Livestock Mortality Composting

FOR LARGE AND SMALL OPERATIONS IN THE SEMI-ARID WEST

Montana State University Extension
Colorado State University
NM State Cooperative Extension Service
University of Wyoming Cooperative Extension Service
NRCS Natural Resources Conservation Service
Western SARE

Authors and Contributors

Thomas Bass
Montana State University

David Colburn,
NRCS

Jessica Davis
Colorado State University

John Deering
Colorado State University

Michael Fisher
Colorado State University

Robert Flynn
New Mexico State University

Sara Lupis
Colorado State University

Jay Norton
University of Wyoming

Nicolette Schauermann
Colorado State University

Editors

Sara Lupis
Colorado State University

Thomas Bass
Montana State University

Associate Editors

Jean Bonhotal
Cornell University

Julia Dafoe
Montana Agricultural Experiment Station

Joshua Payne
Oklahoma State University

Design and Layout

David Ashcraft
Montana State University

The authors and editors wish to thank all of the producers, Extension agents, and conservation professionals who reviewed this publication.

This project was funded by a grant from the Western Sustainable Agriculture Research and Education Program - http://wsare.usu.edu - 435.797.2257.

Contents

Why Compost Animal Mortalities?

Many livestock producers are concerned about proper mortality disposal and management. Proper management of animal mortalities on the farm/ranch/feedlot has important implications for nutrient management, herd and flock health, as well as farm/ranch family and public health. The purpose of proper mortality disposal is to prevent the spread of infectious, contagious and communicable diseases and to protect air, water and soil quality. Also, there are legal issues and requirements related to nutrient management and the permitting of animal feeding operations. To best ensure human health and safety, reduce regulatory risks, and protect environmental resources, livestock producers should become familiar with best management practices (BMPs) for dealing with dead animals. They should also be aware of state laws related to proper disposal or processing of mortalities.

Disposal of routine operational mortalities and catastrophic mortalities must be defined in a comprehensive nutrient management plan, used by most permitted animal feeding operations. In addition, zoos and other facilities that house large animals (or many animals) may benefit from the techniques and resources provided in this manual.

Mortality composting is an increasingly popular and viable alternative compared to other disposal practices because of cost savings, reduced environmental risks, and the generation of a useful end-product. This manual is designed to provide livestock producers in Montana, Wyoming, Colorado, New Mexico and surrounding states with the knowledge, tools, and resources to develop a mortality management plan, with specific focus on the composting option.

Unacceptable Animal Mortality Disposal

Abandonment

Though dragging off a carcass to the “boneyard” has been a historic practice, abandonment is strongly discouraged. Abandonment is likely illegal in most states. Examples of abandonment include: carcasses abandoned on the surface, in open pits, ditches, water features and sinkholes or in wells. Abandonment promotes extreme biological and disease hazard, threats to water quality, odors, flies, scavengers, rodents, and visual pollution.

Methods of Animal Mortality Disposal

Burning

Disposing of animal mortalities by open pyre burning is discouraged. Most producers have difficulty finding proper fuel to maintain temperature and flame, and struggle to obtain complete consumption of the carcass or carcasses in a timely manner. Air emissions are uncontrolled and likely dangerous, depending on the fuel source. Burning should only be considered in emergency situations, and with proper advisement and permission from the appropriate regulatory agency.

Incineration

Incineration is a safe method of carcass management from a bio-security standpoint. Incineration is different from burning because when practiced correctly, the entire carcass is quickly and completely consumed by fire and heat. This practice must be done in an approved device with air quality and emissions controls. Incineration is primarily utilized for disposing of small carcasses (such as poultry). The cost of fuel may limit adoption of this practice because it can be an energy intensive process.

Burial

Burial is probably the most common method of dead animal disposal, although some states have outlawed it. Most states have regulatory burial guidelines outlining site location, distance from waterways, depth to groundwater, etc. If proper procedures are used, burial is safe; however, certain portions of carcasses can persist for years in an anaerobic (low oxygen) environment and there is no assurance of pathogen reduction. During construction projects on former poultry farms, old burial pits have been discovered that contain intact birds. Sites with a high water table and well drained soils do not allow proper depth or cover of burial without threatening ground water. Burial pits are considered mass graves and, if not managed properly, may pose additional risks through the spread of disease and other environmental contamination.

Land Filling

Disposing of carcasses at a licensed landfill is considered an acceptable method of burial. Land filling may be an option in some areas; however, the legality of this will be based on the classification of the facility, local regulations, and the policy of the individual site. Even if the landfill is classified to accept carcasses, management must also grant permission. It is a good idea to have a written agreement with the landfill service if you plan to regularly use this method of disposal. Drawbacks to landfill disposal may include additional handling of the mortality, transportation and tipping fees, and potential disease transmission.

Rendering

Rendering is a heat-driven process that takes place at a special facility in which waste animal tissue is separated and converted into value-added materials. Rendering is a relatively simple method of mortality management for the farmer/rancher, and it leaves no lasting legacy on the farm. However, there are very few rendering facilities across the U.S., and there are often fees associated with a rendering service. This is a recommended practice for those with access to a rendering service. The cost of rendering should be weighed against time management, input cost, and possible bio-security breaches when compared to other available methods. Local livestock or poultry producers and Extension staff may be the best resource for determining if this service exists in your area.

Livestock Mortality Composting

For many species, carcass composting (i.e., the biological process of converting organic matter into fine-particle humus-like material) is an environmentally preferable method for managing mortalities. When performed correctly, the end-product may be reused in future mortality composting, and under certain conditions, applied to animal feed crops and forest crops. Poultry composting is a common practice and much information is available that describes how to dispose of birds in this way.

Composting is practical for larger carcasses. Many operations, even in cold climates, successfully compost larger stock including sows, cattle and horses. Composting large carcasses can save labor and land. This practice allows a dedicated area to be used and reused for carcass management; it is done above ground, thereby reducing the number of labor-intensive burial pits created as well as minimizing the number of buried carcasses on the property.

Technical procedures on composting cattle carcasses are available and continue to be studied and refined; this appears to be a viable option which will be described further in this manual. Most composting requires storm water protection, and possibly roof-type covering. Additional management and monitoring is required to refine the process, maintain temperatures, attain proper decomposition and prevent scavengers. Nutrients and organic matter in finished carcass compost can benefit forest and crop land; however, nutrient management guidelines should be followed. This publication focuses on aerobic composting in piles or windrows on the soil surface. Other methods do exist and are also continue to be studied.

Composting Principles

Composting is the “managed, biological, oxidation process that converts heterogeneous organic matter into a more homogeneous, fine-particle humus-like material” (Field Guide to On-farm Composting, 1999). This definition includes many important principles that need to be considered when composting.

Managing a compost pile can be viewed as “farming microorganisms” to provide optimum conditions for the bacteria and fungi that do the real work of composting. The microorganisms need four things: carbon (C), nitrogen (N), water, and oxygen. Generally, the carbon and nitrogen need to be provided in balance, and we usually aim for a C:N ratio of about 30:1 at the beginning of the composting process. To achieve this, it is important to know the C:N ratios of your composting feedstocks (i.e., carbon materials such as straw, sawdust, animal bedding, etc.) and devise a good “recipe” or mixture. However, departure from this common wisdom for mortality composting will be discussed in this manual as C:N ratios exceed the recommendation (much greater carbon) when dealing with dead animals. Likewise, in the early stages of carcass composting mixing is not feasible.

As noted above, true composting must take place in the presence of air or “under aerobic conditions”. The bacteria and fungi that break down organic wastes in the pile require oxygen to achieve a compost end product. If oxygen is inadequate due to high moisture levels, waste will still degrade, but it will degrade by rotting or fermenting rather than composting. Odor may be excessive, in this case!

Water and oxygen must be provided for the microorganisms and are related to each other. If the compost is too wet, the oxygen levels will be too low. In most composting scenarios best success is attained with a moisture level at about 50%. The moisture content can be determined by weighing a sample, drying it and then reweighing, but it can also be estimated from a "squeeze test." Just squeeze the compost mix in your hand. It should be wet enough to stay together in a ball, and you should only be able to squeeze a little trickle of water out in between your fingers. To achieve this moisture level, watering and shaping the pile to accept moisture is often necessary.

