WESTERN NORTH CAROLINA HARD AND SOFT MAST SURVEY REPORT
41st Year

FALL 2023

North Carolina Wildlife Resources Commission

Compiled and written by:
Colleen Olfenbuttel
Black Bear and Furbearer Biologist
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Funding for the hard and soft mast survey was partially provided through a Pittman-Robertson Wildlife Restoration Grant. The Federal Aid in Wildlife Restoration Act, popularly known as the Pittman-Robertson Act, was approved by Congress on September 2, 1937, and began functioning July 1, 1938. The purpose of this Act was to provide funding for the selection, restoration, rehabilitation and improvement of wildlife habitat, wildlife management research, and the distribution of information produced by the projects. The Act was amended October 23, 1970, to include funding for hunter training programs and the development, operation and maintenance of public target ranges.

Funds are derived from an 11 percent Federal excise tax on sporting arms, ammunition, and archery equipment, and a 10 percent tax on handguns. These funds are collected from the manufacturers by the Department of the Treasury and are apportioned each year to the States and Territorial areas (except Puerto Rico) by the Department of the Interior on the basis of formulas set forth in the Act. Funds for hunter education and target ranges are derived from one-half of the tax on handguns and archery equipment.

Each state's apportionment is determined by a formula which considers the total area of the state and the number of licensed hunters in the state. The program is a cost-reimbursement program, where the state covers the full amount of an approved project then applies for reimbursement through Federal Aid for up to 75 percent of the project expenses. The state must provide at least 25 percent of the project costs from a non-federal source.

Introduction

North Carolina Wildlife Resources Commission (NCWRC) personnel have surveyed hard mast in the Mountain Bear Management Unit (MBMU) of North Carolina since 1983. From 1983-2005, North Carolina's hard mast surveys were conducted and reported using a method developed by Whitehead (1969) with slight modifications (Wentworth et al. 1992). This same protocol was used in whole or part by Georgia and Tennessee for many years and was adopted by South Carolina in the 1990's. To reduce costs and manpower commitments, while maintaining quality data and standard methodology among neighboring states, the member states of the Southern Appalachian Black Bear Study Group (SABBSG; Georgia, North Carolina, South Carolina, and Tennessee) have long searched for an improved technique for monitoring hard mast surveys. Beginning with the 2006 survey, we are using a new protocol and formula for determining mast indices (Greenberg and Warburton 2007). The new protocol only requires simple calculation of percent crown with acorns in the field. In order to maintain consistency with the old technique, the new technique uses statistically verified equations to convert mast index values to numbers previously used with the Whitehead (1969) method. Hard mast results reported in this document utilize the techniques described in Greenberg and Warburton (2007) and are described using the scale used by our agency since 1983. Due to small sample sizes, results will no longer be reported for individual routes for hickory and beech, but overall values for these species will be reported. Sample sizes are sufficient to allow the reporting of values for both the white oak and red oak groups by route.

Hard Mast Overall Results

Survey methodology: The 2023 hard mast survey was conducted by WRC Land and Water Access staff, WRC Wildlife Management Division Operations staff, South Mountains State Park staff, and Carl Sandberg Home National Historic Site staff on 13 routes in western North Carolina. A total of 1,465 trees were sampled including 579 from the white oak group, 696 from the red oak group, 144 hickories, 35 beeches, and 3 walnuts. Of these, 21 trees were reported dead.

All species: Combining all groups of species, mast abundance was rated as fair, with an overall index of 2.73, which is an increase from last year's mast crop index (1.93; Table 1). Since 1983, North Carolina has experienced 26 years out of 41 years in which the hard mast index was rated as fair. Including only the oak species, oak production rated as fair (2.76; Table 1).

White oaks: White oak production rated as poor (1.77) and just below both the long-term average (1.85), but above last year's index (1.16; Table 1). When the white oak group is separated by species, chestnut oak (1.23) rated as poor, while white oak (2.37) production rated as fair (Table 2).

Red oaks: Red oak production rated as fair (3.58) and above the long-term average (2.84) and last year's index (2.37; Table 1) for the species. Separated by species, black oak (2.10) and northern red oak (3.52) rated as fair, while scarlet oak (4.19) rated as good (Table 2).

Hickory and Beech: Hickory production rated as poor (1.99) and below the long-term average (2.37) for the species (Table 1). Beech production (4.81) was good and above the long-term average (4.12; Table 1).

