Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area

November 2015

University of California Cooperative Extension
Alameda County Resource Conservation District
North Carolina State University Center for Environmental Farming Systems

Acknowledgements

This project and the resources provided herein would not have been possible without support from the United States Department of Agriculture Natural Resources Conservation Service Conservation Innovation Grant. We thank them for their support.

Additional funding was generously provided by the University of California Division of Agriculture and Natural Resources, as well as TomKat Ranch and the Alameda County Resource Conservation District.

Tremendous in-kind contributions were made by the following individuals, University of California Cooperative Extension Personnel, North Carolina State University's Center for Environmental Farming Systems staff, Resource Conservation Districts including Alameda, Contra Costa, Gold Ridge, Guadalupe Coyote, and Sonoma, as well as Natural Resources Conservation Service partners and others: Silvana Pietrosemoli, Sheila Barry, Theresa Becchetti, Morgan Doran, Stephanie Larson, Susan Ellsworth, Luke Macaulay, Julie Finzel, Linda Peterson, Jackie Charbonneau, Ling He, Alyson Aquino, Marie Harter, Roger Ingram, Kellyx Nelson, Jim Howard, Adria Arko, Donna Richeson, Ben Wallace, Brittany Heck, Kara Heckert, Kari Wester, Valerie Minton and Nancy Scolari.

The following livestock producers generously contributed their time and wisdom to this project: Dede Boies, Zavra Fortsen, Guido Frosini, George Hohnsbeen, Kylan Hoover, Steven Kopp, Pete Langley, Scott Long, Grace Magruder, Doniga Markegard, Nancy Mueller, Tim Mueller, Don Nash, Tommy Otey, Mark Pasternak, Blair Thompson, Mary Min Vincent, Kevin Watt, Kathy Webster.

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Outdoor Hog Production

Best Practices for Conservation in the San Francisco Bay Area

Introduction and Project Background

By Susan Ellsworth and Silvana Pietrosemoli

Sustainable hog production, as with all sustainable agriculture, requires knowledge of local climate, ecology and economic conditions. Therefore, the development of best management practices for truly ecological production relies on the adaptation of prevailing models to reflect local conditions. This guide contains a series of factsheets intended to support outdoor pork producers, resource managers and agricultural professionals in implementing resource conservation best management practices within the Greater San Francisco Bay Area and Northern San Joaquin Valley. For our purposes, outdoor hog production refers to range or pasture-based, dry lot, or other alternatives to conventional slatted floor systems.

Collaborators

Collaborators on this project include UC Cooperative Extension Livestock advisors, Resource Conservation Districts, and numerous hog producers from around the Greater San Francisco Bay, Northern San Joaquin and Southern Sacramento Valley. Technical expertise was provided by the Center for Environmental Farming Systems at North Carolina State University.

To characterize alternative hog production systems in this region, collaborators visited fourteen operations in eleven counties, including Alameda, Contra Costa, Marin, Mendocino, Nevada, San Joaquin, San Mateo, Santa Clara, Sonoma, Stanislaus and Yolo Counties. These visits allowed collaborators to explore issues related to potential environmental impact, husbandry and overall production, thereby informing the development of this resource guidebook. All farms visited were characterized by high standards of animal health and welfare and a wide diversity of management approaches.

Climate and Ecology

The Bay Area and surrounding counties are characterized by a Mediterranean climate with the majority of precipitation falling between October and April, followed by little to no rain from May through September. Total rainfall varies from 15” in the East and South Bay (Livermore and San Jose) to almost 50” in the North Bay (Mill Valley and Healdsburg). Topography is varied, with rolling hills and valleys, wetlands and estuary, as well as the low lying Coast Range running northwest to southeast. The Coast Range, though modest in elevation (Mt. Diablo at 4261’), nevertheless prevents the ocean air from

Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

readily entering the Central Valley, resulting in a hotter, drier climate to the east and a moister, milder climate to west, with numerous "microclimates" throughout. Given the seasonality of precipitation, both perennial and intermittent streams are common and riparian areas are often the only green vegetation in late summer and fall. Along with topography and rainfall, soils are also highly variable, resulting in a range of forage types and availability throughout the study area. Within the valleys, foothills and grasslands that make up the majority of grazed rangeland, annual grasses and forbs dominate, often interspersed with oak and various woody shrubs. In other areas, larger stands of perennial grasslands are present, also mixed with oaks and other vegetation types. Improved, irrigated pasture is limited to some regions. Lack of rain during the dry season, combined with thin soils and sloping hillsides makes erosion a significant consideration, particularly on annual range.

Economic Context

Hog production has declined significantly in California over the last 50 years. In the Greater Bay Area, the number of operations has dropped by approximately 90%. Yet, during that time human populations have grown, and in the last ten years, demand for locally-raised meat products has increased dramatically (Gwin et al, 2008). In particular, consumer interest in flavorful, hormone/antibiotic free, humanely raised products has created demand for pork that outstrips supply.

Recognizing the opportunity to serve this market demand, an increasing number of direct-market oriented producers are adding hogs to their farms and ranches, in many cases relying on outdoor or forage-based systems. Additionally, given the reproductive capacity, opportunities to vary market age and weight, and relatively short time from birth to market, hogs are an agricultural commodity that has proven viable for many beginning farmers and ranchers.

Case Studies

In an effort to better understand the needs of producers in the area, collaborators visited 14 outdoor hog production sites from a wide range of ecological niches characteristic of the study area, as well as from a diversity of production approaches. Detailed surveys were conducted at 10 of the 14 locations to better understand conservation and production challenges and successes.

Figure 1 : Map of Field Visits to Outdoor Hog Producers by County

Of the 10 operations surveyed, hog production sites ranged in size from 5 to 200 acres on both private and public land, with the majority (80%) operating as farrow to finish systems. The remaining 20% purchased weaned animals for finishing, with nearly all operations harvesting the animals and selling the meat products directly. Of the 10 sites surveyed, all but one operate primarily as outdoor swine units; eight based on natural vegetation, two on natural and established grasses, and the last utilizing a deep bedded system where animals are reared in open-ended hoop houses with ample bedding material. In many cases, those in permanent or semi-permanent enclosures experienced significant loss of vegetative ground cover.

In the majority of operations, animals were reared in groups with plenty of space and freedom to express

instinctive behaviors. Predominant breeds included Tamworth, Large Black, Berkshire, Duroc, Hampshire, Red Wattle, Old Spot Glouchester, Yorkshire and European wild boar.

In general, producers used portable shelters, feeders and drinkers to allow for rotation of areas under production, thereby reducing the potential for nutrient build up, soil impact, parasites and other animal health-related issues. Most operations provided their animals with hay or straw bedding which is composted after use and either reused in pasture and crop fields, or sold as soil amendment.

Drylot, pasture and range-based systems were utilized, as well as alternatives like deep-bedded systems, with the majority of farrowing and lactating areas under continuous use, often with permanent infrastructure. Pasture and range-based grazing was observed more frequently in weaner or finisher areas, though in several operations all aspects of production are under continuous use.

For most operations, vegetative ground cover was comprised of naturally occurring, primarily annual grasses, often resulting in bare ground under continuous use with high stocking rates. Several operations worked to establish forage species through seeding; one as part of an irrigated pasture rotation and the other relying on straw mulch for protection. Stocking density varied widely from less than 1 hog/acre on extensive rangeland to 250 hogs/0.25 acre in the deep bedded system.

Brewers grains mixed with milk and whey. Photo courtesy of Devil's Gulch Ranch.

Most operations utilize at least some alternative feeds, ranging from dairy products such as whey, milk, yogurt or ice cream to bakery and restaurant waste, culled vegetables and fruits, to brewers grain, and cereals. The use of alternative feed contributes significantly to reduced feed costs and to improved economic sustainability; for most alternative hog operations, feed is one of the largest production costs.

The majority of animals were sent to commercial slaughter facilities within the region with average market weights ranging from 220 to 300 lbs per animal. Farmers employ a variety of marketing strategies to sell their products, including direct marketing to consumers through CSAs and on-farm sales, farmers markets and pig share, restaurants, local butchers and in a few cases, auction.

Opportunities to Improve Sustainability

Environmental impact in outdoor swine production systems is generally associated with natural behaviors such as rooting, trampling and selecting dunging areas. If poorly managed, such behavior is often correlated with damage to vegetation, soil disturbance and soil nutrient build up, which in turn can result in erosion, soil compaction, nutrient leaching, and increased nitrogen and phosphorus in watercourses (Menzi et al., 1998, Miao et al., 2004; Eriksen et al., 2006, Quintern and Sundrum, 2006).

All the operations visited during the study were well managed, demonstrating high levels of animal health and welfare. Nevertheless opportunities to improve resource management were also present, exacerbated in many cases by prolonged drought. The following is a list of management successes and challenges observed during case-study visits:

Resource Management Successes

- Use of well-adapted breeds
- Portable shelters with bedding
- Portable feeders
- Seasonal management
- Use of alternative feed sources

Resource Management Challenges

- Bare ground
- Soil compaction
- Potential for excessive nutrients in soil and water
- Excessive wallows
- Lack of shade

Factsheets included within this guide are designed to address many of these resource management concerns and opportunities, by laying out best management practices adapted to the local climate, ecology and market conditions. Also included are recommended conservation practices as developed by the Natural Resources Conservation Service.

Banner photo credit from L to R: Pigs on pasture. Photo courtesy of Root Down and Silvana Pietrosemoli.

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Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area

Introduction to Outdoor Hog Production

By Sheila Barry, Susan Ellsworth and Silvana Pietrosemoli

Approximately 99% of grower/finisher hogs produced in the United States today are reared in confined, indoor slatted-floor systems designed to maximize efficiency of weight gain, waste-management and treatment of potential health conditions. However, there is growing interest among consumers for meat products raised in less industrial environments, particularly outdoor, pastured, and in some cases, organic production systems, which are then sold in specialized niche markets. This factsheet will provide an overview of some of the most common outdoor and alternative hog production systems in California, and across the U.S., and provide background for other resources within this collection.

Depending on their production goals, hog production systems can be classified as farrow-to-wean, farrow-to-finish or grower operations. Farrowing is the process of a sow giving birth to a litter of pigs.

Farrow-to-finish

In a farrow-to-finish system, producers specialize in all stages of growth and development from breeding and farrowing to growing the pigs to market weight (230-300 lbs or more depending on the market).

Farrow-to-wean

In this system, a producer specializes in breeding sows and then raising the pigs until they are weaned, between three and eight weeks, at which time they are sold to another producer for finishing.

Grower/Finisher

A finishing operation typically buys weaner/feeder (pigs from weaning to 10 weeks of age) or growers (from 10 to 16 weeks) and grows them until they reach market weight (22-26 weeks of age).