The oxygen content in a compost pile should be about 5-20%. Some operators purchase hand-held oxygen meters to periodically measure that level. A drop in compost pile temperature after the start of the process is often a sign that there is an inadequate level of oxygen. Turning the pile is a management practice that is commonly used both to mix the ingredients and to add oxygen into the pile. The use of bulking material (a coarse-textured organic waste like wood chips) also aids in aeration of a compost pile. Turning should only be done after the active stage of composting. For poultry, you can turn after 2-3 weeks; large livestock generally require 3-6 months.

Composting Goats and Sheep: Though composting of medium to large carcasses and land applying the material is proving to be feasible, careful consideration must be given for goats and sheep due to the prevalence of scrapie, a prion disease, in flocks across the U.S. This disease is a transmissible spongiform encephalopathy (TSE) similar to BSE (i.e., mad cow disease) and the human Creutzfeldt-Jakob disease. If compost from diseased animals were used as fertilizer, it would create a serious bio-security threat. Fate of compost from sheep and goats should be carefully considered. Be sure to seek expert advice prior to disposal of these species. If a producer has a certified scrapie free flock, then they could proceed with composting in relative safety.

Incorporating Animals into the Composting Process

Influence of Animal Size

Size and volume of mortalities will directly influence the physical footprint of the pile or volume of bin space designed, amount of carbon material required, and the time required to fully compost the carcass(es). Smaller carcasses have more surface area relative to mass; this provides for more carbon material to carcass interaction. Similarly, cutting or breaking apart large carcasses can speed up the composting process. While properly constructed and layered poultry mortality compost will process in a matter of a few short weeks, cattle will take months (6-12) under average conditions (in static piles; i.e., no turning).

Bones remaining at 3 months, skull on left, spine on right. These will nearly breakdown completely when recovered for 3 more months, credit: Schauermann

Preparation and Placement

For larger livestock, the carcass should be laid on its side on the middle of the base material with the body cavity opened and the rumen punctured for cattle, sheep and goats. This is done to prevent bloating and bursting which will displace cover and result in additional odor and nuisance. The carcass should be covered completely with material on all sides (as described in the next section). The finished pile may reach up to six feet in height, in the example of a large cow. Small carcasses should be layered and arranged to maintain carbon margins around each dead animal. Small carcasses can also be stacked in tiers with carbon layers in between.

Calves on base, credit: Dafoe

Cows on base, credit: TX A&M Agrilife Extension

Base and Cover

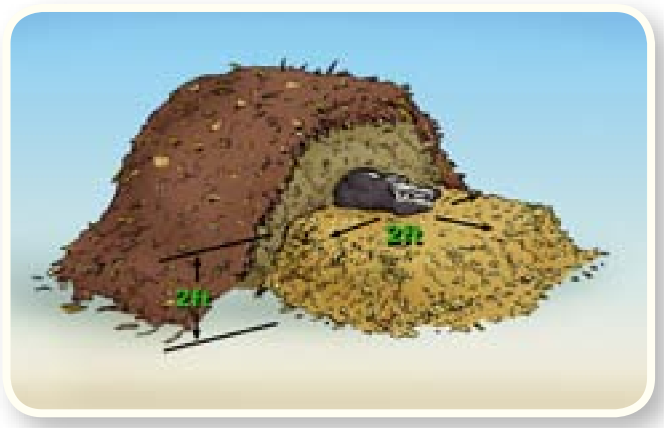
Considering that a large carcass is very high in moisture and nitrogen, adding too much carbon will not likely be a threat to composting success. In the case of mortality composting, proper pile construction will result in unbalanced C:N, considerably higher than the common 30:1 ratio. Moisture distribution will be uneven throughout the pile and there are likely to be pockets of anaerobic decomposition immediately around the mortality. While much of the external carbon does not interact with the carcass at the center, it serves a larger role in bio-filtration and insulation. The extra carbon material is also valuable in absorbing excess moisture from the mortality. Conventional turning and proper C:N balance comes into play at the end of this process, weeks after the mortality has been consumed by the process.

Winter Tip – surrounding the carcasses in warm or active compost will give them a quicker start, especially for winter or early spring mortalities. In Montana, producers have been successful with attaining necessary temperatures by placing non-frozen carcasses in the pile and building the core with silage, warm compost or manure solids. The pile should always be capped with a "clean" material such as sawdust or chopped straw. Likewise, getting carcasses started in compost before they freeze in the field helps the pile attain and maintain desirable temperatures.

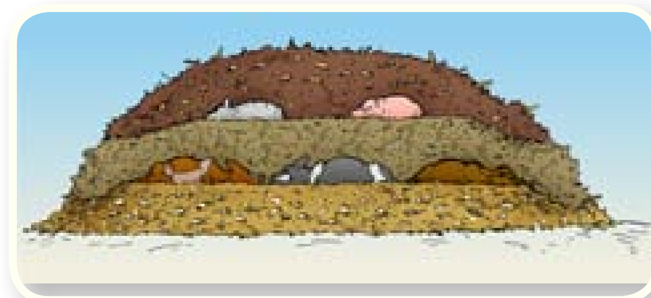
Successful composting of mortalities has been reported with base thicknesses between 12 to 24 inches. The base should be comprised of a material that is both absorbent and bulky, such as wood chips and shreds with sizable pieces being 4 to 6 inches in length. This base material is important for achieving satisfactory porosity for aeration. Material that packs tightly or is excessively wet is not recommended. The base material should not be excessively dry either, but moist like a damp, wrung-out sponge. To save time, always have a couple bases ready to accept animal mortalities. The carcass can be placed once a satisfactory base is established.

Core material can now be placed around the mortality. This is an opportunity to use a variety of materials found onsite or regionally. Tables 1 and 2 provide a list of materials that have been used in the Rocky Mountain region. The material added directly around the sides and top of the carcass does not need to be as porous as the base; also, if the carbon source has odor associated with it, the core around the carcasses is the ideal place for its use. Manure, silage, and other active materials, with a low C:N ratio may be ideal for this layer. Finally, the cap may also be a finer material than the base, and should be low in odor. Core and cap materials such as silage or moist sawdust in the 50-60% moisture range are ideal. The addition of the cap should bring the final margin around the carcass to a range of 18-24 inches, as the illustration shows.

Estimates of total material needed to fully compost a full grown cow are 12 cubic yards, or for 1,000 lbs of carcass, 7.4 cubic yards (200 ft^3). The difference in the estimates can be attributed to the thicker base recommended by some experts. Practically speaking, for a mature cow, a proper base will be about 9 feet wide by 10 feet long. Once the mortality is placed in the middle of the base, cover to achieve at least a 24 inch margin in all directions. Considering side slope, material on top will likely be more than 24 inches above the mortality to achieve the proper margin. When layering smaller carcasses, or parts of carcasses, an 8 to 12 inch margin should be maintained around each carcass. Bins and bunkers can reduce the overall size and foot print of piles.



Cow position in pile, credit: Cornell Waste Management Institute



Layered small carcasses, credit: Cornell Waste Management Institute

Carbon Options

Table 1. Most Commonly used carbon material in the Rocky Mountain Corridor; sources, pros, and cons for each. Ideal pile construction will have coarse material base, with other materials in core around the carcass material and an inert material for a cap such as sawdust or compost.

Material	Source(s)	Pros	Cons
straw & hay (common)	local farms, onsite, zoos	availability	compresses, pore space diminishes quickly; C:N 17:1
hay (alfalfa)	Local farms, onsite, zoos	availability	compresses, pore space diminishes quickly;12:1 C:N
wood chips	timber mill, inert landfill, municipal yard waste, beetlekill	good pore space, especially for base of pile; 300:1	may be expensive
saw dust	timber mill, wood based industry, beetlekill	good cap material for odor control, green saw dust has good moisture for composting; 300:1	may be expensive
compost	onsite, compost distributors	active material, best for core	low pore space
manure (various species)	onsite	active material, best for core	odor, leaching potential, low pore space
horse manure	racetracks, boarding facilities	45:1 C:N	Low pore space, limited by region
separated manure solids	neighbors, onsite	active material, best for core	may still be too wet
silage	onsite	active material, best for core; 40:1 C:N	odor, leaching potential, low/ medium pore space
grain residues/hulls	local mills/granaries	best for core	low pore space, oil seed residues may lead to odors

Table 1 continued

Material	Source(s)	Pros	Cons
waste feed	onsite, feed lanes, storage	Active material	Possible odors, variable composition
cull potatoes	Potato farms	Best for core; could be mixed with dry material	High moisture (~80%)
biosolids	City waste management companies, municipalities	Good N source	Possible heavy metals, pathogens
yardwaste	Homeowners, landscape companies, municipalities	Can be good for base or cap	Variable C/N ratio and irregular flow; 15:1 C:N; potential trash

Table 2. Unique or locally utilized carbon materials of the Rocky Mountain corridor; sources, pros, and cons of each. Ideal pile construction will have coarse material base, with other materials in core around carcass(es) and an inert material for a cap such as sawdust or compost.

