Climate Change: Dealing with Potential Impacts on Ecosystem Restoration

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John F. Henz: “my roots”

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- AMS Boards
- CCM (BCCM)
- Board of Economic Enterprise Development (BEED)
Three words:

- Change
- Dynamic
- Connected
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Climate Change in the News

TIME
The Global Warming Survival Guide

Newsweek
The New Greening of America

BusinessWeek
Global Warming

New York

Vanity Fair
Special Green Issue

Sports Illustrated
As the Planet Changes, So Do the Games We Play

The Economist
The Heat is On

Crisis
Is Global Warming a Myth?

The New Yorker

Sports Illustrated
INSIDE THE STERIOD PIPELINE STING

George Clooney

Sports Illustrated

The heat is on

Sports Illustrated

Sports Illustrated

Sports Illustrated

Sports Illustrated
Change – climate science is always changing

- 1970’s: Little Ice Age very likely by 2000. Running out of oil; shift to solar and nuclear.


- 1990’s: Hydro-climate indices developed to reflect PDO, ENSO, NAO, AMO and related to water resource/climate fluctuations.

- 2000’s: Global warming, IPCC and GCM modeling
Navigation from Bora Bora to Hawaii

A change in perspective was needed.
Dynamic – stationary climate is dead

- Selecting a random or preferred 20–30 years of data won’t reflect the dynamic aspect of climate.

- Need to define climate impact on the distribution of your observations.

- Consider the impact on your projected project: are you entering a 5–15 year period of record that may favor either above or below average values.

- Can use this projection to assist in planning your project.

Stationarity Is Dead: Whither Water Management?
Navigation to future planning

A change in perspective is needed

Static Climatology

Dynamic Climatology

JAMES A. MICHENE HAWAII
Three words:

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Hydro-climate indices provide pulse on ocean-atmosphere

SST ANOM 10/12/03-10/18/03
Base Period: 1982-96
How hydro-climate indices can reflect a pattern = shift balance
Significant basin differences exist in determining seasonal snow/precipitation relationship to hydro-climate indices.

La Nina

PDO, NAO, MEI

El Nino

La Nina

PDO, NAO, MEI

El Nino

PDO, NAO, MEI

La Nina

PDO, NAO, MEI

El Nino

PDO, NAO, MEI
Montana: Flathead River Basin

Flathead Lake Catchment Basin
Source: Montana NRIS
(Maps composed by J. Cooner)

Flathead Lake on a summer day
Major Rivers draining into Flathead Lake Basin dependant on winter snow-pack and spring rains.

Summer Recreation Industry $100 Million – lake level crucial.

Hydro-Power Generation at Kerr and Horse Thief Dams – draws down lake levels = power gen.

COE maintains a flood control pool for spring runoff floods.

Additional concern is minimum in-stream flow for endangered fish.
### PCEP
Physical Cause–Effect Partitioning:
Normal vs. El Nino vs.
La Nina Basin Precipitation

<table>
<thead>
<tr>
<th>Regime</th>
<th>Oct-Dec Inches (+/- avg.)</th>
<th>Oct-Mar Inches (+/- avg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>La Nina = Wet</td>
<td>6.82” (+1.49”)</td>
<td>12.59” (+2.29”)</td>
</tr>
<tr>
<td>Normal</td>
<td>5.33”</td>
<td>10.33”</td>
</tr>
<tr>
<td>El Nino = Dry</td>
<td>4.85” (-0.48”)</td>
<td>8.52” (-1.81”)</td>
</tr>
<tr>
<td>Driest 10 yrs = drought</td>
<td>3.25” (-2.08”)</td>
<td>6.21” (-4.12”)</td>
</tr>
</tbody>
</table>
Wet (La Nina) vs. Dry (El Nino)

No April/May Heat Wave = "No Runoff gusher"

13 rain/snow events and much colder

April Heat Wave = "Runoff gusher"

8 rain/snow events
Compare Average Runoff Hydrographs (average flow periods and peaks)

Wettest Years (15 total) vs. Dry Years (14 total) for Naturalized Flow into Flathead Lake (1929-2004)

Years when flood pool is needed

Years when inflow is minimal

Average Flow

Date

Daily Average Flow (CFS)

0 20000 40000 60000 80000 100000 120000 140000

Comparison of FPRI Early April Forecast vs. Verified Naturalized April-September Flow for 1951-2003

$R^2 = 0.83$

Precipitation data used was from Sno-Tel in the snowpack.
Three words:

- Change
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- Connected
Connected means ....

