

Environmental impacts of ORVs on the Rubicon Trail



Compiled by Chris Kassar, Center for Biological Diversity

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Photo: Little Rubicon Crossing. All Photos taken by Monte Hendricks.

Introduction

There are a multitude of scientific studies that provide sufficient evidence and support for carefully controlled and managed off-road vehicle use on public lands. These studies illustrate the demonstrated, detrimental and interconnected effects of off-road vehicles on wildlife, habitat, vegetation, soil, air, water and other users. The following is an overview of some of the major impacts to species and habitat that are most important to understand when discussing the situation on Rubicon Trail in order to fully grasp the urgent need to rein in abuse on the trail.



Photo 1. County's Rubicon Trail map. Note that the locations of the outflow from Spider and the wet crossing before Buck are on private land.

1. Riparian Zones, Meadows and Wetlands and Associated Wildlife and Plants

Sachet (1988) identified “sensitive” habitats where backcountry recreation is a concern due to 1) the ecological uniqueness of the habitat, 2) the essential habitat it provides for a key species and 3) the potential extreme sensitivity of the habitat to recreation. Two of these “sensitive” habitats are riparian zones and meadows (Sachet, 1988). The severity and extent of off-road vehicle damage can be greater in areas of uncommon habitat. Many species are dependent on riparian zones for their survival. Thus, due to a paucity of these habitats in certain areas in

California, as well as their fragility and importance, damage inflicted by ORVs can have extremely detrimental, expansive and persistent effects on riparian zones and meadows and the creatures that depend on these ecosystems.

Riparian habitat areas or corridors include the vegetated areas along streams, rivers or lakes. Research shows that riparian ecosystems, as well as meadows and wetlands are vital to the health of aquatic and terrestrial ecosystems because they filter out pollutants from land runoff, prevent erosion, and provide shelter and food for many aquatic and terrestrial animals (United States Department of Agriculture, 2002; Sanders and Flett, 1989). These areas are, however, sparse in certain areas (i.e., desert ecosystems in California) and fragile to disturbance from motorized recreation.

Riparian zones attract wildlife because they provide food and water, breeding and rearing areas, and hiding and resting opportunities. Riparian areas do not only provide direct sources of food to animals; they also support the needs of aquatic insects, a key food source for fish, and also provide an area for the growth of a prey base that will feed hawks, eagles, owls, falcons, bears and wolves (Brown, 1985). Riparian areas are ideal for breeding and rearing because of the diversity of resources they provide, including food, water and cover for newly born fawns and calves. In addition to providing nesting sites for raptors and their prey, riparian zones and associated vegetation help maintain the quality of spawning grounds for fish. Riparian areas are often used as corridors for movement because they provide cover and resources while connecting areas of critical habitat (i.e. deer often migrate through riparian cover to get from higher elevation areas in the summer to lower elevation areas in the winter).

Meadows are also extremely important to wildlife because they provide habitat for foraging and other necessary activities; meadow edges often have extremely high species diversity and richness. Deer and elk come to meadows to find nutritious vegetation that is not available in coniferous forests and may also use these areas for rutting and mating. Bear also rely on meadows for food and even sheep will forage in meadows that are associated with rocky terrain and cliffs.

There are countless television and magazine advertisements depicting a motorcycle, ATV or full-size vehicle crashing through a stream, driving up and along a river bank or racing across a muddy, wet meadow. Portrayals that glorify this type of behavior are misleading and only serve to perpetuate this type of action. In actuality, the operation of vehicles in streams and pools has the potential to destroy riparian vegetation and habitat for a range of animals, including invertebrates, fish, amphibians, reptiles, mammals and birds (Manning, 1979; Bury, 1980). ORV use often causes damage to streambanks that leads to increased erosion and sedimentation in streams and rivers. Studies have found that ORV use in wetlands, meadows, bogs and swamps can create ruts which ultimately alter hydrological patterns as they change the path of water (Heede,

1983; Lodge 1994; Duever et al. 1981; Duever et al. 1986). These impacts can alter entire ecosystem processes, affecting the ecology of an entire area. DeMayndier and Hunter (1995) cite studies regarding the importance of riparian zones and streams to amphibians. They argue that impacts to “streamside vegetation and soils may have important effects on both stream-dwelling and upland streamside amphibian fauna (DeMayndier and Hunter, 1995).” For example, as we see on the Rubicon trail mismanagement or abuse of a trail leads to increased erosion and associated increased sedimentation that degrades the quality of habitat for larval and adult animals; this has been shown to lead to decreased amphibian diversity and abundance (Swanson et al., 1990).



Photo 2. Near wet crossing before Buck Island Lake (at ~ 39 degrees 00.872' N and 120 degrees 16.009' W - all coordinates are WGS84 datum). This is an ephemeral stream that flows down the granite east and down into the Little Rubicon.

There is evidence that ORV use in riparian areas can negatively affect birds that depend on this habitat (Sanders and Flett, 1989). Damage to riparian plant communities by ORV use has also had an impact on the ranges and distribution of other western subspecies (Wildlands CPR, 1999). Weinstein (1978) found that off-road vehicles changed the behavior of birds in riparian areas by causing them to move away from certain critical areas, to be flushed more readily and to alter their use of habitat (Weinstein, 1978). In a study in Northeastern California, Barton and Holmes (2007) found that off-road vehicles had negative impacts on nesting success and the abundance of breeding birds. They found that “areas within 100m of OHV trails may provide reduced-quality habitat to nesting songbirds, particularly for species that suffer significant losses of annual fecundity due to abandonment or desertion of individual breeding attempts

(Barton and Holmes, 2007).” As a result, they suggested that managers limit ORV trails in breeding areas of rare or endangered birds (Barton and Holmes, 2007)

Off-road vehicles also directly affect birds by damaging riparian habitat, water caches and vital cover for wildlife. For example, wetlands and riparian habitats provide necessary resting areas, food, and water to resident and migratory birds (Sanders and Flett, 1989). Because off-road vehicles have eased human access to stopover sites used by migrating birds, these critical areas are being destroyed by pollution and direct damage to plants as a result of crushing and cutting for firewood (Bury 1980). In addition, if the passage of off-road vehicles through riparian habitat does not directly destroy the area, it may still disrupt and restrict wildlife use. Sheridan (1979) warns that “...Any rare species inhabiting such uncommon ecosystems may be in danger of local or total extinction as a result of ORV use.

ORVs have increased the accessibility of remote areas, thus, creating the potential for damage in places that were previously protected. For example, when campsites in riparian areas are created and become established, riparian vegetation is often cut for fuel, erosion of heavily used areas occurs and litter and water pollution become common (Bury, 1980). This is very evident on the Rubicon Trail. In addition, when riparian areas are used by ORVs, there is also a good chance for gas and oil pollution from leaks and spills, as is evidenced by the need for the CAO issued by the Regional Board.

In 1999, Wildlands CPR released a document petitioning for a change in regulations regarding off-road vehicles on national forests. This petition identified riparian zones as a habitat requiring special attention because in many instances, the government has failed to meet its own legal obligation to protect riparian areas where “no management practices causing detrimental changes in water temperature or chemical composition, blockages of water courses, or deposits of sediments shall be permitted ... which seriously and adversely affect water conditions or fish habitat (36 C.F.R. §219.28(e)).”

The most valuable management strategies will prevent damage by avoiding the creation of recreation opportunities in riparian zones and will mitigate damage by closing critical riparian, wetland and meadow areas like those found on the Rubicon trail to use.



Photo 3. Outflow from Spider Lake (39 degrees 01.080' N and 120 degrees 16.182' W.) This drops into an alpine pond in the flat where the Rubicon Trail crosses. This ephemeral stream also flows east and down into the Little Rubicon.

