REDUCING THE ENVIRONMENTAL IMPACT OF HORSE KEEPING

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Research Proposal

Equestrian activities require land resources that are in high demand for a variety of uses. Today, horse boarding facilities are being concentrated on smaller amounts of land and closer to urban areas. Keeping horses requires resource and energy inputs that produce potentially polluting waste if not managed properly. These factors can lead to undesirable environmental impacts affecting soil, water, and air as well as human and animal health. Contrary to these issues horse boarding can provide the opportunity for conservation, which would be highlighted by improving the sustainability of horse ownership. In order to address the negative issues related to horse boarding, I want to explore ways to reduce the environmental impact of horse boarding operations using library resources, case studies, and personal experience. My research will focus on making adjustments through retrofit and initial design along with management practices of horse boarding facilities. I plan to adapt methods designed to reduce the impact of the human world to horse boarding and look for solutions unique to horse management. My overall all goal is to raise awareness about the environmental impact of horse keeping, pinpoint the specific areas of impact, and offer solutions.

Annotated Bibliography

(1) Best Practices. 2009. Sustainable Stables. 9 Feb, 2012. <http://sustainablestables.com/index.php?option=com_content&view=category&id=64&Itemid=212>.

The Sustainable Stables website provides a far-reaching guide to environmentally conscious horse keeping. It covers in depth the topics of green products, methane capture from manure, pest management, as well as wildlife and habitat conservation. This website also includes examples of real world horse facilities implementing the practices that are supported by Sustainable Stables. This website will serve as a central source of information for the reduction of the environmental impact of horse keeping in all areas of design and management in my project.

(2) California Climate Data Archive. 8 Feb, 2012. California Energy Commission. 9 Feb, 2012. <http://www.calclim.dri.edu/>.

The California Climate Data Archive serves as an archive for multiple climate and weather networks in the state. The archive provides climate and weather maps that are updated daily as well as maps examining temporal scales of temperature and precipitation. Climate information is important in planning a horse boarding facility because weather will determine some aspects of facility design and management. This website will be a reference for the weather and climate of California, which this project will emphasize.

(3) Equine Land Conservation Resource. 2012. Equine Land Conservation Resource. 9 Feb, 2012. < http://www.elcr.org/index_resc_E.php>.

The goal of the Equine Land Conservation Resource is the protection of land for horse activities. It is stated on the homepage that thirty-six million acres are needed just to feed the nine million horses in the United States. The issue is not only having available land but also protecting it from degradation. Information on environmental protection is also available on the link in their website featuring farm and ranch land management and best practices management and provides many articles on these issues. This website will be helpful to highlight the conservation approach to horse facility design and management.

(4) Green Horse Property. 2012. Merriewold Morgans, LLC. 9 Feb, 2012. <http://www.greenhorseproperty.com>.

The website tracks the development of an eco-friendly horse breeding facility in San Luis Obispo County. The goal of Merriewold Morgans, LLC is to share their experience with others as a resource for a green horse community. Once the property is fully developed they will turn the focus of the website to environmentally sustainable horse and ranch management. This website and the facility itself will provide my project with a local case study of a facility designed to reduce the environmental impact of horse keeping.

(5) Hill, Cherry. Horse Keeping on Small Acreage. Pownal, VT: Storey Books, 1990.

Hill covers many aspects of horse keeping from construction and design to management. Areas of particular importance include the needs of the horse, levels of

managements, pasture, hay, and equipment. Hill's work will be an additional reference for facility design and form the foundation for horse facility management.

(6) Hinrichs, Roger A., and Kleinbach, Merlin. Energy: Its Use and the Environment. Belmont, Californina: Thompson Higher Education, 2006.

This text explains basic physical principles behind the use of energy, aspects of energy resources and conservation, as well as energy policy and strategy. Specific topics of particular interest to my project include, energy conservation of buildings and electricity from solar energy involving photovoltaic systems, solar water heating, and wind power. This book will be used for foundational information on alternative forms of energy.

(7) Home and Farm Scale Wind. 2011. Windustry. 9 Feb, 2012. <http://www.windustry.org/your-wind-project/home-and-farm-scale-wind/home-and-farm-scale-wind>.

This website is a resource for information on small-scale wind power production. According to the website, small turbines with a production capacity of one to one hundred kilowatts can power a small farm, reducing demand on fossil fuels for electricity. I plan to propose the use of wind energy for electricity and water pumping in horse facility design and this website will provide information about implementing a small wind project.

(8) *Horse Keeping: A Guide to Land Management for Clean Water.* 2001. Council of Bay Area Resource Districts, Petaluma, California.

This manual outlines how to keep horses and protect water quality. According to the manual, horse owners and facility managers have a responsibility to minimize water pollution, and can do so through facility design and siting, pasture and paddock care, and management of horse waste and storm water runoff. This manual will contribute to my project through its plan for environmental protection and conservation that directly supports the goal of my project.

(9) Science and Technology: Sustainable Practices.13 Jan, 2012. United States Environmental Protection Agency. 9 Feb, 2012. <http://www.epa.gov/gateway/science/sustainable.html>.

This website provides a source of transdisciplinary work on solutions for a sustainable future, based on the three facets of sustainability: environment, society, and economy. The links provided discuss urban and local sustainability through the topics of waste, water, transportation, and communities. Industrial sustainability is presented regarding areas of technology and chemicals. I can apply the information on water conservation and green infrastructure to horse boarding facilities.

(10) Stoyke, Godo. The Carbon Buster's Home Energy Handbook. Canada: New Society Publishers, 2007.

Stoyke bases this work on the premise that environmental protection is inexpensive and can be achieved through small actions by individuals. The author's goal is to provide homeowners with the tools and information needed to reduce their carbon

emissions. Stoyke demonstrates this through thorough discussions of home improvement, transportation, electric power, and green heating and cooling. I plan to adapt the information provided for homeowners to horse boarding facilities as a way to reduce environmental impact.

