Relationship of mast production to big-game harvests in West Virginia

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Abstract Food availability influences population demographics and harvest of wildlife species throughout the Appalachians. Various combinations of hard- and soft-mast indices were compared to white-tailed deer (*Odocoileus virginianus*), eastern wild turkey (*Meleagris gallopavo*), and black bear (*Ursus americanus*) statewide harvests in West Virginia, USA, 1980–2002. Hard-mast conditions had a negative relationship with total white-tailed deer (r=–0.5774, P=0.004), archery white-tailed deer (r=–0.5979, P=0.003), antlerless white-tailed deer (r=–0.5065, P=0.014), wild turkey (r=–0.6193, P=0.002), and black bear archery (r=–0.6065, P=0.002) harvests. Hard-mast conditions had a positive relationship with black bear gun harvests (r=0.6975, $P\leq0.001$). Negative nonsignificant (P>0.05) relationships were measured between mast conditions and buck white-tailed deer and muzzleloader white-tailed deer harvests. Hard mast+black cherry (*Prunus serotina*) had the strongest negative relationship with wild turkey (r=–0.6497, $P\leq0.001$) harvest, whereas oak (*Quercus* spp.) had the greatest negative relationship with total white-tailed deer (r= –0.6238, P=0.002), archery white-tailed deer (r=–0.6133, P=0.002), and antlerless white-tailed deer (r=–0.5648, P=0.005) harvests. Total hard mast had the greatest positive relationship with black bear gun (r=0.6975, $P\leq0.001$) and greatest negative relationship with black bear archery (r=–0.6065, P=0.002) harvests. Soft-mast conditions did not relate to harvest of any big-game species (P>0.05). Our results supply wildlife biologists with data that may be used in setting seasons or predicting harvests for the public.

Key words black bear, eastern wild turkey, harvest, mast, mast production, *Meleagris gallopavo,* oak, *Odocoileus virginianus, Quercus, Ursus americanus,* West Virginia, white-tailed deer

Wildlife biologists are commonly asked to predict big-game harvests. Food supply, weather, population demographics, vulnerability to hunters, and hunter pressure appear to be important factors in formulating reliable harvest estimates (Pelton et al. 1986, Kane 1989, McDonald et al. 1994, Noyce and Garshelis 1997). Food availability can control movement and distribution of wildlife (Garshelis and Pelton 1981, Rogers 1987, Carlock et al. 1993, McShea and Schwede 1993, McDonald et al. 1994). When food is abundant, animals do not concentrate around specific food sources (Carlock et al. 1993, Burhans et al. 2000) and are therefore less susceptible to hunters. However, abundant food conditions may cause black bears (*Ursus americanus*) to den later, thus exposing them to potential harvests later in the year (Johnson and Pelton 1980). Some evidence suggests that fall wild turkey (*Meleagris gal-*

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lopavo) harvests are greater in years of poor mast production because flocks are more vulnerable to hunting when wild turkeys concentrate around alternative food sources (Menzel 1975, Pack 1994). Food distribution and abundance influence home-range overlap and densities of black bears (Rogers 1987, Pelton 1989), white-tailed deer (*Odocoileus virginianus*; Carlock et al. 1993), and wild turkeys (Burhans et al. 2000).

Baiting for white-tailed deer is legal for hunters in West Virginia and may influence black bear and wild turkey harvests because of their attraction to bait (Kane 1989, Burhans et al. 2000). In Massachusetts black bears were more vulnerable to harvest near alternative food sources during years of mast failure (McDonald et al. 1994). In Vermont Willey (1971) noted that black bears were more vulnerable to harvest during early morning and evening hours in September and October, times when bowhunters were most likely to be afield.

