

# Manure Management for Small and Hobby Farms



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# Manure Management Handbook

## FARM STEWARDSHIP

### Introduction

This handbook is intended to meet the needs of small scale livestock producers. It provides information that can benefit farm operations with any type of farm animal—horses, cows, goats, sheep, llamas, pigs, chickens, and rabbits.

Owners of livestock—no matter what the type of animal—face similar challenges when managing manure. Often manure is stockpiled because farmers do not know what to do with it. These piles can seep manure runoff into waterways or wells. Disposal of manure in gullies, ditches, and other “out of the way” places also can lead to water contamination.

Manure management encompasses a wide range of activities, including pasture and paddock management, manure storage, and manure utilization.

Used on the farm, manure can provide nutrients needed for forage or crop production; used off-farm, manure supplies nutrient resources to crop or organic farmers, gardeners, soil producers, and others. This handbook presents tools to help livestock owners turn manure into an asset, instead of a problem.

### Why Manure Management?

Manure can be a valuable resource if well managed. If improperly managed, manure can be a source of water pollution, odor, flies, parasites, and other nuisances. It can contaminate drinking water, harm wildlife, and reduce property values.

Manure management is an important factor in the health of livestock. Mud and manure can cause abscesses, thrush, rain scald, and other diseases in livestock. Dried manure produces molds that contribute to respiratory problems in horses and cattle. By adopting simple and low cost best

management practices for storing, handling, managing, and utilizing manure, the environment and the health of farm animals will benefit.

#### Goals of Manure Management

- ▶ Utilize manure nutrients for enhancing soil.
- ▶ Protect health and safety of the public and livestock.
- ▶ Prevent surface and ground water contamination.

### The Path to Best Management Practices for Manure

A proper manure management system utilizes the benefits of manure, for on- or off-farm use, without polluting the environment or offending neighbors. Best management practices on small farms are practical, cost effective, and easy to implement. Start by identifying existing and potential pollution sources or problems on your farm.

Farm Map: Walk around your property and make a basic map or sketch.

- Show the location of buildings, pastures, paddocks, manure storage area(s), wells, septic system and drain field, streams, dams, ponds, wetlands, crop land, property lines, and other pertinent features.
- Can the current layout and management systems be improved? Identify areas that may need improvement.

Farm drainage: Manure lying in the path of drainage will inevitably end up in waterways. Manure stored too close to wells can contaminate drinking water.

- Observe the pathways to water.



- ▶ Where are the well(s) and septic tank located?
- ▶ When it rains, what path does water take?
- ▶ Where does the water from the barn roof and sheds go?
- ▶ Where are low lying, wet areas, drainage areas, and waterways?
- ▶ What type of soil does your farm have?
- ▶ Is the soil compacted around farm buildings or other areas?
- ▶ Where are the slopes?
- ▶ Where are your neighbor's property lines?
- Chart the water drainage on your map.

Livestock numbers: Overstocking is the primary cause of water quality contamination on small livestock farms.<sup>1</sup>

- Excessive stocking rates contribute to overgrazing of land.
  - ▶ Check with the local Extension Service for the recommended stocking rates for the type and numbers of livestock your farm can support.
- If pasture is limited and animals are confined for significant periods, larger amounts of manure will be generated in barns (and paddocks), thus requiring additional handling and storage.

Pasture and paddocks: A basic step toward implementing best management practices for manure management is to ensure that manure is

spread uniformly across the pasture or removed as necessary.

- Do you rotate or limit pasture use?
- Are your animals standing in manure or mud?
- Are animals allowed to trample stream banks?
- Is the drainage good in the paddocks? Does water flow through it at any point?
- Do you have a system for spreading manure deposited in pastures or removal in concentrated areas, slopes, and near drainage areas?
- Is brown water running off bare pasture?



Current manure management practices: Best management practices for manure involve collection, storage, and utilization.

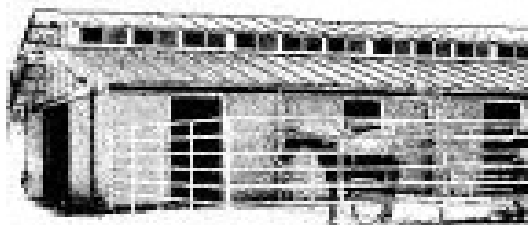
- Does your farm have a basic manure management plan?
- How is manure currently stored?
  - ▶ Is storage adequate to handle generation until manure can be utilized?
  - ▶ Is the storage area easily accessible?
  - ▶ Is it covered?
- Does your farm have manure odor problems? Fly or rodent infestations?
- Is manure utilized cost-effectively and in an environmentally-safe manner?

## Manure Management and Utilization Plan

A basic written plan for managing and using manure is a valuable tool for all livestock farms. The plan should include the following components:

- Quantity of manure and bedding generated annually from all livestock on the farm.
- Manure handling and collection methods and equipment used, including manure handling from barns, stalls, paddocks, and pastures.
- Size and location of storage and/or composting facilities.

- Methods used to prevent drainage through storage areas, paddocks, and pastures.
- Nutrient analysis of manure prior to application (if land applying).
- Soil analysis for lands on which raw or composted manure will be applied.
- Utilization records: land application, compost monitoring, or off-site uses.



## Manure Management Regulations

Livestock owners must take responsibility for the manure generated by their animals in order to prevent water pollution. Federal and state laws prohibit discharging animal wastes into water.

Consult with your State Agriculture Department for specific information on any state regulations that may apply to manure management and

recommended best management practices. The Agricultural Extension Service can provide information on state and local regulations or ordinances. Consult with the local health department for ordinances that may apply to storage and containment, such as design and setbacks.

## WHAT'S TO MANAGE

### How Much Manure?

It's a fact that all livestock generate manure. How much depends obviously on the type of animal. Bedding and how the animals are kept also contribute to manure management needs. The first step to properly manage manure is to calculate how much manure and bedding is generated.

The chart below provides a basic estimate of the amount of manure generated by different types of livestock. Additional charts for manure calculation and storage needs, along with a Manure and Bedding Generation Calculator, are contained in NERC's Manure Management Toolkit.

To estimate the manure generation on your farm, collect the manure and bedding from your farm for one week in a cone-shaped pile and measure the height and diameter of the cone. Multiply this by the number of weeks you estimate will be required for

storing the manure before it is used or composted. This enables you to determine the volume of manure generated and your estimated storage needs.

Average Manure Generation Per Day	
Animal (1AU)	Manure Produced (per 1000 pounds body weight) in ft <sup>3</sup>
Horse	0.7 - .81
Cow	1.1
Goat	0.6
Sheep	0.65
Pig	0.5 - .73
Alpaca/llama	0.68
Chickens	0.96
Ducks	0.73

Source: "Pollution Control for Horse Stables and Backyard Livestock," EPA, 1994 & "Strategies for Collection, Storage & Disposal—Managing Manure," Washington State University Extension, Clark County.

### Stall Waste

Adding soiled bedding to the manure equation can significantly increase the volume of waste material generated. Regularly removing manure and soiled bedding from barns and stalls is important to limit fly infestations and for the overall health of livestock, however options are available to help reduce the amount of bedding you will need to handle as waste material.

#### Bedding considerations

- Use less bedding.
  - ▶ Use enough bedding to soak up urine. Find the right amount of bedding needed to ensure the health of livestock while minimizing waste.
- ▶ Clean stalls carefully, removing only manure and soiled bedding.
- ▶ Pine shavings and sawdust typically result in less material to dispose of than straw.
- Consider rubber mats.
  - ▶ Rubber mats provide cushioning and make stall cleanup easier so that bedding can be reduced.
  - ▶ An initial investment is necessary, but reduced bedding purchases result in long-term savings.
- Alternative bedding products.
  - ▶ Newspaper bedding and wood pellets are more absorbent than wood shavings.

- ▶ Be sure to check recommendations for bedding products for specific livestock.
- Handling and marketing considerations.
  - ▶ The type of bedding used may impact the handling or marketing options for your manure.
  - ▶ Straw, newspaper bedding, and wood pellets will compost better than wood shavings.
- Deep bedding or “bedding pack.”
  - ▶ Typically used for cold weather bedding, this

1 Animal Unit (A.U.) = 1,000 pounds

system works well for smaller numbers of all livestock.

- ▶ A layer of fresh bedding is added over soiled bedding each day. Water and urine seep down to the lower layers of the bedding. The fresh bedding on top should be such that it keeps animals dry. It is important that when using this method, muddy or saturated conditions not occur.
- ▶ In the spring the old bedding must be removed from stalls prior to fly breeding season.

## PASTURE AND PADDOCK MANAGEMENT

### **Smart Grazing Strategies and Manure Management**

Better management of grazing areas not only fosters a healthier environment but also adds to the health of the livestock by creating more nutritional feed. A well-managed pasture will lower feed costs by reducing the amount of hay needed. Bedding and labor can also be reduced by distributing and utilizing manure in the pastures with limited removal.