For more information see the factsheet in this series on Farrowing and Weaning Best Practices.

All of these operations can be adapted to alternative production systems which typically emphasize access

Common Outdoor Hog Systems in the San Francisco Bay Area:

- Pasture & Rangeland Based
- Drylots
- Wood lots
- Deep Bedded Systems
- Integrated Cropping Systems

Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

to forage, outdoor areas, and the ability for hogs to demonstrate various instinctive social and natural behaviors such as establishing herd hierarchy, rooting, wallowing, and nesting.

The following are some of the most common outdoor and alternative hog production systems in northern California:

Pasture & Rangeland Based: In a pasture or rangeland-based system, hogs are raised on pasture (irrigated or improved) or rangeland (dryland), where the consistent presence of vegetative ground cover is a key element of the production system. Though hogs are not ruminants, they will graze as well as root and trample, so careful management is required to ensure the maintenance of ground cover. In such systems, animals generally need to be moved (rotated) to preserve forage and enable recovery of high use areas. They typically rely on portable shelter, feed and watering infrastructure as well as cross-fencing to create multiple paddocks. In some cases hogs may be included in a multi-species rotation, wherein different livestock species are cycled through the same pasture to more fully utilize feed and provide improved nutrient cycling. For more information see the factsheet in this series on Rangeland and Pasture Management and Multi-Species Grazing.

Hogs in an orchard. Photo courtesy of Dinner Bell Farms.

Drylot: Drylot systems are typically permanent, with fixed fencing and higher stocking densities. Though feeders and waters may not be permanent, they often remain in the same location and, due to overall high use, little to no ground cover remains. Sometimes referred to as "dirt lots", these systems are often characterized by wallows as well as areas with high compaction, potentially posing erosion, nutrient or water quality concerns.

A deep bedded system. Photo courtesy of Long Ranch.

Wood lots: Wood lots are wooded or forested areas where hogs are able to forage for vegetation, grubs and acorns. Though rarely used for hog production in California, woodlots are an excellent environment for pigs, allowing them to exhibit their full range of natural behaviors including nesting in leaf debris. If properly managed, pigs can contribute to the management of these areas, particularly through trampling and browsing on undesirable species such as blackberry and poison oak. However, they still need to be rotated to avoid excessive soil disturbance or damage to tree roots or trunks. Wood lot systems are often characterized by electric fencing and portable feeders and troughs to ensure that one area isn't impacted too heavily. See factsheet on Pig Production in Oak Woodlands.

Deep bedded systems: Deep bedded systems involve the raising of hogs in semi-permanent, often hoop house type structures, with 12" or more of bedding. The depth of bedding enables the animals to select and modify their environment through rooting or nesting with less damage to soil or vegetation. Hoop barns are typically low-cost shelters with an arched steel pipe structure, wood walls (4-6 ft), and a stretched polypropylene roof. Though stocked at lower rates than conventional slatted floor systems,

hoop barns often have a significantly higher stocking rate than pastured hogs at approximately 13 ft^2/ animal. The floor beneath the bedding can be of concrete or soil and bedding is periodically replaced, with older bedding removed and composted.

Integrated cropping systems: Hogs can also be integrated into cropping systems such as vegetable or orchard crops whereby they are allowed to consume crop residue after harvest, simultaneously tilling the soil with their snouts, grazing on weeds and adding nutrients with their manure. Hogs can also be used to help till in cover crop prior to planting. It is important in such systems to allow enough time after a hog has been present in the field (at least 120 days before harvest) for manure to break down so as to mitigate food safety-related concerns.

Though some producers may utilize just one alternative production approach, many combine approaches to enable improved management of forage and soil or to rest areas by moving animals to designated sacrifice zones. Some operations may finish pigs in deep bedded systems, while others may allow their animals to forage in a woodlot for a short period of time during acorn season. A producer using an alternative production approach may also take advantage of other niche market opportunities like animal welfare certifications or heritage breeds.

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Banner photo credit: Pigs in pasture. Photo courtesy of Magruder Ranch.

Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area

Site Selection and Planning

By Sheila Barry, Susan Ellsworth and Silvana Pietrosemoli

Deciding where to locate an outdoor swine operation is one of the most important early considerations for any producer. Appropriate site selection will lay the groundwork for a successful business while minimizing environmental impacts, ensuring animal welfare and minimizing conflict with neighbors.

The following is a list of key considerations for choosing your outdoor hog production location:

General location considerations: When locating your operation, you'll want to consider a number of general factors such as access to processing, local zoning, general social acceptance and access to markets. In California, many markets are centered in more densely populated urban areas some distance from agricultural land. Access to feed resources is also important, particularly if you're planning to utilize alternative feeds like whey, brewer's grains or other by-products.

Size: It is critical that a producer consider the size of operation he or she will ultimately manage and ensure that a particular site can accommodate the total number of animals desired without damaging natural resources. The area required per animal will vary considerably depending on site characteristics and management, however the stocking densities provided in Table 1 can be used as a guide.[1]

Irrigated Pasture	Growers/Finishers	15-30 head/acre
	Sows + Litters	4-6 head/acre
Rangeland	Growers/Finishers	4-10 head/acre
	Sows + Litters	0.5-1 head/acre

Table 1. Stocking densities for outdoor hog operations

Soil: Selecting a site with appropriate soil is a key consideration both because of its relationship to forage quantity and quality as well as drainage and erosion potential. Soils should be well-draining in order to minimize plugging or waterlogging, which in turn can result in erosion, run-off or compaction, not to mention management difficulties related to mud. Highly erodible soil should be avoided, particularly for high-use areas – visit web soil survey or talk to your

[1] *Proposed stocking densities are recommendations only and derived from observation of outdoor hog systems in California, Texas, North Carolina and Europe*

Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

local Resource Conservation District (RCD) to determine if this will be an issue in your area. Alternatively, sandy soils or those with shallow ground water should be avoided due to nutrient leaching potential. Because drylots may have limited vegetative cover, locate them on sites with less than 5% slopes to minimize erosion. As with all agricultural production, sites should also be evaluated for flood risk. Hogs have a tendency to follow the same path between shelters, feeders, drinkers and fencelines, so consider overall site layout and potential erosion and compaction from trails. Stony, flinty or rocky soils may pose a risk to hog's hooves and legs and should be avoided if possible.

Neighbors: Even the most well-managed outdoor swine operations have the potential to generate odors, noise and dust, so it is critical to consider your neighbors and ensure that your site has a sufficient buffer to minimize these impacts. This buffer may take the form of vegetation such as a hedgerow or line of trees, topography, or man-made infrastructure such as a large fence or highway barrier. In some cases, simply ensuring enough distance between the production site and a neighbor may sufficiently mitigate these issues. Vegetative buffers such as trees or shrubs have the added value of providing habitat for insects, birds and other wildlife, while creating shade, bedding and potential food sources for livestock. In some cases, vegetative filters may also help capture and utilize run-off before it leaves the site. See factsheet on Riparian and Wetland Management for more details on filter and buffer. If an appropriate vegetative buffer does not exist, consider establishing one as an early site modification and talk to your local Natural Resources Conservation Service (NRCS) office for guidance.

Sensitive habitat: Consider proximity to sensitive habitat such as riparian areas, waterways, rare plant communities or habitat for special status wildlife. Contact your local RCD or NRCS to determine what sensitive species might be present in your area.

Other Swine Operations: Similarly, you'll want to make sure that you aren't located too close to another hog operation as a means of preventing the spread of disease. Generally, 1.5-2 miles is considered sufficient provided appropriate bio-security measures are taken (Levis et al, 2011).

Key concepts: Location matters! When you are deciding on a site for your outdoor hog operation, the following are some essential things to consider:

1) access to markets and feed resources, 2) size of the operation, 3) soil quality, 4) proximity to neighbors and how they'll feel about hogs, 5) any environmentally sensitive areas nearby and 6) whether there are biosecurity risks associated with neighboring swine operations.

Climate is another critical factor to consider in choosing a location for your swine operation. Temperature and precipitation stand to impact both animal health as well as the environment within and immediately adjacent to the production site.

Temperature: Hogs can adapt to varied temperatures, but generally tolerate cold weather better than hot. In Northern California where summer temperatures routinely reach triple digits, hogs should be managed early in the morning or in the evening to reduce heat stress and should have access to drinking water at all times. Water demand will increase at hot times of year and care should be taken to ensure that drinking water does not get too hot, or that pipes don't freeze in winter.

Rainfall: Whether you are a pasture or drylot-based operation, it's critical to understand how much precipitation to expect at a given site. Sufficient rainfall is particularly important for rangeland-managed hogs, to ensure sufficient forage and ground cover. In light of California's Mediterranean climate and low precipitation averages, low stocking rates will generally be required to limit the impact of hogs on the soil and vegetation. In areas prone to large rain events, consider the erosion potential of a drylot or a pasture with degraded cover and how it might impact adjacent waterways, sensitive habitat or neighbors.

Shade and Shelter: Ensuring sufficient shade is essential for keeping hogs cool and minimizing sunburn, to which hogs may be prone if they are not allowed to wallow. In selecting your production site, make note of what areas have natural shade and at what times of day. If natural shade is not available, shade structures may need to be provided. Hogs will also need free access to clean, dry shelter in the case of wind, rain, heat and cold.

Wind: While air movement can help keep hogs cool during hot summer months, locations with persistent or frequent strong winds should be avoided. Wind not only dries out pasture more rapidly, but contributes to erosion and transports odors.

Feeders/Drinkers: Protect high use areas, such as around drinkers, feeders, sprinklers and shelters to minimize impacts to soil and the creation of wallows. Consider installing feeders or drinkers on a cement slab or perforated sheets made of wood, plastic or rubber. Do not locate feeders or drinkers in the vicinity of watercourses.

Wallows: While wallows enable hogs to cool off and minimize sunburn, they typically lead to significant erosion and or compaction damage that may take years to recover. Providing shade or access to sprinkler systems are better alternatives that will minimize ecological damage as well as supporting animal welfare. Hogs will create wallows from any water or food source they can, such as nipples or slop buckets so be conscious in designing your site of this potential. Some producers use nose rings to minimize a hog's interest in rooting which contributes to the creation of wallows, though this practice is somewhat controversial as rooting and wallowing are both considered instinctive behaviors.

Predators: Understanding what wildlife may be present in and around a potential production site is another important consideration. In particular, the potential for predators should be assessed. Predators are primarily a concern for newborn or young pigs and can include foxes, coyotes, feral dogs, and in some cases eagles or crows. While predators are rarely an issue for larger hogs, an attack may cause them to break out of paddocks. Inquire with neighbors or other livestock producers in the area as to the presence of predators. Appropriate housing, exclusion fencing and guard animals will also minimize predation.

