Longleaf Pine Cone Prospects

for 2016 and 2017

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During the spring of 2016, cone production data were collected from selected low-density (e.g., shelterwood) stands of mature longleaf pine, throughout its native range. Binocular counts of green cones and unfertilized conelets were conducted on the crowns of sampled trees, as viewed from a single location on the ground. Visibility of cones and conelets on each tree is enhanced when the observer stands with their back to the sun. A breeze that moves the flexible pine needles about also helps the relatively more rigid cones and conelets standout for the observer. The near-term regional averages and individual site averages for these counts are reported in Table 1.

Table 1. Estimated Longleaf Pine Cone Production.

Cooperator	State and County	Estimated cones per tree from green cones for fall 2016	Estimated cones per tree from conelets for fall 2017
Kisatchie National Forest	Louisiana, Grant	1.5	8.7
T.R. Miller Woodlands	Alabama, Escambia	0.5	59.8
Blackwater River State Forest	Florida, Santa Rosa	1.0	120.0
Eglin Air Force Base	Florida, Okaloosa	2.6	46.7
Apalachicola National Forest	Florida, Leon	0.6	23.0
Jones Ecological Research Center	Georgia, Baker	1.5	58.4
Tall Timbers Research Station	Florida, Leon	3.8	59.9
Fort Benning Military Base	Georgia, Chattahoochee	5.9	74.9
Sandhills State Forest	South Carolina, Chesterfield	6.9	15.9
Bladen Lakes State Forest	North Carolina, Bladen	12.5	33.5
Ordway-Swisher Biological Station	Florida, Putnam	0.4	24.9
Region Averages		3.4	47.8

Regional Summary:

The regional cone crop, based on green cone counts, is **failed for 2016**, at 3.4 cones per tree. The natural variation typically seen throughout the longleaf pine range is less evident in this year's data, with all sites being fairly low in production. Only one site, in Bladen, County NC, produced more than 10 cones per tree. All other sites were below this level of output. It is not unusual for a large cone crop, such as that which occurred in 2014, to be followed by much smaller cone crops during the next couple of years. Once the trees recover their internal energy, by continuing production of photosynthate, a more productive year is possible in the future.

The regional cone crop outlook, based on counts of unfertilized conelets, is **fair for 2017**, at 47.8 cones per tree. The cone crop is forecasted to be a bumper crop at one site, a good crop at four sites, a fair crop at two sites, a poor crop at three sites and a failed crop at one site, reflecting a good deal of natural variability. However, keep in mind that cone crop estimates based on counts of unfertilized conelets are less reliable than those based on counts of green cones, because of conelet losses during their first year, with often fewer than half surviving to become green cones during their second year.

The 51-year regional cone production average for longleaf pine is about 28 green cones per tree. The single best cone crop occurred in 1996 and averaged 115 cones per tree. Good cone crops were observed in 1967 (65 cones per tree), 1973 (67 cones per tree), 1987 (65 cones per tree), 1993 (52 cones per tree) and 2014 (98 cones per tree). Fair or better cone crops have occurred during 49% of all years since 1966, with an increased frequency since the mid-1980s. Reasons for this increasing frequency may be related to genetic, environmental or management factors (or a combination of these). Research analysis of this long-term cone crop data has resulted in the recent publication of two scientific articles, which provide new insights into the reproductive pattern of longleaf pine in an environment with increasingly variable conditions. An electronic portable document file (pdf) of each of these two articles is included along with this report:

Chen, X., Guo, Q., Brockway, D.G., 2016. Analyzing the complexity of cone production in longleaf pine by multiscale entropy. *Journal of Sustainable Forestry* 35(2): 172-182.

Guo, Q., Zarnoch, S.J., Chen, X., Brockway, D.G., 2016. Life cycle and masting of a recovering keystone indicator species under climate fluctuation. *Ecosystem Health and Sustainability* 2(6): 1-11.

Evaluating Longleaf Pine Cone Data:

Observations, concerning the natural variation in longleaf pine cone crops, and field studies, determining of the amount of seed (i.e., number of productive cones per tree) required to successfully regenerate even-aged shelterwood stands, resulted in development of Table 2.

The minimum cone crop needed for successful natural regeneration, using an even-aged management technique such as the uniform shelterwood method, is 750 green cones per acre. This assumes 30 cones per tree, with 25 seed-bearing trees per acre. Thus, cone crops classified as “fair or better” represent regeneration opportunities, for which a receptive seedbed may be prepared through application of prescribed fire during the months prior to seed fall in October.

When uneven-aged management stand-reproduction methods such as single-tree selection and group selection are being used, then “seed rain” incident on a site every year, although of variable intensity from year to year, is often sufficient for successful natural regeneration. While using selection silviculture frees one from dependency on the timing of good cone crops, it may nonetheless be useful for the manager of uneven-aged stands to be aware of cone crop quality from year to year when making management decisions.

It is also worth noting that a good deal of spatial variation occurs among longleaf pine stands across the Southern Region, relative to cone production. Therefore, even during a year with a lower overall regional average number of cones per tree, certain localities can experience substantial longleaf pine cone production. This regional report is intended as a guide, which broadly forecasts the overall status of longleaf pine cone production. Thus, we encourage forest managers to take binoculars to the field and carefully examine any individual stands in which they have an interest. In this way, they can, for those specific stands, acquire more detailed site-specific information that will aid them in making management decisions.

Table 2. Classification of Longleaf Pine Cone Crops*.

Crop Quality	Cones per Tree	Cones per Acre (on 25 trees per acre)
Bumper crop	$\geq$ 100	$\geq$ 2500
Good crop	50 to 99	1250 to 2475
Fair crop	25 to 49	625 to 1225
Poor crop	10 to 24	250 to 600
Failed crop	< 10	< 250

* Cones on mature trees (14-16 inches at dbh) in low-density stands (basal area < 40 $feet^2$/acre).

Study Cooperators:

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Paul Padgett, T.R. Miller Woodlands, Brewton, Alabama
Eric Howell, Blackwater River State Forest, Milton, Florida
Alexander Sutsko, Natural Resources Management, Eglin Air Force Base, Niceville, Florida
Gary Hegg, National Forests of Florida, Tallahassee, Florida
Steve Jack, J.W. Jones Ecological Research Center, Newton, Georgia
Eric Staller, Tall Timbers Research Station, Tallahassee, Florida
James Parker, Natural Resources Management, Fort Benning Military Base, Columbus, Georgia
Brian Davis, Sandhills State Forest, Patrick, South Carolina
Hans Rohr, Bladen Lakes State Forest, Elizabethtown, North Carolina
Stephen Coates, Ordway-Swisher Biological Station, Melrose, Florida

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Figure 1. Two **conelets** on a longleaf pine branch, on either side of a bud.

Figure 2. Three **green cones** on a longleaf pine branch, as they would appear in spring.

Cone Counting Method:

We have received many inquiries about the field method used when counting cones. Therefore, the following protocol and field data sheet are provided, in the event that you may wish to conduct your own observations of pine cone production in your locale. Remember:

- **Conelets** indicate how much production *may* happen next year (see Figure 1).
- **Green cones** tell you how much production will happen this year (see Figure 2)
- Brown cones tell you how much production occurred last year.

Equipment: 8 to 10x binoculars, field data sheet, clipboard, pencil, d-tape, flagging, tree tags, aluminum nails, orange flagging, bark scraper and orange tree paint.

1. Locate a stand that is growing at a shelterwood density of less than 40 square feet per acre (25 to 35 square feet per acre is a typical range) and contains numerous trees of at least 10 inches at dbh. Better cone crops come from larger-diameter trees and poorer cone crops come from smaller-diameter trees. A key consideration is that high brush and/or trees cannot obscure the crowns of your sample trees, or your data collection will be impaired. The midstory must be relatively open, so you can see the entire crowns of sample trees.

2. Select at least 10 trees in the stand to serve as your representative sample for monitoring, by painting a ring around the tree at dbh or higher and a sequence number on each (use a color other than white to avoid confusion with the white rings often painted around trees having RCW nests). You may also attach an aluminum tag to the tree, but attach this high enough so that the tag number will not become obscured by black char from or, even worse, melted during periodic prescribed fires (this happens when tags are too low).

3. Using the field data sheet, enter the following data at the top: location, date and crew. Then, for each tree, enter the tree number and its dbh. Now, you are ready to count the brown cones, green cones and small conelets.

