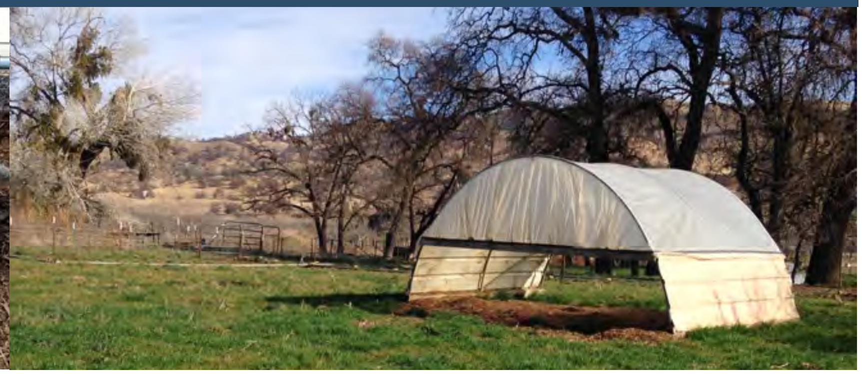
Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area



Farrowing and Weaning Best Practices

By Morgan Doran

Rearing piglets from birth to weaning is the phase in the pork production cycle with the highest mortality losses, especially during the first few days of lactation. To overcome these losses, many commercial pork operations use confined farrowing systems, or crates, that limit mobility of the sow and protect her piglets when she lies down. The use of farrowing crates has remained a common practice since the late 1950's, but alternative farrowing environments are coming into favor due to consumers' awareness of animal production practices and an expressed distaste for livestock confinement. In response to consumer preferences, some producers are shifting away from farrowing crates, and learning how to minimize piglet mortality in more open farrowing environments. This trend is especially prevalent among alternative and outdoor pork producers.

Open farrowing environment. Photo courtesy of Silvana Pietrosemoli.

The farrowing environment has been the subject of considerable research and is a critical consideration in any pork operation. This factsheet will cover various environmental factors that influence maternal behavior, piglet survival and piglet weight gain for alternative hog producers in the greater Bay Area and valley regions of Northern California.

The Farrowing Environment

Prior to the 1950's, most pork producers used open farrowing systems, but lower piglet mortality in farrowing crates created broad adoption of that system and allowed producers to significantly increase production and profitability. A farrowing crate is essentially an enclosure closely matched to the sow's body size which allows piglets refuge when the sow lies down, while still allowing them to nurse. Farrowing crates significantly reduce piglet mortality from crushing, but dramatically limits the sow's ability to move or turn-around. Sows enter a farrowing crate just prior to farrowing and remain until piglets are weaned. Some pork producers will adjust farrowing crates to provide a sow more room 5 to 10 days after farrowing.

Research suggests that sows are strongly influenced by certain environmental factors that, in turn,

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stimulate specific pre and post-partum behaviors (Algers and Uvnäs-Moberg, 2007). The sow's natural maternal behavior is often suppressed when her environment is void of certain stimuli, which can be the case in confined spaces, such as a farrowing crate.

Nest Building

When provided with sufficient space and materials, nest building is a common behavior exhibited by sows prior to farrowing. This begins with the sow digging a hole, then gathering branches and straw that are layered in the hole to create a nest. In a confined environment without nesting materials, sows mimic nest building by pawing the floor and biting the cage. Studies have shown that sows with access to nest materials have higher levels of hormones responsible for maternal behaviors (Yun et al., 2013), demonstrate nesting behavior that begins sooner and persists longer (Yun et al., 2014), have a higher metabolic status for lactation performance, and have piglets that consume more colostrum (Yun et al., 2014). Nest building is especially helpful for gilts which are more sensitive to environmental cues, thereby reducing stress during farrowing, which results in shorter birth intervals (Thodberg et al., 2002) and a shorter farrowing time period.

Noise Disruption

A high noise level in the farrowing area from equipment, e.g. fans, and the cacophony of squealing piglets is an important factor which is often overlooked. In an experiment to determine the effect of noise during farrowing, sows and their new litters were exposed to continuous fan noise at 85 dB, which is typical in many farrowing barns. Observed behavior indicated that audible communication between sows and their piglets was stifled (Algers and Jensen, 1985). Communication between the sow and piglets through vocalizations help synchronize piglet nursing behavior in a manner that maximizes milk production. Another significant source of noise in a farrowing barn is the large number of squealing piglets which limits a sow's ability to hear her own piglets' distress squeals which signal crushing and hunger. Sows are usually responsive to piglet screams, a reaction that reduces piglet crushing (Wechsler and Hegglin (1997), but sow responsiveness has been shown to diminish after the first day following farrowing and in older sows that have had more litters (Hutson et al., 1992), and to be lower in sows confined in a crated farrowing environment (Cronin et al., 1996).

Reducing Piglet Crushing

Piglet crushing, especially in the first 24 hours after farrowing, accounts for more than 50% of piglet mortalities (Marchant et al., 2001). Many factors contribute to piglet crushing by the sow and there has been considerable research examining which environmental factors are most important in reducing piglet mortality by crushing. Open farrowing systems are generally considered to have a higher incidence of piglet crushing compared to farrowing crates, but research is often conflicting which is likely due to differences in environmental factors such as breed, noise, pen size, and comfort level.

