The Potential for Ecosystem Responses to Extreme Climatic Events in the Front Range of Colorado

Mark Losleben, Mountain Research Station, INSTAAR, University of Colorado

Contributors

D. Greenland, N. Caine, P. Tans, R. Monson, D. McKnight, A. Roche, C. Flanagan, C. Woodhouse, J. Lukas, C. Meier

Occurrence or Potential for Responses to Extreme Climatic Events

Main Points:

Integrated approach

More good data needed

To illustrate:

A look at selected extreme climatic events: detectable ecosystem responses?

Definition

Extreme climatic events are statistically rare in frequency, magnitude, and/or duration for a single climate parameter or combination of parameters for a particular ecosystem. The ability to recognize and categorize extreme events is dependent upon the length of reliable observational records. An extreme climatic event may or may not induce an ecological response.

An extreme ecological response is a change in ecological attributes that is statistically rare in frequency, magnitude, and/or duration, or a persistent alteration of ecological properties at any level of organization.

LTER Extreme Events Committee, D. Goodin, 2003

Climatic Events

April 15-16, 1921. Record 24 hour snowfall (1.93 m in 24 hours), Silver Lake, CO.

1981-86. Record cold air temperatures above 3,000 meters.

April and May 1995. Extremely high snowfall, and late, deep snow pack.

2002. Severe Drought. Single year, and possible cascading, impact.

2000-2003. Drought.

Rising Atmospheric CO_2. 1968-present.

(Climate change as an Extreme Event?)

Record 24 hr snowfall

1921

No lasting ecosystem effects found in literature

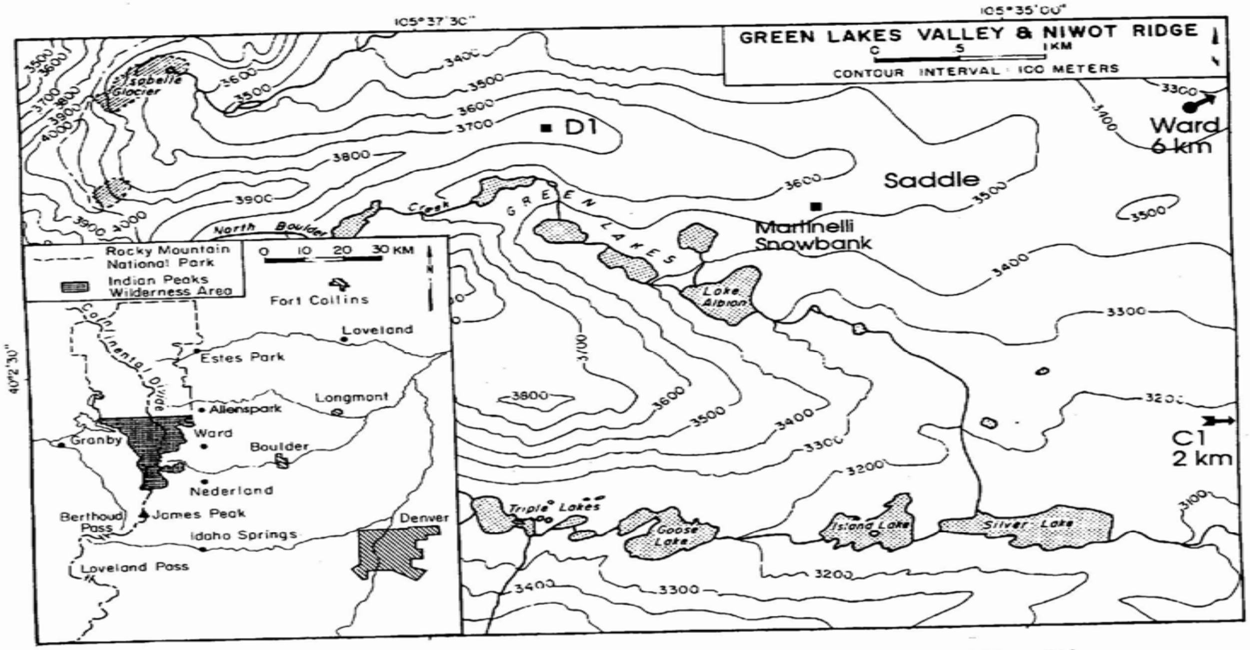


FIGURE 1. Location map of the Colorado Front Range showing Silver Lake and Niwot Ridge.

