# Designing for Sustainability

## Using the BioIntensive Approach

**Design for Resilience in Smallholder Farming Systems**
**Jan 21-22, 2015, Washington DC**

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TOPS Promoting excellence in food security programming


B. H. HAAS

# What is BioIntensive Farming?

- Millennial old production technique
- Permanent beds and pathways
- Low tech hand based production
- Typically organic

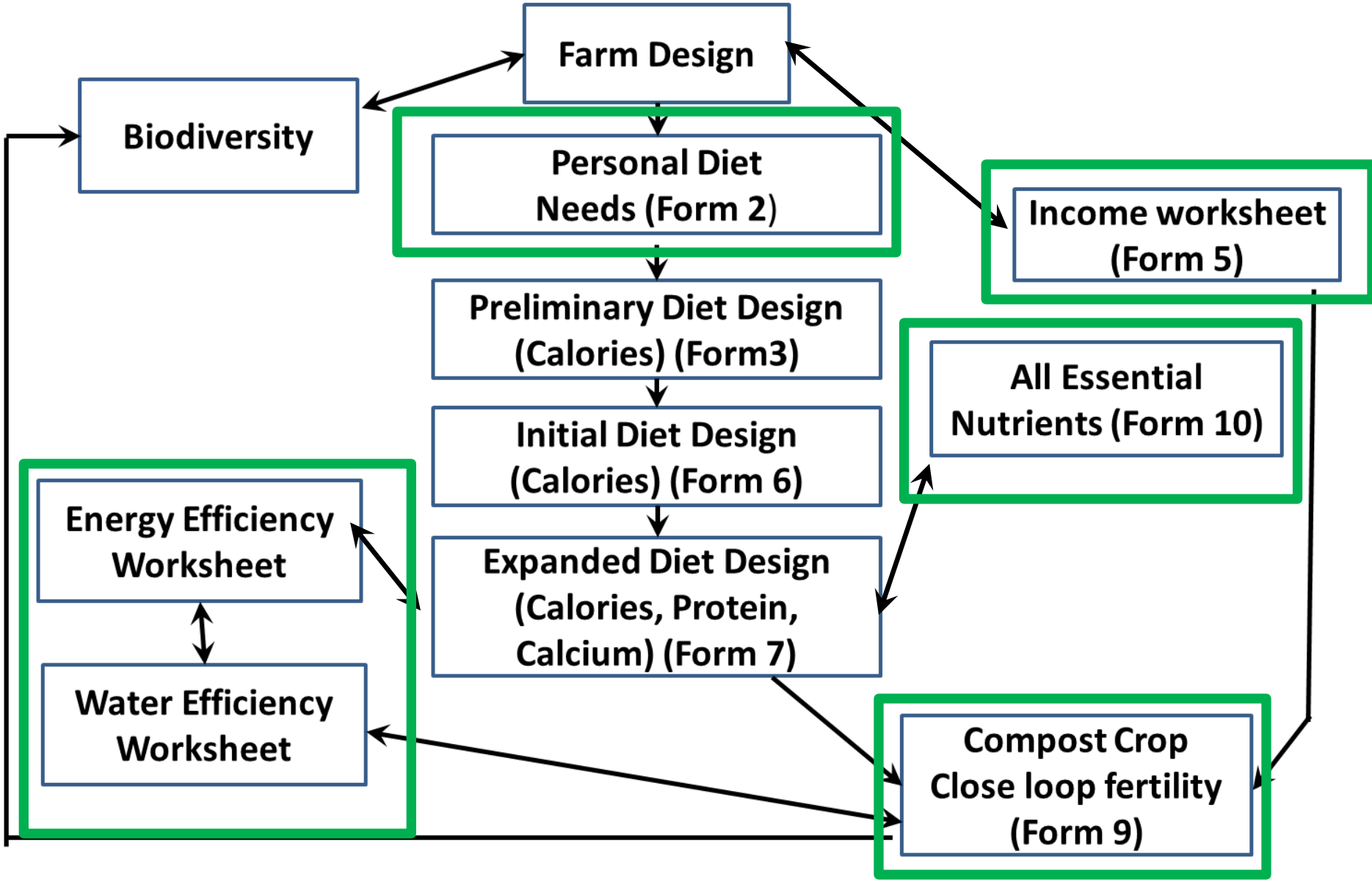
Russian Dacha


¼ of the land area required for an entire personal diet (1,000 sq.ft.)
Temperate USDA Zone 6 PA

# GrowBioIntensive Key Elements

- Deep soil development
- Close plant spacing
- Compost production efficiency
- Multicropping
- Carbon Farming
- Diet Farming
- Open Pollinated Seeds
- Holistic System Design

# Sustainable Food Production design flow chart



# Calories Needed – Form 2

Factors integrated into design needs

- Activity
- Climatic/weather
- Weight
- Gender
- Age
- Sleep/rest

FORM 3

## DIET CROP PRELIMINARY WORKSHEET

NAME:_____ DATE: _____

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| CROP | INTERM. YIELD per BED LB / KG (a) | CALORIES per LB / KG (b) | CALORIES per BED [A x B] | CROPS per YEAR | CALORIES per BED per YEAR [C x D] | NO. BEDS for 876,000 cal per YEAR [876,000 / E] | WEIGHT OF FOOD / DAY [2,400 / B] [x 3* for beans, grains] |
| Tomatoes | 194 | 95 | 18,430 | 1 | 18,430 | 47.5 | 25.3 |
| Potatoes (Irish) | 200 | 349 | 69,800 | 2 | 139,600 | 6.28 | 6.9 |
| Corn (Flour) | 17 | 1,656 | 28,152 | 1 | 28,152 | 31.1 | 1.4 |
| | | | | | | | |
| | | | | | | | |

- Thinking in terms of nutrition not just yield
- Land use efficiency
- Kitchen efficiency (nutrient density: i.e. calories per lb of food)
- Compost crop efficiency
- Categories of crops: Vegetable, special root and calorie dense (seeds)

Data found in How to Grow More Vegetables by John Jeavons

# FORM 7: DIET DESIGN (1)

NAME: S. Moore — It is best to limit this exercise initially to 8 to 12 crops. — DATE:

Y lb, sq ft __ kg, sq m

| | CROPS | A: WEIGHT of FOOD per DAY A1 Eaten [d] | A2 Dry [e] | B: REQUIRED ANNUAL YIELD [A x 365] [f] | C: CROPS per YEAR | D: INTERM. YIELD per BED per CROP (lb or kg) [c] | E: ANNUAL YIELD per BED [C x D] | F: ACTUAL AREA (BEDS [b]) [B / E] | G: MO. IN BED [a] | H: BED-CROPS [C x F] |
|---|---|---|---|---|---|---|---|---|---|---|
| Sp | Potatoes | 2.25 | 2.25 | 821 | 2 | 200 | 400 | 2.0 | 5 | 4.1 |
| | Sweet Potatoes | 1.125 | 1.125 | 410 | 1 | 164 | 164 | 2.5 | 5.5 | 2.5 |
| Rt | Parsnips | .25 | .25 | 91 | 1 | 238 | 238 | .38 | 10 | .38 |
| | J. Artichokes | .25 | .25 | 91 | 1 | 206 | 206 | .44 | 12 | .44 |
| | Garlic | .1 | .1 | 36.5 | 1 | 120 | 120 | .3 | 10 | .3 |
| | Onions | .33 | .33 | 120 | 1 | 200 | 200 | .6 | 8 | .6 |
| V | Tomatoes | .125 | .125 | 46 | 1 | 194 | 194 | .23 | 5.5 | .23 |
| e | Parsley | .05 | .05 | 18.25 | 1 | 52 | 52 | .35 | 12 | .35 |
| g | Peanuts | .03 | .03 | 11. | 1 | 10 | 10 | 1.1 | 4 | 1.1 |
| s | Cabbage | .3 | .3 | 109.5 | 2 | 191 | 382 | .3 | 3.5 | .6 |
| | SUBTOTALS FOR SPECIAL ROOT AND VEGETABLE CROPS 4.81 | | | | | | | 8.2 | | 10.6 |
| Cb | Corn (Blue) | .75 | .25 | 90 | 1 | 17 | 17 | 5.25 | | |
| + | Wheat | .5 | .165 | 60 | 1 | 10 | 10 | 6 | | |
| Cal | Sunflowers | .125 | .125 | 46 | 1 | 5 | 5 | 9 | | |
| | TOTAL WT / DAY 6.18 | | | SUBTOTAL CARBON+CALORIE CROP BEDS | | | | 20.25 | | |
| | | | | | | | | 28.5 | | TOTAL BEDS |

These areas are to be included on the Compost Design Worksheet.

**Maximum Weight of Food per Day**: women: 5.5 lb (2.5 kg); men: 6 lb (2.7 kg)

Eventual Planning Goal: 60% of area for crops producing high amounts of carbon and significant amounts of calories; 30% of area for root crops high in calories; minimum of 2.5% of area for miscellaneous vegetables, maximum of 7.5% for income crops.

You should wait to fill in Columns G, H, and R until the other columns are more or less settled.

[a] HTGMV 6: (Col N + Col. O) / 4.3 [b] BED = 100 sq ft = 9.3 sq m (10 sq m) [c] HTGMV 6, Col. E middle figure

[d] Beans and grains rehydrated: dry weight x 3 (except x 2 for corn made into tortillas)

[e] Beans and grains only [f] Use A2 for beans and grains, A1 for all others

* w/ moderate season extension





# FORM 7: DIET DESIGN (2)

NAME: S. Moore — It is best to limit this exercise initially to 8 to 12 crops. — DATE.

| CROPS | I: CALORIES per lb or kg [HTG Col. MM] | J: CALORIES per BED per YR [E x I] | K: ACTUAL CALORIES per YR [B x I] | L: CALCIUM per lb or kg (mg) [g] | M: CALCIUM per BED per YR (mg) [E x L] | N: ACTUAL CALCIUM per YR (mg) [B x L] | O: PROTEIN per lb or kg (grams) [h] | P: PROTEIN per BED per YR (g) [E x O] | Q: ACTUAL PROTEIN per YR (g) [B x O] | R: BCM [GxH] |
|---|---|---|---|---|---|---|---|---|---|---|
| Potatoes | 279 | 55,800 | 229,128 | 26 | 10,400 | 21352 | 7.7 | 3080 | 6822 | 20.5 |
| Swet Pots | 375 | 61,500 | 153750 | 118 | 19,352 | 48.380 | 6.6 | 1082 | 2706 | 13.8 |
| Parsnips | 293 | 69,734 | 26,663 | 193 | 45,934 | 17563 | 6.6 | 1570 | 601 | 3.8 |
| J Artichoke | 337 | 694.20 | 30,467 | 44 | 9,044 | 4004 | 7.2 | 1483 | 655 | 5.3 |
| Garlic | 547 | 65,640 | 20,039 | 116 | 13,920 | 4234 | 24.8 | 2976 | 905 | 3 |
| Onion | 172 | 34409 | 20,640 | 111 | 22,200 | 13,320 | 6.2 | 1240 | 744 | 3 |
| Tomatoes | 95 | 18430 | 4370 | 59 | 11,446 | 2714 | 5.0 | 970 | 23 | 1.3 |
| Parsley | 163 | 8476 | 29775 | 921 | 47892 | 16808 | 16.3 | 848 | 297 | 4.2 |
| Peanuts | 2,558 | 25580 | 28138 | 313 | 3130 | 3443 | 117.9 | 1178 | 1297 | 4.4 |
| Cabbage | 113 | 43,166 | 12,314 | 200 | 76400 | 21900 | 5.3 | 2025 | 580 | 2.1 |
| | | | | | | | | | | 61.4 |
| Corn | 1579 | 26,843 | 142110 | 100 | 1700 | 9000 | 40.4 | 687 | 3636 | |
| Wheat | 1497 | 14,970 | 89,820 | 209 | 1254 | 12540 | 55.8 | 335 | 3348 | |
| Sunflowers | 2,540 | 12700 | 116,840 | 544 | 2720 | 25024 | 108.9 | 541 | 5009 | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| TOTALS | Annual Daily | 87514 | | | 200,282 | | | | 26,623 | |
| MINI-FARM DESIGN GOALS | Annual Daily | 876,000 2,400 | | | 182,500 500 | | | | 18,615 51 | |

BCM = BED-CROP-MONTHS 2404 549 73

(g) HTGMV Column NN

(h) HTGMV Column LL

# Additional Essential Nutrients – Form 10

- Calculates - carbohydrates, fats, Linoleic acid, folic acid and pantothenic acid
- Calculate - (9) amino acids
- Calculate – (8)  minerals
- Calculate - (7) vitamins

# Form 9 Compost Crops and closing the Fertility Loop

- Carry over of Carbon materials from Form 7
- Determine additional carbon and N needs
- Calculate the C:N ratio for built compost
- Calculate approximate cured compost
- Determine the total farm area
- Calculate the $ft^3$ of cured compost/unit area
- Determine “Bed Crop Months”

# Carbon and Calorie Crops

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# COMPOST CROPS (1)