4. While standing near each tree, count the number of brown cones lying on the ground around the tree. The cones from the most recent year appear brown and fresher than the cones from earlier years which appear weathered and gray. Enter this number. Then, walk toward the sun away from the tree. The precise distance away from the tree is not crucial, but it should be far enough away to give your neck a comfortable angle while looking up, but not so far away that you cannot clearly see the cones with 8 to 10 power binoculars. With the sun at your back, you may need to adjust your position a bit to the left or to the right, so that you can view the entire tree crown without moving from your counting location.

5. Work from the least difficult to most difficult strobili to see. First, count the number of brown cones still hanging on the tree from last fall. I usually start at the lower left of the crown and work my way up to the top of the crown, then across the top of the crown to the right and then down the right side of the crown all the way to the bottom-most

branches. This is a systematic approach that sweeps across the entire crown (left half, top, right half) and leads to consistently accurate counts. Once you have done this, enter the number of brown cones still hanging on the tree into the data sheet.

6. Next, repeat the same up-over-down sweep with your binoculars, counting all of the green cones that can be seen from the single spot on which you are standing. Because these newer cones are green, they are more difficult to see against the green pine foliage. It helps to count these green cones (and other structures) on a bright sunny day, when the light is good. It also helps if there is a light breeze blowing that moves the pine needles about, thereby revealing the more rigid cones. Once you have done this, enter the number of green cones into the data sheet. This is perhaps the most important count you will make, since these green cones contain the seed that will be shed during the upcoming October, and it is these data that will become the numbers upon which the cone crop forecast for the current year will be based (a forecast in which many land managers have a great interest). News of a good cone crop usually alerts forest managers to get busy during the summer, preparing seedbeds that will be receptive to capturing and deriving the most benefit from the upcoming seed shed. You will also note on the data sheet that the raw number you see in your green cone count needs to be multiplied by 2 at the end of the column. Bill Boyer's research, through many years, confirmed that this adjustment to the raw count needed to be performed to obtain an accurate estimate (the actual regression from his work approximated 1.98). In general terms, he explained this as being needed, because the cone count is performed by looking at only one side of the tree, thus the raw count for green cones needs to be doubled.

7. Finally, repeat the same up-over-down sweep with our binoculars, counting the small conelets that can be seen from the single spot on which you are standing. They are small, so this will take more time to locate them. But, they are up there. These conelets were pollinated only one month earlier (during March), but will not become fertilized for almost another 11 months (until a pollen tube grows from the surface of the conelet deep into its ovary). These conelets are the basis for estimating what the cone crop might be during the following year. But, it is worth bearing in mind that conelet abortion happens in nature for a variety of natural reasons (e.g., genetics, disease, insects, adverse weather conditions). Thus, not all conelets will survive to maturity. In fact, the conelet mortality rate is typically more than 50 percent. So, this estimate for next year, based on conelets, is less reliable than the forecast for this year, based on green cones.

Regional Longleaf Pine Cone Study: Female Strobili Count Data - - Field Data

Location: ______________________   Date: ________________   Crew: __________________

Tree Number	DBH	Brown Cones on Ground	Brown Cones on Tree	All Brown Cones	Green Cones	Conelets
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
Total Count =						

