



The Value of Urban Forestry under Extreme Uncertainty

Paul R. Brown, AICP, M.ASCE
Visiting Professor and Director of Applied Research

**It's better to know nothing
than to know what ain't so.**

Where We Began



Cities of the Future

Towards integrated sustainable water and landscape management

Edited by Vladimir Novotny and Paul Brown



While there is a desire among communities, stakeholders, and agencies to make urban areas and their water resources ecologically sustainable, there is no consensus regarding the definition of sustainability or how to achieve urban aquatic ecosystem integrity. Addressing these problems begins with understanding the complexity of ecologically-sustainable urban communities, their connection to water, and their ecological and hydrological resilience or vulnerability to extreme adverse stresses.

Blue Water in Green Cities is an interdisciplinary workshop of worldwide experts convened to develop visionary concepts related to this issue of ecological sustainability. With urban waters as a focal point, this workshop will explore links between urban water quality and hydrology, landscape, the concepts of green cities and smart growth, legal and social barriers and the issue of sustainability during extreme hydrological events.

For more information regarding the challenges and vision driving the development of this workshop, [click here to download the latest conference summary](#) document.



Northeastern
UNIVERSITY

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National Science Foundation
ADVANCING SCIENCE, EDUCATION AND SOCIETY

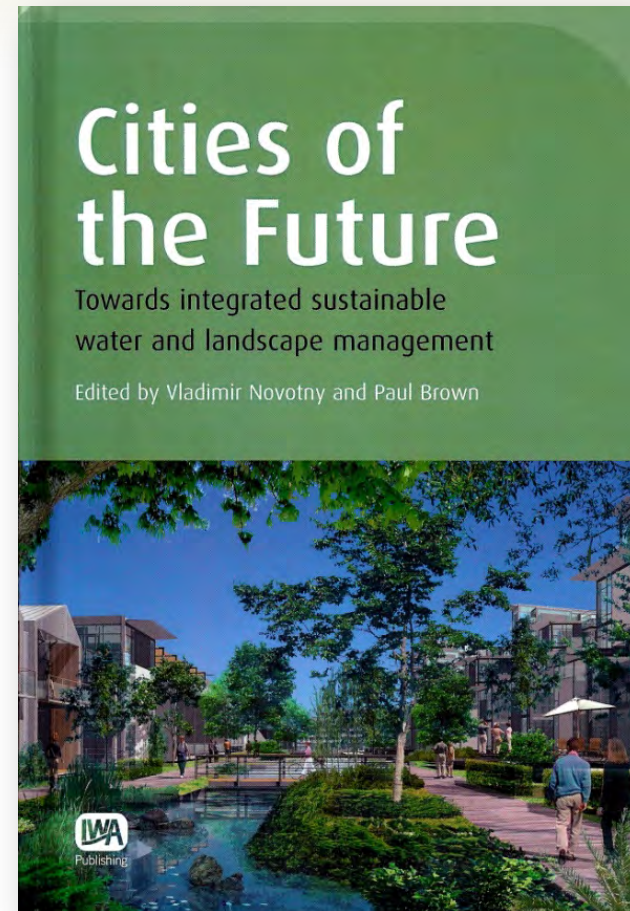
THE JOHNSON FOUNDATION

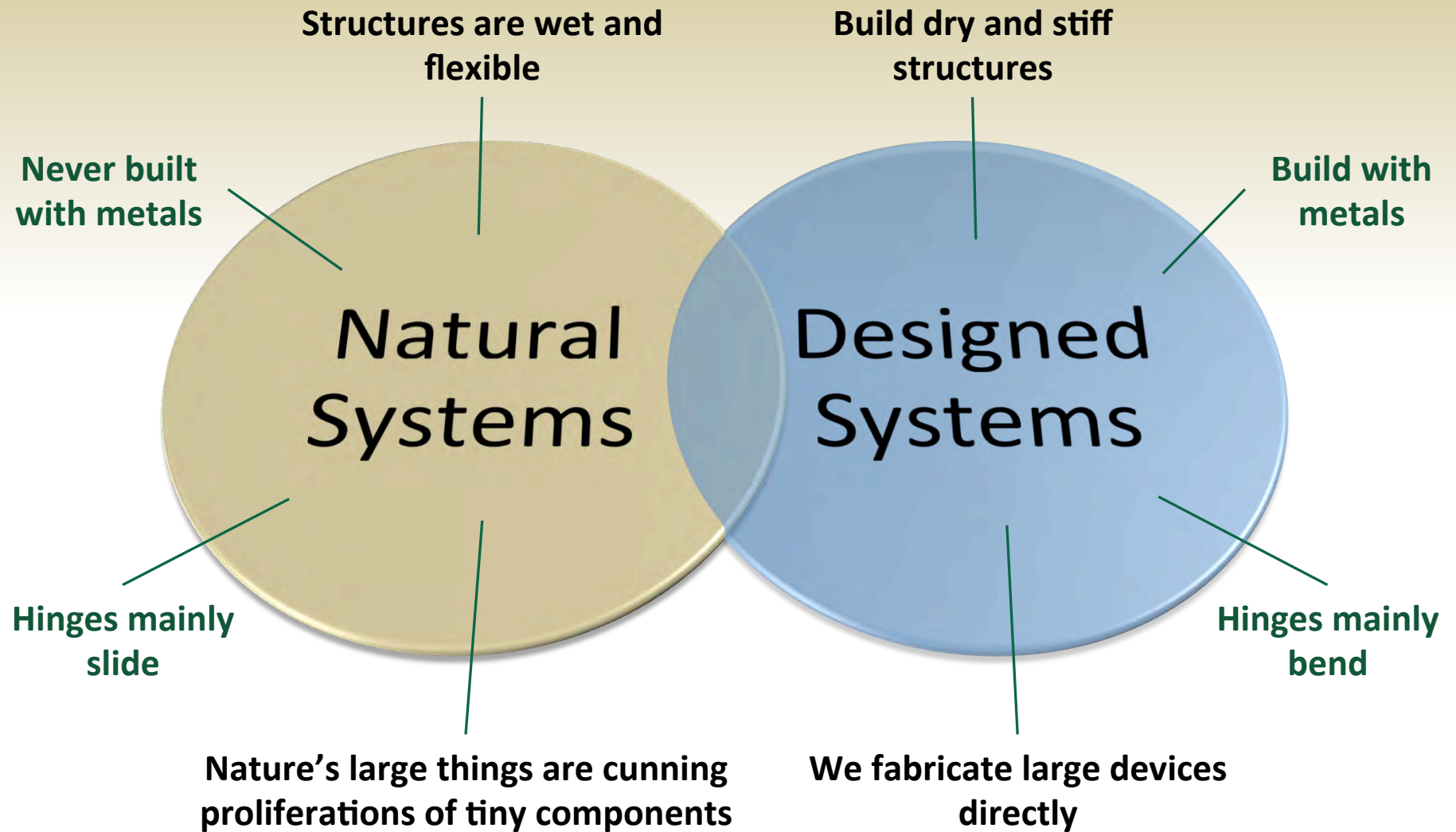
IWA
Publishing

[Instructions](#) | [Logistics and Schedule](#) | [Invited Participants](#) | [Deliverables](#) | [Organizers](#) | [Sponsors](#) | [Contact Us](#)