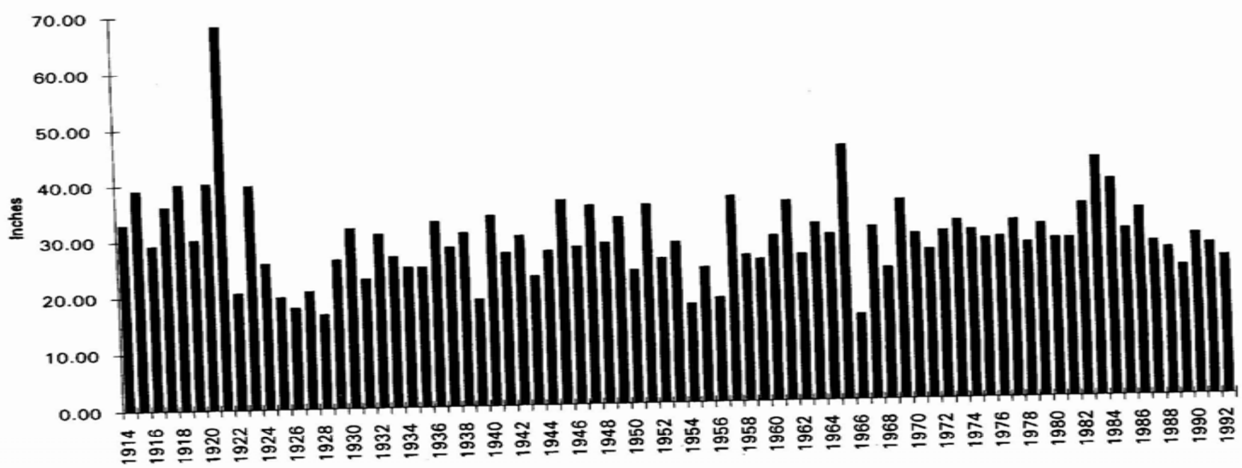
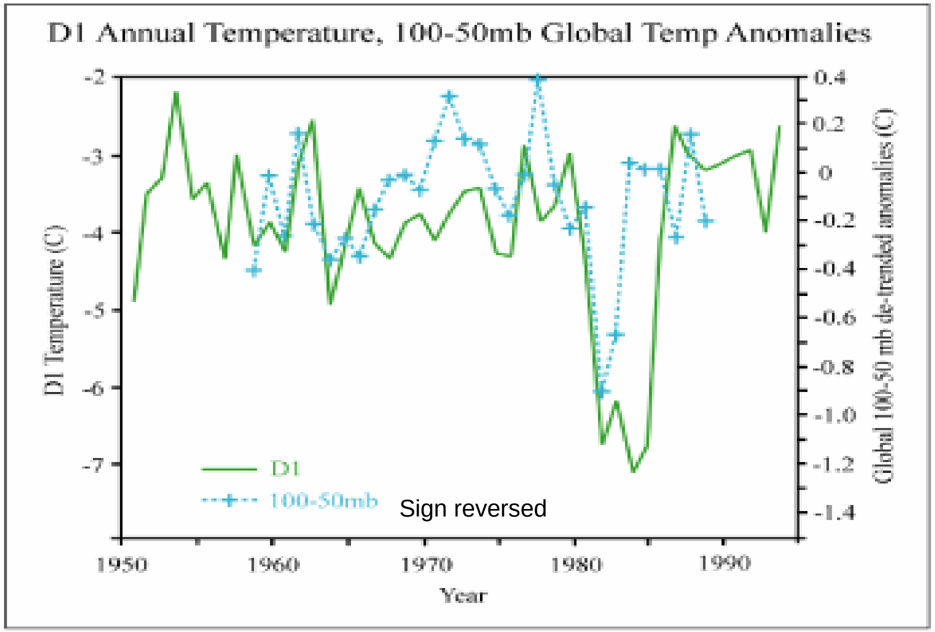


FIGURE 2. Mean annual precipitation values for Silver Lake, Colorado, 1914 to 1992.

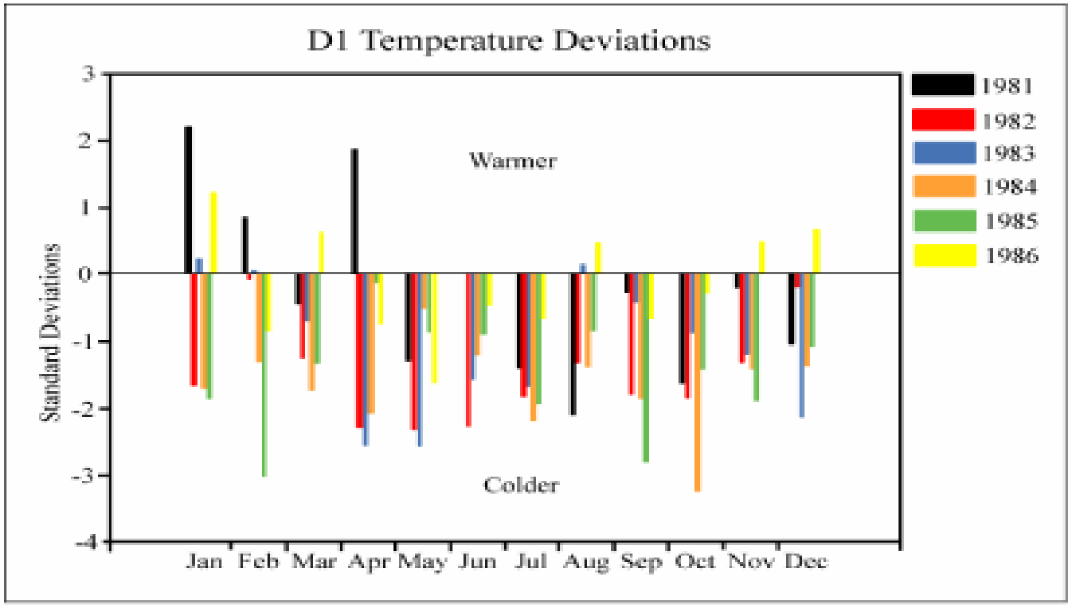
D Greenland, AAAR, v27, no1, 1995, pp19-28

