_____ 1. Read *Commercial Vermiculture* completely.

_____ 2. Read other books, magazines on the subject of vermiculture. Watch available videos on the subject. (See what information your library might have available.)

_____ 3. Determine the size operation you wish to have.

_____ 4. Determine the location for your worms.

_____ 5. Locate bedding and feedstock materials.

_____ 6. Obtain necessary tools

   ___ pitchfork
   ___ pH meter
   ___ compost thermometer
   ___ moisture meter
   ___ cultivating tools
   ___ agricultural lime (calcium carbonate) and/or rock dust
   ___ Canadian sphagnum peat moss
   ___ burlap for covering beds

_____ 7. Obtain bedding material. Leach manure if that will be your source of bedding.
____ 8. Build bins for container (in-vessel) system. (Plywood, concrete block, etc.) Design length and width for windrow system.

____ 9. Prepare source for water (and electricity if desired). Garden hose or sprinkler/irrigation system.

____10. Determine square footage of beds and order initial stock of worms for stocking at the rate of 1 lb. per sq. ft. of bed.

____11. For feeding, follow instructions in *Commercial Vermiculture*.

____12. Check temperature, moisture and pH often. Visual inspection of the condition of your worm beds will tell you what is happening.

____13. Continue to feed worms, keeping the beds moist. Use less water and feedstock in winter, more food and water in spring, summer and fall.

____14. Prepare more beds for your first harvest. Add fresh material for worms if your harvest is for castings only.

____15. Prepare harvesting screen
from 1/4"screen material.

_____16. Separate worms from castings. Screen castings for sale. Add one-half your worm inventory to new bed, keeping one-half for the bed you just harvested. Add fresh bedding to the bed you’ve just harvested.

_____17. Conduct plant growth experiments with your castings. Obtain 3 to 6 of the same type of young plant and prepare different blends of potting soil for each. These plant growth experiments will serve as a demonstration of the value of castings.

_____18. Continue to feed worms. Plan for future growth and harvest. Determine when to sell worms and how often you will harvest (weekly? rotation schedule of harvesting from different bins or windrows?)

_____19. Consider expanding your business with sales of other items besides worms and castings. Develop markets in your area and help other worm growers get started.
This book was written in order to answer a simple question: *Is there a way to make money raising earthworms?* The answer is an unquestionable and emphatic Yes! And you will be shown, step-by-step, how to raise and market worms and other products as well.

Some may recall that raising worms for profit was popular several years ago. In fact, there was a "boom" period in raising worms during the 1970s, followed by a consequent "bust." The chief end-market then was principally bait, but those who got involved toward the end saw the industry "bottom out" and were left bitter and disappointed. There are still a number of those individuals around today who are quick to volunteer a healthy dose of skepticism when they find out someone is going to try to grow worms and make money.

Perhaps the biggest overall difference between this book and those that came out of the 'sixties and 'seventies is reflected in the fact that the marketplace has changed--no, a better term would be "has been revolutionized." Over the past twenty years there have been changing environmental needs, developments in worm technology and advances in worm research that have created new opportunities yet to be fully realized.

Today, there is a groundswell of interest in vermiculture just now forming with the benefits and repercussions yet some distance off. Here are three small indicators of growing "popular" interest in redworm:

1. A winter 1996 episode of the popular television program *ER* featured an exchange of information among the characters about growing worms for profit. The *Can-O-Worms* product, while not mentioned, was said to have been displayed as a worm bin.

2. The February 12, 1996 issue of *Newsweek* carried a story under the Ecology heading entitled, "Kitchen
Help: Wrigglers Under the Sink." (p. 76). The
magazine claimed that "Worm composting, or
vermiculture, is wriggling its way into the hearts of
families and cities across the country. Gardeners have
known about it for decades, but now committed
recyclers and even local governments are turning
wormward to make use of the organic material that
accounts for 15 to 30 percent of all garbage."

3. The mega-wholesale-warehouse Price-Costco
organization, in its April 1996 edition of its
publication, The PriceCostco Connection, featured a
full-page story on one of its members from
Vancouver, B.C. Under the Home & Garden heading,
the article entitled "As the Worm Turns," focused
upon a woman who owns a business, the Worm
Garden, that markets composting bins and red
wrigglers. As other writers on the subject, the author
of this particular article blends observations of home
vermicomposting with projections of reduced landfill
waste: "In a composting bin, redworms can eat half
their weight in food each day. That means worms in a
modest-sized bin can convert 430 pounds of food
scraps per year into usable fertilizer. That's equivalent
to the weight of two newborn elephants that otherwise
would end up in landfills." (Vol. 11, No. 4, p. 21)

The first two items listed above demonstrate the
national coverage vermiculture has been given. The third
item, albeit in a membership discount warehouse newsletter,
reflects, in part, the international interest in vermiculture.
(PriceCostco warehouses are found in So. Korea, Mexico,
Canada, and the United Kingdom as well as throughout the
United States.) Further indication of this worldwide interest
may be seen on the Internet where Websites and vermicomposting forums are beginning to proliferate.

Local newspapers are similarly paying attention to news about growing worms. In Orange County, California, the Register newspaper provided extensive coverage to the Canyon Recycling vermicomposting facility in San Diego, California. In its Focus on Environment section of Friday, March 1, 1996, John Barbour of The Associated Press wrote, "Hard-Working Worms: Turning Green Horticulture Waste into Greenbacks." Describing the commercial recycling company in San Diego as "home to 75 million hungry earthworms," Barbour's article quotes John Beerman, General Manager of the facility: "In his conservative way, Beerman figures he feeds his 75,000 pounds of earthworms about 15 to 20 tons of green waste every day. 'And we harvest that much out every day. Now when we expand the herd (yes, herd), we want up to 100,000 tons'." This quantity will be needed to meet obligations to market the product—worm castings or "VermigroÔ"—to 80 Home Base home and garden supply centers.

Coverage of the present author's own facility on the day after Earth Day (April 23, 1996) was prominently displayed on the front page of Oregon's Medford Mail Tribune, covering Jackson County in southern Oregon. Similar coverage was given in the Grants Pass Daily Courier on April 13, 1996 in the Business section. This is the primary publication serving Josephine county.

While these incidents do not add up to proving that vermicomposting is the most popular and fastest-growing industry in America (and no one is yet making that claim), it demonstrates the great interest shown from many quarters in the wonders of what these little creatures can do. As for the current crop of "insiders," i.e., those actually involved in vermiculture, expectations of future development and progress border on the grandiose. It has been incredible to witness an almost blind-faith-like "will to believe" in several individuals who are industry shapers and leaders. Some of these persons are real visionaries, claiming that vermiculture will be the world's biggest industry by the turn of the century! Some are entrepreneurs, buying up worms, acreage, and making deals with a handshake and a promise. Some are committed "green industry" people, whether they are called
But "getting there" won't be easy. Some severe challenges lie ahead. One such challenge is currently being faced by one of the largest vermicomposting operations in the nation. With over 161 windrows, each one hundred feet in length, Pacific Southwest Farms of Ontario, California feeds tons of MSW (municipal solid waste) brought from MRF (materials recovery facility) to its worms. The problem? Tiny bits of glass in the finished vermicompost currently render the product unsalable, at least at the retail level, until a separating system can be found. But the mere presence of problems such as this has not stopped this operation from continuing. (An agricultural use for the product has been found. And systems to separate glass from vermicompost are available.)

I believe it will be the challenges ahead that will keep vermicomposters motivated. The psychological benefits are there as well as the financial:

It brings great satisfaction to know that something good can come from waste, and that each of us can do something about the waste we create!

Here is a natural way to convert what was perceived as useless into something useful—and the answer has been literally under our feet for generations.

A natural alternative to synthetic soil amendments has been found because worm castings are a type of Super Plant Food. (What ramifications will this have someday on the petroleum-guzzling, commercially-produced fertilizers that leave only depleted soils after years of use?)

New opportunities lie ahead in demonstrating that sustainable agriculture is achieved through understanding and utilizing the closed-loop cycle found already in nature: germination, growth through photosynthesis, maturation, harvest, decay, and finally replenishment of soil nutrients through composting and vermicomposting.

But converting organic waste into marketable soil amendments may threaten established interests, particularly the commercial producers of synthetic fertilizers. And this is
where a future battle may be waged. On one side will be the newly emerging forces of waste resource recovery and organic soil advocacy. On the other will be the naysayers and synthetic, chemical-dependent interests who will seek to disparage the value of what is, organic and demonstrable in nature itself as the most viable means of converting wasted potential plant energy (formerly known as debris) into a plant food now being proven through plant growth trials to be superior to synthetic petrochemicals.

Perhaps the author has taken on too great a task which seeks to include many aspects of a common theme: Commercial Vermiculture. What are the primary elements? Certainly, knowledge of the worm itself. Some acquaintance with past efforts in vermiculture are presented as well as the current status of worm growing today. The goal, however, is the presentation of up-to-date information on vermiculture (breeding worms) and vermicomposting (process of turning organic debris into worm castings). Making information and "raw data" useful is not always easy and may even have been done awkwardly. This could have been written simply as a description of the state of vermiculture today. Instead, I have tried to show that anyone might have a part in growing worms and producing castings--and there can be profit in it.

In order to gain the knowledge of the contemporary status of commercial vermiculture, the author toured many worm-growing operations of different sizes. Interviews with growers of the past and present were conducted. Reading available literature, from the much-dated books of the past 20-30 years to current periodicals on the subject was undertaken. Some research material was only available in university libraries. Experts in the field, both academicians and entrepreneurs, have been consulted. Seminars, where current experts have presented their findings, have been attended in several states. And, finally, hands-on experience in raising worms really does show that "experience is the best teacher."

The greatest regret this author would have after writing this would be if readers somehow lost interest in this fascinating field. Loss of interest could come from many sources: It could be perceived that too much work is required; there might be a lack of understanding, there could be the question of self-doubt, i.e., "Do I have what it takes?", or perhaps even a lack of a sufficient challenge. The only
answer I can give is that of my own experience and what I have seen in others: Once these ideas, concepts and dreams get a hold of you, they don't let you go.

There have been, there are, and there will be many, many people making money in commercial vermiculture. What stands before you now is something like a smorgasbord of opportunity in this re-emerging industry. Read about where this industry stands now. I invite you to do something to make it bigger and better tomorrow.
Chapter 1

COMMERCIAL VERMICULTURE AT THE END OF THE 21ST CENTURY

Why would anyone want to grow earthworms? This is a question you are probably asking now and may be a question you'll someday have to answer. Anyone who grows worms will inevitably face the question: Why do you want to do that?

Of course, the simplest answer is, "for the money." This reason alone is why many individuals start growing worms, but in time even those who are making money will tell you there are other reasons as well.

The Landfill Crisis

As we come to the end of the 20th century, there are few individuals, if any, who do not know about ecology and few who don't realize that everyone must do something in order to keep life on our planet healthy. In this regard, one of our greatest concerns is with the problem of waste and debris. Landfill sites around the U.S. and the world are filling to capacity and closing down. Since 1988 over 4,000 landfill sites have been shut down in the U.S. alone, and by the year 2000 many more will have closed. States such as California are mandating by law (Assembly Bill 939) that communities must reduce their waste by 50% of 1994 levels by the year 2000 or face penalties of up to $10,000 per day!
Efforts in Composting

What does this mean? Everywhere, communities are scrambling to reduce waste. Solutions to major problems must be found and implemented--in a hurry!

<table>
<thead>
<tr>
<th>Common Organic Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food</strong> - Fruits, vegetables, grains, eggs, dairy products, meat and fish</td>
</tr>
<tr>
<td><strong>Clothing and Furnishings</strong> - Cotton, wool, burlap, leather, feathers and down</td>
</tr>
<tr>
<td><strong>Building Materials</strong> - Lumber, plywood and other wood based materials</td>
</tr>
<tr>
<td><strong>Paper Products</strong> - Paper, newsprint, cardboard and tissues</td>
</tr>
<tr>
<td><strong>Animal Wastes</strong> - Manure, bedding and hair</td>
</tr>
<tr>
<td><strong>Landscape Trimmings</strong> - Grass clippings, leaves, prunings, fallen branches and trees</td>
</tr>
</tbody>
</table>

Since a large percentage of waste is biodegradable (green waste from yard trimmings, grass, food waste, paper products, cardboard, septage and sewer sludge) serious efforts in COMPOSTING have been implemented. One form of composting uses the lowly redworm as an agent in transforming waste into something beneficial: worm castings. Worm castings (or worm manure, the excreta that worms produce after ingesting decomposed organic matter) have a tremendous economic benefit because they provide a nutrient-rich soil amendment for landscapers, growers and gardeners. (More about this later.)

So why would anyone want to grow worms? Simply because worms are now, as they have always been, in short supply. The demand, it is predicted, will always exceed the supply, even though worms can double in population every 60-90 days.

It would seem that with their reproductive abilities alone, there would be a surplus of worms, but that just isn't the case.

As of this writing, major landfill diversion sites are feeding millions of redworms tons of composted green waste. These sites earn huge sums of money from several different income streams. In order to understand the huge profit...
potential that exists in growing worms, it is important to look at the "Big Picture." By knowing what is causing the marketplace to demand more and more worms one begins to realize that many individuals can play a supporting role in helping meet the upcoming demand. What follows is a brief description of the tremendous profits landfill diversion sites are now generating and why future sites will be interested in buying your worms.

**Sources of Income for Landfill Diversion Sites**

1. "Tipping fees" are paid by each truck that brings a load of organic waste to a landfill diversion site. Typically fees start at about $15 per ton of waste, but in some areas these fees go as high as $75 per ton or more. *(This income alone would pay for the huge costs these sites incur, but their income is even greater because of what follows.)*

2. Organic waste is shredded and ground into various particle sizes. Some goes into making fine compost; other blends go to make mulch, and other larger materials are purchased by “Cogen” facilities (using organic waste as fuel to produce electricity.) One site in San Diego county sells NINE different types of its shredded material! Private landscaping companies as well as state-owned transportation departments (which use composted materials for roadside landscaping) buy tons of these materials annually. This is a sizeable income stream!

3. Vermicomposting, that is, producing worm compost (castings) is yet another income stream. Typically, long windrows of compost (some rows are 300 feet long or longer) contain millions of worms which are fed tons of waste. These beds can be as wide as 20 feet in some cases. The worms eat their way to the top and leave their castings below. At harvest time the worms are taken from the top 6-8 inches of material and introduced to another row to begin the process again. Their castings are collected and sold in bulk (by the cubic yard) or bagged and sold to home centers, nurseries and the general public.

Because of the superior nutrient content in worm castings, plant growth is dramatic and production is bountiful. Studies have shown that worm castings exceed ordinary compost in its readily available nutrient benefit. Moreover, castings contain a time-release quality, something ordinary
compost cannot claim. Currently, worm castings are being marketed by large vermicomposting facilities to huge home improvement centers, landscape contractors and nurseries. This high-grade soil amendment (one product name is "Vermigro™") brings a premium price because users know it is a premium product.

4. Some sites sell liquid organic fertilizer or L.O.F.. This leachate or percolate is the liquid run-off as water passes through the vermicompost. This liquid is high in plant nutrients and may be sold in bulk to either retailers (who sell it in gallon jugs to the public), or to high-volume users such as landscapers.

5. A fifth possible source of income some sites, on occasion, receive comes from redworm sales. However, large sites are not currently selling their worms (except in a few cases where they can get top retail prices). Rather, their efforts at increasing yields of vermicompost for sale necessitate keeping their own worm inventories high. Moreover, as the economic success of these sites becomes known, new ventures are planned. The result: Even more worms are needed. Currently the demand far exceed the supply.

The Worm Marketplace

Now, let's return to the original question: Why would anyone want to grow earthworms?

The answer should be a little more clear after the foregoing description of where some of our landfill sites are headed. Yet there are other income streams available to worm growers. Anyone seriously considering getting into the worm business should know about the breadth of the entire marketplace.

Traditionally, worm growers sold their stock as bait to fishermen. This is still a huge industry throughout the United States. Years ago it was common see advertisements like "Worm Growers Wanted" in magazines like Popular Mechanics. New growers were expected to develop their own markets to bait and tackle shops. Nowadays, established bait sales by huge worm growing and harvesting operations amounts to millions of dollars.
As a worm grower you may sell your worms at this level. Styrofoam cups with lids are all that's needed. While growing worms to bait shops is a viable option, the grower will need to do some marketing to establish contracts. Bait and tackle shops need reliable suppliers and the new grower may need to demonstrate that production and consistency demands can be met.

Some growers want to build huge inventories in order to sell their worms at a profit to future growers. Their market is to sell breeding stock to those just coming into the business. These growers also have inventories to cover other growers who have orders too large to fill from their own stocks. Sales might be to fishermen who want to have a large supply for themselves, organic gardeners, or composters who want to raise worms for their own continuous supply of both worms and castings.

Earthworms can be sold to institutions using them for experiments. Research on many types of animal and plant life is being conducted worldwide, and laboratory use of worms offers a potential market. High school, university, and private laboratories are large-scale users of worms for classroom and research needs.

Pet stores need worms for food to supply the needs of certain animals. Fish hatcheries, zoos and tropical fish stores need worm suppliers. Game bird breeders and poultry growers might also be potential markets. Here's an example: "The Winfield Files" consist of a data base of almost 14,000 different wild and domestic birds and 10,000 bird owners. By cross-referencing any one of the 14,000 birds to bird owners, another list of almost 30,000 combinations of bird/bird owners has been created. Members who belong to this service can advertise to reach this base which includes almost 200,000 people who have access to national advertisements each month. Their goal is to have 1,500,000 such people by the end of 1996. In addition are the millions of people who would have access to this information after they enter the Internet.
A huge market exists for worm castings. Worm growers can specialize in simply this one area of production for nurseries, landscapers and home-garden use. Castings can be sold in bulk or in bags. Typically castings are sold as a blend, mixed along with compost. Recent studies conducted with castings have demonstrated that blends comprising between 20% to 90% worm castings produce excellent results in plant health and yield. Surveys of nurseries in several areas have revealed that while nurseries would be happy to sell worm castings to the public, the supply is not available in most locations.

