EnviroHorse

3027 St. James Rd. Belmont CA 94002-2955 650-592-0722
envirohorse@yahoo.com www.californiastatehorsemen.com/envirohorse.htm

ENVIRONMENTAL ASPECTS OF HORSES ON TRAILS

Abstract

Due to the urbanization of America, the general population has lost its contact with and innate understanding of most animals, including livestock. The horse, in particular, is a unique animal. Because it is large and seldom encountered, people assume that it is no different than other species of large animals. This paper is meant to help people understand horses and their interactions with the environment when they encounter equines on trails.

Every trail user potentially causes some impact to the environment by their use. For lightweight low-impact users, the effects are usually minimal. Scientific studies indicate that the horse may be more benign to wildlife than hikers, nature studiers and photographers. There are no studies that significantly implicate trail use by horses with spreading weeds. Natural erosive forces are likely to be the major alteration factors in trail erosion. Horses on trails are not detrimental to water quality according to the latest studies by NAHMS, University of Colorado and UC Davis-Tulare.

Equestrian Use of Trails is "Passive" Recreation

Every trail user potentially causes some impact to the environment by his/her use. Compared to motorized usage, hikers, bikers and horses have been variously described as passive, light-weight, and/or low-impact trail users. The effects of passive use on trails are usually minimal. In virtually every mixed use trail reference within the State of California and the nation, the horse has been defined as a passive, low impact or light weight user, *even in the most sensitive environments: Natural Preserves*.

- Edgewood Park and Natural Preserve Master Plan Adopted May 1997 (Parks and Recreation Division San Mateo County) Pg. 11 B. Definitions 6. Definition of Low-Intensity Recreation Uses: "Define low-intensity recreation uses as passive recreation uses that will not create a direct or cumulative adverse environmental impact. Such uses include, but are not limited to, on-trail hiking, walking, jogging, horseback riding, nature observation, education, docent-led group tours, and picnicking and

camping…". This is a natural preserve of rare serpentine grassland that supports numerous threatened and endangered species

- The Mid-Peninsula Open Space District (MROSD) on the San Francisco Peninsula defines Trail Use Suitability to include: Hiking, Running, Equestrian, and Bicycling throughout most of their 43,000 acres of Natural Preserves.

- Santa Clara County Countywide Trails Master Plan, 1995,"identifies hiking, horseback riding, and bicycling trails" as lightweight use.

- The USDA Region Five Shasta-Trinity National Forest Trail Procedure Guide builds trails to include the horse as a lightweight user.

- The US Forest Service/USDA Rocky Mountain Region Guide for Mountain Trail Development builds trails for hikers, joggers, and equestrians, all considered lightweight, low-impact users.

- The California Trails Foundation uses the California Department of Parks and Recreation Klamath District/North Coast Redwoods District Trail Manual. Section 1.4 Trail Standards for Class I Trails states, " These trails include handicapped accessible, equestrian, interpretive and hiking trails assigned a Class I point criteria value. "

- The State of Washington Department of Natural Resources' Recreation Trail Maintenance produced in cooperation with the USDA and NPS designs trails for low-impact users, including equestrians.

- The Bay Area Ridge Trail creates a multi-use trail system around the San Francisco Bay for hikers, bikers, joggers, and equestrians. All considered lightweight users.

- Marin County Countywide Trails Plan (1984 and seq.) considers hiking, horseback riding and bicycling as passive usage of its open space preserves.

- The Rocky Mountain National Park includes equestrians as low-impact users.

Wildlife and Horses

Horses are prey animals. They have eyes on the side of the head. They are herbivores and leave the trace scent of an herbivore on the trail. Humans, dogs and cats are predators. Their eyes are on the front of the face. As they walk, they leave the trace scent of omnivore on the trail that can impact wildlife.

Horses are recognized by wildlife as prey animals, even when a person is sitting on their back. An approaching horse passing along a trail provides sound rhythms in the cadence of a four-footed hoofed prey animal to wildlife, which informs wildlife of a non-threatening presence. For reptiles, rodents and other terrestrial life forms, the percussion pulse of the approaching horse provides warning. Being warned diminishes flushing/flight response that consumes wildlife energy. It is not uncommon to find deer, bobcat and coyotes that allow horses to get within feet of them on trails before calmly moving off. Horses rarely step on lizards, mice and other fast moving wildlife. Riders can easily avoid slower moving wildlife.