Hard Mast Survey Area Results

White Oak by routes and county: Similar to 2022, white oak productivity was poor across almost all areas surveyed (Table 3). During fall 2023, 8 of 10 counties surveyed had poor productivity (Figure 1). White oak productivity rated as poor on 11 of 13 routes (Table 3). The Fires Creek route in Clay County and Poplar route in Mitchell County had fair productivity.

Red Oak by routes and county: Red oak productivity varied more than white oak productivity. Red oak productivity rated as poor on 3 routes, rated as fair on 6 routes, and rated as good on 4 routes (Table 3). At the county level, 5 counties had good red oak productivity, 4 counties had fair productivity, and one county (Macon) experienced poor red oak productivity (Figure 2). In contrast to fall 2022, counties further east had slightly better red oak productivity than counties in the western portion of the survey area.

Oak species by elevation: Red oak productivity slightly increased as elevation increased, peaking between 3,000 and 3,900 feet (4.0; Table 4). White oak productivity declined overall as elevation increased, with fair productivity (3.8) at less than 1,900 feet and declining to poor productivity (1.0) at 3,000 to 3,900 feet and above 5,000 feet (0.4; Table 4).

Summer Soft Mast Survey Results

Survey methodology: A soft mast survey was implemented during the summer and fall of 1993 to document berry production and abundance. The technique used for evaluating the soft mast has remained consistent throughout this period including the current year. Summer soft mast surveys are conducted in conjunction with the Sardine Bait Station Survey (SBSS). During summer 2006, based on an agreement with the member states of the SABBSG, we did not conduct the SBSS. Review of data from the SBSS indicates that we can obtain long-term bear population trend information by conducting the SBSS every other year. Because of the new schedule, the summer soft mast survey is conducted in odd years. The previous summer soft mast survey was conducted in 2021 and the next survey was conducted during the summer of 2023.

Results: During the summer of 2023, blueberry and huckleberry were below the long-term averages, while blackberry and pokeberry were above long-term averages (Table 5). Blueberry, huckleberry, and pokeberry production rated as poor, while blackberry rated as fair, similar to the summer soft most production observed since 2017 (Figure 3). Summer soft mast production varied on a local basis with some areas failing to produce any significant fruit of certain species while producing “fair” to “good” crops of others (Table 6).

Fall Soft Mast Survey Results

The 2022 fall soft mast survey is conducted in conjunction with the hard mast survey. All four species of fall soft mast were below long-term averages and below productivity observed in 2021 and 2022 (Table 7; Figure 4). Pokeberry, cherry, and black gum productivity rated as poor, while grapes rated as fair (Table 7). As observed in previous years, local areas experienced variable production of fall soft mast depending on species and area (Table 8).

Conclusion

This season's hard mast crop was the 26th year since 1983 in which the overall hard mast index was fair. While overall hard mast was fair, the 2023 fall hard mast index was the highest since 2017 and red oak and beech were above long-term averages (Table 1). There is a weak correlation of red oak productivity declining as one moves from eastern to western counties within the Mountain BMU, with western counties having more spotty mast and one county experiencing poor abundance (Figure 2). There was also a slight increase in red oak productivity as elevation increased, peaking at 3,000 to 3,900 feet and declining after that elevation (Table 4). No regional pattern was found with white oak productivity (Figure 1), though as elevation increased, productivity showed a decline (Table 4). It should be noted that the Mountain BMU, and most of North Carolina, experienced a very dry year during 2023, similar to what was experienced in 2022. The overall trend in hard mast production is stable trend since surveys were initiated in 1983 (Figure 5).

In talking to Commission staff that conduct these surveys, they felt the 2023 mast indices matched what they observed on their routes, including fair to good red oak production and red oak production best between 2,000 and 4,000 feet. One noted that scarlet oak mast production did well at lower elevations while northern red oak mast production did well at higher elevations. Staff also noted that production for the white oak group was more scattered with fewer individual trees having acorns across the region.

Comparing our results with near-by states and regions, Georgia reported that white and red oak productivity were both fair (2.8 and 2.7, respectively) and above oak productivity from 2022. South Carolina reported good white oak (4.6) and red oak (4.7) productivity and above last year's productivity. The Great Smokey Mountains National Park anecdotally reported that white and red oak appeared poor to fair this year within their boundaries. The 2023 summer and fall soft mast results were fair to poor, depending on species, and, except for blackberry, productivity was lower than long-term averages (Table 5 and 7).