Van Dersal (1940) indicated the importance of acorns as a major food source for many wildlife species as early as 1940. When mast crops are abundant, acorns may comprise >44% of the diet of white-tailed deer during fall and winter in the southern Appalachians (Harlow et al. 1975, Wentworth et al. 1990*a*, Feldhamer 2002) and greatly influence population dynamics of white-tailed deer (Wentworth et al. 1992), black bears (Vaughan 2002), and wild turkeys (Steffen et al. 2002). Acorns and other seeds represent the most valuable and energy-rich native plant foods available in the dormant season. Only during years of complete mast failure does forage abundance exceed that of mast (Healy et al. 1997).

Mast survey data have been collected annually in West Virginia since 1970 (Pack 2000). We used this long-term data set to study the relationship of mast abundance to big-game harvests. Our objective was to determine whether there were relationships between West Virginia's extensive and qualitative mast surveys and big-game harvests.

We hypothesized that abundant hard mast would have a negative relationship with white-tailed deer, wild turkey, and black bear archery harvests and a positive relationship with black bear gun harvest. We also hypothesized that abundant soft mast would have a negative relationship with wild turkey and black bear archery harvests but not white-tailed deer or black bear gun harvests because such mast usually is not as available during November and December.

Study area

West Virginia was divided into 3 physiographic provinces: the Western Hill Section, the Allegheny Mountain and Upland Section, and the Eastern Ridge and Valley Section (Strausbaugh and Core 1978). The Western Hill Section was characterized as a central hardwood forest with vegetation communities ranging from oak (*Quercus* spp.)–hickory (*Carya* spp.) on drier sites to flood-plain communities along the Ohio River. Sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), and yellow birch (*Betula alleghaniensis*) dominate the Allegheny Mountain and Upland Section; however, oak and black cherry (*Prunus serotina*) may dominate lower elevations and drier sites, and were very important to wildlife (Pack et al. 1999). The Eastern Ridge and Valley Section was predominantly a composition of oak–hickory–pine (*Pinus* spp.). Elevation ranged from 73–1,524 m (Strausbaugh and Core 1978).

Methods

Mast conditions were measured annually during August and indexed for the state from 1980–2002. Division of Forestry personnel, Division of Natural Resources personnel, and volunteers conducted surveys. Personnel rated 9 hard-mast species: American beech, walnut (*Juglans* spp.), hickory, white oak (*Q. alba*), chestnut oak (*Q. prinus*), black oak (*Q. velutina*)–red oak (*Q. rubra*), yellow-poplar (*Liriodendron tulipifera*), scarlet oak (*Q. coccinea*), and scrub oak (*Q. ilicifolia*). In addition, they rated 9 soft-mast species: black cherry, grapes (*Vitis* spp.), hawthorn (*Crataegus* spp.), crabapple (*Malus* spp.), flowering dogwood (*Cornus florida*), blackberry (*Rubus* spp.), greenbrier (*Smilax* spp.), sassafras (*Sassafras albidum*), and apple (*Malus pumila*). Walnut was not included in hard-mast correlations because it is used infrequently by the wildlife species studied (Huntley 1989). Yellow-poplar was considered a soft-mast species for analysis.

We instructed surveyors to perform surveys in the same areas each year and conduct one survey at a high-elevation site on or near the ridge line and one at a low-elevation site closer to the corresponding water drainage. Surveyors recorded location, county, date, elevation, and aspect. Each surveyor described available fruit as abundant (above normal), common (normal), or scarce (below normal). A mast index was calculated for each mast species

Table 1. White-tailed deer residual harvests and mast index correlations in West Virginia, 1980–2002.

	Season									
	Total		Archery		Buck		Antlerless		Muzzleloader	
Mast index	*r* [a]	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Oak	–0.6238	0.002	–0.6133	0.002	–0.3794	0.074	–0.5648	0.005	–0.3835	0.071
Oak + hickory	–0.5885	0.003	–0.6016	0.002	–0.3398	0.113	–0.5344	0.009	–0.3935	0.063
Hard mast	–0.5774	0.004	–0.5979	0.003	–0.3564	0.095	–0.5065	0.014	–0.3819	0.072
Hard mast + BC	–0.5589	0.006	–0.6074	0.002	–0.3617	0.090	–0.4625	0.026	–0.4116	0.051
Soft	–0.0649	0.768	–0.0669	0.762	–0.1039	0.637	–0.0469	0.831	–0.2963	0.169

[a] *r* = Pearson correlation coefficient, *P* = *P*-value.

by adding the percentage of surveyors reporting mast as abundant and one-half of the percentage of the surveyors reporting mast as common. Scarce was given a value of zero (Uhlig and Wilson 1952). Surveys were indexed by species for each year. We compared mast abundance to each specific big-game season for each species.