#### Rotational (“prescribed”) grazing

- The easiest way to distribute manure in pastures and prevent overgrazing is to rotate grazing areas.
- It is generally better to have several small pastures instead of one large one. Subdivide the pasture into four or more areas. If there is insufficient pasture to subdivide into four areas, subdivide into two.
- Rotate livestock so that grass is left standing at about 2 inches (3 inches in mid-summer). Allow the grass to grow to about 8 inches before grazing animals on it again.
- Establishing multiple watering stations in a pasture and rotating feeding stations will foster better manure distribution.
- Do not allow manure to build up in pastures. If the pasture is large enough, spread manure thinly and uniformly using a harrow or pitchfork and rake. This enables manure to dry, reducing fly breeding.
- In the summer months spread manure on a weekly basis to disrupt the fly breeding and egg development cycle. If pasture size is limited or a problem with livestock parasites develops, collect all manure and remove to a storage area to prevent ongoing parasite problems.

#### **Mud Muck**

- Mud makes chore time unpleasant and potentially dangerous.
- Mud can transmit disease and contribute to illness in livestock.
- Mud increases fly breeding areas.
- Mud contributes to pollution runoff.

#### **Prevent Mud Before it Happens!**

- Manure should be removed weekly from heavily deposited locations such as around watering and feed areas, gates, and shade areas. If mud or parasite infestation is a problem, collect manure more often (at least every three days).
- Follow recommended fencing suggestions for your specific livestock.

#### Grazing practices

- Fence off access to streams to prevent manure from being deposited in or near waterways.
  - ▶ It is best to prevent livestock access to streams, rivers, or ponds. Use a tank for watering.
  - ▶ Farms that must rely on streams for watering can install “water gaps” or openings in fences that limit access but allow animals to drink in the stream.
  - ▶ Stationing a water trough in or near the livestock’s normal path to the stream reduces the time animals spend in the stream.



- ▶ Providing shade away from streams and waterways also reduces time spent by livestock in waterways.
- ▶ Avoid use of woven wire to fence off stream areas, as it collects debris and can be more easily damaged.
- Fence livestock out of wetland areas during the rainy season—when standing water or mud is present.
- Try not to graze livestock on pastures during rainy periods. Soils may become saturated, contributing to soil compaction, erosion, and manure runoff.
- Avoid overgrazing as damaged and eroded pastures can lead to increased manure run-off and water contamination.
- It is particularly important that manure is removed and pasture be well maintained in areas where the water table is close to the surface.

### Sacrifice pad

Also known as “pen,” “run,” “confined livestock area,” “feedlot,” “dry lot,” “turn out lot,” “rainy-day paddock,” or “exercise lot.”

- A “sacrifice pad” is a grazing management tool—a term for designating an area that is “sacrificed” from the grazing system.
- A sacrifice pad provides for better control of where and when livestock graze, preventing overuse of pastures, especially during times when soils are saturated and plant re-growth is slow.
- Farms with little acreage may rely on the sacrifice pad for heavy livestock use.
- In developing a sacrifice pad, consider the particular space requirements for your livestock and the amount of time animals are likely to be in regular pasture areas. Minimizing the size of the pad eases manure clean-up and preserves more space for pastures outside the confinement area.
- The sacrifice area should be located on high ground near barns or stables and at least 100 feet from wells, wetlands, and water bodies. A grassy buffer or filter strip around the area will help capture runoff (see below).
- The type of surface depends on the size and use of the pad, as well as the type and number of livestock. Sacrifice pad surface may require removal of topsoil and replacement with gravel, stone dust, or sand/soil mixture. Surface planning and preparation reduce mud in the long term.

- Manure and excess feed should be removed regularly in order to protect from contaminating runoff, reduce mud, and reduce fly-breeding habitat.
- Consult with the Natural Resources Conservation Service (NRCS) for assistance in designing a sacrifice pad suitable for your farm.

### Winter and rainy season considerations

- Grazing livestock on frozen pastures typically does not cause damage to pastures.
- Allowing animals to graze on wet and muddy pastures can lead to erosion problems, soil compaction, and potential permanent damage to pasture sod.
- Use of a sacrifice pad in rainy periods can help preserve pasture areas.

### Grass buffers, filter strips, and riparian areas

- Vegetated filter strips or grass buffers are protected areas of grass or brush located next to streams, wetlands, sacrifice pads, manure storage piles, and other sensitive areas.
- Riparian vegetation is a term that describes plants that grow in wet areas next to streams. These plants provide food and shelter for wildlife.
- Both grass buffers and riparian vegetation slow rain runoff, increase soil infiltration, and filter microorganisms, nitrogen, phosphorus, and organic matter from small volume runoff that may contain manure.
- The recommended size of a filter strip varies with the size and slope of the area draining toward the strip. Suggested widths for greatest effectiveness:
  - ▶ 25-50 feet for 0-3 percent slopes.
  - ▶ 50-100 feet for 3-8 percent slopes.
  - ▶ More than 100 feet for steeper slopes.<sup>ii</sup>
- To be effective, vegetative filter areas need to be well established before put to use.
- A vegetated earthen berm or diversion ditch increases the filtering effectiveness of the strip. Livestock must be kept off the filter areas. Other access (vehicles, tractors) also should be limited, particularly during rainy weather. Strips can be mowed, but not too short.





### Managing runoff and reducing mud

- Grading surface areas to improve drainage reduces runoff.
- Tile drainage, dikes, ditches, curbs, or channels can be used to divert runoff around pastures and into filter areas.
- Barns, stables, and indoor riding arenas should have a gutter and downspout system to collect and divert water away from the building and away from the manure storage area. While potentially a costly investment, such a system helps ensure protection of livestock, human health, and the environment. Downspouts can be emptied into stock watering tanks, rain barrels, dry well, tile line, road ditch, or other clean water outlets. Be sure to protect downspouts from animal and equipment damage. Open ditches that are close to barns or run by animal paddocks should be closed with a buried pipe used to carry water through it.
- The area around barn or stable entrances, paths, gates and other places where animals congregate can become muddy. Up to 18 inches or so of wood chips provides effective footing for most small farms. Reduce low spots where water can accumulate with gravel or fill. Use of geotextile fabric and gravel can provide a low-cost all-weather solution for small farms.

### **The Nutrient Cycle**

Soil organisms, pasture plants, and grazing livestock are all part of the nutrient cycle of a pasture. Healthy soil contains earthworms, fungi, bacteria, protozoa, arthropods, algae, and insects. Bacteria and other soil organisms decompose organic matter (such as manure), release nutrients from organic matter and soil minerals for plants to take up, improve soil structure, fight root diseases, and detoxify the soil.

The organisms, plants, and animals work together to produce healthy soils and pastures. Good quality soil reduces erosion because it enables water to drain rapidly into the ground. Good pastures will provide nutritious forage for livestock. Manure and plant residues break down effectively and contribute to the nutrient cycle.

## **MANURE CONTAINMENT**

### **Handling and Storage**

An effective manure handling system should take into account the farm's storage area(s), location, equipment availability, and manure utilization. Manure should be collected regularly from paddocks and stalls—this may mean daily removal depending on the type of livestock, herd count, and available grazing area.

Manure storage facilities do not need to be fancy. In most instances the storage area is temporary until the manure is land applied or hauled away. If composting the manure, the storage area can be the compost area or bins. The size and type of storage area or facility will depend on the volumes of waste generated and the length of time necessary for storage.



### Storage size

- The storage area must be large enough to effectively hold all the manure and bedding generated until it can be utilized.
- Planning for long-term winter storage of 180 or more days is necessary. Rainy weather and ground saturation in the fall and spring should also be taken into account. For many areas that may mean storing manure from October to April.
- Sizing needs to be based on the type of livestock, herd size, pasture availability, and stable practices.
- Make the storage area larger than estimated to meet the needs, as it is better to have excess room than to run out of space.
- Do not allow manure piles to reach more than 8-10 feet as this may pose a fire hazard.

## Location

- Locate the storage facility near the manure source. If manure is to be applied to cropland that is a significant distance from the barn or stables, a satellite storage area near the cropland may be appropriate (“field stacking”).
- Be sure to consider equipment access and maneuverability—whether wheelbarrow or tractor—when locating the storage area.
- Locate the storage area on high ground and away from drainage or run-off areas. Do not locate the storage area in a floodplain (if this is the only option, the storage facility must be properly protected from inundation during a storm or flood).
- The storage area should be level to slightly sloped (2-4 percent gradient to allow for drainage into a filter strip).
- It is essential that the storage area be accessible during inclement weather.

• The storage area should be located at least 100 feet from wells, potable water sources, wetlands, and surface water bodies (streams, ponds). Storage areas should be 200 feet away from residences and 50 feet from property lines. Do not store manure in stables or paddocks due to potential parasite exposure to livestock. Do not place storage piles near buildings because they can damage walls.

- Place the storage area downwind from stables/barns and (most importantly) neighbors’ residences. Consider prevailing summer winds when locating the storage area.
- If possible, locate the storage area in a remote area that is not visible to neighbors or even farm visitors. If this is not possible, consider using shrubbery or fencing to screen the area from view.
- Check with local town ordinances to see if there are any regulations for minimum setbacks.

## Storage structures

- For most small farms manure storage can be a pile contained on a pad or in a small shed.
- The use of a wooden or masonry “bucking wall” behind the pile will help in unloading and loading manure and will screen the pile from view.
  - ▶ Soil backfill can be used behind the bucking wall.
  - ▶ Reinforced concrete will be necessary for larger structures.