2. Species Affected by ORV use on the Rubicon Trail

In the above discussion of riparian habitat it is clear that the use of ORVs in riparian areas can have impacts on many species ranging from birds to amphibians to plants. The Draft Environmental Impact Report: Rubicon Master Trail Plan (DEIR) supports this fact stating that high mountain lakes and streams in the project area provide: *“important habitat and sustenance for plants and wildlife...Amphibians, insects, and small invertebrates such as fresh-water shrimp (Syncaris pacifica) dominated these high-elevation aquatic ecosystems....In addition to aquatic species, large and small terrestrial mammals and avian species depend on these resources for forage, cover, nursery and nesting habitat, and migration corridors (ESP, 2007).”*

Clearly, a complete discussion of the impacts of the Rubicon trail must include the way in which a range of species – from amphibians to birds to plants – are affected by ORV use.

Herpetiles (Amphibians and Reptiles)

Herpetofauna are very important players in the food web because as a group, they are more abundant, they make-up more biomass and they contribute more

significantly to the transfer of energy along the food web than mammals and birds. These creatures have an impact on communities at each stage of their development; amphibian larvae structure aquatic communities, lizards and metamorphosing amphibians provide a link between aquatic and terrestrial food webs and adults play a key role in maintaining the efficiency of terrestrial food webs. Because of these important roles and the fact that amphibians, and some reptiles, serve as indicators of the health of our environment, the impacts of routes and trails and off-road vehicle activity on herpetiles should be a management concern (Welsh and Ollivier, 1998). Those found in the Rubicon trail area include frogs (*Rana* spp.), alligator lizard (*Gerrhonotus multicarrinatus*), garter snake (*Thamnophis sirtalis*) and western rattlesnake (*Crotalus viridis*).

Off-road vehicle use can lead to the death of reptiles and amphibians due to direct kills, however, the elimination and degradation of vegetation and critical habitat by ORVs has a larger, long-term impact on these animals.

In addition to loss of vegetation and destruction of habitat, road traffic and the use of off-road vehicles can cause increased sedimentation and chemical contamination (as outlined in the CAO issued by the Regional Board) that can be detrimental to adjacent aquatic systems; large amounts of sediment can prove detrimental and even lethal to amphibians. Welsh and Olliver (1998) found a lower density of Tailed frogs (*Ascaphus truei*, a Species of Special Concern in California), Pacific giant salamanders (*Dicamptodon tenebrosus*) and southern torrent salamanders (*Rhyacotriton variegatus*, a Species of Special Concern in California) in streams adjacent to road construction in Redwood National Park. Contaminated sediment and runoff from roads or campgrounds can also negatively affect amphibians and should be considered in management of places like the Rubicon trail where similar species exist.

Routes, trails and the use of off-road vehicles can create barriers to necessary movement (i.e., movement for migration, breeding, foraging). Studies have found a higher proportion of dead frogs and toads on routes with higher traffic volumes. Although this may result from higher direct mortality, it may also occur because traffic changes movement patterns and interrupts anuran behavior (Fahrig et al. 1995).

In a literature review discussing the impacts of forest management practices on amphibians in North America, deMayndier and Hunter (1995), contend that the forest roads can lead to long-term changes in habitat because routes increase fragmentation and decrease the permeability of the landscape. Marcot et al. (1997) also reports that roads can fragment some reptile habitats. Routes and trails that serve as barriers to amphibian and reptile movements can cause populations to become isolated and therefore, more susceptible to detrimental genetic and environmental consequences. Barriers also cause difficulties for herpetiles populations that migrate between aquatic breeding ranges and upland

home ranges and may prevent populations from successfully breeding (i.e., Red-legged frog, *Rana aurora*, California Species of Special Concern, Federally Threatened).

Herpetiles are susceptible to direct mortality from off-road vehicle use, especially during dispersal and migration; however, they are more greatly affected by the associated loss of vegetation that causes the degradation of critical habitat. Marcot et al. (1997) state that “off-road vehicle use has become a major threat to reptiles” while various studies suggest that ORVs are also a threat to amphibians (DeMaynadier and Hunter, 1995; Maxell and Hokit, 1999). Managers should be concerned about “the potential impacts of secondary roads on sensitive species and should construct fewer and narrower roads with little or no verge clearance (DeMaynadier and Hunter, 2000).” Maxell and Hokit (1999) recommend that roads and trails avoid water bodies, wetlands and areas that are key habitat for amphibians and reptiles.

Birds

Riparian areas and associated species are, however, not the only ones affected by the Rubicon trail. Many birds that depend on conifer trees for their homes live in the forested lands along the Rubicon trail. These include cavity nesters such as the yellow-bellied sapsucker (*Sphyrapicus varius*), pileated woodpecker (*Dryocopus pileatus*), white-headed woodpecker (*Picoides albolarvatus*), hairy woodpecker (*Picoides villosus*), and northern flicker (*Colaptes auratus*). Other bird species observed within the project area include red-breasted merganser (*Mergus serrator*), mountain quail (*Oreortyx pictus*), Steller’s jay (*Cyanocitta stelleri*), mountain bluebird (*Sialia currucoides*), warblers (*Dendroica* spp.), and mountain chickadee (*Parus gambeli*).

The fact that these animals depend on habitat along the Rubicon trail is important b/c of what Bury (1980) concludes from previous studies, “Birds apparently are the vertebrates most sensitive to ORV influence.” Compared to areas subject to ORV use, he found 1.5 times the number of birds and twice the biomass and species of birds in control plots (Bury et al., 1977). A further analysis of the impact of ORVs on birds found that birds are susceptible to direct and indirect effects of off-road vehicles. By destroying nests, crushing individuals, harassing individuals and creating noise, off-road vehicles can directly impact birds (Luckenbach, 1978). Indirectly, off-road vehicle use can alter habitat and decrease the amount of shelter and forage available (Luckenbach, 1978; Severinghaus, 1982). ORVs can also effect the breeding success of birds. It is estimated that roads and motorized trails can influence the reproduction of forest birds located up to 200 meters from a trail (Foppen and Reijnen, 1994).

Mammals

The DEIR states that mammal species found on the Rubicon Trail include the striped skunk (*Mephitis mephitis*), chipmunk (*Tamias* spp.), western gray squirrel (*Sciurus griseus*), yellow-bellied marmot (*Marmota flaviventris*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and mule deer (*Odocoileus hemionus*). It also states that black bear (*Ursus americanus*) and other large mammals, including mountain lion (*Felis concolor*), range throughout the project area.

Studies have been done showing that small mammals are also prone to effects of off-road vehicle use; they are subject to direct mortality, disturbance and habitat loss and fragmentation as a result of ORV use and the creation of routes and trails. Small mammal distribution, abundance, behavior and movements are highly influenced by the volume of vegetation present because this represents the amount of food available in a certain area. Off-road vehicles easily damage vegetation quickly destroying critical food sources and habitat for small mammals. The destruction and conversion of habitat (i.e., the poor cover on forest roads) leaves small mammals vulnerable to predation because even routes that are small and of low use may act as barriers and may inhibit movement (Merriam et al, 1989; Burnett, 1992).

In addition to effects on habitat, ORVs also impact the abundance of small mammals by directly killing or crushing individuals or trapping one in a collapsed burrow (Luckenbach and Bury 1983).

Unlike small mammals, carnivores are not under stress from predators (except humans). They are still sensitive to disturbance from recreationists and are directly affected by the damage that ORVs do to the soil, air, water, and other animals. Carnivores will suffer if these resources are degraded because they, and their prey animals, are dependent on all of them for survival. Carnivorous creatures, such as the black bear and the mountain lion need large amounts of space within which to live, hunt, mate and breed. Thus, they are extremely vulnerable to the impacts of habitat fragmentation and loss of connectivity due to roads, trails and off-road vehicle activity. The creation and use of routes and trails, as well as cross country travel by motorized vehicles (which is prevalent along the Rubicon trail) is influential in the distribution and abundance of many carnivores (McReynolds and Radtke, 1978; Claar et al., 1999). In addition, the increased access provided by off-road vehicles and associated trails can be detrimental to the survival of carnivores because it may allow for over hunting or over trapping and illegal poaching, as well as for harassment of individuals.



