Vulnerability vs. Adaptability in Mountain Communities

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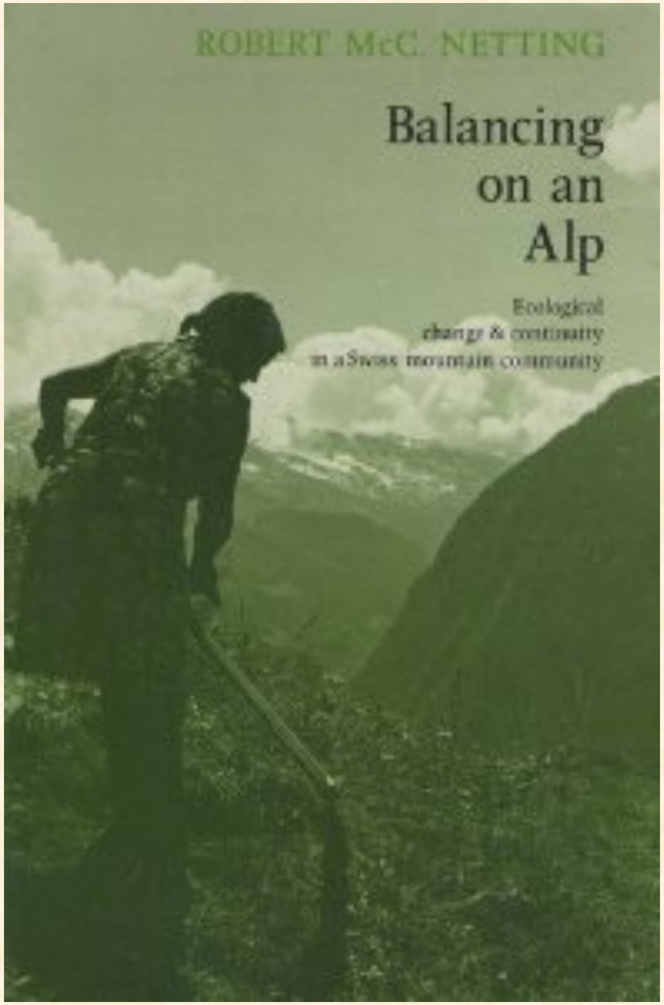
Qualities of "mountain communities"

Roots in:

- Minerals
- Pastoralism
- Recreation/Tourism

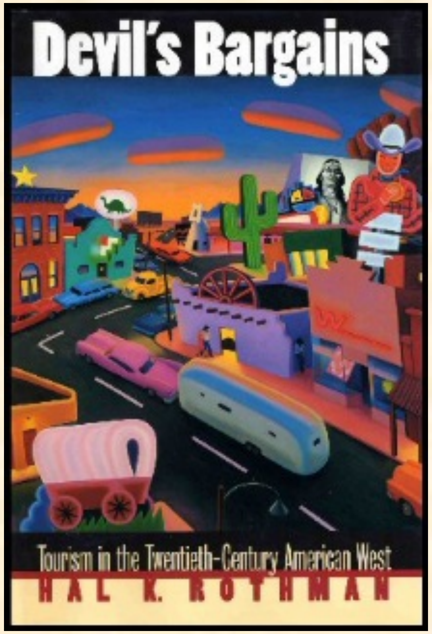
Geographically described:

- Small, isolated, contained
- Less developed
  - (Limited ag, settlement, infrastructure)
- Natural areas
- Public lands
- Resource dependent
- "Resorts"
- Highland – Lowland interaction