If animals have free access to pasture, but are fed in the barn, about half of the manure will end up in the barn.

## **Estimated Storage Size Needed**

<b>Livestock</b>	<b>Area Needed per Animal for Six Months Storage</b>
Horse	72 square feet
Cattle	72 square feet
Sheep	6 square feet
Pig	12 square feet
Goat	6 square feet
Llama	12 square feet

Estimates are based on a 5-foot high manure pile with average bedding. The actual space will vary depending on the type and amount of bedding used, the animal weight, and the height of the manure pile.

Source: “Managing Mud and Manure,” Small Acreage Factsheet # 11, Oregon Association of Conservation Districts and “Pollution Control for Horse Stables and Backyard Livestock,” EPA, 1994.

- ▶ Using three bucking walls contains the manure and leachate (drainage) more effectively and makes manure handling easier.
- Structures for storing larger quantities of manure (e.g., for more than a five horses, or AU equivalents) should be designed with three or four sides, a wide opening, a high permanent roof, and more durable construction in order to allow dumping and cleanout with power equipment.
  - ▶ Wooden or concrete storage sheds are options.
  - ▶ The structures should be constructed with rot resistant wood and reinforced concrete. Use stainless or galvanized steel fastenings to reduce corrosion problems.
  - ▶ Consult the Extension Service for storage structure designs.
- Manure storage structures should be monitored during the wet season to determine the amount of leachate draining from the pile and to ensure that it is properly draining into the filter area (see below).

## Pad or flooring

- Compacted earth or stone dust are adequate for farms with few livestock units, particularly goats, llamas, pigs, and sheep. If possible, elevate the flooring slightly above the surrounding ground.
- Packed gravel, road base material, or crushed limestone base is recommended for farms with horses or larger numbers of animals.
  - ▶ Lay the base on hard-packed or compacted soil. This creates watertight flooring. An impermeable liner can also be used.

- More substantial flooring (and ramp) can be constructed using 4-inch thick concrete over 6 inches of coarse gravel or crushed rock. The concrete can also be placed over compacted soil or 2 inches of sand.

- ▶ Concrete provides a more solid surface for easy removal of manure with power equipment and prevents nitrogen build-up in underlying soil.

- The floor can be slightly sloped to one or both sides to allow leachate to be diverted to the vegetated filter.

- If suitable terrain is available, a below-grade structure works well to contain the manure. Slope the entrance ramp upward to keep surface water from entering.

- ▶ Gravity helps in dumping the waste, the pile is out of view, and it can be easily covered.
  - ▶ Make one side of the structure at ground level for dumping and removal.

### Ramp

- A rough-surfaced ramp should be designed to lead into the storage area.

- A 20-foot width should be adequate for small farm and garden tractors.

- Carts or wheelbarrows can be accommodated with less width or even without a ramp. However, a ramp makes the path more stable, less prone to mud, and makes dumping easier.

- Whether using a small tractor or wheelbarrow, consider the space necessary to maneuver in and out when unloading or loading.

- If concrete or crushed rock is used for ramping, install angle grooves across the ramp to help drain rainwater.

### Covering

It is essential to cover the storage area to prevent run-off from the pile which can lead to water contamination. A covered area also protects the stored manure from losing nutrients.

- Tarp: Depending on the size of the storage area a watertight plastic tarp can be sufficient.

- Roofing: A permanent roof can be built to protect larger manure structures.

- ▶ A permanent roof makes access to the pile



easier as it does not need to be removed every time material is dumped.

- ▶ It isn't susceptible to wind or elements like a tarp.

- ▶ The height necessary for dumping and removing manure with power equipment, if applicable, must be taken into consideration.

- ▶ Install gutters to catch water flowing off the roof.

- If the manure storage area is to be left uncovered, it may be necessary to install channels, floor drains, and/or drainage pipes to divert and capture run-off to a liquid storage tank, holding pond, or treatment system.

### Managing runoff and seepage ("leachate")

- It is important that the storage area not pollute ground or surface waters. Water that is allowed to pool also promotes fly and mosquito breeding, which in turn can lead to livestock diseases.

- Stall waste is usually dry. However, manure from paddock cleanup may contribute to the formation of leachate. If stall bedding is not sufficient to absorb liquid from added manure, consider adding additional straw or similar material.

- ▶ Leaking waterers, wash water from flushing stalls, cleaning milking equipment, etc. may contribute to the moisture content of manure if not captured.

- A grassy or vegetated filter/buffer (at least 3-4 inches in height) should surround the manure storage area to prevent leachate from seeping into waterways. The filter acts as a relatively low cost drainage field for a farm wastewater treatment system.

- Trenching can be used to capture or divert manure pile leachate.

- ▶ Install piping around larger manure storage piles, or any size piles where seepage becomes an issue, to capture the wastewater and divert it to the filter area.

- Divert surface drainage water and roof runoff away from the pile area.

- Grading the area to divert surface runoff reduces soil erosion around the area.

- Filter sizing and design or run-off management may require professional assistance, particularly if the storage area is designed to hold large amounts of manure or if leachate from the pile is a problem. Contact the Extension Service, NRCS, or County Conservation District.

### Limiting other nuisances

- Flies lay eggs in the top few inches of moist manure. Manure removal from stables and paddocks (where concentrated deposits occur or through spreading) on at least a weekly basis breaks the fly-breeding cycle. Keep stables as dry as possible and limit mud in paddocks and pastures.
- Remove manure and bedding at least every three days to help prevent parasite and worm infestations.
- Cover freshly added manure in storage piles with stall waste, straw, or old hay to prevent surface exposure of the manure.
  - ▶ Create a flat surface area on the top of the pile prior to dumping fresh manure. This deters manure from flowing down the sides.
- Some odor from the manure storage area is inevitable, especially when fresh manure is added. It is important to consider placement of the storage area in order to minimize problems with neighbors.
- Shrubs and tree plantings around the pile deter materials from blowing from the pile when it is dry, help to contain odors, and provide a visual screen.
- Try to avoid use of pesticides around the manure pile or compost piles because beneficial fly predators (tiny, non-stinging wasps) and organisms beneficial to natural manure decomposition will be harmed.

A stalled horse requires removal of 60 to 70 pounds of waste per day.

This adds up to 12 to 13 tons of waste per stall, with about 9 tons being manure, 3.5 tons urine, and the remainder bedding.

The annual stall waste from one horse fills a 12-foot x 12-foot stall about 6 feet deep.

Source: "Agricultural Management Practices for Commercial Equine Operations," Rutgers University

### Other Containment Options

- Farms with few animals can store manure in plastic garbage cans with lids, wood or metal bins, or carts.
- Farms that are utilizing manure for land application can store manure and stall waste in the manure spreader.
  - ▶ Bedding may require additional aging or composting before it can be effectively spread.

- ▶ An additional storage area will be necessary to supplement when spreading is not practical (such as during winter and wet seasons).
- Dumpsters: Contract with a hauler to provide a dumpster for temporary storage of manure and stall waste.
  - ▶ Having the manure hauled to a compost operation is the best use of the manure, if possible. Landfill disposal should be considered as a last resort. It is costly because hauling and disposal fees are required and the nutrient value of the manure is wasted.
  - ▶ If being hauled to compost operation, the material in the dumpster must be kept clean (no garbage).
  - ▶ The lid should remain on the dumpster at all times to prevent water from seeping in.
  - ▶ To limit fly infestations, the size of the dumpster should match the storage needs for a week or less during fly breeding season.
  - ▶ The dumpster must be convenient to either the barn or stables, but also accessible to the collection vehicle.
  - ▶ If leachate from the dumpster occurs it is necessary to capture the seepage similar to other manure storage facilities (see above).
  - ▶ The dumpster should be placed on a firm footing. A concrete pad may be necessary.
  - ▶ The hauler will replace a full dumpster with an empty one or dump the waste into a collection vehicle. If a dumpster "swap" is used, space for two dumpsters is necessary in order for the hauler to leave an empty container.
- A truck bed can be used for temporary storage for later removal to the manure storage area. This may be necessary if the storage area is located away from the barn or stalls.
- All storage containers should be placed on woodchips or planted grass to contain spillage. Properly cover containers to prevent water from seeping in and to control odors.

### Manure handling tools and equipment

- For many small livestock farms, equipment for manure removal is a pitchfork or manure fork, shovel, metal rake (a grading or spreading rake works well), and wheelbarrow or handcart. A pick-up truck can also be useful.
  - ▶ Livestock farmers of goats, sheep, and llamas may find metal rakes with close tines, or even a broom and dustpan handy



for collecting manure off hard-packed surfaces.

- Lawn or garden tractors can be equipped with a tractor-mounted bucket for unloading and loading manure.
- Larger tractors are typically equipped with a tractor-mounted manure loader, scraper, or front-end loader.
- Manure should be handled carefully to prevent exposure to potential bacteria and protozoans (E. coli and Giardia) that may be present. Sanitary measures, including hand washing before touching food, eyes, etc., should be followed. Individuals that are sensitive to mold and dust should wear dust masks or properly-fitted respirators.