(11) Wheeler, Eileen Fabian. Horse Stable and Riding Arena Design. Victoria, Aus: Blackwell, 2006.

Wheeler's book is an engineering based manual on horse stable design founded on the principles of horse behavior and health as well as stable function. Her topics cover horse behavior influence on design, construction style and materials, manure management, fencing, arena design and construction, and utilities. This book will be a reference guide to the principles of stable design as it relates to my project.

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Reducing the Environmental Impact of Horse Keeping

Removing horses from a very large natural range to confined areas for domestication leads to negative environmental impacts; therefore, horse owners are responsible for addressing the consequences of keeping horses. The concentration of horses in boarding facilities results in: pollution from manure, impacts to pasture land, impacts from the production and transportation of feed, and impacts caused by the use of water and energy to manage the facility. Such impacts are compounded by loss of rural land to urban sprawl, making sustainable management imperative to the future of the horse industry. Environmental impacts reduced through the processes of design, retrofitting, and management of a horse boarding facility will enhance the land rather than degrade it. This paper serves as a reference for horse and facility owners to increase awareness and offer suggestions for reducing environmental impacts related to horse keeping.

Background on Traditional Horse Keeping and Areas of Impact

Before the widespread use of the automobile the horse was a primary mode of transportation and powerful work animal. Horses in America, needed to be housed in a stable for convenience and regular care as they were required to work all day every day. Today we no longer use horses for our main mode of transportation or as a work animal, but still prefer to keep them in stables or small pasture for sake of convenience (Wheeler, Introduction xiii). This convenience comes with a price. High inputs of time, labor, and money are needed for the careful planning and management of a facility necessary to prevent negative environmental impacts. This is a commitment that many facilities ignore or are unaware of. In most cases, horse boarding is a labor intensive and low profit

business, therefore the reduction of environmental impacts may not be on the top of an owners list of priorities. Careful planning is needed now more than ever due to the encroachment of suburban sprawl into rural areas pushing horse facilities onto smaller parcels of land, which greatly increases environmental impact. New facilities must invest in environmental protection and seek to improve the land they own to ensure the successful future of the horse industry. Horse facilities will face more local regulation if measures are not taken to voluntarily take action toward mitigating impacts (Horse Keeping, Preface i-iii). Existing facilities need to evaluate current status and develop a plan to implement changes to mitigate and reduce impacts where feasible. Individual horse owners looking to board should take environmental impacts into consideration when choosing a facility and also keep in mind their own management practices as well and how they may be improved.

Areas of traditional horse keeping that pose environmental impacts are manure management impacting soil and water quality, indirect facility impacts on resource use through electricity, water, fossil fuel, and construction materials, as well as the disruption of the local natural habitat. When keeping horses there are functions of a boarding facility that cannot be compromised as they relate to the safety and comfort of the animals. These include: shelter for the horse, provision of feed and water, and exercise area (Wheeler, 25). All areas of impact have the potential for mitigation and facilities can even serve and promote conservation.

Reducing the Impact of a Horse Boarding Facility on Land Ecosystems

In reducing the environmental impact of a horse boarding facility the largest scale factor under direct control of the owner is the land itself. As stated above, concentrating

horses into small areas relative to their natural habitat has environmental implications for land. Areas of major degradation of land are over grazing, compaction, and inappropriately placed facility components. These impacts can be resolved through thoughtful site planning, facility design, careful pasture management, and habitat conservation efforts.

Site Planning:

Land characteristics such as slope and soil type will determine the impact of a facility depending on the location of certain features. Facility components such as stable area, outbuildings, arenas, paddocks, and pasture should be organized in a way that works with the land, instead of working against it. Buildings and arenas should be located on high dry ground with a slope of 2-6 percent for drainage. Wells should be located uphill from septic systems and manure storage. For stable area, paddocks, and arenas, well draining sandy mix soil is ideal. If this type of soil is not present the sites for these components should be excavated and filled in with the appropriate material. Soil type is important as it determines the ability of water to percolate; standing rainwater creates mud and can pick up pollutants and carry them to local waterways. For pasture a richer loamy mix is ideal to support healthy vegetation. Keep or plant trees for shade, wind protection, and animal habitat. Stands of trees in a healthy pasture should be safe from horses chewing on them but trees in smaller pasture or paddocks will need to be protected with fencing (Best Practices).

Pasture and Paddock Management:

Preventing overgrazing, soil compaction, pollution from manure, and conservation of wild life habitat are goals of proper pasture and paddock management. In

the wild, horses graze for eighteen hours a day (Hudson Mohawk Resource) if pastures are not actively managed, horses will quickly turn a grass pasture into a barren land. "Over grazing occurs when plants are so heavily grazed that the root system dies back and plants eventually become less productive or die" (Horse Keeping, 33). The best way to prevent overgrazing is to implement a pasture rotational schedule in which periods of grazing are alternated with periods of rest to allow the plants to grow. In a rotation system horses should graze plants down to a height of about two inches then be removed. The plants should be allowed enough rest time to grow up to a height of four to six inches before horses are let back into graze that pasture; regrowth time varies with the seasons and by climate (Hudson Mohawk Resource). Year round grazing can only be accomplished if a facility has enough acres to support the number of horses it houses; most horses need at least one to three acres (Best Practices). If a facility has limited space but still wants to provide pasture grazing, a sacrifice area can be used to house horses while a pasture is resting. The sacrifice area is a paddock that has been excavated and filled with rock and sand to prevent muddy conditions during the rainy season. The best plant combination for a pasture is a combination of three different types: bunch grass, sod grass, and a legume. Legumes, like clover and alfalfa, are nitrogen-fixing plants, which will improve soil fertility without using chemical fertilizers, which could leach into the natural water system (Hudson Mohawk Resource). Keeping land as pasture reduces environmental impact by protecting the soil from erosion, increasing the soil's absorption of rainfall, slowing the rate of overland runoff, and storing moisture to prolong the growing season (Horse Keeping, 32). Soil compaction, the process of soil particles being pressed together under the concentrated pressure of horse hooves reduces the pore space

between soil particles. To reduce soil compaction pasture should only be grazed when the soil is dry because it is more resistant to compaction. Root depth is restricted when soil is compacted which also reduces the plants uptake of water and nutrients. In addition compaction decreases infiltration, which increases runoff (Horse Keeping, 34-35). Bare areas should be addressed by seeding and mulching. Keeping land vegetated as grass pasture can contribute to reversing global warming as the grasses and other plants use carbon dioxide for photosynthesis and transfers carbon to the soil (Cook, 155-156).

