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Safety in Bear Country: Protective Measures and Bullet Performance at Short Range

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Abstract

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Bears are frequently encountered by people working in or enjoying the outdoors. Some government agencies have regulations concerning the firearms their personnel carry for protection against bears.

Guidelines to prevent hazardous encounters with bears are presented, and the performance of commonly used weapons and ammunition is discussed. The ballistic performance of bullets at short range is often considerably different from performance of the same bullet at the longer ranges generally encountered while hunting.

Recommendations are made for weapons and ammunition used as protection from bears.

Keywords: Safety, safety equipment, bears, ballistics, Alaska.

Introduction

Brown bears (*Ursus arctos*) are found from the seashore to the alpine zone on the islands and mainland along most of the Pacific coast of Alaska.[1] The brown bear is a large, fast-moving animal, unpredictable in its response to humans, and a definite hazard to those who must work in areas inhabited by bears.

The USDA Forest Service in Alaska requires at least one member of each work party to carry a rifle.[2] The most common weapon issued is a bolt-action magazine rifle chambered for the .375 H & H Magnum cartridge. Commercial ammunition is used exclusively. For handiness in the dense brush cover of the Alaska coast, most of these rifles have barrels shortened to 20 inches. Receiver (peep) sights or factory-installed open sights are used; recoil pads and slings are usually present.

In the past, most Forest Service professionals working where brown bears occur had personally acquired experience with firearms. In recent years, however, the Forest Service has employed many persons with little or no experience with firearms, and some with a strong aversion to them. The Forest Service provides training programs in the use of firearms for employees who must work in bear country. The extent and quality of these programs vary from a cursory session on how to load and fire a rifle to a rather intensive course in nomenclature, maintenance and handling of rifles, marksmanship under field conditions, and anatomy and behavior of bears. The rifles used for training are like those to be carried in the field (that is, short-barreled, bolt-action, .375 Magnum). Shooting this rifle may be very unpleasant for some inexperienced persons. They become more apprehensive of the rifle (a known effect) than of the bear (an unknown effect).

The difficulties of training inexperienced persons to properly use large-caliber rifles might be lessened by using smaller caliber weapons. Recoil, muzzle blast, and rifle weight could be decreased, but possibly at the expense of killing power. To provide an inadequate weapon just because it was more pleasant to shoot would be unwise. What, then, constitutes an adequate weapon for protection against bears in the coastal regions of Alaska?

Much has been written about the performance of various cartridges and bullets on big game animals. Most tests have been conducted at ranges of 50 or 75 yards to 300 yards or more, ranges at which hunted game is usually shot.

Little information is available on the performance of cartridges and bullets at ranges that could be considered critical in a life-threatening situation. Distances greater than 15 to 20 yards probably do not constitute a dangerous situation, and some other way to avoid a conflict is probably available.

Our purpose was to evalute the commonly used and readily available cartridges (and weapons) for protection from bears at short range. We selected a distance of 15 yards as the "point of no return"—the distance at which an *obviously aggressive* bear must be stopped or a person risks personal injury or death. We stress "obviously aggressive," a term for a bear that is charging, with the assumed intent of doing bodily harm.

[1] The same precautions apply to black bears (*Ursus americanus*). The grizzly bear is considered to be the same species as the brown bear.

[2] The policies of other agencies or institutions may differ. Some agencies do not require firearms to be carried; others prohibit them.

Methods

We selected a range of weapons and ammunition, including those issued by some government agencies to employees working in bear country or carried by the average outdoor person. Other combinations of weapons and ammunition are available, and they may compare favorably with those tested. Interested persons can conduct tests similar to those described here to arrive at their own conclusions for their particular equipment. They will have a better understanding of the capabilities of the weapon and ammunition, and the testing will force the individual to shoot more.

Familiarization with a weapon is at least as important as performance of the bullet in instilling confidence in a person. A person who knows the capability of a firearm is more likely to hold fire until a life-threatening situation is unavoidable or, in a sudden encounter, will react instinctively for defensive purposes.

Most of our testing was done with rifles, but we also evaluated handguns and the 12-gauge shotgun. Handguns are often carried by people working in bear country because they are much more portable and convenient than rifles, especially when work requires both hands. The short-barreled 12-gauge shotgun also has a reputation as a good weapon at close range. We tested both slugs and buckshot loads in the shotgun. In some instances, weapons firing a given cartridge were available with different barrel lengths. We tested these to evaluate the effects of barrel length on bullet performance.

We used ammunition manufactured by several companies, chosen solely on the basis of availability, and made no attempt to compare similar loads of different manufacturers. The ammunition and barrel length of the weapons tested are included in table 1 in the "Results" section.

We fired three shots in random order with each combination of cartridge, bullet weight (or type), and barrel length. This testing method allowed us to measure the penetration of each bullet in a relatively uniform medium, to recover the bullet, and to determine its striking energy. We also measured retained bullet weight and expansion.

To determine penetration and recover fired bullets, we used the testing medium recommended by Hagel (1978), who found that recovered bullets shot into a moistened mixture of 50 percent fine silt and 50 percent fine sawdust (by volume) were similar to bullets removed from various big game animals, including brown bears.

We built an open-end wooden box 12 by 12 by 24 inches to hold the silt-sawdust mixture, covering the open ends with scrap pieces of indoor-outdoor carpet to prevent spillage through bullet holes. To facilitate locating bullets, we placed the mixture in 4- by 10- by 12-inch cardboard file wallets. Six of these tightly filled wallets fit snugly into the box (fig. 1).

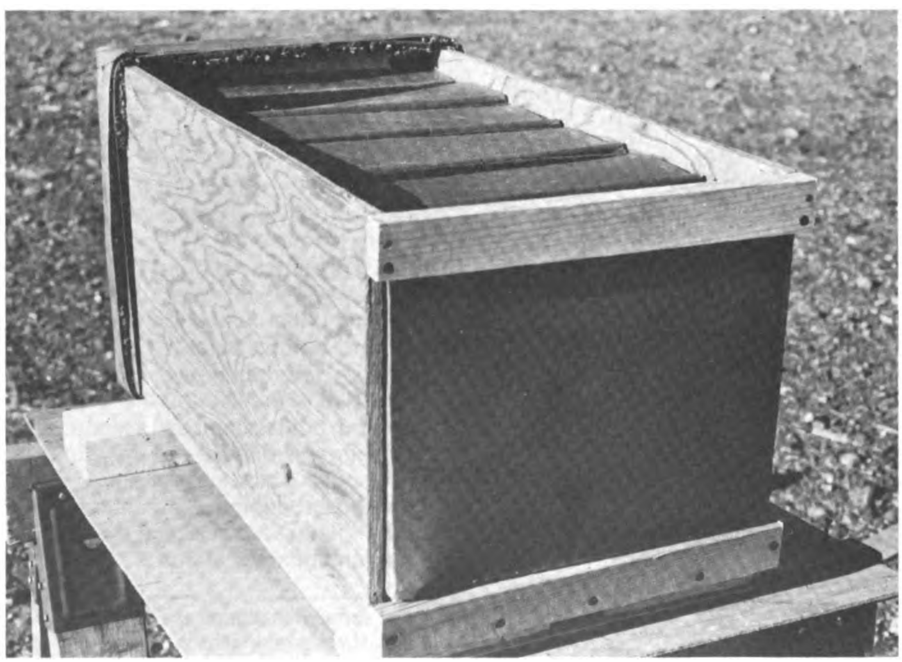

Figure 1. — Bullet recovery box.