The following practices may help reduce piglet crushing:

1. Minimize noise and other stress factors in the farrowing environment.
2. If using farrowing pens, construct refuge areas that provide piglets escape from sows as they lie down.
3. Be sure sows are familiar with the farrowing environment to reduce any stress associated with new surroundings.
4. Move sows to the farrowing area with nesting material, such as loose straw, about 5 days prior to farrowing.
5. Closely monitor and cull sows that are observed to be less responsive to piglet screams and have higher incidences of piglet mortality.

Open Farrowing Systems

There are several alternative farrowing systems that provide a more open environment and allow sows to express instinctual nesting behaviors. These systems vary greatly and often depend on local climate, resources, and the specific interests of the farmer. Open farrowing environments should be designed to meet the piglets' and sow's needs, however, must also work within the farmer's constraints, resources and desire to make such accommodations.

Additional accommodations provided to the sow can include larger space to move around, a dirt floor to encourage nest digging, sticks for nest building and outdoor nesting areas with small shelters. The typical cool and wet winter weather in Northern California may not be appropriate for outdoor farrowing, but open indoor farrowing systems are viable options during winter months with outdoor farrowing scheduled only during months of mild weather.

Before, during and after farrowing, a sow needs:

- nesting material such as straw, twigs, leaves
- a sheltered environment to build a nest
- adequate nutrition
- low-noise environment to communicate to piglets
- space to turn around

During and after farrowing piglets need:

- refuge from the sow
- access to nurse
- ability to hear the sow
- protection from wind, rain and extreme cold
- protection from other sows and predators.

Types of Open Farrowing Systems

Outdoor Pasture Farrowing

Outdoor farrowing is an attractive option for farmers who wish to provide sows a natural environment which allows them to more fully express their nesting behavior and maternal instincts. It is also more favored in areas with a mild climate that will not induce excessive stress from heat and cold. In much of California the climate is mild, but excessive summer heat and extended periods of cold and moisture can create difficult farrowing conditions. Timing outdoor farrowing for fall and spring months can help reduce temperature-related stress for sows during farrowing, which will help sows focus on maternal behavior instead of maintaining comfort. Despite the terminology "pasture farrowing," individual houses or huts located in a pasture are usually provided to protect sows and piglets from the elements. When provided with nesting material, sows will build their nests inside the shelter. Shelters should be separated by about seventy (70) feet and about 7,500 square feet per sow should be allotted in a farrowing pasture. These distance and space allotments will reduce noise and stress as sows establish social hierarchies.

Outdoor farrowing of Red Wattle hogs. Photo courtesy of Pasture 42.

Indoor Farrowing Pens

Many types of farrowing pens have been developed to create more space for the sow to move and nest while providing protected space for piglets to avoid crushing. Farrowing pen designs vary in size, material, costs, piglet refuge areas, heating, bedding and special features. Results of the various designs are mixed and have piglet mortality rates that range from 16 to 28% (Baxter et al., 2012). The design chosen by a farmer will depend on their knowledge, financial resources, existing infrastructure, climate and animal welfare objectives. Baxter et al. (2012) provides a helpful review of farrowing pens.

Deep-Straw Hoop Structures

Hoop structures are an inexpensive livestock housing option as compared to more permanent structures, and are more commonly used in cooler regions to provide shelter and warmth during periods of poor weather. Hoop structures can be designed with partitions and pens for individual or group farrowing areas, but cooling during warm months (May – September) is especially important as gestating sows are more susceptible to heat stress. See Baker (2004) for information on swine's temperature comfort zone. During colder months deep straw bedding is provided to absorb manure and urine, which eventually is covered with more straw. Sows and piglets receive warmth from the straw cover and heat released from composting layers of straw mixed with manure and urine.

Swedish Deep-Straw Farrowing System

This is an indoor farrowing system most often used in cold-weather environments such as Scandinavian countries and the upper Midwest region of the United States. Large amounts of straw (two tons per sow per year) are used as nesting material and to provide warmth for the sows and piglets and composting straw provides additional heat. In this system, sows progress through a series of indoor areas starting with a gestation area where they are comingled with other gestating sows. As farrowing approaches sows are moved to individual and temporary farrowing boxes that provide a space for the sow to nest, farrow and bond with her piglets. A door with a high threshold allows the sow to leave for food, but prevents piglets from leaving the box. Piglets remain in the box for the first seven to ten days at which point the box is removed to allow sows and litters to mingle in a shared nursing area. Although this system may not be entirely appropriate in Northern California's mild climate, some practices may be appropriate for an indoor farrowing systems during the winter months.

Whichever farrowing system is adopted, it is important to understand that most farmers are very adaptive and open to modifying their system to meet their particular needs, resources and variable weather conditions. It is not unusual to develop a hybrid of multiple systems and to continue experimenting with new technologies and techniques.

Managing Nutrients in Farrowing Areas

Any farrowing system requires active management of nutrients (nitrogen, phosphorus, potassium) that get concentrated in farrowing areas. Manure and bedding from indoor farrowing systems should be removed, composted and applied to soils where forages and crops are grown (see factsheet on Hog Manure Management). Nutrient loading on outdoor farrowing areas can be managed and mitigated by slowing and retaining runoff with grassed buffers and waterways, preventing direct runoff into waterbodies such as creeks, and seeding the farrowing area with grasses to increase vegetative cover and nutrient uptake by plants. The Rangeland and Pasture Management factsheet has more information on managing high impact areas.

Nest building. Photo courtesy of Silvana Pietrosemoli.