### Manure removal from storage bins

- It is important to remove the winter's stockpile of manure when the weather is still cold (below 65°F) before fly-breeding begins.
- When removing manure from the storage area leave at least a 4-inch dry pad of old manure/bedding on the bottom of the storage area to provide a stock of beneficial fly parasites and decomposer organisms. This will also help to absorb moisture as new manure is added.

Manure contains valuable plant and soil nutrients, including: nitrogen (N), phosphorous (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), copper (Cu), manganese (Mn), zinc (Zn), boron (B), and iron (Fe).

## **MANURE MANAGEMENT OPTIONS**

### **Overview**

A substantial portion of the nutrients that livestock receive in rations is excreted in manure. Using manure as a resource by recycling these nutrients to produce forage or other crops turns manure into a valuable resource. This can be accomplished by land application of the manure if sufficient forage or cropland is available, through composting, or through off-farm utilization by soil producers, crop or organic farmers, gardeners, or others.

The utilization of manure needs to be determined by the farmer, taking into account individual manure handling capabilities. Farms with readily available land benefit from land application of manure, however, farms with less land or more manure than can be safely land applied may need to consider off-farm utilization options or composting. A combination of manure management options may be most beneficial—look at all available manure management options and use the option or mix of options best suited for your farm.

Whatever the management option(s) used, implement good materials-handling principles: combine or eliminate handling steps, lift and move materials as little as possible, and store materials as close to the point of generation and use, as possible, in order to minimize movement.

As a general estimate, the yearly phosphorus needs for one acre of forage pasture can be met by spreading manure from one, 1,000-lb. horse; a 1,000-lb. beef cow; three, 150-lb. pigs; twelve, 100-lb. sheep; six, 100-lb. goats; or four, 300 lb. llamas.

Source: "Manure Management in Small Farm Livestock Operations: Protecting surface and groundwater," D. Godwin and J.A. Moore.

### **Land Application**

Land application of manure is a low cost option for farmers who have sufficient land space available. Small farms that practice land application of manure should adopt a basic nutrient management

plan. This plan involves setting up a record keeping system to document your farm's nutrient activities, including crop nutrient needs and manure application rates. Farmers must ensure that their

manure storage facility or area is designed to fit the needs of this plan.

Typically stockpiled manure can be applied to pastures or crop fields at least twice a year, at an application rate of 10 tons per acre.<sup>iii</sup> However, many small livestock farms, especially horse stables or boarding facilities, do not have enough land to properly apply the amount of manure generated.

Over-application of manure on pastures used for forage can cause nitrate poisoning and grass tetany in livestock. Applying too much manure or applying it improperly can leach nutrients and bacteria into water. Proper land application of manure involves knowing the needs of your soil, the nutrient content of the manure you are applying, and fertilizer needs of the crop or pasture grass you intend to grow.

#### Nutrient management plan

- Nutrient management addresses the addition, removal, and recycling of nutrients from the farm in a manner that protects the environment and livestock.
- The key to nutrient management is maximizing the utilization of manure nutrients used on pastures and crops while minimizing the potential for water contamination.
- Follow soil test recommendations: add lime, supplementary fertilizers, and amendments as needed or reduce manure application levels, if necessary.

#### Nutrients in manure

- Manure contains valuable soil nutrients. Some of the nutrients in manure are the same as those found in commercial fertilizers: ammonium nitrogen, soluble phosphate, and potassium salts. These “inorganic” nutrients dissolve in water and are readily available for plant uptake. Poultry manure (and liquid manure) contains high levels of inorganic nitrogen.
- Nitrogen in other solid manures is organic and is slowly released when applied to soil. Bacteria and other soil organisms breakdown the organic matter in manure, including nitrogen. In this process, the nitrogen is slowly released as inorganic nitrogen and becomes available for plants to use. How rapidly this occurs depends on the weather (the bacteria in soil are most active in warmer, moist soils) and the type of manure. Fresh

A 1,000-pound horse generates an estimated 0.75 cubic feet of manure daily. In fertilizer terms, this approximates 100-110 pounds nitrogen, 30-34 phosphorus, 90-95 pounds potassium annually.

Source: “Land Application of Horse Manure,” Council of Bay Area RCDs.

manure breaks down faster than composted manure.

- The nutrient values of manure from bedded stalls and paddocks vary considerably depending on the type of livestock, bedding type, and storing conditions. Nitrogen losses through storage and handling can be significant; phosphorus and potassium losses are usually negligible. The level and quality of livestock feed also affect manure nutrients.
- The organic material in manure provides structure that makes soil easier to cultivate, less compactable, less susceptible to erosion, and more able to absorb and retain water. Manure supplies soil micronutrients unavailable in chemical fertilizers and is essential in promoting beneficial soil organisms that lead to healthy soils and pastures.
- Manure with bedding has fewer nutrients per pound as compared to pure manure.
- Manure that is land applied with substantial amounts of bedding may actually take nitrogen from the soil as the soil microorganisms work to decompose the bedding, a process called “nitrogen immobilization.” This reduces the amount of nitrogen available for plants to utilize.
  - For manure mixed with straw, old hay, or paper product bedding this is typically not a concern and it can be applied similarly to raw manure with no bedding.
  - Land-applying manure mixed with sawdust, woodchips, or wood pellet bedding, without first composting the material, may stunt crop growth. Check with local Extension Service for additional information.
- The nutrients in manure readily leach into the air, soil, and water. In order to get the most value from the nutrients in manure, apply it as close as possible to planting time. If the nutrient loss is not a concern, apply it in the fall and plant cover crops on it, such as rye or oats.



- Manure should be harrowed or incorporated into the soil (a rake will do) within 72 hours of application to reduce the potential for run-off contamination and to preserve nutrients.
- A no-till cropping regime can be practiced by spreading manure onto cover crops. Cover crops absorb soluble nutrients from the manure and prevent them from leaching.
- It is not possible to apply enough low-nutrient manures, such as horse manure, to meet crop nutrient needs. Additional supplements are needed. Remember, however, that using manure on fields and crops helps address the manure waste issue and adds necessary organic matter to soil.
- Consider previous manure applications when applying manure to crops since decomposition rates for nutrients will vary.

#### Step 1: Start by getting to know your soil

- Soil testing: Get a soil test for the field or crop area where the manure is to be spread.
- A soil test determines the existing nutrients in the soil and the amount of additional nutrients that can be added for crop needs.
- Soil tests are inexpensive. Information can be found at the Extension Service.

#### Step 2: Know your manure

- The next task is to estimate the amount of manure nutrients generated on your farm. Use the charts in the Quick Reference Guide in the Manure Management ToolKit.
- A nutrient analysis for nitrogen, phosphorus and potassium (“N-P-K”) and moisture content can also be done, but requires a well-mixed sample from your storage pile. The test should be done as close as possible to the time of application.

#### Step 3: Consider crop needs

- Assess crop nutrient needs or application rates by using a fertilizer or production guide to determine the nutrient needs of forage or crops you are growing. Consult the Extension Service if you need assistance.
- Do not apply manure (and other fertilizers) at rates that exceed the amount necessary to meet crop nutrient needs in a growing season. All nutrient sources—manure, compost, and commercial fertilizers—must be taken into account.
- Nitrogen and/or phosphorus are typically the limiting nutrients for manure application.

One ton of typical chicken litter (about 2 yards) contains roughly 70 pounds of nitrogen. If about half the nitrogen becomes available to plants in the growing season, then 4 tons of chicken litter provides about 10 pounds of nitrogen, or enough to grow an acre of sweet corn.

Source: “Manure on Your Farm: Asset or Liability?” LPES.

- ▶ Phosphorus accumulates in soils if it is applied in quantities exceeding those removed by crops. Soil testing reveals existing phosphorus levels in your farm’s soil.
- ▶ Almost all of the total phosphorus and potassium from manure application are available the first growing season.
- ▶ Nitrogen availability is slower, with only about one-third available to crops during the year it is applied, and the remaining becoming available at a rate of about 5 percent a year.<sup>iv</sup>
- Forge or hay crops provide small farms with the greatest flexibility for land application. Cool season grasses, for example, typically utilize manure nutrients from early spring to late fall and application equipment generally will not impact the crop.
- Use data in the Quick Reference Guide in the Manure Management ToolKit to assist in determining the amount of manure to apply based on the crop’s nutrient needs. A list of manure nutrient calculators is also contained in the Toolkit.

#### Manure nutrient management: More is not better!

- Good manure nutrient management is achieved by reaching the proper balance between your soil, the nutrient value of your manure, and the nutrient needs of the crop.
- Look at the total amount of nutrients needed for your soil and crop and the total amount of nutrients estimated in your stored manure. Apply only enough manure on the field to supply the crop’s nitrogen or phosphorus needs (whichever is less). *Typically manure should be applied to meet the phosphorus requirements of the crop.*

#### General land application guidelines

- Spreading the manure evenly allows for more optimal plant use of manure nutrients.
- Do not spread manure near waterways or wellheads. Manure spreading on low-lying fields

should be monitored so that the underlying water table is not affected.

