(3.10) Soils

(3.10a) Existing Condition and Resource-Specific Information

Landtype Associations and Ecological Land Type Phases

Landtype Associations (LTAs) are contiguous areas of land that have similar glacial landforms, overstory plant communities, and soil associations. LTAs correspond with different depositional and erosional landforms that formed as a result of the most recent glacial period. Glacial deposits in northern Lower Michigan consist primarily of sand, silt, clay and gravel. Silt and clay layers are most commonly associated with areas of slow-moving or ponded water. Sand and gravel layers are most commonly associated with more rapidly moving waters. Land acquisition resulted in the more productive silt and clay landforms being retained and developed, principally for agricultural uses, by private landowners, and less productive sandy landforms becoming National Forest lands.

There are eight LTAs present on the Huron-Manistee National Forests; five of these occur within the Project Area. LTAs have consistent general trends in soil parent material and vegetation, but differences in productivity, water table depth, slope, drainage, soil texture, and wildfire frequency and intensity that affect potential natural vegetation. These influences are characterized and mapped as Ecological Land Type Phases (ELTPs), and serve as the basic units of land management (Cleland, et. al. 1993). ELTP descriptions represent a summary of information about a specific site relative to the landform, soils, ground flora, and potential natural vegetation. The ELTPs for the sites proposed for treatment in the Project Area are listed on the Treatment Unit Cards (located in the Project File). Table 3.31, Landtype Characteristics for All Ownerships displays the LTAs and ELTPs that are present within the Project Area, and their relationship to soil names (USDA NRCS/FS 1996).

Table 3.31: Landtype Characteristics for All Ownerships within the Project Area

LTA	Formation	Topography	Ecological Species Group		Associated ELTPs	Acres in ELTP	Soil Types
1- Outwash Plains	Deposited by water from melting glaciers.	Comparatively level, but may be pitted or dissected.	Overstory: jack pine, red pine, black, white, and pin oak.	Understory: blueberry, hair-grass.	210 211	6,594	Plainfield
					212	1,283	Plainfield
					213	874	Arkport Chelsea
2 - Ice-Contact Hills	Formed in coarse to medium textured sandy and gravelly material.	Hilly, with gently rolling to moderately steep slopes.	Overstory: black and white oak, red maple, white pine, and red pine.	Understory: starflower.	220	3,573	Grattan
					222	2,120	Grattan
					224	614	Covert
					221 223 225	769	Coloma Toogood

Table 3.31 (continued): Landtype Characteristics for All Ownerships within the Project Area

LTA	Formation	Topography	Ecological Species Group		Associated ELTPs	Acres in ELTP	Soil Types
3 - Sandy Morainal Hardwood Hills	Formed in sandy, gravelly, and loamy material overlying deposits ranging from sandy loam to clay.	Hilly, ranging from gently rolling to steep.	Overstory: white pine, beech, red oak, and red maple.	Understory: viburnum.	230 233 241 245	560	Spinks Okee Benoa
4 - Wet Sand Plains and Lake Plains	Formed in coarse and medium-textured sandy materials.	Level, with low ridges in some areas.	Overstory: red maple, red oak, and white birch.	Understory: bunchberry, leather-leaf, blueberry.	262 263	165	Saugatuck Jebavy Pipestone
					272 273 274	398	Granby Kingsville Glendora
5 - Alluvial, Fluvial, and Organic	Develop or accumulate along streams in depressions.	Nearly level.	Overstory: white cedar, tamarack, black spruce, hemlock, or red maple.	Understory: Labrador tea, Canada violet.	250 280 282	1,616	Napoleon Houghton Carlisle Kerston Adrian

Soil Productivity

Soil productivity varies naturally by ELTP, and is affected by past land uses which may have caused loss of soil organic matter, increased soil bulk density (compaction), or accelerated erosion. Soil productivity is maintained and improved by:

- Retaining or replenishing organic matter and its associated nutrient and water holding capacity;
- Reducing compaction so that water infiltration rates and plant growth are not impeded;
- Limiting soil displacement so that erosion is within naturally occurring rates; and
- Preventing contamination with organic chemicals. (Brady and Weil 2002).

Soil productivity is influenced by local topography, proximity to open water, depth to the water table, the amount and type of vegetation cover, and how that cover has been established or maintained. Many forests, located on well drained and level topography, have been impacted by timber management or past agricultural practices. In other locations, physiographic limitations have resulted in less intensive management. For example, soils in the riparian areas or on steep slopes adjacent to the White River have been passively managed for decades because the combination of soil characteristics and topography are not conducive to repeated timber harvesting. As a result of these situations, many locations have received moderate to heavy impacts to soil productivity, and other areas have received little to no impacts to soil productivity. The characteristics of the various ELTPs and their capacity to sustain productivity associated across a range of activities have been published in the Soil Survey of Oceana County (USDA NRCS/FS 1996). The effects on soil productivity that may be associated with the management activities included in the project can be assessed by considering the soil organic matter and the compaction and erosion potential.

Organic Matter: The amount and type of organic matter in forested soils varies by the type of forest, the history of land use, the parent material, and the climate. Organic matter (in the form of decaying leaves, sticks, etc.) collects on the surface over time. As this material breaks down through natural processes, it forms a layer on top of the soil profile. This layer serves not only as a source of nutrients that are slowly released back into the profile, but also as a protective buffer against the forces of erosion and compaction. Within the soil profile, organic matter consists primarily of dead and decaying roots of plants and trees. As these roots shrink and decay, they not only add nutrients to the soil system, but also provide channels to increase the rates of infiltration. As a result, increased levels of organic matter typically equate to increased levels of soil productivity. Fluctuations in the organic matter that is present in a particular system at a given time may occur as a result of both human activities (i.e. timber harvesting) and natural events (i.e. wildfire).

The effects on the soil organic matter depend on the timing and methods of forest vegetation treatment (including wood removal, prescribed fire, and skid trail, landing and road construction), the type and amount of vegetation that is re-established after a treatment, wildlife and plant habitat improvement activities in non-forested areas (including prescribed fire, disking, seeding and herbicide application), equipment limitations, and erosion from wind and water. Maintenance of soil organic matter is vital to sustaining soil productivity because it is the principal source of nutrients for vegetation and also affects soil fauna and organisms.

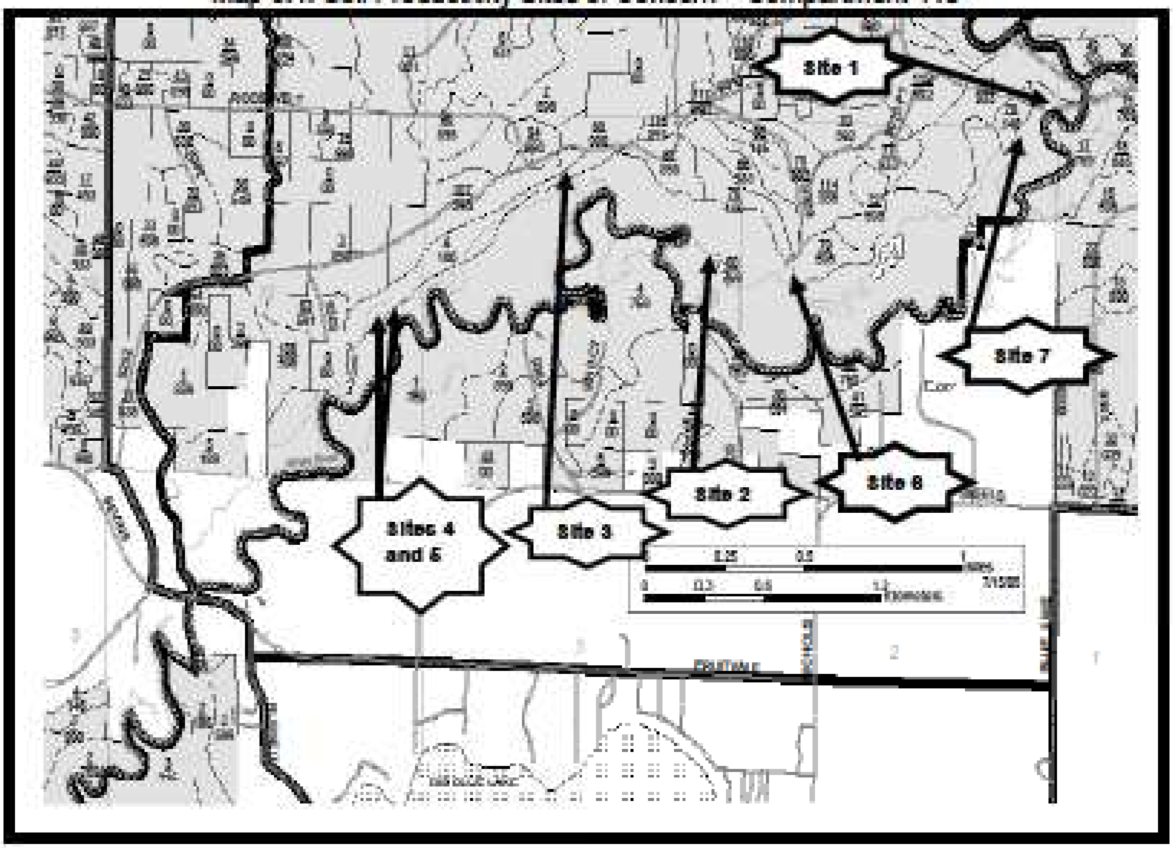
Compaction: Compaction occurs when the pore spaces within a soil are reduced due to the compression of soil particles through natural processes (rainfall) or human activities (motor vehicles, timber harvesting, historic campsites, etc.) As a result, the weight/unit (bulk density) of the soil is increased. Bulk density is used as the measurement for compaction. Compaction results in reduced levels of infiltration and microbial activity within the soil profile, increased run-off potential, and the inability of vegetation to become established or thrive. The susceptibility of a soil to compaction depends on the amount of organic matter in the soil, the overall texture of the soil, and the soil moisture. In general, the greater the organic matter and clay content in a soil, and the drier the soil is when a mechanical treatment occurs, the more resistant to compaction the soil is (Greacen and Sands 1980).

