EARTHWORMS

A Gardener's Best Friend

- Improve the physical structure of the soil

- Improve water filtration rates and absorption rates helping the soil to drain better. Less runoff equals less watering and less erosion.

- Their tunneling activity improves soil aeration, porosity, and permeability.

- Increases moisture absorption by the soil and helps make moisture available to plants. Castings absorb water faster than soil; castings hold more water than equivalent amounts of soil. (Bhawalker Earthworm Research Institute)

- Castings have the ability to absorb moisture from the air and hold it in a manner that plants can use. Bhawalker Earthworm Research Institute

- 25 earthworms per square foot of soil equal 1 million earthworms per acre. Studies in England have shown that in healthy soil forty tons of castings per acre pass through earthworms bodies daily. A new USA study indicates 12 million worms per acre which move 20 tons of earth each year.

- Studies have shown that with good food sources and favorable conditions, a field might have over 100 nightcrawlers per square yard. (National Soil Tilth Lab)

- One earthworm can digest 36 tons of soil in one year. US Soil Conservation Office

- The tunneling activity of worms helps breakup hardpan and other compacted soils.

- Studies have shown that 30% of a field's respiration during the cold wet

winter to spring months is due to earthworms.
-A study in European orchards found that earthworms could increase the pore space in soil by 75-100% and that earthworm burrows accounted for b of a soils air-filled pore. (Earthworm Ecology and Biogeography in North America, 1995)

- Improve soil fertility

- Bring up minerals from deep in the subsurface that are often in short supply in surface layers.- Earthworm activity counteracts leaching by bringing up nutrients from deep in the soil and depositing them on the soil's surface as castings.

- The burrows also allow roots to easily go down deeper into the soil and get nutrients they could not ordinarily reach.

- Removes litter from soil surface - earthworms eat the litter and leave the nutrients in their castings for plants to use as a natural fertilizer that is non-polluting.

- Earthworms process compost residues and waste products. The bacteria and other microbes in a worm's gut help destroy harmful chemicals and breakdown the organic wastes.

- Create fertile root channels - the mucus lining of abandoned burrows are an excellent source of nutrients and root growth promoting hormones.

- They make plant nutrients more available, worms concentrate minerals in their castings in a form that is easy for plants to absorb.

- Earthworms chelate nutrients, making minerals available to plants that would otherwise be in a form that would be chemically unavailable.

- Worms stimulate beneficial microbial populations; nitrogen fixing bacteria

are more numerous near earthworm burrows and in their castings. One study on bacteria and actinomycetes found densities from 10-1,000 times greater. (Earthworm Ecology and Biogeography in North America, 1995)

- Plant growth stimulants such as Auxins are produced in the castings, these hormones stimulate roots to grow faster and deeper.

- Worms neutralize soil pH, cast analysis shows that the product coming out of the back end of a worm is closer to neutral than what goes in the front end.

- Analysis of earthworm castings reveal that they are richer in nutrients than surrounding soil, often 3 times more calcium, several times more nitrogen, phosphorus, and potassium. (K.P. Barley, Advances In Agronomy, Vol. 13, 1961)
- Nitrogen fixing bacteria live in the gut of earthworms and in earthworm casts and higher nitrogenase activity, meaning greater rates of nitrogen fixation are found in casts as compared to surrounding soil.

- One study found that earthworms are responsible for passing nitrogen to the soil at a rate of 100 Kg N per ha per year. (Earthworm Ecology and Biogeography in North America, 1995)

- The earthworms gut is a natural bioreactor, which increases the beneficial microbial density in the material it excretes to 1,000 times that of the surrounding soil. (Worm Digest, Winter 1994)

- Improve plant growth and health

- Tests have shown that crops grown in earthworm-inhabited soil increased yields from 25% to over 300% than in earthworm-free soil. (K.P. Barley, Advances in Agronomy, vol. 13, 1961, p. 262-264)

- Earthworms help eliminate thatch in lawns and grassy areas by eating and digesting the plant debris.

- Studies have shown that soils rich in earthworms have less of the harmful nematodes like root feeders.

- Earthworms create soil conditions that discourage populations of soil organisms such as insects, nematodes and others that are harmful to plants.

