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Wildlife Adaptation to Climate Change

Field Review

A White Paper Prepared by

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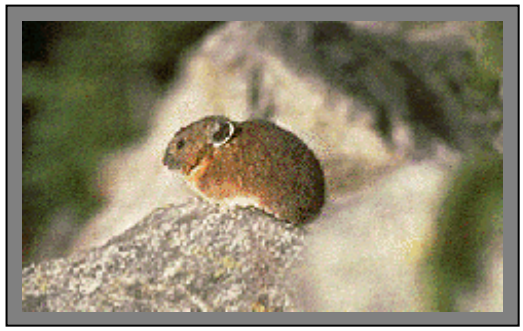

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I. Summary

Environmentalists and others have been working for nearly two decades to limit and reduce the pollution that is causing global warming. In the midst of this fight, talking about how people and wildlife may need to adapt to inevitable, indeed, already manifest, climate change was viewed as a kind of sedition. Within the last year or so, however, a measure of acceptance has evolved, and climate change has come, suddenly and forcefully, to dominate the concerns of the field of wildlife conservation. This paper seeks to inform the thinking of the Doris Duke Charitable Foundation on this issue as the Foundation commences an updating and revision of its Environment Program grantmaking strategy.

The paper is based on more than 40 interviews with scientists and practitioners,[1] an extensive literature review, and a convening of NGO and government scientists. Some of the major findings include:

- The field is in flux. With a few exceptions, both policy specialists and habitat conservation practitioners are still early in the process of grappling with wildlife adaptation to climate change. While U.S.-based foundations that fund abroad have well-developed conservation initiatives around wildlife and climate change, most domestic-focused funders, like practitioners, have begun to examine and assimilate the issue only relatively recently.

- Scientists and practitioners are able to articulate a range of future needs. There was considerable overlap between the needs identified by scientists and by habitat conservationists, less so between these groups and the ideas of policy specialists. However, all agreed on the need for better modeling of species and system responses to climate change and for climate modeling at a fine scale.

- These needs, combined with a range of logical implications so far not well characterized by the field, form the basis of a series of grantmaking opportunity areas, which include: 1) refresh thinking; 2) advance knowledge and forecasts; 3) develop/refine tools; 4) test/implement tools and practices, and 5) invest in leadership.

- Considering a range of factors, the time is ripe for philanthropic action to accelerate the field's efforts to help wildlife adapt to climate change.

The paper is organized as follows: Section II offers a brief overview of the relevance of the issue to the field, Section III surveys the current state and needs of the field, and Section IV outlines a set of opportunity areas, including sample grant ideas.

[1] See Appendix A: Interview List

II. Climate and Wildlife

The Earth's climate is changing and wildlife is responding. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, released in February 2007, average global temperature has increase 0.13° C per decade over the last 50 years. This may seem like a slight change, yet according to recent scientific studies, it is proving significant. A recent meta-analysis of more than 30 studies encompassing 1,598 species indicated that 59 percent of these species showed changes in their distribution and/or life history (phenology) over the past 20 to 140 years. An additional analysis of range boundaries in the Northern Hemisphere found that, on average, species have moved 6.1 km northward and 6.1 meters upward in altitude per decade. Looking more deeply into the distributional and phenological changes, researchers concluded:

> These changes are not random, but are systematically in the direction expected from regional changes in the climate. Responses were documented in every category, across diverse ecosystems (from temperate terrestrial grasslands to marine intertidal to tropical cloudforest), and in many types of organisms (e.g., birds, butterflies, sea urchins, tress, and mountain flowers)."[2]

That such documented impacts from a warming climate are already occurring is unsettling. Even worse, however, is uncertainty about the future. What will be the impact on nature of current and near-future levels of Green House Gas (GHG) emissions? Will we succeed in reducing GHG emissions to an "acceptable" level? What will the world look like in 50 to 100 years? As one pair of academic researchers summed up in a recent volume on biodiversity and climate change, addressing only the first question:

> Clearly, if such climatic and ecological changes are now being detected, when the globe has warmed by an estimated average of only 0.6° C, then many more far-reaching impacts on species and ecosystems are expected to occur in response to the future warming predicted by IPCC (2001), which is stated to be as high as ±6° C by 2100.[3]

Unless the magnitude and rate of climate change can be contained, and unless the species that move in response to climate change can find suitable habitat, and neither is assured, extinctions are inevitable. A study in *Nature* suggested that as many as one-third of the species in many regions may be headed for extinction by mid-century due to climate change.[4]

This situation presents an unprecedented challenge to wildlife conservation: What conservation is possible in a dynamic, unstable, uncertain environment?