Erosion: Erosion is a natural process involving the detachment and movement of soil by water and wind. Accelerated erosion occurs at an increased rate as a result of human activities, which promote the washing or blowing away of soil faster than new soil can form. As a result of accelerated erosion, suitable soil depth for rooting plants is reduced. (Brady and Weil 2002). Soil loss rates are influenced by a variety of factors, including: soil type and texture, slope, vegetation, and land use (i.e., forested, developed, agricultural).

Existing Areas of Highest Impact

Relative to soil productivity concerns at a site-specific level, the following sites have been identified within the Project Area:

Map 3.1: Soil Productivity Sites of Concern – Compartment 418



Site 1: This is the site of an illegal hill climb area. This use has come from a cut through a mid-level topographical bench, leading to two mud holes in the river bottom near the confluence of the North and South Branches of the White River. Trenches and rutting on the slopes are apparent and soil has moved downslope. This site has been identified for rehabilitation and will be completed as part of the 2010 State of Michigan ORV Restoration Grant.
Total Area Impacted: ≤ 1 acre.

Site 2: This site is referred to as Poison Springs. An historic Forest Road leads down into the main basin of the White River drainage. This road comes to a T-intersection. To the west, the road leads to a mudhole that has been created in an oxbow. To the east, the road slopes into an historic campsite that is located along a creek (identified during the Scoping process as Poison Springs). The campsite serves as the terminus of the eastern spur. There are cutbanks located along the historic Forest Road and the movement of soil downslope is evident. The western spur has rutting evident in the wet basin soils. Rutting is also present on the eastern spur and compaction has occurred as a result of the historic camping use. This site has been identified for

rehabilitation and will be completed as part of the 2010 State of Michigan ORV Restoration Grant.
Total Area Impacted: ≤ 2 acres.

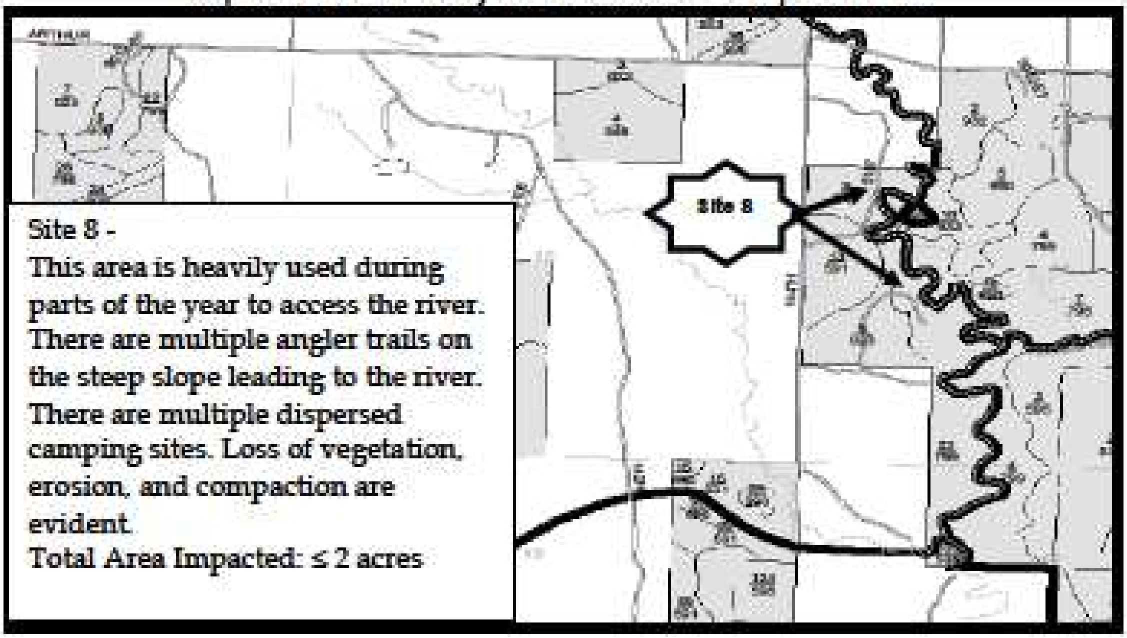
Site 3: There are six separate hillclimb areas associated with this site. Large quantities of soil have eroded and been deposited at the bottom of the slope. This has caused the formation of a land bridge to form across a small oxbow of the White River. The road continues to receive higher levels of use by ORVs than the soils are capable of sustaining, given the steepness of the slope. This site has been identified for rehabilitation and will be completed as part of the 2010 State of Michigan ORV Restoration Grant.
Total Area Impacted: ≤ 2 acres.

Sites 4 and 5: These sites consist of an historic Forest Road and an associated hillclimb. Severe erosion has occurred on the road, which has formed cutbanks upslope and mass deposits of sand downslope. These cutbanks are several feet high and have led to the exposure of entire tree root systems. The road ends downslope at an historic camping area. Site 4 is the hillclimb that is developing from this camping area upslope to connect with the main Forest Road that runs along the White River corridor.
Total Area Impacted: ≤ 1 acre.

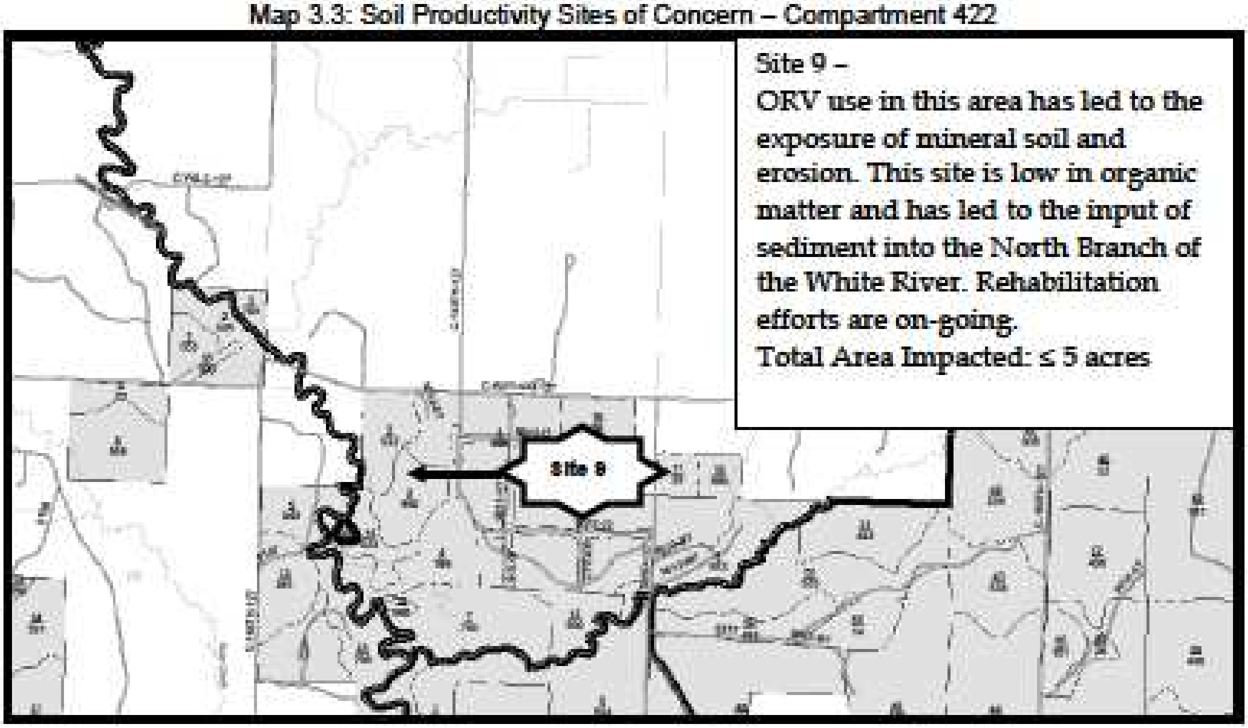
Site 6: This site is referred to as "the bluffs" and is an increasingly high-use area for dispersed recreation. The site is located at the southernmost end of Forest Road 9309 (identified as open on the HMNF Motor Vehicle Use Map (2009). Historical Forest maps indicate that this road dead-ends at a drainage associated with the Main Branch of the White River. The river has more recently altered its course and the road actually now dead-ends at the main branch. The high-use in this area is mainly associated with the sand bluffs which provide recreationists access to the river for swimming, canoeing, etc. The combination of condition and use has led to the mast-wasting of the sandy soil from the bluffs, downslope into the White River. Surrounding the slope to the river there are several dispersed day-use/camping areas where compaction is present.
Total Area Impacted: ≤ 4 acres.