Feral hogs: Feral hogs are a growing issue in California and are now present in 56 of 58 counties. The major danger is the introduction of diseases, and the potential for feral hogs to mate with outdoor kept sows. Make note of whether feral hogs are present in your area and take appropriate exclusionary measures if they are present. See factsheet in this series on Managing Wild Pigs for more information.

Key Concepts: Understand the climate and local ecology

Temperature, wind and rainfall will affect not only the health of your hogs, but will also your ability to manage their impact on natural resources. Climate and geography will also help you understand predator risks or the need to safeguard against feral hogs.

Before bringing animals onto the production location, it is important to create a site plan that takes into account the number of animals you plan to raise and their management needs as well as natural resource considerations both on and adjacent to the site.

It is generally recommended to manage groups of animals according to their age, sex and physiological status. In particular, you will want to consider where each of the following types of animals will be housed and how this will integrate into a larger management plan:

- Boars
- Gestating and dry sows, gilts
- Lactating sows and litters
- Weaners to growers
- Growers to finishers

Farrowing area for sows. Photo courtesy of Hidden Villa

If you will need a quarantine paddock, herd handling or sorting facility, consider where this infrastructure will be located and how roads and paths will work to promote easy and stress-free movement of animals. As a means of minimizing damage to soil and vegetation, fences should be laid on the contour when possible.

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Photo credits from top to bottom; Pg 1: banner photo courtesy of Holm Ranch and Pasture 42; farmers market meat courtesy of Cliff1066; soil courtesy of NRCS; Pg 2: Pig sign courtesy of Skott Reader; stream photo courtesy of Alameda RCD; Pg 3: rain gauge courtesy of woodleywonderworks; hog shelter courtesy of Magruder Ranch; waterer on cement courtesy of Silvana Pietrosemoli; hog in wallow courtesy of Silvana Pietrosemoli.

Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area

Rangeland and Pasture Management

By Morgan Doran, Stephanie Larson, Sheila Barry and Silvana Pietrosemoli

Pasture and Rangeland in California

Forage from rangelands and pastures is the primary, and sometimes only, feed source for beef cattle, sheep and goats, and can be a significant feed source for outdoor-raised hogs. Rangelands are comprised of non-irrigated and non-cultivated grasslands, woodlands and shrublands and provide many important ecosystem services for society, such as: forage for livestock, wildlife habitat, water storage and release, water filtration, recreation and beautiful views to name a few. Pastures are irrigated forage crop systems typically harvested by grazing animals and are located on higher quality soils where irrigation water is available. Pastures are normally seeded with warm or cool-season perennial grasses and clovers and are much less diverse, but more productive than rangelands. While both rangelands and pastures are forage production systems, management of one system is quite different from the other.

Rangelands in the Bay Area and surrounding counties are generally low in productivity, yielding 2,000 to 4,000 pounds forage/acre/year, but have a very diverse mix of annual and perennial plant species. The vegetative growth cycle begins with fall rains and continues through the winter and spring months as long as there is adequate precipitation. By late-spring, herbaceous plants generally release their seed and die or enter dormancy during the summer months. Grazing is typically seasonal to coincide with the forage growth cycle and

Pigs on perennial pasture. Photo courtesy of Magruder Ranch.

rangelands are generally extensively grazed (low stock density and long grazing duration). High-density, short-duration grazing can occur on rangelands, but is only effective when forage is growing rapidly, typically from February through April.

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Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

Pastures are more similar to cropland than rangeland and can produce between 6,000 and 9,000 pounds forage/acre/year. Grazing on irrigated pastures generally occurs from April or May through October or November, but longer grazing periods and an occasional hay harvest are not unusual. The long growing season and high productivity of irrigated pastures makes them well suited for high-density, short-duration grazing, which is much more intensive than grazing on rangelands. Establishing irrigated pasture requires a high initial investment, but once established it will be productive for many years.

Both rangelands and pastures are important forage resources for livestock producers, but their value and productivity can be greatly compromised from poor management. The propensity for hogs to root and create wallows in wet areas obligates the outdoor hog producer to carefully monitor and manage hog grazing to minimize undesirable impacts.

Managing Hogs on Pasture and Range

Maintaining sufficient vegetative ground cover on rangelands or pastures is beneficial for hogs and for the environment in an outdoor hog production system. In the San Francisco Bay Area and surrounding counties, the climate makes it especially challenging to maintain ground cover year around. The area's wet winters and spring months with good forage conditions are typically followed by hot and dry summer months with no forage growth. Extra planning is required to minimize unfavorable livestock impacts, such as the deterioration of ground cover, excessive soil disturbance, and nutrient loading that may lead to soil and water pollution and weed infestations.

Even with good planning, maintaining cover in high use areas is difficult. In outdoor hog production systems, bare soil is common where hogs congregate, for instance around feed and water sources, farrowing pens or pastures, traffic corridors and lounging areas.

Environmental risks of high-use areas include:

- Increased soil compaction which reduces water infiltration and soil productivity
- Increased overland water flow during rain events that transport soil and fecal material offsite
- Soil losses due to erosion
- Downstream water quality impairments from soil and fecal material, and
- Weed infestations.

Pigs consuming corn. Photo courtesy of Pasture 42.

Understanding the Role of Forage in Outdoor Hog Operations

A range or pasture-based hog operation must take into account the nutritional needs of the hog while maintaining the health of the pasture or range ecosystem.

Nutritional Needs

Hogs have a monogastric digestive system, much like a human's, which is very good at digesting sugars, starch and proteins, but cannot digest fiber, except for very minimal hindgut fermentation. In contrast, cattle and sheep have a stomach compartment called the rumen, where billions of microbes ferment (digest) fiber into chemical compounds that can be utilized as nutrients. In any species of animal, the type of digestive system determines the type of diet. For cattle and sheep, the diet is primarily high-fiber forages, but for hogs the appropriate diet consist of feeds with high levels of easily digestible nutrients containing low fiber content. A pasture pork operation must grow forages that can be

utilized by hogs. Appropriate forages for hogs include legumes, such as alfalfa and clovers, root vegetables (tops and roots), young and tender grasses and grain-bearing crops. In an integrated livestock and cropping system, corn can be grown for this purpose and harvested by swine after the grain is fully developed.

Sows will have their highest nutrient demand at the onset of farrowing and during lactation. This demand is best satisfied with a grain-based ration supplemented with high quality forages. The amount of grain-based feed consumed will vary with nutrient demand, quality of forage and amount of feed offered. Keep in mind that gestating sows should not be overfed and allowed to become too fat.

Nutritional requirements of outdoor hogs are generally 15% higher than those of confined hogs to compensate for the additional energy needed to search for food and to maintain body temperature. Hogs might also graze on other forages, such as acorns, which can provide additional energy in their diet.

Food by-products and grocery wastes, such as outdated bread or tortillas, milk whey and bakery waste are commonly used by Bay Area hog producers and can help reduce the need of grain-based feeds. While by-products and food wastes are good grain alternatives, they should not supply a large fraction of the total diet since their nutrient value, and quality may vary considerably. Beware of food scraps from restaurants that can consist of all types of meats, vegetables, fats and carbohydrates.

Grazing System Design

A successful grazing system in California's Mediterranean climate requires adaptation to the unique resources of the farm including soil, terrain, forage mix and animal type. Management will need to be flexible, practical and simple to carry out, while allowing the producer to reach his or her production and conservation goals. To begin, establish your goals and conduct a resource inventory including forage resources (rangeland and pasture), trees, barns, groups of animals, soil, topography and water sources. A ranch map can be very useful in planning resource utilization and management. Your grazing system will need to match resource availability with animal needs, while adjusting stocking rates for forage, soil and climate conditions.

Brewers grain mixed with whey. Photo courtesy of Devil's Gulch Ranch.

Grazing hogs

Grazing guidelines for hogs in the greater Bay Area region are not well established and will vary greatly between rangeland and pasture forage production systems. In either case forage height and ground cover should be monitored regularly so that hogs can be rotated through paddocks before damage to vegetation and soil occurs. Determining an appropriate stocking density (hogs/acre) and stocking rate (hogs/acre/year) is difficult due to variable precipitation and forage growth within the year and year-to-year. Stocking densities provided in Table 1 can serve as approximate starting points in stocking rangeland and pasture systems with hogs, but

Forage System	Type of Hog	Hogs/Acre
Irrigated Pasture	Growers/Finishers	15-30 head/acre
	Sows + Litters	4-6 head/acre
Rangeland	Growers/Finishers	4-10 head/acre
	Sows + Litters	0.5-1 head/acre

Table 1: Stocking densities for outdoor hog systems

adjustments will be needed as forage supply changes and local experience is gained.

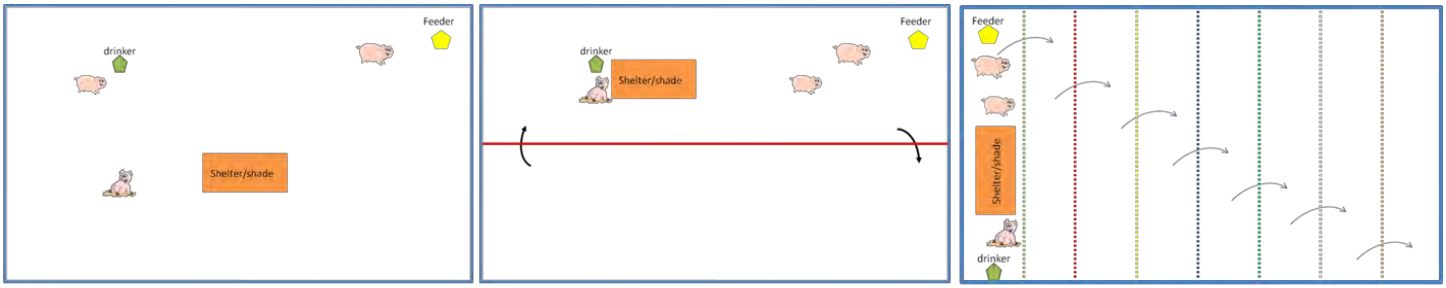
In irrigated pastures, water should only be applied after hogs are removed, and future grazing should be postponed until forages have recovered to 4-8" and the ground is no longer wet. On both rangeland and pastures, grazing when the soil is saturated should be avoided to prevent adverse impacts on forage and soil and the formation of wallows. In rangelands, grazing should be planned to minimize bare ground and maintain adequate Residual Dry Matter (RDM) to protect soil from erosion and positively influence forage growth and composition during the following growing season. RDM is a very useful management tool and there are helpful guides to understand RDM and implement an RDM monitoring program such as (Bartolome et al., 2006; Guenther, K., 2008), as well as a companion video that can be viewed online.