This report and previous annual mast reports (2003 to present) can be found at: http://www.ncwildlife.org/bear and click on "Surveys and Reports" tab, then the "Hard and Soft Mast Surveys" link.

LITERATURE CITED

Greenberg, C.H., and G.S. Warburton. 2007. A fast and reliable hard mast index from acorn presence-absence tallies. Journal of Wildlife Management 71:1654-1661.

Wentworth, J.M., A.S. Johnson, P.E. Hale, and K.E. Kammermeyer. 1992. Relationship of Acorn abundance and deer herd characteristics in the southern Appalachians. Southern Journal of Applied Forestry 16:5-8.

Whitehead, C.J. 1969. Oak mast yields on wildlife management areas in Tennessee. Tennessee Game and Fish Commission, Nashville, USA.

Table 1. Hard Mast Survey Results for Western North Carolina, 1984-2023.

Year	White Oak	Red Oak	All Oaks	Hickory	Beech	Total
1984	1.08	2.73		3.05	4.28	2.30
1985	2.01	3.66		0.80	3.06	2.80
1986	1.32	1.98		2.25	5.22	1.90
1987	1.16	0.56		3.57	5.75	1.31
1988	3.16	4.07		2.04	4.25	3.57
1989	0.43	4.89		2.78	6.44	3.14
1990	1.85	2.62		1.20	1.89	2.17
1991	2.38	1.93		3.75	6.89	2.43
1992	1.07	2.45		0.72	1.17	1.78
1993	0.65	3.58		2.43	4.77	2.48
1994	2.06	3.48		2.02	6.20	2.85
1995	2.80	5.60		2.48	0.36	4.22
1996	3.70	1.99		2.81	4.31	2.72
1997	0.53	1.79		1.17	2.35	1.29
1998	2.26	4.68		3.27	4.70	3.69
1999	3.28	2.76		2.80	6.22	3.05
2000	0.50	2.11		2.73	5.71	1.82
2001	2.83	4.92		2.88	3.97	3.98
2002	1.90	3.01		1.75	3.44	2.47
2003	1.24	0.68		3.58	5.42	1.33
2004	3.99	2.93		1.32	1.65	3.09
2005	0.70	3.11		1.86	4.30	2.14
2006	1.70	1.40	1.50*	3.20	4.10	1.80
2007	3.02	1.19	2.04	0.73	2.71	1.90
2008	1.01	2.40	1.76	3.82	4.34	2.06
2009	0.48	2.47	1.55	1.72	5.58	1.67
2010	3.46	3.97	3.75	3.50	0.87	3.66
2011	1.17	2.22	1.74	1.30	4.96	1.76
2012	1.87	2.68	2.31	2.01	3.14	2.29
2013	1.00	1.43	1.23	2.43	4.45	1.44
2014	4.43	4.36	4.42	2.33	1.23	4.10
2015	1.07	2.65	1.92	2.64	5.77	2.09
2016	2.71	2.60	2.66	2.45	4.08	2.67
2017	2.13	4.42	3.40	3.20	5.69	3.44
2018	0.94	2.14	1.61	1.58	1.11	1.58
2019	1.97	2.84	2.45	3.35	5.54	2.63
2020	1.42	3.23	2.43	2.26	4.67	2.47
2021	2.58	2.38	2.47	3.21	2.63	2.55
2022	1.16	2.37	1.82	2.32	4.81	1.93
2023	1.77	3.58	2.76	1.99	5.29	2.73
Average	**1.85**	**2.84**	**2.32**	**2.37**	**4.12**	**2.48**

Numerical Rating = Crop Quality
0.0 to 2.0 = Poor 2.1 to 4.0 = Fair
4.1 to 6.0 = Good 6.1 to 8.0 = Excellent

* Not reported for prior years.

Table 2. Hard Mast Survey Results by Species, 2023.

Grouping	Species	Index	Number of Trees Sampled
Hickories	MH, PH, SH, GH[1]	1.99	144
Beech	Beech	5.29	35
Red Oaks	Black Oak	2.10	44
	Northern Red Oak	3.52	476
	Scarlet Oak	4.19	173
White Oaks	Chestnut Oak	1.23	310
	White Oak	2.37	269

Numerical Rating = Crop Quality

0.0 to 2.0 = Poor 2.1 to 4.0 = Fair
4.1 to 6.0 = Good 6.1 to 8.0 = Excellent

[1]MH,SH, PH, GH: Mockernut Hickory, Pignut Hickory, Shagbark Hickory

Table 3. Hard Mast Survey Results by Area, 2023.

