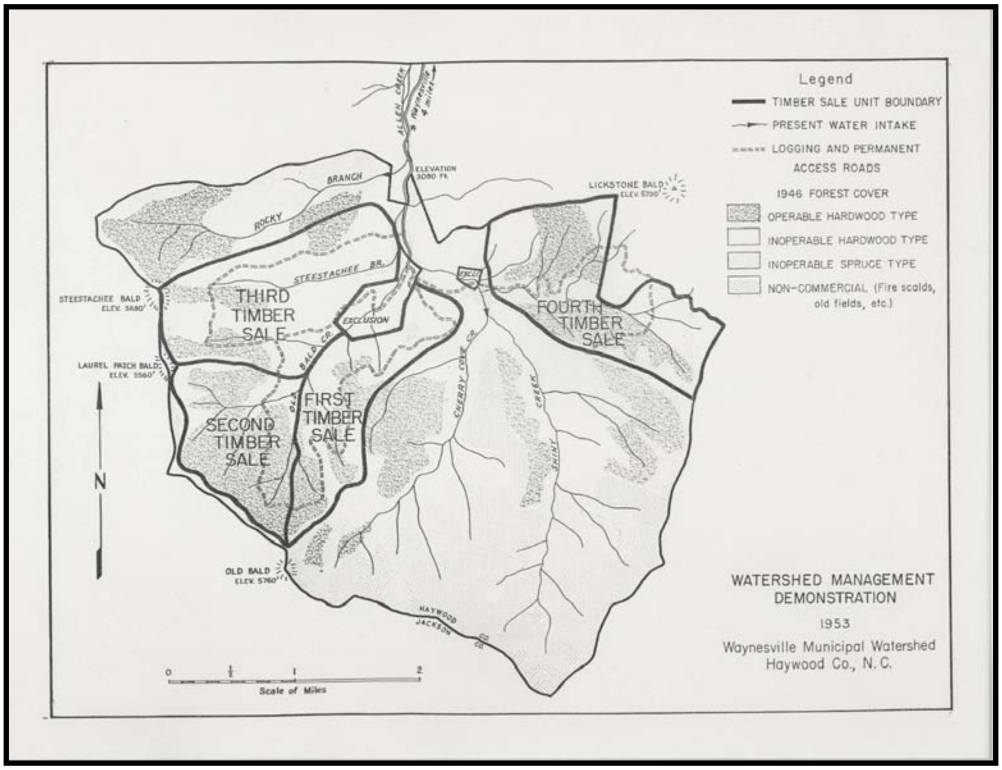


Figure 7. Timber sale units in the Waynesville watershed during the 1940's and 50's (TVA 1953)

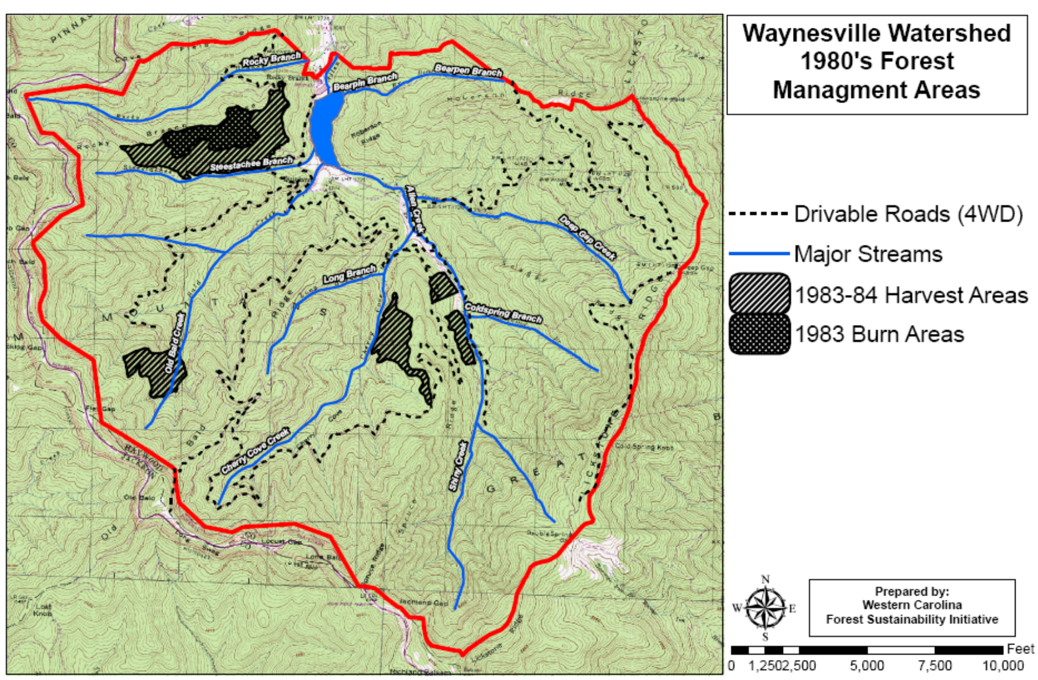


Figure 8. Timber sale units in the Waynesville watershed during the 1980's

Watershed Assessment: Herbaceous Plant Communities

Dr. Norm Christensen from Duke University assessed herbaceous communities in the Waynesville Watershed in 2006. The following is a largely a summary of his work.

Background and Objectives

The herbaceous flora of the Southern Appalachians is among the most diverse of all temperate forest landscapes. This diversity derives in part from this region's moist, warm-temperate climate, and also from its geological and topographic diversity (Braun 1950, Whittaker 1956, Delcourt and Delcourt 2000). Besides its intrinsic value, this diverse array of herbs plays a significant role in the overall ecology of these forests, and it is a key element for nearly all of the ecosystem services they provide (cf. Gilliam and Roberts 2001). Herbs provide critical habitat for a diverse array of animals and are the base for complex forest food webs. Ephemeral herbs absorb the flush of forest soil nutrients released in early spring (nutrients that would otherwise be lost in stream water) and release them to be used by other plants later in the growing season. Herbs stabilize soil and retain water, thereby maintaining water quality, moderating water flows, and preventing erosion. Thus, herbs are especially important to watershed health.

The herbaceous flora of this region also provides direct economic value to communities. They contribute significantly to the aesthetic beauty of Southern Appalachian forests – beauty that draws hundreds of thousands of visitors to this region each year. Many of Appalachian herb species have economic value in their own right. The galax (*Galax urceolata*) is widely harvested and sold for floral arrangements. Several herbs, most notably southeastern ginseng (*Panax quinquefolius*), are prized for their medicinal value.

The introduction of non-native plants is among the most significant of human impacts on southeastern forests. In some cases, such introductions are relatively benign, with plants occurring at only scattered locations. Other non-native species may be invasive in specific circumstances such as princess tree growing along forest edges. Most troubling are non-native herbs and shrubs that are able to invade forests under a wide range of circumstances and often dominate the herbaceous layer where they become established. Among the most pernicious herbs in this category are Japanese honey suckle (*Lonicera japonica*), privet (*Ligustrum* spp.), stilt grass (*Microstegium vimineum*) and garlic mustard (*Alliaria petiolata*). In some cases, invasion of non-native species is facilitated by human caused forest disturbances such as cutting that increases light to the forest floor or excessive soil disturbance. Such changes are often associated with roads and roadsides which not only provide ideal habitat for invasives, but also provide conduits for their spread. Once established, some non-native herbs are able to spread by virtue of their unique competitive abilities. Garlic mustard, for example, releases an organic toxin into the soil that limits the establishment of many other herbaceous and wood species.

In some Southern Appalachian locations invasive non-native species have significantly altered the flora and important ecosystem services. Dominant and aggressive non-native shrubs like privet or multi-flora rose may exclude other herb species, diminish habitat value for many animals and significantly impede movement of humans. Such plants are also known to alter patterns of nutrient cycling and hydrologic flows in forested watersheds.

Natural and human disturbances over the past 150 years have had a significant effect on current forest cover in the Southern Appalachians and the Waynesville Watershed. Logging at various times in the past has produced early successional (often even-aged) stands dominated by shade-intolerant hardwoods (e.g. tulip poplar and red maple) or (where they were planted) by white pine. Roads and historical building sites have had more local effects on plant communities. Early in the last century, chestnut blight removed chestnut from the overstory of forests in many parts of this region.

Historically, fire probably played a significant role in the diversity of many of the forest types, particularly those on dry slopes and ridge tops. The absence of fire from these communities (most especially the pine-oak heath dominated ridges) over the past century has resulted in significant change in these communities, including diminished density of pitch and table mountain pine and increased growth of rhododendron and laurel.

Here, we report on the status of and potential future change in the herbaceous flora of the Waynesville Watershed. This includes description of the plant communities in terms of important indicator species, as well as rare and endemic species often associated with them. This description is based on the extensive work carried out by Dr. Gary Kaufmann. We also provide an assessment of the distribution and abundance of potentially important invasive non-native species in the watershed, with a particular focus on the impacts of roads within the watershed. Finally, we consider the likely trajectories of change in watershed herb communities, as well as the potential impacts of different management alternatives on those trajectories.

Assessment and Sampling

During the summer of 2007, we located twenty-one 30-m long and 5-m wide transects perpendicular to roads at locations distributed across the watershed. In each transect, all herbs were identified, and their relative abundance was estimated by cover class (Present = 1, 1-2% cover = 2, 2-10% cover = 3, 10-25% cover = 4 and >25% cover = 5).

Overview of Plant Communities

The 8,300 acres of the Watershed extends over 2,000+ feet elevation, on a variety of exposures and soils, and much of the rich plant diversity of the southern Appalachians is wonderfully represented in it (Map 4). Acidic and rich cove forests in protected stream valleys give way to several types of oak-dominated forest communities on mountain slopes. At higher elevations northern hardwood cove forest occurs near streams. Ridge top areas are dominated by chestnut oak-heath and pine-oak-heath communities. Spruce-fir forest occurs at the highest elevations of the watersheds. Although some plant species are shared among these different forest types, many species are unique to specific forest communities. Individual communities are discussed in the order of their spatial abundance on the Watershed.

1. Northern Hardwood (Red Oak Type): Herb composition and abundance in this forest cover type is transitional between "typic" northern hardwood forest (also called northern hardwood cove forest) and high elevation red oak forest. The understory in these forests is typically dominated by Pennsylvania sedge (*Carex pensylvanica*). Other common species include New York fern (*Thelypteris noveboracensis*), lady fern (*Athyrium asplenoides*), hay-scented fern (*Dennstaedtia punctilobula*), Curtis goldenrod (*Solidago curtisii*), and whorled loostrife (*Lysimachia quadrifolia*). This cover type does not typically include many endemic or rare species, but Roan rattlesnake root (*Prenanthes roanensis*), pinkshell azalea (*Rhododendron vaseyi*), northern short husk (*Brachyelytrum septentrionale*) lance leaf moonwort (*Botrychium lanceolatum var. angustisegmentum*), and Wood's sedge (*Carex woodii*) are rare species that may be found here.

<u>*2. Northern Hardwood Forest (Typic, Cove, and Blue Ridge Hemlock – Northern Hardwood Forest:*</u> Herb diversity is generally high in this community owning to more mesic conditions and richer soils. Shrubby undergrowth of hobblebush (*Viburnum lantanoides*) and gooseberry (*Ribes cynosbati*) is sparse. Common herbs include white snakeroot (*Ageratina altissima*), heartleaf aster (*Eurybia chlorolepsis*), Core's starwort (*Stellaria corei*), wood ferns (*Dryopteris intermedia*), hedge-nettle (*Stachys latidens*), blue cohosh (*Calulophyllum thalictroides*) and stinking Willie (*Trillium erectum*) consisting of characteristic species. Ramps (*Allium tricoccum*) are an excellent indicatory for this community type. Rare species that may be found here include those identified with the red oak type (above) and blunt-lobed grape fern (*Botrychium oneidense*), fine-leaved sedge (*Carex leptonervia*), mountain bittercress (*Cardamine clematitis*), and starflower (*Trientalis borealis*).

There are over 100 acres of early successional northern hardwood forest (typic and red oak) across the watershed. At the stand level, herb diversity (the total number of species) in such forests is remarkably similar to their older counterparts. However, in younger stands the abundance of some herbs is diminished and their distribution more scattered through the stand. Thus, at smaller spatial scales (1-10 m^2) diversity may be reduced.

<u>*3. High Elevation Red Oak Forest:*</u> Dominated by red oak, much of this community type was dominated by chestnut in the past. Here the shrub layer varies from dense on steep slopes to quite open on lesser slopes. Common shrubs include flame azalea (*Rhododendron calendulaceum),* several species of blueberry (*Vaccinium* spp.), mountain laurel (*Kalmia latifolia*) and great laurel (*Rhododendron maximum*). The herb layer is typically dominated by New York fern and Pennsylvania sedge, with lesser amounts of wood rush, hay-scented fern, Joe-pye weed () and Curtis goldenrod. On steep slopes, Christmas fern (*Polystichum acrostichoides*), galax and heartleaf (*Hexastylis arifolia*) grow beneath the shrubs. Several of the rare species identified with northern hardwood forests may also occur here.