But perhaps the greatest customer base as far as quantity of worm sales goes is the landfill diversion sites. There are at least three reasons these facilities will need greater and greater numbers of worms: 1) More and more states are introducing 50% waste reduction goals. The May 1996 issue of *Waste Age* reports that increased populations, particularly in western states, and statewide recycling goals have caused a tremendous growth of composting facilities. "In 1989, there were fewer than 20 facilities in the West. Today, there are more than 300, and the growth shows little sign of slowing." (Matthew Cotton, "Composting Moves West," *Waste Age*, p. 222.) In the West, California, Colorado, New Mexico, Oregon and Washington all have 50% waste diversion goals, the most stringent being California's AB 939 which calls for substantial penalties for non-compliance. An increase in vermicomposting has been a concomitant effect. 2) It is now being demonstrated that worm castings provide such a superior growth medium that demand will continue to escalate, providing continued profits to producers. Evidence in support of this is supplied by current sites such as Canyon Recycling in San Diego which is looking to start nine other satellite facilities and is seeking large contracts for worms. 3) While propagation of red worms can be substantial at these sites, there is tremendous loss of potential worm biomass (actual weight of worms) in production because of frequent harvesting. As windrows are culled of both castings and worms approximately every thirty days, small worms and millions of cocoons representing the next generation of worm productivity are lost in the castings which are sold off monthly to meet contractual obligations. This loss of potential increase in worm biomass which is the result of
frequent mechanical harvesting of adult worms holds down expected increases in worm population.

There is a great need for worms TODAY. What can be learned about the make-up and behavior of these little creatures to benefit from their activity?
Almost everyone has seen worms in their garden or on a sidewalk or path after a rain. (Rain is unsettling to many worms and causes them to migrate.) A worm is a worm to many people, but even the most casual of fishermen knows a nightcrawler from a red wiggler. You might have heard that gardeners like them in their backyards because they help aerate the soil. But other than being used for bait and aiding the home gardening enthusiast, the lowly earthworm's reputation hasn't been all that glamorous. Even among cartoon characters of bears, ducks, mice and dogs, who is there to represent worms in the comics or on Saturday morning television?

Actually, the worm has gotten much better press quite some time ago, and eloquent words from some fairly formidable scholars have been put to paper. Aristotle, for example, called worms "the intestines of the earth," some 2500 years ago. Charles Darwin, best known for popularizing the evolutionary model of species development, was a lifelong researcher on worms. In 1881 he published *The Formation of Vegetable Mould Through the Action of Worms*. (Vegetable mould is his term for castings.) At the conclusion of his work he penned the following words:

> The plough is one of the most ancient and most valuable of man's inventions, but long before he existed the land was in fact regularly ploughed, and still continues to be thus ploughed by earthworms. It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures.

Izaak Walton, in his classic book *The Compleat Angler*, described his experience while fishing one day:

> And that one day especially, having angled a good part of the day with a minnow, and that in as hopeful a day, and as fit a water as could bwished for that purpose, without raising any one fish; I at last fell to it
with the worm, and with that took fourteen in a very short space.

Anglers who have gone through their favorite lures, plugs and expensive bait formulations seem to come back to the good ol' worm when nothing else is working.

If you want to grow worms commercially and be successful in producing healthy worms for sale, it would be wise to know as much as possible about the little critters, since these creatures, when treated kindly, will earn you a nice profit after your initial investment.

Let's start with some frequently asked questions about worms and in this way get to know them a little better.

**QUESTION:** If I want to grow worms commercially with the intent to sell them later, can I just go out to my backyard garden and dig them up? In other words, do I have to start by going out and buying them? It seems like I can get started faster and cheaper by doing some of the work myself.

**ANSWER:** For those who are "do it yourselves" and want to save a few bucks, there will be plenty of ways you can cut expenses in commercial worm growing. We'll try to share as many of these cost-cutting tips as possible.

However, the one place you don't want to "cut corners" is in your initial inventory of worms. While red wigglers are found in native soils (after all, how did commercial breeders get started originally?) buying a number of pounds from a reputable worm grower will be the best investment you can make. There are several reasons. First, serious growers want a consistent, uniform species of worms for breeding purposes. Growers supply red worms that have been commercially bred for generations. You don't want to have a mixture of different species-types plucked out of your garden since your aim is to sell these worms to a buyer who will want all red worms. Second, you will need to start with a sufficient quantity for breeding. This means buying several pounds of worms, not several dozen individual worms. Harvesting enough worms out of native soil would be a very large task! Worms will not be found in dense enough concentrations to make this job worthwhile. Third, your initial purchase of worms should contain worms of different sizes and may contain a number of cocoons. These will begin
hatching soon in their new environment, and the smaller worms will adapt quickly to their new surroundings. Finally, if it is your intention to sell worms to a grower, it is best to build a relationship with that grower so that he knows what he is buying from you. If the buyer knows that he is buying back the progeny of the worms he initially sold to you, he will be more likely to do business with you than if you told him you started with a bunch of worms from your garden.

**QUESTION:** Is this why growers sell "hybrid" worms?

**ANSWER:** Some growers advertise their worms as hybrid worms or give them other fancy names like Red Hybrids, California Reds, Red Stripers or Hybrid Red Wigglers. A hybrid, however, is cross between two species and there is no scientific evidence that commercial growers have been able to cross two different species. The worms that are used for composting are essentially two: Eisenia fetida and Lumbricus rubellus. These are both red worms which have been known for generations and are the worms used in commercial operations. Over the years some growers have been led to believe (falsely) that they are producing a unique worm that cannot be found anywhere except from commercial growers. Whether they want to discourage would-be growers from digging them up in their own backyards or whether they are trying to "hype" their own product by suggesting they have a superior worm, the outcome is the same. Be wary of growers who claim they have a unique worm not available from anyone else.

**QUESTION:** What about nightcrawlers? This seems like a much bigger worm. Wouldn't it be useful to grow these along with the others?

**ANSWER:** The species name for nightcrawlers is Lumbricus terrestris. While it is closely related to the other species we call redworms, it is a different creature insofar as its usefulness for commercial breeding and castings production. The nightcrawler, a much larger worm, is useful in aerating the soil because of its burrowing abilities. Nightcrawlers make their burrows deep in the soil (6 feet or more in depth) which encourages greater water absorption and effectively minimizes water run-off or erosion of top soil. Plant life is enhanced by nightcrawler activity since root systems are well-watered at greater depths than without their activity. Nightcrawlers come to the surface at night and
search for decomposing organic matter, such as leaves, which they drag toward their burrows. They also leave their castings which are readily visible on the surface near their burrows. While nightcrawlers are also instrumental in mixing the topsoil with subsoil (which contains valuable minerals also needed by plants), they do not possess the same features as redworms insofar as commercial breeding and casting production goes. In other words, the nightcrawler, while a beneficial worm in nature is not a useful creature for our purposes. They are typically "harvested" from orchards at night utilizing flashlights (with red lenses) and gathered by hand. Nightcrawlers are then, in most instances, sold as bait to fishermen.

**QUESTION:** How do worms breed?

**ANSWER:** Earthworms are hermaphrodites or hermaphroditic. This means they possess both sexes, male and female. They have both testes and ovaries. This does not mean, however, that they can produce offspring without mating. A cross-fertilization process is involved.

About one third down the length from their anterior or head is a prominent band in sexually mature worms. This is called the clitellum. From this swollen area (an increased width from the remaining segments of the worm) they mate with other worms. Worms in mating exchange sperm which reaches eggs that have been released during the process when worms have lined up next to each other with their bands touching, the worms facing in opposite directions. Mucus is secreted to encapsule both the egg and sperm for each worm. The mucus tube, containing the fertilized egg then moves along the top portion of the worm and is then slipped off the head, sealing off the two ends. The resulting capsule, known as a cocoon, is lemon-shaped and is at first a greenish-yellow color much like an unripe lemon. These cocoons are visible
to the naked eye and can be found throughout the worm bed as worms (in the right temperature) are constantly mating and producing offspring. (A worm's activity is a little more dormant in temperatures outside the 55 to 80 degree F. range.)

**QUESTION:** What happens to the cocoons?

**ANSWER:** Each cocoon is capable of producing between 2 and 20 worms. The average, according to one study is about 4 (this particular scientist said 3.8) worms that emerge from each cocoon. Mature earthworms can produce egg capsules every 7 to 10 days, and each cocoon may hatch within 14 to 21. As cocoons mature and come closer to the point of hatching they turn darker in color. Sometimes they become more difficult to find in the worm bed because their color is closer to the bedding material, turning a darker, more brownish color. In nature, worms may produce more cocoons in drier conditions, anticipating early death because of heat and lack of moisture. Some growers believe they can temporarily boost cocoon production by artificially creating drier conditions by withholding moisture for a brief period, re-moisturizing the bed later. Worms in nature anticipate dying off in the hot summer but leaving behind a plentiful supply of cocoons which hatch in the spring. This cycle of activity, (that is, a worm's expectation of eminent demise) not to mention the issue of predation, goes far in helping explain the paucity of worms found per square foot in natural soil.

**QUESTION:** So what is the lifespan of a worm?

**ANSWER:** Scientists have performed studies by observation of natural conditions (this tends to be difficult because of the lack of controls) and in closely-monitored laboratories. Their findings have disclosed the earthworm's lifespan to be, variously, one, four-and-a-half, ten, and even fifteen years. The best answer to the question of lifespan will consider the worm's environment. In nature where uncertain conditions exist concerning availability of both feedstock and moisture, and where temperature extremes are not mitigated, and where predators are likely to feast on their defenseless prey of choice, a worm's lifespan is minimal at best. However, commercial breeders who are able to control environmental conditions will find worms living and breeding much longer. A factor which may also influence lifespan of commercially-bred worms is the number of times they are
subjected to the mechanical harvesting process, by which they are separated from their bedding in a rotating trommel device. Precise studies on this type of worm "stress test" are not currently available.

**QUESTION:** What does the worm eat? What is it really looking for as far as nutrition?

**ANSWER:** Scientists as well as commercial worm growers have found many types of feedstocks for worms and investigation and experimentation continue as of this date.

Typically the redworm, because it is a manure worm, is grown in a bedding of aged manure to which fresh manure may be added. Frequently these worms are found in manure piles left on the ground at farms and ranches, but other worms may also be attracted. Horse manure consists of a carbon-to-nitrogen ratio that is favorable to worms. The C:N ratio, as it is called, is about 25:1 for horse manure, making it about ideal. (More about this later.)

In nature, redworms eat decomposing organic waste. However, scientists are looking at the likelihood that worms are actually consuming the bacteria and protozoa found in the environments of decomposing waste. These environments are rich in a variety of life as various visible creatures and microorganisms participate in breaking down decaying vegetable matter. Some scientists have studied worms in sludge from wastewater treatment plants. There are studies indicating greater weight gain on sludge but better reproduction on manure than on sludge.

Other feedstocks include fruit and vegetable waste, cardboard, newspaper, yard trimmings including grass clippings, coffee grinds including filters, tea bags, and just about anything else that was once living.

Most growers avoid the introduction of meat and dairy products. These invite rodent problems and are not generally
found to be desirable by worms. Dog and cat feces should not be fed to worms, although scientists continue to study combinations of currently unacceptable feedstocks.

A more comprehensive treatment of feeding worms is found later in this book.

**QUESTION:** How much does a worm eat?

**ANSWER:** Reports of the amount of food consumed by worms vary. The folks who market the Can-O-Worms™ say that you can feed about half a pound of kitchen scraps per day to each pound of worms. Mary Appelhof in *Worms Eat My Garbage* (1982) relates one experiment in which about a pound of worms consumed 65 pounds of garbage during a 110 day period. She recommends, however, a worm to garbage ratio of 2 : 1 (but later says that "worms have been shown to consume more than their weight each day, regardless of their size." (p. 32) Edwards and Lofty in *Biology of Earthworms* (1972) report the following: "Worms consume large amounts of food, for instance, Guild (1955) calculated that worms of 0.1 g body weight eat as much as 80 mg of food per day per g of body weight of worm." (p. 138) Other calculations cited in studies found intake of food to be 20-30% body weight per day (p. 140).

Undoubtedly climate and worm bed conditions affect feeding rates of worms. Many say that worms will eat "up to their weight" every day. Observations by growers are that worms tend to eat less during winter months. Crowded conditions, unsavory feedstock, too little moisture, and anaerobic conditions will also interfere with worms' consumption.

**QUESTION:** How fast will my worm population grow?

**ANSWER:** The rapid rate at which worms multiply is generally accepted. There are differences, however, between
what some growers "say" and what scientists have demonstrated regarding earthworms' reproductive potential. Exaggerated claims of worm fecundity have been made by some growers whose projections are made by using available statistics to yield a "best-case scenario." Optimum conditions for realizing high propagation rates are mandatory. Unfortunately, controlling the environment for achieving maximum worm reproduction is often better done by scientists than entrepreneurs.

What has been said about worm reproductivity? Here's one instance of unfettered optimism:

[It] is possible for one mature breeder to produce a conservative 1,200 to 1,500 offspring in a year. Of course, all of this is based on favorable year-round food, moisture, and temperature conditions. But even under average natural conditions, the results are tremendous. It is estimated that 2,000 mature breeders can produce more than 1,000,000 earthworms and capsules in a year or close to 1,000,000,000 earthworms and capsules in 2 years.

What does this mean to the earthworm grower? It means that your earthworm population will double every 60 to 90 days depending on environmental conditions. Thus, one commercial earthworm bed (3 feet wide by 8 feet long by 1 foot deep) stocked with 100,000 earthworms can provide the earthworm grower with 32 to 64 beds in 12 months. This is accomplished by dividing the beds every 60 to 90 days. (Ronald E. Gaddie, *Earthworms For Ecology & Profit, Vol. I* (1977) p. 5.)

Note that if a 60-day cycle is used and you began with one bed on January 1st, you could have two beds by the end of February, four on April 30th, eight at the end of June, sixteen beds by the close of August, thirty-two by Halloween, and perhaps 64 by New Year's Eve. If the ninety-day cycle were used, you would have the following: Jan 1st: one bed; March 31st: two beds; June 30th: four beds; September 30th: eight beds; December 31st: 16 beds.

There are at least two factors overlooked when making projections about worm "doubling," even when accepting the assumption that the worms enjoy optimum
conditions. One critical item often overlooked is that it takes time for worms to develop sexual maturity. One study showed that it took up to six weeks for 50% of a population of red worms to reach sexual maturity. Another factor is the added time it takes for a cocoon, once produced, to hatch. If it takes 14 to 21 days for a cocoon to hatch, there is an additional delay.

Mary Appelhof provides some statistics that include developmental stages:

The time it takes for a baby worm to become a breeder varies, depending on the same factors—temperature, moisture, food availability, and population density. A redworm can be sexually mature and produce cocoons in four weeks, but six is more common. Once it breeds and begins laying cocoons, it can deposit two to three cocoons per week for from six months to a year. Conservatively, then, if a two-month old breeder laid two cocoons a week for 24 weeks, and two hatchlings emerged from each cocoon, one breeder would produce 96 baby worms in six months (2 cocoons x 24 weeks x 2 hatchlings).

The situation is more complicated than that, however. Before the first two months are up, the first hatchlings will be able to breed. These could produce two cocoons for 16 weeks with two hatchlings coming from each of the four worms resulting from the original breeder's first week's production, or 256 more worms before the six month period is up. The math quickly gets complicated, but since optimal conditions for such geometric increases in numbers will never be achieved, theoretical projections are more confusing than informative. Dr. Roy Hartenstein of Syracuse, New York, has calculated that eight individuals could produce about 1500 offspring within six months time. (Mary Appelhof, *Worms Eat My Garbage* (1982) p. 28.

Dr. Matthew Werner, Soil Ecology Specialist from the University of California at Santa Cruz, compared two worms, the *Amynthus hawayanus* (also known as the *Pheretima hawayana*), a tropical earthworm that originated from China, and the manure worm *Eisenia foetida*. In a laboratory study, both worms were reared in aerobically digested sewage
sludge with the following reproductive potential measured for each worm:

<table>
<thead>
<tr>
<th></th>
<th><em>Amynthus hawayanus</em></th>
<th><em>Eisenia foetida</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. cocoon production/worm/week</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Percent of cocoons hatched</td>
<td>79%</td>
<td>83%</td>
</tr>
<tr>
<td>Offspring/cocoons hatched</td>
<td>1.2</td>
<td>3.8</td>
</tr>
<tr>
<td>Offspring/worm/20 weeks</td>
<td>72</td>
<td>223</td>
</tr>
</tbody>
</table>

(Matthew Werner, "*Amynthus hawayanus* (Fact Sheet)," in *Worm Wise News*, The International Worm Growers Association, (1996), Vol I, Issue 1, p. 3.)

Variables to look for in calculating "worm doubling" would include species of worm, average number of cocoons produced per week, hatching percentage, average number of cocoons hatched, time to reach sexual maturity, and of course environmental factors. In addition, the number of worms present in a worm bed (i.e. density) will have an impact on propagation.

