## CHAPTER 3. STUDY SITES

This chapter summarizes the data collected at each of the seven sites. The discussion includes a general discussion of the location's landscape character, soil properties, the type of vehicles, and the number of passes made by each. The locations are: the Tonto National Forest, Arizona; Land Between the Lakes, Kentucky; Kisatchie National Forest, Louisiana; Minnesota State Forest, Minnesota; Mark Twain National Forest, Missouri; Beaverhead-Deerlodge, Montana; Wenatchee National Forest, Washington.

# Arizona

## Tonto National Forest

The ATV testing was conducted on the Mesa Ranger District of the Tonto National Forest in the Southwest Region (R-3). Because of the close proximity of Phoenix, Arizona, this ranger district receives an estimated 5,000 ATV users per week. The topography is flat to gently rolling and is defined by hills and numerous alluvial washes. The area's vegetation consists of numerous grasses, shrubs, and trees. These include rabbit brush, saltbush, mesquite, and ocotillo, cholla, and saguaro cactus.

In preparation for ATV testing, four loop trails were laid out that ranged in length from 900 to 1,500 feet. Slopes through the transects for all loops ranged from 17 to 24 percent. The distance between transects ranged from 12 to 30 feet. The downhill and curve segments for loops C and D were combined or partially combined.

Prior to riding, trail segments, including the uphill, downhill, turns, and straight sections, were identified on the ground for all loops. The trails were brushed and cleared of any hazards, and transects were placed for each trail segment. All four loops were located on undisturbed ground.

### Soil Properties

Representative soil samples from the four loop trails were taken for analysis. These soils were classified as poorly graded sand. They are characterized as medium strength and have a medium-to-high susceptibility to surface erosion. Other soil properties are shown in table 19.

*Table 19—Soil properties for Tonto NF study site.*

| Forest | USCS Group Symbol-Description | Surface Erosion | Dry Strength | Saturated Strength | Rutting (Saturated) | Raveling | Dust |
|---|---|---|---|---|---|---|---|
| TNF | SP-poorly-graded sand | Medium-high | Medium | Medium-high | Low | High | Low-medium |

### Vehicle Types

Table 20 provides the model, ATV type, and total number of passes for each loop.

*Table 20—Loops, vehicle characteristics, and total number of passes.*

| Loop | Vehicle Model/ Type | OEM/ AM | Total Passes |
|---|---|---|---|
| A | Honda Sport | OEM | 160 |
| B | Kawasaki Prairie Utility | OEM | 160 |
| C | Kawasaki Prairie Utility | AM | 60 |
| D | Honda Sport | AM | 160 |

### Condition Class Summary

One study objective was to determine if ATVs affect the natural resources and, if so, to what degree. Table 21 provides a summary of the condition-class assessments and, specifically, how condition classes changed over time with subsequent passes.

*Table 21—Summary of condition classes.*

| Tonto National Forest<br>ATV TEST Summary of Condition Classes | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Summary of Condition | | | |
| **Equipment Type** | **Tire Type** | **Loop** | **Number of Passes** | **Uphill** | **Curve** | **Downhill** | **Straight** |
| Sport | OEM | A | 40 | Low | Low | Low | Low |
| | | | 80 | Med | Low | Low | Low |
| | | | 120 | Low | Med | Low | Low |
| | | | 160 | Med | Med | Low | Med |
| | | | | | | | |
| Utility | OEM | B | 40 | Low | Med | Low | Low |
| | | | 80 | Low | Med | Low | Low |
| | | | 120 | Low | Med | Low | Low |
| | | | 160 | Low | Med | Med | Low |
| | | | | | | | |
| Utility | AM | C | 40 | Med | Med | Low | Low |
| | | | 60 | High | High | Med | Med |
| | | | | | | | |
| Sport | AM | D | 40 | Low | Low | Low | Low |
| | | | 80 | Low | Low | Low | Med |
| | | | 120 | Med | Med | Med | Med |
| | | | 160 | Med | Med | Med | Med |

**Summary of Effects**

The area's soils are classified as poorly graded sand. On some of the loops, the sand was quickly dispersed to the sides, exposing the bedrock underneath. Riding was halted after 160 passes on loops A, B, and D, and after only 60 passes on loop C.

*Figure 24—Loop B uphill, rated medium.*

*Figure 25—Loop A straight, rated low.*

*Figure 26—Loop C straight, rated medium.*

Loop C reached a high disturbance class in two of the four transect areas and a medium disturbance class in the other two transects. Thirteen of 16 transect areas reached medium or high after only 80 passes. Three had reached bedrock or highly compacted soils after only 40 passes, and condition classes did not change further.

*Figure 27—Loop A uphill, rated medium.*

Loops A and D showed similar effects moving from low- to medium-disturbance levels between 120 and 160 passes for uphill, downhill, and straight segments of trail.

*Figure 28—Loop A straight, rated low.*

The effects of ATV traffic showed the greatest disturbance in the curves for all loops. Loop C showed the most dramatic change moving from medium to high after 20 additional passes. Riding through the downhill and curve transects was rerouted after 60 passes, and data collection for these transect areas was discontinued. The rerouted section was rated medium after 40 passes.

*Figure 29—Loop C curve after 60 passes, rated high.*

The curves in loops B and C, as well as the uphill for loop C, were all rated at medium levels of disturbance within the first 40 passes.

*Figure 30—Loop A turn, rated high.*

Vegetation cover was reduced by 20 to 25 percent on all loops and, conversely, bare soil was increased by 20 to 25 percent on all loops. In the curves on all loops, bare soil increased from a before-riding level of 42 percent to an after-riding level of 50 percent (figures 31 and 32). Vegetation cover was reduced from 58 percent before riding to 44 percent after riding, with a proportional increase in rock and root exposure of 6 percent.

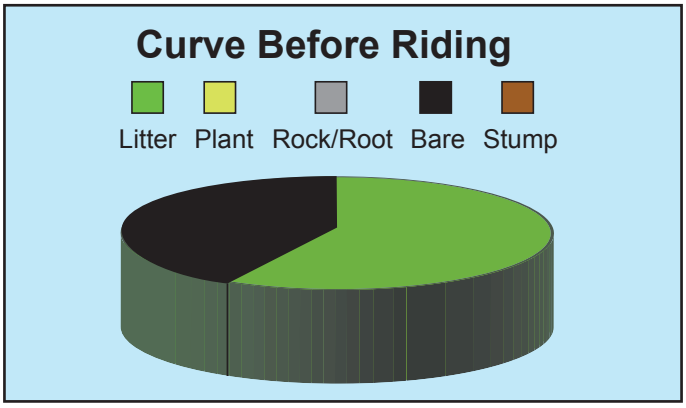


*Figure 31—Illustration of proportional amounts of litter and bare soil on the curve segment before riding began.*

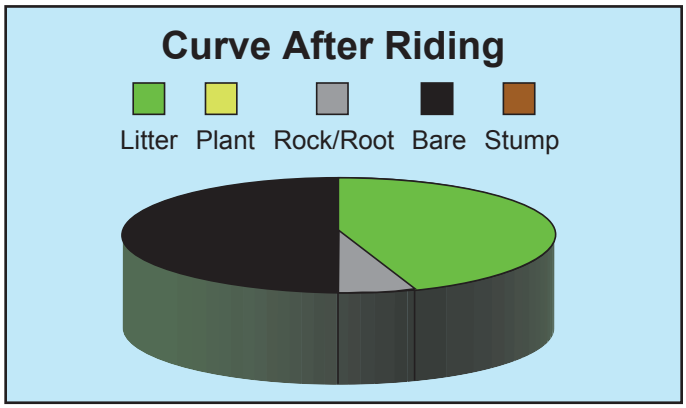


*Figure 32—Illustration of proportional amounts of vegetation and litter removed, bare soil, rock/root exposure, and stump exposure on the curve segment at completion of total passes.*

*Figure 33—Loop C curve, rated high.*

Rut depths up to 16 inches were recorded in the curves and some uphill segments. Shallower (2- to 4-inch) depths were recorded on straight and downhill sections.

# Kentucky

## Land Between the Lakes

Land Between the Lakes (LBL) National Recreational Area site is located near Cadiz, Kentucky, at Turkey Bay, a 2,200-acre, off-highway vehicle (OHV) area open to trail and cross-country riding. The OHV area is centrally located within the LBL and consists of three seventh-level watersheds that contribute 3,166 acres to Turkey Bay. The watershed consists of the North Forks of Turkey and Turner Creeks. The streams of these main channels are intermittent, and the headwaters are ephemeral.

The topography of the area is moderately dissected because of the nearby Tennessee and Cumberland Rivers. The slopes range from 6 to 50 percent and, due to steep slopes and narrow, closely spaced drainage valleys, surface-water runoff has contributed to the erosion process. Streambeds are filled with chert gravels transported from upper slopes. Annual rainfall for LBL averages 46 inches.

Cretaceous gravels, sands, and clays are overlain by a thin layer of brown Tertiary-Quaternary-age cherty gravels. The gravels have a matrix of reddish sandy clay and are interbedded with reddish-brown argillaceous sand. The upland is veneered with tan-to-buff colored Quaternary-age loess. The loess is generally believed to have a wind-blown origin and is probably related to past glaciations.