- Do not spread manure on saturated, frozen, or snow-covered ground.
- Avoid applying manure on sloped areas because rain may carry it into waterways.
- The field should be firm enough to prevent spreaders from packing the soil and dry enough so that manure does not run off.
- Do not apply manure if a storm is on the way, as heavy rain will wash away manure.
- The use of grassy or riparian buffer zones around fields is strongly recommended to protect waterways and wetlands from manure runoff that may occur.
- Incorporate manure into soil soon after spreading in order to control odors. Spread manure on days when there is little or no wind. Apply manure early in the day when the air is warming and rising to help minimize odors. Try to avoid spreading on weekends and holidays to lower the chance of offending neighbors.
- Applications on cultivated fields typically are limited to pre-planting and post-harvest.
- Manure spreading on pasture forage areas should be done so as to limit livestock exposure to parasites. Do not spread on pastures unless livestock can be kept off for at least several days. If parasite infestations are a concern do not spread manure on forage pastures unless it has been properly composted.
- Applying manure at too heavy a rate on pastures or hayfields can smother crops and slow growth.
- To reduce fly infestation problems, spread manure thinly on fields. Avoid leaving large clumps of manure where adult flies can develop and lay additional eggs. Tilling or raking manure into the soil soon after spreading disrupts the fly development cycle.
- Field stacking provides a storage option when manure cannot be immediately land applied. The stack must be on flat ground and away from surface waters or drainage paths.

#### Problems from over-fertilization or improper application

- Nutrient excesses through over-fertilization can contribute to reduced crop yields in the same manner as applying too much fertilizer.

The nutrient content of manure is roughly equivalent to a 50-pound bag of 12-4-8 commercial fertilizer.

- Applying too much manure can lead to nitrogen filtration into ground water and contamination wells and aquifers.
- Manure must be applied so that run-off is minimized in order to avoid problems associated with too much nitrogen or phosphorous in streams and waterbodies.
- Manure with sawdust bedding, particularly chicken and pig manures, can acidify soil.
- Excessive salinity can occur through over application of manure especially under dry conditions.
- Increased weed problems may occur from application of raw manures, either from weed seeds contained in the bedding or from seeds present in the soil that are stimulated by the addition of raw manure (an excess of potash and nitrogen can encourage weed growth).

#### Using raw manure on food crops

- Fresh manure may contain pathogens (bacteria and viruses) that can cause illness in people, such as salmonella and E. coli. This is a particular concern if fresh manure is applied to crops that grow in or close to the soil (such as strawberries and root vegetables) and vegetables or fruits eaten raw (such as lettuce). To be safe, only use composted manure on these types of food crops or allow at least four months between the time manure is applied and the crop is harvested. *Pig manure should not be used on any crops for human consumption.*
- Using raw manure may adversely affect the quality of some vegetable crops. If this is a concern, do not apply it directly on the crops; spread it on cover crops planted the previous season. Suggested restrictions on when to apply manure for use on food crops, regulatory requirements for organic growers, and other information on the use of raw manure on food crops can be found in a variety of references contained in the Manure Management ToolKit.

#### Equipment

- Smaller farms can use a pick-up truck and rake to spread manure in small areas.
- A tractor with a pull-type spreader is recommended for land application over larger areas. This ensures that the manure is applied in a thin and relatively uniform layer on the soil.
  - ▶ Tractors and manure spreaders come in all sizes to fit any size farm.



- ▶ Spreaders can also be fitted for “farm utility vehicles” and other ATV-type vehicles.
- Calibrating the manure spreader is important to gauge how much manure is being spread. It is done similarly to calibrating a fertilizer spreader, planter, or sprayer. Several references are available on calibrating. Consult the Extension Service or see the references in the Manure Management Toolkit.
- Purchasing a tractor and manure spreader is expensive for small livestock farms. Consider hiring (or trading with) neighbors who own the proper

equipment for manure removal, spreading, or composting or jointly purchasing equipment with other farmers.

The “*Nutrient Management—Simplified*” fact sheet is included in the Manure Management ToolKit as a reference to assist farmers who raise small numbers of multiple types of livestock and want to land-apply manure.

## Composting

Composting is a controlled and managed aerobic (“with air”) decomposition process for manure, bedding, and other organic materials (yard waste, food scraps, etc.). It produces a stable, nutrient-rich, humus-like material that can be used as soil amendment on fields and gardens. Adding one part compost to two parts of any soil type makes it more “loamy.”

Manure stockpiling or storing is not composting. Manure that is being stockpiled decomposes very slowly, reduces in volume relatively little, and still maintains the same bacteria and weed seed issues as raw manure.

Composting involves the proper mixture of materials, oxygen, moisture, area design, and maintenance to provide an environment for microbial activity. The microbes or beneficial bacteria and other organisms digest and process the manure and bedding. Through this process, and with proper maintenance, compost pile

temperatures should rise high enough to kill unwanted pathogens, weed seeds, residual hormones, antibiotics, and pesticides. Manure and bedding volume will reduce by about 60 percent, odor will be minimal, and nutrients will become concentrated.

Composting is a viable option for any size farm operation. It is a flexible system that can be designed to meet the needs of any farm. However, it requires upfront planning and good management. Farmers need to weigh the labor and time involved as a factor. If insufficient land is available for direct application of manure, composting may be a cost effective option. It will significantly reduce the volume of manure and present more options for land application and other on-farm uses.

If odor issues from manure storage and land application occur due to the proximity of neighbors, composting may be a beneficial alternative. If off-farm uses cannot be found or hauling charges are high, composting may also prove to be a viable option, as it significantly reduces manure volume and provides a more marketable product. However, if off-farm options exist that are economical, then the time and labor required to maintain a compost system may not be worth it.

### Elements of composting

- *Aeration*: The microorganisms that decompose organic materials in a compost pile need sufficient air to breathe.
  - ▶ The key to successful composting is getting enough air or oxygen into the pile. The pile must have adequate aeration through regular turning and /or the addition of pipes through the pile, windrow, or bins.

C:N Ratios of Common Livestock Bedding	
Material	C:N Ratio
Average barnyard manure	14:1
Horse manure without bedding	25:1
Straw	50-100:1
Timothy hay	60:1
Sawdust	500:1
Woodchips	100-500:1
Source: “Manure Management for Small Scale Livestock Operations.”	

▶ *Nutrient balance and porosity:* Successful composting requires a pile that contains roughly 20 to 40 parts of carbon to each one part of nitrogen.

▶ Manure is a nitrogen source (as is food waste and wet grass clippings).

▶ Bedding, such as wood pellets, shavings, and straw, is a carbon source.

▶ Horse manure can be high in carbon due to shavings or wood pellets used as bedding and typically collected with the manure. It may need additional nitrogen, such as cow manure or grass clippings.

▶ Cow and cattle farmers may need to supplement manure with additional carbon sources, as bedding is typically less.

▶ Goat, sheep, chicken, llama, pig, and rabbit farmers should have an adequate mixture of carbon and nitrogen with typical bedding and manure generation, depending on how much bedding is used. Wasted hay, which can be considerable with these animals, may need to be factored in as a carbon component as well.

▶ Manure on its own has a relatively low C:N ratio, depending on the manure. Manure with larger portions of bedding can have C:N ratio of 50:1. As long as there is adequate moisture and aeration in the pile, this high carbon ratio should compost effectively. If desired, or if the pile does not heat up sufficiently, nitrogen sources, such as grass clippings, chicken manure, or blood meal can be added.

▶ In addition to having the right C:N balance, the porosity of materials is important. If the materials are too compacted or the materials contain too much moisture there will not be enough air flow in the pile for proper composting. Mixing at least equal portions of bedding and manure should achieve the desired balance. Periodically mixing materials helps to achieve additional porosity.

• *Moisture*

▶ Composting works best with a moisture content of 40 to 65 percent.

▶ The material in the compost pile should be uniformly moist at a level of a damp, wrung-out sponge. A few drops of water should drip out when the material is squeezed.

▶ Depending on the manure and bedding used, additional water may need to be added at the beginning of the compost process and periodically during the process. Using a drip irrigation tubing or sprinkler system works well

for additional watering. Piles can also be exposed during the rain.

▶ Manure without bedding is usually too wet for composting. Wet manure, common from free stall dairy barns, hog barns, and cage-managed poultry houses, may require additional carbon sources to attain proper moisture levels.

▶ Manure with bedding from dairy tie stall barns, packed bedding, and well-bedded sheep, goat, or beef barns, litter from floor-managed poultry operations, and horse stables will be drier. This bedding and manure mix may require additional moisture when used for composting; it also is useful as an amendment with manure gathered from paddocks and pastures. You may want to set aside some bedding (and wasted hay) and add it to the compost pile as needed when fresh manure is gathered.

• *Temperature*

▶ If properly maintained, a compost pile will generate its own heat though the microbial action involved in decomposing the compost materials. Within two days a pile should reach temperatures between 120° and 160°F.

▶ To ensure the killing of pathogens, parasites, and weed seeds, the temperature needs to be at least 131°F for 15 days.

**Basic Compost Recipe**

- ▶ One part manure
- ▶ Two parts bedding or other carbon source
- ▶ Moisture
- ▶ Aeration
- ▶ Containment & cover

Location

• If space is not available to combine the composting area with the manure storage area, use the information for “manure containment,” above, as a general guideline for setting up a suitable location for the compost area.