## COMPOST MATERIALS

lb & sq ft ____
kg & sq m ____

| COMPOST CROPS (Maximum of 4) Goal (see below) DRY MATERIALS | A MONTHS IN BED [HTGMV: O+P / 4.3] | B CROPS per YEAR | C** ACTUAL AREA IN BEDS* | D BED-CROPS [B x C] | E INTERMEDIATE YIELD / BED / CROP * D R Y * (lb or kg) | F ANNUAL YIELD per BED * D R Y * (lb or kg) [B x E] | G % DRY MATTER *DRY* | H ANNUAL "100% DRY" MATTER YIELD / BED lb or kg [F x G x 0.01] | I ACTUAL "100% DRY" MATTER YIELD lb or kg [C x H] |
|---|---|---|---|---|---|---|---|---|---|
| EXAMPLE: Corn | 4 | 1 | 5.25 | 5.25 | 48 | 48 | 90.6 | 43.5 | 228.4 |
| Wheat | 9 | 1 | 6 | 6 | 30 | 30 | 92.5 | 27.8 | 166.8 |
| Sunflowers | 5 | 1 | 9 | 9 | 40 | 40 | 90.6 | 36.2 | 325.8 |
| | | | | | | | | | |
| Our Actuals 2000-2003 | | | | | | | | | |
| Corn | | | | | | | | | |
| Wheat | | | | | | | | | |
| Sunflowers | | | | | | | | | |
| | | | | | | | | | |
| DRY SUBTOTAL | | | 20.3 | | | | | | 721 |
| GREEN MATERIALS | MONTHS IN BED ** [HTGMV: O+P / 4.3] | CROPS per YEAR | ACTUAL AREA IN BEDS | BED-CROPS [B x C] | INTERMEDIATE YIELD / BED / CROP * G R E E N * lb or kg | ANNUAL YIELD per BED * G R E E N * lb or kg [B x E] | % DRY MATTER *GREEN* | ANNUAL "100% DRY" MATTER YIELD / BED lb or kg [F x G x 0.01] | ACTUAL "100% DRY" MATTER YIELD lb or kg [C x H] |
| EXAMPLE: Alfalfa | 12 | 1 | 9 | 9 | 276 | 276 | 26.3 | 72.33 | 651 |
| Comfrey | 12 | 1 | 1 | 1 | 184 | 184 | 11 | 24.2 | 24 |
| | | | | | | | | | |
| | | | | | | | | | |
| GREEN SUBTOTAL | | | 10 | | | | | | 675 |
| TOTALS | | | 30.3 | | | | | | |

* BED = 100 sq ft = 9.3 sq m (10 sq m)

** For perennials: Months in Bed = 12; Crops per Year = 1.

Goal for Compost Crop area (excluding Diet Crop area):
- 67% producing significant amounts of dry (carbonaceous) material
- 33% producing significant amounts of green (nitrogenous) material.



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# COMPOST CROPS (2)

| | | CARBON (BUILT) | | | NITROGEN (BUILT) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| COMPOST CROPS DRY MATERIALS | J % C *DRY* | K ANNUAL C per BED lb or kg [H x J x 0.01] * | L ACTUAL C lb or kg [K x C] | M % N *DRY* | N ANNUAL N per BED *DRY* lb or kg [H x M x 0.01] | O ACTUAL N *DRY* lb or kg [N x C] | P C / N RATIO [L / O] | Q B-C-M [A x B x C] |
| EXAMPLE: Sunflowers | 52.1 | 18.9 | 170.1 | .93 | .34 | 3.06 | 55.6 | 45 |
| Corn | 52.3 | 22.8 | 119.7 | .94 | .40 | 2.1 | 56.8 | 21 |
| Wheat | 50.9 | 14.12 | 84.7 | .62 | .17 | 1.02 | 83 | 54 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| DRY SUBTOTAL | | | 374.5 | | | 6.18 | | 120 |
| GREEN MATERIALS | % C *GREEN* | ANNUAL C per BED lb or kg [H x J x 0.01] * | ACTUAL C lb or kg [K x C] | % N *GREEN* | ANNUAL N per BED *GREEN* lb or kg [H x M x 0.01] | ACTUAL N *GREEN* lb or kg [N x C] | C / N RATIO [L / O] | B-C-M [A x B x C] |
| EXAMPLE: Alfalfa | 54.3 | 39.2 | 352.8 | .7 | 1.93 | 17.37 | | 108 |
| Comfrey | 54.3 | 13.14 | 13.14 | .54 | 1.18 | 1.18 | | 12 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| GREEN SUBTOTAL | | | 365.94 | | | 18.55 | | 120 |
| TOTALS | | | 740.44 | | | 24.73 | | 240 |

AVERAGE PRODUCED PER BED

Average 'BUILT' Carbon per bed: Col. L Total / Col. C Total = 24 (lb) or kg C

Average 'BUILT' Nitrogen per bed: Col. O Total / Col. C Total = .8 (lb) or kg N

'BUILT' C / N RATIO (Col. L Total / Col. O Total): 30 / 1

MINIMUM GOAL: C / N RATIO: ~ 30 / 1

* Whether the crop is harvested green or dry, "%C" refers to the percentage of carbon in the crop when it is dehydrated. For this reason, multiply the %C by the dehydrated weight (Column H).

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# COMPOST CROPS (3)

## CURED COMPOST

lb & sq ft ✓
kg & sq m ____

| COMPOST CROPS — DRY MATERIALS | R — ACTUAL "BUILT" VOLUME DRY MATERIAL cu ft or cu m [C x F / 3.6 lb or 57.7 kg#] | T — CURING FACTOR ## (approx.) | U — ACTUAL CURED VOLUME *WITHOUT* *SOIL* cu ft or cu m | | V — ACTUAL CURED VOLUME *WITH* *SOIL* cu ft or cu m |
|---|---|---|---|---|---|
| EXAMPLE: Sunflower | 9 x 40 / 320 ÷ 88 | | | | |
| Corn (flour) | 5.25 x 48 / 252 | 70 | | | |
| Wheat | 6 x 30 / 180 | 50 | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| TOTAL DRY MATERIAL | 208 | / ~6.57 = | 32 | | |
| GREEN MATERIALS | GREEN MATERIAL cu ft or cu m [C x F / 8.5 lb or 136.2 kg#] | | | | |
| EXAMPLE: Alfalfa | 9 x 272 / 2484 | 292 | + | | |
| Comfrey | 1 x 184 / 184 | 21 | | | |
| | | | | | |
| | | | | | |
| TOTAL GREEN MATERIAL | 313 | / ~8.50 = | 37 | | |
| | TOTAL ORGANIC MATTER | | 69 | x 2 = | 138 |

**RATIO OF 'BUILT' VOLUME TO CURED VOLUME:**

**Approximate Total 'Built' Volume with Soil: [ (Col. R Dry + Col. R Green)** 521
**x 1.11 (assuming soil in built pile = approx. 10% by volume) =** 573 **]**

**/ Total Cured Volume with Soil (V) =** 41.3
(Will vary according to materials used.)

# These conversion weights are averages based on data from five diverse research piles (33, 34, 37, 49, 53).
## Based on curing percentages approximated in Booklet #10, p. 7. Can be lower for cold piles.



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# COMPOST CROPS (4)

## CURED CARBON AND NITROGEN

TOTAL 'BUILT' CARBON 374.5 / 2 = ~ 187.2 TOTAL CURED CARBON (lb or kg)
(Column L Total)

/ 30.3 Total Beds = 6.2 Average Cured Carbon per Bed
(Column C Total)

TOTAL CURED CARBON 6.2 / 10 * = ~ .6 TOTAL CURED NITROGEN (lb or kg)
(from previous line)

/ 30.3 Total Beds = ~0.02 Average Cured Nitrogen per Bed
(Column C Total)

## COMPOST AVAILABLE

Indices for Productivity Reference:

[ W ] Average Cured Compost Volume With Soil Produced per Compost Bed
Col. V / Col. C Total = 4.5 cu ft or cu m

[ X ] Average Number of Crops per Bed (Col. D Total / Col. C Total) = 1

[ Y ] Average Cured Compost Volume (with soil) per Crop (Col. W / X) = 4.45 cu ft or cu m

**APPROXIMATE GOAL: 0.09 cu m or 3.2 cu ft**
(More may be needed; less may be adequate, depending on growing season length and crop selection.)