The study area was located in a 90-percent wooded area with a predominant cover of oak or hickory with little understory. The terrain is characterized as hilly with shallow to deep soils with a limestone-chert base. The soils are well drained with depths ranging from shallow to deep.

The selected study sites were similar in topography and tree cover to the Turkey Bay ATV open-riding areas. Loops A and B were adjacent to each other with steep uphill and downhill sections. Loops C and D were slightly gentler than loops A and B. The topography was hilly with slopes ranging from 17 to 24 percent on all loops.

*Figure 35—Loop D downhill.*

The area had been without rainfall for over 2 months, which was considered an unusually long dry spell. This resulted in very dusty, dry conditions and soils medium to high in strength.

Prior to riding, trail segments for all loops, including the uphill, downhill, turns, and straight sections, were identified on the ground. Because the testing occurred in the autumn, many trees had dropped their leaves and ground cover (duff) was abundant. The trails were brushed and cleared of any hazards and transects for each trail segment were placed. The downhill, uphill, and straight sections for all four loops were on newly cleared areas.

### Soil Properties

Representative soil samples from the four loop trails were taken for analysis. These soils were classified as silt and silty sand. They are characterized as medium strength and have a medium to high susceptibility to surface erosion. Other soil properties are shown in table 22.

*Table 22—Soil properties for LBL study site.*

| Forest | USCS Group Symbol-Description | Surface Erosion | Dry Strength | Saturated Strength | Rutting (Saturated) | Raveling | Dust |
|---|---|---|---|---|---|---|---|
| LBL | SM-silty sand | Medium-high | Low-medium | Low-medium | Low-medium | Medium-high | Medium-high |
| LBL | ML-silt | High | Low-medium | Low | High | Low | High |

### Vehicle Types

Table 23 provides the model, ATV type, and total number of passes for each loop.

*Table 23—Loops, vehicle characteristics, and total number of passes.*

| Loop | Vehicle Model /Type | OEM/ AM | Total Passes |
|---|---|---|---|
| A | Kawasaki Prairie Utility | OEM | 800 |
| B | Kawasaki Prairie Utility | AM | 800 |
| C | Honda Recon Sport | OEM | 760 |
| D | Honda Recon Sport | AM | 280 |

### Condition-Class Summary

One study objective was to determine if ATVs affect the natural resources and, if so, to what degree. Table 24 provides a summary of the condition-class assessments and specifically how condition classes changed over time with subsequent passes.

*Table 24—Summary of condition classes.*

| Land Between The Lakes<br>ATV Test Summary of Condition Classes | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Summary of Conditions | | | |
| **Equipment Type** | **Tire Type** | **Loop** | **No of Passes** | **Uphill** | **Curve** | **Downhill** | **Straight** |
| Utility | OEM | A | 40 | Low | High | High | Low |
| | | | 80 | Low | High | High | Low |
| | | | 160 | Low | High | High | Low |
| | | | 200 | Med | High | High | Low |
| | | | 240 | Med | High | High | Low |
| | | | 280 | High | High | High | Med |
| | | | 480 | High | High | High | Med |
| | | | 520 | High | High | High | Med |
| | | | 560 | High | High | High | Med |
| | | | 600 | High | High | High | Med |
| | | | 800 | High | High | High | Med |
| | | | | | | | |
| Utility | Aftermarket | B | 40 | Low | Med | Low | Low |
| | | | 80 | Med | Med | Med | Med |
| | | | 120 | Med | Med | Med | Med |
| | | | 160 | Med | Med | Med | Med |
| | | | 200 | Med | Med | Med | Med |
| | | | 280 | Med | Med | Med | Med |
| | | | 320 | High | High | Med | Med |
| | | | 360 | High | Med | Med | Med |
| | | | 400 | High | High | Med | Med |
| | | | 440 | High | Med | Med | Med |
| | | | 480 | High | High | Med | Med |
| | | | 520 | High | Med | Med | Med |
| | | | 560 | High | Med | Med | Med |
| | | | 600 | High | High | Med | Med |
| | | | 640 | High | Med | High | Med |
| | | | 680 | High | High | High | High |
| | | | 800 | High | High | High | High |
| | | | | | | | |
| Sport | OEM | C | 40 | Low | Low | Low | Low |
| | | | 80 | Med | High | Med | Med |
| | | | 160 | Med | High | Low | Med |
| | | | 200 | High | High | Med | Med |
| | | | 240 | Med | High | Med | Med |
| | | | 280 | Med | High | Low | Med |
| | | | 320 | Med | High | Low | High |
| | | | 360 | High | High | Med | High |
| | | | 440 | High | High | Med | High |
| | | | 480 | High | High | Med | High |
| | | | 560 | High | High | Med | High |
| | | | 600 | High | High | Med | High |
| | | | 640 | High | High | Med | High |
| | | | 720 | High | High | Med | High |
| | | | 760 | High | High | Med | High |
| | | | | | | | |
| Sport | Aftermarket | D | 40 | Low | Med | Low | Low |
| | | | 120 | Low | Med | Low | Low |
| | | | 160 | Low | Med | Low | Low |
| | | | 240 | Med | Med | Low | Low |
| | | | 280 | Med | Med | Med | Low |

**Summary of Effects**

Between 280 and 800 passes were made on each of the transect areas of uphill, downhill, curves, and straight sections of trail. All trail sections were rated medium or high for all four loops with the exception of loop C's straight section, where a low rating was sustained from 40 to 280 passes (figures 36 through 41).

In the straight sections of loop A, the rating changed from low to medium at 280 passes and remained at medium through the 800 passes of the test.

*Figure 36—Loop C straight, rated medium.*

Loops B and C showed a change from low to medium at 80 passes. Loop C showed a change from medium to high at 320 and remained high to the end of the test, 760 passes. Loop B showed a high rating on the straight section of trail at 680 passes and remained high to the end of the test at 800 passes.

Uphill and downhill sections on loop D remained low from the start to completion of 240 and 280 passes, respectively.

*Figure 37—Loop A uphill, rated high.*

For all sections on loop D, no condition-class rating ever exceeded medium. However, this was not the case on loops A, B, and C. On loop A, the rating for the uphill section changed from medium to high at 280 passes. Notably, the downhill section on loop A was rated high from 40 passes through 800 passes.

For uphill and downhill section on loop B, a high rating was indicated at 320 and 640 passes, respectively, and remained high for the test's 800 passes.

*Figure 38—Loop B downhill, rated medium.*

*Figure 39—Loop A downhill, rated high.*

*Figure 40—Loop D turn, rated high.*

On loop C, a high rating was achieved on the uphill section at 360 passes and remained high through the total of 760 passes made on the loop. On this section, a medium rating was indicated at 360 passes and this rating was sustained through test's full 760 passes.

ATV use in curves appeared to show the greatest effects on loops A and C. On loop A, the rating was high after only 40 passes, and on loop C, a high rating was indicated after only 80 passes. Riding through this transect was rerouted after 162 passes, and data collection was discontinued. The curve for loop B indicated a high rating at 320 passes, but fluctuated between medium and high until 680 passes, when a high rating was continued through the test's 800 passes. On loop D, the condition-class rating of medium was indicated from 40 through the test's 280 passes.

Vegetation cover was reduced from 41 to 99 percent on all loops. Conversely, on all loops, bare soil was increased by 43 percent on straight sections and up to 58 percent on curves. In the curves on all loops, bare soil increased from a before-riding level of 5 percent to an after-riding level of 58 percent (figures 42 and 43). Vegetation cover was conversely reduced from 95 percent before riding to 42 percent after riding.

*Figure 41—Vegetation/cover completely removed on loop D turn.*

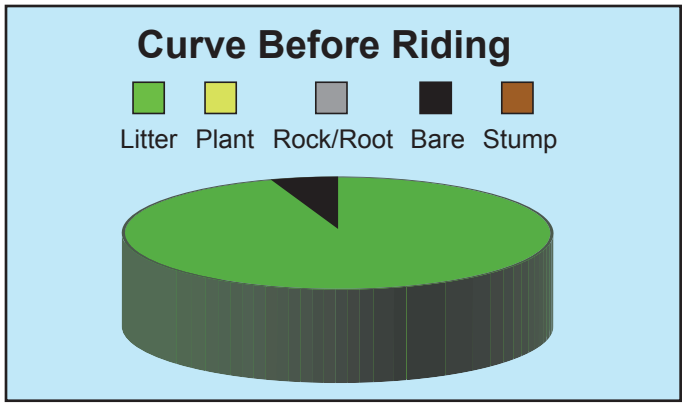


*Figure 42—Illustration of proportionate amounts of litter and bare soil on the curve segment before riding began.*

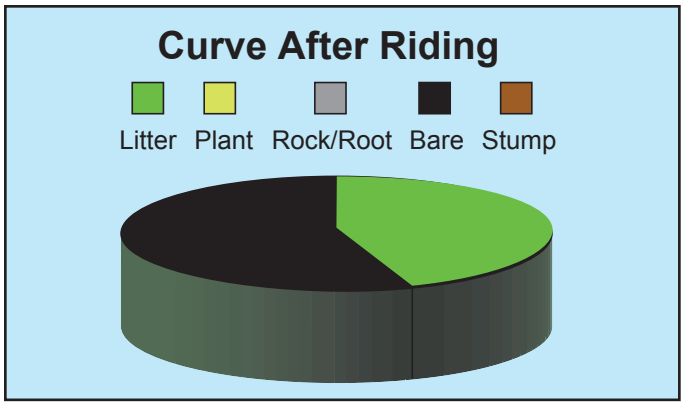


*Figure 43—Ilustration of proportionate amounts of vegetation and litter removed, bare soil, rock/root exposure, stump exposure on the curve segment at completion of total passes.*

Rut depths to 4 inches were recorded in the turns, with the trail widening up to 6 feet. Rut depths to 3 inches were measured in uphill segments, with the trail widening to 3 feet in these segments. Rut depths of 1 to 4 inches were recorded on straight and downhill sections (figure 44).