Scientists and growers alike agree that increasing population density affects worms' reproductive potential. One study noted that "at low population density *E. foetida* appears capable of reproducing for up to one year, while at the highest density tested, 16 worms/300 cc. reproduction would cease after about 6 months." (Roy Hartenstein, et. al., "Reproductive Potential of the Earthworm *Eisenia foetida*, Oecologia, 43, 336 (1979).

So, how fast will your worm population grow? That will largely depend upon you and the conditions you are able to provide for your worms. While it would be wonderful to confidently assert that guaranteed doubling will occur every two to three months, a number of factors would have to be present. Certainly, geometric growth is possible, but exact predictions for growth potential are impossible.
The very fact that an enormous growth rate is possible keeps many growers searching for ways to maximize their production. Several growers have found ways to promote worm propagation through intelligent use of available data and constant experimentation. Now that we realize what the greatest potential of worm reproductivity has to offer, we face the continued challenge of providing optimum conditions in commercial vermiculture.
GETTING STARTED

Where are worms being grown today?

Worms can be grown almost anywhere. The largest users of worms are the landfill diversion sites where green waste is diverted from the huge solid mass of other waste our culture produces: rubber tires, plastic containers of all kinds, metal cans and appliances, and the millions of discarded plastic and synthetic gadgets and novelties consumers once so desperately had to buy. A few but expanding number of communities divert biodegradable waste and convert this into usable compost. Compost can be made of the branches, leaves, twigs and grass clippings from landscapers, pre and post-consumer food waste, cardboard and paper, paper sludge, wood waste from construction and demolition, and sewage sludge from waste water treatment facilities. Some of these facilities feed this composted organic waste to millions of redworms. Soon, the sight of long windrows of worms working their way through tons of waste will be more common than it is today.

That is why today's worm growers are standing on the threshold of incredible opportunity as the need for millions of worms becomes widespread. The sixty to ninety day cycle of the earthworm's reproductive development, while considered "fast" by ordinary standards of livestock production, will not be nearly "fast enough" for the growers wanting to meet the demand from vermicomposting facilities.

Next on the scale of worm growing operations is the large commercial worm farm which typically is operated by one grower who may hire occasional help during busy times of the year. While composting facilities at diversion sites are characterized by large acreage, expensive state-of-the-art technology and equipment, and considerable start-up and maintenance costs ($2 million start-up, several hundred thousand dollars of which is for permits, costs for leasing equipment, staff, etc.), the medium-size operations have greatly reduced costs but still may have sales of over $500,000 per year. These growers supply worms to smaller growers and have established accounts they may service in the bait market. These growers, however, are fast becoming
the first-line of supply for the larger landfill operations. As vermicomposting facilities wish to expand or start other sites, they call upon large established growers to supply them with worms. These growers, however, have their established accounts to service and cannot possibly meet the enormous needs of the giant landfills.

The third size operation is the small grower who operates usually without the benefit of mechanization. He or she may have a mechanical harvesting unit, but lacks the capacity to move thousands of pounds of feedstock to the worm beds. Small growers will do best to associate in networks in order to help one another in meeting sudden demands. Independent growers' networks allow for the pooling of resources, sharing of tips, help with troubleshooting, and, of course, covering the needs for large orders that one grower cannot individually meet.

Where would I start my worm business?

One of the attractive aspects about getting into the worm business is that anyone can participate and the cost to begin doesn't have to be much at all. Young people can start out growing worms in their backyards as can men and women of all ages. Worm bins can be made out of scrap material, or a pre-made unit can be purchased for convenience and for "showing off" to friends and neighbors. You can use a portion of the space you have in your backyard or put a container on a patio, deck, in a garage, shed or basement.

The cost of starting a worm business can be no more than your first pound of worms. Considering that worms will double in approximately 60 to 90 days, it won't take long before a new grower can have a significant inventory. Simply do the multiplication, and you can see how fast your worm business will grow. Two pounds will become 4, then 8, then 16, and then 32. Meanwhile, you'll have plenty of time to construct extra bins or plan on making space to occupy your inventory. Also, while you are growing your worms, you can discover sources of feedstock if you don't have them already. That is one of the nice things about starting out in this business. You will have time to plan ahead. Most people start out with enough worms they feel they can care for comfortably. It might be a 4 x 8 bin with about 30 lbs. of worms (you want to stock your worms at the
rate of about one pound per square foot of bedding). Some entrepreneurs who want to grow faster will start out with more. (These are the ones who know the power of multiplication.)

Getting started in a worm-growing business raises many questions and new growers are not sure about the commitment it takes. That's why starting out at a comfortable level is recommended. You'll have time to see if this is really something you want to do, either as a business or just a hobby.

For example, let's say you were interested in supplementing your income and wanted to make an extra $200 per month. If you knew that you could sell your worms for a minimum of $5.00 per pound, you'd have to raise 40 lbs. a month. To harvest that amount of worms, you'd want to build your inventory to reach three or four times that total so that you could remove about 40 lbs. every month.

As you are selling off your inventory, your worms keep doubling roughly every ninety days. If you remove about a third of your worms each month to sell, the rest of the worms will continue to multiply. Precise math calculations are really not possible here because factors of feedstock and temperature will come into play. But the idea of regular, monthly harvesting to maintain a regular income and to keep inventory at a consistent level is an attractive thought for many.

Naturally if you sell your worms at higher prices you can count on increased income.

Whether you want to continue "doubling" your inventory from cycle to cycle or keep your income consistent, the choice is up to you.

Worm growers have many stories to tell about how they started out. One grower remembers cutting up one-inch cardboard squares and soaking them in his bathtub for bedding. Many growers have used old discarded bathtubs, galvanized metal cans, old troughs, window boxes, dresser drawers, crates, or just about anything else that could be called a container. After all, the worms don't really comment on the structure they're dwelling in: they can't see too well
(actually, they don't have eyes). So, as far as what you have to put them "in," that's entirely up to you.

Blueprints to make heated, insulated worm bins are sold for as much as $50.00. The cost of new materials to build just one of these 3 x 4 units (12 square feet, capable of stocking an initial 12 lbs. of worms) is estimated at over $300. That's a pretty fancy worm bin that any redworm would be happy to call home. Because they can be thermostatically controlled, worms can "do their thing" to their hearts' content in an environment that stays between 72 and 74 degrees. Now, that's living! (Read more about this later in this chapter.)

But not everyone wants to start with such an incubation unit, the cost of which cannot be recovered until sometime in the future.

**How do I get started?**

Here are a few suggestions for starting your own commercial worm growing business.

1. **PLAN.** Think about where you will grow worms, for what purpose and how much money you want to invest in your business. This means you'll need to consider the SIZE of your operation.

   Here are 3 examples of possible plans:

   **Small:** If your available space is limited, or you don't feel ready to invest in a large quantity of worms, or you simply want to take a gradual approach into worm growing, then start with a couple pounds of worms and a small bin.

   A manufactured "worm bin" is ideal. The best we've seen is the Can-O-Worms™, made in Australia. This particular unit has been intelligently designed, economically priced and makes recycling green waste easy and fun. Start with one or two pounds of worms in one tray, introducing the worms into the bedding provided with the Can-O-Worms™. (A block of coconut fiber which comes with the unit is submerged in water and becomes the bedding for the worms.) Fruit and vegetable waste may be added daily for feedstock.
Each of the three stacking trays has a mesh bottom allowing the worms to migrate upward toward the new feedstock and leave their castings in the lower tray. By the time the worms reach the top level, the bottom level contains castings which may be harvested. (Because the worms have traveled upwards in search of food, leaving their castings behind, this system becomes a type of "self-harvesting" unit, separating worms from their castings, an often time-consuming process.) Once emptied, this tray will be added to the top of the Can-O-Worms™ and the process of upward migration continues.

What's nice about this ingenious system is that it is small (20" diameter, 29" high) and can be placed anywhere. Indoor: basement, pantry, laundry room, even the kitchen. Outdoors: garage, by the garbage cans, on the deck or patio, in a shed, etc. Made of recycled plastic, it weighs only 13 lbs. It is supported by five sturdy legs and has a collector tray at the bottom level where the "worm tea" or liquid fertilizer is collected and released through a tap.

The unit is well-made with tightly fitting trays to discourage entrance by fruit flies, yet with ventilation holes on the lid to allow air into the system. Because it is attractive and unique, it makes for a marvelous demonstration tool for introducing the concept of worm composting to others. What we've seen happen frequently is that even individuals who
have aspirations of growing huge amounts of worms on a commercial scale find that the Can-O-Worms™ is a good way to get their "feet wet" and it also becomes an additional aid in the promotion of the concept of worm composting.

You can get started out in a small way by using a container already available to you, or by making one. It is best to consider the issue of drainage before stocking just any container with worms. If your container has a solid bottom with no chance for moisture to escape, there is a good chance that water will collect at the bottom and your worms will not be happy. They may even drown. Make sure you drill holes in the bottom of the container or design a way for excess liquid to pass through and out of the container. Aeration is also important. Toward the top of the container, if it is to have a lid, make sure that ventilation holes are present since your worms will need oxygen to survive.

**Medium size.** A 4' x 8' plywood bin in the usual starting place for intermediate growers. In this size bin you'll want to stock worms at the rate of about one pound of worms per square foot. After about six months when the worms have increased their population, you can decide on either harvesting some worms for sale or splitting the bin's contents to start a second bin. To split the bin, simply build a second 4' x 8' plywood bin and fill with eight to twelve inches of bedding (aged horse manure is best). Add half the contents of the first 4' x 8' bin to this second bin. Then add fresh bedding to the first plywood bin.

It should be added that the 4' x 8' plywood bin is a typical, but by no means mandatory container for redworms. A number of other methods for growing worms have been used. Some have used concrete block (with or without mortar) to make worm beds. Concrete block beds have a couple advantages over wood beds: First, they will last
longer than beds made from wood which is subject to deterioration over time. Second, because of the insulation concrete block provides, the block beds will be cooler in the summer and warmer in the winter than plywood bins.

**Large Scale.** Those who want to proceed rapidly in the worm growing business and work toward owning a large-scale operation need to plan for their space requirements as well as feedstock. Plentiful horse, cow, or pig manure, shredded, composted yard waste or reliable supplies of pre or post-consumer food waste must be ready at hand. The consideration of bins open windrows must also be determined.

Naturally there is much to consider regarding the layout of the operation and planning for use of mechanized equipment. Irrigation, feeding methods, harvesting worms, harvesting castings and other necessary functions must be planned in detail before actual construction begins.

2. **Location**

In general, think about the availability of the following items as you choose your location:

A) **Shade.** Depending upon where you live and how warm the summers can get, this will have some bearing on your need for shade. Since it has been demonstrated scientifically that worms do best around 25 degrees Centigrade (around 72-74 degrees F), your worms will appreciate a shade location in the summer if one is available. Naturally, if you use any sort of container or bin with a lid, you will be providing some sort of protection from the harsh effects of the sun.

B) **Water.** This is probably the most important consideration for determining location. A garden hose is handy for growers and some small growers may use sprinkling can. Large growers have automatic sprinkler systems installed while commercial landfill sites utilize watering trucks that distribute up to 25,000 gallons of water per day.

C) **Electricity.** Some growers use lights over their beds to discourage worm migration at night, but not all growers have this fear. Provided your worms are in the right
type of bedding, are well-watered and fed, they won't need to search out better accommodations. But is there a chance that even happy worms will still crawl away at night?

Rain commonly makes worms want to crawl away from open windrows or worm beds without lids. The worms probably fear drowning in the excessively wet beds and try to leave for "higher ground." On open windrows, one grower tries to put a couple inches of very dry feedstock when he knows it is going to rain. Some use carpet or burlap to cover their beds, but without a solid lid like plywood, excessive moisture could still be a problem.

In addition to lighting, electricity may be needed nearby if a grower intends on using a mechanical harvester.

D) **Accessibility.** Whether you're using a wheelbarrow or a truck or a tractor with a front-end loader, you'll need to have easy access for bringing in your feedstock, harvesting your worms, and carting off the castings.

E) **Storage.** Consider where you'll keep various tools and other items that need to be sheltered or protected from theft.

### 3. Build a Bed

There are almost as many types of worm beds as there are worm growers. One thing about vermiculturists is that they tend to be individualists, more ready to experiment and find what works for them rather than rigidly copying someone else's plan. That's part of the fun you can have in raising worms: Find new and more efficient ways of doing things.

But we all need some ideas on where to begin. So, here are a few suggestions:

A) **Wooden Bins**

Some years ago 3 x 7 or 3 x 8 bins were common in vermiculture, but since lumber yards stock materials such as plywood in 4 x 8 sheets (and other lumber is common in increments of 4' and 8') it seems best to make a bin in these dimensions.
Should the bin be placed directly on the ground without a bottom? While some growers do not utilize a bottom for their bins, consider some reasons you may want to have one.

1) If you have moles present, your worm inventory may be in jeopardy.

2) If you do not use a lid, your worms may be subject to drowning in prolonged periods rain, if the ground under your worm bed gets saturated and does not offer good drainage.

3) While redworms won't burrow deep into the soil, nightcrawlers may enter from below and mix with your redworms.

4) Without a bottom, there would be no way for you to collect the leachate.

Raised bins with a bottom should have holes drilled in the floor for drainage. Holes one-inch in diameter covered with window screen (stapled onto the floor) will allow excess moisture to drain while keeping worms in. These bins are placed on 4 x 4 blocks or anything else you have to keep the bed off the ground.

To capture the "worm tea," use sheets of corrugated fiberglass under the worm bed, slightly elevating one side of the bed and the sheets below, allowing the leachate to drain from the worm bed onto the corrugated material and down into a receptacle. Or, perhaps a better plan is to split 4" or larger plastic pipe lengthwise and place these portions directly under the drain holes. Collect the fluid into a receptacle. This leachate is an excellent liquid organic fertilizer.

The sides of the bin can be one to two feet in height. Some growers construct the sides of their beds to a maximum of one foot in height so a wheelbarrow of bedding or feedstock can be emptied into the bed with greater ease. This eliminates extra shoveling.

If you choose to use plywood, obtain 5/8" CDX (you can get by with 1/2 inch as well). You may decide to coat
your wood with a waterborne sealer to increase its longevity. Oil-based products containing petroleum distillates should be avoided for wood coatings, especially for the interior portion of the bed, since these chemicals may be harmful to your worms. If you decide to paint your bins, a lighter color will reflect light and tend to absorb less heat than a darker color.

Some growers use 1 x 12 or 2 x 12 lumber for the sides and ends of their worm beds. This makes for greater sturdiness and longer life of the worm bed. Plywood is used only for the lid and the floor.

Hinges may be used to secure the lid on top of the bed. This makes for greater ease in lifting and replacing the lid over the bed during feeding and watering times.

To provide for aeration, holes may be drilled in the sides or on the lid surface, then covered with window screen which is stapled or tacked onto the wood. In order to provide a tighter fit, keeping out flies and other insects, weather stripping may be applied to the surface where the lid meets the sides of the bin.

In order to conserve lumber, other dimensions for wooden bins have been used. These bins are simply longer, usually retaining a width of 4 feet. Beds that are made longer are usually made in increments of 8 feet. When worms beds are made wider than four feet, it becomes more difficult to reach from the edge of the bed into the center, particularly when harvesting.

B) Concrete Bins.

Bins made from concrete block are sturdy and offer the advantage of providing a form of insulation. Use nearly any type of block size, from 8" x 8" x 16" or the smaller varieties. As in the wooden bins described above, you may want to keep to the same dimensions, particularly if you are going to use a lid. Concrete block bins usually do not have a floor, but are placed on the open ground. While mortar is used to provide extra strength and
inhibit block movement, larger blocks can probably be used without mortar. Filling the cells or cavities of the block can also provide greater insulation and weight.

C) Pits

Some growers have used pits dug into the ground. In cold climates this can be advantageous since the surrounding earth serves as a barrier to extreme cold, providing insulation for the worms. While some pits have been lined with various materials, other are simply holes in the ground.

The chief disadvantages of pit construction are two: 1) Pits in the ground that do not have adequate drainage may get flooded; and 2) Bending over to work these areas may cause greater back strain than raised beds.

D) Heated, insulated bins

Dan Holcombe's Oregon Soil Corporation publishes blueprints for making heated, insulated plywood bins, called the Oregon Soil Corporation Reactor (OSCR or "Oscar"). Essentially this is a large vermicomposting bin (36" wide x 48" long x 36" high) that a person may construct out of plywood and 2 x 4 lumber. It has the capacity to process around 30 pounds of food waste per week, but is capable of processing up to 60 lbs. per week. The concept and name is based on Holcombe's automated commercial vermicomposting system measuring 8 feet wide and 120 feet long. Worm castings are harvested from below the worm bed as progressive layers of feedstock are added above.

The guide, which sells for $50.00, contains construction drawings, an operator's guide, an operation plan and a site license of building an OSCR. The first eleven pages of the "blueprint" are well-written and informative. Some of the subjects covered are: Targeting waste streams, carbon/nitrogen ratio desired, harvesting castings and worms, marketing castings and worms, and trouble-shooting for problems. Once you have read these pages on "operation" you are then given the construction plans. These are a series of diagrams and step-by-step written instructions for building an OSCR from lumber, woodscrews and easily-obtained hardware. While the assembly instructions are fairly accurate (there are a few mistakes in measurements recommended for certain cuts), there are some places where clarity is lacking.
Part of the package is a "site license" granting the purchaser an "unlimited number of OSCR vermiculture compost bins at a single site designated by the recipient." This license also discourages copying and building derivative designs. Estimated cost to build one of these units from new materials is slightly over $300.00. Scrap lumber and used materials can reduce the cost by two-thirds to under $100.