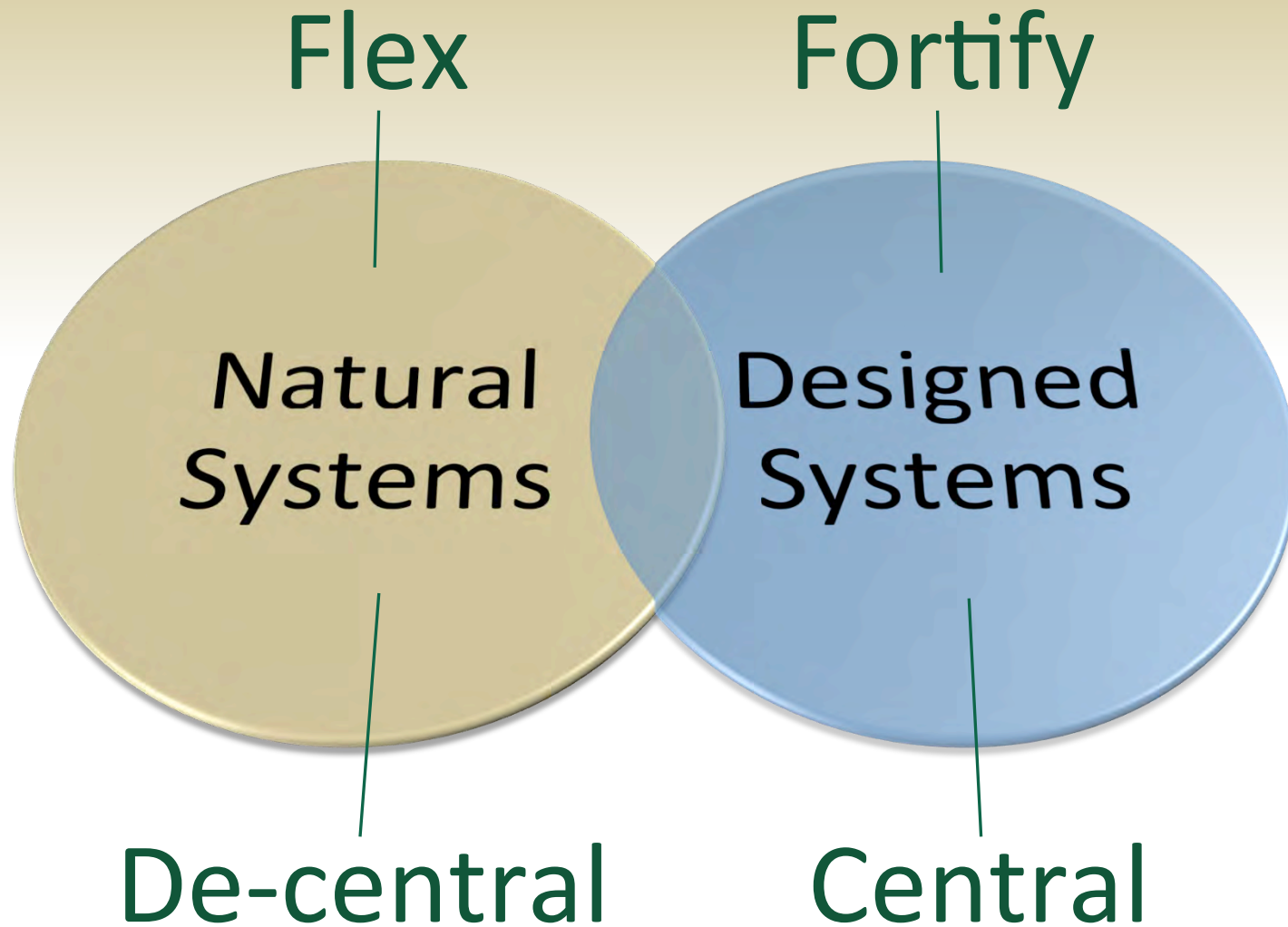
Novotny's Fifth Paradigm

- Systems approach to the urban watershed
- Water supply, stormwater, and wastewater – to One Water
- Urban landscape designed to function like natural systems
 - Reduced imperviousness and increased infiltration
 - Surface storage and use of plants/trees to store water
 - Less reliance on underground, fast-conveyance conduits





Steven Vogel, Cats' Paws and Catapults: Mechanical Worlds of Nature and People



Steven Vogel, Cats' Paws and Catapults: Mechanical Worlds of Nature and People

Stationarity is Dead

“In view of the magnitude and ubiquity of the hydroclimatic change apparently now under way . . . we assert that stationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning.”

Source: P.C.D. Milly et al. “Stationarity is Dead: Wither Water Management.” Science, 319, February 2008.

Point #1: Our New Reality is Extreme Complexity and Extreme Uncertainty



U.S. Drought Monitor California

September 19, 2006
(Released Thursday, Sep. 21, 2006)
Valid 7 a.m. EST



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	84.97	15.03	0.82	0.00	0.00	0.00
Last Week 9/12/2006	84.97	15.03	2.62	0.13	0.00	0.00
3 Months Ago 6/20/2006	92.46	7.54	0.07	0.00	0.00	0.00
Start of Calendar Year 1/3/2006	98.32	1.68	0.00	0.00	0.00	0.00
Start of Water Year 9/27/2005	99.58	0.42	0.00	0.00	0.00	0.00
One Year Ago 9/20/2005	99.41	0.59	0.05	0.00	0.00	0.00

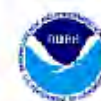
Intensity:

 D0 Abnormally Dry	 D3 Extreme Drought
 D1 Moderate Drought	 D4 Exceptional Drought
 D2 Severe Drought	

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:

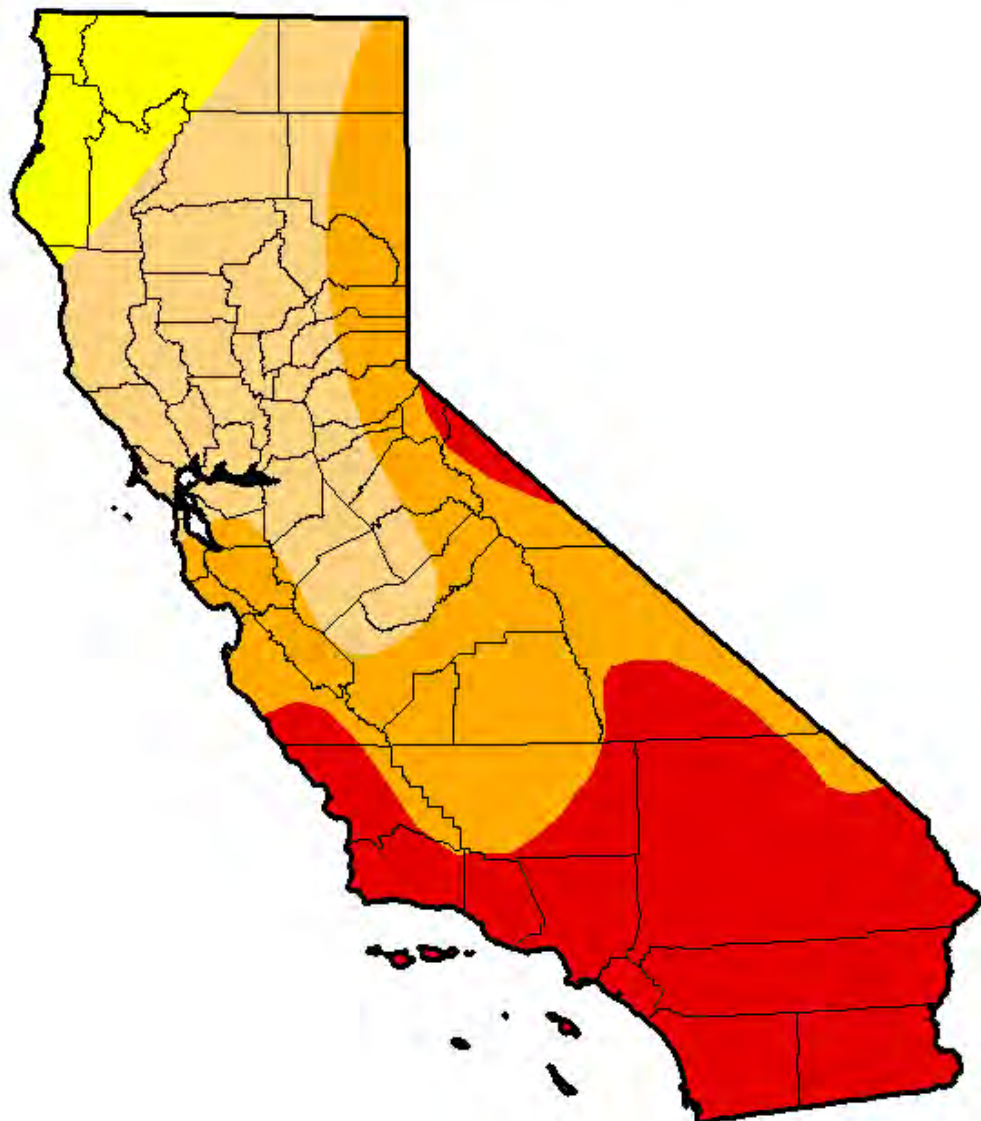
Ned Guttman
NOAA/NESDIS/NCDC



<http://droughtmonitor.unl.edu/>

U.S. Drought Monitor California

September 18, 2007
(Released Thursday, Sep. 20, 2007)
Valid 7 a.m. EST



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	92.56	65.34	35.23	0.00
Last Week 9/11/2007	0.00	100.00	92.56	65.34	35.22	0.00
3 Months Ago 6/19/2007	0.00	100.00	92.32	65.34	34.31	0.00
Start of Calendar Year 1/2/2007	40.73	59.27	26.77	0.00	0.00	0.00
Start of Water Year 9/26/2006	84.97	15.03	0.82	0.00	0.00	0.00
One Year Ago 9/19/2006	84.97	15.03	0.82	0.00	0.00	0.00