Photo 4. Outflow from Buck Island Lake found below the Little Rubicon crossing (39 degrees 00.338' N and 120 degrees 15.377' W).

Special Status Species

The Initial Study done in March 2006 by Eldorado County to determine if an EIR was needed for the Rubicon Trail Master Plan concluded that there were *potentially significant impacts to species and habitat associated with continued ORV use along the Rubicon Trail*. This study and the DEIR conclude that there are also sensitive animal and plant species that occur in the area that may be affected by ORV use on the Rubicon trail stating: “vehicle operations outside of the primary route result in substantial increased potential for species or habitat disturbance. The illegal creation of bypasses or variants has the potential to modify habitat and adversely affect candidate, sensitive, and/or special status species as recognized by the U.S. Fish and Wildlife Service and the California Department of Fish and Game (CDFG).”

The following is a brief discussion of the potential impacts to some species based on the information available (See Attached Table 3-8.1 and 3-8.2 for the list of

sensitive species from the DEIR and the attached list showing the species found on the Homewood Quad from a search of the CNDDDB.)

ORV use has the potential to directly or indirectly affect special-status plant species or other sensitive natural communities.

Several sensitive plant species have the potential to exist in the Rubicon Trail vicinity. The DEIR states that the area supports potential habitat for Stebbin's phacelia and shore sedge and limited or marginal habitat for northern adder's-tongue and marsh skullcap. This may not be a comprehensive list due to the fact that the DEIR focused only on the El Dorado County portion of the Rubicon trail. The DEIR states that the primary threat is not ORV operation along the trail, but the proliferation of off-trail travel that will result in substantial increased potential damage to species or habitat, including sensitive, candidate or special-status species.

ORV use on the Rubicon Trail has the potential to directly or indirectly affect mountain yellow-legged frog.

Mountain yellow-legged frog (MYLF; *Rana muscosa*) occurs in streams, lakes, and ponds, in montane riparian, lodgepole pine, subalpine conifer, and wet meadow habitat types at elevations above 6,000 feet. MYLF prefers habitat with rocks and vegetation at the shallow perimeter. They typically crouch on rocks or in vegetation within 30 feet of the aquatic habitat and takes refuge in vegetation, under rocks, or at the bottom of ponds. MYLF adults hibernate beneath ice covered streams, lakes, and ponds during the winter months. Reproduction takes place after mountain lakes and streams are free of ice when MYLF eggs are laid in shallow water attached to gravel or rocks..

The DEIR identifies the fact that ORV use on the trail has the potential to significantly affect the mountain yellow legged frog (*Rana muscosa*).The DEIR also states that “potentially suitable habitat was observed along the Rubicon Trail for the mountain yellow-legged frog (MYLF) and this species was also reported in the California Natural Diversity Database (CNDDDB) with recorded occurrences within the vicinity of the Rubicon Trail (ESP, 2007 at 3.8-7).” In the absence of a clear and enforceable management plan, the MYLF is at risk if ORV use is allowed to continue unchecked.

ORV use on the Rubicon Trail has the potential to directly or indirectly affect Yosemite toad.

The Yosemite toad (*Bufo canorus*) occurs in wet meadows and seasonal ponds in the central high Sierra Nevada Range at elevations between 6,400 and 11,300 feet. They typically prefer quiet pools in alpine meadows and seek cover inside abandoned rodent burrows or adjacent forested areas. They typically remain near water where they retreat if threatened. The DEIR considers the impact on the

Yosemite toad, but dismisses it as less than significant saying that because the Rubicon Trail is generally beyond the northern extent of the range for Yosemite toad, it is unlikely that use on the Rubicon would impact it. This is, however, based on the fact that no individuals were found in surveys and is therefore inconclusive.

ORV use on the Rubicon Trail has the potential to directly or indirectly affect the Marten, Fisher, and Wolverine

The DEIR identifies all 3 of these species of federal concern as those that occur in the vicinity of the Rubicon Trail. The primary factors influencing this group are direct mortality from trapping, habitat alteration (largely as a result of logging and development) and disturbance responses. Because of their life history and behavior, all 3 of these animals are commonly caught and over harvested (Powell, 1979; Thompson, 1994; Witmer et al. 1998). Recreational trails and roads increase access for humans, thereby increasing the susceptibility of forest carnivores to trapping (Hodgman et al., 1994; Witmer et al., 1998; Claar et al., 1999). In addition, animals crossing trails or wide open areas where ORVs travel can lead to direct mortality. The combination of over harvesting and road kill can be even more significant in small populations found in fragmented habitat because movement and dispersal is limited.

Animals respond physiologically to disturbance (MacArthur et al., 1982; Yarmoloy et al., 1988; Gutzwiller, 1995). These responses can include change in heart rate, body temperature, respiration rate, etc. Claar et al. (1998) state that it is likely that human disturbance, including off-road vehicle use, evokes similar responses and an expenditure of energy in martens, fishers and wolverines. Forest carnivores are especially vulnerable to disturbance caused by recreational activities because they need large home ranges, have specific habitat requirements and have a low reproductive potential. Thus, the preservation of areas of undisturbed habitat without roads, off-road vehicle use, hunting or trapping is necessary for the persistence of forest carnivore populations, especially those who are, like the pacific fisher who are facing increased pressure and who need further protections (hence its status as a candidate for listing).

3. Extent of Impacts

We contend that it is not biologically sound to evaluate impacts to resources, such as riparian vegetation and wildlife habitat on a restrictive, area- specific basis. We present the following information based on peer-reviewed scientific research to support the idea that the effects of motorized trails, like the Rubicon, extend well beyond the actual area that they occupy on the ground. Based on the following scientific concepts: the virtual footprint, indirect effects, road effect zone and road avoidance zone, it can be argued that the Rubicon trail has the potential for

much more significant impact on the environment than just those impacts associated with the length and width of the trail.

A true assessment of environmental impacts would reference and apply the myriad scientific literature that exists regarding road ecology and cumulative environmental impacts. A scientifically valid and ecologically representative analysis of the Rubicon Trail must consider all of the cumulative impacts of the route at a broader scale to accurately determine the true effects of the route within the broader context of the landscape.

Virtual Footprint

Forman et al. (2003) state all roads not only have a physical footprint, but also a “virtual footprint” surrounding their actual location. This virtual footprint includes the “accumulated effect over time and space of all of the activities that roads induce or allow, as well as all of the ecological effects of those activities (Forman et al. 2003).” For example, the United States has 6.4 million km of public roads that are used by over 200 million vehicles (FHWA, 2003). Road corridors cover approximately 1% of the United States; however, the ecological impacts of these roads are not restricted to this area alone. It is estimated that 19% of the land surface in the U.S. is directly affected by roads, while in total, 22% of the U.S. may be ecologically altered by the road network (Forman 2000). This concept extends to forest roads, as they have been shown to cause fragmentation, habitat loss, damage to riparian ecosystems and soil degradation well beyond their actual footprint (Gucinski et al., 2000).

Because a larger virtual ecological footprint is associated with the physical footprint of roads, “road planners//builders and environmentalists need to be concerned with the broad landscape rather than the one-dimensional road corridor (Forman et al. 2003).” The environmental evaluations completed for the Rubicon (i.e. in the Draft Environmental Impact Report) largely focus on the one-dimensional road corridor, thus they are not complete and/or accurate in their evaluation of the actual ecological impacts made by the virtual footprint.

Indirect and direct effects

Many scientists suggest that motorized recreation is the greatest threat to wildlife on our public lands because it can alter habitat, cause disturbance and lead to the direct death of animals (Luckenbach, 1975, 1978; Bury and Luckenbach, 1983, 2002; Sheridan, 1979; Berry, 1980; Brattstrom and Bondello, 1983; Boyle & Samson, 1985; Havlick, 1999; Joslin and Youmans, 1999; Lovich and Bainbridge, 1999; Lawler, 2000; Belnap, 2003).