Husbandry Practices and Matching Genetics to Management System

One consequence of the large scale, intensive swine production systems widely used since the late-1950's is the diminution of animal husbandry skills. Such skills are crucial in alternative production systems which are more reliant on the animal's natural instincts and require more attention from the farmer to appropriately respond to animal behavior, while minimizing ecological impacts. Creating an open farrowing system is a good example, wherein the farmer must correctly identify a sow's nesting behavior in order to accommodate her with the necessary space and materials to enable nest building. The farmer must also carefully observe interactive behaviors among groups of sows and sows with piglets so as to avoid overly aggressive behavior that increases stress and mortality. Sows will

Structure for indoor farrowing. Photo courtesy of Riverdog Farm.

naturally establish social hierarchies and large groups tend to increase aggression and stress. Some farms try to limit group size to five to ten sows, though this varies with environmental stressors.

Another result of intensive swine production systems is the selection of swine genetics over many years resulting in reduced maternal instincts in sows. A sow that performs well in a confined environment may not perform well in an open environment if genetic selection practices have focused on production traits in confinement at the expense of maternal and foraging traits. Choosing the appropriate breed and genetic composition for a particular production system is a continual process of trial and error and refinement. Breed influences desired carcass traits, performance on available feeds, production goals, maternal traits and adaptability to the local environment. The crossing of multiple breeds is a strategy used to balance desired traits and care should be taken to choose genetics based on the suite of desired traits rather than focusing on one or two traits. Oklahoma State University has an extensive listing of swine breeds with descriptions that can help identify breeds and their traits and the The Livestock Conservancy has a list of heritage breeds and a useful breed comparison chart.

Breeding to Farrowing to Weaning

Northern California's mild climate works well for pasture pork production systems, especially if the more stressful periods of a sow's physiological cycles are properly timed to match the less stressful seasonal periods. This can be accomplished by timing farrowing in the fall and spring months when temperatures are mild and weather is generally favorable. The advantage to fall and spring farrowing is reduced sow stress which can reduce piglet mortality and increase piglet growth. A fall – spring farrowing strategy must be balanced with the need to supply a year-round market, but variable growth rates by individual pigs combined with extended breeding and farrowing cycles can help ensure a consistent market supply. Ensuring that ambient temperatures for sows and piglets are within their comfort zone will help optimize performance (Baker, 2004).

The gestation period for a sow is approximately 114 days, which places breeding at 3 months and 3 weeks prior to the desired time of farrowing. Pigs can be weaned at six to eight weeks by penning pigs of similar size away from the sows. The sow will enter her first heat cycle about 5 days after weaning with the heat cycle persisting for 2-3 days. The interval between heat cycles is about 21 days. Sows should be bred during the second heat cycle after weaning. The number of days from one breeding cycle to the next breeding cycle can be timed very close to six months:

114 days gestation + 42 days to wean + 5 days to first heat + 3-day heat cycle + 21 days to next heat = 185 days

Group	Breeding Dates	Farrowing Dates	Weaning Dates
1	Nov 15 – Dec 10	Mar 5 – Mar 31	Apr 15 – May 10
2	Dec 15 – Jan 10	Apr 5 – Apr 30	May 15 – Jun 10
3	Jan 15 – Feb 10	May 5 – May 31	Jun 15 – Jul 10
Next Breeding Cycle			
1	May 15 – Jun 10	Sep 5 – Sep 30	Oct 15 – Nov 10
2	Jun 15 – Jul 10	Oct 5 – Oct 31	Nov 15 – Dec 10
3	Jul 15 – Aug 10	Nov 5 – Nov 30	Dec 15 – Jan 10

Table 1: Hypothetical schedule for a sow herd divided into three breeding groups in an extended breeding/farrowing cycle.

Piglets crossed between domestic and European Wild Boar. Photo courtesy of Silvana Pietrosemoli.

A breeding-to-weaning calendar is an essential tool in understanding the general production cycle, but slight deviations from the calendar are sometimes necessary as part of an adaptive process of optimizing sow and piglet performance. An important determinant of sow fertility at breeding is her body condition at the time of the previous farrowing. This University of Kentucky publication (Coffey et al., 1999) provides information and pictures on evaluating swine body condition and using a 1 to 5 scoring system. At farrowing, the sow should have a body condition score at or close to 3. During lactation body condition will decline due to the high energy demand of milk production, but the body condition should not fall below 2.5 at the time of weaning. Sow condition should be frequently monitored so that steps can be taken before weight loss is too severe. Effective practices to increase body condition include providing more feed and early weaning of piglets. Early weaning will quickly allow the sow to divert energy from milk production to body growth and provide more recovery time prior to the next breeding cycle.

While early weaning may be helpful for the sow, it can be very stressful for the piglets. Some strategies to reduce piglet stress are to move the sow and keep piglets in the same familiar pen or paddock area for 3 to 4 days post-weaning and using a Pavlovian conditioning practice in which piglets associate specific audible sounds with a reward. In a study by Dudink et al. (2006) stress indicators in weaned piglets were much lower when they received an audible stimulus announcing a reward (i.e. toys, rubber hose, chain) compared to weaned piglets that only received the reward and weaned piglets that received neither the announcement nor the reward. Although an announced reward does not completely eliminate weaning stress, it is a simple practice that reduces stress and improves animal welfare.