County	Area	White Oak	Red Oak	All Oaks
Transylvania	Avery Creek	1.3	5.5	3.7
Henderson	Carl Sandberg	0.4	0.4	0.4
Haywood	Cold Mountain	1.2	2.7	2.2
Avery & Caldwell	Edgemont	1.8	4.6	3.2
Clay	Fires Creek	3.5	3.5	3.5
Haywood	Harmon Den	1.4	1.9	1.7
Burke & McDowell	Linville Mtn.	1.6	3.1	2.2
Macon	Nantahala	1.6	2.2	2.0
Mitchell	Poplar	3.9	4.4	4.3
Graham	Santeetlah	1.3	4.7	3.2
Haywood	Sherwood	0.7	3.7	2.9
Burke	South Mountains	0.6	3.3	1.8
Macon	Standing Indian	1.3	1.4	1.4

Numerical Rating = Crop Quality

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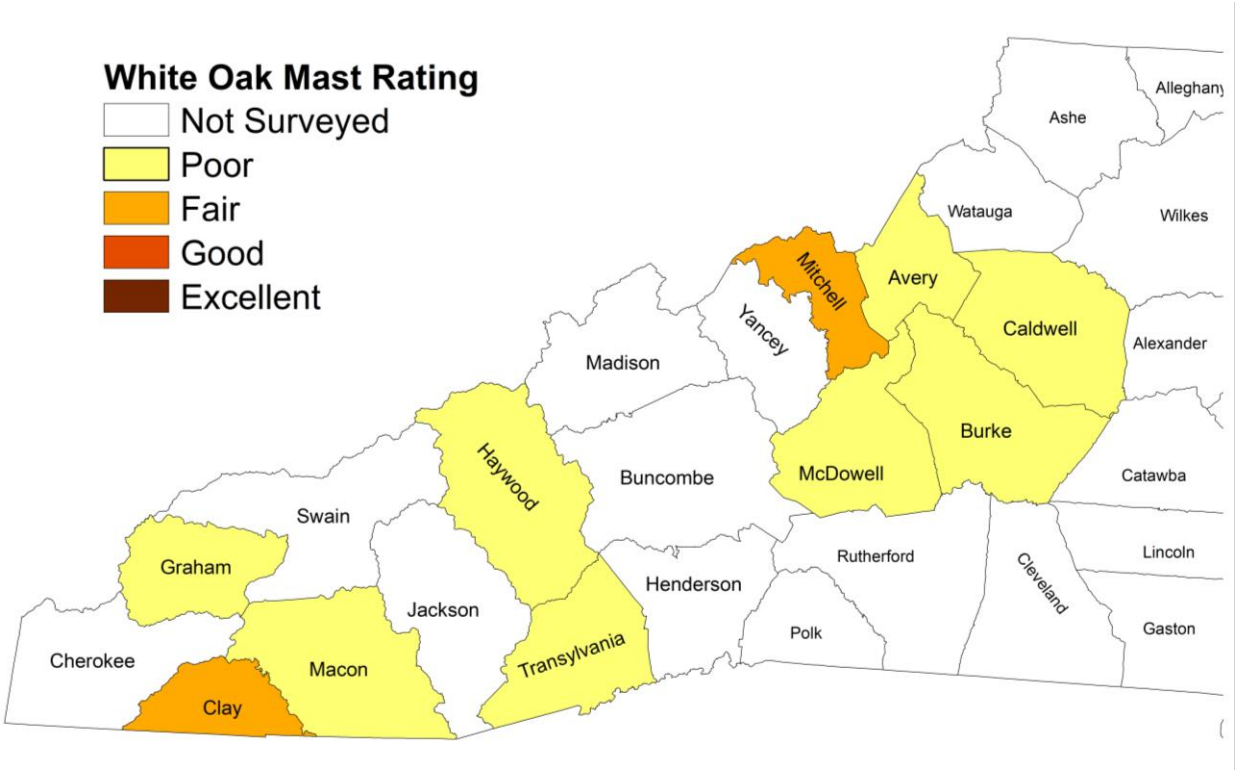

Figure 1. White Oak Index by County in western North Carolina, 2023.