- By passing soil and organic matter through their bodies, gradually make acid soil less acid and alkaline soil less alkaline. (The Rodale Book Of Composting, 1993)

- A recent study found that earthworm produced compost (vermicompost) dramatically increases germination and growth in many plants. Adding only 5% of the compost to commercial growing media (95%) significantly increased plant growth. Dr. (Clive Edwards, Ohio State University, Nursery Management & Production, January 1995)

- Research has shown that twice as many roots grew in pure worm castings than in sphagnum. (Dr. Clive Edwards, Ohio State University)

- Many species of earthworms actually eat the bad microbes (fungi, bacteria, etc.) that are plant pathogens and in the process they also increase the good beneficial microbes.

- It has recently been discovered that in feeding, earthworms consume spores
of mycorrhizae, a beneficial fungi that help roots take up nutrients. These spores are deposited in the worm castings, deep in their burrows, where roots easily find them as they grow. (The Avant Gardener, p. 87, 1995)

- Studies have shown that earthworms can increase barley yields 78-96%, spring wheat and grass yields 400%, clover yields 1,000%, and peas and oats by 70%. Other studies found that yields were increased for millet, soybeans, lima beans, and hay. Studies in New Zealand found that earthworms at least doubled yields in all cases and adding worms to crops

has become standard agricultural practice. (Earthworm Ecology and Biogeography in North

America, 1995)

- Experiments at Tennessee Technological University found that 10% vermi-compost in a potting mix improved the germination of seeds of low viability (Echinacea purpurea) by 43%.

- Researchers at Oregon State University have found that a tea made from the worm castings speeds up the sprouting of hard to germinate seeds following just one hour of pre-soaking.

- A large earthworm population suppresses weed growth

- The tunneling activity of earthworms prevents many of the conditions that weed seeds need to germinate.

- Earthworms often eat weed seeds and either destroy them or reduce their ability to germinate.

- Earthworms stimulate the growth of microorganisms in the soil and some weed seeds are destroyed by these microorganisms.

- Some microorganisms (bacteria and fungus whose growth is stimulated by
worms) live in a symbiotic relationship with plant roots and help plants grow better hence shading out weeds and out competing them for water and nutrients.

- Worms often help clean up dangerous chemicals in the environment.

- Researchers have found that bacteria living in the guts of worms breakdown (detoxify) many hazardous chemicals such as hexachlorocyclohexane (HCH). (Organic Gardening, May/June 1993)

- Microbes living in worms have the ability to breakdown complex organic molecules like cellulose and lignin.
- Improve water absorption and prevent erosion

- Increase the water stability of the soil, earthworm castings can take a direct hit by a raindrop and maintain their shape, this reduces erosion and runoff hence helps the soil absorb water.

- A research study conducted in Minnesota showed that earthworms added to cornfields increased water absorption rates 35 times over control fields without the earthworms, within a 6 week period. (Acres USA, March 1994

- Soil in a field with 100 nightcrawlers per square yard, 2 inches of water (a very heavy rainfall) could be absorbed by the soil in 12 minutes. The same soil without earthworms took over 12 hours to absorb that much water. (National Soil Tilth Lab)

- If the top 3 feet of soil contained 25% macropores (earthworm burrows) then that soil should be able to absorb at least a 9 inch rainfall without runoff.
(Natural Food & Farming, July/August 1991)

- One study showed that on a sloping field with no-till practices, there were 155 earthworms' holes per square yard and an average runoff of 0.08 inches per year. This compares to a tilled field with 6 holes per square yard and 4.9 inches of runoff per year. The average rainfall for this area is 39.4 inches. (Natural Food & Farming, July/August 1991)

- Scientists from the Agricultural Research Service found that grass and leave mulched plots had twice as many earthworms as those mulched with cornstalks. Water penetrated the earth-worm filled soil up to 4 times faster.

- Chemicals produced in the earthworm cause the castings to form aggregates in the soil that are resistant to erosion.

