Environmental Impacts of Mountain Biking: Science Review and Best Practices

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Mountain biking is still a relatively new activity whose environmental impact and contribution to trail degradation is poorly understood. As with all recreational pursuits, it is clear that mountain biking contributes some degree of environmental degradation. In the absence of adequate research, land and trail managers have frequently been cautious, implementing restrictive regulations in some instances (Edger 1997). Surveys of managers have shown that they frequently perceive mountain biking to be a substantial contributor to trail degradation but lack scientific studies or monitoring data to substantiate such concerns (Chavez and others 1993; Schuett 1997). In recent years, however, a small number of studies have been conducted that help clarify the environmental impacts associated with mountain biking. This article describes the general impacts associated with recreational uses of natural surface trails, with a focus on those studies that have examined mountain biking impacts.

Trails are generally regarded as essential facilities in parks and forests. They provide access to remote areas, accommodate a diverse array of recreational activities, and protect resources by concentrating visitor trampling on narrow and resistant tread surfaces. Formal or designated trails are generally designed and constructed, which involves vegetation removal and soil excavation. These changes may be considered "unavoidable," in contrast to "avoidable" post-construction degradation from their subsequent use (e.g., trail widening, erosion, muddiness), or from the development and degradation of informal visitor-created trails.

Common environmental impacts associated with recreational use of trails include:

- Vegetation loss and compositional changes
- Soil compaction
- Erosion
- Muddiness
- Degraded water quality
- Disruption of wildlife

This article is organized into four broad categories: impacts to vegetation, soil, water, and wildlife.

Impacts to Vegetation: General Research

On formal trails, most vegetation is typically removed by construction, maintenance, and visitor use. This impact is necessary and "unavoidable" in order to provide a clear route for trail users. One goal of trail construction and maintenance is to provide a trail only wide enough to accommodate the intended use. Trails made wider than this through visitor use or erosion represent a form of "avoidable" impact. For example, a doubling of trail width represents a doubling of the area of intensive trampling disturbance. Wider trails also expose substantially greater amounts of soil to erosion by wind or water.

The creation and maintenance of trail corridors also removes shrubs and trees, allowing greater sunlight exposure that favors a different set of groundcover plants within trail corridors. Occasional trailside trampling within trail corridors also favors the replacement of fragile plants with those more resistant to trampling traffic. For example, shade-tolerant but fragile broadleaved herbs are frequently replaced by grasses and sedges that are trampling-resistant and require more sunlight to survive. Trail construction, use, and maintenance can also be harmful when trails divide sensitive or rare plant communities.

Trampling—the action of crushing or treading upon vegetation, either by foot, hoof, or tire—contributes to a wide range of vegetation impacts, including damage to plant leaves, stems, and roots, reduction in vegetation height, change in the composition of species, and loss of plants and vegetative cover (Leung & Marion, 1996; Thurston & Reader, 2001). Trampling associated with "avoidable" off-trail traffic can quickly break down vegetation cover and create a visible route that attracts additional use. Complete loss of vegetation cover occurs quickly in shady forested areas, less quickly in open areas with resistant grassy vegetation. Regardless, studies have consistently revealed that most impact occurs with initial or low use, with a diminishing increase in impact associated with increasing levels of traffic (Hammit & Cole, 1998; Leung & Marion, 1996). Furthermore, once trampling occurs, vegetative recovery is a very slow process.

Compositional changes in the vegetation along trail corridors can have both beneficial and adverse effects. Trampling-resistant plants provide a durable groundcover that reduces soil loss by wind and water runoff, and root systems that stabilize soils against displacement by heavy traffic. The ecological impacts of such compositional changes are not fully known, except when non-native vegetation is introduced to and spreads along trail corridors. Many of these species are disturbance-associated and are naturally limited to areas where the vegetation is routinely trampled or cut back. However, a few non-native species, once introduced to trail corridors, are able to out-compete native plants and spread away from the trail corridor in undisturbed habitats. Some of these species form dense cover that crowd out or displace native plants. These "invasive" species are particularly undesirable and land managers actively seek to prevent their introduction and spread. Unfortunately their removal is difficult and expensive.

Impacts to Vegetation: Mountain Biking-Specific Research

Only one study found specifically addresses the vegetation impacts associated with mountain biking. Thurston and Reader (2001) conducted an experimental trampling study involving mountain bikers and hikers in Boyne Valley Provincial Park of Ontario, Canada. The researchers measured plant density (number of stems/area), diversity (number of species present), and soil exposure (area of mineral soil exposed) before and after 500 one-way passes by bikers and hikers.

Data analysis and statistical testing revealed that the impacts of hiking and biking were not significantly different for the three indicators measured. They also concluded that impacts from both hikers and bikers were spatially confined to the centerline of the lane (trail).

Impacts to Vegetation: Management Implications

Trail managers can either avoid or minimize impacts to vegetation through careful trail design, construction, maintenance, and management of visitor use. Here are some recommendations to reduce vegetation impacts:

- Design trails that provide the experience that trail users seek to reduce their desire to venture off-trail.
- Locate trails away from rare plants and animals and from sensitive or critical habitats of other species. Involve resource professionals in designing and approving new trail alignments.
- Keep trails narrow to reduce the total area of intensive tread disturbance, slow trail users, and minimize vegetation and soil impacts.
- Limit vegetation disturbance outside the corridor when constructing trails. Hand construction is least disruptive; mechanized construction with small equipment is less disruptive than full-sized equipment; skilled operators do less damage than those with limited experience.
- Locate trails on side-hills where possible. Constructing a side-hill trail requires greater initial vegetation and soil disturbance but sloping topography above and below the trail bench will clearly define the tread and concentrate traffic on it. Trails in flatter terrain or along the fall line may involve less initial disturbance but allow excessive future tread widening and off-tread trampling, which favor non-native plants.
- Use construction techniques that save and redistribute topsoil and excavated plants.

There are also important considerations for maintaining and managing trails to avoid unnecessary ongoing impacts to vegetation:

- While it is necessary to keep the trail corridor free of obstructing vegetation, such work should seek to avoid "day-lighting" the trail corridor when possible. Excessive opening of the overstory allows greater sunlight penetration that permits greater vegetation compositional change and colonization by non-native plants.

• An active maintenance program that removes tree falls and maintains a stable and predictable tread also encourages visitors to remain on the intended narrow tread. A variety of maintenance actions can discourage trail widening, such as only cutting a narrow section out of trees that fall across the trail, limiting the width of vegetation trimming, and defining trail borders with logs, rocks, or other objects that won't impede drainage.

• Use education to discourage off-trail travel, which can quickly lead to the establishment of informal visitor-created trails that unnecessarily remove vegetation cover and spread non-native plants. Such routes often degrade rapidly and are abandoned in favor of adjacent new routes, which unnecessarily magnify the extent and severity of trampling damage.

• Educate visitors to be aware of their ability to carry non-native plant seeds on their bikes or clothing, and encourage them to remove seeds by washing mud from bikes, tires, shoes, and clothing. Preventing the introduction of non-natives is key, as their subsequent removal is difficult and costly.

• Educate visitors about low impact riding practices, such as those contained in the IMBA-approved Leave No Trace Skills & Ethics: Mountain Biking booklet (www.LNT.org).

For further reading see: Cessford 1995; Gruttz and Hollingshead 1995; Thurston and Reader 2001.

Impacts to Soils: General Research

The creation and use of trails also results in soil disturbance. Some loss of soil may be considered an acceptable and unavoidable form of impact on trails. As with vegetation loss, much soil disturbance occurs in the initial construction and use of the trail. During trail construction, surface organic materials (e.g., twigs, leaves, and needles) and organic soils are removed from treads; trails built on sidehill locations require even more extensive excavation. In addition, the underlying mineral soils are compacted during construction and initial use to form a durable tread substrate that supports trail traffic.

In contrast, post-construction soil displacement, erosion, and muddiness represent core forms of avoidable trail impact that require sustained management attention to avoid long-lasting resource degradation. This degradation can reduce the utility of trails as recreation facilities and diminish the quality of visitor experiences. For example, soil erosion exposes rocks and plant roots, creating a rutted and uneven tread surface. Erosion can also be self-perpetuating when treads erode below the surrounding soil level, hindering efforts to divert water from the trail and causing accelerated erosion and muddiness. Similarly, excessive muddiness renders trails less usable and aggravates tread widening and associated vegetation loss as visitors seek to circumvent mud holes and wet soils (Marion, 2006).

Research has shown that visitors notice obvious forms of trail impact, such as excessive muddiness and eroded ruts and tree roots, and that such impacts can degrade the quality of visitor experiences (Roggenbuck and others., 1993; Vaske and others., 1993). Such conditions also increase the difficulty of travel and may threaten visitor safety. Remedying these soil impacts can also require substantial rehabilitation costs. Clearly, one primary trail management objective should be the prevention of excessive soil impacts. Let's examine four common forms of soil impact in greater detail:

The Four Common Forms of Soil Degradation on Trails:

- Compaction
- Muddiness
- Displacement
- Erosion

Compaction: Soil compaction is caused by the weight of trail users and their equipment, which passes through feet, hooves, or tires to the tread surface.

Compacted soils are denser and less permeable to water, which increases water runoff. However, compacted soils also resist erosion and soil displacement and provide durable treads that support traffic. From this perspective, soil compaction is considered beneficial, and it is an unavoidable form of trail impact. Furthermore, a primary resource protection goal is to limit trailside impacts by concentrating traffic on a narrow tread. Success in achieving this objective will necessarily result in higher levels of soil compaction.

The process of compacting the soil can present a difficult challenge, especially on new trails. Unless soils are mechanically compacted during tread construction, initial use compacts the portions of the tread that receive the greatest traffic, generally the center. The associated lowering of the tread surface creates a cupped cross-section that intercepts and collects surface water. In flat terrain this water can pool or form muddy sections; in sloping terrain the water is channeled down the trail, gaining in volume, speed, and erosive potential.

Displacement: Trail users can also push soil laterally, causing displacement and development of ruts, berms, or cupped treads. Soil displacement is particularly evident when soils are damp or loose and when users are moving at higher rates of speed, turning, braking, or other movements that create more lateral force. Soil can also be caught in hooves, footwear, or tire treads, flicked to the side or carried some distance and dropped. Regardless of the mechanism, soil is generally displaced from the tread center to the sides, elevating inslopes or berms, and compounding drainage problems.

Muddiness: When trails are located in areas of poor drainage or across highly organic soils that hold moisture, tread muddiness can become a persistent problem. Muddiness is most commonly associated with locations where water flows across or becomes trapped within flat or low-lying areas. Soil compaction, displacement, and erosion can exacerbate or create problems with muddiness by causing cupped treads that collect water during rainfall or snowmelt. Thus, muddiness can occur even along trails where there is sufficient natural drainage. Subsequent traffic skirts these problem spots, compacting soils along the edges, widening mud holes and tread width, and sometimes creating braided trails that circumvent muddy sections.

Erosion: Soil erosion is an indirect and largely avoidable impact of trails and trail use. Soil can be eroded by wind, but generally, erosion is caused by flowing water. To avoid erosion, sustainable trails are generally constructed with a slightly crowned (flat terrain) or outsloped (sloping terrain) tread. However, subsequent use compacts and/or displaces soils over time to create a cupped or insloped tread surface that intercepts and carries water. The concentrated run-off picks up and carries soil particles downhill, eroding the tread surface.

Loose, uncompacted soil particles are most prone to soil erosion, so trail uses that loosen or detach soils contribute to higher erosion rates. Erosion potential is closely related to trail grade because water becomes substantially more erosive with increasing slope. The size of the watershed draining to a section of trail is also influential—larger volumes of water are substantially more erosive.

Water and the sediment it carries will continue down the trail until a natural or constructed feature diverts it off the tread. Such features include a natural or constructed reversal in grade, an outsloped tread, rocks or tree roots, or a constructed drainage dip or water bar. Once the water slows, it drops its sediment load, filling in tread drainage features and causing them to fail if not periodically maintained. Sediment can also be carried directly into watercourses, creating secondary impacts to aquatic systems. Properly designed drainage features are designed to divert water from the trail at a speed sufficient to carry the sediment load well below the tread, where vegetation and organic litter can filter out sediments. A well-designed trail should have little to no cumulative soil loss, for example, less than an average of one-quarter inch (6.3 mm) per year.

Impacts to Soils: Mountain Biking-Specific Research

Several studies have evaluated the soil impacts of mountain biking.

Wilson and Seney (1994) evaluated tread erosion from horses, hikers, mountain bikes, and motorcycles on two trails in the Gallatin National Forest, Montana. They applied one hundred passes of each use-type on four sets of 12 trail segments, followed by simulated rainfalls and collection of water runoff to assess sediment yield at the base of each segment. Control sites that received no passes were also assessed for comparison. Results indicated that horses made significantly more sediment available for erosion than the other uses, which did not significantly vary from the control sites. Traffic on pre-wetted soils generated significantly greater amounts of soil runoff than on dry soils for all uses.

Marion (2006) studied 78 miles (125 km) of trail (47 segments) in the Big South Fork National River and Recreation Area, Tennessee and Kentucky, measuring soil loss along transects across the trail to evaluate the influence of use-related, environmental, and management factors. Sidehill-aligned trails were significantly less eroded than trails in valley bottom positions, in part due to the influence of periodic floods. Trail grade and trail alignment angle were also significant predictors of tread erosion. Erosion rates on trails with 0-6 percent and 7-15 percent grades were similar, while erosion on trails with grades greater than 16 percent were significantly higher. And there was significantly greater erosion on fall line trails (alignment angles of 0-22 degrees) than those with alignments closer to the contour.

This study also provided an opportunity to examine the relative contribution of different use types, including horse, hiking, mountain biking, and ATV. Trails predominantly used for mountain biking had the least erosion of the use types investigated. Computed estimates of soil loss per mile of trail also revealed the mountain biking trails to have the lowest soil loss.

White and others (2006) also examined trails predominantly used for mountain biking in five ecological regions of the Southwest along 163 miles (262 km) of trail. Two trail condition indicators, tread width and maximum incision, were assessed at each sample point. Results show that erosion and tread width on these trails differed little in comparison to other shared-use trails that receive little or no mountain biking.

Goeft and Alder (2001) evaluated the resource impacts of mountain biking on a recreational trail and racing track in Australia over a 12-month period. A variety of trail condition indicators were assessed on new and older trail segments with uphill, downhill, and flat trail sections. Results found that trail slope, age, and time were significant erosion factors, and that downhill slopes and curves were the most susceptible to erosion. New trails experienced greater amounts of soil compaction but all trails exhibited both compaction and loosening of soils over time. The width of the recreational trail varied over time, with no consistent trend, while the width of the racing trail grew following events but exhibited net recovery over time. Impacts were confined to the trail tread, with minimal disturbance of trailside vegetation.

Bjorkman (1996) evaluated two new mountain biking trails in Wisconsin before and for several years after they were opened to use. Vegetation cover within the tread that survived trail construction work declined with increasing use to negligible levels while trailside vegetation remained constant or increased in areas damaged by construction work. Similarly, soil compaction within the tread rose steadily while compaction of trailside soils remained constant. Vegetation and soil impacts occurred predominantly during the first year of use with minor changes thereafter.

Wohrstein (1998) evaluated the impacts from a World Championship mountain biking race with 870 participants and 80,000 spectators. Erosion was found only on intensively used racing trails in steep terrain where alignments allowed higher water runoff. The mountain biking routes exhibited higher levels of compaction but to a shallower depth in comparison to the spectator areas, where compaction was lower but deeper.

Cessford (1995) provides a comprehensive, though dated, summary of trail impacts with a focus on mountain biking. Of particular interest is his summary of the two types of forces exerted by bike tires on soil surfaces: The downward compaction force from the weight of the rider and bike, and the rotational shearing force from the turning rear wheel. Mountain bikers generate the greatest torque, with potential tread abrasion due to slippage, during uphill travel. However, the torque possible from muscle power is far less than that from a motorcycle, so wheel slippage and abrasion occur only on wet or loose surfaces. Tread impact associated with downhill travel is generally minimal due to the lack of torque and lower ground pressures. Exceptions include when riders brake hard enough to cause skidding, which displaces soil downslope, or bank at higher speeds around turns, which displaces soil to the outside of the turn. Impacts in flatter terrain are also generally minimal, except when soils are wet or uncompacted and rutting occurs.

Impacts to Soils: Management Implications

Soil loss is among the most enduring forms of trail impact, and minimizing erosion and muddiness are the most important objectives for achieving a sustainable trail. Soil cannot easily be replaced on trails, and where soil disappears, it leaves ruts that make travel and water drainage more difficult, prompting further impacts, such as trail widening.

Existing studies indicate that mountain biking differs little from hiking in its contribution to soil impacts. Other factors, particularly trail grade, trail/slope alignment angle, soil type/wetness, and trail maintenance, are more influential determinants of tread erosion or wetness.

There are a number of tactics for avoiding the worst soil-related impacts to trails:

• Discourage or prohibit off-trail travel. Informal trails created by off-trail travel frequently have steep grades and fall-line alignments that quickly erode, particularly in the absence of tread maintenance. Exceptions include areas of solid rock or non-vegetated cobble.

• Design trails with sustainable grades and avoid fall-line alignments. (See p. 112 for more)

• When possible, build trails in dry, cohesive soils that easily compact and contain a larger percentage of coarse material or rocks. These soils better resist erosion by wind and water or displacement by feet, hooves and tires.

• Minimize tread muddiness by avoiding flat terrain, wet soils, and drainage-bottom locations.

• Use grade reversals to remove water from trail treads. Grade reversals are permanent and sustainable—when designed into a trail's alignment they remain 100 percent effective and rarely require maintenance.

Other strategies are more temporary in nature and will require periodic maintenance to keep them effective:

• While the use of a substantial outslope (e.g., 5 percent) helps remove water from treads, it is rarely a long-term solution. Tread cupping and berm development will generally occur within a few years after tread construction. If it is not possible to install additional grade reversals, reshape the tread to reestablish an outsloped tread surface periodically, and install wheel-friendly drainage dips or other drainage structures to help water flow off the trail.

• If it is not possible to install proper drainage on a trail, consider rerouting trail sections that are most problematic, or possibly hardening the tread.

• In flatter areas, elevate and crown treads to prevent muddiness, or add a gravel/soil mixture in low spots.

Finally, it is important to realize that visitor use of any type on trails when soils are wet contributes substantially greater soil impact than the same activities when soils are dry. Thus, discouraging or prohibiting the use of trails that are prone to muddiness during rainy seasons or snowmelt is another effective measure. Generally such use can be redirected to trails that have design or environmental attributes that allow them to better sustain wet season uses.

For additional information about minimizing soil impacts through trail design, construction, maintenance, and tread hardening, see *Trail Solutions*.

Impacts to Water Resources: General Research

Trails and their use can also affect water quality. Trail-related impacts to water resources can include the introduction of soils, nutrients, and pathogenic organisms (e.g., Giardia), and alter the patterns of surface water drainage. However, in practice, these impacts are avoidable, and properly designed and maintained trails should not degrade water quality. Unfortunately there is very little research to draw from on these topics, and none that is specific to mountain biking.

Poorly sited and/or maintained trails can be eroded by water, with tread sediments carried off by runoff. Generally, if water control features such as grade reversals and outsloped treads are used to divert runoff from trails, the water drops its sediment close to trails, where it is trapped and held by organic litter and vegetation. Soils eroded from trails rarely enter water bodies, unless trails cross streams or run close to stream or lake shorelines and lack adequate tread drainage features. Since many recreational activities, such as fishing, swimming, boating, and viewing scenery (e.g., waterfalls) draw visitors and trails to the vicinity of water resources, it is often necessary to route trails to water resources or visitors will simply create their own informal trails.