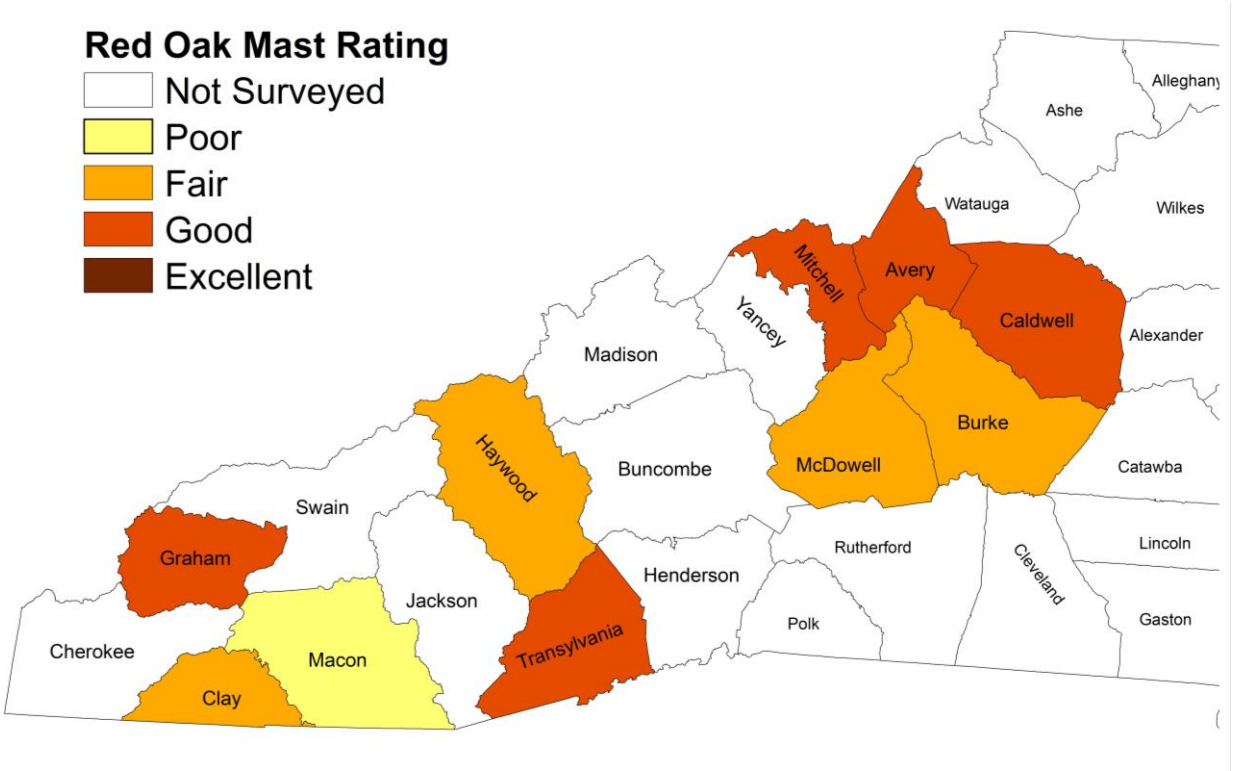

Figure 2. Red Oak Index by County in western North Carolina, 2023.

Table 4. Hard Mast Survey Results by Elevation, 2023.

Elevation (ft.)	Red Oak	White Oak
<1900	2.8	3.8
2000-2900	3.4	2.1
3000-3900	4.0	1.0
4000-4900	3.4	2.4
5000+	1.6	0.4

Numerical Rating = Crop Quality

0.0 to 2.0 = Poor 2.1 to 4.0 = Fair

4.1 to 6.0 = Good 6.1 to 8.0 = Excellent

Table 5. Results of Mountain Summer Soft Mast Surveys, 1993-2023[1].

Year	Blueberry	Huckleberry	Blackberry	Pokeberry
1993	3.24	3.56	3.81	2.44
1994	3.17	3.54	3.53	1.44
1995	1.92	2.46	3.12	1.20
1996	2.02	1.97	3.39	1.51
1997	2.84	2.95	3.78	1.96
1998	1.73	1.09	3.00	2.10
1999	2.72	2.45	2.90	1.78
2000	2.70	2.72	2.99	1.64
2001	2.27	2.73	2.87	0.87
2002	1.87	2.22	3.55	1.32
2003	2.27	2.74	3.20	1.02
2004	1.67	1.61	4.25	1.41
2005	1.57	1.41	4.07	1.48
2007	2.11	1.23	2.48	1.84
2009	2.08	2.06	2.78	1.09
2011	1.69	1.53	3.28	1.37
2013	1.87	1.07	3.73	1.89
2015	2.14	1.38	3.97	2.28
2017	1.64	1.15	2.74	1.04
2019	1.65	1.60	3.47	1.20
2021	1.08	0.72	2.82	1.68
2023	1.68	1.48	3.35	1.75
Average	**2.09**	**1.98**	**3.32**	**1.56**

[1] After 2005, summer soft mast surveys are conducted every two years.

