THE EFFECTS OF OFF-ROAD VEHICLES ON ECOSYSTEMS

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For many years, the impacts and effects of off-road vehicles (ORV) on ecosystems have been a controversial subject across the United States and throughout the world (Webb and Wilshire, 1983). In the United States, it became an issue during the 1970s when environmentalists became concerned with ORV use on federal properties. During this time, scientific investigations were conducted to evaluate the environmental effects of human uses on resources in the California Desert Conservation Area. The findings from this research were published in a book entitled "Environmental Effects of Off-Road Vehicles". More recently, a book entitled "No Place Distant" investigated and revealed a more complete story of the effects of all roads on America's public lands (Havlick, 2002). This paper is intended to review research documenting the effects of ORV traffic on the ecosystems.

According to Kockelman (1983), the problems associated with ORV traffic were recognized by user and conservation groups, state and federal agencies, professional societies, individual scientists, the United States Council of Environmental Quality, state courts, Congress, and two former presidents. This prompted the 1972 Executive Order 11644 to control ORV use on federal public lands. This was followed by Executive Order 11989, in 1977, to provide immediate closure of trails to ORVs, which are causing or "will cause" considerable adverse effects to the ecosystem (Kockelman, 1983).

According to Sheridan (1980), the use of ORVs was a recognized management problem in the deserts of the southwestern United States and elsewhere (Webb, 1983). Not satisfied with traditional access areas, many people utilize ORVs to go past the traditional areas and into more remote locations. These vehicles are made to transverse mud, sand, gravel and water where standard vehicles cannot go. Off-Road Vehicles sales have substantially increased over the last decade. Not surprisingly, ORV activities along the waterways also increased. In Texas, recent attention has focused on the Nueces River Basin where it is not uncommon to see 50-100 ORVs in and around the river. Organized rallies can result in even greater numbers. A common concern between ecologists and environmental groups is the degree of effect these vehicles have on sensitive ecosystems.

The natural resources of Texas include 15 major river basins and to date, ORV activity has been documented in eight of them (Gordon Linam, pers. com.). Accordingly, Texas probably has the greatest diversity of waterways than any other state (Belisle and Josselet, 1974). Most of the other states have vast amounts of federal lands, whereas, Texas being approximately 97% privately owned, has very little public lands. Since Texas has such a very small amount of public land set aside as parks and forests, etc., navigable rivers and streams provide a significant source of public property. Public lands in Texas and other states typically have regulations and enforcement governing recreational activities and access. In Texas, minimal such consideration and planning has been given to ORV use in waterways. While the concerns of ORV traffic on the ecosystem has been studied for the past 25 years throughout the United States, the information has been slow to reach Texas. To understand the effects of ORV traffic on the ecosystem, one must review literature that has been documented. While only limited research has been conducted in Texas, numerous other studies have been conducted in other states that we can draw from for better education.

According to Havlick (2002), ORV use near streams, rivers, and lakes, creates a serious water pollution threat. With ORV use exceeding 80 million visitor days in national forests alone including all terrain vehicles (ATVs), tens of millions of gallons of gasoline and motor oil likely enter the soils and waters of our public lands each year, as a result of inefficient combustion and emissions (Havlick, 2002). Oil has been observed on the gravel beds of the Nueces River and many vehicles frequently ford areas deep enough to dislodge or wash off engine fluids into the river. In Texas, response to concerns regarding negative ORV environmental impacts on riparian communities and endangered and threatened species, the United States Forest Service closed numerous off-road vehicle trails in the Angelina National Forest. These included red cockaded woodpecker areas, streamside and lakeshore zones to 100 feet, research natural areas, protected river and stream corridors, cultural areas and sensitive bog sites (Evans, 2001).

Soils in arid regions can be severely affected and damaged by ORV through disruption and compaction. Soil stabilizers include macrofloral elements (plants), microfloral elements (lichen, fungal, and algal crusts) and inorganic elements (soil crusts)(Wilshire, 1983). These natural soil protective elements in the desert are highly vulnerable to vehicle use. The force of rolling wheels on soil can cause compaction and have a serious long lasting negative effect (Webb, 1983). Soil compaction can decrease water infiltration, increase runoff, and cause severe erosion problems. Webb (1983), reported that soils most susceptible to compaction are loamy sands and gravelly soils with a wide range of particle sizes. These soil types are very similar to many areas along Texas rivers. Where riverbeds are predominantly gravel, ORV traffic frequently travels outside the gravel bed and onto upland habitat.

The majority of the earth's surface has been shaped through various forms of natural erosion including water, wind, and mechanical. Water is the most important erosive agent, either flowing across land or in rivers and streams (Hinckley et al, 1983). Mechanical or man induced erosion can accelerate the natural processes of water and wind erosion. In the Nueces River Basin, greater erosion was documented in areas with off-road vehicle use, where floodwaters removed and redistributed gravel, than in areas where off-road vehicle traffic was absent (Taylor, 2001; Garrett, 2001).