<u>*4. Acidic Cove Forest:*</u> Acidic cove forest occurs in sheltered areas from low to mid elevations. It is especially important on steep slopes along streams. Here, soils are thin, acidic and infertile, conditions that favor the growth of evergreen shrubs such as great rhododendron and dog-hobble. Herbs are sparse and include galax, rattlesnake plantain (*Goodyera pubescens*), partridge berry (*Mitchella repens*) and wintergreen (*Chimophila maculata*). The environment here is conducive to the growth of mosses and lichens. Indeed, this cover type is habitat for 14 rare mosses and lichens in Jackson and Haywood counties. The only vascular plant with a high likelihood of occurrence within the Waynesville watershed is pirate bush (*Buckleya distichophylla*).

<u>*5. Montane Oak-Hickory Forest:*</u> This is generally the most common forest type across the Southern Appalachians and includes a wide range of variation in understory cover that is determined by gradients of moisture and soil fertility and pH. It is likely that fire played a significant role in this community type in pre-settlement times, although its exact role is poorly understood. The shrubby understory here includes species that are typical of low pH soils such as members of the heath family (blueberries, huckleberry (*Gaylussacia* spp.) and buffalo-nut (*Pyrularia pubera*)). Understory herbs are scattered and include New York fern, Curtis goldenrod, whorled loosestrife, trefoil (*Desmodium nudiflorum*), perfoliate bellwort (*Uvularia perfoliata*) and switch grass (*Dichanthelium bosci*). On higher pH soils (basic subtype), herb diversity is much higher and similar in composition to northern hardwood cove forest. Many of

the rare species that occur in northern hardwood forests, can also occur here. In addition mountain catchfly (*Silene ovata*), carrion flower (*Smilax hugeri*), sweet pinesap (*Monotropsis odorata*), small whorled pogonia (*Isotria medeoloides*), and Porter's reedgrass (*Calamagrostis porteri*) are rare or endemic species that may occur here.

6. Red Spruce – Northern Hardwood Forest (shrub and herb types): This forest type includes areas formerly dominated by red spruce and Fraser fir, as well as transitions into high elevation hardwood forests. The shrub type of this forest cover is most common across the watershed. Here, the understory is dominated by hobblebush, red elderberry (*Sambucus racemosa*) and Rhododendrons. Herbs are scattered in abundance and include such species as mountain wood fern (*Dryopteris campyloptera*), mountain wood sorrel (*Oxalis montana*), yellow blue-bead lily (*Clintonia borealis*), whorled aster (*Oclemena acuminata*), and Appalachian turtlehead (*Chelone lyonii*). Rare plants that may occur in this cover type include northern beech fern (*Phegopteris connectilis*), mountain bittercress (*Cardamine clematitis*), Smoky Mountain manna grass (*Glyceria nubigena*), red raspberry (*Rubus idaeus* var. *strigosus*), white mandarin (*Streptopus amplexifolius*), fowl meadow-grass (*Poa palustris*), and a number of moss species.

7. Chestnut Oak Forest (Xeric Ridge Type): This forest type is associated with steep south-facing slopes and ridges on shallow, acidic soils. Where soils are deeper, these forests were likely dominated by chestnut a century ago. Shrubs, including mountain laurel, bear huckleberry and low blueberries dominate the understory, and herb cover is quite sparse. In pre-settlement times, frequent, low-intensity fires probably kept this understory open, with a greater herb cover. Typical herbs include yellow-eyed grass (*Hypoxis hisutus*), trailing arbutus (*Epigaea repens*), greenbriar (S*milax rotundifolia*), pink lady's slipper (*Cypripedium acaule*), little bluestem (*Schizachyrium scoparium*), and bracken fern (*Pteridium aquilinum*). Sweet pinesap (*Monotropsis odorata*) and Porter's reedgrass (*Calamagrostis porteri*) are rare species that might be found in this cover type.

8. Rich Cove Forest: The Rich Cove Forests are typical of mesic protected sites at middle elevations in the watershed. Where the understory is open, wild hydrangea (*Hydrangea* arborescens), maple leaf viburnum (*Viburnum acerifolium*) and spice bush (*Lindera benzoin*) the most common shrub. The herbaceous layer is diverse and includes erect trillium (*Trillium erectum*), maidenhair fern (A*diantum pedatum*), bedstraw (*Galium latifolium*), foam flower (*Tiarella cordifolia*), bluet (*Houstonia purpurea*), whorled loosestrife, Christmas fern, New York fern, may apple (*Podophyllum peltatum*), ginseng, and several species of bellwort, violet and sedge. The herb layer here is remarkably diverse, especially with regard to early spring ephemerals. A diverse array of rare species may occur in this cover type, including mountain catchfly (*Silene ovate*), glade spurge (*Euphorbia purpurea*), twinleaf (*Jeffersonia* diphylla), goldenseal (*Hydrastis Canadensis*), Wood's Sedge (*Carex woodii*), Hitchcock's sedge (*Carex hitchcockiana*), Carey's *sedge (Carex careyana*), Blue Ridge bindweed (*Calystegia catesbiana var. sericata*), American beakgrain (*Diarrhena Americana*), tall larkspur (*Delphium exaltatum*), spiked coralroot (*Hexalectris spicata*) and sweet trillium (*Trillium simile*).

9. Blue Ridge Table Mountain Pine – Pitch Pine Woodland: This forest cover type occurs on ridges and shallow soils and grades into the chestnut oak forest type. Exclusion of fire from this forest type has resulted in widespread invasion by mountain laurel and other shrubs. The herbaceous layer here is very similar to that of the chestnut oak forest cover type. As with that cover type, more frequent fires in the past probably supported a more robust and diverse herb layer.

Non-Native Species

A total of 220 herb species was tallied in the census of transects along Watershed roads (Appendix 3). Only three of these species, *Prunella vulgaris*, *Achillea millifolium*, and *Senecio vulgaris*, are not native, and none of these is particularly invasive. These were found along the immediate roadside. Thus, the watershed is remarkably free of alien species. We do note the scattered occurrence of multi-flora rose in a few lower elevation locations. Our transects off the Blue Ridge Parkway into the watershed found no invasive species except along immediate roadsides and rights-of-way. This is likely because of the higher elevations along the Parkway.

Roads are the primary conduit for invasion of non-native plants, and the cover of invasive species decreases away from roadsides. In the development and maintenance of roads within the watershed, care should be taken to minimize roadside disturbance. Similar care should be taken to minimize soil disturbance in logging activities and around loading decks. In general, threats posed by invasive species such as those listed above, diminish with increasing elevation.

Several woody and herbaceous aliens are potentially quite invasive in the southern Appalachians, and their impacts on the structure of native plant communities can be pernicious. Among these are Chinese yam, garlic mustard, Japanese stilt grass, kudzu, multiflora rose, Oriental bittersweet, privet, princess tree and tree of heaven. When found, every effort should be made to remove these species. We did note scattered populations of multiflora rose outside our transects. These should be monitored for any additional spread. Mechanical removal can control populations of this species, but it is difficult to eradicate.

Management for Herb Diversity

The Waynesville Watershed has a remarkable diversity of herb species and a very representative complement of the plant communities of the southern Appalachians. There is little evidence that species are being lost, nor is there evidence of any serious problems with non-native invasive species. In studies in the Little Tennessee Watershed, we have found that understory herb diversity and composition in hardwood stands selectively cut 20-30 years previously is similar to that in stands that have been undisturbed for 80-100 years. We did observe a greater number of non-native species in some of those stands than observed in the Waynesville Watershed. This probably reflects the lower elevations and, perhaps, more abusive past cutting in those areas.

Where fire was historically important, such as in the Pine-Oak dominated ridge tops and dryer oak-dominated slopes, prescribed fire should be considered for community maintenance. It is likely that the pitch and table mountain pine dominated ecosystems were much more widespread and that fire exclusion has resulted in their contraction to isolated patches. The role of fire in other hardwood types is less known, and its effects on the herbaceous community remain largely unstudied. A number of recent studies have raised concern that prescribed burning may encourage invasion of alien herbs, shrubs and trees, even in areas where fires were historically common and natural. Thus, any prescribed fire program should be monitored carefully, and executed in an adaptive management framework.

Little or no management is required in the more mesic hardwood types (cover and northern hardwood forests). However, many of these stands are in an early successional stage and their succession to more mature forest can be accelerated by selective cutting. If done so as to minimize soil disturbance and to retain significant canopy cover, such cutting has a minimal impact on the herbaceous community.

Management of ramps *(The following is based on the work of Dr. Jim Chamberlain, Non-Wood Forest Products specialist with the US Forest Service who has been studying ramps in the watershed for the past 7 years.)*

Currently, ramps are the only forest resource to be regularly harvested from the Waynesville watershed. One local civic group harvests ramps from the watershed every spring for use in an annual ramp festival. The impacts of this harvesting on the long-term viability of ramp populations in the watershed are not known; however, the following recommendations should be considered regarding the harvesting and management of ramp populations in the watershed:

1. Delay the harvest of ramps as long as possible. Data collected weekly on the development of ramp bulbs suggests that the bulbs are not fully developed until around the end of April. Knowing that the ramp festival occurs on the first weekend of May, delaying harvest until the end of April may present a challenge for the harvesters. But, it would be possible to delay it a few days, which can make a significant difference.
2. Restrict collection to plants that do not exhibit a flower stalk (known as a scape). Collecting plants that are developing a scape removes the potential seed source and reduces the reproduction of the population. This would require collectors to examine the plants more closely and would require a manager to watch more closely the collection, but it would help to ensure that plants of reproducing nature are allowed to stay in the ground.
3. Encourage groups to use more of the plant. The leaf also is edible. Including the leaf in cooking would reduce the amount of ramps needed.
4. Make efforts to regenerate ramp patches. Two approaches are possible. First, collect seed from within the watershed and disperse, accordingly. This may have limited advancements as the amount of seed available is limited by the plants providing such. A second approach would be to procure and plant ramp seeds to increase reproduction. A pound of ramp seeds costs approximately $300. A pound has about 10,000 seeds, which could go along way to regenerate ramp patches. These would need to be planted in the fall, just prior to the drop of tree leaves.
5. Inventory the watershed to find new patches with the intent of moving harvesting to different patches each year. This has been partially implemented with the foresight of the manager who several years ago started moving the harvesters to different patches each year. Harvesting is now on about a five year rotation; harvesters do not go back to the same patch each year, but wait about 5 years. This needs to be expanded to give more time for the patches to recuperate.

Watershed assessment: Wildlife

The information summarized below was compiled with the assistance from staff of the North Carolina Wildlife Resources Commission and from information available in the North Carolina Wildlife Action plan

The town of Waynesville identified that protecting and enhancing wildlife habitat in the watershed was a high priority to be balanced with other stewardship objectives. Because the watershed is currently off limits to hunting, special emphasis was given to protecting state or federally rare, threatened or endangered species.

Methods

The North Carolina Wildlife Resource Commission (WRC) has done little survey work in the Waynesville watershed at this point. What survey work has been done is confined to bats in an abandoned mica mine and sampling for small mammals. All other information regarding wildlife in the watershed is from WRC's assumptions based on data in the areas surrounding the watershed and from data in habitat types similar to those found in the watershed.

Results

The abandoned mica mine now serves as cave habitat for the eastern small-footed bat (federal and state listed as Special Concern) and northern long-eared bat (State listed as Special Concern). A single federally endangered Indiana bat was found in the mine this year (2008), but the mine is not believed to be critical habitat for this species. However, WRC does believe this mine to be important for the former two species and warrants appropriate protection. The WRC will continue to monitor populations of these bats to determine whether additional management actions are necessary to protect their habitat.

In 2004 the WRC conducted small mammal surveys targeting water shrew (Sorex palustris) and rock shrew (Sorex dispar) both of which are state listed as special concern. Five locations within the watershed were surveyed using pitfall trap methods. A total of 2597 trap nights yielded 62 captures of which three were water shrews and three were rock shrews.

The WRC provided the following management concerns and lists of rare species by forest cover type detailed in the bullet points below and in Table 10. These concerns are based on knowledge of current forest habitat conditions and assumptions regarding what species may occupy these habitats. Here are the major management concerns in regards to wildlife:

- The evergreen component of high elevation forest types provided by red spruce and Fraser fir has diminished due to past clear-cutting and the exotic insect balsam wooly adelgid. This evergreen component provides important habitat to the federally endangered northern flying squirrel among other species of concern. Management which enhances this evergreen component through protection, release, or direct planting would prove beneficial.
- In mesic deciduous forest, including cove and northern hardwood types, management that enhances structural diversity and mimics mature forest conditions through creation of gaps is beneficial for numerous wildlife species.
- In oak dominated forests management should perpetuate oak dominance in addition to enhancing structural diversity. This can be done with gaps that allow sufficient sunlight to

reach the forest floor (0.5 acre gaps or larger) or by prescribed fire. Fire also is beneficial in reducing dense shrub layers of mountain laurel or other species which in turn enhances overall forest regeneration and stability, providing mast and herbaceous forage for wildlife.

- Table mountain pine-pitch pine woodlands are a fire dependent forest type by which fire is required to release seeds and establish new pine growth. In the watershed, this type has become dominated by chestnut and scarlet oak and mountain laurel due to fire suppression. Prescribed fire in combination with selective harvesting of the hardwoods would help to restore this forest type and its associated wildlife species.
- If funds are available, wildlife that depend on evergreen cover would benefit from selecting and protecting specimen hemlock trees from the exotic pest hemlock wooly adelgid. Such protection can save a few of these trees such that a seed source is available when a biological control mechanism becomes available.
- Entrances to caves and mines should be shut off to the public and a forested buffer should be left around them.