Adjusted Count performed only for Green Cones (is the Total Count x 2) =

Number Per Tree =					
			last year	this year	next year

Regional and Local

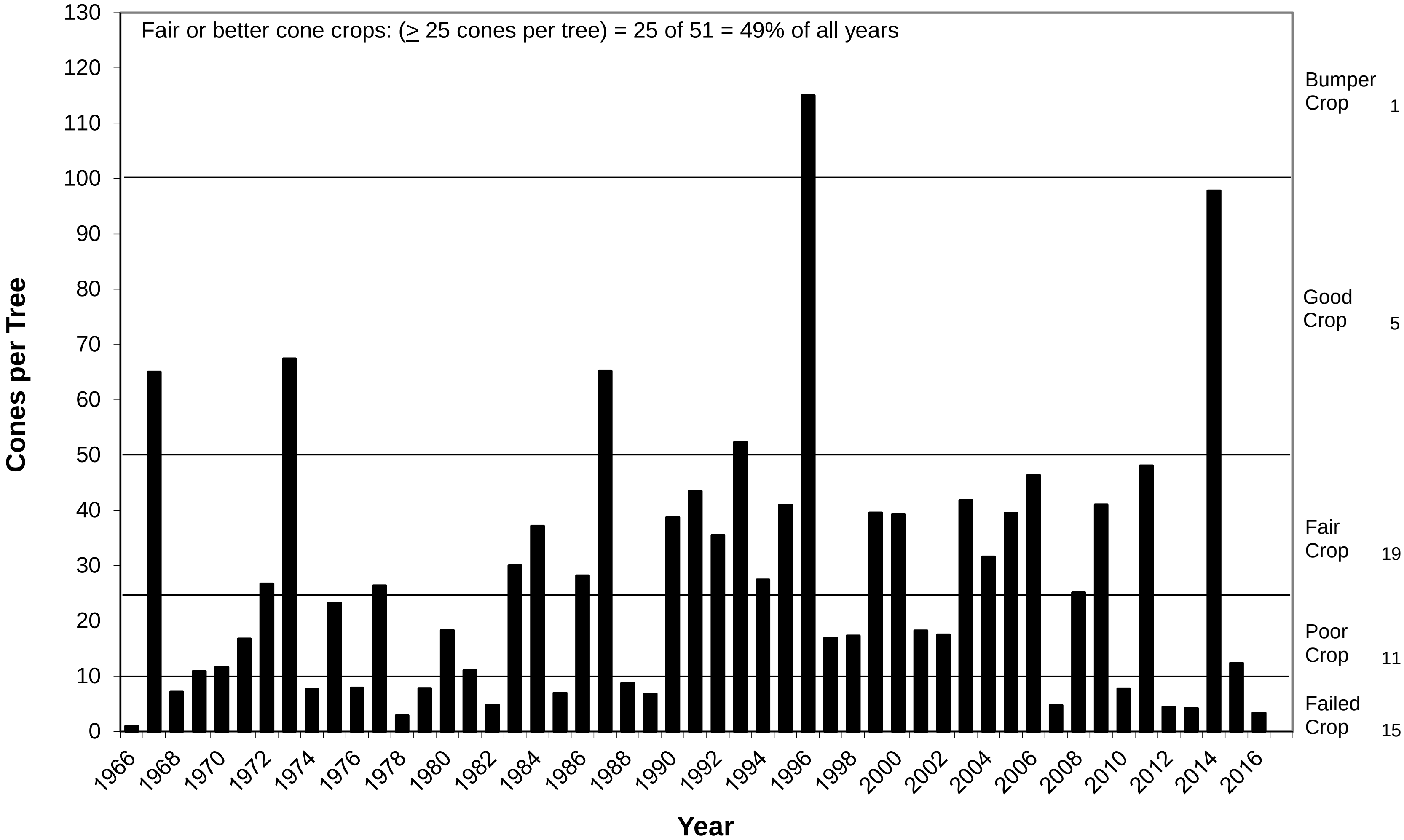
Summary and Graphs

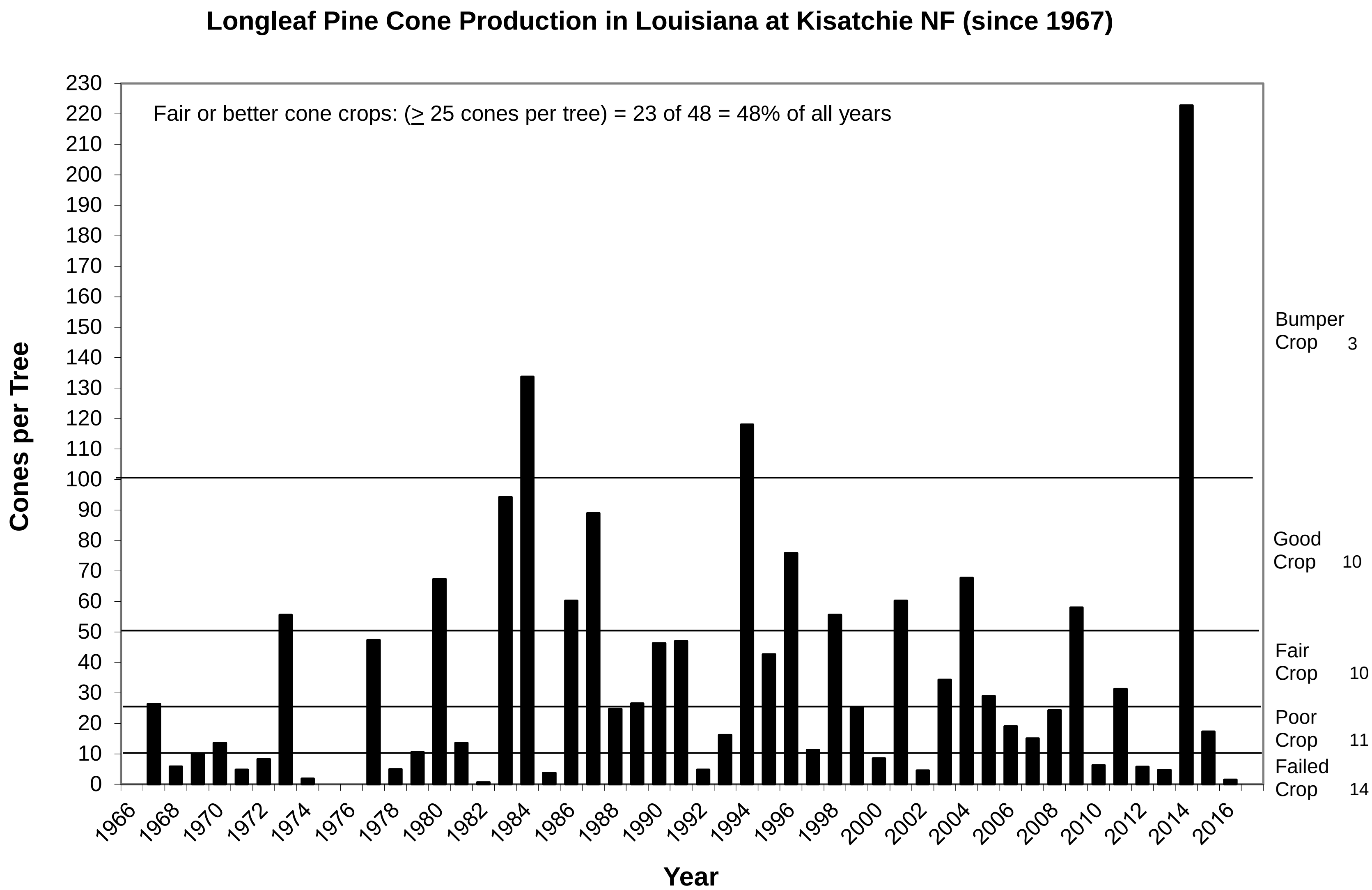
Year	**Southern Region**	LA-Kisatchie National Forest	AL-Escambia Exp. Forest	W FL-Blackwater River State Forest	W FL-Eglin Air Force Base	W FL-Apalachicola National Forest	SW GA-Jones Res. Center	Red Hills-Tall Timbers Res Station	W GA-Fort Benning Military Base	SC-Sandhills State Forest	NC-Bladen Lakes State Forest	FL Pen.-Ordway-Swisher Biological Station
1958			63.00									
1959			9.00									
1960			19.00									
1961			43.00									
1962			8.00									
1963			1.00									
1964			12.00									
1965			4.00									
1966	**1.01**		1.02			0.60						
1967	**65.06**	26.35	53.35	13.75		18.65	2.65					
1968	**7.19**	5.80	34.38	2.50	0.20	9.85	0.40				0.20	
1969	**10.06**	10.05	15.75	2.45	0.60	5.15	0.75			9.20	1.85	
1970	**11.65**	13.55	2.21	1.65	0.90	1.00	7.50			7.05	0.90	
1971	**16.80**	4.75	21.60	29.20	4.05	14.35	1.50			10.15	2.73	
1972	**26.75**	8.25	5.41	0.90	3.50	0.20	0.40			50.95	25.55	
1973	**67.44**	55.55	28.34	14.40	10.60	27.15	7.15			92.00	8.80	
1974	**7.67**	1.86	24.70	3.00	1.55	9.60	0.30			6.71	0.30	
1975	**23.23**		15.73	17.50	10.61		5.00			67.30		
1976	**7.94**		3.90	1.50	1.70	22.90	1.60			16.05		
1977	**26.42**	47.35	19.80	9.85	1.10	89.70	1.10			25.50	16.94	
1978	**2.89**	4.95	4.67	0.80	0.25	2.65	1.00			8.50	0.28	
1979	**7.81**	10.55	11.33	5.50	4.40		3.05			18.40	1.42	
1980	**18.31**	67.30	3.03	0.50	0.55		2.25			36.20		
1981	**11.10**	13.60	6.56	1.15	0.95		0.85			43.50		
1982	**4.83**	0.65	13.05	3.20	8.10		1.70			2.30		
1983	**30.03**	94.20	14.58	11.75	22.85		11.00			25.80		
1984	**37.18**	133.75	19.15	12.27	5.86		1.45			50.60		
1985	**7.01**	3.75	13.28	8.50	6.05		1.20			9.30		
1986	**28.22**	60.25	31.34	19.20	28.32		19.40			10.80		
1987	**65.22**	89.00	104.22	58.70	18.05		11.22			110.15		
1988	**8.75**	24.75	6.50	8.24			1.20			3.05		
1989	**6.87**	26.56	0.17	2.07			0.74			4.80		
1990	**38.75**	46.31	43.86	35.53			50.32			17.75		
1991	**43.50**	46.96	23.78	33.74			1.21			117.50	37.80	
1992	**35.51**	4.76	1.02	8.26		76.60	0.21			152.40	5.31	
1993	**52.27**	16.15	128.06	89.79		5.70	91.23		15.60	70.95	0.67	
1994	**27.49**	118.06	14.81	9.68	20.10	11.07	24.89			3.70	17.62	
1995	**40.97**	42.69	7.64	10.85	10.05	17.89	66.11		10.40	51.00	152.06	
1996	**115.02**	75.88	157.24	206.39	87.75	190.83	123.67		34.90	48.20	110.33	
1997	**16.95**	11.25	1.40	8.19	6.70	38.56	16.90		52.70	7.20	9.67	
1998	**17.35**	55.62	38.50	27.06	11.25	1.20	3.92		16.10	1.07	1.40	
1999	**39.55**	25.06	9.74	12.95	15.55	3.80	112.50	43.70	21.70	52.20	98.27	
2000	**39.32**	8.50	59.36	30.47	15.80	22.00	106.08	58.80	22.40	8.07	61.73	
2001	**18.26**	60.25	57.36	8.80	8.35	9.80	2.30	14.20	17.60	2.93	1.00	

2002	**17.52**	4.50	2.23	3.72	7.85	2.20	6.91	63.30	12.80	40.00	31.73	
2003	**41.85**	34.25	103.40	69.44	31.80	13.80	89.09	42.60	8.40	7.33	18.40	
2004	**31.62**	67.75	8.41	24.90	43.56	37.90	88.91	32.80	2.40	4.53	5.00	
2005	**39.52**	28.94	44.17	23.00	57.05	36.10	117.09	26.80	21.24	37.36	3.47	
2006	**46.34**	19.00	18.41	4.10	16.85	14.00	129.18	56.80		49.93	108.80	
2007	**4.73**	15.06	0.96	0.00	0.78	2.80	5.80	2.00	15.36	0.71	3.87	
2008	**25.13**	24.25	57.13	38.60	30.16	38.40	8.55	30.60	16.20	7.00	0.40	
2009	**41.05**	58.00	40.50	31.60	14.26	6.00	65.09	20.20	81.40	55.29	38.13	
2010	**7.77**	6.25	3.30	4.00	3.74	0.80	1.64	2.60	39.80	5.57	10.00	
2011	**48.09**	31.25	73.20	141.20	65.10	32.80	66.20	7.00	38.12	18.43	7.60	
2012	**4.46**	5.75	7.24	1.00	0.60	1.80	2.36	12.14	2.24	8.14	3.33	
2013	**4.22**	4.68	11.30	2.60	1.81	0.80	0.91	1.33	12.68	3.86	2.27	
2014	**97.81**	222.80	159.81	149.00	74.90	7.00	134.36	13.56	138.48	54.10	24.10	
2015	**12.43**	17.33	18.60	16.80	2.76	21.40	6.50	14.70	32.00	1.10	4.30	1.20
2016	**3.38**	1.47	0.48	1.00	2.64	0.60	1.45	3.78	5.92	6.86	12.53	0.40
2017												
Means	**27.65**	36.57	28.90	24.43	15.34	21.50	27.98	24.83	28.11	30.03	23.02	0.80
	Southern Region	LA-Kisatchie National Forest	AL-Escambia Exp. Forest	W FL-Blackwater River State Forest	W FL-Eglin Air Force Base	W FL-Apalachicola National Forest	SW GA-Jones Res. Center	Red Hills - Tall Timbers Res Station	W GA-Fort Benning Military Base	SC-Sandhills State Forest	NC-Bladen Lakes State Forest	FL Pen.-Ordway-Swisher Biological Station