Material	Source(s)	Pros	Cons
Fruit wastes	Orchards, vineyards, wineries	For core; may need to be mixed w/ drier material	Very wet (60-90% water)
Chile skins	Chile processors	Bulking agent	excess water directly from processor, nuisance factor
Cotton gin waste	Cotton gins	Aerates well, holds moisture, good pore space	Hauling costs, varies by region, 14:1 C:N
Garment processing fibers	garment processor	46:1 C:N	Wet product, hauling, very poor pore space
Paper mill waste	pulp and paper plants	95:1 C:N	Distance
Pecan cleanings	pecan processors	Bulking agent	Possible odor issues
Pecan trimmings	pecan farms	Bulking agent	Post processing

Windrows, Wooden Bins, or Hay Bale Bins/Bunkers—Footprint and Sizing

As previously mentioned, the size of a compost pile can be reduced through the use of bins or bunkers. Windrows and piles, while providing the best passive air flow, will have the largest physical footprint and may pose the greatest attraction to scavengers if the area is not appropriately fenced. The use of some type of structure to contain the area and reduce physical footprint is recommended. This also provides visual screening. Permanent, slatted wooden or metal walls can also be constructed for large carcasses, though it represents a greater expense. Some engineers recommend roofs over mortality compost bins, even in arid climates. A producer can discuss this and other compost facility decisions with their county agent or local USDA-NRCS conservation professional. Large square or round hay bales can be used to construct temporary bins; bales placed around the pile's perimeter help exclude pests and absorb any possible run-off. Bins for small ruminants, pigs or other stock, could be built with small square bales. Temporary fencing or stock panels can be used to bar the front of the mortality compost bin and exclude nuisance and scavenger animals. (Additional information and USDA-NRCS standards for this practice and related facilities can be found in Practice Standard 316 and the National Engineering Handbook; see References Section for full citation.)

Bin and base, credit: Dafoe

Monitoring and Management

Composting

Now that the mortality are properly enveloped or incorporated the process of composting takes 4-12 months depending on mortality size and mixture. During this phase it is a good practice to monitor the piles and intervene at the appropriate times, i.e.: when additional cover is needed or pile is emitting odor. Some operators will leave a marker where the last mortality is located to avoid accidentally disturbing the active site. The process of composting mortality is passive. This phase of the process should not be disturbed for three to six months depending on animal size. During this time, microbial activity from bacteria and fungi are performing their function by reducing the carcass to a homogenous organic material. Most of the easily decomposed tissue is virtually “gone” within 6-weeks. Fungi need the extra time to continue working on the remains. The pile can be disturbed for mixing, watering and stockpiling for curing after 4-6 months in the passive phase.

Temperature

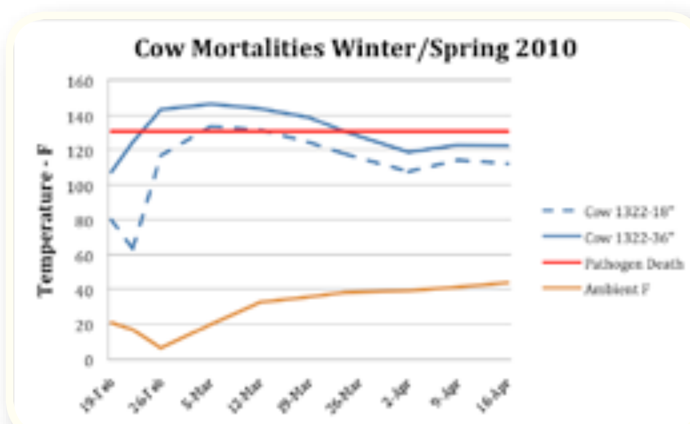
Temperature management is a critical component of successful composting. Monitoring involves both taking and recording the temperature of your compost piles and making observations about their condition. A long-stem thermometer inserted into the pile after construction is the first step in monitoring. Reaching temperatures of 120-150 F, assures the operator of effective composting. A compost thermometer has a long probe (18-60 inches long) in order to measure the internal temperature of a compost pile.

Temperature is a reflection of microbial composting activity in the pile. When microbes feast, they multiply and give off heat. If temperatures are cool (<80° F), there is some reason why the microbes are not thriving. Temperature should be checked every couple days during the first 7 to 10 days after covering the mortality. Thereafter it is wise to check on temperatures at least weekly. Graph the temperature as a function of time and you’ll see it rise quickly up to about 130-160° F and then decline gradually. Under normal composting conditions, when temperature declines for a week or more, it is time to turn the pile in order to aerate it. This typically results in rising temperatures again, if conditions remain optimum. Temperatures in the 140 to 160 degree range, held for 48-72 hours are necessary to sterilize weed seeds and destroy pathogens.

However, when composting mortalities, the piles need to sit, undisturbed for a few weeks or months; temperatures will be quite variable during this time. Because of the high moisture content of a large carcass, there will be pockets of wet anaerobic degradation around animal; a proper pile will naturally correct this. Once the pile is turned it should be evaluated for water content (see below) and temperatures tracked for another month. In the Rocky Mountain west, times to achieve this status range from 4-8 months. This final period after turning should continue composting prior to curing. Bones will continue to break down in this phase, which follows more traditional composting recommendations.

Moisture Content

You can use the squeeze test described previously to evaluate whether your compost piles in the post-turning final stage have adequate moisture. If piles entering the final stage do not have enough moisture, the best time to add water is at the time of turning. In static piles (the beginning stage of mortality composting), turning and watering do not typically take place unless there is a problem (lack of temperature rise, for example). Because of this, it is even more important to get the moisture content right from the start. Moisture of 40-60% in the carbon based compost materials is ideal. If necessary, add water to the compost material you are using to bury the carcasses in a few days prior to or on the day you start



the carcass composting (prior to adding the cap). The cap will reduce evaporation from the piles and help to maintain optimum water levels.

Moisture Management

If carbon is very dry, add moisture to the layers as you are building the pile. The compost feedstock should be at 40-60% moisture (this has proven to be a good range for arid climates). Piles/ windrows can be shaped to shed moisture or include it depending on climate and weather conditions. Piles with peaked tops will shed moisture in high precipitation areas. Creating a flat top will allow moisture that falls on the pile to soak in. Creating a trough will allow moisture to collect and soak in. When piles are working efficiently it is hard to add moisture, as much of it is released into the atmosphere.

Other

In addition to temperature and moisture content, it is important to monitor your piles regularly for scavenger activity, odors, and flies. These issues are addressed in the *Issues* section of this document.

Curing and Storage

Curing is the stage of composting that occurs after the thermophilic (hot) process has ended and mesophilic (warm) conditions are established. Curing usually takes place by simply allowing the compost to sit for an additional period of time on-site. Winter conditions can potentially prolong this phase of the composting process because very cold conditions may prevent adequate microbial activity.

There must be sufficient aeration and moisture during this phase as oxygen loving organisms are at work to further breakdown the organic material. Anaerobic conditions can still occur so it may be necessary to turn or mix the pile during this phase. Curing also gives organisms more time to breakdown some of the larger bones to a more brittle and smaller form that is easier to incorporate into the soil. Bones can be screened out of compost that will be land applied, and introduced into new piles to continue breaking down. There should not be a large increase in temperature after this mixing but some increase in temperature is expected and is a good sign of microbial activity and the curing phase is underway. Observe the pile temperature after mixing with a long-stem thermometer to assure the pile is proceeding according to plan. The pile should be left for another 4 to 8 months. By this time very few bones will remain visible, large bones will be brittle, and the material can be appropriately used.