| | |
|---|---|
| Total Compost Crop 'Bed-Crops' [Col. D Total from Compost Crops (1) sheet] | 30.3 |
| Total Diet Crop 'Bed-Crops' [Col. H Total from Diet Crops (1) sheet] | + 8.4 |
| Total Income Crop 'Bed-Crops' [Col. D Total from Income Crops sheet] | + 1.25 |
| TOTAL MINI-FARM 'BED-CROPS' | 39.95 |

| % BED-CROP-MONTHS | B-C-M | % B-C-M |
|---|---|---|
| COMPOST CROPS Col. Q | 240 | 74 |
| DIET CROPS Col. R | 70.6 | 22 |
| INCOME CROPS Col. K | 12 | 4 |
| TOTAL | 322.6 | 100 |

**CURED COMPOST VOLUME (including soil) AVAILABLE PER BED-CROP FOR ALL CROPS GROWN:**

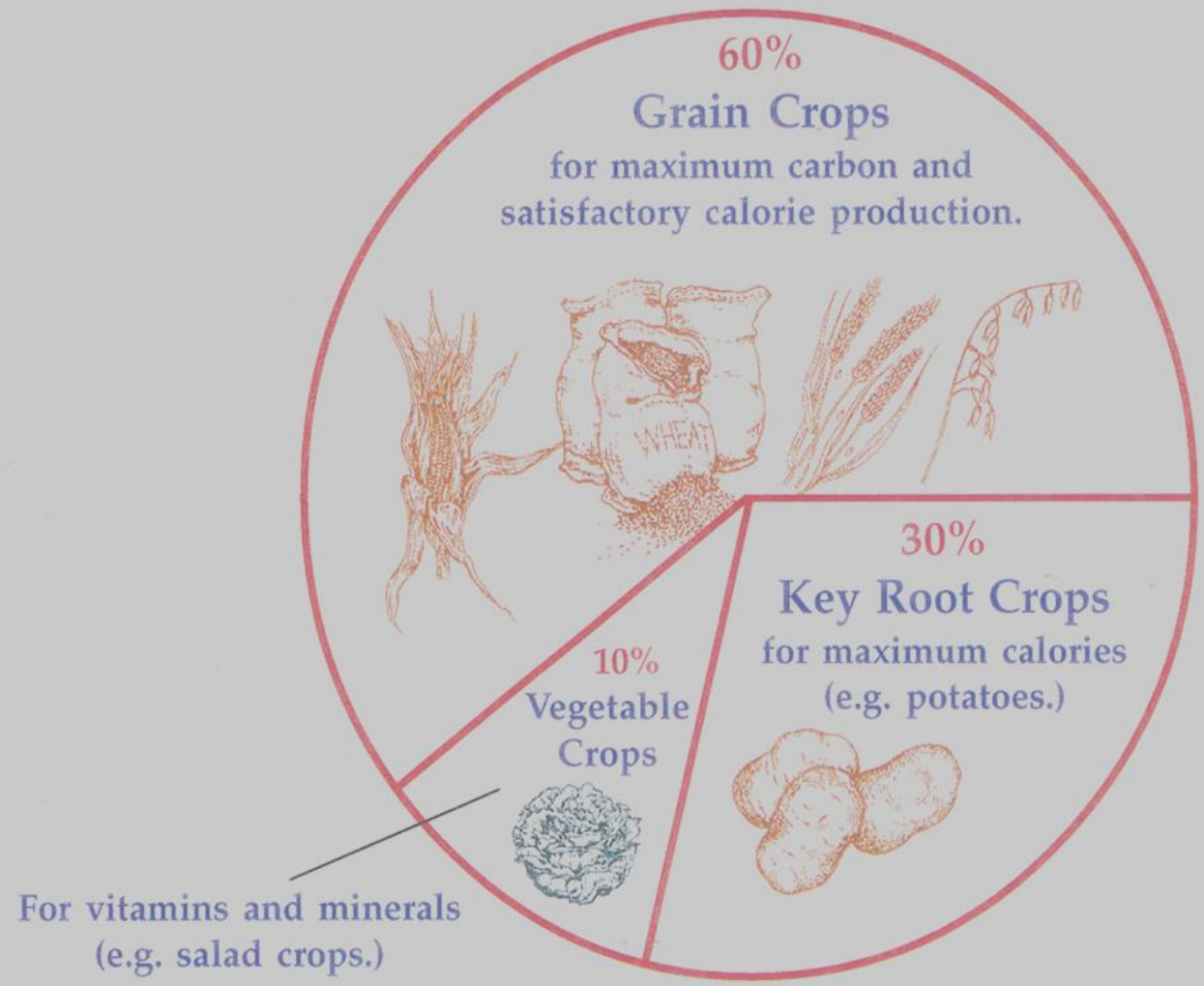
Col. V [from Compost Crops (3)] ____ ÷ TOTAL MINI/FARM 'BED-CROPS' (above)

= 3.45 cu m or cu ft. = 5 1/4 (5 qB)

**MINIMUM GOAL: 0.05 cu m or 1.6 cu ft (More is desirable.)**

* The carbon-to-nitrogen ratio of the organic fraction of cured compost is reported to be between 10 and 20 to 1.
10 to 1: Helmut Kohnke, *Soil Science Simplified* (Prospect Heights, IL: Waveland Press, 1966), p 39.
15 to 20 to 1: Paul D. Sachs, *Edaphos* (Newbury VT: The Edaphic Press, 1993), p 113.
17 to 20 to 1: Robert Parnes, *Fertile Soil* (Davis, CA: agAccess, 1990), p. 53.

