

# KLAMATH RIVERKEEPER

An Affiliate of the Waterkeepers Alliance

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## Comments regarding the listing of the mid-Klamath for sediment under the state 303d list.

Many of the tributaries of the Klamath Basin are listed for sediment impairment, or are well known Areas with Watershed Concerns (AWWC's) due to sediment impacts. However the mid-Klamath between the mouth of Cottonwood Creek and the Trinity River is not yet listed for sediment, though it is warranted. The following comments detail that many of the tributaries of the Klamath are sediment impaired and that a sediment listing for the mid-Klamath is warranted.

The Trinity, and the Scott, two of the largest tributaries in the California part of the Klamath are listed and have TMDL's for sediment, the lower Klamath also has recently been listed for sediment. Beaver Creek, Horse Creek, Elk Creek, and Indian Creek in the mid-Klamath River have long documented sediment problems. There are no bigger issues for the tributary creeks, and some of the river of the mid-Klamath then sediment.

The Klamath River from Cottonwood Creek to the mouth should be listed for sediment, as this area shows very similar road and timber harvest related issues to the Scott River, have the same levels of road density and are underlain with the same decomposed granite soils and are also riddled with slides. Cottonwood, Beaver, Horse Creek, Bluff Creek and Elk Creek are of special concern to us as some of these creeks have as many as five road miles for square miles of forest. Many of these roads are located on Decomposed Granite or schist soil types that are highly erosive. Furthermore many of these creeks are of checkerboard ownership and therefore are not given time for recovery between harvest. Due to the fact the Klamath National Forest often only provided anecdotal information and not actual data in their watershed analysis, and the fact that much of the actual sediment data is only available to the Forest or through the lawsuit information sharing process, are

information is limited to the creeks where litigation has recently occurred. For this we apologize but know the agreement for these creeks will be sufficient, especially in light of all the sediment listed rivers entering the Klamath.

Beneficial uses affected by the sediment problems in the Klamath are the following; Native American cultural uses, water contact recreation, commercial and sports fishing, subsistence fishing, cold freshwater habitat, habitat for rare threatened and endangered species, migration of aquatic organisms, and spawning reproduction and early development.

Road decommissioning and limits on Timber Harvest Plans are necessary within these watersheds for them to continue to meet beneficial uses. Many of these watersheds are Coho Salmon habitat in which spawning grounds are filling in due to sediment. Due to poor road building and management nearly all years with above average winter storm many of the roads in these watershed fail on a massive level leading to serious water quality issues. Creek mouths are also washed out in these storm effects; leaving fish species unable to reach refugia areas and spawning holes due to sedimentation and above normal peak flows. The storm damage is an large yet unpermitted discharge into the waters of the United States and they affect beneficial uses in an extreme manner.

The following arguments and quotes are either from the Beaver Creek Timber Sale administrative record, the Horse Creek Watershed Analysis, the Beaver Creek Watershed Analysis, The Environmental Assessment (EA) for the Westside 11 Project, the Administrative Record for the Elk Creek Timber Sale, the Lower mid-Klamath Watershed Analysis or the ???

Basin Plan water quality objectives:

"The suspended sediment load and suspended discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses." WQCP 3-3.00.

"Turbidity shall not be increases more then 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof." WQCP 3.3.00.

Klamath National Forest quotes: Westside 11 Project EA

"Roads contribute the highest per acre sedimentation rate of all watershed disturbances, averaging 58 times background from landsliding and 290 times background from surface erosions." p2

"As the availability of road maintenance funds allocated to the Forest Service decreases, down nearly 50% in the past six years, the necessity to evaluate and implement measures which reduce the risk of road related impacts to aquatic ecosystems is greater then ever." p 4 and 5

"The Klamath National Forest road system sustained over 30 million dollars worth of damage during the "New Year's Day" flood of the winter of 1996-1997. Stream channels, riparian areas, and fish habitat were impacted by excessive scour and deposition during that storm. The impact was severe in some places."

"One section of the Environmental Protection Agency Clean Water Action Plan includes natural resource stewardship of Federal Lands. A Key Action in this Section calls for substantially increasing maintenance of forest roads and trails on Federal lands to protect water quality, to improve water quality protection on over 2,000 miles of roads per year, and to decommission 5,000 miles of road."

p 5 and 6

Road sediment Source Inventory and Risk Assessment Grider Horse and Main Stem Salmon River watersheds, Westside 11 project  
Klamath National Forest March 15th, 2002

Furthermore many of the monitoring reports for the Klamath National Forest show that the applied BMP's are not working in many situations.