Understanding animal behavior will also help minimize grazing impacts. Hogs are social animals and tend to concentrate their activities in small areas with high impact. In general, groups of 15-20 are easier to manage than bigger groups and mixing pigs from different groups may lead to fights as the animals establish new hierarchies. For these reasons and in light of their foraging behavior, a rotational and/or strip grazing system may allow for better utilization of forage while providing rest between grazing periods. This may include the use of narrow lanes or alleys to move animals among paddocks or sections of the farm.

Fencing

The use of temporary, electrical fences in different configurations can help determine appropriate fencing and rotational patterns before permanent or semi-permanent fences are constructed. In some cases, establishing permanent perimeter fences may prove most convenient, with temporary or semi-permanent cross-fencing to facilitate rotation between paddocks. Fences must follow the lay of the land and landscape features, taking into consideration the need for buffer strips when in the vicinity of water courses or other sensitive areas. See factsheet on Riparian and Wetland Management.

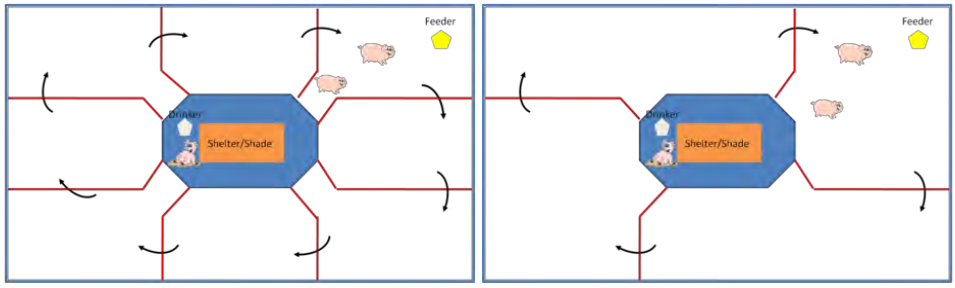
Figure 1 demonstrates several different grazing systems for outdoor hog production.



Continuous system
Periodic movement of feeder and drinkers

Alternate grazing

Strip grazing



Rotational Grazing

Figure 1: Grazing systems for outdoor hog production (blue line depicts permanent fence). The rotational grazing design encompasses two phases for a 12 week forage growing and grazing period: Phase 1 includes 8 paddocks for weeks 1-8 and Phase 2 combines paddocks to create 4 larger enclosures for weeks 9-12. Design will vary according to the length of the forage growing season. Images courtesy of Silvana Pietrosemoli, North Carolina State University Center for Environmental Farming Systems.

Managing High Impact Areas

Any type of livestock system will have congregation points where impacts will be very high relative to more extensively grazed areas. These heavy use areas are sometimes determined by humans when choosing where to locate water or feed troughs, as well as corrals, barns or other structures that cause animals to persist at high densities. Animals often favor locations with naturally occurring shade (trees), water (creeks or ponds) or feed (acorns or fruit). Congregation points are a necessary part of animal husbandry, but care should be taken to locate and manage them to minimize their corollary environmental impacts such as bare soil, compaction, and above-normal nutrient loads from manure and urine. One practice used by some producers to reduce impacts around feeding and watering sites is to locate the trough on a movable platform that is slotted or perforated. This allows water to drain to the ground, but prevents hogs from disturbing the soil.

Portable shelters help minimize impact to pasture or range. Photo courtesy of Magruder Ranch.

Minimizing Impacts of Bare Soil

Adequate vegetative ground cover is critical during the winter months to protect soil from intense rainfall events. Grasses increase water infiltration, which reduces overland water flow and erosion. Deep-rooted forbs, such as chicory, will also increase infiltration and add more variety to the suite of forages and nutrients for hogs. A useful guide by Lennox et al. (2007) provides advantages of seeding high impact areas on coastal dairies which can be applied to Bay Area hog operations. Even moderately impacted sites can be treated by simply broadcasting

Slatted matt for drinkers. Photo courtesy of Silvana Pietrosemoli.

a seed mix over areas with disturbed soil in the late-summer or early-fall months. Establishing desirable plants in high impact areas will reduce the occurrence of undesirable plants and mitigate negative environmental impacts.

Contaminated groundwater is another potential risk from high impact areas as nutrients, especially nitrogen, leach through the soil carried by water from precipitation and irrigation. Vegetation buffers this nutrient leaching by utilizing the nutrients for plant growth before they are transported below the root zone. Vegetation also slows overland water flow which increases the time nutrients are available for plant uptake as well as improving animal welfare by altering the temperature and humidity near the soil surface and reducing joint problems by acting as a cushion. Most importantly, improved animal welfare derived from a healthy rangeland or pasture environment can result in better sow reproductive performance (see factsheet on Farrowing and Weaning) and higher financial returns.

Weed Management

Common Bay Area Weeds

Weeds are a common problem in almost any agricultural system and can vary from being a mild nuisance to extremely noxious or poisonous. Compared to rangelands, irrigated pastures and drylots are more intensively managed or disturbed, have higher levels of nutrients, and may have more bare soil due to excessive water or animal use. Once established, weeds are difficult to control, let alone eradicate, because seeds can often persist in the soil for several years.

Common Bay Area weeds in rangelands include grass species such as: medusahead, goatgrass, Mediterranean barley; and red brome and broad-leaf species such as: thistles, perennial pepper-weed, fiddleneck (toxic) and black mustard. Rangelands can often become heavily infested with noxious weeds due to a competitive advantage under specific conditions that result from management and the environment. Common weeds in irrigated pasture and drylot areas (bare dirt) include common cocklebur, turkey mullein, smutgrass, foxtail barley and English plantain, of which the latter three are indicative of too much or pooling water in pastures.

Managing Weeds

Options for controlling and managing weeds include: herbicides, hand pulling, mowing, disking, prescribed fire and prescribed grazing. The size of the weed population, dispersal and type of weeds, as well as constraints (i.e. terrain, organic certification) will help determine the correct method or combination of methods used to control weeds. Very small infestations can often be controlled by hand pulling or spot spraying individual plants before the population is too large. Mowing may work on annual weeds if the plants are cut below the growing points. Yellow starthistle and Mediterranean barley are notoriously difficult to control with mowing since the growing points are often at ground level. Perennial weeds cannot be controlled with mowing since the plant will continue growing from the root. Prescribed fire can be very effective on some grass and thistle species, but burning requires extensive planning, often with local fire districts, and is extremely limited by air quality regulatory controls. Herbicides can be very effective if properly selected and applied and are helpful in gaining initial control of very large weed populations. There are many types of herbicides available for use on rangelands and pastures and consultation should be sought from a pest control advisor (PCA) or from UC Cooperative Extension before choosing and applying an herbicide. It is important to follow all labeled directions and uses of each herbicide, including any grazing restrictions that are required after application.

No single method will effectively control all weed infestations, which is a good reason to use an integrated approach that employs multiple methods. A good weed control program begins with preventing weed infestations by maintaining healthy growth of desired plants that will competitively exclude weeds. Persistent monitoring for unusual plants that could be weeds will help with early detection of small weed populations which are much easier to control. Once weeds become established, a combination of weed control methods applied over several years is the most effective approach.

Nutrient Management Planning

Hog operations typically depend on a significant importation of feeds from off the farm. Any importation of feed also imports nutrients, some of which are retained in growing animals while the remainder is lost as un-utilized feed or excreted as manure and urine. Growing hogs will utilize about one-third of consumed feed for tissue development and energy while two-thirds will be excreted. Stender (2012) provides a good summary of feed efficiency for growing hogs.

Soil sampling can assist with nutrient management. Photo courtesy of Chris Bordeaux.

Imported nutrients, in the form of feed and hog wastes, can be managed by distributing them across a rangeland or cropping system, either on- or off-farm that will utilize the nutrients for forage or crop production. A nutrient budget should be developed to ensure nutrient applications are balanced with nutrient off-take by harvested forage or crops.

A grazing system that favorably influences and utilizes nutrient distribution will ensure that grassland and cover crops have sufficient nutrient bases to promote crop health. Uniform distribution of nutrients will also help prevent accumulated "point" source pollution sources in either the soil or in surface runoff which could negatively impact ground and surface water quality.

Because of the significant potential for off-site transport of nutrients from outdoor hog operations, a modified nutrient management plan should be prepared. Contact your local Natural Resources Conservation Services (NRCS), Resource Conservation District (RCD) or private consultants to assist in preparing a nutrient management plan for your outdoor hog operation (see Conservation Practices for Outdoor Hog Systems factsheet).

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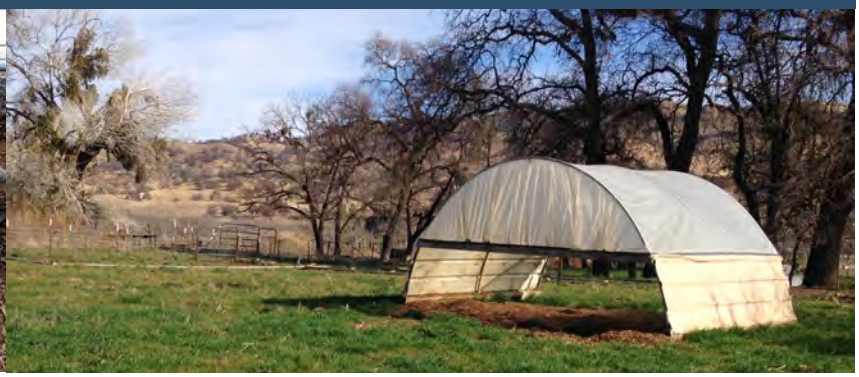
Banner photo credit: Pigs in pasture. Photo courtesy of Magruder Ranch.

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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Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

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.

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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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Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

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)

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

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.

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Banner photo credit from L to R: Stream with pigs, courtesy of Silvana Pietrosemoli & Stream, courtesy of NRCS.

Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area

Hog Manure Management

by Sheila Barry, Cole Smith and Susan Ellsworth

Hog manure and bedding from outdoor production systems can typically be treated as a solid and may be managed in several ways depending on the structure of the operation. In the Bay Area, outdoor production systems, even when pasture or rangeland -based, typically include a drylot. Periodic removal of hog manure is essential in a drylot to protect water resources, reduce pathogens and avoid nutrient accumulation. Composting can recycle hog manure and bedding in an environmentally friendly and sustainable manner.

Rotational Pasture, Range and Cropland–based Systems

In systems where hogs are moved through pasture, range or cropland, manure is typically distributed and in many cases is viewed as a beneficial nutrient to promote forage or crop growth. However, because hogs are monogastrics and rely on grain or other nutrient dense feeds typically imported from off the farm, their manure contributes additional nutrients to the farm system which can result in nutrient loading. This is different from ruminants that can rely purely on forage, therefore recycling existing nutrients from on-site forage in their manure without adding any to the system.