After each shot, we located the bullet by sequentially lifting the wallets (fig. 2). We then carefully removed the silt-sawdust mixture from the wallet containing the bullet until the bullet was exposed and measured the distance from the bullet to the front of the box to the nearest 0.5 inch. We removed the bullet, including adjacent fragments, from the medium and placed it in a paper envelope for future examination.

We replaced the silt-sawdust mixture in the wallet where the bullet had stopped and repaired all bullet holes with plastic packaging tape. To avoid bias, we rearranged the front-to-back sequence of all six wallets according to a preselected random sequence after recovering each bullet. We shook the wallets before replacing them and added mixture if needed to keep the content relatively constant. It was necessary to replace all wallets after each six to eight shots. We replaced badly damaged wallets immediately.

We evaluated each cartridge-bullet weight-barrel length combination tested by four ballistic categories: striking energy, penetration, retained bullet weight, and bullet expansion. We also measured bullet velocity because energy is a function of bullet weight and velocity.

We fired all shots through the sky-screens of a Ballistocraft chronograph to determine bullet velocity (fig. 3).[3] We used a 5-ft screen spacing with the first screen at 10 ft. The velocity recorded was considered to be at 12.5 ft. The three-shot average velocity was converted to average velocity at 15 yards from tables provided by Hatcher (1962). Striking energy in foot-pounds (ft-lb) was determined from the formula $E = WV^2/450{,}240$, where W is the bullet weight in grains (gr), V is the velocity in feet per second, and $450{,}240 = 2 \times 32.16 \text{ ft/s}^2 \times 7000 \text{ gr/lb}$ (Hatcher 1962).

[3] Names of products are for information only; the chronograph was the personal property of one of the authors.

Figure 2. — Bullet box wallet insert.

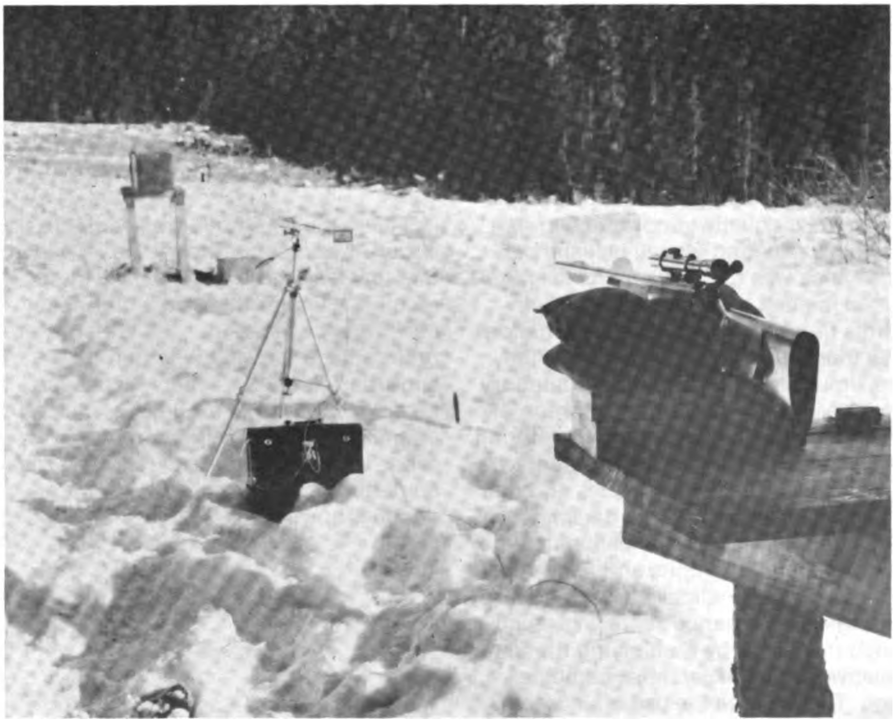

Figure 3. — Cartridge performance testing facility, showing chronograph and bullet recovery box.

Results and Discussion

We washed recovered bullets and bullet fragments in hot water and detergent to remove silt-sawdust medium. We rinsed, dried, and weighed each to the nearest grain. To determine expansion, we measured to the nearest 0.01 inch the maximum diameter of the bullet (or the largest fragment) and the diameter at 90° to the maximum diameter. The cross-sectional area of this ellipse was determined by the formula $A = 3.1416\ ab$, where a = maximum diameter and b = diameter at 90° to a. Both retained bullet weight and expansion were expressed as a percentage of the weight and cross-sectional area of an unfired bullet pulled from a cartridge identical to that fired in the tests.

We determined the free recoil energy using the method described by Mannes (1981). Although recoil is not directly involved in short-range terminal ballistics, it is a significant factor in the overall evaluation of rifles used for protection from bears.

Because we had no unbiased way to determine the relative importance of each ballistic category, we considered each to be equally important. Our first step in evaluating overall ballistic performance was to calculate the average value in each category for the three shots fired from each test combination. We then divided each average by the maximum average value in its category to convert it to a relative proportion of the maximum value encountered during the tests. We rounded the quotient to two significant decimal places and multiplied by 100 to eliminate decimals. This transformation also eliminated the different category units and allowed all four to be arithmetically combined into a single performance score. We calculated this score by multiplying the four relative scores of each test combination. To eliminate the use of unwieldy eight-digit numbers as scores, we divided the product by 100,000 and rounded the quotient to the nearest whole number. This provided a two- or three-digit score for each test combination, which we ranked in highest to lowest order.

Results of the tests are presented in table 1 and figure 4. We discuss each cartridge tested in the following categories: (1) large-, medium-, and small-caliber magnum rifle cartridges; (2) large-, medium-, and small-caliber standard rifle cartridges; (3) large- and medium-caliber magnum and standard handgun cartridges, and (4) the 12-gauge shotgun.