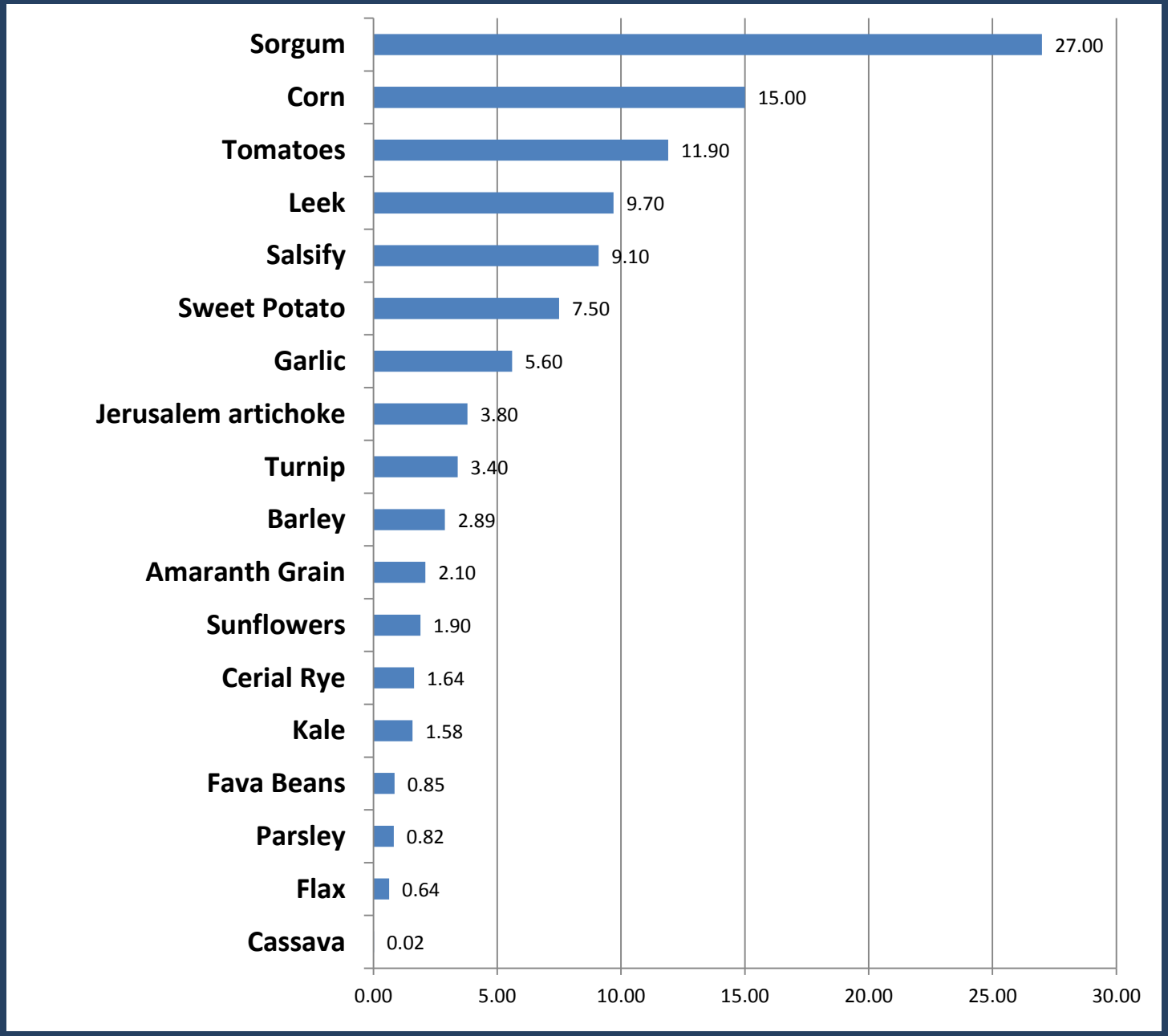
# Guiding Land Use Percentages for Diet and Compost Crop



# Open Pollinated Seeds

- Seed saving
- Localized plant breeding for
  - larger genetic pool
  - Local adaptability
    - for specific pests
    - climate change
    - Multicropping systems
- Increased viability and vigor

