

# Food Production Workshop: Greenhouses, Hydroponics & Aquaponics

Colorado  
State  
University

Extension



COLORADO  
AQUAPONICS

# Contact info:

**Brooke Edmunds, PhD**

Regional Specialist with CSU Extension

brooke.edmunds@colostate.edu

303/637-8016

**JD Sawyer**

Owner of Colorado Aquaponics

jd@coloradoaquaponics.com

(303) 246-3750

# Schedule for today

- Greenhouses
- Hydroponics
- Lunch (on your own)
- Aquaponics

Do you own a  
greenhouse?

Do you use  
hydroponics to grow  
food crops?

Do you have an  
aquaponics system?

Any commercial growers  
in the audience?

Any teachers or  
educators in the  
audience?





# Greenhouses for Colorado

# Please don't build this greenhouse!



Visqueen plastic  
PVC frame  
Sits on the ground  
Inexpensive, but....

# Why not?

- Snow
- Wind
- Intense sun
- Frost zone
  
- Best option:
  - Specifically designed solar greenhouses



# Solar Greenhouse Principals

1. Orientate to collect most solar heat
2. Store the heat
3. Insulate all other areas
4. Minimize heat loss to leaking
5. Maximize natural ventilation

Adapted from Solar Greenhouses, ATTRA publication #IP142

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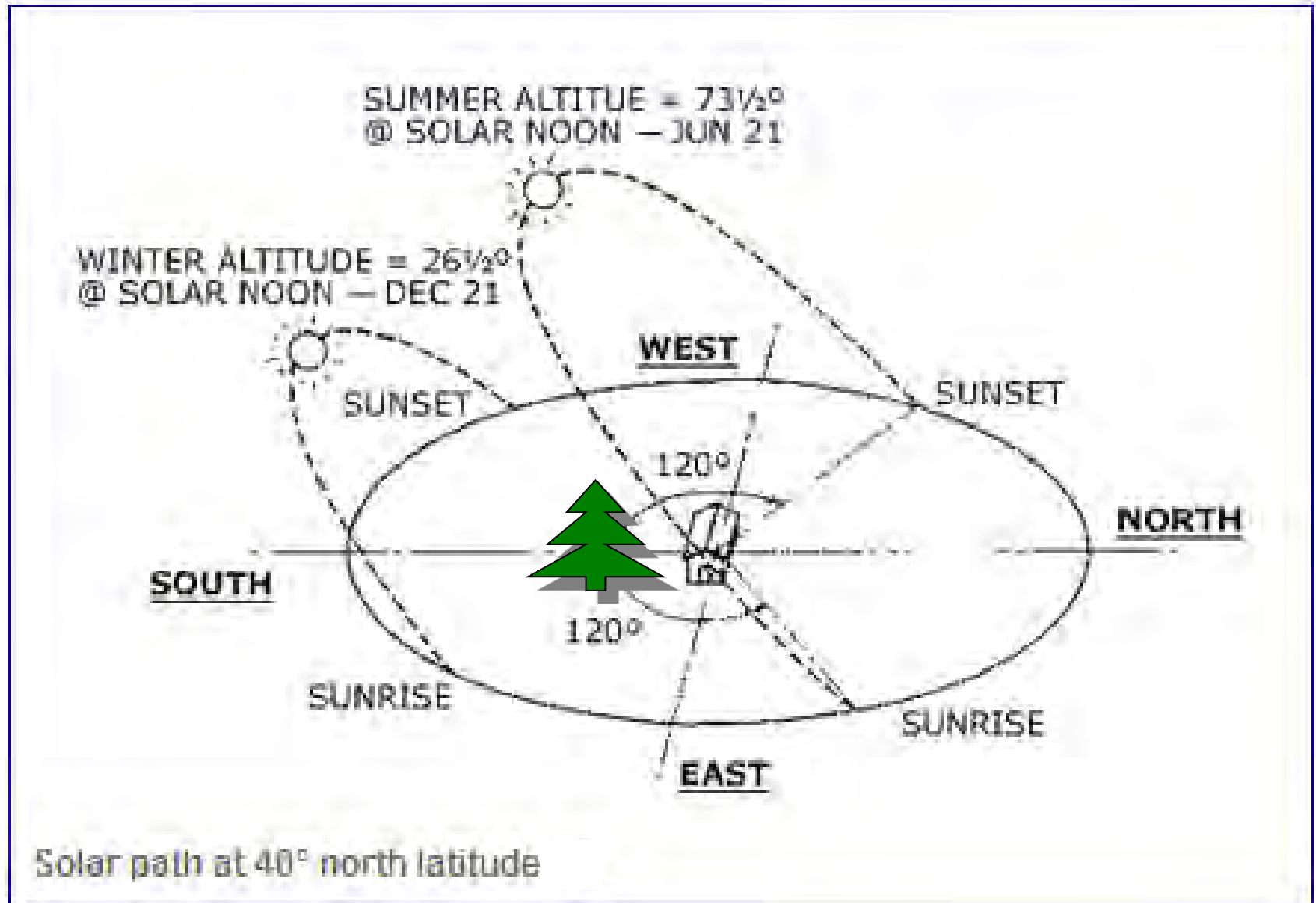
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# Light