Site 7: This site is locally identified as "twelve rocks" (as discovered during the Scoping process). This serves as a comparatively large area that is highly used by recreationists during the summer months. The banks along the river at this site were previously rehabilitated and large boulders were placed along the river to prevent further degradation (hence the name). There is a road that connects this site with Site 1. The soil at this site consists of exposed mineral soil and there is rutting and cutbanks present along the road that leads to Site 1.
Total Area Impacted: ≤ 2 acres.

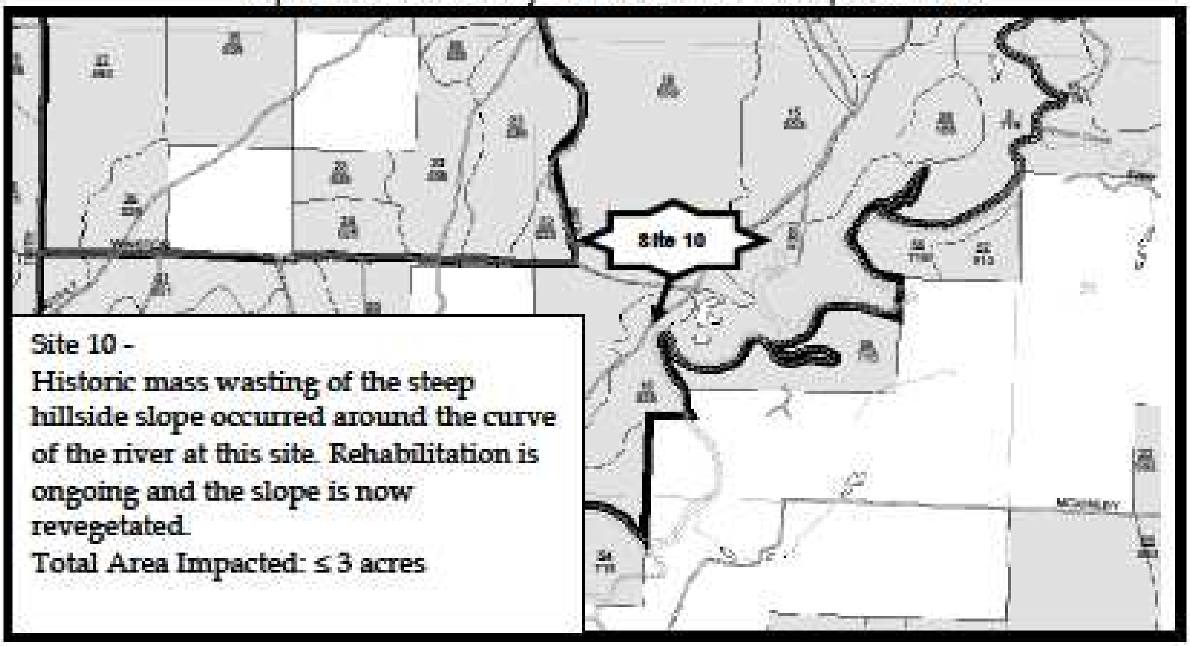
Map 3.2: Soil Productivity Sites of Concern – Compartment 421



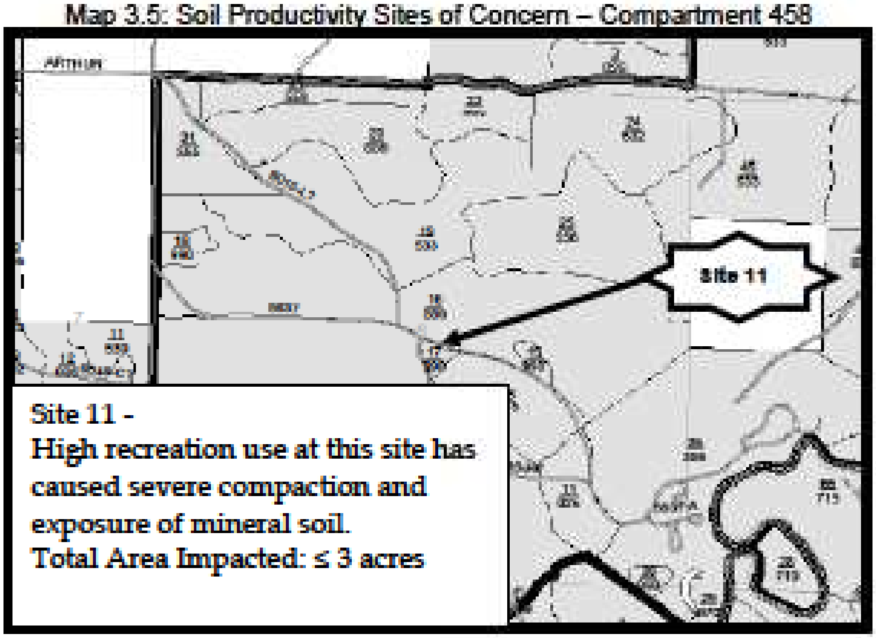
Map 3.3: Soil Productivity Sites of Concern – Compartment 422



Map 3.4: Soil Productivity Sites of Concern – Compartment 439



Map 3.5: Soil Productivity Sites of Concern – Compartment 458



In addition to these sites, soil productivity has been impacted at multiple sites in both the White River and Otto Metapopulation Areas by user-created dispersed camping areas. The level of compaction and the exposure of mineral soil at each of these sites vary by the size, location, and intensity of use. Dispersed Uses (camping, parking, etc.): Dimensions are variable; sites are chosen informally or from prior use; no standards for site protection, and not maintained; used primarily in spring, summer, and fall seasons; open to mixed user group types.

Within the White River Metapopulation Area, there were 38 dispersed camping areas identified. The following describes the parameters that were used to determine the existing size of the different sites:

Small (3 sites): ~ 30′ x 40′ – These sites typically contain enough room to accommodate a passenger vehicle and tent or small pop-up trailer or a truck and small horse trailer for day-use parking.

Medium (16 sites): ~ 40′ x 50′ – These sites typically contain enough room to accommodate one small RV and a passenger vehicle, one large RV, or one truck and small horse trailer for day use parking.

Large (12 sites): ~ 60′ x 80′ – These sites typically contain enough room for one large RV and a large horse trailer or a rig that accommodates both horses and living quarters pulled by a full-size truck.

X-Large (7 sites): ~ 1 acre – These sites typically contain enough room for several large rigs to camp next to each other. These areas are commonly referred to as group campsites.

Based on these parameters, the existing dispersed camping areas within the White River Metapopulation Area are currently impacting soil productivity through compaction and the exposure of mineral soil on approximately 9 acres. Within this area, there are also numerous sites along the White River that were used for motorized recreation/camping prior to the gating of the roads. Restoration activities (i.e. installation of water bars and retaining walls) occurred at the worst sites in an attempt to curtail the deposition of sediment into the river via erosion. Human-related impacts at these sites are now minimal and rehabilitation is on-going.

Existing dispersed camping sites were also identified for the Otto Metapopulation Area. Utilizing the same size parameters identified for the White River Metapopulation Area, the Otto Metapopulation has approximately 19 small sites, 9 medium sites, 7 large sites, and 3 x-large sites. The total area of impact to soil productivity related to these sites is 5 acres.

All of the sites that have been identified are related to the use of motor vehicles, which utilize the existing road system to access these sites. According to the most recent information from the USFS Geographical Information System (GIS), there are approximately 137.3 miles of roads (County, Forest Service, and private roads combined) that currently exist within and adjacent to the Project Area. Assuming an average road width of 12′, there are approximately 200 acres of land within the Project Area existing as exposed or semi-exposed roadbed.

The general features of the transportation system are as follows:

1. Open County roads: Traveled portion of the ROW graded annually, and ROW clearance dimensions infrequently maintained; traveled width 15-40′; maintained principally for high clearance vehicles; used primarily in spring, summer, and fall seasons; open to equestrian uses, OHV use prohibited.