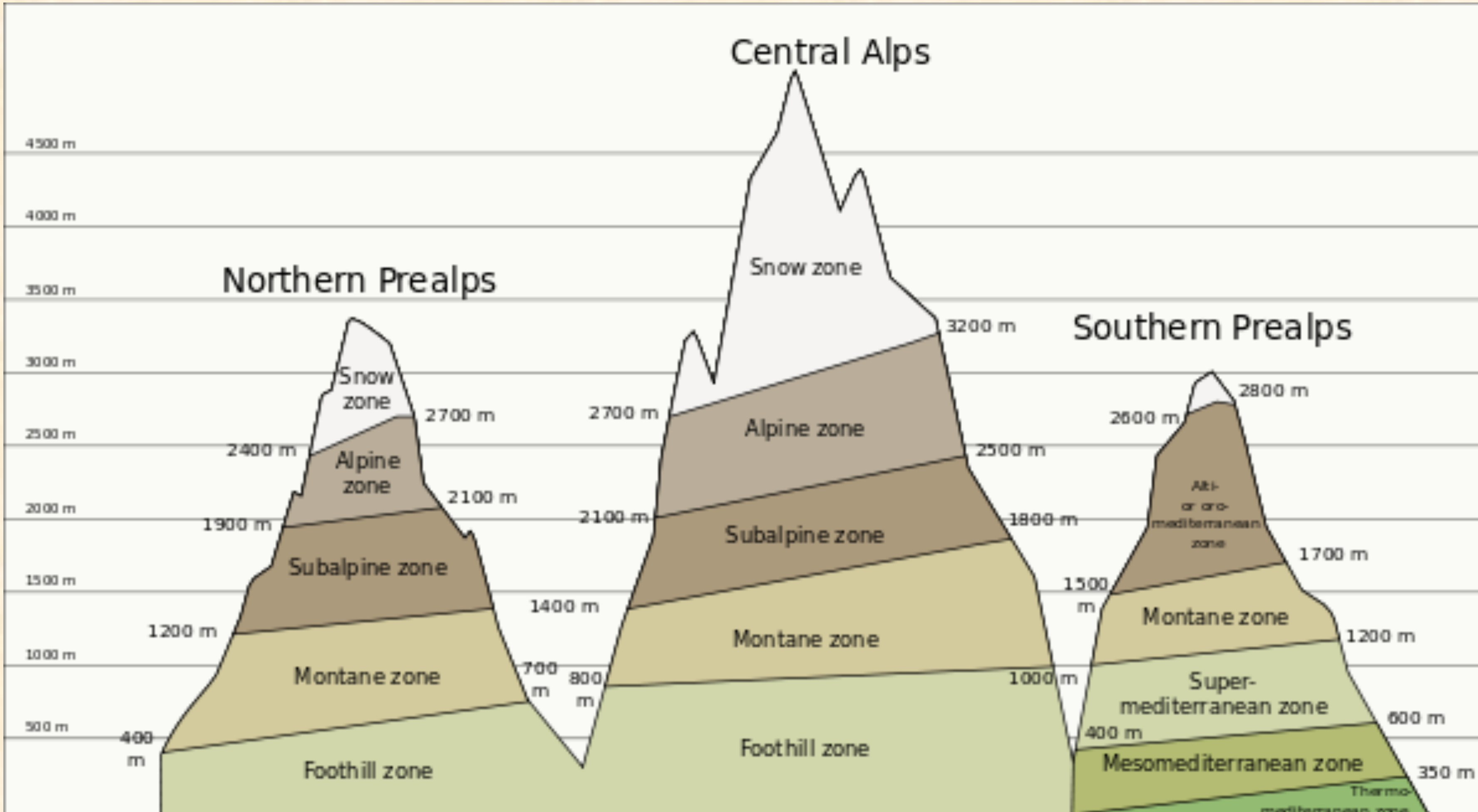
Mountain Resort studies

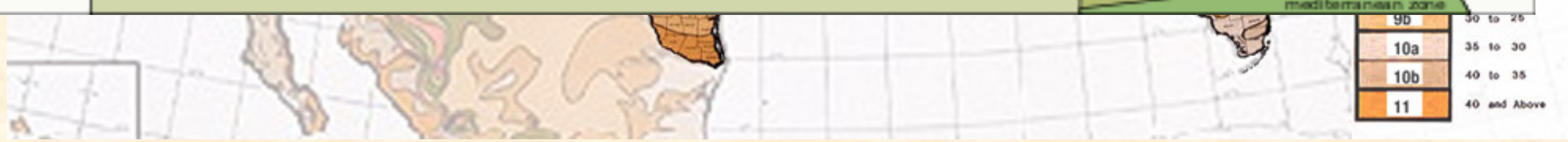
- Classic Swiss studies (Bruno Messerli) and the "Obergurgl" model: descriptive modeling of resort development and LU
- Mtn resort literature in the US, focused on West, with:
- Resort development cycle
- "Aspenization" (wealthy second homes)
- Problem-orientation: economy (boom-bust), land use, housing, transportation
- Public lands / gateways
- Challenge of sustainability