"Project Design Features (PDF's) and Best Management Practices (BMP's) are intended to reduce on-site impacts, not eliminate them. As a 1998 Forest Service Study noted: "Attempts to avert cumulative impacts through the implementation of best management practices" BMPs have failed in the past in part because they did not fully reflect the possibility that significant adverse cumulative effects might accrue even from reduced levels of impact. P.22 Plaintiffs' Memo. In Supp. Of mo. For Summary judgment. Held up by the United States District court for the Eastern District of California. Attached

Beaver Creek sediment issues:

Timber harvest and road building effects to the waterways of Beaver Creek are perhaps the most intensive and within the mid-Klamath River drainage. Sediments are filling in Coho holes throughout the drainage, and it has some of the highest road densities in the Klamath National Forest. However Beaver Creek still remains a strong hold of Coho salmon despite these effects. Extra protection measures need to be taken in this watershed. The problem is so bad that a federal judge has had to stop logging of the forest in the watershed, and the Forest Service's own scientists have recommend long period of no cutting to let the watershed heal. There is currently a proposal by the Forest Service to build nine more miles of roads in this watershed. This shows that regulation of background levels and strict enforcement of the Basin Plan is necessary in this area.

"Bumble Bee and Hungry Creek sub watershed appear below threshold only when the ERA model is applied. When the

USLE and mass wasting models were applied these sub watersheds appear over threshold do to the high erodibility of soils.”

-Beaver Creek ID Team Meeting Notes 1/25/00 Page 1.

“Most of the day was spent traveling the road system in the Beaver Creek watershed. This watershed is comprised of checkerboard Forest Service/private land. There are over 900 miles of roads in what is approximately a 75,000-acre watershed, and they are stacked one above another. The watershed is bisected by the Condrey Mountain Thrust Fault, which is the boundary between the highly-erodible Condrey Mountain Schist on the west and the intermixed units of dioritic intrusive rocks, ultramafics, schists and metasediments of the Western Paleozoic and Triassic Belt to the east. **The impact on the watershed has been so great that Mr. Fox pushed for, and the Supervisor’s office agreed to, a total deferment on logging activities for the next ten years.**”

“The last stop of the day was at Hungry Creek, a tributary to Beaver Creek. This area is underlain by decomposed granite, where the sugary texture of the deeply weathered granite leads to frequent gully erosion and transport of sediment to watercourses...It appears that the Forest Service recognizes the problem of accelerated erosion on much of the land in the Oak Knoll [now the Scott River] Ranger District. **Deferral of logging in Beaver Creek**, a WIN inventory in the same watershed, a devotion of resources to MR. Fox’s shop, identification of other problem areas such as Seiad Creek Road, are all steps that they have taken. In addition, our attention to the problem will ensure an increased emphasis on repairing past damages and an avoidance of future problems. However, the magnitude of the problem means that water quality impacts will continue for the foreseeable future.

-California Regional Water Quality Control Board North Coast Region. Interoffice Memo. 31 October 1991. **See attachment #2.**

It is apparent that the Klamath National Forest estimates significantly less roads than what is acknowledged by the Regional Water Board. However even at their estimate Beaver Creek Road density is over 4 to 5 miles of road per mile of forest in Beaver Creek

“The disturbances that contribute to the majority of current accelerated erosion are roads and timber harvest. Road construction began over 100 years ago and the current

transportation system contains nearly 440 miles roads, including National Forest, cooperative and private roads. Roads can contribute to increased landsliding, especially in granitic soils. According to data from the Salmon River “(which is also not listed for sediment, but should be), “a watershed about 40 miles to the south and west of Beaver Creek, road related landslides rates range from 60-800 times greater than undisturbed rates in granitic soils (de la Fuente and Haessig 1991) In other geomorphic terrances, increase in landslide rates from 2.3 to 80 times greater with roads than in undisturbed areas.” Beaver Creek Watershed analysis page 3-3” “Roads also increase surface erosion, both on the road surface and on cut and fill slopes. Roads through granitic soil are the most susceptible to erosion although Condrey Mt. Schist also makes easily erodible road surface.”