Lovich and Bainbridge (1999) acknowledge the significance of direct mortality but argue that the more detrimental repercussions of linear recreation corridors

include habitat fragmentation, restriction of wildlife movements and gene flow, and increased human access to remote areas. They also explore other consequences of off-road vehicles, including destruction of soil stabilizers, soil compaction, reduced water infiltration rates, destruction of vegetation, and increased erosion (Lovich and Bainbridge, 1999).

To the casual observer, the impacts of forest roads and motorized recreation on wildlife may not be as evident as their effects on the surrounding physical environment (i.e. loss of trees, damage to ground surface, etc.). In reality, however, wildlife are affected beginning when a route is first cut (legally or illegally) and continue to be even after the route is no longer being used. As ORVs affect soils, air, water and vegetation, they also impact wildlife species because animals depend on all of these other factors for their survival. Thus, ORV activity and associated routes have both direct and indirect effects on animals (Davenport et al, in press).

Animal mortality, a significant direct effect, can occur when off-road vehicles hit ground-dwelling animals, destroy birds or small mammals by crushing ground nests or vegetation that contains nests, or cause the collapse of needed burrows. Although animal mortality is an obvious and familiar direct effect, displacement, avoidance and disturbance at specific sites, often associated with breeding and raising young, are the most commonly reported direct effects of motorized trails on wildlife (Bury et al. 1977; McReynolds and Radtke, 1978; Bury, 1980; Luckenbach and Bury, 1983; Sachet, 1988; United States General Accounting Office, 1995 Youmans, 1999).

Off-road vehicle activity and harassment can stress animals, resulting in a measured physiological stress response or increase in energy use (Schultz and Bailey, 1978; King and Workman, 1986; Canfield et al., 1999). Changes in animal behavior, (i.e., the abandonment of important activities like hunting, foraging and mating), have been attributed to the passage of off-road vehicles. These behavioral and physiological responses to motorized human disturbance may not only impact individuals, but also entire populations. It has been suggested that the impacts associated with disturbance from ORVs can increase the risk of individual mortality and decrease the productivity and viability of an entire population (Knight and Cole, 1991). For example, if the passage of an ORV causes a male yellow warbler in a canyon to change his habitat use pattern

While the consequences of direct effects (i.e. a road kill) may be more evident, indirect effects on wildlife are significant and often impact habitat in areas subject to motorized recreation. For example, ORV activity that destroys vegetation by crushing it and exposing roots, also disturbs soil, thereby negatively effecting future plant growth and the potential for healthy habitat for many animals. The destruction of habitat can increase fragmentation and decrease connectivity, breaking previously suitable habitat into smaller patches which may make it less

usable and can jeopardize the survival of certain species. “Edge effects” increase and are magnified in areas with small, isolated patches of habitat. Increased edge effects can impact wildlife that need interior habitat for foraging, hunting or establishing home ranges (i.e., mountain lions, martens, black bears). Research also shows that fragmentation and increased edge habitat support the invasion of non-native, noxious and weedy species that eventually displace native interior species. The destruction of native vegetation and changes in the density and diversity of plant communities as a consequence of prolonged off-road vehicle use can even further change the composition of desert reptile and small mammal communities (Bury, 1980).

Indirect effects often have such broad implications because the “road effect zone,” or the outer limit of a significant ecological effect, extends much further than the actual road, route or trail (Forman 2000). Disturbance due to noise, pollution, ground impact, and speed will travel beyond the actual surface of any route. In addition, ecological effects will ripple, expanding well beyond the perimeter of a route and potentially affecting an entire ecosystem. For example, in aquatic areas like the Rubicon Trail, off-road vehicles can increase the amount of silt and turbidity in a stream by increasing erosion (Moyle and Leidy, 1992). If this causes degradation of habitat to the point where spawning sites are not available and food sources are destroyed, less fish will survive and so will those creatures that depend on the aquatic ecosystem for survival.

In an evaluation of threats to biodiversity, Wilcove et al. (1998) ranked habitat destruction and the spread of alien species as the two greatest threats; off-road vehicles contribute to both of these. There are a number of causes of habitat destruction, including land conversion, agriculture, development and outdoor recreation. From their study of these causes, they reported that 15 % of all endangered species are affected by roads. Twenty seven percent (27%) of all endangered species, including plants and animals, are harmed by outdoor recreation while 13% of endangered species have been specifically, negatively impacted by the use of off-road vehicles (Wilcove et al. 1998).

Studies with similar findings regarding the impacts of off-road vehicles on wildlife and their habitat abound. Bury et al. (1977) studied the impacts of ORV use on wildlife in creosote shrub habitat in the California desert. The authors found a negative effect on desert wildlife wherever ORVs were used. In a comparison with control areas, they reported significantly less species diversity, fewer individuals present and lower biomass of mammals and reptiles in areas used by ORVs. Diversity, abundance, and biomass of avian species were also significantly greater in undisturbed areas than in those used by ORVs (Bury et al., 1977). Results also support the idea that a decrease in fauna is correlated with the level of off-road activity. The authors conclude that activity related to ORV use negatively affects desert wildlife and creosote shrub habitat, both of which they argue are irreplaceable (Bury et al., 1977).

Luckenbach and Bury (1983) conducted a study to determine the ecological impacts of ORV use on biota by comparing presence and density of vegetation, rodents, arthropods and lizards on plots with and without use by off-road vehicles in sand dunes in south eastern California. They found that ORV activity in the Algodones dunes reduced the biota; in areas of ORV use, there were less herbaceous and perennial plants, arthropods, lizards and rodents. Researchers found almost no native plants or wildlife in areas of heavy ORV use and also cited negative impacts to the biota in areas with low levels of ORV activity. They argue that ORV activities very negatively affect dune biota and even low levels of use can cause a reduction in the biota of ecosystems.

Although we discuss them separately, the actual environmental effects of these factors are not individual. Rather, they are cumulative and synergistic because seemingly may result in large scale changes in the reproductive success and survival of organisms, thereby altering the entire ecology of an area. The combination of these impacts has the potential to cause disturbance at the landscape level (McLellan and Shackleton, 1988; Eaglin and Hubert, 1993). Few species or habitats are completely immune to the effects of off-road vehicle recreation and many are threatened by similar impacts: habitat loss or fragmentation, disturbance, displacement and direct mortality.

Clearly, any complete analysis of off-road vehicle activity in a delicate riparian ecosystem like the Rubicon Trail is not complete if it only quantifies direct effects based on specific acreage of impact; , it must also take into account the far reaching indirect effects.

Road effect zone

Roads are responsible for a suite of indirect effects that impact species dynamics, soil characteristics, water flow regimes, and vegetation cover (Bashore et al. 1985; Reijnen et al. 1996, Forman et al. 2003). The degree of indirect effect varies in relation to the distance from a road, extending to what is known as the “road effect zone” or the outer limit of significant ecological effect (Forman et al. 1997; Forman and Deblinger 1998, 1999). Forman and Deblinger (2000) found that the effects of all nine ecological factors studied extended more than 100 m from the road, with some extending outwards of 1 km of the road. The road-effect zone was asymmetric, had convoluted boundaries and a few long fingers and averaged approximately 600m in width.

Road-avoidance zone

Native wildlife species are less common or absent near roads, suggesting the existence of a road-avoidance zone (Forman and Alexander, 1998). Evidence of a road- avoidance zone exists for deer, elk, coyote, small mammals, birds,

amphibians, snakes and caribou. Road-avoidance zones, extending outwards tens or hundreds of meters from a road, generally exhibit lower population densities compared with control sites. Forman et al. (2005) conclude that the ecological impact of road avoidance probably exceeds the impact of either road-kills or habitat loss in road corridors.