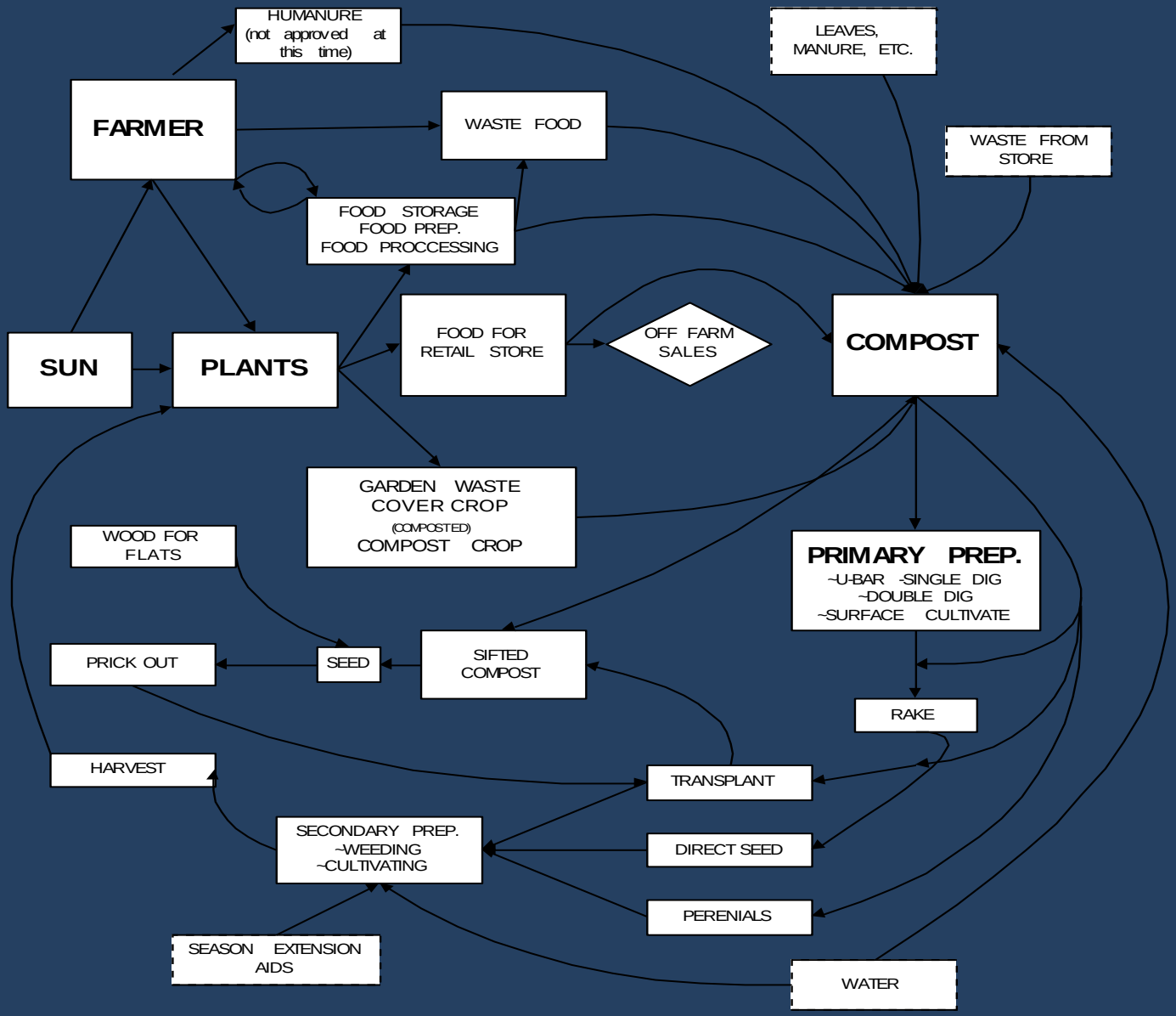



# Calories produced per gallon of water

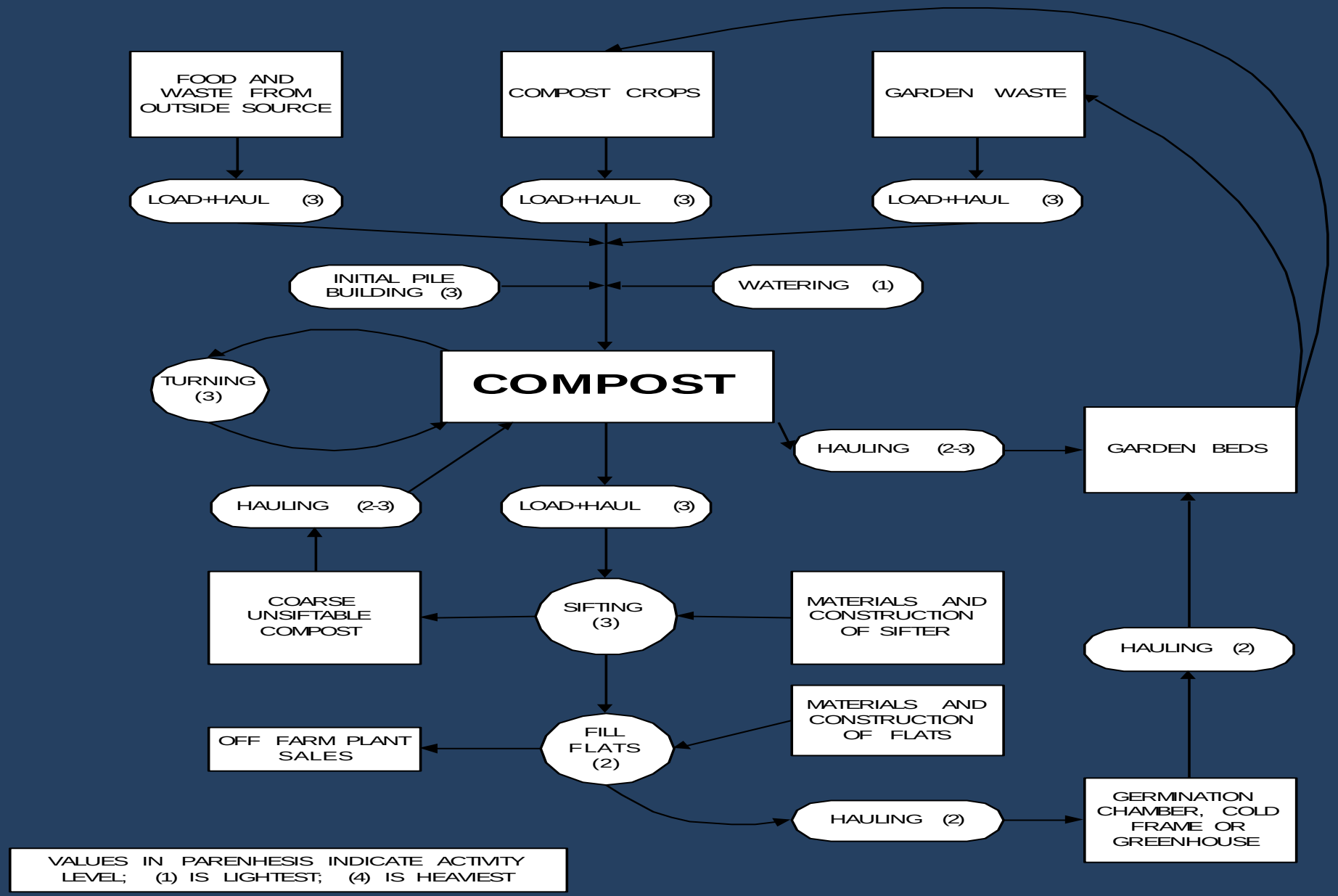
# Energy use (LCA)

- Embodied energy of numerous hand tools
- Calculating activity levels for various farm tasks
- Factor in climate, gender and workers age
- Calculate EER (energy efficiency ratio)

# ENERGY FLOW CHART



# COMPOST ENERGY FLOW CHART



# Determining Caloric Value of Labor

- Assign an activity level: 1-4
- Climate factor
- Weight and gender of worker
- Measure time required per task

| DAILY ACTIVITIES | VERY LIGHT WORK | LIGHT WORK | MODERATE WORK | HEAVY WORK |
|---|---|---|---|---|
| | seated and standing activities, driving a vehicle, sewing, computer work, laboratory work | walking on level ground 2.5-3 mph, golf electric trade, | walking 3.5-4 mph, scrubbing floors, tennis, dance | walking with a load, pick and shovel work, swimming |
| FARMING AND GARDENING ACTIVITY | Planting flats | Harvesting | U-baring (light) | U-baring (rapid or difficult) |
| | Planting Biointensive Beds | Hauling (light) | Hauling (heavy) | Double digging |
| | Watering | Weeding (light) | Hoeing | |
| | Broadcast seeding | Filling flats | Weeding (difficult) | |
| | | Raking (light) | Sything (grain, compst crops etc) | |
| | | Hoeing (light) | Sifting compost | |
| | | Mechanical seeding | Raking (heavy) | |
| | | Single dig (light) | Shoveling (light) | |
| | | Surface cultivate | Single dig (heavy) | |
| | | | | |
| | | | | |
| | | | | |