Trails that are close to water resources require special consideration in their design and management to prevent the introduction of suspended sediments into bodies of water. Eroded soil that enters water bodies increase water turbidity and cause sedimentation that can affect aquatic organisms (Fritz and others 1993). Trout and other fish lay their eggs in gravels on the bottom of streams and lakes, and sediments can smother those eggs, reducing reproductive success. Sedimentation can also hurt invertebrate organisms, which serve as food for fish and other creatures. In addition, some sediment may contain nutrients that can contribute to algal blooms that deplete the dissolved oxygen in water bodies when they die off.

Poorly designed trails can also alter hydrologic functions—for instance, trails can intercept and divert water from seeps or springs, which serve important ecological functions. In those situations, water can sometimes flow along the tread, leading to muddiness or erosion and, in the case of cupped and eroded treads, the water may flow some distance before it is diverted off the trail, changing the ecology of small wetland or riparian areas.

Trail users may also pollute water with pathogenic organisms, particularly those related to improperly disposed human waste. Potential pathogenic organisms found through surveys of backcountry water sources include Cryptosporidium spp., Giardia spp., and Campylobacter jejuni (LeChevallier and others, 1999; Suk and others, 1987; Taylor and others, 1983). This is rarely a significant concern where trail use is predominantly day-oriented, and waste issues can be avoided by installing toilet facilities or following Leave No Trace practices (i.e., digging cat-holes for waste away from water resources).

Impacts to Water Resources: Management Implications

The same trail design, construction, and maintenance measures that help minimize vegetation and soil impacts also apply to water. But there are also some additional efforts needed to protect water resources:

• Trails should avoid close proximity to water resources. For example, it is better to build a trail on a sidehill along a lower valley wall than to align it through flat terrain along a stream edge, where trail runoff will drain directly into the stream.
• It is best to minimize the number of stream crossings. Where crossings are necessary, scout the stream carefully to select the most resistant location for the crossing. Look for rocky banks and soils that provide durable surfaces.
• Design water crossings so the trail descends into and climbs out of the steam crossing, preventing stream water from flowing down the trail.
• Armor trails at stream crossings with rock, geotextiles, or gravel to prevent erosion.
• Include grade reversals, regularly maintained outsloped treads, and/or drainage features to divert water off the trail near stream crossings. This prevents large volumes of water and sediment from flowing down the trail into the stream, and allows trailside organic litter, vegetation, and soils to slow and filter water.
• On some heavily used trails, a bridge may be needed to provide a sustainable crossing.
• Where permanent or intermittent stream channels cross trails, use wheel-friendly open rock culverts or properly sized buried drainage culverts to allow water to cross properly, without flowing down the trail.

Impacts to Wildlife: General Research

Trails and trail uses can also affect wildlife. Trails may degrade or fragment wildlife habitat, and can also alter the activities of nearby animals, causing avoidance behavior in some and food-related attraction behavior in others (Hellmund, 1998; Knight & Cole, 1991). While most forms of trail impact are limited to a narrow trail corridor, disturbance of wildlife can extend considerably further into natural landscapes (Kasworm & Monley, 1990; Tyser & Worley, 1992). Even very localized disturbance can harm rare or endangered species.

Different animals respond differently to the presence of trail users. Most wildlife species readily adapt or become "habituated" to consistent and non-threatening recreational activities. For example, animals may notice but not move away from humans on a frequently used trail. This is fortunate, as it can allow high quality wildlife viewing experiences for visitors and cause little or no impact to wildlife.

Other forms of habituation, however, are less desirable. Visitors who feed wildlife, intentionally or from dropped food, can contribute to the development of food-related attraction behavior that can turn wild animals and birds into beggars. In places where visitors stop to eat snacks or lunches, wildlife quickly learn to associate people with food, losing their innate fear of humans and returning frequently to beg, search for food scraps, or even raid unprotected packs containing food. Feeding wild creatures also endangers their health and well-being. For instance, after food-attracted deer in Grand Canyon National Park became sickly and dangerously aggressive, researchers found up to six pounds of plastic and foil wrappers obstructing intestinal passages of some individuals.

The opposite conduct in wildlife—avoidance behavior—can be equally problematic. Avoidance behavior is generally an innate response that is magnified by visitor behaviors perceived as threatening, such as loud sounds, off-trail travel, travel in the direction of wildlife, and sudden movements. When animals flee from disturbance by trail users, they often expend precious energy, which is particularly dangerous for them in winter months when food is scarce. When animals move away from a disturbance, they leave preferred or prime habitat and move, either permanently or temporarily, to secondary habitat that may not meet their needs for food, water, or cover. Visitors and land managers, however, are often unaware of such impacts, because animals often flee before humans are aware of the presence of wildlife.

Impacts to Wildlife: Mountain Biking-Specific Research

The impacts of mountain biking on wildlife are similar to those of hikers and other non motorized trail users.

Taylor and Knight (2003) investigated the interactions of wildlife and trail users (hikers and mountain bikers) at Antelope Island State Park in Utah. A hidden observer using an optical rangefinder recorded bison, mule deer, and pronghorn antelope response to an assistant who hiked or biked a section of trail. The observer then measured wildlife reactions, including alert distance, flight response, flight distance, distance fled, and distance from trail. Observations revealed that 70 percent of animals located within 330 feet (100 m) of a trail were likely to flee when a trail user passed, and that wildlife exhibited statistically similar responses to mountain biking and hiking. Wildlife reacted more strongly to off-trail recreationists, suggesting that visitors should stay on trails to reduce wildlife disturbance. While Taylor and Knight found no biological justification for managing mountain biking any differently than hiking, they note that bikers cover more ground in a given time period than hikers and thus can potentially disturb more wildlife per unit time.

This study also surveyed 640 hikers, mountain bikers, and horseback riders on the island to assess their perceptions of the effects of recreation on wildlife. Most respondents felt they could approach animals far closer than the flight distance suggested by the research, and 50 percent felt that recreational uses did not have a negative effect on wildlife.

Another study evaluated the behavioral responses of desert bighorn sheep to disturbance by hikers, mountain bikers, and vehicles in low- and high-use areas of Canyonlands National Park (Papouchis and others., 2001). Following observations of 1,029 bighorn sheep/human interactions, the authors reported that sheep fled 61 percent of the time from hikers, 17 percent of the time from vehicles, and 6 percent of the time from mountain bikers. The stronger reaction to hikers, particularly in the high-use area, was attributed to more off-trail hiking and direct approaches to the sheep. The researchers recommended that park officials restrict recreational uses to trails, particularly during the lambing and rut seasons, in order to minimize disturbance.

An experimental study in Switzerland evaluated the disturbance associated with hiking, jogging, and mountain biking on high elevation chamois, which are goat-like mammals found in the European mountains (Gander & Ingold 1997). The authors assessed alert distance, flight distance, and distance fled, and found that approximately 20 percent of the animals fled from trailside pastures in response to visitor intrusions. The authors found no statistically significant differences, however, between the behavioral responses of animals to the three different types of user, and authors concluded that restrictions on mountain biking above timberline would not be justified from the perspective of chamois disturbance.

A study of the Boise River in Idaho examined flushing distances of bald eagles when exposed to actual and simulated walkers, joggers, fishermen, bicyclists, and vehicles (Spahr 1990). The highest frequency of eagle flushing was associated with walkers (46 percent), followed by fishermen (34 percent), bicyclists (15 percent), joggers (13 percent), and vehicles (6 percent). However, bicyclists caused eagles to flush at the greatest distances (mean = 148 meters), followed by vehicles (107m), walkers (87m), fishermen (64m), and joggers (50m). Eagles were most likely to flush when recreationists approached slowly or stopped to observe them, and were less alarmed when bicyclists or vehicles passed quickly at constant speeds. Similar findings have been reported by other authors, who attribute the difference in flushing frequency between walkers and bikers/vehicles either to the shorter time of disturbance and/or the additional time an eagle has to "decide" to fly (Van der Zande and others. 1984).

Safety issues related to grizzly bear attacks on trail users in Banff National Park prompted Herrero and Herrero (2000) to study the Morraine Lake Highline Trail. Park staff noted that hikers were far more numerous than mountain bikers on the trail, but that the number of encounters between bikers and bears was disproportionately high. For example, three of the four human-grizzly bear encounters that occurred along the trail during 1997-98 involved mountain bikers. Previous research had shown that grizzly bears are more likely to attack when they first become aware of a human presence at distances of less than 50 meters. Herrero and Herrero concluded that mountain bikers travel faster, more quietly, and with closer attention to the tread than hikers, all attributes that limit reaction time for bears and bikers, and increases the likelihood of sub-fifty meter encounters. In addition, most of the bear-cyclist encounters took place on a fast section of trail that went through high-quality bear habitat with abundant berries. To reduce such incidents, they recommended education, seasonal closures of the trail to bikes and/or hikers, construction of an alternate trail, and regulations requiring a minimum group size for bikers.

Impacts to Wildlife: Management Implications

Many potential impacts to wildlife can be avoided by ensuring that trails avoid the most sensitive or critical wildlife habitats, including those of rare and non-rare species. There are a number of tactics for doing this:

- Route trails to avoid riparian or wetland areas, particularly in environments where they are uncommon. Consult with fish and wildlife specialists early in the trail planning phase.
- For existing trails, consider discouraging or restricting access during sensitive times/seasons (e.g., mating or birthing seasons) to protect wildlife from undue stress.

The education of trail users is also an important and potentially highly effective management option for protecting wildlife. Organizations should encourage Leave No Trace practices and teach appropriate behaviors in areas where wildlife are found:

- Store food safely and leave no crumbs behind—fed animals too often become dead animals.
- It's OK for wildlife to notice you but you are "too close" or "too loud" if an animal stops what its doing and/or moves away from you.
- It's best to view wildlife through binoculars, spotting scopes, and telephoto lenses.
- All wildlife can be dangerous—be aware of the possible presence of animals and keep your distance to ensure your safety and theirs.

Conclusion

While land managers have long been concerned about the environmental impacts of mountain biking, there are still very few good studies published in peer-reviewed journals. White and others (2006) and Hendricks (1997) note that the majority of mountain biking research has focused on social issues, such as conflicts between trail users. As a consequence, the ecological effects of mountain biking on trails and natural resources remain poorly understood.

Still, an emerging body of knowledge on the environmental impact of mountain biking can help guide current management decisions. All of the existing scientific studies indicate that while mountain biking, like all forms of recreational activity, can result in measurable impacts to vegetation, soil, water resources, and wildlife, the environmental effects of well-managed mountain biking are minimal.

Furthermore, while the impact mechanics and forces may be different from foot traffic, mountain biking impacts are little different from hiking, the most common and traditional form of trail-based recreational activity.

Key observations about the environmental impacts of mountain biking:

1) Environmental degradation can be substantially avoided or minimized when trail users are restricted to designated formal trails. Many studies have shown that the most damage to plants and soils occur with initial traffic and that the per capita increase in further impact diminishes rapidly with increasing subsequent traffic. Many environmental impacts can be avoided and the rest are substantially minimized when traffic is restricted to a well-designed and managed trail. The best trail alignments avoid the habitats of rare flora and fauna and greatly minimize soil erosion, muddiness, and tread widening by focusing traffic on side-hill trail alignments with limited grades and frequent grade reversals. Even wildlife impacts are greatly minimized when visitors stay on trails; wildlife have a well-documented capacity to habituate to non-threatening recreational uses that occur in consistent places.

2) Trail design and management are much larger factors in environmental degradation than the type or amount of use. Many studies have demonstrated that poorly designed or located trails are the biggest cause of trail impacts. As evidence, consider that use factors (type, amount, and behavior of trail visitors) are generally the same along the length of any given trail, yet there is often substantial variation in tread erosion, width, and muddiness. These impacts are primarily attributable to differences in grade and slope alignment angle, soil type and soil moisture, and type of tread construction, surfacing, and drainage. This suggests that a sustainable trail that is properly designed, constructed, and maintained can support lower-impact uses such as hiking and mountain biking with minimal maintenance or degradation.

3) The environmental degradation caused by mountain biking is generally equivalent or less than that caused by hiking, and both are substantially less impacting than horse or motorized activities. In the small number of studies that included direct comparisons of the environmental effects of different recreational activities, mountain biking was found to have an impact that is less than or comparable to hiking. For example, Marion and Olive (2006) reported less soil loss on mountain bike trails than on hiking trails, which in turn exhibited substantially less soil loss than did horse and ATV trails. Similarly, two wildlife studies reported no difference in wildlife disturbance between hikers and mountain bikers (Taylor & Knight 2003, Gander & Ingold 1997), while two other studies found that mountain bikers caused less disturbance (Papouchis and others. 2001, Spahr 1990). Wilson and Seney (1994) found that horses made significantly more sediment available for erosion than hikers or mountain bikers, which were statistically similar to the undisturbed control. One final point to consider, however, is that mountain bikers, like horse and vehicle users, travel further than hikers due to their higher speed of travel. This means that their use on a per-unit time basis can affect more miles of trail or wildlife than hikers. However, an evaluation of aggregate impact would need to consider the total number of trail users, and hikers are far more numerous than mountain bikers.

Mountain Bike Management Implications

So what does this mean for mountain biking? The existing body of research does not support the prohibition or restriction of mountain biking from a resource or environmental protection perspective. Existing impacts, which may be in evidence on many trails used by mountain bikers, are likely associated for the most part with poor trail designs or insufficient maintenance.

Managers should look first to correcting design-related deficiencies before considering restrictions on low-impact users. By enlisting the aid of all trail users through permanent volunteer trail maintenance efforts, they can improve trail conditions and allow for sustainable recreation.

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Ecological Impacts of Mountain Biking: A Critical Literature Review

Introduction

In the post-World War II period, public interest in outdoor recreation has grown steadily. As affluence and leisure time have increased, use of public lands for recreation has risen steadily, often exceeding 10% annual growth rates through the 1960s (Knight, 1995). Today, in many areas, intensive activity by recreational users, not industrial enterprise, poses the chief challenge for land managers and activists (Knight, 1995).

In recent years, participation in some recreational pursuits has grown at a much faster rate than others. Mountain biking, in particular, has expanded rapidly. In this announcement it reported "an estimated 13.5 million mountain bicyclists visit public lands each year to enjoy the variety of trails. What was once a low use activity that was easy to manage has become more complex" (BLM, 2002). Despite this, there is currently a relative lack of scientific literature on the differential effects of mountain biking on natural systems. While the effects of recreation generally have been well studied, the extent to which mountain bicyclists affect natural systems differently remains only thinly represented in the literature (Knight, pers. comm.).

This paper will undertake a comparative review of the extant scientific literature on the impact of recreational mountain biking on ecological systems. It will then identify key areas of weakness in the literature and suggest a framework for future research.

A note on political context

This has proven to be an interesting time to write this report. The Bureau of Land Management in November finalized and released their National Mountain Bicycling Strategic Action Plan. This document will guide local land managers across the United States as they develop their approach to mountain bike recreation in their territories. In addition, California Senator Barbara Boxer has introduced a bill into the U.S. Senate (California Wild Heritage Act of 2002) that would expand California's total 14 million acres of designated wilderness by 2.7 million acres. The International Mountain Bicycling Association, now a mature, well-funded advocacy group objects to about half of the proposed new areas because they encompass current mountain biking trails. Once designated as wilderness all mechanical conveyances, including bicycles, would be banned.

As the numbers of recreational users, wilderness advocates, and industrial firms in the United States continues to increase, political controversy over America's backcountry will only intensify and become more complex. Generally, this controversy is centered on on-site conflicts between user groups (the purview of the local regime) or political conflicts between advocacy groups representing, generally speaking, certain user groups (a question of status under the 1964 Wilderness Act).

Scientific issues

Like all recreational groups, mountain bikers affect the land they use. As the numbers of mountain bikers have increased steadily and as improving technology has increased their range, these affects have increased. These impacts can be classified, broadly, into the following categories:

- "Trampling:" Defined as the mechanical destruction and mortality of ground level vegetation on undeveloped terrain (off-trail).
- "Erosion:" Defined as the mechanical mobilization of sediment. In an off-trail context, this is related to trampling. For the most part, when erosion is studied individually, it is in the context of a developed trail.
- "Wildlife disturbance:" The disruption of animal ecosystems through human presence, leading to added stress and consequent affects on populations and individuals.

Long intuitively grouped with other "ecologically friendly" users such as hikers, mountain bikes are regarded to be relatively low impact in these categories. However, there really isn't much data currently showing that mountain bikers do, in fact, impact land similarly to hikers. On the other hand, as it turns out, there is also very little data showing they don't.
Differences between bicyclists and other user groups can generally be divided into two categories:

- Behavioral
- Mechanical

The clearest if these two differences are the mechanical. A mountain bike tire, propelled by human power, would seem intuitively to exert much less erosive force on trails and vegetative cover than a motorcycle tire. However, it may inflict sufficient damage to these surfaces to be better grouped with a motorcycle than with a hiker. Further, the distance a bicyclist can travel in an hour with the advantage of modern gearing far exceeds that of a hiker. A mountain bike traveling downhill at a high speed might stress wildlife more than a hiker.

However, there may also be behavioral differences between groups. It could be that bicyclists are more (or less) likely to go off-trail, cut switchbacks, or litter in the backcountry. Mountain bicyclists may be more prone to bringing off-leash dogs that harass wildlife. This study will focus on the scientific literature as it addresses impact differences between hikers and bicyclists. To the extent that credible experimental treatment design must attempt to reflect real-world use of wilderness areas, some behavioral attributes of hikers and bikers (e.g. how fast they travel) are an important component of any study. In fact, a lack of this tends to be a weakness of all experimental designs discussed here.

Behaviors characteristic of mountain bikers but not necessarily of the bikes themselves (i.e. higher propensity to litter as opposed to speed of travel) will not be addressed in this report as they vary from location to location. For example, some areas are likely to be near a population center with riders willing to build illegal trails, while other areas may have fewer such riders. Such issues are questions for local management and enforcement; the study of them requires sociological methods.

Vegetation affects: Trampling
Trampling is the mechanical exertion of force on a vegetative structure. The total amount of damage inflicted on vegetation can be understood as a function of the energy released onto the structures by the means of transportation (York, 2000). Terence York has developed a general model for understanding the varying impact of different modes of travel:

Land Impact = ((weight + output acceleration) x swath)).

In the above equation, "Output Acceleration" is defined as vehicle power (horsepower) divided by its mass. "Swath" is the width of the vehicles track (tire, foot, or tank-style track) multiplied by its length of travel.

York's methodology provides a very useful analytic framework for examining the amount of energy transmitted to plant structures by various modes of travel. He applies this formula to a range of common modes of transportation, from hiker to military battle tank.

There are some problems with this method of measuring a vehicle's impact on land, particularly when evaluating a specific user type in a specific area. For example, it has been shown that motorcycles actually widen and deepen downhill sections of trail less than horses, but more than horses on uphill sections of trail (Weaver, 1978). This is explained by the fact that walkers (human or animal) must check their speed as they proceed downhill by generating friction with the ground surface. Wheel-driven vehicles can check their speed by using braking mechanisms integral to the vehicle, without necessarily applying a shearing force to the soil surface. Though, again, operator skill and decisions can influence this, as in the case of a novice mountain biker skidding downhill.
These problems with applying this framework to actual results in the field cited above, suggest some limitations as a practical tool for managing land use. However, according to York, "the weight, power, and swath equation that was presented here is consistent with long term observations of vegetation, soil, and pavement changes following land use" (York, 1997).