Multi-year event

1981-86

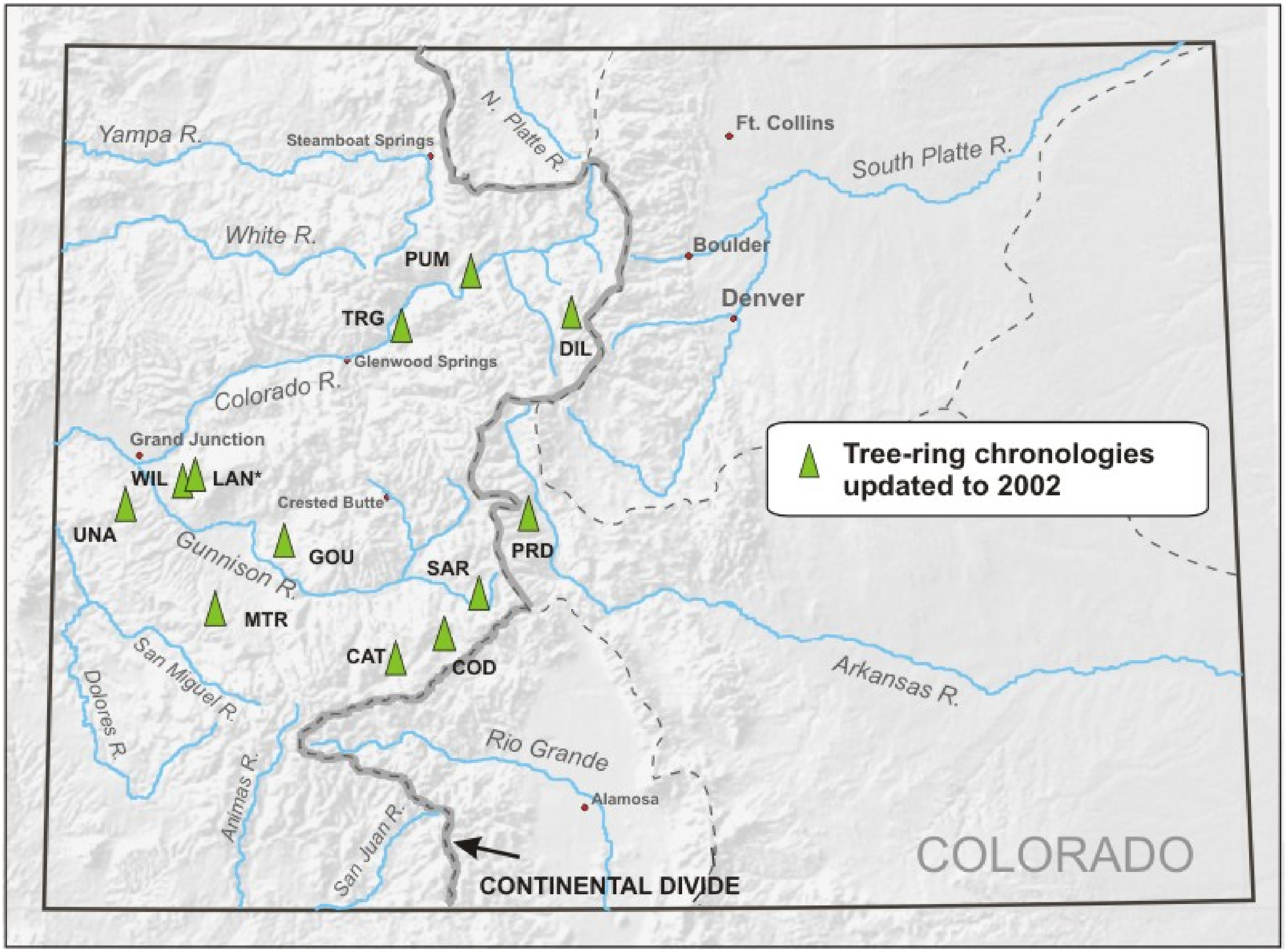


The Northern Hemisphere annual temperature anomalies at 100-50 mb.