2. Open Forest Service Roads, Maintenance Level 3 (Pines Point access road): Traveled portion paved and clearance dimensions regularly maintained; traveled width 2-lanes; maintained principally for safe travel by passenger vehicles; used primarily in spring, summer, and fall seasons; open to equestrian uses, OHV use prohibited.

3. Open Forest Service Roads, Maintenance Level 2: Traveled portion rarely graded and clearance dimensions not generally maintained; maintained principally for high clearance vehicles; used primarily in spring, summer, and fall seasons; open to equestrian uses, OHV use prohibited.

4. Closed Forest Service Roads, Maintenance Level 1: Traveled portion not graded and clearance dimensions not maintained; maintained principally for high clearance Forest Service vehicles; used primarily in spring, summer, and fall seasons; open to equestrian uses, OHV use prohibited.

Due to the soil types and the seasonally high volumes of traffic, most of the roads within the Project Area consist of exposed and compacted soils having a high sand content. While varying by the site-specific soil characteristics, the areas of lower volumes of traffic typically have less exposure of mineral soil than those areas with higher volumes of traffic. The roadbeds of the existing network currently contain little in the form of vegetation; however on the lower-use roads vegetative strips may occur in the center of the roadbeds. There are some locations where the combination of sandy soils, topography, and mixed use has contributed to the development of road segments that are impassable to passenger motor vehicles due to the depth of loose sand. In other locations, the combination of topography and motor vehicle use has contributed to the formation of deep ruts on slopes and the loss of soil downhill. In some locations, there are several feet of soil that have been transported downslope. This is most evident in the Otto Metapopulation Area (sites 1 through 7 on Map 3.1), as similar sites in the White River Metapopulation have been previously limited to non-motorized use. The loss of soil is considered to be irretrievable.

National Forest Land Suitability

The National Forest lands within the Project Area are generally classified as 1) non-forest, 2) suited for timber production, or 3) suitable for timber production, but proposed for other emphasis. Each forest stand has a land suitability code (LSC) which indicates these classifications. Forested lands suitable for timber management (LSC 500) are planned for long-term timber production, including regenerating to forest in the future. Stands with a LSC of 600 are forested lands that are suitable for timber production, but are proposed for other emphasis that preclude regulated timber production in order to achieve multiple-use objectives. Non-forest land (less than 10% tree cover or developed for non-forest use) has a LSC of 200, and also includes areas of large permanent streams or open water. Lands classified as LSC 700 are physically unsuitable for timber harvest (i.e. due to soils or watershed protection). LSC 800 are lands identified for minimum level management (isolated National Forest land).

Lands in LSC 600 include: 1) Other Emphasis (i.e. savanna restoration), 2) Water Yield Emphasis (i.e. White River Wild and Scenic Study River), 3) Old Growth, and 4) developed recreation sites (i.e. Pines Point Campground). Given the Purpose and Need of this project, implementation of the Karner Blue Butterfly Recovery Plan, the Land Suitability Classes (LSC) within the Project Area under Alternatives 2 and 3, are shown in Table 3.32, Land Suitability Classes.

Table 3.32: Land Suitability Classes within the Project Area

Compartment	Land Suitability Class (acres)				
	LSC 200	LSC 500	LSC 600	LSC 700	LSC 800
414	147	865	77	0	16
416	143	503	259	0	51
417	42	954	69	0	0
418	203	2158	962	0	8
421	12	483	126	0	21
422	47	227	93	0	0
437	147	1756	334	0	0
438	136	1715	480	0	0
439	132	286	1381	0	2
458	67	599	434	0	57
Total	**1,076**	**8,546**	**4,215**	**0**	**153**
% of NFS Lands in Project Area	7.7%	61.1%	30.1%	0%	1.1%

(3.10b) Area of Analysis

The area of analysis for the direct and indirect effects on soil productivity is the National Forest System lands within the Project Area where vegetative treatments would occur, the specific locations of non-motorized trail designation, existing roads, and the locations where human action or natural processes would be likely to directly or indirectly impact the resource. The area of analysis for the cumulative effects is the Project Area, as the effects on the soils related to this project would be unlikely to reach beyond this boundary and the area is large enough to consider the influences on the soil resources that may be associated with activities on lands that are not under the jurisdiction of the Forest Service.

(3.10c) Direct and Indirect Effects

Alternative 1: The Effects on the Soils Related to the Management of the Vegetation

Under this alternative, there would be no impacts on the soil organic matter related to vegetative treatments. This alternative would result in the highest above and below-ground biomass levels (Pritchett and Fisher 1987). Through the decaying of dead trees and litter fall, carbon would either be released into the atmosphere as carbon dioxide, or become part of the above and below ground biomass soil carbon pools. Increasing soil organic matter would be accompanied by an increase in the relative abundance of soil nutrients, microorganisms, and fungi. There would be a net increase in soil carbon and other nutrient levels as organic matter accumulates within the upper soil profile, undergoes decomposition, and becomes incorporated in the soil profile. This would be the result of natural forest maturation and re-growth, as commercial treatments that would export wood or reduce litter and biomass would not occur. The result of these natural processes is that young forests accumulate soil organic matter at a greater rate than mature forests, while mature forests maintain relatively higher soil organic matter levels than young forests. Areas converted from forest to non-forest cover types experience a decrease in above ground (deadwood, litter, and humus) soil carbon pools following the reduction of tree cover, and experience an increase in below ground soil carbon pool as the fibrous roots of herbaceous species become established (Brady and Weil 2002). Therefore, as the forested areas continue to grow and mature and herbaceous species become dominant in non-forest areas, soil productivity would gradually increase and recover from previous impacts.

Vegetation treatments associated with mechanical equipment and hand-tool use would occur only in those areas where treatments have already been analyzed and approved. The low intensity of the prescribed fire, mechanical equipment and hand-tool treatments, combined with the short-term effects on soil displacement and fertility, and the continuous or rapid re-establishment of vegetation on these locations have been previously documented in the Savanna/Barrens Restoration Project and Karner Blue Butterfly Habitat Restoration Project. Therefore, the effects of these treatments on the Project Area's vegetation would be local in scale and minor in severity.

There are some locations within the Project Area where vegetation has become re-established on soils that were compacted as a result of historical land use. At these locations, the level of compaction would continue to decrease as soil organic matter accumulates and soil microorganisms reduce the bulk density of the soil and restore water infiltration rates (Brady and Weil 2005). Recovery from compaction would occur over a period of many years, but the long-term effects on sandy soils would be less than in other soils (Stone, et. al. 1999, and Stone 2000).

No herbicide applications would occur under Alternative 1.

<u>Alternative 1: The Effects on the Soils Related to the Transportation System</u>

The current transportation system would remain unchanged. Forest Service Roads that are on the HMNF Motor Vehicle Use Map as currently open would remain open. The existing roadbeds would continue to lack vegetation and susceptible areas would continue to erode, depositing sand in road depressions and increasing downslope accumulations. The existing open roads would not contribute to the production or accumulation of additional organic matter. Expansion of the existing road system would not be likely, as prior road closure efforts have been effective at deterring the development of new user-created roads. However, widening of the existing roads would be likely in locations where soil conditions make specific portions of the roads seasonally impassable due to roughness, high sand content, or puddling. Areas along existing roads would continue to be the most susceptible to erosion, especially where slopes exceed 2%, the ground vegetation is sparse to non-existent, and the amount of vehicle traffic is greatest.

User-developed roads or the roads on National Forest System lands that are not included on the Motor Vehicle Use Map would be subject to closure at any time. Restricting vehicle access in these areas would affect not only the existing roadbeds, but also the locations where dispersed camping occurs along these roads. In these areas, there would be increased levels of organic matter accumulation. As these areas become revegetated, the level of compaction would gradually lessen due to the penetration of the plant root systems and the soil loosening activities of insects and microbes.

On most roads, micro-topography plays a key role. As the sandy soil from higher spots is washed off by precipitation, it settles in lower elevations. This, in conjunction with the erosive forces of vehicle tire treads, leads to the formation of gullies and wash-outs on some road segments. These areas are present within the Project Area, and would be likely to increase in both size and number, as a result of the "go-arounds" created by users in areas where the existing roadbed is impassable. In addition, the areas of existing OHV damage would remain attractive to users, despite the restriction of this use to designated routes. The continued use by OHVs on sandy soils would continue to create erosion problems in these areas, as the size and number of the locations increases and the soil washes out and moves from areas of higher elevation to areas of lower elevation. On level topography, OHV use would promote the formation of a sand pit, void of all vegetation and susceptible to additional erosion (i.e. Site 9 of Compartment 422, Map 3.3).

Compaction would continue to increase the bulk density of the soils in and along road corridors related to the road traffic and where mechanical equipment is used to complete the three projects that are on-going within the Project Area. The areas affected by compaction would increase at some locations due to the development of by-pass roads to avoid wet pockets in the roadbed and the expansion of unclassified roads off of the managed road system. Activities that promote compacted soils would continue to occur at popular parking locations and along the roads leading into and out of frequently used areas. The compaction on and around the roadbeds may require 40 years for full recovery of infiltration rates (Greacen and Sands 1980).

