The Frustrating Effects of Hills On Small Arms Marksmanship

by Thomas Smith

'Elevate them guns a little lower!'

—Order given by Andrew Jackson as the United States fought against the British at the Battle of New Orleans.

One of the many factors that distinguish a military fighting force from a mob is the ability to accurately employ small arms. The Marine Corps, as a capable fighting force, realizes this and concentrates heavily on individual marksmanship. The frequently repeated phrase, "Every Marine is a rifleman," is both fitting and well deserved. Yet there are some aspects of marksmanship that the Marine Corps is not conveying to the average Marine that is, quite predictably, degrading the ability of the Corps to accurately employ their small arms. What am I referring to? The perplexing phenomenon that causes a bullet to hit off the mark when it is fired at acute angles, either up or down. Put another way, if your weapon was sighted-in on level ground, don't expect to hit the same mark if you are firing on an angled slope at the same distance. Shooting a weapon uphill or downhill is quite unlike shooting a weapon on a horizontal plane.

I have talked with Marine after Marine and have found, without fail, a total lack of knowledge concerning the effects of accuracy over hilly terrain. If the effects of the phenomenon were not great, or not frequent, then perhaps it would be understandable that Marines don't know about it. But the effects are great, and also frequent. Hunters run into this situation more times than they care to remember. If you have ever talked to hunters who have shot at their prey from hillsides or cliffs—or even a bow hunter sitting in a tree stand 20 feet above the ground—you will usually find a quizzical look cover over their faces when they tell you they missed their prey. Most of them will seldom know why they missed, but they will tell you with all the candor they can muster that the prey was square in their sights and their hands were as steady as a fence post. So where is the bullet hitting? Well, in either case—whether shooting uphill or downhill—the bullet will always hit higher than the point of aim. How much higher? The exact distance is a function of a number of variables: absolute distance; the slope of the hill; and finally, the velocity, weight, and shape of the projectile.

Although I am not aware of any M16A2 field tests conducted on slopes, I am aware of a .30-30 field test conducted on a slope angled at 45 degrees. Jim Carmichel, the distinguished hunter and weapons expert, and now the Shooting Editor for *Outdoor Life*, provides the example in his book, *Book of the Rifle* (Copyright 1985, Outdoor Life Books, 380 Madison Ave, NY, NY 10017). The .30-30 was loaded with a 150-grain flat-nose bullet and had a velocity of 2,100 feet per second. It was zeroed-in at 200 yards on level ground and was fired at the same distance, but on a 45 degree slope. It hit a full 5.65 inches above the point of aim. And, of course, if the angle of the slope or the distance were increased, the amount of bullet rise would be even greater. But let's not mire ourselves down in the details of the exact amount a particular bullet will hit high. First, and most importantly, we need to understand why this happens.

The Reasons Why

When a weapon of any kind is zeroed-in, various components (I'll later refer to them as vectors) have to be delicately tuned and integrated to force the bullet to hit the point of aim: 1) the line of sight; 2) the line of the barrel; and finally, 3) the trajectory (bullet path) of the projectile itself (see Figure 1). Additionally, it is important to understand that a bullet drops, however slightly, the moment that it exits the barrel of a firearm. So the barrel of the weapon will never be parallel with the line of sight; it has to be angled above it to compensate for the pull of gravity over distance and time. (This holds true even for distances as short as 50 yards.)

Looking at Figure 1, you can see that when firearms are sighted-in, the line of sight is a straight vector that extends from your eye to the target itself. The line of the barrel, as I just mentioned, is not the same or even parallel to the line of sight; it is pointing on an angle above it. It really has no correlation to the line of sight. But the path of the projectile, however, correlates with both the line of sight and the line of the barrel, but at different times. Once the projectile is fired, it initially follows the line of the barrel, but over time and distance it veers away from this vector, and bends toward earth and the line of sight.