*Figure 44—Rut depths of 1 to 4 inches were recorded.*

ATVs for loops B and D were fitted with aftermarket tires that appear to have influenced ratings in all sections on loop D. ATVs for loops A and C were fitted with OEM tires and showed much higher condition-class ratings overall (figures 45 and 46).

*Figure 45—Loop C turn, rated high.*

*Figure 46—Loop A downhill, rated low.*

# Louisiana

## Kisatchie National Forest

The Kisatchie National Forest encompasses 603,769 acres. All of Louisiana is considered typical coastal plain. The forest's topography ranges from hilly to undulating on the uplands to level on stream terraces and flood plains. Elevations range from 80 feet above sea level in flood plains to 425 feet above sea level in the Kisatchie hills. The area's general slope is southward to the Gulf of Mexico.

Most soils in the forest area are highly weathered and acidic, with low nutrients. Their productivity, however, is generally high because they are generally deep with abundant plant-available moisture. The area's climate is subtropical.

Weather is highly variable. Annual rainfall averages 59 inches. Summer temperatures range from 85 to 95 °F in the afternoons and 65 to 75 °F in the early morning hours. Winter temperatures range from 55 to 65 °F in the afternoons and 40 to 50 °F in the early morning hours. The average temperature is 68 °F, and the average humidity is 74 percent.

Located within the forest boundaries today are four, broad, historically present plant or vegetation communities: longleaf pine, shortleaf pine/oak-hickory, mixed hardwood-loblolly pine, and riparian.

The study area was located on an old military base on the Kisatchie National Forest's Calcasieu Ranger District. Much of the area was roaded and covered with mature pines and a tall grass understory. Prior to riding, four trail loops were identified that ranged in length from 900 to 1,500 feet. Loops were selected that had similar characteristics: uphill and downhill of approximately 10 percent, a sharp hairpin turn, and a straight section to allow for acceleration and higher speed.

**Soil Properties**

Representative soil samples from the four loop trails were taken for analysis. These soils were classified as silt and silty sand. They are characterized as medium strength and have a medium-to-high susceptibility to surface erosion. Other soil properties are shown in table 25.

*Table 25—Soil properties for Kisatchie NF study site.*

| Forest | USCS Group Symbol-Description | Surface Erosion | Dry Strength | Saturated Strength | Rutting (Saturated) | Raveling | Dust |
|---|---|---|---|---|---|---|---|
| KNF | SM-silty sand | Medium-high | Low-medium | Low-medium | Low-medium | Medium-high | Medium-high |
| KNF | ML-silt | High | Low-medium | Low | High | Low | High |

**Vehicle Types**

Table 26 provides the model, ATV type, and total number of passes for each loop.

*Table 26—Loops, vehicle characteristics, and total number of passes.*

| Loop | Vehicle Model /Type | OEM/ AM | Total Passes |
|---|---|---|---|
| A | Suzuki Vinson 4 by 4 500 Utility | OEM | 480 |
| B | Honda Foreman Rubicon 500 Utility | AM | 640 |
| C | Suzuki Ozark Sport | OEM | 720 |
| D | Suzuki Ozark Sport | AM | 600 |

**Condition Class Summary**

One study objective was to determine if ATVs affect the natural resources and, if so, to what degree. Table 27 provides a summary of the condition-class assessments and specifically how condition classes changed over time with subsequent passes.

*Table 27—Summary of condition classes.*

| Kisatchie National Forest<br>ATV Test Summary of Condition Classes | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Summary of Condition | | | |
| **Equipment Type** | **Tire Type** | **Loop** | **No. of Passes** | **Uphill** | **Curve** | **Downhill** | **Straight** |
| Utility | OEM | A | 40 | Low | Low | Low | Low |
| | | | 80 | Med | High | Low | Low |
| | | | 120 | Low | Med | Low | Low |
| | | | 160 | Low | Med | Low | Low |
| | | | 200 | Low | Low | Low | Low |
| | | | 240 | Low | Med | Low | Low |
| | | | 360 | Low | Med | Low | Low |
| | | | 400 | Med | Med | Low | Low |
| | | | 480 | Low | Med | Low | Low |
| | | | | | | | |
| Utility | Aftermarket | B | 40 | Low | Med | Low | Low |
| | | | 80 | Low | Med | Low | Low |
| | * Stopped riding at 162 passes | | 160 | Low | High* | Low | Low |
| | in Curve | | 240 | Low | | Low | Low |
| | | | 280 | Med | | Low | Low |
| | | | 360 | Med | | Low | Low |
| | | | 400 | Low | | Med | Low |
| | | | 440 | Med | | Med | Low |
| | | | 520 | Med | | Med | Low |
| | | | 500 | Med | | Med | Low |
| | | | 560 | Med | | Med | Low |
| | | | 640 | Med | | Med | Low |
| | | | | | | | |
| Sport | OEM | C | 40 | Low | Low | Low | Low |
| | | | 80 | Low | Low | Med | Low |
| | | | 120 | Med | Med | Low | Low |
| | | | 200 | Med | Low | Med | Med |
| | | | 240 | Med | | Med | Med |
| | | | 580 | Low | | Low | Low |
| | | | 640 | Low | | Low | Low |
| | | | 720 | Low | | Low | Low |
| | | | | | | | |
| Sport | Aftermarket | D | 40 | Low | Low | Low | Low |
| | | | 120 | Low | Med | Low | Low |
| | | | 200 | Med | High | Med | Low |
| | | | 240 | Med | High | Med | Low |
| | | | 280 | Med | High | Med | Low |
| | | | 320 | Med | High | Low | Low |
| | | | 360 | Low | High | Med | Med |
| | | | 400 | Med | High | Med | Med |
| | | | 560 | Med | High | Med | Low |
| | | | 600 | Med | High | Med | Med |
| | | | 640 | Med | High | Med | Med |
| | | | 680 | Med | High | Med | Med |
| | | | 720 | Med | High | Med | Med |
| | | | 740 | High | High | Med | Med |

**Summary of Effects**

For loops A and B, riding was stopped after 480 and 640 passes respectively, because very little change was observed and documented in the test segments. Loops C and D showed some change in condition classes over time; however, they both remained in a condition class for a long period of time.

Between 480 and 740 passes were made over the four transect areas of uphill, downhill, curve, and straight segments. Downhill and straight trail segments were rated low for all four loops, with two exceptions. Loop B indicated a change from low to medium at 640 passes and loop D indicated a change from low to medium at 720 passes.

*Figure 48—Loop C downhill, rated low.*


*Figure 49—Loop C straight, rated low.*

*Figure 50—Loop A straight, rated low.*

ATVs appeared to have the greatest effects in curves. On loop B, the condition-class rating changed from low to high after only 160 passes. Riding through this transect was rerouted after 162 passes and data collection was discontinued. The curve in loop C demonstrated a similar dynamic. The condition class changed from low to medium at 80 passes and riding was terminated after 200 passes out of concern for rider safety.

*Figure 51—Loop B turn, rated high.*

The condition-class rating for the curve segment on loop D changed at 120 passes from low to medium and remained so until changing to high at 720 passes.

In the uphill section, loop B changed from low to medium at 560 passes and loop D changed from low to medium at 680 passes. Loops A and C indicated a low condition class throughout the study.

The condition class summary (table 27) shows the different condition classes found during the test runs. In some cases, the test segment was excluded after a number of passes due to either a condition class being obtained or to safety concerns with continued riding. Loop B attained a high-condition class on the turn at approximately 150 passes. With additional loops, it was determined that rut depths could no longer increase because of the vehicle's clearance limitation.

Vegetation cover was reduced by a range of 41 percent to 62 percent in the downhill and straight sections of all loops. Vegetation cover was reduced by as much as 99 percent in the curve of loop B. Bare soil was increased to 30 percent early in the number of passes and remained the same on straight sections. Bare soil increased to up to 73 percent on curves on all loops (figures 52 and 53).