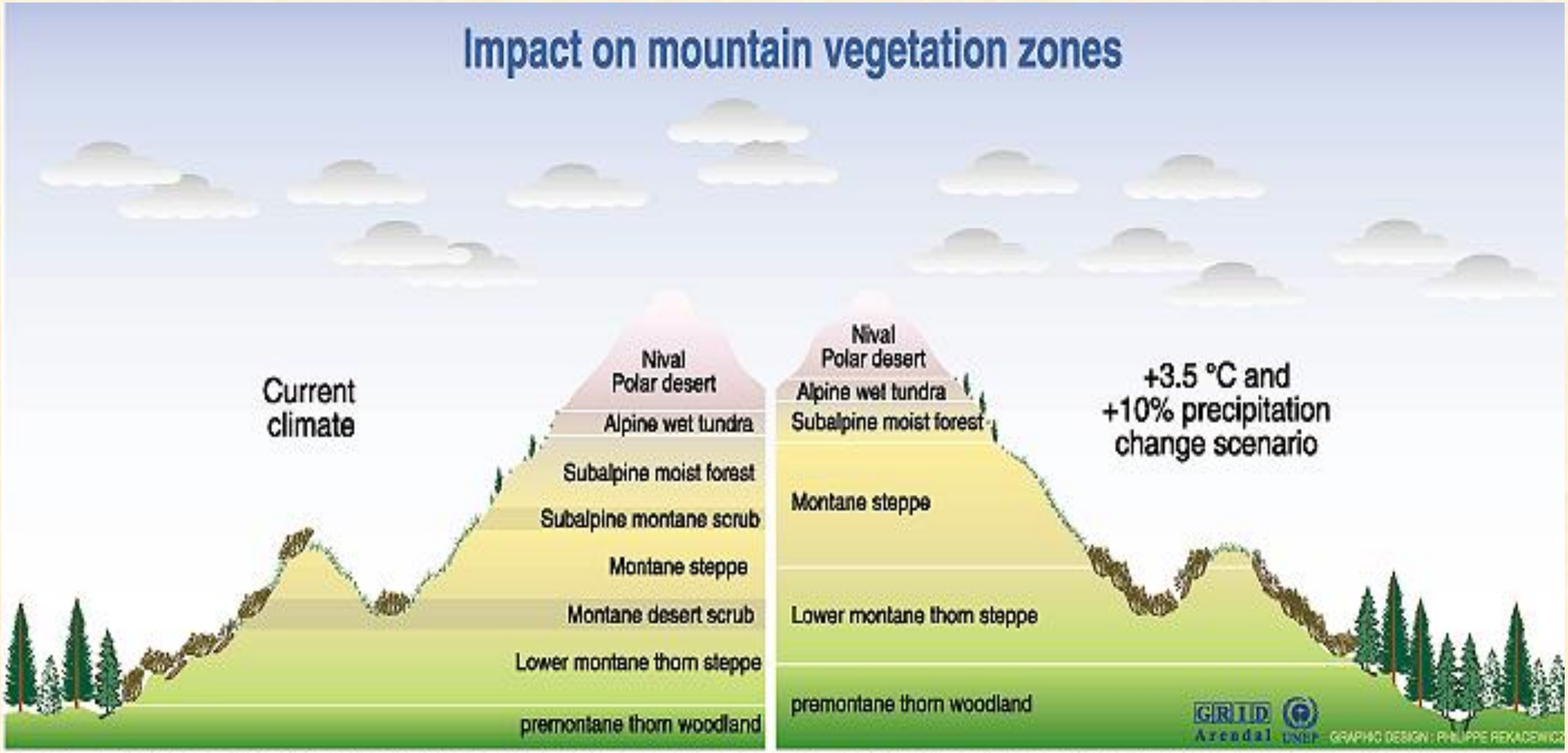


Climate-related Resources

- Cool/cold climate as resource
- Ground-based access to a range of the atmosphere's lapse rate (cooler than surrounds) and to the cryosphere (snow, ice and very cold water)
- Orographic precipitation and runoff
- Strong seasonlity
- Diverse landscapes based on elevational gradients and altitudinal zonation; slope, aspect; micro-climates
- Forests in otherwise non-forested regions
- Refugia for species


Central Alps
Northern Prealps
Southern Prealps
4500 m
4000 m
3500 m
3000 m
2500 m
2000 m
1500 m
1000 m
500 m
Snow zone
Alpine zone
Subalpine zone
Montane zone
Foothill zone
2700 m
2400 m
2100 m
1900 m
1200 m
400 m
700 m
800 m
1400 m
2700 m
2100 m
3200 m
2500 m
1800 m
1000 m
Snow zone
Alpine zone
Subalpine zone
Montane zone
Foothill zone
2800 m
2600 m
1700 m
1500 m
1200 m
600 m
400 m
350 m
Alti- or oro-mediterranean zone
Montane zone
Super-mediterranean zone
Mesomediterranean zone
Thermo-mediterranean zone





Sources: Martin Benitson, Mountain environments in changing climates, Routledge, London, 1994; Climate change 1995, Impacts, adaptations and migration of climate change, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change (IPCC), UNEP and WMO, Cambridge press university, 1996.

Whither mountain community oriented climate change studies?

✓ Mts not a significant thread in IPCC reports, even in physical science or IAV (see this from TAR: ***7.2.2.2. Riverine, Coastal, and Steeplands Settlements-Impacts on Infrastructure***)

✓ Some mountain issues appear in "forest", "rural" "natural resource dependent" and brief treatments of recreation/tourism

✓ Large body of work snow cover and snow sports

Whither mountain community oriented climate change studies?

- ✓ Difficult to find in IPCC assessments; TAR:

7.2.2.1.5. Tourism and recreation

The SAR noted that tourism-a major and growing industry in many regions-will be affected by changes in precipitation patterns, severely affecting income-generating activities (IPCC, 1998). The outcome in any particular area depends in part on whether the tourist activity is summer- or winter-oriented and, for the latter, the elevation of the area and the impact of climate on alternative activities and destinations. For example, in spring 1997, when conditions in alternative destinations in the Alps were poor, the number of skiers in the High Atlas in Morrocco increased (Parish and Funnell, 1999). Scotland has been predicted to have less snow cover at its lower elevation ski areas with global warming but may have drier and warmer summers for hill-walking and other summer activities (Harrison et al., 1999) (see regional chapters for other examples).

The impacts of sea-level rise on coastal tourism are compounded by the fact that tourist facility development planning and execution in many cases has been inadequate even for current conditions, leading to environmental problems such as water shortages (Wong, 1998). Furthermore, tourism businesses, which usually are location-specific, have a lower potential than tourists themselves (who have a wide variety of options) to adapt to climate change (Wall, 1998). Small island states may find themselves especially vulnerable to changes in the tourism economy because of their often high economic dependence on tourism, concentration of assets and infrastructure in the coastal zone, and often poor resident population (see Chapter 17).

Whetton et al. (1996) quantified the effects of climate change on snow cover in the Australian Alps, which illustrates the problems of snow-based recreation activities. Under the best-case scenario for 2030, simulated average snow-cover duration and the frequency of more than 60 days cover annually decline at all sites considered. However, this effect is not very marked at higher sites (above 1,700 m). For the worst-case scenario, at higher sites, simulated average snow cover roughly halves by 2030 and approaches zero by 2070. At lower sites, near-zero average values are simulated by 2030.

http://www.socioeconimpacts.org/

Go back to the SAR chapter for systematic attention to “mountain regions” and mountain communities.