York (1997) further conducted a meta-analysis of the 400 citations dealing with the impact of foot and vehicle impacts on vegetation, "Toleration of Traffic by Vegetation: Life Form Conclusions and Summary Extracts from Comprehensive Data Base" (York 1997). In this study, he distilled the data into a uniform Access database format. York's work provides a very useful examination of trampling studies, only two thirds of which were sufficiently detailed for York to normalize the data for the purposes of his database. With others he made some compromises, reducing the level of detail in some to allow comparability among various data sources.

Given the constraints he faced in aggregating diverse studies utilizing differing endpoints, York reached some interesting conclusions about the effects of trampling. First, graminoids appear to have the greatest resistance and recovery capacity among plant forms. Climbers and cactoids are the most vulnerable overall to trampling. Shrubs and trees suffer the greatest long-term reductions in diversity following traffic impact.

While all vegetation forms suffer impact linearly increasing from added traffic as predicted by York's (2000) overall formula, this database is telling in its lack of attention to the affects of mountain bikes specifically. None of York's records includes a specific mention of the application of trampling by mountain bike users, though an otherwise wide array of conveyances is listed (from hikers to armored vehicles).

I can only speculate as to the reason from personal observation: Unlike other user groups, there is very little use of mountain bikes off-trail. In fact, for the majority of the mountain bikers, the trail is the most desirable place to ride for safety and pleasure. Hikers often wander off trail, regarding their own diffuse impact as negligible. Other groups, such as ORVs and four-wheel drive light trucks often regard off-trail travel as the point of their sport. Military tank are used off-trail in a localized but intensive manner for training purposes.

York's work provides a macro-level analysis of the various mechanisms by which human movement through ecological systems damages vegetation. However, it does not provide an in-depth examination of effects on a very local level. York's work is in part a response to the difficulty in making management decisions based on all the extant knowledge about trampling on vegetation (York, 1997).
Cole and Bayfield (1992) proposed a set of standard experimental procedures for studying the recreational trampling of vegetation. This is an effort "to promote an increased ability to compare results from different studies" (Cole and Bayfield, 1993). When such forces are applied, changes in vegetation can be measured using two primary measures, relative cover and relative height. In both cases, "conditions after trampling are expressed as a proportion of the initial conditions, with a correction factor applied to account for spontaneous changes on the control plot (Cole and Bayfield, 1992).

Relative cover, using Cole and Bayfield (1992) methodology, can be expressed as:

Relative Cover = (surviving cover on trampled subplots / initial cover on trampled subplots) x correction factor x 100%

The advantage of measuring relative cover is that it serves as good measure of total plant mortality and recovery. It can be measured for either overall total vegetation or by individual species. This enables an observer to determine if certain plant species are affected disproportionately to others, as less resistant species occupy ground lost to trampling effects. Total cover may remain constant, but species proportion change.

Total height is calculated by Cole and Bayfield (1992) by adding the height measures of a fixed number of observations per sample plot and dividing by the total number of observations to obtain a mean height. These mean height numbers can be substituted in the formula for cover above to obtain relative height. Relative height provides a sensitive quantification of trampling effects where total cover is not reduced (e.g. where trampling is intermittent and modestly damaging).

Thurston and Reader (2001) attempted to specifically compare the trampling affects of mountain biking and hiking through the use of a controlled experimental design. This is the only citation I could find to use a controlled experiment to ascertain the differential trampling effects of mountain biking versus hiking on vegetation.

Thurston and Reader (2001) applied five different intensities of experimental use to test lanes in Boyne Valley Provincial Park, Ontario, Canada. The intensities of treatments were 0, 25, 75, 200, and 500 passes each for hiking and mountain bicycling. Before and after these treatments they measured plant stem density, species richness, and soil exposure. They made follow up measurements of these endpoints at two weeks and one year after treatment. They found no significant differences between the mountain biking and hiking plots. Both stem density and species richness were reduced by nearly 100% at the highest treatment intensities, but recovered within the study period to pre-treatment levels. From this they conclude that both mountain biking and hiking impose fairly similar short-term damage and that vegetation recovers quickly once either use is halted.

This study is useful in that it is the only study to use a controlled experimental design to measure the trampling effects of mountain biking and hiking on untrammeled vegetation. More studies like it in different ecological areas and with different treatment intensities would be useful. However, it suffers from some weaknesses that limit its real world applicability. Chiefly, this study's treatment passes at best loosely approximate the forces exerted by actual mountain biking. On real trails, riders possess widely varying levels of skill, resulting in variant speeds, turning, and braking. This study does not address these variables.

Soil and trail affects: Mechanical erosion

Most literature examining the direct effects of a recreational use on the surface of the soil itself focus on pre-existing trails. Most of these studies examine the factors that contribute to the degradation of trails by all user groups. Few studies have attempted to compare various user class effects on the trails. These studies differ significantly in that they examine the effect of recreational use on trails, which can be considered a form of environmental impact themselves.

In the August 1999 issue of Outside magazine, Jill Danz wrote, "a 1987 effort, funded by the U.S. Department of Agriculture, found that only one user group clearly messes up wild places, those who build trails in the first place. Every group's impact after that is relatively negligible." This study highlights one of the key challenges in studying the effect of mountain bikes and other user groups on ecological systems. The majority of damage off-trail is done by the very earliest activity-whether sanctioned (trail building) or not (off-trail travelers). As such, in the context of an existing trail, it may be the case that distinctions between user groups are less meaningful than most other factors, including enforcement of regulations, overall use level, ground conditions, and topography. Some studies discussed below tend to reinforce this.

Weaver and Dale (1978) examined the differential effects of these three user groups on trails in a northern Rocky Mountain ecosystem. The authors assert that theirs is the first study comparing differences between user groups. In the study, the investigators applied 1000 passes each from hikers, motorcycles, and horseback riders in a meadow and a forested area, both in Montana.

They found that the percentage of ground eroded bare increased with the number of applied passes and that the exposure was more rapid on sloping sites than on level sites. On level ground horseback riders cause the most damage and hikers the least. On grassy, sloped terrain, motorcycles cause more damage than horses. Hikers in all situations cause substantially less damage than all other user groups. Most importantly there is a non-linear relationship in most situations and user group combinations between damage done and number of treatment passes. Early users widen and deepen trails much more than later users. This suggests managers can limit unplanned compaction and vegetation damage by appropriately planning and building the trail in the first place.

This study's strength was the number of experimental passes applied and the number of endpoints examined, including sediment erosion measurements as well as vegetation trampling. However, its chief weakness today is the motorcycle used-a Honda Trail 90 built in the 1970s (one of which this review's author rode many thousands of miles while on family camping trips in elementary school). The Honda Trail 90 is a small, fat-tired motorcycle with an engine much lower in power than even the very smallest of today's off-road motorcycles. It cannot be compared to the dirt bikes of today.

Kuss (1983) compared the difference between the effect of conventional lug-soled boots and corrugated rubber compound sole boots on woodland trails. While this study finds no difference between the two types of boots, it is frequently cited as a prototype methodology for examining different user classes' impact on hiking trails (in this case wearer's of lugged and non-lugged soles).

One study specifically compares the impact on trails of four user classes, hikers, horses, motorcycles, and off-road bicycles. Wilson and Seney (1994) applied experimental passes to various sites on an existing trail system in the Gallatin National Forest of Montana. They found that users on foot (hikers and horses) make more sediment available than do users on wheels (mountain bikes and motorcycles).

Wilson and Seney (1994) applied 100 experimental passes by hiker, horse, mountain bicycle and motorcycle to 108 sample plots on existing trails in the Gallatin National Forest of Montana. They then used a rainfall simulator to measure the amount of sediment mobilized during the rain event as a result of user-created soil disturbance. Using statistical analysis they found that about one third of total sediment mobilization could be attributed to the various user groups, and the remaining two thirds attributed to the solid texture and the slope of the sample trail plot. Further, they determined that feet (hooves and boots) made somewhat more sediment available than did wheels (motorcycles and bicycles).

The results of this study are much more applicable to the real world than, for example, Thurston and Reader (2002). First, they used many more test plots on trails that varied in slope, soil, and pre-existing moisture. Second, treatment passes were applied along longer lengths of trail, making it more likely that experimental behavior more closely approximated actual user behavior. Finally, they examined many more variables.

Wheels and feet

The available comparisons of wheeled and foot- or hoof-based methods of transportation measure endpoints associated with trail use, such as sediment mobilization or vegetative cover reduction. They do not directly attempt to describe the varying mechanisms by which these different modes transportation create these effects. For example, York's theoretical model comparing the total impact of different conveyances only accounts for the power, size, and distance traveled by a vehicle. While his model approximates the effect of these vehicles accurately (when validated against empirical data), it does disregard the mechanism (wheel or foot) through which these different modes operate on vegetation and soil. Weaver and Dale (1978) confirmed there may be meaningful differences in impact when comparing wheels and hooves/feet unrelated to power, weight, and distance traveled.

Quinn et al. (1980) found that the feet of a hiker damage trails and vegetation in two distinct phases. First the heel applies compaction in the first part of the step. Second, the toe applies shearing forces as it rotates through the step. Quinn et al. (1980) determined that this shearing accounted for the greatest share of a human foot's damage.

Wheels also apply both compaction and shearing damage, but they do so in different ways (Cessford, 1995). Wheels apply a constant swath of compaction, unlike feet, which apply an interrupted series of localized compactions. However, wheels apply shearing force to the ground either during acceleration or braking (Cessford, 1995). In this, mountain bikes and motorcycles will differ greatly as a motor has the ability to exert sustain shearing force over time and uphill. Such loss of traction for a mountain bike causes a halt to forward progress and cannot be sustained meaningfully.

Keller (1990) described some other ways that wheels will impact ground surfaces differently. For example, because wheeled vehicles create long, continuous swaths of wear, they may be more prone to "channelizing" the soil (the creation of gullies through which water can readily flow). Wear caused by feet create discontinuous pockets of disturbance less likely to result in such gullies. This effect remains untested, however, in a controlled experimental design.

Cessford (1995) noted that the mechanism of compaction, when applied to a hardened, planned trail should not be considered damage per se, as a compacted soil surface is an intentional design aspect of backcountry trails. Shearing, particularly when associated with water flows, does cause damage to existing trails, but this is generally an issue for the trail engineer whose design should result in a trail capable of handling the demands of the planned user groups.

Wildlife affects: Disturbance

The studies discussed so far look at the mechanical impact of mountain bike recreation on vegetation and soil. Another key area of concern is the effect of mountain bike recreation on wildlife. There are two basic mechanisms by which mountain bikes can affect wildlife populations:

- Direct mortality: Impact at high speed resulting in death-in practice, this only affects small animals.
- Disturbance: Changes in animal behavior associated with the presence of recreational users in their habitat.

Direct mortality is virtually unstudied. I could find no references to it in the literature. Anecdotal evidence suggests, however, that small mammals are vulnerable to impact and are not uncommonly killed (Switalski, pers. comm.).

While a great deal of literature exists on the effect of human recreation on animals, very little of it attempts to compare the effects of mountain bikers with those of other user classes. Difficulties in study design may be a main obstacle to such comparative studies. In studying influences on vegetation and soil, controlled, experimental designs can be readily conducted. While first-hand observation of animals can possibly show differences in response to various recreational user classes, in most areas it is not realistic to separate the effects various user groups have on wildlife populations over time.

Animals will exhibit one of three responses to the presence of humans in their environment: attraction, avoidance, and habituation (Knight, 1995). For mountain bike recreation, the most important of these are avoidance and habituation. Attraction is most commonly associated with food availability, where animals are conditioned to approach humans in search of food.

While study design is very problematic when looking at the effect of one specific user class on wildlife, opportunities do present themselves. Stake (2000) looked at the impacts of mountain biking activity on golden-cheeked warblers at Fort Hood, Texas, a military training area. In 1998, a local mountain biking club was allowed by the U.S. Army and U.S. Fish and Wildlife Service to open a mountain biking park at the Belton Lake Outdoor Recreation Area on Fort Hood in Texas. The golden-cheeked warblers in the area had already been under study by Stake, so he was able to make direct comparisons between the area before and after. He reported no impacts from the new mountain biking activity on Warbler territory density, return rates, or age structure (Stake, 2000).

Such opportunities to look at the effect of mountain biking before and after introduction to a given area are rare, however. A more typical study is that conducted by W. Sue Fairbanks, who looked at the distribution of pronghorn antelope on Antelope Island. This island in the Great Salt Lake of Utah was once home to a native population of pronghorn antelope. After being hunted to extinction, wildlife recovery teams reintroduced the species to the island in the 1980s. In 1983, a flood destroyed the causeway providing vehicle access to the island. In the 1990s, the island was re-opened to recreational use. The addition of recreational access created an opportunity to study the effect of people on the pronghorn population (Fairbanks, 2002).

Fairbanks (2002) measured the distance from recreational trails that pronghorn antelope tended toward before and after the re-introduction of human recreation. She found that pronghorn antelope did in fact alter their behavior based on the presence of humans, moving and staying further from the trails and recreational corridors after the re-introduction of human use than before. The smallest groups of

pronghorn tended to stay further from recreational trail areas than did the larger groups, particularly groups with mixed sex and fawns. From this, Fairbanks (2002) concluded that pronghorn are affected by non-consumptive recreation (activities that do not involved killing of wildlife) and that management strategies should incorporate this in planning use rules.
The chief drawback of this study for the purposes of this paper is that it does not (and could not have) separated out the affects of various user groups. As a result it provides only a perspective for management of all recreational use. In addition, this study examines only short-term behavioral changes, which may or may not have implications for long-term population viability.

Antelope Island was also used by a graduate student at Colorado State University, Audrey Taylor, to examine the differential effect of hikers and mountain bikers and several species, including bison, mule deer and pronghorn antelope. Taylor (2001) observed and calculated the probability of each animal flushing when approached by both hikers and bicyclists. Taylor (2001) found no difference between mountain bikers or hikers in flushing response. For both user groups, alert distance and flushing distance did not significantly vary (Taylor, 2001).

Taylor (2001) concluded that short-term behavioral changes do not vary between bicyclists and hikers on a per encounter basis. However, because bicyclists are capable of and, in most areas, typically do travel much farther than hikers; it is reasonable to conclude that they will create a somewhat higher total number of encounters and flushings. In addition, Taylor's (2001) methodology does not attempt to measure long-term population changes in the animals studied.

Future research needs
Taylor (2001) asserted "Mountain biking is emerging as a form of outdoor recreation which may compete with more traditional forms of recreation, such as hiking, for space on public lands. Virtually nothing is known about whether wildlife respond differently to mountain biking versus hiking" (emphasis added). Little is also known about the erosion and trampling effects of mountain biking. More research is needed in both areas to help inform the development of local management regimes.
Three broad areas should be given priority for study: (1) mountain biking styles, (2) broad behavioral differences, and (3) long-term population studies.

Broad behavioral differences
This area of inquiry should be pursued using sociological survey techniques. It would seek to understand some of the specific chosen behaviors exhibited by mountain bikers versus hikers. Accompanying it should be a series questions about the value systems of the two user groups. The main purpose would be to find answers to such questions as:

- Are mountain bikers more likely to cut switchbacks?
- Do mountain bikers litter more or less often than hikers?
- How often do mountain bikers go off trail?

Because these behaviors are not inherent to the bicycle as a mode of transportation, the management of adverse ecological effects caused by them would fall to local management and enforcement.

Mountain biking styles
Some aspects of mountain biker behavior, however, should be comparatively studied using many of the same controlled scientific study designs used in the various works discussed in this literature review. For example, some mountain bikers will travel faster than others, skid more going downhill, or jump logs more often. In order to understand how much trampling, erosion, and wildlife disturbance mountain bikes

cause, factors like these should be introduced as variables in studies examining these endpoints. One could suggest that experimental treatment passes or experimental harassment of wildlife would not be a reliable source of data if such factors as speed and propensity to skid were not introduced as variables.

Long-term population studies

The most important-and certainly most difficult-research need made evident by the extant literature on mountain biking and wildlife is the need for more long-term population studies comparing the effects of various user classes. In practice, few opportunities such as Stake (2000) are available. It is, in most cases, impossible to sort out the long-term effects of various user groups on an animal population. However, for macro-level management of natural areas, such studies are the most important for securing wildlife health.

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The Ecological Effects of Roads on Wetlands

Wetlands, vitally important ecological systems, have a history of inadequate protection. The impacts of road construction and road operation on wetlands are numerous and broad in scope; negative impacts range from changes to the chemistry and biology of the local area to changes in hydrology that go well beyond the immediate area. Loss of wildlife habitat, loss of species and biodiversity, and introduction of alien species are among the consequences of such changes. These impacts result from a roadøs location, construction, maintenance, manner of use, and further effects that occur once the road is in place.

Wetlands are extremely important habitats with a variety of functions. One of the most important is the prevention and reduction of flooding due to their ability to hold large amounts of water. Because of their capacity to hold so much water, wetlands also control erosion. In addition, wetlands recharge groundwater, improve water quality and provide habitat for wildlife. Eighty percent of Americaøs breeding bird population and more than fifty percent of the eight hundred species of protected migratory birds rely on wetlands (Mitsch and Gosselink 1993).

Knowing these ecological functions, it is vital to understand what effects roads can have on them. Roads have six general effects on wetland ecosystems that those who are concerned about preserving them must consider (Trombulak and Frissell 2000; Findlay and Bourdages 2000).

Alteration of the Physical Environment

Wetlands are dependent on hydro-periods, where flooding occurs seasonally and for a length of time. Once the hydrological processes are disrupted, many changes occur in a dominoeffect. When a road is introduced into a wetland, it acts as a dam in the system, which can affect areas some distance away.

A road can cause the upland side of a wetland to flood and the downland side to drain, diverting the surface water flow in the process and causing the biological characteristics to change. A road can also critically impact the subsurface water flow in a wetland, depressing the water table and affecting the amount of groundwater available (Darnell 1976). This depression can affect many water-dependent fauna and plants.

Often during road construction, channels are excavated to divert water straight towards culvert installations. This channelization can substantially alter the rate and character of surface and subsurface flow (Darnell 1976). Channelization can destroy both upstream and downstream wetland areas by giving them either too much or too little water. This effect is reported to reduce the diversity of the habitat and cause shifts in species composition (Darnell 1976).

As soil erosion accelerates due to this alteration in water volume and levels, there is a reduction in bank stability, and therefore, an increase in sediment loading. These fine sediments can increase the turbidity of the water, clouding it and preventing sufficient light penetration, which adversely affects the health of the flora and fauna (Darnell 1976).

Alteration of the Chemical Environment

Roads facilitate the alteration of the chemical environment. Highways can introduce oil and heavy metals, such as lead, aluminum, and cadmium, which can contaminate a wetland (Adamus and Stockwell 1983). In aquatic environments especially, these contaminants can travel far and fast. Such contamination can have adverse impacts on wildlife health, especially to animals higher up the food chain.

Salt from deicing roads also alters the chemical environment by contributing ions to the soil, changing the pH, and altering the soiløs chemical composition (Darnell 1976).