Maintaining good sow hygiene is an issue that can arise in outdoor production, especially if sows are kept in areas with wallows and little vegetative cover. Mud covering the sow's vulva during breeding and farrowing increase the risk of bacterial infection. The pig's natural cooling system is limited to evaporative cooling through water loss by the snout and from breathing as they lack the ability to sweat. During warm weather, pigs seek water and create wallows to help cool their bodies, but this behavior often creates undesirable impacts on vegetation, soil and water quality and hygiene. Practices that reduce wallow creation include the use of movable shade structures and water sprinklers to distribute such impacts, using appropriate stocking densities, and allowing sufficient pasture recovery periods in a rest – rotation grazing regime (see factsheet on Rangeland and Pasture Management).

Resources

Breeds of Livestock. Department of Animal Science, Oklahoma State University. http://www.ansi.okstate.edu/breeds/swine

Profitable pork: Strategies for hog producers. Livestock Alternatives Bulletin, an online publication of Sustainable Agriculture Research and Education (SARE). http://www.sare.org/Learning-Center/Bulletins/Profitable-Pork.

FreeFarrowing.org is a web site that offers information on open farrowing systems including outdoor, group systems and individual farrowing pens.

Hogs Your Way: Choosing a hog production system in the upper Midwest. 2001. An online publication of the Minnesota Institute for Sustainable Agriculture and the Minnesota Department of Agriculture. http://www.misa.umn.edu/Publications/HogsYourWay/index.htm.

Honeyman, M. and Roush, W. Outdoor Pig Production: A Pasture-farrowing Herd in Western Iowa. ASL-R1498. Iowa State University. http://

www.extension.iastate.edu/Pages/ansci/swinereports/asl-1498.pdf.

The Livestock Conservancy, www.livestockconservancy.org.

Luce W.G., Williams, J.E. and R.L. Huhnke. Farrowing Sows on Pasture. ANSI-3678. Oklahoma Cooperative Extension Service. 6 pages. http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-2139/ANSI-3678web.pdf.

Literature Cited

Algers, B. and P. Jensen. 1985. Communication during suckling in the domestic pig: effects of continuous noise. Appl. Anim. Behav. Sci. 14: 49-61.

Algers, B. and K. Uvnäs-Moberg. 2007. Maternal behavior in pigs. Hormones and Behavior 52: 78-85.

Baker, J.E. 2004. Effective environmental temperature. J Swine Health Prod. 12(3): 140-143. https://www.aasv.org/shap/issues/v12n3/v12n3ptip.html

Baxter, E.M., A.B. Lawrence and S.A. Edwards. 2012. Alternative farrowing accommodation: welfare and economic aspects of existing farrowing and lactation systems for pigs. Animal 6(1): 96-117.

Blackshaw, J.K and A.M. Hagelsø. 1990. Getting-up and lying-down behaviours of loose-housed sows and social contacts between sows and piglets during day 1 and day 8 after parturition. Appl. Anim. Behav. Sci. 25: 61-70.

Coffey, R.D., G.R. Parker and K.M Laurent. 1999. Assessing sow body condition. University of Kentucky, College of Agriculture, Cooperative Extension Service. Online publication ASC-158, http://www2.ca.uky.edu/agc/pubs/asc/asc158/asc158.pdf.

Cronin, G.M., G.J. Simpson and P.H. Hemsworth. 1996. The effects of the gestation and farrowing environments on sow and piglet behavior and piglet survival and growth in early lactation. Appl. Anim. Behav. Sci. 46: 175-192.

Dudink, S., H. Simonse, I. Marks, F.H. de Jonge and B.M. Spruijt. 2006. Announcing the arrival of enrichment increases play behavior and reduces weaning-stress-induced behaviours of piglets directly after weaning. Appl. Anim. Behav. Sci. 101: 86-101.

Hutson, G.D., Argent, M.F., Dickenson, L.G., Luxford, B.G., 1992. Influence of parity and time since parturition on responsiveness of sows to a piglet distress call. Appl. Anim. Behav. Sci. 34: 303–313.

Marchant, J. N., D. M. Broom, and S. Corning. 2001. The influence of sow behavior on piglet mortality due to crushing in an open farrowing system. Anim. Sci. 72: 19–28.

Thodberg, K., K.H. Jensen and M.S. Herskin. 2002. Nest building and farrowing in sows: relation to the reaction pattern during stress, farrowing environment and experience. Appl. Anim. Behav. Sci. 77: 21-42.

Wechsler, B., Hegglin, D., 1997. Individual differences in the behaviour of sows at the nest-site and the crushing of piglets. Appl. Anim. Behav. Sci. 51: 39–49.

Yun, J., K.M. Swan, C. Farmer, C. Oliviero, O. Peltoniemi and A. Valros. 2014. Prepartum nest-building has an impact on postpartum nursing performance and maternal behavior in early lactating sows. Appl. Anim. Behav. Sci. 160: 31-37.

Yun, J., K.M. Swan, K. Vienola, Y.Y Kim, C. Oliviero, O.A.T. Peltoniemi and A. Valros. 2014. Farrowing environment has an impact on sow metabolic status and piglet colostrum intake in early lactation. Livestock Science 163: 120-125.

Photo banner photo credit from L to R: Farrowing pigs and farrowing shelter, Riverdog Farm.

Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area

Multi-Species Grazing Systems

By Morgan Doran

Multi-species grazing is a practice of grazing multiple types of livestock or wild herbivores on the same range or pasture either at the same time or different times of the same year.

The main advantages of multi-species grazing are:

- improved forage utilization
- higher carrying capacity and
- grazing impacts that can enhance plant diversity.