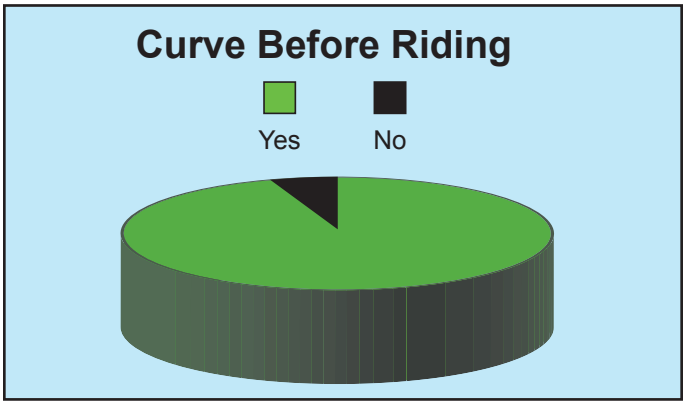


*Figure 52—Illustration of proportionate amounts of litter and bare soil on the curve segment before riding began.*

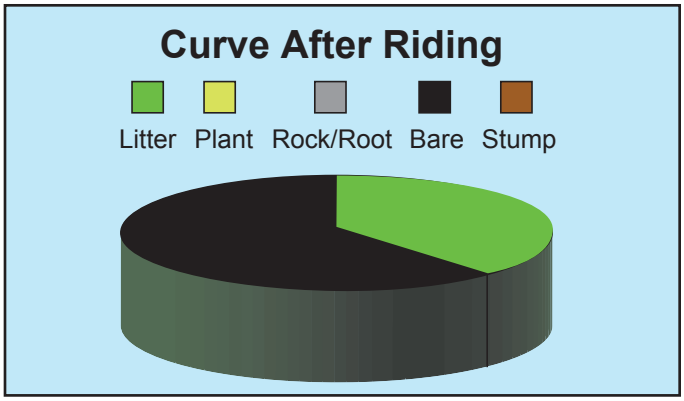


*Figure 53—Illustration of proportionate amounts of vegetation and litter removed, bare soil, rock/root exposure, stump exposure on the curve segment at completion of total passes.*

Rut depths up to 8 inches were recorded in the curves with trail-shoulder mounding up to 9 inches in curve segments (figure 54). Rut depths up to 4 inches were measured in uphill segments with the trail-shoulder mounding up to 6 inches in these segments. Shallower depths, 0.5 to 3 inches, were recorded on straight and downhill sections.

*Figure 54—Loop B, 8-inch rut on the turn.*

Vehicles for loops B and D were fitted with aftermarket tires that achieved a high condition class in the curve, uphill, and downhill segments. They achieved a medium rating on the uphill segments of loop B.

Vehicles for loops A and C used OEM tires. They achieved a low rating for the entire test for all trail segments except the curve on loop A. The turn for loop A indicated a medium condition class.

# Minnesota

## Department of Natual Resource Lands

The Minnesota test site was located on Minnesota Department of Natural Resources (DNR) land adjacent to the Superior National Forest and the Big Aspen Trail loop. The test included portions of existing trails, as well as new or uncompacted trail segments. The trails varied in length from 600 to 1,100 feet.

Sites were selected that followed the natural topography and included slopes typically encountered on existing trails. Uphill and downhill slopes ranged from 16 to 30 percent. On two loops (B and D) tight, hairpin turns were included in the design and layout. On loop A, a more gentle sweeping turn was incorporated as a test segment.

Once the four trails were identified, the trails were cut-in to remove the dominant vegetation, including young aspen saplings 1 to 2 inches in diameter. Stumps, roots, low branches, and other obstacles to riding were removed. In test segments, the trails were widened slightly to aid in the measurement process. Surface rocks and decaying logs were left in place.

Prior to riding, trail segments including the uphill, downhill, turns, and straight sections were identified on the ground for loops A and B. Loop A had the downhill, uphill, and straight section totally on uncompacted soils or newly cleared trails. The sweeping turn was on both new and existing trails.

The uphill and part of the hairpin turn on loop B were on existing trails. The downhill and straight sections on loop B were located on uncompacted or newly cleared trails.

At each segment, three cross sections were placed to record changes to the natural resources that included changes to vegetative cover and soil profile. The three cross sections were extended to approximately 30 feet to reflect the lessons learned in Louisiana. A pretest soil core sample was taken at each of the four trail sections on loops A and B, and at two sections on loops C and D (figures 56 and 57).

One of the few times we had the opportunity to observe ATV effects on an existing trail was on loop C. Loop C was located on an existing road that was primarily used as a snowmobile route and for logging access. An uphill segment was set up in the shoulder of the road using a bypass on the return trip to prevent double counting. The straight segment was set up in the roadbed itself. A bypass was not setup for the return trip, and double counting was allowed. Data collection for the downhill and turn segments were omitted but observed.

*Figure 56—Loop C uphill, rated low.*

Loop D was located on an existing cross-country ski trail and thought to be used previously as a skid trail for logging. An uphill area and a sharp hairpin curve were cleared of vegetation for use as test sections. These test sections were on predominantly uncompacted soils. Data collection for the downhill and turn segments were omitted but observed.

*Figure 57—Loop D, rated medium.*

**Soil Properties**

Representative soil samples from the four loop trails were taken for analysis. These soils were classified as predominately organic silt/clays. They are characterized as low in strength and medium in susceptibility to surface erosion. Other soil properties are shown in table 28.

*Table 28—Soil properties for Minnesota DNR study site.*

| Forest | USCS Group Symbol-Description | Surface Erosion | Dry Strength | Saturated Strength | Rutting (Saturated) | Raveling | Dust |
|---|---|---|---|---|---|---|---|
| MDNR | PT,OL/OH-peat, organic silt/clays | Medium | Low | Low | High | Low | Medium-high |

### Vehicle Types

Table 29 provides the model, ATV type, and total number of passes for each loop.

*Table 29—Loops, vehicle characteristics, and total number of passes.*

| Loop | Vehicle Model /Type | OEM/ AM | Total Passes |
|---|---|---|---|
| A | Kawasaki Prairie Utility | OEM | 500 |
| B | Kawasaki Prairie Utility | AM | 700 |
| C | Suzuki Ozark Sport | OEM | 1,200 |
| D | Suzuki Ozark Sport | AM | 620 |

### Condition-Class Summary

One study objective was to determine if ATVs affect the natural resources and, if so, to what degree. Table 30 provides a summary of the condition-class assessments and, specifically, how condition classes changed over time with subsequent passes.

*Table 30—Summary of condition classes.*

| Minnesota-DNR ATV Test Summary of Condition Classes | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Summary of Condition | | | |
| **Equipment Type** | **Tire Type** | **Loop** | **No of Passes** | **Uphill** | **Curve** | **Downhill** | **Straight** |
| Utility | OEM | A | 40 | Med | Low | Med | Low |
| | Cumulative daily | | 80 | Med | Low | Med | Med |
| | passes | | 120 | Med | Low | High | Med |
| | | | 160 | Med | Med | High | Med |
| | | | 280 | Med | Med | High | Med |
| | | | 320 | Med | Med | High | Low |
| | | | 440 | High | Med | High | Med |
| | | | 500 | Med | High | High | Med |
| | | | | | | | |
| Utility | Aftermarket | B | 40 | Med | Low | Low | Low |
| | | | 80 | Med | Low | Low | Low |
| | | | 120 | Med | Med | Med | Low |
| | | | 200 | Med | Med | Med | Med |
| | | | 320 | Med | Med | Med | Med |
| | | | 360 | Med | Med | Med | Med |
| | | | 440 | Med | Med | Med | Med |
| | | | 700 | Med | Med | Med | Med |
| | | | | | | | |
| Sport | OEM | C | 40 | Low** | All | All | Low** |
| | ** Uphill and | | 160 | Low | passes | passes | Low |
| | straight sections | | 320 | Low | in | in | Low |
| | of trail located | | 400 | Low | roadbed | roadbed | Low |
| | where vegetation | | 640 | Low | NA | NA | Low |
| | present in roadbed | | 1,040 | NA | NA | NA | Low |
| | | | 1,200 | NA | NA | NA | Low |
| | | | | | | | |
| Sport | Aftermarket | D | 40 | Med | Med | Bypass | Low |
| | | | 80 | Med | Med | (see | Low |
| | | | 220 | Med | High | summary | Med |
| | | | 260 | Med | High | of | High |
| | | | 300 | High | High | findings) | High |
| | | | 420 | High | High | | High |
| | | | 500 | High | High | | High |
| | | | 620 | High | High | | High |

**Summary of Effects**

Between 500 and 1,200 passes were made on each of the transect areas of uphill, downhill, curves, and straight sections of trail. All trail segments were at some point rated medium or high, except loop C. In the straight section of loops A, the rating changed from low to medium at 80 passes and remained generally at medium through the test's 500 passes. Straight sections of loops B and D indicated a change from low to medium at 200 and 220 passes, respectively.

The straight segment of loop C remained low through the 1,200 passes completed. The straight segment has a higher number of passes recorded because of the double counting as the vehicle passed back and forth over the same area as it completed each lap.

The uphill sections on loop C remained low from the start to completion of 640 passes. Loop D indicated a high rating on the straight section of trail at 260 passes and remained high through the end of the test at 620 passes. Uphill sections on loops A, B, and D indicated a medium condition class at 40 passes. Loop B remained at medium throughout the test of 700 passes on the uphill section.

Loop A indicated a medium condition class in the uphill section of trail until 440 passes, when a high condition class was indicated. This condition class changed back to medium at the end of the test, 500 passes. Loop D indicated a change from medium to high at 300 passes and remained at this condition class until the end of the test, 620 passes.

On the downhill section of loop A, a medium condition class was indicated at 40 and 80 passes. At 120 passes, a high was indicated and remained the condition class for the downhill section of loop A through the end of the test, 500 passes. On loop B, the condition class was low at 40 and 80 passes and then indicated medium at 120 passes, remaining the same throughout the test, 700 passes.