Storage of compost increases the size, or footprint, of the composting site. However, it is a necessary component to the system that provides maximum flexibility in the end use of the material. Compost should only be stored within the protected composting area after the curing phase when little to no risk of continued heating will occur. Slightly more storage area may be needed if active composting occurs during the winter months when potentially less mass is lost during composting as compared to summer. The goal with storage is keep it from becoming a nuisance but accessible for land-application, or recycling into new mortality piles when the time is right.

Site Selection and Environmental Management

Good stewardship of the land means taking the necessary steps to prevent possible problems that could negatively impact water, air, and soil quality. Most states have regulations regarding management practices for handling wastes; often dependent on type of waste, and size or tonnage of the operation. Best management practices are encouraged for all composting operations even if exempt from specific regulations. The information below can help identify some best management practices that should be considered.

Site Selection

When choosing an appropriate site for composting there is a variety of general characteristics that should be considered. An appropriate site will:

- Help to protect water and soil quality,
- Protect bio-security (prevent spread of pathogens or disease),
- Prevent complaints and negative reactions of neighbors,
- Decrease nuisance problems, and
- Minimize the challenges in operating and managing the composting operation.

In addition, the location of the composting site should be:

- Above/out of floodplains
- Easily accessible (in most weather),
- Require minimal travel,
- Be convenient for material handling, and
- Maintain an adequate distance from live production animals to help reduce the risk of the spread of disease.

Although specific site selection requirements may vary from state to state, the location should have all-weather access and allow for storage of carbon/compost materials, and should also have minimal interference with other operations and traffic. The site should also allow clearance from underground or overhead utilities for safe maneuvering of equipment.

Consideration should be given to visibility and location of traffic patterns required for moving dead animals, adding carbon/compost materials, and removing finished compost. An adjacent storage area for compost materials (i.e., sawdust, straw, crop residue, etc.), will eliminate the need to transport amendments from a distance. In the arid west, moisture may be needed in the final composting steps, once the mortality has been consumed. Consider how you may get water to the site for this purpose.

A compost site should be located in a well-drained area (but not well drained soils) that is at least 3 to 4 feet above the high water table level, at least 300-500 feet from sensitive water resources (e.g., streams, ponds, wells, etc.), and that has adequate slope (1-3%) to allow proper drainage and prevent pooling of water.

The base of the compost site should consist of soil with low permeability. If the predominant soils create a wet muddy working area, a compacted layer of sand or gravel about 15 cm (6 in) thick could be used to improve the working surface. If protecting ground water is a concern, a constructed concrete pad or imported clay pad may be necessary. Seek local guidance regarding soil type, groundwater issues, and related management options. Engineered pads and heavy use area protection practices pay for themselves during periods of extreme weather conditions. Similar recommendations would apply to where cured and finished compost is stored.

Composting areas should be located, when possible, with consideration to wind patterns that minimize potential odors or dust being carried to neighboring residences. Although composting does not usually generate odors, regular handling and composting of dead animals may be offensive to neighbors.

Stormwater Management

Most states have recommendations or requirements for stormwater management, especially for permitted facilities. There are three basic principles to consider in site management regarding runoff: 1) prevention, 2) collection, 3) distribution. Preventing water from running onto the composting site helps keep the site manageable and is likely the law in many states. Run-on water is diverted from the compost area with berms, ditches or swales. This, in turn, minimizes the amount of runoff generated by the compost site, especially in the arid west. Orienting windrows (when used) perpendicular to the slope of the site allows the windrows to absorb moisture and prevents erosion in-between. Situate the compost site to avoid water ponding, and facilitate collection/movement of excess water to a buffer, vegetative filter strip or an engineered storage structure if the run-off will be significant. If a composting area uses a run-off collection pond, the effluent should be treated in accordance with the laws and best management practices associated with land application of liquid animal waste. It will likely be evaporated or land-applied at agronomic rates.

Big Rain Events—Permitting Issues, Applicable Rules

Big rains can bring big problems even for small operation. Adopting conservation practices that lessen the effects of big rains can decrease non-point source pollution of nearby streams or shallow groundwater, reduce impact of odors, and decrease the likelihood of the spread of disease or pathogens. The National Oceanic and Atmospheric Administration has developed different time scale maps for storm events such as the 24-hour, 25-year precipitation maps that can help with planning (http://hdsc.nws.noaa.gov/hdsc/pfds/index.html). USDA-NRCS can also assist with assessing runoff potential and recommending conservation practices.

Dust Control

Evaporation generally exceeds precipitation, in the arid west, on a yearly basis; traffic in the composting areas may generate dust. Dust from soil can be avoided by maintaining a work area surface that is either compacted or uses a layer of compost or other carbon material that is not as prone to becoming airborne. A short-term fix to excess dust is to use water trucks to moisten the work area. Otherwise, equipment traffic should be limited when conditions for airborne dust are favorable.

Take steps to be prepared for fires as well. Mistakes in moisture control can lead to fires at compost sites. Smoke can travel a very long way and can lead to nuisance complaints. Assuring that adequate water supplies are near the compost pile and having a fire intervention plan in place will make all the difference in managing the compost site. It is not advisable to water a compost fire; this starts a dangerous cycle that will actually lead to greater combustion potential. Instead, spread out the materials that are reaching high temperatures. You should not see temperatures in mortality compost much over 160 degree F. Charring and fire potential becomes serious when piles approach 180 degrees F.

(Additional information and USDA-NRCS standards for this practice and related facilities can be found in Practice Standard 316 and the National Engineering Handbook; see References Section for full citation.)

Equipment Decisions

Since the goal of animal mortality composting is environmentally sound, labor-efficient disposition of animal carcasses and related waste, and not a fully functional comprehensive composting program for manure and other organic materials, equipment choices are easier to make. For a full discussion and overview of equipment for a comprehensive composting program, please reference: Compost Fact Sheet #7 from the Cornell Waste Management Institute, “Compost Equipment” 2004/2005. At a minimum, carcass composting will require a front-end loader, but a probe thermometer and screen are also recommended for the best success.

A tractor with a bucket or skid-steer loader are imperative for building the pile or loading the bin, in addition to easily moving and placing larger mortalities. The size and number of carcasses to be encountered throughout the year will dictate the needed loader size. A poultry facility will obviously be able to utilize smaller equipment than a beef feedlot or dairy. A dairy may have up to 8% operational mortalities throughout the year with Holsteins weighing as much as 1,400 pounds. Beef steers may be smaller, in the 500 to 1,000 pound range; sows (350 to 500 pound range) on a hog operation can also be quite large, requiring appropriate sized equipment.

Rotary Drum Composters – Several manufacturers in the U.S. and Canada are now manufacturing rotary drum, or in-vessel composters suitable for mortality management. These are mechanically driven horizontal drums that are loaded with carbon material and mortalities. Sizes vary from 200 gallons (suitable for poultry) on up to units the size of a standard semi-tanker trailer. The insulated drums slowly, and continuously, turn. For small and medium carcasses, time to finished compost can be as short as 3-7 days. This technology requires the purchase of a unit, or hired services of a contractor with a trailer-mounted mobile drum system.

Home-made screen, credit: Bass

Probe thermometers will help in finishing the compost once the bulk of the carcass material is degraded. Reaching benchmark temperatures in the final product will help destroy pathogens and sterilize weed seeds. These temperatures are discussed in the *Composting Principles* section of this document. Probe thermometers are available in dial or digital format. A 36" dial probe thermometer can be found at several agricultural and natural resource supply companies for under $100. They are often listed as "dial soil and compost probe thermometer." Digital versions are also available, at a higher price, and may be part of comprehensive packages that also measure oxygen and moisture.

A screen is also helpful in improving final product quality, especially if the compost will be land applied. A screen allows for the separation of compost fines from residual bones and other trash such as bailing twine, ear tags or other material. The simplest screen, ideal to have near the mortality compost site, is a frame of angle iron with an expanded metal face. The face should be angled at 45 degrees or more, and elevated 1 to 5 feet off of grade with the top of the screen appropriate to the reach of the loader being used. The width should also be relative to the width of the bucket on the operation's loader. For example, screen area should be five to six feet wide by six to eight feet long, angled and elevated as previously described. More discussion of bones and screening is found in the *Issues* section of this document.