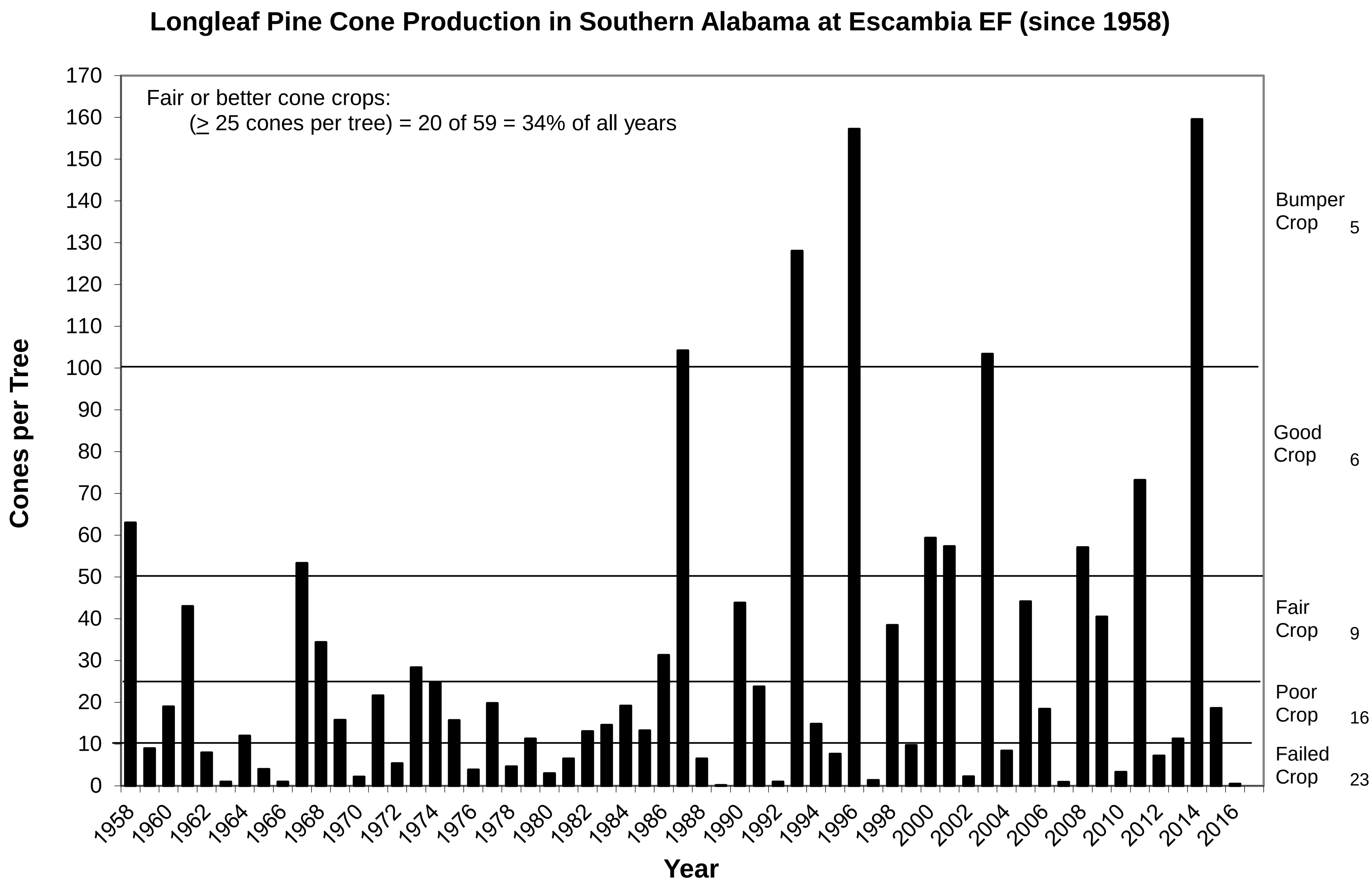
Data are the average number of cones per longleaf pine tree forecasted for the fall (late October), with estimates based on counts of **green cones** during the spring (April and May) of each year.

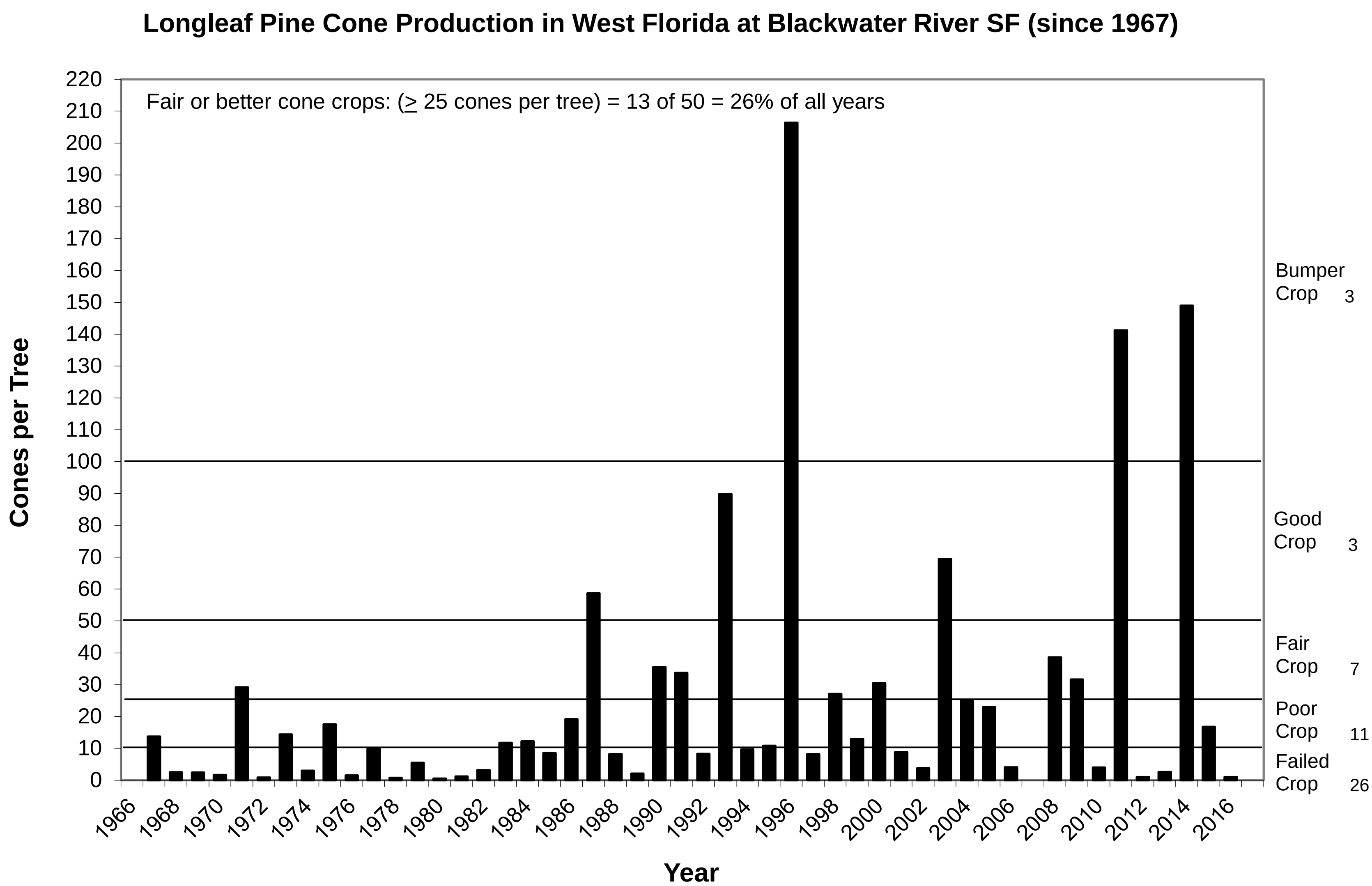
Longleaf Pine Cone Production in Southern Region (since 1966)