M. Losleben

2002 Drought



C. Woodhouse, 2005

2002 Drought

West slope chronologies
20 lowest-growth years, 1440-2002

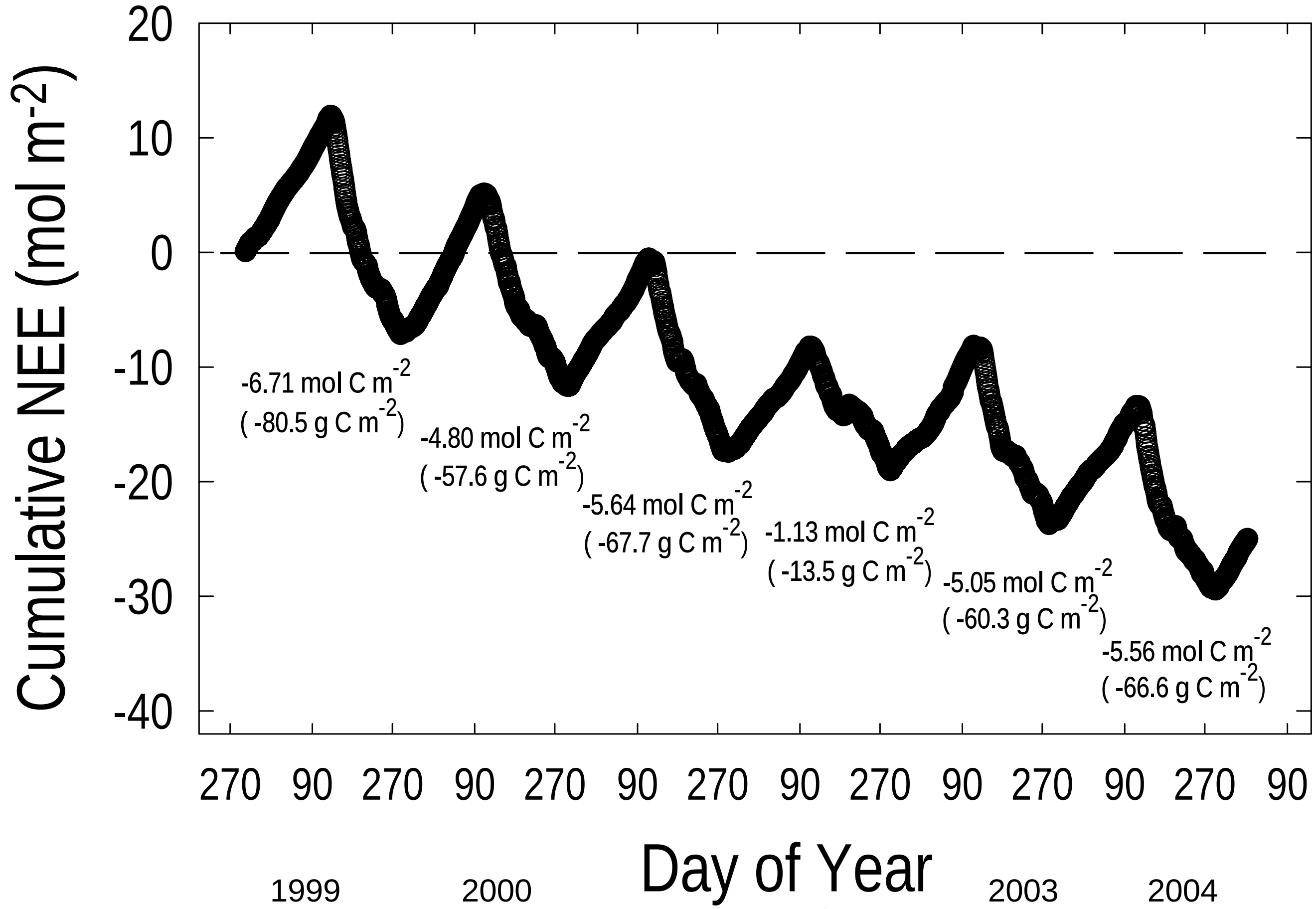
	CAT	COD	DIL	GOU	LAN	MTR	PRD	PUM	SAR	TRG	UNA	WIL		Average
1	1495	1748	1845	**1685**	**1685**	1748	1522	**1851**	1729	1607	1959	**1851**	**1**	**1685**
2	1645	**2002**	1954	1654	1654	1714	1974	1798	1664	1977	1600	1495	**2**	**1851**
3	1729	1729	**1851**	**1851**	1495	**1851**	1729	1845	1495	1735	1574	1542	**3**	**2002**
4	1480	1922	1871	1861	1729	1861	1902	1879	1967	1845	1902	1722	**4**	**1598**
5	1950	1495	1902	1580	**2002**	1902	1764	1598	1500	1773	1714	**1685**	**5**	**1748**
6	1573	1500	1584	1664	**1851**	1845	1598	1902	1528	1902	**2002**	1847	**6**	**1902**
7	1528	1824	**1685**	1879	1977	1977	1475	1855	1493	1646	1654	1729	**7**	**1729**
8	1874	1773	1898	1795	1598	1798	1645	1607	1598	**1685**	1722	1584	**8**	**1584**
9	1748	1506	1887	1765	1624	1773	1899	1584	1934	1584	1934	1645	**9**	**1495**
10	**1851**	1737	1609	1590	1455	1778	1493	1871	1609	1442	1861	**2002**	**10**	**1654**
11	1598	1934	**2002**	1598	1989	**1685**	1524	1654	1685	1598	1542	1590	**11**	**1714**
12	1773	1522	1531	1729	1590	1735	1573	**1685**	1444	1714	1977	1956	**12**	**1506**
13	1506	1961	1863	1714	1573	1542	1694	1736	1590	1879	1506	1654	**13**	**1798**
14	1500	1664	1542	1584	1584	**2002**	1625	1542	1538	**2002**	1780	1558	**14**	**1590**
15	1493	1954	1559	1977	1488	1654	**1851**	1634	1954	1600	1757	1598	**15**	**1977**
16	1558	1590	1770	1748	1645	1580	1705	1506	1515	**1851**	1763	1963	**16**	**1500**
17	1745	1967	1575	1954	1754	1873	1893	1714	**2002**	1896	1580	1748	**17**	**1542**
18	1668	1904	1748	1829	1500	1506	1552	1825	1871	1654	1551	1460	**18**	**1879**
19	1824	1700	1580	1735	1722	1684	1623	1686	1573	1861	1750	1670	**19**	**1845**
20	1961	1653	1786	1666	2001	1722	1558	1977	1496	1798	**1685**	1735	**20**	**1954**