What is actually happening here is that when the bullet exits the barrel, it immediately drops, but is traveling on a vector that is above the line of sight and will converge with the line of sight at the point of aim. As you

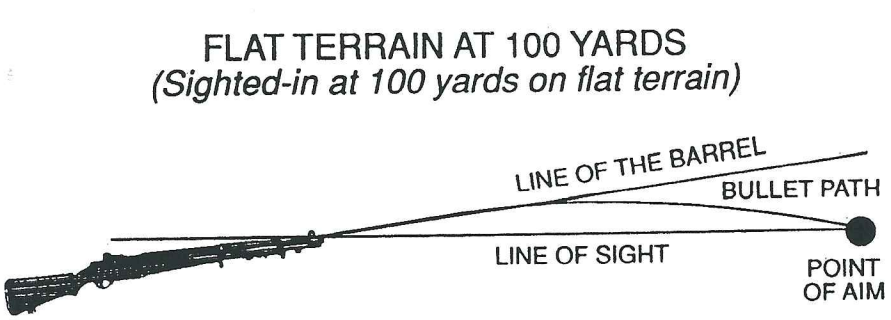

Figure 1.

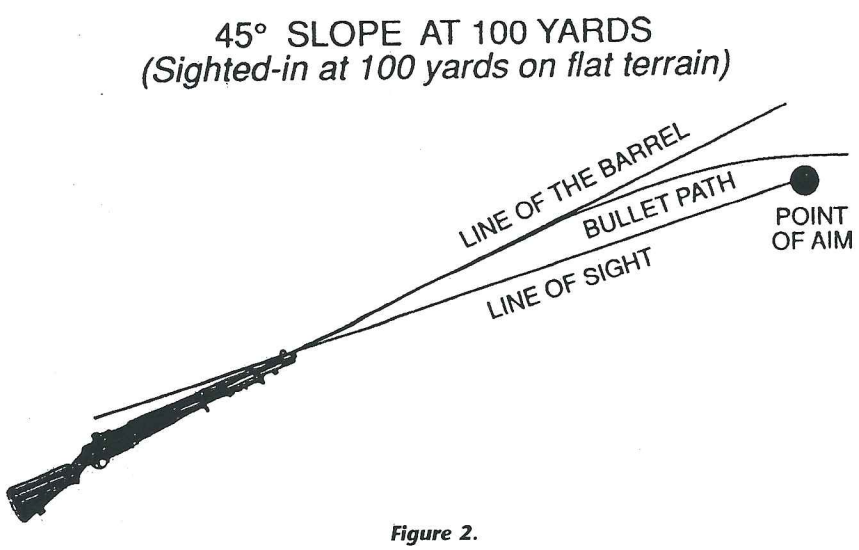

Figure 2.

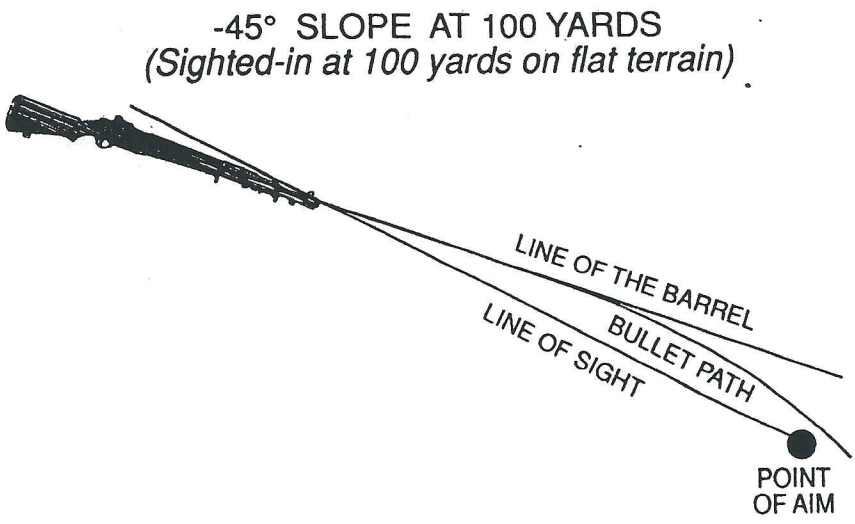

Figure 3.

can see from Figure 1, the trajectory of the bullet takes on the shape of a hyperbolic curve with its hopeful destination, the target or point of aim.

But when a weapon is being fired up or down a hill, the bullet trajectory flattens out and becomes more in line with the line of the barrel pointing upwards and above the line of sight. (Figures 2 and 3). Why? Well, imagine a flyrod that you are holding straight up and then gradually lower it until it becomes horizontal with the ground. When it is pointing straight up, the curvature of the rod is nonexistent. But when you lower it, the curvature of the rod itself is increasing until the rod is horizontal—its maximum point of curvature. Likewise, when you now take that horizontal rod and lower it, curvature is decreasing until it is pointing straight down. When it is pointing straight down, the curvature is, again, nonexistent. Thus the rod is perfectly void of curvature when pointing either straight up or straight down. This tells us that gravity exerts the same decreased influence over objects directed either uphill or downhill.