Bennett and Zuelke (1999) undertook an extensive review of recreation effects on birds and concluded that disturbance from recreation has temporary effects on behavior and movement of birds. Direct approaches caused greater disturbance than tangential approaches, rapid movement by joggers was more disturbing than slower hikers; children and photographers were especially disturbing, and passing or stopping vehicles were less disturbing than human foot traffic. Horses and riders did not disturb birds.

Sporadic human use can disturb wildlife. However, “many animals are less afraid of horseback riders than hikers. Riders seldom dismount to touch flora or fauna. Riders can be a dedicated and energetic volunteer and advocacy group. The horse-rider relationship promotes a non-anthropocentric worldview that facilitates ecological understanding. Horses are useful for patrols, supplying trail maintenance, and doing surveys. Horse traffic can be used to maintain firebreaks and seldom-used trails.” (Williams and Conway-Durver, 1998)

Weed Seeds and Horses

The primary vectors of weed seed spread are wind, water, avians, and rodents. There is no documented evidence of the horse spreading weeds. A Montana study by Tyser and Worley (1992) implicated timothy (*Phleum pratense*) and bluegrass (*Poa pratensis*) as species that had been included in past roadside seeding by the local highway authority. In California, the Department of Transportation (CalTrans) has recently been identified as the number one spreader of yellow star thistle by its past practices of scattering various weed-laden hays during roadside rehabilitation projects to control erosion. CalTrans has now switched to wetland chaff from rice crops for soil stabilization purposes that does not contain thistle seeds.

It is unknown to what extent high quality livestock forage available contains weed seeds. However, most horse owners would not buy junk hay for their horses. Garbage in, poor performance out! The days of large populations of lower-grade, inexpensive stock horses are long gone. Horses cost money, and the purchase price

is only the down payment for ownership. Horsemen cannot afford to compromise their investments by feeding weedy hay. Responsible horse owners are concerned about getting quality feed that has been properly planted, harvested, and cured for their horse food dollar. (Berto 2000). Many horses are fed processed or pelletized feedstock. This is forage that is heated. The heat destroys weed seeds.

According to Dr. Deanne Meyer (1997), UC Davis Manure Management Specialist, the majority of all horse excrement occurs at home in pastures or paddocks. It is, therefore, highly unlikely for the horse ever to be a major vector of weed seed spread simply from its use on a trail.

By 2003, all forage brought into trailheads on federally- and state-managed properties will be required to have a weed-free feed certificate. Equestrian trail users have been active participants in designing this program in collaboration with land managers. Information on this subject can be found at www.weedfreefeed.com .

The horse has a very inefficient gut: it's a one-way through-put system. Horses are physiologically incapable of vomiting or regurgitating. If something gets stuck on the way through, the only way to get it out is by surgery or physical intervention (at arm's length!). As a consequence, horses must be fed carefully to avoid the common and potentially fatal condition of colic. The bulk of unprocessed forage consumed by California horses is alfalfa (Medicago sativa), rye grass (Lolium multiflorum or perenne), Timothy hay (Phleum pratense) and oat hay (Avena sativa (white cultivated oats)). If horses were a vector of seed spread, these grasses could be prevalent in our open spaces and parks, but they are not, except possibly in places where they were introduced in earlier times as grazing forage for cattle.

The California Exotic Pest Plant Council (www.caleppc.org) lists the following plants as the major invasive culprits: Tamarisk, knapweed, and thistles. Horses do not eat these species, many of which are actually toxic to the equine. Star thistle consumed by horses can cause a potentially fatal Parkinson-like disease. Stinging nettles recently killed two trail horses at Pt. Reyes National Seashore. Knapweeds are very toxic to horses. For the health of our animals, equestrians are keenly interested in the abatement of exotic and invasive plants.

Because the horse is not perceived as a major contributor to the spread of weed seed from trail use, trail manure has been little studied. However, there is much literature on composted horse manure. Harmon and Keim (1934) note that composted horse manure virtually kills all weed seeds.

Janzen (1981, 1984) is the researcher who has done the most studies on seeds in horse manure. Among his conclusions are:

- Most seeds are dry or otherwise inconspicuous and are not associated with specific dispersal agents (e.g., the horse). Seeds are primarily

dispersed by gravity, wind, surface water movement, soil erosion, birds, ants, dung beetles and rodents.