The chief value in constructing this bin (which will take 3-5 days to build) is that it allows for maximum worm productivity, even in cold conditions. By using the recommended soil heating cables (thermostatically controlled), the interior temperature of the bin is kept around 72-74 degrees. These bins make great "incubation" units. Perhaps the "highest and best use" is for institutions, schools, hospitals, nursing homes etc. Functioning as a large "garbage bin," the OSCR could handle a steady supply of pre- and post-consumer food waste from institutional cafeterias. Your acquaintance with building an OSCR could lead to consulting with institutions about creative and ecologically beneficial ways to recycle food waste.

4. **Stock the worm bed with bedding material**

Bedding for worms consists of organic material in which worms make their home. In time, as fresh feedstock is added on top in layers, worms consume both feed and bedding.

*What about "Soil-less" beddings?*

Worms can do well in beddings of cardboard, newspaper and coconut fiber, provided that plenty of moisture is available. These beddings are generally used when manure is not available or simply inconvenient to obtain. There have been many indoor beds made with these "soil-less beddings," and worms have happily made their homes in them. It is not recommended that you use peat moss alone as a bedding material since it may be too acidic for worms.

As an experiment, one grower soaked dozens of cardboard boxes and tore them into pieces about one inch square. (Cardboard is easier to tear when wet; using scissors or a table saw to cut dry cardboard can also be done, but the material is more rigid and requires more effort.) An old
bathtub was used as a container. The wet cardboard squares were added to the bathtub along with several pounds of worms. While the worms seemed to work their way around the cardboard and feed, there are some disadvantages to using this particular system: First, cardboard squares tend to become matted together in a short time. This causes anaerobic conditions in the worm bed since oxygen cannot penetrate through the layers of wet, matted cardboard. Second, harvesting is a greater problem because the cardboard does not decompose as quickly as the feedstock being added to the bed. In time, you have a combination of worms, castings, matted cardboard, a decomposing feedstock that needs to be aerated periodically.

Worms seem to like to burrow in the corrugated portions of the cardboard and worms of all sizes, castings and cocoons are readily visible on these surfaces. But the difficulty of separating worms out of this material is such that it becomes better to blend it with other materials (manure) and allow all the cardboard to totally decompose over several months.

Shredding cardboard is highly recommended, if cardboard is to be used at all. The principal lesson here pertains to all beddings: The finer particle size you start with, the faster consumption of material you will see, and the finer the end-product when harvest time comes.

What are more typical beddings?

Since the redworm is also called a "manure worm," you have your first clue as to the preferred form of bedding. Many different types of manure are good candidates for bedding: Horse, cow, pig, sheep, goat and rabbit manures have all been used successfully.

For bedding, use only aged manure, at least 30-60 old. This will insure that it has composted enough past the thermophilic range where temperatures can reach 150 degrees F. To speed the process of composting, apply moisture to the manure pile and turn with a pitchfork.

Leaching manure is also recommended. The leaching process removes urine, salts and, in the case of horse manure, helps remove any residue of de-worming medication given to horses that may found in the horse manure. (Note: These
cautions are also repeated in the section ahead on "Using Manure as a Feedstock.")

You will want to start with a minimum of eight to twelve inches of bedding for your worms. In colder times of the year, a deeper worm bed is advisable in order to provide worms with a greater degree of insulation against the cold. The addition of calcium carbonate, while not followed by all growers, is a precaution taken by some. Calcium carbonate also known as agricultural lime, will neutralize any excess acidity in the manure. Because redworms have calciferous glands in their digestive tract, it is also believed by some that the addition of calcium carbonate serves as a digestive aid. It is a good idea to keep a quantity of calcium carbonate on hand which may become necessary if your worm bed ever becomes too acidic. Be sure to obtain agricultural lime, limestone flour, or calcium carbonate (also called "Ag-lime") and not agricultural slacked (or unslacked) or dehydrated lime. The chief item to look for is the presence of phosphate; there should be little or no phosphate present because this can be harmful to your worms. You can add about a pound of calcium carbonate (3 or 4 cupfuls) to a 4' x 8' area. (Note: Typically this product is also used to make "chalk lines" on baseball and football fields; if it is not available from your agricultural supply, perhaps a sporting goods distributor can help you obtain it.)

Soak the bedding material prior to introducing your supply of worms. Make sure all material is chopped or mulched and large stones have been removed. You want to maintain your bedding to be consistently "crumbly moist," and not soggy wet. To be able to wring a few drops of water out of the bedding when squeezed by the hand is a good indicator. This moisture condition is easily achieved when using any type of bin operation where excess moisture is allowed to drain from below. Where improper drainage occurs, worm beds can suffer from a lack of aerobicity. Scientific data at this time indicates it is better to err on the moist side in maintaining beds than to lean toward a drier bed. Worms seems to thrive best with a moisture content of around 80 to 90% according to some recent data.

As stated elsewhere in this book, optimum conditions for worms include proper temperature, moisture content, soil pH and aerobicity. By using a compost thermometer, moisture meter, pH tester and turning the bed to allow
aeration, you will insure your bed is ready to receive your first shipment of worms.

5. **Add worms to their new bedding**

A typical rule of thumb for stocking worms in new bedding is to add one pound of worms per square foot of material (this could also be stated as "cubic foot" if your bedding was one foot deep). Recent scientific studies suggest a one to eight ratio of worms to bedding, or about 12% by weight. You won't go wrong by estimating the square feet of bedding you have available and using the one pound/sq. ft. rule. The main idea is that you have a sufficient worm population to begin breeding and moving through the organic waste presented to them. Too few worms means that you will see results more slowly. There may be the tendency to overfeed a small population of worms and the bed may become sour or too acidic. Too many worms stocked in a small area shouldn't pose an immediate problem unless you notice the prolonged tendency to migrate. This might mean that adult worms want to make room for the smaller worms and are looking for new territory. Frequent attention to providing adequate feed for dense populations of redworms should be given.

6. **Add a small amount of feedstock to top of bed**

Once the redworms arrive in their new bedding, they'll start making their new location into a "home." As in any move from place to place, an "adjustment" period is often needed, usually only a day or two. Some redworms want to express their "independence" right away to let you know that they came from somewhere "better." In time they'll all settle in.

Some growers have advocated the use of electric lights at night over worm beds to minimize the tendency for worms to crawl away from their new bedding. A persistent case of "worm migration" would be a strong indicator that all is not well within the worm bed. Re-testing a batch of bedding for purity should be done immediately if your worms don't adapt.

If you are using bins, the tendency for worms to migrate can be checked by the use of a lid over the bin. If
you are using open windrows, a covering of burlap or old carpeting can be used to cover the bed. This may help keep the worms "in at night."

After the worms have been added to their new bedding, add a small layer of the feedstock you will use. (See the upcoming section on "Feeding Your Worms" for details.) Depending upon what this feedstock is, it is likely the worms will not go after it right away. Remember, their new bedding also contains nutrients they will ingest. If the feedstock introduced on top is not yet ready for the worms to be digested, it will be eaten in a few days. Just begin to monitor their activity in this area. Many growers use a measuring system (by weight or by volume) to know how much to feed their worms. Initially, you can start adding about one-half pound of food to every pound of the beginning worm weight in your bed. In time, however, you won't be able to calculate the growth of the worm population and know how many pounds to feed. It will have to be measured somewhat visually. Worms have been known to consume up to their body weight daily. Keeping records of what you feed and how often you do so will help you make proper calculations and projections. Keep a record of the date, the amount fed to each bin, the feedstock used, and any other activity performed, such as the addition of water, bed conditioners (such as calcium carbonate or peat moss) or aerating the bed with a fork. With experience, you may choose to eliminate this close scrutiny of your operation, but as a learning device the careful monitoring of your worm beds may pay dividends in ways you might not be able to immediately foresee.

7. **Cover the worm bed**

Many worm growers use burlap or old carpeting placed directly on top of the worm bed. Worms seem to like coming right up to a covering like this. Even when cardboard is used, one can readily observe the presence of a number of worms directly under the covering. There seem to be more advantages to using coverings than disadvantages. One disadvantage of using old carpeting is the unknown presence of cleaning solvents or harmful dyes in the fabric. Growers who do use old carpet (which can obtained from carpet retailers who will be glad to get rid of the stuff!) claim that in time the worms will even eat through the carpet itself. Burlap can be obtained from agricultural or nursery supply dealers.
Advantages to using a covering include the reduction of pests (flies in particular) and the moisture retention a fabric offers.

A lid or raised covering device suspended over the worm bed allows protection from the elements: too much sun or too much rain. Remember: Not all growers use all these systems. Some growers utilize a number of different systems. Here's one example. There is a grower in Southern California who has at least three different systems in use. 1) He has worm beds on the ground (no floor) with wooden sides covered by shade cloth that is supported by PVC pipe. 2) Another system uses containers that were once used to haul tomatoes on flat bed trucks. A few inches above the bottom of these containers he built another perforated floor to support the worm bed above, but to allow the leachate to be captured below. These bins are tilted so that the leachate runs to the end where the liquid can be removed from a tap. 3) A third system in use on the same premises is the open-windrow system, simply utilizing manure and compost piled on the ground in long rows about 6 to 8 feet wide. All three systems use irrigation by PVC pipe with sprinklers. Only one of the three systems captures the leachate.

Now that your worms are in their new environment, what will you need to do in order to keep them happy?
MONITORING CONDITIONS IN WORM BEDS

There have been many scientific studies performed on worms concerning their habits, (for example, breeding), and their consumption of various feedstocks. As a result of these investigations worm growers are better able to care for their worms by having accurate information and applying this knowledge to their operations.

KEEPING YOUR WORMS HAPPY

Optimum conditions for worms include the following: Proper temperature, moisture content, soil pH, and aerobicity.

1. TEMPERATURE

Scientists have found that worms eat and breed best at a temperature of 25 degrees Centigrade which is about 72-74 degrees Fahrenheit. When the temperature of their environment either exceeds 80 degrees or becomes less than 55 degrees, worm activity slows down but does not cease altogether.

What are the possible dangers to worms when soil temperatures are extreme (either too warm or too cold) and how can the grower control these factors?

Before answering these questions directly, it would be best to consider the redworm in nature. Two factors should be noted.

First of all, redworms have lived for ages in European and North American soils. (Evidence appears to be that they are not native to North America but were brought over inadvertently as cocoons "hitch-hiked" across the Atlantic Ocean in soil, horses' hooves, or in containers of goods brought by early European visitors.) The species Eisenia foetida and Lumbricus rubellus are indigenous to latitudes where hot summers and cold winters are common. These worms, unlike some subtropical species like Pheretima hawayana, are more hearty and resilient to temperature
extremes, although the grower should do everything possible to minimize extreme conditions.

Secondly, the medium in which they dwell in nature (decomposing organic matter and soil) will have a temperature that is more regulated than the air temperature. Thus, on a very warm summer day when the air temperature is, say 100 degrees, you can measure the temperature of soil in your garden and find that it is much cooler than the air temperature. Conversely, on a very cold day, even if the temperature is at freezing or below, the soil will be warmer than the air temperature. While worms will slow down their activity during this time, it does not mean they are in danger, provided you take steps necessary to insure that prolonged periods of extreme conditions are not present.

Since commercial growers want to maximize worm activity both in breeding and in producing castings, several steps can be followed to enhance the worms' environment.

a. **Cold Weather**

Protecting worms from the effects of cold weather can involve great or little expense. Depending upon space availability and cost, the grower may choose to grow worms in an indoor atmosphere. This can include using a barn, shed or specially-built structure to keep worms away from the effects of wind, rain and cold weather. Any type of bin or container also affords some protection from the elements for worms. A worm bin might also have insulation installed to keep worms warmer in winter and cooler in summer. Styrofoam insulation is available at some building supply centers. One type is made by Dow. It is one inch thick and measures 2'x 8' which is a convenient size when building 4' x 8' bins.

Soil-heating cables are available at some nurseries. Gardeners use them to keep the soil at a constant temperature (about 72 degrees) when they are starting plants from seeds. Worm growers can use these cables to heat their worm bins. They are available with pre-set thermostats which will maintain the bin at a comfortable temperature.
Bins can also be covered with a tarp when excessively cold weather arrives. This will help contain some heat and serve as a buffer for wind and rain.

Growers who have their beds on the ground generally use copious amounts of straw to cover their worm beds. Worms have made it successfully through periods of freezing and snow when they are covered with ample amounts of mulch or straw to keep out some of the cold.

In very cold weather it is best to make sure that worm beds are not too wet, particularly if raised beds are being used. The excess moisture in the beds makes it colder for the worms who are seeking areas in the bed that are less dense and more porous where air can circulate.

b. **Warm Weather**

In very warm temperatures, added moisture becomes important. Initially, if the worm bed is shaded from direct sunlight, there is some measure of temperature reduction provided. But since evaporation of moisture is more rapid in warm weather, care should be taken to water worm beds more frequently. Sprinkling beds three or more times per day becomes necessary.

Many large growers install sprinkler systems or some form of drip irrigation system to insure a steady, uniform supply of moisture to their beds.

If you are using a container to grow your worms, a covering helps keep in moisture and coolness. Burlap sacks, a piece of old carpet, wet cardboard or wet newspaper serve this purpose well. By sprinkling directly on top of the covering, moisture is then slowly filtered down throughout the contents of the bed and the covering serves to keep the entire bed moist, allowing the worms to come toward the top to feed while still enjoying a dark atmosphere. Coverings such as these minimize moisture loss. Additionally, if an organic-type bed covering is used, it will eventually decompose and become part of the vermicompost.

**HOW CAN YOU KNOW THE TEMPERATURE OF YOUR WORM BEDS?**
Because temperature control and monitoring should be important to the commercial grower, a compost thermometer is highly recommended. Compost thermometers have long stems (24” or longer) that can be inserted in the worm bed to accurately measure the bed's temperature. The head of the thermometer, normally reading temperatures up to 200 degrees or more, is attached to a metallic shaft that is inserted into the soil. Once the thermometer is inserted in the pile, an accurate measurement is obtained within 45 seconds.

We have found that the Reo-Temp compost thermometer is a lasting investment in a quality instrument. When used carefully and in accordance with the instructions, it should serve the user well for a lifetime.

Later, in the section concerning feedstocks, you'll find that having a compost thermometer is advantageous when determining the composted quality of manures and yard waste.

2. Moisture Content

In general, the moisture content of the worm bed should be crumbly moist. That is, when a handful of the bedding is squeezed, there should be only a drop or two of water that emerges at the most. Earthworms are related to aquatic worms and abundant moisture is critical to the earthworms' environment. However, worms will not tolerate soggy conditions and will seek to avoid excessively wet bedding. Drainage control is important, particularly when using containers so that water does not accumulate at the bottom.

A moisture meter can be an important aid in monitoring the proper moisture content of the worm bed. Like the compost thermometer which also has
a long shaft, the moisture meter is inserted into the worm bed and indicates whether the bed is dry, moist or wet. Having this tool can help in determining the frequency of adding water.

Many beginning worm growers will notice the top of the worm bed drying out and will use that indication as a sign to add water to the bed. This drying out of the top layer might be especially noticeable if there is no covering material on the surface of the bedding. When this occurs, however, it is not necessarily indicative that additional water is needed. The degree of moisture will vary throughout the bed, generally more moist toward the bottom of the bed and tending to be less moist closer to the surface. If it appears that the worms are avoiding the surface and congregating toward the bottom of the bed, it is probably a sign that the bed needs watering. Keep in mind, though, that worms are top-feeders and if you are regularly placing moist feedstock on the top of the bed, they will be moving upward to eat while leaving their castings below. The tendency of many growers is to over-water their worms (probably due to paying attention only to surface conditions of the bed). In order to obtain a correct diagnosis of the moisture content of the bed, a moisture meter should be used.

If worms are fed fruit and vegetable waste, some 80% of the total weight of these foods will be composed of water. Other organic waste fed to worm beds will also have a significant moisture content (composted yard waste, manures) and these will also help provide necessary moisture to the bed.

Excessive moisture passing through the vermicompost as a leachate is beneficial when collected and fed to plants. This "worm tea" serves as a liquid organic fertilizer, high in nutrient content because it has "percolated" through the vermicomposting process. While not all worm growers have designed their operations to capture the "worm tea" by-product, those who have collected this leachate have profited from its sale.

3. Soil pH

The pH of soil is an indication of its alkalinity or acidity. The range of pH (which is a chemistry term for
"potential hydrogen") is from 1 to 14 with a reading of 7 showing the soil to be neutral (i.e., neither alkaline nor acid). Acid soils measure from 1 to 6 (the lower the number, the more acidic the soil), while alkalinity ranges from 8 to 14 (higher numbers indicating greater alkalinity). In general, plants and especially redworms do best in the neutral range of pH, somewhere between 6 and 8 on the pH scale.

Acidic beds can be made less so by the addition of agricultural lime, also known as limestone flour (calcium carbonate). A cupful of this powder added to several cubic feet of a bed that measures some acidity will help neutralize the acidity as well as aid the earthworm's digestive process. Beds that are too alkaline may be made more acidic by the addition of peat moss.

Fortunately for worm growers there are also ways to measure soil pH of a worm bed or potential bedding. One of the commonly available methods for gardeners to measure soil pH is with a "test kit" often sold at garden supply centers or nurseries. This usually involves a very small vial or tube for placing a "pinch" of soil in. Also into this tube is placed some water (preferably distilled water) and a chemical which causes a reaction to take place, turning the soil sample a particular color that is then matched on a chart. The color of the sample in the vial when matched to the color chart will show an accompanying pH value (somewhere on the acid-alkaline scale).