Effect of Climate

Temperature and Precipitation

Composting can occur practically all year, even in the cold and semi-arid climates of the upper plains and Rocky Mountains. Winter temperatures usually slow the process down, and can prevent adequate initial heating. It has been documented in southern Canada, during winter, to lower the amount of decomposition by 20 percent during the thermophilic (hot) and mesophilic (warm) stages of composting. However, research in Montana has shown temperatures in a mature cow compost bin to reach above 130 degrees F within days of start, even during winter conditions. As previously mentioned, some tips for mitigating the effects of cold ambient temperature include: incorporating the carcass before it freezes, using an active material (silage, manure solids, warm compost) around the carcass and core of the pile, and capping the pile with extra insulating material such as sawdust.

Though carcass moisture will be sufficient to start the process, proper moisture in the co-composting materials (carbon sources) is also important. Fresh or green sawdust and shavings are excellent. The arid western climate can inhibit complete composting and curing. After several weeks (or months) of static composting, the pile should be turned and watered to finish off the process moving into the curing phase. Warm weather increases the amount of water that is lost to evaporation; curing piles should be monitored more closely to assure adequate moisture, assuring that sufficient microbial activity can occur during this phase of the process.

While much of the northern plains and Rocky Mountains are dry for most of the year, there are periods when moisture can become excessive. Excess moisture is not so much an issue with the piles themselves but with traffic lanes and carbon sources. Carbon sources should be properly stored or covered if precipitation could saturate them. Carbon sources in the previously mentioned 40-60% moisture range are very ideal for mortality composting and continue to absorb moisture, preventing leaching. Excessively dry compost piles will actually shed water for a time before they begin to absorb moisture. Snow does not seem to affect the pile and may serve as an insulating blanket during periods of extreme cold. Bad weather, of course, can increase mortality and base piles should be constructed ahead of time in expectation of weather-related deaths.

Snow on pile/bin, credit: Dafoe

Issues To Watch Out For

Bones

Bones and miscellaneous trash can impact quality of material for end use, especially if moving off-farm. Shards of un-degraded large bones such as long leg bones and hip girdles can even puncture tires on farm equipment. Therefore, screening is advised to remove bones or other trash from the compost. Bones may be reincorporated to new mortality compost piles, for further break-down; residual bone can be used in the base of a new pile adding pore space for air circulation.

Small vs. Large Operations: Issues of Scale

A primary issue with scale will be selecting the site and sizing the area dedicated to mortality composting. General site recommendations are previously covered in the *Site Selection* section of this document; however, sizing for a small livestock operation will be different than a large dairy. Consider the operation's operational mortalities. A single large cow may require a compost pile with a base of 10 by 12 feet if not contained in a bin or bunker of some sort, whereas one could compost several small animals in the same space. Likewise, the amount of carbon material needed to incorporate large carcasses will be greater for more and larger animals. This is discussed in the *Incorporating Dead Materials into the Carbon Process* section of this document. Finally, scale affects equipment selection, such as the size of a loader or tractor needed to haul, lift into place, and cover mortalities with material. Equipment selection is discussed in the *Equipment Decisions* section of this document.

Scavengers

Proper coverage and capping of mortality compost piles is vital to discouraging scavengers. Also, fencing around mortality compost is advisable for the same reason. At two sites in rural Montana with known dog and coyote populations, little to no scavenger activity has been noted. In some areas, the practice of composting, in general, should be carefully considered and protected in order prevent attraction of dangerous scavengers such as grizzly bears.

Odors

Properly managed compost, even mortality compost, should not produce great odor. Some materials available for composting may cause more odor than the mortality itself. This may be the case with silage, manure or some crop residues, especially oil seeds or spoiled feed. An adequate cap on the pile of inert material such as sawdust or finished compost will help reduce, if not eliminate, odor.

Nuisance

The greatest nuisance associated with mortality compost is likely to be flies and other insects. Additionally, longer term compost piles may harbor noxious weeds whose seeds are introduced to the pile by carbon materials used or from the surrounding environment. Moisture and temperature will play a role in managing both. High moisture can lead to better breeding for flies. Turning the compost towards the end of the process and allowing re-heating to around 140° F after the bulk of the carcass is degraded will help sterilize most weed seeds. An overall weed control program and knowledge about the carbon sources will also help control this potential problem. Herbicides used on or near compost, or on source materials can persist in the final product. Therefore, their use should be carefully considered.

Neighbor Relations

Proper management of the previously listed issues is important for neighbor relations. While it is discussed in this publication that mortality compost sites should have good all-season access, they should also be visually screened from public roads and neighboring properties. Likewise, good management practices that prevent scavenger activity, reduce odors, and limit flies are all imperative for maintaining good neighbor relations.

Prion Diseases and Composting

The science on this issue is still inconclusive; composting suspect animals should be avoided. Prion diseases, such as scrapie (sheep), chronic wasting disease (CDW; deer and elk) and bovine spongiform encephalopathy (BSE; cattle), are diseases that cause a degeneration of the central nervous system. Prion diseases appear to be extremely durable in the environment, likely because of their ability to bind with soil minerals. In one experiment, scrapie remained infectious after burial in garden soil for three years and anecdotal evidence suggests that the disease persisted for 16 years in an abandoned sheep barn.

One recent study suggests that composting may have the potential to degrade the part of the protein responsible for causing infection, called PrPSc. In this study, the PrPSc in samples of scrapie-infected sheep tissues (i.e., central-nervous-system, lymphoid system, and various organs) experimentally composted in a static-pile passive-aeration system were demonstrated to have degraded after 108 days; however, this study did not specifically measure infectiousness of composted tissues.

Another study, which simulated a natural scenario in which an infected animal dies and remains at ordinary physiological and ambient temperatures, indicated that the N-terminus of brain-derived PrPSc, a section of the protein vulnerable to cleavage, was lost after 7-35 days(3). While this study demonstrated that PrPSc can be degraded in certain environmental conditions, it did not determine the infectivity of the resulting, damaged protein.

Based on this recent work, it appears that composting conditions that include high heat and bacteria may degrade PrPSc, but that these conditions are not typical of natural environments. The risk of disease transmission appears to be most heavily influenced by the degree of by-pass, which is the compost that does not reach critical temperature because of its location in the pile. A United Kingdom investigation of BSE concluded that composting and compost spread on pasture were safe when a 2-tier (primary and secondary) composting system was used together with a 2-month grazing ban for the treated pasture.

Because prion diseases are transmissible between mammalian species, are incurable, and are highly infectious, extreme caution should still be used when disposing of infected carcasses. Incineration and burial in landfills, practices often used to dispose of infected carcasses, may create air and water contamination risks and may be publically unpalatable. Certification of flocks for scrapie free status can be done and may open up composting as safe mortality management tool.

Compost Quality, Use and Other Considerations

Mortality Compost Quality and Use

The practice of mortality composting has been explained in this document as an alternative to other management methods. There are environmental and financial benefits to the practice compared to alternative disposal methods and composting may result in value added product. Mortality composting has also been discussed here as a stand-alone process and not necessarily part of a larger compost business that may also be related to the livestock or poultry operation. At this time, *mortality* composting should be considered a management option and not something that would be highly marketable. This is especially true where there are other composting operations going on. The benefits are reaped from use on-farm.

Mortality compost is finished when the soft tissues, odors, and most of the bones are no longer present in the bins, piles or windrows. Since safe animal disposal is the goal, the compost quality would not necessarily be that of retail quality compost. Large bones and fragments can persist, as well as misplaced vet waste (syringes, needles or vials), implants, ear tags or other non-degradable materials. The appearance of these items in material sold or given away could be a liability against the producer. Finally, even with well-managed mortality composting, there is a possibility that not all pathogens were destroyed. Even if cause of death was not known to be the result of disease, exporting mortality can be a great bio-security risk (please see *Prions* section, particularly if you are considering composing of small ruminants).