Early successional grassy bald and shrub habitats should be protected from forest encroachment by mowing and/or cutting tree.

The following is a note from the WRC regarding hunting in the Waynesville watershed: *We would highly recommend discussing the potential of future hunts within WWS boundaries – not so much to initiate hunts on the property immediately, but instead to keep the option open. Hunting has many benefits and the town could have control over how the hunts take place (with NCWRC helping out). There are well-documented ecological benefits to hunting (population control etc.), and the committee might also be interested in the economic benefits. We would have to check the statutes to be sure, but the town could develop a lottery system where hunters pay a fee to have their name thrown in a pot. Selected hunters would then have to pay an additional "access" fee to actually hunt the property. This would bring additional money into the coffers that could be directed at natural resource management and allow Waynesville to control the amount of hunters allowed onto the property. Waynesville could further control the hunt by creating allowable hunt zones and assigning the number of hunters to each zone. They could do this for each species and each season. This would also allow WRC to better support management efforts by monitoring game species through check stations. There are many ways to go about this and many benefits.*

Table 10. Wildlife Summary Table

Wildlife Habitat Type	Forest Cover Types Included	Endangered (E), Threatened (T), Special Concern (C), or Rare (R) that may occur in the Waynesville Watershed	Management Concerns and Actions
Spruce-Fir Forests	Red Spruce - Northern Hardwood Forest (Shrub Type) Red Spruce - Northern Hardwood Forest (Herb Type)	E-Northern Flying Squirrel[1] T-Saw Whet Owl[1] C-Brown Creeper[1] C-Red Crossbill[1] C-Black-capped Chickadee[1] R-Sharp-shinned Hawk[3] R-Magnolia Warbler[1] R-Pigmy Salamander[3]	1. Pursue management to ensure Fraser fir survival. 2. Plant spruce in areas dominated by Northern Hardwoods. 3. Recommend mechanical release of red spruce seedlings suppressed in hardwood understories.
Northern Hardwoods	Blue Ridge Hemlock - Northern Hardwood Forest Northern Hardwood Forest (Red Oak Type) Northern Hardwood Forest (Typic Type) Northern Hardwood Forest (Rich Type)	E-Northern Flying Squirrel[1] T-Saw Whet Owl[1] C-Cooper's Hawk[1] C-Brown Creeper[1] C-Black-capped Chickadee[1] C-Yellow-bellied Sapsucker[1] C-Rock Shrew[2] C-Water Shrew[2] R-Sharp-shinned Hawk[3] R-Black-billed Cuckoo[1] R-Canada Warbler[1] R-Pigmy Salamander[3] R-Dusky Salamander[3]	1. Increase evergreen component by planting spruce. 2. Increase structural diversity and understory development in even-aged stands. 3. Enhance mature forest conditions in young to middle-aged stands. 4. If funds are available for long-term and sustained treatment it would be desirable to treat hemlock in selected areas using soil drench treatments. Yellow birch and American Beech (including snags) should be retained. Consult USFWS Recovery Plan for Appalachian northern flying squirrel before conducting any forest management at high elevations (i.e., >4000').

Cove Forests	Appalachian Acid Cove Forest Appalachian Cove Forest	C-Cooper's Hawk[3] C-Brown Creeper[1] C-Yellow-bellied Sapsucker[1] R-Sharp-shinned Hawk[3] R-Black-billed Cuckoo[1] R-Cerulean Warbler[1] R-Seepage Salamander[3] R-Pigmy Salamander[3] R-Dusky Salamander[3]	1. Mimic old growth gap dynamic conditions through selective harvesting. 2. Pursue long timber rotations (100+ years)
Early Successional	Grassy Bald (Southern Grass Type) Red Spruce - Northern Hardwood Forest (Shrub Type) Rocky Bar and Shore (Alder-Yellowroot Type)	C-Rock Vole[2] C-Timber Rattlesnake[2] R-Alder Flycatcher[1] R-Least Weasel[2]	1. Maintain grassy bald and shrub habitat by reducing encroachment from surrounding forests.
Dry Coniferous Forest	Blue Ridge Table Mountain Pine - Pitch Pine Woodland	C-Timber Rattlesnake[2] C-Cooper's Hawk[3] R-Sharp-shinned Hawk[3]	1. Restore fire. 2. Combine fire with harvests of hardwoods and planting of pitch or table mountain pine.
Oak Forests	High-Elevation Red Oak Forest (Deciduous Shrub Type) Montane Oak Hickory Forest Chestnut Oak Forest (Xeric Ridge Type)	C-Cooper's Hawk[3] C-Brown Creeper[1] C-Black-capped Chickadee[1] C-Yellow-bellied Sapsucker[1] C-Four-toed Salamander[3] C-Timber Rattlesnake[2] R-Sharp-shinned Hawk[3] R-Black-billed Cuckoo[1] R-Cerulean Warbler[1] R-Least Weasel[2]	1. Perpetuate oak regeneration through use of fire and appropriate management. 2. Promote structural diversity and an array of age classes.
Caves and Mines	Mines known to occur on property	E- Indiana Bat[2] R- Eastern Small-Footed Bat[2] R- Northern Long-Eared Bat[2]	1. Protect mines and caves; exclude public entrance, leave forested buffer around entrances

[1]Species which have records in the NC Natural Heritage Program database within the watershed or in the surrounding Great Balsams or Plott Balsams
[2]Species with a high probability to occur in the Waynesville Watershed
[3]Species that could possibly occur in the Waynesville Watershed

Watershed Assessment: Roads

There are approximately 29 miles of drivable roads (some areas only drivable with 4WD vehicle) in the Waynesville Watershed. These drivable roads are distributed across the watershed so that each sub-watershed is at least partially accessible by road. When originally constructed, these roads were well designed as to minimize potential for erosion or washout and have been maintained to minimize erosion risk over time.

In addition to the roads considered drivable, there are many more miles of secondary trails and roads that were used for past timber harvesting. Many of these secondary roads are abandoned and almost entirely vegetated and stabilized. However, some of the secondary roads are still used by the town for administrative responsibilities, including law enforcement. These roads are occasionally cleared to be made passable, at least by ATV. From limited observation, these roadbeds appear stable, with little evidence of channelized erosion. There is some surface erosion occurring along some cut banks, and some culverts on these roads are not large enough to handle heavy storm events. Only a small amount of the bank erosion would get into the streams, as most of these roads are located some distance away from the streams, and the sediment will be trapped in leaves and leaf litter before it reaches open water.

There were no major erosion risks or hazards observed during our extended use of the watershed's road network while inventorying the forest between 2002 and 2006. During the catastrophic hurricanes of 2004, only one major road washout occurred. This washout has since been stabilized, and fortunately did not occur near any stream crossing.

There are approximately 114 locations where roads cross streams, both perennial and ephemeral (Map 13). These 114 points should be the focal point of a more thorough inventory since these intersections are major potential entry points for sediment into streams. While our observations showed no major problems, there are numerous instances where roads ford streams, banks are sloughing slightly and where additional dips, water bars and other diversion features are needed.

Roads that will be utilized during forest management require special attention to improve, maintain, and monitor road conditions during and after management. Additional improvements to roads and water crossings may be necessary in areas where heavy use of large trucks or equipment will occur.

Principles guiding forest management within watershed areas

There is a significant body of work regarding forest management impacts on forest health and water quality. The current land management plan for the Quabbin Reservoir system in Massachusetts represents perhaps the most comprehensive examination of forest management practices within a municipal watershed (MDCR 2007). The Quabbin reservoir is one of a series of reservoirs created to supply water to the city of Boston. The Massachusetts Department of Conservation and Recreation (MDCR), and previous state organizations have been managing nearly 54,000 acres within the Quabbin watershed since the late 1800's. During that time, they have incorporated the current state of science into their management practices, and they have developed management principles to guide their forest management activities. Below we have identified some of those principles that are particularly relevant to the Waynesville watershed. The scientific literature that provides the basis for these principles is listed in Appendix 4. The full management plan and report is available at http://www.mass.gov/dcr/waterSupply/watershed/documents/2007QuabbinLMP.pdf).

Guiding Principles behind Forest Management in Forested Watersheds (from MDCR 2007)

- No other land cover has been shown to protect the quality of drinking water better than forest cover.
  - The accumulation of organic matter, the growth of fine and coarse roots, the actions of soil-dwelling microbes, invertebrates, and other natural processes develop properties of infiltration, hydraulic conductivity, and water storage that are unique to forest soils and contribute to the protection of water quality.

- Critical protection of water quality for predominantly forested and actively managed watersheds includes the following principles:
  - Minimizing land use/cover changes in order to maintain forest cover across the majority of the watershed provides the most effective primary barrier for protecting tributary and reservoir from pollutants
  - In actively managed areas, Conservation Management Practices (i.e., Best Management Practices), correctly designed and applied effectively will protect water sources from sediment/nutrient losses otherwise associated with forest management activities.
  - The most common sources of water quality degradation by timber harvesting operations are intersections between harvesting roads or staging areas and water sources. Disconnecting roads/staging areas from water sources prevents water quality degradation.
  - To prevent contamination of surface and ground waters, petroleum products on water supply watersheds must be tightly contained or replaced with biodegradable alternatives.
  - Maintaining a species and age/size diverse forest cover may increase that forest's resistance to disturbance and ability to recover quickly when disturbance occurs. Active management can maintain or develop a broad range of tree sizes, and can increase species diversity where past land use or natural disturbances have homogenized forest cover.

- The proper management and protection of wetland and riparian zones is a critical component of watershed protection, in part because these frequently are concentrated water supply source areas and because they represent the final opportunity to capture mobile sediments/nutrients before they enter surface waters.

- Within a variety of watershed land cover types, the best regulation of nutrients is provided by maintaining vigorously growing forest across the vast majority of watershed sites. Forests developed through silvicultural methods that include the range from single-tree to small group and patch regeneration cutting will include a range of size and age classes, as well as a mix of species across the continuum from shade tolerant to shade intolerant.

- Fire protection, watershed monitoring, water sampling, and watershed management activities all depend on an adequate, well-maintained watershed road system. Poorly designed or inadequately maintained roads represent the greatest potential source of sediment inputs to tributaries in undeveloped watersheds.

<u>The Effects of Forest Disturbance on Watershed Protection</u>

- Disturbances can be described as endogenous (originating within the ecological community, such as through the death of single trees) or exogenous (originating from forces outside the ecological community, such as through major wind storms).

- Endogenous disturbances generally pose minimal threats to water supplies.
    - Endogenous disturbances generally occur at a rate of between 0.5 and 2% of forest area annually.

- Exogenous disturbances can create either chronic or catastrophic landscape scale changes that may result in direct or indirect effects on these supplies.

- Overstory windthrow, in the absence of rapid regeneration, can temporarily increase erosion and nutrient leaching, by disturbing soils, increasing decomposition rates, and causing a setback in biomass accumulation.

- Severe forest fires can significantly reduce soil infiltration, thereby increasing overland flow of water, sediments, organic materials, and nutrients.

- A forest that is diverse in age structure and species composition limits the impacts of age- and species-specific disturbances.

- Forests with advance tree regeneration in the understory will recover more quickly from disturbances to the forest overstory than will forests with poor understory development.

- Younger, shorter trees will sustain less damage from severe windstorms than taller, older trees, due to both their lower tendency to “catch” the wind, and to stem flexibility.

- While tightly grown, aerodynamically smooth stands may deflect wind better than those that are aerodynamically rough, individual trees that have been grown in more open stands will develop strongly tapered stems that resist wind better than non-tapered stems of trees grown in tight stands.

- Saturated overland flow from infrequent, large storms with intense rains and rapid snowmelt account for much of the annual particulate, sediment, and dissolved nutrient outputs from watersheds in any given year.

Forest Stewardship Objectives and Implementation Strategies

The overall stewardship goals for the Waynesville watershed property are clearly described in the Strategic Forest Management plan that was included as part of the Conservation Easement. Those objectives are listed below:

> ***The primary forest management goal is to create and maintain a vigorous, healthy, and diverse forest that will ensure the production of high quality drinking water from the Waynesville Watershed land area.*** Other objectives for the management of this forest will also be pursued, but only in a manner that is consistent with the primary objective stated above. These other objectives include:
>
> - The preservation and protection of biodiversity and of rare and unique plant and animal species.
> - The protection of the visual quality of the watershed, particularly as it is viewed from the Blue Ridge Parkway and other surrounding vistas.
> - The generation of income through the sale of timber and non-timber forest products.
> - The development of a forestry education resource for the surrounding community.

Articulation of Specific Forest Stewardship Objectives and Implementation Strategies

The strategic forest management objectives listed above are broad in scope, and do not contain enough specificity to drive on the ground forest management decisions. More detailed forest stewardship goals were needed that could be achieved through specific management actions. These objectives were identified based on (1) a series of workshops and open meetings designed to solicit public input regarding the most important values for the watershed property, (2) the current state of knowledge regarding the condition of the watershed forest, and (3) the principles of forest management summarized earlier in this document. Specific objectives and suggested implementation strategies for achieving those objectives are listed below. Note that many of these objectives overlap, and are otherwise complimentary. The order in which they are listed does not imply priority.