The problems with this system are several. First of all, if you want to test a truck full of horse manure, removing one little pinch of this material and placing it in a little vial will help you learn the pH of only that small sample. What if that small sample of horse manure had more urine or salt or was less aged or had been mixed or contaminated with some other substance? The second problem with this system is that only a small amount of the chemical is sold with the vials and color strips. The actual number of times you may conduct tests with one kit will be very few. You will need to go back to the nursery often in order to buy more "test kits" if you plan to do pH testing often. Third, this system involves more fuss and bother than most folks want to contend with. Once you've placed your sample in the vial (and found some distilled water to add to it), you add the chemical (sometimes
found in a little gelatin capsule you must take apart, hoping the contents don't spill out) and carefully pour this into the vial that looks about as small as the perfume samples they give out at cosmetic counters. Shake this up and hope that this "sample" is indicative of your whole pile of bedding.

However, there is a better way. There are pH meters designed with long stems (like the other two meters mentioned) one can place into the desired soil and obtain an accurate reading. How simple! Once this meter was invented, you wonder why the other system is still being sold. That may not be for us to figure out, but at least measuring pH often and easily is available without the awkward mess of the chemical system.

4. **Aerobicity**

The last factor one should monitor frequently in the worm bed is aerobicity, that is, the amount of oxygen that is allowed to flow throughout the bed. In the worm bed environment decomposition of organic matter is taking place through bacterial action. Millions of microscopic organisms are feeding upon the carbon and nitrogen molecules which make up the decaying matter. In order for the breakdown of organic matter to take place, moisture and oxygen must be present. When this process of biological decomposition takes place without worms it is called composting. When worms are added, feeding off the organic material and bacteria, the process is known as vermicomposting. In both cases, moisture and oxygen must be present for the living organisms (bacteria and/or worms) to thrive.

When an insufficient supply of air is present in the decomposing pile, anaerobic conditions occur. The best indicator of insufficient oxygen is the olfactory sense, that is, the sense of smell. Anaerobic conditions are present when foul odors are noticed. This lack of oxygen means that bacteria and worms are not in an optimum state of performance and are in danger if conditions are not improved.

Simply turning the matter in the pile will allow oxygen to enter and aerobic conditions can be restored.
Sometimes anaerobic conditions are encouraged with the addition of too much water (reducing the amount of oxygen in the pile) or by adding too much fresh feedstock causing the build-up of carbon dioxide. By reducing the amount of water and holding back on adding organic material, the pile is allowed to take in more oxygen after it is turned and aerobic conditions are re-established. Turning the pile can be done with a pitchfork or claw-type cultivating tool, sometimes called a "worm fork." Growers can increase the aerobicity of their worm beds by turning the contents every two or three weeks. This re-distributes the material in the bed, breaks up clumps, and improves overall aeration.

SUMMARY

Whereas worms were once raised through trial and error methodology, we now know there are specific conditions in which worms grow to be healthy and productive. When temperature, moisture, pH and aerobicity are monitored, the grower feels confident that he or she has provided the best environment for maximum growth and productivity. Making regular use of the compost thermometer, moisture meter, pH meter and cultivating tools will help keep the grower right on target and minimize worm loss through carelessness or lack of knowledge.
FEEDING YOUR WORMS

By now you know that worms consume decomposing organic matter. By “organic” is meant anything that has a carbon atom but, more to the point concerning worms, any material that was once "living." Now this includes fruits and vegetables as well as any other plant material (with a few exceptions which we’ll mention below). Leaves and grass clippings (which worms have consumed in abundance for ages) provide both carbon and nitrogen which worms need. Landscaping debris which has been shredded and composted can be fed to worms. Other "once living" material includes newspaper and cardboard, since this material originated from trees.

In nature, worms eat decaying matter, not living plants or roots. Worms are considered detritivores from detritus meaning "any disintegrated material, debris," and -vore meaning "one that eats." They are also called saprophytes which are organisms that live on dead organic matter (a designation used for bacteria as well). For this reason, worms do not pose a threat to living plants in the soil. Rather, worms provide a service to plants growing in soil through their burrowing action. This allows greater penetration of water as well as aeration. By excreting their nutrient-rich castings and mixing them in around plants in native soil, worms help "fertilize" the plants while discouraging erosion and run-off. This is why farmers and gardeners welcome the presence of worms in their soil.

Frequently red worms are found in piles of aged horse and cow manure. This is their feedstock of choice in natural circumstances. They are primarily top-feeders that leave their castings below the surface. (Nightcrawlers, by contrast, pull leaves on the surface of the ground into their burrows to feed on while they deposit their clumps of castings on the soil surface.) Since the red worm is primarily a manure worm, it
makes sense to consider manure as your principal feedstock (when it is available).

Plentiful quantities of feedstock should be the grower's first concern. Since the worm is "nature's recycler," it makes sense to harness this creature's love for decaying debris by utilizing it to take care of our "waste." This means that worm growers should not be thinking in terms of "buying" feedstock for their worms (as you would have to buy feed for other livestock), but finding what is waste and debris and transforming it into "black gold" --worm castings. In many farm and ranch areas manure is readily available and, as some have discovered, too plentiful. Many ranchers have to pay to have their manure removed. Worm growers can find abundant supplies of manure just about anywhere.

**USING MANURE AS A FEEDSTOCK**

One reason worms thrive on manure from horses and ruminant animals like cows and sheep is that the cellulose-rich food these animals have eaten is not thoroughly, but only partially digested. There is still a substantial remnant of nutrient material left in pre-digested form.

Scientists have measured the content of carbon and nitrogen in various organic materials and have found that worms prefer the carbon-to-nitrogen ratio (C:N ratio) of their feedstocks to be in the range of 20:1 to 40:1. Horse manure, for example, has a C:N ratio of 25:1 (meaning 25 parts of carbon to one part of nitrogen). This makes it an ideal feedstock.

Before introducing your red worms to horse manure, however, a few words of caution should be mentioned. First, if horse manure is being used for bedding, then aged manure should be used. This is manure that has gone past the initial heating phase of composting, where thermophilic action sends temperatures to 150 degrees or more. While this particular phase of composting only lasts a few days, fresh horse manure can be turned with a pitchfork during this time to encourage thorough composting and aeration. Aged horse manure is important to use as bedding because it will not heat up conditions in the worm bed which will harm your
wigglers. Fresh manure can be added later to the top of the bed as additional feedstock.

A second caution with horse as well as with other types of manure, particularly where animals are kept in enclosed areas, is the concern for urine and salts in the manure. These must be leached from the manure as great concentrations of urine and salt in manure can be harmful to worms. In addition to leaching out these substances, the worm grower must also be concerned with leaching out any traces of de-worming medication given to horses. Many horses are given a worm-paste substance every three months or so to inhibit certain intestinal worms from developing in their bodies. Consequently, any residue from this medication found in the horses’ manure could be detrimental to your red worms. Leaching the manure can render the material safe for use.

The process of leaching is simply that of soaking the material so that water is able to pass completely through and wash away any harmful elements. Some growers have leached their manure right in the truck bed or trailer that is used for picking it up. A garden hose is then used to apply water at the top of the manure pile which is then thoroughly soaked. Manure can also be placed in a container, like a garbage can, with holes in the bottom to allow the water to pass through. Some recommend leaching horse manure 3, 4 or 5 times for absolute safety, particularly when information about the frequency of horse-worming is unknown.

Finally, testing the manure for its acceptability to worms is recommended. Take a sample amount of manure, perhaps a quarter cubic foot or less, and introduce a handful of worms from your inventory. Allow these worms to occupy this sample bedding for 12 to 24 hours and observe what happens. If the worms are not happy and are crawling away (or dying), there is obviously a problem with the manure. If, however, the worms seem to settle down and are alive after this test period, you can feel that it is safe to introduce the remainder of your worms to the proposed bedding material.

Dairy and steer manure are frequently used both for bedding and for feedstock. In some situations these manures contain anywhere from five to eight percent soluble salts which are detrimental to worms. These salts can be leached out by using the same process described above.
Rabbit manure and the wasted feed that is mixed in along with it makes an excellent worm feedstock. Because rabbit manure generally contains a high content of urine, greater leaching efforts are usually required. Adding calcium carbonate (limestone flour) to neutralize the acidity of this manure may also be a necessity.

Sheep and goat manures are also used for feeding worms. They have a higher nitrogen and protein percentage than previously mentioned manures and may require the addition of calcium carbonate. Manure from pigs can also be used.

Poultry droppings from chickens or turkeys may be used, but only in small quantities. These manures are considered to be "hot" because of their high nitrogen and protein content.

**USING COMPOST AS A FEEDSTOCK**

In nature, decomposition of organic material results in the production of compost, an earthy-smelling blend of humus, micro-organisms and stabilized chemical compounds providing nutrients to plants. Introducing worms to the composting process elevates the final value of the product, "vermicompost," to a superior form of soil amendment. Since both "composting" and "vermicomposting" are at work in nature, more often together than not, it stands to reason that using composted organic matter such as grass clippings, leaves, clippings from trees and bushes, and other forms of plant and vegetable material to feed worms is practical and natural.

Decomposition of organic matter occurs in three stages: Psychrophilic bacteria are active in the beginning stages of composting at temperatures below 70 degrees F. The second stage, when mesophilic bacteria are active, occurs at the range of 70 to 100 degrees. These bacteria are the most active in rapidly affecting decomposition. In the third stage thermophilic
bacteria are active in temperatures exceeding 100 degrees F. Oxygen and water must be present in the composting process in proper amounts in order that anaerobic conditions do not become dominant.

When conditions are appropriate for making compost from green waste, temperatures will begin to rise. In the first two or three days, temperatures may ascend to 110 to 120 degrees F. In four or five days the temperature should rise to approximately 150 degrees F. Turning helps to encourage evenness in composting and brings a temporary drop in temperature. In a couple of weeks, depending on the type of material used, temperatures begin to drop back to around 100 degrees F. The composting process is basically done at this point.

One reason to apply compost as feedstock is to use a stabilized, decomposed organic material that worms would ordinarily find available in nature. By introducing it to worms after the heating stage, endangering your livestock will not be a problem. If the material has been shredded at the outset, the particle size will have diminished even further during the mesophilic and thermophilic phases. This further enhances the availability of the feedstock to worms.

**A NOTE ON WORM DIGESTION**

Earthworms digest their food through a gizzard, a type of "grinding" instrument in the worm gut. Small particles of sand-type substances are used by the worm in its gizzard to process its food intake. In many cases where organic matter is gathered for wormfood (manure, compost, etc.) there will be present tiny grains of sand for worms to ingest along with the feedstock. In this way their gizzards are helped to keep the food a-grinding.

But as an insurance policy, particularly when large amounts of household food waste are used to feed worms, the addition of a couple handfuls of fine sand is beneficial to aid in the worms' digestive process. Adding some sand to provide "grit" for the worms every few weeks will insure that your worms are grinding along efficiently.

**WHAT NOT TO FEED WORMS**
In nature worms feed primarily on vegetable debris. However, as all organic matter, including decaying animal flesh or "meat" decomposes, worms will eventually transform the entire surroundings to vermicompost. It is not recommended that you introduce any type of meat products into your worm beds, largely for the reason that meat is exceptionally high in protein and may attract rodents or other unwanted pests. Excessive carbon dioxide and anaerobic conditions may become problematical. However, it has been observed that the introduction of small amounts of animal flesh has not caused severe problems. It is not recommended, however, that the commercial grower intentionally add meat or meat by-products to worm beds.

Similarly, other products containing high amounts of fats or oils like dairy products, especially cheese, are not desirable. While some institutions (cafeterias, restaurants) feed worms an unseparated blend of post-consumer food waste, it is best to avoid high concentrations of meat and dairy products whenever possible.

Other items to avoid include sawdust from redwood or cedar. Frequently sawdust is mixed with horse manure, and the tannic acids in certain trees like redwood are harmful to worms.

Worms will incorporate cardboard and newspaper in their diet, but it is best to stay away from colored ink on these products. By now all newspapers use soy-based ink which is no problem for worms. Some time ago newspapers used ink with a certain lead content, but concern for children ingesting this has led to the universal use of soy-based ink products.
Finally, the introduction of dog, cat or other feces is discouraged. While certain manures from other mammals are recommended (and these have been mentioned), the worm grower needs to stay within recognized parameters of feedstock.

**SOURCES OF FREE FEEDSTOCK**

If you don't own livestock or make your own compost, there are many ways to get free feedstock for your worms. You may even be able to work out an arrangement in which you can collect a fee for others bringing you their organic material.

**Manure**

- Fairgrounds
- "Horse Hotels" i.e. boarding stables
- Dairies
- Private Ranches
- Zoos

Many operations where livestock are raised, boarded or where the public comes to watch their activities (horse racing, rodeos, 4-H events) have a problem in getting rid of manure. This is a worm grower's chance to obtain free feedstock. In most cases there will be limitless opportunities for a worm grower to obtain all the manure he or she can handle. In time, as the success of your operation becomes better known, you might consider discussing the value of worms with the operators of these types of facilities. Many livestock operations face a continual burden of getting rid of their manure surplus, and your ability to teach them how to transform their waste into "brown gold" may lead to consulting fees and worm sales. You may even profit from the marketing of the castings as you gain contacts in the worm business or among nursery owners and landscapers.

**Pre-Consumer Food Waste**

- Supermarkets
• Small grocery stores
• Restaurants
• Organic Food Growers
• Farmers Markets
• Packing Houses
• Commercial Growers
• Institutions (Hospitals, School Cafeterias, Nursing Homes, Any business with a cafeteria)

Pre-consumer food waste is abundant and available by simply asking proprietors what they are currently doing to dispose of their waste. You will find that while some operations grind up their waste and send it down the drain, others throw it out along with the rest of their garbage.

Wherever possible, particularly in the case of restaurants and cafeteria waste, it is best if the green waste you are able to obtain is pre-consumer waste. This, of course, means that the fruit and vegetable waste you collect is not the uneaten portions of prepared foods which may contain meat and dairy products, along with strong spices. While worm beds have been fed food waste from school cafeterias which included such delicacies as pizza, hamburgers and other non-vegetarian delights, it is preferable to avoid these foods if possible. If it is impossible to avoid the introduction of these foods into your worm bed, we suggest burying these items in the bed to avoid pests. The final outcome, however, once the worms have been exposed to many different types of organic wastes, seems to be that all waste is turned into vermicompost.

One lengthy study was conducted in King County, Seattle utilizing vermicomposting of residual food wastes at the Food Bank. While tons of donated food were distributed to the needy in Seattle through the Food Bank, a significant portion of this donated food was unfit for human consumption. This included canned foods as well as less-than-fresh fruits and vegetables. Worm beds were constructed out of pallet boxes and worms were fed the residual waste. The entire project was deemed successful and
was managed efficiently with minimal expenditure of money and effort.

**Yard Debris**

- Landscapers
- Gardeners
- City Collection of yard waste

It might be possible for you to collect yard trimmings from landscapers and gardeners working in your neighborhood. Perhaps your city or county picks up yard waste and will make it available to you. Green waste such as this can be composted and fed to your worms.

**Hints on Feedstocks**

1. Cultivate a relationship with providers of free feedstocks. Get to know the owners of businesses which must get rid of organic waste. One of the essential keys to success in the worm growing business involves obtaining substantial amounts of feedstock upon which to raise worms. Keep in mind that we are in a resource recovery business. What is "waste" to others is really misappropriated energy, a source of storable plant energy when it is converted by worms.

2. Be professional and courteous. If you pick up your free feedstock, make sure you do it with a smile. People appreciate reliability too. If you say you are going to regularly remove the pre-consumer waste from a restaurant or grocery store, it will only take a few missed appointments for you to lose that source. Business owners who are concerned about pests, fruit flies and the accumulation of waste need to be assured that their waste is being removed promptly.

3. Find ways to save others money. They will be more inclined to use your service if you can save them money.

4. Plan ways to derive income as a kind of "tipping fee" for picking up waste. One worm grower uses this method to increase his profitability. It starts by the grower "paying" the
supermarket a fee to "buy" residual food waste (let's say $12 per ton). Then the supermarket makes a "donation" to the enhancement of worm technology for a certain fee, say $62 per ton. The difference, of course, is a $50 per ton fee which the worm grower collects.

Note: There may be regulations in your city or county with respect to the collection of waste for a fee. Some arrangements, such as the one listed above, have been used to circumvent regulations regarding the pick-up of waste. We are not advocating that you break any law. Please work within the legal system as it exists in your community. This example is mentioned as a creative alternative to obtaining permits necessary for a waste disposal operation.

MISTAKES TO AVOID IN BEDDINGS AND FEEDSTOCKS

1. Don't use manure without testing it first. Know the source of the manure you are introducing into your worm bed. Ask questions if you are using manure that is not under your direct control. Manure that comes from stables or pens will likely have a higher urine content and will need to be leached.

2. Don't use large quantities of fresh, uncomposted green waste for your initial bedding. Because of the thermophilic (heating) action of green organic debris (leaves, grass clippings, even manure) a period of time for the "pile" to heat up is needed. Using a compost thermometer helps monitor this process.

3. Try to avoid green waste where pesticides and herbicides have recently been applied.

4. Don't overwater or underwater. Worms need a moist environment. Monitor their bedding periodically in winter, more often in summer, to maintain optimum moisture content.

5. Avoid using the leaves of spicy plants such as eucalyptus, magnolia, bay, etc. Needles of pine, fir and cedar trees are also aromatic and may either kill worms or drive them from their bedding.
FATTENING YOUR WORMS

Since worms are sold by the pound, it makes sense to encourage maximum weight gain in your worms. Also, if worms are to be sold as bait, a fatter worm is desirable by fishermen.