Rangelands in the greater Bay Area are dominated by exotic annual grasses and forbs that have been intentionally and accidentally introduced over the past three centuries. Spanish missionaries introduced many of these annual species along with livestock knowing they were good forages and adapted to a Mediterranean environment. The annual grasses and forbs are well adapted to grazing and thrive under moderate grazing impacts. Appropriate grazing regimes on annual rangelands maintain appropriate vegetative cover, while reducing fire loads (Russell and McBride, 2003), preserving fragile habitat and species (Bartolome et al., 2014; Ford el al., 2013; Marty, 2005) and maximizing forage production and species richness (Bartolome and Betts, 2005). Grazing is an important factor in maintaining productive and diverse rangelands that support multiple species of grazing animals.

Cattle and hogs on pasture. Photo courtesy of Rob Purvis.

Dietary Preferences in Multi-Species Grazing

Multi-species grazing can work very well when there is little dietary overlap between the different livestock species. Dietary overlap occurs when animals of the same or different species compete for the same types of vegetation. The many species of hoofed animals have a wide range of dietary preferences which are typically separated into one of three classes (Frost and Mosley, 2015): grazers, browsers or intermediate feeders.

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1. Grazers: Herbivores that consume large quantities of relatively low quality forage and have a limited ability to select high quality forages due to a large mouth. Cattle and horses are considered grazers.
2. Browsers: Herbivores that have a small, narrow mouth with the ability to selectively consume plants (clover and other forbs) and plant parts (tree and shrub leaves) with greater nutritional value. Goats are the most common livestock species classified as a browser.
3. Intermediate feeders: Herbivores with a mouth small enough to selectively consume high quality plants and plant parts, but with a digestive anatomy that allows consumption of low quality forages. Sheep are a common intermediate feeder.

Including Hogs in Multi-Species Grazing

Multi-species grazing systems that include hogs may be ideal systems to consider because of dietary limitations of the hog. As described in the Rangeland and Pasture Management factsheet, hogs have a monogastric digestive system which limits their ability to digest fiber. Since fiber is a primary nutrient in forage-based feeds, hogs are not able to utilize a large percentage of the forage nutrients in pastures and rangelands. Cattle and sheep are able to utilize fiber as a nutrient because microbes in their rumen digest this fiber into chemical compounds that are converted to glucose by the animal. The dietary limitation of hogs obligates them to consume, or graze, only the higher quality forages, such as clovers and young grass shoots, with highly digestible nutrients and leave much of the lower-quality forage. A pasture or range grazing system that only includes hogs will have poor forage utilization and will require frequent mowing to mechanically break down or remove mature plant material in order to return plants to a growth stage more suitable for consumption by hogs (see the National Forage and Grassland Curriculum for more information on growth stages). Rather than spending time and resources mowing excess forage, allowing cattle or sheep access to that same pasture or paddock will make better use of the forage resource and diversify farm returns from livestock production. Combining species of grazing livestock may even increase total productivity, as demonstrated in a research study by Sehested et al. (2004) in which heifers and sows grazing together and in sequential time periods improved weight gains for both species and increased total forage intake per acre of land.

Implementing Multi-Species Grazing

Multi-species grazing offers many potential benefits to a farming operation, but does increase overall complexity of the production system. Giving careful attention to specific details and being observant of grazing animal behavior and impacts will improve the successful implementation of grazing multiple species of livestock.

Infrastructure

One of the first considerations in planning a multi-species grazing system is the infrastructure necessary to safely contain each species. Fences, corrals and pens built for hogs are often suitable for sheep which greatly reduces the cost of additional infrastructure in a combined grazing system. Combining hog and cattle grazing will require a significant investment in infrastructure specifically

Multi-species fencing. Photo courtesy of James T. Green

for handling cattle in alleys, corrals and chutes. Pasture and range fencing for hogs will be adequate for cattle as long as the fencing is built high enough for cattle (about 54 inches). Ensuring that watering resources are secure and cannot be used by hogs to create wallows is another critical consideration.

Partitioning large grazing units into smaller paddocks with cross fencing (See factsheet on Conservation Practices) will facilitate the movement and management of grazing hogs. In grazing units where hogs are grazed with other livestock species it may be necessary to construct supplemental feed access points that permit access by hogs and exclude other species.

Stocking Density

Managing the grazing impact with respect to forage utilization and stocking density is important in any grazing system, and even more important in a multi-species system. The benefits of multi-species grazing (Sehested et al., 2004) can diminish as stocking densities increase (Ruyle and Bowns, 1985), most likely due to an increase in dietary overlap as competition increases. An added complexity in managing appropriate stocking densities is the variable forage growth rates throughout a growing season. The growing season on California rangelands is primarily January through April, and April through October on irrigated pasture. When planning a multi-species grazing system, it may work best to start with lower stocking densities, especially near the beginning and end dates of the growing season, and adjust upward as forage resources allow. Refer to the Rangeland and Pasture Management factsheet for suggested hog stocking densities. Another strategy is to reserve much of the annual stocking capacity for young feeder hogs, lambs and cattle that can be bought and sold as needed rather than stocking heavily with breeding sows, ewes and cows that are always on the farm or ranch. This strategy requires that the farm maintain a lower number of year-round breeding animals, but a high number of feeder animals when forage resources are abundant. It will take a few grazing seasons to gain a good understanding of the grazing system and adaptive management will always be a necessity.