Clearly, most of the ecological effects of road systems are negative and their cumulative effect covers an extensive area (Forman 2000). Landscape ecologists and scholars of related fields increasingly recognize ecological flows across the landscape as critical for long-term nature protection (Forman 1995, 1999; Harris et al. 1996). Forman suggests that because of this, the road effect zone should be the basis for transportation planning, implying that a landscape perspective is necessary to maintain spatial and biological diversity.

A report by Gucinski et al. (2000) suggests that this type of full analysis is necessary and is within the realm of possibility for government agencies charged with managing our public lands:

This overview of scientific information leads us to conclude the following: The emerging science of the effects of roads as networks in the landscape requires considerable new research. Because of the high degree of variability of roads from place to place and region to region, a framework for evaluating benefits, problems, risks, and tradeoffs among them would provide a powerful decision-making tool. We believe such a framework is now in place (USDA 1999). Conducting these analyses is well within the grasp of capable specialists, planners, and managers to bring their expertise to bear on the problem of reducing risks from past, current, or planned roads, and targeting future road-restoration activities. The science pieces for analyzing and integrating road systems and their effects are already developed.

Despite the fact that this capability exists, assessments like the one completed for the Rubicon Trail in the DEIR continue to neglect to consider the virtual footprint of a route or the road-effect zone. Angermeier et al. (2004) argue that assessments of environmental impacts of roads are inadequate to ensure informed decision making because direct, localized or acute impacts are emphasized whereas indirect, dispersed or chronic impacts are neglected. This bias reflects the typical level of analysis wherein attention is narrowly focused on points of impact or species rather than ecosystems, on site-specific scale rather than regional scale and on short-term rather than long-term environmental impacts. This is particularly disturbing due to the fact that: “The mismatch between scales of assessment and impact is especially problematic for roads because there is compelling scientific evidence that long-term, large-scale impacts are the greatest threats to biota (Angermeier et al. 2004).”

We agree with the above scientific evidence and argue that further analysis of the impacts of the Rubicon Trail must be completed before use is allowed to continue. The current lack of a management plan means that there is insufficient consideration of the far-reaching cumulative effects of off-road vehicle travel on a riparian ecosystem and a complete failure to address the indirect effects of the mere presence of trail alongside and in a creek. When the virtual footprint of a route is considered, along with the road-effect zone, the road avoidance zone and the further reaching indirect effects, the Rubicon Trail has the potential for a much more significant impact on the environment than has yet been considered.



Photo 5. Pond below Little Sluice Box (39 degrees 01.288' N and 120 degrees 16.517' W). This receives the run off in the ephemeral stream that runs down the Little Sluice Box. The County's DEIR for the Rubicon Trail Master plan reported cadmium and copper in the sediments. Taken May 9, 2007.



Photo 6. Same pond as photo 5, but taken Oct 13, 2007. This pond receives everything that comes down the Little Sluice Box drainage and joins with the flows which come down the Trail from west of this spot. The inflow is on the left side of the photo and the sediment filling that end of the pond is evident.

4. Pollution

Research suggests that off-road vehicles, including motorcycles, all-terrain vehicles (ATVs), snowmobiles, etc. contribute greatly to the pollution of water and

air in the United States (Gucinski et al., 2000). They increase pollution by depositing unburned fuel into the soil, snow or water and by emitting pollutants into the air. This directly alters the composition of soil and snow while indirectly affecting vegetation and aquatic systems. Off-road vehicles also emit dangerous levels of toxins, including carbon monoxide (CO), nitrogen oxides (NO), and hydrocarbons (HC). In addition, off-road vehicles release compounds that are known human carcinogens (particulate matter (PM), benzene and polycyclic aromatic hydrocarbons, (PAHs)), and a suspected carcinogen (methyl tertiary butyl ether, MTBE). Thus, the effects of pollution generated by ORVs are pervasive as they extend well beyond any route or trail, affecting the health of humans, wildlife, vegetation and entire ecosystems.

A significant amount of damage can be attributed to the unburned fuel that ORV engines deposit into the environment. Off-road vehicle engines may be either two-stroke or four-stroke; two-stroke engines use fuel less efficiently and emit more unburned hydrocarbons (HC) and particulate matter (PM) than four-stroke engines. The Environmental Protection Agency estimates that 25 to 30% of the fuel in a 2-stroke motor remains unburned and is released into the air and water (Natural Trails and Water Coalition, 2005b). Because they are more powerful, lighter weight and are less expensive, two-stroke engines can be found in 60-65 % of off-highway motorcycles and 10 to 15 % of all ATVs in the United States (United States Environmental Protection Agency, 2001a). In 1993, the California Air Resources Board found that motorcycles with 2-stroke engines release 10 times the amount of hydrocarbon emissions as 4-stroke motorcycles. As a result of the amount of emissions released, use of 2-stroke engine motorcycles are now responsible for 90% of the emissions from ORVs that contribute to the formation of smog in California (California Air Resources Board, 2001). This is of interest on the Rubicon trail because the Eldorado National Forest is within a designated non-attainment area for state standards PM10 and ozone.

In 1994, the Environmental Protection Agency (EPA) definitively announced that non road engines “are significant contributors to ozone or carbon monoxide concentrations.” Durbin et al. (2004) report that off-road vehicles are “one important source of emissions that make a disproportionately high contribution to the emissions inventory.” For instance, between 1989 and 1998, pollution due to off-road vehicles grew from 17 to 22 percent of the total produced by mobile sources in the U.S, while pollution from cars decreased from 62 to 56 percent despite the fact that the number of these vehicles and the miles driven increased (United States Environmental Protection Agency, 2001b). This may be due to the fact that the hydrocarbon and carbon monoxide emissions released by a new passenger car are much lower than those released by 2-stroke or 4-stroke engines.

A significant proportion of the research conducted on ORV pollution relates to its impact on air quality and human health. However, pollution emitted by ORVs can have severe impacts on aquatic and terrestrial systems. The substantial amount

of unburned fuel released by ORVs may be deposited into the soil where it has the potential to penetrate into underground water, adversely impact vegetation or run off into the aquatic system. A rapid pulse of these toxins into a system can quickly increase the acidity of a stream or waterway, causing the death of aquatic insects and amphibians (Hagen and Langeland, 1973). Acidification due to atmospheric deposition and pollution has been shown to effect the survival and distribution of amphibians, including tiger salamanders, boreal toads, and northern leopard frogs (Freda and Dunson, 1985; Harte and Hoffman, 1989; Corn and Vertucci, 1992). By releasing hydrocarbons and volatile organic compounds into streams and lakes, off-road vehicles can also disrupt the biological functions of fish, disrupting their ability to maintain their metabolism and immune system while also jeopardizing their reproductive success and survival (Tjarnlund et al. 1995, 1996; Juttner et al., 1995a,b). In addition, there is evidence that low levels of PAHs released by ORVs are toxic to zooplankton, restricting the reproductive success of zooplankton and many fish (Giesy, 1997;Oris, 1998).

The consideration of pollution is especially important on the Rubicon because the Regional Board found these types of impacts as a result of ORV use on the Rubicon trail; low levels of oil and grease were identified in water and soil samples and low levels of copper and cadmium were identified in soil samples. The Regional Board concluded that this contamination is due to motor oil, grease, and other petroleum-based fluids spilling and leaking from ORVs that have overturned or have damaged mechanical components while traversing rocky segments of the trail.

Off-road vehicles release detrimental pollutants, including carbon monoxide and particulate matter that work their way into the air, water, soil and snow, affecting human and environmental health. The same toxic chemicals and compounds that impact human resources and health can also affect the health and survival of wildlife and vegetation that are exposed to polluted air, water and/or food sources. Although these impacts may be silent or unnoticeable to the eye, governmental organizations and land management agencies have a legal and ethical responsibility as set out by the Clean Air Act and Clean Water Act to address the overwhelming amounts of pollution that currently threaten our lands and the people and wildlife who use them.

Figures

Figure 1. Table 3.8-1 From DEIR. Special-status wildlife species potentially occurring in the vicinity of the Rubicon Trail.