On loop C, the downhill section was conducted in an existing roadbed and on loop D, a bypass for the downhill section was used that replicated the conditions on the uphill section of trail on this loop. Only the curves on loop A and loop D reached a high condition class. On loop A, a low was indicated from 40 through 120 passes. Then, at 160 passes through 440 passes, a medium was indicated. At 500 passes and to the end of the test on this loop, the condition class was high. This gradual change in condition class was not the case in the curve section of loop D. A medium rating was indicated from 40 through 220 passes. However, at 220 passes through the end of the test at 620 passes, a high condition class was indicated.

On loop B, a low was indicated at 40 through 80 passes in the curve. The condition class changed to medium at 120 passes and remained the same through the test's 700 passes on this loop. Loop C was located in a roadbed where vegetation was present.

Overall, the effects of ATV use on loop B were never rated high on any one of the trail sections. This result is most striking in comparison to the straight sections of loops C and D where high condition class was indicated at 400 and 260 passes, respectively.

The percentage of ground cover disturbed ranged from a low of 47 percent on the straight section of loop D, to 96 to 100 percent on all other sections of all loops. As an example, vegetation cover was reduced from 37 to 14 percent in the curve on loop D. Bare soil was increased from none before riding to 10 percent after riding.

Root/rock exposure changed from a before-riding level of 1 percent to an after-riding 3 percent. Litter increased from 62 percent prior to riding to 73 percent after riding in the curve on loop D. This

increase in litter was due to ground disturbance, exposure, and loose vegetation from the effects of riding (figures 58 and 59).

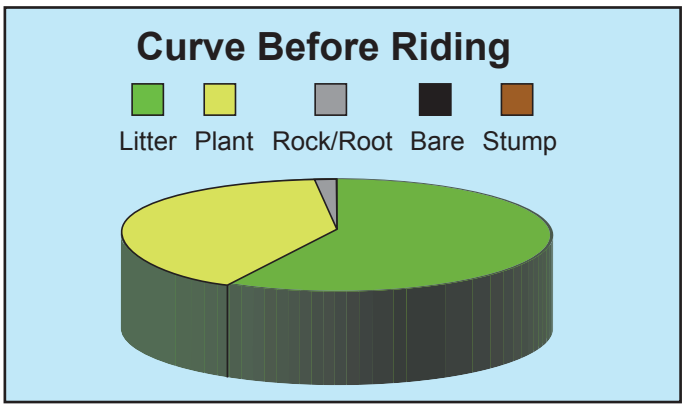


*Figure 58—Illustration of proportionate amounts of litter and bare soil on the curve segment before riding began.*

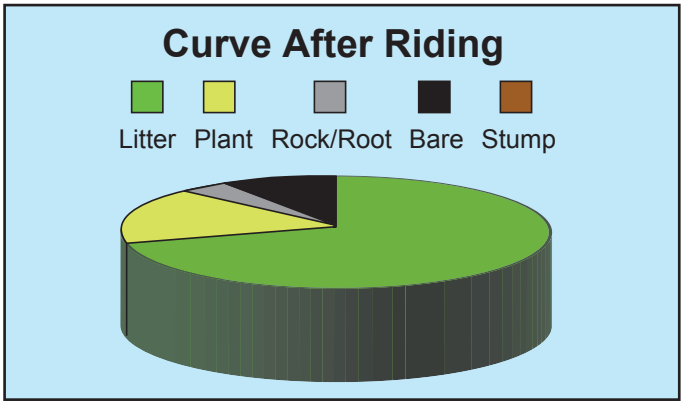


*Figure 59—Illustration of proportionate amounts of vegetation and litter removed, bare soil, rock/root exposure, and stump exposure on the curve segment at completion of total passes.*

Rut depths up to 5 inches were recorded in the curves, with shoulder mounding up to 4 inches. Rut depths up to 2 inches were measured in uphill segments, with shoulder mounding up to 3 inches in these segments. Rut depths of 1 to 2 inches were recorded on straight and downhill sections.

Vehicles for loops B and D used aftermarket tires, and vehicles for loops A and C used OEM tires. It is difficult to discern any differences due to tire type alone as to the effects of ATV use on all loops. This is especially highlighted on the downhill section of loop A, where a high condition class was reached after only 80 passes with the OEM-tire-equipped vehicle. Conversely, on loop D, with aftermarket tires on the sport vehicle, a high condition class was indicated in the curve at 220 passes, the uphill section at 300 passes, and the straight section at 260 passes.

# Missouri

## Mark Twain National Forest

The Mark Twain National Forest encompasses roughly 1.5 million acres, mostly within the Ozark Highlands. Located across southern and central Missouri, the Mark Twain National Forest has the largest base of public land open for a variety of uses.

The Mark Twain is characterized by large permanent springs, caves, rocky barren glades, old volcanic mountains, and nationally recognized streams. A trademark of the forest is plant and animal diversity. The eastern upland oak hardwood and southern pine forests converge with the drier western bluestem prairie of the Great Plains, creating a distinctive array of open, grassy woodlands and savannas. These diverse and ecologically complex vegetative communities provide a home for nearly 750 species of native vertebrate animals and over 2,000 plant species. The study area was located in the Sutton Bluff ATV trail area, about 40 miles southeast of Salem, Missouri. The watershed consists of the West and Middle Forks of the Black River. This is an area of well developed karst terrain that is characterized by the presence of caves, springs, and sinkholes. Soils are developed from cherty limestone and are both stony and acidic. Slopes (10 to 35 percent) are gently rolling to steep near the bigger drainages. The major landform in this area is the Salem Plateau, which is part of the Ozark Plateau. Elevation is about 1,200 feet. The dominant vegetation type is oak and shortleaf pine. Average annual rainfall is 38 inches.

The ATV study was conducted on October 9 and 10, 2004. Riding was to begin on October 8, but was postponed 1 day due to rain and slick riding conditions. The test trail site was located on slopes adjacent to existing trails.

Test trails were laid out on September 29, and the forest conducted subsequent brushing and clearing of small diameter deciduous hardwood trees to accommodate rider safety (figures 61 and 62).

Loops A and B were located next to each other on similar soils and slopes suitable for 4-wheel-drive vehicle use.

*Figure 61—Figure 8 Loop D uphill, rated low.*

*Figure 62—Figure 8 Loop D downhill, rated low.*

Loop C was the shortest and loop A was the slowest due both to length and drivability. Approximately 500 passes were completed on each loop.

Prior to riding, trail segments, including the uphill, downhill, turns, and straight segments, were identified on the ground for all loops. In early October many of the trees had dropped their leaves, and ground cover (duff) was abundant. The study area was predominantly an oak hickory forest with little understory.

The trails were brushed and cleared of any hazards, and transects for each of the trail segments were placed. The downhill, uphill, and straight sections for all four loops were located in undisturbed areas.

**Soil Properties**

Representative soil samples found at the four loop trails were taken for analysis. The results of the analysis concluded that the soils were predominately silty sand. These soils are low to medium in strength and are medium-high to highly susceptible to surface erosion. Other soil properties are shown in table 31.

*Table 31—Soil properties for Mark Twain NF study site.*

| Forest | USCS Group Symbol-Description | Surface Erosion | Dry Strength | Saturated Strength | Rutting (Saturated) | Raveling | Dust |
|---|---|---|---|---|---|---|---|
| MTNF | SM-silty sand | Medium-high | Low-medium | Low-medium | Low-medium | Medium-high | Medium-high |

### Vehicle Types

Table 32 provides the model, ATV type, and total number of passes for each loop.

*Table 32—Loops, vehicle characteristics, and total number of passes.*

| Loop | Vehicle Model /Type | OEM/ AM | Total Passes |
|---|---|---|---|
| A | Kawasaki Prairie Utility | OEM | 480 |
| B | Kawasaki Prairie Utility | AM | 520 |
| C | Honda Recon Sport | OEM | 500 |
| D | Honda Recon Sport | AM | 500 |

### Condition-Class Summary

One study objective was to determine if ATVs affect the natural resources and, if so, to what degree. Table 33 provides a summary of the condition-class assessments and, specifically, how condition classes changed over time with subsequent passes.