We obtained harvest figures each year from tags collected at mandatory check stations throughout the state. White-tailed deer archery season typically ran from the Saturday closest to 15 October until 31 December. Buck white-tailed deer (with at least 1 antler of length ≥7.62 cm) season ran 2 weeks beginning the Monday of Thanksgiving week and was followed by one week of antlerless white-tailed deer season and then by one week of muzzleloader white-tailed deer season. Wild turkey season ran 3 weeks beginning the Saturday after the start of archery season and normally reopened for 1 week in December. Black bear archery ran from the Saturday closest to 15 October until the Saturday before Thanksgiving. Gun season for black bear typically started the first Monday of December and ended the last day of the month.

Big-game harvest increased over the course of the study period. We used simple linear regression equations to correct for these changes over time, using (actual) year as the independent variable to calculate the predicted harvest.

We computed pairwise associations between the big-game harvest residuals (difference between predicted versus actual harvest figures) and the various combinations of hard- and soft-mast indices using the sample Pearson correlation coefficient, r (SAS Institute 1987). Correlation coefficients indicated the relationship between big-game harvest and various mast indices after correcting for changing harvest trends.

We compared 8 big-game seasons with 5 combinations of mast for each season: oak, oak+hickory, all hard mast, all hard mast+black cherry, and soft mast. We selected these mast conditions based on predominant cover types for the state, availability, and species preference by wildlife.

Because most of the harvest figures were pairwise correlated with mast indices (Tables 1 and 2), we constructed regression equations that could be used to predict (or explain) big-game harvest (Tables 3 and 4). We used Akaike's Information Criterion (Akaike 1973) and the methodology of Burnham and Anderson (2002) to select appropriate models. We used the 5 previously described indices; a global model (all mast species individually); a partial model with beech, hickory, white oak, black oak–red oak, chestnut oak, scarlet oak, and black cherry; and a mast model with every mast species averaged by respective year. We included year in all models to account for changes in harvest. We used AICc to correct for small-sample-size bias. The best-approximating model was selected based on minimum AICc, ΔAICc, and Akaike weights (w_i) (Burnham and Anderson 2002). We considered models within 2 ΔAICc units of the best model competing models for explaining harvest.

Table 2. Eastern wild turkey and black bear residual harvests and mast index correlations in West Virginia, 1980–2002.

	Wild turkey		Black bear archery		Black bear gun	
Mast index	*r* [a]	*P*	*r*	*P*	*r*	*P*
Oak	–0.5682	0.005	–0.5217	0.011	0.6082	0.002
Oak + hickory	–0.5806	0.004	–0.5607	0.005	0.6498	≤0.001
Hard mast	–0.6193	0.002	–0.6065	0.002	0.6975	≤0.001
Hard mast + BC	–0.6497	≤0.001	–0.5674	0.005	0.6818	≤0.001
Soft	–0.2794	0.197	–0.1454	0.508	0.2808	0.194

[a] *r* = Pearson correlation coefficient, *P* = *P*-value.

Table 3. Predictive regression equations using year and mast indices for white-tailed deer with a ΔAICc < 2 from West Virginia, 1980–2002.