- The horses killed a substantial fraction of the seeds they swallowed through chewing and the inorganic acids and enzymes of digestion.
- Horse gut differs from cow gut. No horse had a seed passage rate anywhere near as fast, or a seed survival rate as high, as the cow.
- The primary sites of seed digestion in the horse are corners, folds, and eddies of the gut and the caecum (a specialized pouch for fermentation of ingested nutrients). In the horse, the caeca somehow remove hard objects (and seeds) and retain them for unknown periods of time. Only one brass button out of 57 fed was voided for the duration of a 70-day study!
- There is no evidence that passage through the horse "enhances" germination of surviving seeds
- Seeds must be sufficiently small, tough, hard, and inconspicuous to escape the molar mill and spitting response of a large mammal. Seed coats must have the ability to resist digestion during a transit period of days to months. Horses are as likely to be an intense seed predator as they are to be a possible dispersal agent. "The seed that is so impervious that the horse does not kill it by molar or chemical scarification may then be so slow to be scarified by soil processes that it has significantly fewer generations than the less impervious morph."
- The longer the seeds are in the animal (or buried in composted dung), the higher the seed mortality by digestive processes.
- If a seed germinates immediately in the dung, the community of dung-degrading organisms may kill it.
- Severe mortality to seed sprouts in a manure pile is likely, due to inter- and intraspecific crowding.
- Large herbivores do not significantly carry seeds in hair or coats.

Finally, Benninger-Truax (1989, 1992) studied edge effects of trails in Colorado. She notes that seeds can pass through horses unharmed and be deposited in feces. *She states that she found no documentation that horses are major source of exotic species in her literature search.* In her Master's thesis, Benninger did a greenhouse study on seeds extracted from horse manure. Seeds from 15 plants grew, but only 8 were identified. While all 8 were exotic, NONE of them appeared in her test plots on the trail, although she observed them elsewhere along trails. She determined that horses from the stable in the park that were not allowed to graze in the park (which had exotics along some trails) and had controlled diets were not a problem for weed seed dispersal along the trails. A simple Best Management Practice (BMP) is obvious here.

The erroneous assumption that manure is a major source of exotic species suggested by some should be put to rest by Benninger-Truax's statement: "…however, I have found no documentation of this in the literature." Neither has EnviroHorse a decade later. While some seeds can survive the journey through

the horse mouth and gut, Janzen's statement suggests its fate: " While an *Enterolobium* seedling germinating in a dung pile is picturesque, its chances of surviving the dung beetles, mice, dryness, and root exposure characteristic of dung piles are very slim."

Seeds are primarily dispersed by gravity, wind, surface water movement, soil erosion, birds, ants, dung beetles and rodents. Since the majority of horses are carefully fed domestic grasses, have physiology mitigating against seed survival, and primarily defecate in their home paddocks/pastures, it is unlikely that horses are a significant vector for seed spread when they are on trails.

Trails and Horses

Soil erosion is a two-part process: soil particles are loosened largely by wind or raindrop impact (lesser by freeze/thaw, wet/dry cycles) and transported by the flow of wind and water. The four primary factors involved in erosion are climate, soil characteristics, topography and ground cover. In the United States soil erosion removes an estimated 2,100,000,000 tons of soil per year (Gergus, 2002).

The literature is divided about whether horses compact trails, or stir them up. This is likely to be a variable dependent on soil type, its structure, and possibly climate.

According to public testimony to the MROSD on December 16, 1998 given by Professor and Chair Gordon E. Brown Jr., Stanford University Dept. of Earth Sciences Synchrotron Radiation Laboratory Faculty, the primary causes of erosion are natural and far surpass any impact of use of horses on trails.

In a 5-year study, Summer (1990, 1996) concluded that horse traffic was not the single dominant process active on trails. Trail degradation was a function of landform, climatic and catastrophic events, and geomorphic processes. Seasonal use was important in keeping the soil exposed and vegetative cover absent on trails. Such processes as sheetwash, rilling, gullying, and soil creep actively modified and eroded the trails and resulted in a measurable fluctuating rate of change over time. Limited data suggested that foot traffic produced effects similar to horse traffic in exposing the trail to the effects of geomorphic process or climatic events. Intensive runoff resulting form natural events can cause significant geomorphic change in a trail from such processes as gullying and earth slumps. Erosion from these events may overshadow effects of horse use on trails.

Williams and Conway-Durver (1998) concur that factors other than user type are more closely linked to trail degradation. Lightly used trails may grow over and require more maintenance, whereas moderate horse activity may help to

maintain a multiple-use trail. The bottom line is that horse trails can be maintained on most natural preserves without unacceptably impacting ecological values.