5

Impacts of Climate Change on Mountain Regions

MARTIN BENISTON, SWITZERLAND; DOUGLAS G. FOX, USA

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Some attention in the published literature dribbling out (but not apparently enough to make much impression on forthcoming IPCC Fifth Assessment)

Mitig Adapt Strateg Glob Change
DOI 10.1007/s11027-013-9449-z

ORIGINAL ARTICLE

Mountain communities and climate change adaptation: barriers to planning and hurdles to implementation in the Southern Rocky Mountain Region of North America

Kelli Marie Archie

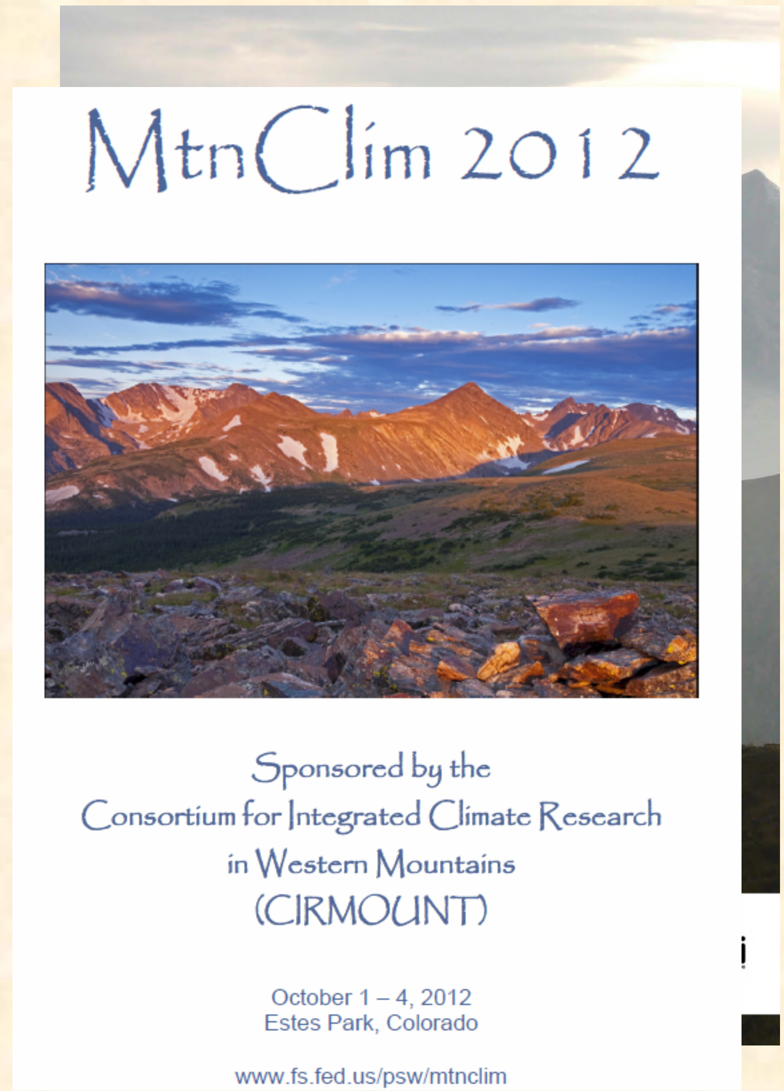
Received: 27 October 2012 / Accepted: 15 January 2013

Abstract Geographic factors make mountain communities around the world vulnerable to the direct effects of climate change, and reliance on recreation and tourism can increase vulnerability to the secondary economic impacts.The goal of this research was to investigate the current state of community adaptation planning in the Southern Rocky Mountain region of North America. Using original survey data this paper discusses the challenges that community and county officials currently face, the perceived effects of future climate change

Research and Applications Initiatives: *Scattered About*

✓ Center for Mt Studies, Perth, Scotland
✓ MtnClim conferences organized by CIRMOUNT
✓ Mountain Studies Institute
✓ Mountain Research Initiative, etc.

mri
mountain research initiative



Themes in this literature

- ✓ Mts as especially vulnerable physically snd socially (but sub-scale in climate modeling)
- ✓ Snow and snow sports at risk
- ✓ Mtn communities as recreation / resort / tourism based, and that is "especially vulnerable"
- ✓ Forest dynamics, disturbance regimes
  - ✓ Avalanche
  - ✓ FIRE
  - ✓ INSECTS (forest die off)
- ✓ Especially prone to extremes and natural hazards (though mtns not prominent in SREX)
- ✓ Difficulty of modeling climate change in mtns

Long and established research thread on snow cover and snow sports; this classic has been among the top five cited articles from *MRD*.