Large-Caliber Magnum Rifle Cartridges

.458 Winchester Magnum. — In overall ballistic performance, the .458 ranked first. Bullet penetration was the deepest of all the cartridges tested — average depth, 19 inches. Striking energy was 79 percent of the .460 Weatherby (ranked second), part of which may be attributed to the extra 10 gr of bullet weight in the .458. The bullet expanded well (4.6 times) and retained 82 percent of the unfired weight. The 510-gr Winchester factory bullets used in the .458 did not fragment, but the 500-gr bullets of the .460 Weatherby did. This was the major reason for the first-place ranking.

Recoil in the 9.4-lb rifle was 54.7 ft-lb or about 71 percent of that of the .460 in a rifle that was 1.3 lb heavier. The lesser recoil in a lighter rifle and better bullet performance make the .458 Winchester preferable to the .460 Weatherby. A short-barreled, bolt-action .458 would be an excellent rifle for an experienced rifleman. Shortening the barrel to 22 or even 20 inches should not reduce ballistic performance much. Any weight reduction, however, would increase recoil.

.460 Weatherby Magnum. — The .460 Weatherby Magnum cartridge ranked second in overall performance. The large-caliber, heavy bullet at relatively high velocity had good, but not the deepest, penetration. Although the chronographed velocity did not approach the advertised velocity, bullet energy exceeded that of the .458 Winchester by over 1300 ft-lb. Average retained bullet weight was 65 percent of the unfired weight. The bullets had a tendency to fragment. It appears the high striking energy exceeded the design limits of the bullet at the short test range. Cross-sectional area expansion was adequate and overall bullet performance good, but not the best.

The high overall performance of the .460 Weatherby was obtained in a heavy-recoiling, 10.7-lb rifle with a 26-inch barrel. We used a Weatherby Mark V rifle equipped with a receiver sight. It was very difficult to use this sight because of the high comb[4] of the Weatherby stock. This plus the heavy recoil made it very uncomfortable to shoot. The stock shape, heavy weight, and long barrel detract from the utility of the rifle in the heavy bush of coastal Alaska. This could be ameliorated if the rifle were remodeled, but shortening the barrel to 20 inches would lower velocity and energy. This might be beneficial if it also reduced the tendency of the bullet to fragment; however, there is little reason to reduce the .460 if a .458 is available.

A short-barreled .460 would have tremendous muzzle blast, and the recoil of a .460 Weatherby less than 10 lb in weight would be so severe that it would be difficult for the shooter to recover from the recoil and operate the bolt to rapidly chamber a second cartridge. For these reasons, we think the .460 Weatherby rifle is generally a poor choice for protection from bears in coastal Alaska.

[4] The comb is the top portion of the stock where the shooter's cheek rests.

Table 1 — Short-range ballistic performance

Cartridge	Ranking		Bullet			Ballistic performance					Firearm		
	Score	Rank	Weight	Type[1]	Brand[2]	Velocity, 15 yd	Energy, 15 yd	Penetration	Retained weight	Expansion ratio	Recoil	Weight	Barrel length
			Grains			*Ft/s*	*Ft-lb*	*Inches*	*Percent*	*Times*	*Ft-lb*	*Lb*	*Inches*
Rifle:[3]													
.458 Win. Mag.	538	1	510	RSP	W-W	2074	4871	19.0	82	4.6	54.7	9.4	24
.460 Wby. Mag.	487	2	500	RSP	WBY	2364	6204	17.2	65	3.8	76.8	10.7	26
.375 H & H Mag. (L)[4]	301	3	300	SSP	W-W	2541	4903	16.8	67	4.0	41.1	8.6	24
.338 Win. Mag. (S)	260	4	300	RSP	W-W	2314	3568	16.2	61	4.8	35.6	7.4	20
.375 H & H Mag. (L)	239	5	270	RSP	R-P	2659	4241	14.2	64	4.0	37.2	8.6	24
.338 Win. Mag. (S)	213	6	200	PSP	W-W	2699	3235	15.0	69	4.2	28.9	7.4	20
.338 Win. Mag. (S)	197	7	250	SSP	W-W	2507	3491	12.2	57	5.3	33.4	7.4	20
.338 Win. Mag. (L)	191	8	200	PSP	W-W	2834	3563	12.3	60	4.7	26.0	8.6	24
.338 Win. Mag. (L)	186	9	300	RSP	W-W	2360	3710	16.8	57	3.4	31.2	8.6	24
.375 H & H Mag. (S)	185	10	300	SSP	W-W	2401	3843	13.8	63	3.6	44.1	7.2	20.5
.30-06 U.S.	157	11	220	RSP	R-P	2261	2498	17.7	65	3.6	15.3	8.8	22
.30-06 U.S.	153	12	180	RSP	R-P	2456	2411	13.2	71	4.4	14.8	8.8	22
.444 Marlin	146	13	240	FSP	R-P	2237	2668	11.0	72	4.5	27.6	7.3	22
.358 Winchester	142	14	200	SSP	W-W	2366	2488	12.0	71	4.4	33.4	7.4	22
7 mm Rem. Mag.	141	15	175	PSP	W-W	2709	2853	13.0	44	5.6	18.5	9.1	24
.375 H & H Mag. (S)	137	16	270	RSP	R-P	2456	3735	12.3	50	3.9	39.4	7.2	20.5
.45-70 U.S. (S)	133	17	300	HSP	FED	1573	1649	13.0	84	4.8	15.6	7.1	20
.308 Winchester	128	18	180	RSP	FED	2430	2360	12.7	73	3.9	13.6	8.4	22
.45-70 U.S. (L)	124	19	300	HSP	FED	1666	1849	11.0	96	4.1	18.6	7.8	22
.358 Norma Mag.	115	20	250	PSP	NOR	2730	4139	15.2	41	2.9	25.0	8.4	24
8 mm Rem. Mag.	107	21	185	PSP	R-P	2991	3676	10.7	32	5.5	29.1	9.4	24
.300 Wby. Mag.	104	22	180	PSP	WBY	3033	3678	15.2	46	2.6	28.0	9.6	24
.338 Win. Mag. (L)	100	23	250	SSP	W-W	2594	3735	14.7	45	2.6	30.0	8.6	24
.350 Rem. Mag.	93	24	200	SSP	R-P	2568	2931	12.2	52	3.2	34.5	6.4	18.5
7x57 mm Mauser	87	25	175	RSP	FED	2419	2274	13.8	52	3.6	12.7	8.9	24
12-ga x 2¾ inch	74	26	438	LRN	FED	1398	1902	15.3	96	1.7	26.1	7.1	20
.45-70 U.S. (L)	65	27	405	RSP	R-P	1322	1572	15.8	93	2.1	17.7	7.8	22
.300 Win. Mag.	60	28	200	PSP	FED	2699	3237	15.2	36	2.2	25.9	7.8	24
.300 Wby. Mag.	59	29	220	RSP	WBY	2798	3826	15.2	34	2.0	30.8	9.6	24
.45-70 U.S. (S)	50	30	405	RSP	R-P	1211	1319	17.8	98	1.4	13.6	7.1	20
8 mm Rem. Mag.	49	31	220	PSP	R-P	2779	3773	12.8	28	2.5	18.9	9.4	24
.44 Rem. Mag. (L)	[5] 47	32	240	LGC	R-P	1401	1046	11.5	97	2.6	13.9	3.1	7.5
.300 Win. Mag.	44	33	180	PSP	FED	2959	3268	10.3	30	2.8	26.3	7.8	24
Handgun:													
.44 Rem. Mag. (L)	[6] 77	1	240	LGC	R-P	1401	1046	11.5	97	2.6	13.9	3.1	7.5
.44 Rem. Mag. (M)	64	2	240	LGC	R-P	1317	925	12.2	97	2.3	14.1	3.2	6.5
.44 Rem. Mag. (L)	63	3	240	JSP	W-W	1383	1019	14.5	94	1.8	12.4	3.1	7.5
.44 Rem. Mag. (S)	60	4	240	LGC	R-P	1265	853	11.3	97	2.5	15.8	2.9	5
.44 Rem. Mag. (S)	59	5	240	JSP	W-W	1370	1001	9.5	97	2.5	15.1	2.9	5
.44 Rem. Mag. (M)	57	6	240	JSP	W-W	1348	969	11.5	96	2.2	16.4	3.2	6.5
.357 S&W Mag.	27	7	158	JSP	CCI	1226	528	9.5	99	2.1	7.2	2.3	4
.45 Colt (L)	13	8	255	LRN	W-W	825	386	14.3	98	1.0	5.9	2.6	7.5
.45 Auto	12	9	230	SMJ	R-P	819	343	14.2	100	1.0	5.2	2.4	5
.41 Rem. Mag.	11	10	210	LFN	R-P	952	423	10.5	97	1.0	6.0	2.4	4.8
.45 Colt	11	11	225	LHP	FED	813	330	13.3	97	1.0	4.6	2.6	7.5
.45 Colt (S)	10	12	255	LRN	W-W	796	359	11.8	97	1.0	5.9	2.4	4.8
.44 S&W Spec.	9	13	246	LRN	W-W	745	303	12.1	99	1.0	3.9	3.1	7.5