- Know the sun's path in all seasons
- Why?
  - Consider winter shadows
- How?
  - Observation
  - Solar Pathfinder
  - Sun path chart
    - Available online
    - Many different formats
    - Same concept



# Know the sun's path in all seasons

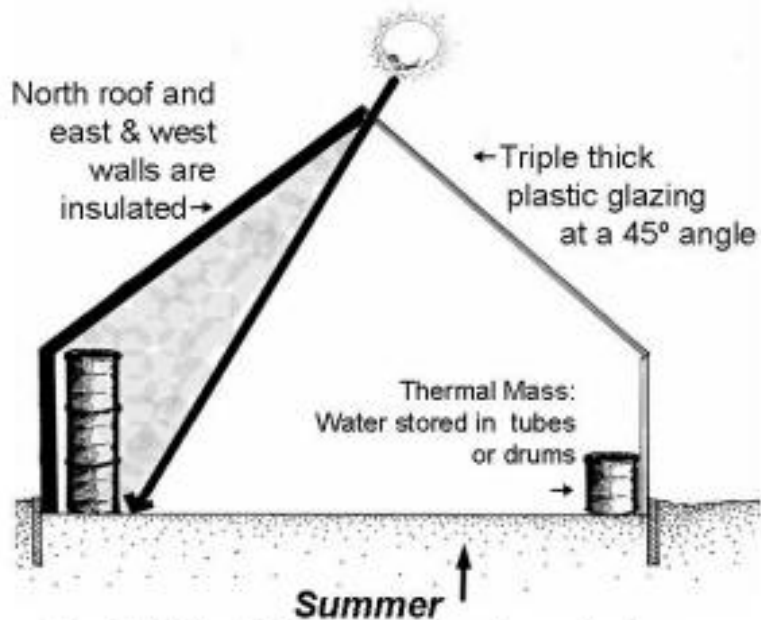




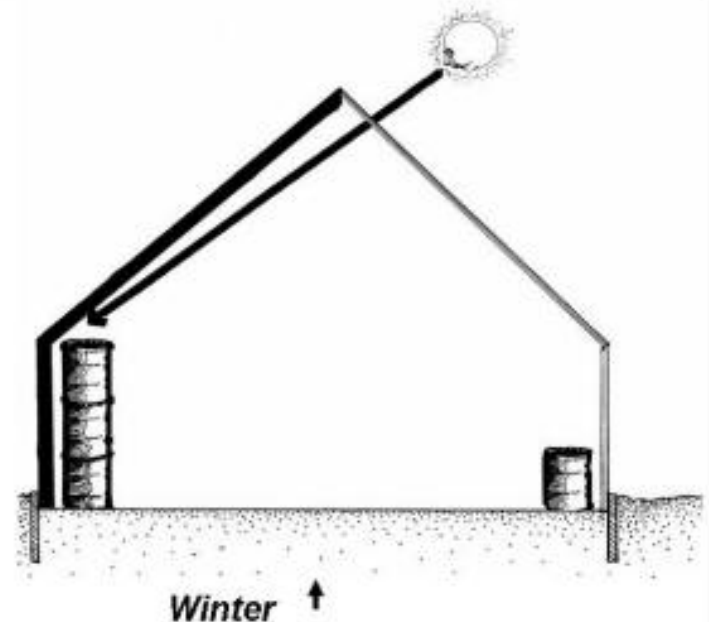
# Roof Angle

- 45° to 60° slope of the glazing
- Rule of thumb add 10° to 15° to latitude
- Longmont greenhouse:
  - 50-55° slope of south facing glazing

# Cheyenne Botanic Garden



Sun is higher in the sky and casts a shadow over the water-filled tubes and drums of the Botanic Gardens greenhouse helping to keep the greenhouse cool.



