

**DESIGN FOR CLIMATE CHANGE**  
**Presentation Outline**  
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**A. SUMMARY**

Comprehensive responses to climate change require the development of resilient biological and built systems (*human habitats*) that are adaptive in the face of shifting of climatic influences. This workshop highlights strategies for creating integrated building and landscape systems that can function in an age of climate extremes; longer droughts, hotter summers, colder winters, higher winds, increased pests, heavier precipitation events, and other patterns that have always tested humanity's ability to thrive in a place. Developing climate-responsive human habitats starts with a working understanding of four primary aspects of site settlement.

- I. Climate Challenges
- II. Site design
- III. Biological systems design
- IV. Built systems design

**I. Climate Challenges**

High performance landscapes and buildings are designed to meet the following results of Earth's changing climate. Many of these challenges are already occurring in the New England:

- Precipitation via disastrous forms (e.g. high volumes of rain, snow, hail)
- Increasing frequency and severity of freeze-thaw cycles
- Increasing likelihood of soil and roadway erosion
- Increasing infrastructure failure
- Increasing crop failure
- Increasing heating and cooling needs
- Increasing severity and probability of high wind events
- Increasing overall success of pests
- Decreasing influence of pollinators
- Increasing likelihood of drought conditions
- Increasing likelihood of annual crop failure due to spring flooding
- Increasing water demand
- Increasing extremes of aridity and humidity
- Decreasing water table heights

- Increasing sea levels
- Increasing probability of early flowering and fruit-set, and consequent crop failure from frost damage
- Increasing failure of perennial crops due to reduced snowpack on the ground surface
- Increased penetration of frost

## **B. STRATEGIES & PRINCIPLES**

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Neither predominant agricultural models nor common housing and transportation systems are designed to withstand significant climate changes. These human systems will either adapt to changing conditions, or suffer increasing system failure. Land developments that intentionally adapt to these changes employ the following components:

1. **Buffered siting and microclimate development** including windbreaks, snow-retaining hedgerows, thermal mass via water and stone, and sun-trapping vegetated and/or built arcs. These systems provide a buffer against regional climatic stresses by *localizing climate at the site level*.
2. **High biodiversity and connectivity** of species from neighboring warmer and colder climate zones (U.S.D.A. hardiness zones +/- 2 zones). Such polycultural diversity supports the resilience of the land system at the species level, and the adaptability of crop genetics at the varietal level. This genetic complexity helps revive the loss of crop diversity caused by monoculture in the 20<sup>th</sup> century while adding to the abundance of foods to choose from and enhancing our prospects for survival and good living.
3. **Passive, low-input built systems** that can heat, cool, water and electrify themselves more self-sufficiently, withstand heavier snow and wind loads, deeper-penetrating frost and other challenging conditions posed by severe weather patterns.

### **Working Definitions**

*Climate*: Weather patterns over time: general pattern of temperature, moisture, sunshine and wind in a specific area.

*Microclimate*: A discrete area within a larger area of differing climate. Microclimates usually occur close to the surface of a material, commonly earth, a building façade or vegetation. They occur in a nested manner at all scales and over various periods of *time*.

*Climate Change (as opposed to global warming)*: More rapid changes in global and local climates entailing increased severity of weather patterns, not simply a general warming.

## **II. Site Design**

Selection of the site and the design of its climate and structure form the basis of the site's ecosystem and its habitability for humans and other community members.

### **Site Selection – Step 1**

Some landscape features cannot be changed at all or only to a small extent. These usually include: *relative location to surrounding landscape (elevation, distance from water bodies and mountains, etc.), aspect, slope, general hydrology, bedrock exposure, etc.* Only at the

*site selection stage can these primary features be considered and selected for and against.* Site selection is the first and most influential decision to be made in developing your human habitat.