[1] RSP = round nose soft point; SSP = semipointed soft point; PSP = pointed soft point; FSP = flat nose soft point; HSP = hollow soft point; LRN = lead round nose; LGC = lead gas-check; JSP = jacketed soft point; SMJ = solid metal jacket; LFN = lead flat nose; LHP = lead hollowpoint.
[2] W-W = Winchester-Western; R-P = Remington-Peters; FED = Federal; WBY = Weatherby; NOR =Norma; CCI = Speer.
[3] All rifles except 1 shotgun and 1 handgun included for comparison.
[4] L = long barrel; M = medium barrel; S = short barrel; applies only when the same cartridge was tested in different length barrels.
[5] Score calculated on same basis as rifles and shotgun.
[6] Score calculated for handguns only; not equal to rifle scores.

Medium-Caliber Magnum Rifle Cartridges

.375 H & H Magnum. — The .375 H & H Magnum was one of the cartridges tested with different bullet weights and in rifles with different barrel lengths. With the 300-gr bullet in a rifle with a 24-inch barrel, it ranked 3; with the 270-gr bullet in the same length barrel it ranked 5. Performance rankings for the rifle with a 20.5-inch barrel were 10 for the 300-gr bullet and 16 for the 270-gr bullet. Energy exceeded 4200 ft-lb in the longer barreled rifle for both bullets and 3700 ft-lb for the shorter barreled rifle. Bullets of both weights fired in the longer barreled rifle penetrated about 2 inches deeper, but there were only minor differences in retained bullet weight and relative bullet expansion. Velocity losses in the shorter barrel were 203 ft/s for 270-gr bullets and 140 ft/s for 300-gr bullets. Chronographed velocities were close to those advertised for the rifle with a 24-inch barrel.

Recoil in the 8.6-lb rifle with a 24-inch barrel ranged from 37 to 41 ft-lb. The 7.2-lb rifle with the shorter barrel had heavier recoil — 39 and 44 ft-lb for the 270- and 300-gr bullets, respectively. The heaviest recoil value was 57 percent of the recoil value of the .460 Weatherby and 81 percent of the .458 Winchester.

The similarity in overall ballistic performance and not too severe recoil make the lighter rifle with the shorter barrel preferable, although some ballistic performance is lost. The 300-gr bullet is preferable to the 270-gr bullet. This type of .375 rifle is commonly carried in coastal Alaska. The rifle must be rated at a capacity of three cartridges (magazine capacity) since it is unsafe to have a cartridge loaded in the chamber and depend on a mechanical safety to prevent discharge. Moving through thick brush, leaning the rifle against a tree, or laying it on the ground while working can cause inadvertent release of the safety on most bolt-action rifles. This applies to bolt-action rifles with the possible exception of those made on military actions, such as the Mauser or Springfield with their 180° safety levers, which are slow to operate; however, few .375 caliber rifles have such safeties. Regardless, the .375 H & H Magnum is an excellent cartridge for protection from bears at close range. Our tests merely reinforced its already excellent reputation.

.338 Winchester Magnum. — The .338 Winchester was tested with three bullet weights (200-, 250-, and 300-gr) and in rifles with two barrel lengths, 24 and 20 inches. The recently available 225-gr bullet was not produced at the time we made the tests, and the 250-and 300-gr bullets are no longer manufactured. The shorter barreled rifle gave slightly better overall ballistic performance. With the 300-gr bullet it was ranked 4 and was close to the 300-gr .375 H & H with a 4 inch longer barrel, although the .375 H & H had 1335 ft-lb more striking energy with a 300-gr bullet. The 300-gr .338 Winchester bullet had only 0.6 inch less penetration, retained slightly more bullet weight, and had slightly greater expansion than the 300-gr bullet in the .375. The 250-gr bullet gave much poorer overall ballistic performance than either the 300- or the 200-gr bullet. The .338 with the 200-gr bullet ranked 6 and 8, the rifle with the shorter barrel giving the better performance; it averaged 15 inches of penetration compared with 12.2 inches for the 250-gr bullet.