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[2] Information in this paragraph, and quote, from Parmesan, C and Yohe, G. 2003. *Nature.* 399:579-83.
[3] Root, T.L., and Hughes L., "Present and Future Phenological Changes in Wild Plants and Animals," in Biodiversity and Climate Change, Hanna, L., and Lovejoy, T. E., Eds, Yale University Press, 2005, p. 67.
[4] Thomas,C.D., Cameron,A., Green,R.E., Bakkenes,M., Beaumont,L.J., Collingham,Y.C., et al. 2004. *Nature.* 427:145-148.

III. Conservation in a Climate-Changed World

The scientists, practitioners, and funders who concern themselves with wildlife preservation are beginning to take on this challenge. Their efforts are uneven and in many instances, if not most, formative. For instance, in the broadest sense, scientists are far ahead of practitioners and funders in exploring the central conservation-related questions raised by climate change. Those concerned with habitat protection and management seem largely confounded as to how to translate knowledge about climate change into practice, while conservation policy specialists are consumed by a laser-like focus on current efforts to develop a funding mechanism for wildlife conservation within cap and trade legislation now making its way through Congress. Most U.S.-based foundations are just starting to formulate their thinking on the issue.

To be fair, until as recently as a year ago, the subject of adaptation, that is, accepting that a measure of climate change is inevitable and helping people and wildlife adapt to this change, was taboo. The prevailing idea was that every resource had to be put into mitigation, that is, into efforts to reduce GHG emissions. "There was a fear that if you talked about adaptation, that GHG emissions were okay, that we had to stay on message," comments one academic. Numerous practitioners both in government and nonprofit organizations echo this observation. While no one was able to explain why, nearly all the practitioners interviewed for this study agreed that only within about the last year has it become acceptable to discuss wildlife adaptation to climate change within their organization. Still, enough is now underway by enough people and organizations that their work can be assessed and their needs for the future articulated.

A. Science

Current State of the Field

Science leads practice, and this is in a way understandable. Wildlife adaptation to climate change is infused with uncertainty. Yet while uncertainty stimulates anxiety and a measure of paralysis in the practitioner, it is exciting to the scientist. Scientific careers are made by exploring uncertainty. Even so, scientific inquiry into climate impacts on wildlife is somewhat recent. Of some 866 papers written on the topic between 1899 and 2006, 40 percent were published between 2003 and 2006.[5]

While a number of avenues of inquiry are underway, two areas of scientific work on wildlife and climate change seem most well developed: impact assessments and modeling.[6] Impact assessments study and document on-the-ground effects of climate change. Most typically, these studies examine the impact on individual species or groups of species. For example, at the University of Washington, an important center for research on climate change and wildlife, there are currently 160 ongoing research projects on climate change adaptation and impacts, according to one interviewee. In

[5] Parmesan, C. Annu Rev Ecol Evol Systems. 2006. 37: 637-669. p. 640.
[6] See Appendix B for a review of current literature on wildlife adaptation to climate change.

addition, this area includes efforts to synthesize these studies into more generalized knowledge and insight into species responses.

Modeling is essential to understanding wildlife adaptation to climate change. It is occurring both within and outside the conservation field. Within the field, modelers seek to understand and predict changes in species distribution, vegetation dynamics and other areas, in response to climate change. By way of illustration, one researcher is looking into how much change in wildlife composition National Parks will experience (it may be in the range of 40 to 60 percent) and studying the implications of climate change for endangered species on several military bases.