#### STRATEGIES:

- Develop closer to population centers
- Develop closer to mobility (waterways, roads, paths)
- Choose low to mid slope sites
- Avoid steep sites and steep long road accesses
- Choose multiple-aspect (multiple climate) sites
- Dig soil pits – locate water table and ID soils
- ID micro-topography of the site
- Rehab a landscape
- Allow for gravity-fed water distribution

#### PRINCIPLES:

Select a site to harness optimal:

- **Regional influences** (wind, temperature, moisture)
  - Large lake/river valley buffering
  - Mountain wind funneling, katabatic/anabatic winds
  - Mountain rain shadow or upslope effect
- **Solar-aspects**
  - All day sun and shade choices: Multiple aspects with a generally south-facing exposure is ideal
- **Slope(s)**
  - Air movement and all season energy capture and distribution: varied slopes are optimal
  - Consistent slopes avoiding frost pocket depressions in a slope are important
- **Elevational relationships**
  - Above valley frost bottom, below cold slopes
- **Hydrology**
  - Stable water supply and varied water tables: some clay content is optimal, below large slopes/aquifers is optimal
- **Existing windbreaks and exposure**
  - The basis of wind buffering: berms/mounds/vegetation

*EXAMPLE: A south-facing hillside that has some east and west facing slopes within it. The site would slope from 1 to 10% with large areas at 3-8% grade. The site would be 200-600 ft above the valley bottom, (valley size and region of the state dependent). The site would have a mix of soil types, depth to water table and depth to bedrock. The site would have year-round surface water and have significant amounts of land upslope (e.g. be on the side of a large hill versus on its own small knoll, unless springs are present). The site would be within the buffering reach of Lake Champlain or the CT River Valley.*

#### **Site Design – Step 2**

Once a site has been chosen a handful of strategies, planned for and implemented carefully, can optimize the existing climate characteristics of the site to more fully meet the

needs of the site's inhabitants.

**STRATEGIES:**

Make ponds, swales and mounds (hold water and vary soil moisture)  
Store water high in the land  
Diversify site microclimates by planting and berming east to west  
Build structures to enhance wind protection and solar surfaces  
Secure steep slopes, increased erosion control especially on roads  
Assure low angle paths and roads  
Assure more significant drainage/stormwater measures  
Grow wildlife –provide movement corridors and cover  
Plant windbreaks and hedgerows  
Plant and promote edge

**PRINCIPLES:**

- Capture and store solar energy utilizing:
  - Angled surfaces (vs. horizontal planes)
  - Bowls/arcs = sun traps*
  - High mass: stone and water = primary storage materials*
- Minimize radiative losses – cover
- Buffer winds
- Hold snow in the landscape
- High absorption (low albedo)
  - Color
  - Texture
- Timing
- Diversity site climates

**EXAMPLE:** See Figure 1

**Examples of intentional microclimates in “nature”**

Termite mounds  
Beehives  
Burrows  
Animal nests  
Plant leaves, animal and plant growth forms

**Microclimate creating landscape features**

Hills – fields – trees/forests – cliffs – boulders – gullies – ridges – depressions – ridges – slopes  
– streams/drainages - groundwater – ponds – lakes – roads – buildings – lawns – roofs –  
courtyards - stonewalls

**III. Biological Systems Design**

The resiliency and health of a site is largely determined by the diversity of the site's biological elements and by the number ways in which these elements are connected and interact. Biological systems adaptive to changing climates are intentional and resilient ecosystems

that offer numerous yields for human sustenance along with ecosystem services.

#### **STRATEGIES:**

Plant for 2 zones warmer and 1 zone colder

Reference neighboring climates and climate-analogues

Mulch more

Encourage edge by thinning the thick and planting the thin

Establish drip irrigation

\*\*\*Build organic matter\*\*\* (prime climate change reduction strategy)

Encourage mycelium

Keep bees, plant flowers, encourage pollinators

Plant across roots, fruits, shoots, leaves

Plant across wet loving and dry (corn to potatoes)