“Preliminary surveys indicate that many culverts in Beaver Creek are undersized and may fail during large (ten year recurrence interval or greater) flood events. Notes these large events are only ten-year storm events.

Recent Watershed Improvement Needs (WIN) inventories identified several hundred projects to help decrease erosion for roads in Beaver Creek”  
Beaver Creek WA page 3-3

A sediment listing is needed to encourage road decommissioning and to make the Forest Service and private timber companies use actual data in the assessments.

**“Be careful when stating specific cumulative effects (“I expect sediment to increase” rather than “350 tons of sediment will go to the stream”). Use non-specific words (like “approximately”).**  
Beaver Creek Project IDT Meeting, April, 18, 2000

“The extensive areas in early serial stage, high elevations at the headwaters, erodable soil types and a road network of over 450 miles make Beaver Creek a high risk for cumulative watershed effects. There were 64 road-related failures in the watershed and only 28 landslides away from roads in January 1997. Road failures at higher elevations were a substantial contributor to channel scour in some tributaries. Approximately one third of the Beaver Creek channel changed as a result of the 1997 storm. Timber harvest on private land has accelerated in the Beaver Creek watershed and the USFS is also planning a timber sale in the watershed in the near future.”

Quote: The effects of the 1996-07 storms; Klamath National Forest. I could not attach the document due to the fact the forest would not give it to me.

“The addition of roads to clearcutting in small basins produced a quite different hydrological response than clearcutting alone, leading to significant increases in all sizes of peak discharges in all seasons, and especially prolonged increases in peak discharges of winter events. These results support the hypothesis that roads interact

positively with clear-cutting to modify water flow paths and speed delivery of water to channels during storm events, producing much greater changes in peak discharges than either clearcutting or roads alone.

Road interactions with clear-cuts also appeared to increase peak discharges in large basins. Despite differences in basin size, geology, and elevation, all six basins had the same rate of response to cumulative cutting. Differences in peak discharges were detectable when basins differed by only 5% in cumulative area cut. These results support the hypothesis that water balance effects diminish and flow routing changes are increasingly important as basin size increases.”

“Such changes have implications for stream geomorphology and ecology. If all peak discharges have been increased systematically, there may be more frequent inundation of the riparian zone, more rapid turnover of riparian zone vegetation, and perhaps increased transport of woody debris and sediment. “Jones and Grant

“A fisheries biologist commenting on the Beaver project noted the Beaver Creek watershed experienced major changes in the January 1997 storm, and that the entire basin is recognized in the Klamath national Forest Land Management Plan as an “Area with Watershed Concerns” (AWWC). Beaver administrative record 1865. He noted that the watershed is characterized by an extensive road network and a substantial level of prior timber harvest. The biologist noted that this places the watershed “at substantial risk of catastrophic channel change in a large storm event...The principal concern with regard to rain on snow potential is that snow builds up faster in areas that have experienced timber harvest. When rain on snow events occur, stream flows may be increased by up to 200-300%.” AR 1865-66.”

“Beaver Creek provided summer rearing refugia for many salmonids on the Klamath River system, but this function is “at risk”. AR 550. The riparian Reserves in this area are recovering for being heavily impacted by roads, mines, and logging. AR 991, 992.

Environmental baseline indicators for the seventh – and fifth-field watersheds affected by this timber sale show that watershed conditions are currently impaired and suffering from significant watershed effects.

Fish habitat conditions in the Beaver Creek 5<sup>th</sup>-field watershed are “not properly functioning” for substrate, pool frequency, pool quality, and large woody debris. AR 443. Hydrology and watershed conditions are “not properly functioning” for peak/base flow, drainage network and road density. “

All above quotes Taken from the Beaver Creek Timber Sale Administrative record. P 12 Plaintiffs’ Memo In Supp. Of mo. For Summary judgment. Held up by the Eastern District of California Attached

“Hungry and Bublebee/Deer subwatersheds (both to be logged in this project) have high rates of predicted sediment delivery (488% of the assumed “background” levels for Hungry and 282% for Bumblebee) AR 993. The principal reason for these risks is high road density on sensitive landforms. The Forest Service states that values about 200% indicate at-risk conditions. These two subwatersheds also have elevated erosion rates, exceeding background eleven-fold in Hungry Creek and nearly thirteen-fold in Bumblebee. See AR 1058. The forest considers models above 800% are indicative of at-risk conditions. AR 993”

“Hungry Creek is an “Area with watershed concerns”(AWWC), and is already a major contributor of sediment to the Beaver Creek Watershed. AR 443, 549. Hungry Creek is rated as having high channel sensitivity because of roads adjacent to stream and unstable banks: and the creek and its floodplain have experienced debris slides. AR 992. In addition mining activity in North Fork Hungry Creek alerted the stream channel and increased sediment” AR 992.

