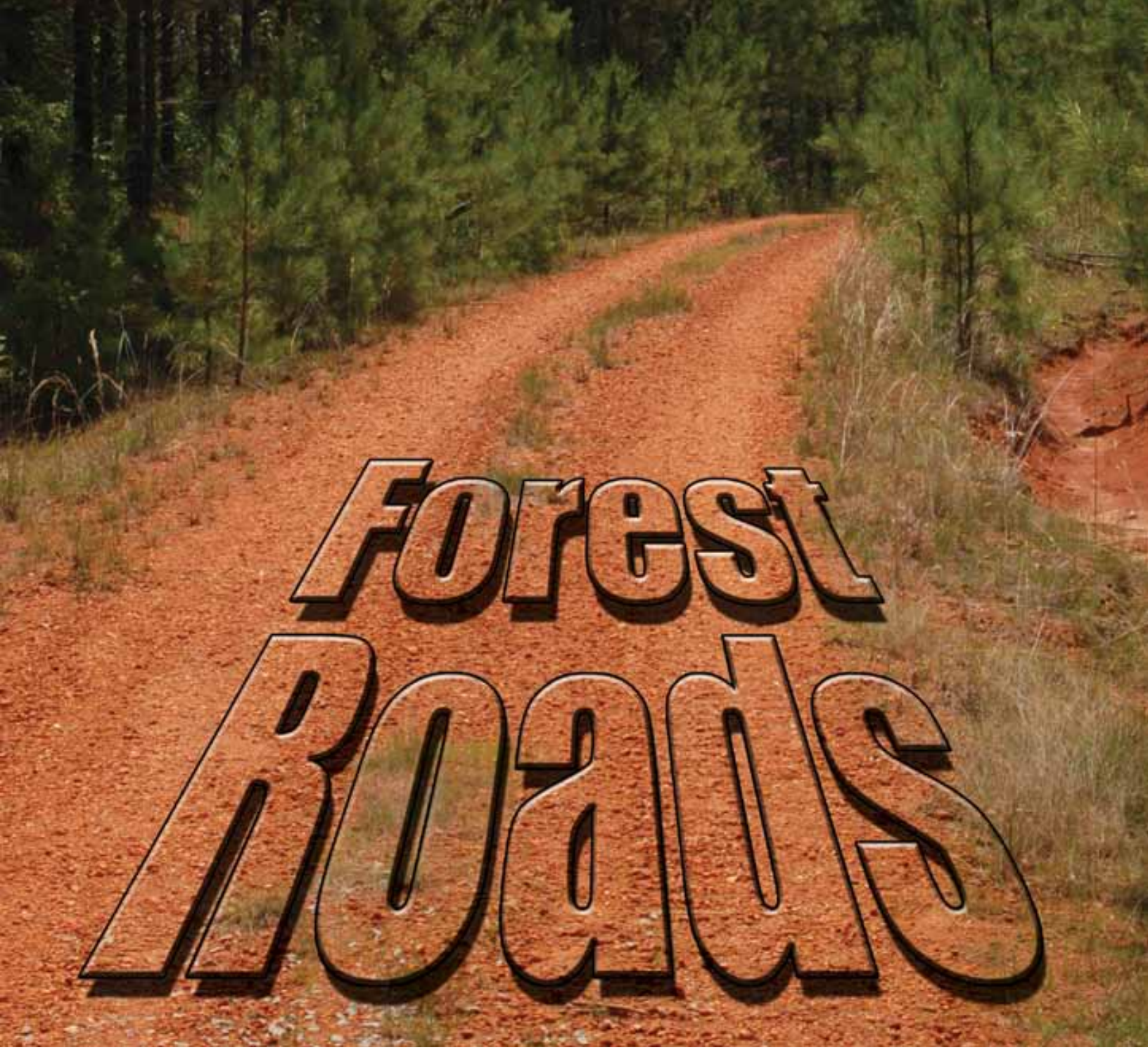

Forest Roads

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A forest cannot be managed without the access provided by a road network. However, this access system also causes most of the water quality problems from road surface material washing into streams. Therefore, the road network should be planned to minimize both water quality and road maintenance issues.

The primary cause of road maintenance issues and erosion is water, either water running across the road and eroding the road surface, or water soaking into the road and weakening the load-bearing capacity of the road. So, water needs to be shed from the road so it will not soak in, but not allowed to run off so fast that it erodes the road surface. If the water does soak into the road, then traffic needs to be eliminated until the road dries out.

The Wetter the Road the Weaker the Road

Sun and wind are the agents that dry out a road. Therefore, as much as possible, roads should be located on south- or west-facing slopes. Obviously a southern exposure will receive more

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direct sunlight than a northern exposure. The east side of a hill will receive morning sun which must heat the air before any moisture can be evaporated from the ground; so, afternoon exposure is more effective at drying the road surface than morning. Wind will remove moisture in the air above the road so that more moisture can be evaporated from the road surface.

A common technique to increase the effect of the sun and wind is "daylighting" or clearing trees near the road to allow more light and wind to reach the road surface. Since the sun is seldom north of Alabama's latitude, it is not as effective to clear on the north side of an east-west road; and since afternoon sun is better than morning, it may be more effective to clear on the west side of a north-south road. Remember that clearing on the inside of the road in a curve is a safety precaution to allow a longer sight distance.

Putting rock on a road surface will also improve the load-bearing capacity of the road; however, rocking a road will at least double the cost of the road. There are three classifications of material that are applied to forest roads: large rock (#1 or #2), crusher-run (a variety of rock sizes from 3/4-inch and smaller that compact well) and pit-run (a mixture of sand, clay, and gravel from old streambeds).