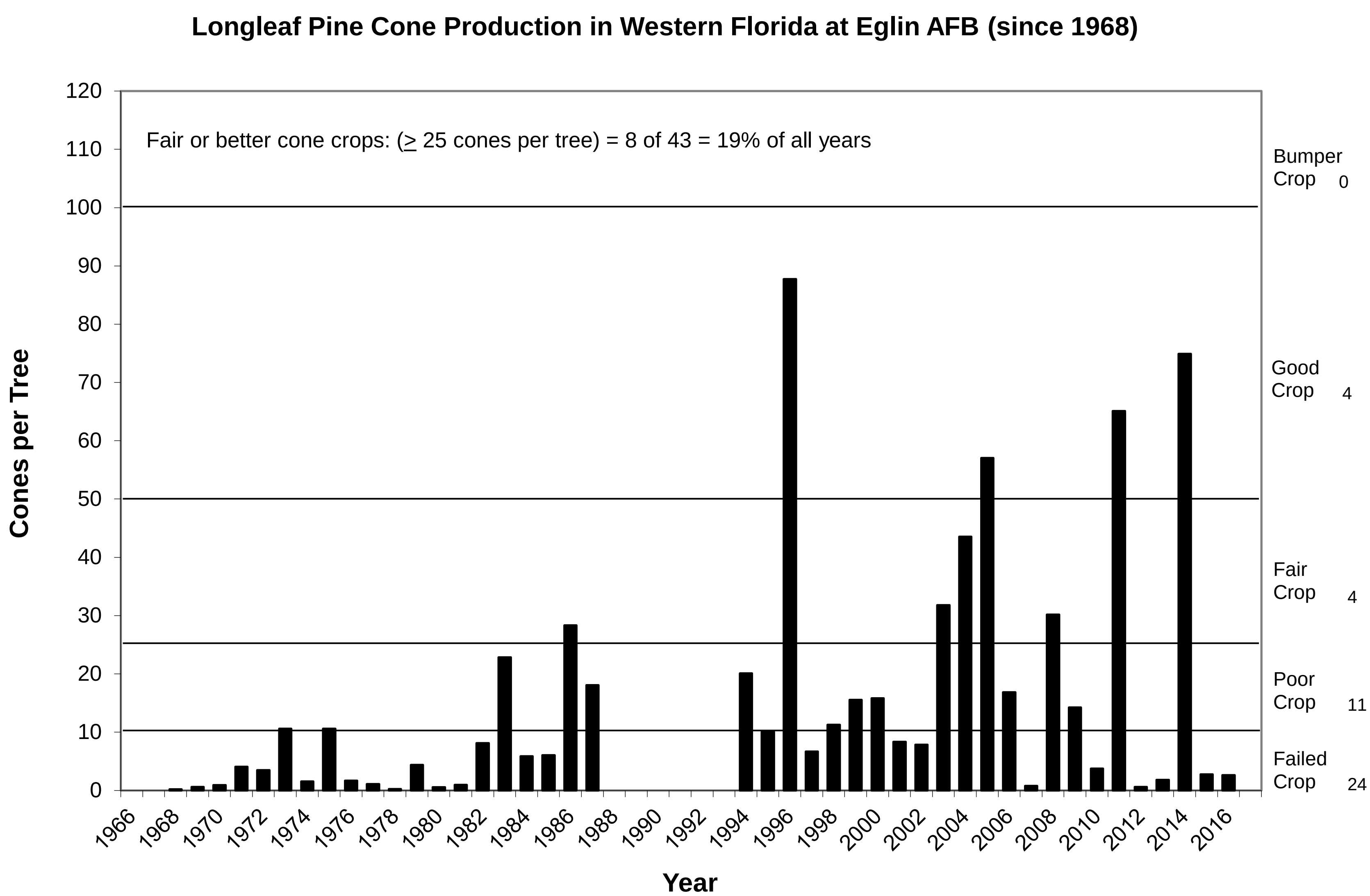




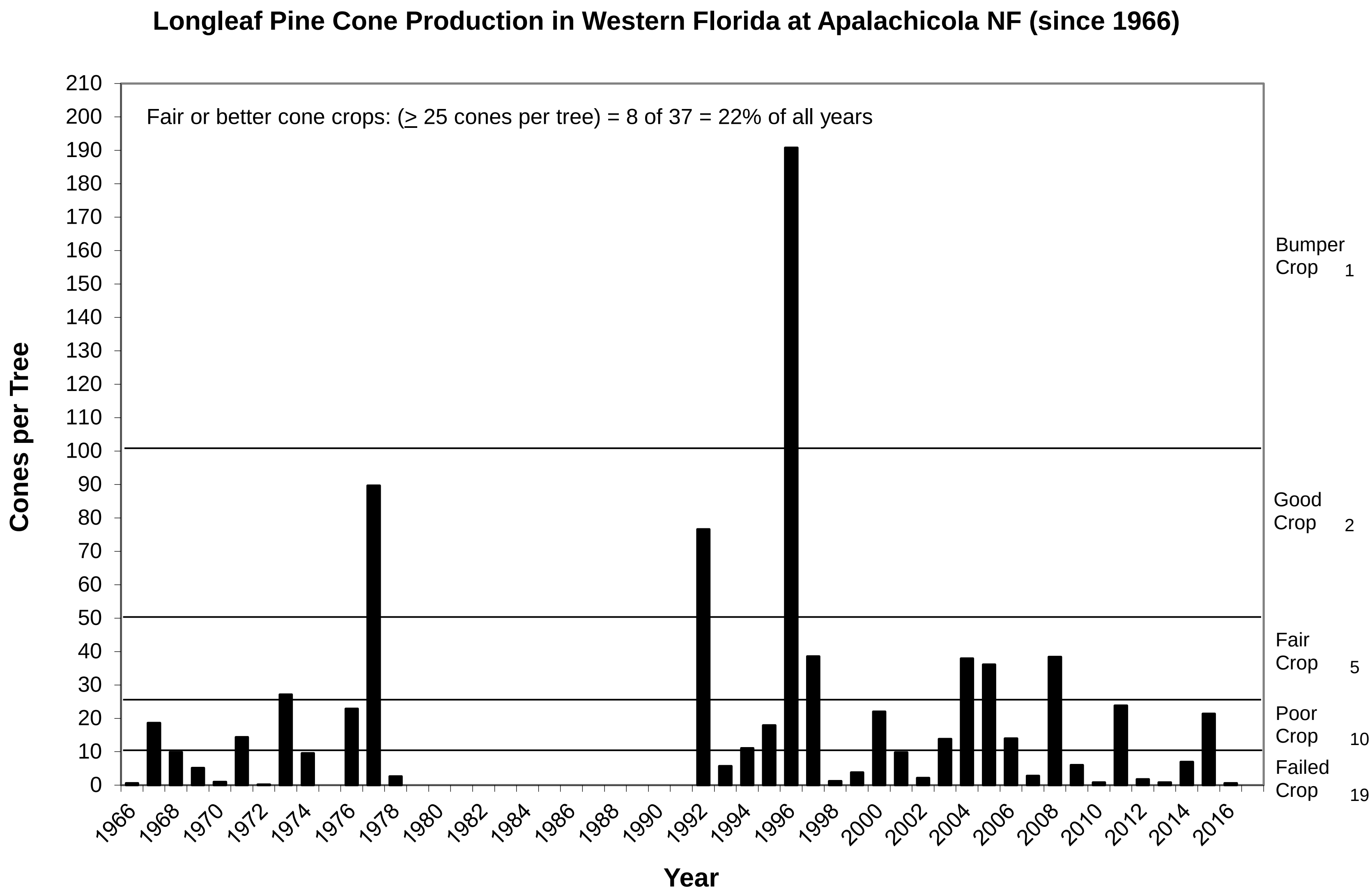
Longleaf Pine Cone Production in Louisiana at Kisatchie NF (since 1967)
Fair or better cone crops: (≥ 25 cones per tree) = 23 of 48 = 48% of all years
Cones per Tree
Year
Bumper Crop 3
Good Crop 10
Fair Crop 10
Poor Crop 11
Failed Crop 14


Longleaf Pine Cone Production in Southern Alabama at Escambia EF (since 1958)
Fair or better cone crops:
(≥ 25 cones per tree) = 20 of 59 = 34% of all years
Cones per Tree
Year
Bumper Crop 5
Good Crop 6
Fair Crop 9
Poor Crop 16
Failed Crop 23