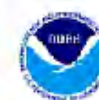
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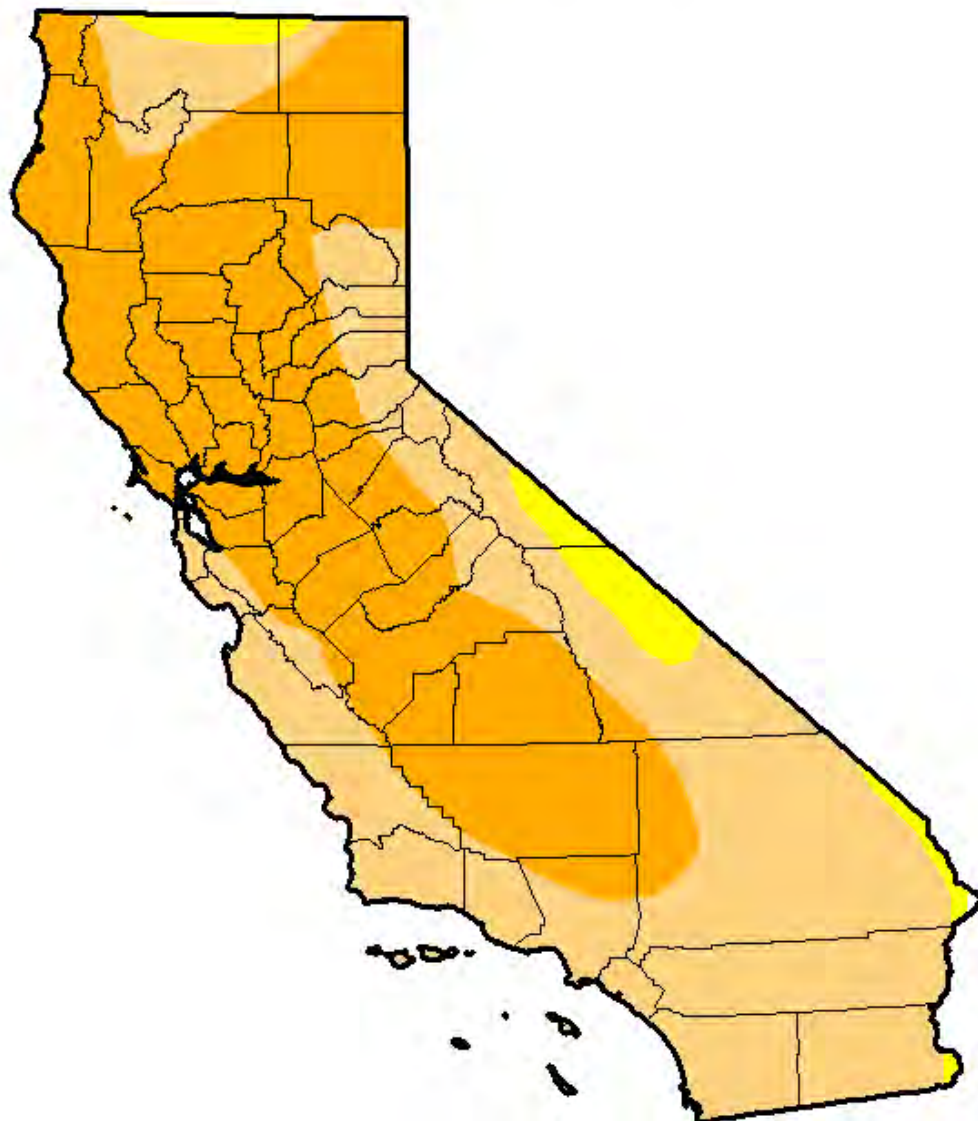
David Miskus
NOAA/NWS/NCEP/CPC



<http://droughtmonitor.unl.edu/>

U.S. Drought Monitor California

September 16, 2008
(Released Thursday, Sep. 18, 2008)
Valid 7 a.m. EST



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.04	99.96	95.90	48.77	0.00	0.00
Last Week <i>9/9/2008</i>	0.04	99.96	95.90	48.77	0.00	0.00
3 Months Ago <i>6/17/2008</i>	0.17	99.83	89.20	18.07	0.00	0.00
Start of Calendar Year <i>1/1/2008</i>	8.87	91.13	84.70	58.04	14.55	0.00
Start of Water Year <i>9/25/2007</i>	0.00	100.00	92.56	64.62	33.76	0.00
One Year Ago <i>9/18/2007</i>	0.00	100.00	92.56	65.34	35.23	0.00

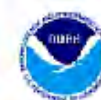
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D2 Severe Drought	

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:

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<http://droughtmonitor.unl.edu/>

U.S. Drought Monitor California

September 15, 2009

(Released Thursday, Sep. 17, 2009)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	73.44	45.82	0.00	0.00
Last Week <i>9/8/2009</i>	0.00	100.00	73.44	45.82	0.00	0.00
3 Months Ago <i>6/16/2009</i>	2.81	97.19	72.01	44.26	0.00	0.00
Start of Calendar Year <i>12/30/2008</i>	1.69	98.31	88.21	43.02	2.77	0.00
Start of Water Year <i>9/30/2008</i>	0.04	99.96	95.90	55.23	2.05	0.00
One Year Ago <i>9/16/2008</i>	0.04	99.96	95.90	48.77	0.00	0.00

Intensity:

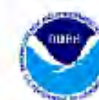
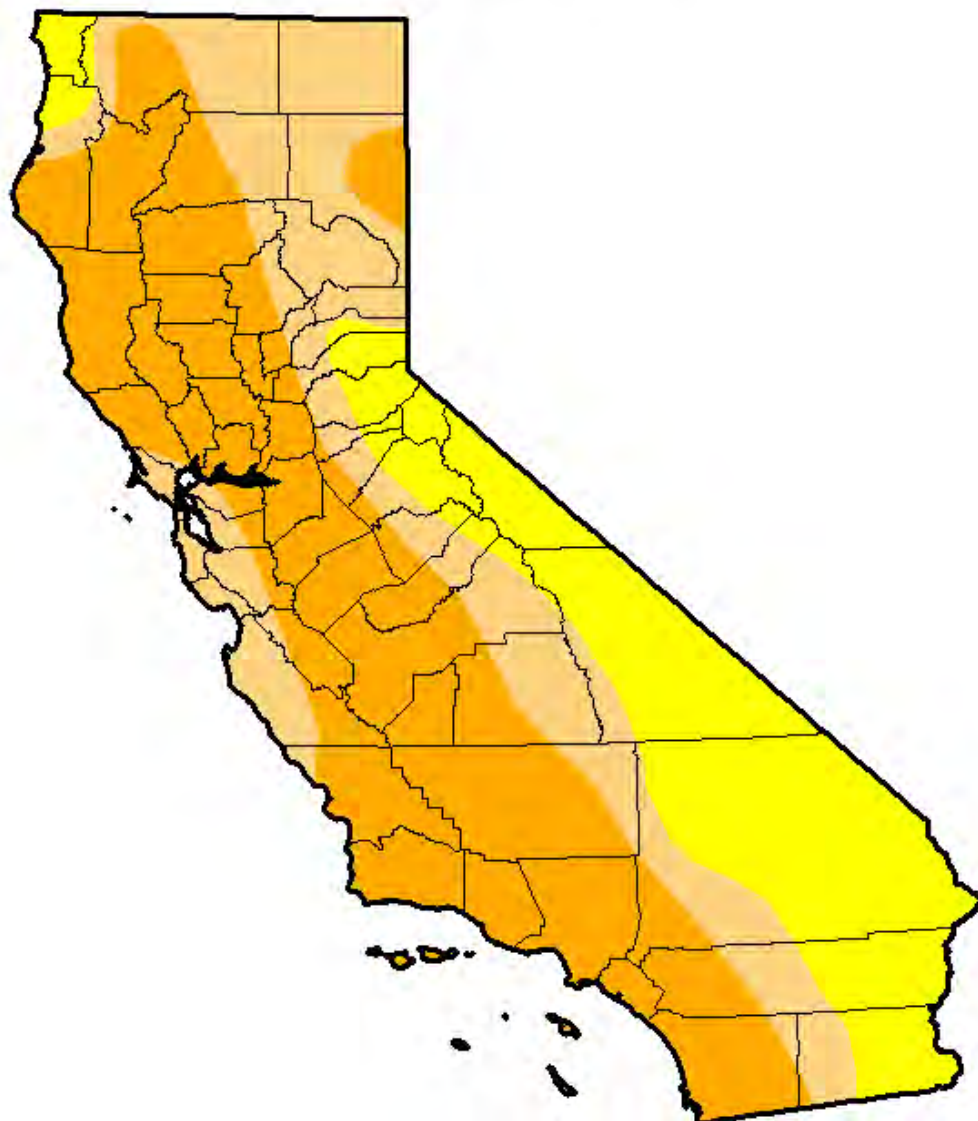
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Author:

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<http://droughtmonitor.unl.edu/>

U.S. Drought Monitor California

September 21, 2010

(Released Thursday, Sep. 23, 2010)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	85.44	14.56	8.08	0.24	0.00	0.00
Last Week <i>9/14/2010</i>	85.44	14.56	8.08	0.24	0.00	0.00
3 Months Ago <i>6/22/2010</i>	87.97	12.03	8.08	0.24	0.00	0.00
Start of Calendar Year <i>12/29/2009</i>	6.56	93.44	72.16	9.24	0.00	0.00
Start of Water Year <i>9/29/2009</i>	0.00	100.00	73.44	45.82	0.00	0.00
One Year Ago <i>9/22/2009</i>	0.00	100.00	73.44	45.82	0.00	0.00

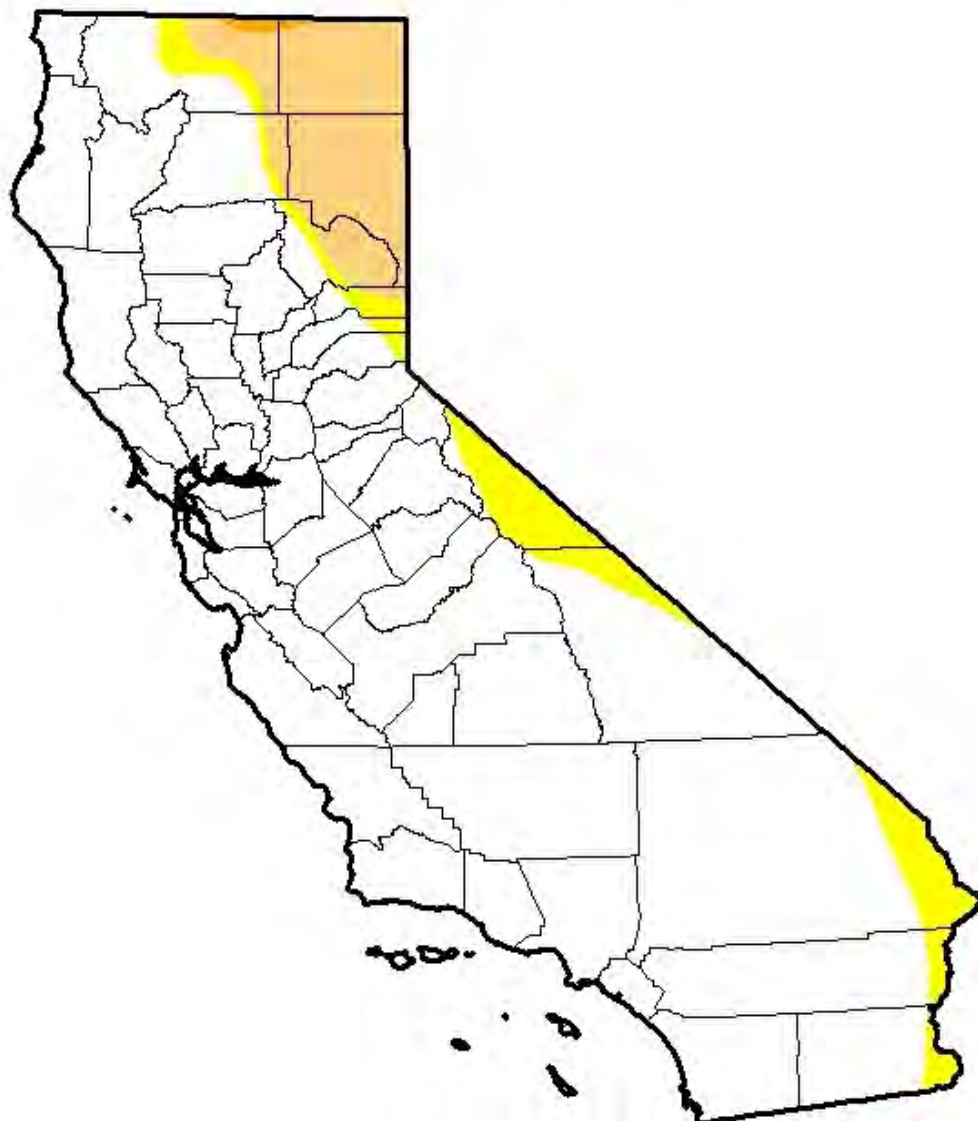
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 D2 Severe Drought	

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:

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<http://droughtmonitor.unl.edu/>

U.S. Drought Monitor California

September 20, 2011

(Released Thursday, Sep. 22, 2011)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	89.14	10.86	0.00	0.00	0.00	0.00
Last Week <i>9/13/2011</i>	87.36	12.64	0.00	0.00	0.00	0.00
3 Months Ago <i>6/21/2011</i>	99.99	0.01	0.00	0.00	0.00	0.00
Start of Calendar Year <i>1/4/2011</i>	98.62	1.38	0.00	0.00	0.00	0.00
Start of Water Year <i>9/28/2010</i>	85.44	14.56	8.08	0.24	0.00	0.00
One Year Ago <i>9/21/2010</i>	85.44	14.56	8.08	0.24	0.00	0.00

Intensity:

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 D1 Moderate Drought	 D4 Exceptional Drought
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Author:

Michael Brewer

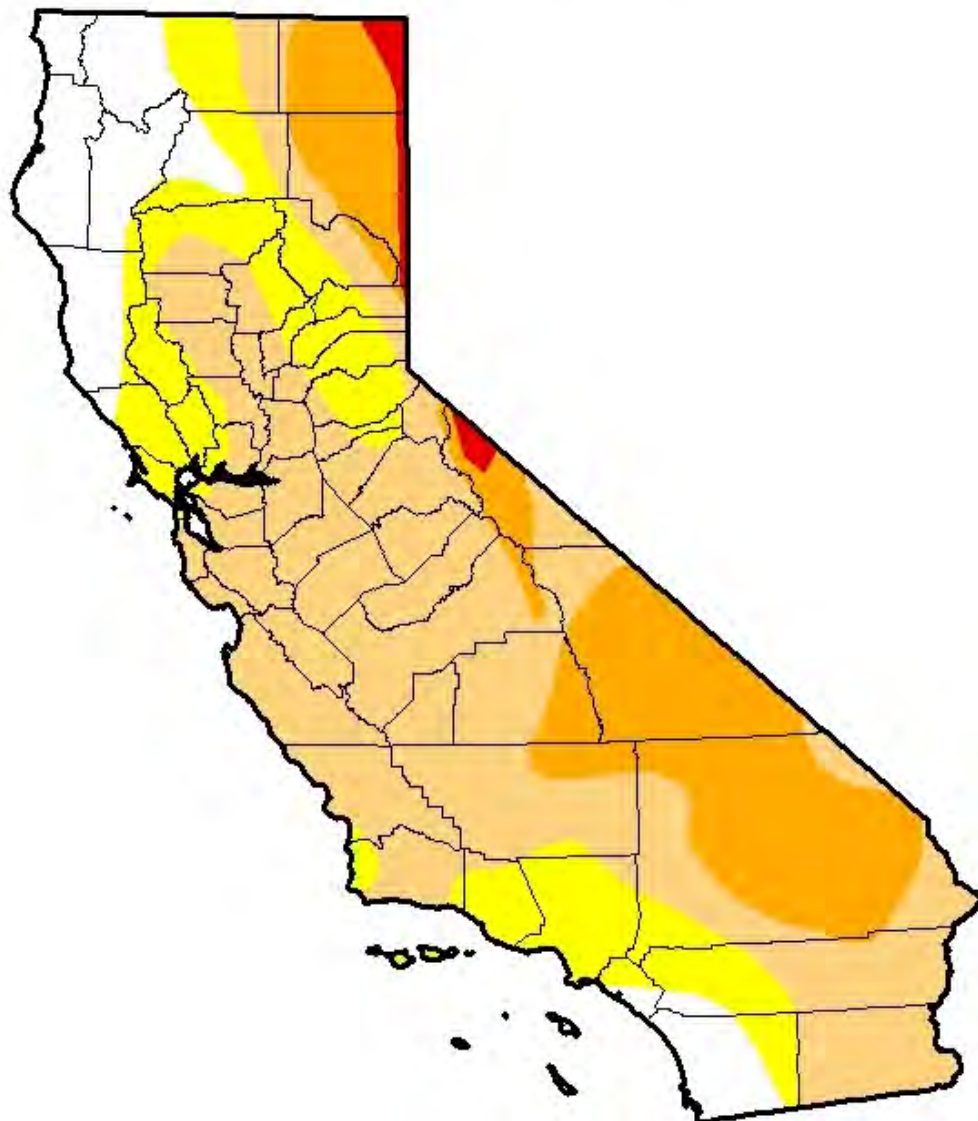
NCDC/NOAA



<http://droughtmonitor.unl.edu/>

U.S. Drought Monitor California

September 18, 2012
(Released Thursday, Sep. 20, 2012)
Valid 7 a.m. EST



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	11.95	88.05	69.09	22.27	1.14	0.00
Last Week 9/11/2012	11.74	88.26	69.13	22.31	1.14	0.00
3 Months Ago 6/19/2012	15.89	84.11	59.51	22.60	0.00	0.00
Start of Calendar Year 1/3/2012	29.91	70.09	46.34	0.00	0.00	0.00
Start of Water Year 9/27/2011	89.14	10.86	0.00	0.00	0.00	0.00
One Year Ago 9/20/2011	89.14	10.86	0.00	0.00	0.00	0.00

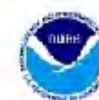
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<http://droughtmonitor.unl.edu/>

U.S. Drought Monitor California

September 17, 2013

(Released Thursday, Sep. 19, 2013)

Valid 7 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	2.63	97.37	96.04	89.84	11.36	0.00
Last Week <i>9/10/2013</i>	0.00	100.00	97.08	92.94	11.36	0.00
3 Months Ago <i>6/18/2013</i>	0.00	100.00	98.21	67.07	0.00	0.00
Start of Calendar Year <i>1/1/2013</i>	31.75	68.25	55.32	22.50	0.00	0.00
Start of Water Year <i>9/25/2012</i>	11.95	88.05	69.41	22.27	1.14	0.00
One Year Ago <i>9/18/2012</i>	11.95	88.05	69.09	22.27	1.14	0.00

Intensity:

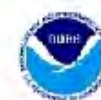
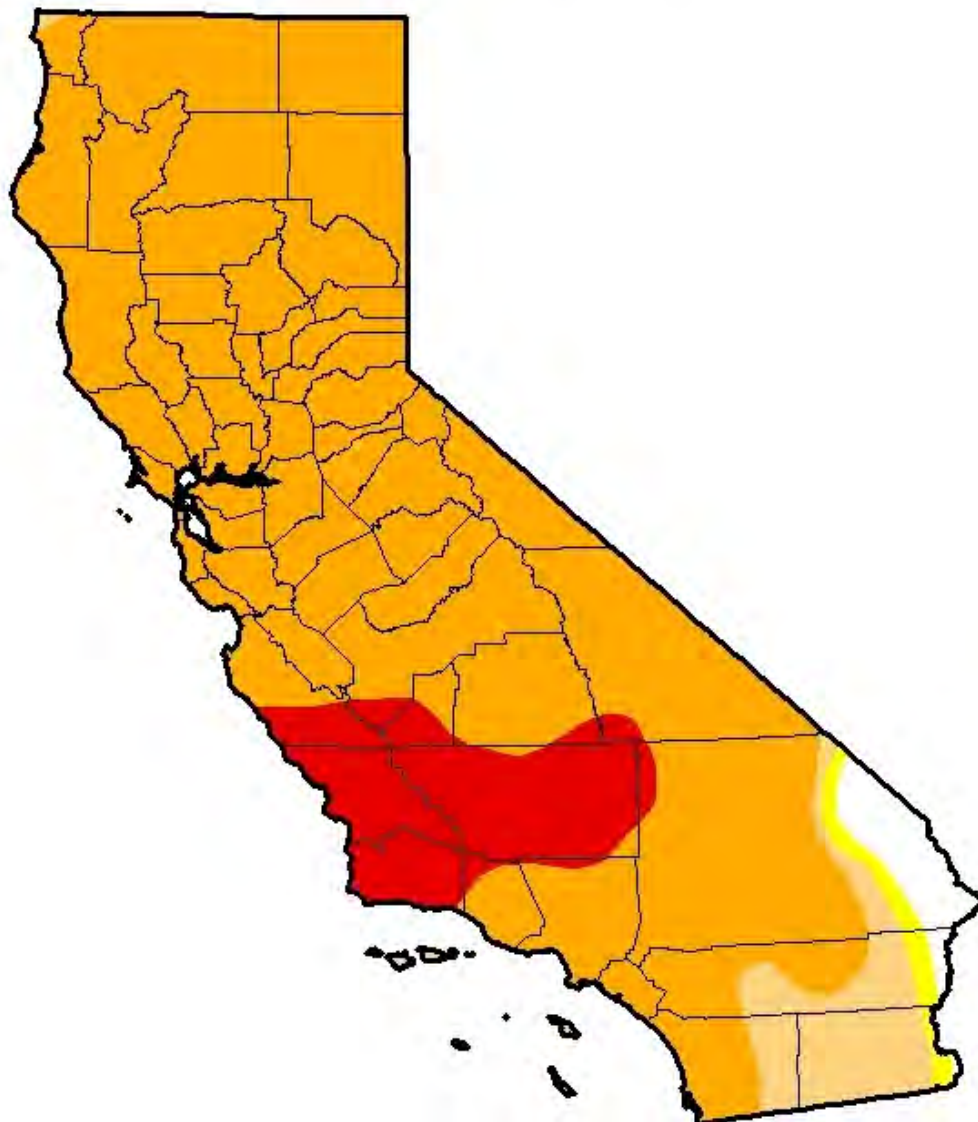
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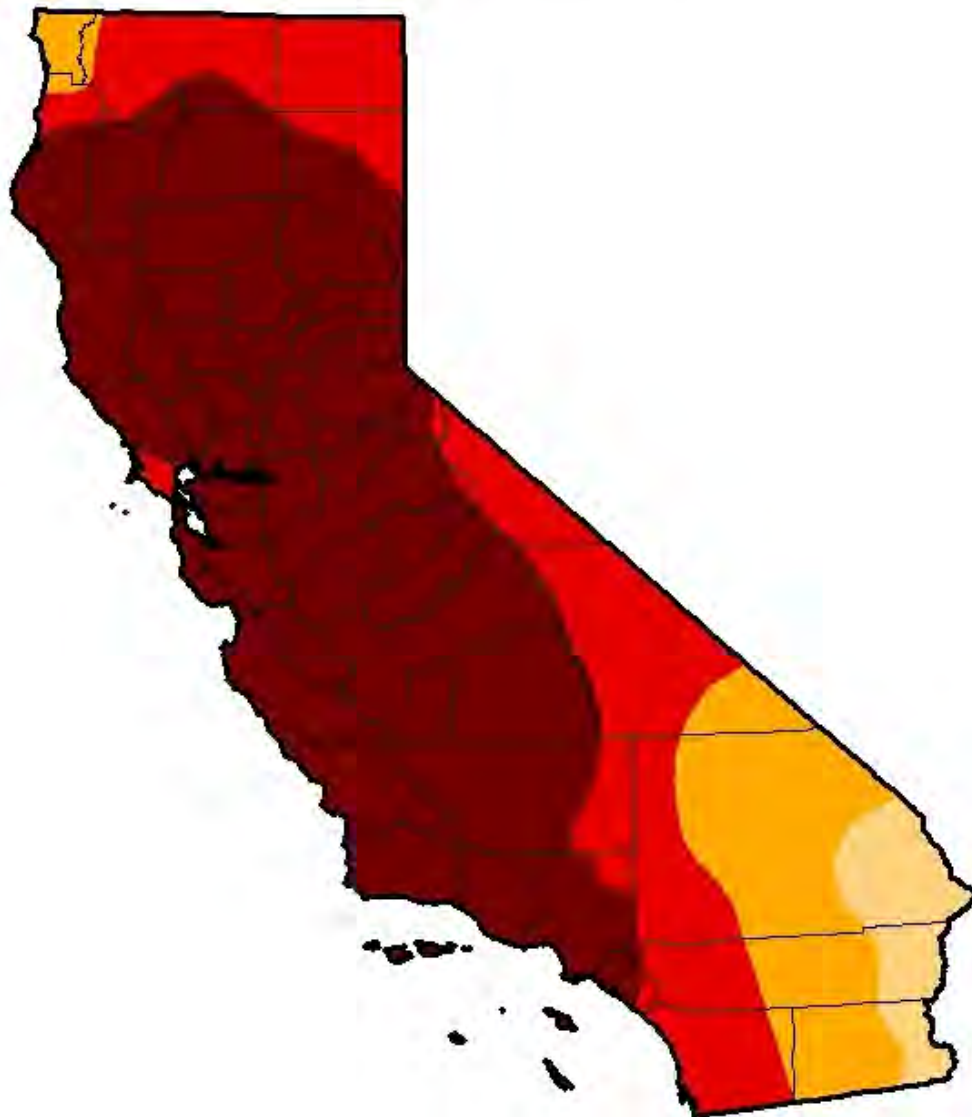
David Miskus