All above quotes Taken from the Beaver Creek Timber Sale Administrative record. P 12 Plaintiffs’ Memo. In Supp. Of mo. For Summary judgment. Held up by the Eastern District of California Attached

In 1991 the California Regional Water Quality Board visited the Beaver Creek watershed and made the following comments:

“[T]he Beaver Creek watershed...is comprised of checkerboard Forest Service/private land. There are over 900 miles of roads in what is approximately a 75,000-acre watershed, and they are stacked one above the other...The impact on the watershed has been so great that Mr. Fox pushed for, and the Supervisors office agreed to, a total deferment on logging activities for the next ten years.

..[Hungry Creek] is underlain by decomposed granite, which the sugary texture of the deeply weathered granite leads to frequent gully erosion and transport of sediment to watercourses.... IT appears that the Forest Service recognizes the problem of accelerated erosion on much of the land in the Oak Knoll [now the Scott River] Ranger District. Deferral of logging in Beaver Creek,...identification of other problem areas such as Seiad Creek Road, are all steps they have taken. In addition, our attention to the problem will ensure an increased emphasis on repairing past damages and an avoidance of future problems. However, the magnitude of the problem means that water quality impacts will continue for the foreseeable future.”

Regional Board memo Oct. 31, 1991

Due to the lack of information on the following tributaries most of the following quotes are from a section of the report of the 1996-1997 storms found on the Internet. The full report is not available on the Internet, nor did the Klamath National Forest provide it. Therefore it is not attached.

Horse Creek issues:

“Active landslides are scattered throughout the watershed and range in size from a few hundred square feet to several acres” Horse Creek Watershed Analysis (WA)

“In the Horse Creek watershed analysis area these AWWC’s (Areas with watershed concerns) include all of Middle, Buckhorn, Kahl/Dona, Doggett, and Quigley watershed areas. In addition, the Lower Horse watershed from the mouth of Middle Creek to Seiad Low Gap, and portion of the Collins/Lime watershed area, north of the Klamath River are considered AWWC’s”

“AWWC’s represent drainages where cumulative watershed effects (CWE) are a special concern due to a combination of high disturbance levels (roads, harvest, fire, etc), potential for landsliding, surface erosion, and degraded aquatic conditions” Horse Creek WA

Please see page 3-6 the tables 3-6. Universal Soil Loss Equation (USLE) Index Sources and Table 3-7 Mass Wasting Index Sources from the Attached Current Conditions Section of the Horse Creek WA.

These tables show that roads sediment are up to 1304.39 or 619% background for soil loss. 200% is considered an issue by the Klamath. These charts also show creeks at 200% background for mass wasting.

“Pure cool water from tributaries is important, and may be critical, in maintaining water quality in the Klamath River and providing thermal refugia for fish” Horse Creek WA 3-9 Quote is related to importance of tributaries to fish due to the poor water quality from the Upper Basin and Scott and Shasta Rivers.

“The overall average density for the analysis area is 4.2 mi/mi, with 53% of the area having over 4mi/mi”. Page 3-26 Horse Creek WA  
Please also see table 5-6 Universal Soil Loss Equation Index scores, which shows scores of 1051% Background.

“The primary management related component of episodic sediment originates from road associated landslides, road-associated fill and cut failures, and road/stream crossing failures. According to “The Flood of 1997: Klamath National Forest” (de la Fuite et al. 1998), 83% of flood damage sites resulting from the January, 1997 floods were the result of these three sources of episodic sediment. See table 5-7 for the mass wasting indices for each sub-watershed. Horse Creek WA 5-5

“Many of the roads were built to highway standard that did not allow water to disperse off the road surface” Page 5-4 Horse Creek WA  
Please see table 5-3 in Chapter 5 where the chart shows several roads with more than 5 miles of road per mile of forest.