Common Name (Scientific Name)	Status	Habitat
Northern goshawk (<i>Accipiter gentiles</i>)	FSC	CF, RF
Sierra Nevada mountain beaver (<i>Aplodontia rufa californica</i>)	FSC	RF, CF
California wolverine (<i>Gulo gulo luteus</i>)	FSC, ST	CF,
Bald eagle (<i>Haliaeetus leucocephalus</i>)	FT	CF, LK
American marten (<i>Martes Americana</i>)	FSC	CF
Pacific fisher (<i>Martes pennanti pacifica</i>)	FSC	CF, RF
Mountain yellow-legged frog (<i>Rana muscosa</i>)	FE	ST, PO
Yosemite toad (<i>Bufo canorus</i>)	FC	
Sierra Nevada red fox (<i>Vulpes vulpes necator</i>)	ST	CF

Status: FE = Federal Endangered FT = Federal Threatened FSC = Federal Species of Concern SE = State Endangered ST = State Threatened FC = Candidate for Federal Listing	Habitat Codes: CF = Coniferous Forest ST = Stream PO = Pond RF = Riparian Forest LK = Lake (permanent water body)
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Figure 2. Table 3.8-2. From DEIR. Sensitive plant species potentially occurring in the Vicinity of the Rubicon Trail.

Table 3.8-2 Sensitive Plant Species Potentially Occurring in the Vicinity of the Rubicon Trail						
Common Name (Scientific Name)	Status	Blooming	Habitat	Elevation	Duration	Growth Form
Stebbin's phacelia (<i>Phacelia stebinsii</i>)	1B	June to July	W, CF, M, S	2,000 to 6,600'	Annual	Herb
Northern adder's-tongue (<i>Ophioglossum pusillum</i>)	CNPS-2	July	G, WT	3,300 to 6,600'	Perennial	Herb
Marsh skullcap (<i>Scutellaria galericulata</i>)	CNPS-2	June to Sept.	CF, M, S, WT	0 to 6,900'	Perennial	Herb
Shore sedge (<i>Carex limosa</i>)	CNPS-2	June to August	CF, M, S, WT	4,000 to 8,900'	Perennial	Herb
Tahoe yellow cress (<i>Rorippa subumbellata</i>)	1B	May to Sept.	M, S, CF	6,250 to 6,270'	Perennial	Herb
Alpine dusty maidens [*] (<i>Chaenactis douglasii</i> var. <i>alpina</i>)	CNPS-2	July to Sept.	BR	9,900 to 11,200'	Perennial	Herb
Fell-fields claytonia [*] (<i>Claytonia megarhiza</i>)	CNPS-2	July to August	BR, CF	8,500 to 10,900'	Perennial	Herb
Long-petaled lewisia [*] (<i>Lewisia longipetala</i>)	1B	July to August	BR, CF	8,250 to 9,650'	Perennial	Herb

^{*} Not likely to occur within the project area due to elevation range.

Habitat codes:

G	=	Grassland
W	=	Woodland
S	=	Seep
BR	=	Alpine Boulder/Rock Field
WT	=	Wetland
CF	=	Coniferous Forest
M	=	Meadow

Figure 3. List of Species found in the Homewood Quad. Accessed from CNDD.

California Department of Fish and Game
 Natural Diversity Database
 Selected Elements by Scientific Name - Portrait

Scientific Name/Common Name	Element Code	Federal Status	State Status	GRank	SRank	CDFG or CNPS
1 <i>Accipiter gentilis</i> northern goshawk	ABNKC12060			G5	S3	SC
2 <i>Botrychium crenulatum</i> scalloped moonwort	PPOPH010L0			G3	S2.2	2.2
3 <i>Botrychium montanum</i> western goblin	PPOPH010K0			G3	S1.1	2.1
4 <i>Capnia lacustra</i> Lake Tahoe benthic stonefly	IIPLE03200			G1	S1	
5 <i>Carex praticola</i> northern meadow sedge	PMCYP03B20			G5	S2S3	2.2
6 <i>Empidonax traillii</i> willow flycatcher	ABPAE33040		Endangered	G5	S1S2	
7 <i>Helisoma newberryi</i> Great Basin rams-horn	IMGASM6020			G1Q	S1	
8 <i>Lepus americanus tahoensis</i> Sierra Nevada snowshoe hare	AMAEB03012			G5T3T4Q	S2?	SC
9 <i>Martes americana sierrae</i> Sierra marten	AMAJF01014			G5T3T4	S3S4	
10 <i>Martes pennanti (pacifica) DPS</i> Pacific fisher	AMAJF01021	Candidate		G5	S2S3	SC
11 <i>Myotis volans</i> long-legged myotis	AMACC01110			G5	S4?	
12 <i>Rorippa subumbellata</i> Tahoe yellow cress	PDBRA270M0	Candidate	Endangered	G1	S1.1	1B.1
13 <i>Scutellaria galericulata</i> marsh skullcap	PDLAM1U0J0			G5	S2.2?	2.2

References (provided on CD rom)

- Angermeier, Paul L., Andrew P. Wheeler and Amanda E. Rosenberger. 2004. A conceptual framework for assessing impacts of roads on aquatic biota Fisheries. **29**(12): 19-29.
- Barton, D. C. and A. Holmes. 2007. Off-Highway Vehicle Trail Impacts on Breeding Songbirds in Northeastern California. JOURNAL OF WILDLIFE MANAGEMENT 71(5):1617–1620.
- Bashore T. L., W. M. Tzilkowski, and E. D. Bellis. 1985. Analysis of deer-vehicle collision sites in Pennsylvania. Journal of Wildlife Management **49**:769-74.
- Belnap J. 2003. The world at your feet: desert biological soil crusts. Frontiers in Ecology and Environment **1**:181-9.
- Berry K. H. 1980. The effects of four-wheel vehicles on biological resources. *In* R.N.L. Andrews and P. Nowak (editors), Off-road vehicle use: A management challenge. U.S. Department of Agriculture, Office of Environmental Quality, Washington, D.C.
- Boyle S. A. and F. B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: A review. Wildlife Society Bulletin. **13**:110-6.
- Brattstrom B. H. and M. C. Bondello. 1983. Effects of off-road vehicle noise on desert vertebrates. Pages 167-206 *in* R.H. Webb and H.G. Wilshire (editors), Environmental effects of off-road vehicles: impacts and management in arid regions. Springer-Verlag, New York. (not included)
- Brown G. 1985. Landslide damage to the forest environment in Proceedings of a Workshop on Slope Stability: Problems and Solutions in Forest Management General-Technical-Report, PNW 180 p. 26-29. Available online at: http://www.fs.fed.us/pnw/publications/pnw_gtr180/
- Burnett S. E. 1992. Effects of a rainforest road on movements of small mammals: mechanisms and implications. Wildlife Research **19**:95-104.
- Bury R. B. 1980. What we know and don't know about off-road vehicle impacts on wildlife. Pages 110-123 *in* Andrews, R.N.L. and P.F. Nowak, editors. Off-road vehicle use: A management challenge. USDA Office of Environmental Quality, University of Michigan.
- Bury R. B., and R. A. Luckenback. 2002. Comparison of desert tortoise (*Gopherus agassizii*) populations in an unused and off-road vehicle area in the Mojave Desert. Chelonian Conservation and Biology, International Journal of Turtle

and Tortoise Research. **4**:457-63.

Bury R. B., and R. A. Luckenbach. 1983. Vehicular recreation in arid land dunes: Biotic response and management alternatives. In R.H. Webb and H.G. Wilshire (Eds.). Environmental effects of off-road vehicles. Impacts and management in arid regions. Springer-Verlag, New York. 534 pp.