The degree to which outdoor hog manure is sufficiently distributed to minimize nutrient loading depends on the stocking rate and how frequently the animals are moved. See factsheet on Rangeland and Pasture Management for more information. In many cases, hogs will select a particular area to dung in, resulting in a higher concentration of nutrients in that area. For this reason, it is recommended that outdoor hog farmers monitor nutrients through periodic soil testing.

Animal waste storage system. Photo courtesy of the Alameda County RCD.

Drylot Systems

In drylot systems, by comparison, manure is less likely to be distributed, as the area within which the animals are housed is smaller and stocking rates are higher. As such, the collection and removal of

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manure is more manageable and in many cases, imperative to the well-being of the animals. This factsheet focuses on composting hog manure and bedding from confined or drylot hog systems as a means of reducing the volume of waste, minimizing flies, pathogens and odors and potentially producing a high quality soil amendment.

Composting Hog Waste

Collection of material

Collecting manure is the initial step to develop a successful composting system. Since hogs often dung in one place, collecting material may be simplified by encouraging hogs to dung in the best location for collection and in area that does not receive runoff. The manure may be scraped from the ground in a drylot system or removed with bedding from a concrete or hoop house arrangement. During the rainy season it may be necessary to scrape drylots twice weekly. Rain runoff from drylots may become contaminated and should never flow directly into a waterway. Although scraping removes most of the solids, any runoff from a drylot should pass through a vegetative buffer before reaching a waterway to minimize the possibility of contaminating water with nutrients or pathogens.

It is important to know the moisture content and the initial bulk density of the waste to determine whether a bulking agent is necessary. If the material is excessively moist (>60%) such as a slurry or liquid material without a litter component, a bulking agent may be necessary.

Bulking agents are carbon-based material that add volume to the manure, soak up any excess liquid and balance the C/N ratio necessary to produce high quality compost. Examples of effective bulking agents include: straw, sawdust, peat moss or wood chips. The manure must be mixed evenly throughout the bulking agent to ensure consistency of the final product.

Storage

The location and site where the manure is stored is critical for the stability of the material as well as the reduction of potential environmental contaminants. Once collected, manure must remain covered. Allowing the material to come into contact with rain will increase the amount of nutrient and possibly pathogenic contaminants running off the pile or leaching into surface or groundwater. In addition to posing environmental concerns, the loss of nutrients from a compost pile also results in a decrease of nitrogen retention within the final compost product.

Initially, raw un-composted manure should be kept under a covered area or tarp if possible. The ground on which the manure is stored should be impermeable, such as hard packed earth or cement, with the intention of prohibiting leachate from penetrating the soil profile as well as controlling runoff. A minor grade in the storage surface is favorable in order to collect runoff in a specific location, such as a collection lagoon or biological filtration pool. It is imperative that manure or leachate is not stored near water sources or allowed to flow freely into waterways.

Turned Windrow method. Photo courtesy of NRCS

Compost method

Active v. Passive Aerated Windrows

Aerated composting, either active or passive, is a method designed to provide the composting material with even air pressure throughout the pile, with the volume of airflow often determining the amount of time necessary to complete the process. The more oxygen the material receives during composting the faster the material will break down to become a finished product. Active aeration methods include using powered fans to force air through a series of perforated pipes, evenly distributing oxygen throughout the material. Passive aeration, often a more affordable method than active aeration, consists of placing perforated Schedule 80 PVC pipe evenly throughout the pile. In both active and

passively aerated piles the material should be turned once a month, moving the outer material towards the center of the pile. The pipes may need to be removed prior to turning in an active aerated pile.

Turned Windrow method

Windrow composting is a method in which the manure/bulking agent mixture is piled in long rows, with a minimum size of at least 3ft x 3ft x 3ft and actively turned by hand, tractor bucket or windrow turner for larger piles. To achieve even decomposition throughout the pile the material mixture should be as homogenous as possible, with a moisture content between 65 – 55%. The frequency of turning will determine the speed of decomposition; the more frequently a material is turned the faster the material will compost. Turn approximately every two weeks, based on moisture and temperature to produce compost in a timely manner. Material is considered mature in approximately 49 days using this method.

Finished compost ready for application: photo courtesy of NRCS

Requirements for Safety

Any animal, including hog manure, contains pathogens that can be harmful to human health; precautions must be taken to ensure that the material is safely composted. To kill harmful pathogens it is imperative that the material reaches 55°C (130°F) for at least 3 days. A 3' foot compost thermometer is useful to monitor temperature. In the Bay Area, due to dry climatic conditions, maintaining moisture within the material is imperative to achieving proper sterilizing temperatures. The location of the pile should be out of direct sun to prevent excess moisture loss. These temperatures can be achieved via the methods mentioned above if followed properly. A critical factor in pathogen elimination is that all of the material being composted is exposed to the required high temperatures. This can be achieved by adequately turning the material, making sure to mix the outer material thoroughly into the center.

Use of Product

Once maturity is reached (~7 weeks) the product can be safely used. Visual indicators such as steam no longer rising from the pile can also determine maturity. Properly finished, mature compost can be applied to pastures and fields to increase fertility and soil organic matter. Application rates for compost vary based on the intended outcome, but generally 1-2 inches is sufficient. If compost is being incorporated into the soil profile it should be incorporated at a depth of approximately 5 inches. Due to the risk of pathogen contamination from unfinished processing, compost should not be applied to ground-harvested crops (ie. strawberries, root-crops, squash).

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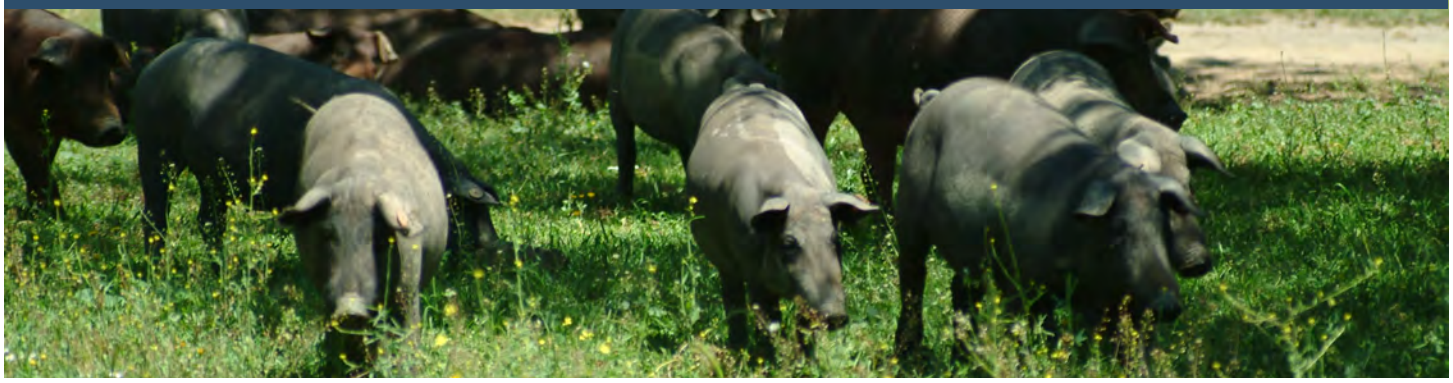
Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area



Pastured Pig Production in California Oak Woodlands: Lessons from the Spanish *Dehesa*

By Luke T. Macaulay

Spaniards have been raising pigs on pasture for hundreds of years, and because Spain and California share a Mediterranean climate as well as extensive oak woodlands, Spain's production system is a natural starting point to inform such efforts in California. Pastured pig production in Spain often occurs on oak woodlands referred to as the *dehesa*, which is found in the Southwestern parts of the Iberian Peninsula (Fig. 1). The *dehesa* is managed for a grass or crop understory as part of a multifunctional agricultural unit that often includes grazing by Iberian pigs. Other enterprises might include cattle, cork, charcoal, firewood, grain crops, hunting, mushroom harvesting, and beekeeping.

Although the practices occurring on these lands are ancient, in the last several decades, Spaniards have successfully marketed pig products from the *dehesa* as high-priced gourmet food items. Due to the long evolution of the management and economics of the oak woodlands in Spain, Californians interested in raising pigs on a mixture of pasture and acorns can learn much from the Spanish experience.

Spanish *dehesa*. Photo courtesy of Luke Macaulay

Ecology of Spain and California

Although several species of oaks occur in the *dehesa*, the two primary species are evergreen oaks: the holm oak (*Quercus ilex*) and the cork oak (*Quercus suber).* In California the five most common oak woodland species are the coast live oak (*Quercus agrifolia*), the interior live oak (*Quercus wislizeni*), the blue oak (*Quercus douglasii*), the black oak (*Quercus kelloggii*), and the valley oak (*Quercus lobata*). Tanoaks (*Notholithocarpus*

Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

Pig foraging in the Spanish *dehesa*. Photo courtesy of Luke Macaulay

densiflorus), a relative of the oak, are commonly found in the northern Coastal Range of California and produce nuts that are similar to acorns which can be utilized by pigs.

Acorn production in both locations is highly variable, and driven by climate and predation by insects (i.e. weevil and moth larvae) and animals (i.e. squirrels, birds, deer) (Koenig et al. 1994, 2013). In California, different oak species react differently to weather conditions (Garrison et al. 2008; Koenig et al. 2013) and have different timings for acorn production. As such, producers may seek to fatten pigs on a property with multiple species of oaks, which reduces the chances of acorn crop failure from 23.5% with one species, to 11.8% with two species, and 8% with 3 species (Koenig & Haydock 1999).

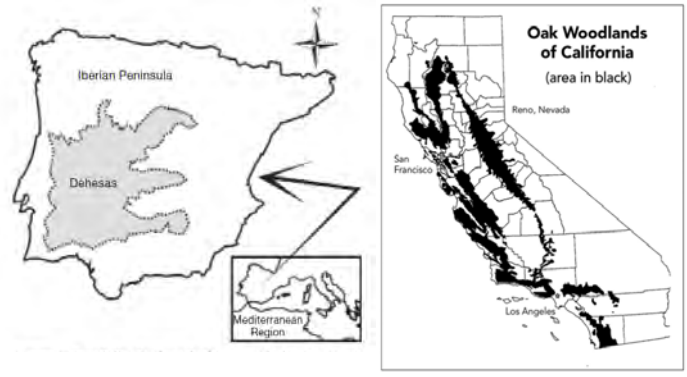


Figure 1: Distribution of oak woodlands in Iberian Peninsula and California. (Allen-Diaz et al. 2007; Gea-Izquierdo et al. 2006)

Ecological Concerns

Pigs can cause ground disturbance through rooting behaviors that can lead to increased potential for erosion and noxious weed invasion. In order to minimize impacts on the land from rooting, many producers place nose rings in the pig snout to prevent deep rooting behaviors. Other ecological concerns include the risk of pigs escaping from enclosures and forming feral pig populations, which have been known to cause environmental consequences in California—see factsheet on proper Feral Pig Management (Macaulay et al. 2013). This can be minimized by providing a daily ration of supplemental feed, which also allows managers to monitor pigs on a daily basis for illness. Heavy use of acorns by pigs would likely lead to reduction in acorns available for wildlife, especially ground-foraging species that eat acorns like deer, mice, and woodrats, which utilize acorns (acorn woodpeckers and scrub-jays take acorns almost exclusively off the tree branch). Additionally, consistent and intensive pig consumption of acorns is likely to impact the regeneration of oak species. Due to these concerns, producers should be cognizant of wildlife use of acorns, noting wood rat dens and areas utilized by deer or other wildlife species. To reduce these ecological impacts producers should consider reserving certain areas of oak woodlands exclusively for wildlife populations, removing pigs from the pasture before all the acorns have been consumed, and using a rest rotation system to reduce the impacts to oak regeneration.