Mountain Research and Development Vol 21 No 4 Nov 2001: 335–339

The Vulnerability of the Snow Industry in the Swiss Alps

Hans Elsasser
Paul Messerli

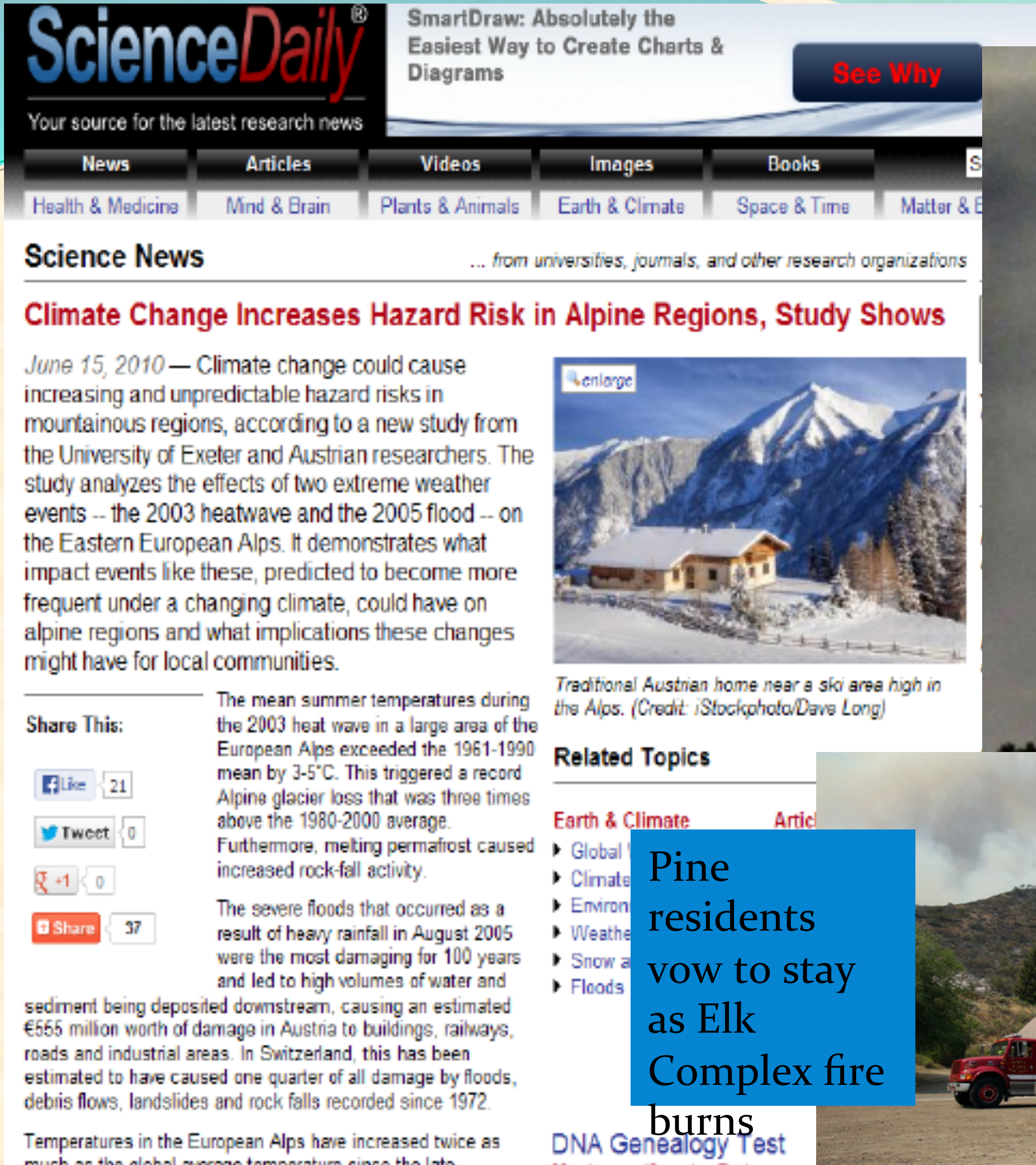
The future of Swiss alpine winter tourism must be reassessed in view of global climate change in order to determine possible strategies for overall development of mountain regions. At present, 85% of all Swiss ski areas still have sufficient snow cover. A 300-m rise of the snow line, however, would reduce this to about 63%. As a consequence, skiers will expect more artificial snow, go on winter holidays less often, and concentrate on ski areas at higher altitudes. On the supply side, climate change will be used to justify increased use of artificial snow and advances into areas above 3000 m. This raises a variety of new problems, both economic and ecological. Developments in the Swiss snow industry indicate the rise of 2 distinct classes of tourist resorts. Climate change may increase economic pressure in terms of capital concentration and division into "winners" and "losers." Although global climate change certainly has an influence on tourism, it is not the only factor that determines the conditions of tourism.

FIGURE 1 Situated at an altitude of 1559 m, the ski resort of Saas Grund in the Valais currently has "reliable snow cover." This view shows a ski field at 2400 m. (Photo by Suter Rud, Keystone)

Introduction

Tourism, particularly winter tourism, still plays a very important economic role in Swiss mountain areas. Sufficient snow cover at the right time is an indispensable prerequisite for the economic survival of alpine winter sports resorts (Figures 1, 2). Among the diverse needs expressed by vacationers in ski areas, reliable snow cover is the first priority. A combination of Swiss tourism research and practical experience has established the following definition of reliable snow cover (*Schneesicherheit*):

Hazards theme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Climate Change Increases Hazard Risk in Alpine Regions, Study Shows

June 15, 2010 — Climate change could cause increasing and unpredictable hazard risks in mountainous regions, according to a new study from the University of Exeter and Austrian researchers. The study analyzes the effects of two extreme weather events -- the 2003 heatwave and the 2005 flood -- on the Eastern European Alps. It demonstrates what impact events like these, predicted to become more frequent under a changing climate, could have on alpine regions and what implications these changes might have for local communities.

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The mean summer temperatures during the 2003 heat wave in a large area of the European Alps exceeded the 1961-1990 mean by 3-5°C. This triggered a record Alpine glacier loss that was three times above the 1980-2000 average. Furthermore, melting permafrost caused increased rock-fall activity.

The severe floods that occurred as a result of heavy rainfall in August 2005 were the most damaging for 100 years and led to high volumes of water and sediment being deposited downstream, causing an estimated €555 million worth of damage in Austria to buildings, railways, roads and industrial areas. In Switzerland, this has been estimated to have caused one quarter of all damage by floods, debris flows, landslides and rock falls recorded since 1972.