Usually outside the conservation field, and there are notable exceptions, climatologists forecast future climate variables for various geographic scales. Climate modeling bears more explanation, as there is perhaps no question more fundamental to the concerns of scientists and land managers than, "What will the climate of my area look like in the future?"

Global climate forecasts, including those that serve as the basis for analysis and reporting by the Intergovernmental Panel on Climate Change, are derived from General Circulation Models (GCMs).[7] Run on supercomputers and housed at major research centers around the globe, GCMs simulate the Earth's climate in a series of simplified, uniform grids measuring in many cases 200km in scale. This large scale is essential for global forecasting, but it is too large for conservation practitioners to apply. For instance, a single GCM grid cell, yielding only one set of predicted temperature, precipitation, etc., may cover all of New England or much of the Rocky Mountains. The quest to more satisfactorily answer the question of what the local weather conditions will look like in the future has generated a range of efforts to develop long-term climate forecasts at a much smaller scale.

There are two main approaches to developing these finer-scale climate projections, Regional Climate Models (RCMs) and statistical downscaling. RCMs are mini-climate models. They are built from the ground up for a much smaller geographic area than a GCM, incorporating weather conditions at their boundary from GCM outputs. Because they are regional in scope, they can take into account more physical processes and yield information at a smaller scale, ranging from about 10km to about 50km. Even so, RCMs are highly complex, costly, and time consuming to run. A single simulation for four separate future decades for one scenario can take several months on a supercomputer.[8]

Statistical downscaling takes many forms. In general, it involves using statistical methods to establish a relationship between historical climate data for a given geographic area and a model. That relationship is then projected into the future to yield forecasted climate conditions. This information can be developed for a scale similar to, and even

[7] For a list of GCMs and modeling challenges and priorities, see Appendix B.

[8] There are several efforts underway to improve regional climate modeling in North America, including the Arctic Regional Model Intercomparison Project, and the recently initiated North American Regional Climate Change Assessment Program (NARCAP), managed by the National Center for Atmospheric Research and supported with NOAA funding.

finer than, RCM output. A single run can take a month on a work station. The recent assessment of climate impacts on the northeastern U.S. is an example of a study of regional climate change that used a statistically-based climate model.[9]

The approaches to statistical downscaling vary, with some people interviewed for this study claiming the models can be run on a laptop and at a scale down to 1km, and others asserting nothing less powerful than a workstation can do the work properly, and that results could not yet be predicted with confidence and at a scale less than 1/8°, or 12km.

There was general agreement that statistical methods were a necessity for now, given current computing power and the likelihood that the development of RCMs that can produce fine-scale output will take time. "I hope in five years, I'm afraid in ten, RCMs will serve this function. They're superior, but they're not ready," commented one modeler.

Climate models contain many inherent uncertainties. Most of those interviewed thought that the models were invaluable tools for habitat management so long as these uncertainties were kept in mind and the models were developed in ways that maximized the opportunity for high-confidence prediction. Others said the uncertainty in climate models made their finer-scale forecasts speculative to the point of useless. Still others cautioned that dependency upon time-consuming models could delay action based upon the basic insights about climate change that exist today.

In addition to these main areas of research – impact assessments and modeling – scientists are pursuing a broad range of other avenues of inquiry related to wildlife and climate change. One area involves research into the utility of natural systems for climate change mitigation. "Biodiversity conservation is adaptation," comments one researcher involved in this field. He cited studies that showed that more biodiverse systems drew down CO2 faster. "Diversity helps stabilize the climate," he said. Another group of scientists have begun exploring the range of issues around the question of what was to be done about species that would not be able to move or adapt fast enough to avoid critical threats from climate change. Called assisted migration, this area is very early along in seeking to develop frameworks for how to think about what species should be moved, when, and where to move them to. A current effort recently funded by NSF will bring together a panel of lawyers, economists, policy specialists to discuss the policy and other implications around assisted migration. Work is also developing on the role of protected areas, as well as policy responses.

Future Research Needs

Scientists articulated a range of research needs for the future. Their ideas fell into five categories: applied science, species and systems models, climate models, decision support/planning tools, and coordination/connections. Most of those interviewed stressed the overarching need for scientists and modelers to know the questions – specific

[9] "Climate Change in the U.S. Northeast: A Report of the Northeast Climate Impacts Assessment," Union of Concerned Scientists, October 2006.

variables, specific timeframes – practitioners want answered. Responses by scientists to the question of needs are summarized in Table 1.