Some growers use separate "fattening beds" and apply special feed mixes to adult worms in these beds. They add up to 400 mature worms per square foot of area in a heavily-watered bed and feed these worms twice a day. The theory is that worms have plenty of easily-ingested food available without overcrowded conditions. One grower claims worms will double in size in a week to ten days.

The Can-O-Worms™ instruction manual contains a recipe for "Worm Fattener." It claims to "fatten and toughen up your worms:"

- Chicken Layers Pellets 50%
- Wheat or Corn Flour 10%
- Powdered Whole Milk 10%
- Bran or Wheat Meal 20%
- Agricultural lime or dolomite 10%

The directions continue as follows: "Mix the ingredients and sprinkle lightly on the food wastes about once a week. After several months you will have fat, tough worms in ready supply for fishing."

The use of laying mash for fattening worms has been around for a long time. By grinding it into a fine flour you will be encouraging more rapid ingestion by the worms.

Another recipe calls for a mixture of 70% lay mash and 30% dehydrated alfalfa leaf meal. An equal amount of peat moss (by volume, not by weight) is added. To this mixture add enough water until you have thick soup. One grower buries this concoction in the middle of his worm beds (first removing a one-foot width of the bedding from the center of the bed for the entire length, holding back the two sides of the bed with long 1 x 6 boards). The mixture is
added to the center of the bed consisting of about six to eight inches in width of material. Add the mixture to the bed up to a couple inches near the top of the bedding. Cover the remainder with bedding you have removed.

This method of feeding is suggested for beginners who start with few worms and who desire to encourage heavy reproduction.

Perhaps the biggest mistake new growers can make is applying too much feed at once. Too much feed can produce acidic or sour conditions. It may be necessary to add calcium carbonate and turn the contents of the bedding if this condition occurs.
HOW TO ELIMINATE WORRY OF PESTS AND PREDATORS

An investment in worms is an investment in a form of livestock, and anyone who has ever owned a pet or has raised any type of living thing realizes that there are pests and predators for everything in the "food chain." Clearly, in any worm bed there are a greater number of creatures present than simply worms. While many of these are invisible micro-organisms, there will be other creatures that will show up from time to time. Knowing a little more about what is going on in the worm bed will help you decide when to take action and when to sit back and let nature take its course.

In general, creatures larger than the earthworm can be predatory, while most insects you'll find in and around the worm bed are merely pests. "Diseases" as such, aren't problematical to redworms; conditions causing their early demise are attributable to improper bed maintenance.

In the predator category are birds, snakes and moles. Ground moles can burrow under worm beds and gobble up vast quantities of worms before they're ever noticed. Those who use windrows have taken precautions such as laying 4-6 inches of gravel down under the windrow. Additional insurance would be provided by using some type of screen material, like 1/2" hardware cloth, but this could be expensive for long rows. Those who have chosen not to risk the invasion of moles through subterranean burrowing have opted for some type of bin construction.

Similarly, protection from predators above the ground is afforded by some type of barrier that a bin would provide. However, the use of screen or cloth material over a worm bed would provide adequate protection without the use of a solid lid.

Other creatures such as mice and rats are usually more interested in the grains that might be in a worm bed. Gophers do not eat earthworms.
The one creature that will prey on redworms is the centipede which will be drawn mainly toward younger worms. Centipedes have one pair of legs per segment on their bodies and are thus distinguished from the harmless millipedes which have two pairs of legs per segment. Centipedes should be removed and killed when found in the bed.

Most other creatures present in the worm bed are more a nuisance than a threat. Ants and flies are perhaps the most bothersome and steps can be taken to try to eliminate them. Ant control products may be used on the perimeters of the beds. There are some products available on the market which kill the whole nest of ants. Ants will be competing for some food elements in the worm bed, particularly sugars. Flies, particularly fruit flies, can probably never be wholly eliminated. The use of traps has been suggested. Burying food scraps in the worm bed rather than keeping them on top can help eliminate some problems. The use of a damp covering, such as old carpeting, burlap, wet cloth or newspaper will also keep down fly infestation.

A frequent visitor to the worm bed is a small, whitish-colored worm that may first look like it may be a newly-hatched redworm. Because it lacks any pinkish or reddish colors, it most probably is the enchytraeid worm. This worm, often confused with a "nematode" (which would not be visible without magnification) is relatively harmless and may be present because the bed is slightly acid. Some growers advocate the liberal use of calcium carbonate to de-acidify worm beds where pests are congregating. Others use melon rinds to attract troublesome mites and other insects and simply remove the rinds and dispose them. Another method used to remove mites and bothersome insects is to heavily water the bed to bring all the unwanted creatures to the top. A hand-held butane or propane torch is then used to burn off the pesky invaders.
You will also see sowbugs and pillbugs, earwigs and beetles, crickets and springtails, and perhaps other creatures not known by you. Avoid the use of poisons as much as possible, in and around your beds. Often, the cause of infestation by unwanted visitors is due to an imbalance in the worm bed. Monitor the conditions of your bed frequently to insure that all is being done to keep it in balance. A too-plentiful supply of fresh feedstock may be attracting other insects before the worms in your bed can get to it. You may have to slow down the feeding rate.
HARVESTING METHODS

Harvesting worms is the term used to describe the process of separating worms from their bedding and castings. Over the years a number of techniques have been developed. The simplest technique, manual harvesting, involves picking out the worms by hand. Mechanical techniques will harvest greater quantities of worms, but the equipment used is costly for a new or small grower.

Separating worms from their castings and bedding may be done for different purposes. Of course, when selling worms to a buyer, worms need to be harvested and weighed. If they are to be shipped, the worm weight is calculated and then appropriate packing materials are added. Worms can also be harvested when it is time to sell castings. The worms can then be introduced into fresh bedding.

One grower recommends that worm beds be harvested every 30 days in order to discourage overcrowding and encourage larger-sized worms. One indication of the need for a bed to be harvested is if the adult worms seem to be moving toward the sides and even crawling away from the bed. This could mean that there are plenty of small worms hatching throughout the bed and adults are making room for this new growth. Another indication for harvesting is the production of castings. If the material in the bed is turning darker in color and your feed is being quickly consumed, the time for separating worms from their castings has arrived.

Manual Harvesting

Some worm harvesters simply set up a table near the worm bed and scoop up worms and bedding onto the table. Then they begin picking the largest worms from the pile, placing the worms in a small container nearby. Usually, enough of the bedding material is picked up in addition to the worms to provide shelter for the worms in the new, small container. Placing a small amount of damp peat moss (see below) in the container will also allow the worms a place to burrow. This is the "tried and true" method of worm harvesting. The principal drawback, of course, is that this method is labor intensive. On the other hand, some have
found this kind of work enjoyable. One woman called it "therapeutic."

You'll find that the worms congregate together in a large ball. With little bedding material about them, they really have nowhere else to go! If you are weighing your worms for sale, make sure you shake off the extra bedding material clinging to the worms so you give your customer an accurate worm weight measurement. Then add back moistened peat moss for packaging.

Usually the largest worms are harvested in this manner because they're the easiest to grab. It has been said that there are about 1,000 mature breeders to the pound. Some have ventured that there are as many as 4,000 worms of all sizes in a "bed-run" pound. There are arguments for buying both types (if you have a choice). Obviously, mature breeders are larger and ready to start mating when they arrive to their new destination. You won't have to wait until they become sexually mature as you would with juvenile worms. Mature breeders will be able to produce cocoons sooner and you will be able to see your total biomass of worms increase faster. Others believe bed-run worms are better because the greater number of smaller worms will adapt more quickly to their new surroundings than the older adult worms.

While there may be some truth to the idea that young worms adapt quicker, you'll find that a greater number of adult worms is usually harvested and sold simply because they are easier to harvest. Whether manual harvesting or mechanical harvesting is used, the larger worms tend to be plucked out for sale and the smaller worms tend to get left behind. The important thing in buying and selling worms is weight more than numbers. This weight is referred to as total biomass of worms. Unless you are planning to sell worms for bait, which means that a larger size worm should be sold to an angler, as a commercial grower you are more concerned with the weight of your worm shipments that come into and exit your operation.

**Self-Harvesting Methods**

Portable bins such as the Can-O-Worms encourage worms to migrate toward the top tray and leave their castings in lower trays. Systems such as this can be built from plywood or other materials, provided a mesh bottom is used.
Because of the considerable weight of the worms, bedding and castings (all of which is made heavier due to the moisture content) trays would have to be made that could be easily lifted, unless a forklift is handy.

Using various types of mesh or screens on the bottom of a box-type container is all it takes to build a system in which worms are fed in one tray at a time. When the worms are near the top of the tray, a second tray in added on top. Worm food is placed in this tray (with a mesh bottom) and the worms begin their upward migration.

This type of system is self-harvesting of castings, inasmuch as a continuous supply of food is added to the top levels and worms are working their way upwards. Lower trays, containing castings, can be harvested as worms work their way to the top levels.

What is an easy way to encourage worms to leave their bedding on their own--in other words, to "harvest" themselves?

Start by making a square or rectangular frame and attaching some 1/8" screen to it. One way to make a frame is to cut a 30" square piece of plywood. Then measure an inner square about two-and-a-half inches from the outside edge. Cut out this portion. Staple 1/8" screen to the resulting frame. Then use wood screws to attach 2 x 2 wood strips to the frame, keeping the screen material in between.

With this harvesting screen you can add worms to the top side and allow worms to work their way to a collector tray below. Support the harvesting screen with blocks so that you can place a tray container below it. The tray will collect the worms. Scoop from the worm bed enough bedding and worms to fill the harvesting tray an inch or two in width. If you are working in daylight the worms will begin working their way to the bottom of the harvesting screen and, eventually, through the screen and down into the collector tray below. If there is not enough light where you are working, shine an electric light on top of the harvesting screen, encouraging the worms to escape the light and burrow below.

This approach takes a little more time than simply picking out the worms by hand, but the worms will drop into
the collector tray below in order to escape the light above. Your bedding may be added back to the bed, or if you are harvesting your castings, you may wait until all the worms have passed through the screen and simply put your castings aside for future sale.

Using the Migration Technique

Since castings are toxic to worms, using their instinct to seek edible feedstock and leave behind their castings can be helpful in separating worms and castings. One way to do this is to encourage migration to a new bedding/feedstock area.

Best results in migration are generally in an upward direction. Removing worms from a bin or windrow can be done by starving the worms for a week or so, making sure that they have eaten all available food in their bed. Then introduce an inch or so of feed to the top of the bed. Worms will be found in the top few inches and can be harvested and removed to a new bed. Their castings below can be then be screened to make a fine, marketable product. Commercial operations with long windrows allow their beds to get 18 inches to two feet high or higher. They use a front-end loader to remove the top 6-8 inches of material which consists of worms which they move to another bedding area to establish a new windrow. The castings are then scooped up and screened, later to be sold in bulk or in bags.

A lateral or sideways migration technique can be employed, but it seems less effective. Placing fresh bedding and feedstock beside a worm bed will encourage worms to migrate toward the new material. While many worms make the journey over several days, there are always many worms left behind. Complete separation almost never occurs.

Mechanical Harvesting

The most practical and time-saving method for separating worms from their castings is the mechanical harvester. This is a trommel device, a rotating cylinder about 8-10 feet in length and 2-3 feet in diameter. The cylinder walls are composed of screen material of different mesh sizes. The cylinder is rotated by a small electric motor mounted on one end of the cylinder. This trommel is set at an angle; at the upper end of the rotating trommel worms and their
bedding (including castings) are added. As the cylinder rotates, the castings fall through the screen. The worms "ride" the entire distance of the trommel and pass through the lower end into a wheelbarrow. To date, this is the most efficient method of separating worms from their castings. Devices such as this cost anywhere between $1,800 and $3,500.
PACKAGING AND SHIPPING YOUR WORMS

Packaging

Worms are shipped all over the world. What is the best way to ship worms and what precautions should you take?

The best container to use for shipping worms seems to be a wax-coated cardboard box. Ordinary cardboard boxes have been used (non-wax coated) but they are subject to collapsing if the contents are too moist. The UPS delivery drivers don't appreciate picking up a box labeled "live earthworms" and then having the bottom fall out with worms crawling over the floors of their trucks. This might be funnier if it were not true.

A cardboard box measuring 14" x 14" x 14" could handle 40-50 pounds of total weight, perhaps 25-30 pounds of that weight consisting of worms. The rest of the material would be damp peat moss, used for keeping the worms moist and alive.

Scales

Your harvested worms need to be weighed before shipping. Scales of various types and prices can be found in your area. Look in the yellow pages of your phone directory for outlets that sell scales. Frequently, used scales are available, either through a dealer who takes in used scales on a trade-in, or through the classified ads of your local newspaper. Placing a "wanted" ad in your local newspaper or "shopper" type classified ad paper for scales will get people to call you who want to sell their used equipment. Consider the maximum weight you want to measure. Scales vary considerably in weights measured: Some scales go up to 10 pounds; others 30 pounds; 70 pounds, etc. After you've weighed the worms you are going to ship, you might want to throw in some extra, as an overcount, which some consider normal in the industry. Now you're ready to pack your worms for shipping.
Peat Moss

Canadian sphagnum peat moss has been found best for shipping worms. Other types of peat moss may be more acidic. To prepare peat moss for shipping, soak the contents for at least 24 hours. Then squeeze out all the excess water by hand to make a damp, not soggy, packing material. Try to squeeze out all the water you can. It has been said that worms can handle this packing material for up to two weeks, depending on the temperature, provided the peat moss is not too wet. Too much water in the peat moss causes acid build-up. Sprinkle some calcium carbonate (agricultural lime) on the peat moss to reduce the acidity of the peat moss. Use a pH meter to reach a slightly acid level of 6.5.

Add enough peat moss to the shipping container to make it about half full. Then add the worms you have harvested and weighed. Use a good quality sealing tape to seal up the cardboard box.

Using Ground Transportation

United Parcel Service (UPS) can usually ship within a couple days to any destination in the U.S. It is important to keep in mind that they do not make Saturday or Sunday deliveries. Thus, plan your shipping for the beginning of the week. You do not want to ship worms at the end of the week, only to have them spend the weekend in a place where the temperature might be harmful to them.

It is best to alert your customer about the shipment leaving your location. UPS will allow packages to be picked up at their depots prior to being loaded on the delivery trucks in the morning. Your customer can call the UPS office and pick up your package in the morning, thus reducing the amount of time the worms would stay in a container and delivery truck which may be subject to extreme temperatures.

If you plan to do a lot of shipping, it might be wise to ship a small quantity of worms to a friend or relative as an initial "test run" to see how your worms make the journey. By finding out from experience what is involved in shipping, you will eliminate potentially costly mistakes in the future. Worm growers who have improperly packaged their shipments or who did not plan ahead properly have lost
valuable inventory which had to be replaced at their cost. A little pre-planning may pay dividends.

**Shipping Huge Quantities**

There are times when worm growers have been asked to ship hundreds and thousands of pounds of worms. Are these worms first harvested, then weighed and boxed? How many people would it take to fill such a large order?

When landfill diversion sites place orders for thousands of pounds of worms, the sheer quantity involved dictates that an alternative plan come into use. Separating worms from their bedding, weighing them and packaging them in boxes is too labor intensive for huge orders. Instead, growers scoop up the whole bed and ship it by truck!

In order to ascertain the quantity of worms being purchased and shipped, an audit must first be taken. A cubic foot of bedding and worms is removed from several representative portions of a windrow. A device, somewhat like a shovel, but with an open-ended, box-like design can be used to dig into the worm bed and remove a cubic foot of bedding. Worms are removed from these samples by harvesting, then they are weighed. The resulting measurement gives an approximate worm weight per cubic foot of bedding. What remains is simply to calculate the size of the windrow in cubic feet and multiply that figure by the weight of the worms taken in the samples. The final figure is the approximate weight of worms per windrow of that size.

Once a price per pound has been agreed upon, the worms can be shipped in a truck with a moving or "walking" floor. Front-end loaders scoop up the entire windrow and place the contents into the truck bed. The redworms are shipped within the confines of their own bedding and castings, ready to be taken to their next vermicomposting home.

**What about shipping cocoons?**

Some growers have found a way to separate cocoons from their bedding, harvest these, and ship only cocoons, each estimated at producing two or more hatchlings. The advantages of this system are indeed substantial. First of all, the shipping weight is dramatically reduced. The weight of
thousands of cocoons is but a small fraction of the weight of live earthworms. Since the cost of shipping is calculated by weight, a tremendous savings is realized in shipping charges. Of course the compactness of the container is also advantageous. Less space is required initially to store the newly arrived cocoons than would be required for adult worms. More time to make adequate preparations is available to the new grower as well. Perhaps waiting for a more opportune moment to begin growing worms is desired. The shipment of cocoons can be kept in a cool place until the new grower decides to implant them in their new bedding.

Perhaps the disadvantages of ordering cocoons are two: First, there will be a greater delay for the new grower to see results in vermicomposting and breeding new worms. Obviously, the new cocoons will need time to hatch and the young worms will take several weeks to become sexually mature. The amount of feedstock they can transform into castings will be minimal. Secondly, there is no guarantee of 100% hatching rate. From studies in scientific literature, it has been reported that not all cocoons can be expected to hatch. Some factors accounting for this might be conjectured, but absolute certainty is unavailable. At any rate, the "hoped for" yield from a quantity of cocoons and the "actual" yield of young hatchlings may be quite a distance apart. This is a caveat not all purveyors of cocoons may announce.