Temperatures in the European Alps have increased twice as much as the global average temperature since the late

enlarge

Traditional Austrian home near a ski area high in the Alps. (Credit: iStockphoto/Dave Long)

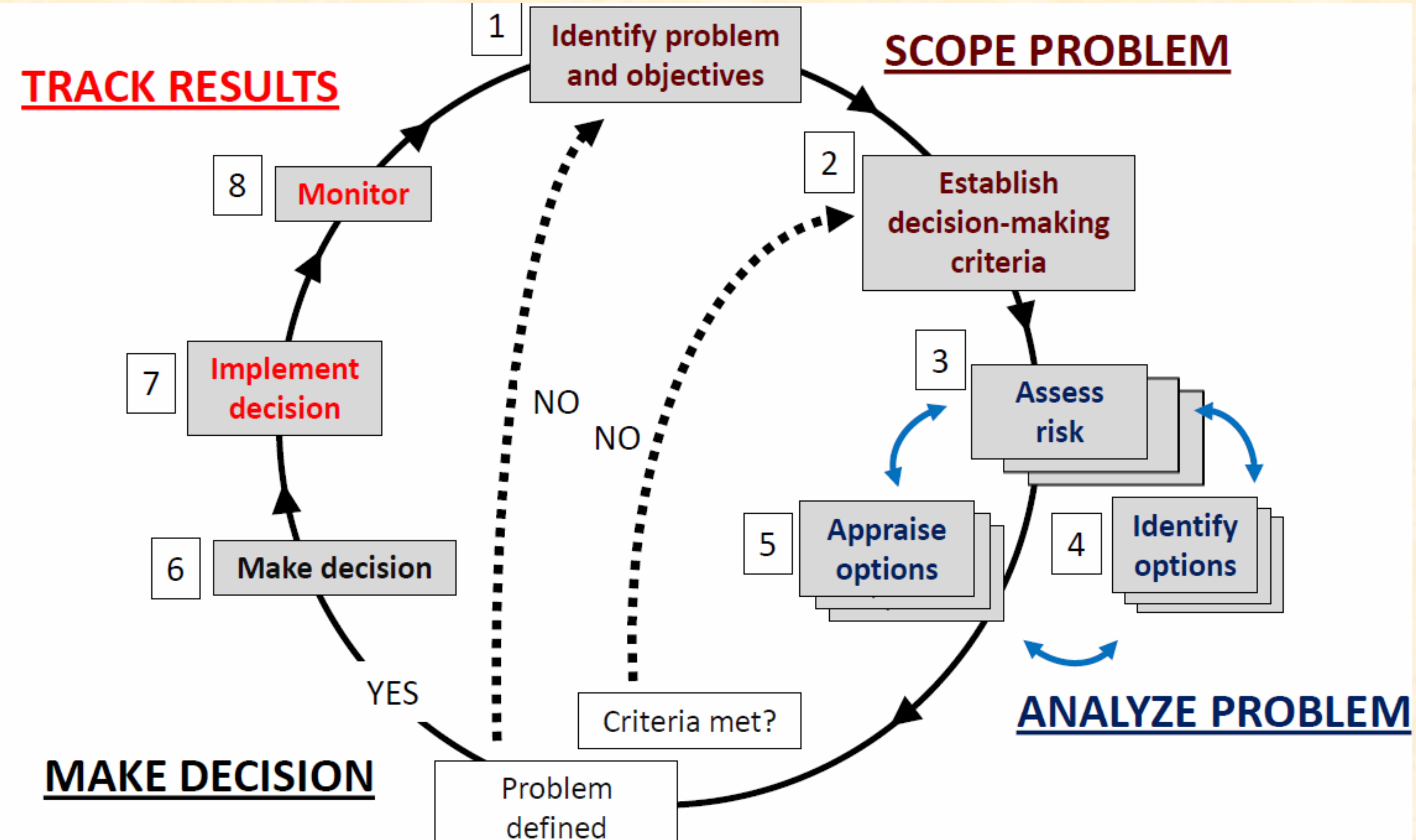
Related Topics

Earth & Climate
- Global
- Climate
- Environ
- Weathe
- Snow a
- Floods

Artic

Pine residents vow to stay as Elk Complex fire burns

What would a "risk and response" analytical and planning posture look like for mtn communities?



Source: America's Climate Choices
National Research Council, 2010.

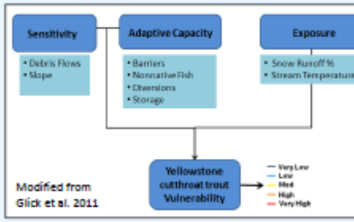
A vulnerability assessment tool for adapting Yellowstone cutthroat trout to climate change on the Shoshone National Forest

Janine Rice[1], Linda A. Joyce[2], L. Scott Baggett[2], Ray Zubik[3], Bryan Armel[3], Kerri Cary[3], and Greg Bevenger[4]

YELLOWSTONE CUTTHROAT TROUT

Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*) are a cold-water salmonid of special concern that has been considered for listing under the Endangered Species Act. These native fish occupying Wyoming, Montana, Idaho, Utah, and Nevada have experienced population distributions reductions to 42% of their historical range, of which 28% is occupied by genetically unaltered populations (Gresswell et al 2011). This reduction has been attributed to the introduction of nonnative fish species as well as anthropogenic activities, and the trout is expected to be sensitive to climate change (Rice et al. in review). A case study on the Shoshone National Forest, WY has been conducted by the Forest Services' West wide Climate Initiative. One effort of this case study has developed a vulnerability assessment tool for Yellowstone cutthroat trout in order to assist in the development of climate change adaptation strategies that support and guide planning and decision-making efforts .

METHODS



Modified from Glick et al. 2011

A customized vulnerability framework for Yellowstone cutthroat trout was developed using GIS based data indicators.