2002 was third lowest-growth year post-1440, and lowest since 1851, averaged across 12 sites in western Colorado

2002 Drought

Cumulative Annual Net Ecosystem CO_2 Exchange

Measure of carbon sequestration in a sub-alpine forest



2002

respiration

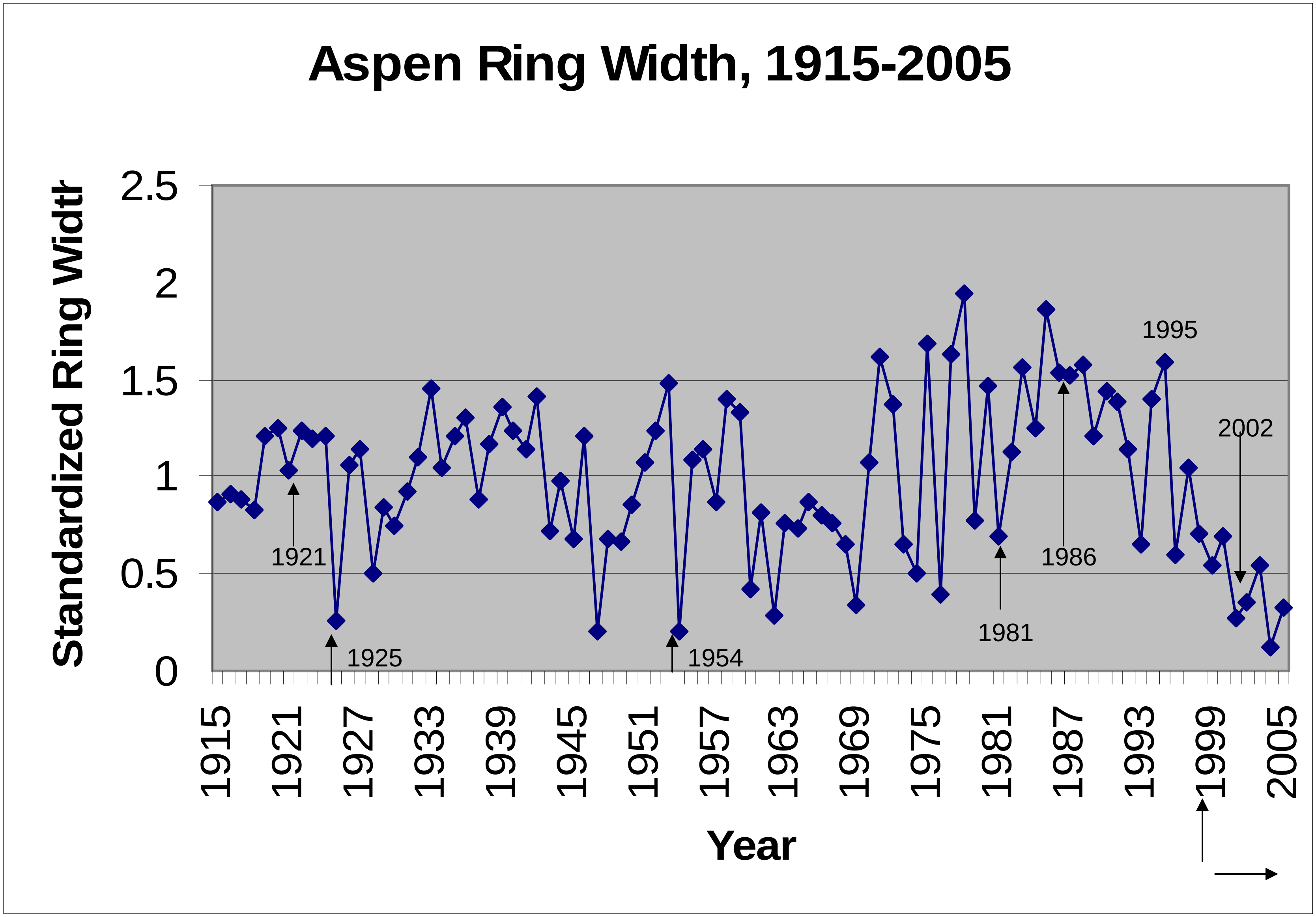
photosynthesis

Increasing C sequestration

R. Monson 2005