The 250-gr bullet had a tendency to shatter in the test medium which may account for the lower penetration. The 200-gr bullet should be selected if the 300-gr is not available. In the 7.4-lb .338 rifle with a 20-inch barrel, recoil was 35.6 ft-lb with the heaviest bullet. This was somewhat less than in the .375 with the same weight of bullet in both light and heavy rifles. The 200-gr bullet load generated 28.9 and 26.0 ft-lb of recoil in the rifles with 20- and 24-inch barrels, respectively, and was not uncomfortable to shoot. Shortening the barrel seemed to lower velocities only slightly for the 300- and 250-gr bullets, but a greater reduction in velocity occurred for the 200-gr bullet (see table 1). Chronographed velocities were similar to advertised velocities.

The reasonable recoil in a light, short-barreled rifle with impressive overall ballistic performance makes the .338 Winchester cartridge a good choice for rifles for protection from bears. Limitations are the same as for the other bolt-action magnums — low magazine capacity and the safety hazard inherent in a mechanical safety. Discontinuation of the 300-gr bullet in factory loading decreases the potential of the .338 as a cartridge for close-range protection.

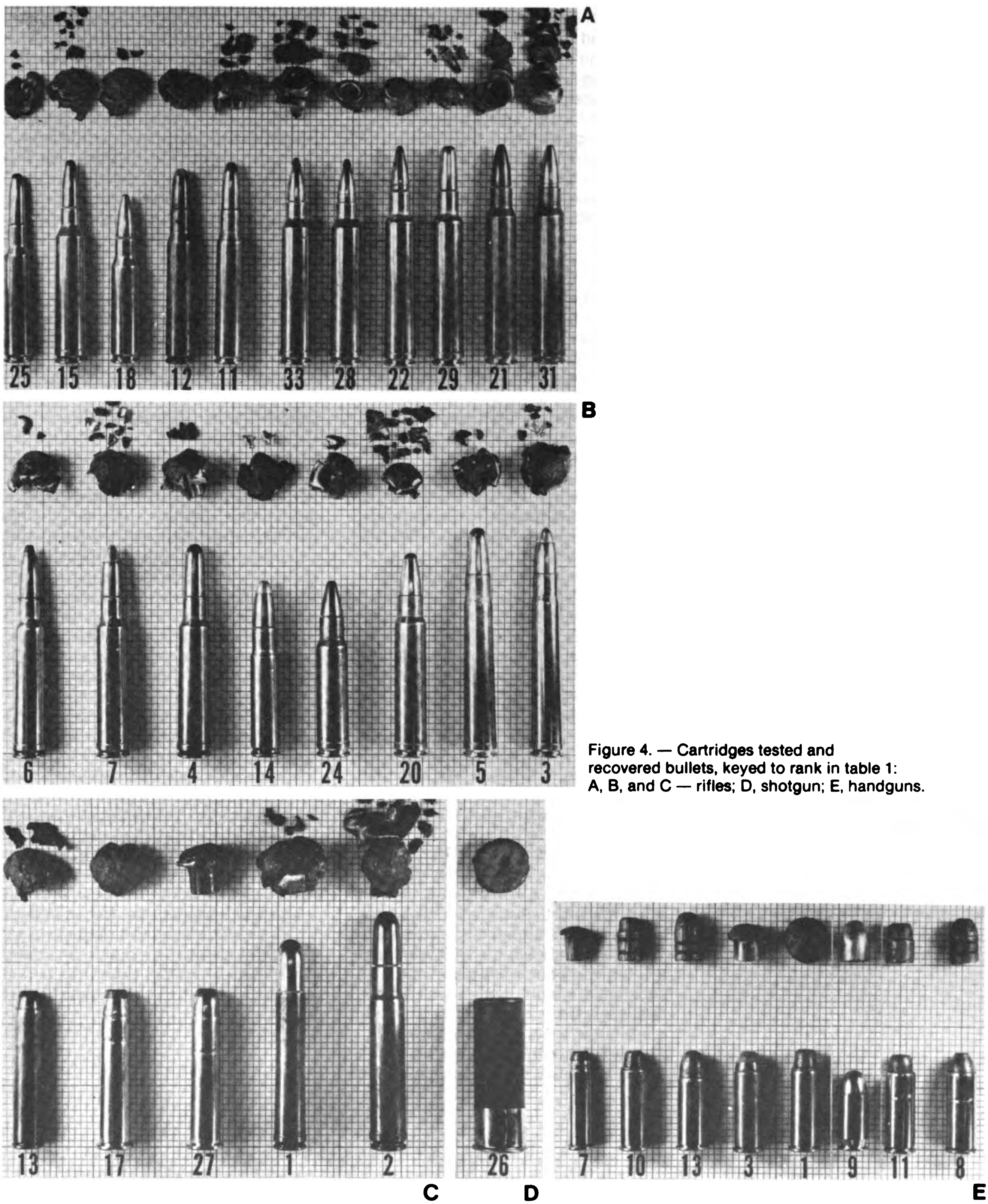

Figure 4. — Cartridges tested and recovered bullets, keyed to rank in table 1: A, B, and C — rifles; D, shotgun; E, handguns.

.358 Norma Magnum. — The .358 Norma Magnum was ranked 20 in our tests. Its relatively low ranking was mainly due to poor retained bullet weight and relative expansion. The 250-gr Norma factory bullets did not hold together well in the test medium. Retained bullet weight was low since this parameter is based on the largest recovered bullet fragment. The .358 Norma bullet reacted similarly to the 250-gr bullet in the longer barreled .338 Winchester (ranked 23). Although the bullets fragmented, penetration of the largest fragments was relatively deep.

Recoil of the .358 Norma Magnum was similar to recoil in the .338 and .375 rifles with 250- and 270-gr bullets, respectively. If suitable bullets were available in factory-loaded ammunition, the .358 Norma would be an excellent cartridge for rifles for protection from bears. Other disadvantages are the cost and difficulty of obtaining the ammunition. Because of these considerations, the .358 Norma Magnum is not recommended.

Small-Caliber Magnum Rifle Cartridges

7 mm Remington Magnum.—The 7 mm Remington Magnum was the highest ranked (15) of the small-caliber magnum cartridges. Bullet penetration was only moderately deep, and the bullets fragmented to some extent as the average retained weight was only 44 percent. Bullet expansion was the highest of all the bullets tested; this attribute gave the 7 mm Remington its relatively high overall rank. In contrast, most other small-caliber magnum cartridges had relatively poor expansion values. The exception was the 8 mm Remington 185-gr bullet which had high expansion but also had substantial weight loss and poor penetration. The striking velocity of the 7 mm Remington 175-gr bullet was barely 2700 ft/s at 15 yd, well below what would be expected from published ballistic data; nevertheless, it appears the design limits of the bullet were exceeded.