▶ The setback distances from water, use of filter buffers, and other siting specifics should be strictly adhered to in establishing a location for composting.

• If a separate storage area is necessary, build the manure storage to hold sufficient wastes until the material can be moved to the compost area.

• A separate manure storage area may still be desired to supplement the composting operation and allow flexibility when materials are added and

as a backup if the composting operation is interrupted. A storage facility used in the winter can serve as a pad for summer composting or as a mixing pad for composting.

- Locate the compost area on a level or gently sloped surface (2-4%). Windrows should be parallel to the slope.
- Access to a garden hose or other watering source is necessary.
- A sketch of the compost area would be beneficial to determine prevailing wind direction, traffic flow patterns, land slope, runoff patterns, surrounding land uses, and the location of wetlands or water bodies.
- The NRCS can provide assistance with site planning, soil information, and drainage control.

### Pad

- Compacted soil or sod is adequate as a pad for composting, as long as other precautions for siting the compost area are met (distance from water sources, filter area, etc.).
  - ▶ Consider soil types when locating a pile on unimproved soil. Sand or silt soils may allow too much drainage, while clay soils will rut in wet weather making access and turning difficult. Moderate- to well-drained soils should be adequate.
- Six inches of compacted and graded sand or gravel should be installed if soil conditions are not sufficient for drainage.
  - ▶ Use small diameter dark gravel.
  - ▶ Gravel can present problems when mixing materials as it can become mixed in with the composting materials.
- A concrete pad provides an area that will limit mud problems and provides a good foundation for equipment. However, it is typically unaffordable for most small farm operations.

### Bin or shed system

Two bins are adequate for one to three large animals (or A.U. equivalent). A three-bin system should be adequate for up to five large animals (or A.U. equivalent). Additional bins can be added.

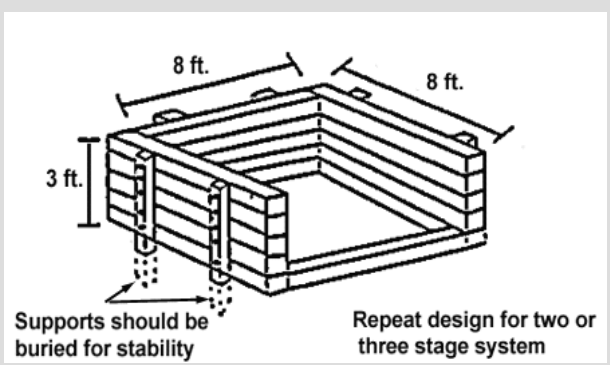
- Bins can be constructed of wood, pallets, or concrete blocks. A grain bin or bulk storage building can be used.
- Wood pallets make free and easy to construct bins. Nine pallets make a 3-bin set; simply nail them together. Steel rods or rebar can be used to affix the pallets to the ground for stability.

- Landscape timbers can also be used. Use wood that is rot resistant but not pressure treated with arsenic.
- A shed composter consists of three or more three-sided bins with a roof. When constructing a shed composter take into account the method of turning the materials (such as the width of the bucket and height it will go to dump materials).
- Bins should be 3-5 feet high, with enough capacity to hold about 4 cubic yards of material (about 16 wheelbarrows worth of material). Widths can range from 5 to 8 feet.
- Consider the equipment to be used in loading or turning material when sizing the bins. If a wheelbarrow is used to dump materials and turning will be done by hand, size the bins smaller so that turning material into the next bin is easier. If a tractor is used, size the bin according to the size of the bucket.
  - ▶ See "Composting for Small Livestock Operations" in the Manure Management ToolKit for additional information and bin designs.
- Manure and bedding wastes are piled into the first bin until it is full. Water the materials as they are added, if necessary.
  - ▶ Materials should not be piled higher than 6 feet.

Equipment and supplies for two 3' x 8' x 8' bins:

- ▶ 50 - 8' landscape timbers (or similar wood)
- ▶ 100 - 5/16" x 5" lag screws
- ▶ Ratchet & socket set
- ▶ Plastic sheet/tarp to cover top
- ▶ Post hole digger or shovel
- ▶ Drill & bit
- ▶ Carpenter's level
- ▶ Power or hand saw

Source: Washington State University Cooperative Extension.



- ▶ When the first bin is full, begin filling the second bin.
- ▶ Use the third bin to turn the compost from the first bin into for aeration.
- ▶ Add additional bins if necessary.
- Cover the bins with a tarp, durable plastic sheet, or roof to prevent too much moisture from entering the pile. Covering also prevents rainwater from washing nutrients out of the compost.
- To increase aeration and reduce the need for turning the pile, place a few 5-foot PVC pipes (4- to 6-inch diameter) into the bin as you put in materials so that the pipes reach the center of the pile. These should stick out of the pile several inches. Drill small holes into the pipes before inserting them. The holes should be about a half-inch in diameter at 4- to 6-inch intervals.
  - ▶ Additional water can be added through the PVC pipes to ensure water is getting into the center of the piles.
- Monitor the temperature of the materials in the bins once full. Adjust or turn the materials as necessary in order to achieve optimum temperatures for composting. Once temperatures start to decline, turn the pile into the empty bin to continue composting.
  - ▶ Materials should be turned once per week for the first 3 months of composting. If pipes are used for aeration, turning can be less frequent.
  - ▶ When turning the pile make sure that material is turned into the inner part of the pile in order to ensure even heating of all materials in the pile.
- After about 3 months the contents from previously filled bins can be turned into one bin. Turning frequency of this material can be reduced to once per month until the compost is ready for curing.

### Compost pile

- A compost pile can be managed “passively” (“static pile”), where the piles are turned infrequently, and aerated by running a pipe or pipes through the pile, as described in the bin method, above.
- Alternatively, piles can be turned about once per week using a pitch fork or bucket loader.
- Layer materials in the same way as described under the bin method. Form a haystack type pile by adding waste until the pile reaches 4-6 feet high.
  - ▶ Piles should be no more than 6 feet high and 12 feet wide in order to ensure sufficient air movement through the pile.

- Cover the first pile and begin building a new pile; repeat as necessary. Sufficient space should be available for 2-3 additional piles, depending on manure volume.
- Piles should remain covered.
- The compost pile method takes several months to 1 year or more depending on the air flow through the pile or the frequency of turning.

### Windrow

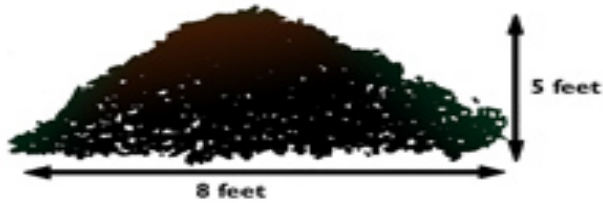
- Farms with more than a few large animals (or A.U. equivalent) may find it more practical to use the windrow composting method. A windrow is a long, narrow pile, which is turned on a regular basis.
  - A windrow should be 10-15 feet wide by 3-5 feet high. Windrows can be built using a manure spreader, dump wagon, dump truck, bucket loader, or wheelbarrow and pitchfork.
    - ▶ If using a wheelbarrow, use a wide board as a ramp to build the piles to sufficient height and mass.
    - ▶ Keep windrow piles as straight and uniform as possible.
    - ▶ If building more than one windrow, leave sufficient space between them for drainage and to allow for turning.
- Typically windrow composting of manure will take about eight weeks to nine months, depending on how often the pile is turned.
- During an eight-week compost process the windrow will require turning about eight times.
- The size of the pile must be sufficient to achieve desired temperatures, but not too large to be managed by available farm equipment.

### General guidelines for all composting methods

- See the “Compost” section of the Quick Reference Guide in the Manure Management Toolkit for recommended conditions for successful composting, charts on material specifics (C:N ratio, moisture content, etc.), and troubleshooting.
- Small farm composting operations may require special permitting from state or local jurisdictions. Typically this only applies if materials are brought into the operation from off-farm. Check with the



**Figure 1.** Diagram of a static pile construction with a perforated pipe insert.



state environmental agency and local health department.

- Lay down a 6- to 8-inch layer of wood chips under your bins, pile, or windrow to enable airflow through the bottom of the pile.
- In order to begin the compost process, materials need to be stacked at least 3-5 feet high.
- The compost temperature should be taken every 5-10 days, moisture levels assessed, and general appearance gauged. This is particularly important for novice composters. After the pile has been turned once or twice, less frequent monitoring is required.
- Once the temperature goes below 120°F it should be turned. Typically a compost pile with proper ingredients and moisture level require turning once a week during the first month or two of the process, then once or twice a month after that. If pile temperatures are not raised sufficiently it may need to be turned more often. Depending on the materials and compost management, the active composting phase will last six to ten weeks. Compost should also be turned if it reaches temperatures above 140°F.
- Bedding and manure from barns or stalls is usually mixed sufficiently to add to the compost pile. Manure added from pasture or paddock clean-up should be layered with bedding material—for each 6-24 inches of manure, add a 6-inch bedding layer (or other carbon source, such as straw or old hay).
- Sawdust can compact relatively easily, so may require the addition of straw or other material to allow sufficient airflow through the pile. Very fine sawdust, such as from carpentry or cabinetmaking (often used by horse farmers), will more than likely require the addition of other bulking material.
- Piles or bins should remain covered, especially in the winter, to retain temperature and moisture levels. They can be uncovered in the rain to add moisture, if necessary. Larger windrows do not need to be covered.
- Carbon materials will decompose at different rates. Straw will decompose faster than wood materials. Wood chips may never entirely decompose.