- Studies have shown that earthworms in soils can easily triple infiltration rates and cut run-off in half. (Earthworms in Agroecosystems, 1995)

- Some scientists now believe that earthworms have the potential to eliminate soil erosion! This could save society billions of dollars in erosion control, reduce pollution from dangerous synthetic chemicals and improve the environment.

- In an acre of good soil researchers have found more than 1 million worms and 1,200 miles of earthworm holes or burrows.

- Earthworms are valuable

- One-million earthworms per acre is about 25 earthworms per square foot of soil. If one had 1 nightcrawler per square foot at a value of $1.00 per dozen then one would have $3,630 worth of earthworms. Full retail value of one million earthworms would be over $83,000. If earthworms would work only 100 days per year and eat their weight of soil and/or residues daily, then at that
rate with one ton of earthworms per acre you would have 100 tons of earthworm manure (castings) per acre per year. This is about 2/3 inch deep layer over an entire acre of land. (Natural Food & Farming, July/August 1991)

- One million earthworms will have burrows which will have the equivalent space of 4,000 feet of 6 inch drain tile. At a installed price of $1.20 per foot for drain tile, those burrows are worth $4,800 per acre. (Natural Food & Farming, July/August 1991)

- Soil samples from a field not fertilized for 5 years but with a active earthworm population was analyzed. Based on the reported analyses it was found that 100 tons of earthworm castings will contain 4 lbs. of nitrate

nitrogen, 30 lbs. of phosphorus, 73 lbs. of potassium, 90 lbs. of magnesium, 500 lbs. of calcium. That is the equivalent to a 4-69-86 fertilizer and 3/4 ton of limestone worth $34.15 per acre with no fee for spreading or transportation.
- Research presented at the ISEE 5 (International Symposium on Earthworm Ecology at Ohio State University) point at earthworms being a important biomedical resource. It has been found that ingredients from earthworms have anti-cancer properties.

- The bodies of earthworms are extremely nutrient rich from minerals to amino acids, proteins and vitamins. When earthworms die these nutrients are released into the soil.

- How to attract and promote earthworms

- Mulch all soil with organic mulches which help stabilize soil temperature and moisture. Earthworms love Native Mulch and grow big and fat in it.

- Mulch provides food and shelter for earthworms. Compost is an excellent

mulch and as a soil amendment to attract (food source) earthworms.

DO NOT USE DANGEROUS SYNTHETIC CHEMICALS:

- Agricultural chemicals such as salt based artificial fertilizers (i.e. 13-13-13), pesticides, etc. can kill earthworms. Even if a few pesticides do not kill earthworms, such as DDT, birds are killed when they eat the worms. (Pesticide Reviews, Vol. 57, 1975)

- Earthworms and other beneficial organisms are destroyed by synthetic chemical fertilizers and fungicides, pesticides, etc. (Reviews of Environmental Contamination and Toxicology, 1992). In the absence of earthworms, the soil becomes lifeless, sterile, nutrient deficient and develops lots of problems.

- Studies have found that most organic fertilizers tend to have a positive effect on earthworms and increase population densities. (Earthworm Ecology and Biogeography in North America, 1995)

- Soils that are not tilled have 3-4 times as many nightcrawlers (surface feeding earthworms) as soils that are tilled in the spring or fall. Tilling greatly accelerates the breakdown of organic matter in the soil that worms need. (National Soil Tilth Lab)

Studies have shown that mulches produced from grass cuttings or leaves have twice the earthworm population than course mulches from straw or corn stalks, etc. (National Soil Tilth Lab)

- Mulches made from wood wastes that have lots of "fines" or small particles sizes are easier for worms to use (swallow and eat). The increased particle surface area of the small sizes also allows for greater microbial activity that is preferred by worms.

- Rough (unfinished) compost is one of the best worm-food mulches there is. (The Avant Gardener, p. 87, 1995)

- Types of earthworms

- Over 3,000 worm species have been identified. Experts disagree as to what distinguishes one type of worm from another and if one species is a true earthworm or not. All soil worms are beneficial and most references lump all soil worms into the category of "earthworms".

- Two basic types of worms, those that feed on the surface and those that feed in the subsurface. The surface feeders eat plant residue, are generally large worms and live in vertical burrows often over 6' deep. Subsurface feeders are smaller than surface feeders like nightcrawlers but outnumber them 9 to 1. They eat their way through the subsurface loosing, aerating and improving soil structure in the process.

