

## **NOTES – Climate Change and Biodiversity in the Southwest: Assessing Vulnerability, Building Resilience**

A presentation to the Carson/Santa Fe National Forests Climate Change Adaptation Workshop  
Ghost Ranch, Abiquiu, New Mexico  
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### **1 – TITLE – Climate Change and Biodiversity in the Southwest: Assessing Vulnerability, Building Resilience**

Thanks to the workshop organizers for this opportunity to present information about climate change and biodiversity in the Southwest. I'm here this morning representing both The Nature Conservancy's New Mexico chapter and the Southwest Climate Change Initiative, which includes many federal, state, tribal and local partners as well as our chapters in Arizona, Colorado, New Mexico and Utah.

### **2 – Introduction**

It's rare we see a headline such as "climate change will make life easier for Mexican spotted owl." In fact, every day it seems there are more headlines like these in the popular press and scientific literature, increasing our sense of urgency about preparing for climate change. As resource managers, we want to know what climate change means for the things we care about – species, habitats, ecosystem services like water supply – and, of course, we want to know what we can do to reduce adverse impacts.

I'd like to state my take-home messages right up front. First, the climate of the Southwest has already changed, and it is affecting biodiversity – ecosystems, ecological processes, habitats and species – in ways we can see and measure. Climate change is likely to accelerate in the coming decades, transforming the Southwest beyond recognition, in a discontinuous, non-linear and altogether messy way, into what have been called "no-analog" ecosystems – species assemblages the likes of which have never been seen.

The second message is a positive one. Thanks to our powers of observation, analysis and foresight, we have opportunities for to foster sustainability – that is, action that we, as natural resource managers and conservationists, can take now to help ecosystems change without loss.

In fact, we have enough information about the trajectory of climate change to take action – and we already have many of the management tools we need. But, to succeed, we must change the way we set goals and priorities, how and where we conduct treatments, and how we monitor conditions and effects.

### **3 – Overview of the Talk**

I'll provide a broad summary of observed and projected ecological effects in the region, drawn from the literature and expert interviews. Then I'll share findings from our recently-published

assessment of climate change and its effects on biodiversity in New Mexico, Arizona, Colorado and Utah. Thirdly, I'll touch on our four climate adaptation pilot projects in the Jemez Mountains, the 4FRI area in northern Arizona, the Gunnison Basin in Colorado, and the Bear River Basin in Utah. I'll close by identifying some regional and local implications and lessons learned.

#### **4 – Ecological Effects of Climate Change: Basic Principles**

Let's start with basic principles: Living things are intimately connected to their physical surroundings. Ecosystems are affected by changes in, temperature, rainfall/moisture, pH, salinity, activities and distribution of other species, and many other factors

This is the foundation of ecological classification systems and maps like Bailey's ecoregions and the Terrestrial Ecosystem Survey, which tightly links ecosystems to local and regional climates that were believed to be relatively stable. They assumed something that hydrologists call "stationarity," a concept that suggests that conditions in the future will track conditions in the past, and that we can manage them accordingly.

#### **5 – Ecological Effects of Climate Change: Factors and Interactions**

As a result of climate change, species and ecosystems are experiencing changes in ranges, timing of biological activity, growth rates, relative abundance of species, cycling of water and nutrients, and amplified disturbances from fire, insects, and invasive species.

Even small changes can have significant effects on living things, depending on which climate factors to which they are sensitive: soil temperature in January, water temperature in July, earliest or latest frost, and so on.

Each species is affected by such changes individually, but those individual impacts can quickly cascade through the network of life that makes up an ecosystem.

#### **6 – Range and Ecotone Shifts**

About 40 percent of wild plants and animals that have been studied over decades are relocating to stay within their tolerable climate ranges. Examples include dozens of plants on Mt. Lemmon in the Santa Catalina Mountains of southern Arizona, and the well-documented expansion of piñon pine into ponderosa pine forests and ponderosa pine into mixed-conifer forests in the Jemez Mountains.

Some organisms—those that cannot move fast enough or those whose ranges are actually shrinking—are being left with no place to go. For example, as alpine climates shrink, so too shrink the habitats of animals that call these areas home, such as the alpine butterflies of the Sangre de Cristo Mountains. I'll give more examples of distribution shifts in the Southwest in a few minutes.

## **7 – Shift or Disappearance of Local Climates**

It's important to understand that local climates will not simply shift northward or uphill. Earl Saxon and colleagues used climate projections in a 2005 paper to show that, while some local climates – unique combinations of ranges in climatic variables – will move to new locations, others will disappear. This poses obvious risks for species that are adapted to these disappearing climate envelopes.