<u>Alternative 1: The Effects on the Soils Related to Recreation</u>

Recreational activities (i.e. camping) in the Pines Point Campground, and at dispersed locations along Forest and County roads and the White River, would continue to limit permanent vegetative cover and promote increased levels of soil compaction and displacement at these sites. As evidenced by the historical progression of use within the Project Area, the most heavily used dispersed areas would likely continue to expand and new locations would likely become established by users to meet their immediate needs.

Equestrian and pack animal use would continue to be allowed throughout the Project Area and a non-motorized route would not be designated. Consequently, the amount and severity of areas that are entrenched due to the compaction and accelerated erosion related to this use would continue to increase. These effects would be the most pronounced in areas having a high water table, riparian areas, or in locations where this use occurs on slopes. Areas of concern within the Project Area would include Knapp Lake, Knutson Creek, and the slopes that are adjacent to the basins of the North and South Branches of the White River. Corrective action to maintain or rehabilitate areas that have been compacted or experienced accelerated erosion as a result of this use has not occurred. Without such efforts, alternate segments would form in the areas that are heavily used. These alternate segments would likely become similarly impacted by compaction and erosion. Natural processes to reverse and restore entrenched areas would be inadequate because of the loss of topsoil and organic matter and the corresponding shifts in accelerated runoff and patterns of infiltration.

Equestrian and pack animal use would be expected to be much less in the Otto portion of the Project Area than in the White River Metapopulation Area. However, damage to the soil systems related to OHV use and trash dumping would be likely to occur more frequently in this part of the Project Area because of the fragmented ownership and historical land use patterns. Sites of existing OHV damage would continue to degrade and would likely expand, further displacing top soil and damaging vegetation in surrounding areas. Trash dumping would directly impair soil productivity by introducing pollutants, NNIS, or smothering small vegetation.

<u>Alternative 1: The Effects on the Soils Related to the Restoration of Savanna</u>

Under this alternative, there would be no new restoration activities; however, the restoration activities already approved within the Project Area would continue. Mineral soil would be exposed by mechanical equipment where forests are under conversion to savanna, but not in the other locations where only maintenance with hand tools is allowed. The sandy soils and relatively flat terrain on these sites would result in the exposure and displacement of soil caused by equipment use. This would allow the soils in these locations to be susceptible to the erosive forces of water and wind. This susceptibility would be of short duration. Harvested sites would continue to have a sufficient density of large trees (existing) and herbaceous vegetation (existing or established) to stabilize exposed mineral soil. The acceptable threshold of soil displacement would be ≤40% of any treatment area fo r longer than one growing season, with a maximum sub-location size ≤0.1 acre. Landing sites and skid trails would also be susceptible to erosion due to the exposure of mineral soils in some of these locations. However, if surface infiltration is not impeded by compaction, adequate coarse woody debris is retained, and skid trails have slopes <6%, the erosion hazard potential is slight.

Follow-up treatments at these sites would include post-harvest burning and seeding. Exposed soil would be anticipated as a result of these activities and could increase exposed soil available for transport by wind or water due to the construction of control lines and seed bed preparation. The acceptable threshold of displacement related to these activities would be the same as those identified for timber harvesting activities.

The effects on the soil resources from the activities associated with these projects were considered in the environmental analysis for each of those projects, respectively.

<u>Alternatives 2 and 3: The Effects on the Soils Related to the Management of the Vegetation</u>

The forest and shrub canopy in areas subject to vegetation treatments would be reduced using mechanical harvesting equipment. This reduction in overall canopy cover would alter the existing temperature regime of the soil systems in these locations, causing greater seasonal flux. Seasonal increases in soil temperature would result at the sites where vegetation is removed due to increased direct solar radiation reaching the soil surface. This increase would change the dynamics of biomass accumulation by stimulating organic matter decomposition. Consequently, the thickness of the O horizon would decrease and proportionately more organic carbon would accumulate in the A and B soil horizons as the herbaceous root mass increases. This change would promote short-term nutrient mineralization that would be lost through leaching if prompt revegetation does not occur (Brady and Weil 2002). The magnitude of these effects would be proportional to the amount of canopy removed, the amount of soil exposed, the existing levels of organic matter at the soil surface, and the site-specific historical impact related to land use (i.e. relatively undisturbed vs. old pasture).

Stone (1999, 2000) has documented the loss of soil productivity on similar harvest sites on the Huron National Forest. When considering the effects of harvesting on soil carbon storage in temperate forests, Nave et. al. (2010) found that carbon stored in the organic horizon (O horizon) of Spodosols (ELTPs 220 – 245) declined more than the carbon stored in the mineral horizons (A and B horizons), and that a period of 50 – 70 years may be required for the soils to recover to pre-harvest levels. These effects were more pronounced in hardwood than in conifer cover types. The on-site retention of the majority of woody material <4" in diameter from harvested trees (slash) in clearcutting units (and a lesser amount of this material in oak regeneration and pine thinning units) reduces this effect on soil productivity. This retention would help maintain above- and below-ground organic matter and provide a substrate for fungi, bacteria, and other micro-organisms in the soil. In addition, harvesting during periods of non-saturated soil conditions and plant dormancy would sustain site productivity by conserving organic matter in litter and root storage in hardwood species (Hallett and Hornbeck 2000). Nutrient cycling processes and organic matter decomposers would mitigate the presence of slash as a hazardous fuel within 5 years of the harvest.

Individual timbered stands would experience an immediate export of site nutrients through the removal of trees. This export would vary in intensity based on the type of harvest (i.e. clearcutting v. thinning). This loss of nutrients would be related to the source/sink processes of the existing vegetation. Nutrients being stored and utilized by the trees at the time of harvest would be lost from the system. In clearcut and overstory removal harvests, this loss would be greater than in the proposed thinnings; however, stand replacement at these sites would occur more rapidly, increasing the ability of the stand to cycle the nutrients available in the upper soil profile. Tree regeneration would be expected to occur the first year after harvest. This, coupled with the extensive root systems left from the previous stand, would reduce the susceptibility of a site to short-term nutrient loss due to the erosive properties of wind and water. In thinning harvests, fewer nutrients would be exported from the system and replacement would occur more slowly through the additive processes of understory development. Skid trails and low standard roads occupy a small percentage of the area, and organic matter removal or relocation would not cause a significant loss of inherent soil productivity.

Compaction would occur on collector skid trails (where more passes occur than are typically associated with only tree felling and loading) and at log landing sites. This compaction would not surpass acceptable thresholds if the increase in soil bulk density remained <15% or the decrease in soil porosity remained <10% (USDA-Forest Service, FSM2509.18). Harvesting during periods of non-saturated soil conditions would minimize compaction of soil macropores and micropores, maintaining aeration and drainage and plant root growth potential (Brady and Weil 2002). As the root systems of felled trees decay, water infiltration would increase due to channeling and would provide increased nutrient and microorganism mobility in these areas. These natural processes would slowly reverse the effects of compaction from the harvesting activities. In general, thinning activities would result in channeled skid trails receiving higher volumes of harvesting equipment traffic over a single area, compared with clearcut areas where skidding would be dispersed. The length of time for a compacted soil to be restored to its original bulk density depends on the soil texture and degree of compaction. Sandy soils with compacted zones > 6-10" below the surface may require 5-18 years to recover. On sandy soils in lower Michigan, Page-Dumroese et. al (2006) found that soil bulk density on moderately compacted sites varied by depth one year after treatment, with recorded increases ranging from 9- 24%. After five years, the range of recorded increase was 8-17%. Powers et. al (2005) found that after 10 years, soils rarely recovered from severe compaction, regardless of their initial bulk densities.

Appendix A (see General Timber) contains conservation measures to reduce the adverse effects on soil organic matter loss, compaction, and accelerated erosion from vegetation treatments. Therefore, the effects on the Project Area's soil resource would be local in scale and minor in severity.

<u>Alternatives 2 and 3: The Effects on the Soils Related to the Transportation System</u>

The impacts on soil productivity from Forest and County roads, and to a lesser degree from recreation/OHV uses, are associated with soil erosion and the reduced amount of organic matter produced from these non-vegetated areas. The affects on soil productivity by recreational uses are most influenced by a combination of soil texture, topography, and by the type and frequency of recreational activities.

The soil bulk density on closed roads would slowly decrease as the main force of compaction (motor vehicles) would be removed or greatly reduced. As a result, those roads not used for management would begin to sustain vegetation. Penetration of vegetative roots would loosen compacted soil layers over time and promote the natural effects of soil aeration and channeling brought about by worms, insects, and microorganisms. The time to restore these soils within normal ranges would depend on the existing compaction levels, the physical properties, and the type of vegetation re-occupying the site.