Manure Management:

The most prominent impact of keeping horses is the manure they produce. The average thousand pound horse produces fifty pounds of raw waste per day and if kept in a stall, soiled bedding can add eight to fifteen more pounds (Wheeler, 91). Manure has the potential, if mismanaged, to pollute water resources (Horse Keeping, 24). A complete manure management strategy should include manure collection, storage, and disposal or use (Wheeler, 91). Several factors to take into account when developing a manure management strategy are: number of horses, labor, equipment, locations of creeks and streams, depth of near-surface ground water, runoff/drainage, and soil type. The first step in reducing impacts from manure is to remove manure and soiled bedding from stalls, paddocks, and arenas daily. Harrow or drag pastures to break up manure and remove manure from high use areas to reduce the amount of pollution runoff. Many facilities store manure directly on the ground with little attention to site preparation and location in terms of pollution runoff. A manure storage area should include: a watertight surface like tamped clay or concrete to prevent seepage into groundwater, good drainage to route rainwater runoff away from stored manure as well as diverting any runoff from stored

manure to a vegetation filter, a cover in the form of a slanted roof or tarp to protect it from rainwater, and a location away from creeks and wells (Horse Keeping, 25-26). Long-term storage of manure will result in decomposition into compost through either passive, active, or aerated bin composting. Whatever type of composting is used the same factors are involved: oxygen, moisture, microbes, heat, the proper carbon to nitrogen ratio from the mix of manure, bedding, yard waste, and food scraps, and time (Best Practices). The ideal carbon to nitrogen ratio is 30:1 for optimal composting (Horse Keeping, 29). Passive composting, also known as static composting, involves letting the process of decomposition occur without human assistance. Naturally occurring oxygen, moisture, heat, and microbes will turn manure and bedding into usable soil. This is a long process that could take one to two years, depending on conditions (Wheeler, 105). Active composting is manually turning the compost materials, by hand with a shovel or with a tractor, to increase aeration and speed up decomposition (Best Practices). Bin composting requires the construction of a series of covered containers to store and compost manure in small batches. The composting process is sped up due to the small amount of manure per bin, making compost available to use more often. As each bin becomes full it is left alone to compost while the next bin is used for fresh manure (Cook, 106). Manure in the bins can be aerated by means of manually turning the contents or have perforated pipe installed to allow for air to reach the interior of the pile. In cases where more airflow is needed an air blower can be used in combination with the perforated pipe. In this fashion, composting time is one to three months with this method (Best Practices). There are many benefits composting manure, it reduces the volume of manure as well as reducing the risk of invasive plant seed survival and killing parasite

eggs. Composted manure when applied as fertilizer and soil conditioner provides macro and micronutrients that can be used by plants. Compost: stabilizes loose soil to help resist erosion, lightens heavier soil by allowing more air and water to penetrate the surface, and the high level of organic matter improves the ability of soil to retain water therefore reducing runoff (Cook, 101-102). The disposal and utilization of manure includes removal of manure from the facility, use of composted manure on the facility, sale or removal of composted manure, and capture of gases released from manure for conversion to usable energy (discussed in section on energy). Many facilities spread fresh manure directly on pastures; this practice can lead to the spread of unwanted weeds, and expose horses to parasites (Cook, 101). Fresh manure spread near streams or on steep slopes will pollute water resources if intercepted by eroding sediment or rainwater runoff (Horse Keeping, 27). Removal of un-composted manure from a facility may be accomplished through contract removal by a commercial service or private party for disposal, use, or composting elsewhere (Wheeler, 104). If composted manure is intended for use on facility pastures it should be analyzed for nutrient content to ensure the needs of the plants can be met. Using a manure spreader for large pastures will require calibration of the machine to prevent over application that wastes nutrients and pollutes water resources. Compost should be applied to actively growing pasture in the spring when the ground is firm. The soil should be disked or harrowed to incorporate the compost into the soil and increase nutrient availability. Good quality compost can be given away or sold to landscapers, gardeners, or local farmers as fertilizer and topsoil (Horse Keeping, 26-28).

Water Resource Protection:

Horses can impact water resource quality in five ways: sediment erosion into surface water features from overgrazed or bare soil in living and exercise areas, polluted water entering surface and ground water draining from horse wash areas and manure piles, excessive nutrients from horse waste carried off the surface by rain water runoff, trampling or removal of vegetation in riparian areas will lead to stream bank erosion and sedimentation, and removal of vegetation that filters and absorbs water and pollutants from runoff (Horse Keeping, 2). Stewardship objectives in regards to water resource protection include controlling erosion, keeping clean water clean, and managing polluted water. Erosion, the removal of exposed soil by rainfall, wind, gravity, and flowing water, is a natural process. The magnitude of erosion is influenced by slope, vegetation, geology, and rainfall; erosion is often accelerated by human activity, like keeping horses. Controlling erosion is important in protecting surface water features from excessive sedimentation that carries pollutants, threatens aquatic life, and alters stream flow dynamics by accumulation in streambeds. Accelerated erosion is caused by uncontrolled concentrated surface flows that form gullies, damage roads, and destabilized stream or creek banks. Sources of concentrated surface water flow are rainwater runoff from roads, runoff from overgrazed pasture, roofs, and rain gutters. To prevent accelerated erosion keep land and riparian areas well vegetated wherever possible as plant roots stabilize the soil as well as increase infiltration of water, therefore reducing surface runoff. Maintain a vegetation filter strip downhill from bare areas (paddocks, turnouts, arenas, roads, and parking areas) to absorb and filter surface runoff. Practice rotational grazing and harrowing in pastures to reduce over grazing and polluted surface runoff. Use diversions