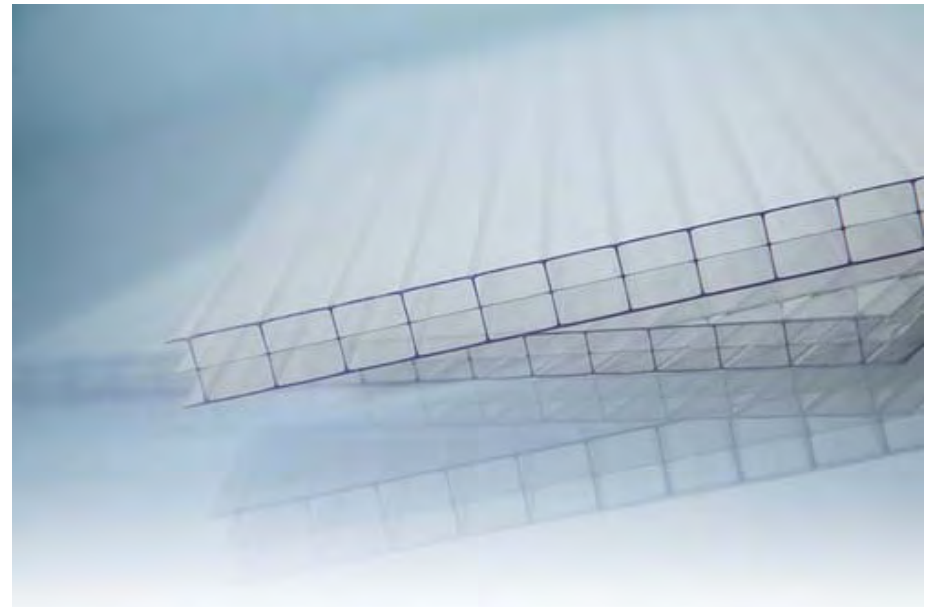
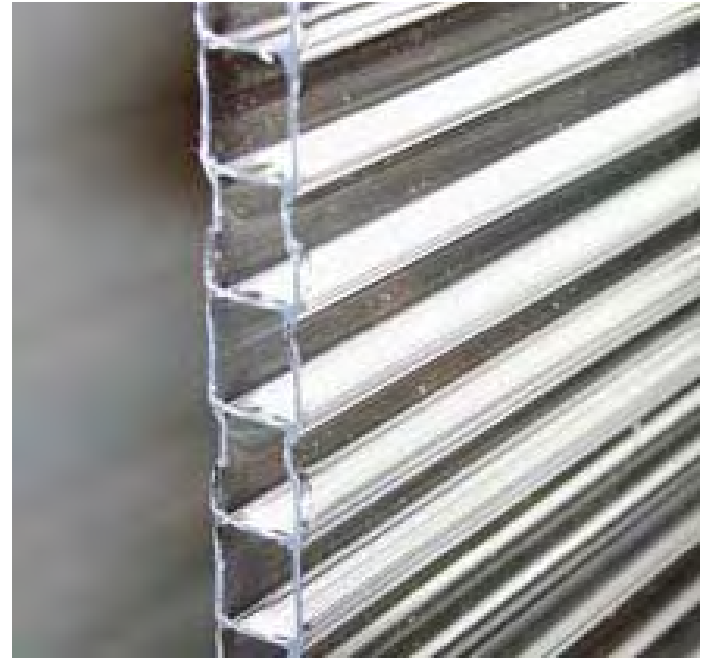
Sun is lower in the sky shining directly into the Botanic Gardens greenhouse directly illuminating and warming the water-filled tubes and drums. This helps keep the greenhouse warm.

# Glazing-which to choose?

- Glass (regular or tempered)
- Polyethylene sheeting (single or double layer)
- Acrylic
- Polycarbonate (single, double, triple wall)
- Fiberglass

# Polycarbonate

- Different thicknesses
- Double-wall
- Triple-wall
- Requires crating & freight shipping = \$\$\$



# Polyethylene Sheeting







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# Dark, non-reflective barrels



- Fill with water
- Milk jugs can also be used-more surface area
- 5 gallons per sq ft of glazing

# Water wall





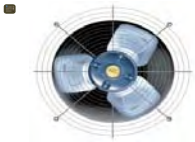
# Phase change materials?

- Disodium phosphate dodecahydrate
- Sodium thiosulfate pentahydrate
- Paraffin
- Glauber's salt (sodium sulphate decahydrate)
- Calcium chloride hexahydrate
- Fatty acids