Fragmentation of Habitat

Roads act as barriers that fragment wetlands habitat and have short and long term impacts on wildlife. îFragmenting landscapes into disjunct patches and restricting and isolating wildlife populations by amplifying the risks associated with movement have drastic consequences for the preservation of biological diversity" (Harris and Gallagher 1989). Over the short term, roads cause an obvious loss of habitat as well as increased wildlife mortality. Over the long term, the damage can be much more severe.

Roads can disrupt population and metapopulation dynamics that maintain local and regional wildlife populations (Jackson and Griffin 1998). Roads fragment the migration and interaction between populations, which can eventually cause a loss of genetic variability (Reh and Seitz 1990). Thus, roads that fragment habitat, particularly in critical breeding habitat or between separate and different habitats, can adversely affect species. For every population, there is a threshold of mortality. When mortality rates exceed this threshold, there is a risk of extinction (Means 1999).

Increased Wildlife Mortality Rates

Roads increase the chance of wildlife-vehicular collisions (Trombulak and Frissell 2000). Often wildlife is migrating toward decreasing habitat or between fragmented habitats and must cross a road, where mortality is more likely. Scavenger species, too, suffer higher mortality rates when they feed on roadkill and are struck, with a potential impact on predatorprey population dynamics (Bernardino and Dalrymple 1992).

Modification of Animal Behavior

Animal behavior is also modified through road avoidance and disturbance (Forman and Alexander 1998). Terrestrial animals, such as amphibians and turtles, as well as others, exhibit reluctance in crossing roads (Fahrig et al 1995). Also, roads create their own microclimates. As temperatures rise, a warm column of air causes an effective barrier to some animals such as birds and butterflies (Van der Zande 1980).

Bird species are particularly sensitive to traffic noise pollution and undergo population density depressions from the presence of a road at distances from 200m to 2000m (Van der Zande 1980). Many choose not to nest near roads. While some species avoid roads altogether, others, particularly reptiles, are drawn towards the heat of a road, which can have fatal consequences (Trombulak and Frissell 2000).

Introduction of Exotic Species

Roads act as a dispersal corridor, enabling exotic species to penetrate into previously inaccessible areas. Vehicles or vehicular effects may introduce exotic species. Plants mayspread along roads due to vehicle-caused air turbulence (Forman and Alexander 1998). In wetlands where roads have been constructed, the native plants are already stressed due to a disturbance in flood frequencies and therefore cannot fend off the colonizers (Mitsch and Gosselink 1993). This can have large impacts on the overall health and biodiversity of the wetland.

Conclusion

The ecological effects of roads on wetlands range from the alteration of the physical and chemical environment to the unfavorable impacts on wildlife populations due to habitat fragmentation, modification of animal behavior and collisions with vehicles. In view of such ecological impacts, it is important to look for ways in which to lessen the effects. Certainly avoidance of road construction through wetland systems is the best alternative available.

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Management and Conservation Article

Behavioral Responses of North American Elk to Recreational Activity

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ABSTRACT Off-road recreation on public lands in North America has increased dramatically in recent years. Wild ungulates are sensitive to human activities, but the effect of off-road recreation, both motorized and nonmotorized, is poorly understood. We measured responses of elk (Cervus elaphus) to recreational disturbance in northeast Oregon, USA, from April to October, 2003 and 2004. We subjected elk to 4 types of recreational disturbance: all-terrain vehicle (ATV) riding, mountain biking, hiking, and horseback riding. Motion sensors inside radiocollars worn by 13 female elk recorded resting, feeding, and travel activities at 5-minute intervals throughout disturbance and control periods. Elk fed and rested during control periods, with little time spent traveling. Travel time increased in response to all 4 disturbances and was highest in mornings. Elk travel time was highest during ATV exposure, followed by exposure to mountain biking, hiking, and horseback riding. Feeding time decreased during ATV exposure and resting decreased when we subjected elk to mountain biking and hiking disturbance in 2003. Our results demonstrated that activities of elk can be substantially affected by off-road recreation. Mitigating these effects may be appropriate where elk are a management priority. Balancing management of species like elk with off-road recreation will become increasingly important as off-road recreational uses continue to increase on public lands in North America. (JOURNAL OF WILDLIFE MANAGEMENT 73(3):328–338; 2009)

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KEY WORDS all-terrain vehicles (ATVs), Cervus elaphus, elk, elk behavior, hiking, horseback riding, human disturbance, mountain biking, recreation.

Recreational use of public lands in the United States has increased dramatically since the 1970s, especially off-road recreation such as all-terrain vehicle (ATV) riding (United States Department of Agriculture Forest Service 2004). Other popular types of off-road recreation include mountain biking, horseback riding, and hiking. Off-road recreation, especially ATV riding, can negatively impact wildlife (Knight and Gutzwiller 1995, Havlick 2002), but the topic has received little research attention. Only recently have a few studies examined effects of different types of off-road recreation on wildlife in a comparative manner (Taylor and Knight 2003, Wisdom et al. 2004a, Preisler et al. 2006).

Although effects of off-road recreation are not well-known, effect of roads and road use on wildlife has been well-documented (Trombulak and Frissell 2000). Wild ungulates such as North American elk (Cervus elaphus) have been shown to consistently avoid roads open to motorized vehicles across a variety of environments (e.g., Perry and Overly 1977, Lyon 1979, Edge and Marcum 1985, Cole et al. 1997, Rowland et al. 2000). Moreover, human disturbances associated with road access increases movements and decreases survival of elk (Cole et al. 1997). Accordingly, we evaluated effects of off-road recreation on elk because of the species' noted sensitivity to human disturbances, combined with its economic, social, and recreational importance. We also selected elk for study because the species may habituate to some road uses and other human disturbances in nonhunted areas such as National Parks (Schultz and Bailey 1978). Elk may also habituate to human disturbances in urban fringe areas, where elk find refuge from hunting pressure (Thompson and Henderson 1998). We designed our study so that we monitored the same individuals before, during, and after disturbance events, thereby making it possible to detect potential habituation to those events.

Our objective was to evaluate effects of off-road recreational activities on elk behavior and to determine if different types of recreation elicited different responses. We were specifically interested in elk responses to 4 recreational activities: ATV riding, mountain biking, hiking, and horseback riding. We developed 4 hypotheses to guide our research: 1) off-road recreation (also called disturbance) produces a change in elk behavior patterns, altering the percentage of time that elk travel, rest, and feed; 2) different types of off-road recreation cause different behavioral responses in elk, with each type of recreation causing a different change in time spent traveling, resting, and feeding; 3) the time required for elk to return to predisturbance behavior patterns of traveling, feeding, and resting varies with each disturbance type; and 4) continued exposure to off-road recreation leads to conditioning of elk to the disturbance, resulting in reduced behavioral responses (i.e., habituation).

STUDY AREA

We conducted our research from April to October 2003 and 2004 at the United States Department of Agriculture Forest Service Starkey Experimental Forest and Range (hereafter,

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Starkey), 35 km southwest of La Grande in northeast Oregon, USA (45812'N, 11883'W). In 1987, approximately 10,125 ha (25,000 acres) of elk summer range within the area was enclosed by a 2.4-m-(8-foot)-high elk-proof fence for long-term ungulate research (Thomas 1989, Bryant et al. 1993, Rowland et al. 1997). We conducted our study in the 1,453-ha northeast study area (Northeast) which was further subdivided by an elk-proof fence into 2 pastures, East (842 ha) and West (610 ha; Stewart et al. 2005). Vegetation was a mosaic of forests and grasslands dominated by ponderosa pine (*Pinus ponderosa*), grand fir (*Abies grandis*), Douglas fir (*Pseudotsuga menziesii*), bluebunch wheatgrass (*Pseudoroegneria spicatum*), and Idaho fescue (*Festuca idahoensis*). The study area and its extensive history of ungulate research are described in detail in Wisdom (2005).

METHODS

Actiwatch Calibration

We used motion-sensitive accelerometers (Actiwatche; Mini Mitter Company Inc., Sunriver, OR) to record elk behaviors. These sensors were housed in battery packs of Global Positioning System (GPS) collars worn by female elk. We calibrated sensors to detect 3 behaviors—feeding, resting, and traveling—using visual observations of 6 randomly selected, tame female elk (Gates and Hudson 1983, Kie et al. 1991). Sensors collected activity data over 1-minute time periods and calibration followed methods described by Naylor and Kie (2004).

During summer 2003 we observed tame elk equipped with activity sensors for 1,073 minutes over 12 observation periods (Trials), ranging from 25 minutes to 106 minutes each. To ensure that only one behavior was causing the Actiwatch measure, we selected data when we observed only one behavior during a given 1-minute period, providing 868 minutes of observations for analysis. We recorded elk behavior on a hand-held personal digital assistant (Newton MessagePade; Apple Computer, Inc., Cupertino, CA) running Ethoscribee dedicated software (Tima Scientifice, Halifax, NS, Canada). We then identified class intervals for the range of Actiwatch measures associated with each behavior for each 1-minute recording period.

We used Discriminant Function Analysis (DFA) to establish the percentage of correct classifications of Actiwatch measures into each of the 3 behaviors (Naylor and Kie 2004). Sample sizes and frequencies of behaviors were not equal; therefore, prior probabilities in the DFA were proportional to sample sizes. Activity monitors on wild elk recorded activity over 5-minute periods. Consequently, we established class intervals for Actiwatch data associated with traveling, resting, and feeding for the time frame of 5 minutes. Actiwatches recorded the aggregate of motion over the recorded interval, not an average (Mini Mitter 1998). We estimated class intervals for the 5-minute periods for each behavior by ordering the 1-minute data chronologically and summing the recorded measure of each continuous 5-minute period where only one behavior occurred.

Disturbance Method

Field work began each year in April, when we fitted 16 female elk (8 animals/pasture) with GPS radiocollars containing Actiwatch activity monitors set to record at 5-minute intervals. We released these elk as part of a larger herd of approximately 24 and 97 individuals into the West and East pastures. We released the same female elk into the study area each year.

Following the early April release of elk we implemented a 14-day period of no human activity. We then randomly selected and implemented each of the 4 recreation activities, individually, for 5 consecutive days, with no other human activities occurring in the study area during a particular treatment. Each treatment period was followed by 9 days of control, during which no human activity occurred in the study area, thereby providing data on elk activity in the absence of human disturbance.

Elk may return to areas associated with disturbance within a few hours or days after cessation of human activity (Stehn 1973, Wisdom et al. 2004a). Consequently, we assumed that the 9-day control period between treatments provided sufficient time to allow animals to return to predisturbance activity patterns. The alternating pattern of 5-day treatments and 9-day controls allowed for us to replicate each of the 4 treatment types 3 times each year (Apr to Oct).

We applied each treatment by establishing approximately 32 km of routes, composed of trails and primitive roads, which encompassed all portions of the study area. We traveled these routes twice a day (once each morning and afternoon) during each 5-day treatment. To allow coverage of the entire study area by each of the 4 recreation activities, one group (1–3 people) of ATV riders covered the 32 km of routes each morning and afternoon, traveling at approximately 5.3–5.7 km/hour. By contrast, to cover the same distance along the routes required 2 groups of mountain bikers (each covering approx. 50% of the 32-km routes), traveling at 2.6–2.9 km/hour, and 3 groups of hikers and horseback riders (each covering approx. 33% of the 32-km routes), traveling at 1.6–1.9 km/hour. This design provided the same coverage of routes among all activities and saturated the study area such that all 4 activities were applied to all portions of East and West pastures (Wisdom et al. 2004b). Each treatment followed a tangential experimental approach in which observers did not directly pursue animals but remained along the predetermined routes (Taylor and Knight 2003). Each group of recreationists traveled together under an interrupted movement design, which allowed momentary stops to record observations of elk and take short rest breaks (Wisdom et al. 2004b).

During data collection in 2003, one elk activity monitor failed and 2 were not retrieved from the study area; therefore, we used data from 13 elk in our analysis. During 2004, one monitor was not retrieved and 2 monitored elk crossed from the East to the West pasture when a gate was left open at the end of a treatment week. Consequently, we

Table 1. Discriminant Function Analysis results, based on Actiwatch recordings (from 868 1-min record intervals collected over 12 trials) to discriminate among 3 behavior classes of Rocky Mountain elk at Starkey Experimental Forest and Range, La Grande, Oregon, USA, during summer 2003. We set prior probabilities to proportional in the Discriminant Function Analysis.

Observed behavior	Classified behavior (min)				
	Resting	Feeding	Traveling	Total	% correct
Resting	459	11	4	474	96.84
Feeding	20	299	3	322	92.86
Traveling	0	7	65	72	90.28
Total	479	317	72	868	93.32

did not include data from these elk in our analysis, resulting in 13 elk for the analysis.

Data Analysis

We organized data for each replicate into 10-day periods, 5 days for each treatment paired with the last 5 days for its prior control. We calculated the difference in activities for each elk as percentage of time spent in each behavior within the treatment period minus percentage of time spent in each behavior during the paired control period. Consequently, a positive value for the activity difference indicated elk spent more time in that behavior during the treatment compared to the control, and a negative value indicated less time was spent. We then calculated and plotted the mean difference and 95% confidence intervals for each behavior per treatment, replicate, and year. We summarized behavior of female elk hourly and averaged it for each hour across all control periods to describe how animals allocated their activities in the absence of human disturbance.

We used a univariate procedure to check for a normal distribution of the residuals of activity differences between each treatment type and its control. Plots of residuals showed that data were normally distributed. We analyzed the activity difference for each year using a Proc Mixed Repeated Measures model (SAS Institute 2001) to test for differences among treatments, replicates, and treatment 3 replicate interaction, with each female elk repeatedly measured throughout the year. We determined covariance structure for each model using the lowest Akaike's Information Criterion score. For 2003, the covariance structure was a first-order ante-dependence (ANTE [1]); for 2004, we used a first-order autoregressive structure (AR [1]). A priori significance level for all statistical tests was 0.05. We adjusted significance level of all pairwise comparisons of least-square means using the Tukey Honestly Significant Difference procedure (Harris 1998).

To test for differences among pastures and time-of-day (morning or afternoon), we analyzed the activity difference for travel, resting, and feeding for each year using a Proc Mixed Repeated Measures model. This model included treatment, replicate, pasture, and time-of-day variables and all interaction terms. We adjusted significance levels of all pairwise comparisons using a Bonferroni critical value (Harris 1998).

RESULTS

Actiwatch Calibration in Lotek GPS collars

Calibration of activity data with tame elk, using DFA based on 1-minute data, correctly classified 96.8% of resting, 92.9% of feeding, and 90.3% of travel activities (Table 1), with an overall correct classification of 93.3%. Ranges of Actiwatch measures for each 5-minute data were estimated as 0–1,896 for resting, 1,900–5,135 for feeding, and • 6,166 for traveling. We could not correctly classify Actiwatch measures that were between these intervals and we discarded them from the wild elk dataset (, 2% of data).

Treatment and Replicate Differences

Elk spent little time traveling during all control periods (, 5% of each hr); feeding and resting comprised most of their activities (Fig. 1). Resting was highest at approximately 0800 hours (80% of their activity budget) and gradually decreased during daylight hours as feeding increased. Peak feeding activity occurred at dawn and dusk (Fig. 1). Activity budgets were similar for 2003 and 2004 (Naylor 2006).

Results of the mixed-model repeated-measures analysis of travel activity showed a treatment 3 replicate interaction in both 2003 and 2004 (2003 $F_{6,72}$ • 12.28, P , 0.001; 2004 $F_{6,72}$ • 2.31, P • 0.042; Table 2). Percentage of travel time also was different among treatments for both years (2003: $F_{3,36}$ • 32.25, P , 0.001; 2004: $F_{3,36}$ • 7.65, P , 0.001). In addition, there was a treatment 3 replicate interaction for resting (2003: $F_{6,72}$ • 15.11, P , 0.0001; 2004: $F_{6,72}$ • 8.29, P , 0.0001). We also found differences among treatments in resting time for both years (2003: $F_{3,36}$ • 10.60, P , 0.001; 2004: $F_{3,36}$ • 11.62, P , 0.001; Table 2).

Similarly, time elk spent feeding was different for the treatment 3 replicate interaction (2003: $F_{6,72}$ • 21.45, P , 0.001; 2004: $F_{6,72}$ • 7.89, P , 0.001). As with travel and resting, time spent feeding also was different among treatments (2003: $F_{3,36}$ • 16.41, P , 0.001; 2004: $F_{3,36}$ • 13.35, P , 0.001; Table 2).

Elk traveled more during ATV and mountain biking treatments than during controls in all 2003 and 2004 replicates (Fig. 2, Table 3). Elk traveled more than the controls during 5 of 6 hiking replicates and during 3 of 6 horseback riding replicates (Fig. 2, Table 3). Elk spent more time resting during 4 of 6 ATV treatments compared to controls. Elk rested less during mountain biking in contrast to controls during 4 of 6 replicates. Resting time by elk was not different from controls for 3 of 6 hiking replicates and was less than controls during 2 replicates. Elk rested more than controls during 4 of 6 horseback replicates (Fig. 3). Elk spent less time feeding compared to controls during 5 of 6 ATV replicates, 3 mountain biking replicates, 2 hiking replicates, and 4 horseback replicates (Fig. 4).