The physical impact of horses on trails is highly variable-dependent. In high rain regimes and certain soil types, more physical impact would be expected. Seasonal closure of some trails may be appropriate. Water should be diverted off of all trails to prevent erosion. In order to further mitigate an impact in more susceptible areas, rocking equestrian trails may be appropriate. Spreading 3/4" hard native rock, decomposed granite (DG), or basalt provides a firmer trail tread. Over time, this rock sinks into the soil and "hardens" the trail tread, improving year-round conditions for all users. Repeated rock application over time provides excellent tread surfaces for mixed users and does not significantly alter soil chemistry in sensitive habitats (Murarka, 1996). The Clarkia Trail in San Mateo County's Edgewood Park and Natural Preserve is an excellent example of how a trail can be maintained year-round in potentially mucky black clay soil using local serpentine rock. Specifications for construction of mixed use trails can be found in Appendix A.

Water Quality and Horses on Trails

The endpoints of scientific inquiry for water quality studies are human exposure to pathogens for health implications and nutrient/sedimentation pollution for environmental implications. Excrement or wastes of any type should never be deposited or disposed of in water bodies.

Human Health

Coliforms are ubiquitous in the environment. While they are not necessarily harmful to people if ingested, coliforms are an indicator that unwanted matter is present in the water system. Their virulence is little understood; hence the precautionary care to prevent human exposure to excess amounts of them. Coliforms, however, have not been known to injure aquatic organisms or wildlife according to Dr. Michael Rugg, Toxicologist, California State Fish and Game, Yountville CA.

Recent scientific studies and their replicates confirm that adult horse guts do not significantly contain *E. coli* 0157:H7, *Salmonella, Cryptosporidium, or Giardia,* which are the organisms of most concern in water-borne spread of disease. (Atwill, et al; see several references.)

Groundwater

We have found no studies that we found implicating equids in groundwater contamination. Horses eliminate primarily in their pastures and paddocks (Meyer 1997). Manure left in a loose heap in deposits on trails loses its nitrogen rapidly (New Hampshire 1990). It is inconceivable that trail horses

making dispersed deposits could possibly impact ground water. Most contamination of this sort occurs from areas associated with feedlots where thousands of commercially harvested animals are confined at one time, or from excessive fertilization added to soils.

Compared to other large livestock, horse manure is relatively “dry” and “hot” due to unique digestive enzymes and flora. Once deposited, it can achieve total mineralization in as short a time as 21 days (Ajwa, et al 1994). Because it is so dry at excretion, nutrients tend to volatilize rapidly into the atmosphere. One of the challenges in preserving nutrients in horse manure is to get them turned into the soil as rapidly as possible before the nutrients are lost to the air.

Surface Water

Again, there are very little data about impacts from horses. Bacteriological and nutrient effects (on water bodies) are seldom detectable except next to stables. (Williams and Conway-Durver, 1998). As part of the 319(h) grants from the Clean Water Act, new data are becoming available. Five studies have taken place in the San Mateo County watersheds to date (2002). It is important to keep in perspective that these studies involve settings where horses live 24 hours/day next to a creek. Thus far, data have not confirmed significant adverse affects on the surface waters immediately adjacent to them. Leaking aging septic systems, residential over-fertilizing, and certain agricultural practices are suspected where data exceed recommended standards. Given this, it is difficult to conceive of a situation where the manure from a few horses on a trail could adversely impact surface water nearby. Again, most trails are not sited immediately adjacent to water bodies and Mother Nature has a marvelous buffering capacity when even as little as 10 feet of vegetation is available at the side of a trail.
www.ca.nrcs.usda.gov/rts/sec4.htm

Phosphorus and potassium are the trace constituents of most concern in horse urine. They bind to soil particles and may be eroded away into surface water bodies. They would be present only in the minutest of quantities in manure on trails, thus of little concern. For horses paddocked near streams, a recent study by Dr. Michael Rugg on accumulation of urine salts in soil in arid climates demonstrated that these salts could be dissipated in just three days by watering dry paddocks to invite biological degraders to the soil. Thus a simple BMP of turning on a sprinkler once a day will not only keep dust down, but will mitigate urine salt accumulation in paddock soils.

Stream Crossings

There is a trend to protect stream banks from erosion by trail use and discourage trail users from disturbing streams that support fisheries. Bridges are being built across historic fords. It is known that as little as 0.025ppm of ammonia in water can kill salmonoid species (Rugg).

While horses can readily defecate on trails, they do not as readily urinate on trails. (Gosslin and Wolford, 2001). Because of their physiology, horses under saddle generally signal riders of their need/intent to urinate. They are allowed to stop walking. Horses then stretch their bodies out in a rather awkward position to urinate, often standing on the front edges of their hooves simultaneously in a splayed posture. This places them in a vulnerable position if attacked by a predator. 60 million years of evolution and survival means that this is an activity not undertaken lightly by the horse. Many horses prefer the safety and security of their stall or paddock to undertake this function (UC Davis Book of Horses 1996). Because of this unique behavior, it is easy for the rider to spur the horse out of a stream to avoid urination in a water body. Because the urination posture is impossible to achieve during locomotion, it will be more apt to occur with a relaxed horse at rest (Horst 2000). Urination can be readily managed to avoid elimination in water bodies.