and culverts to protect drainage ditches and earthen surfaces from erosion. Attempt to avoid soil-disturbing activities just before and during the rainy season to reduce erosion (Horse Keeping, 6-7). Keep clean water clean through diverting rainwater away from sources of pollutants like manure piles and high use areas (paddocks, arenas) with berms, grassed waterways, or underground pipes and make sure that this diverted water will not create problems elsewhere (Horse Keeping, 63). Fence horses out of riparian areas to prevent the deposit of waste directly into the water. Only graze riparian areas during the dry season when the banks and vegetation can hold up to grazing and trampling (Horse Keeping, 37). It is easier to keep water clean than to manage polluted water (Horse Keeping, 8). Water becomes polluted when it picks up chemical, physical, or biological material elements and is carried to surface water resources, like streams and ponds, or leaches through the soil into the groundwater. If excessive nitrogen and phosphorus from urine and manure accumulates in surface water resources these nutrients increase the growth of algae blooms and when the algae dies and decays oxygen levels are reduced leaving the remaining aquatic life deprived of oxygen. This process especially harmful to fish and other aquatic life may also be impacted by concentration of toxic ammonia from horse urine. Salts and nutrients from manure can leach into ground water during the rainy season with the potential to affect drinking water as well as the water quality of adjacent properties. To manage polluted water: keep the size of intensively used areas small to reduce the volume of polluted water running off these surfaces and place vegetation filter strips to trap pollutants running off of manure piles and high use areas like paddocks, turn outs, and wash areas. Manage manure through regular collection and proper storage as discussed previously (Horse Keeping, 9). A waste pond can be used to store polluted

runoff for application when the land has the ability to absorb the excess nutrients. Another option for treating wastewater is collection in a constructed wetland. Wetland plants are capable of absorbing large quantities of nutrients reducing the amount of pollutants present in the water. Both constructed wetlands and waste ponds must be permitted and designed by a professional to handle wastewater volume (Horse Keeping, 72). Maintain a riparian buffer of grasses, shrubs, and trees along streams to stabilize stream banks and reduce excess sediment, organic material, and pollutants from entering the stream. Riparian buffers also provide habitat for local wildlife and improve fish habitat in the stream (Horse Keeping, 68). Regularly test water to monitor the effectiveness of water resource protection strategies, test streams where they enter and leave the property to see if water quality is affected by passing through the facility (Horse Keeping, 92).

Wildlife and Habitat Conservation:

According to the National Resources Conservation Service, seventy percent of fish and wildlife habitat in the United States is on privately owned land (Fish and Wildlife). Larger horse boarding facilities have the opportunity to be stewards of wildlife habitats and become rural area conservationists. To achieve this, the facility can protect diverse habitats, promote native plant species, set aside land for a conservation easement, and join programs to get paid for ecosystem services or mitigation. The simplest conservation measure is to leave as much wildlife habitat intact as possible and incorporate other habitats into pasture thus providing diversity for the horses (does not have to be strictly grass). Habitats that can be integrated into pasture include forest, meadow, and shrub land while streams and wetlands should be protected from direct

contact with horses to avoid sedimentation and pollution. Native plants are adapted to local environments meaning they require less water, fertilizer, and pesticides; they also provide food and shelter for native animals and insects that may be beneficial to the health of local ecosystems (Best Practices). Under the right circumstances a large facility may consider adopting a conservation easement, a voluntary legal agreement between landowner and a non-profit conservation organization to protect the land from future development while retaining some rights and activity use. Tax benefits and government programs are available for the protection of significant natural resources (Balliet). Federal and state assistance programs exist to help farmers conserve land and can be applied to horse facilities if they are considered agricultural operations. Options in the private sector through ecosystem markets assign economic value to environmental benefits; private landowners can make a profit by maintaining ecosystem services. Facility owners can also be compensated through mitigation banking in which a developer pays a landowner to restore and maintain ecosystem services in order to offset the impacts of development projects (Best Practices).

Reducing the Impact Related to the Stable Area

Impacts and improvements of the stable area include roads, the barn itself, energy use, water use management, and recycling. The stable area is where the majority of activity will be and the most inter-species interactions between horses and humans.

Road Design and Maintenance:

Without erosion control measures un-surfaced roads can contribute to sedimentation of streams. When constructing or repairing a road, long-term solutions to erosion problems include a durable road base, sufficient compaction, and gravel

surfacing. Roads can be constructed or repaired for proper drainage in three different ways: roads cutting across slopes can be graded toward the slope so runoff is drained to an inboard ditch that provides surface drainage, roads can be graded away from the slope to follow the natural drainage of the terrain, and for level terrain roads, they can be crowned, graded to be higher in the middle so water flows off both sides into drainage ditches. When constructing a road, follow the natural contour of the terrain as much as possible to minimize the disturbance of natural drainage patterns. Locate roads away from streams and maintain a riparian buffer for nearby streams to prevent sedimentation. Keep drainage ditches maintained by lining with rock or vegetation for stabilization (Horse Keeping, 42-43).

Barn Construction Materials:

The most important function of a barn is to provide a safe, comfortable, and healthy living space for horses. Barns must be constructed of strong materials and hardware to hold up to the size, strength, and occasionally destructive behavior of horses (Hill, 51). Solid construction will also ensure the longevity of the building. Barn design must be suited to each individual facility needs. Traditionally, a barn will have 12 ft by 12 ft 'box' stalls, a feed room, and tack room (Hill, 55). When building a new barn, areas of environmental impact include: construction materials, stall bedding, lighting, and appliances.