Pig Production

Finishing Styles

The Spanish pork market is famed for a variety of cured hams made from the rear legs of the pig known as *jamón*. The finest and most expensive variety is the *jamón ibérico de bellota*, (literally "Iberian ham of acorn"), which comes from the black Iberian pig breed, and is finished exclusively on a free-range diet primarily composed of acorns and grass. The black Iberian pig breed is not widely available in the U.S., although a couple of individuals have imported purebred stock in recent years (one can be contacted through

acornseekers.com). Many producers in the U.S. choose to use Duroc or Berkshire breeds for acorn fed pork. Crossing with Durocs is common in Spain today, although specific limitations are required for the product to qualify for the *jamón ibérico* designation.

Table 1: Summary estimates for pig production in the Spanish *dehesa*	
Length of time in *montanera* fattening	42-100 days
Average acorn yield/tree	18-31 lbs
Range of acorn yield/tree	1-324 lbs
Acorns consumed per lb of pig gain	22-33 lbs
Pig weight gain per day	1-2 lbs
Weight gain during *montanera*	88-110 lbs
Stocking rate	.16 - .4 pigs/acre
Total weight of acorns consumed per pig during *montanera*	882-1654 lbs
Total weight of grass consumed per pig during *montanera*	185-463 lbs

Production Timing and Weight Gains

There are three traditional phases of Iberian pig production: lactation, growth, and finishing. The finishing stage, known as the *montanera*, is where pigs feed on acorns and pasture. Lactation and weaning can occur between 1-2 months of age, after which animals are castrated and fattened on available feed including pastures, sown fields, stubble, farm byproducts, or grain-based feeds (Lopez-Bote 1998; Benito et al. 2006). The timing for the finishing stage is based upon the maturation of oak acorns, which begins in October and continues to February. In California, acorn fall follows a similar pattern, beginning in October, with most acorns having fallen by December, with the notable exception of coast live oaks, which frequently retain acorns until February and in some cases into March and April (Koenig et al. 2014). Pigs are put onto the oak pasture when they are 12-18 months old and weigh 200-265 pounds. They are fattened on acorns and grass for 42-100 days (Lopez -Bote 1998; Benito et al. 2006). They gain between 1 -2 pounds per day, reaching a finishing weight of 330-350 pounds (Benito et al. 2006). See table 1 for a summary of production estimates.

Vegetation Consumption

Iberian pigs consume approximately 98-99% of their diet in grass and acorns during the *montanera*, with the remainder composed of roots, bushes, berries, soil, and even inorganic rubbish (Rodríguez-Estévez et al. 2009). Pigs spend similar amounts of time grazing on grass and acorns, consuming 15 to 22 lbs. of acorns daily (~4.5 lbs. of that value is the shell which is discarded by the pigs) and 4.4 to 6.6 lbs. of grass daily (Rodríguez-Estévez et al. 2009).

The early phases of grass growth in autumn and winter are important as they include important digestible nutrients, including protein content of 14-17%, which is much higher than the 4-6% found in acorns. Acorns in contrast, provide a much higher energy content (Table 2). Grasses are thought to contribute important fatty acids and *alpha-Tocopherol*, a form of vitamin E, which are believed to contribute to development of flavor characteristics and assist in the curing process (Lopez-Bote 1998). As grasses mature in spring and summer, the concentration of cell walls and compounds such as lignin increase making grass much less digestible for pigs.

Table 2: Chemical composition, metabolic energy, and alpha-Tocopherol of acorn and grass (Garcia-Valverde et al 2007, Lopez Bote 1998, Olea et al., 1990, Rodriguez-Estevez et al., 2009, Ruiz, 1993, Rey et al., 1997).

	Acorns	**Grass**
Dry matter	56-67%	21-27%
Crude protein	4-6%	14-17%
Fat	6-11%	4-6%
Crude fiber	3-6%	20-23%
Ash	2%	7-10%
Metabolic energy (MJ/kg DM)	17.6	10.27
alpha-Tocopherol (mg/kg DM)	20	171

Setting Stocking Rate

Pigs usually consume 10-15 lbs. of acorns for each pound gained in live weight (Benito et al. 2006). In Spain, acorn production on average ranges from 18-31 lbs. per tree (Rodríguez-Estévez et al. 2007, 2009); although, the range of acorn production can be as low as 1.1 lb of acorns/tree and up to 324.1 lb of acorns/tree (Koenig et al. 2013). Considering that Iberian pigs eat approximately 15 to 22 lbs. of acorns per day, the Iberian pig should eat approximately the

acorn production of 0.5 – 1.25 trees/day during *montanera* fattening period. Densities of trees on the Spanish *dehesa* range from 4 to 20 trees/acre, which is a similar range of density of oak woodlands in California, and can support a stocking rate between 0.16 to 0.4 pigs/acre (Benito et al. 2006; Olea & San Miguel-Ayanz 2006).

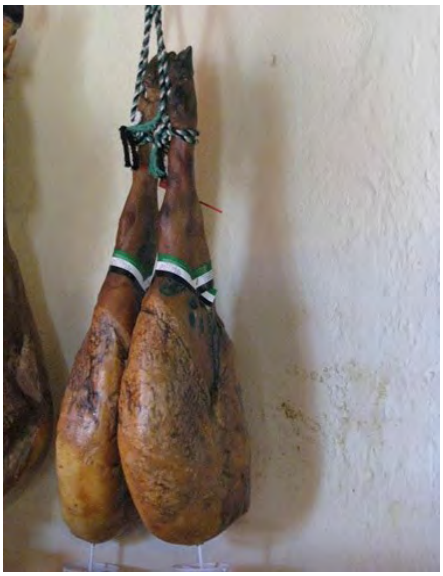
Processing and Marketing

A variety of dry cured meat products are obtained from Iberian pigs: chorizo, loin, shoulders, hams, etc. The most valuable meat product obtained from the Iberian pig is the dry cured ham, which has also the longest processing time (18-36 months) (Lopez-Bote 1998). The Spanish have successfully enhanced the value of acorn-finished pig products by providing protected designation of origin (PDO) status under European Union law for Iberian ham, somewhat similar to the American Viticultural Area (AVA) designation of wine grape appellations in the U.S. Because of the considerable time, effort and land area that is devoted to producing this product, these cured hams are sold at very high prices. In 2013, *jamón ibérico de bellota* sold for about $85/lb for the whole unsliced ham (McLaughlin 2013).

Conclusion

California producers can learn from the Spanish experience in producing high quality pork products fattened on acorns. However, the introduction of pigs into the oak woodland can cause impacts to the ecosystem, and producers should evaluate their pastures for wildlife utilization and adopt appropriate and flexible stocking rates that adapt to seasonal changes in forage productivity of both acorns and grass. Producers should also utilize grazing systems such as rest rotation to allow for oak regeneration and consumption of acorns by wildlife. If particular areas are heavily utilized by wildlife species, producers should consider reserving these areas exclusively for wildlife use. The *jamón* produced from California acorns will develop a flavor unique to the area in which it is raised, providing the opportunity for local food purveyors to market the product in a similar way to wines. When produced in consideration of the needs of the ecosystem, producers can develop a sustainable local meat product with distinctiveness based on the centuries-old methods developed in Spain.

Hogs foraging in a California oak woodland. Photo courtesy of Magruder Ranch.



Jamón ibérico de bellota. Photo courtesy of Luke Macaulay

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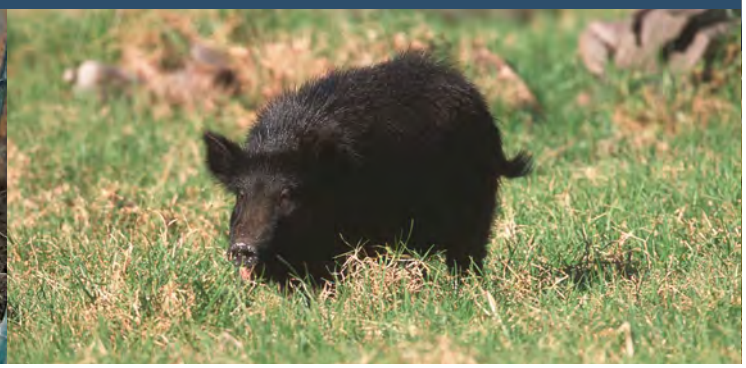
Banner photo courtesy of Dr. Jean-Marie Luginbuhl.

Outdoor Hog Production

Best Practices for Resource Conservation in the San Francisco Bay Area



Managing Wild Pigs

By Julie Finzel and Silvana Pietrosemoli

Origin and Appearance: Domestic pigs were introduced to California in 1769 by Spanish missionaries and in the 1920's, Russian wild boar were introduced in Monterey County for sport hunting. The wild pigs found in California today are descendants of the domestic Spanish pigs and the Russian wild boar; as a result, their appearance can vary dramatically. See Table 1 for general physical characteristics of domestic pigs versus wild pigs.

General Characteristics: Wild pigs typically live to be four to eight years old. Full-grown males weigh, on average, 200 pounds, while full grown females weigh about 175 pounds. Wild pigs can grow larger than this, but it is not common. Females are sexually mature at six to nine months of age, though most females do not have their first litter until they are over a year old. The average litter size is five or six young, but litter size and success rates can vary and are highly correlated with annual precipitation.

Biology: Wild pigs live in matrilineal groups called sounders, where up to 80% of females remain with the sounder in which they were reared. Males are nomadic and known to move about within a home range. Wild pigs like to rest and nest in areas with low growing, dense vegetation. Pigs do not have sweat glands, so they wallow in seeps and springs to cool themselves in hot weather. Additionally wild pigs show a dietary preference for a number of riparian plants, so their home range is often dictated by proximity to riparian ecosystems.