Recoil was calculated at 18.5 ft-lb in the 9.1-lb rifle used. This is mild, but greater than that of the 220-gr .30/06 cartridge from a lighter weight rifle. There does not appear to be any special reason for selecting the 7 mm Remington for short-range protection. Its overall ballistic performance is marginal for this purpose.

.300 Weatherby, .300 Winchester, 8 mm Remington Magnums. — These three cartridges are considered together. All are loaded with moderate-weight bullets (180- to 185-gr) at velocities between 2950 and 3050 ft/s and heavier bullets (200- to 220-gr) between 2700 and 2800 ft/s. These high velocities with moderately heavy bullets resulted in striking energies that exceed the design level of the bullets, especially the heavier ones. Fragmentation was prevalent for these bullets, and weight losses were 60 percent or more. The average weight of the largest fragment of the 8 mm Remington 220-gr bullet was only 28 percent of the unfired bullet weight. The 185-gr bullet in the 8 mm Remington was the best of the lighter weight bullets in these three cartridges, with a ranking of 21 in overall performance. Penetration was poor, however, and fragmentation excessive. The 180-gr bullet in the .300 Winchester also had poor penetration and substantial weight loss, as well as relatively poor expansion, all of which contributed to its last place ranking. The ranking of the .300 Weatherby with the 180-gr bullet was a disappointment. Factory cartridges are loaded with 180-gr Nosler partition bullets which have an excellent reputation. In our test, the 180-gr bullets in the .300 Weatherby penetrated well but lost over 50 percent of the unfired bullet weight and did not have particularly good expansion. The 180-gr bullet was much better in overall performance than the 220-gr bullet which fragmented badly. This was also true for the 200-gr bullet in the .300 Winchester.

None of the small-caliber magnum cartridges can be considered good selections for protection from bears at short range because of the excessive fragmentation of bullets.

Large-Caliber Standard Rifle Cartridges

.45-70 U.S. — We tested the .45-70 in two bullet weights (300- and 405-gr) and in rifles with two barrel lengths (20 and 22 inches). Both rifles were Marlin 1895 lever-action. In both, the 300-gr bullet ranked much higher than the 405-gr bullet, primarily because of the poor expansion of the 405-gr bullets. At the 1200-1300 ft/s striking velocity, some of these bullets acted as solids and penetrated as much as 24 inches. This was the greatest penetration recorded in the tests. The 300-gr bullets, with 300 to 400 ft/s more velocity, did not penetrate deeply but held together and expanded well and uniformly. Low velocities resulted in low striking energy. Shortening the barrel by 2 inches had no effect on the performance of the bullet; in fact, the rifle with the 20-inch barrel performed better with the 300-gr bullet than did the longer barreled rifle. Recoil in this rifle, which weighed less than 8 lb, was much less severe than in the large-caliber magnums; it is thus not a detracting factor. The poor action of the 405-gr bullets may limit their use for protection from bears. The 300-gr bullets in the commercial ammunition we used are designed for animals the size of deer and may expand too rapidly and lack sufficient penetration for use against bears. In our test they did not fragment too badly. The lack of a proper bullet is unfortunate. The .45-70 can be obtained in a compact, moderate weight, lever-action rifle that may be easier and faster to operate, particularly for left-handed people.

Perhaps the current reinterest in .45-70 rifles will cause the manufacturers to produce a more suitable bullet. We do not consider factory-loaded .45-70 ammunition particularly suitable for a rifle for protection from bears, especially with the 405-gr bullet.

.444 Marlin. — In overall performance, the .444 Marlin cartridge ranked 13. Although penetration was not especially deep, the bullet held together and expanded well. Striking velocity exceeded 2200 ft/s in the rifle with the 22-inch barrel. Consequently, striking energy was over 2650 ft-lb.

The flat nose soft point bullet loaded in the .444 Marlin appears similar to that of the .44 Remington Magnum revolver cartridge. Although the .444 cartridge ranked relatively high, we have reservations about shooting at a brown bear with a bullet designed for a handgun cartridge. If a well-constructed bullet of about 300-gr weight was available in factory-loaded ammunition, the .444 could become an adequate cartridge for protection from bears. We were unable to obtain the recently introduced cartridges factory-loaded with a 265-gr bullet.

Medium-Caliber Standard Rifle Cartridges

.358 Winchester, .350 Remington Magnum.[5] —The .358 Winchester and the .350 Remington Magnum were included to fill out the full range of cartridge possibilities. The .358 Winchester ranked higher (14) than the .350 Remington (24). Better retained bullet weight and greater bullet expansion accounted for the higher rank of the .358 Winchester. These two cartridges illustrate the poor relation between penetration and striking energy. The .350 Remington had 443 ft-lb greater striking energy than the .358 Winchester, but only 0.2 inch more penetration. In our tests there was relatively little difference between the .358 Winchester and some much larger, more powerful cartridges. We were unable to obtain 250-gr bullets for either cartridge. The 200-gr bullet in the .358 Winchester, however, seems to be a well-balanced load. The relatively low striking energy reduced the ranking of the .358 Winchester, and, to some extent, the .350 Remington. In addition, the average retained bullet weight for the .350 Remington was 52 percent compared with 71 percent for the .358 Winchester.

Recoil was moderate and similar in both rifles. The .350 Remington rifle weighed a pound less than the .358 Winchester rifle. Both cartridges can be considered minimal for protection from bears at close range.

[5] The .350 Remington Magnum was considered a standard cartridge because its case has a relatively small powder capacity.

Small-Caliber Standard Rifle Cartridges

.30-06 U.S. — With the 220-gr bullet the .30-06 ranked 11, and with the 180-gr bullet it ranked 12 in overall ballistic performance. The 220-gr bullet penetrated 17.7 inches. This was 4.5 inches deeper than the 180-gr bullet, but the striking energy of the two bullets was similar. The 220-gr bullet had only 87 ft-lb greater energy at 15 yd. The 180-gr bullet retained slightly more weight than the 220-gr bullet and also expanded slightly more relative to the initial cross-sectional area. The 180-gr bullet also had less tendency to fragment than did the 220-gr bullet.

Recoil for both bullet weights was mild compared with large- and medium-bore magnums. Chronographed velocities were much lower than advertised. The 220-gr bullet averaged 2261 ft/s for three shots, whereas the 180-gr bullet averaged only 2456 ft/s velocity at 15 yd.