The best recommendation for use of mortality compost is to re-incorporate it into the mortality management process. Finished compost can be used for core and cap, though old exposed bones may attract unwanted attention. Reusing the compost in this manner will continually break down residuals from the last batch and often help jump-start the next mortality pile. If this compost is land applied, it should be used carefully on the producer's property. As a final precautionary measure, avoid using mortality compost on crops or plants such as vegetables that are for direct human consumption. Have the material tested for nutrient value before using it as fertilizer or a soil amendment.

Emergency Situations

Emergency Response Plan

All livestock operations need to have an emergency response plan (ERP, also known as an emergency action plan, EAP) developed that describes how to deal with catastrophic mortality loss. This is also a requirement in nutrient management plans for permitted animal feeding operations. Local Emergency Management Coordinators and County Extension Agent should be consulted prior to developing that plan, as they have access to resource materials and are acquainted with the local, state, and federal officials who will need to be contacted following a catastrophic mortality event. In addition, in many major livestock production areas, the Emergency Management Coordinator will have already developed an ERP for the county that a livestock operation may be able to "piggyback" onto.

Catastrophic Mortality Loss

Routine mortality losses are relatively simple to deal with. However, a livestock operation may encounter a catastrophic mortality loss at some point. In this situation, a producer is faced with the death of many animals as a result of one incident or event. Some examples could be a barn fire, flooding, tornado, ventilation failure in a building, poisoning, animal disease, heat stress, or a blizzard.

Carcass disposal following a catastrophic mortality loss can be a daunting task and may pose a unique set of issues. Typical carcass disposal regulations are designed with the intent of routine on-farm losses, where one or two animals are lost from time to time. A catastrophic mortality event may require disposal of more animals than what current regulations will allow. Therefore, special permitting may be required. In addition, the circumstances of death may require that the mortalities be disposed of in a specified fashion. As an example, if a large number of cattle are poisoned; those animals would not be disposed of via a rendering service; as there could be potential of contaminating pet foods.

Having an ERP in hand will speed the response to catastrophic losses and do so in a fashion that will hopefully help to limit liability and public health and safety concerns. Often times a catastrophic mortality loss coincides with a disaster or event that is already a major news event, such as a tornado striking a community including five beef cattle feedlots. The ability to quickly and efficiently execute a well-planned, environmentally friendly, humane, and health conscious response can help avoid poor public perceptions and negative press.

Many of the people tasked with responding to a catastrophic mortality event have expressed a preference for composting, especially when the land space and resources are available. When proper precautions are taken, composting can help protect water quality and air quality when compared to mass burial or incineration.

High Water Events & Your Compost Pile

Compost piles, no matter how they are constructed, should never be situated in a flood plain. Should a heavy water event occur, the compost operation should be inspected as soon as possible, to ensure that erosion of the compost has not occurred. Damaged compost piles may require reforming or even complete reconstruction. Although rare in the Rocky Mountains, for areas that receive more than 40 inches of annual rainfall, it is recommended that compost bins/pits be covered by a roof if possible.

Tornado/High Winds & Your Compost Pile

Tornados and/or excessively high winds may cause damage to a compost operation. Following high-wind events, compost piles should be inspected to determine if recovering or reforming of the pile is necessary. In addition, in some cases carcasses may have been removed from the compost and transported elsewhere by a tornado. In this type of situation, the local Emergency Management Coordinator should be contacted and informed in order to manage any possible public health risks.

Economics of Livestock Mortality Disposal

Mortality Composting as a Viable Option

Mortality composing is becoming a viable option for many farmers and ranchers out of sheer economic necessity. For many years, rendering services were the preferred choice for disposal of animal mortalities and, in many cases, is still a preferred method if the price is right. However, these services have become so few and far between that their fees are usually too expensive to justify. As in any enterprise, necessity and expense are great incubators of invention. This turn of events, along with an improved understanding of composting principles, have led many to turn to composting as a viable alternative for disposal. As composting practices have become more widely researched and implemented, they have emerged as a viable and economically smart solution for livestock operations.

Equipment and Facility Needs

The equipment required to conduct composting on an individual operation will vary with size of operation and volume of mortality losses. In general, many medium to large operations may already have the needed equipment. A front-end loader with capacity to move the types of carcasses encountered, and composting material, will serve basic equipment needs for most operations. Those also composting manure or other materials in windrows have specialized equipment dedicated exclusively to composting activities. The cost of a new commercial compost turner or windrow machine may range from $30,000 to more than $100,000. Although used composting equipment and leases are available; this type of equipment is not necessary for mortality composting, and not recommended for bin and single pile composting. A more in-depth discussion of equipment is included in the section titled “Equipment Decisions.”

Facility needs for a successful composting operation primarily includes open space to place windrows of composted material. This space should be sufficient to place windrows of composted material for a period of at least six months without need to remove. Sufficient room to maneuver equipment in and around compost windrows is also necessary. A complete discussion of site and facility needs is included in the section titled “Site Selection.”

Making the Decision

The decision to move away from conventional disposal methods and towards mortality composting requires some thought into the benefits and costs of such a change. All producers can use the partial budgeting principle to compare various benefits and costs associated with making a change in their mortality management procedures. This process will help producers visualize the potential savings and/or costs of one method over another in real numbers.

The partial budget form provided in this manual is designed to help produces look at adjustments in a portion of any business enterprise and evaluate whether it is a desirable option. Because partial budgeting only looks at incremental changes that come with a change of business practices, only the items specific to the decision are considered.

Key to the process of partial budgeting is the concept that changes in a business will result in one or more of the following: additional returns (+), additional costs (-), reduced costs (+), and reduced returns (-). As designated by the +/- symbol behind each of these results (Figure 1), offsetting effects of positive and negative result in a final result when all figures are totaled. If the net result of the above figures is positive, the change is thought to be positive to the bottom line of the business.

Partial Budgeting and Avoided Cost

Partial budgeting is a form of budgeting that looks at potential changes in an operation to gauge whether the proposed change(s) would be a benefit to the profitability of the enterprise. While many portions of a business are fixed in the short run, partial budgeting looks at changes in resources that are not fixed, often times looking at long-term structural changes to a business practice. Only items that change from one alternative to the next are considered in the calculations.

The partial budgeting example in Figure 1 illustrates some items that might be considered in evaluating the financial feasibility of transitioning to composting versus continuing to use a rendering service. In the left column, positive returns to the operation after the proposed change are totaled. These items include Additional Returns to the operation and Reduced Costs. If it is possible to sell compost, this might be an example of an additional return, while reduced rendering fees would be an example of reduced costs.

The right column of the partial budget totals negative returns to the operation after the proposed change. Additional Costs and Reduced Returns comprise these negative financial aspects of a proposed change. An example of additional costs is additional equipment, labor, and repairs specific to the composting operation.

After all items are accounted for in the partial budgeting process (Additional Returns, Reduced Costs, Additional Costs, and Reduced Returns), the negative column (B) is subtracted from the positive column (A) to show the final result of the partial budget. If the result of this calculation is positive, the proposed change is considered to be a financial benefit to the operation. In the above example, the result is a positive $400 ($1,250–$850 = $400). This means that, assuming all items are accounted for, the operation would be $400 better off by switching to a composting operation.

Of course, the result of this calculation will vary depending on operation size, location and resources. The intent of the partial budgeting process is to “clear the smoke” of all aspects of the operation that will not be changed under the proposed change. By only considering the items relevant to the proposed change, the true effects on an operation's profitability are highlighted.

A blank partial budget form has been provided (Figure 2).

Partial Budget Form

Proposed Change: Composting Livestock Mortalities Vs. Rendering Service (10 Cows Annually)

Additional Returns		**Additional Costs**	
Compost/Fertilizer		Equipment Repairs	150.00
		Carbon Source	200.00
		Equipment Labor	500.00
Total Additional Returns	$ -	Total Additional Costs	$ 850.00
Reduced Costs		**Reduced Returns**	
Rendering Charges	1,250.00		
10 @ $125			
Total Reduced Costs	$ 1,250.00	Total Reduced Returns	$ -
A. Total Additional Returns & Reduced Costs	$ 1,250.00	**B. Total Additional Costs & Reduced Returns**	$ 850.00
		Net Income Change (A Minus B)	$ 400.00

Figure 1. Example of a partial budget comparing composting and a rendering service.