| WORKERS NAME examples | WEIGHT (LBS or KG) | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | VERY LIGHT WORK | LIGHT WORK | MODERATE WORK | HEAVY WORK |
| | | Cal/lb/hr: men .68, women .60 | Cal/lb/hr: men 1.32, women 1.17 | Cal/lb/hr: men 1.96, women 1.88 | Cal/lb/hr: men 3.81, women 3 |
| | | Cal/kg/hr: men 1.5, women 1.3 | Cal/kg/hr: men 2.9, women 2.6 | Cal/kg/hr: men 4.3, women 4.1 | Cal/kg/hr: men 8.4, women |
| | | wt(lbs or kg) x Cal/lb/h r= | wt(lbs or kg) x Cal/lb/hr = | wt(lbs or kg) x Cal/lb/hr = | wt(lbs or kg) x Cal/lb/hr = |
| *Steve (S)* | *190 lb* | *190 x .68 = 129 Cal/hr* | *190 x 1.96= 251Cal/hr* | *190 x 1.96 = 372 cal/hr.* | *190 x 3.81 = 729 Cal/hr* |
| *Carol/Elaine (E)* | *125 lb* | *125 x .60 = 75 Cal/hr* | *125 x 1.17 = 146 Cal/hr.* | *125 x 1.86 = 233 Cal/hr.* | *125 x 3.52 = 440 Cal/hr.* |
| *Sarah* | *70 lbs* | *70 x .60 = 42 Cal/hr.* | *70 x 1.17 = 82 Cal/hr.* | *70 x 1.86 = 130 Cal/hr.* | *70 x 3.52 = 246 Cal/hr.* |
| *Rose* | *45 lbs* | *45 x .60 = 27 Cal/hr.* | *45 x 1.17 = 53 Cal/hr.* | *45 x 1.86 = 84 Cal/hr.* | *45 x 3.52 = 158 Cal/hr.* |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| | B | C | D | E | I | G | H | I | N | O | P | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | STEEL | | | | WOOD | | | | | | | |
| Tools | Weight (Steel) lbs | (B) X 6,816 Cal / tool for Steel Produced*+ (B) X 912 Cal/tool steel manufacture and assembly* | useful life (years) | [(C) ÷ (D)] steel embodied energy per year (Calories) | Weight (wood) lbs | (F) X 1100 Cal./ tool for harvest and transport**+ (F) X 1320 Cal/tool for drying, working and assembly**Ply wood 1128 cal/lb | useful life (years) | [(G)÷(H)] wood embodied energy in calories per year | [(E)+(I)] TOTAL EMBODIED ENERGY PER TOOL (Calories /year) | Number of times a tool is used per bed /yr or farm/yr or# of beds | Total number of beds X (O) number of times the tool is used per bed/year= Cal/tool/ bed/year(365days) | (J)÷(K)= Calories per bed or hr. use per tool |
| Cart, big two wheel (2)(3) | 60.2 | 465226 | 30 | 15508 | 33.8(1) | 81796 | 15 | 5453.1 | 20961 | 1 hr/day | 1 hr/day | 57 cal/hr use |
| Cart , small two wheel (3) | 42.25 | 326508 | 30 | 10884 | 22 | 53240 | 15 | 3549.3 | 14433 | 0.25hr/day | 0.25hr/day | 40 cal/hr use |
| Cart, all metal (3) | 43 | 332304 | 30 | 11077 | 0 | 0 | | 0.0 | 11077 | 0.1hr/day | 0.1hr/day | 30 cal/hr use |
| Compost box 30"x30"x41"(3) | 0 | 0 | | 0 | 80.5 | 194810 | 30 | 6493.7 | 6494 | 15/yr | 433cal/box | 20.6 cal/cuft |
| Compost screen | 4.75 | 36708 | 25 | 1468 | 12.3 | 14,520 | 15 | 968.0 | 2436 | 15/yr | 229 cal/box | 10.7 cal/cuft |
| Compost screen rollers (two) | 8.5 | 65688 | 40 | 1642 | 0 | | | 0 | 1642 | 15/yr | 109 cal/box | 5 cal/cuft |
| Cultivator, 5 prong | 2.1 | 16229 | 40 | 406 | 1.1 | 2662 | 20 | 133.1 | 539 | 0.2hr/wk | 10 hrs/yr | 54 cal/hr use |
| Digging board (1) 2'x4'x5/8" | | | | | 16 | 18,040 | 10 | 1,805 | 1805 | 150 beds/y | 30%x500beds | 9.9 cal/use |
| Flat wood ave.deep and reg | | | | | 6 | 14,520 | 8 | 1,815 | 1815 | 10/ year | | 181 cal/use |
| Flat plastic 10x20 | | | | | | | | | | | | |
| Flat pan (aluminum) | | | | | | | | | | | | |
| Fork, digging (D handle) | 3.5 | 27048 | 25 | 1082 | 1 | 2420 | 10 | 242 | 4631 | 100 beds | 20%x500beds | 11cal/bed/yr |
| Hoe, stirrup(7") | 2 | 15456 | 10 | 1546 | 1.25 | 3025 | 10 | 302.5 | 1848 | 3hrs/wk | 156hrs/yr | 12 cal/hr use |
| Hoe, trapezoid (6.5") | 0.85 | 6569 | 5 | 1314 | 1.25 | 3025 | 10 | 302.5 | 1616 | 3hrs/wk | 156hrs/yr | 10 cal/hr use |
| Rake, garden steel | 1.75 | 13524 | 25 | 541 | 1.25 | 3025 | 10 | 302.5 | 843 | 3hrs/wk | 156hrs/yr | 5 cal/hr use |
| Seeder, 4 row | 2.6 | 20093 | 40 | 502 | 1.5 | 3630 | 20 | 181.5 | 684 | 0.25hrs/wk | 91 hrs/yr | 8 cal/hr use |
| Shears , harvest offset sheep | 0.6 | 4637 | 25 | 185 | 0 | 0 | 10 | 0 | 185 | 1 hr/wk | 52 hrs/yr | 4 cal/hr use |
| Shovel, pointed or flat | 2.5 | 19320 | 25 | 773 | 1.5 | 3630 | 10 | 363 | 1136 | 3hrs/wk | 156hrs/yr | 7 cal/hr use |
| Fork, 6 prong pitch | 2.5 | 19320 | 25 | 773 | 1.5 | 3630 | 10 | 363 | 1136 | 3hrs/wk | 156hrs/yr | 7 cal/hr use |
| Spade, square (D handle) | 3.5 | 27048 | 25 | 1082 | 1 | 2420 | 10 | 242 | 1324 | 100 beds | 20%x500beds | 13cal/bed/yr |
| Sythe, Kaman hand | 1.8 | 13910 | 25 | 556 | 0.25 | 605 | 10 | 60.5 | 617 | 50 beds | 10%x500beds | 12cal/bed/yr |
| U-Bar (30" W) [P.Johnson] | 35.5 | 274344 | 25 | 10974 | 0 | 0 | 20 | 0 | 10974 | 400 beds | 80%x500beds | 27 cal/bed |
| U-Bar (30" W) [J.Allen] | 26.3 | 202860 | 25 | 8114 | 0 | 0 | 20 | 0 | 8114 | 400 beds | 80%x500beds | 20 cal/bed |
| U-Bar (30"W)[S.Moore] | 49.5 | 382536 | 25 | 15301 | 0 | 0 | 20 | 0 | 15301 | 400 beds | 80%x500beds | 38 cal/bed |
| Wheelbarrow pipe handle(3) | 45.5 | 351624 | 30 | 11721 | 0 | 0 | 30 | 0 | 11721 | 1 hr/day | | 32 cal/hr use |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | (1) plywood (www.cdarchitect.com) (2) Innertube needs repairs (3) see capacity sheet for demensions | | | | | | | | | | | |
| | * Pimentel, David, "Energy Inputs in Production Agriculture", in Fluck, Richard C., Ed, Energy in Farm Prod | | | | | | | | | | | |
| | ** Personal Communication; David Pimentel, via e-mail 8/1/03 | | | | | | | | | | | |
| pg1 | Assumes no energy for maintenance and repairs and no salvage energy value at the end of life cycle | | | | | | | | | | | |

**CROP NAME / Variety** Onion

**DATE** 2003 **LOCATION** SNF and Harmony Essentials; PA,USA

**PRODUCTION (Energy Input)**

| LABOR ENERGY INDIVIDUAL TASK weight (lbs.) and sex (M or F) of laborer | TIME / BED (min.) | Activity/ cal/hr Level (1) | BxC cal /task/ individual /bed/yr | Climate Factor (2) | D x E CAL/BED /yr | COMMENTS |
|---|---|---|---|---|---|---|
| U-bar | 15 | 3-S; 372 | 93 | 1 | 93 | % of total energy use |
| Rake | 5 | 2-S; 251 | 20 | 1 | 20 | |
| Transplant | 70 | 2-E; 140 | 163 | 1 | 163 | |
| Hoe and weed (3x/year) | 20 | 2-S; 251 | 251 | 1 | 251 | 42% |
| Compost (load, haul, spread) | 10 | 2-S; 251 | 42 | 1 | 42 | |
| Seeding (seed flat) | 5 | 1-E; 72 | 6 | 1 | 6 | |
| Seedling care (3 trimings, | | 2-E; 140 | 58 | 1 | 58 | |
| daily watering, hardening) | | | | | | |
| 10 min/day, 150 days, | | | | | | |
| flats | | | | | | |
| Harvest pull onions, haul, cut | 30 | 2-E; 140 | 70 | 1 | 70 | |
| tops, 8 min/task/bed | | | | | | |
| | | | | | | |
| | | | | | | |
| TOTAL LABOR | | | | | 703 Cal. | |
| SOIL AMENDMENTS | CU FT/ BED | CAL/CU FT | CAL/BED | | | |
| Compost general | 4 | 65 | 260 | | | 16% |
| Other | Lbs/BED | CAL/LB | CAL/BED | | | |
| | | | | | | |
| | | | | | | |
| PEST control | amt/BED | CAL/amt | CAL/BED | | | |
| | | | | | | |
| | | | | | | |
| IRRIGATION | HRS/BED | CAL/HR | CAL/BED | | | |
| 5sets@5.6/set+10 hrs pumping @54 Cal/bed | | | 568 | | | 34% |
| SEEDS | Lbs/BED | CAL/Lbs | CAL/BED | | | |
| | | | | | | |
| EMBODIED TOOLS&EQUIP. | | | CAL/BED | | | |
| Shovel | | | 7 | | | 8% |
| U-bar | | | 20 | | | |
| Rake | | | 1 | | | |
| Hoe | | | 3 | | | |
| Big Cart | | | 10 | | | |
| Flat | | | 100 | | | |
| | | | | | | |
| | | | | | | |
| TOTAL | | | 141 | | | |
| ENERGY INPUT TOTAL (embodied + fuel + Labor) | | | | | 1672 | 100% |