Perennials with varied bearing and flowering times

Animals with varied hardiness characteristics

Grow wildlife – plant calorie-rich foods like bush and tree nuts, clovers

#### **PRINCIPLES:**

*Diversity + connectivity = resiliency*

#### **DIVERSITY**

- Genetics
  - Many crops
  - New crops
  - Cold hardy crops
  - Warm hardy crops
- Function
  - Food values
  - Medicinal values
  - Ecosystem values
    - i. Soil
    - ii. Wildlife
    - iii. Nectary/pollination
- Flowering, fruiting and harvest time
- Hardiness
  - soil type
  - moisture levels: drought/inundation
  - cold/heat
  - pest
  - wind
  - snow
- Growth rate and form
- Lifespan

#### **CONNECTIVITY/COORDINATION**

- Guilds/Mutualism
  - enhanced fertility

- decreased pests
- resource partitioning
  - i. sun
  - ii. soil horizon
- harvest timing
- Community-based, community-driven and connected

#### **IV. Built Systems Design (structural, heating/cooling, electric)**

*“My favorite axe is 40 years old – I’ve replaced the handle a dozen times and the head twice.”*

- Unknown

Choosing technical systems which transform the least amount of raw material and energy into the most value of service (e.g. building material into habitable space, insulation into R-value, fuel into mileage, etc) while being as simple and durable as possible is fundamental to an adaptive and sustaining built environment. Technical systems inspired by living systems in which built elements respond to their contextual conditions like an organism (e.g. a building cooling itself passively when temperatures reach a certain point) is an ideal goal, however built systems have not yet been able to self organize like living systems and transcend the dominance of entropy, always tending toward decay and disintegration over time. Consequently, the best technical systems developed combine ease of use with durability and beauty so that active human participation is facilitated. History shows that most durable technical systems are not monuments but functioning systems that people can manage easily and depend on for their daily needs.

#### **STRATEGIES:**

##### **Buildings**

Integrate within the site for optimal performance of all functions

Super-insulated envelope and weather detailing

Steep roofs

Heavier framing systems (snow, ice and wind)

Passive solar

Connect to site's gravity-fed water system

Employ rainwater catchment

Composed of local materials and methods

Thermal storage/high mass construction methods

More pest-resistant detailing

Increased summer shading

More durable materials and methods

Increased frost-heave prevention measures

More accessible

More breathable wall systems and greater moisture control

More self-sufficient in heat and electrical/other inputs

More daylight

## Fuel/Heat/Electric Systems

More locally-sourced materials  
Produce more on site (e.g. fuel wood hedge)  
Lower loads  
Backup and diversify power and heat sources  
Use multi-fuel technologies

### PRINCIPLES:

Simplicity - Passivity - Durability - Fix-ability/maintainability - Legibility/Accessibility - Efficiency  
- Connectivity – Beauty

1. Small
2. Durable
3. Simple
4. Solar
5. Dynamic
6. People-oriented, hand-made, community-vested
7. Compelling

## B. RESOURCES

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### WRITTEN

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Taylor, John S. *A Shelter Sketchbook: Timeless Building Solutions*. White River Junction, Vermont: Chelsea Green Publishing Co., 1983.

Theodoropoulos, David I. *Invasion Biology: Critique of a Pseudoscience*. Blythe, California: Avvar Books, 2003.

#### **SERVICES**

Northeast Organic Farming Association of Vermont (NOFA VT)  
[www.nofavt.org](http://www.nofavt.org)

Sustainable by Design – sun position and path information  
[www.susdesign.com](http://www.susdesign.com)

Whole Systems Design  
[www.wholesystemsdesign.com](http://www.wholesystemsdesign.com)

Yestermorrow Design-Build School  
[www.yestermorrow.org](http://www.yestermorrow.org)

#### **VIDEO**

Aquaculture: The Synergy of Land and Water, Dir. Heidi Snel and Malcolm St. Julian Bown, Crystal Lake Video, 2002.

Ecological Design: Inventing the Future, Dir. Chris Zelov; Brian Dantz; Phil Cousineau, Knossus Publishing, 1994.

