Design for Climate Change

Presentation Outline

NOFA VT, February 16 & 17, 2008
Ben Falk, Whole Systems Design, LLC
www.wholesystemsdesign.com

CONTENTS:

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

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 adapts 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 20th 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 daylit

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

WRITTEN

Alexander, Christopher. *A Pattern Language: Towns, Buildings, Construction*. New York: Oxford University Press, 1977.

Berge, Bjorn. *The Ecology of Building Materials*. Oxford: Architectural Press, 2000.

Chiras, Daniel D. *The Natural House: A Complete Guide to Healthy, Energy-efficient, Environmental Homes.* White River Junction, Vermont: Chelsea Green Publishing Co., 2000

Diamond, Jared. *Collapse: How Societies Choose to Fail or Succeed*.
New York: Penguin Group, 2005.

Falk, Ben. *Climates Change: Design for It*. The Natural Farmer. Winter Issue, 2007/2008.

Jacke, David and Toensmier, Eric. *Edible Forest Gardens*. Chelsea Green, 2005.

Mann, Charles C. *1491*. New York: Alfred A. Knopf a division of Random House, Inc, 2005.

Mollison, Bill. *Permaculture, A Designer's Manual*. Tyalgum, Australia: Tagari Publications, 1988.

Potts, Michael. *The New Independent Home: People and Houses that Harvest the Sun*. White River Junction, Vermont: Chelsea Green Publishing Co., 1993.

Seidl, Amy. *Early Spring: Waking to a Warming World*. Beacon Press. to be printed – 2008)

Smith, J. Russell. *Tree Crops: A Permanent Agriculture*. Old Greenwich, Connecticut: The Devin-Adair Company, 1950.

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

Sustainable by Design – sun position and path information
www.susdesign.com

Whole Systems Design
www.wholesystemsdesign.com

Yestermorrow Design-Build School
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/

Elmore Roots Nursery
Wolcott, Vermont
1-800-42-PLANT
www.elmoreroots.com/

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

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

Teal Farm
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

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
1. Plastic a. Sheeting/membranes b. Piping/hose/water containment c. Medical and Safety equipment d. Netting e. Spray foam	Greenhouses (microclimate creation) Distributing water Crop support and protection Insulation/air infiltration detailing
2. Synthetic rubbers a. Membranes b. Waterproofing liners	Living roofs, irrigation ponds
3. Nylon/Polyester/Textiles a. Cordage/rope/line b. Clothing fabric c. Filter/landscape fabric d. Row cover	Safety, emergency, rigging, gardening Cold and wet weather clothes Erosion control, soil holding, weed suppression, cold weather and pest protection
4. Powders/mixtures a. Water holding soil amendments (hydrophilic gel)	Dry-lands reclamation through plantings
5. Lubricants a. oils	In extreme situations (such as intense cold where plant-oils are not sufficient)
6. Fuel a. Prescribed burning b. Excavation c. Emergency heat/lighting	Forest management Earthworks for water and soil Refugee villages, in natural disasters/ displaced populations

Design reference compiled and updated by Whole Systems Design, LLC

Whole Systems Design, LLC
Whole Human Habitats