Season	Regression equation	R^2
Total white-tailed deer	Y = –15616830 + 7946.87950 (Year) –1319.80612 (Oak index)	0.9326
	Y = –15695036 + 7985.94933 (Year) –1252.29039 (Oak + hickory index)	0.9278
Archery white-tailed deer	Y = –2541640 + 1291.00919 (Year) –160.52109 (Oak index)	0.9580
	Y = –2532101 + 1286.70392 (Year) –172.88491 (Hard mast + Black cherry index)	0.9575
	Y = –2550578 + 1295.59071 (Year) –158.35808 (Oak + Hickory index)	0.9570
	Y = –2538827 + 1289.53142 (Year) –148.73533 (Hard mast index)	0.9567
Buck white-tailed deer	Y = –4692254 + 2400.47011 (Year) –351.03952 (Oak index)	0.8230
	Y = –4674137 +2392.14767 (Year) –363.92398 (Hard mast + Black cherry index)	0.8203
	Y = –4688239 + 2398.07836 (Year) –313.38902 (Hard mast index)	0.8195
	Y = –4714661 + 2411.33844 (Year) –316.15776 (Oak + Hickory index)	0.8170
Antlerless white-tailed deer	Y = –6844299 + 3476.32935 (Year) –701.90697 (Oak index)	0.8759
	Y = –6885699 + 3497.05059 (Year) –688.02835 (Oak + Hickory index)	0.8698
Muzzleloader white-tailed deer	Y = –1530459 + 775.47865 (Year) –124.11659 (Hard mast + Black cherry index)	0.8488
Muzzleloader white-tailed deer	Y = –1544098 + 781.96960 (Year) –109.74619 (Oak + Hickory index)	0.8461
	Y = –1538636 + 779.07085 (Year) –106.33855 (Oak index)	0.8447
	Y = –1513582 + 767.30176 (Year) –123.74002 (Mast index)	0.8445
	Y = –1536387 + 777.94038 (Year) –100.67333 (Hard mast index)	0.8445

In cases where a number of models were within 2 ΔAICc units of the best model, we concluded a high level of model uncertainty. Essentially this meant that considerable variation could be expected from using only the best selected model (Burnham and Anderson 2002)

Results

Mast conditions fluctuated widely by year. Bumper crops were produced in 1983, 1984, 1989, and 1998. Mast failures occurred at approximately 5-year intervals, with the most extreme failures observed in 1982, 1992, 1997, and 2002. Large fluctuations in big-game harvests were most noticeable during abundant or failure years.

There was a negative relationship ($P < 0.05$) between hard mast and total white-tailed deer, archery white-tailed deer, and antlerless white-tailed deer harvests (Table 1). Oak conditions had the highest negative correlation with total white-tailed deer ($r = -0.6238$, $P = 0.002$), archery white-tailed deer ($r = -0.6133$, $P = 0.002$), and antlerless white-tailed deer ($r = -0.5648$, $P = 0.005$) harvests (Table 1). Oak-mast conditions were not correlated to buck white-tailed deer ($r = -0.3794$, $P = 0.074$) or muzzleloader white-tailed deer ($r = -0.3835$, $P = 0.071$) harvests. Soft-mast conditions were not correlated to any type of white-tailed deer harvest ($P > 0.05$; Table 1).

Hard-mast conditions had a direct negative relationship with wild turkey harvests ($P < 0.05$), but soft mast did not ($r = -0.2794$, $P = 0.197$; Table 2). Hard mast+black cherry had the strongest negative correlation with wild turkey harvest of any mast combination ($r = -0.6497$, $P \leq 0.001$).

Table 4. Predictive regression equations using year and mast indices for wild turkey and black bear with a ΔAICc < 2 from West Virginia, 1980–2002.