When worms are separated into "worms" and "earthworms" then following applies:

- Redworms, often called manure worms, brandling worm, or red wigglers, they are reddish brown in color, and they live in the soil in the surface layer of decaying vegetation (litter). They feed on this layer, multiplying rapidly in numbers, expand into poorer surrounding soil and die thereby distributing the nutrients contained in the excess wastes over a larger area. Often used in small scale worm bins. Eisenia foetida and Lumbricus rubellus (tends to be more soil dwelling if large amounts of organic material are in the soil) are

examples of redworm species.

- Earthworms, often called soil processing worms, they are a burrower, a soil processor, eating dead organics and rock particles, grinding and excreting

them as a finely ground mix which serves as food for bacteria. They tend to survive in harsh conditions better than redworms. They do not assimilate the organics to the same extent as redworms for themselves; hence they do not multiple as quickly as redworms whose assimilation rates are much higher. The higher rate of assimilation (redworms) means that the nutrients consumed by the redworms goes into building their own biomass while the earthworm passes on these nutrients in a soluble form in their castings.
- Pheretima elongata, deep burrowing earthworm used in Bombay India to convert garbage into vermicompost. Recommended by Uday Bhawalker (Bhawalker Earthworm Research Institute) as the most efficient organic waste converter. Waste conversion occurs at the soil surface, not in a bin hence less material handling is required.

- Lumbricus terrestris, called nightcrawlers, dew worms, rain worm, orchard worm, etc. They like soil temperatures less than 50EF. They are also dig burrows and do not like to have their burrows disturbed. They come to the surface to feed on dead grass leaves etc. drawing them into their burrow hence taking organic matter deep into the soil layer. A good garden

worm.

- Garden worms, Allolobophora caliginosa, A. chloritica, Aporrectodea turgida, A. tuberculata, etc. often found in pastures.

- Most worms found in U.S. soils are not native
- Some earthworms from the southern hemisphere can grow 3-5' long, 1" in diameter and weigh up to 1.3 pounds

- Earthworms have many uses from soil farmer to food for animals. Most recently they are being used as a diagnostic tool since they have the ability to hyper accumulate toxins and environmental pollutants found in the soil

(since they ingest soil). As a result they are often collected and their tissue

analyzed for chemical contaminants.

- Earthworm Math
25 earthworms/sq. ft. = 1 ton of worms/acre
1 ton worms = 100 tons of castings or b" manure (castings) on surface per acre
Macropore equivalent to 4,000 ft. of 6" tile drain pipe per acre

Nutrients added to 1 acre of soil each year:
4 lbs of nitrate of nitrogen
30 lbs of phosphorus
72 lbs of potash
90 lbs of magnesium
500 lbs of calcium
or in terms of a fertilizer analysis = 4-68-96 plus 3/4 ton of limestone for a nutrient value of $34.15/acre in 1998.

WORM SPECIES:
Allolobophora chlorotica - the green worm, native to U.S.

Aporrectodea rosea - the pink soil worm, native to U.S.
Aporrectodea trapezoides - the southern worm, native to U.S.
Aporrectodea turgida - the pasture worm, native to U.S.
Bimastos tumidus - often found in compost piles, tolerates medium C:N ratios and cooler temperatures better than Eisenia foetida, multiplies rapidly in old straw and spoiled hay, hardy to Z-5 and will survive in ordinary soil conditions hence once established it would survive without extensive preparations. Earthworm Ecology and Biogeography in North America
Chumiodrilus zielae:
Eisenia foetida: (the tiger or brandling worm), often used for composting sometimes called E. andrei, (composter or surface worker species)
Eudrilus eugeniae: (African nightcrawler) do well but cannot withstand low temperatures,(composter or surface worker species)
Hyperiodrilus africanus: (west African)