“This watershed had been identified as being over cumulative effects thresholds by the USFS (Larsen, 1976) with regard to a rain-on-snow event. Larsen (1976) suggested that increased risk of peak flows warranted a cessation of timber harvest for 11 years.

Fox also noted that the watershed has an extremely high number of roads and that geology in the basin was inherently unstable with both decomposed granitic and schist formations.”

Fox also noted that the watershed has an extremely high number of roads and that geology in the basin is highly erosive.

“On Salt Gulch, a tributary to Horse Creek, we visited the site of another, much larger debris flow. A Forest Service road crossing, which for some reason was built far from the natural slope and with high fill, resulted in a very large catchment area. This basin succeeded in catching thousands of cubic yards of debris transported as a flow in response to a heavy thunderstorm last July. It filled the entire basin, resulting in some water overtopping the road and eroding the traveled way and fill slope....Downstream

they constructed an off-channel settling basin, resulting in deposition of over ten feet of silt and sediment. This event very likely contributed a significant amount of turbidity to the Klamath”

California Regional Water Quality Control Board North Coast Region Interoffice memorandum Oct 31, 1991 )attached

Walker Creek:

“The Walker Creek drainage likely had extremely high rainfall intensity, similar to Grider Creek, but it also had a much more extensive road network.”

“The Flood of 1997: Klamath National Forest” (de la Fuede et al. 1998)

Cottonwood Creek:

“The Cottonwood Creek watershed includes a substantial amount of decomposed granitic terrain that can contribute fine sediment to the stream. A major impoundment and irrigation cause the stream to go dry in some reaches during summer as inherently unstable with both decomposed granitic and schist formations.”

“The Flood of 1997: Klamath National Forest” (de la Fuede et al. 1998)

Elk Creek:

The NW ROD, the project-specific CRWQCB letter of 2/11/03, and the Elk Creek Ecosystem analysis all indicate that road densities should be reduced in this Key Watershed which includes 7<sup>th</sup> field watersheds that are designated as “Areas With Watershed Concerns.” Rather than heed the advice and management direction contained in these documents, the KNF insists on building “temporary” logging roads that will have both short and long-term impacts on soil and hydrological resources.

Page 126 of the EA Orleans Transportation EA acknowledges that:

“If insufficient funds are available to maintain roads or decommission roads, it is likely that during large storm events, the intent of the Clean Water Act will not be met if/when roads fail due to lack of maintenance.”

The Lower Mid-Klamath

“The Klamath Basin Assessment (USFS 1997). Completed by the Klamath, Six Rivers, and Shasta-Trinity National Forest in 1996, notes that the geological terrains and geomorphic types that occur downstream of Happy Camp are especially susceptible to sediment delivery from mass wasting and accelerated erosion.... Their capacity to generate sediment can be and often has been exacerbated by human disturbance of these lands”

“When the storms occurred, slopes that had been clear-cut or on which roads had been constructed were more susceptible to mass wasting processes than other undisturbed slopes” (both above excerpts are from the Lower-Middle Klamath Watershed Analysis most of the quotes above that are flow studies of the 97 storms)

### **Slate Creek**

“ For example 34 miles of roads were surveyed in the Slate Creek watershed. Some of these were mid-slope maintenance level 1 or 2 roads and others have saturated fills, showing signs of incipient failure. The level of acceptable risk in this watershed is lower and restoration priority is higher because of existing downstream Coho salmon habitat”

### **Page four of the Orleans Roads Analysis indicates:**

“The road system on [the] Orleans District has substantial levels of maintenance backlog. The maintenance Levels 1 and 2 roads have an estimated \$450,000 in deferred maintenance. The majority of the backlog of maintenance work within the District is associated with maintenance Level 3, 4, and 5 roads and estimated at \$9.2 million... The disparity between the amount of maintenance funds needed for the current road system and the amount available is expected to continue.” included an attachment containing a peer-reviewed article by Trombulack and Frissell detailing some of the negative impacts of road density and use on Terrestrial and Aquatic ecosystems.