NOAA/NWS/NCEP/CPC



<http://droughtmonitor.unl.edu/>

U.S. Drought Monitor California



September 16, 2014
(Released Thursday, Sep. 18, 2014)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	95.42	81.92	58.41
Last Week 9/9/2014	0.00	100.00	100.00	95.42	81.92	58.41
3 Months Ago 6/17/2014	0.00	100.00	100.00	100.00	76.69	32.98
Start of Calendar Year 12/31/2013	2.61	97.39	94.25	87.53	27.59	0.00
Start of Water Year 10/1/2013	2.63	97.37	95.95	84.12	11.36	0.00
One Year Ago 9/17/2013	2.63	97.37	96.04	89.84	11.36	0.00

Intensity:

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D1 Moderate Drought	D4 Exceptional Drought
D2 Severe Drought	

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Author:

Michael Brewer
NCDC/NOAA



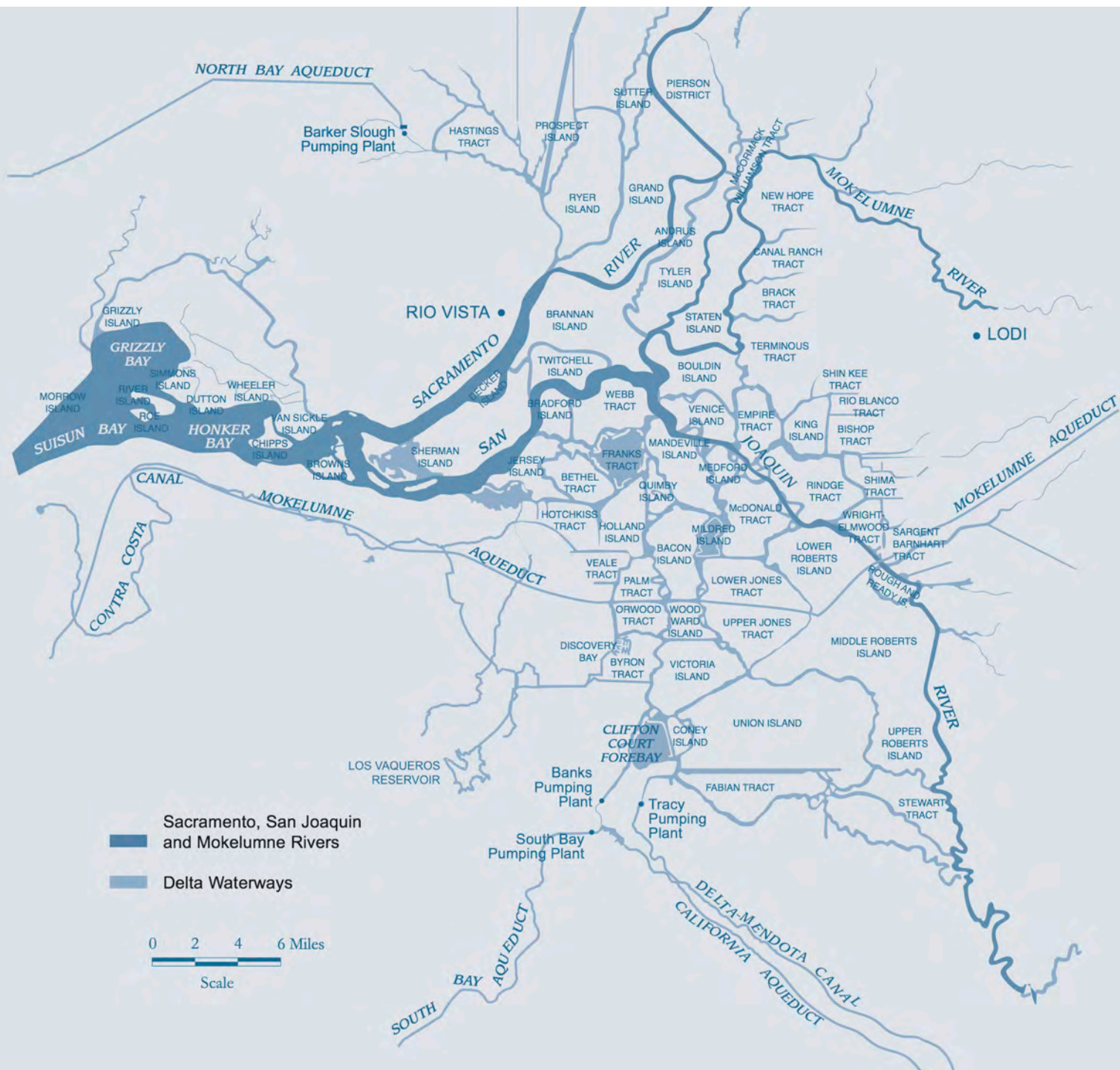
<http://droughtmonitor.unl.edu/>

January 2013



January 2014



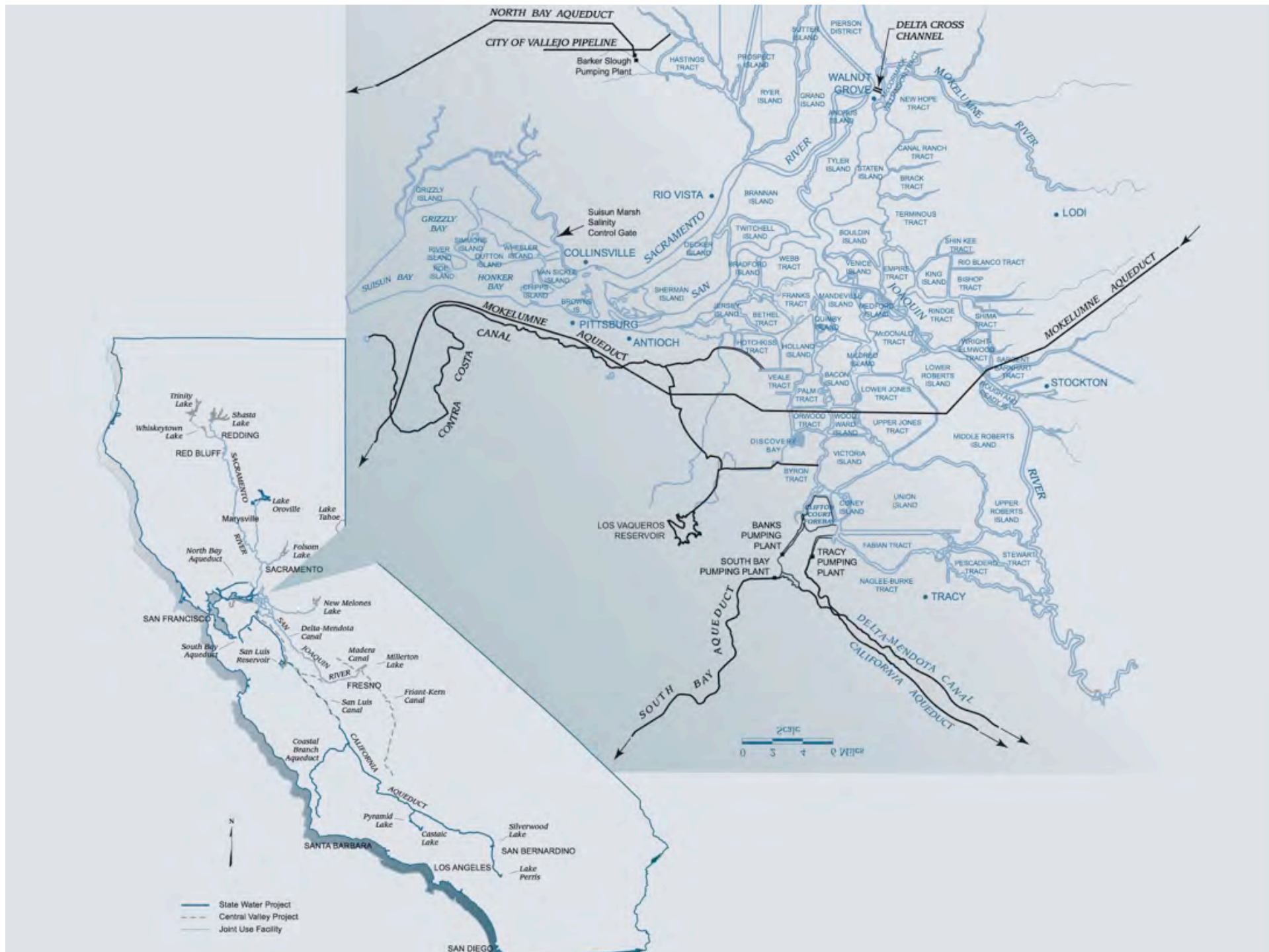


Fun Facts About the Delta

- Largest estuary on West Coast
- 1,100 miles of levees and 57 major reclaimed islands
- 52 mammals, 22 reptile and amphibian species, 225 birds, 54 fish species, including 260 invasive species
- Anadromous salmon, striped bass, steelhead trout, American shad, sturgeon
- Drinking water supply for 25 million people and a \$27 billion agricultural industry







The BDCP is...

...a long-term strategy to secure California's water supplies and improve the ecosystem of the Sacramento-San Joaquin River Delta.

The BDCP Co-Equal Goals



WATER SUPPLY RELIABILITY

3 INTAKES

2 GRAVITY FLOW TUNNELS

30 MILES IN LENGTH

9,000 CFS*
CAPACITY

*Cubic Feet per Second



ECOSYSTEM RESTORATION

150,000
ACRES OF RESTORED AND
PROTECTED HABITAT

56 PROTECTED
SPECIES

IMPROVED FLOW
CONDITIONS TO BENEFIT
FISH IN THE DELTA



The BDCP Would Benefit Millions of Californians

The BDCP is one part of California's overall water portfolio. It aims to protect our unique Delta ecosystem and secure water supplies for a vast part of the California economy.

SECURING WATER SUPPLIES



4.7-5.6

MILLION ACRE-FEET ON AVERAGE ANNUALLY

(An acre-foot is roughly as much water as two California households use, indoors and outdoors, in a year)

CREATING & PROTECTING JOBS



1.1 MILLION

**FULL-TIME EQUIVALENT JOBS CREATED
AND SAVED FOR CALIFORNIA**

(Based on a year by year estimate)

BOOSTING THE ECONOMY



\$84 BILLION

INCREASE IN STATE ECONOMIC PRODUCTIVITY

What we know with high certainty