# Rock wall

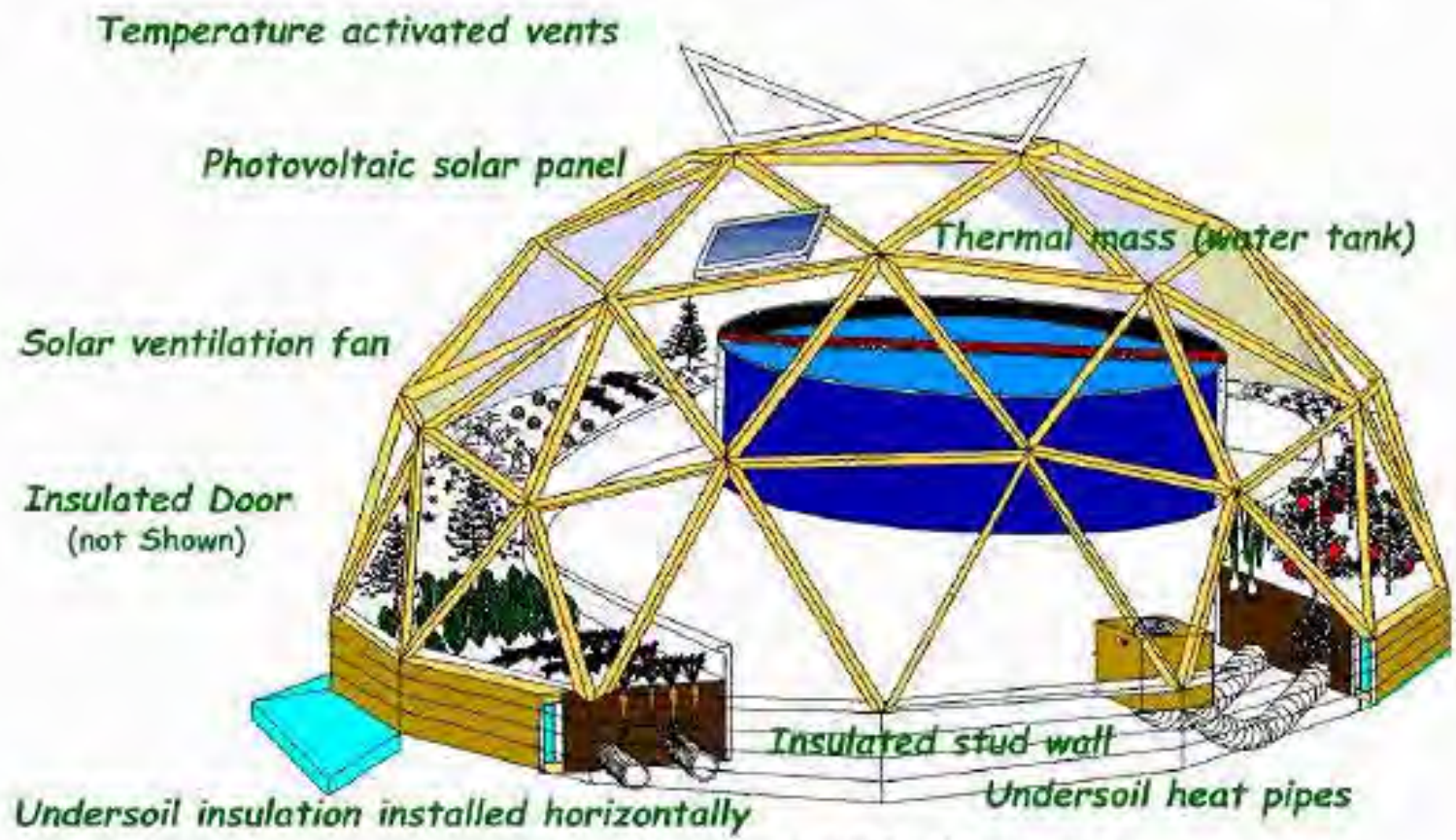
- 80-200 lbs per sq ft of glazing
- Low heat holding capacity than water

# Soil heat storage

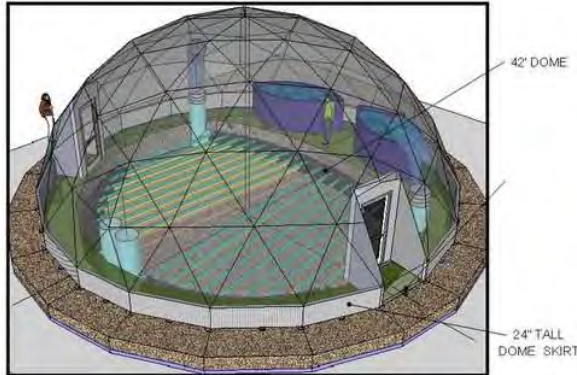




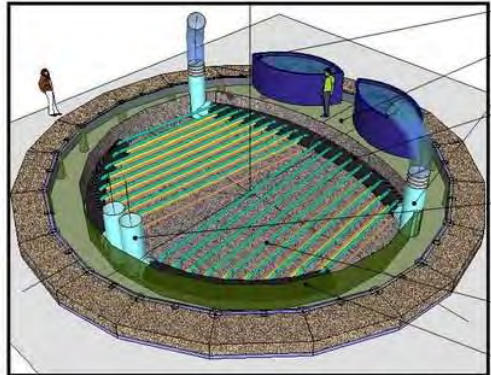
- Perforated ,  
corrugated  
polyethylene  
tubing  
(4" diameter)
- Hook up to  
fan and force  
warm air into  
soil
- Could also  
use water or  
phase change  
material







**Dome 3D**  
perspective (D)



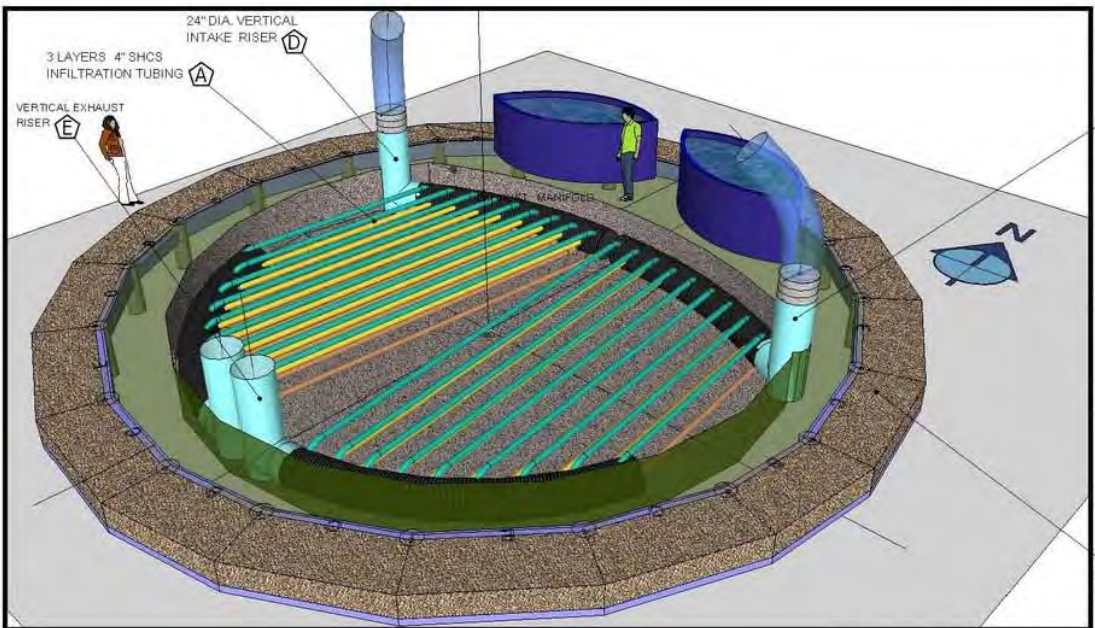
**Climate Battery Installed**  
perspective (C)