The light recoil potential and the good overall ballistic performance make the .30-06 a reasonable cartridge for protection from bears. Because of the deeper penetration of the 220-gr bullet, it is better than the 180-gr bullet. For inexperienced persons or those of small stature, the .30-06 with 220-gr bullets may be a better choice than one of the large- or medium-bore magnums. A 7- to 7.5-lb .30-06 with a 20-inch barrel would be a handy, portable rifle for protection from bears. The use of the .30-06 has a major advantage over use of magnum cartridges —magazine capacity is increased to five rounds. Another advantage is the availability of left-handed bolt-action rifles in this caliber. The .30-06 is also available in slide-action and semiautomatic rifles.

.308 Winchester, 7x57 mm Mauser. — These two cartridges were included in the tests to represent the "minimal" cartridges that might be used for protection from bears. They are also often used by deer hunters. The ranges of the brown bear and the Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) overlap through much of coastal Alaska, and deer hunters need protection from bears similar to that of working professionals. Of the two cartridges, the .308 Winchester ranked higher (18) than the 7x57 mm Mauser (25). The greatest difference was in retained bullet weight. The 7x57 mm Mauser bullets lost almost half their weight, whereas the .308 Winchester bullets shed less than 25 percent of their original weight. The 7x57 mm bullets had about 1 inch deeper penetration, but the range in penetration varied less in the .308 Winchester. Penetration of the 175-gr bullet in the 7x57 mm Mauser was greater than that of the same weight bullet in the 7 mm Remington Magnum, although striking energy was almost 600 ft-lb less in the 7x57 mm Mauser.

Recoil was mild for both cartridges; however, both of the rifles used weighed more than 8 lb. We do not recommend either of these calibers for protection from bears.

Large-Caliber Magnum Handgun Cartridge

.44 Remington Magnum. — The .44 Remington Magnum load fired from a handgun ranked 32 compared with loads fired from rifles and the 12-gauge shotgun but ranked first compared with other handgun cartridges (table 1). It was included with the rifle cartridges for comparison purposes only and was ranked by the rifle and shotgun attributes. In overall performance it was similar to the 8 mm Remington Magnum 220-gr bullet and the .300 Winchester Magnum 180-gr bullet. The 240-gr lead gas-check bullet held together well, penetrated more than 11 inches, and expanded moderately well. Only the low energy value reduced its ranking in the rifle and shotgun category.

The .44 Remington Magnum was by far the best handgun cartridge. Two bullets (240-gr lead gas-check; 240-gr jacketed soft-point) were tested in revolvers with 5-, 6.5-, and 7.5-inch barrels. No substantial difference was observed between the velocities of the two bullets in the same length of barrel, but the lead gas-check bullet ranked higher overall in ballistic performance than did the jacketed soft-point bullet. The lead gas-check bullet ranked 1, 2, and 4. Generally, the lead gas-check bullet expanded well and retained almost all its original weight. The jacketed soft-point bullet had somewhat greater average penetration, but also much greater variation in penetration than the lead gas-check bullet. It also had slightly greater striking energy.

As expected, recoil was greater in the .44 Magnum revolvers than in any other handgun tested. It ranged from 16.4 ft-lb in the 6.5-inch barrel revolver with the jacketed soft-point load to 12.4 ft-lb in the 7.5-inch barrel revolver with the same load.

The superiority of the .44 Remington Magnum makes it the cartridge choice for a *backup* weapon. A revolver using this cartridge should not be considered a primary weapon for protection from bears.

The slight difference in overall ballistic performance between long and short barrels makes a revolver with a short barrel just as effective as one with a longer barrel. A short-barreled revolver is lighter, easier to carry, and may be drawn from a holster more quickly. Carried in a cross draw or shoulder holster, a short-barreled .44 Magnum revolver is at hand at all times. When work requires both hands, a rifle is often put aside. A rifle a few feet away is useless for protection from bears, but a handgun can be useful. Although much practice is necessary to become proficient with a shoulder arm, even more practice is required to attain competence with a handgun.

Other Large- and Medium-Caliber Handgun Cartridges

.357 S&W Magnum, .41 Remington Magnum, .44 S&W Special, .45 Auto, .45 Colt. — The overall ballistic performance of these handgun cartridges was much poorer than that of the .44 Remington Magnum cartridge. They were included in the test because they are commonly owned by many persons working in coastal Alaska and might be carried in the field. With one possible exception, we do not recommend them, even for backup protection. The exception is the .41 Remington Magnum. We were unable to obtain the high-velocity, jacketed 210-gr bullet factory load for our tests. This loading may be suitable for backup use because its ballistics are closer to those of the .44 Remington Magnum than are any of the other cartridges. The .357 S&W Magnum was the best of the other handgun cartridges, but it was much less effective in all categories than the .44 Remington Magnum. The factory bullets of the .44 S&W Special, the .41 Remington Magnum, and the .45 Colt were non-jacketed lead. At their low striking energies, these bullets did not expand. Consequently, penetration was relatively deep. The full-jacketed bullets used in the .45 Auto also penetrated deeply but did not expand.

Shotgun Cartridge

12-Gauge × 2¾-Inch Chamber. — The variety, rapid-fire potential, and reasonable prices of 12-gauge repeating shotguns with short barrels and the impressive appearance of the 1-ounce (438-gr) rifled slug have made this combination popular as a weapon against bears. The slide-action shotgun with a short barrel is relatively light and compact, has good pointing characteristics and a large magazine capacity, and can be fired rapidly. Recoil was similar to that of weapons firing small-caliber magnum rifle cartridges. In our tests, the 12-gauge rifled slug did not have a high overall rank because of the relatively low striking energy and the lack of bullet expansion. The lack of bullet expansion is somewhat misleading. The unfired rifled slug is 0.672 inch in diameter (0.355-in^2 area); the 1.7× expansion ratio increases this to a cross-sectional area of 0.62 square inch, which is only slightly smaller than that of the expanded bullets of the .458 Winchester and .460 Weatherby magnum rifle cartridges. The penetration of the rifled slug was good (15.3 inches), and only 4 percent of the unfired weight was lost. No fragmentation occurred. Low energy was due to the low velocity of the slug.

We also tested the penetration of 00 buckshot. The first round was fired at the box from 15 yd. At this range, the nine pellets had a spread of about 12 by 12 inches and a penetration of only 2 to 3 inches. We then shortened the range to 15 ft. From this distance, the spread was 2 inches in diameter, and the maximum penetration of a single shot was 7 inches. At the shorter range, the nine pellets appear to act as a single projectile and the 00 buckshot load might be relatively effective.