Permanent County and Forest roads would also be impacted in the short-term by the traffic from hauling timber products, resulting in periods where increased compaction and rutting would occur on the main haul roads. Temporary roads and landings constructed for timber harvest activities would also remove vegetation, compact soil, and promote the erosion of exposed mineral soil.

Under both of these alternatives, the reduced road density would promote increased soil organic matter accumulation on roads that are closed to motor vehicle use. As evidenced by the presence of old railroad grades on the existing landscape, the majority of roads closed by this project would be evident on the landscape for an extended period of time (50-100 years). However, selected roads within the White River Metapopulation Area would be obliterated, seeded, and become part of the individual management units. The remaining roadbeds of the closed roads not needed for management purposes would be slowly overgrown by herbaceous and woody vegetation. This would promote increased levels of detritus deposits and organic matter, which would provide improved growing conditions for new vegetation in these locations. Over time, the root systems of this vegetation would serve to increase the amount of the soil organic matter, and thus increase the soil productivity in these areas. Severely damaged areas would not recover within the range of normal soil parameters unless activities to correct site-specific problems (e.g. topsoil replacement) were undertaken. While the soil that has already been lost to erosive forces at these locations would not be re-captured, these rehabilitation practices would allow natural processes to re-vegetate denuded areas. This would reduce additional soil loss and discourage the destruction of additional vegetation. Scarring that has occurred as a result of these activities would remain into the reasonably foreseeable future.

Under Alternative 3, FR9310 in the Otto portion of the Project Area would be closed to motor vehicles, but left open to snowmobiles as part of the West Shore Snowmobile Trail. FR9310 is considered a Level 2 road that receives moderate to high levels of use during the peak recreation season. The traffic from this road would then be re-directed onto to an existing Level 3 road (FR9870/71) to the east. For the latter road to be able to support this sudden increase in traffic there would be substantial reconstruction (clearing, grading, widening, etc.) necessary which would increase the existing footprint of this road. As a result, there would be increased mineral soil exposure, compaction and erosion potential, and loss of vegetation associated with this re-route. However, the result of FR9310 being reduced to administrative and seasonal snowmobile traffic would provide an opportunity for the soils along this route to recover from the historical levels of compaction and mineral soil exposure. Over time, the density of herbaceous and woody vegetation along FR9310 would increase. This would contribute to gradual increases in the organic matter on the soil surface layers and to loosening of the sub-surface layers as a result of penetrating of root systems.

The approximate land area (in acres) that management of the transportation system would have the potential to affect the soil resources is displayed in the following table. The values displayed in this table assume an average road width of 12'.

Table 3.33: Approximate Total Acres of Soils Impacted by the Transportation System on National Forest System Lands within the Project Area (assumes an average road width of 12')

Road Status	Management Area	Road Type	Alternative 1	Alternative 2	Alternative 3
Roads Left Open	Semiprimitive Nonmotorized	FS	11.0	1.0	1.0
		County	11.0	11.0	11.0
	Rural	FS	9.4	8.9	8.2
		County	14.6	14.6	14.6
		Unclassified	0	0.8	0.8
Total Miles			**46**	**36.3**	**35.6**
Total Acres			**67.0**	**53.2**	**51.8**
% of NFS Lands Effected within the Project Area			0.4	0.3	0.3

<u>Alternatives 2 and 3: The Effects on the Soils Related to Recreation</u>

Within the White River Metapopulation Area, the number of dispersed campsites would be reduced from the existing level (approximately 38 sites) to 11 designated sites. Campsites within this area are linked intrinsically to motorized access. Therefore, the reduction in dispersed camping sites would be due to the reduction in motorized access throughout the area.

As the sites that would no longer be available to motorized-dependent camping there would be a gradual decrease in the levels of compaction and an increase in the capacity of water to infiltrate the soil at these sites. The natural accumulation of organic matter on the soil surface, coupled with the soil loosening effects of rooting vegetation, would eventually bring these impacted areas into equilibrium with the surrounding areas where these impacts have not occurred over time. At some locations, it would be expected the existing sites that are currently used for motorized-dependent camping would continue to be used by campers that are not dependent on motorized vehicles.

There are areas within the southern portion of the White River that were used extensively by motorized-dependent recreation in the recent past (5-10 years). While some restoration activities occurred at some of these locations to reduce the input of sediment into the river and to prevent erosion on the slopes, there was little work done to rehabilitate the effects that occurred to the soil systems in these areas as a result of the high levels of use. The type and level of use that was occurring in this area was very similar to that which is currently taking place on the dispersed sites with existing motorized access. The sites without motorized access serve as an example of what would be expected to occur at the sites that are currently open, but would be closed to motor vehicles under these alternatives. The following qualitative characteristics (relative to soil condition) were noted at the southern sites, in comparison to the existing dispersed camping sites:

- Increased levels of leaf litter and organic matter on the soil surface;
- Reduced levels of exposed mineral soil;
- Increased levels of coarse woody debris;
- Increased levels of herbaceous plant establishment;
- Reduced run-off; and
- Reduced trash dumping.

Due to the similarities in soil and vegetative characteristics between these two areas, it would be likely that the sites in the north would exhibit similar qualitative changes if motorized-dependent camping was restricted from these areas.

As the number of existing sites would be decrease under these alternatives, there would be an increase in dispersed motorized-dependent recreational use on the sites that remain and on those that would be developed. All of these designated sites would be adjacent to existing County roads. The level of impact on the soil at these sites would depend on the size of the site. Larger sites would be able to accommodate larger (and heavier) equipment and a greater number of users at any particular time. When compared with the smaller sites, these areas would be more susceptible to increased compaction and reduced water infiltration. In addition, equine enthusiasts have historically utilized multiple locations within the Project Area for group camping. As these alternatives would limit those activities to a few designated areas, the sites remaining would be heavily impacted, especially during the spring, summer, and fall. It is during this time when the soil is most susceptible to the effects of compaction and erosion due to the moisture content and exposure of the surface layer. There would also likely be nutrient spikes to the soils surrounding the larger sites, due the dispersal/disposal of horse manure. While these activities would alter the soil chemistry and nutrient levels at these locations, the effects would be localized and minor in severity.

Based on historical use on the Forest, without containment and enforcement, all of the designated sites would be subject to "creep", as motorized-dependent campers expand the sites into non-designated areas. The large sites would be more prone to these effects, as equine campers tend to seek alternate and multiple places to tether their horses while at camp. This expands the area of soil impact.

Under Alternative 2, equestrian and pack animal use would be confined in the White River portion of the Project Area to a designated non-motorized route. Assuming an average impact area of 48" for this trail, this would directly affect approximately 7 acres of National Forest land. Compaction and accelerated erosion effects would be most pronounced in locations of high water tables and riparian areas, and on non-road locations where the slope exceeds 6%. These effects would be substantially less where the route is coincident with County and closed Forest Service roads. Under this alternative, there would also be a parking area of approximately 2 acres in the northern portion of the White River that would be constructed to facilitate the use of this trail. There would be increased levels of compaction associated with the use of this area for parking; however, the total area within the White River Metapopulation Area impacted by parking would be reduced due to the loss of parking sites that are currently being utilized for recreational day-use. Surface protection would occur at the locations selected for watering to protect the soil resources from accelerated erosion.

Under Alternative 3, a non-motorized trail system would not be established within the White River Semiprimitive Nonmotorized Area, horse use would be prohibited in this area, and the creation of a designated parking area to facilitate this use would not occur. As a result, the impacts related to these uses would not occur.

Under Alternatives 2 and 3, a parking area (<1 acre) would be developed at the eastern terminus of Winston Road within the White River Semiprimitive Nonmotorized Area. This location is currently used as a non-designated parking area and there is an old grade that is open to allow foot travel to the river. Due to the slope and soil types, the existing unimproved parking area consists of deep, loose sand. Activities would occur to harden and protect the surface of this area reducing the potential for accelerated downslope erosion at this site and limiting the compaction to the developed area. As other locations that are currently used for recreational day-use parking would be off-limits (due to the closure of other Forest Roads), there would be an overall decrease to the effects on the soils related to parking under both of these alternatives.

Alternatives 2 and 3 would both allow for other forms of non-motorized recreation (i.e. hiking, biking, non-motorized dependent camping) to occur throughout the Project Area. Based on the current level of this use and the characteristics associated with these forms of recreation, the resulting impacts on the soils would be localized and minor in severity.

Table 3.34: Approximate Acreage of Soils Impacted by Recreation within the Project Area

Source of Impact	Project Area Location	Alternative 1	Alternative 2	Alternative 3
Dispersed Campsites	White River	9.1	0	0
	Otto	4.7	4.7	4.7
Designated Campsites[1]	White River	0	3.6	3.6
Designated Non-Motorized Trail	White River	0	7.2	0
Designated Parking Areas[1]	White River	0	2.5	2.5
Total		**13.8**	**18**	**10.8**

[1]*Does not include features associated with the Pines Point Campground.*

Alternatives 2 and 3: The Effects on the Soils Related to the Restoration of Savanna

As a result of a project previously planned within this Project Area (Savanna/Barrens Restoration Project and the Karner Blue Butterfly Habitat Restoration Project), there would be approximately 474 acres within the Project Area where the seeding of native vegetation and prescribed burning would occur. These acres are in addition to those proposed by the project being evaluated. At some locations, these activities would overlap with the activities currently being proposed. This would be to allow the full suite of treatment options to be available for the restoration or creation of savanna at these sites. Additional sites proposed for savanna restoration under this project consist of upland openings and red pine, white pine, and oak forest cover types.