- WATER TANKS UNEXCAVATED UNDER TANKS
- 24" DIA. VERTICAL INTAKE RISER
- INTAKE MANIFOLDS 24" DIA. ADS FLEX CULVERT, 18' R, 15' LONG X 2
- 24" DIA. VERTICAL EXHAUST RISER
- FOUNDATION: 20 - 12" DIA. CONCRETE PIERS 36" DEEP, W/ 3 - #4 VERT. REBAR
- 4" ADS PERF. INFILTRATION TUBING
- EXHAUST MANIFOLDS 24" DIA. ADS FLEX CULVERT, 20' R, 17' LONG X 2



**C.B. Excavation**  
perspective (B)

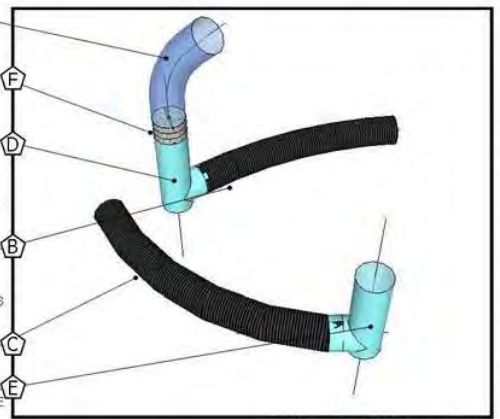
4" WIDE HORIZONTAL INSULATING BOARD - SEE SECTION C/GH-1



**Climate Battery 3D**  
perspective (A)

- 3 LAYERS 4" SHCS INFILTRATION TUBING (A)
- 24" DIA. VERTICAL INTAKE RISER (D)
- VERTICAL EXHAUST RISER (E)

- 24" DIA. ROUND DUCT EXTENSION (F)
- 24" DIA. DRUM FAN (F)
- 24" DIA. VERTICAL INTAKE RISER (D)
- INTAKE MANIFOLDS 24" DIA. ADS FLEX CULVERT, 18' R, 15' LONG X 2 (B)
- EXHAUST MANIFOLDS 24" DIA. ADS FLEX CULVERT, 20' R, 17' LONG X 2 (C)
- 24" DIA. EXHAUST RISER W/ TOP GRATE (E)



**Climate Battery**  
perspective (E)

GRAVEL BED 6" TH. OVER 3" DOW SM INSUL.BD. 4" W

For Component Specs, See GH-3



# Yampah Mtn H.S., 22' dome







# Roaring Fork H.S., 42' dome







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# Wall and Floor Insulation

- All non-glazed walls should be insulated
- Consider adding plastic film as vapor barrier
- 1-2" of foam on outside of foundation
- Strawbales?
  - Use with caution due to high moisture

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# Venting



- Very Important!
- Vent area= $\frac{1}{5}$  to  $\frac{1}{6}$  of floor area
- Manual or automatic
- Rely on wind?



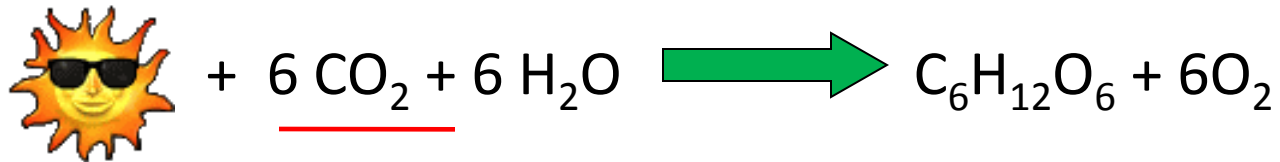
# Solar Powered Vent Openers

- ~\$60
- Set to open between 55-75F
- Wax cylinder contracts/expands
- Weight limits
- Freedom!



# Fresh Air Exchange

- Plants need carbon dioxide
- Especially in winter when greenhouse closed



# Other considerations

# Fertilizing options

## Organic

- Fish Emulsion
- Compost
- Guano
- Kelp
- Blood meal
- Molasses
- Yeast
- Etc.