Single year, Multi-year event

Possible Cascade

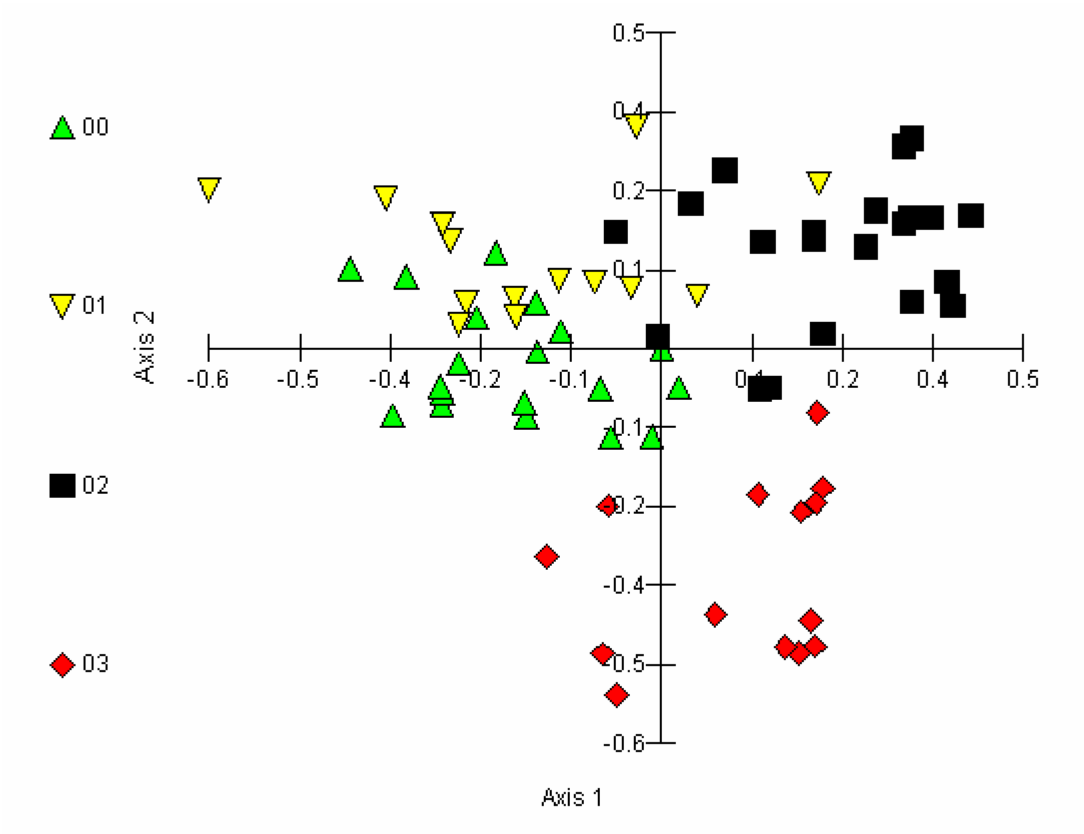


Lukas & Losleben, 2005

Possible Cascade

PCA of Phytoplankton Populations in Green Lake 4, CO

Summers of 2000-2003

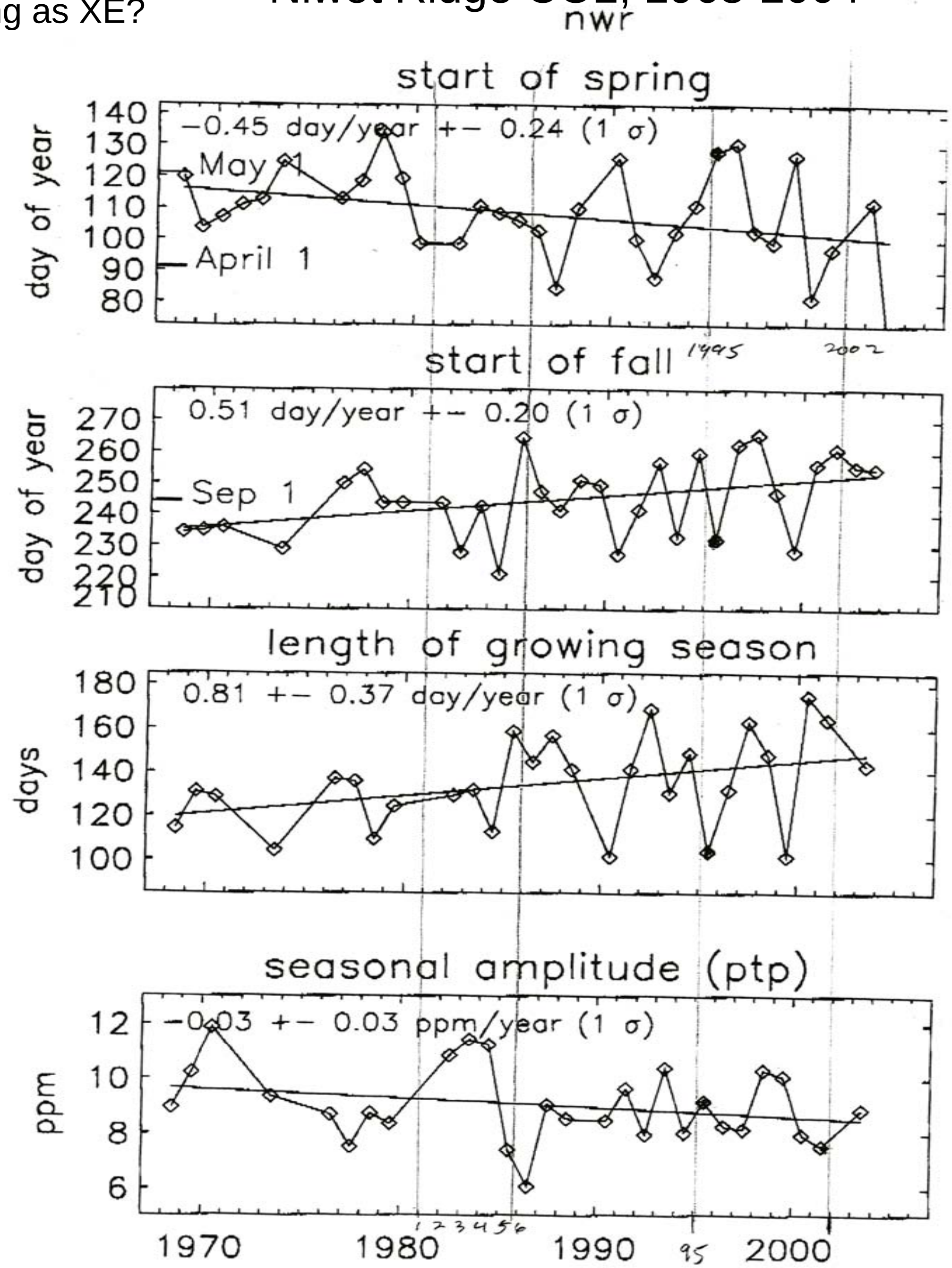


2000-01 ‘normal’, 2002 drought, 2003 population shift; 2004&05?

Mc Knight, Roche, Flanagan 2005

Global Warming as XE?