- *Objective:* *Protect water quality.*
    - Riparian and streamside management zones will be established adjacent to all streams, and these areas will be managed to maximize their value in protecting surface water quality.
    - North Carolina Best Management Practices will be met or exceeded during all management activities.
    - Roads should be regularly monitored for erosion hazards, particularly following major storms. Problems should be recognized and treated quickly. A thorough assessment of current road conditions with improvement recommendations should be done as soon as possible (Chapter 13).
    - While the annual average of the area treated will range from 0.5 to 2% of the forest area, attempts will be made to combine several years' worth of activities into a single year. This would mean there would be no treatments during some years,

which would reduce the amount of time that forest roads are in a disturbed state. Also, in some cases, it would allow for larger volumes of timber to be sold, which could make it more feasible to utilize low-impact, but expensive equipment (such as helicopters).
    - Operation managers will abide by contractual terms relating to maintaining high water quality (Chapter 14). Operators should be selected, in part, based on assessment of their equipment's potential impact on water quality. Low-impact equipment which minimizes erosion potential is preferable.
    - Forest stewardship treatments will be favored in areas and stand types that provide the greatest potential benefits with the least amount of risk. This assessment will be based on the ecological importance of the forest stand type, erosion hazard, access, other logistical constraints, and potential commercial value.

- *Objective: Protect important, rare, and unique species and their habitats.*
    - Identify and map important habitats (Table 10, Chapter 7 and Chapter 8).
    - Limit management in these areas to practices designed to enhance critical habitat elements.
    - Identify and protect (and perhaps create) rare micro-habitats within larger management units. These are typically areas or features that are too small to be mapped, and might include springs, vernal pools, or den trees.

- *Objective: Promote a healthy and aggrading watershed forest by creating and maintaining a diversity of naturally occurring forest stand types throughout the watershed. This diversity should be reflected in species composition, age class distribution, and successional stage.*
    - Implement treatments that promote a naturally occurring mixtures of diverse species. Regeneration treatments will be designed to achieve natural regeneration of native species.
    - Utilize management practices that (1) mimic natural disturbance, (2) increase the proportion of uneven-aged and two-aged stands within the watershed, (3) and create a rough balance in the area occupied by trees in different age classes. With consistent and careful management over the next century, it will be possible for the watershed to represent all stages of succession and 5-10 different age classes (e.g. 0-20, 20-40, 40-60, 60-80, 80-100 and >100 yr) (Table 11).
    - Enhance the vigor of selected dominant and codominant trees through crown thinnings that reduces stand basal area by no more than 1/3. Select residual trees (trees to favor) based on species, health, form, and desire to maintain a diverse, naturally occurring mix of overstory tree species.

- *Objective: Protect and enhance ecosystem services and mitigate green house gas emissions.*
    - Management strategies will be designed to maintain and enhance key ecosystem functions, including the sequestration of carbon to help address global climate change.

- <u>Objective:</u> *Apply treatments that mirror natural patterns of stand disturbance. In eastern hardwood forests, endogenous forest disturbances typically impact about 0.5 to 2% of forest land area per year, and these disturbances typically create relatively small gaps in the canopy associated with wind throw or disease.*
  - Forest stewardship treatments will attempt to mimic natural disturbances both in scale and frequency.
  - Treat, on average, no more than 0.5 to 2% of the actively managed forest area annually, with approximately ½ of this amount dedicated to regeneration treatments. Using this approach, would allow for the treatment of between 30 and 120 acres per year and the regeneration of 15-60 acres per year.
  - The Waynesville watershed property will be divided into 5 management compartments (see Table 12 and Map 15), generally defined by the major sub-watersheds within the property. Forest management practices will be limited such that no more than 25% of the land area within a compartment will be treated within any 10 year period.

- <u>Objective:</u> *Maintain aesthetic appeal, particularly from the vantage points along the Blue Ridge Parkway, shall be maintained.*
  - Areas within the viewshed of Blue Ridge Parkway overlooks have been identified (see Map 11). The visual impacts of forest management treatments in these areas will be minimized by designing smaller treatment units, feathering the edges of treatment boundaries, and blending treatment areas into the local topography.

- <u>Objective:</u> *Utilize the watershed as an educational resource for the community.*
  - Management activities within the watershed will be fully documented and open to public inspection.
  - Treatments will represent the highest standards, and based on the best science and technologies available.
  - Members of the community will be provided opportunities to learn about their watershed and express their views on its management.
  - Students of all ages will be educated about the management of the watershed, and when possible, provided opportunities to learn through participation in the management process.

- <u>Objective:</u> *Achieve these objectives in a way that is financially most efficient to the Town of Waynesville.*
  - Forest stewardship treatments will be favored in areas and stand types that provide the greatest potential benefits with the least amount of risk. This assessment will be based on the ecological importance of the forest stand type, erosion hazard, access, other logistical constraints, and potential commercial value.
  - The town's financial interests will protected when soliciting bids for forest products and when contracting for services to achieve management objectives.

<u>General Forest Management Implementation Guidelines</u>

In order to implement forest management practices within the watershed it is first necessary to (1) identify manageable areas by taking out of the management land base plant communities and other areas where management is precluded or severely restricted; (2) define management goals for stands that fall within manageable areas; and (3) develop silvicultural prescriptions to achieve those goals.

Each stand or stand area was assigned to one of the following 4 management categories in order to identify manageable areas (see Tables 13 and 14, and Map 8):

- ***Category P:*** *Protected habitats* – rare or unique stand or community types where most active management practices would be precluded except to restore critical habitat components, or areas that are protected by easements or other legal restrictions. This category includes the area in the forever wild conservation easement held by the State of North Carolina. The forever wild easement area is bound by an additional unique set of restrictions detailed in the property's conservation easement document which should be closely consulted before management is considered in this area.
- ***Category R:*** *Riparian zones* – areas within 50 ft of streams, where management activities will be tightly controlled in order to protect water quality. While the other management categories are generally defined by forest cover type, riparian zones cut across all types which contain flowing surface water.
- ***Category M:*** *Manageable areas (mesic)* – areas not in protected habitats or riparian zones, and with no other significant limitations to management. These areas also possess relatively high site productivity.
- ***Category X:*** *Manageable areas (xeric)* – areas not in protected habitats or riparian zones, and with no other significant limitations to management. These areas possess relatively low site productivity.

A series of desired forest conditions was identified for each stand type. These are stand conditions that can be achieved during the next 20 years with a single stand treatment. These do not reflect the total of desired forest conditions for each stand type, but instead reflect a reasonable set of conditions that can be achieved over the next several decades, and that will begin the process of creating a more diverse watershed forest. We have identified up to 3 desired conditions for most stand types, and in every case, one of those conditions is to allow succession to occur without active management (i.e., do nothing). The desired forest conditions for each stand type are presented in Table 15.

We have identified silvicultural treatments designed to achieve each of the desired conditions. In most cases these are treatments that mimic natural stand disturbances or accelerate diversity in developing stands. These prescriptions are summarized below, and are also presented in Table 16.

<u>Silvicultural Objectives, Justifications, and Implementation Strategies by Habitat Type</u>

This section repeats the silvicultural objectives and implementation information presented in Tables 15 and 16, but also provides justification for each objective and implementation strategy. For this section, forest cover types are lumped into broader forest habitat types (see Table 16 for information relating forest cover types to broader habitat types). The forest cover types within each habitat type have similar objectives and implementation strategies.

Spuce-Fir Forests (Category P)

- *Objectives: Maintain, protect, and restore habitat.*
  - Implementation strategy: No active management at this time.
  - Justification: Active forest management is restricted in these stand types because of their difficult access and ecological importance. However, these are unique high elevation forests which provide important habitat to numerous species including the endangered northern flying squirrel. Evergreen cover at high elevations has decreased dramatically over the past century due to both extensive logging and the balsam wooly adelgid, which killed all mature Fraser fir trees. As a result, areas previously dominated by red spruce and Fraser fir have become dominated by northern hardwoods species. Species of concern, such as the northern flying squirrel, benefit from the evergreen component in this forest type. Habitat enhancement through increasing evergreen cover, such as by planting or promoting the regeneration of red spruce, should be considered in the future, though no such restoration treatments are planned at this time.

Northern Hardwood Forests (Category M)

- *Objectives: Increase diversity of species and forest structure. Improve forest health and vigor of dominant overstory trees.*
  - Implementation strategy: Create small gaps of ½ acre or less in size, with the exception of the Red Oak Type which can have gaps of up to 2 acres in size. These gaps are designed to create an intimate mosaic of mixed-aged and even-aged aggregations. The specific location, size, and orientation of individual gaps will be determined by access (existing road and trail locations), topography, and the status of advanced regeneration.
  - Justification: Current and long-term forest condition will be improved through transitioning the current even-aged forest condition into a more diverse multi-aged condition. Northern hardwoods species are shade tolerant and can regenerate in small gaps created by individual trees (Nyland 1998). While northern red oaks and black cherries sometimes regenerate in gaps less than ½ acre in size, they are usually more successful regenerating in gaps ½ acre or greater because these species require more sunlight (Kelty 2003).

  - Implementation strategy: Enhance the vigor of selected dominant and codominant trees through crown thinnings that reduces stand basal area by no more than 1/3. Appropriate application of this treatment will require that an experienced forester select residual trees (trees to favor) based on species, health, form, and desire to maintain a diverse, naturally occurring mix of overstory tree species. This treatment explicitly recognizes that both timber and non-timber values should be enhanced.
  - Justification: Overstory trees are entering the understory reinitiation phase of stand development and competing heavily with each other for limited resources, which is slowing their growth rates. This reduced vigor may increase their vulnerability to environmental stresses. The even-aged nature of the forest compounds this problem by making it difficult for trees to differentiate into dominant, co-dominant, intermediate and suppressed crown classes. A crown

thinning can facilitate this natural differentiation of trees that would naturally in uneven-aged forests (Smith et al. 1997).

Cove Forests (Category M)

- *Objectives: Increase diversity of species and forest structure. Improve forest health and vigor of dominant overstory trees.*
    - Implementation strategy: Create small gaps of ½ to 2 acres in size. These gaps are designed to create an intimate mosaic of mixed-aged and even-aged aggregations. The specific location, size, and orientation of individual gaps will be determined by access (existing road and trail locations), topography, and the status of advanced regeneration
    - Justification: Current and long-term forest health will be improved through speeding the transition of the current even-aged forest condition into a multi-aged condition. Cove forests are very diverse, containing species both shade tolerant and intolerant. Smaller gaps (< ½ ac) will favor more tolerant species and larger gaps (up to 2 ac) will favor less tolerant species (Clebsch et al. 1989).

    - Implementation strategy: Enhance the vigor of selected dominant and codominant trees through crown thinnings that reduces stand basal area by no more than 1/3. Appropriate application of this treatment will require that an experienced forester select residual trees (trees to favor) based on species, health, form, and desire to maintain a diverse, naturally occurring mix of overstory tree species. This treatment explicitly recognizes that both timber and non-timber values should be enhanced.
    - Justification: Overstory trees are entering the understory reinitiation phase of stand development and competing heavily with each other for limited resources, which is slowing their growth rates. This reduced vigor may increase their vulnerability to environmental stresses. The even-aged nature of the forest compounds this problem by making it difficult for trees to differentiate into different crown class positions. A crown thinning would promote the vigor of selected trees and would speed the differentiation of trees into different crown classes (Smith et al. 1997).

Oak Forests (Category M and X)

- *Objectives: Increase diversity of species and forest structure. Improve forest health and vigor of dominant overstory trees. Maintain oak canopy dominance.*
    - Implementation strategy: Create small gaps of ½ to 5 acres in size. These gaps are designed to create an intimate mosaic of mixed-aged and even-aged aggregations. The specific location, size, and orientation of individual gaps will be determined by access (existing road and trail locations), topography, and the status of advanced regeneration
    - Justification: Current and long-term forest health will be improved through speeding the transition of the current even-aged forest condition into a multi-aged condition. While this transition may occur naturally over a long period of time, regeneration treatments can hasten this process. Future oak dominance in these forest types are threatened by more shade tolerant species such as red maple that

dominate in the understory and midstory positions (Aldrich et al. 2005). It is generally desirable to maintain oak as a major component of these stands because of their wildlife (hard mast), aesthetic, and commercial values. Oak species regenerate best in full to intermediate levels of sunlight, requiring gaps of ½ acre or larger (Kelty 2003).

- Implementation strategy: Enhance the vigor of selected dominant and codominant trees through crown thinnings that reduces stand basal area by no more than 1/3. Appropriate application of this treatment will require that an experienced forester select residual trees (trees to favor) based on species, health, form, and desire to maintain a diverse, naturally occurring mix of overstory tree species. This treatment explicitly recognizes that both timber and non-timber values should be enhanced.
- Justification: Overstory trees are entering the understory reinitiation phase of stand development and competing heavily with each other for limited resources, which is slowing their growth rates. This reduced vigor may increase their vulnerability to environmental stresses. The even-aged nature of the forest compounds this problem by making it difficult for trees to differentiate into different crown class positions. A crown thinning would promote the vigor of selected trees and would speed the differentiation of trees into different crown classes (Smith et al. 1997).