Mean travel during all ATV replicates in 2003 was higher than the other treatments (Fig. 2, Table 3). For 2004, travel during ATV riding was not different from other treatments except for being higher than horseback riding during replicate 2 (Fig. 2). Travel time by elk was higher during mountain biking compared to horseback riding for replicate 3 of 2003

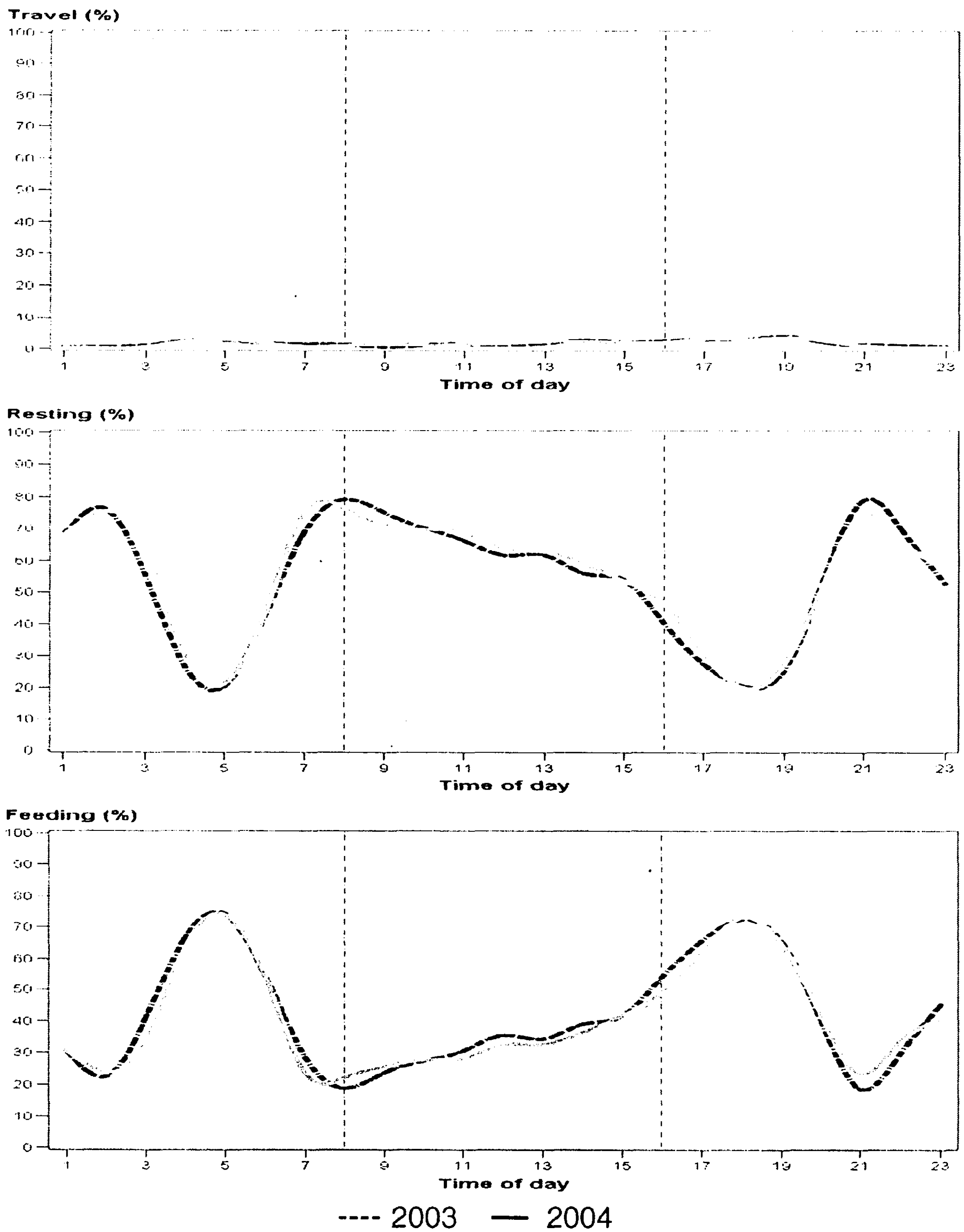

Figure 1. Activity budgets (% time spent traveling, resting, and feeding) of female elk during the first 2-week control periods of 2003 and 2004 at Starkey Experimental Forest and Range, La Grande, Oregon, USA. We averaged data for each hour, over 24-hour periods, expressed in Pacific Daylight Time.

and 2004. Hiking and horseback treatments were similar in the percentage of time that elk traveled during both years. Time elk spent resting was greater during ATV treatments compared to other treatments for 3 of 6 replicates and was greater during the horseback treatment compared to mountain biking and hiking for 4 of 6 replicates. Resting time was similar during both mountain biking and hiking replicates each year (Fig. 3). Elk fed less during ATV riding compared to other treatments in 4 of 6 replicates (Naylor 2006: fig. 4, appendix 1, tables A4, A7). There was no difference in duration of feeding between mountain biking and hiking treatments during 2003 or 2004. Elk fed less during the horseback treatment compared to mountain biking and hiking for 2 of 6 replicates (Naylor 2006: fig. 4, appendix 1, tables A4, A7).

Table 2. Results of a mixed-model repeated-measures analysis of elk activity time. Test was for differences between treatments and replicates of mean activity time by 13 female elk in the Northeast study area of Starkey Experimental Forest and Range, La Grande, Oregon, USA, 2003 and 2004.

Effect	Numerator df	Denominator df	2003		2004	
			F-value	P-value	F-value	P-value
Feeding						
Treatment 3 replicate	6	72	21.45	, 0.001	7.89	, 0.001
Treatment	3	36	16.41	, 0.001	13.35	, 0.001
Replicate	2	24	30.05	, 0.001	9.87	, 0.001
Resting						
Treatment 3 replicate	6	72	15.11	, 0.001	8.29	, 0.001
Treatment	3	36	10.60	, 0.001	11.62	, 0.001
Replicate	2	24	11.19	0.004	6.36	0.006
Travel						
Treatment 3 replicate	6	72	12.28	, 0.001	2.31	0.042
Treatment	3	36	32.25	, 0.001	7.65	0.001
Replicate	2	24	8.50	0.001	1.74	0.196

Differences in elk behavior between treatments and controls were evident only during the periods of each day that treatments occurred. Elk behavior patterns were similar to control periods before treatments commenced each day, showed differences during each treatment activity, and returned to a predisturbance level approximately 1–2 hours after each treatment ended (Fig. 5). Behavior patterns outside the treatment times appeared unaffected by the treatment activity (Naylor 2006: appendix 1, figs. A2–A13).

Travel time by elk was greater than controls for ATV treatments both years, with the greatest response of the 4 treatments being for ATV replicate 1 of 2003. Travel response by elk to ATVs during 2003 declined with each replicate (Fig. 2, Table 3). This decline continued through replicate 1 of 2004. However, travel time then increased for replicates 2 and 3 of 2004 to levels similar to those recorded in 2003 (Fig. 2, Table 3).

Elk also reduced travel time during each horseback riding replicate in 2003, with no difference observed between the treatment and control for replicate 3. During 2004, travel response to horseback riding was less than that of 2003 and was not different from control periods in 2 of 3 replicates (Fig. 2). Overall, horseback riding caused the lowest travel response in elk among treatments. By contrast, elk were consistent in their travel time during all mountain biking treatments, with travel time being higher than controls. Elk travel time during hiking was the most variable among treatment responses, with no evident pattern.

Pasture and Time-of-Day Differences

Differences in travel response between the high elk density (East pasture) versus low elk density (West pasture) areas, considering time-of-day, replicate, and treatment indicated a 4-way interaction of these variables for both years (2003: $F_{6,132}$ • 21.94, P , 0.001; 2004: $F_{6,132}$ • 6.40, P , 0.001). All 3-way and most 2-way interactions were significant as were all individual effects. For each treatment, elk travel time in the 2 pastures was similar during mornings. Exceptions to this pattern were ATV, replicate 1 of 2003 and horseback riding, replicate 2 of 2003, when elk traveled more in the east than west pastures. Differences between pastures during the afternoons for 2003 were not significant (Naylor 2006: appendix 1, table A15) with the exception of replicate 1 of the ATV treatment, when travel time was higher in the west pasture (P , 0.001).

Elk travel time also differed between pastures during the afternoons in 2004 for ATV replicate 3, mountain bike replicates 2 and 3, and hiking replicate 2 (Naylor 2006: appendix 1, table A16). At these times, elk traveled more in the east pasture during the ATV treatment and more in the west pasture during biking and hiking. Differences in travel time between morning and afternoon in the same pasture showed some significance for 2003, with the morning disturbance causing the greater travel response (Naylor 2006: appendix 1, table A17). There were fewer differences in mean travel activity between mornings and afternoons in 2004 for the same pasture (Naylor 2006: appendix 1, table A18).

DISCUSSION

Activity budgets of elk during control periods were consistent with the literature on elk circadian cycles (Green and Bear 1990, Ager et al. 2003, Kie et al. 2005). Movements of elk (m/min), estimated from telemetry relocation data during the 2002 phase of our study, provided further evidence of elk circadian patterns of movement in the absence of human disturbance (Preisler et al. 2006). Our activity budgets during control periods provided a compelling basis for evaluating changes in activity budgets during each of the recreational activities.

Our results supported hypothesis 1, which postulated that off-road recreation produces a change in elk behavior. Results clearly demonstrated that activity budgets of elk were altered during off-road recreation treatments. Elk increased their travel time during most treatments, which reduced time spent feeding or resting. We recorded an increase in travel throughout the period of disturbance but it was generally greater in mornings than in afternoons. This response was similar to that recorded by Wisdom et al. (2004b), where movement rates of elk were higher than that

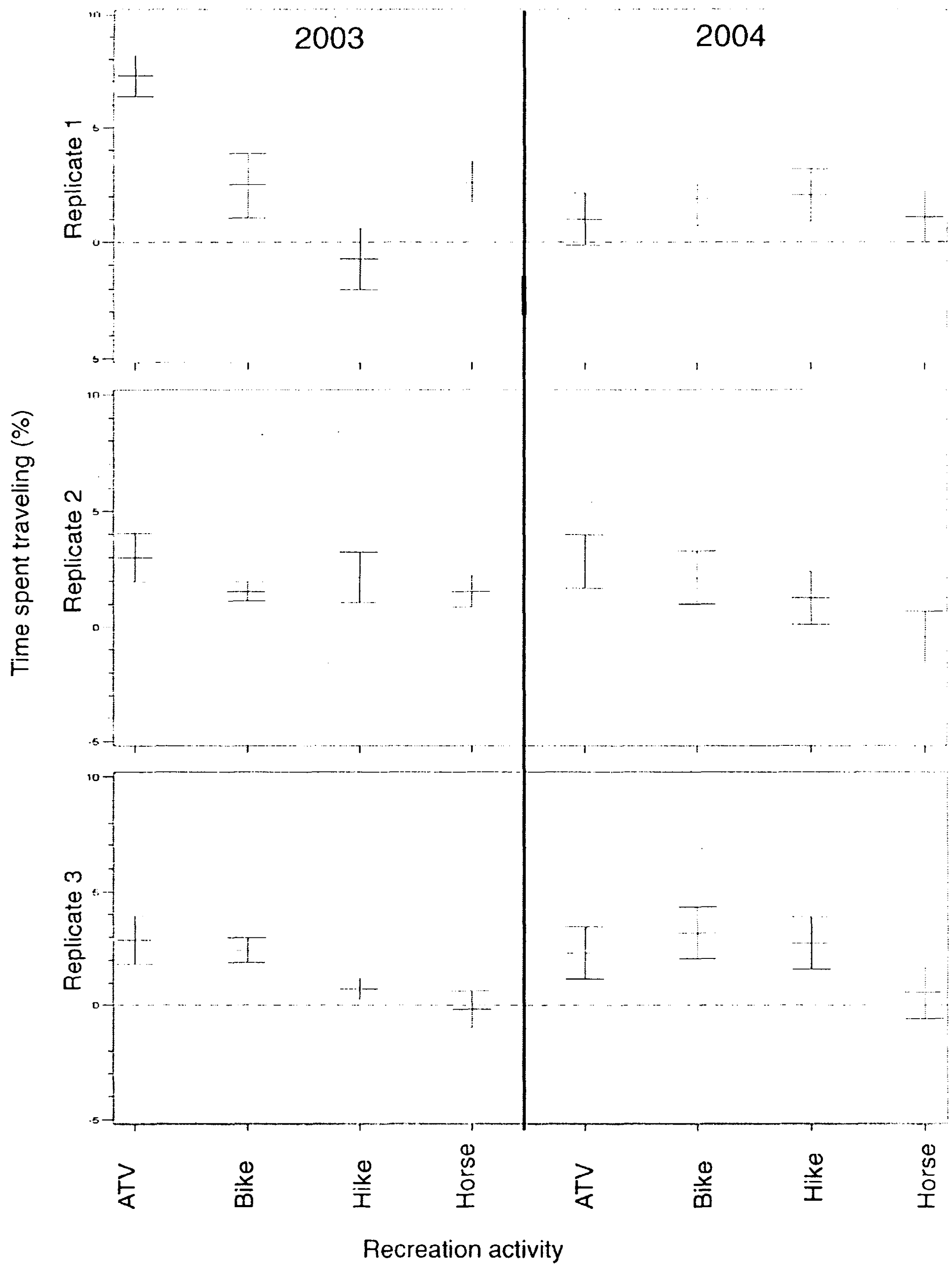

Figure 2. Mean and 95% confidence intervals of the difference in the percent travel time by elk between paired treatments and control periods. Data are for 13 female elk in the Northeast study area of Starkey Experimental Forest and Range, La Grande, Oregon, USA, 2003 and 2004. We calculated activity difference as percent time spent traveling during treatment minus that during control; negative values indicate activity less than that of the control. Treatments were all-terrain vehicle (ATV) riding, mountain biking (Bike), hiking (Hike), and horseback riding (Horse).

of controls in the hours immediately after initiation of the disturbance each morning. The reduced response by elk to each treatment in afternoons compared to mornings was likely due to elk moving away from the disturbance routes and avoiding them for the remainder of the day, which reduced the need for more travel and thus conserved energy (M. J. Wisdom, United States Department of Agriculture Forest Service, personal communication).

Table 3. Weekly averages and standard errors of percent time spent traveling above that of paired control periods for 13 female elk at Starkey Experimental Forest, La Grande, Oregon, USA, 2003 and 2004. A positive number indicates elk spent more time traveling during the treatment compared to the control period (no human activity) and a negative number indicates less time was spent traveling. ATV = all-terrain vehicle riding, Bike = moutain biking, Hike = hiking, and Horse = horseback riding.

	ATV		Bike		Hike		Horse	
Replicate	x̄	SE	x̄	SE	x̄	SE	x̄	SE
2003								
1	7.27	0.46	2.47	0.70	−0.70	0.66	2.56	0.45
2	3.00	0.52	1.55	0.20	2.14	0.54	1.54	0.34
3	2.87	0.52	2.44	0.27	0.72	0.24	−0.18	0.40
2004								
1	0.99	0.57	1.86	0.57	2.03	0.57	1.11	0.57
2	2.83	0.57	2.13	0.57	1.26	0.57	−0.43	0.57
3	2.31	0.57	3.20	0.57	2.75	0.57	0.54	0.57

The reduced travel by elk in the afternoons also could be due to the benefits of conserving energy by remaining in a particular habitat. Presumably, more time spent hiding would outweigh the loss of energy caused by fleeing from disturbance. Our study did not include information on elk locations in relation to disturbance routes; therefore, we could not determine any shifts in habitat use during treatments. However, Preisler et al. (2006) demonstrated that elk in our study area moved away from the routes to hiding places near or against fences during 2002.

Hypothesis 2, which postulated that different types of human activity cause different behavioral responses in elk, also was supported by our results. The highest travel response by elk was during ATV exposure and was followed by increased resting time. This type of recreational activity may have forced elk to forgo foraging in favor of hiding until the disturbance ended. In contrast to this any disturbance during the mountain biking and hiking treatments resulted in feeding activity increasing. It is possible that, being quieter than the ATVs, mountain biking and hiking did not disturb elk once they moved away from the routes; elk were, therefore, able to make up any energy lost by resuming foraging activity.

For horseback riding, travel activity during 3 of the 6 replicates was not different from the controls, indicating that elk were not affected as much by this recreational activity. When elk did display an increased travel response to horseback riding, the effects on feeding and resting time were mixed.

Hypothesis 3, which postulated that time required for elk to return to predisturbance behavior varies with disturbance type, was not supported by our results. For all treatments, elk returned to behavior patterns similar to those of the controls once the disturbance ended each day (Naylor 2006: appendix 1, figs. A2–A13). Reduction in foraging time during treatments was not compensated for after the disturbance ended, because elk did not increase feeding intensity or duration beyond that of controls.

Our study design mimicked the daytime pattern of motorized traffic on National Forests (Wisdom 1998), most of which does not occur during peak elk feeding activity at dawn and dusk. Thus, our treatments did not overlap with peak feeding periods of elk. With their main intake of digestible material being unaffected by disturbances, reduced foraging time during treatments may not have had substantial short-term biological consequences for these elk. Elk may have satisfied their immediate nutritional requirements before and after disturbances occurred.

A potential disadvantage to elk is the energy expense of traveling during each disturbance, coupled with a loss in forage intake. A shift away from disturbance routes (as noted by Preisler et al. 2006) to areas of potentially lesser quality forage could have a cumulative effect on long-term body condition. Cook et al. (2004) suggested that if elk body fat was reduced below 9% as the animal enters winter, there is an increased probability of that individual not surviving winter. Comparisons of elk body condition before and after each treatment were beyond the scope of our study. Consequently, we could not conclusively assess long-term physiological effects of repeated disturbance to elk from April to October each year.

Hypothesis 4, which postulated that continued exposure to disturbance leads to conditioning of elk to the disturbance and results in unaltered or reduced behavioral responses (i.e., habituation), was partially supported by our findings.

A complicating factor in our evaluation of potential habituation of elk to recreation treatments is that we did not simultaneously evaluate changes in elk distributions. However, as part of the radiotelemetry monitoring of the same elk we studied, Preisler et al. (2006) found that elk moved away from travel routes during ATV riding with repeated ATV treatments. These movements allowed elk to resume activities similar to those of controls, while avoiding recreation routes. Such avoidance would not be considered habituation, but rather a different type of negative response to recreation.

Travel by elk during 2 horseback replicates was not different from control periods in 2004. Reduction in elk travel during horseback riding in 2004 compared to 2003 suggested that, unlike other treatments, elk may have habituated to horseback riding. Alternatively, elk could have simply avoided areas near horseback routes during 2004, as was done by elk in response to ATV treatments over time (Preisler et al. 2006). Under this possibility, elk could have maintained the same activity patterns as during controls, but farther away from travel routes.

In contrast to horseback riding, elk travel time during mountain bike riding was above that of controls for each year and was consistent among years. Thus, elk showed no evidence of habituation to mountain biking. Similarly, elk travel time in response to hiking was above that of control periods, with the exception of replicate 1 for 2003, suggesting a similar response by elk to each hiking disturbance (i.e., no habituation).

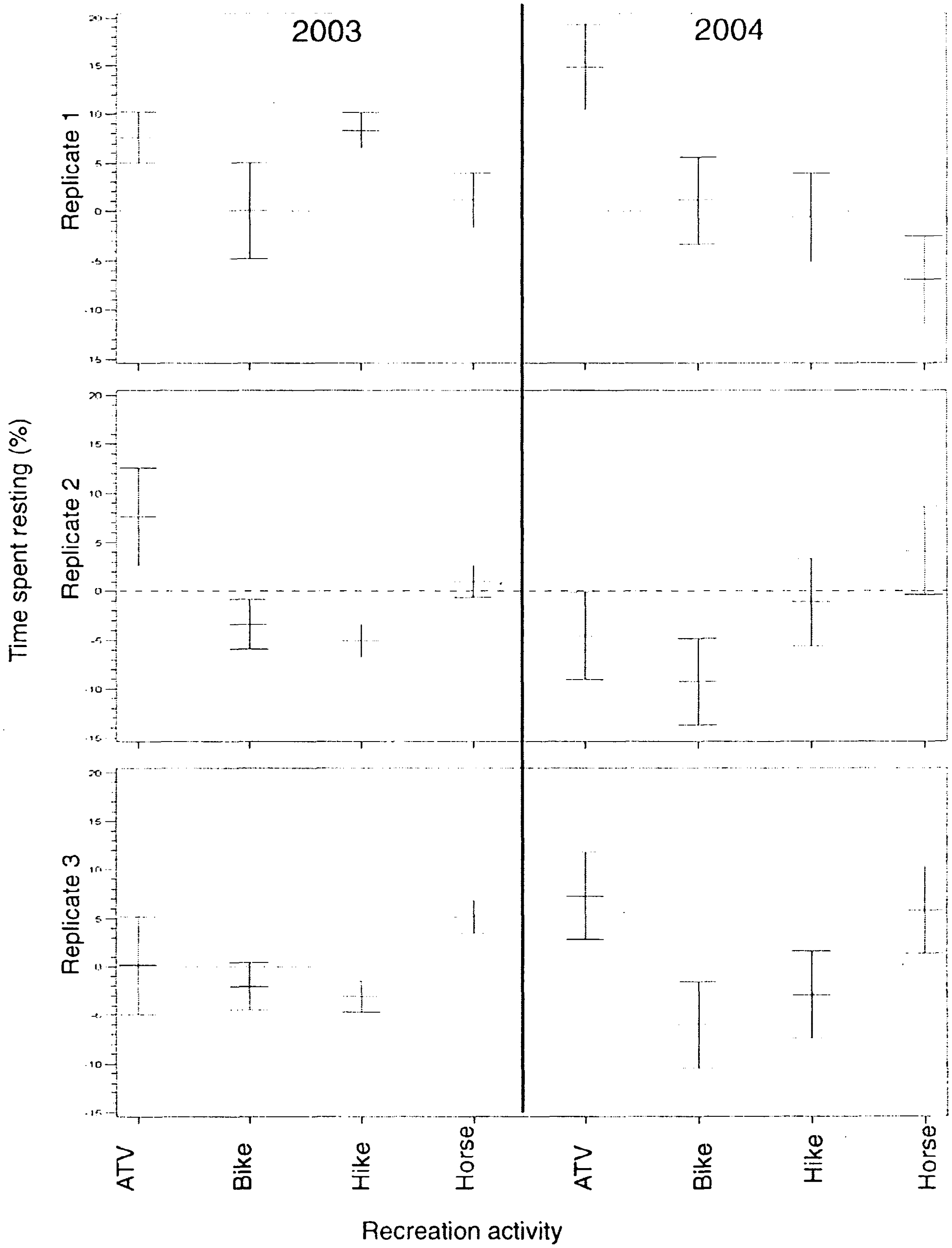

Figure 3. Mean and 95% confidence intervals of the difference in percent resting time by elk between paired treatment and control periods. Data are for 13 female elk in the Northeast study area of Starkey Experimental Forest and Range, La Grande, Oregon, USA, 2003 and 2004. We calculated activity difference as percent time spent resting during treatment minus that during control, so negative values indicate activity less than that of the control. Treatments were all-terrain vehicle (ATV) riding, mountain biking (Bike), hiking (Hike), and horseback riding (Horse).