Equestrians are being educated not to allow their animals to eliminate during stream crossings. BMPs have evolved such as stopping prior to a crossing to allow the animal to rest, relax, and (hopefully) eliminate PRIOR to the crossing. Simply not allowing the horse to stop and dawdle in the water will also help to prevent contamination. Many horses do not like getting their feet wet and have a natural aversion to taking any more time than necessary in water. A small study is underway to collect data on horses eliminating while crossing streams. It is expected to take several years before a robust database is available. But preliminary data collected in 2000-2001 indicated that very few horses eliminated during stream crossings. In a letter to equestrians dated July 2, 2001 Dr. Michael Rugg described the risk of stream crossing to fish and aquatic species, but concluded by saying, “However, as long as the riders are aware of the risks, and make an effort to avoid having their animals urinate or defecate in or near the creek, the risks to fish and aquatic life (of horses making a stream crossing) are acceptable.”

Trail Etiquette and Horse Physiology

For safety sake, other trail users should always yield the right-of-way to equestrians. Would you argue with a Mack Truck if you were a VW bug on the highway? Stop and stand quietly off the trail until the horse passes. Failure to do so can endanger the hiker / runner as well as the horse and rider. Fast-moving trail users may startle horses and slower-moving people. Please verbally announce your presence immediately, especially when approaching horses from behind, and ask the rider for instructions on how to pass the animal. The rider may ask you to step off the trail so he/she can ride by, or may ask you to walk by while he/she stands the horse. The circumstance may vary depending on the personality of the horse involved and physical conditions of the site.

Why do horses “spook”? Horses have large eyes that provide a wide range of peripheral vision. Each eye boasts a field of 215 degrees of monocular fixation (focusing one eye on a subject) with the fields overlapping in front of the horse’s head to create 60-70 degrees of binocular fixation (where both eyes can focus on a single object). This allows the horse to view the ground ahead more sharply and with depth perception (stereopsis). However, horses have small blind spots in front of and behind them that can only be clarified by turning the head to observe with its monocular vision. Any stationary object in the horse’s blind spots may seem to “jump” when its image moves in and out of the peripheral field of vision, as the horse turns its head in an attempt to focus. This can result in a typical fleeing or “spooking” behavioral response. Unlike humans, a horse must move its head up and down to focus its eyes on an object. When a horse holds its head upright and high, it is usually focusing on an object in the distance and cannot clearly see the ground directly beneath its nose. The vision of a trotting or galloping horse is not as acute as that of a stationary horse. A horse’s range of vision along with its degree of visual acuity should always be taken into consideration when you approach a horse on the trail, particularly from behind. (UC Davis Book of Horses 1996)

Disclaimer

About the Author and this Paper

Adda Quinn worked for a nationally known research institute for 21 years prior to her retirement. Her research projects focused on contaminated soil and groundwater issues. As a trail advocate, she has provided research results in a variety of regulatory debates, both nationally and locally. She is a founding member of and on the Board of Directors for EnviroHorse.

This paper is a work in progress. It is our intention to update it periodically as new information becomes available. For the most recent version, always consult the website at www.californiastatehorsemen.com/envirohorse.htm

About EnviroHorse

Mission

EnviroHorse identifies, gathers, and disseminates information to ensure/enhance equine access to public / private lands. Where data gaps exist, EnviroHorse sponsors research to fill them.

Goals

1). To establish and provide a clearinghouse for information on horses, horse trails and other related equine uses. This effort will include

· synthesis papers on important environmental and health issues
· hard copy of source data by subscription
· electronic network site with linkage to other resources
· electronic database for pertinent papers
· linkage to environmental and community benefits from horses
· linkage to legal resources for equine issues

2). To identify and raise funding for research on priority issues.

3). To work with other equestrian organizations to assure continued equine access to public and private lands.
If you have any scientific studies that you think would be helpful, these papers are a work-in-progress and EnviroHorse would love to have copies of them. Please contact us at envirohorse@yahoo.com .
If you have found these citations helpful, please consider a donation to EnviroHorse to help us find and sponsor more research. Papers are housed at www.californiastatehorsemen.com/envirohorse.htm

REFERENCES

Ajwa, H. A. and Tabatabai, M. A. 1994. "Decomposition of different organic materials in soils". Biol. Fertil. Soils Vol. 18. Pp. 175-182.