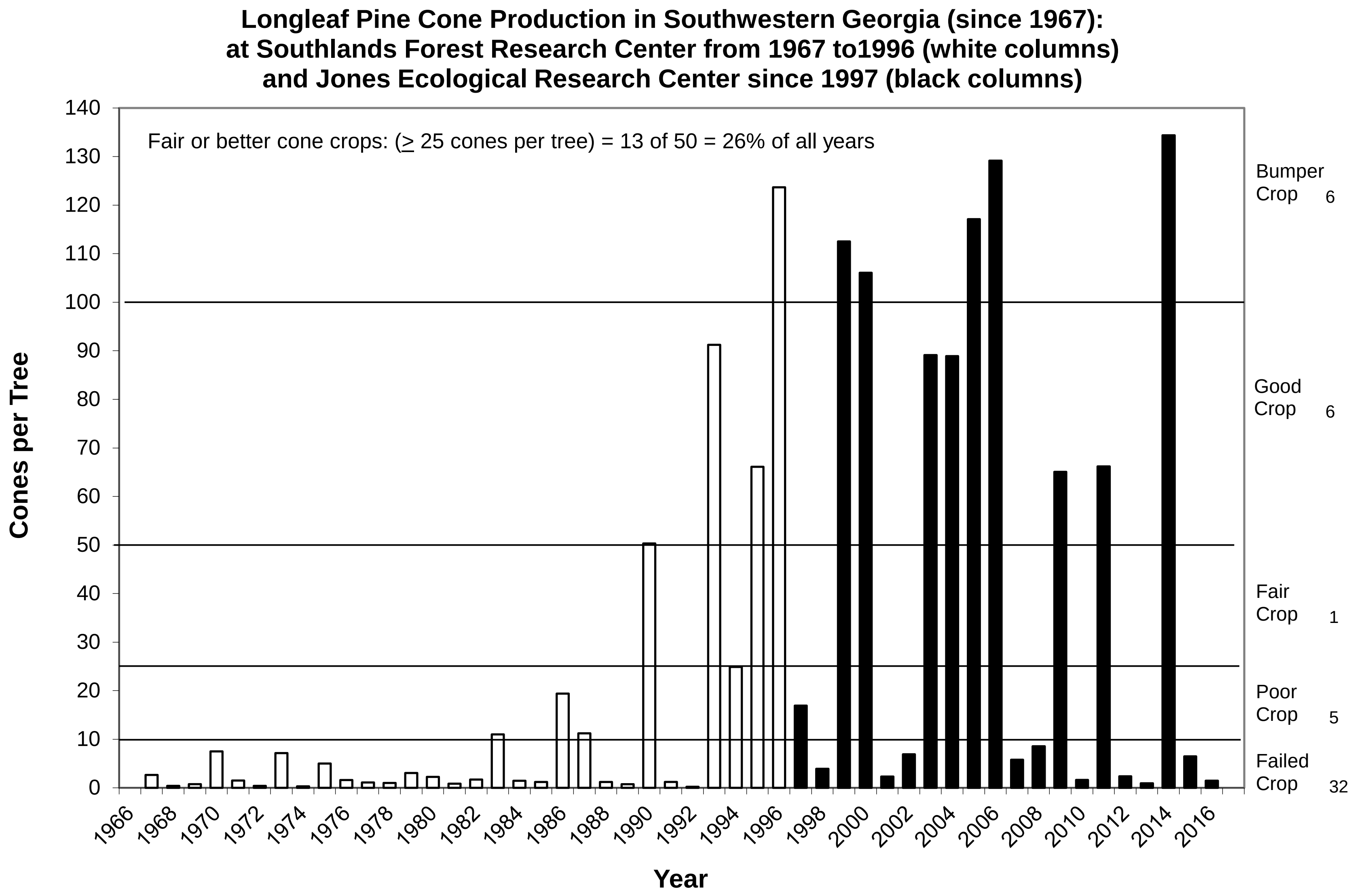

Longleaf Pine Cone Production in West Florida at Blackwater River SF (since 1967)
Fair or better cone crops: (≥ 25 cones per tree) = 13 of 50 = 26% of all years
Cones per Tree
Year
Bumper Crop 3
Good Crop 3
Fair Crop 7
Poor Crop 11
Failed Crop 26



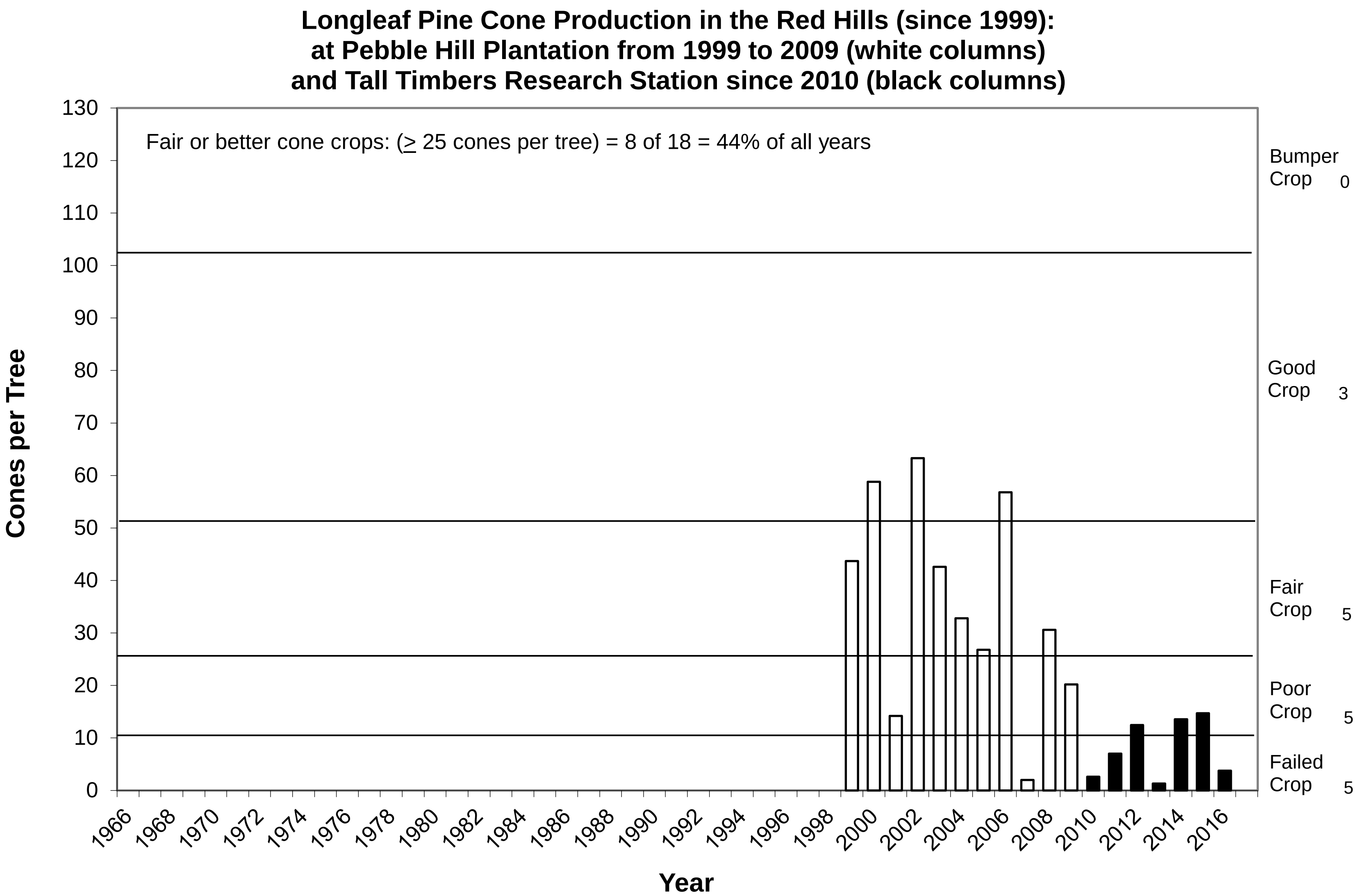
Longleaf Pine Cone Production in Western Florida at Eglin AFB (since 1968)
Fair or better cone crops: (≥ 25 cones per tree) = 8 of 43 = 19% of all years
Cones per Tree
Year
120
110
100
90
80
70
60
50
40
30
20
10
0
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Bumper Crop 0
Good Crop 4
Fair Crop 4
Poor Crop 11
Failed Crop 24