Eastern White Pine Successional Forests (Category M)

- *Objectives: Increase diversity of species and forest structure. Improve forest health and vigor of dominant overstory trees. Covert to mixture of white pine and hardwoods.*
  - Implementation strategy: Remove majority of white pine overstory.
  - Justification: White pine has been planted on several occasions in the watershed, primarily in the Allen Creek compartment. The most recent plantings occurred in the 1980 to stabilize and reclaim areas where soil was removed for construction of the dam. In many areas these white pine were planted too closely, resulting in intense competition that has left them in poor health and with small live crowns. Consequently, these trees are susceptible to mortality, most likely in the form of an outbreak of southern pine beetle in the next 2-5 years (McNulty 1997). Additionally, it is in keeping with aforementioned management objectives to restore naturally occurring forests. While white pine is a native species, the sites in which it was planted are mostly hardwood sites. In some areas, abundant native hardwoods are regenerating beneath the white pine canopy. In these areas, removal of the white pine would quickly result in a young stand of native hardwoods. Some of the healthiest white pines and mature hardwoods that became established at the same time as the pines should be left in the overstory to create stand structure and provide a seed source.

  - Implementation strategy: Enhance the vigor of selected dominant and codominant white pines through crown thinnings that reduces stand basal area by approximately 1/3. Appropriate application of this treatment will require that an experienced forester select residual trees (trees to favor) based on species, health, form, and desire to maintain a diverse, naturally occurring mix of overstory tree species. Select residual white pines (trees to favor) based on health and form. All residual pines should have at least a 1:3 live crown to height ratio. Mature and healthy hardwoods should also be favored as residuals where found.

- <u>Justification:</u> In many areas this white pine was planted too closely, resulting in intense competition that has left them in poor health and with small live crowns. Consequently, these trees are very susceptible to mortality, most likely in the form of an outbreak of southern pine beetle in the next 2-5 years (McNulty 1997). While nearly all overstory trees should be removed in areas where all trees are in poor health, areas which have a large number of healthy white pines should be thinned, leaving residuals for harvest in 10-20 years. Also, areas that lack advanced hardwood regeneration should be thinned to promote new regeneration and to maintain continuous canopy coverage. Crown thinning would promote the vigor of selected trees and would speed the differentiation of trees into different crown classes (Smith et al. 1997).

<u>Dry Coniferous Forests (Category X)</u>

- *<u>Objectives:</u> Restore pine-oak woodland condition.*
  - <u>Implementation strategy:</u> Reduce amount of laurel, scrub hardwoods, and other woody species. This can be accomplished through an initial fuel reduction burn, chemical treatments, or mechanical treatments (Waldrop 2002). Where possible, existing pines should be protected from these treatments. In addition, existing pines should be released from competing hardwoods surrounding them to ensure their survival until broader actions are taken to restore this type. After initial fuel reduction treatments, the open woodland can be maintained by low-intensity prescribed burning at frequent intervals (perhaps once every 3 to 5 years) (Waldrop 2002). Pines will also need to be planted to fully restore the natural condition of this type.
  - <u>Justification:</u> Pitch and table mountain pine forests have become increasingly rare since the era of fire suppression began in the 1930s. Since then, these forests have become increasingly dominated by oak species and red maple, with a dense understory of mountain laurel (Williams 1998). Because these pine species need full sun and mineral soil to regenerate, the lack of fire which would open up more light to the forest understory will cause these forests to fully transition to oak and red maple dominance the near future. Restoration treatments are necessary to ensure this cover type remains part of the watershed.

Early Successional Forests (Category M)

- *Objectives: Release 30 stems per acre from competition. .*
    - Implementation strategy: About 30 crop trees per acre (average of about 50 ft. spacing between trees) should be selected for release. Crop tree should be selected in order to enhance stand diversity and to potentially increase future commercial value. Crop trees should be healthy, of good form, with live crown ratios ≥ 30%. Crop trees should be released by removing all trees with crowns that touch or shade their crown. Competing trees can be removed by chemical treatment (stem injection or basal bark application) or mechanically (Perkey 2001).
    - Justification: Crop Tree Release (CTR) is a forest management technique that can enhance growth and diversity of a forest stand by reducing trees surrounding and competing with pre-selected "crop trees" (Miller and Kochenderfer 1998, Miller 2000). Crop trees are trees selected for their larger crowns, large diameters, superior form, superior health, preferred aesthetic beauty and/or type of species compared to competing trees. Crop trees are often selected to increase diversity. For example, the watershed's early successional rich cove forests, clear-cut in the 1980s, have regenerated as 90% yellow poplar. Crop trees may be selected to represent the other 10% of species such that their relative proportion in the stand may increase and thereby increase overall diversity.

Table 11. Changes in age class distribution in each compartment over time assuming 10% of each compartment is regenerated every 10 years according to the following sequence. In the following table numbers in bold are ages and numbers in brackets refer to the percent of that age class in the compartment.

Treatment Year	Management compartment				
	Shiny	Old Bald	Cherry Cove	Deep Gap/Allen Creek-Reservoir/Bearpen	Rocky Branch/Steestachee
2010				**0**[10]-**80**[90]	
2012					**0**[10]-**80**[90]
2014		**0**[10]-**80**[90]			
2016			**0**[10]-**80**[90]		
2018	**0**[10]-**80**[90]				
2020				**0**[10]-**10**[10]-**90**[80]	
2022					**0**[10]-**10**[10]-**90**[80]
2024		**0**[10]-**10**[10]-**90**[80]			
2026			**0**[10]-**10**[10]-**90**[80]		
2028	**0**[10]-**10**[10]-**90**[80]				
2030				**0**[10]-**10**[10]-**20**[10-**100**[70]	
2032					**0**[10]-**10**[10]-**20**[10-**100**[70]
2034		**0**[10]-**10**[10]-**20**[10-**100**[70]			
2036			**0**[10]-**10**[10]-**20**[10-**100**[70]		
2038	**0**[10]-**10**[10]-**20**[10-**100**[70]				
2040				**0**[10]-**10**[10]-**20**[10]-**30**[10]-**110**[60]	
2042					**0**[10]-**10**[10]-**20**[10]-**30**[10]-**110**[60]
2044		**0**[10]-**10**[10]-**20**[10]-**30**[10]-**110**[60]			
2046			**0**[10]-**10**[10]-**20**[10]-**30**[10]-**110**[60]		
2048	**0**[10]-**10**[10]-**20**[10]-**30**[10]-**110**[60]				
2050				**0**[10]-**10**[10]-**20**[10]-**30**[10]-**40**[10]-**120**[60]	

Table 12. Acres by Cover Type and Sub-Watershed								
Type	**Shiny**	**Old Bald**	**Cherry Cove**	**Deep Gap**	**Allen Creek-Reservoir**	**Rocky Branch**	**Steestachee**	**Bearpen**
Southern Appalachian Northern Hardwood Forest (Red Oak Type)	157	297	343	235	0	110	108	0
Southern Appalachian Northern Hardwood Forest (Typic Type)	350	483	276	0	0	65	0	0
High-Elevation Red Oak Forest (Deciduous Shrub Type)	116	186	116	366	0	103	38	0
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	0	195	62	173	316	16	1	12
Southern Appalachian Acid Cove Forest (Typic Type)	86	173	142	241	28	61	46	30
Red Spruce - Northern Hardwood Forest (Shrub Type)	378	0	278	0	0	0	0	0
Chestnut Oak Forest (Xeric Ridge Type)	165	143	18	129	28	19	13	102
Southern Appalachian Cove Forest (Typic Montane Type)	113	67	99	0	40	17	17	145
Southern Appalachian Northern Hardwood Forest (Rich Type)	23	21	102	92	0	0	39	0
Red Spruce - Northern Hardwood Forest (Herb Type)	218	0	56	0	0	0	0	0
Early Successional Montane Oak Hickory/White Pine Forest	0	0	0	0	22	10	202	0
Blue Ridge Hemlock - Northern Hardwood Forest	209	0	0	0	0	0	0	0
Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type)	0	0	0	0	0	167	0	0
Early Successional Cove Forest	47	0	72	0	11	0	0	0
Early Successional Northern Hardwood Forest	50	61	0	0	0	0	0	0
Eastern White Pine Successional Forest	0	5	0	2	65	0	6	0
Reservoir	0	0	0	0	51	0	0	0
Grassy Bald (Southern Grass Type)	40	0	0	0	0	0	0	0
Southern Appalachian Boulderfield Forest (Typic Type)	34	0	0	0	0	0	0	0
Appalachian Montane Alluvial Forest	0	0	0	0	32	0	0	0
Appalachian Felsic Cliff	15	0	6	0	0	0	0	0
Cove Forest/White Pine Successional Forest	0	0	0	0	17	0	0	0
Meadow	0	0	0	0	13	0	1	0
Rocky Bar and Shore (Alder - Yellowroot Type)	7	0	0	0	4	0	0	0
Total Acres	**2,009**	**1,631**	**1,569**	**1,239**	**649**	**568**	**471**	**291**

Table 13. Area (ac) by forest cover type and management category				
Type	**Protected Habitats**	**Riparian Zones**	**Manageable (Mesic)**	**Manageable (Xeric)**
Southern Appalachian Northern Hardwood Forest (Red Oak Type)	140*	116	995	0
Southern Appalachian Northern Hardwood Forest (Typic Type)	11	161	1,001	0
High-Elevation Red Oak Forest (Deciduous Shrub Type)	288*	58	579	0
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	17*	79	688	0
Red Spruce - Northern Hardwood Forest (Shrub Type)	607	50	0	0
Chestnut Oak Forest (Xeric Ridge Type)	96*	48	0	466
Southern Appalachian Acid Cove Forest (Typic Type)	31*	303	443	0
Southern Appalachian Cove Forest (Typic Montane Type)	116*	55	326	0
Red Spruce - Northern Hardwood Forest (Herb Type)	254	20	0	0
Southern Appalachian Northern Hardwood Forest (Rich Type)	0	53	224	0
Early Successional Montane Oak Hickory/White Pine Forest	0	27	209	0
Blue Ridge Hemlock - Northern Hardwood Forest	170	39	0	0
Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic)	0	16	0	151
Early Successional Cove Forest	0	14	111	0
Early Successional Northern Hardwood Forest	0	17	94	0
Eastern White Pine Successional Forest	0	15	60	0
Grassy Bald (Southern Grass Type)	39	2	0	0
Southern Appalachian Boulderfield Forest (Typic Type)	16	17	0	0
Cove Forest/White Pine Successional Forest	0	4	14	0
Appalachian Montane Alluvial Forest	14	18	0	0
Appalachian Felsic Cliff	11	10	0	0
Meadow	0	5	7	0
Rocky Bar and Shore (Alder - Yellowroot Type)	5	6	0	0
Early Successional Eastern White Pine Forest	0	15	2	0
Total Acres	**1,127**	**1,139**	**5,323**	**735**

Table 14. Area (ac) by Management category and sub-watershed								
Management	**Shiny**	**Old Bald**	**Cherry Cove**	**Deep Gap**	**Allen Creek-Reservoir**	**Rocky Branch**	**Steestachee**	**Bearpen**
Potential Management (Mesic)	789	1,267	1,039	557	410	321	393	27
Stream 50' Buffers	270	208	203	184	98	77	66	34
Protected Habitat	800	0	311	390*	15	0	0	214*
Potential Management (Xeric)	150	156	17	108	23	170	13	16
Reservoir 300' Buffer	0	0	0	0	50	0	0	0
Reservoir	0	0	0	0	48	0	0	0
**Acreage protected by Forever Wild Conservation Easement*								

Table 15. Desired stand conditions: This table outlines up to 3 desired conditions for each stand type. These are stand conditions that can be achieved during the next 20 years with a single stand treatment. These do not reflect the total goal of desired forest conditions for each stand type, but instead reflect a reasonable set of conditions that will begin the process of creating a more diverse watershed forest.