Season	Regression equation	R^2
Wild turkey	Y = 90069 – 42.3778 (Year) –64.62985 (Hard mast +Black cherry index)	0.4731
	Y = 87238 – 41.19648 (Year) –53.84600 (Hard mast index)	0.4371
Black bear archery	Y = –48281 + 24.44919 (Year) –5.55276 (Hard mast index)	0.8665
	Y = –48129 + 24.38312 (Year) –5.94279 (Hard mast + Black cherry index)	0.8568
	Y = –48766 + 24.68894 (Year) –5.43147 (Oak + Hickory index)	0.8550
Black bear gun	Y = –73288 + 36.79643 (Year) + 10.04569 (Hard mast index)	0.8774
	Y = –73656 + 36.95325 (Year) + 11.23436 (Hard mast + Black cherry index)	0.8724

Black bear gun harvest ($r=0.6975, P \leq 0.001$) was positively correlated and black bear archery harvest ($r=-0.6065$, $P=0.002$) was negatively correlated with hard mast (Table 2). Soft mast was not correlated with black bear gun or archery harvest ($P>0.05$).

In our model selection process, we found high levels of model uncertainty in the white-tailed deer, wild turkey, and bear harvest models (Tables 5 and 6). Because no individual model was clearly the best-approximating model, for predictions we recommend selecting those competing models that provide a 95% confidence set of KL best models (Burnham and Anderson 2002) and weighing model predictions based on Akaike weights (w_i) (Burnham and Anderson 2002).

Discussion

Results supported our hypothesis that abundant hard-mast conditions were negatively related to white-tailed deer harvests. The most likely reason was that hard mast, particularly oaks, is a primary food source during hunting season. White-tailed deer reduce movements and concentrate closer to food plots during mast failures (Carlock et al. 1993), and these food plots appear to be an important food source when acorns are in short supply (Wentworth et al. 1990*b*). Thomas et al. (1976) and Giles and Gwynn (1962) determined that behavior of hunters was influenced by characteristics of areas they hunt. Proximity of roads, trails, clearings, parking areas, and campgrounds influenced hunter locations and white-tailed deer harvest (Thomas et al. 1976). Therefore, white-tailed deer located closer to food plots during years of poor mast production (Carlock et al. 1993) were more likely to encounter and be killed by hunters frequenting these areas (Thomas et al. 1976). Buck white-tailed deer season is the most popular hunting season in West Virginia, and the first 3 days of the season have the most hunters afield. Due to the large number of sportsmen afield during a short time, buck white-tailed deer season harvest is primarily controlled by a combination of factors including weather, hunter pressure, population densities, and mast availability and is probably why mast production was not significant at the $\alpha=0.05$ level.

Our results supported Menzel (1975) and Pack (1994), who hypothesized that mast abundance may influence wild turkey harvest. Mast failures were correlated with high harvests, whereas

Table 5. Models (ranking from best to worst) relating relationship of mast indices on white-tailed deer harvests in West Virginia, during 1980–2002.

Model structure	*K*	AICc	ΔAICc	Akaike weight
Total white-tailed deer				
Oak	4	451.45	0.00	0.477
Oak + hickory	4	453.03	1.57	0.217
Hard mast	4	453.46	2.01	0.175
Hard mast + black cherry	4	454.16	2.71	0.123
Mast	4	460.08	8.63	0.006
Soft	4	462.69	11.24	0.002
Partial	10	473.81	22.36	0.000
Null	2	507.86	56.41	0.000
Global	19	687.79	236.34	0.000
Archery white-tailed deer				
Oak	4	355.80	0.00	0.295
Hard mast + black cherry	4	356.04	0.23	0.262
Oak + hickory	4	356.34	0.54	0.225
Hard mast	4	356.47	0.67	0.211
Mast	4	363.95	8.15	0.005
Soft	4	366.52	10.72	0.001
Partial	10	381.83	26.03	0.000
Null	2	423.07	67.27	0.000
Global	19	579.73	223.93	0.000
Buck white-tailed deer				
Oak	4	421.18	0.00	0.263
Hard mast + black cherry	4	421.52	0.34	0.222
Hard mast	4	421.63	0.45	0.210
Oak + hickory	4	421.94	0.76	0.180
Mast	4	423.67	2.49	0.076
Soft	4	424.51	3.33	0.050
Partial	10	442.18	21.00	0.000
Null	2	455.38	34.20	0.000
Global	19	636.25	215.07	0.000
Antlerless white-tailed deer				
Oak	4	429.48	0.00	0.461
Oak + hickory	4	430.60	1.11	0.264
Hard mast	4	431.50	2.02	0.168
Hard mast + black cherry	4	432.78	3.30	0.089
Mast	4	436.81	7.32	0.012
Soft	4	438.30	8.82	0.006
Partial	10	449.32	19.84	0.000
Null	2	471.86	42.37	0.000
Global	19	692.83	263.34	0.000
Muzzleloader white-tailed deer				
Hard mast + black cherry	4	365.05	0.00	0.229
Oak + hickory	4	365.47	0.42	0.186
Oak	4	365.67	0.62	0.168
Mast	4	365.70	0.65	0.166
Hard mast	4	365.70	0.65	0.166
Soft	4	367.05	2.00	0.084
Partial	10	391.76	26.70	0.000
Null	2	402.89	37.83	0.000
Global	19	601.97	236.91	0.000