According to Hinckly et al. (1983), ORV increases overland flow sediment transport capacity by causing surface changes that alter runoff hydraulics and that channelization in vehicle tracks has especially important implications for accelerated erosion. Obstructions to overland flow are smoothed, resulting in greater flow rates over riparian areas, often leading to erosion and the creation of channels and gullies. Hinckly et al., (1983) and Kirkby and Kirkby (1974) noted that measurable erosion on natural desert hill slopes was often confined to areas of channelized flow. These studies corroborate Texas Parks and Wildlife (TPW) biologists' observations within the Nueces River Basin where water is channeled through vehicle tracks. As the degree of slope length increases, the magnitude of net erosion caused by ORV traffic reduces infiltration rates and surface roughness markedly increase (Hinckley et al, 1983). Off-Road Vehicle traffic can change the speed, timing, quantity, and quality of water moving through the landscape.

Off-road vehicle induced rilling and gullying proceeds much more rapidly than other land use practices such as grazing. According to Heede (1970), rills and gullies were often discontinuous in natural undisturbed areas, consequently; water flow velocities and energies do not reach the large magnitudes attained by continuous flows. The tracks of ORVs, especially on erosion sensitive soil surfaces, form continuous rills and channels, which can grow into continuous gullies (Heede, 1983).

As with the physical effects of ORV on the ecosystem, the biological effects of ORV traffic on the ecosystem is just as alarming. Hall (1980) concluded that ORVs reduce perennial and annual plant cover and density, and the overall above ground biomass. The degree of loss is dependent on the intensity of use, although the terms moderate and heavy use are relative and may vary from site to site. Smaller shrubs are often the first to be damaged or eliminated.

Payne et al. (1983), found that losses of plant species increased as the summer progressed due to the phenology of the plant. In the spring, grasses and forbs are growing and more pliable; however, as the plant matures it becomes drier and brittle making it more susceptible to loss. A single vehicle pass can destroy or disrupt many types of plants, microfloral crusts, and soil. Plants with shallow root systems typical of many of the desert and arid region species are especially vulnerable. Certain tough, deep-rooted plants may require many passes to destroy (Wilshire, 1983; Lacey et al.1997). The loss of vegetative cover increases susceptibility to wind and water erosion, which accelerates decomposition of remaining organic matter, weakens soil aggregate stability, and results in the formation of inorganic surface crusts. These surface crusts increase runoff, inhibit the germination and emergence of seedlings, and reduce water penetration, resulting in a harsher environment for plants and animals to survive (Dregne, 1983). In southwest Texas, where droughts are frequent and the summers are very hot and dry, the chances of vegetation damage is great, as the plants are less likely to reestablish at this time of year. Unfortunately, this stress period for plants coincides with the peak use of ORV activities, thus magnifying the problem.

Additionally, ORVs are frequently cited as the key link in the spread of invasive or noxious plants that are becoming a threat to numerous grassland and forest ecosystems in the United States. A study in Montana found that the undesirable spotted knapweed could hitchhike thousands of seeds on the undercarriage of ORVs for distances of up to 10 miles (Lacey et al., 1997). Restoration of disturbed lands occurs only through the process of natural revegetation and recovery may take many years (Lathrop and Rowlands, 1983). Although frequent floods occur within the confines of river systems, ORV interrupts the natural process of revegetation, even on a temporary scale.

In addition to stirring up sediment and increased stream bank erosion when ORVs ford streams, the loss of vegetation in riparian areas may result in increased water temperatures and turbidity (from suspended solids). Elevated water temperatures reduce the solubility of dissolved oxygen and decrease the oxygen carrying capacity of the water. These high temperatures increase metabolism, respiration, and oxygen demand of fish and other aquatic organisms (Kolbe and Luedke, 1993). Turbidity reduces the penetration of sunlight into the water that may affect the primary producers such as algae, phytoplankton, and other aquatic plants; thus potentially limiting photosynthetic activity, which many organisms depend on for survival (Kolbe and Luedke, 1993). Suspended solids can settle over eggs and fish nests resulting in lower reproductive rates, as well as disrupts the food base filling the interstitial spaces between larger substrates such as gravel and cobble rendering this habitat as marginal at best for those macro invertebrates which typically reside in these spaces. The changes in the physical characteristics of streams and rivers can critically affect aquatic insects, fish, and other animals who depend upon clear cold waters for habitat, spawning, or food (Hynes, 1987, in Havlick, 2002).

Lathrop and Rowlands (1983) stated "the desert is not as "tough" as some off-road enthusiasts have so glibly put it, and restoration as a management objective is for all practical purposes unattainable as long as ORV activity occurs, even on a regular basis". Similar statements have been made regarding Texas rivers and that ORV traffic traveling within the riverbed are no more damaging to the physical and biological features of the river than naturally occurring floods. In the Angelina National Forest, Evans (2001) observed that the banks were cut and collapsing where ORV trails traversed the sites along the Angelina River, resulting in a loss of habitat for benthic macro invertebrates and the reduction of vegetation.