Forest Type	Mgmt cat.	Ac	Desired conditions	Prescription
Southern Appalachian Northern Hardwood Forest (Red Oak Type)	**M**	**1254**	1. Mature, even-aged forest condition. 2. Mature overstory with gaps in the canopy designed to stimulate regeneration of new age class and the development of multiple aged stand structure 3. Reduce overstory stand density in order to enhance vigor of selected canopy trees and to allow the opportunistic establishment of selected regeneration. Where possible favor species that enhance diversity and have potentially high commercial value	1. No treatment 2. Group selection harvests creating gaps ½ to 2 acre in size 3. Crown thinning to reduce residual basal area to about 80 ft^2 per acre
Southern Appalachian Northern Hardwood Forest (Typic Type)	**M**	**1174**	1. Mature, even-aged forest. 2. Mature overstory with gaps in the canopy designed to stimulate regeneration of new age class and the development of multiple aged stand structure. 3. Reduce overstory stand density in order to enhance vigor of selected canopy trees and to allow the establishment of selected regeneration. Where possible favor species that enhance diversity and have potentially high commercial value	1. No treatment 2. Group selection harvests creating gaps ½ to 2 acre in size 3. Crown thinning to reduce residual basal area to about 80 ft^2 per acre

High-Elevation Red Oak Forest (Deciduous Shrub Type)	**M**	**1022**	1. Mature, even-aged forest condition. 2. Mature overstory with gaps in the canopy designed to stimulate regeneration of new age class and development of multiple aged stand structure 3. Reduce overstory stand density in order to enhance vigor of selected canopy trees and to allow the establishment of selected regeneration. Where possible favor species that enhance diversity and have potentially high commercial value	1. No treatment 2. Group selection harvests creating gaps ½ to 5 acre in size 3. Crown thinning to reduce residual basal area to about 80 ft^2 per acre
Southern Appalachian Acid Cove Forest (Typic Type)	**M**	**788**	1. Mature, even-aged forest condition. 2. Mature overstory with gaps in the canopy designed to stimulate regeneration of new age class	1. No treatment 2. Group selection harvests creating gaps ≤ ½ acre in size
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	**M**	**800**	1. Mature, even-aged forest condition. 2. Mature overstory with gaps in the canopy designed to stimulate regeneration of new age class 3. Reduce overstory stand density in order to enhance vigor of selected canopy trees and to allow the establishment of selected regeneration. Where possible favor high value stems in the overstory	1. No treatment 2. Group selection harvests creating gaps ½ to 5 acre in size 3. Crown thinning to reduce residual basal area to about 80 ft^2 per acre
Red Spruce - Northern Hardwood Forest (Shrub Type)	**P**	**663**	1. Unique forest type, maintain in current forest condition. 2. Future studies or knowledge may indicate possible habitat restoration treatments	1. No treatment 2. No planned treatments at this time

Chestnut Oak Forest (Xeric Ridge Type)	**X**	**632**	1. Mature, even-aged forest condition. 2. Mature overstory with gaps in the canopy designed to stimulate regeneration of new age class 3. Restoration of open oak woodland, with open overstory allowing abundant light to reach the forest floor.	1. No treatment 2. Group selection harvests creating gaps ½ to 5 acre in size 3. Initiation of frequent, low-intensity ground fires, possibly in combination with other treatments to reduce component of laurel, red maple, and other undesirable species
Southern Appalachian Cove Forest (Typic Montane Type)	**M**	**500**	1. Mature, even-aged forest condition. 2. Mature overstory with gaps in the canopy designed to stimulate regeneration of new age class 3. Reduce overstory stand density in order to enhance vigor of selected canopy trees and to allow the opportunistic establishment of selected regeneration. Where possible favor species that enhance diversity and have potentially high commercial value	1. No treatment 2. Group selection harvests creating gaps ½ to 2 acre in size 3. Crown thinning to reduce residual basal area to about 80 ft^2 per acre
Red Spruce - Northern Hardwood Forest (Herb Type)	**P**	**290**	1. Unique forest type, maintain in current forest condition. 2. Future studies or knowledge may indicate possible habitat restoration treatments	1. No treatment 2. No planned treatments at this time
Southern Appalachian Northern Hardwood Forest (Rich Type)	**M**	**277**	1. Mature, even-aged forest condition. 2. Mature overstory with gaps in the canopy designed to stimulate regeneration of new age class 3. Reduce overstory stand density in order to enhance vigor of selected canopy trees and to allow the opportunistic establishment of selected regeneration. Where possible favor species that enhance diversity and have potentially high commercial value	1. No treatment 2. Group selection harvests creating gaps ½ to 2 acre in size 3. Crown thinning to reduce residual basal area to about 80 ft^2 per acre

Early Successional Montane Oak Hickory/White Pine Forest	**M**	**239**	1. Even-aged, fully stocked, pole sized coppice stand. 2. Even-aged, poles-sized coppice stand with about 30 stems released to be free to grow on 4 sides	1. No treatment 2. Crop tree release treatments on about 30 stems per acre evenly distributed throughout stand. Crop trees should be released on all sides by chemically or mechanically treating competing stems
Blue Ridge Hemlock - Northern Hardwood Forest	**P**	**211**	1. Unique forest type, maintain in current forest condition. 2. Future studies or knowledge may indicate possible habitat restoration treatments	1. No treatment 2. No planned treatments at this time
Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type)	**X**	**174**	1. Mature scrub oak and mixed hardwood stand with dense laurel and shrub understory. 2. Restoration of open oak woodland, with open overstory allowing abundant light to reach the forest floor.	1. No treatment 2. Initiation of frequent, low-intensity ground fires, possibly in combination with other treatments to reduce component of hardwoods, laurel, and other undesirable species.
Early Successional Cove Forest	**M**	**130**	1. Even-aged, fully stocked, pole sized coppice stand. 2. Even-aged, poles-sized coppice stand with about 30 stems released to be free to grow on 4 sides.	1. No treatment 2. Crop tree release treatments on about 30 stems per acre evenly distributed throughout stand. Crop trees should be released on all sides by chemically or mechanically treating competing stems
Early Successional Northern Hardwood Forest	**M**	**111**	1. Even-aged, fully stocked, pole sized coppice stand. 2. Even-aged, poles-sized coppice stand with about 30 stems released to be free to grow on 4 sides	1. No treatment 2. Crop tree release treatments on about 30 stems per acre evenly distributed throughout stand. Crop trees should be released on all sides by chemically or mechanically treating competing stems

Eastern White Pine Successional Forest	**M**	**79**	1. Mature, even-aged forest condition allowing mortality of the white pines in the overstory (minimally desirable). 2. Mature overstory of mixed pines and hardwoods with gaps in the canopy designed to stimulate regeneration of new age class 3. Removal of white pine from the overstory.	1. No treatment 2. A combination of crown thinning and group selection harvests. Goal is to remove most of the overstory white pine with a live crown ratio ≤ 30%, and selected low quality stems of other species. Create canopy gaps ranging from ½ to 5 acre in size. 3. Remove all white pine from the overstory
Grassy Bald (Southern Grass Type)	**P**	**44**	1. Unique community type, maintain in current forest condition. 2. Future studies or knowledge may indicate possible habitat restoration treatments	1. Mowing or other treatment 2. No planned treatments at this time
Southern Appalachian Boulderfield Forest (Typic Type)	**P**	**34**	1. Unique forest type, maintain in current forest condition. 2. Future studies or knowledge may indicate possible habitat restoration treatments	1. No treatment 2. No planned treatments at this time
Appalachian Montane Alluvial Forest	**P**	**33**	1. Unique forest type, allow natural stand development to occur 2. Future studies or knowledge may indicate possible habitat restoration treatments	1. No treatment 2. No planned treatments at this time
Appalachian Felsic Cliff	**P**	**21**	1. Unique land cover type, allow natural stand development to occur 2. Future studies or knowledge may indicate possible habitat restoration treatments	1. No treatment 2. No planned treatments at this time

Meadow	**P**	**17**	1. Unique community type, maintain in current forest condition. 2. Future studies or knowledge may indicate possible habitat restoration treatments	1. Mowing or other treatment 2. No planned treatments at this time
Cove Forest/White Pine Successional Forest	**M**	**17**	1. Mature, even-aged forest condition allowing mortality of the white pines in the overstory. 2. Mature overstory of mixed pines and hardwoods with gaps in the canopy designed to stimulate regeneration of new age class	1. No treatment 2. A combination of crown thinning and group selection harvests. Goal is to remove most of the overstory white pine with a live crown ratio ≤ 30%, and selected low quality stems of other species. Create canopy gaps ranging from ½ to 5 acre in size.
Rocky Bar and Shore (Alder - Yellowroot Type)	**P**	**11**	1. Unique forest type, maintain in current forest condition. 2. Future studies or knowledge may indicate possible habitat restoration treatments	1. No treatment 2. No planned treatments at this time

Table 16. **Silvicultural treatments proposed to achieve reference conditions for major habitat types.**

Forest Habitat Type	Forest Cover Types Included			
		Desired condition for stands at the understory reinitiation stage of stand development, or later		
		Maintain condition, allow stand to develop naturally	**Unique habitat restoration**	
Spruce-Fir Forests	• **Red Spruce - Northern Hardwood Forest (Shrub Type)** • **Red Spruce - Northern Hardwood Forest**	No treatment	Restoration goals and treatments not defined at this time	
		Desired condition		
		Maintain condition, allow stand to develop naturally	**Maintain mature overstory, create gaps to initiate regeneration**	**Reduce overstory stand density to increase vigor of residual stems**
Northern Hardwood Forests	• **Blue Ridge Hemlock - Northern Hardwood Forest** • **Northern Hardwood Forest (Red Oak Type)** • **Northern Hardwood Forest (Typic Type)** • **Northern Hardwood Forest (Rich Type)**	No treatment	Regeneration will be accomplished by creating small gaps in the canopy. Because the goal will be to regenerate shade tolerant species typical of the northern hardwood stand types, gaps will be less than ½ acre in size. The Red Oak Type is an exception to this gap size because it is dominated by shade intermediate northern red oak and shade intolerant black cherry. Gaps in this type will range from less than ½ acre to 2 acres in size.	Crown thinning (removal of trees with crowns in the upper canopy) will be implemented to achieve this objective. Overstory basal area will be reduced by about $1/3^{rd}$ to about 80 ft^2 of basal area per acre. The goals are to promote vigor of the trees remaining after thinning and to enhance stand diversity and future stand value. Desired residual stems should represent a mixture of northern hardwood species, be healthy, and of relatively good form. Trees selected for removal during the thinning will be those that are competing with desired residual stems. In

				some cases it may be preferable to girdle or chemically treat undesirable stems rather than felling them.
Cove Forests	• **Appalachian Acid Cove Forest** • **Appalachian Cove Forest**	**Desired condition**		
		Maintain condition, allow stand to develop naturally	**Maintain mature overstory, create gaps to initiate regeneration**	**Reduce overstory stand density to increase vigor of residual stems**
		No treatment	Regeneration will be accomplished by creating small gaps in the canopy that will regenerate to a mixture of both tolerant and intolerant species typical of cove forests. Gaps will range in size to facilitate this pattern of regeneration. Smaller gaps (< ½ ac) will favor more tolerant species and larger gaps (up to 2 ac) will favor less tolerant species.	Crown thinning (removal of trees with crowns in the upper canopy) will be implemented to achieve this objective. Overstory basal area will be reduced by about 1/3rd to about 80 ft^2 of basal area per acre. The goals are to promote vigor of the trees remaining after thinning and to enhance stand diversity and future stand value. Desired residual stems should represent a mixture of cove hardwood species, be healthy, and of relatively good form. Trees selected for removal during the thinning will be those that are competing with desired residual stems. In some cases it may be preferable to girdle or chemically treat undesirable stems rather than felling them.
Dry Coniferous Forest	• **Blue Ridge Table Mountain Pine - Pitch Pine Woodland**	**Desired condition**		
		Maintain condition, allow stand to develop naturally	**Restoration of oak woodland condition**	
		No treatment	This condition requires the removal of laurel, scrub hardwoods, and other woody species that occupy these sites in order to create an open pine woodland with abundant sunlight reaching the forest floor. This can be accomplished through an initial fuel reduction burn, chemical treatments, or mechanical treatments. Where possible, existing pines should be protected from these treatments. The open woodland can be maintained by prescribed burning at frequent intervals	

			(perhaps once every 3 to 5 years). Pines will also need to be planted to fully restore the natural condition of this type.	
Eastern White Pine Successional Forest	• **Eastern White Pine Successional Forest**	**Desired condition**		
		Mature, even-aged forest condition allowing mortality of the white pines in the overstory	**Mature overstory of mixed pines and hardwoods with gaps in the canopy designed to stimulate regeneration of new age class**	**Removal of white pine from the overstory**
		No treatment	A combination of crown thinning and group selection harvests. Goal is to remove most of the overstory white pine with a live crown ratio ≤ 30%, and selected low quality stems of other species. Create canopy gaps ranging from ½ to 5 acre in size.	Remove all white pine from the overstory
Oak Forests	• **High-Elevation Red Oak Forest (Deciduous Shrub Type)** • **Montane Oak Hickory Forest** • **Chestnut Oak Forest (Xeric Ridge Type)**	**Desired condition**		
		Maintain condition, allow stand to develop naturally	**Maintain mature overstory, create gaps to initiate regeneration**	**Reduce overstory stand density to increase vigor of residual stems**
		No treatment	Regeneration will be accomplished by creating small gaps in the canopy that will favor a significant amount of oak. This will be accomplished be creating gaps that range from ½ to 5 ac in size. It will be necessary to monitor the regeneration that occurs in these gaps to ensure the growth and survival of the oaks. In some cases it may be necessary to release desired oak seedlings and saplings from other species that	Crown thinning (removal of trees with crowns in the upper canopy) will be implemented to achieve this objective. Overstory basal area will be reduced by about 1/3rd to about 80 ft^2 of basal area per acre. The goals are to promote vigor of the trees remaining after thinning and to favor the continued presence of oak in the overstory of these stands. Desired residual stems should favor a mixture of oak and hickory species, be healthy, and of relatively good form. Trees selected for removal during the thinning will be those

			are overtopping them.	that are competing with desired residual stems. In most cases it will also be desirable to remove red maple, black birch, and other more tolerant species that are replacing oaks in the overstory. In some cases it may be preferable to girdle or chemically treat undesirable stems rather than felling them.
Early successional Forests	• **Montane Oak Hickory/White Pine Forest** • **Cove Forest** • **Northern Hardwood Forest**	**Desired condition for Early successional stands not past the stem exclusion stage of stand development.**		
		Even-aged, fully-stocked pole size stand		**Even-aged, fully stocked pole-sized stands with about 30 stems per acre released**
		No treatment		About 30 crop trees per acre (average of about 50 ft. spacing between trees) should be selected for release. Crop tree should be selected in order to enhance stand diversity and to potentially increase future commercial value. Crop trees should be healthy, of good form, with live crown ratios ≥ 30%. Crop trees should be released by removing all trees with crowns that touch or shade their crown. Competing trees can be removed by chemical treatment (stem injection or basal bark application) or mechanically.