Atwill A number of excellent references are now available on horse gut pahogens

E. Johnson, Atwill, E. R., Filkins, M. E., and Kalush, J. "The prevalence of shedding of *Cryptosporidium* and *Giardia* spp. based on a single fecal sample collection from each of 91 horses used for backcountry recreation." Journal of Veterinary Diagnostic Investigation. Vol. 9. Pp. 56-60. 1997.

In the winter 2000-2001, Dr. Atwill of UC Davis-Tulare, conducted a further research study on 250 horses in the San Francisco Bay Area. Due to concerns expressed by organic gardeners about the safety of using composted horse manure as a soil amendment, Atwill determined again that insignificant levels of E. coli 0157:H7 and *Salmonella* were in adult horse guts. Composted manure showed no E. coli 0157:H7 after 24 hours in pile residence. Research results should be available in the near future. A 1998 NAHMS study on "*Salmonella* and the US Horse Population" confirms *Salmonella* is not an issue in horses (www.aphis.usda.gov/vs/ceah/cahm/Equine/eq98salm.htm).

K. N. Ford, Swinker, A.M., Traub-Dargatz, J. L., and Cheney, J. M. "The Prevalence of *Cryptosporidium/Giardia* in the Trail Horse Population Utilizing Public Lands." Proceedings of 15th Equine Nutritional Physiology Symposium. Pp. 223-237. 1997, and JEVS 18 (1) 1998. And paper available by Laurie Fio with Rob Atwill: "Cryptosporidium in the Water – Are Horses to Blame?"

M. M. Peng,[1] Xiao, L.,[2] Freeman, A. R.,[2] Arrowood, M. J.,[2] Escalente, A. A.,[2] Weltman, A. C.,[3] Ong, C. S. L.,[4] MacKenzie, W. R.,[2] Lal, A. A.[2], and Beard, C. B.[2] "Genetic Polymorphism Among *Cryptosporidium parvum* Isolates: Evidence of 2 Distinct Human Transmission Cycles." Emerging Infectious Diseases. Vol. 3. No. 4. Oct.-Dec. 1997. Pp. 567-573. University of Michigan[1], CDC Atlanta[2], PA Dept. of Health[3], University of British Columbia[4].

Bennett, KA and E. Zuelke . 1999. The effects of recreation on birds: a literature review. Delaware Natural Heritage Program, Smyrna, DE 1977.

Benninger, M. 1989. "Trails as Conduits of Movement for Plant Species in Coniferous Forests of Rocky Mt. National Park, Co." Miami of Ohio Univ. Masters Thesis.
Benninger-Truax, M., JL Vankat and RL Schaefer. 1992. "Trail Corridors as Habitat and Conduits for Movement of Plant Species in RMNP, Co. Landscape Ecology. 6(4):269-278.

Berto, Connie. 2000. Marin County Horse Council. Personal Conversation,

Brown, Gordon E., Jr. D.W. Kirby Professor of Earth Sciences, Professor and Chair, Stanford Synchrotron Radiation Laboratory Faculty Stanford Universit. on December 16, 1998 public testimony before the Midpeninsula Regional Open Space District (MROSD).

Gosselin, Dr. Larry DVM, pers. comm. 4-10-01; Dr. Larry Wolford specializing in equids, pers. comm. 4-5-01.

Gergus, Scott. North Coast Regional Water Quality Control Board. "Soil Erosion Causes and its Problems". April 10, 2002. Equestrian Planning Course Santa Rosa Junior College. Many citations offered.

Harmon, G., and F. Keim. 1934. "The Percentage and Viability of Weed Seeds recovered in the Feces of Farm Animals and Their Longevity when Buried in Manure." American Society of Agronomy Vol. 26. Pp. 762-767.

Horst, Toby. Chairman BackCountry Horsemen, pers. comm. 2000.

Janzen, D. 1984. "Seed Dispersal of Small Seeds by Big Herbivores: Foliage is the Fruit", The American Naturalist. V1223, pp.338-353.
Janzen, D. 1981. "*Enterolobium Cyclocarpum* Seed Passage Rate and Survival in Horses, Costa Rican Pleistocene Seed Dispersal Agents". Ecology 62(3), pp. 593-601.

Meyer, Dr. Deanne. 1997. "Horses spend most of their time in pastures or paddocks where the majority of their excrement is deposited, collected and managed. Horse manure is about 70-80% liquid and 20-30% solids." Personal communication, UCDavis Manure Management Specialist.