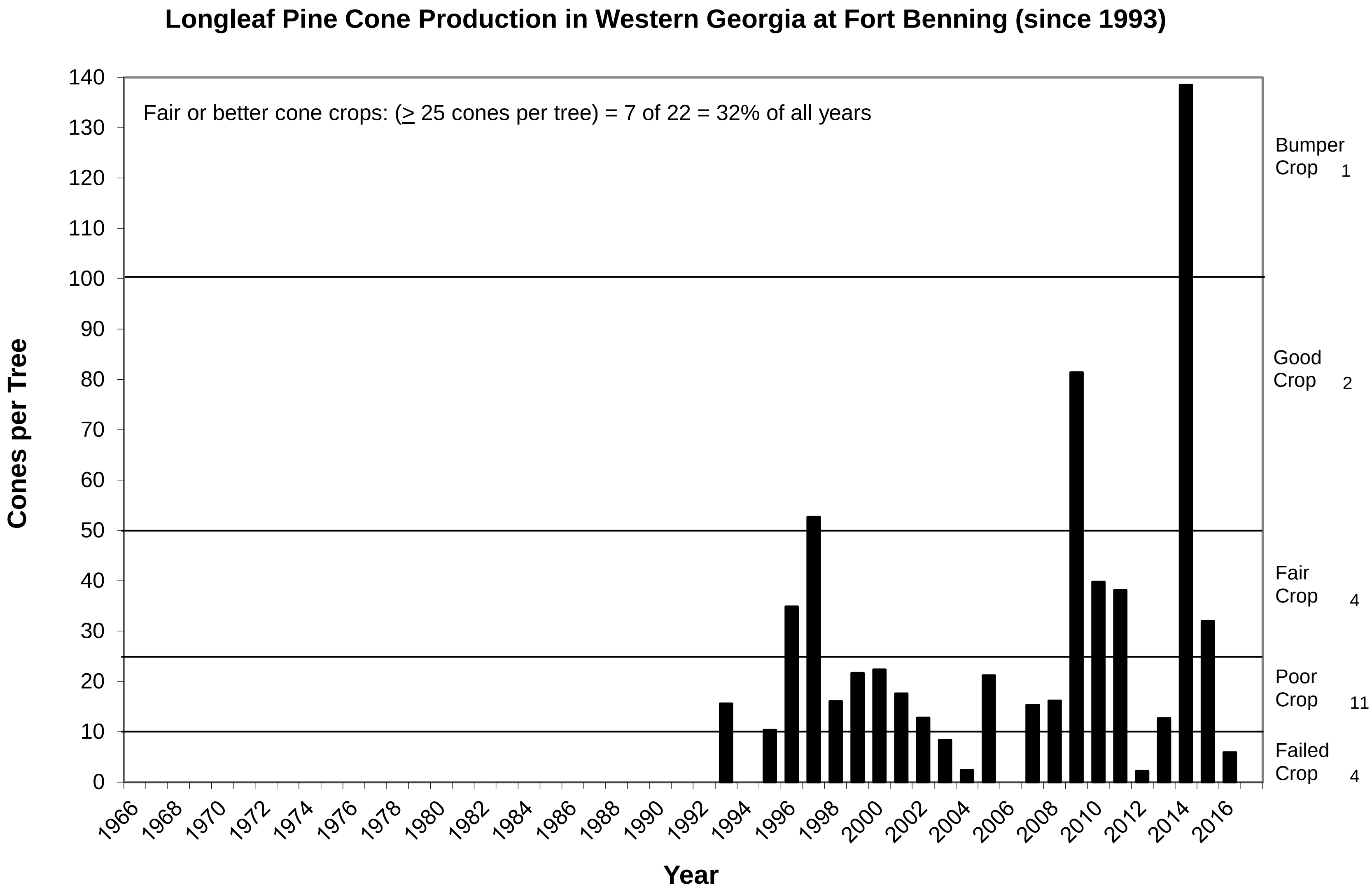


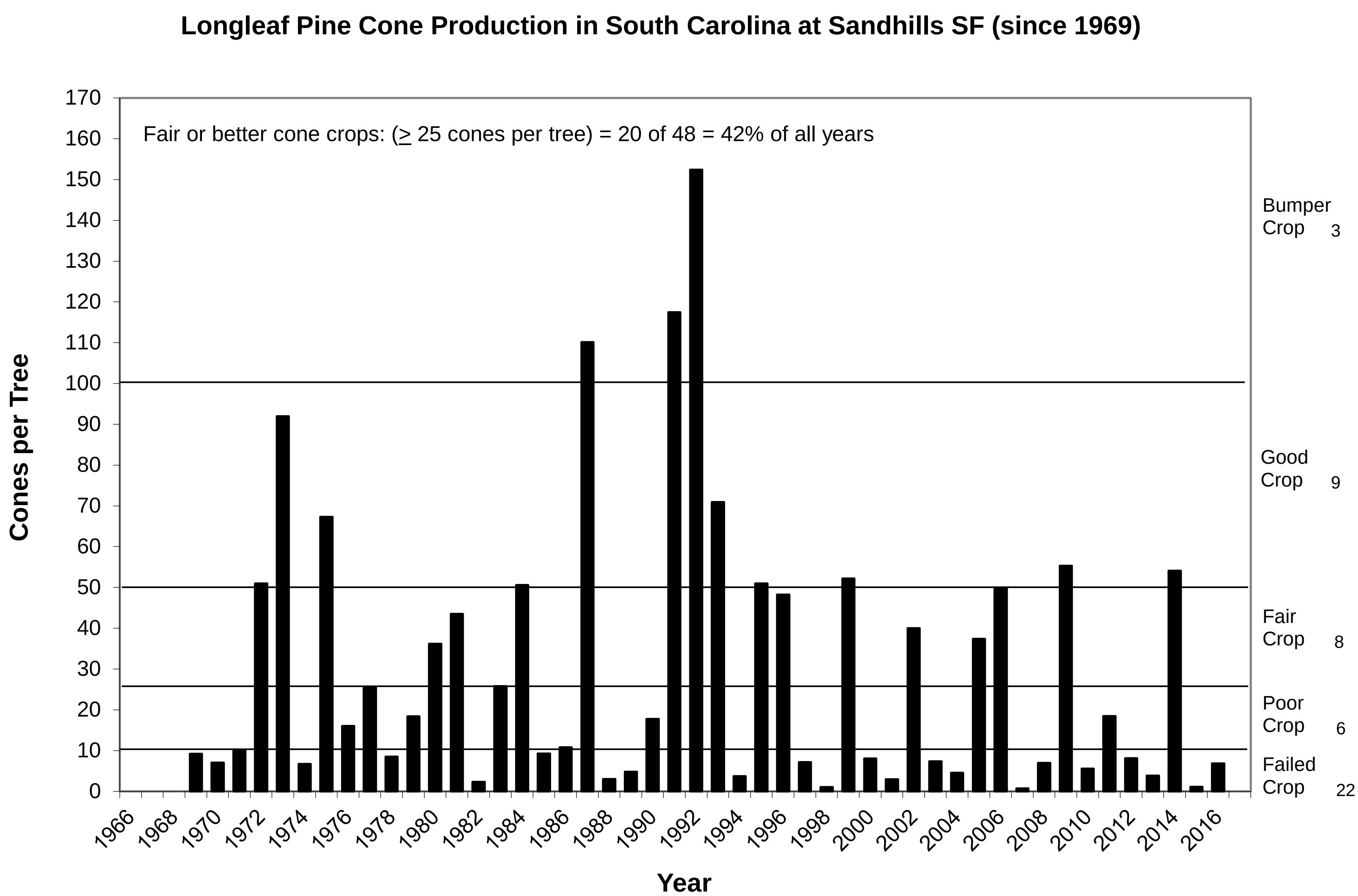
Longleaf Pine Cone Production in Western Florida at Apalachicola NF (since 1966)
Fair or better cone crops: (≥ 25 cones per tree) = 8 of 37 = 22% of all years
Cones per Tree
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Year
Bumper Crop 1
Good Crop 2
Fair Crop 5
Poor Crop 10
Failed Crop 19



Longleaf Pine Cone Production in Southwestern Georgia (since 1967):
at Southlands Forest Research Center from 1967 to1996 (white columns)
and Jones Ecological Research Center since 1997 (black columns)
Fair or better cone crops: (≥ 25 cones per tree) = 13 of 50 = 26% of all years
Cones per Tree
Year
Bumper Crop 6
Good Crop 6
Fair Crop 1
Poor Crop 5
Failed Crop 32
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016