MANAGEMENT IMPLICATIONS

A comprehensive approach for managing human activities to meet elk objectives should include careful management of off-road recreational activities, particularly ATV riding and mountain biking, which caused the largest reductions in feeding time and increases in travel time. Evidence of little or no changes in travel by elk as a response to horseback riding can also be used by managers when planning access to

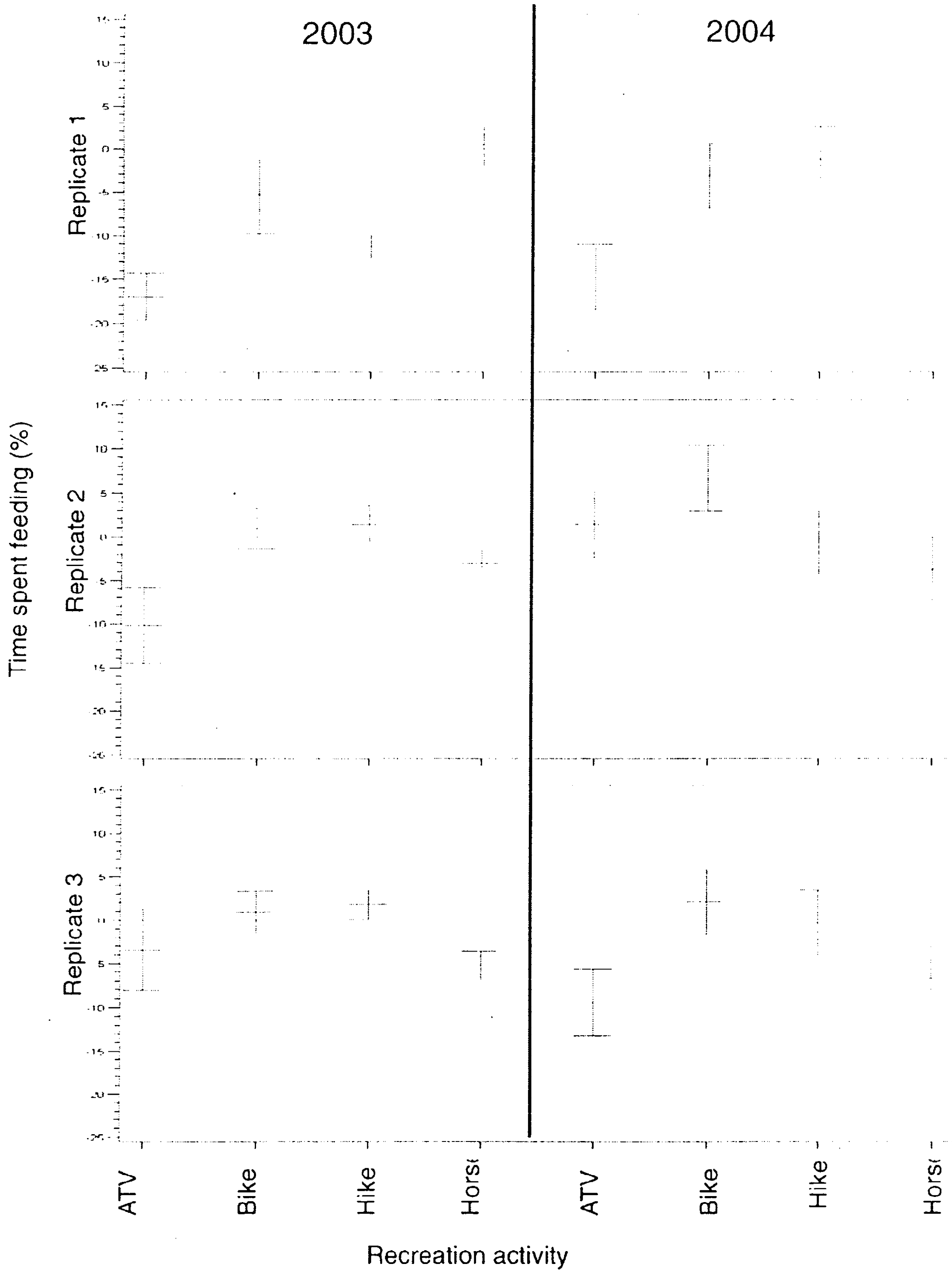

Figure 4. Mean and 95% confidence intervals of difference in the percent feeding time by elk between paired treatment and control periods. Data are for 13 female elk in the Northeast study area of Starkey Experimental Forest and Range, La Grande, Oregon, USA, 2003 and 2004. We calculated activity difference as percent time spent feeding during treatment minus that during control, so negative values indicate activity less than that of the control. Treatments were all-terrain vehicle (ATV) riding, mountain biking (Bike), hiking (Hike), and horseback riding (Horse).

areas where disturbance of elk is to be minimized. Such resource allocation trade-offs between management of elk and off-road recreation will become increasingly important as off-road recreation continues to increase on public lands.

ACKNOWLEDGMENTS

Funding was provided by the Oregon Department of Parks and Recreation, Oregon Department of Fish and Wildlife, and Pacific Northwest Region and Pacific Northwest

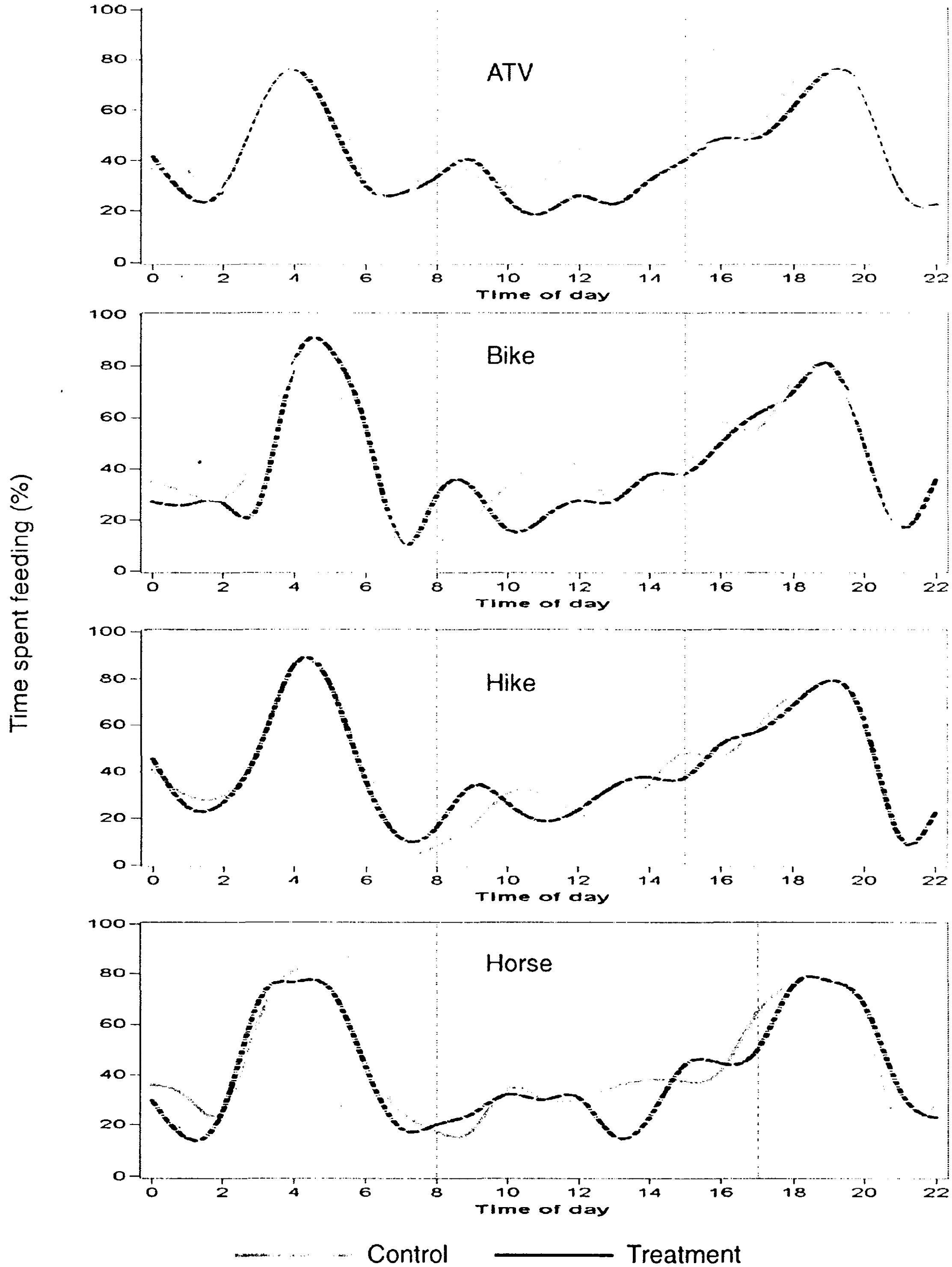

Figure 5. Feeding activity (%) of 13 female elk for replicate 2 of each treatment and its paired control during 2003 at Starkey Experimental Forest and Range, La Grande, Oregon, USA. Area between dotted vertical lines represents times (hr) treatments occurred. Results in this figure typify the pattern of elk activity returning to that like controls each day after a recreation treatment ended.

Research Station of the United States Department of Agriculture Forest Service. A. Ager, C. Borum, and N. Cimon provided database and telemetry support. L. Ganio and M. Huso provided statistical advice. A. Bartuszevige provided helpful comments on an earlier draft of this paper. B. Naylor produced study area maps and J. Boyd edited the manuscript and helped prepare figures. B. Johnson helped write proposals to obtain funding for this project. We also

wish to thank K. Mundy and . 50 individuals who assisted with data collection by participating in recreation activity treatments.

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Associate Editor: McCorquodale.

From: Meb787@aol.com [mailto:Meb787@aol.com]
Sent: Monday, February 01, 2010 10:51 AM
To: Beck, Michael
Cc: newboard@wpra.net; cwbogaard@earthlink.net; emina@earthlink.net; hearst@usc.edu; Bogaard, Bill; Gordo, Victor; Haderlein, Steve; Holden, Chris; Madison, Steve; McAustin, Margaret; Robinson, Jacque; Tornek, Terry
Subject: Re: [Arroyo_Seco_News] Digest Number 1457

Michael,
Thank you for taking the time to write this long email. I stand by all the points I have made and will address the points you have made as briefly as I can:

1. - if the rationale is the removal of non-natives, why would they "potentially" be removed? Wouldn't all of them be removed sooner or later? The earlier versions of the plan stated that the City was going to remove as few trees as necessary to complete the projects. The first version called for the removal of only 5 trees. Then it was 7 -19 trees. Now it's up to 70. You say that it is false that the trees will be clear cut. I sincerely hope that is the case, particularly in terms of the 33 trees in the corridor.

2. - there are 800 trees on the Annex but of the 70 non-natives, 33 or almost half, are in the formerly proposed road/greenway corridor so the impact of these removals would not be dispersed equally across the 30 acres.

3. Your discussion concerning the non-natives overlooks an important point concerning the Arroyo Seco Design Guidelines which differentiate between landscaped and habitat restoration areas. As I pointed out, the trees on the Annex were all planted - they did not just grow up wild and invasive. They are ornamentals as are all the California peppers, Italian stone pines, deodars, etc in other landscaped areas of the Arroyo which are not slated for removal. (Take a look next time you walk around the Rose Bowl - you will see many of the same trees as on the Annex including many lush and beautiful California peppers!) The Arroyo Seco Design Guidelines do not call for ripping out planted areas - they only suggest using native plants when new plantings are desired.

4. As for the so-called invasives, rather than a blanket policy of ripping them out which gives great latitude for getting rid of them when they get in the way of other projects, why not examine them on a case by case basis? None of the trees on the Annex have spread out into the basin and they have been there for decades.

5. I agree with your comments about the opposition to a road. The sentiment of all the Commissions and the community has been uniformly against cutting a road into what is an amazingly serene and peaceful natural area. You are also right that I would like to preserve the recreational opportunities that have been available on the Annex for almost a century (there was a riding academy on the Annex as early as the 1930s). It is broader than that, however. It is really the same impetus that drove the community to save Annandale Canyon and to come out against storage facilities in the Eaton Wash - it is a recognition of how few and precious our remaining open spaces are and that we must work tenaciously to preserve them.

6. I don't quite understand your point about the trees not serving a variety of wildlife. I saw the western grey squirrel myself just a couple of weeks ago and we have a photo of him. These have been almost extirpated from the Los Angeles basin. The Cooper's hawks are seen repeatedly altho I will defer to the birders.

7. In terms of the proposed bikeway, Friends of Hahamongna in their presentations presented the bikeway as for hikers and bicyclists because staff had originally stated that it was the equestrians who had to be separated from other users. We then proposed an hiking/biking trail in the north corridor and an equestrian/hiking trail to the south to lessen the width of the corridor. Never once during all

the advisory group meetings did the staff inform the Commissioners that the FOH plan would not work. The administrative record will show that we were careful to refer to the bikeway as for bikers and hikers at these meetings. Staff never corrected us nor did they refer to the bikeway as for "bikes only" in the documents until the final version. As you probably know, bikeways are commonly for pedestrians and bicyclists as a review of CalTrans materials will show. The significance of what is now in the Plan is that JPL employees have to walk out into the park on that bikeway. Building ONLY the 10 foot bikeway doesn't work unless pedestrians can use it too!

What I said about the trail/bikeway combination was that at its widest it is 40 feet. Exhibit 4.1 in the Initial Study "Draft Bikeway Trail Alignment Study, p.4-3 is drawn to scale. At its widest this configuration is almost 40 feet wide. And, as you know, a focused environmental evaluation of the bikeway and all the trails was included in the Initial Study even tho the Hahamongna Advisory Committee was told that it would not be included. The trail is also still in the Mobility element in the Plan. I don't see that there is much to prevent building exactly the kind of wide greenway that the Commissions voted against. I will grant you that the language in the Mobility section of the Plan is vague but it is worrisome nevertheless.

Speaking of the Mobility section of the Plan, the error was not just in the graphic. The following language is also in the Mobility section: "Improve existing pedestrian/equestrian trail from the transit stop at the park entrance at Oak Grove Drive and Foothill Blvd, north, to and through the Annex." p 3-19 There is only one existing pedestrian trail to and through the Annex and it is the existing trail in the corridor between Rose Bowl Riders and LA County Fire Camp 2. So it isn't so clear that the trail isn't still in the Plan.

I have to respectfully disagree about the other sections of the bikeway in Hahamongna. The bikeway as a paved path with dirt shoulder(s) for the trail and no meanders or buffers is standard in ALL the other locations in the park existing and proposed:

1. Flint Wash bridge and approaches
2. Planned bikeway/trail to Equestrian picnic area (see attached illlustration from the grant request)
3. Planned bikeway north of the Annex described in the HWP Master Plan as a paved bikeway with a dirt trail immediately adjacent (available width here varies from 12 to 24 feet
4. Planned northern bridge and approaches

This configuration - 10 foot paved bike path with a 4 or 5 foot dirt shoulder is what should be created on the Annex with a small a footprint as possible. This is an alternative which could be implemented satisfactorily so that all trail users could share the Annex corridor without turning it into the enormous greenway that the advisory bodies voted against. Please give the community an opportunity to help make this happen.

Thanks so much for reading. I look forward to working with you as the City's moves forward with what I have often told my readers is a visionary plan for all of Hahamongna.

Mary Barrie
Friends of Hahamongna

In a message dated 2/1/2010 8:43:24 A.M. Pacific Standard Time, mbeck@cityofpasadena.net writes:

> Mary,

As we prepare for the Hahamongna Annex Public Hearing tonight I thought it would be helpful to answer and clarify the statements from a recent posting. Please see the comments below, which are incorporated into your original message for clarity.

Thanks,

...Michael

Michael J. Beck

City Manager

City of Pasadena

(626) 744-7927

Hahamongna Annex Plan From: meb787@aol.com

Posted by: "meb787@aol.com" meb787@aol.com
<mailto:meb787@aol.com?Subject=%20Re%3AHahamongna%20Annex%20Plan> meb787
<http://profiles.yahoo.com/meb787>

Sun Jan 17, 2010 4:01 pm (PST)

Friends,
At long last it looks like the Hahamongna Annex Plan is finally going to the Pasadena City Council. The hearing is scheduled for Monday, February 1, 2010 at 7:30 pm in the City Council Chambers in City Hall, 100 N. Garfield St.

And what a plan it is!

TREES

Seventy non-native trees are slated to be removed from the Annex in the name of "habitat restoration." Not surprisingly, thirty-three of the trees to be cut down are located in the formerly proposed road corridor.

A more accurate description is that the Initial Study (IS) evaluated the "potential" impacts of tree removal, meaning it evaluated the "worst case scenario" based on what is known about the proposed Annex improvements at this time. Regarding the bikeway, because of the meetings between staff and Friends of Hahamongna, a detailed study of various bikeway alternatives was prepared by staff that led to the recommendations made by the various commissions and that ultimately resulted in the current plan. The current proposal is largely based on criteria provided to staff and various commissioners by FOH, namely minimal grading, minimal encroachment into the equestrian use areas, minimal tree removals, safe bikeway width, etc. The proposal is the option that best meets all the desired criteria in the most balanced way. Please note, a study of this detail was highly unusual at the master plan level and would typically be done once a project is to be implemented. Nevertheless, this exercise did allow staff to evaluate more detail on this portion of the site than in any other area of the Annex that hence led to more clearly seeing which trees may be impacted by the bikeway proposal.