Interior polywire fence can be used for multi-species grazing. Photo courtesy of Silvana Pietrosemoli

Hogs and chickens on pasture. Photo courtesy of Sugar Mountain Farm

Comingled and Sequential Grazing

Multi-species grazing can be managed in different ways to best accommodate compatibility between species, animal handling practices and forage utilization. Livestock of different species can be comingled to graze the same grazing unit together or species can be separated to graze the same grazing unit at sequential times. Since hogs and cattle have very little dietary overlap, comingling can be effective barring any logistical challenges. Sheep may have slightly more dietary overlap with hogs than cattle, but aggressive behavior may limit their compatibility. Feeder animals may provide more flexibility in adjusting stocking densities than breeding animals, but feeder animal weight gains should be closely monitored to ensure that comingled grazing does not compromise gains. If the grazing system is better suited for sequential grazing, hogs should be grazed at a time when forages are in an earlier growth stage and have younger, more succulent leaves and shoots which are high in nutritional quality. Cattle and sheep are well adapted to consume a lower quality diet than hogs and should graze forage in stage 2 of the growth cycle (see the National Forage and Grassland Curriculum). A prescribed, rotational grazing system will work best for grazing multiple species together or sequentially to ensure forage resources are effectively utilized and not overgrazed. Keep in mind that this sequential grazing rotation only works when forage is actively growing and will not work at times when forage is dormant or senesced. Below is one example strategy for sequential multi-species grazing:

Example sequential grazing strategy:

1. First give hogs access in the early growth stages (late-stage 1 to early-stage 2
2. Remove hogs and rest pasture or range until the forage is in stage 2 of growth
3. Graze cattle or sheep which returns forages back to stage 1 of growth
4. Remove cattle or sheep until forage is ready for hog grazing (step 1)

Literature Cited

Bartolome, J.W. and A.D.K. Betts. 2005. Residual dry matter impacts on water quality and biomass production. Proceeding of the University of California Sierra Foothill Research and Extension Center field day, April 21, 2005.

Bartolome, J., B. Allen-Diaz, S. Barry, L. Ford, M. Hammond, P. Hopkinson, F. Ratcliff, S. Spiegal and M. White. 2014. Grazing for biodiversity in Californian Mediterranean grasslands. Rangelands. 36(5):36-43.

Ford, L.D., P.A. Van Hoorn, D.R. Rao, N.J. Scott, P.C. Trenham and J.W. Bartolome. 2013. Managing rangelands to benefit California red-legged frogs and California tiger salamanders. Alameda County Resources Conservation District, Livermore, California.

Frost, R. and J. Mosley. 2015. Diet selection of grazing animals. eXtension online publication, http://www.extension.org/pages/58109/diet-selection-of-grazing-animals#.VdzKw_RWJia.

Marty, J. 2005. Effects of cattle grazing on diversity in ephemeral wetlands. Conservation Biology 19:1626-1632.

Russell W. H., and J.R. McBride. 2003. Landscape scale vegetation-type conversion and fire hazard in the San Francisco bay area open spaces. Landscape and Urban Planning. 64: 201-208.

Ruyle, G.B. and J.E. Bowns. 1985. Use by cattle and sheep grazing separately and together on summer range in Southwestern Utah. Journal of Range Management 38(4): 299-302.

Sehested, J., K. Søegaard, V. Danielsen, A. Roepstorff and J. Monrad. 2004. Grazing with heifers and sows alone or mixed: herbage quality, sward structure and animal weight gain. Livestock Production Science 88: 223 –238.

Banner Photo credit: Hogs and goats on pasture. Photo courtesy of Silvana Pietrosemoli .

Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area

Riparian and Wetland Management

By Theresa Becchetti, Sheila Barry, Susan Ellsworth, and Silvana Pietrosemoli

Ensuring the health of riparian corridors and wetlands is an important consideration for site selection and ongoing management of outdoor hog operations in San Francisco's Bay Area. Though riparian areas comprise a small portion of the overall landscape in California, they are vital to the health of our ecosystems. Wetlands and riparian areas not only act as filters for surrounding uplands, but the waterways within them provide critical habitat and food sources for many species, as well as recreation opportunities and other functions to human users.

Many riparian areas in Northern California contain intermittent or ephemeral water bodies, and are often the only green spots on the landscape, particularly in late spring and summer. For this reason, livestock may spend a disproportionate amount of time in these areas looking for shade and green forage. Unlike cattle or sheep, which can provide significant benefits to riparian area if properly managed, hogs can be particularly damaging to these sensitive zones. In particular, rooting, trampling, wallowing and dunging in these areas has the potential to jeopardize some of their critical ecological functions. Just how far hogs should be kept away from the riparian area is related to many factors such as how wet the area is, configuration of the farm operation and the adjacent waterway including slope and soil type, what vegetative species are present, as well as fencing and how the riparian area is managed. All of these factors should be taken into account in an outdoor hog operation with proximity to a riparian area or waterbody.

Pasture riparian area, Sonoma, CA. Photo courtesy of Lynn Betts, NRCS.

Management Approaches

Listed below are some of the different management tools and approaches to help minimize the impact of hogs on adjacent waterways. Contact your local

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Natural Resource Conservation Service, (NRCS), Resource Conservation District (RCD) or University of California Cooperative Extension (UCCE) Advisor for assistance in designing these tools so they are of maximum benefit.

Filter Strips

Vegetative filter strips are a critical tool for protecting riparian areas and waterways from the potential impacts of outdoor hog production. A filter strip is an area of herbaceous (non-woody) vegetation located between an agricultural production zone and sensitive areas to provide protection from overland flow of sediments, nutrients, or pathogens.