**YIELD (Energy Output)**

| Lbs or kg /bed | Cal / lb | Cal / Bed | | |
|---|---|---|---|---|
| 459 High 380 ave. | 157 | 72,000 high 60,000 low | | |

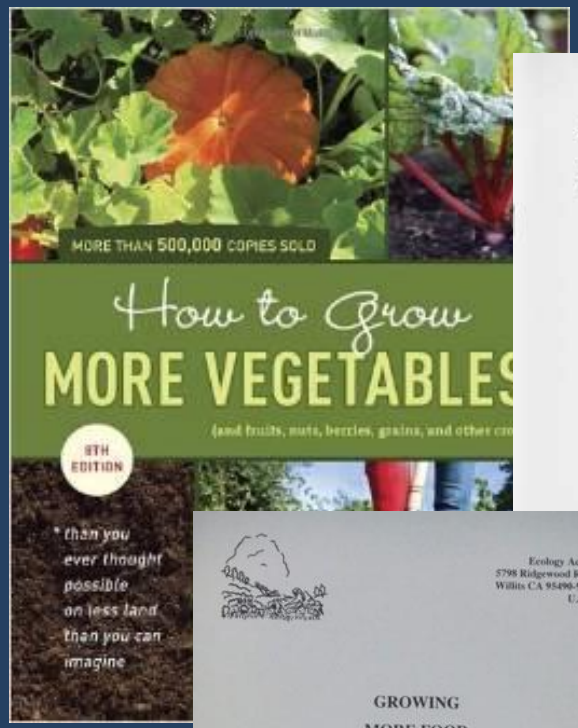
**ENERGY EFFICIENCY RATIO (Output / Input)** 43 high 36 ave.

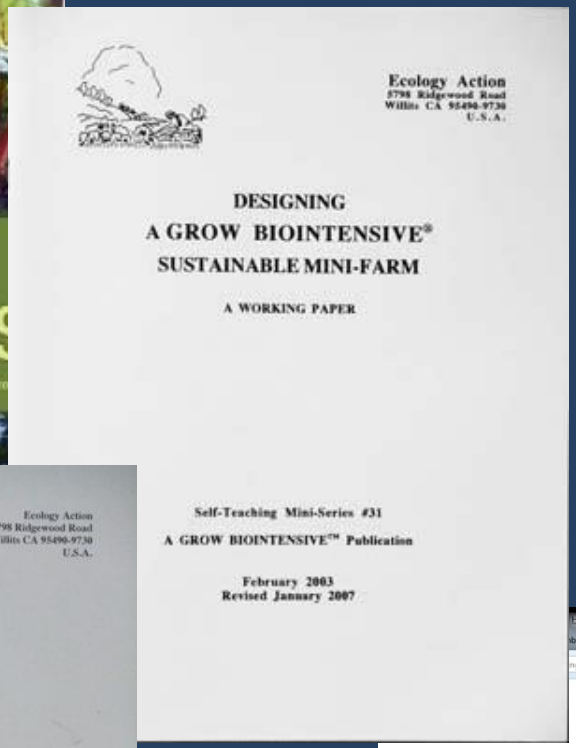
**US ave.** .9 **Relationship** 54 times (high) 45 times (low)

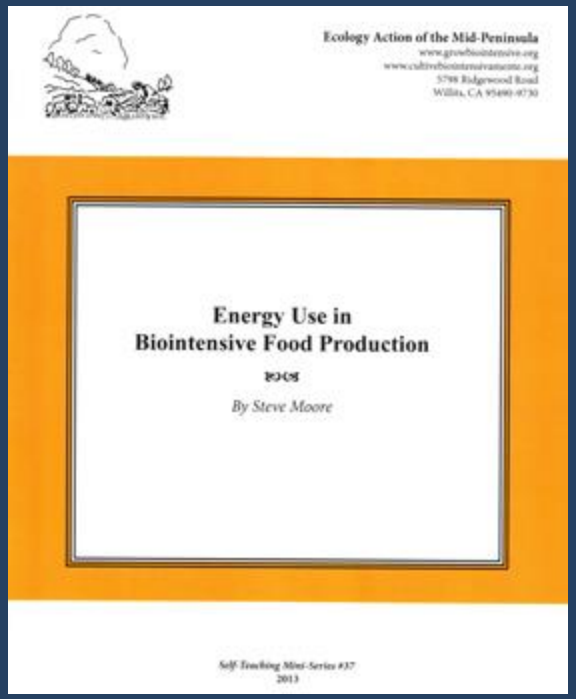
# Additional Benefits of BioIntensive/GrowBiointensive

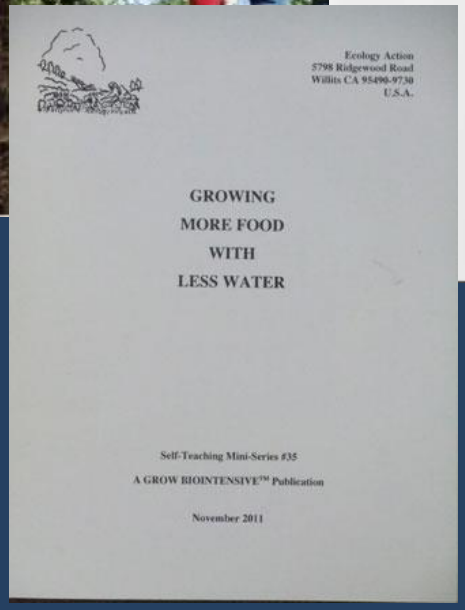
- SOM and Carbon sequestration
- Reducing GHG emissions from agriculture
- Urban farming needs
- Biodiversity enhancements
- Food sheds and food sovereignty
- Climate change adaptability
- Enable environmental and political refugees
- Plant breeding, genetic material diversity and seed ownership
- Economic options
- Social context (community based)
- Water infiltration and retention
- Accruing soil capital (building soil quality on a human time scale)
- Adaptable to farmer to farmer transfer of technology

# Sustainable Food Production Design Tools




# G-BIACK

## GROW BIOINTENSIVE AGRICULTURAL CENTER OF KENYA


FOOD SOVEREIGNTY PRIZE

# Global Utilization