## **8, 9 & 10 – Species Move Individualistically**

It's also important to note that species will move independently, not as the assemblages we are familiar with. For example, piñon and juniper, which of course now co-occur, may well dissociate and form communities that we'll have to call P-O woodlands or P-G woodlands.

In other words, familiar communities will dissociate through a combination of death and migration, eventually re-aggregating in uncharacteristic and probably surprising ways.

## **11 – Changes in the Timing of Biological Activities**

Some seasonal biological activities are happening 15-20 days earlier than several decades ago:

- Trees blooming earlier
- Migrating birds arriving earlier
- Butterflies emerging earlier

Changes in timing differ from species to species, so ecological interactions are disrupted.

If all of the species in an ecosystem shifted their seasonal behavior in exactly the same way, shifts in the timing of biological activity might not create problems. But when a species depends upon another for survival and only one changes its timing, these shifts can disrupt important ecological interactions, such as that between predators and their prey.

## **12 – Population Decline**

Species can be stuck with nowhere to move as warmer temperatures, and formerly lower-elevation species, creep up to higher elevations.

Here's an example from another part of the West. From 1898-2008, there was a nearly five-fold increase in the rate of local extinction of American pikas. During the last ten years, there was an eleven-fold increase in the rate of upslope range retraction compared to during the 20<sup>th</sup> century. Four of ten local pika extinctions have occurred since 1999, and across this ecoregion the low-elevation range boundary for this species is now moving upslope at an average rate of about 145 m/decade. The cause, studies suggest, is simple heat stress.

### **13 – Habitat Disruptions**

Earlier springs and warmer summers are beginning to have a major impact on trout streams of the western U.S.. With mountain snow melting earlier in the spring, the cool snowmelt water that used to flow through late summer is now slowing to a trickle.

In Utah and Wyoming's Bear River Basin, for example, Bonneville cutthroat trout populations are already fragmented by irrigation dams and diversions. Thermal imagery for the basin shows that summer water temperatures are increasing and some reaches have become too warm for trout. Moreover, the risk of severe fire in headwaters is increasing, increasingly the likelihood of suffocation by catastrophic ash flow. The map on the lower right, produced by Trout Unlimited and Utah State University scientists, is an innovative way to measure and map climate change vulnerability, with the most vulnerable areas shown in red.

### **14 – Interacting Stresses**

The Mexican spotted owl faces habitat loss, what with some projections that more than 40% of the ponderosa pine forest of northern Arizona will die off and be replaced by other natural communities in the 21<sup>st</sup> century. What will happen to the Mexican spotted owl, which already faces stresses from habitat degradation, small population size and damaging wildfire?

In general, we do not know the thresholds for such major changes – such as large-scale forest dieback or species extinction – before they occur. This example highlights the threat that a stressful event that would not normally trigger a dramatic ecological change may do so when an ecosystem and a species are subject to many interacting stresses.

### **15 & 16 – Southwestern Regional Analyses – Overview**

Turning the page on this survey of the effects of climate change on biodiversity, let's now take a look at the results of our regional and local studies of how habitats, watersheds and species have already been exposed to warming over the past 60 years. When we began this assessment in 2009, no study had yet looked at the distribution of T change across the units on which many managers focus: habitats, watersheds and species.

The foundation of our analysis is a look at how the temperature changed from 1951 to 2006, based on the best available, most comprehensive climate data from the past fifty years: PRISM data. We started with a retrospective look because (1) we wanted to know how the climate has already changed and how this is affecting ecosystems, and (2) empirical data is not subject to the kind of uncertainty inherent in climate projections.

On the map on the right, decreases in MAT are shown in green, increases from yellow to red, with red indicating the greatest warming. These results reflect an increase in MAT of between 1

and 2 degrees F. Maybe the most important finding from this analysis is that the climate has warmed at different rates, which means that global warming will have different effects across the Southwest.

Now I'll step us through a handful of slides that capture the results of our assessment of (1) habitats, (2) watersheds and (3) species.

### **17 – Habitat Exposure**

To assess exposure of southwestern habitats, we overlaid the temperature trend map with a map of major habitat types. This revealed that 90% of habitats in the Southwest have been subjected to significantly warmer air temperatures over the past 55 years.

It also showed that some habitats have been exposed to twice as much warming as others. For example, temperatures were as much as 2 degrees warmer in some alpine and desert habitats than in our reference period (see the red box on the right). Other habitats, such as shortgrass prairie, did not warm as much (orange box on the left). (Investigation of the mechanisms causing differential temperature change was beyond the scope of this study.)