From our tests it would appear the slug is much superior to buckshot for protection from bears. Whether buckshot would be lethal to a bear at ranges beyond 5 yd is doubtful. A mixed magazine load of slugs and buckshot can be used, but there appears to be little advantage to this. To be effective, the 12-gauge slugs must be thought of as similar to the bullets in a rifle. Hitting vital areas is the important thing. Hitting a brown bear with a load of buckshot at ranges beyond 5 yd may mean a nonlethal wound and a very angry, active bear.

A Note on Velocity

Because bullet velocity is an inherent component of bullet energy, it was not one of the factors we used to rank ballistic performance. We did, however, look at its relation to bullet penetration because velocity is the most common single factor used to rank ballistic performance (table 1). In general we found that bullet penetration decreased as striking velocity increased. Notable examples of this were the high-velocity small-bore magnum cartridges, such as the .300 Winchester and .300 Weatherby magnums with lighter weight bullets. The inverse relationship between striking velocity and bullet penetration should be viewed only as a tendency; our data demonstrated considerable variability.

When penetration is compared with striking energy (table 1), the relationship is direct — that is, in general, penetration increases with an increase in energy. Again, the predictive ability of this relationship is poor and should also be considered a tendency. For both striking velocity and energy, the confounding factors appear to be design of the bullet and strength of the bullet materials.

There is no well-defined distinction between combinations of weapon and ammunition that are adequate or inadequate for protection against bears. The final decision on adequacy must be made by each individual and should include consideration of weapon size and weight, recoil, and the person's experience with firearms. Our data can, however, be used as a general guide to the effectiveness of the weapons and ammunition tested. A rifle in .375 H & H Magnum caliber in the hands of a person who can comfortably tolerate the recoil is a much better choice than a .30-06 or comparable caliber. A .30-06 with 220-gr bullets, however, might be a better choice for a person sensitive to recoil, who may shoot the lighter caliber weapons with more confidence and accuracy.

Based on our tests, four cartridge-bullet combinations appear superior for protection against bears:

- .458 Winchester Magnum, 510-gr soft-point bullet. For a shooter who can handle the recoil of this cartridge, a bolt-action rifle in .458 Winchester Magnum is the surest weapon available.

- .375 H & H Magnum, 300-gr soft-point bullet. The recoil of a rifle in this caliber, although considerably less than that of the .458 Magnum, is still severe for many people. Our tests indicate that the 270-gr soft-point bullet in this caliber is only slightly less effective than the 300-gr bullet and has only slightly less recoil.

- .338 Winchester Magnum, 300-gr bullet. This combination appears to be a good choice. Recoil is somewhat less than that of the .375 Magnum, and our tests indicated that effectiveness would not be much less than that of the .375 Magnum. If the 300-gr bullet cannot be obtained, the 200-gr bullet should be used.

- .30-06, 220-gr bullet. Mild recoil, compared with that of the large- and medium-bore cartridges, even in a lightweight rifle, makes this cartridge a strong contender for shooters who are sensitive to recoil. The .30-06 also has

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other advantages. It can be found in several rifle actions — bolt, pump (slide), semiautomatic — and can be obtained as, or customized into, a short, handy, lightweight weapon.

Our tests of the performance of bullets at short range were conducted by shooting into a uniform test medium, not into brown bears. The medium did not have a thick, wet coat of hair; thick, resilient skin; dense muscle tissue; or heavy bones; and it was not angry and excited. Consequently, the validity of the tests may not be directly applicable to a real situation involving a bear.

Nevertheless, we believe the tests were a good relative evaluation of bullets shot at short range and can be used to compare different cartridges and bullets. Two major points can be inferred from our tests: (1) none of the many different types of bullets tested was completely adequate, and (2) high striking velocities may not be particularly beneficial at short range. The best results were from bullets relatively heavy for their caliber fired at moderate velocity. Many experienced people have also observed this; we have verified their observations under controlled conditions.

The high-intensity cartridges needed for protection against bears require the use of strong breech mechanisms. The strongest and simplest breech mechanism in a repeating rifle is the bolt action.[6] This section will apply to rifles with that type of action, although many of the comments on stock design, sights, and so forth also apply to rifles with other types of actions.

Several models of bolt-action rifles are available. Of those made in the United States, the Savage Model 110, the Ruger Model 77, the Remington Model 700, and the Winchester Model 70 are the best known. All are turn-bolt operated, magazine fed, and have well-designed trigger mechanisms and safeties. The Savage Model 110 and the Remington Model 700 are available with left-handed actions, but commonly only in .30-06 or smaller calibers. Left-handed .458-, .375-, and .338-caliber rifles might be available on special order. All factory-supplied rifles require modification to increase their suitability for use against bears.

Our tests show fairly similar bullet performance when the same cartridge-bullet weight combination was fired in long- and short-barreled rifles. Most rifles using magnum cartridges have a factory-supplied barrel 24 inches long. These can be shortened to 20 inches for increased portability, with little loss in ballistic performance at short range. This job must be done by a competent gunsmith because the barrel should be cut off in a lathe and the muzzle reshaped (crowned) to insure concentricity.

Cutting off the barrel also requires remounting the ramp that holds the front sight. The ramp should be relocated so its forward end is about three-quarters of an inch from the muzzle. This provides sufficient room to cover the muzzle with a small piece of electrician's tape and to secure this with another piece of tape wrapped around the barrel. Taping the end of the barrel is a worthwhile safety precaution. Bullet performance is not affected; when the rifle is fired, the bullet merely passes through the tape. The tape, however, will prevent any foreign material (mud, duff, rotten wood, vegetation, snow) from entering the muzzle. If the muzzle becomes plugged with this type of material and the rifle is fired, *the barrel may burst.*

Under no circumstances should an attempt be made to clear a plugged barrel by shooting out the plug. The proper way to clear a plugged barrel is to push the plug out with a cleaning rod. Makeshift cleaning rods, such as slender sticks, will usually break off in the barrel. If the plug is not too tight, it may be dislodged by blowing into the barrel — from the breech end is the best way — or by sloshing the barrel in a stream or pool of water. A couple of small pieces of electrician's tape over the muzzle will eliminate the problem of plugs. Taping the muzzle also keeps water from running into the barrel and consequently reduces the possibility of rust.

Because there is almost no possibility of a slung rifle being brought into action during a short-distance confrontation, rifles carried in bear country should not be permanently equipped with slings. The sling should be mounted on detachable swivels, and should be removed when conditions exist for a possible confrontation. The forward sling swivel should be mounted on the barrel about 4 inches in front of the fore-end tip of the stock. This eliminates the possibility of injuring the hand grasping the fore-end of the stock when the rifle is fired, and reduces the amount of barrel projecting over the shoulder when the rifle is slung in the barrel-upward position.

[6] We do not recommend single-shot rifles for protection from bears because of the time necessary for a followup shot.