B. Practice

Current State of the Field

Policy specialists and habitat conservationists have begun to integrate climate change considerations into their work. To date, policy work on wildlife funding in cap and trade legislation has been intense and productive, while land managers are beginning to ask the right questions and to pilot approaches. Still, virtually no one interviewed for this study articulated a coherent institutional approach to wildlife adaptation to climate change. Most were wrestling with what they could do to respond, and a fuzziness permeated practitioner descriptions of their efforts and plans.

There appears to be a measure of unsettledness across the field. This unsettledness seems uneven, and practitioners and their organizations seem to be in different stages of a process of making sense of the issues around climate change and wildlife. Figure 1 outlines a somewhat caricatured attempt to represent this process.

Habitat Conservation

Most of the nonprofits and the government agencies examined in the course of this study are in the midst of grappling with the issue. They have begun asking questions about how they should adjust their plans and practices, to the point of convening key players within their organizations and participating in external conferences. Still, they are at different stages of the process of what one agency official called "sense making."

In the nonprofit land conservation world, at the beginning phases of that process are groups such as small and mid-sized land trusts. Larger regional land trusts are farther along in the process. And closer to the operational end is a group like The Nature Conservancy, which has assembled a core climate science staff and participated in adaptation-related pilot projects and assessments in an organic fashion at the local level. Internationally, World Wildlife Fund-US has systematized a basic approach to integrating climate change into its conservation work. WWF published a planning framework on wildlife adaptation in 2003[10], holds a Climate Camp for its field staff, and has worked with some two-dozen WWF ecoregional projects around the world to begin to develop adaptation plans. WWF-US recently hired a new head of its climate team. Table 2 presents a summary of the current work of several selected habitat conservation organizations on the issue.

Some of the leading federal land management agencies have begun discussing adaptation and climate change in a relatively systematic fashion, with a few engaging in exploratory projects. "There's no consensus as to what we should be doing," says one agency staff

[10] WWF-US, "Buying Time: A Users Manual for Building Resistance and Resilience to Climate Change in Natural Systems." 2003. This guidebook is reportedly currently in revision.

member. "You can't jump to solutions without defining the problem." At the state level, a number of states incorporated climate issues into their State Wildlife Action Plans, while many others did not.

In addition to these organization-based efforts there are a number of multi-organizational and/or regional projects around the country that are worth mentioning. For example, the Wildlife Conservation Society has teamed up with the National Center for Ecological Analysis and Synthesis (NCEAS), and other partners, to develop guidelines for conservation planning and land management in the intermountain West. The work includes case studies in New Mexico and Greater Yellowstone which involve roundtables with a range of stakeholders, downscaling of climate data (by USGS), and assessments of adaptation options. In another case, the Western Governors Association is nearing the end of a year-long effort to develop a multi-sectoral strategy around wildlife corridors and critical habitat in the West. The work includes a climate task force which will examine how climate change will impact corridors and critical habitat. A likely outcome is a recommendation that states include climate scenarios in their planning.

Future Needs

Habitat conservation practitioners articulated a range of future needs. Their ideas fell into many of the same categories, and covered some of the same ground, as those offered by scientists, indicating the potential for productive collaboration. The categories where the ideas of the two groups overlapped include applied science, species and systems modeling, climate modeling, decision support/planning tools, and coordination/ connections. Practitioners offered two additional areas of need: pilot projects and messaging and communications. Specific responses to the question of needs by conservation practitioners can be found in Table 3.

Conservation Policy

The conservation policy organizations examined in the course of this study appeared to have something of a bi-modal response to the issue of wildlife and climate change. At one end is their work on securing funding for wildlife adaptation. The National Wildlife Federation and Defenders of Wildlife have been among those at the forefront of this effort. These two institutions, along with other stakeholders, have worked out a compromise approach, which is now in several of the leading climate change bills, including Warner-Lieberman. Given that funding of more than $9 billion a year could well be at stake, it is no surprise that this legislative opportunity has captivated these prominent policy groups.