*Table 33—Summary of condition classes.*

| Mark Twain National Forest<br>ATV Test Summary of Condition Classes | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Summary of Condition | | | |
| **Equipment Type** | **Tire Type** | **Loop** | **No of Passes** | **Uphill** | **Curve** | **Downhill** | **Straight** |
| Utility | OEM | A | 40 | Low | Med | Low | Low |
| | | | 80 | Med | High | Low | Low |
| | | | 120 | Med | High | Low | Low |
| | | | 160 | Med | High | Med | Med |
| | | | 320 | Med | High | Med | Med |
| | | | 360 | High | High | Med | Med |
| | | | 480 | High | High | Med | Med |
| | | | | | | | |
| Utility | Aftermarket | B | 40 | Low | Med | Low | Low |
| | | | 80 | Low | High | Low | Low |
| | | | 120 | Low | Med | Low | Low |
| | | | 280 | Med | High | Med | Low |
| | | | 320 | Low | High | Med | Low |
| | | | 360 | Med | High | Med | Med |
| | | | 400 | Med | High | Low | Med |
| | | | 440 | Med | High | Med | Med |
| | | | 520 | Med | High | Med | Med |
| | | | | | | | |
| Sport | OEM | C | 40 | Low | Low | Low | Low |
| | | | 120 | Low | Med | Low | Low |
| | | | 200 | Med | Med | Low | Low |
| | | | 240 | Low | Med | Low | Low |
| | | | 320 | Med | Med | Low | Med |
| | | | 360 | Low | Med | Low | Low |
| | | | 440 | Med | Med | Low | Low |
| | | | 480 | Med | High | Low | Low |
| | | | 500 | Med | High | Med | Med |
| | | | | | | | |
| Sport | Aftermarket | D | 40 | Low | Low | Low | Low |
| | | | 80 | Low | Low | Low | Low |
| | | | 280 | Low | Med | Low | Low |
| | | | 400 | Low | Low | Low | Low |
| | | | 440 | Med | Med | Low | Low |
| | | | 520 | Med | Med | Low | Low |
| | | | 560 | Med | Med | Low | Med |

**Summary of Effects**

Between 480 and 560 passes were made over the transect areas on each of the uphill, downhill, curves, and straight sections of trail (figures 63-69). The downhill section of trail was rated low for loop D and low for loop C until after 500 passes, when the rating changed to medium.

*Figure 63—Loop D downhill, rated medium.*

Loop A changed from low to medium at 160 passes in the downhill section of the trail, and loop B changed from low to medium at 280 passes in the downhill section as well.

*Figure 64—Loop A downhill, rated low.*

The straight sections of trail on all loops indicated very similar condition-class ratings as those in the downhill sections.

ATV use in curves on loops A and B indicated the greatest effects early in the number of passes. On loop A, the condition-class rating changed from medium to high after only 80 passes. The curve for loop B demonstrated a similar dynamic. Its condition-class rating changed from medium to high at 80 passes, fluctuated back to medium at 120 passes, and then back to high for the remainder of the test's 520 passes.

*Figure 65—Loop A, rated medium.*

*Figure 66—Loop B, rated high.*

*Figure 67—Loop A turn, rated high.*

*Figure 68—Loop C turn, rated high.*

The effect rating for the curve section on loop C changed at 120 passes from low to medium and changed at 480 passes from medium to high and remained at high for the remaining passes. Loop D changed from low to medium at 280 passes.

In the uphill section, loop B changed from low to medium at 280 passes, and loop C changed from low to medium at 200 passes. On loop C, however, the rating fluctuated from medium to low and then back to medium between 240 and 440 passes. At 440 passes, the condition-class rating on loop C remained at medium until the end of the test at 500 passes.

*Figure 69—Loop D uphill, rated high.*

Loop A changed from low to medium at only 80 passes on the trail's uphill section. The condition-class rating changed again on loop A from medium to high at 360 passes on the uphill section of trail. The uphill section of trail on loop D did not change from low to medium ratings until 440 passes and remained at medium through the end of the test, 560 passes.

Vegetation cover was reduced from 41 percent to 62 percent in the downhill and straight sections of all loops to as much as 99 percent in the curve of loop B and 98 percent in the curve on loop A. In the curve section of loop A, bare soil was increased to 57 percent at 80 passes. Bare soil increased up to 58 percent on curves on all loops (see figures 70 and 71). Bare soil increased to 51 percent on the uphill section of loop A.

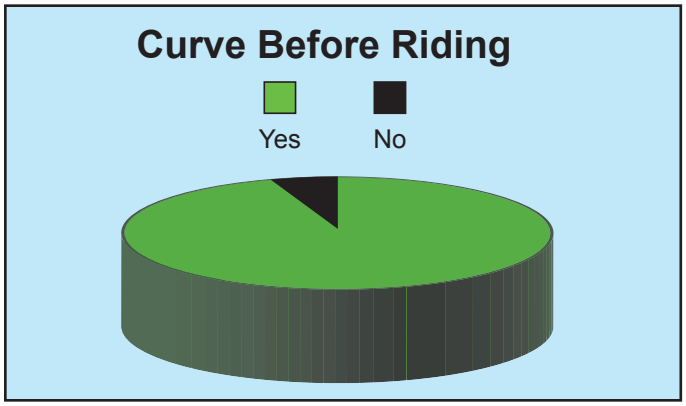


*Figure 70—Illustration of proportionate amounts of litter and bare soil on the curve segment before riding began.*

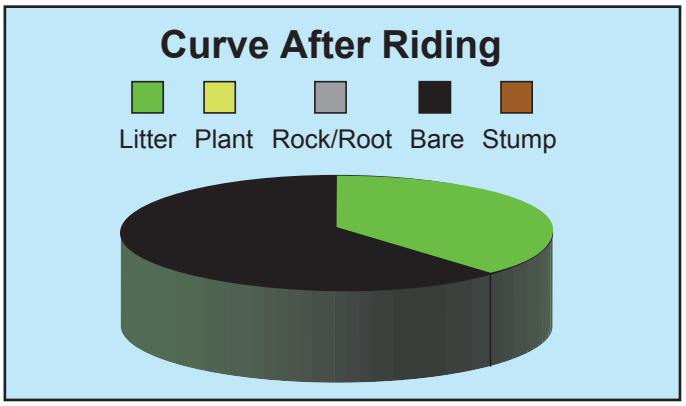


*Figure 71—Illustration of proportionate amounts of vegetation and litter removed, bare soil, rock/root exposure, stump exposure on the curve segment at completion of total passes.*

Rut depths up to 7 inches were recorded in the curves, with the trail widening up to 6 feet in curve segments on all loops and in the uphill section of loop D. Rut depths up to 6 inches were measured in uphill segments, with the trail shoulder mounding up to 10 inches in these segments. Shallower depths—1 to 2 inches—were recorded on straight and downhill sections.

ATV use in turns appeared to show the greatest effects on loops B and D. On loop B, the rating was high after only 80 passes and, on loop D, a high rating was achieved after only 40 passes. Riding through this section was discontinued after 80 passes, as a high-condition class was reached and sustained. The turn for loop A indicated a high rating at 240 passes, after a medium rating was sustained from 40 through 200 passes.

# Montana

## Beaverhead-Deerlodge National Forest

The Beaverhead-Deerlodge National Forest (BDNF) is located in the Middle Rocky Mountain steppe-coniferous forest/alpine meadow ecological province. It is the largest national forest in Montana, covering 3.32 million acres in 8 counties. The forest is in 11 separate landscapes spread across a number of island mountain ranges and accounts for approximately 42 percent of the lands within those counties.

The unique pattern of forest and meadow in southwest Montana makes the land more physically and visually accessible than the more heavily timbered forests of northern Montana. This characteristic of the landscape is also more visually diverse than the open rangelands of eastern Montana. An array of vegetation types characterize the forest, including lodgepole pine, Douglas fir, spruce, sub-alpine fir, whitebark pine, aspen, and juniper, along with great expanses of sagebrush and grasslands.

Four loop trails were laid out for the ATV test. Loops A and B had slopes up to 25 percent for the uphill and downhill sections. Uphill and downhill sections on loops C and D had slopes of 23 percent and 16 percent, respectively. Overall, loops C and D were gentler in slope than loops A and B and were used for the sport ATVs.

**Soil Properties**

Representative soil samples from the four loop trails were taken for analysis. These soils were classified as silty sand, clayey sand, and silt. They are characterized as low-medium strength and have a medium to high susceptibility to surface erosion. Other soil properties are shown in table 34.

*Table 34—Soil properties for Beaverhead-Deerlodge NF study site.*

| Forest | USCS Group Symbol-Description | Surface Erosion | Dry Strength | Saturated Strength | Rutting (Saturated) | Raveling | Dust |
|---|---|---|---|---|---|---|---|
| BDNF | SM-silty sand | Medium-high | Low-medium | Low-medium | Low-medium | Medium-high | Medium-high |
| BDNF | SC-clayey sand | Medium | Medium-high | Low | Low-medium | Low-medium | Medium |
| BDNF | ML-silt | High | Low-medium | Low | High | Low | High |

**Vehicle Types**

Table 35 provides the model, ATV type, and total number of passes for each loop.

*Table 35—Loops, vehicle characteristics, and total number of passes.*

| Loop | Vehicle Model /Type | OEM/ AM | Total Passes |
|---|---|---|---|
| A | Kawasaki Prairie Utility | OEM | 840 |
| B | Arctic Cat Utility | AM | 840 |
| C | Yamaha Bearcat Sport | OEM | 960 |
| D | Honda Sport Trax 250 Ex Sport | AM | 960 |

**Condition-Class Summary**

One study objective was to determine if ATVs affect the natural resources and, if so, to what degree. Table 36 provides a summary of the changes in condition class and, specifically, how they illustrate change over time with subsequent passes.