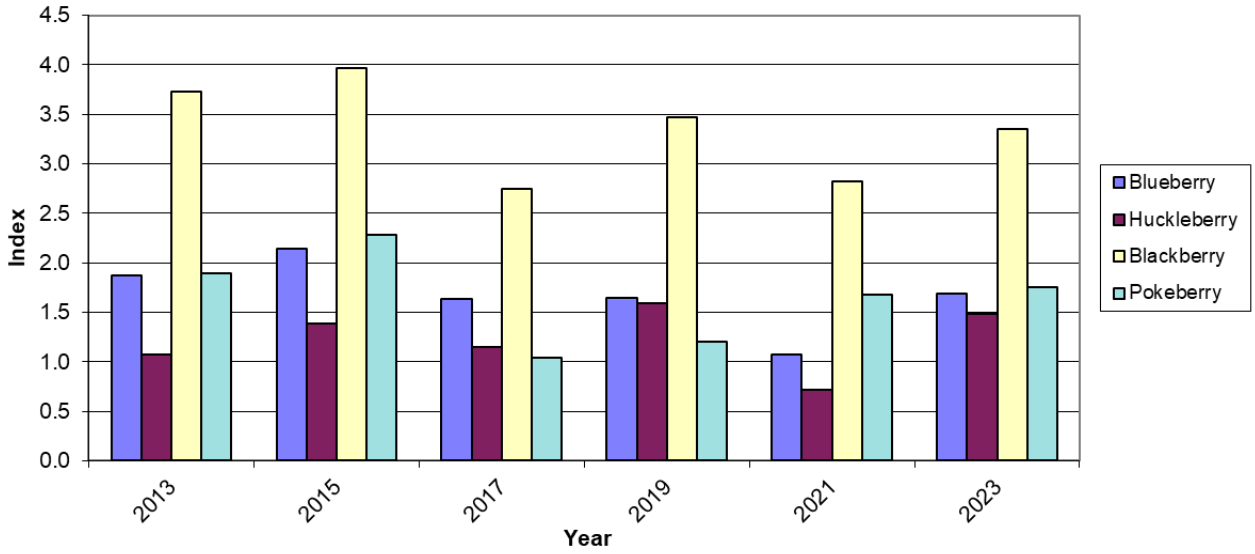

Figure 3. Results of Mountain Summer Soft Mast Surveys by species, 2013-2023

Table 6. Mountain Summer Soft Mast Survey Results by Area, 2023.

Area	Blueberry	Huckleberry	Blackberry	Pokeberry
Daniel Boone	1.33	1.33	2.00	1.00
Fires Creek/Santeetlah	1.40	1.00	2.60	1.60
Flattop	1.00	1.00	6.00	2.00
Harmon Den Area	2.33	1.67	3.33	1.67
Mt. Mitchell	2.67	1.00	3.67	0.00
Pisgah Area	1.20	1.20	2.00	0.60
Rich Mountain	2.00	2.00	2.00	2.00
Standing Indian	1.33	4.00	3.17	0.67
T. Chatham	3.00	2.00	4.00	2.25
Cheoah	1.00	1.00	2.50	2.50
South Mountains	3.00	0.00	2.00	0.00
Highlands	0.00	0.00	0.00	0.00
Gorges State Park	1.00	4.00	2.00	2.00
Sandy Mush	2.00	2.00	9.00	6.00
Green River	2.00	0.00	6.00	4.00
Average	**1.68**	**1.48**	**3.35**	**1.75**

Numerical Rating = Crop Quality	
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Table 7. Results of Mountain Fall Soft Mast Surveys, 1993-2023.