## Non-organic

- Water soluble
  - Miracle Grow
  - Peters
- Controlled release
  - Osmocote
  - Sierra



# Soil testing

- Electrical conductivity (EC) and pH pens
  - EC measurement of soluble salts
    - K, Na, Cl, NO<sub>3</sub>, NH<sub>4</sub>
  - <\$160 for handheld combo meter
  - Calibration is important
- Full nutrient analysis
  - Send to lab for best analysis
  - CSU Soil, Water and Plant Testing Lab
  - Check “Alternative Soil Testing Laboratories” publication by ATTRA

# Irrigation water testing

- Check for EC, pH, hardness, salinity
- Send to testing lab
  - Colorado Analytical Labs, Ward, others
- At home kits

# Water Based on Need not Calendar

- What are the plants' irrigation needs?
- Depends on:
  - Evaporation
  - Frequency
  - Amount
  - Method of water application
  - Type of media
  - Plant cultivar
  - Environmental conditions

# Harmful Gases

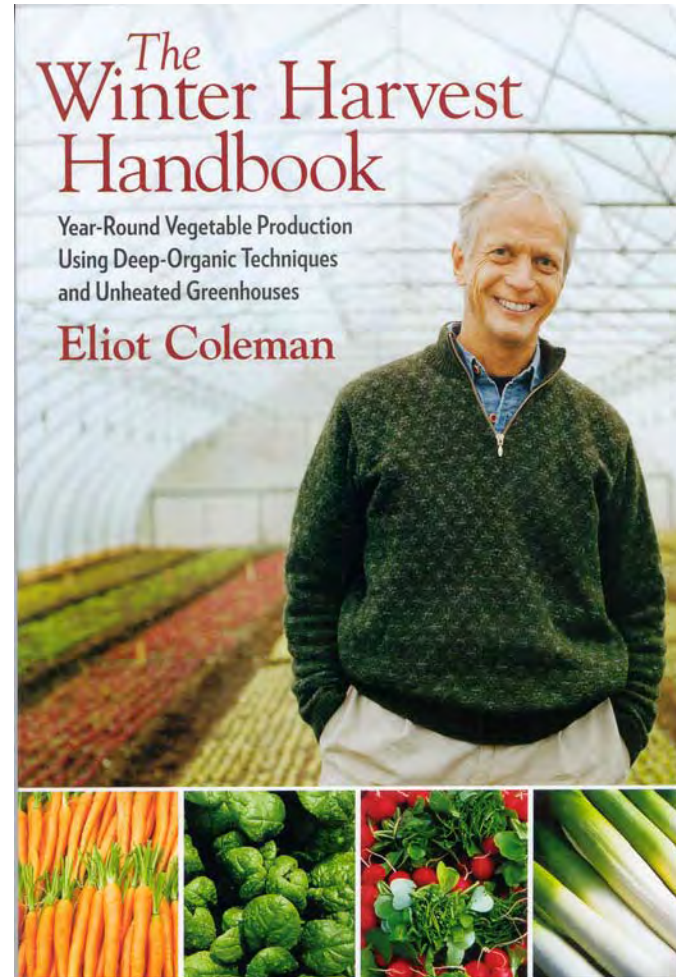
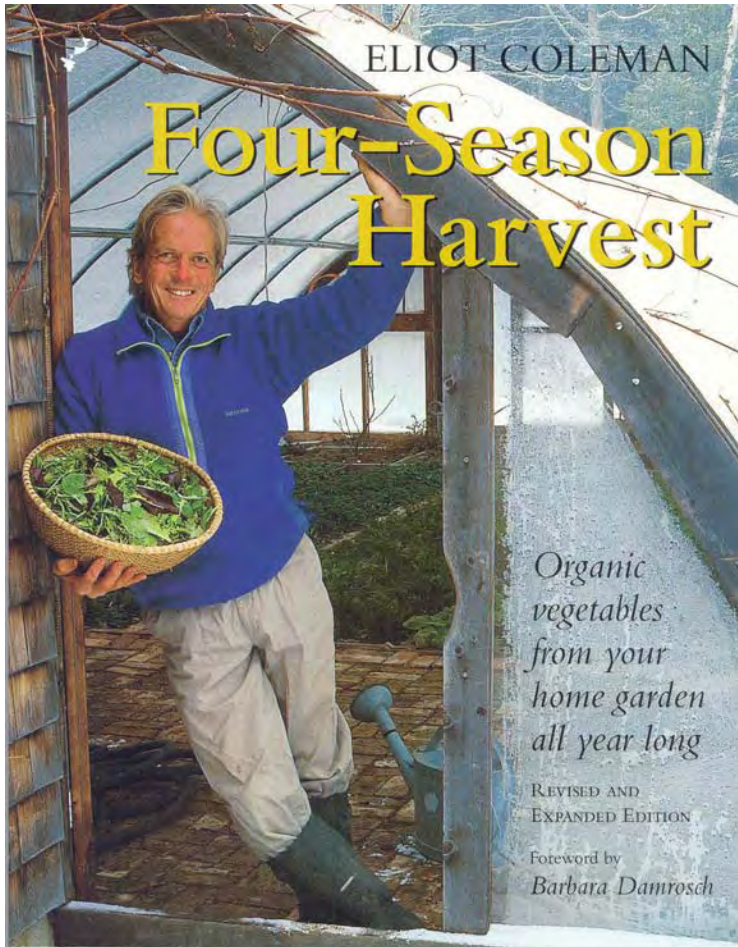
- Natural gas
  - Leaky heating system
  - Epinasty
- Ethylene
  - Reduced blooms
  - Epinasty