In the Project Area, the locations where the activities associated with savanna restoration/creation would occur are found on soils with ELTP units 210, 211, and 220. The soils associated with these ELTPs have deep, sandy profiles. The depth to the water table in these ELTPs is >15 feet, and the thickness of the O horizon (fresh and decomposing organic material) in these units is variable, but averages 0-1" thick. The upper soil layers in all of these ELTP units have low nutrient content and cation exchange capacities (Cleland, et. al. 1993). Typically, the highest soil productivity for tree species occurs in ELTP unit 220, and is associated with its comparatively thick layer of humus and a well-defined A horizon (topsoil). Once herbaceous vegetation is established, deep rooted species (e.g., lupine, bluestem, and oaks) exploit subsurface soil layers for moisture and nutrients. The establishment of these species is dependent on the favorable growing-season soil moisture and a mineral seedbed that promotes germination. Pennsylvania sedge and bracken fern compete for moisture in the upper soil layers, and reducing the amount of these two species would be necessary to establish other savanna plant species.

There would be soil compaction from the increased amount of mechanical equipment used to restore the barrens/savanna cover type. Harvesting methods for restoration would facilitate dispersed skidding (except at landings). This would minimize the number of concentrated skid trails within each location. Where compaction occurs on skid trails and landing sites, mechanical site preparation and seeding would reduce the bulk density of these sandy soils by increasing aeration, water infiltration, and herbaceous vegetation recovery. The effects of mechanical equipment from prescribed burning and the seeding of native plant species would result in short-term soil displacement where prescribed fire control lines are constructed, and where mineral seedbeds are prepared. Fire-line construction would occur on the perimeter of many locations, and be rehabilitated and seeded afterwards using mechanical equipment and hand tools.

The sandy soils, high infiltration rates, and relatively flat terrain of the proposed restoration sites would limit accelerated erosion caused by equipment use to these locations. Treated sites would continue to have a density of large or regenerating trees and herbaceous vegetation sufficient to stabilize, or re-vegetate, exposed mineral soil if the displacement of the forest floor does not exceed 40% of any location, and if any one displaced sub-location does not exceed 0.1 acre in size. Landing sites and heavily-used skid trails would be susceptible to the erosive forces of water due to exposure of mineral soils in some of these locations; however, if surface infiltration is not impeded by compaction, adequate coarse woody debris is retained, and skid trail slopes are <6%, the erosion hazard is slight.

Soil organic matter would be affected by mechanical equipment used for site preparation and seeding of herbaceous species. The effects would be limited to humus disturbance and nutrient mixing within 10–20% of the treated areas, moving organic matter from the O and A horizons to the B horizon, and altering the composition of nutrients available for emerging seedlings (Troeh, Hobbs, and Donahue 2004). Mechanical treatments to expose mineral soil will have small, temporary effects on soil productivity, hastening decay and exposing disturbed areas to small-scale wind erosion. Mechanical site preparation for seeding would be coordinated with strip application of herbicides, particularly where Pennsylvania sedge mats are dense. In situations where mechanical cultivation is necessary, the depth of humic material mixing within the profile would increase. The amount of disturbance would depend on the amount of the residual vegetation and the physical obstacles of each site (e.g., stumps and slash) and the growing requirements of the plants being seeded, but would typically not exceed a depth of 6". Mechanically disturbed sites would be seeded using mechanical equipment and hand tools, and are expected to become fully vegetated within two growing seasons of treatment.

Appendix A contains mitigation measures to reduce the adverse effects on soil organic matter loss, compaction, and accelerated erosion from the treatments related to the restoration/creation of savanna. Therefore, the effects on the Project Area's soil resource would be local in scale and minor in severity.

<u>Prescribed Burning:</u> In addition to the approximately 3,061 acres of burning related to savanna restoration/creation, there would be approximately 1,050 additional acres of burning conducted within the Project Area. The effects of prescribed burning on the soil organic matter in these locations would be influenced by the site-specific soil and fuel moisture levels, fuel loading and arrangement, and the residence time of the fire. These factors are directly related to fire intensity (USDA-Forest Service 2005). In most areas, the desired range of fire intensity would be between 90-300 BTU/ft/sec., with a spread rate of 75'–500'/hour. These intensity levels would be considered light to moderate, but would be sufficient to top-kill the majority of oaks < 2" in diameter at the ground line (Bova and Dickinson 2005). The expected consumption levels of such a fire would be 90+% of the herbaceous vegetation and < 10% of the surface organic

layer. Prescribed fires having this level of intensity on similar sites of the Manistee National Forest have resulted in < 15% mineral soil exposure (Hatting, personal communication, 2007).

There would be an immediate and short-term increase in available nutrients at the soil surface in areas burned at this level of intensity. This spike would occur through the deposition of nutrient-rich ash on the upper soil layers; however, due to pyrolysis and translocation of nitrogen (N) in the humus layer and N volatilized into the air, low productivity sites need to retain substantial amounts of soil organic matter (USDA-Forest Service 2005). This change in nutrient status and chemical status would be of short duration (1-3 years) as the nutrients are used by the existing vegetation, adhere to soil particles, are leached through the soil profile, or lost to transport (wind and water). Despite the combination of low fire intensity and short duration, short-term porosity of the mineral soil would decline where runoff deposits ash and other fine debris in nearby surface depressions (Ibid). Typically, prescribed fires would also increase the availability of calcium (Ca), magnesium (Mg), and potassium (K) via combustion of soil organic matter; N and phosphorus (P) are modestly decreased from volatilization. The majority of soil organic components containing these nutrients are converted into chemical forms that are either readily available to plants or soon lost through leaching. Although in acid soils (such as those found throughout the Project Area), P chemically binds to aluminum (Al), iron (Fe), and manganese (Mn) oxides (Certini 2003). Prompt re-vegetation on areas exposed to prescribed fire would minimize the leaching of N (Pritchett and Fisher 1987). If nitrogen-fixing species are a component of the vegetation re-growth, burning activities may restore the original nitrogen pool in the soil (Certini 2003).

Soil microorganisms have a strong resilience to fire and the re-colonization to pre-burn levels is common. The amount of time required for recovery to pre-burn levels would vary in proportion to the fire severity. Soil microorganisms are most vulnerable to heat damage and habitat changes in the litter and duff, so prescribed burns conducted when the upper layers of the soil are sufficiently dry to carry a surface fire, but moist enough to avoid consumption of the forest floor, humus layers, and soil humus, would ensure a functioning soil biotic community (USDA-Forest Service 2005).

Appendix A (see General Timber and Prescribed Fire) contains conservation measures to reduce the adverse effects on soil organic matter loss, compaction, and accelerated erosion from prescribed fire treatments. Therefore, the effects on the Project Area's soil resource would be local in scale and minor in severity.

<u>Herbicide Applications:</u> The herbicides identified for application in the Project Area (glyphosate, imazapyr, and triclopyr) are known to degrade within the soil profile through various photochemical, chemical, or biological (microbial metabolism) reactions. Herbicides may be immobilized by adsorption to soil particles or uptake by non-susceptible plants. These processes isolate the herbicide and prevent it from moving in the environment. Adsorption is often dependent on the soil/water pH, and generally increases with increasing soil organic content, clay content, and cation exchange capacity. Adsorption is also dependent on water solubility, with less soluble herbicides being more strongly adsorbed to soil particles. Ester formulations are generally the least water solvent, and are therefore more strongly adsorbed by soil particles. In addition, ester formulations are more volatile than salt or acid formulations,

and are therefore more easily evaporated from soil and plant surfaces or leached down into the soil (Tu, et. al. 2001).

The commercial formulation of glyphosate (including the surfactants and inert ingredients) has a benign affect on the microbial community structure when applied at the recommended field rate in forest soils having clay loam and sandy loam textures (Ratcliff, et.al. 2006). There does not appear to be any adverse effects on soil microorganisms from applications of imazapyr when used as an effective herbicide; however, it may persist in soils of arid regions, and does not bind tightly to alkaline soils with low organic matter (Syracuse Environmental Research Associates 2004a). The effects of triclopyr on soil microorganisms suggest that a transient inhibition in the growth of some bacteria or fungi could be expected. This could result in a shift in the population structure of microbial soil communities, but substantial impacts on soil (i.e., gross changes in capacity of soil to support vegetation) would not be likely (Syracuse Environmental Research Associates 2004b).