- Temperatures will continue to go up
- Evaporative demands for water are increasing
- The ratio of mountain rain to snow will rise
- Snowpack will diminish
- The timing of runoff will change
- Sea-level will rise affecting estuaries & aquifers
- Severe earthquakes will periodically interrupt supply delivery and impact water quality

Definition of extreme uncertainty

“There are no stationary trends, no data points close to the relevant values of a variable and no theory to guide the forecast. . . an environment approximating an information vacuum.”

Source: Michael Schwarz, 1999

Point #2: Risk is Different from Uncertainty when Making Decisions



IPCC Definitions

‘Risk’ . . . To the extent that there is a detailed understanding of the characteristics of a specific event, experts will normally be in agreement regarding estimates of the likelihood of its occurrence and its resulting consequences.

‘Uncertainty’ denotes a cognitive state of incomplete knowledge that results from a lack of information and/or from disagreement about what is known or even knowable.

Source: IPCC 5th Assessment Report "Climate Change 2014: Mitigation of Climate Change"

Are we taking this advice?

“The place to start our investigation . . is with the question: can ignorance be modeled probabilistically? The answer is ‘no’. The ignorance which is important to the decision maker is a disparity between what is known and what needs to be known in order to make a responsible decision.”

Source: Yakov Ben-Haim, *Info-Gap Decision Theory: Decisions Under Severe Uncertainty*.

Are we taking this advice?

"The world today faces the enormous, dual challenges of renewing its decaying water infrastructure and building new water infrastructure. Now is an opportune moment to update the analytic strategies used for planning such grand investments under an uncertain and changing climate."

Source: P.C.D. Milly et al. "Stationarity is Dead: Wither Water Management." Science, 319, February 2008.

Point #3: Transition to Post-Recovery Solutions before the Plausible Crisis



DR. KIRAN C. PATEL COLLEGE OF
GLOBAL SUSTAINABILITY



Canadian Urban
Forest Conference

Urban Forests by Design



UNIVERSITY OF
SOUTH FLORIDA



Protecting the City, Before Next Time



Architecture Research Office and dlandstudio

URBAN WETLANDS A rendering of Lower Manhattan that shows tidal marshes to absorb waves.