Niwot Ridge CO2, 1968-2004



16.65 days earlier

18.87 days later

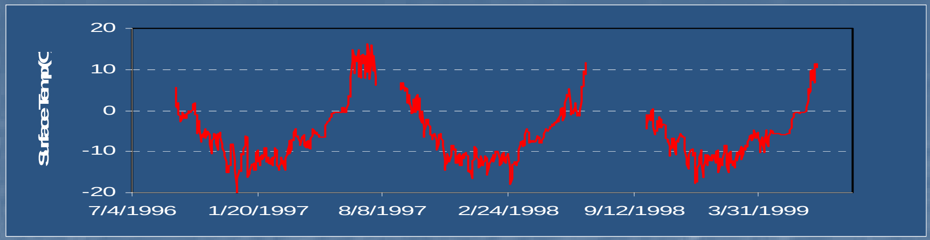
29.97 days longer

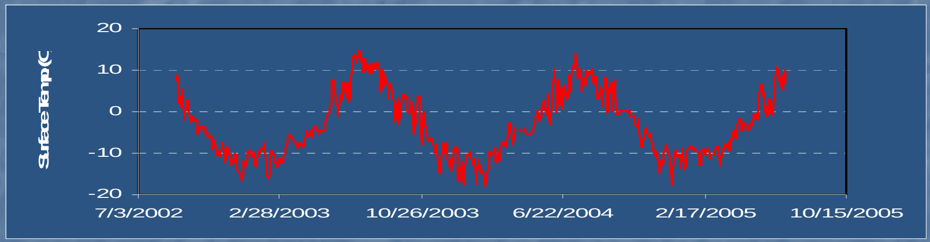
Decreased 1.11 ppm

P. Tans, NOAA CMDL

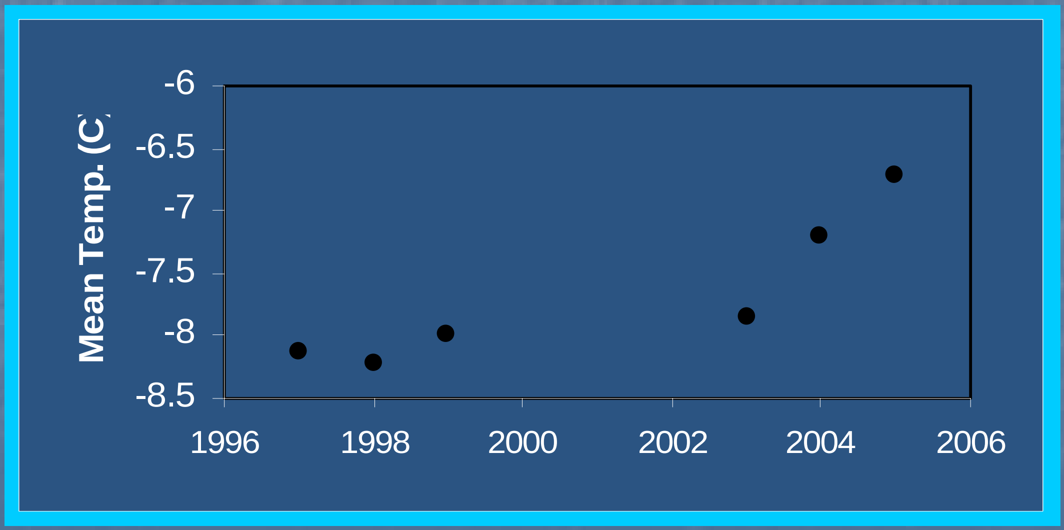
Warming

GL5 Rock Glacier: Surface Temperatures



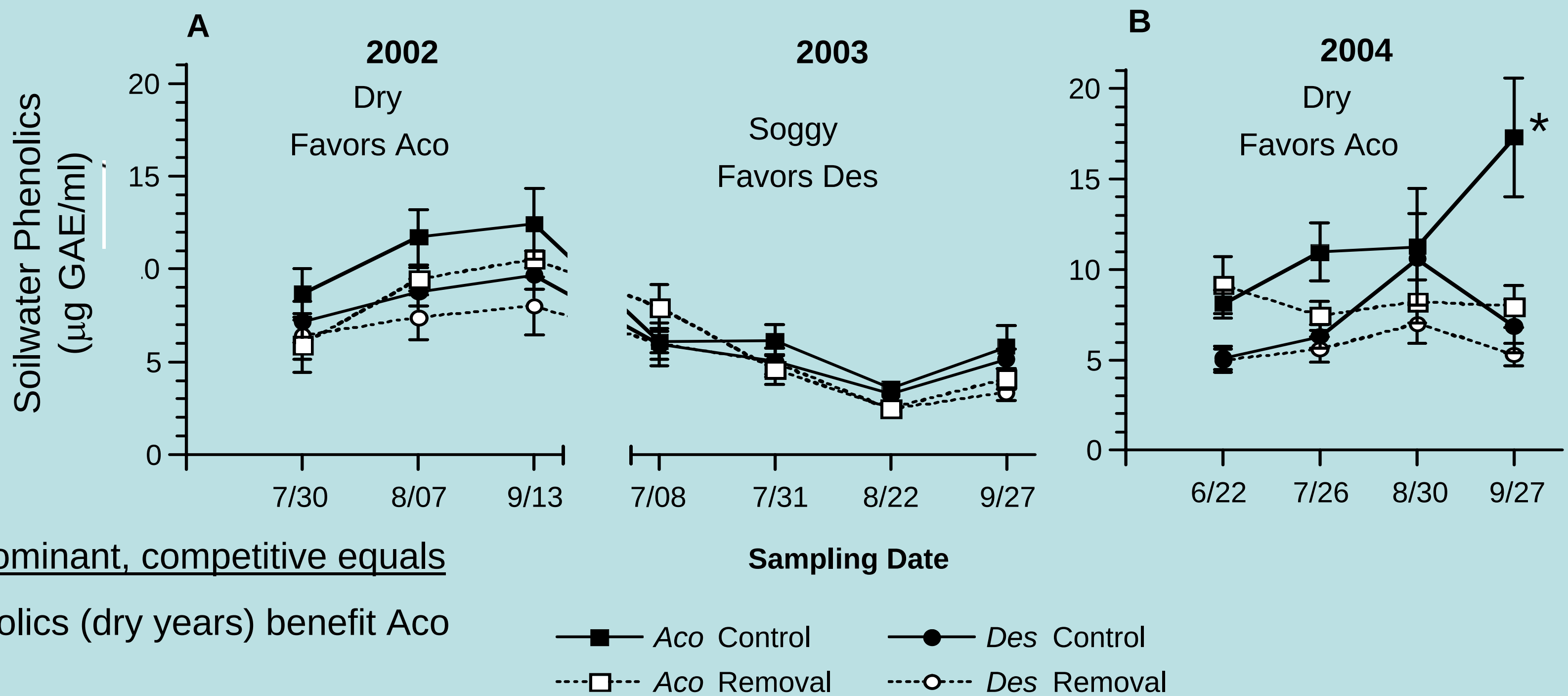


Mean Oct – May Temperature -7.7°C but:



N. Caine, 2005

Linkage /process   Species Diversity / Shift in Competitive Advantage



<u>Co-dominant, competitive equals</u>

Phenolics (dry years) benefit Aco

Acomastylis rossii (high phenolics, slow-growing, low N use) and *Deschampsia caespitosa* (very low phenolics, fast growing, high N use) in the alpine moist meadows

Figure 1. Bulk soilwater phenolics under *Acomastylis rossii* and *Deschampsia caespitosa* dominated patches of alpine moist meadow. “Removal” refers to patches for which above-ground biomass was removed for at least four years; “control” patches were left intact. (A) Soilwater samples were taken from six replicate blocks within one moist meadow on Niwot Ridge. (B) Soilwater phenolic samples for 2004 were taken from 7 replicate moist meadows across Niwot Ridge. Asterisk indicates soilwater phenolics under Aco control patches were statistically greater than all other groups ($p<0.01$), Tukey post-hoc test. For all figures, means are ± 1 SE.

Wet years (low phenols) & increasing N deposition benefit Des

C. Meier 2005

Extreme Event Characteristics

Occur on all spatial, temporal scales

May or may not induce response in any environmental system (i.e. eco-, hydro-, biogeochemical, climatic, …)

Impacted system recovers (i.e. only a single year response), or not (i.e. new baseline conditions are established) .

Varying Ecosystem Response timelines and mechanisms:

-Immediate response

-Single event promotes others (cascading or “domino” effect)

-Threshold response (Lorenz, chaos, abrupt change) effect

Conclusion

Use an integrated system approach to detect responses to extreme events

More good data needed.

- Advertisement-

So, support your local, and every, measurement station and network!!!
Including CIRMOUNT Mountain Climate Network (MoNet), K. Redmond, chair