Bury R. B., R. A. Luckenbach, and R. D. Busack. 1977. Effects of off-road vehicles on the California Desert. U.S. Fish and Wildlife Service. Wildlife Resource Report 8. 23 p. (not included)

Canfield, J. E., L. J. Lyon, J. M. Hillis, and M. J. Thompson. 1999. Ungulates. Pages 6.1-6.25 in G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307pp. Available online at:
<http://joomla.wildlife.org/Montana/images/Documents/6ung.pdf>

Claar J. J., N. Anderson, D. Boyd, M. Cherry, B. Conard, R. Hompesch, S. Miller, G. Olson, Ihsle, H. Pac, J. Waller, T. Wittinger, and H. Youmans. 1999. Carnivores. Pages 7.1– 7.63 in Joslin, G. and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A review for Montana. Committee on Effects of Recreation on Wildlife. Montana Chapter of The Wildlife Society. 307pp. Available online at:
<http://joomla.wildlife.org/Montana/images/Documents/7carn.pdf>

Corn P. S. and F. A. Vertucci. 1992. Descriptive risk assessment of the effects of acidic deposition on Rocky Mountain amphibians. *Journal of Herpetology* **26**: 361-9.

Davenport J., D. P. Sleeman, L. Bach, and P. Smiddy. 2006. Disturbance of mammals by roads. In Shore, RF, Grogan, A & Sangwine A , editors. Mammals and Roads. Highways Agency, London.

DeMaynadier P. G. and M. L. Hunter. 1995. The relationship between forest management and amphibian ecology: a review of the North American literature. *Environmental Review* **3**:230-61.

DeMaynadier P. G. and M. L. Hunter. 2000. Road effects on amphibian movements in a forested landscape. *Natural Areas Journal* **20**:56-65.

Duever, M. J., Carlson, J.E., Riopelle, L.A., & National Audubon Society, Ecosystem Research Unit. (1981). Off-road vehicles and their impacts in the Big Cypress National Preserve: Final report. Homestead, FL, National Park Service, South Florida Research Center: Everglades National Park.

- Duever, M. J., Riopelle, L.A., McCollom, J.M., & National Audubon Society, Ecosystem Research Unit. (1986). Long term recovery of experimental off-road vehicle impacts and abandoned old trails in the Big Cypress National Preserve: Homestead, FL. National Park Service, South Florida Research Center: Everglades National Park.
- Durbin T. D., M. R. Smith, R. D. Wilson, and S. H. Rhee. 2004. In-use activity measurements for off-road motorcycles and all-terrain vehicles. *Transportation Research Part D, Transport and Environment* **9**:209-19.
- Eaglin G. S. and Hubert. W.A. 1993. Effects of logging and roads on substrate and trout in the streams of Medicine Bow National Forest, Wyoming. *North American Journal of Fisheries Management*. **13**:844-6.
- Fahrig L., J. H. Pedlar, S. E. Pope, P. D. Taylor, and J. F. W. Wegner. 1995. Effect of road traffic on amphibian density. *Biological Conservation* **74**:177-82.
- Federal Highway Administration. 2003. Highway Statistics 2003. Roadway extent, characteristics and performance. <http://www.fhwa.dot.gov/policy/ohim/hs03/re.htm>
- Foppen R. and R. Reijnen. 1994. The effects of traffic on breeding bird populations in woodland: II. Breeding dispersal of willow warblers in relation to the proximity of a highway. *Journal of Applied Ecology*. **31**:95-101.
- Forman R. T. T. 2000. Estimate of the area affected ecologically by the road system in the United States. *Conservation Biology* **14**:31-5.
- Forman, R. T. T. 1995. *Land Mosaics: The Ecology of Landscapes and Regions*. Cambridge University Press, Cambridge
- Forman R. T. T. and Robert. D. Deblinger. 1998. The ecological road-effect zone for transportation planning and Massachusetts highway example. *International Conference on Wildlife, Environment and Transportation*:78-83.
- Forman, R.T.T. and Robert D. Deblinger 2000. The Ecological Road-Effect Zone of a Massachusetts (U.S.A.) Suburban Highway . *Conservation Biology* **14** (1), 36–46.
- Forman R. T., D. Sperling, A. P. Clevenger, J. A. Bissonette, C. D. Cutshall, V. H. Dale, L. Fahrig, R. France, C. R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine, and T. C. Winter. 2003. *Road ecology: Science and*

Solutions. Island Press, Washington, D.C.

Forman, R. T. T., D. S. Friedman, D. Fitzhenry, J. D. Martin, A. S. Chen and L. E. Alexander. 1997. Ecological effects of roads: toward three summary indices and an overview for North America. Pages 40-54 in *Habitat Fragmentation and Infrastructure*. Canters, K, ed. Ministry of Transport, Public Works and Water Management, Delft, Netherlands.

Freda J. and W. A. Dunson. 1985. The influence of external cation concentration on the hatching of amphibian embryos in water of low pH. *Canadian Journal of Zoology* **63**:2649-56

Giesy J. P. 1997. Testimony of John P. Giesy at the Tahoe Regional Planning Hearing on Boating Impacts. February 26, 1997. (not included)

Gucinski H., M. J. Furniss, R. R. Ziemer, and M. H. Brookes. 2000. Forest roads: a synthesis of scientific information. General Technical Report PNW-GTR-509. Portland, OR. U.S Department of Agriculture, Forest Service, Pacific Northwest Research Station:103 p.

Gutzwiller K. J. 1995. Recreational disturbance and wildlife communities. Pages 169-181 *in* R.L. Knight and K.J. Gutzwiller, editors. *Wildlife and recreationists: Coexistence through management and research*. Island Press, Washington, D.C., USA. (not included)

Hagen A., and A. Langeland. 1973. Polluted snow in southern Norway and the effect of the meltwater on freshwater and aquatic organisms. *Environmental Pollution* **5**:45-57.(not included)

Harris L. K., P. R. Krausman, and W. W. Shaw. 1995. Human attitudes and mountain sheep in a wilderness setting. *Wildlife Society Bulletin* **23**:66-72.

Harte J., and E. Hoffman. 1989. Possible effects of acidic deposition on a Rocky Mountain population of the Tiger Salamander (*Abystoma tigrinum*). *Conservation Biology* **3**:149-58.

Havlick D. 1999. Roaring from the past: Off-road vehicles on America's National Forests. Prepared for Wildlands Center for Preventing Roads, Missoula, MT.

Heede B. H. 1983. Control of rills and gullies in off-road vehicle traffic areas. Pages 245-264 in R.H. Webb and H.G. Wilshire (eds.), *Environmental effects of off-road vehicles: impacts and management in arid regions*. Springer-Verlag, New York. (not included)

Joslin G. and H. Youmans. 1999. Effects of recreation on Rocky Mountain

wildlife: a review for Montana *in* Committee on Effects of Recreation on Wildlife, Montana Chapter of the Wildlife Society. Available online at http://joomla.wildlife.org/Montana/index.php?option=com_content&task=view&id=200&Itemid=350

Juttner F., D. Backhaus, U. Matthias, U. Essers, R. Greiner, and B. Mahr. 1995a. Emissions of two and four stroke outboard engines I. Quantification of Gases and VOC. *Water Research* **29**:1976-82.

Juttner F., D. Backhaus, U. Matthias, U. Essers, R. Greiner, and B. Mahr. 1995b. Emissions of two and four-stroke outboard engines II. Impact on Water Quality. *Water Research* **29**: 1983-1987.

King M. M. a. Workman, G. W. 1986. Response of desert bighorn sheep to human harassment: management implications. *Transactions of the North American Wildlife and Natural Resources Conference* 51:74-85.

Knight R. and D. Cole. 1991. Effects of recreational activity on wildlife in wildlands. *Transactions of the North American Wildlife and Natural Resource Conference* 56: 238-247.

Lawler M. 2000. Shattered solitude/eroded habitat: The motorization of the lands of Lewis and Clark. Sierra Club, Seattle, Washington, USA.

Lodge T. E. 1994. *The Everglades handbook: Understanding the ecosystem*. St. Lucie Press.

Lovich J. E. and D. Bainbridge. 1999. Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration. *Environmental Management* **24**:309-26.