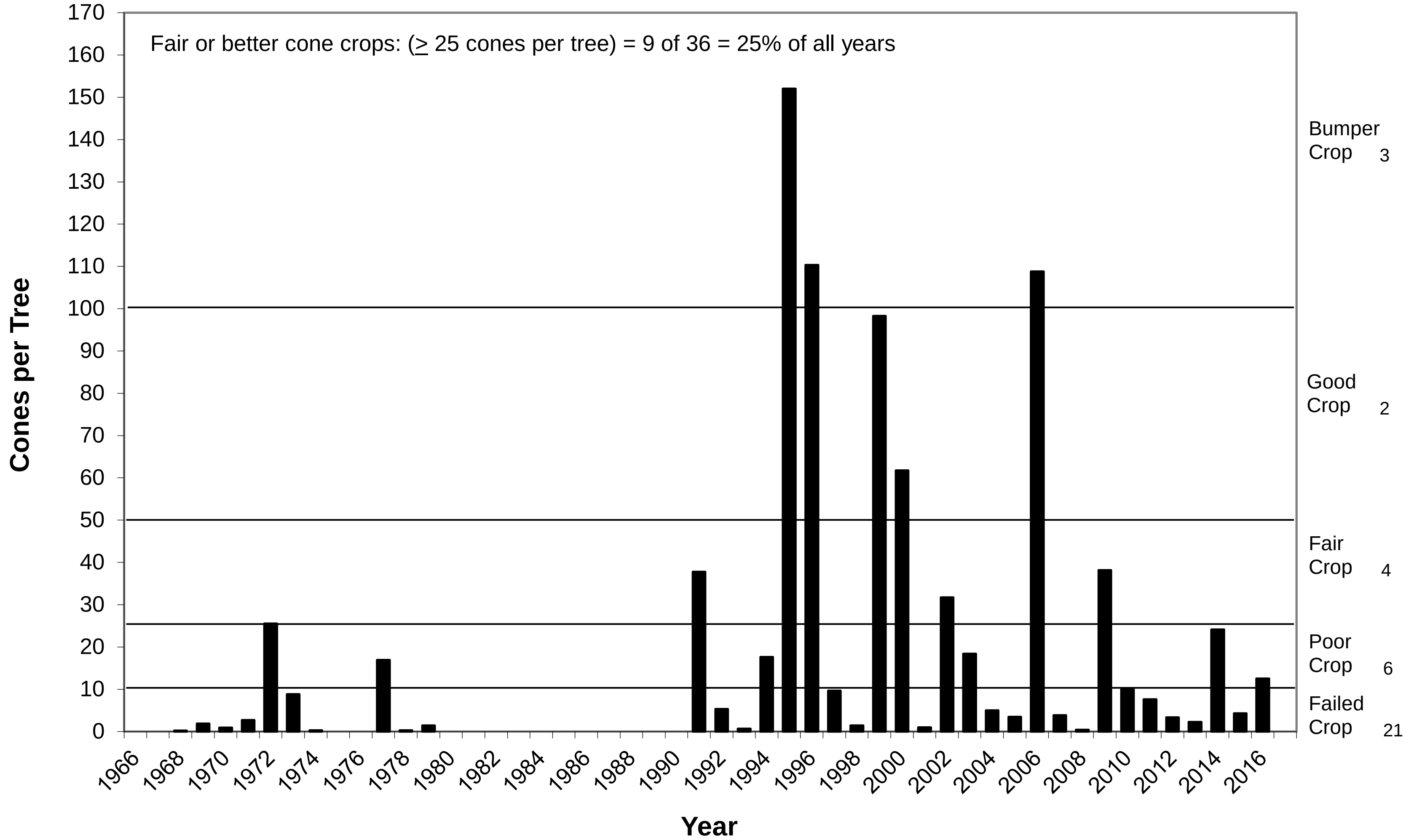

Longleaf Pine Cone Production in the Red Hills (since 1999):
at Pebble Hill Plantation from 1999 to 2009 (white columns)
and Tall Timbers Research Station since 2010 (black columns)
Fair or better cone crops: (≥ 25 cones per tree) = 8 of 18 = 44% of all years
Cones per Tree
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Bumper Crop 0
Good Crop 3
Fair Crop 5
Poor Crop 5
Failed Crop 5

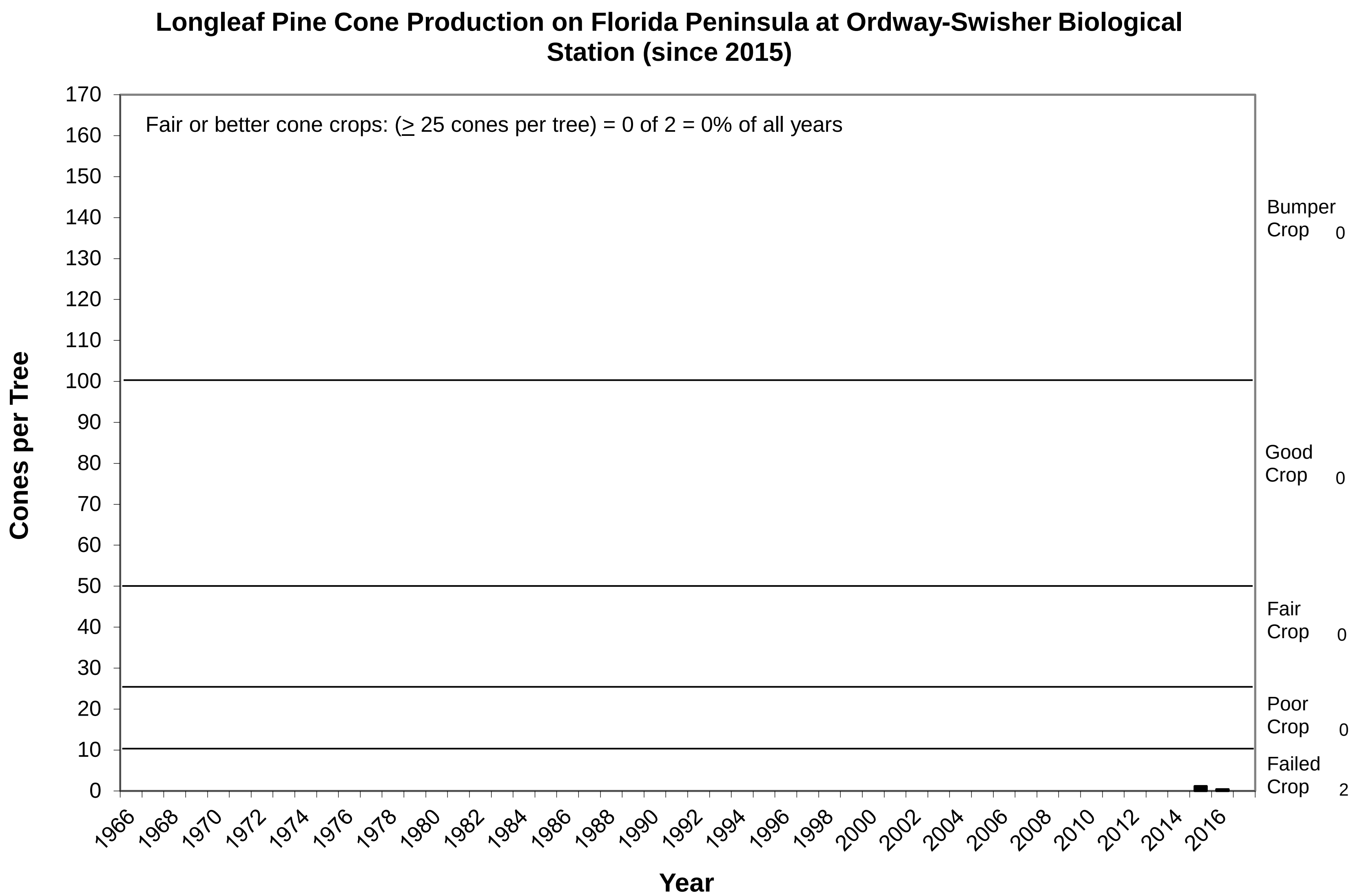

Longleaf Pine Cone Production in Western Georgia at Fort Benning (since 1993)
Fair or better cone crops: (≥ 25 cones per tree) = 7 of 22 = 32% of all years
Cones per Tree
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Bumper Crop 1
Good Crop 2
Fair Crop 4
Poor Crop 11
Failed Crop 4
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Year



Longleaf Pine Cone Production in South Carolina at Sandhills SF (since 1969)
Fair or better cone crops: (≥ 25 cones per tree) = 20 of 48 = 42% of all years
Cones per Tree
Year
Bumper Crop 3
Good Crop 9
Fair Crop 8
Poor Crop 6
Failed Crop 22

Longleaf Pine Cone Production in North Carolina at Bladen Lakes SF (since 1968)




Longleaf Pine Cone Production on Florida Peninsula at Ordway-Swisher Biological Station (since 2015)
Fair or better cone crops: (≥ 25 cones per tree) = 0 of 2 = 0% of all years
Cones per Tree
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Bumper Crop 0
Good Crop 0
Fair Crop 0
Poor Crop 0
Failed Crop 2
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Year