Building a 'green' barn involves: knowing where the construction materials come from, how they are produced or harvested, how to dispose of them, and the environmental impact of disposal (Cook, 60). Additional specific factors to consider when choosing products for a barn are: embodied energy to produce the product, what

kind of energy was used to produce the product (i.e., renewable or non-renewable), what kind and how much pollution or waste is created due to the production process, will disposal of the product be considered pollution, is the product local, is the product made from reused or recycled material, can the product be reused or recycled when it is no longer useful for the purposes of a horse facility, what is the longevity of the product, and overall product performance for intended function or use (Cook, 62). Consider the energy demand of the barn for lighting, appliances, and temperature control, as well as water demand for horse watering and washing, toilets, sinks, and drinking water (Best Practices).

Barns are traditionally built out of wood, concrete, masonry, or metal (Wheeler, 19-21). Options for 'green' construction materials include: sustainable harvest lumber certified by the Forestry Stewardship Council (FSC), and lumber reclaimed from other structures or harvested on site. Locally sourced materials reduce resources used in transportation. Bamboo is a fast growing renewable plant of which several species are harder than wood and it can be engineered to make laminated structural support to use in barn construction (Nelson). A common construction product used in horse facilities is pressure treated wood. The wood is treated to prevent decay with preservatives containing toxic chemicals (creosote, pentachlorophenol, and chromated copper arsenate) and can only be disposed of as a hazardous material at a landfill. Less toxic preservatives include amine copper quat, copper azole, and borate. Use FSC certified sustainably harvested lumber and coat with water based sealant and non-toxic paint to preserve it on a regular basis to maintain protection (Cook, 82-83). Conventional roofing includes metal, asphalt shingles, and wood shingles (Wheeler, 17-18). Environmentally conscious

roofing options including materials constructed from recycled rubber or metal decreases waste in landfills and sustainable wood shingles (Cook, 81). Stall flooring and bedding is an area in the barn that can have significant impact. The most popular type of stall flooring is rubber mats on top of tamped earth or gravel, and the most common type of bedding is soft wood shavings (Hill, 67). The following are suggestions for reducing impacts related to barn stalls. Because stalled horses require large amounts of bedding that must be harvested and transported, they have a larger impact than horses kept on well-managed pasture. Reducing the amount of bedding used is important and the simplest option is to use stalls as little as possible (Cook, 64). Water permeable flooring, such as a grid made of recyclable elastic high-pressure polyethylene, allows urine to filter into the ground reducing the amount of soiled bedding and therefore the amount of bedding used (Cook, 65-66). The stall floor must be sloped and layered with fine gravel and crushed rock to filter urine (Cook, 66). Another way to reduce bedding is to use stall mattresses made from layers of rubber. They provide a cushion so bedding is only needed to absorb urine (Wheeler, 87). Another option is to bed stalls with sand or top soil, these materials will absorb or allow urine to filter but must be frequently replaced if horses are stalled year round (Wheeler, 83), this may be a good option for stalls that are rarely or lightly used, especially if sand can be locally sourced. If wall insulation is needed, use non-toxic, recycled, and sustainable options like cotton, cellulose, or soy based foam (Cook, 71). A renewable flooring option for tack rooms, feed rooms, offices, and onsite residences is cork oak flooring made from reclaimed by-product of the cork wine stopper manufacturing process. Cork oak is harvested from the bark hence leaving the tree standing to re-grow the bark. Cork flooring acts as a thermal insulator due to air spaces in

the board and it also contains suberin, a natural substance that replies insects and mold (Green Horse Property). Any counters or cabinets needed should be second hand or made of recycled/recyclable or sustainable materials. Some options include FSC certified sustainably harvested wood, paper resin composite (two thirds paper, one third plastic), or composite lumber (Cook, 81).

Wash areas for horses are called a wash racks and they can contribute to pollution runoff and erosion if poorly designed. Wash racks are usually located in the barn or just outside and need direct access to water and availability of heated water is desirable (Wheeler, 204). To avoid environmental impacts, wash areas should be designed thoughtfully. Runoff from wash areas could transport soap, manure, or chemicals and pesticides from grooming and health products to surface or ground water sources. Wash areas should be elevated or sloped so water drains to a vegetated filter strip and not to streams or storm drains. Filter strips need to be large enough to handle the volume of water generated, additional treatment areas may be necessary in the form of constructed wet lands or waste ponds (Horse Keeping, 31). A rather new flooring material for wash areas is pervious concrete. A porous concrete is laid on top of layers of stone and gravel. As water passes through the porous layer pollutants are trapped and broken down by bacteria. The water percolates through a layer of gravel to reduce the speed of discharge the water then hits a layer of stone and drains out (horizontally) to a vegetated filter or other treatment system. For proper function, regular pressure washing will be required to prevent concrete pores from clogging with debris (Higgins).

Energy:

As an industrial nation, the United State's energy consumption is almost entirely from fossil fuels (oil, natural, gas, and coal) and nuclear energy which are not renewable, therefore our sources for these fuels will eventually run out. Renewable energy sources are those that are perpetual, they cannot be used up. Sources include: solar, wind, water, and biomass (Hinrichs, 9). The processing and use of fossil fuels and nuclear energy is very damaging to the environment and contributes to increasing concentration of greenhouse gases in the atmosphere. Energy for necessary electricity needs of a horse facility should come from available renewable energy sources such as solar, wind, or manure.