- Physical cause–effect relationship exists.
- Relationship creates “non–random” measurable distribution.
- Weakens uses of Monte Carlo statistical approach.
- Strengthens use of physically partitioned data sets.

HUH?
Eco-System Impacts – a few

- **Temperature**: air, water, soil, surface, time of day and year. **Relative humidity**.
- **Precipitation**: form, amount, intensity, timing, season, spatial coverage, volume.
- **Stream flow**: volume, intensity, peaks, timing, quality, soil moisture, source.
- **Wind**: transport, direction and speed, timing.
- **Water Quality**: chemical, purity, source.
- **Cloud cover**: amount, impact on radiation, variation.
Working on EIS/EIR team on Bay Delta in CA - climate change task leader
Seal Level Rise

- Connects to salinity and water quality
- Connects to fish species, agriculture and water supply
- Connects to flood hazard changes
We need to change our perspectives

Climate is always changing

Urban heat island
Local Warming/Urban Heat Island in California
Projected growth and potential ecosystem “connections”

The sprawling region: Projected increase in population densities on private land, 2000-2050

The sprawling region: Exurban and rural land threatened by development

Urban Heat Islands

- Local temperature, relative humidity, soil moisture and wind fields.
- Can re-direct spatial precipitation patterns.
- Energy and water usage patterns are skewed by very hot/very cold and very wet/very dry patterns.
- Water quality and surface pollution runoff can impact local watersheds.
- Climate changes directed influence distributions of these relationships.
Very bright areas suggest UHI areas likely spreading
Climate “cone of uncertainty”

Cone of climate uncertainty, Waage, 2009
IPCC AR4 Multi-model ensemble or “spaghetti” diagram
Natural Variability fills more of the cone – do you see a trend?

**MULTIVARIATE ENSO INDEX**

Cross-references:
- NOAA/ESRL/Physical Science Division - University of Colorado at Boulder/CIRES/CDC
Is there a trend? An increase of +0.18 in 58 yrs.
Cyclo-progressive trend: very apparent
What if the cycle repeats but is adjusted by both the observed trend and GCM predicted warming?

Nothing repeats in nature but cycles are powerful scenarios to consider.
Climate modeling uncertainty reduced by using Natural Variability Cause/Effect Trend/Cycle

Refined cone of climate uncertainty,
Henz, 2009

Global Climate Model Scenarios

Natural Variability
Trend/Cycle analyses
Our climate change tool box

- Analyze the cause–effect relationships between climate variability and perceptible parameter changes.

- Examine paleo–climate information for long term variability.

- Use Global Circulation Models (GCM) to assist with possible scenarios.
Intelligent Phased Adaptation of Design to Climate Change

- Initial design to 25-yr climate change impact.
- At 20-yr point, re-assess climate design impacts to 50-yr impact.
- At 40-yr point, re-assess climate design impacts to 100-yr impact.
Update design data base.
Consider HCI trends.
Adapt IPA design

- Paleo–trend analyses
- Natural variability (NV) trend analyses
- Consider GCM

GCM scenarios
Down–scaled statistical or dynamical
NV trend analyses

0–30 years | 30–50 years | 50–100 years

Planned life cycle of infra–structure
Three words:

- **Change**: use of “stationary climate” is over. Use longest period of record available and look at regional records. Climate science is evolving. Stay in touch.

- **Dynamic**: consider climate change and impacts on your eco-system. Odds are they exist! Define them quantitatively.

- **Connected**: you are working where the climate meets the earth and society = “the most exciting place to be”.
"Climate is what you expect; weather is what you get"

– Robert A. Heinlein

www.hdrweather.com – check it out!

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