By [ALAN FEUER](#)

Published: November 3, 2012

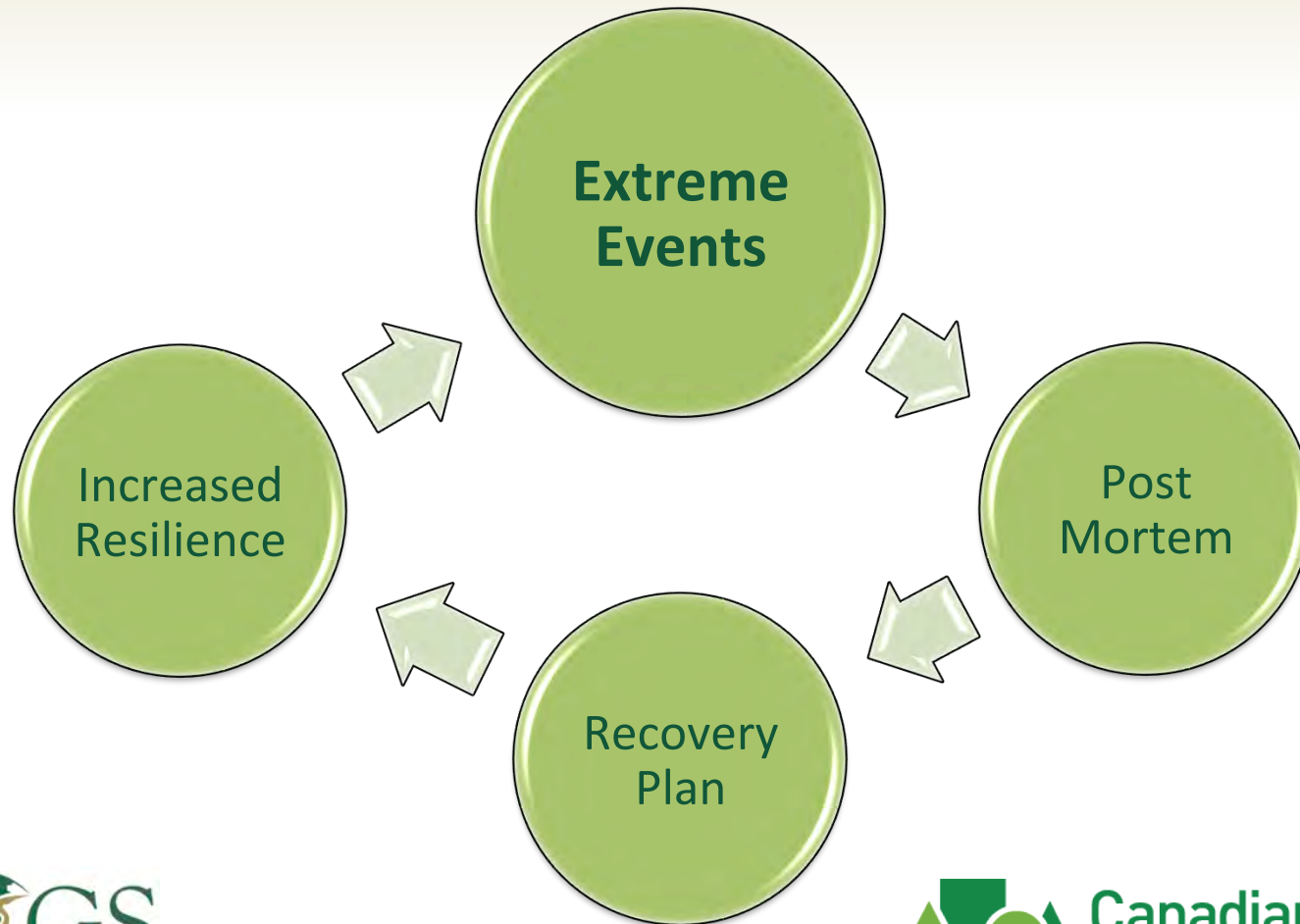
Rebuild by Design Winner: BIG U

THE BATTERY BERMS

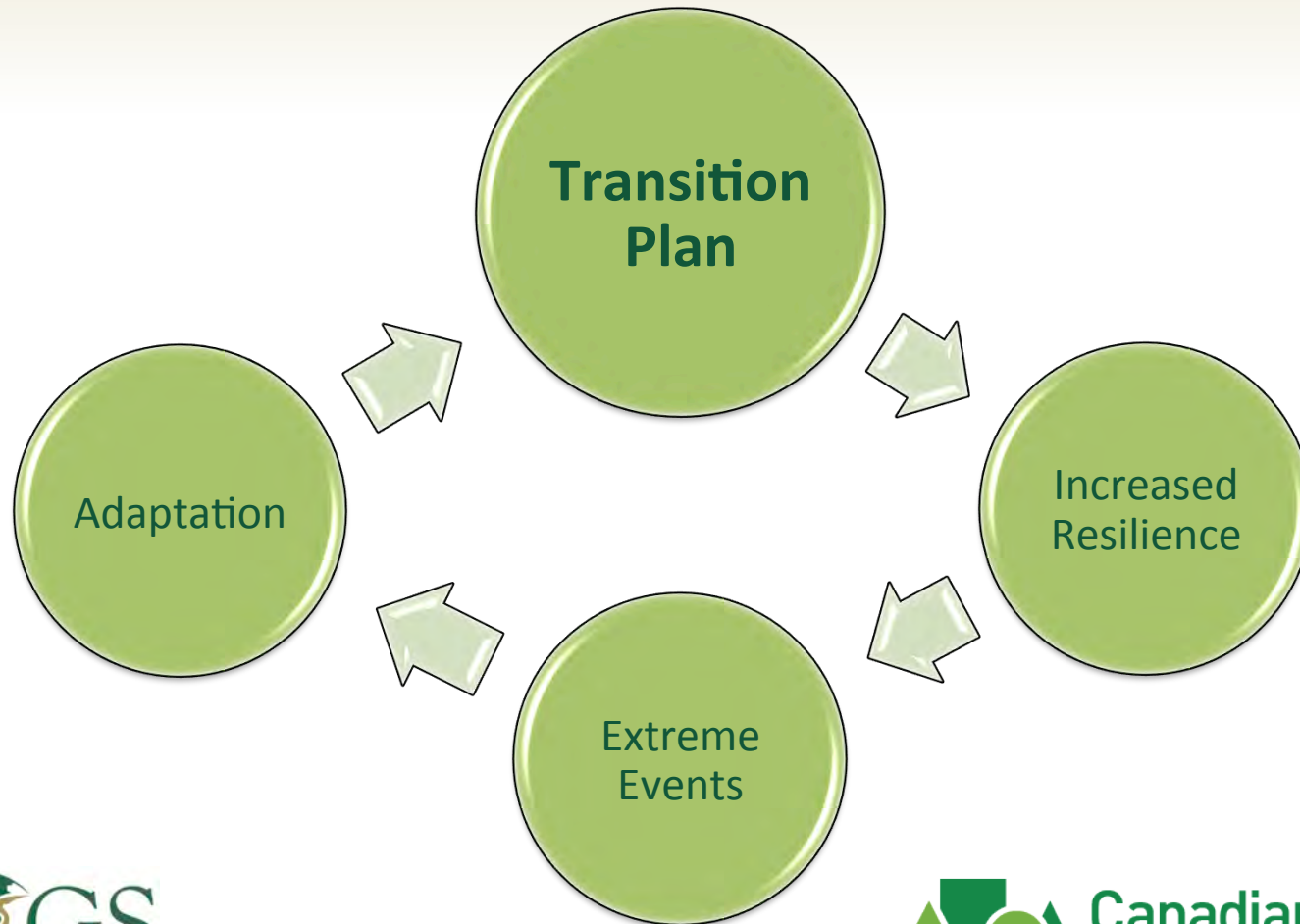


<http://www.rebuildbydesign.org>

Breaking the cycle of catastrophe-driven change



Breaking the cycle of catastrophe-driven change



Keeping mistakes small and learning constant

- Diversified
- Multi-purpose
- Smaller-scale
- Incremental
- Context Sensitive
- Flexible
- Resilient
- Low Regret
- Locally Managed
- Distributed

Transitioning to an urban form designed to function more like a natural system

Original 1828 Royal Charter of the Institution of Civil Engineers

**"...the art of directing the great
sources of power in nature for the
use and convenience of man."**

“The Best way to predict the future is to invent it” – Alan Kay 1989

“In some sense our ability to open the future will depend not on how well we learn anymore – but how well we are able to unlearn.”



PCOGS



DR. KIRAN C. PATEL COLLEGE OF
GLOBAL SUSTAINABILITY



Canadian Urban
Forest Conference

Urban Forests by Design



UNIVERSITY OF
SOUTH FLORIDA