Partial Budget Form

Proposed Change: ____________________

Additional Returns		**Additional Costs**	
Total Additional Returns	$ -	Total Additional Costs	$ -
Reduced Costs		**Reduced Returns**	
Total Reduced Costs	$ -	Total Reduced Returns	$ -
A. Total Additional Returns & Reduced Costs	$ -	**B. Total Additional Costs & Reduced Returns**	$ -
		Net Income Change (A Minus B)	$ -

Figure 2. Blank partial budget form.

State Regulations and Permitting

The following discussions are based on state level regulations at the time of publishing. Local county or city regulations need to be researched before composting because they can place additional constraints on a composting operation. Likewise, consult the regulatory agency directly, or an Extension specialist knowledgeable on the subject.

Montana

State Regulations

Montana Code Annotated (MCA) 75-10-213 concerns dead animal disposal. Animal composting facilities are listed as approved disposition of dead animals; there is also reference to the required use of permitted composting facilities. However, in the exclusion that follows, it states that a person cannot be prohibited from disposing of waste generated in reasonable association with the person's agricultural operation upon land owned or leased, as long as no public nuisance or health hazard is created. Other rules imply that dead animal management cannot negatively impact waters of the state.

The Montana Department of Environmental Quality (MT-DEQ) reserves the right to revoke such privileges or exclusions if a proper plan for construction, operation, and maintenance of the composting facility is not followed, thereby resulting in a nuisance or public health hazard. Generally, the exclusion would not apply to divided land with tracts of land five acres or less in area. An alternate interpretation for permitted animal feeding operations (CAFOs with an MPDES Permit) is that mortality management practices defined and approved through that process would be authorized. In conclusion, properly designed and managed mortality composting can be done without a permit on property under the producer's legal control with said producer's animals, unless a nuisance or health hazard [or water quality impact] is declared.

Permitting Considerations

The MT-DEQ Solid Waste Division issues permits for composting operations in the state. They have a two-tiered system differentiating between large composters, that require a Class II Solid Waste Management System Permit, and small composters, which require a Small Composter Facility License. However, on-site mortality composting with that producer's animals may be done without permit under the conditions referenced in State Regulations for Montana. Contact the Montana Department of Environmental Quality–Solid Waste Division at 406.444.5300 for more information.

Wyoming

Regulations

Regulations that would apply to mortality management with composting are tied to Wyoming's Department of Water Quality. Section 14 of the state's water quality guidance states that dead animals or solid waste shall not be placed or allowed to remain in Wyoming surface waters. Compost is generally considered to be part of the solid waste stream and as such must stay out of the state's surface waters.

Animal feeding operations have specific regulations that require the preservation of water quality. Any activity that would jeopardize water quality is not allowed; this would include inappropriate carcass disposal. All Wyoming surface waters which have the natural water quality potential for use as an agricultural water supply shall be maintained at a quality which allows continued use of such waters for agricultural purposes. Unless otherwise demonstrated, all Wyoming surface waters have the natural water quality potential for use as an agricultural water supply.

Permitting

A permit to compost dead animals associated with a livestock operation is likely not needed. Those considering composting in Wyoming are encouraged to read Solid Waste Guideline #17 from the Wyoming Department of Environmental Quality and Wyoming Department of Agriculture. Questions should be directed to the WDEQ (307.777.7752).

Colorado

Regulations

In Colorado, there are two regulatory bodies involved in composting, the Colorado Department of Public Health and Environment (CDPHE) and the Colorado Department of Agriculture (CDA). The CDPHE's focus is on protecting public health and the environment at the composting site, while the CDA's focus is on protecting consumers from poor quality compost and guiding compost uses. CDA also has regulations related to burial of mortalities.

Permitting Considerations

The CDPHE is responsible for the Solid Waste Regulations in Colorado as they apply to composting facilities (Section 14). There is, however, an agricultural exemption that is granted under certain conditions:

- The composting feedstocks are all agricultural wastes (from crop or animal production) generated onsite.
- The only feedstocks allowed to be imported onto the composting site from off-farm are wood chips and tree branches. They can only be brought on-farm in quantities necessary for effective composting, and they can only be stored for a maximum of nine months. In the case where off-farm feedstocks are brought on-farm for composting, the finished compost can only be applied to agriculturally zoned land.

Detailed information describing these requirements is found online in the regulation itself (http://www.cdphe.state.co.us/hm/sw/section14/basispurpose.pdf). Mortality composting sites co-located at permitted animal feeding operations will be subject to AFO/CAFO regulations also.

New Mexico

Regulations

In New Mexico, the primary regulatory body that addresses composting is the Solid Waste Bureau with the New Mexico Environment Department. Secondary authority is found in the Groundwater Quality Bureau for protection of water resources in, around, and below a composting site. Regulations are applicable based on tonnage per year. The regulations are summarized in the *Permitting Considerations* section.

Permitting Considerations

The New Mexico Administrative Code requires any person operating or proposing to operate a composting facility that accepts greater than 25 tons per day annual average compostable material or greater than five tons per day annual average of material that would otherwise become special waste (e.g., sludge, offal), shall submit a permit request and plans outlined in the administrative code. Much of the language is intended for those that intend to accept mortality or offal from outside sources. An individual that generates less than five tons per day of what would be considered special waste (i.e., offal, mortality, etc) would not be subject to regulation but should follow best management procedures and be especially mindful of nuisance ordinances and any county regulations. For more detail and information please visit the Title 20 website at http://www.nmcpr.state.nm.us/nmac/parts/title20/20.009.0003.htm or the Solid Waste Bureau's website at http://www.nmenv.state.nm.us/swb/

References By Section

Animal Mortality Composting

Bonhotal, et. al. 2002. Natural Rendering: Composting Livestock Mortality and Butcher Waste. Fact Sheet. Cornell Cooperative Extension, Ithaca, NY.

Fulhage, C. D. 2001. Management of Livestock Mortalities through Composting. International Symposium Addressing Animal Production and Environmental Issues. National Center for Manure and Animal Waste Management. North Carolina State University, Raleigh, NC.

Looper, M. 2002. Whole Animal Composting of Dairy Cattle. Guide D-108. New Mexico State University, Cooperative Extension Service, Las Cruces, NM.

VanDevender, K. and J. Pennington. 200_. Organic Burial Composting of Cattle Mortality. FSA1044-PD-7-04N. University of Arkansas, Cooperative Extension Service, Little Rock, AR.

Natural Resource, Agriculture, and Engineering Service. 1999. Field Guide to On-farm Composting. NRAES-114. Natural Resource, Agriculture, and Engineering Service, Ithaca, NY.

Site Selection and Environmental Management

Alberta Agriculture, Food and Rural Development. 2002. Livestock Mortality Management (Disposal). Retrieved April 23, 2003, from http://www.agric.gov.ab.ca/engineer/livestock_mortality.html

AUSVETPLAN. 1996. Operational procedures manual disposal, Edition 2.0, Disposal Plan, 8-130-131. Retrieved April 21, 2003, from http://www.aahc.com.au/ausvetplan/disfnl2.pdf

Bagley, C.B. 2002. Alternatives for dead animal disposal. Logan, Utah: Utah State University Wild West Veterinary Conference.

Cornell Waste Management Institute. 2004/2005. Compost Fact Sheet #7: Compost equipment. Cornell Waste Management Institute, Department of Corp and Soil Sciences, Cornell University. Ithaca, NY.

Fulhage, C. 1997. Feed Facts: Composting Swine Carcasses. University of Missouri, Columbia, Missouri. Retrieved March 5, 2003, from http://www.moormans.com/feedfacts/swine/hogjan97/compost.htm

Harner, J.P. 2006. Environmental Considerations for Composting Livestock Mortalities. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF2729.

Haug, R.T. 1993. The practical handbook of compost engineering. Boca Raton, Florida: Lewis Publishers, Press, Inc.

Keener, H.M., & Elwell, D.L. 2000. Mortality composting principles and operation. In Ohio's Livestock and Poultry Mortality Composting Manual. Ohio: The Ohio State University Extension.