The flyrod in this simple analogy is the flight path of the projectile. So as the angle of the firearm approaches straight up or straight down, the projectile's path will not fall victim to the effects of gravity just as the flyrod's doesn't. The projectile's path has straightened out and is now adhering more to the vector from which it started—the line of the barrel. The projectile will not curve back toward earth and hit the point of aim; it will travel over the point of aim and cross the line of sight at a distance greater than the point of aim. And it will hit the same distance above the point of aim when fired either uphill or downhill. (Figures 2 and 3).

Erasing the Frustration

Before being irretrievably lost in all the theoretical details, remember that the problem is not that a bullet will hit high when fired on angled slopes; rather it is simply that the everyday Marine does not know about it and thus will not take the appropriate corrective action. There are many ways in which this problem can be dealt with. But a few seem to present themselves with more force and clarity than the others. I will present them from the simplest and least effective to the most effective and probably most costly. Keep in mind that all of them can be integrated into the rifle range training curriculum at the recruit depots, Officer Candidates School, The Basic School (TBS), the schools of infantry, and infantry sustainment training.

The simplest method would be to introduce recruits and officer candidates to "hill marksmanship" integrating it into the rifle range training courses at both the recruit depots and TBS. Once they realize that they have to aim lower at the enemy who is situated either above or below them, they will have taken a large

step toward decreasing the amount of misses they would have otherwise made. I would even go a step further and counsel them that they must aim a good 4–5 inches below where they would normally aim.

An extension of this would be to field test the M16A2 on varying slopes at, say, 30, 45, and 60 degree angles at 50, 100, 200, and 300 yards. And for each of these angles and distances, a reading of the amount of projectile rise should be taken. The results could then be calibrated and reduced to a rule of thumb guide for each Marine. Now, I realize that the subject of the article concerned small arms, and there are many more small arms that could, likewise, be tested–namely, the M249 squad automatic machinegun, the M240G medium machinegun, M9 pistol, and the M203 40mm grenade launcher. However, subjecting all of these weapons to such a field test would be onerous, expensive, and ultimately confusing for the Marine who is forced to pick up a weapon from another Marine whose rule of thumb guide for that weapon was never committed to memory. Also, the M16A2 is the most prevalent small arm in the U.S. military arsenal. It is the workhorse that performs the lion's share of the killing in conventional battles. So limiting the tests to the M16A2 would have the greatest benefit to Marines and the Marine Corps. It would also be less confusing to the Marine, in the insane atmosphere of battle, to only have to remember one rule of thumb guide, instead of up to five or six.

Perhaps the most effective measure would be to build an angled rifle range at 100, 200, or 300 yards so that each Marine can experience and feel the effect themselves. The Marine will be able to approximate from the feel–like the Western-style of shooting from the hip–as to how he has to aim lower at such and such a distance. He can remember how it feels, rather than counting 7.32 inches below the point of aim as the rule of thumb would tell him. The Marine will learn that if he wants to hit the enemy in the heart at 200 yards on a 45 degree slope, he will have to aim lower, say at his crotch, because at this angle, aiming for the heart will send the bullet sailing right over the enemy's shoulder. A heart-shot, then, becomes an over-the-shoulder shot, and a crotch-shot becomes a heart-shot. The angled range would compensate for this difference and give the Marine that remembered feel–just by looking and estimating.

Parting Thoughts

The Marine Corps spends a lot of time on individual rifle marksmanship at 200, 300, and 500 yards on level ground. But all of this is rendered somewhat ineffectual when the enemy is situated on an angled slope either above or below the Marine at the same distances. Since this ballistic phenomenon is alive and well, and will continue to be, we need to confront it squarely. If we continue to ignore it, our Marines will find themselves as confused, or at least as contradictory, as Andrew Jackson was at the Battle of New Orleans.

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>Mr. Smith submitted this article some time ago when he was a second lieutenant. The Gazette *felt that the message was still relevant today, as well as useful when planning to train for tomorrow's battlefields.*