Roads are a widespread and increasing feature of most landscapes. We reviewed the scientific literature on the ecological effects of roads and found support for the general conclusion that they are associated with negative effects on biotic integrity in both terrestrial and aquatic ecosystems. Roads of all kinds have seven general effects: mortality from road construction, mortality from collision with vehicles, modification of animal behavior, alteration of the physical environment, alteration of the chemical environment, spread of exotics, and increased use of areas by humans. Road construction kills sessile and slow-moving organisms, injures organisms adjacent to a road, and alters physical conditions beneath a road. Vehicle collisions affect the demography of many species, both vertebrates and invertebrates; mitigation measures to reduce roadkill have been only partly successful. Roads alter animal behavior by causing changes in home ranges, movement, reproductive success, escape response, and physiological state. Roads change soil density, temperature, soil water content, light levels, dust, surface waters, patterns of runoff, and sedimentation, as well as adding heavy metals (especially lead), salts, organic molecules, ozone, and nutrients to roadside environments. Roads promote the dispersal of exotic species by altering habitats, stressing native species, and providing movement corridors. Roads also promote increased hunting, fishing, passive harassment of animals, and landscape modifications. Not all species and ecosystems are equally affected by roads, but overall the presence of roads is highly correlated with changes in species composition, population sizes, and hydrologic and geomorphic processes that shape aquatic and riparian systems. More experimental research is needed to complement post-hoc

correlative studies. Our review underscores the importance to conservation of avoiding construction of new roads in roadless or sparsely roaded areas and of removal or restoration of existing roads to benefit both terrestrial and aquatic biota.

“Roads represent considerable long-term liabilities with respect to risk to water quality, particularly given the present trend in declining road maintenance funding.”

-Orleans Transportation EA page 19.

“Roads are still the leading source of management-related sediment impacts, predominately associated with mass wasting features such as shallow debris slides and debris torrents.”

-Orleans Transportation EA page 19.

**During winter storms sediment delivery from roads are the biggest sources of pollution in the Klamath River**

“In the 1970’s and 1980’s, road building and commercial timber harvest caused a noticeable increase in suspended sediment transport during period of intense precipitation (a few episodes per year).”

-Elk Thin EA page 21.

**Klamath Basin Public and private lands roads, timber harvest effects to sediment**  
Consideration of water quality for fisheries habitat is no larger possible without equal consideration of the quality of fish habitat is no longer possible”

“Poor road design, location, construction, lack of maintenance, disposal techniques, and improperly places or inadequately sized culverts can cause mass soil movement, surface erosion, gullies, stream bank erosion, and blockage of upstream and downstream migration of fish, all of which may impact at-risk fish species and their habitat”

“Many smaller tributaries enter the main stem Klamath between Iron Gate Dam and Orleans. These creeks largely drain mountainous watersheds dominated by forest. Most creeks are affected to some degree by logging, mining, grazing, and agriculture... Water Quality has not been extensively studied, but these tributaries many be particularly important in providing cold-water habitat for salmonoids.”

**Grazing impacts to Sediment**

**Impacts of Non-Contained Grazing**

Wherever livestock grazing occurs in western North America, it poses a potential threat to the integrity of salmonoid habitats. On uplands, soil is compacted and the vegetative composition is changed, increasing runoff and erosion. Closer to the stream, stream bank vegetation and stability decline when livestock concentrate near water. The combination of upland erosion, loss of riparian canopies, and breakdown of streambanks lowers local water tables and causes streams to become wider but more shallow, warmer in summer but colder in winter, and poorer in instream structure but richer in nutrients and bacterial

populations. All these effects can adversely influence salmonoid populations (Meehan 1991).

Grazing effects compacts soils, eliminates vegetation, disrupts hydrology through changes to channel incision and overland flow, and increases bank erosion through livestock-initiated bank sloughing (Kauffman et al. 1983; MacDonald et al. 1991; Parsons 1965; Platts 1981a, 1981b; Rhodes et al. 1994),

Livestock grazing may initiate instability within a stream system, and/or can amplify natural instability. Overgrazing by livestock can lead to a reduction of soil structure, soil compaction, and damage or loss of vegetative cover (Lee et al 1997).

Loss of soil structure, soil compaction, and damage or loss of vegetative cover contributes to an increase in the rate and erosive force of surface runoff (Meehan and Platts 1978; Thurow 1991). The concomitant increase in soil erosion leads to a loss of stored nutrients in the soil and a decrease in the level of vegetative productivity (Thurow 1991).

Thank you for your time and effort on this process.

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