Looper, M. 2002. Whole animal composting of dairy cattle. East Syracuse, New York: Dairy Business Communications. Retrieved May 2, 2003, from http://www.dairybusiness.com/western/Nov01/NovWDBcompost.htm

McGahan, E. 2002. Pig carcass composting. Australia: Queensland Government Department of Primary Industries. Retrieved May 14, 2003, from http://www.dpi.qld.gov.au/pigs/5131.html

Mescher, T., K. Wolfe, S. Foster, & R. Stowell. 1997. Swine composting facility design (Fact Sheet AEX-713-97). Columbus, Ohio: The Ohio State University Department of Food, Agricultural and Biological Engineering. Retrieved May 12, 2003, from http://ohioline.osu.edu/aexfact/0713.html

Morse, D.E. 2001. Composting animal mortalities. St. Paul, Minnesota: Minnesota Department of Agriculture Agricultural Development Division.

Rosenfeld, P. E., & C. L. Henry. 2001. Activated carbon and wood ash sorption of wastewater, compost, and biosolids odorants. Water Environment Research, 73 (4).

Rynk, R. 1992. On-farm composting handbook. Ithaca, New York: Northeast Regional Agricultural Engineering Service.

Sciancalepore, V., M. Colangelo, C. Sorlini & G. Ranalli. 1996. Composting of effluent from a new two-phase centrifuge olive mill. Toxicological and Environmental Chemistry 55 (1-4), 145-158.

USDA-NRCS. Hydrometeorological design studies center, precipitation frequency data server. 2010. [accessed online, http://hdsc.nws.noaa.gov/hdsc/pfds/index.html].

USDA-NRCS. 2000. National Engineering Handbook, Part 637, Chapter 2 Composting. United States Department of Agriculture. Washington D.C.

USDA-NRCS. 2010. Conservation Practice Standard, Animal Mortality Facility (no.) Code 316. United States Department of Agriculture. Washington D.C.

Issues to Watch Out For

Morse, D.E. 2001. Composting animal mortalities. St. Paul, Minnesota: Minnesota Department of Agriculture Agricultural Development Division.

Rosenfeld, P.E., & C. L. Henry. 2001. Activated carbon and wood ash sorption of wastewater, compost, and biosolids odorants. Water Environment Research, 73 (4).

Compost Quality, Use, and Other Considerations

Wiggins, R. C. 2009. Prion stability and infectivity in the environment. Neurochem Research 34:158-168.

Saunders, S. E., S. L. Bartelt-Hunt, and J. C. Bartz. 2008. Prions in the environment. Prion 2:162-169.

Saunders, S. E., J. C. Bartz, G. C. Telling, and S. L. Bartlet-Hunt. 2008. Environmentally-relevent forms of the prion protein. Environmental Science and Technology 42:6573-6579.

Huang, H., J. L. Spencer, A. Soutyrine, J. Guan, J. Rendulich, and A. Balachandran. 2007. Evidence for degradation of abnormal prion protein in tissues from sheep with scrapie during composting. The Canadian Journal of Veterinary Research 71:24-40

Berge, A. C. B., T. D. Glanville, P. D. Millner, and D. J. Klingborg. 2009. Methods and microbial risks associated with composting of animal carcasses in the United States. Journal of the American Veterinary Medical Association 234:47-56

Xu, W., T. R. Reuter, G. D. Inglis, F. J. Larney, T. W. Alexander, J. Guan, K. Stanford, Y. Xu, and T. A. McAllister. 2009. A biosecure composting system for disposal of cattle carcasses and manure following infectious disease outbreak. Journal of Environmental Quality 38:437-450.

State Regulations, Permitting, and Tax Considerations

Colorado Department of Public Health and Environment. 2008. Amendments to the regulations pertaining to solid waste sites and facilities (6 CCR 1007-2 Part 1) – Revision of Section 14 Solid Waste Composting Regulations. http://www.cdphe.state.co.us/hm/sw/section14/basispurpose.pdf (accessed August 10, 2010).

New Mexico Environment Department. Solid Waste Bureau. http://www.nmenv.state.nm.us/swb/ (accessed August 10, 2010).

New Mexico Environment Department. Permits, certificates, and license. http://www.nmenv.state.nm.us/permits.html (accessed August 10, 2010).

New Mexico Solid Waste Facility Permits and Registration, Title 20 Environmental Protection, Chapter 9 Solid Waste. http://www.nmcpr.state.nm.us/nmac/parts/title20/20.009.0003.htm (accessed July 27, 2010).

Quick Reference Guide

Critical components of livestock mortality composting. Refer to text for more complete explanations.

Step	Considerations
Planning	**Does it make sense for your operation?** Composting is a good alternative for any operation that has appropriate space and equipment for moving mortalities and compost materials. **Permitting:** Check with county and state agriculture and environmental offices (see section "State Regulations and Permitting" for more information). **Minimum tools:** tractor with frontend loader; 36- to 48-inch compost thermometer.
Select a site	**Size:** About 200 cubic feet per 1000 lbs. of livestock mortality, or 10 x 10 x 6 feet for a single large animal pile, or 6 x 6 x 6 feet for a bin. **Shape:** Windrows are best for airflow and ease of management, but bins made from wood or large hay bales allow tighter piling and a smaller footprint. **Location:** Choose an area with enough space to build and turn compost, deliver and move mortalities and base, core, and cover materials. It should be away and downwind from neighboring properties where scavenger activity can be monitored and discouraged. **Drainage:** Choose fine (not sandy or gravelly) well drained soils at least 3 feet above ground water and 300 feet from streams, ponds, wells, other water resources. An ideal site would have a gentle slope for drainage. Underlay piles on coarse soils with 6 inches of compacted sand or gravel, or sometimes clay or concrete. Construct berms to divert runoff if necessary. **Covering:** Compost piles in the semiarid west generally do not need to be covered, but should be monitored for runoff or seepage during unusually wet periods events.
Build the compost pile	**Lay the base:** 12 to 24 inches of wood chips or shreds that allow air flow and are not compactable or excessively wet. Spread to allow 18- to 24-inch margin. **Prepare the animals:** Breaking up large mortalities will speed the process. The body cavity should be opened and the rumen punctured for cattle, sheep, and goats to prevent excessive bloating and displacement of cover material. **Place the animals:** Place large mortalities on one side in the center of the base material. Smaller mortalities can be stacked with 8 to 12 inches of core material between layers. **Place the core:** 12 to 18 inches of fine, actively composting material with 50 to 60 % moisture content, such as manure, silage, or recycled compost is ideal *(squeeze test: at 50-60% moisture a few drops can be squeezed from a handful of material)*. Adding water is often necessary to start at this moisture level. **Place the cap:** 6 to 12 inches of fine, moist, low-odor material such as sawdust with 50 to 60 % moisture content to achieve 18- to 24-inch final margin around mortalities. Form flat or troughed top to collect moisture in dry regions. Peak the top to shed moisture in wetter areas.

Composting stage: 3 to 6 months	**Monitor temperature:** Thermophilic phase: Interior temperature should rise to 130-160^0 F within 2 weeks; if it doesn't, check moisture, start over. **Monitor cover:** Watch for odors, flies, and exposed mortalities from scavenger activity or movement by wind or water and cover with more material as needed. **Manage:** Turn the pile when temperature declines to $<80^0$ F for seven days. Check the moisture content right after turning and add water if necessary. If the temperature spikes again after turning, turn again when it declines.
Curing stage: 4 to 8 months	**Monitor temperature**: Mesophilic phase; warm, not hot temperatures. Bones breakdown during this stage in a slower decomposition process. The process is complete when the temperature stabilizes near ambient air temperatures. **Manage:** If temperature drops, the pile may need to be turned or mixed and moisture adjusted again. A small temperature increase after mixing indicates that the mesophilic curing process is underway.
Storage	Screen to remove remaining bones to reincorporate in to composting process. Store until land application or reuse in the core of a new compost stage.
Field application	Apply on the premises, or on fields where owner/manager is aware of the source of the material. Bone fragments can cause alarm if unexpected. Have the material tested for nutrient content and apply to non-food crop fields according to soil test based recommendations.

MONTANA STATE UNIVERSITY EXTENSION

Colorado State University

NM STATE Cooperative Extension Service

UNIVERSITY OF WYOMING COOPERATIVE EXTENSION SERVICE

NRCS Natural Resources Conservation Service

WESTERN SARE