#### **SITES AND PLANT SUPPLIERS**

Carbon Farmers of America  
[www.carbonfarmersofamerica.com/](http://www.carbonfarmersofamerica.com/)

Elmore Roots Nursery  
Wolcott, Vermont  
1-800-42-PLANT  
[www.elmoreroots.com/](http://www.elmoreroots.com/)

Oikos Tree Crops  
Kalamazoo, Michigan  
(269) 624-6233  
[www.oikostreecrops.com/](http://www.oikostreecrops.com/)

St. Lawrence Nursery  
Potsdam, NY  
(315) 265-6739  
[www.sln.potsdam.ny.us/](http://www.sln.potsdam.ny.us/)

Teal Farm  
[www.tealfarm.com](http://www.tealfarm.com)

**Check out the 3-day intensive at Yestermorrow for a more in-depth look at  
designing for climate change: March 19-21, 2008**  
*[www.yestermorrow.org/courses/wbc/climate.htm](http://www.yestermorrow.org/courses/wbc/climate.htm)*

**SAVE THE PETROLEUM!**

*“It’s far too valuable to burn.”*

-Dmitri Mendeleev upon isolating the structure of crude oil

Petroleum is perhaps the most valuable liquid on Earth, aside from water, that humans have ever utilized. Presently we have a unique but waning opportunity to apply this exceptional material to our most pressing challenges before it becomes too expensive or scarce to use. The remaining petroleum resource can be used flagrantly or it can be employed the development of systems that support humanity for life beyond petroleum. Future prospects for humanity will largely be determined by the degree to which petroleum is used to develop sustaining infrastructure, food, mobility and fuel systems that can function without it. To do this we must leverage the remaining petroleum resource for its highest, most valuable, and least destructive applications. Such uses tend to be in developing materials rather than for energy harvesting. The table below shows some of the most valuable applications of petroleum for developing sustainable food and shelter systems. A small number of these are for highly useful energy applications while the majority are for material uses. Petroleum has thousands of incomparable applications; this is not an exhaustive list.

FORM	APPLICATION
<p><b>1. Plastic</b></p> <ul style="list-style-type: none"> <li>a. Sheeting/membranes</li> <li>b. Piping/hose/water containment</li> <li>c. Medical and Safety equipment</li> <li>d. Netting</li> <li>e. Spray foam</li> </ul>	<p>Greenhouses (microclimate creation)                      Distributing water</p> <p>Crop support and protection                      Insulation/air infiltration detailing</p>
<p><b>2. Synthetic rubbers</b></p> <ul style="list-style-type: none"> <li>a. Membranes</li> <li>b. Waterproofing liners</li> </ul>	<p>Living roofs, irrigation ponds</p>
<p><b>3. Nylon/Polyester/Textiles</b></p> <ul style="list-style-type: none"> <li>a. Cordage/rope/line</li> <li>b. Clothing fabric</li> <li>c. Filter/landscape fabric</li> <li>d. Row cover</li> </ul>	<p>Safety, emergency, rigging, gardening                      Cold and wet weather clothes                      Erosion control, soil holding, weed suppression, cold weather and pest protection</p>
<p><b>4. Powders/mixtures</b></p> <ul style="list-style-type: none"> <li>a. Water holding soil amendments (hydrophilic gel)</li> </ul>	<p>Dry-lands reclamation through plantings</p>
<p><b>5. Lubricants</b></p> <ul style="list-style-type: none"> <li>a. oils</li> </ul>	<p>In extreme situations (such as intense cold where plant-oils are not sufficient)</p>
<p><b>6. Fuel</b></p> <ul style="list-style-type: none"> <li>a. Prescribed burning</li> <li>b. Excavation</li> <li>c. Emergency heat/lighting</li> </ul>	<p>Forest management                      Earthworks for water and soil                      Refugee villages, in natural disasters/                      displaced populations</p>

Design reference compiled and updated by Whole Systems Design, LLC