As vermi-technology increases in the next few years, undoubtedly new developments in maximizing the effectiveness of harvesting, shipping and successfully hatching cocoons will become more widespread. Current efforts in this area are already underway and exciting possibilities are ahead for international shipment of huge quantities of cocoons at minimal cost. One such researcher is now negotiating multi-million dollar deals with a number of Asian countries. His facility, located in San Diego county in California, uses a batch system of cocoon development with several stacking trays housed in a greenhouse-type bungalow. The technology utilized in obtaining maximum cocoon production and separation has been in development for some twenty years, and proprietary considerations prohibit the release of this technology to the greater public. Nevertheless, as more vermiculturists share their findings and research with one another, new vistas are ahead for the next generation of worm growers.
THE VALUE OF WORM CASTINGS

Most leaders in the vermiculture industry today consider the greatest product value to be found in worm castings. Actual sales of worms is second to income derived from castings.

The most accurate term for describing the end product produced by the worm is actually "vermicompost." This is a blend of actual worm castings (the part excreted by the worms) and the remaining organic matter. In a worm bed where sawdust, egg shells, and cornstalks might be present, it is too much to ask that the tiny worm will be able to actually ingest all that is placed before it. We know that worms consume the micro-organisms which feed upon this decomposing organic material. Thus, in vermicompost, you will see the decomposed remnants of all that had been placed in the worm bed as well as actual "castings."

One of the best places to find actual worm "casts" in their pure form is to pick up a piece of corrugated cardboard that has been left in a worm bed for some time. Peel off one of the outer layers and look at the inner corrugated ridges. Most likely you will find worms and many small, dark globs of worm excreta left along the ridges. Here the castings have been deposited on the cardboard and can be clearly identified.

Exact nutrient content of castings will depend largely upon what the worm has been fed. It is recommended, where a high nutrient value of castings is desired, to offer a variety of feedstocks to the worms. As in most equations, whatever is put "in" is taken "out."

Best comparisons of worm castings are made with other compost. Whereas the making of fine grade compost
can take a period of about 240 days, vermicompost can be made in 30 days. When ordinary compost is placed on the ground to enrich plants, the available nutrients are quickly leached into the soil after rainwater or sprinkler irrigation systems are turned on. Vermicompost provides a time-release benefit, slowly nurturing the plants over a greater length of time.

While disease-resistance may be difficult to prove, it should be recognized that a healthier plant is more able to ward off pests and disease than an unhealthy plant. If worm castings contribute to the increased vitality of a plant, greater disease-resistance will be a concomitant effect.

Here are some documented quotes from individuals who know from experience something about the value of worm castings:

1. The science is not new. "Vermiconversion," or using earthworms to convert waste into soil additives, has been done on a relatively small scale for sometime. "But nobody's done it on a large commercial scale," says John Beerman, the general manager of the operation. [Canyon Recycling in San Diego.] The soil additive is marketed in the form of mulch, compost or vermicompost, in bulk or in bags. "We can't make enough earthworm castings to meet our demand here," he says. The Orange County Register, Friday March 1, 1996. "Hard-working worms: Turning Green Horticulture Waste into Greenbacks." John Barbour AP

2. Analysis of earthworm castings reveals that they are richer in plant nutrients than the soil, about three times more calcium and several times more nitrogen, phosphorus and potassium. (K.P. Barley, Advances in Agronomy, Vol. 13, 1961, p. 251)

3. Redworm castings contain a high percentage of humus. Humus helps soil particles form into clusters which create channels for the passage of air and improve its capacity to hold water. Humic acid present in humus, provides binding sites for the plant nutrients but also releases them to the plants upon demand. Humus is believed to aid in the prevention of harmful plant pathogens, fungi, nematodes and

4. "Vermicompost outperforms any commercial fertilizer I know of." continues [Dr. Clive A.] Edwards, who began his earthworm research in his native England in the early 1970s before coming to Ohio State. "I think the key factor is microbial activity. Research that I and others have done shows that microbial activity in worm castings is 10 to 20 times higher than in the soil and organic matter that the worm ingests." Dr. Clive Edwards, in "Worldwide Progress in Vermicomposting" by Gene Logsdon in BioCycle October 1994, p. 63.

5. A worm casting (also known as worm cast or vermicast) is a biologically active mound containing thousands of bacteria, enzymes, and remnants of plant materials and animal manures that were not digested by the earthworm. The composting process continues after a worm casting has been deposited. In fact, the bacterial population of a cast is much greater than the bacterial population of either ingested soil, or the earthworm's gut. An important component of this dark mass is humus. Humus is a complicated material formed during the breakdown of organic matter. One of its components, humic acid, provides many binding sites for plant nutrients, such as calcium, iron, potassium, sulfur and phosphorus. These nutrients are stored in the humic acid molecule in a form readily available to plants, and are released when the plants require them. Mary Appelhof, Worms Eat My Garbage, 1982, p.68.

6. Castings contain slow release nutrients which are readily available to plants. Castings contain the plant nutrients which are encased in mucus membranes which are secreted by the earthworms. They dissolve slowly rather than allowing immediate nutrient leaching. The product has excellent soil structure, porosity, aeration and water retention capabilities. The product can insulate plant roots from extreme temperatures, reduce erosion and control weeds. It is odorless and consists of 100% recycled materials.

7. The activity of the earthworm gut is like a miniature composting tube that mixes, conditions, and inoculates the residues. Moisture, pH, and microbial populations in the gut are favorably maintained for a synergistic relationship, and then a terrific end product. Dr. Bill Becker, "The Benefits of Earthworms," *Natural Food and Farming*, July/August, 1991, p. 12.

8. Earthworm castings are the best imaginable potting soil for greenhouses or house plants, as well as gardening and farming. It will not burn even the most delicate plants and all nutrients are water-soluble, making it an immediate plant food. Earthworm castings, in addition to their use as a potting soil, can be used as a planting soil for trees, vegetables, shrubs, and flowers. They may be used as a mulch so that the minerals leach directly into the ground when watered. The effects of earthworm castings used in any of these ways are immediately visible. They make plants grow fast and strong. Nematodes and diseases will not ruin gardens or plants if the soil is rich enough for them to grow fast. It is the weak plant in poor soil that is destroyed by nematodes and diseases. R.E. Gaddie and D.E. Douglas, *Earthworms For Ecology and Profit*, Vol. I "Scientific Earthworm Farming," 1975, p. 175.

9. Castings contain: 5 times the available nitrogen, 7 times the available potash and 1 1/2 times more calcium than that found in 15 cm of good top soil. Therefore, castings are supplied with available nutrients. The nutrients are also water soluble and immediately available to plant life. You will find that most potting soils have nutrient life of 2-5 days, where worm castings will last up to 6 times as long as other types of potting soils. You will need 5 times as much potting soil to do the same job as the worm castings. So, in the long run, worm castings are much cheaper and do a much better job. Also, castings hold 2-3 times their weight in water. That means you water less and the pot will stay damper for a longer period. Worm castings will not burn your plants; unlike using
any fresh raw manures (cow, horse, etc.) which can burn root systems if it is not applied properly. The advantage of using castings is the manure passes through the worms' digestive system producing rich organic plant food and a slow releasing fertilizer which allows for better growth. *Kids for Landcare: Wormwatch*, Education Department of South Australia, 1992, p. 35.

10. "Vermigro™ Compost is produced using two composting processes. The first, thermophytic composting, has been in use over 60 years in the U.S. The process raises the temperature to over 131°F to help ensure a product free of weed seeds and harmful organisms. The second, vermicomposting, adds valuable attributes such as water retention, texture, nutrient availability, a rich earthy fragrance and an ability to fight soil-borne plant diseases such as root rot." Resource Conversion Corporation, San Diego, CA.
While the activities and benefits of worms in nature have been known for generations, commercial breeding of worms, vermiculture, has been in practice for a relatively short period of time. Years ago, interest in fishing prompted growers to produce baitworms for tackle shops around the country. A rapid "boom" phase in worm growing later went "bust" as a number of "get-rich-quick" schemes were put out of business. Sadly, the entire industry was held suspect and even some honest individuals experienced great loss. It is only in the last few years that wide-scale use of red worms to aid in waste management has been implemented and found to be economically rewarding. Vermicomposting, the manufacture and sale of worm castings, is now being practiced on major landfill diversion sites as large as 60 acres. Worm growing is now a re-emerging industry with new participants and a whole new focus. Lessons from the past have been learned and expectations for a bright future are ahead.

The Early Years

A trip to your local library to find information about commercial vermiculture may prove to be an effort in vain. There has not been a great deal written about the subject of earthworms that is readily available to the public. That which has been written regarding commercial vermiculture is certainly dated material.

Books written on the subject of earthworms have been few and limited to two major publishers, one in Wisconsin (Shields Publications) and one formerly in California (Bookworm Publishing Co.). The latter company is no longer printing copies of its copyrighted material.

Since Darwin's 1881 study on *The Formation of Vegetable Mould Through the Action of Worms*, interest in
the benefits worms provided was negligible until the late 1930s. In 1936 Thomas Barrett, physician and "renaissance man" of many interests, established his Earthmaster Farms in El Monte, California. Here he conducted his experiments in raising earthworms and recorded his recommendations in *Harvesting the Earthworm* in 1946. Other early pioneers in earthworm investigations included Henry Hopp and particularly Robert Rodale whose publications in health, nutrition and organic gardening are known to millions around the world.

In the 1950s Earl B. Shields began publishing his *Earthworm Buyer's Guide* which is now in its 45th year of publication. Along with his *Raising Earthworms for Profit* (1959), his Shields Publications offers a selection of books available on subjects of raising red worms and nightcrawlers. One of these publications, *Let an Earthworm Be Your Garbage Man* (1954), put out by Home, Farm and Garden Research, Inc., focuses on reducing household and garden waste to produce vermicompost for use in one's garden. The entire line of Shields Publications bears testimony to the fact that literature on commercial growing has not been updated for over 20 years.

During the 1960s individuals such as Charlie Morgan and Ruth Myers published their findings. Morgan's *Earthworm Feeds and Feeding* (1961) educated worm growers in various phases of troubleshooting and producing commercially-bred worms with better results. Ruth Myers recorded her experiences as a homemaker starting on a small budget in *A-Worming We Did Go* (1968). The following year her *The ABC's of the Earthworm Business* was written as an aid to serious growers.

By the decade of the '70s, more scientific data and advanced technique became available as the worm growing industry took off. Clive Edwards and J.R. Lofty's *Biology of the Earthworm* (1972) was based on nearly 600 scientific references, more than half having been published since 1950.

But it was Ronald E. Gaddie, Sr. who catapulted the interest in growing earthworms to new heights. In 1967 Gaddie began his earthworm business after having been disabled by a back injury. (Similarly, Ruth Myers claimed to be "handicapped" yet would not allow that to get in the way of becoming a successful worm grower and author.) By 1972
Gaddie's North American Bait Farms of Ontario California was approaching $100,000 in gross sales and over $600,000 in 1975. Gaddie teamed with Donald E. Douglas, a technical writer in the field of electronic communications, and together co-wrote two volumes entitled Earthworms For Ecology and Profit. The first volume, Scientific Earthworm Farming (1975) credited Charlie Morgan, Earl Shields and Thomas Barrett for their contributions. Volume II, Earthworms and the Ecology (1977) credited Edwards and Lofty among others. Gaddie's Bookworm Publishing Company in Ontario California produced these volumes and published other books which had gone out of print. He also sold Shields publications through his huge network of growers around the country and the world.

In northern California at about the same time, Herb and Les Lanser of Paradise founded their Clear Creek Bait Farms. Their guidebook, Profit from Earthworms (1976) was written for those desiring to grow worms as a business. In 1972 Herb Lanser said that by his second year as a worm grower his success was "beyond my wildest expectations; I couldn't believe what a lucrative activity I'd gotten into." By April of 1978, Lanser had relinquished all interests in the business.

The Great Worm Wars of the Late Seventies

Gaddie's own business and his extensive network of growers began to feel the heat of government investigations and litigation. In a personal interview with the present author, Gaddie explained that at the height of his greatest success, his "empire" came crashing down amid a trying time of having to defend his actions and those of others. In the second half of the 70s, Gaddie's North American Bait Farms grew wildly. He reported that his network of growers exceeded 1,100 in California alone. He shipped worms across the U.S. and around the world. Worms were being shipped to Italy, France, Korea and Japan. In 1977 Japanese businessmen offered to buy North American Bait Farms from Gaddie for $2 million, asking him to stay for six months to help run the business and train others. Gaddie turned down the offer. His publishing company earned tremendous profits from the sale of his writings and those of others. He claims that over 750,000 copies of Volume I of his book were printed and 250,000 copies of Volume II. (A third volume,
completed more than 12 years ago, has not been published.) His writings were translated into Japanese, French and Spanish.

Then came reports that worm growers were involved in "pyramid schemes" and in violation of Securities and Exchange Commission laws. An expose was printed in the Wall Street Journal and another damaging article appeared in a newspaper in Oregon. Gaddie traveled to Oregon and represented himself in Salem. According to him, this period of time began the downward spiral. Gaddie was investigated by the Assistant Attorney General's office but was not formally charged with any violations. At least fourteen other worm growers, however, were closed down. "Sting" operations were set up in order to catch unscrupulous business owners.

Gaddie continued to be accused but was never found to be guilty. At one trial he showed up with over 320 pounds of evidence, none of which was admitted for his defense. The great cost and aggravation of having to defend himself and others eventually took its toll. Just as the foreign markets were exploding (Italy ordered $170,000 of worms) Gaddie was forced to close his doors in early 1980. The once million-dollar-per-year business in worms alone (not counting book sales) collapsed. Gaddie still lives in southern California, but he maintains little contact with worm growers. Today he breeds Beagles.

**What was the problem?**

In 1974 the Securities and Exchange Commission began informing North American Bait Farms that a price guarantee offered to buy back worms from potential investors could be construed as a sale of a security that would have to be registered under the Securities Act of 1933. Gaddie responded in a letter to his growers quoted here in part:

In place of our former guarantee, we will continue to purchase all of the progeny of our breeding stock, subject to our quality regulations (set forth in the contract) at the wholesale market price or more. We wish to point out that our firm is the most substantial in the area, with the longest record of widespread purchases and sales. We are favorably rated by Dun and Bradstreet and, most importantly, by our suppliers
and customers. We have consistently paid the full market price for bait raised by our growers, despite the fact that their purchase and sale contracts with us were made at a time when the agreed prices were lower than we've paid. (*Earthworms For Ecology & Profit*, Vol. I, p. 21.)

In spite of all attempts to warn others away from violating S.E.C. laws, Gaddie became caught in attempt to impose guilt by association on him for the actions of others. One individual who was active in the worm business at the time, Sherrel Hall, estimates that nearly 100,000 people could have been involved in growing worms in this country alone, and that nearly 98% of them left the business. Hall says that not only those who went to jail but others were guilty as well and should have been jailed. The rapidly expanding interest in worms that "boomed" out of southern California in the 1970s went "bust" in the 1980s.

**The Work of Mary Appelhof**

In 1982, Mary Appelhof, a biologist and educator self-published *Worms Eat My Garbage*, now said by Newsweek (Feb. 12, '96) to sell some 15,000 copies per year. (Appelhof reported in Carlsbad, CA on 5-4-96 that over 90,000 copies are in print.) Perhaps the most popular guide to setting up a home vermicomposting system, this book aims at reducing kitchen waste for the ecology-minded homemaker. Because of her background in biology, Appelhof's information is accurate and useful. The commercial grower, however, will not find out how to build a business by reading this book. It is geared mostly to home and school applications for the recycling of kitchen waste.

In April of 1980, Appelhof helped organize the Workshop on the Role of Earthworms in the Stabilization of Organic Residues held at Western Michigan University in Kalamazoo. Participants included 22 academic scientists, 2 public sector representatives, and 14 entrepreneurs. Two volumes were published after this conference in 1981. Volume I, compiled by Appelhof, is entitled "Proceedings," and provides the papers read at the conference. Volume II contains a bibliography of 3036 references to earthworms and other annelids produced from 1969 to January 1980. With the publication of these two volumes, a major step was taken...
in the advancement of both scientific data on earthworms, and
the intelligent application of earthworm science to
commercial vermiculture.

**VERMICULTURE IN THE NINETIES**

*BioCycle: The Journal of Composting and Recycling*

Catering to the burgeoning industry of composting and recycling, *BioCycle* is the pre-eminent publication of interest in the spread of information on large-scale composting. Published since 1960 by Jerome Goldstein's JG Press of Emmaus, Pennsylvania, *BioCycle* periodically features articles on vermicomposting efforts being made in the U.S. and around the world. However, this trade journal is not found on newsstands and, like the technical data and laboratory experiments reported in obscure journals lodged in major university libraries, vermicultural advances reported here are not disseminated to the general public.

In 1991 *BioCycle* published *The BioCycle Guide to the Art and Science of Composting*. One of the fifty-six articles in this volume described a vermicomposting operation in Fallbrook, California where wastewater sludge was fed to worms. Entitled "Vermicomposting in a Rural Community," the authors reported on the production of castings from sludge mixed with straw. "The earthworm accelerates the stabilization of many organic materials and produces a compost with superior plant-growth enhancement properties. Earthworm excreta (castings) are an excellent soil-conditioning material with a high water holding capacity and a 'natural time release' for releasing nitrogen into the soil," said the authors of this report.

The vermicompost beds at the Fallbrook Sanitary District were arranged on an open tarmac in windrows approximately 8-feet wide and of varying length. Beds were started with a 3-inch-thick layer of material with worms added at one pound per cubic foot. Feeding and harvesting were described as follows:

As the worms feed upon the freshly applied compost at the upper levels of the bed, they deposit their castings in the lower levels. Compost is continually
applied to the top of the beds until the beds reach a height of approximately 3 feet after about six months. The worms at this time are concentrated in the top 6 to 8 inches of the bed. The rest of the bed is stabilized vermicompost. Before harvesting, the top section containing the worms is scraped off. The lower section of vermicompost is then transferred to the screening facility for further processing. Part of the top section of the original bed containing the worms is then returned to the site of the original bed where it serves as the seed for the next generation bed. Compost and bulking material are reapplied and the cycle begins anew.