Sensitivity was represented by indicators for Debris flow presence (GIS hazard maps) and Stream Slope (NHDPlus and 30m DEM)

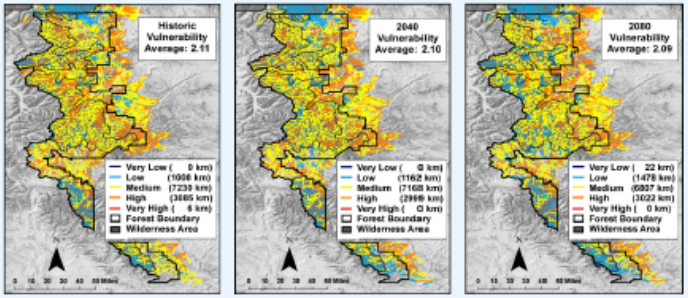
Adaptive Capacity was represented by indicators for Barriers (protective and inhibiting) and Nonnative fish (WY Game and Fish GIS Data), Diversions (WY Water Resource Data), and natural and manmade water Storage (NHDPlus)

Exposure was represented by indicators for Snow runoff % (VIC Snow projections using A1B scenario, Wenger et al. 2010), and Stream Temperature (regression model using A1B GCM temperature projections from Littell et al. 2011)

Rankings for the indicators were averaged and categorized into 5 vulnerability categories.

RESULTS

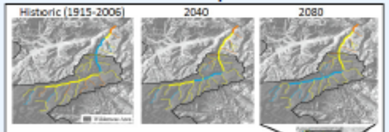
The amount of High and Very High vulnerability classified stream miles decreased, while the amount of Low vulnerability classified stream miles increased by 2040 and 2080. Higher elevation mountains tended to have improving conditions due to warming stream temperatures and retention of snowmelt-dominated runoff, while lower elevation areas especially on the east side of the Shoshone tended not to have improving conditions due to more rain-dominated runoff. The resulting vulnerability conditions point to the Shoshone's higher elevations serving as a refugia for Yellowstone cutthroat trout under climate change.



IMPLICATIONS FOR MANAGEMENT

Conservation Project Planning

Conditions Improve

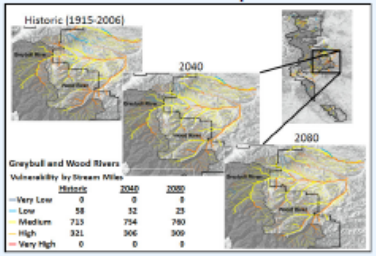


Dead Indian Creek Vulnerability by Stream Miles

	Historic	2040	2080
Very Low	0	0	0
Low	14	11	21
Medium	44	53	43
High	14	8	8
Very High	0	0	0

The Dead Indian Creek project removed nonnative fish species from the main tributary of this natural barrier protected stream and stocked genetically pure Yellowstone cutthroat trout in 2010. This assessment result provided evidence that Yellowstone cutthroat trout at the Dead Indian Creek watershed may see improving habitat conditions over time.

Conditions Don't Improve

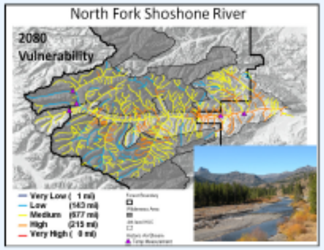


Greybull and Wood Rivers Vulnerability by Stream Miles

	Historic	2040	2080
Very Low	0	0	0
Low	58	32	23
Medium	713	754	780
High	321	306	309
Very High	0	0	0

The Greybull and Wood Rivers did not show improving conditions due to more rain-dominated runoff that offset the positive effects of stream temperature warming. Potential restoration projects in this area may not see improving conditions under climate change.

Monitoring



Resource managers on the Shoshone used the vulnerability assessment tool to guide monitoring planning by identifying areas of improving conditions and higher adaptive capacity, and where gradients of vulnerability were defined in watersheds. The North Fork Shoshone River was chosen as a focus area for a monitoring project as it provided a range of vulnerability, adaptive capacity, and climatic conditions. Many high elevations of this area showed improving conditions that could be targeted for future conservation projects. Continued monitoring could provide more detailed guidance as to when streams that are currently too cold to support Yellowstone cutthroat trout may become thermally suitable. The choice of this watershed for monitoring offered a further benefit as gathered information would be representative of climate conditions and potential vulnerabilities that may occur outside of the study area where monitoring information does not exist.