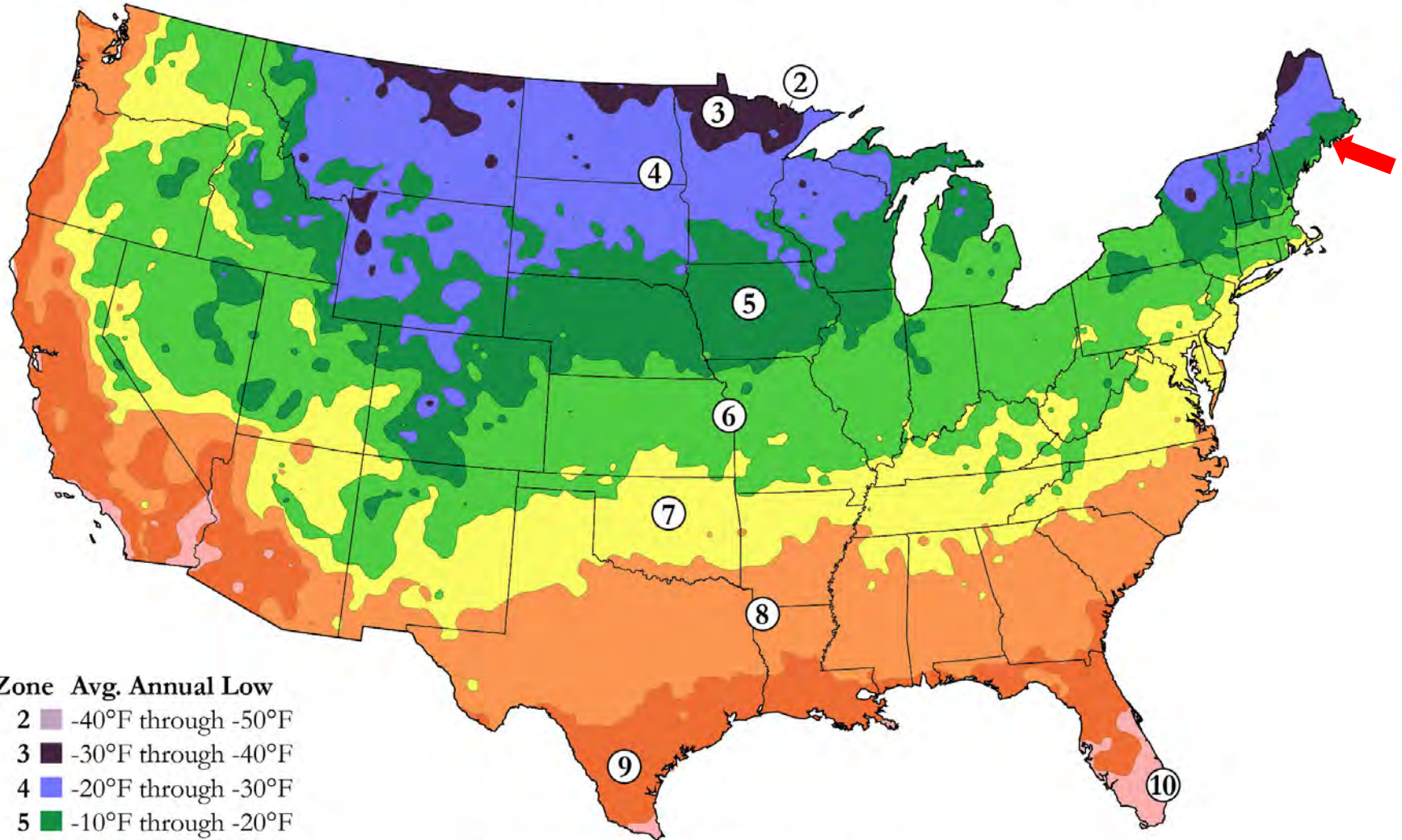
# Wood preservatives

- No treated wood in certified organic
- Direct toxicity (roots in contact)
- Gases given off
- Common preservatives
  - Pentachlorophenol
  - Creosote
- Can paint over with special paint B-I-N<sup>®</sup>

# Season extension resources



# 2006 arborday.org Hardiness Zones Map



Zone	Avg. Annual Low
2	-40°F through -50°F
3	-30°F through -40°F
4	-20°F through -30°F
5	-10°F through -20°F
6	0°F through -10°F
7	10°F through 0°F
8	20°F through 10°F
9	30°F through 20°F
10	40°F through 30°F

**Go to [arborday.org](http://arborday.org)  
to find the zone for your zip code.  
You can also find trees for planting in your zip code.**