An herbicide's persistence in the soil is often described by its half-life, or the time it takes for ½ of the herbicide applied to the soil to degrade from its original chemical structure. The half-life can vary depending on soil characteristics (texture, pH), weather (temperature and soil moisture) and the existing vegetation at the application site (Ibid).

Table 3.35 illustrates the interaction that the herbicides proposed to be used have within the soil, and pertains to both Alternatives 2 and 3.

Table 3.35: Herbicide Mobility and Persistence in the Soil'

Herbicide	**Mechanisms of Degradation**	**Half-life in the Soil**	**Mobility**
Glyphosate	Degradation is primarily due to soil microbes.	Average of 47 days.	Glyphosate has an extremely high ability to bind to soil particles, preventing it from being mobile in the environment.
Imazapyr	Degraded primarily by microbial metabolism.	1 to 5 months.	Below pH 5, the adsorptive capacity of imazapyr increases and limits its movement in soil. Above pH 5, greater concentrations of imazapyr become negatively charged, fail to bind tightly with soils, and remain available for plant uptake and/or microbial breakdown.
Triclopyr	Rapidly degraded to triclopyr acid by photolysis, microbes in the soil, and hydrolysis.	30 days.	Ester formulation binds readily with the soil, giving it low mobility. The salt formulation binds only weakly in soil, giving it higher mobility (%). However, both formulations are rapidly degraded to triclopyr acid, which has an intermediate adsorption capacity, thus limiting mobility.

'*Tu et al., 2001*

These herbicides would be used for spot-treatment of small, dispersed locations of NNIS, strip treatment for seeding site-preparation, and to control the stump-sprouting of recently harvested trees. Application would occur using ground-based mechanical and hand-tools. Specific information related to the use of glyphosate, imazapyr and triclorpyr are documented in Appendix C.

Appendix A (see Herbicides) contains conservation measures to reduce the adverse effects on soil microorganisms from organic chemical applications. Therefore, the effects on the Project Area's soil resource would be local in scale and minor in severity.

(3.10d) Cumulative Effects on the Soil Resources

Alternative 1

The soil resources of the Project Area were impacted in the late 1800s and early 1900s through logging practices, the conversion of portions to agriculture and rangelands, mineral extraction, and periodic fire events. Reforestation efforts, wildlife habitat treatments, and timber harvesting operations also impacted the soils in the Project Area from 1935 to 2009. Since the early 1930s, soil productivity has generally been stabilized or improved. A constant and cycling supply of organic matter has been present throughout the Project Area through the promotion of consistent vegetative cover since the 1930s. This has allowed for the incorporation of leaf litter and the retention of dead and decaying mast. The increase and maturation of vegetative cover over this time period has been accompanied by root growth, which subsequently has increased the sequestration and cycling of nutrients. Generally, nutrients have accumulated in the humic layers or within the existing vegetation. Based on the site-specific soil characteristics, nutrients unused by the vegetation have either accumulated within the upper mineral horizons, or have leached out of the system. The overall effects of the activities that have occurred throughout the Project Area have likely led to increased levels of soil productivity as compared to the 1930s, but reduced levels when compared to the native soil environment.

Live vegetation on National Forest lands within the Project Area would be retained except in the three areas already approved for treatment activities that are on-going. Dead and down timber could be removed throughout the Project Area for use as firewood. In the three on-going treatment areas, there would be reductions in the soil organic matter as a result of red pine removal. At other treatment locations with forest types other than red pine, the treated vegetation will remain on-site or be redistributed within each area. As individual groups of trees, shrubs, and herbaceous species complete their life cycles, general levels of biomass and soil organic matter accumulation would continue to exceed removals. This would result in an overall increase in soil productivity. Timber harvesting activities would likely occur on private property within or adjacent to the Project Area into the future, and would have minimal impacts to the productivity of National Forest System lands. The short-term loss of litter fall from forested areas onto adjacent land would have minor effects to sustaining site-productivity if these private lands remained in a forested, or partially forested, condition.

Currently, areas of eroding and compacted soils occur on Forest Service and County roads and areas that have had timber harvesting activities in the recent past. The effects related to harvesting activities are most severe on the soils receiving concentrated equipment use, such as skid trails and landing sites. Variable amounts of soil compaction, rutting, puddling, and accelerated erosion would continue to occur on areas within the Project Area that are open to motor vehicle and equestrian use. The soils that were impacted by timber harvesting, mechanical tree planting, fire, log landings, and skid trails would slowly recover through natural processes. This natural rehabilitation assumes that damage caused by past management activities have not surpassed the physical thresholds of a given area, and that partial or complete vegetative cover has been maintained. The most severely affected locations, such as permanent roads and OHV use areas, would continue to be adversely effected unless maintained within designed standards, relocated, or closed and re-vegetated.

Due to the proximity of the Project Area to larger population centers (i.e. Muskegon and Grand Rapids) and the presence of the North, South, and Main Branches of the White River, the Project Area has historically served as a popular location for those that use the Forest for the recreational purposes. The effects of this use on the soils in this area have been described. It is likely that, as the surrounding private lands are further divided and the population increases, the use in this area will. The effects of this are already evident in the Otto portion of the Project Area, where there has been an increase in use as a result of the road closures that have occurred within the White River Semiprimitive Nonmotorized Area. The result has been an increase in new user-created roads and dispersed campsites. In conjunction with these, there would also likely be increases in other recreational uses (i.e. horseback riding and hiking), consumptive uses (i.e. firewood gathering and hunting), and illegal use (i.e. OHV use and trash dumping). The combination of all of these would have a qualitative cumulative impact on the soils within the Project Area.

Within the Project, the soil systems that are associated with the existing riparian areas and stream/river corridors would continue to store larger nutrient levels of carbon and nutrients than surrounding upland areas. This is due to a combination of the historical land use patterns, the existing soil characteristics, and a decreased likelihood that vegetative management activities would occur in these areas.

Conclusion: In considering the past, the present, and reasonably foreseeable future, the duration and magnitude of taking no action would incrementally add to the capability of soil(s) to produce specified plants or plant succession (soil productivity) within the Project Area, primarily by conserving soil organic matter and top-soil, and retaining continuous herbaceous and forest canopy vegetation.

Alternatives 2 and 3

Live vegetation on forested areas would be treated with a variety of management activities; dead and down timber could also be removed for use as firewood. As individual groups of trees, shrubs, and herbaceous species are felled or otherwise complete their life cycles, general levels of biomass and soil organic matter accumulation would continue to exceed removals. In areas that are harvested commercially, the accumulation rate of organic matter on the soils would be less. The retention of slash in these areas would ameliorate loses from stemwood transported off-site. The soil productivity would increase in areas not harvested. There will be fewer acres of land classified as suitable for timber management due to the reclassification of the Land Suitability Class in the areas where savanna restoration/creation is occurring. These areas would no longer be considered suited for timber production. This change would alter the sources and rates of organic matter accumulation to the soil resource by foregoing commercial harvests in some locations, and potentially increasing commercial harvests in other locations.

The savanna restoration activities would alter the soil formation processes where this treatment suite is proposed. Restored savannas would experience changes in soil chemistry and nutrient cycling different from areas continuously or intermittently in forest cover. The organic matter inputs and accumulation would be concentrated in the mineral soil horizons, instead of primarily in non-mineral soil layers. This alteration to the soil resource would be reversible if reforested again in the future.

With the closure of the Forest roads within the White River Semiprimitive Nonmotorized Area, the county road system in this area would receive more concentrated use by motor vehicles. As a result, there would be increased levels of infiltration, nutrient cycling, and site productivity in the areas closed to motor vehicles and increased levels of compaction, accelerated erosion, and road widening on the county roads remaining open.

Under Alternative 3, the road in Otto Township that would be restricted to public vehicle use would not result in a change to the established levels of adverse soil impacts. Vehicle use on other County roads in Otto and Greenwood Townships is likely to remain the same or increase over time and exacerbate existing adverse soil impacts.

Public interest in utilizing National Forest System lands for motorized-dependent recreation is likely to increase. With the limitations of this form of recreation allowable within the White River Semiprimitive Nonmotorized Area, it is likely that other portions of the Project Area will receive increased use. This would impact the soils through the increased creation and use of existing roads, dispersed camping areas, and non-designated river access sites. The on-going and upcoming restoration projects at the most heavily impacted sites throughout the Project Area, in conjunction with the implementation of the Motor Vehicle Use Map, will serve to reduce most of the soil resource damages related to the changes in recreational use patterns to localized areas of minor severity.

Conclusion: In considering the past, the present, and reasonably foreseeable future, The duration and magnitude of activities included under Alternatives 2 and 3 will incrementally add to the capability of soil(s) to produce specified plants or plant succession (soil productivity) within the Project Area, primarily by conserving soil organic matter and top-soil, retaining sufficient amounts of these elements so that existing soil productivity is sustained following intensive treatment, and by promoting/retaining continuous herbaceous and forest canopy vegetation.