The authors also report that after bacteriological analyses of the final compost product, little or no evidence of coliform bacteria was found. (George D. Harris, Weldon L. Platt, and Benton C. Price, "Vermicomposting in a Rural Community," in The BioCycle Guide to the Art & Science of Composting (1991), 143-145.

New Horizons For Commercial Vermicomposting

The October 1994 issue of BioCycle featured a cover filled with a close-up photo of redworms. Vermicomposting was now on center stage in a publication targeted to reach landfill sites around the world.

Five articles covered stories on various aspects of vermiculture. In "Expanding Horizons for Commercial Vermiculture," new methods were touted for transforming waste into compost. BioCycle reported that "Technologies based on earthworms offer effective methods to compost larger portions of organics in the residential and commercial waste streams." Described in this first article were vermicomposting operations in Toronto, Canada, Portland, OR., San Diego, CA., Simi Valley, CA., and Orlando, FL.

A second major article, entitled "Worldwide Progress in Vermicomposting" reported on researchers and project developers who met at Ohio State University to discuss earthworm ecology and its role in organics recycling. Dr. Clive Edwards, Ohio State entomology professor, who has spent much of the last 20 years in earthworm research, was
the primary organizer of an international symposium on earthworm ecology.

Other articles reported on South American operations, classroom worm bins, and using red wigglers as teaching tools.

With this issue, BioCycle gave credence to the fact that vermicomposting can play a major role in transforming organic waste into a highly desirable and marketable product.

**BioCycle Conferences Span the U.S.**

Regional conferences are hosted by the publishers of BioCycle every quarter in the United States. The March 1996 conference was held in Seattle with one workshop title concerning vermicomposting. In May 1996, the National Conference held in Phoenix, Arizona featured a wealth of vermicomposting experts including Dr. Clive Edwards who spoke on the topic, "History and Overview of Vermicomposting." Dr. Edwards elaborated on current commercial projects, international studies, urban food residual composting potential, large-scale vermicomposting systems, and challenges to widespread use of vermicomposting. His slides detailed the use of his continuous flow reactor, a raised worm bed measuring 120 feet in length, 10 feet in width and about 3 feet in depth. A gantry-fed top-loading system for applying a couple tons of waste per day on the bed rolls along side rails of the worm bed. Castings are harvested below with the aid of a scraper which removes castings from the bottom of the mesh bed.

Rola Atiyeh, a graduate student at Ohio State University, reported on the "Potential of Vermicompost for Plant Growth." Her address dealt with research with ornamentals and vegetable crops, application rates, and comparison with standard fertilizer applications. Several slides of the results of plant growth trials were shown, demonstrating the clear superiority of worm castings over commercial fertilizers.

Mary Appelhof reported on vermicomposting operations in Australia and Uday Bhawalkar of Pune, India presented a lively and informative description of using earthworking worms (of the nightcrawler type) in transforming waste in India.
VERMICULTURE TODAY

The International Worm Growers Association

Headquartered in Palmdale, California, the I.W.G.A. is a newly created, non-profit organization aimed at helping worm growers with information, quarterly meetings, a newsletter and future projects to aid vermiculturists. At this time, membership is $50 per year and quarterly meetings have been held, up to now, in the southern California area. Plans are being made to move the meeting sites to other locations, but at this time the leadership and most members are southern Californians. Membership information can be obtained from Rick Best, Chairman, International Worm Growers Association, PO Box 900184, Palmdale, CA 93543. Telephone Number: (805) 944-2994; E-mail address: wormwise@aol.com

Worm Digest

Worm Digest is published quarterly by the Edible City Resource Center, a non-profit entity in Eugene, Oregon. Stephen White says that 10,000 copies of Worm Digest are printed every three months and are distributed to about 3,000 subscribers. U.S. individual subscriptions are $12.00 per year and bulk rates of current issues are available at greatly reduced prices. Worm Digest's first issue was published in the summer of 1993. It has grown from its original size of eight pages to the current 24-page magazine-style edition printed on recycled paper. The Digest features articles by educators and backyard vermicomposters as well as book reviews, tips, and a calendar of worm-related events. A number of worm growers and purveyors of worm paraphernalia advertise throughout the Digest. Back issues are also available.

Worm Digest, Box 544, Eugene, OR 97440-0544
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Production Editor/Advertising: S. Zorba Frankel (541) 485-0456
1. Keep learning. You can never know "too much" about vermiculture. It is amazing to see how much two worm growers have to talk about! Learn by reading books, reading magazines, learning more about the related composting industry, waste management trends, and talking to other growers. Ask questions, follow directions, and keep an open mind toward new ideas.

2. Don't take chances, but be free to experiment, particularly on a small scale. Worm growers are known for their individuality and creativity. Try different bed plans, different beddings, different feedstocks. Experiment with propagation beds, fattening products, and harvesting techniques.

3. Do something every day in your vermiculture business. How can you expand? How can you increase your sales? Whether it involves making colorful signs for your property, taking a trip to your library to find books on worms, learning how to get on the Internet, appearing at Growers' Markets, finding out about new products, or visiting other operations, there is always something to do, even after the worms are fed and watered.

4. Let people know what you are doing. Advertising is the most obvious and perhaps the most expensive, but there are inexpensive "shopper" type publications you can use to get started. Business cards are an inexpensive means to obtain a more professional image. Getting a business telephone number with a listing will allow those that hear of your business or those who want to get started growing worms in your area to find you.
5. Keep your eyes open for opportunities. Vermiculture and vermicomposting are vitally connected with two major industries: the waste industry and the horticultural industry. Contacts with key individuals in these industries can open doors of opportunity for management of all types of organic waste through vermicomposting and sales of the end product to a myriad of users in gardening, landscaping, nurseries, and associated botanical, horticultural and agricultural operations.

6. Offer to perform volunteer services. Many schools would welcome a brief presentation on worms and vermiculture. Educational aids are available to assist teachers and guest lecturers for help in putting together a presentation. Instructional videos also make these presentations easy to do. Many clubs, 4-H groups and other associations, such as a Master Gardeners group in your area would welcome an informative presentation about the virtues of vermicomposting.

7. Press Releases. Many local newspapers are hungry for new stories. When was the last time you read a story about a worm grower? How many people realize the value of worms and the potential they have in waste management? You will be surprised to find out that editors of many newspapers would greatly appreciate learning about your business. And there are a number of sections an editor may choose to feature your story. The environment, home and garden, and new business sections of a newspaper are perhaps the three top candidates for printing your story. Mail or fax a brief description of your business to several local papers. Try to direct your press release to the attention of the editor of the section you wish to cover your story. Newspapers, however, retain the right to place your story in the section of their choice. By targeting one contact person initially, however, you may follow-up on your press release by calling the same individual a few days after you've sent in your story. When newspapers decide to run your story, they will usually send out a reporter and photographer to get the information they want. Be ready for them! Have your facts available and a few handfuls of worms ready to hold up to the camera!
You'll experience a tremendous increase in business by this type of "advertising" that money cannot buy.

8. Join associations of worm growers like the I.W.G.A. There is strength in numbers but also encouragement and a conduit for valuable information. Associations like the International Worm Growers Association hold regular meetings, publish newsletters, offer field trips, provide contacts with experts, and provide a wealth of other useful services. By "networking" with other growers, you can learn from others' mistakes before they become your own!

9. Spend time planning. Think about the future of your operation. Where do you want to be at the end of a year? In five years? In ten years? How can you improve and grow? There's an old saw: "No one plans to fail, but many fail to plan." Having a business plan in the early stages of your development will be extremely beneficial. A well-written business plan serves as a blueprint, keeping you on track and helping you to put aside distractions. Often, the most crucial decisions in life are not between what is good and not good, but in making crucial distinctions between what is better and what is best. A carefully crafted business plan can be an aid in such decision-making times. "The extent to which you begin with the end in mind often determines whether or not you are able to create a successful enterprise. Most business failures begin in the first creation, with problems such as under capitalization, misunderstanding of the market, or lack of a business plan." Stephen R. Covey, The Seven Habits of Highly Effective People.

10. Keep good records. Keeping records of your worm-growing activities is certainly recommended, but financial records are equally, if not more important. As a business owner, you are entitled to a number of business deductions, including office expenses travel, and other investments and expenditures you make.
FIVE WAYS YOU CAN START YOUR WORM BUSINESS TODAY

1. Order a Can-O-Worms™

The easiest way to begin growing worms is to use the Can-O-Worms™. It comes complete with a bedding block and instructions for getting started. All you need to do is add the worms and kitchen scraps. The eleven-minute instructional video answers nearly every question a first-time vermicomposter can pose. Experience has shown that this item is extremely useful in promoting the benefits of vermicomposting to others. It is a simple system to set up and maintain. While it is not intended for large-scale vermicomposting, there are a number of huge vermicomposting operations selling these units! There are other home vermicomposting systems available, but the unique design of this product put it head and shoulders above the competition.

2. Build a 1-2-3 Worm Box

A simple worm box can be built with plywood in the following dimensions: one foot in depth, two feet in length and three feet in width. A plywood floor can be attached with wood screws or nails. Holes 1/2" in diameter can be drilled in the bottom for drainage. An average of 6 pounds of food waste per week can be handled by such a unit according to Mary Appelhof in her book, Worms Eat My Garbage (pp. 12-13) The bed can be raised by setting it on bricks or blocks and a plastic sheet or tray can be used to catch the leachate and any worm castings that may fall through the holes (if screen material is not used to cover the holes).

3. Build a 4 x 8 plywood bin (or a concrete block bin)

If you are using plywood exclusively to build a bin, it will take 3 and 1/2 sheets of plywood per bin. One sheet will be used for the lid, a second sheet for the floor, the third sheet can be cut lengthwise (forming 2 panels measuring 2' x 8') to make the sides, and the remaining half sheet can be cut to make two panels measuring 2' x 4' to make the ends of the box. Two-by-four lumber can be "ripped" lengthwise and the resulting 2 x 2 lumber can be used to make the frame of
the box. Drill pilot holes and use wood screws when assembling. Hinges can be used to make lifting and closing the lid easier. Drill holes 1" in diameter about 12 to 18 apart in the floor for drainage. Cover the holes with window screen and staple to the floor. The same size holes made be drilled in the sides and ends toward the top of the bin to allow for the penetration of air into the bin. Cover these holes with window screen as well to discourage entrance of pests. The construction of concrete block bins has also been mentioned elsewhere in this book. Using mortar will take more time to make a more professional-looking worm bed.

4. **Use a container already available to you**

An old discarded bathtub makes a perfect container for a worm bed. The drain at the bottom will allow excess liquid to leave the system, and the tub can be easily raised on blocks. Other containers of various sizes have been cleverly re-cycled to serve the needs of worm growers.

5. **Establish a windrow on the ground**

Because redworms are not burrowing worms, but inhabit piles of decomposing organic material, there is no danger of losing your worms into the soil. The very largest vermicomposting systems utilize windrows, adding layers of feedstock and water with mechanized equipment. Even on a smaller scale, a windrow of any dimension may be utilized. Rows are easier to work when no wider than the four foot suggested width of bins. Their length is entirely up to the grower and whatever the terrain will allow. A level place is recommended and the proximity to water is crucial. An "instant" worm bed is created by dumping aged and properly leached manure on level ground to a height of 8-12 inches. Irrigation systems are greatly preferred over any type of manual watering.
Chapter 12

MORE THAN WORMS: OTHER WAYS TO PROFIT FROM A WORM BUSINESS

Catch the wave of vermiculturing enthusiasm and you can ride it to increased profits. Here are but a few suggestions, some of which are already being practiced. But there is plenty of room for creative minds offering new ideas for expanding markets.

1. Books, books, books. Have you noticed that not much is available in libraries or bookstores about the subject of vermiculture? Some books are available through publishers such as Shields Publications in Wisconsin, but on the whole, these books are dated. You can obtain these books wholesale and sell them at suggested retail prices. As you develop your clientele, you might want to expand your book sales as well.

2. Equipment. Offering helpful products such as compost thermometers, moisture meters, pH testers, wax-coated cardboard boxes and other tools and equipment for worm growers can earn you extra income.

3. Worm bins. Several have been developed. You already know the worm bin this book recommends. These can be sold to individuals, schools and offices. They can be marketed through nurseries and home garden centers. They can be offered to millions of potential customers through gardening catalogs. They can be sold at growers' markets, fairs, garden shows, swap meets, etc.

4. Castings. The castings you produce have great value. They can be sold through the same channels as worm bins. Attractive packaging may help you sell more castings down the line, but initially you can put them in a one or two-gallon zip-lock baggie. Just affix a label on it with a description and some directions such as this: **CONCENTRATED WORM CASTINGS:** Nature's Best Fertilizer. **Top Dressing:** Spread a layer about 1/2 inch deep around plants. **Seed-Raising Mixture:** 3 parts aged compost to 1 part
castings. Potting Mix: 2 parts aged compost, 1 part castings, 1/2 part vermiculite. What can you charge for castings? The prices vary substantially. In bulk, they have been sold for $36-$40 per cubic yard (and this is a blend of castings and compost!) Another grower sells pure castings in bulk for $50 per cu. yd. In 1 cu. foot bags castings can be sold for as much as $7.00. 1/4 cu. ft. bags are being sold for $2.40 by one grower. Yet another grower sells a 1 lb. box of finely screened castings for $5.00. The price range is governed somewhat by what competing soil amendments cost. Worm castings, however, are unique and natural! A premium product can command a premium price!

5. Education. Schedule vermiculture presentations to schools, from elementary to high schools. The younger children love to feel the worms in their hands. Science teachers love to have special speakers come in to their classrooms with visual aids. Use the 11 minute Can-O-Worms™ video or Mary Appelhof's half-hour Wormania! video along with a worm bin, some bedding and a pound or two of worms. Teachers can purchase educational materials that you make available to them (such as the workbook, Worms Eat Our Garbage or the Can-O-Worms™ Primary Education booklet). It has been said that for each worm bin sold to a classroom, another five sales have resulted as the kids take the idea home to Mom and Dad.

6. Composting Workshops. Offer your services to your community and surrounding communities for a composting/vermicomposting workshop. 4-H Extension Offices can help you schedule and promote the event. Show a video, bring a worm bin and some worms, and show how easy it is to get started in home vermicomposting. Teach others how to build a small worm bin of their own. Bring examples of feedstocks and samples of castings. Show your own plant-growth experiments using castings. Hand out flyers explaining the basics of vermicomposting with your name and phone number.

7. Consultant to Municipalities. Get involved in your community and find out what is happening with green waste. Is it all going to the landfill? Are there efforts being made in composting? Are the individuals who are composting interested in vermicomposting? Do they know the nutrient difference between ordinary compost and vermicompost? Would they be interested in started up a test station for
vermicomposting? Would they consider using you as a consultant?

8. Write instructional materials. If you are a writer, the field of vermiculture is wide open for your skills. Nurseries could use pamphlets on the value of castings. Schools and teachers would benefit from lesson plans on earthworms and castings. Newspapers can use press releases. Organic gardening magazines would publish articles on plant growth experiments comparing various blends of castings versus commercially-produced fertilizers.

9. Make a video. Consider the widespread use of videos, not only as an entertainment medium, but as an instructional and sales medium in this country. The vermiculture industry stands in great need of more publicity through all available means such as high-quality video tapes.

10. Design a new product. Whether it's a new bin, a bumper sticker, or a "worm" baseball cap, there are going to be innovations galore in the days to come. How about new harvesting systems, or propagation techniques? Some of the greatest success in vermiculture in the days ahead will come to those who innovate. In the words of a leading business consultant and guru, W. Edwards Deming, "Loyal customers are not enough. You must continually introduce, by innovation, new products that will do the job better. It is necessary to innovate, to predict the needs of the customer, to give him more."

11. Organize an association or network. Form a local network of worm growers. Create a co-op to obtain equipment to bag and market castings. The expense of a mechanical harvester might be shared among the membership. Hold regular meetings to exchange information. Join the I.W.G.A. and make your association a chapter of it.


13. For the Birds. Explore opportunities for worm sales to bird owners, breeders, zoos, laboratories, etc.

14. Worm Clothing. Hats, T-shirts, jackets and other gear can promote vermicomposting.
15. Write a Newsletter. Help others stay in touch with what's happening in the worm industry. Offer tips to new growers, coverage of worm events, and offer insight into upcoming opportunities.

16. Contact organic gardeners and farmers. Share vermiculture with those who might appreciate it the most! Do the organic gardeners in your area use vermicompost? Would they be interested in producing it on their own?

17. Dairies and horse ranches. Are owners of these having trouble getting rid of their manure? Would they be interested in learning about vermicomposting so that they could turn their "waste" into a marketable product?

18. Nursery demonstrations. Offer to set up a worm bin at your local nursery. Some home and garden centers and nurseries encourage week-end demonstrations to get people into the store. Talk to the store manager to find out how you might present a "worm talk" or demonstration.

19. Growth studies. Get involved with the research side of castings. Use different plants and different blends of castings. Compare these with soil amendments currently available on the market. Record your findings both in print and with photos.

20. Liquid Organic Fertilizer. The "worm tea" that you collect can be marketed through the same outlets as your castings. Collect this leachate in one gallon plastic milk containers and sell for $1.00 to $3.00 per gallon.