Implementation of Forest Stewardship Strategy for First Five Years

We believe the town should gradually begin the process of implementing an active forest management program in the watershed, and we propose that the first treatments occur in the successional white pine stands located in the Allen/Creek Reservoir compartment. These pines were planted to stabilize soils around the reservoir, and do not represent natural stand conditions. In some areas, natural hardwood regeneration has developed in these stands, and those hardwoods are ready to be freed from the white pine competition. Furthermore, the pines are approaching maturity, and are becoming increasingly susceptible to bark beetle attacks should we enter another period of drought. There are already some white pine stands that have suffered severe mortality from past beetle attacks. These areas also have relatively flat topography, which would make it a good place to demonstrate management practices within the watershed.

We believe the Rocky Branch subwatershed presents another good opportunity. The topography and stand types in this subwatershed are more typical of the rest of the watershed property, yet this area does not drain into the reservoir. We believe this would be a logical place to continue the demonstration process.

We suggest the following timeline of activities:

2008: Continue collecting baseline water quality data, develop and implement a continuous forest inventory system, and conduct initial assessment of road/stream intersections (Map 13). As discussed in the monitoring section of this report, a set of indicators should be developed to determine whether key management objectives are being met. At the very least, initial indicators should be developed for assessing potential changes in water quality and forest condition, as reflected in diversity of forest types.

2009: Finalize continuous forest inventory system. Begin planning treatment in Eastern White Pine Successional Forests and Cove Forest/White Pine Successional forests in Allen Creek Compartment.

2010: Finalize planning for treatment in Eastern White Pine Successional Forests and Cove Forest/White Pine Successional forests in Allen Creek Compartment including marking all timber and developing timber contracts. Complete timber sale by the winter of 2010/2011. Perform crop tree release treatments in early successional forests in Shiny Creek Compartment.

2011: Begin planning treatment of 140 acres of various types in Rocky Branch Compartment and perform crop tree release treatments in early successional forests in Cherry Cove Compartment. Perform release treatments for survival of pitch and table mountain pine within Rocky Branch compartment.

2012: Finalize planning and implement treatment of 140 acres of various types in Rocky Branch Compartment and perform crop tree release treatments in early successional forests in Cherry Cove Compartment. Perform release treatments for survival of pitch and table mountain pine within Rocky Branch compartment.

2013: Evaluate results of forest management strategy in relationship to objectives. Develop new, long-term, forest stewardship plan that outlines management practices to be implemented over the next 10 to 20 years.

Tables 17 and 18 and Maps 16 and 17 describe the specific management activities and locations for these initial treatments.

Table 17. Allen Creek/Reservoir 2008-2010 Treatments by Acreage and Type
2008-2010 Sub-watershed Regeneration: 7.7%, Thinning: 6.3%
2008-2010 Entire Manageable Area of Watershed Regeneration: 0.7%, Thinning: 0.6%

Type	Total Acres	2010 Thinning Acres	2010 Regeneration Acres
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	316	0	0
Southern Appalachian Acid Cove Forest (Typic Type)	28	0	0
Chestnut Oak Forest (Xeric Ridge Type)	28	0	0
Southern Appalachian Cove Forest (Typic Montane Type)	40	0	0
Early Successional Montane Oak Hickory/White Pine Forest	22	0	0
Early Successional Cove Forest	11	0	0
Eastern White Pine Successional Forest	65	25	40
Appalachian Montane Alluvial Forest	32	0	0
Cove Forest/White PIne Successional Forest	17	12	5
Rocky Bar and Shore (Alder - Yellowroot Type)	4	0	0
Total	585	37	45

Table 18. Rocky Branch 2011-2012 Treatments by Acreage and Type
2011-2012 Sub-watershed Regeneration: 12.5%, Thinning: 12.5%
2011-2012 Entire Manageable Area of Watershed Regeneration: 1.2%, Thinning: 1.2%

Type	Total Acres	2011 Thinning Acres	2011 Regeneration Acres
Southern Appalachian Northern Hardwood Forest (Red Oak Type)	110	35	15
Southern Appalachian Northern Hardwood Forest (Typic Type)	65	20	10
High-Elevation Red Oak Forest (Deciduous Shrub Type)	103	0	40
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	16	5	0
Southern Appalachian Acid Cove Forest (Typic Type)	61	0	0
Chestnut Oak Forest (Xeric Ridge Type)	19	0	5
Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type)	167	0	0
Southern Appalachian Cove Forest (Typic Montane Type)	17	10	0
Total	558	70	70

Watershed Monitoring

It is important to monitor a variety of biophysical conditions in the watershed to ensure that overall management objectives are being satisfied, and in the sections below we outline a number of factors that should be monitored. We believe it is important that the Town of Waynesville take to heart the information discussed during the workshops conducted in 2005 to develop indicators of sustainability (Bates et al. 2006). To be useful, these indicators should be metrics that can be practically measured and which provide a quantitative assessment as to whether management objectives are being achieved (Hagan and Whitman 2004). In particular we feel it is important to develop indicators related to water quality (Turbidity and Total Suspended Solids as per SD2, Water Quality Assessment), Aquatic health (EPT populations as per SD3, Aquatic Health assessment), and forest condition (we propose developing an index of forest diversity that will serve as a surrogate for forest health). Other indicators related to other watershed values can also be developed for important resource values.

<u>Continuous Forest Inventory (CFI)</u>
The intent of CFI is to gather periodically updated information on the current condition of the forest, sufficient to guide the improvement of both water and forest values on the watershed. The objectives include an assessment of the current vegetative cover that may be compared to past assessments and thus allow for projections of future conditions. Current and expected future conditions can then be compared against ideal conditions, and adjustments to management strategy may be adopted in the process of managing toward that ideal.

We propose a system of 200 permanent plots that are evenly distributed between sub-watersheds and forest cover types (Tables 19 and 20). This system of plots should be remeasured at least every ten years. At each plot, we will measure overstory tree species greater than 2 inches dbh using a 10 BAF variable radius plot. We will measure understory advanced woody regeneration >4.5 feet and less than 2 inches dbh in a 1/50th acre plot and woody regeneration between 1 foot and 4.5 feet in a 1/100th acre plot. Shrub and groundstory attributes will be measured as percent coverage within a 1/50th acre plot Groundstory attributes will include coarse wood debris >6' diameter, moss and lichen, ferns, herbs/forbs, grass/sedge, blackberry, buffalonut, invasives, and rock/boulder. For the shrub layer, coverage will be estimated at 0-1 and 2-5 meter heights. Shrub layer measurements will include shrubs (deciduous), shrubs (evergreen), rhododendron, and mountain laurel. Plots will be located and measurements will be documented in a manner that allows for efficient data collection and interpretation to be made every 10 years.

<u>Water Quality</u>
To date our attention has focused on the collection of high quality data from a single point within the channel, a process that has provided detailed insights into the geochemical nature of the water entering the reservoir and the variations in selected water quality parameters through time. Our future monitoring activities will expand upon these fixed point data by collecting semi-continuous data at an additional 5 sites within the watershed to enhance our understanding of the spatial variations in water quality within the basin. These additional sites, which we expect to be installed by the end of 2008, will be instrumented with a Solinst pressure transducer and a Stevens's turbidity probe. The pressure transducers provide information on surface water elevations, flow depths, and temperature within the channel, thereby allowing for the estimation

of discharge. These particular devices are self-contained, meaning that they both record and store the information in a digital format until it is downloaded onto a laptop for easy manipulation. They can be placed within a stilling well on the side of the channel or, more frequently, within a perforated metal pipe anchored in the channel. We typically collect depth measurements at 5-minute time intervals. The Stevens turbidity probes are also designed for the collection and storage of continuous data in a digital format. Three of the units are self-contained and can be installed directly in the channel, while the remaining two units are linked via a cable to 12-Volt (marine) battery along the side of the channel. Both types allow for the collection of turbidity measurements at sub-minute intervals, although we will likely collect information at 5-minute increments. Because the utilized probes can be easily moved, these roaming site monitoring stations will allow for a detailed analysis of the spatial variations in discharge within the watershed prior to any management activities.

The potential impacts of future management activities on water quality will be determined using a multi-pronged approach which involves the collection of data over differing scales of space and time. Because the investigated water quality parameters vary as a function of the flow conditions within the channel, the magnitude of the measured parameters must be interpreted on the basis of the discharge for which they were collected. Thus, a common approach to determine changes in water quality in other areas has been to document differences in the statistical relationships between discharge and total suspended solids (TSS), or between discharge and turbidity. Although such an approach is now possible using data from the fixed monitoring station, the relationships between these variables in the Waynesville watershed are extremely weak. The approach, then, will need to be modified to identify changes in water quality (unless changes in TSS or turbidity are on the scale of an order of magnitude or more). Improvements upon the approach will likely involve the development of discharge – turbidity/TSS relationships for specific types of flood events, where flood types are classed according to storm intensity, season, etc. as discussed earlier. The approach should allow for the development of much stronger discharge-TSS/turbidity relationships, and for the identification of more subtle changes in water quality.

A closely related methodology using the fixed station data will be to examine peak TSS and turbidity values for individual storms of a given storm type, and the nature of the hysteretic loops which accompany them. This will provide insights into changes in the peak values which occur, if any, as well as potential changes in the source of those sediments (as described earlier).

In addition to the examination of discharge-turbidity/TSS relations, we will monitor changes in the frequency with which flows of a given turbidity or TSS occur. This approach will involve the development of frequency histograms and cumulative frequency curves depicting the frequency during which flows of a given turbidity or TSS occur during a 6-month period. For example, these data may show that for a given six month period, a turbidity value of 10 NTUs was exceeded 1 percent of the time. Clearly, this approach represents a long-term analysis of water quality change, but one which is likely to identify even minor alterations in TSS or turbidity and be indicative of cumulative impacts.

Data from the roaming sites, instrumented with stage (water depth), temperature, and turbidity probes, will also be extensively utilized to identify potential changes in water quality. These analyses fall into two categorizes: at-a-station analyses and a paired-basin type analyses.

At-a-station analyses will involve the collection of stage (water level), temperature, and turbidity data from one or more sites located immediately downstream of planned management activities, and the comparison of data collected prior to the disturbance to that collected during and following the disturbance. It will be important to locate the roaming stations downstream of the site months in advance (the longer, the better) to obtain as much information on the variability in runoff and sediment loads as possible. In terms of indices, we will concentrate on changes in peak turbidity values during storm events of a given magnitude/frequency range as well changes in the overall frequency with which flows of a given turbidity occur. These indices have proven effective in characterizing water quality responses to storms in the data collected to date. Turbidity is primarily a function of suspended matter. Thus, it will also be necessary to monitor changes in the particle size distribution of the channel bed material to determine if sand-sized or finer sediments are accumulating on (in) the channel bed. Changes in bed material composition will be monitored by selecting 3-6 monitoring sites downstream of the management activity and visually documenting the site's bed material composition, both in the field and through the comparison of photographs of the channel bed, consistently obtained from the same location. Changes in bed composition indicate changes in the sediment budget of a stream and may indicated changes in stream habitat quality.

The paired-basin approach involves the comparison of discharge-turbidity relations of subbasins where management activities are ongoing with subbasins where they are not. This approach relies on data from the roaming stations, which be will installed in 2008. An assumption inherent in the approach is that the control and disturbed subbasins are similar in character. To account for the possible effects of differing basin size, geology, soils, relief, etc. on sediment loads, it may be necessary to normalize the collected information.

There are a number of new, more sophisticated methods of determining the source and timing of sediment to the channel, which may be utilized if funding of these experimental approaches can be obtained. One possible approach involves an examination of the short-lived radionuclide content of the channel bed sediment before, during, and after the management activities. Cesium-137, for example, is a product of nuclear bomb tests of the 1950s and early 1960s. Fallout over North America reached a maximum in 1963, after which its concentrations have declined. In many area, Cs-137 is concentrated in surface soils and its concentration within in a stream channel is related to (1) the amount of upland soil erosion, (2) its mixing with sediment derived from other sources low in Cs-137, such as bank materials, or from deeply eroded gullies, and (3) the residence time of sediment within the channel. Thus, it may be possible to document changes in the source and contribution of sediments to the channel bed by examining alterations in the Cs-137 content of the channel bed sediments before and after management activities have occurred. Similar analyses may also be undertaken using Be-57. A disadvantage of these methods is that they are relatively expensive; thus, they will only be performed if funding can be obtained.