- As the compost process continues, piles will diminish in size. Contents from separate bins, piles, or windrows can be mixed together to conserve space and ensure that there is a sufficient volume of material to continue the composting process.
- Limiting odor concerns:
  - When the pile is turned, especially with fresh materials in it, it will give off a strong odor. Try to turn it when there is no wind and on cooler days. Consider turning it on a weekday when neighbors are less likely to be home.
  - If unpleasant odors persist, there is something wrong with the pile. Check the Compost “Troubleshooting” chart in the Quick Reference Guide.
  - Odors can be contained by covering the composting materials with a layer of peat moss and/or woodchips (about a 4-inch layer of each). Cover this with a tarp that is several inches above the pile; string the tarp from poles or other firm structure.
  - Swine manure can be strong smelling. If proximity to neighbors may bring odor complaints, consider handling swine manure in another manner.
- Additional amendments or bulking agents may need to be added to manure for successful composting, depending on the amount of bedding material already in the compost mix. These materials are added to adjust the moisture level, texture, or the C:N ratio. Common materials used include: straw, spoiled hay, or dry leaves.
- Shape piles with a flat or concave top to absorb as much rainfall, snowmelt, or watering as possible.
- Typically the composting process will not occur in colder weather. Covering the pile ensures that leaching will not occur; using black plastic will help the pile heat up faster on warmer days. Once the weather warms up sufficiently the pile should be turned.
- If rapid composting is desired, it is important to stay within the preferred range of conditions for all factors impacting the composting process. See the



Compost section of the Quick Reference Guide.

- As with handling manure, sanitary measures, including hand washing before touching food, eyes, etc., should be followed. Individuals who are sensitive to mold and dust should wear dust masks or properly fitted respirators; those with allergies, asthma, weakened immune systems and other conditions should not work in a composting operation.

#### Tools and equipment

- An essential tool for all compost operations is a non-mercury compost thermometer at least 2-3 feet long. These are available at garden or hardware stores or on the Internet.



- Equipment
  - Livestock owners with just a few animals can easily compost using a pitchfork and shovel. This, of course, is labor intensive, depending on how many animals are kept, and it will require a strong back!
  - Larger operations should consider a front-end loader or tractor with a bucket for loading and turning. Many garden-sized tractors can be equipped with bucket loaders.
  - A manure spreader can be used for mixing and turning materials as well as forming windrows or piles.
  - A dump wagon or dump truck can also be used for dumping materials into piles or windrows.
  - Specialized equipment, such as a windrow turner, is available for larger compost operations.

#### Monitoring the process

- Compost is “finished” once all of the available nutrients in the pile are used up and the bacterial activity declines. When decomposition is complete, or nearly complete, the compost pile heats up very little, even after turning or aerating the pile.
- Finished compost should have a uniform, crumbly appearance, and an earthy smell.
- The more bedding material in the pile, the longer it will take for the composting process to work because of a high carbon to nitrogen ratio.
- A quick and easy test to see if compost is “done” is to put a few inches of material in a small bag. Close the bag and set it in the sun for a few hours. Open it up. If there is a strong smell the material is not done.

#### Curing finished compost

- Curing ensures that the compost is stable so that it will not burn plants. The curing process allows any remaining ammonia nitrogen to convert to nitrate nitrogen. Any remaining large woody particles will also continue to break down. By the end of the curing process compost ingredients (wood shavings, etc.) should not be recognizable. Wood chips, however, may not entirely decompose.
- Curing can be done outside compost bins to allow room for additional materials to be composted.
- Compost to be applied to fields does not require curing before use.
- If the finished compost is not to be utilized right away it should be covered to protect the nutrients from leaching.

#### Compost utilization

- Compost use is typically seasonal, especially if marketed off-farm. Storage of finished compost may need to be considered.
- Composted manure is safer than raw manure as a soil amendment. It is low in soluble salts, so it will not burn plants. It can be applied directly to growing vegetable crops. Compost is less likely to cause nutrient imbalances. It is typically pH-neutral.
- Compost typically contains less nitrogen than fresh manure; however, the nitrogen is more stable and less susceptible to leaching.
- Compost quality depends on the materials used to make it. Most combinations of livestock manures and beddings produce fine quality compost. Some, however, do not. Broiler litter, for example, is typically high in phosphates but low in calcium—regular applications of this compost could lead to imbalances in soil.
- Compost application rates can typically be as much as 40 to 60 tons per acre on low fertility soils or as little as 10 tons per acre on soils with higher fertility.<sup>v</sup> A good guideline is to spread about ¼ inch of compost on fields three to four times a year.<sup>vi</sup>
- Compost use for gardens or intensive cropping systems can be higher. A layer of compost about 2 inches thick can be applied.
- Compost that is to be used regularly for crop or forage production should be tested (along with soil) to monitor nutrient levels.
- As with manure, salt concentrations can build up in compost. It is important to blend compost with

soil when using it. Mix one part compost to 2 or 3 parts soil in gardens.

- Pig manure (fresh or composted) should not be used to grow produce or food crops. Never compost dog, cat, or human manures.
- Composted manure/bedding works well as a footing for riding arenas; mix with sand and wood shavings or sawdust. Do not apply too much because it can hold in excess moisture.
- Compost is used as bedding for some livestock. However, check specific information regarding its use for this purpose for your livestock.
- Organic growers may require testing of the finished material. They may be concerned about nutrient and pH levels in compost. Certified organic growers may also require compost turning and monitoring records. Residual hormones, antibiotics, and pesticides are typically destroyed in the composting process. However, feed rations may contain arsenic, copper, and other substances that are not allowed in compost used by organic growers. While these should not be present in levels of concern for small farm generators, they may be a concern to organic growers.
- Compost has its best effect on forage or crops if applied just prior to planting. Some crop plants, however, do better if compost is applied the previous year.

Mature compost may contain:

15-30 lbs. /ton Nitrogen  
5-10 lbs. /ton Phosphorous  
30 lbs. /ton Potassium

Source: "Manure Management and Composting," COG Organic Field Crop Handbook.

#### Marketing compost

- Compost creates a potentially more marketable product than raw or even aged manure.
- It is easier to handle than raw manure, allowing for greater storage options for use as needed.
- Compost is an excellent soil amendment and one of the best sources of organic matter available.
- Many communities are interested in supporting local products and local farmers. Ensuring potential customers that all of the inputs for your compost came from your farm should help in marketing.
- Composting is also an environmentally beneficial process—keeping organic materials out of landfills helps to reduce greenhouse gas emissions. Composting manures properly helps protect waterways from manure contamination.
- The price received for compost depends on the demand in your area, the types of markets, and the quality of the finished product.
- Screening of compost may be required to sell the product to some markets.

### **Off-Site Utilization**

If you have more manure than can be safely land-applied and you do not want to compost the manure you need to develop other use strategies. Check with state and local regulators about regulations that may apply to hauling, selling, or giving away manure or compost.

#### Buy or rent more land

- Farmers with excess manure might consider renting or purchasing land elsewhere to land-apply manure for growing additional forage (for use or sale) or other crops.

#### Off-site land application of manure

- Advertise at feed stores, farmers markets, and other locations for potential farmers interested in land-applying manure.
- Large livestock farms may have sufficient land available to apply their manure and additional amounts from small farms.
- 

- Hauling large amounts of manure can be expensive, due to its bulkiness. You may need to deliver to farmers for land application in order to develop this market or be willing to pay a hauling fee.
- If feed or hay is purchased from local suppliers, consider asking them if they could use your manure for land application.

#### Off-site compost operation

- Contract with a hauler to provide a dumpster for temporary storage of manure and stall waste.
- In addition to a hauling fee, there may be a processing fee at the compost operation.

#### "Free" or "low-cost" garden fertilizer

- Developing customers to take manure or compost away may take some time, depending on the location of your farm and local interest. Cheap, natural fertilizer enthusiasts are around—the trick is to locate them.



- Getting the word out about manure availability may take some time and marketing, but word of mouth, fliers, and business cards work well in small communities.
- Some manure is easier to sell or give away than others.
  - ▶ Aged manure is easier to give away than fresh manure. It looks nicer, smells better, and has a more uniform texture.
  - ▶ Composted manure is even better!
  - ▶ Poultry manure is in high demand because of its nutrient-rich nature—this is typically a commodity that can be sold.
  - ▶ Horse manure easily composts and is well liked by mushroom growers and gardeners.
  - ▶ Cow manure is also well liked by gardeners, as it can be used in greater volumes in gardens.
  - ▶ Many gardeners and organic farmers are not familiar with manure from goats, sheep, and llamas. Additional education may be required to market these manures.
- Potential customers.
  - ▶ Blended soil producers provide one of the best market potentials. They take raw manure and compost to use in making soils.
  - ▶ Organic farmers require organic fertilizers, including manure, for growing crops.
    - Certified organic growers use only composted manure. Temperature and monitoring records may be required.
  - ▶ Home gardeners typically need smaller amounts of manure, so are often eager to purchase or at least remove manure from local farms.
  - ▶ Schools and public buildings: If a public compost facility operates in your area, chances are you may not be able to market to schools or public agencies.
  - ▶ Mushroom growers: Bedding considerations are important when marketing manure to mushroom producers, as they cannot use manure with pine shavings or sawdust bedding. Straw is acceptable. Mushroom growers require large amounts of horse manure. If your farm

does not generate enough, consider forming a horse manure cooperative to meet the demand and share hauling expenses.