The appropriate width of a filter strip depends on several factors including slope, density of vegetation and expected sediment and nutrient flow; steeper slopes with less vegetation require wider filter strips. Vegetative filter strips should be wide enough to filter sediment, nutrients and fecal pathogens. Atwill et al. (2002 and 2006) demonstrated California annual rangelands are able to reduce movement of the pathogen *Cryptosporidium spp.* within one yard under different slopes (up to 35%) and different amounts of vegetation (as low as 250 lbs/acre) over the period of two years of actual rainfall events, while Tate et al. (2006) found the same results for *E. coli* under the same conditions. On irrigated pastures with slope, Tate et al. (2000) found that a 10 yard filter strip was effective at reducing sediment for both flood irrigation and sprinkler irrigation and effective for reducing phosphorous under sprinkler irrigation, but not nitrogen for either irrigation types. Follow up research by Bedard-Haughn et al. (2004) found that

	Plant Characteristics	Lbs/Acre	Filter Strip	Grassed Waterway	Critical Area	Pasture
1. Berber orchardgrass[1]	Perennial grass	16	X	X		
2. **Creeping wildrye**[1,2]	Perennial grass	30[3]	X	X		
3. 'Blando' brome 'Zorro' annual fescue Rose clover[4] **California poppy**[5] **Arroyo lupine**[5,6,7] Crimson clover[4]	Annual grass Annual grass Annual legume Annual wildflower Annual wildflower Annual legume	18 10 9 1 1 1	X	X	X	
4. **California brome**[1] **Blue wildrye**[1] **California poppy**[5] **Arroyo lupine**[5,6,7]	Perennial grass Perennial grass Annual wildflower Annual wildflower	25 18 1 1	X		X	
5. Blando brome Annual ryegrass	Annual grass Annual grass	25 24			X	
6. 'Berber' orchardgrass[1] Tetraploid perennial ryegrass[1] Subclover[4,7] Rose clover[4]	Perennial grass Perennial grass Annual legume Annual legume	4 6 6 4				X
7. 'Blando' brome Rose clover[4] Subclover[4,8]	Annual grass Annual legume Annual legume	6 6 6				X

Table 1: Seeding Recommendations for Horse Facilities in the San Francisco Bay Area. The following table from "Seeding Recommendations for Horse Facilities in the San Francisco Bay Area" (2001) can be used as a reference. Note: Species in bold are native to California.

[1] Mulch must be used to provide initial erosion control when establishing perennials
[2] Also known as beardless wildrye
[3] Or use plugs at 1' x 1' spacing
[4] Also see "legume inoculation" section below
[5] Optional, use for color
[6] *Lupinus succulentus*, also known as hollowleaf annual lupine
[7] Lupine may be toxic to horses. Only use where horses will not graze.
[8] Use locally adapted varieties recommended by UC Cooperative Extension

managing the vegetation in the filter strips with grazing was necessary for the filter to remove nitrogen under both irrigation types. Research in other areas suggests anywhere from 5 yards to retain the majority of sediment (Collins, et. al, 2004, Dabney, et. al, 2006, Dorioz, et. al, 2006) to 30 yards (McNeill, 1992) to decrease pathogens. Based on research done in California, the recommendation would be to create a riparian pasture that can be managed by other species (cattle, sheep, goats, horses, etc.) as appropriate to maintain a functioning filter strip to remove nutrients. A riparian pasture should be wider than 10 yards in order for it to be an effectively managed pasture, thus exceeding the research findings. If it is not possible to create a riparian pasture, a minimum filter width of 10 yards should be implemented following California research and it should be managed by mowing. See table 1 and contact your local NRCS, RCD, or UCCE for assistance in designing your filter strip and selecting appropriate vegetative species.

Vegetative filter strip. Photo courtesy of Lynn Betts, NRCS.

Fencing and Infrastructure

While in some cases filter strips may benefit from managed grazing by cattle or other ruminants to avoid the build-up of excess vegetation (Bedard-Haughn et. al, 2004 and 2005), hogs will be less effective at managing this vegetation and will cause damage to wet areas. This will likely require hog-proof fencing, either permanent or electric between the livestock area and the filter strip with gates as needed. The establishment of this exclusion zone may necessitate modifications of farm infrastructure,

Alleyways between paddocks are heavy use areas and should be managed to minimize erosion into waterways. Photo courtesy of Riverdog Farm.

such as the establishment of off-stream or portable watering systems, as well as the creation of reinforced bank areas, river crossings or bridges. In some cases, farm roads may need to be relocated if they have the potential to act as channels for run off to water courses during heavy rains.

Planning Heavy Use Areas

Particular care should be taken when locating heavy use areas, such as feeding or watering facilities, or farrowing or shade structures. Such high use areas tend to decrease vegetation, increase manure deposition and lead to soil compaction and increased erosion risks. The combination of these impacts may result in the transport of sediments, pathogens or excess nutrients into the riparian area or waterbody, resulting in water quality impairments locally or further downstream. Heavy use areas should follow the same general rule of thumb and be located at least 10 yards away from riparian areas and wetlands, ideally separated by a vegetative filter strip and should be sloped away from drainages to prevent direct run-off.

Ensuring Vegetative Cover

Within a functioning filter strip, herbaceous vegetation is the primary tool for slowing, capturing and filtering run-off. Ensuring sufficient coverage and density of vegetation is critical, particularly in advance of the rainy winter months.