Another experimental study that could be performed if additional funding is secured is to assess the impact of management activities on basin hydrology. For example, commonly there is an increase in overland flow and soil erosion in disturbed land. With the increase in overland flow, there is a reduction in the recharge of groundwater. To better understand any hydrologic impacts of management, as well as potential reasons for changes in sedimentation, studies to determine the pathways of water and the water budget would need to be carried out. There are numerous ways to carry out such a study, but most would involve utilizing chemical and physical traits of water to make inferences about hydrologic pathways. For example, during the summer months, groundwater typically has cooler temperatures, a higher pH, and a high conductivity than storm runoff waters. These traits are reflected in the water quality collected in the Waynesville watershed at the fixed station; stream pH tends to drop during storms because groundwater makes up less of the stream flow. A related method is to monitor stream bed temperatures paired with the temperature about 15 cm below the bed of the stream (temperature data loggers would be used to collect the data and operate similar to other loggers described previously). By analysis of the temperature trends at these paired locations, inferences can be made about the locations and amounts of groundwater contributing to a stream.

Harvest Monitoring

In addition to assessing the condition of the entire watershed it is important to pay special attention to areas where active management has recently taken place. The purpose of this monitoring is to determine whether objectives for the specific management area have been met by comparing post-management conditions to those prior to management. Monitoring should pay special attention to any problems related to water quality in addition to forest overstory and understory conditions. The following form (Fig. 9) provides an example of the attributes that should be assessed following any management operation.

Figure 9. Sample Post Harvest Evaluation Forms

Post Harvest Evaluation

Date:	________	Evaluator:	________
Sale Name:	________	Sub-watershed:	________
Dates Marked:	________	Dates Harvested:	________
Marked Volume:	________	Harvested Volume:	________
Compartments:	________	Operator:	________
Stands:	________	Mode of sale:	________
Area:	________	Sale Price:	________

General Comments

	Excellent	Acceptable	Poor
	None	Some	Excessive
Conditions of Landings:			
Rutting/Erosion:			
Waterbars:			
Roads (graded/graveled):			
Proper Waste Disposal:			
Residual Stand Damage:			
Unmarked Trees Cut:			
Slash Height:			
Notes:			

Post Harvest Overstory

	Years After Harvest					
BA/acre	**0**	**1**	**2**	**3**	**4**	**5**
BF/acre	**0**	**1**	**2**	**3**	**4**	**5**
Stems/acre	**0**	**1**	**2**	**3**	**4**	**5**

Post Harvest Regeneration

	Years After Harvest					
Seedlings/ac	**0**	**1**	**2**	**3**	**4**	**5**
Saplings/ac	**0**	**1**	**2**	**3**	**4**	**5**
% Cover/Height	**0**	**1**	**2**	**3**	**4**	**5**

Road Conditions

Roads used during active management should be visited at least weekly to ensure that erosion control features are in place and functioning properly, and to assess whether operators are abiding by other contractual agreements. Additional road monitoring should be conducted in association with major storm events, where road conditions should be evaluated no later than 12 to 24 hours after the onset of these storms.

All roads should be continuously monitored, throughout the year. This can be accomplished by the watershed staff in coordination with other resource professionals. A system should be devised for documenting the location and cause of problematic road condition, and for reporting this information to the watershed supervisor. Problems should be corrected rapidly to protect water quality and maintain the integrity of road network.

Invasive Species

Exotic invasive species threaten to diminish many of the values provided by the watershed including biodiversity, forest health, and revenue. Currently there is very little evidence of invasive species in the watershed. Because roads and management areas are more prone to the invasion of unwanted exotic species, these areas should be carefully monitored. Once identified, populations of invasive species will be geographically determined and catalogued using GIS. Whether or not to eradicate a given exotic should be decided on a case by case basis, with the understanding that it is most efficient to eradicate early before an invasive has time to spread over a larger area.

Wildlife, Herbaceous Plants, and Other Monitoring

While there are no specific plans set forth at this point to monitor wildlife and herbaceous populations, we hope that such plans will develop in the near future. In keeping with the educational objectives for the watershed, the town should continue to seek out partnerships with public and educational institutions that may provide research and insight. Valuable research would include investigating the long-term relationships between forest stewardship practices as defined in this plan and wildlife and herbaceous species populations.

Table 19. Number of CFI plots in each cover type		
Type	**Acres**	**CFI Plots**
Southern Appalachian Northern Hardwood Forest (Red Oak Type)	**1,254**	**30**
Southern Appalachian Northern Hardwood Forest (Typic Type)	**1,174**	**28**
High-Elevation Red Oak Forest (Deciduous Shrub Type)	**1,022**	**24**
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	**800**	**19**
Southern Appalachian Acid Cove Forest (Typic Type)	**788**	**19**
Red Spruce - Northern Hardwood Forest (Shrub Type)	**663**	**16**
Chestnut Oak Forest (Xeric Ridge Type)	**632**	**15**
Southern Appalachian Cove Forest (Typic Montane Type)	**500**	**13**
Red Spruce - Northern Hardwood Forest (Herb Type)	**290**	**7**
Southern Appalachian Northern Hardwood Forest (Rich Type)	**277**	**7**
Early Successional Montane Oak Hickory/White Pine Forest	**239**	**6**
Blue Ridge Hemlock - Northern Hardwood Forest	**211**	**4**
Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type)	**174**	**3**
Early Successional Cove Forest	**130**	**3**
Early Successional Northern Hardwood Forest	**111**	**3**
Eastern White Pine Successional Forest	**79**	**3**

Table 20. Number of CFI plots by cover type and sub-watershed

Type	Shiny	Old Bald	Cherry Cove	Deep Gap	Allen Creek-Reservoir	Rocky Branch	Steestachee	Bearpen	Total CFI Plots
Southern Appalachian Northern Hardwood Forest (Red Oak Type)	4	7	8	5	0	3	3	0	**30**
Southern Appalachian Northern Hardwood Forest (Typic Type)	8	11	7	0	0	2	0	0	**28**
High-Elevation Red Oak Forest (Deciduous Shrub Type)	3	4	3	9	0	3	2	0	**24**
Appalachian Montane Oak Hickory Forest (Typic Acidic Type)	0	4	2	4	7	1	0	1	**19**
Southern Appalachian Acid Cove Forest (Typic Type)	2	4	3	5	1	2	1	1	**19**
Red Spruce - Northern Hardwood Forest (Shrub Type)	9	0	7	0	0	0	0	0	**16**
Chestnut Oak Forest (Xeric Ridge Type)	3	3	1	3	1	1	1	2	**15**
Southern Appalachian Cove Forest (Typic Montane Type)	3	2	2	0	1	1	1	3	**13**
Southern Appalachian Northern Hardwood Forest (Rich Type)	1	1	2	2	0	0	1	0	**7**
Red Spruce - Northern Hardwood Forest (Herb Type)	5	0	2	0	0	0	0	0	**7**
Early Successional Montane Oak Hickory/White Pine Forest	0	0	0	0	1	1	4	0	**6**
Blue Ridge Hemlock - Northern Hardwood Forest	4	0	0	0	0	0	0	0	**4**
Blue Ridge Table Mountain Pine - Pitch Pine Woodland	0	0	0	0	0	3	0	0	**3**
Early Successional Cove Forest	1	0	2	0	0	0	0	0	**3**
Early Successional Northern Hardwood Forest	1	2	0	0	0	0	0	0	**3**
Eastern White Pine Successional Forest	0	0	0	0	3	0	0	0	**3**
Total CFI Plots	**44**	**38**	**39**	**28**	**14**	**17**	**13**	**7**	**200**

Contracts and other operational concerns

It can be argued that the manner in which forest management activities are implemented on the ground is the most critical factor in determining their success. As such, all forest management activities will be carried out by skilled operators utilizing equipment suitable for the designated job. Most forest practitioners are required to receive a minimal amount of safety training in order to secure adequate insurance coverage; however, the Town of Waynesville, should also require that operators be competent in the skills required to work in a productive and environmentally friendly manner. Such competence might be demonstrated by proof of attendance at training workshops and short courses, and examples of work completed in similar forest and topographic conditions.

Conservation easement requirements

The Working Forest Conservation easement provides the following language concerning pre-approval and oversight responsibilities of the easement holders:

Prior to any harvest of timber, a harvest plan must be prepared by a registered forester and submitted to the Designated Party, along with the expected date of initiation of the harvest and all related management activity, for its review in accordance with the notice on review provisions of Article VIII, Paragraph J.

Forest management contracts

Contracts between the town of Waynesville and logging operators will be written in a manner that is consistent with the management objectives and guiding principles set forth in this plan. All contracts should be approved by the Waynesville Town Attorney to ensure that the Town's interests are being fully protected. While some contract details will vary due to the specific objectives and particulars of any given operation, the following principles shall be covered under any contract agreement:

- *Registered Forester*: It is highly recommended that the Town use a NC registered forester as its agent in overseeing logging operations and enforcement of the contract.
- *Payment*: Payment arrangements can be set up in a number of different ways, each having some benefits and constraints. The details of how payment is arranged should maximize the interests of the town by receiving the highest possible price for the timber while achieving all other objectives.
- *Performance bond*: A specified amount, often approximated at 10% of the estimated timber value, shall be deposited with the Town (or its agent) prior to timber harvesting. The Town (or its agent) will hold this deposit to be returned only when the terms of the contract have satisfactorily completed.
- *Insurance*: The timber operator will furnish the Town with a certificate of public liability insurance covering the period of logging operations on the Town's property for: $1,000,000 single limit liability for personal injury or $1,000,000 bodily injury per person and $1,000,000 per occurrence; and (b) $100,000 property damage. The operator

shall agree to protect, defend, indemnify, and save the Town and Town's agents harmless from any and all claims, judgments, orders, decrees, awards, costs, expenses, including attorney's fees, settlements, and claims on account of damage to property or personal injury, including death.

- *Time Frame*: The contract shall state a specific time frame in which harvesting operations should begin and be completed. The contract shall require that the logger notify the Town or its agent before beginning operations and after operations have ceased.
- *Harvest plan*: The logger is to abide by a written harvest plan prepared by a NC registered forester that states the means by which timber is to be harvested and removed. This plan will state how roads are trails will be constructed or improved to extract timber, how water crossings and other sensitive areas will be managed, what timber shall be harvested (i.e. only timber marked with blue paint or only white pine etc.), and by what means the timber shall be transported from stump to landing. The operator is required to remove all timber designated for harvest and the town's forester maintains the right to designate additional timber for harvest within the sale area. This plan will also be submitted to the conservation easement holders as required by the terms of the easement.
- *Stumps*: Unless otherwise indicated, stumps will be cut lower than 10 inches above a tree's uphill ground level unless a rock or other obstruction prevents such cutting.
- *Residual timber*: The timber operator should take all reasonable steps to ensure that trees not designated for harvest are protected and not damaged by timber operations. Any trees that are felled or severely damaged, which have not been designated for harvest shall be paid for by the timber operator at a price agreed upon prior to harvest.
- *Infrastructure*: The timber operator shall leave access roads in the same or better condition than at the commencement of operations.
- *Incidental damage*: it shall be the responsible of the logging operator to repair any incidental damages resulting from the logging operation such as damage to roads, bridges, culverts etc.
- *Abiding by NC Laws and Best Management Practices:* The operator shall agree that all logging activities will be conducted in accordance with the most current North Carolina Forest Practices Guidelines [As of this writing these are found under NC statutes 15 NCAC 1I.0101 - .0209 as outlined in the North Carolina Forestry Best Management Practices Manual To Protect Water Quality (Amended September 2006)]. The operator shall agree to abide by all federal, state, and local laws and regulations pertaining to the harvest and transportation of timber, including, without limitation, all applicable OSHA and environmental regulations. The operator shall agree to hold the Town harmless and indemnify the town for any violations of said laws and regulations by the operator or its agents or employees and further hold town harmless and indemnify town for any and all acts of the operator and its employees, agents and contractors.
- *Erosion control:* Any potential erosion areas identified by the Town, or its agent, shall be stabilized within a manner and timeframe that is satisfactory to the Town. Logging trails and roads shall be stabilized satisfactorily at the end of each workday such that no erosion occurs during rainfall events.
- *Daily cleanup:* All refuse that is part of or incidental to the logging operation shall be removed daily by the operator.
- *Hazardous materials:* Any oil changes, refueling and other regular maintenance to the operator's equipment shall take place in designated areas only and with the use of

absorbent pads to contain any spills. The operator should maintain on the site at all times adequate supplies/equipment for containment and cleanup of diesel fuel, gasoline, hydraulic fluid, or any other hazardous material likely to be part of the harvesting operation. Specific emergency procedures should be established and followed in the case of any accidental spills of hazardous materials.

- *Suspending Operations*: The Town, or Town's agent, maintains the right to suspend or terminate logging operations if it is determined that unreasonable damage to infrastructure or residual timber has occurred or on account of weather conditions in which operations may cause excessive soil erosion, soil compaction, or damage to infrastructure.
- *Post-operation cleanup*: Any landings or temporary trails and roads shall be cleaned up of all forms of waste, including unmerchantable logs or portions of logs, graded, seeded, and stabilized to the satisfaction of the town's forester. In addition, the operator may be required to lop all tops of fallen trees to lie no higher than 5 feet off ground level and to cut all bent over or severely damaged trees to lie flat on the ground.

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