Year	Pokeberry	Cherry	Grapes	Blackgum
1993	2.00	2.71	2.14	0.43
1994	3.11	2.00	3.78	1.71
1995	2.67	5.00	2.22	1.78
1996	2.40	1.63	3.25	1.75
1997	4.20	1.25	3.14	0.75
1998	4.63	2.67	2.80	1.50
1999	2.40	2.70	3.25	1.10
2000	2.20	2.70	3.30	1.00
2001	2.80	3.30	4.18	2.33
2002	1.10	2.45	2.73	1.27
2003	2.33	3.00	2.55	2.22
2004	1.67	2.70	3.00	1.44
2005	2.45	2.09	1.36	1.55
2006	3.73	2.00	3.17	2.50
2007	2.08	1.58	2.73	0.67
2008	2.91	4.64	4.08	2.58
2009	1.92	1.82	2.33	1.83
2010	2.90	5.80	4.80	1.40
2011	2.50	1.67	2.33	1.42
2012	2.50	1.08	2.92	1.00
2013	2.00	2.75	2.75	1.08
2014	2.55	3.91	4.55	2.18
2015	2.17	2.09	2.23	1.82
2016	3.00	3.27	2.75	1.92
2017	2.73	1.82	2.45	1.18
2018	1.83	1.58	3.00	1.17
2019	2.08	1.69	2.15	1.85
2020	1.83	2.00	2.25	1.50
2021	3.09	4.08	3.92	2.75
2022	2.45	2.27	3.27	1.09
2023	1.33	1.33	2.42	1.08
Average	**2.50**	**2.57**	**2.96**	**1.54**

Numerical Rating = Crop Quality

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4.1 to 6.0 = Good 6.1 to 8.0 = Excellent

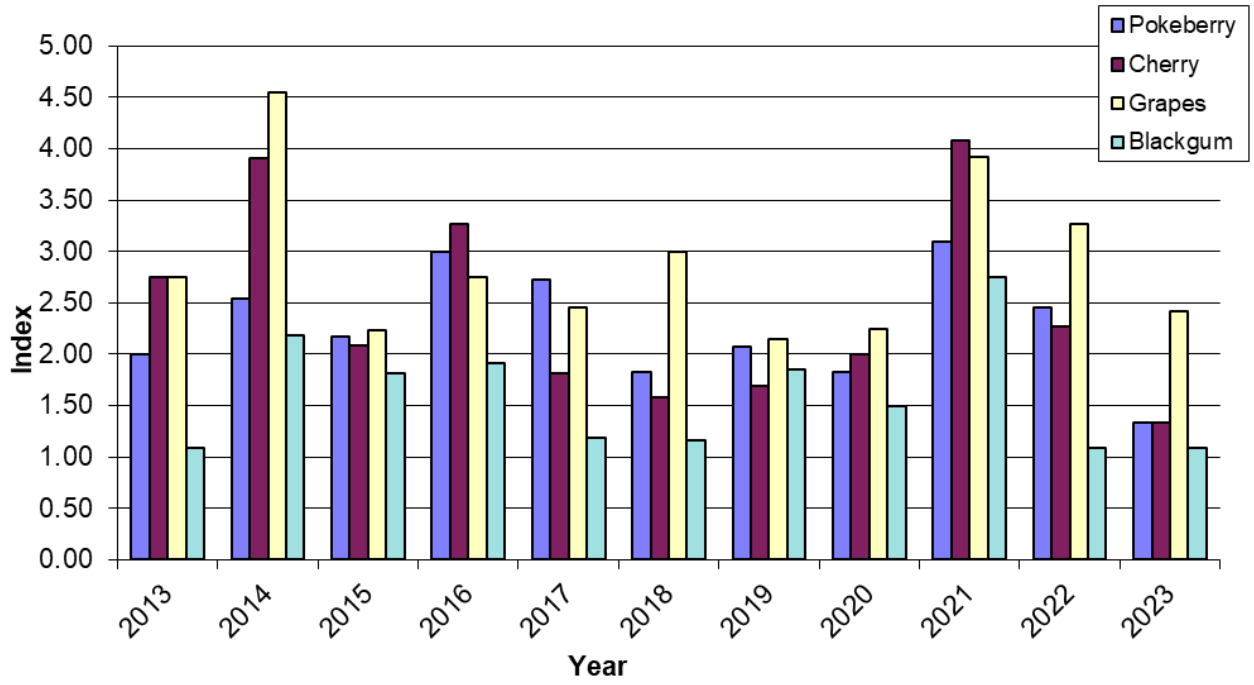

Figure 4. Results of Mountain Fall Soft Mast Surveys by species, 2013-2023.