*Table 36—Summary of condition classes.*

| Beaverhead-Deerlodge National Forest<br>ATV Test Summary of Condition Classes | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Summary of Condition | | | |
| **Equipment Type** | **Tire Type** | **Loop** | **No of Passes** | **Uphill** | **Curve** | **Downhill** | **Straight** |
| Utility | OEM | A | 40 | Low | Low | Low | Low |
| | | | 80 | Low | Med | Low | Low |
| | | | 120 | Low | Med | Low | Low |
| | | | 240 | Med | Med | Low | Low |
| | | | 320 | Med | Med | Med | Low |
| | | | 360 | High | Med | Med | Low |
| | | | 400 | High | Med | Med | Med |
| | | | 520 | High | Med | Med | Med |
| | | | 640 | High | High | Med | Med |
| | | | 840 | High | High | Med | Med |
| | | | | | | | |
| Utility | Aftermarket | B | 40 | Low | Low | Low | Low |
| | | | 80 | Low | Med | Low | Low |
| | | | 120 | Low | Med | Low | Low |
| | | | 200 | Med | Med | Low | Low |
| | | | 280 | Med | Med | Med | Low |
| | | | 320 | Med | Med | Med | Med |
| | | | 360 | Med | Med | Med | Low |
| | | | 400 | Med | Med | Low | Med |
| | | | 440 | Med | High | Med | Med |
| | | | 520 | Med | Med | Med | Med |
| | | | 560 | Med | Med | Med | Med |
| | | | 640 | Low | Low | Low | Low |
| | | | 680 | Med | Med | Low | Low |
| | | | 720 | Med | Med | Low | Low |
| | | | 760 | Med | Med | Med | Med |
| | | | 840 | Med | Med | Med | Med |
| | | | | | | | |
| Sport | OEM | C | 40 | Low | Med | Low | Low |
| | | | 120 | Low | High | High | Med |
| | | | 200 | High | High | High | Low |
| | | | 320 | High | High | High | Med |
| | | | 400 | High | High | High | Med |
| | | | 560 | Low | High | High | Med |
| | | | 720 | High | High | High | Med |
| | | | 960 | High | High | High | Med |
| | | | | | | | |
| Sport | Aftermarket | D | 40 | Low | Med | Low | Low |
| | | | 120 | Low | High | Low | Low |
| | | | 160 | Med | High | Low | Low |
| | | | 240 | Med | High | Low | Low |
| | | | 320 | Med | High | Low | Med |
| | | | 360 | Med | High | Low | Low |
| | | | 400 | Med | High | Low | Low |
| | | | 560 | Med | High | Low | Med |
| | | | 640 | Med | High | Med | Med |
| | | | 800 | Med | High | Med | Med |
| | | | 960 | Med | High | Med | Med |

**Summary of Findings**

Between 840 and 960 passes were made over the transect areas on the trail's uphill, downhill, curves, and straight sections. Downhill and straight sections of all four trail loops were rated high, with one exception. Loop C changed from low to high at 120 passes on the downhill section of the trail and remained at a high condition class to the end of the test, 960 passes. Loop D changed from low to medium at 640 passes on the downhill section of the trail and remained the same to the end of test, 960 passes (figures 73 through 76).

*Figure 73—Loop C turn, rated high.*

The greatest effects of ATV passes were documented in the curves on loops C and D. The effects of ATVs on the curve of both loops C and D were significant, and a condition-class of high was achieved quite early in the number of passes. In both cases, the condition class was medium at only 40 passes and changed to high at 120 passes, remaining high for the remainder of the test, 960 passes.

The condition class for the curve section on loop A changed from low to medium at 80 passes and from medium to high at 640 passes. Loop B changed from low to medium at 80 passes and remained at medium with two exceptions, a low rating at 640 passes and a high rating at 440 passes.

The uphill sections on loop C were low from the start to 200 passes, when the condition class changed to high. The condition class remained high with the exception of one change to low from 560 passes to 720 passes. A high was indicated through the remainder of the test, 960 passes.

Uphill sections on loops A, B, and D indicated a medium condition class at 240, 200, and 160 passes, respectively. Loop B remained at a medium throughout the test, 840 passes, with the brief exception of a low condition class rating from 640 to 680 passes. Loop A indicated a medium condition class in the uphill section of trail from 240 through 360 passes, when a high was indicated. The condition class remained high through the 840 passes of the test. Loop D indicated a medium from 160 passes through the end of the test, 960 passes.

On the downhill section of loop A, a medium condition class was indicated at 340 passes and remained medium through the rest of the test, 960 passes. On the downhill section of loop D, the condition class was low until 640 passes and then medium for the remaining test, 960 passes. On loop B, the downhill section indicated a low from the start of the test through 280 passes, at which time a medium was indicated generally through to the end of the test, 840 passes. At 400 passes—and from 640 to 720 passes—a low was indicated briefly.

Vegetation cover was reduced by 100 percent on all loops, and bare soil was increased to 36 percent on straight sections and up to 78 percent on curves on all loops (figures 77 and 78).

*Figure 74—Loop B downhill, 640 passes rated medium.*

*Figure 75—Loop A downhill, rated low.*

*Figure 76—Typical vegetation and ground cover.*

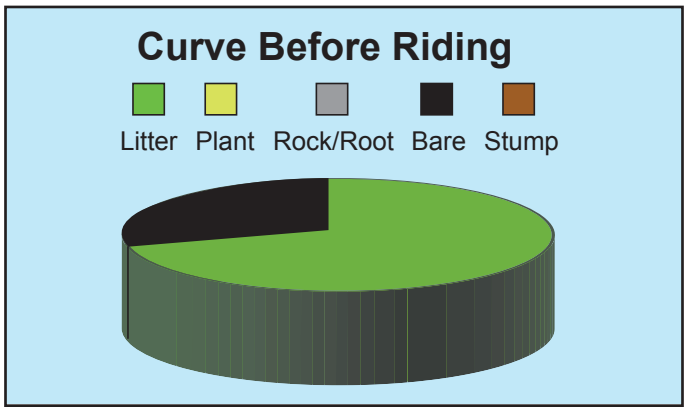


*Figure 77—Illustration of proportionate amounts of litter and bare soil on the curve segment before riding began.*

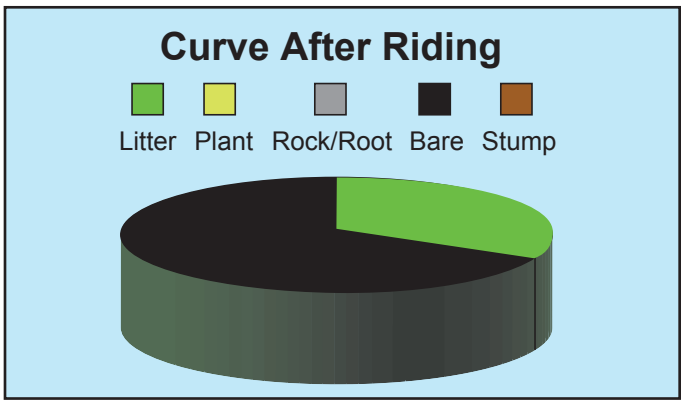


*Figure 78—Illustration of proportionate amounts of vegetation and litter removed, bare soil, rock/root exposure, stump exposure on the curve segment at completion of total passes.*

Rut depths to 7 inches were recorded in the curves. Rut depths to 4 inches were measured in uphill segments, with the trail widening to 6 feet in these segments. Shallower depths—0.5 to 3 inches—were recorded on straight and downhill sections of trail.

A Honda Sporttrax 260 Ex, with a more aggressive aftermarket tire, was used for loop D. The effects of ATV passes—regardless of tire or vehicle type—are significant in curves where shallow soils and rapidly diminished vegetative cover are inherent.

# Washington

## Wenatchee National Forest

The Wenatchee National Forest has a net area of 2,164,180 acres. Elevations on the forest range from 800 feet to more than 9,500 feet, encompassing three major landforms and more than 30 different geologic formations. This geologic variety—and a wide difference in precipitation across the forest—leads in turn to an unusual diversity in vegetation and an associated richness of wildlife species. The vegetation changes with elevation and moisture as the forest rises from grass, sage, and bitterbrush in the low-lying eastern areas, through open stands of orange-barked ponderosa pine, and into mixed forests of pine, Douglas fir, and larch. Next, it rises into subalpine areas with true firs and lodgepole pine, and finally reaches lush alpine meadows fringed with hardy stands of alpine firs, larch, and whitebark pine.

Areas near the Cascade crest receive up to 140 inches of precipitation and as much as 25 feet of snow accumulation each year. Moisture declines markedly to the east, resulting in near-desert conditions with less than 10 inches of precipitation on the eastern fringes of the forest. However, the generous precipitation and snowpack in the high mountain areas supply hundreds of sparkling alpine lakes and dozens of tumbling streams and rivers.

The study area was located in the planned—and yet to be developed—Preston Creek OHV on the Entiat

Ranger District. Most of the planning area was severely burned in the 1970 Entiat Fire. Vegetation consists predominately of stands of young trees with a shrub/grass understory. The study was on an abandoned logging road that was identified for conversion to trails for the Preston Creek OHV area.

The primary bedrock unit in the area is quartz and granodiorite of the Duncan Hill Pluton. This light-colored granitic rock weathers to a very well-drained, relatively coarse-textured sandy soil with rounded rock fragments. Glaciation was the primary land-forming process on the mid and lower slopes. Soils are derived primarily from volcanic ash and pumice, overlying or mixed with residuum and/or colluvium from granodiorite and, locally, glacial till.