Murarka, Dr. Ishwar. Edgewood Park and Natural Preserve Master Plan Adopted May 1997, Environmental Services Agency Parks and Recreation Division, San Mateo County California. Appendix C-1 "Potential Impacts of Using Identified Non-Native Rocking Materials in Serpentine Grassland".

New Hampshire Dept. of Ag and USDA. Good Neighbor Guide for Horse-Keeping: Manure Management. 1990.

Rugg, Dr. Michael Toxicologist, Calif. Dept. Fish and Game in personal communication to Adda Quinn and Alistair Bleifuss (RCD TAC), 1998. That year, EnviroHorse provided Dr. Rugg with a bucket of soil heavily contaminated by horse urine from an equine who refused to urinate anywhere but in one spot for 10 years from which he determined that urine salts could be mitigated by light watering of dry paddocks during summer in three days. A letter dated July 2, 2001 by Dr. Michael Rugg to Michael Murphy, Santa Rosa RCD liaison, described the risk of stream crossing by horses to fish and aquatic species as acceptable, if no deposition occurs.

Santa Clara County Countywide Trails Master Plan. November 1995. Figures G-2 and 3. Permission to use only if distributed at no cost.

Summer, RM. 1996. Geomorphic Impacts of horse traffic on montane landforms. J. Soil and Water Cons. 41(2): 126-128.
Summer, RM. 1980. Impacts of horse traffic on trails in RMNP. J. Soil and Water Cons. 35(2): 85-87.

Tyser, RW and CA Worley. 1992. Alien flora in grasslands adjacent to road and trail corridors in Glacier National Park, Montana USA. Conservation Biology 6:253-262.

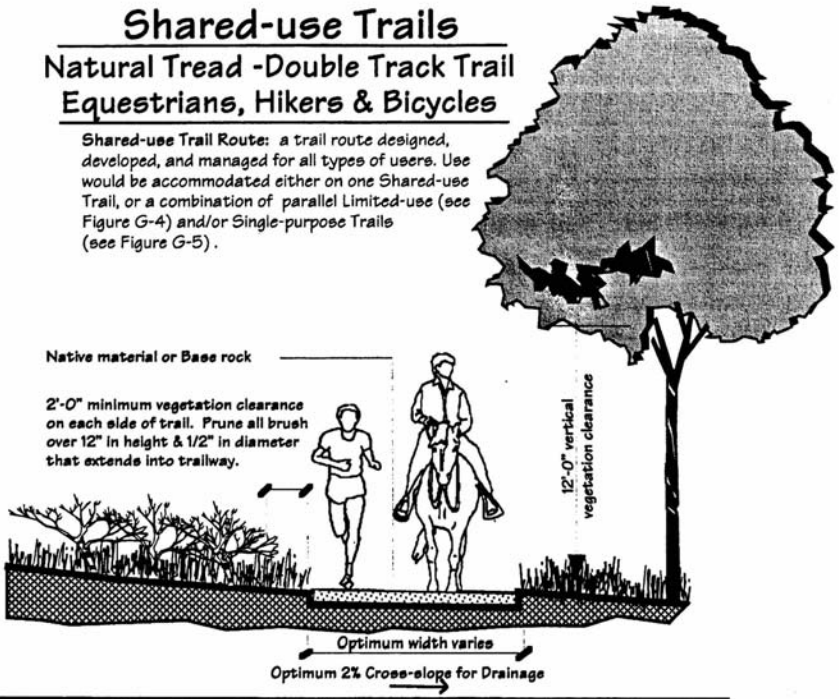
Williams, B. and L. Conway-Durver. "HORSE TRAILS IN ECOLOGICAL RESERVES" presented at Clemson University Horse Trails Symposium, 1998 by Conway-Durver. Mr. Williams holds a BS Degree in Forestry from Clemson University. He worked for the U.S. Forest Service as a River Ranger on the Sumter National, organized the Association of Forest Service Employees for Environmental Ethics and is the Executive Director of the Chattooga River Watershed Coalition. Conway-Durver is a PhD with experience in ecological consulting.

UCDavis School of Veterinary Medicine, Ed. Mordecai Siegal. Book of Horses: A Complete Medical Reference Guide for Horses and Foals 1996. Chapter 4 Equine Behavior by Carolyn Stull Pg 59.

Shared-use Trails

Natural Tread -Double Track Trail
Equestrians, Hikers & Bicycles

Shared-use Trail Route: a trail route designed, developed, and managed for all types of users. Use would be accommodated either on one Shared-use Trail, or a combination of parallel Limited-use (see Figure G-4) and/or Single-purpose Trails (see Figure G-5).