Large rock is usually applied in a thinner layer (3 inches or less) with the intent that the rock will be incorporated into the road subgrade. A thick layer of larger rock makes a poor running surface (rough with no compaction, the rock tends to roll under the rotational force of the truck tires), and the rock can become lodged between the tandem tires on a truck causing excessive wear. A thin layer of larger rock that becomes incorporated into the road subgrade is the best application for sloping sections of forest roads.

Crusher-run compacts well and provides a better application for flat sections of road that may lose strength due to moisture. Crusher-run is applied in layers of 6 inches or more. The compacted rock acts more like a bridge to reduce the load on the weaker soil layer. Because the internal angle of friction of rock is approximately 45 degrees, a 100 psi load at the rock surface will translate to only 25 psi on the road subgrade below 8 inches of rock. (40,000 lb axle load or 20,000 lbs per set of tandems, then divide by 100 psi of pressure in the tires for a footprint of 200 in^2. Assuming a circle, 200 in^2 would equal a radius of 7.98 inches. If the internal angle of friction were 45 degrees, then at 8 inches of depth the circle radius would be 15.98 inches for an area of 802 in^2. 20,000 lbs spread over 802 in^2 equals 24.9 psi.) Remember that soil strength decreases as moisture content increases. In low, wet areas it may be better to use a geotextile between the native soil and the rock. Rock generates its strength from rock-on-rock friction. If mud is pumped up into the rock, it will lubricate the rock and the rock will sink into the subgrade. The purpose of the geotextile is to serve as a barrier to prevent the silts and most of the clays from pumping up into the rock. A layer of sand may be used instead of the geotextile. Because crusher-run has a lot of fines, it is not appropriate for slopes where the fines will be washed out of the rock surface.

Pit-run does not have the strength of rock because of the clay; however, the clay binds the sand and rock, creating the smoothest running surface. The clay also swells with the addition of some moisture and makes a more impervious surface causing most of the rainfall to run off instead of soaking into the road subgrade. The sand reduces the slickness of the clay, and the rock gives the material some strength. Pit-run is an ideal surface for sandy material that needs to be confined.

A well-designed road with a gentle grade; crowned, rock surface; drainage; daylighting; and vegetation for stabilization.

Water Volume and Velocity Equals Erosion

The formula for kinetic energy, k, equals one-half the mass times the velocity squared, $k = 1/2 * m * v^2$. The more energy a moving mass has, in this case water, the greater the number and larger the size of particles it will move. This formula gives us the key to minimizing erosion: reduce the volume (mass) and velocity of water, with velocity being more important than volume. However, without volume there is no velocity; this

A broad-based dip used to divert water from the road surface.

is why one of the keys to minimizing erosion is to spread the water into shallow, sheet flow instead of deep, channelized flow.

Slope is the most important factor affecting velocity – the steeper the road, the greater the velocity and the greater the erosion. Ideally, the road network will be planned from a topographic map and consist of roads with the flattest grade possible. (If the soil type will be stable at slopes of 4 percent or less, the worst thing you can do is plan a whole road network of 6 percent grade roads. You should plan for some 4 percent grade roads and some 8 percent grade roads that are stabilized.) If the road surface is eroding or showing signs of rills and gullies, then the road is too steep for that soil type. If the road is too steep, then the surface must be stabilized or the volume of water reduced. In many cases the landowner inherits the road network, along with all its problems, from the previous owner. Seldom is it practical to relocate the roads to a flatter slope; so, the road must be stabilized with large rock or possibly pit-run surfacing, and the amount of water on the road must be minimized.

Side-sloping a road either with a crown (higher in the middle and lower on the edges) or a 3 percent slope across the road is commonly used to remove water from the road. Since water tends to soak in instead of run off at slopes less than 2 percent, a side-slope of 3 percent or more is recommended. If velocity is a problem, then the road grade is probably steeper than 3 percent and the water will tend to run across the road at a diagonal. There are two problems with side-sloping. First, if traffic is allowed on the road when it is wet, ruts will be created in the road surface and no amount of side-sloping will dump the water out of a rut going down a hill at say 8 percent. Second, a downhill slope on a curve with a slick surface is a potential safety hazard. Side-sloping works best with rock-surfaced roads and poorest with roads constructed from the native soil.

Broad-based dips are the best method of removing water from a road surface on moderately steep slopes. The broad-based dip consists of a section of reverse grade (e.g. on an -8 percent downhill grade, there will be a segment of +3 percent or more grade at an angle to the road). The reverse grade stops the water from continuing down the road, forcing it to the side of the road into a wing ditch which then carries it onto the surrounding terrain. The broad base on the dip allows normal pickup-truck traffic to drive over the dip without losing much speed. The angle of the dip may cause a twisting of longer truck frames, and loggers are not big fans of broad-based dips. However, they are easily constructed with a dozer, and can be flattened out during harvesting, then reconstructed to maintain the long-term stability of the road. Since there is a section of reverse grade, broad-based dips are not practical on steep roads. If the road grade was 10 percent, the section of reverse grade may create a short section of 15 percent grade. This steeper grade may lift the drive wheels from contact with the road as the tractor goes over the hump, preventing the truck from being able to ascend the hill when loaded. For steeper grades, the road should be stabilized with larger rock incorporated into the subgrade with a crowned center and no broad-based dips.

The key to road maintenance is controlling water. There are more solutions than those few presented here, but these concepts should give the reader enough information to develop their own road maintenance strategies.