Precipitation within the study area ranges from approximately 27 to 45 inches (35-inch average) annually, generally increasing with elevation. The majority of the precipitation falls in October to March, mostly as snow; however, periodic high-intensity convective storms in the summer months also account for a small percentage of the total precipitation.

The study was conducted on roads that had been closed to vehicle access for about 20 to 30 years. The road segments were selected because the Wenatchee National Forest administration was considering reopening some of the road segments to ATV use. To enable the forest personnel to better understand the potential effects of ATV use on the roads, minimal clearing was done. The road prism was a cut-and-fill and easily identified. Heavy vegetation and waterbars were within the trail.

Due to the width of the road segments, loops were constructed that shared the road and had some road segments in which traffic was combined. Downhill and uphill test segments had narrow adjacent areas. Riders had to carefully skirt the test section on their return trip (either uphill or downhill) so they would not be double-counted. Other areas, including the straight sections, had traffic in both directions.

For each loop, uphill and downhill test segments were located on the steepest segments. These loops, however, showed little adverse effect, because riders had to slow down for vegetation or waterbars before or after the test segment.

Encroaching vegetation was purposefully left in the trail to encourage slower speeds and to challenge riders. The road section for loop B had trees and shrubs, with some trees as tall as 15 feet. The other loops had manzanita and grasses growing within the road prism.

**Soils Properties**

Representative soil samples from the four loop trails were taken for analysis. The results showed that the soils were predominately poorly graded sand and silty sand. These soils tested low-medium to medium-high in strength and medium-high in susceptibility to surface erosion. Other attributes of these soils are indicated in table 37.

*Table 37—Soil properties for Wenatchee NF study site.*

| Forest | USCS Group Symbol-Description | Surface Erosion | Dry Strength | Saturated Strength | Rutting (Saturated) | Raveling | Dust |
|---|---|---|---|---|---|---|---|
| OW | SP-poorly-graded sand | Medium-high | Medium | Medium-high | Low | High | Low-medium |
| OW | SM-silty sand | Medium-high | Low-medium | Low-medium | Low-medium | Medium-high | Medium-high |

**Vehicle Types**

Table 38 provides the model, ATV type, and total number of passes for all loops.

*Table 38—Loops, vehicle characteristics, and total number of passes.*

| Loop | Vehicle Model /Type | OEM/ AM | Total Passes |
|---|---|---|---|
| A | Arctic Cat Utility | OEM | 240 |
| B | Honda 2 WD Sport | AM | 960 |
| C | Honda 2 WD Sport | OEM | 240 |
| D | Kawasaki 650 Utility | AM | 440 |

**Condition-Class Summary**

One study objective was to determine if ATVs affect the natural resources and, if so, to what degree. Table 39 provides a summary of the condition-class assessments and, specifically, how condition classes changed over time with subsequent passes.

*Table 39—Summary of condition classes*

| Wenatchee National Forest<br>ATV Test Summary of Condition Classes | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Summary of Condition | | | |
| **Equipment Type** | **Tire Type** | **Loop** | **No of Passes** | **Uphill** | **Curve** | **Downhill** | **Straight** |
| Utility | OEM | A | 40 | Low | Med | Low | Low |
| | | | 80 | Low | Med | Low | Low |
| | | | 200 | Med | Med | Low | Low |
| | | | 240 | Med | High | Low | Low |
| | | | | | | | |
| Utility | Aftermarket | B | 40 | Low | Med | Low | Low |
| | | | 80 | Low | High | Low | Low |
| | | | 120 | Low | High | Low | Low |
| | | | 200 | Low | High | Med | Low |
| | | | 240 | Med | High | Med | Low |
| | | | 360 | Med | High | Med | Low |
| | | | 480 | Med | High | Med | Med |
| | | | 960 | N/A | N/A | N/A | Med |
| | | | | | | | |
| Sport | OEM | C | 40 | Low | * | Low | Low |
| | | | 80 | Low | * | Low | Low |
| | *Curve abandoned for | | 120 | Low | * | Low | Low |
| | this loop. | | 160 | Low | * | Low | Low |
| | | | 200 | Low | * | Med | Low |
| | | | 240 | Low | * | Low | Low |
| | | | | | | | |
| Sport | Aftermarket | D | 40 | Low | High | Low | Low |
| | | | 80 | Low | High* | Med | Low |
| | *Riding stopped after 80 passes | | 160 | Low | | Med | Med |
| | after reaching High on curve segment. | | 240 | Med | | Med | Med |
| | | | 360 | Med | | Med | Med |
| | | | 440 | Med | | Med | Med |

## Summary of Effects

Between 240 and 960 passes were made on each of the transect areas of uphill, downhill, curves, and straight sections of trail. All curve sections of trail were rated medium or high, with the exception of loop C. This exception was due to the fact that the curve was abandoned on this loop (figures 80 through 86).


*Figure 80—Loop A straight.*

The straight section of loop A also remained at a low condition class throughout the 240 passes.

On loop B, the straight section indicated a low rating until 480 passes, when the condition class rose to medium. The rating remained medium to the end of the test, 960 passes.


*Figure 81—Loop B straight after 960 passes.*


*Figure 82—Loop D after 440 passes.*

On loop D, the condition class was low from 40 through 120 passes. At 160 passes, it switched to medium and remained the same to the end of the test, 440 passes.

On the straight and uphill sections of loop C, the condition-class rating remained low from 40 passes through the end of the test, 240 passes.


*Figure 83—Loop C downhill, rated low.*

The downhill section of loop C remained low until 200 passes, when it increased to medium. The condition class reverted to low again on the downhill section at 240 passes.

The downhill section on loop A remained low from the start to completion, 240 passes.

*Figure 84—Loop C uphill, rated low.*

On the uphill, downhill, and straight sections of trail on all loops, no condition-class rating exceeded medium. On loop A, the rating for the uphill section changed from low to medium at 200 passes and remained at medium to the end of the test, 240 passes.


*Figure 85—Loop B downhill, rated medium.*

On loop B, on uphill and downhill sections, a medium rating was indicated at 240 passes and 480 passes, respectively, and remained medium to the end of the test, 480 passes. On loop D, a medium rating was achieved on the uphill section at 240 passes and through the end of the test, 440 passes. Again on loop D, a medium rating was achieved on the downhill section at 80 passes. On this section, a medium rating was sustained to the end of the test, 440 passes.


*Figure 86—Loop D, rated high after 80 passes.*

The percentage of ground cover disturbed increased from 41 percent to 98 percent on all loops. Bare soil on the curve segment of loop B was decreased from 96 to 91 percent. In the curve on loop B, litter increased from a before-riding level of 1 percent to an after-riding level of 3 percent (see figures 87 and 88). Vegetation cover remained at 3 percent before and after riding, while root and rock exposure increased from none to 3 percent after riding in the curve segment of loop B.

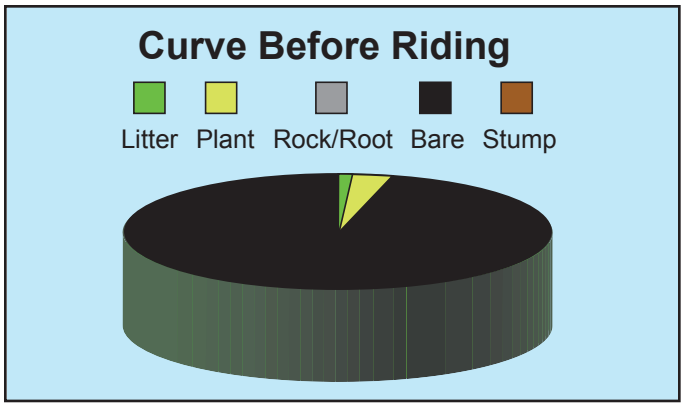


*Figure 87—Illustration of proportionate amounts of litter and bare soil on the curve segment before riding began on loop B.*

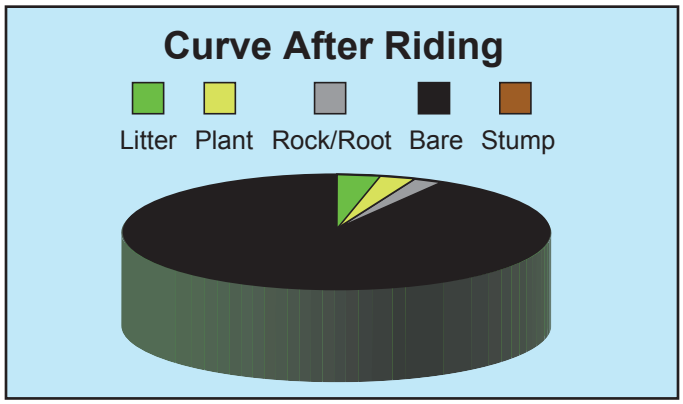


*Figure 88—Illustration of proportionate amounts of vegetation and litter removed, bare soil, rock/root exposure, stump exposure on the curve segment at completion of total passes on loop B.*

*Figure 89—Loop B turn, rut depth 10 inches, trail widening to 6 feet.*

*Figure 90—Loop D turn, rut depth 10 inches.*

Rut depths up to 10 inches were recorded in the turns, with the trail widening to 6 feet. Rut depths up to 3 inches were measured in uphill segments, with the trail widening to 4 feet in these segments. Rut depths of 1 to 4 inches were recorded on straight and downhill sections (figures 89 and 90).