### **18 – Habitat Vulnerability**

The next step in the habitat analysis involved a rough estimate of vulnerability to climate change. We placed habitats into 4 vulnerability classes based on two variables: temperature increase and number of species of conservation concern. The greater the temperature change and the larger the number of species of concern, the more vulnerable we assumed the habitat type to be. This analysis is coarse in that it assumes equal sensitivity to increase in MAT across habitat types and species. But it may be useful in that it highlights broad trends in exposure.

Our analysis suggests that the most vulnerable habitats include subalpine forests, piñon-juniper woodlands and sage shrublands.

We reviewed the literature for effects of warming on habitats and species and found that effects attributable to climate change have been documented already in at least 40% of the habitats of the Southwest, involving at least 119 species. Changes in ecological processes such as fire and insect outbreaks may lead to greater impacts on more species because these disturbances may affect millions of acres.

### **19 – Watershed Vulnerability**

Let's move to our analysis of the distribution of temperature change across large watersheds. We used the same method as the habitat analysis, except that we considered only aquatic and obligate wetland species that are likely to be dependent on hydrologic regimes affected by climate change.

We found that 70%, by area, of large watersheds have been exposed to a rise in mean annual temperature.

The most vulnerable watersheds, with respect to level of warming and number of species of concern, are shown in dark red on the map. Clearly this is a first approximation, given the many interacting factors that contribute to vulnerability (exposure, sensitivity and adaptive capacity). But this analysis provides a regional overview – a first approximation.

Our literature review revealed that hydrological changes associated with climate change have already been documented in at least half of the Southwest's HUC-6 watersheds. These changes include snowpack reductions and a shift in the timing of peak stream flow earlier in the spring— observations consistent with regional warming.

## **20 – Ecological Effects – Review**

Our assessment of the ecological effects of regional climate change, based on literature review and expert interviews:

- Warming is having impacts on both distribution and phenology: the timing of biological events such as migration and flowering.
- Warming is amplifying the effects of natural disturbances, causing ecological thresholds to be crossed and ecosystems to be transformed.

An important new paper on southwestern forests reinforces the latter point. Williams and colleagues suggest that, with only two more droughts similar to or worse than recent events, forested area of the Southwest could be reduced by >50% due to the deadly interactive effects of warming and drought.

## **21 – Management Implications**

Our analysis carries implications for planning and management at the regional scale:

- Use adaptive management and monitoring to test our assumptions about climate change, and to evaluate the effectiveness of the actions we take to moderate impacts.
  - ✓ We have a fifty-year ongoing experiment in T change going on now. Let's take advantage of existing monitoring data and programs to investigate whether the effects of climate change on species and habitats are recorded – and whether our interventions are successful.
  - ✓ Redesign or intensify existing monitoring programs so that we can detect and respond to change – especially extreme events -- quickly
- Coordinate management of shared habitats and species across jurisdictions. We've shown the range of P-J in the map at right, with the colors indicating level of temperature change.

- ✓ There's variability in temperature change across the range of P-J. Different management units fall into the high end or low end of temperature change, meaning that managers should be talking with each other about how to manage the habitat for sustainability.

## **22 – Landscape Demonstration Adaptation Projects – Overview**

- Build understanding of how rapid climate change will affect the landscape; assess vulnerability of species and habitats.
- Resetting goals in the context of a warmer world with more frequent and deeper drought.
- Identify strategies for building resilience and reducing negative impacts: what, how much, where, when, at what cost?
- Set priorities among the many strategies identified at the workshops.
- Follow up on workshop, developing on-the-ground projects.

## **23 – Lessons Learned**

There is no recipe book for climate adaptation. But I'd like to offer a few principles for building ecosystem resilience.

1. **Stable climates and ecosystems are history.** Climate impacts will require big changes in the way we manage fire, water and biodiversity, including reprioritizing or abandoning some ecosystem types or species, revising goals, or modifying management actions.
2. **Embrace change** – it's unavoidable and accelerating – but find ways to minimize damage to water supplies, habitats and species.
3. **We have enough information about climate change and its effects to take action now.** Incorporating climate considerations into project must become the new normal. Use the climate and hydrological science produced by NCAR, the Western Water Assessment, CLIMAS and Forest Service Research to understand and respond to local effects – it's robust, it's available now, and it's highly relevant.
4. **We have many of the tools we need** to get started on building resilience and reducing adverse effects. Some management strategies will be effective in a variety of scenarios. Invest in these, and then experiment with other promising approaches.
5. **Network, coordinate and monitor** across jurisdictions, documenting your goals, assumptions and activities, and monitoring the results. This is more important than ever as ecosystems disintegrate and reassemble across the continent.

## **24 – There is no Planet B**

In closing, the time is now for us to take action to sustain ecosystems: **we are informed and we have the tools.** We cannot afford to let water supplies fade away and species disappear.