Critical information left out of your communication include: 1) there are approximately 800 trees within the 30 acre annex site, the great majority of which are native species. Up to 70 non-native trees "could potentially be" recommended for removal over the entire site, over a period of 2 to 15 years as funding and resources permit, all to be implemented *in keeping with the habitat restoration goals of the adopted Arroyo Seco Master Plans.* 2) When the bikeway project (or any other project) is funded, further designed, and ready to be implemented, staff will be required to do further CEQA analysis, seek approval from the City's Urban Forestry Advisory Committee regarding any tree removals, etc. and not proceed until these occur. 3) The assertion that the City will be "clear cutting" trees is simply false. The City has continually stated that any tree removals proposed would happen only when necessary and in accordance with City ordinances and policy. I refer to the pages of the IS and the Addendum document where it is printed that "Recognizing the benefits that any mature tree provides, removal/replacement of non-native trees would occur in phases (i.e., as improvement projects are implemented) to maintain an appropriate tree canopy on the annex site."

(Remember that road? It was to be cut across the Annex to provide access to a 1200 space JPL parking garage, which was removed from the 2003 Hahamongna Master Plan after strong community opposition.)

I am not sure how we can make this more clear, but there is no road that the City is secretly planning to build across the Annex. The proposal being recommended to City Council by staff is for a dedicated bikeway only along the northern boundary of the Annex property. This point was further emphasized by the Planning, Design, and Hahamongna Watershed Park Advisory Commissions when they each recommended their support of the Annex Plan to the City Council.

The non-natives include majestic Italian stone pines, liquid ambers, Chinese elms, California peppers and others too numerous to mention. These trees will be cut down despite the fact that the Annex is a landscaped area which was planted by the Forest Service, LA County Fire and Rose Bowl Riders many decades ago. The trees are an integral part of the history and uniqueness of the property just as the same species are in the Central Arroyo where no one is trying to cut them down.

The goal of the adopted Arroyo Seco Master Plans, to restore habitat by eliminating invasive non-native species, will be considered for the trees in the Arroyo and will be evaluated on a case by case basis at that time a project within the Arroyo is ready to be implemented.

Habitat restoration is a scientific, ecological process with long term goals and benefits. Removal of non-native species is just one element of the habitat restoration process, along with planting native species, proper management to promote the natural regeneration of existing native species, and providing an environmental benefit for native wildlife to nest, feed, and live. There are areas where non-invasive, non-native trees may remain if they are determined to not inhibit habitat restoration efforts and support the other goals of the ASMP.

We understand your sentiments regarding no desire to see anything change from what has been in existence over the past 50 years.

The trees serve a variety of wildlife. Cooper's hawks, a species of concern, have raised their young in their branches and western gray squirrels, driven from higher elevations by the Station Fire, have taken refuge in them - not to mention the human generations who have enjoyed their beauty and shade.

This point has been presented to several qualified biologists and ecologists of the Forest Service and other agencies and was not supported. In fact, all those questioned by City staff in an effort to confirm the point stated (and is written within the federal report prepared by the USFS for the Station fire) the greatest threat to recovery of the native Chaparral and Mixed Conifer Forest is non-native species. Not just the invasive non-natives but all non-native species. In all our restoration efforts, we look to the work of our fellow experts in watershed restoration and the studies they have conducted such as the LA/San Gabriel River Watershed Council's 'Los Angeles Regional Invasive Plant Guide', California Native Plant Society and the Cal-IPC Statewide Inventory. Interestingly, some of the species mentioned above are considered highly invasive to natural habitats by these sources, and have been removed to meet habitat restoration goals in other parts of the Arroyo. For every non-native removed, many times more native species have been planted with great success. As is required by law, nesting bird surveys will be conducted if any work should take place during nesting season.

The presence of a nest certainly supports the city's habitat restoration goals, and staff would follow the necessary and appropriate course of action in consultation with a qualified biologist and regulatory agencies to provide protection of any documented active bird nest and for any protected species.

This drastic proposal wasn't always in the Annex documents. An earlier version says that "it is the city's intent to align the trails in a manner that preserves as many existing trees as reasonably possible... city estimates that the number of trees that would be impacted... in the range of 7 - 19 trees." Why the complete about face - is the plan now to do a Colorado Blvd-style chainsaw massacre on the trees in the corridor and just be done with it?

BIKES ONLY

The latest proposal from staff, put forth only AFTER the documents had been seen by the advisory groups, is that the northern bikeway will be for "bikes only". Obviously that isn't going to work since JPL employees walk on that trail to get from the lab into the park. So staff's answer is a trail/bikeway which is almost 40 feet at its widest!

The proposed bikeway has always been described by staff for bicycle use only. The earlier proposal was for a bikeway and separate, parallel pedestrian/equestrian trail. The current proposal for a bikeway only, in the location described, is based on the recommendations of the Planning Commission, Design Commission, and HWP Advisory Committee. The Annex plan expressly recommends a bikeway width of no more than 10 feet. The bikeway will meander through a vegetated space where all the existing native trees will be preserved within that space. The restoration or enhancement of tree and understory plantings with native species to improve the habitat as well as the aesthetics of this space is planned. We do not see how you calculated that staff is recommending a combination trail/bikeway that is almost 40 feet wide?

Now you may have noticed that elsewhere in Hahamongna down by the Flint Wash Bridge, horses, bikes and pedestrians all share a 12 foot hard surface path with a 4 foot shoulder. This is what is also proposed for the three other new segments of the bikeway in Hahamongna - a hard surface path and an immediately adjacent soft surface trail - no buffers or barriers. Why do you think it is only in the formerly proposed roadway corridor that an ultra-deluxe "meandering" greenway with buffers and vegetation is necessary and everywhere else in the park the bikeway/trail is shared use and not more than 20 feet wide?

To be clear, the Flint Wash Bridge has no shoulders....it is one bridge with a maximum width of 12 ft. This was the maximum allowed safe width for a multi-use crossing without having to build a 2nd bridge. The trail/path as you leave the bridge is known as the "bridge approach" and is in essence a short section of trail/paved path whose purpose is to serve as a "safe transition zone" where the perimeter trail and bikeway converge at these bridge approaches and then funnel down to the bridge crossing. The bridge approach on the east side of the Flint Wash bridge is 150 ft. in length and 12 feet wide and the bridge approach on the west side of the Flint Wash bridge is 100 ft. in length and 12 feet wide. These bridge approaches have a 4 foot shoulder along the northern edge for those equestrians who choose to use it. This bridge crossing is a unique spot around the perimeter of HWP because of the approaches, bridge crossing and Devil's Gate Dam; a similar proposed bridge crossing project at the north end of the park will present the same design challenge whenever that project is funded and implemented.

Any shared bikeway/trails in the Hahamongna Plan are that way for very specific reasons as described above and then, only for the shortest possible distances. The space along the northern edge of the Annex is a confined space where, as with any project, the safety of users must be considered. A 10 ft. bikeway is an accepted safe width for that use. So too is the separation of cyclists *on a bikeway* from pedestrians and equestrians. A multi-purpose path that is intentionally designed for use by bikes AND equestrians AND hikers is not supported as it is not safe.

DON'T BLAME THE CITIZEN COMMISSIONS

The Planning Commission, the Design Commission, the Transportation Advisory Commission and the Hahamongna Watershed Park Advisory Committee all supported nothing wider than a 10 foot path for bicyclists and hikers in the northern corridor . The Transportation Advisory Commission went so far as to say that it should be designed in such a manner that it could never become a road.

As stated above, the City has consistently defined the bikeway as 10' wide. The description of a "path for bicyclists and hikers" is inaccurate. Staff did not present the bikeway this way and the commissions and committees did not recommend a shared surface. The recommendation in the plan addendum is consistent with the recommendations of all the commissions where this item was presented, which was for a bicycle width of no more than 10 ft. The following is an excerpt of the minutes from each of the commission meetings on this point

Transportation Advisory Committee

* That the bikeway and trail be designed in a manner that does not lend itself to becoming a road.

Planning Commission/Design Commission

* Modify the Recreational Trail Greenway to reflect a bikeway, not more than 10 feet in width, and delete the proposed pedestrian/equestrian trail;

Hahamongna Watershed Park Advisory Committee

* That the City proceed with a 10 feet wide bikeway along the northern perimeter of the HWP Annex with a design that includes environmentally friendly paving, minimum grading, arroyo stone walls (where walls are needed) and landscape screening where possible;

They all tried their best with what were incredibly confusing documents. There were four different versions of the Plan in the space of seven months and the Plan seen by one Commission wasn't necessarily the same plan seen by the next. The Final Draft even had material that was not seen by any of the advisory groups whose purpose is to advise the City Council. The documents they approved will not be the documents before the Council.

This statement is not correct. There was an initial preliminary draft document of the plan addendum, followed by 2 separate "redlined" versions of the preliminary draft document, each in an effort by staff to respond to the public's comments and the comments of the commissions and prepared in that manner largely at the specific request of the Commission. To avoid further confusion, staff prepared a list of the suggested edits recommended for the last redline version of both documents and presented these to the HWPAC on September 29, 2009.

In the final Plan, the trail portion of the greenway seems to have been removed until you take a close look. The trail was taken out of the Exhibits and the Land Use section of the Plan where the casual reader would expect to find it but it is still included in the Mobility section. So is it in the Plan or not? If it is not in the Plan, then why is it being studied in the Initial Study? Questions such as these abound.

I do thank you for pointing out a graphic error on our part regarding the trail running parallel to the bikeway...we also caught the error. The indication of a trail running parallel to the bikeway is not what the draft plan addendum proposes, and the Council will be made aware of this. You are also correct that under the "Project Characteristics" and specifically on pg. 2-25 of the IS, it indicates that a pedestrian/equestrian trail would parallel the bikeway from the end of the park road eastward to the Hahamongna basin, which is not a recommendation in the plan. Council will be made aware of this and a recommendation to make this correction will be presented.

Lest you think I am anti-trail, nothing could be further from the truth. What I am anti is a corridor which will be as wide as Foothill Boulevard once the trees are cut down. The Annex, and all of Hahamongna, is a rustic, peaceful place that should remain that way for future generations which is what the community has been saying for over 20 years. I've been accused of being against progress. If "progress" is bulldozing and asphalting over this little green corner of the world that has miraculously escaped it thus far, I'll admit to the charge gladly.

This statement really doesn't have anything to do with the plan being presented for adoption. The bikeway and trail has never been designed with any width near the size of Foothill Blvd. The plan was never to bulldoze any part of the Annex or trail.

Enough on what has been quite an amazing process which will take much more than an email to document properly (a case study for a class on CEQA perhaps).

I would make one suggestion to those of you who love Hahamongna and have been involved at one time or another in the over 20 year fight to save it. Now is the time to get back in the game before the chainsaws and the bulldozers start firing up. When that happens, there will be howls of protest and disbelief but by then it will be way too late.

It's up to you. You have my email.
Mary Barrie
Friends of Hahamongna

Proposed Site Plan

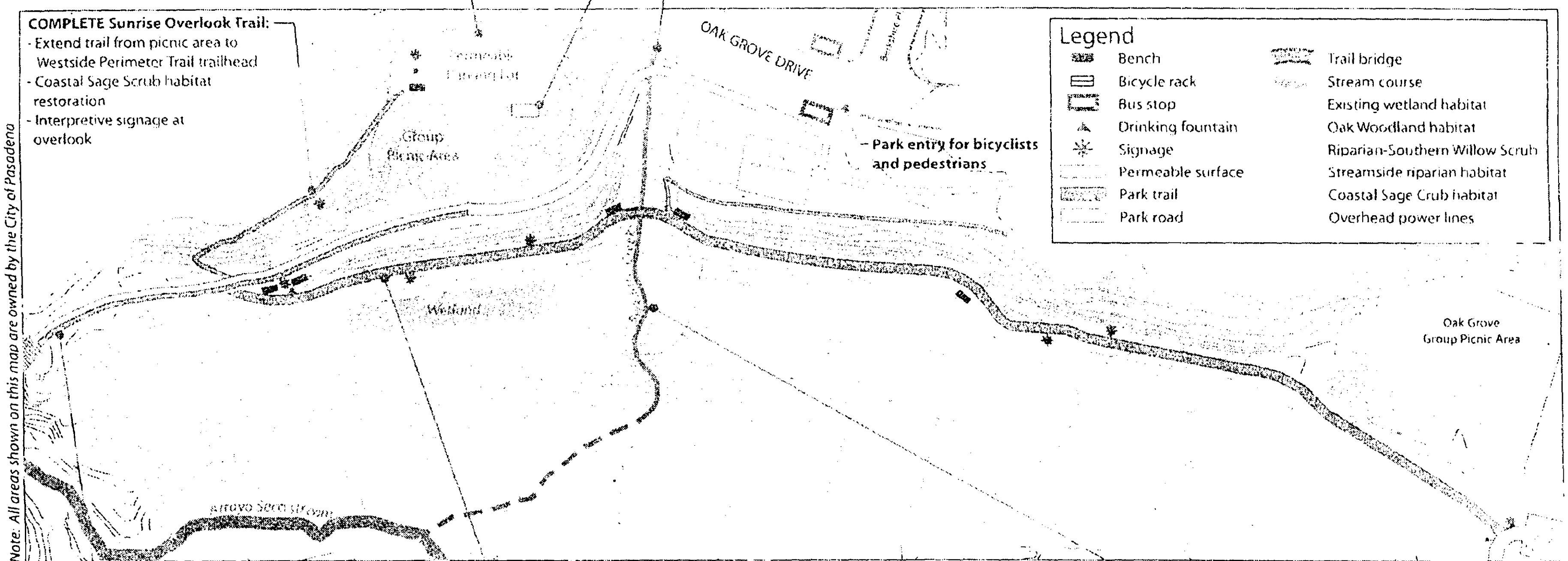
IMPROVED Group Picnic Area and Parking Lot
- Remove all asphalt, replace with permeable parking surface
- Provide ADA accessible parking
- Reduce parking area to expand Oak Woodland
- New ADA accessible picnic tables
- Wayfinding and directional signage
- Naturalize drainage course
- ADA accessible drinking fountain
- Add Grant acknowledgment signage
- Retain equestrian facilities

UPGRADED ADA compliant restrooms
Restroom improvements: ADA compliant, upgrade fixtures, add stalls, upgrade exterior to blend with natural environment

ENGINEERED Berkshire Storm Drain Outlet
- Install drop structure, box culvert, and apron with baffles and boulders designed for 100-year storm to dissipate energy of storm water and prevent future erosion of Berkshire Creek
- Raise and widen park road to allow for new culvert at crossing only
- Place 7 storm drain inserts at this location and upstream to prevent non-point source pollutant trash in Berkshire Creek

Restore, protect and/or enhance native habitat throughout project area (12.3 acres)
- Coast Live Oak Woodland habitat: 4.2 acres
- Coastal Sage Scrub habitat: 1.0 acres
- Streamside Riparian habitat: 1.0 acres
- Riparian - Southern Willow Scrub Habitat: 5.85 acres
- Existing Wetland habitat: 0.25 acres

COMPLETE Sunrise Overlook Trail:
- Extend trail from picnic area to Westside Perimeter Trail trailhead
- Coastal Sage Scrub habitat restoration
- Interpretive signage at overlook



MULTI-USE park trail:
- Remove asphalt park road
- Paved bicycle route/maintenance road
- Hiking/equestrian trail

0 40 80' 160'

RESTORED Westside Perimeter Trail:
- Restore historic 12' wide trail from park road, north to Berkshire Creek, permeable, ADA compliant, able to withstand infrequent inundation
- Berkshire Creek bridge, interpretive signage, benches, ADA accessible
- Raise trail from Berkshire Creek to Oak Grove parking lot, interpretive signage
- South trailhead/overlook with bench, drinking fountain, directional & interpretive signage, and vehicular control
- Habitat restoration along trail, removal of non-native plants and revegetate with native plants
- North trailhead with directional signage and vehicular control

RESTORED Berkshire Creek:
- Raise creek bed for erosion control/bank stabilization
- Add grade controls (2 locations)
- Restore riparian habitat
- Bridge crossing at new Westside Perimeter Trail

Sharon Yonashiro
1067 Linda Glen Drive
Pasadena, CA 91105
(626) 792-4436
sharon.y@mac.com

February 1, 2010

Delivered via E-Mail

Mayor Bogaard
Councilmember Robinson
Councilmember McAustin
Councilmember Holden
Councilmember Haderlein
Councilmember Gordo
Councilmember Madison
Councilmember Tornek

Dear Honorable Mayor Bogaard and Councilmembers,

RE: February 1, 2010 Council Agenda
Item #6: Adoption Of The Initial Study and Approval of the Hahamongna Watershed Park Master Plan Addendum for the Hahamongna Annex

I am writing today to express my support for the request of the Friends of Hahamongna (FOH) that the Council reject the Initial Study before you in the subject Agenda Item.

My concerns are simple.

First, there is a growing and alarming pattern developing at the City to short-change the California Environmental Quality Act (CEQA) requirements for a thorough and impartial review of projects. This leaves many opportunities to delegate to staff critically important project impact reviews and mitigation without the need to inform the public. I concur with the summary of the situation presented to the City by the FOH and request that you give strong consideration to the totality of their request.

Second, over the recent past the City has made decisions to destroy/remove what appear to be healthy mature canopy trees. What comes to my mind is not only the highly visible destruction of the trees in the Playhouse District, but also the removal of many trees along Holly Street between Marengo Avenue and Garfield Avenue. Yes, replacement trees are planned or have been planted but it will be 20 years before these sites will look "tree lined" again.

This wholesale removal of trees is very damaging to our environment and should only be allowed in the most severe emergencies to protect public safety.

A tree that has flourished for 20 years or more in an area, such as Hahamongna, has sort of "become native" and our fauna have learned to adapt to them in lieu of what **might** have been there originally.

The Hahamongna Plans before you seek your approval to remove 70 mature trees in the name of habitat restoration. Please send this proposal back to staff without your approval and require that they rethink this "old idea" about habitat before even one tree is removed for this purpose. I ask that we develop a clear plan to only remove obviously damaged trees and that any replacements be made with trees of substantial size to compensate for the loss of the canopy.

We need to do this to help in the fight to protect our environment from the crippling effects of the Urban Heat Islands. Please ask your staff to work with Dr. William Patzert of the Jet Propulsion Laboratory or a similarly qualified professional and representatives of the Audubon Society and other such protection/preservation organizations to understand and develop innovative solutions that limit our need to replace viable mature trees.

Thank you for your consideration of my concerns.

Sincerely,

Sharon Yonashiro

January 28, 2010

Via Email
Mayor Bill Bogaard
Pasadena City Council Members
Pasadena City Hall
100 N. Garfield Ave. Room S228
Pasadena, CA 91109

RE: The Draft Hahamongna Watershed Park Master Plan Addendum for the Hahamongna Annex (Annex Plan) and Initial Study

Dear Mayor and Councilmembers,

The West Pasadena Residents' Association (WPRA), dedicated to preserving the character, beauty and quality of life of our neighborhood, has supported , through the years, protection of and access to areas throughout the Arroyo Seco. We would like to call your attention to the (potential) trail/bikeway corridor in the Annex Plan and the Initial Study that is before you.

During the Master planning process in 2003 staff proposed a 30 foot wide road in the northern corridor (to the JPL garage.) However, there was strong community opposition and the road was removed. But at the start of the planning process for the Annex Plan in 2009 the road and a wide greenway reappeared. Over the past year, the Annex Plan has gone before the Transportation Advisory Commission, the Planning Commission, the Design Commission and the Hahamongna Watershed Park Advisory Committee. All rejected the proposed road and wide greenway corridor. The Transportation Advisory Commission went so far as to say that the path should be designed in such a way that it could never become a road. The Planning and the Design Commissions and the HWP Advisory Committee supported an alternative which would have split user groups giving each a separate, narrower path thus eliminating the need for one wide corridor.