Table 8. Local Results of Mountain Fall Soft Mast Surveys, 2023.

County	Area	Pokeberry	Cherry	Grapes	Blackgum
Transylvania	Avery Creek	3	2	4	2
Henderson	Carl Sandburg	n/a	n/a	n/a	n/a
Haywood	Cold Mountain	0	0	0	0
Avery & Caldwell	Edgemont	2	0	2	2
Clay	Fires Creek	1	6	9	1
Haywood	Harmon Den	0	2	0	1
Burke & McDowell	Linville Mtn.	2	1	4	6
Macon	Nantahala	0	4	4	1
Mitchell	Poplar	2	0	2	0
Graham	Santeetlah	2	1	1	0
Haywood	Sherwood	0	0	1	0
Burke	South Mountains	4	0	2	0
Macon	Standing Indian	0	0	0	0
	Average:	**1.45**	**1.45**	**2.64**	**1.18**

Numerical Rating = Crop Quality	
0.0 to 2.0 = Poor	2.1 to 4.0 = Fair
4.1 to 6.0 = Good	6.1 to 8.0 = Excellent

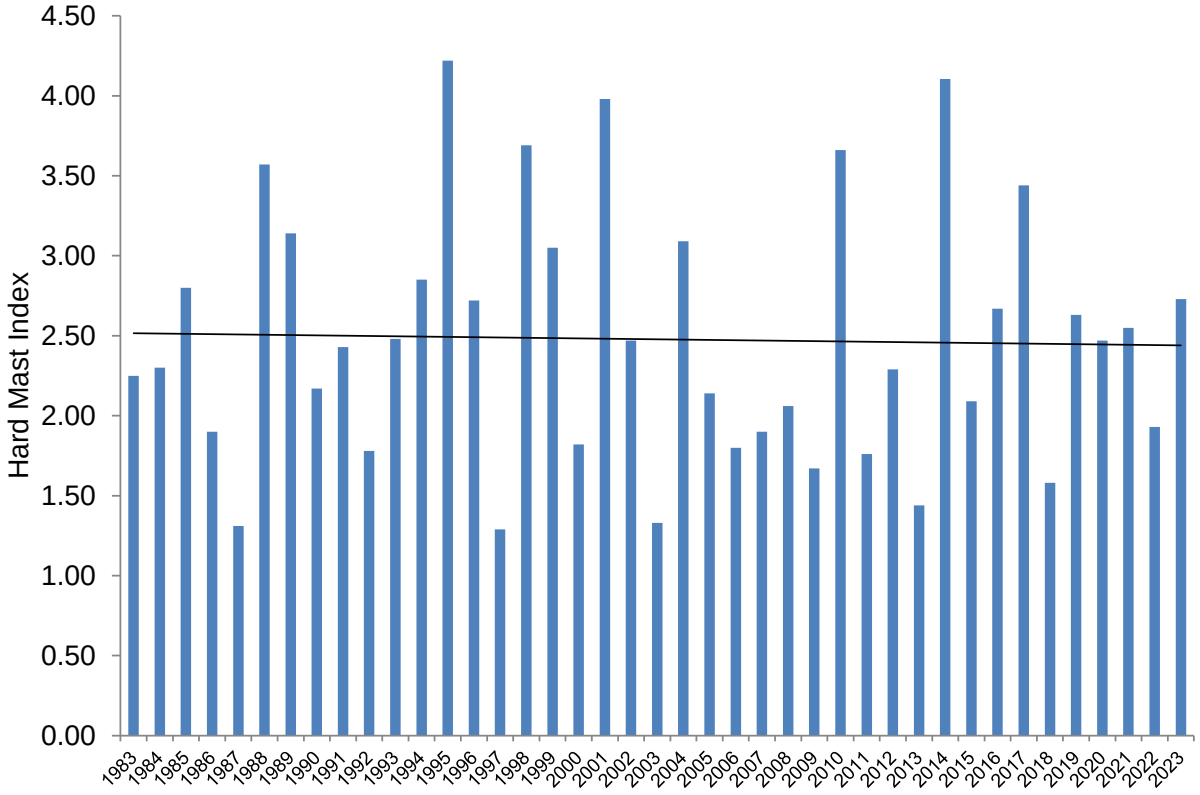

Figure 5. Annual hard mast index in western North Carolina, 1983 through 2023.