For a horse facility, solar radiation can be converted to power all electrical needs that include: indoor and outdoor lighting, water pumps, hot water heaters, and can also be used as back up during power outages (Dyer, 114). Energy from solar panels consisting of an array of photovoltaic cells must be converted from direct current (DC) to alternating current (AC) and stored in batteries if the facility is not connected to the grid (Cook, 25-26). Solar panels can be mounted on a south facing roof or on a pole for remote electrical needs. To install panels, proper zoning approval and permits are required and rebates and incentives are available to reduce cost (Dyer, 114-115). Solar thermal for heating buildings uses panels that absorb the sun's heat and transfers it through tubes of circulating water in specially designed walls (Cook, 24-25).

A wind turbine's blades are moved by the wind and that movement is converted to electricity by a generator. Turbine can be mounted on a tower or on a roof (Cook, 26). Turbine towers are typically eighty to one hundred twenty feet tall must be at least ten

feet higher than anything within five hundred feet, special permits and zoning approval are required, turbines can be connected to the local power grid. Power capacity of one kilowatt up to twenty-five kilowatts is sufficient for a small farm with an average of twelve mile per hour wind speeds (Dyer, 117-120).

Large facilities can take advantage of technology that extracts useful energy from manure. Anaerobic digestion is the natural process in which methane gas is produced from the breakdown of manure. The methane gas can be captured and used like natural gas. Manure can be incinerated to create flue gases to heat a boiler containing water and the hot water can be used directly or circulated through pipes for radiant heating. The by-product is ash that can be used as fertilizer. Gasification extracts gases from manure without oxygen or high temperatures making it carbon neutral. Ash is a by-product that can be used as fertilizer or an ingredient in cement and asphalt. This technology is only feasible for large-scale operations. Heat extracted from steam produced during normal decomposition can be used to heat buildings, greenhouses, and water (Best Practices).

There are simple steps to take to reduce energy use at a horse facility, many that are applied to residential homes. Light is needed in barns and associated buildings, and a good way save energy is to use compact florescent (CFL) bulbs that are four times as efficient as incandescent bulbs and last much longer. Some are also specially designed CFL bulbs for outdoor use (Stoyke, 56-60). Another light bulb option is light emitting diodes (LED), which last one hundred times longer than CFLs and are equally efficient, LEDs can operate at low wattages (Stoyke, 62-63) and therefore are appropriate to use in conjunction with solar or wind power systems. Solar lights can be used to illuminate walk-ways at night. Use hand crank LED (or solar powered) flashlights as a mobile

source of light (Cook, 97). Install motion sensors for outdoor lights. Reduce lighting needs during the day by using skylights and exterior windows. Tubular daylight devices (TDD) are reflective roof domes that collect and redistribute sun light through tubes and can be installed without roof modification (Pomeroy). Replace all old appliances with efficient models labeled by Energy Star. Depending on needs of the facility a compact refrigerator kept well stocked will conserve energy. Keeping bottles of water or gel packs in the freezer and fridge full allows the motor to run more efficiently (Cook, 96). Use a tank-less or solar water heaters to save energy. Tank-less water heaters use gas or electricity to flash heat water on demand for horse bathing, laundry, and restroom facilities (Cook, 98). Solar water heaters are solar collection panels that heat water. They should positioned facing south with unobstructed sun light during peak solar gain (10 am-2 pm) (Stoyke, 115). Any farm vehicles should be as fuel efficient as possible or electric. Buy used or rent large agricultural equipment like tractors, spreaders, or mowers (Cook, 91). Use small electric tools and equipment for regularly performed maintenance tasks and an electric golf cart or riding lawn tractor for mowing and towing carts (The Electric Ox Series). Invest in a small electric truck for larger tasks and supply trips (Dyer, 125).

Water Use Management:

Conservation goals of water use include reducing the amount used and also reusing water where possible. Use the following measures to conserve water around the barn. Fix or replace anything that leaks water including nozzles on hoses to control and stop flow and use water saving appliances (Dyer, 23-24). Install a low flow or dual flush toilet in the barn restroom to reduce water use (Cook, 128). If a new toilet is not feasible displace water in the tank with bricks, stones, or weighted bottles that will reduce the

amount of water used per flush (Cook, 90). Invest in a front loading washing machine for any laundry facilities in the barn. Front loading machines are three times more efficient than top loading machines and reach higher spin speeds which reduces the amount of time to dry (Stoyke, 82-83). Barn laundry facilities should not need a dyer and all washed items should be air dried. When washing horses use buckets of water instead of running the hose (Cook, 90). Do not use exotic plants for landscaping around the barn, native plants are adapted to the local climate and require less water (Cook, 91). Landscaping could include organically grown fruits and vegetables that provide fresh food for people and horses (Dyer, 23). Reuse water by installing a gray water system that collects, filters, and disinfects shower, sink, and laundry water to be reused for the toilet (Cook, 127). Harvest water by collecting rainwater runoff from all roof surfaces on the facility. In addition install gutters and downspouts with screens to filter debris, into a rain barrel or cistern for later use to water arenas, plants, pastures, or animals (Cook, 83-85).

Recycling:

Setting up a recycling program at the barn will reduce the volume of material sent to the local landfill. Set up clearly labeled receptacles for paper, plastic, glass, metal, and even food (for composting) along side a trashcan with a separate container to properly dispose of hazardous waste (Cook, 89). Promote the reduction of waste by encouraging the use of refillable water bottles and finding new uses for empty containers (Dyer, 4). Buy stall bedding packaged in paper so it can be reused or recycled or find a way to recycle plastic bedding packaging (Dyer, 6-7). Purchase recycled paper products for restroom and office (Dyer, 5-6).

Reducing Impact Related to Direct Care and Riding of Horses

Areas of environmental impacts associated to the direct care and riding of horses includes feed, chemicals in grooming and health care products, trail riding, and showing. These measures can be followed by anyone who cares for horses whether or not they own a facility.