We are concerned that, while staff is no longer actually proposing the road, they are recommending that all the impediments to the road be eliminated, including 33 trees in the path of the formerly proposed 30 foot wide road, and a total of 70 mature shade trees throughout the landscaped areas of the Annex. When the environmental study is done for the road in the future,

WEST PASADENA RESIDENTS' ASSOCIATION
POST OFFICE BOX 50252 • PASADENA, CA 91115

there will be nothing to stop it. It should be noted that despite the large number of trees to be removed, the Urban Forestry Commission has never reviewed this plan.

We believe that planning documents should be derived from the will and priorities of the citizens of Pasadena. Therefore, we would ask you to carefully consider the documents before you and the process that brought it to you to determine if the community's expressed concerns have been honored.

And, as we have in the past, the WPRA asks your help in fostering straight forward processes, clearly written documents and transparency and forthrightness in the planning process. In the meantime, we urge you to review and seriously consider the Hahamongna Watershed Park Advisory Committee recommendations.

Sincerely,

Audrey O'Kelley, President
West Pasadena Residents' Association

Cc: Martin Pastucha

Jomsky, Mark

From: Meb787@aol.com
Sent: Monday, February 01, 2010 4:03 PM
To: Laveaga, Rosa
Cc: Bogaard, Bill; Jomsky, Mark
Subject: FOH Responses to Annex Plan Responses to Comments
Attachments: IMG.jpg

VIA EMAIL

February 1, 2010

Ms. Rosa Laveaga
Arroyo Seco Parks Supervisor
233 W. Mountain Ave.
Pasadena, CA 91103

Dear Rosa:

...e following are Friends of Hahamongna's responses to the Hahamongna Annex Plan Responses to Comments prepared by the City of Pasadena and released on Friday, January 29. Since the time is short, we will respond to only the most significant issues.

A. Comprehensive biological surveys of the Annex area were conducted?

PAS-3, FOH-b33 As the attached email, obtained through a California Public Records request, indicates, any reference to the Annex (MWD property) in the Hahamongna Master Plan and the Arroyo Seco Master Environmental Impact Report was done at the last minute and was not based on a thorough analysis.

B. "Bikes Only"

FOH-b62, FOH-b76 This response is incorrect in that the administrative record will show that there was extensive discussion of a biking/hiking path. This was the alternative which was proposed by the Friends of Hahamongna which would have routed hikers/bicyclists to the north and hikers/equestrians to the south. The FOH alternatives were discussed at all the advisory group meetings. The City also posted the FOH alternatives on the Internet. The comment about a shared bike/pedestrian/equestrian path is a red herring since that was not what FOH had recommended nor discussed in our letter other than on a paved path/dirt shoulder which is the City standard throughout the rest of Hahamongna.

FOH mentioned repeatedly that the northern path had to include pedestrians because JPL employees used it extensively. The advisory groups all supported the 10 foot wide northern bike path. At no time during the advisory group meetings, were they informed by staff that the alternative they were supporting would not work because

JPL employees would not be permitted to walk on it. FOH even included an example in our presentation illustrating a northern bike/hiking path and staff did not inform the Committee that this would be an unacceptable configuration.

The comment is incorrect in stating that the existing through-routes are preserved. According to the Final Draft Plan's "Bikes Only" prohibition, the existing through-route is preserved only for bicyclists. The trail to the south is not an existing through-route, even though the Planning Commission was given this impression.

The response is also inadequate in that it does not address other users such as in-line skaters who would be excluded from a "Bikes Only" path.

C. All iterations of the Annex Plan did NOT call for the removal of all non-native trees

FOH-b15, FOH-b74 These responses assert that "all iterations of the Master Plan Addendum included removal of all non-natives trees from the Annex site for habitat restoration." This is not true as is clearly proven by the excerpts from the documents provided below. The most compelling evidence is that there is no discussion of the removal of any non-native trees in the Biological Resources sections of any of the earlier versions of the Initial Study. Had the plan been to remove the trees when the earlier versions of the documents were prepared, the environmental impacts would have been discussed in the Biological Resources section. The Plan when it was reviewed by all the advisory groups except the Hahamongna Watershed Park Advisory Committee called for the removal of as few trees as necessary. A major change in the Plan was made by staff in the middle of the review process.

1. Initial Study, April 2009 version, Biological Resources, p. 3-19:

"The only improvement included in the proposed HMP Addendum that would result in the removal of trees is the proposed multi-use trail corridor along the northern boundary of the Equestrian Center. Forty-two (42) trees are located along this corridor, including 14 oaks, 1 cypress, 1 sugar bush, and 26 non-natives. As identified in Table 3.4.1, this proposed trail improvement would result in the removal of 5 trees. For the purposes of this evaluation, Table 3.4.1 also identifies the 12 trees that would need to be removed if the main park access road was extended to the JPL west parking lot."

Table 3.4.1, entitled Trees Impacted by the Proposed HMP Addendum, includes only two columns: trees to be removed for the trail and trees to be removed for JPL West Parking Lot Access Road. There is no column for trees recommended to be removed for habitat restoration.

This section goes on to discuss habitat restoration as follows:
"It should be further noted that a major component of the proposed HMP Addendum is habitat restoration, including revegetating the existing oak woodland onsite (this is not near the greenway corridor but to the south on the property) and establishing/restoring a sycamore woodland near the site's eastern border (not near the corridor either), p.3-20.

There is no discussion in the Biological Resources section of the first version of the Initial Study of any non-native tree removal whatsoever. If non-native tree removal was indeed contemplated in the Annex Plan as staff asserts, its environmental impacts would have been required to be studied in this section of the Initial Study.

2. Initial Study version, last revised 6-2-09, Biological Resources, p.3-19

"The only improvement included in the proposed HMP Addendum that would result in the removal of trees is the proposed multi-use trail corridor along the northern boundary of the Equestrian Center. Forty-three (43) trees are located within this corridor, which for master planning purposes, is 30 feet in width. The trees within this corridor include 12 oaks, 1 cypress, 1 sycamore, 1 sugar bush, and 28 non-natives (Table 3.4.1).

While the proposed trail corridor is 30 feet in width, the proposed improvements would not encompass this entire corridor and, as such, not all of the 43 trees within this corridor would be removed. Rather it is the City's intent to align the trails in a manner that preserves as many existing trees as reasonable possible. While exact trail dimensions and alignments have not yet been designed, the City estimates that the number of trees that would be impacted by the proposed trail improvements is in the range of 7-19 trees.

The same paragraph about restoring the oak woodland and the sycamore woodland quoted above is also included in this version of the Initial Study. Once again there is no discussion in the Biological Resources section of any non-native tree removal whatsoever.

3. Initial Study version – revisions made after 6/2/09 – no changes to the above

4. Initial Study, Final Draft, 11/20/09 This is the first version in which language about non-native tree removal appears: "In addition to preserving and enhancing natural open space, the proposed Master Plan Addendum recommends removing all trees that are not native to California from the Annex site, and replacing such trees with native species where appropriate", p.2-23

In the Biological Resources section, for the first time, there is the statement that "the proposed HMP Addendum recommends the phased removal/replacement of non-native trees on the Annex," p. 3-19 and for the first time, the table depicting impacted trees includes a column entitled "Recommended removal for habitat restoration?" Table 4.2 Trees Impacted by the Bikeway and Trail Along the Northern Property Boundary, p.4-23 and 4-24.

See Appendix A below for more language from the actual documents which prove that the removal of the non-native trees was added only in the Final Draft of the Annex Plan and the Initial Study.

E. Some other Inadequate Responses in order as they appear in the document

FOH-b19, FOH-b80 "Figure 1" is reflected in the proposed Master Plan Addendum. The rearranging of the equestrian area purportedly for drainage corresponds to that proposed for circulation. Neither the response to comments nor the documents explain why there has to be costly rearranging of the equestrian area and realignment of access roads for drainage purposes alone.

FOH-b21 This response to comment once again does not explain satisfactorily why the JPL east lot is not included in the exhibit of available parking for the Annex. There are portions of the Annex, the equestrian area in particular, that are well within one half mile of the JPL east lot. Portions of the Environmental Education Center may be more than half a mile from the East Lot but that is not true of the entire Annex. If the intent were to provide an accurate portrait of available parking for the Annex rather than to downplay available parking, this exhibit would be modified. For example, it could show this parking as within a half mile of the Equestrian Center rather than the entire Annex.

FOH-b43 It is not the responsibility of the commenter to identify the impacts of unauthorized changes to the park Master Plan. It is the responsibility of the lead agency.

FOH-b45 The response downplays the aesthetic impact of tree removal but fails to note that 33 of the 70 trees, almost half, are all found within the formerly proposed road corridor. Should they be removed simultaneously for some now unidentified future project, the aesthetic impacts would be significant.

FOH-b46, FOH-b47 The Annex Plan does conflict with the Arroyo Seco Design Guidelines which are very clear in the differentiation of landscaped areas vs. habitat restoration areas. The Plan is also not in accordance with the Hahamongna Master Plan which clearly specifies the westside as an area of concentrated recreational activity. Neither of these responses gives any explanation as to why the plain language of these documents should be ignored.

FOH-b49 The response states that native plant species will be planted along the edges of the bikeway alignment. The edge of the bikeway alignment in no way corresponds to the replacement of trees throughout a 40 - 50 foot wide corridor. If native trees are only planted along the edge of the bikeway alignment, then the rest of the corridor will be free of trees.

FOH-b52 This comment gives a general response but does not respond to the fact the these particular California pepper trees, planted on the Annex for decades, have not spread out into the Arroyo. Nor does it address the fact that California peppers are a protected tree on the neighboring 8.5 square miles of La Canada Flintridge and have not spread invasively out into the immediately adjacent Angeles National Forest.

FOH-b61 This response to comments concerning climate change and greenhouse gas emissions is surprising from a city that prides itself on being green. Millions of small damages worldwide have gotten us into the environmental mess we find ourselves in! Shouldn't the city be setting an example rather than cutting down mature shade trees which have many environmental benefits?

FOH-b72 This response is inadequate in that it does not acknowledge that the Hahamongna Watershed Park Advisory Committee was given misinformation which, had they been given the correct information, might have resulted in them making a different decision.

FOH-b73 The comment concerning a "shared bike/equestrian/pedestrian path" is irrelevant and misleading because that was not what was under discussion in our letter except for the shared multi-use paths which are the City standard throughout the rest of Hahamongna – that is a paved bikepath with a dirt shoulder.

FOH-b75 Contrary to the response, the approved bikeway route north of the Annex is within the natural area covered by the Spirit of the Sage agreement according to Exhibit A, Area designated as natural preservation area, pursuant to Settlement Agreement, Spirit of the Sage v. City of Pasadena, prepared January 12, 2004

FOH-b77 The unauthorized change in the Hahamongna Master Plan which resulted in an additional 20 parking spaces in the park is certainly germane to the issue of parking which may of central importance as to whether or not a road is built across the Annex at some time in the future.

FOH-b86 All the non-native trees are known at this time and the theory in the Annex Plan is now that all non-native trees must be removed for habitat restoration so it is still unclear why only the non-native trees in the formerly proposed road corridor are included in the Initial Study Table 4.2.

FOH-b111 This is a very strange response. There are any number of improvements that are identified at the master plan level and not the project level. Why does just the oval teaching arena require a "worst case scenario?" If the formerly proposed road is the improvement which will require the oval teaching arena to be modified/repaired/relocated, this should be disclosed at this time so that the cumulative effects of all projects can be studied.

H-b120 This response is inadequate because it does not answer any of the questions about why the bikeway on the Annex is to be built to so much higher standards than all the other segments of the bikeway in Hahamongna.

FOH-b122 This response is incorrect or nearly so. There is room to put the bike path on the Annex with little or no impact to the equestrian facilities. At most, the jumping arena would need to be moved by a few feet because there is already an existing path in the location where the bikepath could go alongside the jumping arena.

Thank you.

Mary E. Barrie
Friends of Hahamongna

Cc: Mayor Bill Bogaard
Mr. Mark Jomsky, City Clerk

Appendix A

ditional language which proves that the removal of all non-native trees on the Annex was not in all the iterations of the Plan:

May, June, July Master Plan Addendum Section 3.3:

3.3 THE NATURAL ENVIRONMENT

The existing conditions section explained the pertinent issues surrounding the natural environment or the Annex site and in response to these, the following recommendations for the natural environment are made.

Recommendations for the natural environment:

- Consider the wildlife corridors of the larger HWP and extend these corridors through the Annex site wherever possible, through a diversified habitat restoration effort. This would improve the Annex's function as a wildlife corridor;
- Restore, protect and expand natural habitat and plant communities as indicated on the master Annex site plan;
- Landscaping on the Annex site shall be comprised of native plant species;
- Structures within the Annex site need to be located above the 1075.0 flood line or be designed to handle remotely possible, short-term inundations. Trails, emergency/maintenance access and recreation activities need to be located above elevation 1045 to avoid seasonal inundation.

November Master Plan Addendum Section 3.3:

3.3 THE NATURAL ENVIRONMENT

The existing conditions section explained the pertinent issues surrounding the natural environment on the Annex site and in response to these, the following recommendations for the natural environment are made.

Recommendations for the natural environment:

- Consider the wildlife corridors of the larger HWP and extend these corridors through the Annex site wherever possible, through a diversified habitat restoration effort. This would improve the Annex's function as a wildlife corridor;
- Strive for minimal fencing;
- Restore, protect and expand natural habitat and plant communities as indicated on the master Annex site plan;
- Encourage non-native tree/shrub removal and replacement with native species. Any removals shall be done in a phased approach as Annex projects are funded and implemented over the course of the project;
- Landscaping on the Annex site shall be comprised of native plant species;
- Structures within the Annex site need to be located above the 1075.0 flood line or be designed to handle remotely possible, short-term inundations. Trails, emergency/maintenance access and recreation activities need to be located above elevation 1045 to avoid seasonal inundation.

May, June, July Master Plan Initial Study Section 2.4.3:

The proposed Master Plan Amendment designates the site for a variety of natural open spaces along the site's southern, northern, western, and eastern boundaries. The existing and proposed natural open spaces on the Annex site include:

- An oak woodland in the southern portion of the site, which would be restored through implementation of the proposed Master Plan Amendment;
- A meadow area within the oak woodland, which would be created through implementation of the proposed Master Plan Amendment; and

- A sycamore woodland on the eastern border of the site, which would be restored through implementation of the proposed Master Plan Amendment.

The proposed Master Plan Amendment includes a variety of efforts to restore and improve the natural open space onsite. To improve connectivity and enhance habitat value, the proposed Master Plan Amendment designates the fence along the site's southern border for removal. The former team building play area/van parking area would be restored to a meadow within the oak woodland. To protect the habitat value of this area while allowing human use, formal access routes and a permeable parking surface would be provided to limit destruction of vegetation. Likewise, to limit the impact footprint, the proposed Master Plan Amendment calls for management and restriction of *Initial Study/Addendum to the Arroyo Seco Master Plan MEIR City of Pasadena HWP Master Plan Addendum for the Hahamongna Annex Page 2-23* equestrian activity in the oak woodland area, which has historically degraded this area. Finally, all of the natural drainage areas onsite would be preserved and enhanced.

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May, June, July Master Plan Initial Study Section 2.4.3:

d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with
established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

The Arroyo Seco Master EIR indicated that no significant interference with fish or wildlife species movement or nursery sites would occur as a result of the HWP element of the Arroyo Seco Master Plan, largely because the project proposed low-intensity uses and significant habitat restoration. The HMP Addendum would renovate "developed area" and "landscaped vegetation" similar to those areas described in the Master Plan (Arroyo Seco Master EIR, p. 3.3-10) and would preserve the onsite oak woodland. Notably, the HWP Master Plan Addendum, Goal 1, "Preserve, Restore and Enhance the Native Habitats," sets forth nine specific objectives that would support wildlife movement and nursery sites; these objectives are further clarified in section 2.4.3, Natural Open Space, which calls for oak and sycamore woodland restoration, fence removal and protection from equestrian uses. With these objectives in place, any impacts to wildlife movement or reproduction would be less than significant, and no additional impact on the environment pursuant to CEQA § 21166 would occur.

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November Initial Study Section 2.4.3:

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d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with
established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

The Arroyo Seco Master EIR indicated that no significant interference with fish or wildlife species movement or nursery sites would occur as a result of the HWP element of the Arroyo Seco Master Plan, largely because the project proposed low-intensity uses and significant habitat restoration. The HMP Addendum would renovate "developed area" and "landscaped vegetation" similar to those areas described in the Master Plan (Arroyo Seco Master EIR, p. 3.3-10) and would preserve the onsite oak woodland. Notably, the HWP Master Plan Addendum, Goal 1, "Preserve, Restore and Enhance the Native Habitats," sets forth nine specific objectives that would support wildlife movement and nursery sites; these objectives are further clarified in section 2.4.3, Natural Open Space, which calls for oak and sycamore woodland restoration, fence removal and protection from equestrian uses. With these objectives in place, any impacts to wildlife movement or reproduction would be less than significant, and no additional impact on the environment would occur.

In August and September of 2009, a wildfire known as the "Station Fire" burned 161,189 acres[2] of land in and around the Angeles National Forest. This fire burned within 4,000 feet (0.75 miles) of the Annex site. Due to the resulting loss of vegetation in the nearby Angeles National Forest, interested parties have expressed concerns that the proposed HMP Addendum could impact wildlife that may be seeking temporary refuge on the Annex site. Specifically, commenters expressed concern for the removal of trees that could support displaced wildlife.

As discussed below in response to question (e), the proposed HMP Addendum recommends the phased removal/replacement of non-native trees on the Annex site for habitat restoration, removing individual trees over time to allow for certain proposed improvements, and removing unhealthy, diseased, or hazardous trees.

Cox, John

From:	Laveaga, Rosa
Sent:	Monday, July 07, 2003 5:30 PM
To:	Cox, John
Subject:	RE: Sect 2 Existing Conditions

thank you....I read this and it sounds great....saved it as is and making part of the final. I appreciate how fast you went thru this.

-----Original Message-----
From: Cox, John
Sent: Monday, July 07, 2003 10:40 AM
To: Laveaga, Rosa
Subject: FW: Sect 2 Existing Conditions
Importance: High

Rosa,
Here are my edits regarding the inclusion of the MWD property. Sometimes I added "and the MWD property" for emphasis, and other times I deleted "HWP" and added "the master plan study area" for simplicity. Should master plan be capitalized? I deleted a reference to the turtle caprice I found that Jim later identified as a non-native species. Give me a call so we can discuss two items I did NOT change, but maybe we should. John

-----Original Message-----
From: Laveaga, Rosa
Sent: Sunday, July 06, 2003 5:58 PM
To: Cox, John
Subject: Sect 2 Existing Conditions
Importance: High

Hey John,
Here is Section 2 with my redlines.....like I said, the only thing I need help with here is making sure we include anything we have about the MWD property under the various topics discussed. At this point, we can't go dig up data, so I think we keep it very general and simple, and just drop in what we do know. I hope it's as easy as I am making it sound.
Keep your track changes on in red....you don't have to differentiate what you do....when you're done, just ship it back to me so I can put on my master floppy disk. Again, I hope to get this back from you by noon if possible.

<< File: Sec 2 - Existing Redlined Version for 7-28-03 CC Mtg.doc >>

Rosa Laveaga
City of Pasadena
Arroyo Seco Park Supervisor
Parks and Natural Resources Division
Phone (626)744-3883