Luckenbach R. 1975. What the ORVs are doing to the desert. *Fremontia* **2**:3-11.

Luckenbach R. A. 1978. An analysis of off-road vehicle use on desert avifaunas. *Transactions of the North American Wildlife National Resource Conference*. **43**:157-62.

Luckenbach R. A. and R. B. Bury. 1983. Effects of off-road vehicles on the biota of the Algodones Dunes, Imperial County, California. *Journal of Applied Ecology* **20**:265-86.

MacArthur R. A., V. Geist, and R. H. Johnston. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. *Journal of Wildlife Management* **46**:351-8.

Manning R. E. 1979. Impacts of recreation on riparian soils and vegetation. *Water Resources Bulletin* **15**:30-43

Marcot B. G., M. A. Castellano, J. A. Christy, L. K. Croft, J. F. Lehmkuhl, R. H. Naney, K. Nelson, C. G. Niwa, R. E. Rosentreter, R. E. Sandquist, B. C. Wales, and E. Zieroth. 1997. Terrestrial ecology assessment. Pages 1497-1713 *in* T. M. Quigley and S. J. Arbelbide, editors. An assessment of ecosystem components in the interior Columbia Basin and portions of the Klamath and Great Basins. Volume III. USDA Forest Service General Technical Report PNW-GTR-405. USDA Forest Service Pacific Northwest Research Station, Portland, OR. 1713 pp. Available online at: http://www.fs.fed.us/pnw/publications/pnw_gtr405/.

Maxell B. and G. Hokit. 1999. Amhiblings and reptiles. Pages 2.1-2.29 in G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of the Wildlife Society: 307 pp.

McLellan B. N. and D. M. Shackleton. 1988. Grizzly bears and resource-extraction industries: effects of roads on behaviour, habitat use and demography. *Journal of Applied Ecology* **25**:451-60.

McReynolds H., and R. Radtke. 1978. The impact of motorized humans on the wildlife of forested lands. *Wildlife and people: Proceedings of the 1978 John S. Wright Forestry Conference*. Purdue University, West Lafayette, Indiana, edited by CM Kilpatrick:102-17.

Merriam G., M. Kozakiewica, E. Tsuchiya, and K. Hawley. 1989. Barriers as boundaries for metapopulations and demes of *Peromyscus leucopus* in farm landscapes. *Landscape Ecology* **2**: **227-35**.

Moyle P. B. and R.A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems: Evidence from fish faunas. *In* P.L. Fiedler and S.K. Jains, editors. *Conservation biology: The theory and practice of nature conservation*. Chapman and Hall, New York.

Natural Trails and Waters Coalition. 2005a. National Forests Fact Sheet. Available at www.naturaltrails.org. Accessed September 20, 2005.

Natural Trails and Waters Coalition. 2005b. Off-road vehicles pollute. Available at www.naturaltrails.org. Accessed September 20, 2005

Oris J. T. 1988. Toxicity of ambient levels of motorized watercraft emissions to fish and zooplankton in Lake Tahoe, California/Nevada. Center for Environmental Toxicology and Statistics, Miami University, Oxford, OH.

- Powell R. A. 1979. Fishers, population models and trapping. *Wildlife Society Bulletin* **7**:149-54.
- Reijnen R., R. Foppen, and H. Meeuswen. 1996. The effects of car traffic on the density of breeding birds in Dutch agricultural grasslands. *Biological Conservation* **75**:255-60
- Sachet G. A. 1988. Wildlife evaluation processes for ORV, hiking, and horse backcountry recreation use in Washington Forests. Department of Wildlife, State of Washington, Olympia, WA.
- Sanders, S. and M.A. 1989. Montane Riparian Habitat and Willow Flycatchers: Threats to a sensitive environment and species. USDA Forest Service Gen. Tech. Rep. PSW-110.
- Schultz R. D. and J. A. Bailey. 1978. Responses of National Park elk to human activity. *Journal of Wildlife Management* **42**:91-100.
- Severinghaus W. D. and M. C. Severinghaus. 1982. Effects of tracked vehicle activity on bird populations. *Environmental Management* **6**:163-9.
- Sheridan D. 1979. Off-road vehicles on public land. 041-011-00041-6. Washington, D.C., U.S. Government Printing Office, Council on Environmental Quality.
- Swanson F. J., J. F. Frankel, and J. R. Sedell. 1990. Landscape patterns, disturbance, and management in the Pacific Northwest, USA. Pages 191-213 *in* I.S. Zonnevald and R.T.T. Forman, editors. *Changing landscapes: an ecological perspective*. Springer-Verlag, New York, USA.
- Thompson, ID. 1994. Marten populations in uncut and logged boreal forests in Ontario. *Journal of Wildlife Management*. 58 (2): 272-280.
- Tjärnlund, Ulla, Gunilla Ericson, Eric Lindesjö, Inger Petterson and Lennart Balk. 1995. *Marine Environmental Research*, **39**: 313-316
- Tjärnlund, Ulla. Gunilla Ericson, Eric Lindesjö, Inger Petterson, Gun Åkerman and Lennart Balk. 1996. *Marine Environmental Research*, **42**: 267-271
- United States Department of Agriculture, Forest Service. 2002. Management and techniques for riparian restoration: A roads field guide. General Technical Report RMRS-GTR-102. Volume 1. Rocky Mountain Research Station. Fort Collins, CO.

- United States Department of Agriculture, Forest Service. 1999. Roads Analysis: informing decisions about managing the National Forest transportation system. Miscellaneous Report FS-643. Washington, DC: U.S. Dept. of Agriculture Forest Service. 222 p.
- United States Environmental Protection Agency. 2001a. Final Report of the Small Business Advocacy Review Panel On Control of Emissions from Nonroad Large Spark Ignition Engines, Recreational Engines (Marine and Land-based), and Highway Motorcycles (Report #EPA420-R-01-049). Washington, D.C., USA. Available online at:
<http://www.epa.gov/otaq/regs/nonroad/proposal/r01049.pdf>
- United States Environmental Protection Agency. 2001b. Proposed Rule, Control of Emissions from Nonroad Large Spark Ignition Engines and Recreational Engines. Washington, D.C., USA. Available online at:
<http://www.epa.gov/otaq/regs/nonroad/2002/cleanrec-final.htm>
- United States General Accounting Office. 1995. Federal lands: Information on the use and impact of off-highway vehicles (GAO/RCED-95-209). Washington, D.C., USA. 77p.
- Weinstein M. 1978. Impact of off-road vehicles on the avifauna of Afton Canyon, California. Contract CA-060-CT7-2734. U.S. Department of the Interior, Bureau of Land Management, California Desert Program, Riverside, California, USA.
- Welsh H.H., and L. M. Ollivier. 1998. Stream amphibians as indicators of ecosystem stress: a case study in California's redwoods. *Ecological Applications* **8**:1118-32.
- Wilcove D. S., D. Rothstein, J. Dubow, and A. L. E. Phillips. 1998. Quantifying threats to imperiled species in the United States. *Bioscience* **48** : 1-15.
- Wildlands CPR and the Wilderness Society. 1999. Petitions to enhance and expand regulations governing the administration of recreation off-road vehicle use on National Forests. Published by Wildlands CPR. Missoula, MT. 188 pgs..
- Witmer G. W. and D. S. deCalesta. 1985. Effect of forest roads on habitat use by Roosevelt elk. *Northwest Science* **59**:122-5.
- Yarmoloy C., M. Bayer, and V. Geist. 1988. Behavior responses and reproduction of mule deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle. *Canadian Field-Naturalist* **102**:425-9.

Youmans H. 1999. Project overview. Pages 1.1.-1.8 *in* Josiln, G. and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A review for Montana. Committee on Effects of Recreation of Wildlife, Montana Chapter of the Wildlife Society. 307 pp. Available at:
http://joomla.wildlife.org/Montana/index.php?option=com_content&task=view&id=200&Itemid=350