Feed:

What horses are fed has an impact due to how it was produced, transported, and packaged. The majority of a horse's diet is hay and most horse and facility owners purchase hay from a grower or intermediary (i.e., feed store). Without a direct relationship to the grower it is difficult to know how the hay was grown. Conventional agriculture methods include tilling, fertilizing, seeding, irrigation, application of pesticides and herbicides, harvesting, and transportation (Hill, 117-125). Tilling disturbs topsoil leaving it vulnerable to erosion. Attempt to buy hay from growers who use low or no till methods of soil preparation and seeding (Cook, 151 and 155). Pesticides and herbicides are chemicals that kill insects and weeds and these chemicals use fuel for application, are ingested by the horse, and could pollute water surface and ground water. Support growers who do not use chemicals to control pests and weeds (Cook, 173). Harvesting of hay requires large equipment and hence consumes fuel and compacts soil and can only be avoided by grazing horses year round on pasture (Hill, 124). Transportation of hay directly to a feed store or facility requires tractor trailer trucks that consume large amounts of diesel fuel. Therefore, when possible buy hay from local growers (Cook, 154). Many facilities do not have surplus land to grow hay but those who do should use composted manure to fertilize fields and practice low till or no till farming.

Planting a shelter belt of trees around hay fields will provide a wind break protecting soil from wind erosion, sequester atmospheric carbon, and provide shelter and food for wildlife (Cook, 155). Start a hay growing cooperative in which several facilities pool resources to grow hay (Cook, 151). This may not provide local feed year round but would result in some reduction of impact due to less fuel transportation and direct control over land management practices. Some horses will not have their nutritional requirements met by hay alone and require grain and or supplements for added protein, fats, vitamins, minerals and possibly supplements for joint, hoof, skin, or digestive health. Along with these products are vast amounts of mostly plastic packaging. Seek to purchase products that use recycled plastic packaging. Consult with a veterinarian as to the specific needs of an individual horse to avoid unnecessary supplementation. Buy the least processed grain products that are appropriate for a horse's needs and choose a brand that uses paper bags for packaging.

Health Care Products:

Many horse health and grooming products contain chemicals that should be replaced with alternatives or disposed of properly to prevent environmental contamination. Chemicals in horse de-wormers could pollute the environment from manure and improper disposal of applicator. These chemical de-wormers are considered hazardous waste. Contact the local agricultural extension office to find out where to take applicators for disposal (Cook, 164). Alternatives to chemical de-wormers include medicinal plants (blackberries, periwinkle, pine needles, queen anne's lace, tarragon, wild ginger, and wild onion) and diatomaceous earth (glass like powder from fossils of aquatic organisms that cuts the parasites) (Cook, 167-166). To determine if a particular

parasite control strategy is working, send manure to a lab for a fecal egg count test (Cook, 166). Horses are exposed to parasite eggs and larvae when they are passed in manure and ingested. To reduce this exposure, remove manure from stalls, paddocks, and high use areas of pastures. Regular harrowing of large pastures breaks up manure thereby killing parasite eggs. Battle flies and mosquitos with non-toxic repellents, these can even be home made, instead of chemical sprays. Use non-toxic methods to control insect populations with traps and manure management to reduce the need for repellents (Cook, 166-168). Use caution when purchasing bathing products and look for products without artificial ingredients because what rinses off the horse could end up in local waterways (Dyer, 40). Use bathing products sparingly, as even biodegradable products can have a negative effect on water quality (Horse Keeping, 31). If there is not an alternative to a potentially hazardous product that you must use be cautious and be sure to handle, store, and dispose of the product and its container safely (Dyer, 43).

Trail Riding:

Trail riding is a way for horse owners to enjoy the environment they are trying protect and many parks offer trail use for horseback riding. Recently, efforts have been made to ban horses from trails with claims of environmental damage (Cook, 193). Horses can impact trails by making gullies in the path because their hooves dislodge wet soil expanding muddy areas. They will also try to eat plants and drink from creeks or streams, which causes to damage riparian areas. Invasive plant seeds have a slight chance of germinating if passed in horse manure. Riding can churn up sediment resulting in trail deterioration (Cook, 193-194). To reduce impact on trials and surrounding land in general: stay on designated horse trails, plan rides ahead of time, avoid sensitive habitat

areas, and pack out what you pack in (Best Practices). Riders should also bring water to their horses instead of allowing them to drink from streams and avoid allowing horses to eat plants along the trail. To reduce potential erosion and stream sedimentation choose switchback trails, only use designated stream crossings, and do not ride in riparian areas (Cook, 195-196). If riders act responsibly, trails will remain open to horses.

Showing:

Regularly attending riding competitions can be an important part of a horse business. Good performance at competitions is publicity and exposure for a boarding or training facility and for the horse trainers and riding coaches that work at a facility. Regardless if a boarding facility can offer competitions, traveling to other facilities is necessary for show circuit competition. Horses must be hauled in specially designed horse trailers towed by a truck. In order to conserve fuel and prolong the life of the rig, take into consideration the maintenance of the tow vehicle and trailer, as well as driving habits. Carpool by traveling to shows with a full trailer and truck and keep speeds at sixty miles per hour or below because fuel efficiency decreases at higher speeds. Moreover, carefully plan trips in advance to avoid the stop and go of cities. When choosing a tow vehicle consider a diesel engine because diesel fuel is a by-product of gasoline production and is more efficient than gasoline engines. Choose a tow vehicle that has enough power to tow a trailer loaded with horses but not excessively powerful. To reduce drag, remove any empty roof racks off of the truck and trailer. Keep the tow vehicle and trailer well maintained with tires properly inflated to maximize fuel efficiency and prolong the life of the vehicle by reducing stress. If a large trailer is needed for more than two horses choose a lightweight trailer constructed with aluminum. A person who only

hauls one or two horses should consider a Brender-Up trailer. These trailers are designed to be very light and aerodynamic with aluminum and phenol resin panels, thus allowing them to be towed by an average sized vehicle. When hauling a trailer balance the load to maximize tow ability and reduce stress on the tow vehicle (Cook, 178-189). While on the show grounds walk or use a bicycle to get around and use a bike trailer for small children and hauling equipment. Outfit an electric golf cart with solar panels to avoid having to use electricity. If recycling is not available on the show grounds take home personally used recyclables. Suggest to the organizers that they start a recycling program to reduce waste (Dyer, 81-84).