Table 6. Models (ranking from best to worst) relating relationship of mast indices on wild turkey and black bear harvests in West Virginia, during 1980–2002.

Model structure	*K*	AICc	ΔAICc	Akaike weight
Wild turkey				
Hard mast + black cherry	4	305.64	0.00	0.531
Hard mast	4	307.16	1.52	0.248
Oak + hickory	4	308.86	3.22	0.106
Oak	4	309.34	3.69	0.084
Mast	4	311.97	6.33	0.022
Null	2	314.76	9.12	0.006
Soft	4	316.29	10.65	0.003
Partial	10	327.70	22.06	0.000
Global	19	570.94	265.30	0.000
Black bear archery				
Hard mast	4	204.19	0.00	0.478
Hard mast + black cherry	4	205.79	1.60	0.215
Oak + hickory	4	206.09	1.89	0.185
Oak	4	207.45	3.26	0.094
Mast	4	210.09	5.90	0.025
Soft	4	214.45	10.26	0.003
Partial	10	229.94	25.75	0.000
Null	2	244.88	40.69	0.000
Global	19	452.74	248.55	0.000
Black bear gun				
Hard mast	4	220.23	0.00	0.500
Hard mast + black cherry	4	221.15	0.92	0.315
Oak + hickory	4	222.99	2.76	0.126
Oak	4	224.97	4.74	0.047
Mast	4	227.82	7.59	0.011
Soft	4	233.73	13.50	0.001
Partial	10	245.85	25.62	0.000
Null	2	262.88	42.65	0.000
Global	19	458.52	238.29	0.000

bumper mast crops produced lower than expected harvest. A change from low to high mast production produced better survival from hunting in other studies (Pack et al. 1999, Norman and Steffen 2003). Our results support these findings over an extended time period, differing mast conditions, and large geographic area. The percentage of acorns consumed by wild turkeys is influenced by a combination of habitat structure, acorn availability, and food preference (Steffen et al. 2002). Acorns have been shown to be a significant part of the diet of eastern wild turkeys (Kozicky 1942, Korschgen 1967) and have a strong relationship to harvest in the present study.

During years of abundant mast conditions, wild turkey flocks do not need to move as often to locate quality food sources and thus have smaller fall home ranges (Lewis and Kurzejeski 1984, Kelley et al. 1988), but during years of poor mast production will have greater shifts (Kurzejeski and Lewis 1990, Healy 1992). However, Burhans et al. (2000) provided evidence that the home range of wild turkeys may be influenced by artificial feeding during years of poor mast conditions, and baiting makes it easier to locate birds initially and continue to find them at the same locations when mast is scarce. Conversely, because West Virginia is heavily forested (DiGiovanni 1990), with an abundance of oaks, beech, and black cherry, it becomes very difficult to pinpoint flocks during bumper mast years when birds are not concentrated around a specific food source. Heavy hunting pressure may magnify poor mast conditions and must be taken into consideration when fall seasons are set (Steffen et al. 2002).