Lumbricus rubellus: (common redworm or red marsh worm), used in Cuba's vermicomposting program, (composter or surface worker species), native to U.S.
Lumbricus terrestris: nightcrawler, native to U.S.
Millsonia anomala:
Perionyx excavatus: (Asian species) do well but cannot withstand low temperatures. (composter or surface worker species)
Octolasion tyrtaeum - woodland white worm, native to U.S.
Pheretima elongata:
- bigger, stronger and livelier than common species such as red worm (esienia foetida). It is a deep burrowing worm. Recently found in Missouri. Agricultural Research Service scientists are attempting to breed and spread this species as it would be useful for breaking up hardpans and for erosion control (increase infiltration). (Avant Gardener, p.87, 1995)

- deep burrowing earthworm used in Bombay India to convert garbage into vermicompost. Recommended by Uday Bhawalker (Bhawalker Earthworm Research Institute) as the most efficient organic waste converter. Waste conversion occurs at the soil surface, not in a bin hence less material handling is required.

Polypheretima elongata:
Ponotscoex corethrurus: (common through-out humid tropical zone)
Pontoscolex corethrurus:
Stuhlmannia porifera:Earthworm predators:
Artioposthia triangulata - "flatworm", from New Zealand, destroying earthworms in Great Britain, worm is dark brown, flattened with cream speckled margins, likes moist conditions with moderate to cool temperatures.
Australoplana sanguinea - "flatworm", from Australia, destroying earthworms in Great Britain, tolerates warmer and drier conditions than A. triangulata

USEFUL REFERENCES:

The Earth Moved, by Amy Stewart, Algonquin Books, P.O. Box 2225, Chappel Hill, North Carolina 27515 ISBN 1-56512-337-9

The Biology of Earthworms, C.A. Edwards and J.R. Lofty
Earthworms, K.E. Lee

Worms Eat My Garbage, Mary Appelhof, ISBN 0-942256-03-4

Worm Digest Magazine, P.O. Box 544, Eugene, OR 97440-9998

The Farmer's Earthworm Handbook: Managing Your Underground Moneymakers, David Ernst, Lessiter Publications, Brookfield, Wisconsin. 1995.

"Worm Wise News", International Worm Growers Association,

P.O. Box 900184, Palmdale, CA 93590
Soil Biology & Biochemistry, Special Issue: 5th International Symposium on Earthworms Ecology, ISSN 0038-0717
Earthworm Ecology, Soil and Water Conservation Society, Edited by Clive Edwards, PhD, St. Lucie Press, Copyright 1998, ISBN: 1-884015-74-3

SOURCES OF WORMS:

Texas:

Twin Oaks Farm (Georgia Brown Nose...a heat tolerant worm)
Jim McCarter
Rt. #1 Box 78A
Purdon, Tx 76679-9801
(817) 578-1272

Rabbit Hill Farm
Jay Mertz
Rt. 3 Box 2936
Corsicana, Tx 75110

(903) 872-4289

Earthworm Institute
City of Grapevine
Larry Wilhelm
(817) 424-0540

Pat's Worm Ranch (Louisiana Wigglers - soil worm..not for containers)
Sonny or Pat Kellum
P.O. Box 3194
San Antonio, Tx 78211
(210) 922-1592

OTHER:

Brown's Worm Farm
Rosemary Brown
Box 284
Marietta, OK 73448
(405) 276-3897

Flowerfield Enterprises (good source of educational material for children)
Mary Appelhof ("The Worm Lady")
10332 Shaver Road

Kalamazoo, MI 49002
(616) 327-0108

Jim Knight
Rt. 2 Box 183
Eudora, AR 71640
(510) 294-2603

Southern Worm Enterprize
12118 Marilyn Lane

Hammond, LA 70403
(504) 294-2603

Willingham Worm Farm
Rt. 1 Box 241
Butler, GA 31006
(800) 223

-WORMSOURCES OF WORM BINS & OTHER INFORMATION:

Gardener's Supply Company
128 Intervale Rd.
Burlington, VT 05401
(800) 955-3370

Garden's Alive
5100 Schenley Pl.
Lawerenceburg, IN 47025
(812) 537-8650

Peaceful Valley Farm Supply
P.O. Box 2209
Grass Valley, CA 95945
(916) 272-4769

101 Sherbrook Circle • Conroe, Texas 77385-7750
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