Hosting a horse show is an opportunity for facility owners to promote environmentally conscious horse keeping to the larger horse community (Cook, 190). When hosting a competition: have clearly labeled recycling bins conveniently placed, do not sell bottled water, give away refillable water bottles as prizes, do not offer styrofoam for coffee cups and charge a little extra for a refillable mug, print programs and schedules on recycled paper, have a tack swap, seek environmentally conscious sponsors, if RV hookups are in place power them with solar panels, and have an information booth to educate attendees (Cook, 190). Offer guided tours to highlight impact-reducing features of the facility and its management.

Reducing the Impact of Horse Owners and Riders

As long as a person owns or cares for a horse the following steps can be taken to reduce the direct human impact on the environment.

Residence:

If possible the home should be constructed from or retrofitted with sustainable materials and incorporate technology for maximum energy and water efficiency. To reduce the amount of waste sent to a landfill, have a recycling system set up in the home and compost all food and yard waste. It can be added to the manure composting of the facility. Boarders should be permitted and encouraged to add compost from their homes to the facility compost and be given access to finished compost for landscaping and gardens. Plant an organic garden and shop at the local farmers market instead of the supermarket when possible (Stoyke, 123-124). Install a rainwater catchment system for house, garage, and storage-shed roofs to water landscaping and gardens around the house (Dyer, 107 and 111). Clean up after household pets, their waste can enter a water system. Power residences with solar or wind systems (Stoyke, 96). To reduce electricity and water usage: install energy star rated appliances and electronics, use a tank-less or solar collector for heating water, install low flow or dual flush toilets, and replace incandescent bulbs with CFLs or LEDs (Stoyke, 16-17). Reduce impacts related to transportation by purchasing a small fuel-efficient car for everyday use and consider a hybrid or plug–in electric model (Stoyke, 38). Bike and take public transit when possible (Stoyke, 31-32).

'Green' Options for Riders:

In addition to what has been previously discussed, there are a few choices a person can make to reduce the unique impacts of being a horseback rider. Just like any athlete a rider needs to stay hydrated. Use a refillable water bottle instead of buying bottled water. Buy and donate gently used riding apparel and tack. Consider new lines of riding apparel made from organic and sustainable natural fibers like cotton, hemp, and

bamboo. Recycle worn out fleece apparel. Resole boots as an alternative to throwing them away. For the up keep of show attire use a 'green' dry cleaning service. Polish boots with vegetable oil instead of chemical polishes that are considered hazardous waste (Dyer, 63-71).

***Case Study: Merriewold Morgans, LLC Huasna, California**

Merriewold Morgans LLC is a Morgan horse breeding and training operation that purchased undeveloped property in Huasna Valley of San Luis Obispo County, California for the purpose of building a new environmentally friendly facility called La Ranchita. Development decisions were based on minimal waste and impact and combined both the latest information and traditional of agricultural wisdom. The new facility was opened in March of 2012 (Green Horse Property). The facility components include two houses, a barn, covered arena, and a shop with storage for hay and equipment attached to grooms quarters, paddocks, and large pasture with shelter. The pastures were placed on the most level part of the property, which will reduce erosion from horse grazing. The barn was built on an area where the ground had been previously disturbed to avoid disruption of intact topsoil. In addition, stalls and arena were constructed from a composite lumber. Stalls feature automatic waterers and mattresses to reduce the amount of bedding. The barn design is open, with two covered rows of stalls facing each other reducing the need for light. The facility's windmill pumps well water continuously and excess water is stored in a basin until needed. The barn and covered arena feature metal roofing and rainwater catchment system piped to a pond equipped with a pump to be used as needed for watering landscaping. This water system is designed to reduce impact on natural waterways. Native plants that are non-toxic and deer tolerant were used for landscaping

around the barn and residences. The eco-friendly management practices include: weighing hay in order to reduce wasted feed and spreading manure on grassland. They call the grassland area the native pasture, this is an area that is left untouched and so it preserves natural habitat (La Ranchita Open House). The shop with the groom's quarters was constructed of a recyclable expanded polystyrene foam structural hip system that reduced waste to less than three percent. The two homes built on the property also incorporated 'green' design features. South facing windows, concrete floor, and thick insulation take advantage of passive solar heating with radiant heating installed in the floor for an additional heat source. The homes also make use of sustainable products like bamboo, cork oak, and recycled wood (Green Horse Property). La Ranchita is just one of many horse facility's across the United States that has taken on the challenge of reducing their environmental impact.

Conclusion

Environmental impact of the horse industry may not be a subject that people think about on a daily basis. However, the first step on the path to sustainability is to recognize problems in order to become aware and observant of the cause and effect. The goal of this paper is to pinpoint impacts and offer a variety of options to mitigate them. What many of these options require is time, work, and planning with foresight. In our fast pace world it is a challenge to predict what an impact might be 20 or 30 years in the future. Without a shift toward forward thinking decision-making the land will reach a point of exhaustion and will no longer be able to support certain lifestyles. Horseback riding is a lifestyle choice and recreational activity that does have contribute to degradation of natural systems. Now more than ever it is essential for the future continuation of horse

related activities that facilities begin moving in the direction of sustainable operation. If every facility implemented only a few mitigation efforts in the critical areas of energy use, manure management, and water management their impact would be greatly reduced and make a difference for the future of the horse industry. It is a privilege to experience the rewarding relationship between human and horse. In order to ensure the future of such relationships the connection between humans and horses with ecosystems should have the same, if not more respect and appreciation.

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