Landscape Designation	Typ. Maximum Trail Grade	Average Terrain Slope	Optimum Trail Tread Width
Valley Floor Areas	8.33%	0-15%	12'-0"
		16-30%	12'-0"
		>30%	N/A
Foothill Areas	10%	0-15%	12'-0"
		16-30%	10'-0"
		>30%	8'-0"
Mountain Areas	12.5%	0-15%	6'-0"**
		16-30%	6'-0"**
		>30%	4'-0" to 6'-0"

Notes:

- For trails typically outside of Urban Service Areas as shown on the County General Plan Land Use Map.
- "Optimum:" the best or most favorable condition for a particular trail situation from the perspective of responsible management.
- ** Should a situation be encountered where the optimum width indicated can not be achieved or a staged development approach is used where narrower trails precede the optimum buildout width, mitigation measures should be used to provide for trail user safety. Such measures could include, but are not limited to: brush removal and clearing to augment lines-of-sight, trail pullouts at regular intervals, one-way trail managment, signage, or dismounting requirements.

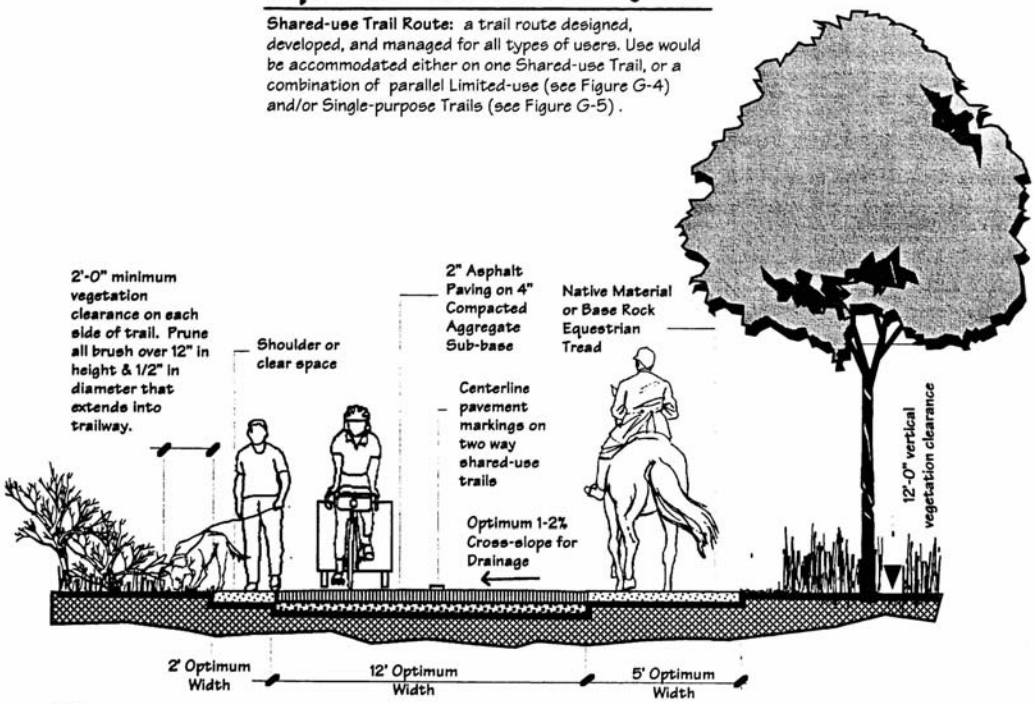
Santa Clara County Trails Master Plan Update: Design Guidelines **Figure G-3**

November, 1995

Shared-use Trails

Paved Tread - Double Track Trail
Equestrians, Hikers & Bicycles

Shared-use Trail Route: a trail route designed, developed, and managed for all types of users. Use would be accommodated either on one Shared-use Trail, or a combination of parallel Limited-use (see Figure G-4) and/or Single-purpose Trails (see Figure G-5).



Notes:

- "Optimum:" the best or most favorable condition for a particular trail situation from the perspective of responsible management.
- Should a situation be encountered where the optimum width indicated can not be achieved or a staged development approach is used where narrower trails precede the optimum buildout width, mitigation measures should be used to provide for trail user safety. Such measures could include, but are not limited to: brush removal and clearing to augment lines-of-sight, trail pullouts at regular intervals, one-way trail managment, signage, or dismounting requirements.

Santa Clara County Trails Master Plan Update: Design Guidelines **Figure G-2**

November, 1995