Benthic communities are macro-invertebrates living in, or on the bottom, or attached to substrate on the bottom of aquatic systems and are frequently used to assess water quality (Evans, 2001). Example of benthic communities include may flies, dobson flies and damsel flies which exhibit a range of responses to environmental stress. Evans (2001), found statistically significant effects from ORV on benthic macroinvertebrates and water quality in pools. Repeated benthic community sampling conducted by the Nueces River Authority staff indicated significant differences exists between disturbed versus non disturbed riffle areas at various locations along the Nueces River (Sky Lewey, pers.comm.). In the Angelina National Forest, Evans (2001), observed habitat deterioration and erosion at each ORV crossing site that was not reported in the ecological analysis. This analysis agrees with the unpublished reports submitted by Texas Parks and Wildlife biologists in their assessments of ORV disturbance in the Nueces River Basin (Garrett, 2001; Taylor, 2001).

A preliminary assessment by TPW indicated that ORV does have an effect on the aquatic communities of the Nueces River (Taylor, 2001; Garrett, 2001). Garrett (2001), compared an impacted site to an unimpacted site and documented that 79% of the fish at the impacted site were comprised of environmentally tolerant species and that environmentally sensitive species were absent. At the unimpacted site numerous indicator species were found that require clean, flowing water, aquatic macrophytes and sand and gravel for spawning. These characteristics were absent at the impacted site. Taylor (2001), observed numerous areas where vegetation was impacted including loss of first stage growth, roots above ground and uprooted grasses, bank destabilization, cut banks, diverted stream flows, and extensive pollution. This author conducted site and photo comparisons of pre-flood and post flood area. It was clearly documented that gravel was lost and moved from locations where ORV traffic had previously followed the side of the river bed, whereas an unimpacted island within the Nueces river with adequate grass, shrubs, and trees showed very little disruption by the major flood (Fig. 1).

Havlick (2002), cites numerous investigations that indicate wildlife including birds, reptiles, and large ungulates respond to disturbance with accelerated heart rate and metabolic function, and suffer from increased levels of stress. These factors can lead to displacement, mortality, and reproductive failure. He also noted wildlife will tend to avoid areas with high disturbance levels. The direct effects of ORV on wildlife have been documented in various areas throughout the desert southwest. Noise may negatively affect certain small mammals and reptiles by interfering with their specialized senses used for protection from predators and to find prey themselves. Studies on desert kangaroo rats have shown that noise from ORV can directly impact these senses causing frantic behavior, ear bleeding and temporary loss of hearing. The magnitudes and frequencies of sounds generated by ORV in the California desert had direct impacts on populations of desert kangaroo rats and presented a clear and present danger to the well being of the natural wildlife of the arid regions. Brattstrom and Bondello (1983), found that the acoustical sound of dune buggies induced hearing loss in the Mojave fringe-toed lizard even under moderate intensity of short duration. In another study, motorcycle sounds of intermediate intensity caused a captive burrowed Couch's spadefoot toad to emerge from underground. These toads generally burrow underground and emerge following thunderstorms primarily to breed. Premature immergence prior to the natural season of the toad may have devastating effects due to stress, dehydration, and lack of available food. Ultimately ORVs could have a disruptive influence on these populations (Battstrom and Bondello, 1983). Similar effects on small mammals and reptiles in the arid regions of Texas may also take place.

Wildlife depends upon soils, plants, air, and water to survive for their sustenance and shelter. When any of these natural requirements are altered, dependent wildlife will be affected (Havlick, 2002). Whereas the indirect effects of ORV have been documented, direct effects include increased mortality by accidental collisions with wildlife species, which may resting or loafing under rocks or brush in the heat of the day (Havlick, 2002). Additionally, access to more remote areas may increase the likelihood of poaching, thus impacting the economics of wildlife enterprises.

During the last 25 years, use of public areas has greatly increased throughout the United States including Texas. While the concerns of ORV traffic on the ecosystem has been studied for the past 25 years throughout the U.S., the information has been slow to reach Texas. Research and literature regarding the issues of ORV overwhelmingly document the negative impact the environment sustains from them. Throughout the United States, these impacts adversely affect natural ecosystems including erosion, soil compaction, bank stability, water quality, destruction and loss of vegetation, aquatic losses, and wildlife impacts. This is especially true in sensitive and arid areas. Recovery times are dependent on many factors including soil types, magnitude of soil compaction, rainfall rates, propagation rates of vegetation, and the degree of human disturbance (Webb et al., 1983). Webb et al. (1983) state, "It is clear that the full recovery time required to ameliorate severe ORV impacts probably should be estimated in terms of human life spans". As the human population in Texas grows, there will be an ever-increasing demand outdoor recreation. The effect this demand has on our natural resources needs to be carefully considered and strategic plans developed to cope with conflicts, which will certainly arise in the future.

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Figure 1. Using the encircled rock as a point of reference, one can evaluate the loss of gravel accelerated by ORV traffic (mechanical erosion) between the pre-flood (A) and post-flood (B) photographs.