In some cases, a riparian forest buffer, which consists of predominantly woody trees or shrubs, may also be appropriate with the goal of enhancing riparian habitat, creating shade and increasing carbon storage. Mature buffers will also reduce sediment and organic materials. In either the case of a filter strip or forest buffer, avoid invasives and consider the use of appropriate natives to maintain diversity.

Riparian Buffer Species for the Bay Area	
Shrubs	
mule fat	For riparian areas
Coyote brush	Can be weedy and invasive
California rose	
common snowberry	Common understory species
California blackberry	Prefers shade
coffeeberry	
blue elderberry	
red elderberry	Prefers wetter areas
Trees	
willow	Species vary by location
Fremont cotton	
Pacific dogwood	Prefers wetter areas

Table 2: Riparian Buffer Species for the Bay Area

In addition to filter strips and riparian buffers, working to maintain vegetative cover in pastures, paddocks and high use areas is ultimately the most effective means of protecting sensitive riparian areas and waterways. This generally requires a careful rotation of animals, as well as feed, water and shelter, throughout different pastures or paddocks, allowing for adequate rest after use - see factsheet on Rangeland and Pasture Management for more information. When multiple pastures or paddocks are available, hogs should be moved to those as far away from riparian areas as possible when there is a high possibility of runoff.

Additional Tools to Minimize Run-off

Straw wattles and berm and swale systems can also be used to help prevent overland flow and erosion from entering sensitive areas. A straw wattle is a biodegradable tube often made of compressed straw wrapped in jute, roughly 20-25 feet in length. Wattles are generally installed in a shallow trench along a contour to intercept runoff from up-slope. A berm and swale system consists of a narrow trench or depression (swale) dug on a contour, with a ridge on the downslope side (berm) often constructed from the soil removed to create the swale. Runoff is trapped in the swale, thereby preventing sediments or other contaminants from leaving the site and allowing water to percolate back into the ground. In cases where significant runoff is expected and slopes are such that a filter strip or buffer will not sufficiently slow and filter contaminants, a pond or sediment basin can also be installed to capture and store overland flow. Your local NRCS or RCD office may be able to assist in determining what structures are needed to safeguard resources.

To function successfully, riparian areas need to be properly managed and periodically inspected to identify excessive vegetation growing in the bank. Native deep rooted vegetation, such as willows, can be used to protect or reinforce banks, improving their stabilization. Do not dispose of waste in riparian areas and remove debris from the banks of watercourses or ditches, streams and rivers. Consult with your local UCCE, NRCS or RCD before removing fallen trees as these can serve as valuable habitat niches

A well managed rotation may be required to maintain vegetation adjacent to riparian areas. Photo courtesy of Magruder Ranch.

Literature Cited

Atwill, E.R., L. Hou, B.M. Karle, T. Harter, K.W. Tate, and R.A. Dahlgren. 2002. Transport of *Cryptosporidium parvum* Oocysts through Vegetated Buffer Strips and Estimated Filtration Efficiency. *Applied and Environmental Microbiology*. 68:5517-5527.

Atwill, E.R., K.W. Tate, M. Das Gracas C. Pereira, J.W. Bartolome, and G.A. Nader. 2006. Efficacy of Natural Grass Buffers for Removal of *Cryptosporidium parvum* in Rangeland Runoff. *J. Food Protection*. 69:177-184.

Bedard-Haughn, A., K.W. Tate, and C. van Kessel. 2004. Using 15N to Quantify Vegetative Buffer Effectiveness for Sequestering N in Runoff. *J. Environmental Quality*. 33:2252-2262.

Bedard-Haughn, A., K.W. Tate, and C. van Kessel. 2005. Quantifying the Impact of Regular Cutting on Vegetative Buffer Efficacy for 15N sequestration. *J. Environmental Quality*. 34:1651-1664.

Collins, R., Donnison, A., Ross, C., and McLeod, M. 2004. Attenuation of effluent-derived faecal microbes in grass buffer strips. New Zealand Journal of Agricultural Research. 47:565-574.

Council of Bay Area Resource Conservation Districts. 2001. Seeding Recommendations for Horse Facilities in the San Francisco Bay Area.

Dabney, S.M., Moore, M.T., and Locke, M.A. 2006. Integrated management of in-field, edge-of-field, and after-field buffers. Journal of the American Water Resources Association 42:15-24.

Dorioz, J.M, Wang, D., Poulenard, J., and Trevisan, D. 2006. The effect of grass buffer strips on phosphorus dynamics – A critical review and synthesis as a basis for application in agricultural landscapes in France. Agriculture, Ecosystem and Environment 114:4-21.

McNeill, A. 1992. The ecological roles of riparian vegetation: The role of buffer strips in the management of waterway pollution: Aspects relating to pathogens and bacteria. In J. Woodfull et al. (eds). Proceedings of the Role of Buffer Strips in the Management of Waterway Pollution from Diffuse Urban and Rural Sources. International House, University of Melbourne, October 9, 1992.

Land and Water Resources Research and Development Corporation and Centre for Environmental Applied Hydrology, University of Melbourne, Victoria, Australia. P 83-91.

Tate, K.W., G.A. Nader, D.J. Lewis, E.R. Atwill, and J.M. Connor. 2000. Evaluation of Buffers to Improve the Quality of Runoff from Irrigated Pastures. Journal of Soil and Water Conservation, 55(4):473-478.

Tate, K.W., E.R. Atwill, J.W. Bartolome, G.A. Nader. 2006. Significant Escherichia coli Attenuation by Vegetative Buffers on Annual Grasslands. Journal of Environmental Quality 35:795-805.

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