Physical Characteristic	Wild Pigs	Domestic Pigs
Hair	Amply covered with coarse, long hair	Sparse, short hair
Ears	Relatively small and erect	Relatively large and floppy
Tail	Straight, covered in hair	Curly, little hair present
Body	Razor-backed, shoulders higher and wider than hindquarters	Wide body, flat back
Tusks	Long and sharp	Relatively short
Head	Longer snout with flat profile	Shorter snout, concave profile
Color	Mostly black, some pied or russet	Usually white, sometimes russet or pink
Young	Dark with horizontal stripes	Same uniform color as parents

Table 1: Physical characteristics of wild vs. domestic pigs

Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

Wild pig. Photo courtesy of Billy Higginbotham-Texas A&M AgriLife Extension Service

Potential Conflicts between Wild and Domestic Populations

Major disease risk: Pigs, both domestic and wild, have been called a "petri dish" for diseases. They are susceptible to and can carry at least 30 viral and bacteriological diseases and can serve as hosts for up to 37 different types of parasites. As such, wild pigs have the potential to transmit diseases to nearby livestock operations, including domestic pigs, cattle, sheep and goats, as well as local wildlife populations. Pigs can also pose a threat to human health as numerous diseases that pigs can carry and transmit are zoonotic.

Diseases and Transmission: Some examples of diseases carried by pigs include: African swine fever, classical swine fever (Hog Cholera), E. coli, Hepatitis E, Foot and Mouth disease, Plague, Psuedorabies, Salmonella, Swine Influenza Virus, Swine Brucellosis, Toxoplasmosis, Trichinosis, and Tularemia. An outbreak of a disease like pseudorabies in wild pigs could mean serious economic loss for an outdoor pig operation, as well as nearby cattle operations, and a negative impact on domestic pets, and local wildlife. Disease transmission typically occurs from the passing of bodily fluids between animals, though the virulence of the disease causing pathogens varies.

Interbreeding and Crossbreeding: If domestic and wild pigs interact directly there is potential for them to breed, as wild and domestic pigs are from the same species, *Sus scrofa*. In many cases, domestic pigs have been bred for specific production traits that would most likely be diluted by interbreeding with wild pigs. However, a growing number of outdoor pig operations in California have begun to intentionally cross domestic species with Russian Wild Boar in an effort to enhance the animal's ability to utilize forage and thrive in a range or pasture context.

Impact: Wild pigs impact ecosystems by rooting, wallowing, foraging, and hunting. A conservative estimate of wild pig damage is $1.5 billion in economic damage annually across the nation. Their rooting overturns and tills the soil, their wallowing disturbs seeps and springs and they are also known to cause damage to livestock water facilities. Their foraging behavior and diet preferences make them highly competitive with other wildlife species. It is estimated that they consume about 3% of their body weight in food daily; however, they will binge eat with one study reporting 49 toads in the stomach of one harvested pig. Domestic pigs can become feral quickly. It does not benefit the outdoor pig production operation or the natural resources of an area for additional pigs to be added to the wild pig population through the release of domestic pigs.

Rooting damage from wild pigs. Photo courtesy of the Alameda RCD.

Risk of Interaction: Some of the factors that can affect the relative risk of interaction between wild and domestic pigs include the number of wild pigs in the area; proximity to riparian areas; access to desirable feed including hay, grain, scrap food, lawns, etc.; past wild pig issues; current weather conditions (pigs only travel as far as they need to for food and water and a drought year will increase the likelihood of wild pigs invading as they search for

food and water); pig management of neighbors; and, current pig management efforts of the outdoor pig production operation.

One recent study identified the distance between pig paddocks and buildings, closeness to wooded areas, use of electric fences or use of fences lower than 2 ft as risk factors for contact between domestic and wild pigs.

Preventing Interaction between Wild and Domestic Populations

Fencing: The most effective fence to prevent interaction between wild and domestic pig populations would utilize woven or welded wire, strong enough to withstand significant pressure from full grown pigs. A strand of tightly stretched four-barb wire is recommended at ground level or even underground to discourage rooting. It is recommended that the facility maintain a perimeter fence, as well as interior fences for separating pastures. All interior fences should be placed four feet from the perimeter fence to prevent nose-to-nose contact and reduce disease transmission risks between wild and domestic pigs. A single strand of electric wire is not considered sufficient to prevent interaction between wild and domestic pigs, however, it may be sufficient to manipulate the foraging patterns of domestic pigs within a more rigorous perimeter fencing system.

Woven wire fencing between feral and domestic pigs. Photo courtesy of Jared Timmons, Texas A&M AgriLife Extension Service.

Population Management: Managing the local wild pig population and actively reducing numbers is the best way to reduce the likelihood of wild pig to domestic pig disease transmission. Active pig management efforts also discourage wild pigs from visiting and living near the outdoor pig production facility.

Resources

General information:

www.dfg.ca.gov/wildlife/hunting/pig/

http://feralhogs.tamu.edu

Feral Hog Biology, Impacts, and Eradication Techniques. USDA APHIS Wildlife Services New Mexico. Published November 1, 2010

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Hunting and Shooting:

http://www.dfg.ca.gov/wildlife/hunting/pig/

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Banner Photo credit from L to R: Wild piglets courtesy of Silvana Pietrosemoli & Feral pig, courtesy of NRCS.

Conservation Practices for Outdoor Hog Systems

By Susan Ellsworth and Sheila Barry

The Natural Resources Conservation Service (NRCS) is an agency of the USDA tasked with promoting conservation on working lands though financial and technical assistance. Farm or ranch conservation planning is one of the many services provided by the NRCS for interested producers. The NRCS' Environmental Quality Incentives Program (EQIP) can then be utilized to help share the cost of specific conservation improvements identified within the conservation plan.

What follows is a description of various practices developed by NRCS that directly support outdoor hog management best practices in California and how they might be utilized. The chart also includes an explanation of how these practices would address potential natural resource concerns. To learn more about the NRCS and its programs, contact your local office by visiting http://offices.sc.egov.usda.gov/locator/app?state=CA.

Resource Conservation Practice	Practice Description	Application in Outdoor Hog System
Compost Facility 	A structure to contain and facilitate the aerobic transition of animal manure and/or plant waste into stable organic matter suitable for use as soil amendment.	Use to manage hog manure and bedding for animals in confined or deep-bedded systems. • Will address potential nutrient loading in soil, runoff or leaching associated with accumulated hog manure
Cover Crop 	Crops including grasses, legumes and forbs planted seasonally to reduce erosion, increase soil organic matter, suppress weeds, manage soil moisture, minimize compaction and support other goals.	Use as part of integrated cropping/hog production system – where cover crop can be grazed after achieving its resource goal. Can also be used between forage crops in pasture systems to build soil or replenish nutrients for enhanced forage production. Cover crops provide the following benefits: • Promote nutrient recycling or redistribution within soil • Reduce compaction in soil after use by hogs • Suppress weeds resulting from disturbed soil • Provide soil cover in rotationally used paddocks after hogs are removed

Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

Resource Conservation Practice	Practice Description	Application in Outdoor Hog System
Fencing – permanent or temporary 	A constructed barrier to animals or humans. May include permanent fencing such as woven, barbed, smooth and high tensile wire as well as temporary fencing such as electric.	Use to exclude animals from sensitive habitat or riparian areas and/or to create cross fencing to facilitate improved rotation and distribution of animals across a field. Appropriate fencing provides the following benefits: • Facilitates rotational grazing which can help to minimize disturbance, compaction, and nutrient loading associated with permanent systems (animals are not rotated through fields/paddocks) Note: NRCS does not assist with perimeter property fencing.
Field Border/Windbreak 	A strip of permanent vegetation, often trees or shrubs, established at the edge of a field to create a physical barrier with resource benefits both on- and off-site.	Establish at the perimeter of a hog operation to provide the following benefits: • Minimize erosion from wind and water • Create a visual barrier for outdoor hog operation as well as minimizing the impact of odor, noise or dust on neighbors • Intercept dust or other off-site particulate matter from entering the operation • Provide shade, shelter and possibly nesting material and forage for hogs as well as other beneficial organisms • Protect animals and plants from wind damage
Filter Strip 	A strip of herbaceous vegetation used to remove contaminants from overland flow and/or reduce erosion. Filter strips are established adjacent to sensitive areas to minimize impact from contaminants or sediment.	Establish upslope of sensitive habitat and adjacent to heavy use areas such as feeders, waterers, shelters or farrowing areas to provide the following benefits: • Intercept sediments, nutrients, and pathogens in runoff from entering sensitive habitats, waterways or otherwise leaving the production site
Forage & Biomass Planting (for pasture) or Range Planting (for range) 	Establishing herbaceous species suitable for grazing or the production of hay or biomass.	Use to establish forage appropriate for hogs in pasture/range based systems, including hay or other dry forage. Forage planting can assist with the following resource concerns: • Improve soil cover during low forage periods, thereby reducing erosion and improving soil and water quality

Resource Conservation Practice	Practice Description	Application in Outdoor Hog System
Heavy Use Area Protection 	Stabilizing areas heavily used by livestock, such as feeders or waters, by establishing vegetative or permanent cover. May include the use of materials such as gravel or cement.	Establish stable non-eroding surfaces in locations with heavy use such as feeders, waterers, farrowing areas or shelters to provide the following benefits: • Minimize rooting and wallowing, particularly around water facilities or sites for liquid feed such as whey or milk • Minimize compaction and erosion impacts from excessive animal traffic, wallowing, and rooting • Improve livestock health
Mulch 	Applying (or maintain) plant residues, such as wood chips, straw or other materials to the land surface. In some cases this may include inorganic mulches such as plastic.	Apply around high use areas such as feeders, waterers, shelters or farrowing areas to minimize erosion, compaction and nutrient loading.
Nutrient Management 	Analyzing and managing nutrient deposition, including manure, to maintain or improve the condition of soil and vegetation.	Use to assess impacts of hog manure, particularly in high use areas, and consider alternative management and utilization options. This practice may provide the following benefits: • Improve soil, water and air quality • Increase availability of composted hog waste to improve forage quality and quantity.
Riparian Forest Buffer 	An area of woody vegetation such as trees and shrubs located next to or up-slope from riparian areas or waterways. Buffers should generally be combined with filter strips to avoid bare ground between trees or shrubs.	Use to support the health of riparian areas and waterways including the following: • Reduce the amount of sediment, organic material, nutrients or pathogens in surface runoff. • Create shade to lower water temperature, which might also provide shade to adjacent livestock.