# Row Covers



**Spun-bonded  
Fabric**



**Hoops**

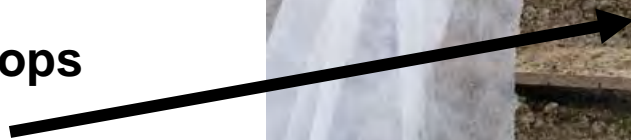






Photo: MN Institute for Sustainable Ag

# Planting Methods

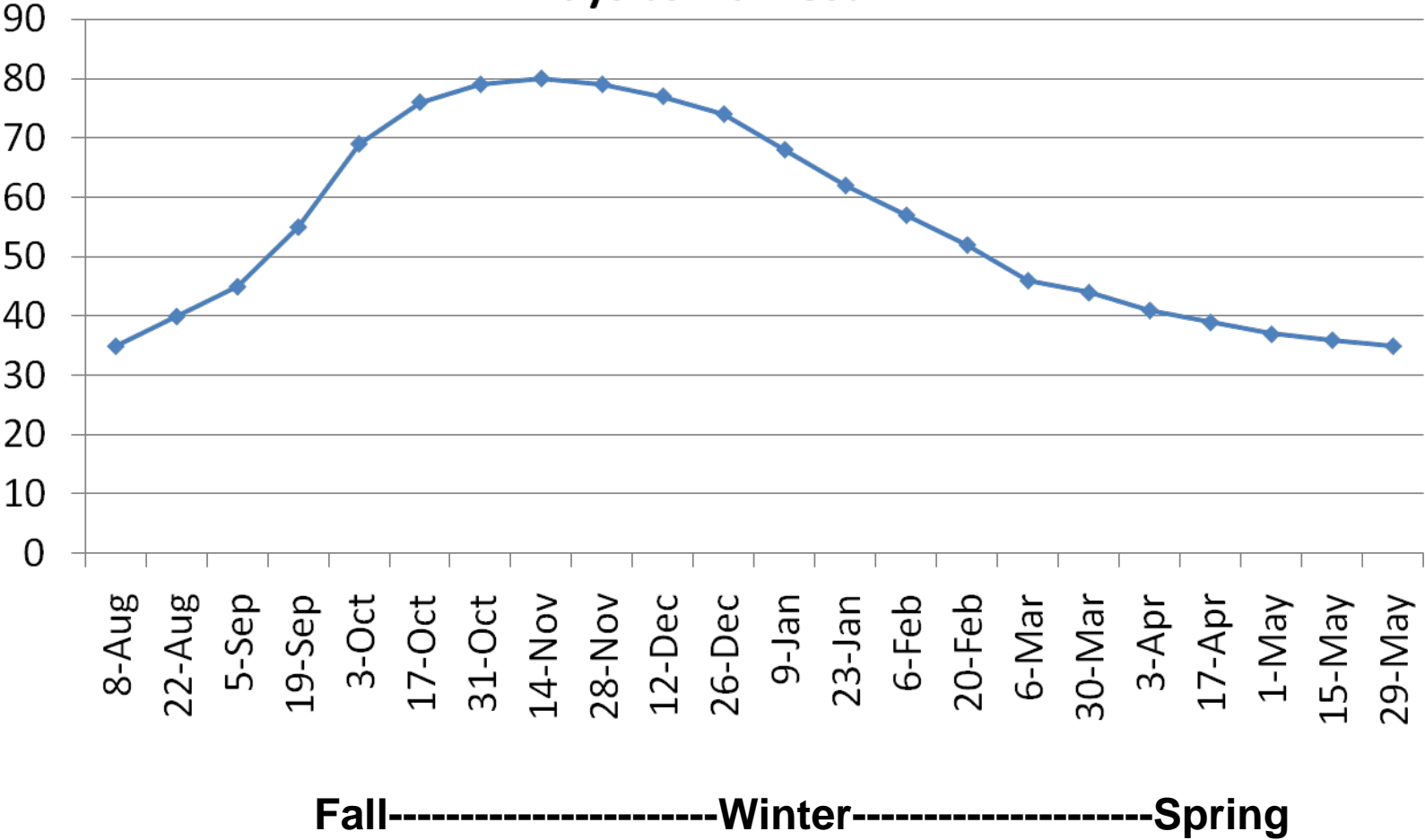
- Intercropping
- Succession planting
- Some plants can be harvested multiple times-  
Spinach, leaf lettuce, herbs
- Others only once-carrots, head lettuce, etc



# Planting Schedules

- Depends on light and temperature
  - Slowed growth in the winter
- Grower research will be required
- Resource: The Winter Harvest (Eliot Coleman)

# Days to Harvest



Adapted from The Winter Harvest Handbook, E. Coleman

# Greenhouse vs. Field Varieties

- Not all varieties perform as well in greenhouse conditions
- Personal research will be needed
- Talk to other growers & attend meetings
- List serve:  
<http://listserv.ksu.edu/web?A0=HIGHTUNNELS>

# Pollinating Concerns



# Hybrid, Heirloom, Open Pollinated?

- Hybrid/F1: specifically bred/crossed for certain traits, can't save seed
- Heirloom: Adapted over time to conditions where they have been grown, can save seed
- Open pollinated: May or may not be heirloom, can save seed but may not be true unless plant is isolated



# Vertical growing

- Saves space
- Need structure that can support weight