Mast conditions had a positive correlation with black bear gun harvests. Food availability during a given year affects black bear denning chronology (Alt 1980, Johnson and Pelton 1980, Schooley et al. 1994). Acorns are the most important fall food for black bears throughout the Appalachians (Cottam et al. 1939, Beeman and Pelton 1980, Garner 1986, Schrage 1994, Vaughan 2002) and may greatly affect denning ecology of West Virginia's black bears. Black bears den later during years of abundant mast (Johnson and Pelton 1980, Schooley et al. 1994), potentially making them more vulnerable to hunters during West Virginia's gun season in December. During years of mast failure black bears enter dens earlier than normal (Schooley et al. 1994), thereby potentially reducing gun harvests.

Mast conditions were negatively correlated with black bear bow harvest. When acorns are abundant, black bears' home-range shifts are minimal between seasons (Pelton 1989) but they increase their activity (Amstrup and Beecham 1976) in a specific area, making them less likely to encounter a bowhunter in a treestand (the most popular form of bowhunting in West Virginia). Black bears roam farther during mast failures in search of food (Pelton 1989, Kasbohm 1994), which increases their chance of being harvested or being attracted to human-related food sources (Noyce and Garshelis 1997). In the present study, the most noticeable changes in the black bear bow harvest occurred during mast failures or abundant crops. Black bears respond to drastic decreases in fall food supply by general long-range movements, using an area with high acorn concentration, intensive use of small areas, or accommodations of a prime acorn area (Pelton 1989). Any or all of these reasons outlined by Pelton (1989), Kasbohm (1994), or Noyce and Garshelis (1997) would directly influence the archery harvest and could make black bears more susceptible to harvest during mast failure.

It was legal to bait white-tailed deer but not black bears in West Virginia (West Virginia Division of Natural Resources 1998). Hunters who used bait (corn, apples, horse feed, etc.) for white-tailed deer also attracted black bears. Because white-tailed deer and black bear archery seasons coincide, hunters had opportunities to illegally take black bears because bait attracted both species, especially during poor mast years (Rogers 1987, McDonald et al. 1994).

Our results support Koenig (1999) in that mast condition may be symmetrical within a given year across large geographical regions. West Virginia is divided into 3 physiographic provinces (Strausbaugh and Core 1978), and if these regions had high variability in mast conditions, it is doubtful that significant correlations between mast condition and harvest would occur. Our results also provide evidence that mast conditions may be used to help predict big-game harvest over large geographic areas.

Huntley (1989) ranked oaks as the most important woody plant in relation to the 6 major game species in the Southern Appalachian Region. In our study oaks were the principal species that correlated with big-game harvests. Oak was the most heavily weighted model for most white-tailed deer models. However, hard mast or the combination of all hard mast + black cherry were the most heavily weighted for wild turkey and black bear and show evidence of being biologically significant. We feel these additional mast species should be included in surveys and models because it increases their accuracy and precision for most species.

Soft mast is more important for wildlife during late spring and early summer (Huntley 1989). Hunting seasons for all big-game species in this study occurred during fall and early winter. Our results did not show relationships between any big-game harvest and soft-mast conditions and imply that soft mast is not important to big-game animals during hunting seasons in West Virginia. West Virginia is also heavily forested (DiGiovanni 1990) with mature hard-mast species, and soft mast is limited in availability and abundance.

Management implications

Mast surveys have been used in West Virginia to forecast white-tailed deer, wild turkey, black bear, and squirrel (*Sciurus* spp.) harvests for 30 years. Our results provide analytical support for using mast condition as a harvest-trend indicator for big-game species, and they show that mast surveys have potential to predict harvest over wide geographic areas. The mast survey methodology used in West Virginia is simple to conduct and analyze, and easy to activate for agencies wanting to monitor mast. Survey results also provide useful information for the hunting public. Future studies that include demographic data, hunter-pressure information, specific mast species, and weather patterns in analyses may improve precision and accuracy.

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