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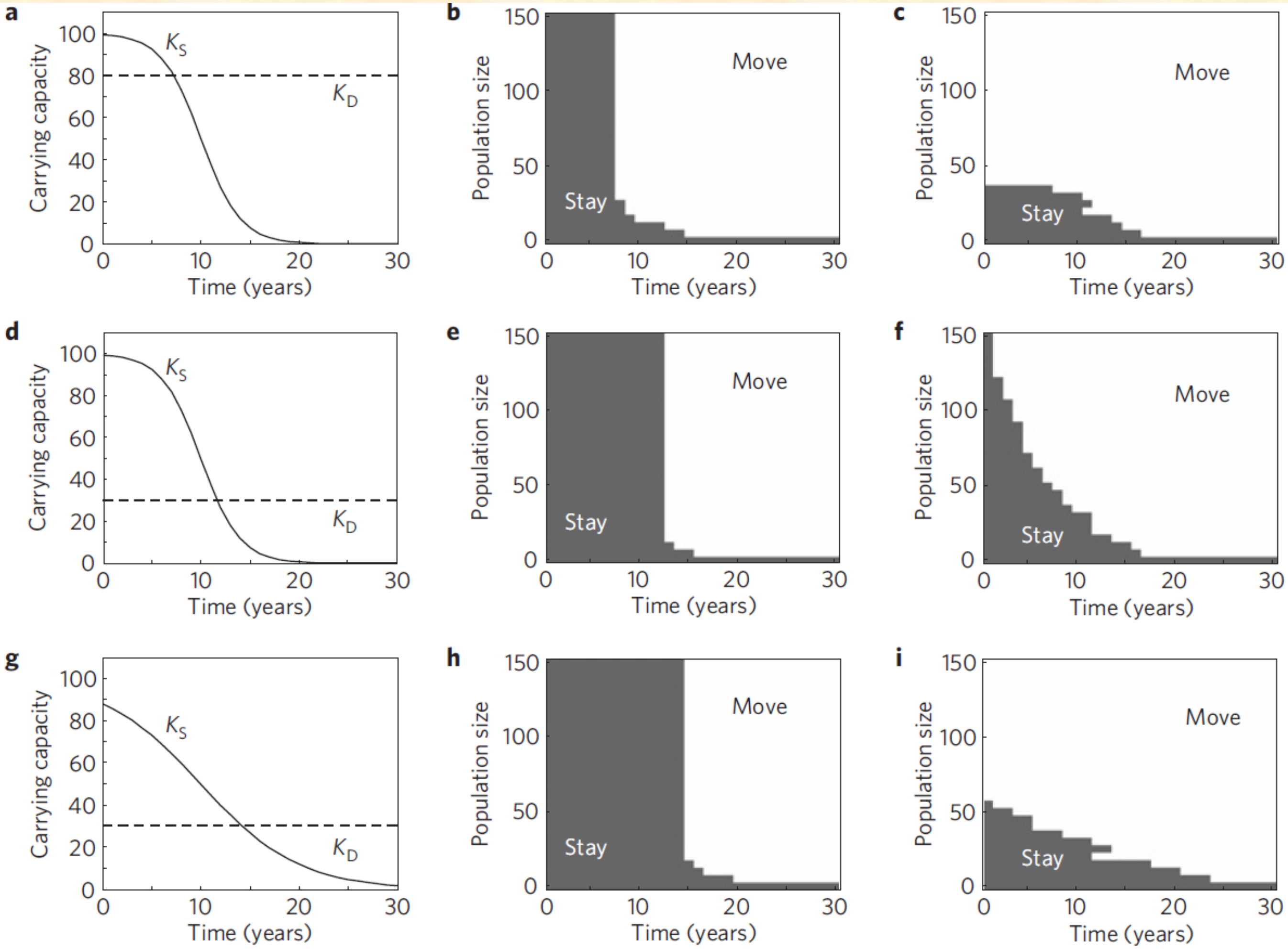
nature climate change

LETTERS

PUBLISHED ONLINE: 24 JULY 2011 | DOI: 10.1038/NCLIMATE1170

Optimal timing for managed relocation of species faced with climate change

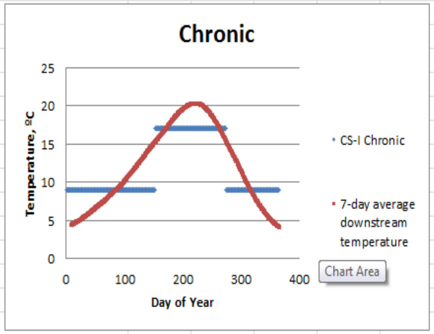
Eve McDonald-Madden[1,2,3]★, Michael C. Runge[4,5,6], Hugh P. Possingham[2,3] and Tara G. Martin[1,3]

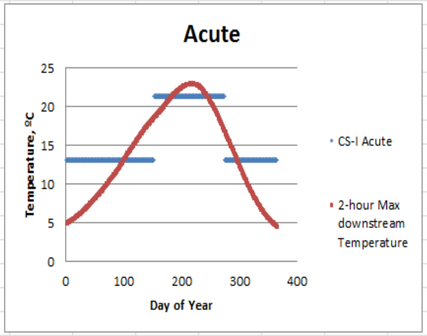


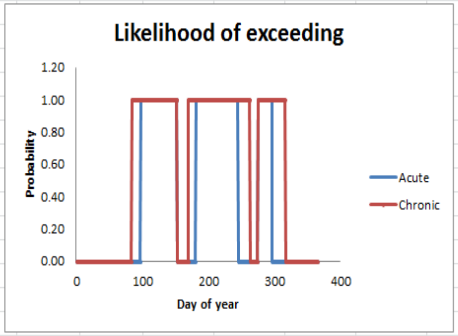
WWTP.DST.model.08132013 - Microsoft Excel

B8: =RiskNormal(B12,B13,RiskStatic(B12))

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
INPUTS														
			WS-I Chronic	WS-I Acute	WS-II Chronic	WS-II Acute	WS-III Chronic	WS-III Acute	CS-I Chronic	CS-I Acute	CS-II Chronic	CS-II Acute		
Stream Temperatures Tier Chronic	8		2	3	4	5	6	7	8	9	10	11		
Stream Temperatures Tier Acute	9													
Elevation (ft)	5826													
Month	1	1	2	3	4	5	6	7	8	9	10	11	12	12
Day of the year	1	15	46	75	105	135	166	196	227	258	288	319	349	365
Stream Discharge mean (cfs)	23.7	23.2	20.3	23.5	47.4	123.1	245.4	200.3	84.8	42.6	23.3	23.3	24.3	23.7
Effluent Discharge mean (cfs)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Stream Discharge mean (cfs)	23.7	23.2	20.3	23.5	47.4	123.1	245.4	200.3	84.8	42.6	23.3	23.3	24.3	23.7
Stream Discharge variation (cfs)	18.5	16.2	10.3	10.2	31.0	77.3	141.0	137.0	49.1	21.7	13.2	11.5	20.7	18.5
Effluent Discharge mean (cfs)	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Effluent Discharge variation (cfs)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5







Vulnerability vs. Adaptability

- ✓ Habitat diversity = resilience?
  (that's the roots of sustainable pastoralism, "Balancing on a Alp")
- ✓ Relative cool climate: lapse rate means always cooler than surrounds
- ✓ Orographic precip: better to be at the headwaters, no?
- ✓ Refugia