Resource Conservation Practice	Practice Description	Application in Outdoor Hog System
Watering Facility 	A permanent or portable structure to provide livestock water.	Use in concert with a rotational grazing plan and/or cross-fencing to help provide the following: • Improve distribution of hogs across a pasture or paddock and more evenly utilize forage • Reduce the number of high impact areas in light of improved distribution Note: facilities must be at least 300' from a creek or spring

Photo credit from top to bottom: Pg. 1 Compost photo courtesy of the ACRCD; Red clover photo courtesy of Rebecca Wilson; Hogs in fence courtesy of Robin Webster; Filter strip courtesy of NRCS; Windbreak photo courtesy of Silvana Pietrosemoli; Forage photo courtesy of Silvana Pietrosemoli; Heavy use photo courtesy of Silvana Pietrosemoli; Mulch Photo courtesy of Hidden Villa; Nutrient management photo courtesy of Long Ranch; Riparian forest buffer courtesy of Root Down Farm; Watering facility photo courtesy of Silvana Pietrosemoli

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Outdoor Hog Production:

Best Practices for Conservation in the San Francisco Bay Area

The following chart contains data compiled from surveys conducted at 10 different outdoor and alternative hog production sites throughout the Greater Bay Area, Northern San Joaquin Valley and Southern Sacramento Valley. Visits were conducted in 2013 and 2014 and used to inform the development of recommendations in this resource guide. Many thanks to the producers who opened their farms and ranches to us.

	Site 1	Site 2	Site 3	Site 4	Site 5
County	Marin/Sonoma	Santa Clara	San Mateo (1)	Stanislaus	Santa Clara
Production System	Farrow to Finish	Farrow to Wean	Wean to Finish	Wean to Feeder	Farrow to Finish
Years raising pigs	20+	7	3	2	6 – depending on current manager
Swine Production Area	30 acres	1/10 acre	200 acres	1/2 acre	10 acres
Breed(s)	Berkshire, Duroc, Old Spot, Glouchester, Yorkshire	Berkshire x	Hampshire, Berkshire, some wild genetics	Duroc, Hampshire, Landrace, Yorkshire	Tamworth, Duroc, Berkshire
HERD					
Boars	5	1	0	1	0
Sows	50	1	0	1	3
Piglets	130	0	0		7
Weaners	150/year	0	0	15/year (none at time of visit)	0
Growers/Finishers	125/125/year	0	50-100/year (none at time of visit)	0	6
Top Hogs	0	0	0	0	6
Gilts	25	0	0	0	0
Weaning Age, Wk	6-8 weeks	n/a	n/a	n/a	8 weeks

Funding provided by the Natural Resources Conservation Service Conservation Innovation Grant # 86-9104-3-179

	Site 1	Site 2	Site 3	Site 4	Site 5
FEED					
Commercial concentrated	X	X (.5 coffee can/day/ animal)	X (50-75%)	X (2-2.5 lbs/day/animal)	X (2 coffee cans/day/animal)
Forage	v. minimal	X purchased	X (25%)	X – grown and purchased	X – grown; ¼ of total feed
Bakery waste	X	X	X	X	X
Restaurant waste					
Culled fruit/ vegetables		X	X	X	X
Whey	X		X (only in am or pm)		
Milk, yogurt, cheese	X				X
Brewer's grains	X		X		
Other			X - Wine pressing, black-berries	X – medicated milk	
Market weight, lb	270	30-40	250-300	40	275-300
MANAGEMENT					
Production System	Drylot & Rotational	Drylot	Rotational/Seasonal	Rotational	Rotational & Drylot
Veg Species	Drylot – very little pre-sent; unk for rotational pasture	None present	Eucalyptus woodland; pasture	Irrigated pasture	Cover crop (broad beans, vetch, field peas); wild oat & thistle.
Estimated ground cover, %	10% for drylot; 75% for pasture; 30% oak wdlnds; 60% range	0%	n/a	60%	60%
Estimated height, inches	2" for dry lot	n/a	n/a	2"	2.5'
Length of time in paddock	Continuous for drylot; unk for rotational	Continuous	1-2.5 weeks	Depends	2 weeks
Stocking density, hogs/ac	unk	2/.1 acre OR **20 hogs/ acre**	**30 hogs/acre**	15/.5 acre OR **30 hogs/acre**	6 hogs/.25 acre OR **24 hogs/ acre**
Rest	Unk	None	1-2 years	Yes, depends on above	1 year
Housing/Shelter	Barns, shelters	Shelter	Natural shade	Shelter	Shelter (Quonset hut, tarp)
Bedding	Y			Y	Y – grass
Feeder	Permanent	Permanent	Mobile	Permanent	Mobile
Waterer	Permanent	Permanent	Mobile	Permanent	Mobile - nipple

	Site 1	Site 2	Site 3	Site 4	Site 5
MARKET					
CSA			X		
Farmers Market	X				X – 75%
Restaurants	X				X – a few
Pig share			X		
Local Butcher/Retailer	X				
Marketed as	Milk fed; Moving towards AWA		Forest-raised, GMO free		
Other		Auction		Craigslist, Auction, 4-H	On-site meat sales
RESOURCE MANAGEMENT					
Erosion	Likely	Likely	Unknown	Y	N
Compaction	Y	Y	Unknown	Likely	Possible
Excess nutrients	Likely	Y	Unknown	Likely	Possible
Sediment in waterway	Unknown	Likely	Unknown	N	N
Nutrients in waterway	Likely	Likely	Unknown	N	N
Excessive Wallows	Y	Y	Unknown	Likely	Limited
Excessive soil disturbance	Y	Y	Unknown	Y	Limited
Loss of Veg Cover (25%)	Y	Y	Unknown	Y	N
Impact to upland plant communities	N	N	Unknown	LIkely	N

	Site 6	Site 7	Site 8	Site 9	Site 10
Location	San Joaquin	Mendocino (2)	San Mateo	Yolo	Marin
Production System	Wean to Finish	Farrow to Finish	Wean to Finish	Farrow to Finish	Farrow to Finish
Years raising pigs	10+	5+	4	5+	2
Swine Production Area	15 acres	300 (200 oak wdlnd; 100 pasture)	Approx 5 ac – 10 small paddocks (.5-.75 ac)	60	10
Breed(s)	Duroc, Yorkshire	European Wild, Berkshire, Tamworth	Duroc, Hampshire, Berkshire, Black Wattle	Tamworth, European Wild, Hampshire, Yorkshire	Tamworth, Large Black, Berkshire
HERD					
Boars	0	3-4	0	10	2
Sows	0	0	0	61	9
Piglets	0	0	0	20	27
Weaners	0	0	0	0	0
Growers/Finisher	10400	127 (70 108-240 lbs & 60 37-108)	10	300	28
Top Hogs	0	0	0	0	0
Gilts	0	0	0	0	0
Weaning Age, Wk	n/a		6-8 weeks when purchased	8 weeks	8 weeks
FEED					
Commercial concentrated	X	X	X	X – organic, primary feed	X - limited
Forage	X – grown & purchased (oat/straw)	X – grown	X	X – grown	X - grown
Bakery waste			X		X
Restaurant waste					X
Culled fruit/vegetables				X	X
Whey		X	X	X	X
Milk, yogurt, cheese				X – ice cream	X
Brewer's grains			X		
Other		Mash		Okara, wheat	Barley, Rice bran
Market weight, lb	300		250	200	220

	Site 6	Site 7	Site 8	Site 9	Site 10
MANAGEMENT					
Production System	Deep bedded & Cement	Rotational on pasture & continuous on oak wood-land	Rotational/Seasonal	Rotational & Drylot	Rotational, Drylot & Deep Bedded
Veg Species	Oat hay and wheat straw placed in hoops in bales; cement in flush barn	Rye, oat, foxtail, thistle in oak wdlnd; rye, orchard, harding grass; soft chess, clover, fescue	Eucalyptus, blackberry, poi-son oak	Alfalfa, turnip, mixed grasses in rotational/Dirt in drylot	Annual and Perennial Range (velvet grass etc.)
Estimated ground cover, %	100% in deep bedded due to straw	90% pasture; 75% oak wdlnd	90%, mostly leaf litter, shrubs	75% in pasture; 5% in dry lot	50%
Estimated height, inches	6-12” deep bedding	6” on pasture; 1’ on oak wdlnd	n/a	4” in pasture; n/a in dry lot	2” in pasture; n/a in dry lot
Length of time in paddock	100 days in hoop then 30 days in cement	1 week on pasture; stay in oak wdlnd all fall	1-2 weeks	3-5 mos on pasture; con-tinuous in drylot	1 wk on pasture for weaners; continuous for sows/boars in drylot breeding areas
Stocking density, hogs/ac	200 hogs/.20 acre OR **1000 hogs/acre**	70 pigs/200 acres on oak wdlnd OR **.35/acre**; 20 pigs/.17 acre in pasture OR **120/acre**	10 pigs/.25 acre OR **40/acre**	unknown	varies
Rest	none – old hay removed, replaced with new hay and pigs put back in	Rest oak wdlnd 4-5 months; several weeks +	Wet-season; Sometimes re-seed.	Pasture: 3 mos; limited rest for non-pasture pad-docks	One growing season then reseed and cover with hay
Housing/Shelter	Open-ended hoop barn	Oaks in wdlnd; structure in pasture	Natural shade	Pasture: trees; paddocks: shelters; Farrowing: hoop	Shelters in breeding area
Bedding	Y – deep straw/hay until flush barn then limited straw	Grass		In paddocks, not pastures	Straw
Feeder	Dry/wet self-feeder	Mobile	Mobile	Permanent	Mobile and permanent
Waterer	Dry/wet self-feeder	Mobile trough w. float valve and grate	Mobile	Permanent	Mobile

MANAGEMENT	Site 6	Site 7	Site 8	Site 9	Site 10
MARKET					
CSA			X		X
Farmers Market			X	X	X
Restaurants	X - majority	X		X	X
Pig share					X
Local Butcher/Retailer		X		X	
Other	On-site direct sales to individuals (CDFA slaughter on site)	Marketed from ranch; grocery stores		Retail markets	
Marketed as	Antibiotic free				AWA, Organic
RESOURCE MANAGEMENT					
Erosion	N	In sacrifice area	Y	Y	Y in semi-permanent
Compaction	N	In sacrifice area	N or limited	Y	Likely in semi-permanent
Excess nutrients	Possible	N	N or limited	Likely	Likely in semi-permanent
Sediment in waterway	N	N	Possible	Possible	N
Nutrients in waterway	?	N	Possible	Possible	N
Excessive Wallows	N	N	N	Y	N
Excessive soil disturbance	N	In sacrifice area	N or limited	Y	Y in semi-permanent
Loss of Veg Cover	N/A	In sacrifice area	N, though would be desirable given plant mix	Y, primarily in dry lot areas	Y in semi-permanent
Impact to upland plant communities	N/A	In sacrifice area	Y, limited disturbance to poison oak, blackberry and eucalyptus –desired	Yes, some tree damage	Y in semi-permanent