- ▶ Horse boarding operations can ask horse boarders to take away manure for reduced boarding rates. People who come to watch others ride provide a possible manure outlet for horse owners.
- ▶ Some containerized nurseries, greenhouse operations, and ornamental crop growers use aged manure or compost as potting material.
- ▶ Community and neighborhood gardens provide an excellent market for fresh and composted manure. These gardens are unlikely to pay for the material (although they may purchase compost); however, they provide a potential market for significant volumes.
- ▶ Other possibilities: vegetable farmers; landscapers; turf growers; and operators of golf courses. These businesses all require soil amendments for their operation.
- Making a sellable product.
  - ▶ It is necessary to consider your market in order to decide on the best marketing techniques.
  - ▶ Organic or crop farmers may want delivery of the material.
  - ▶ Small gardeners and landscapers may prefer material to be bagged.
    - Using empty feed sacks or shavings sacks works for this purpose.
    - Tightly close the full sacks to prevent spillage and make hauling easier.
  - ▶ Appearance matters! Manure that is easy to handle and relatively dry is much easier to market than material that is smelly and wet.
    - A weedy pile or one too full with bedding material is also more difficult to market.
  - ▶ Manure or compost must be free of garbage, fly larvae, and other undesirable materials.
- Marketing
  - ▶ Marketing manure or compost means selling it as resource and finding customers to purchase or haul away that resource.
  - ▶ Manure use or compost can be marketed as a means of supporting local farmers, protecting the environment, and recycling farm by-products into valuable soil nutrients.
  - ▶ Marketing manure may require some education. Be sure to include information about the value of manure as a soil enhancer.



- ▶ Consider using your manure or compost to grow a demonstration garden or flower plot that visitors can see. Put signs up advertising the material availability.
  - Poultry manure sells well as a “natural fertilizer.”
  - Other types of manures can be advertised as “soil amendment.”
  - Composted manure is an easier product to market.
  - Manure is a valuable resource!
- ▶ Advertise availability on agricultural Web sites, such as organic growers or greenhouse sites.
  - ▶ Check for manure wanted postings on local, state, and regional listings of farm organizations, farmers markets, organic growers, landscapers, and greenhouse

- operators. Join listservs on these Web sites or consider other ways to make contact.
  - ▶ Advertise on Craig’s List, FreeCycle, and similar listservs.
  - ▶ Stop in local or regional farmers markets to make contacts.
  - ▶ Many newspapers offer free or low-cost advertising.
  - ▶ Display signs or put out “free” bagged manure at the curb.
  - ▶ Post fliers around town or leave business cards, especially at garden and hardware stores.

#### Forming a manure cooperative

- Groups of farms can work together to collect and distribute manure or establish a compost operation.

## **ANIMAL MANURE SPECIFICS**

### Cow

Cow manure is lowest in nutrients compared to other livestock manures. It typically has a high moisture content and generally requires a large amount of dry, high carbon amendment for composting (two-to-three parts amendment to every one part manure). Bedded pack manure should have sufficient carbon source for composting. It decomposes quickly. It has a relatively low odor risk. It is good for gardens, as it can be used in larger quantities. It should be aged or composted prior to use.

### Horse

Horse manure has only about half the nutrients of chicken manure, but is higher in nitrogen than cow manure. It usually has a substantial amount of bedding with it, so has a high C:N and is typically dry. It often composts well with just the bedding and no additional carbon. Cattle manure or other nitrogen source may be necessary for extra nitrogen. It has a low odor potential when stored or composted. It decomposes quickly, especially if the bedding used is straw. Horse manure typically contains a lot of weed seeds and should be composted at sufficiently high temperatures to kill weed seeds prior to use if weed seeds are a concern, or apply aged manure on fields or cover crops in the fall.

### Poultry

Poultry manure is the most nutrient rich manure. It is very high in nitrogen and moderately moist. When used to make compost, it needs a high carbon amendment, but it is a good compost material due to its high nitrogen. Litter with wood shavings or sawdust is excellent compost material. Due to the high nitrogen content and high pH, nitrogen loss may contribute to odor issues from ammonia. If composting or land applying, low pH amendments may be necessary. It should be composted prior to use in gardens.

### Goat and sheep

Both sheep and goat manures are relatively high in nutrients. The manure is naturally dry and in pellet form. It is easily handled, has minimal odor, and normally does not attract flies. Manure and bedding from one goat can average around 10 pounds per day. Manure from sheep and goats that are primarily fed hay and grains is higher in nutrients than that of pastured animals. Manure from goats that are allowed to forage should be composted in order to avoid problems with weed seeds. If collected as bedded manure pack it makes an excellent compost source with good C:N ratio. Goat and sheep manures should be composted or added to a garden in the fall.

### Rabbit

Rabbit manure is higher in nitrogen than some poultry manures and contains a high amount of phosphorus. It has a relatively low odor potential.

### Llama and alpaca

Llama and alpacas typically deposit manure in "communal" areas, thus making clean up in pastures relatively easy. The manure is in "pellet" form and easily handled. Llama and alpaca pellets have virtually no odor and do not attract insects, a benefit for their use as fresh manure. Llama and alpaca dung is high in nitrogen and potassium nutrients ("N-P-K") as compared to other livestock manures. The phosphorus is relatively low, as it is with most other livestock manures. The calcium and magnesium level is about average. Llama manure has a lower organic material content compared to other livestock manure, although it is ample for adding soil texture and water-holding capacity. The lower organic content is the reason that fresh llama manure can be spread directly onto plants without "burning" them. Mix four parts manure to one part soil for use on gardens,

landscaping plants, and indoor plants. Due to the nature of the llama and alpaca digestive system, weed seeds do not remain in manure. Be aware, however, that llamas and alpacas will not eat dung-contaminated grass, thus it is not advisable to spread manure in areas that the llamas or alpacas will be grazing unless sufficient time is allowed for it to decompose. Llama and alpaca manure is easily composted and makes an excellent fertilizer, or mulch. The salt content of llama manure is not particularly high, but nonetheless llama manure should not be applied directly to seedlings unless mixed well into the soil.

### Swine

Swine manure is high in nitrogen and very wet. If composted it will need a dry, high carbon amendment. Due to the wetness and nitrogen content there is a strong odor potential when storing and composting. Raw or composted swine manure should not be used on food crops.

## **MANURE USE IN GARDENS**

- Manure should be composted or aged at least six months prior to use in gardens.
- Manure should be applied at least 60 days before harvesting of vegetables to be eaten without cooking.
- If manure is applied within 60 days of harvest, use only well aged or composted manure.
- Do not apply fresh manure after a garden is planted.
- Do not use dog, cat, pig, or human manure in vegetable gardens or in compost piles where the compost will be used to grow vegetables or fruits.

## Credits

### *Pictures*

- Static pile: p. 19, University of Massachusetts, Agricultural Department, [www.umass.edu](http://www.umass.edu).
- Compost bins: p. 20. University of Minnesota Extension.  
[http://www.extension.umn.edu/distribution/naturalresources/components/7540\\_04.html](http://www.extension.umn.edu/distribution/naturalresources/components/7540_04.html)
- Various clip art: [www.garden-services.com/gallery/garden\\_clipart/index.htm](http://www.garden-services.com/gallery/garden_clipart/index.htm) and various pictures: Google images.

See also “Sources and Additional References” in the Manure Management Toolkit.

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This guide and other manure management resources are available for download at the Northeast Recycling Council, Inc. Web site, [www.nerc.org](http://www.nerc.org). For more information contact NERC at (802) 254-3636, or by email at [info@nerc.org](mailto:info@nerc.org).



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<sup>i</sup> “Small-Scale Farmers and the Environment: How to be a Good Steward,” Mark Rice. LPES Small Farms Fact Sheet Series.

<sup>ii</sup> “Manure Management in Small Farm Livestock Operations,” D. Godwin and J.A. Moore, Oregon State University Extension Service, May 1997.

<sup>iii</sup> Equine Facts: Guidelines for Horsekeeping in Maine, Bulletin #1011.

<sup>iv</sup> “Best Management Practices: Land Application of Animal Manure,” Ohio State University Extension, Department of Horticulture and Crop Science.

<sup>v</sup> “The Horse Owner’s Guide to Composting,” Steven Wisbaum, 2002.

<sup>vi</sup> “Strategies for Collection, Storage, & Disposal: Manure Management,” Small Acreage Program, Washington State University Clark County Extension, 2005.