The relatively well thought-out and well-developed approach by policy organizations on legislation contrasts with their efforts on the rest of the spectrum of policy work. Some groups have future plans to try to bring federal land managers together to discuss policy and management changes needed in response to climate change. Others have just hired staff to focus on climate and wildlife, or are in the process of doing so, and it will take time for their efforts to develop. Individual attorneys within some national groups are beginning to explore the implications of climate change impacts on wildlife for existing

laws, but these efforts have yet to coalesce into a coherent approach. The state of several selected conservation policy organizations in regards to wildlife adaptation to climate change is summarized in Table 4.

Future Needs

Conservation policy practitioners articulated a range of future needs. Their ideas were less aligned with scientists and habitat conservationists, though all three groups agreed on the need for both more climate and species/systems modeling. The policy group agreed with the habitat conservation group on the need for improved messaging around the issue. Above and beyond the ideas of these other groups, policy practitioners expressed the need for more intellectual groundwork (i.e., to further develop the arguments around wildlife adaptation funding in the climate bills in Congress), legal, policy and management reviews at the federal level, and the development of selected conservation tools. Their responses to the question of needs can be found in Table 5.

C. Funder activity

Most U.S.-based foundations with existing wildlife conservation funding programs who were interviewed as part of this study are only beginning to formulate their thinking on the issue of wildlife adaptation to climate change. Perhaps because of their contact with the climate issue through prior funding or through other areas of their foundation, U.S.-based international funders seem to be more advanced in their thinking than their domestic-oriented counterparts, though, even so, their efforts date back no more than four or five years.[11] The U.S.-focused grantmakers interviewed have at most made an initial grant or two to aid their learning and strategy development, or are just initiating taking up the issue.

International funders with more well-developed approaches include the MacArthur Foundation and the Christensen Fund. MacArthur has a history of supporting climate change mitigation work in the form of avoided deforestation. In 2005, the MacArthur board endorsed a wildlife adaptation strategy that concentrates largely on helping existing MacArthur focus areas with impact assessments, refinements in regional science, and specific issues (e.g., in Madagascar, conservation versus rice cultivation). The initiative also includes field-wide support for new technology and tools. The foundation made eight grants in September 2007 under this initiative.

The Christensen Fund has a long history of international grantmaking. Their interest is the connections between cultural diversity and biological diversity. In 2002, the foundation assessed what it would take to maintain these values in their focal landscapes over time. The implications of climate change emerged in the course of this assessment. Christensen's grantmaking is focused on local actors (150 grants were made in 2007), trying to advance both environmental management and cultural management. For

[11] As an interesting aside, a number of those interviewed observed that U.S. practitioners in nonprofits and government lag the rest of the world in thinking about both wildlife and human adaptation to climate change.

example, in central Alaska, the foundation has supported a collaboration between ecologists, natural resources agency officials, and native elders around the issue of fire. The forest ecosystem of the region did not have a history of fire, and fire is not in the native traditions. Now that fire has arrived, the stakeholders are working toward a shared view of how to understand and manage it.

Domestic-only funders with emerging approaches include the Kendall Foundation, the Wilburforce Foundation, and the Doris Duke Charitable Foundation (DDCF). Kendall started looking at their programs in light of climate change about a year ago, when it made a major strategic commitment to the issue. Water is likely to be a key element, and Kendall's longstanding investments in the Yellowstone to Yukon region and more recent Two Countries-One Forest initiative (northeast U.S. and Canada boundary) will probably be a factor. Last year Kendall made a $60,000 grant to the Wildlife Conservation Society to support the WCS-NCEAS project described above.[12]

The Wilburforce Foundation is assessing the relationship of climate to their two ongoing priorities: promoting connectivity at a continental scale and protection of ecologically effective wildlife populations. So far, Wilburforce has not seen a reason to change their focus or the kinds of grants they make, however one recent grant funded a university in British Columbia to get policy and academics together to talk about impacts from climate change.

DDCF launched a $100 million Climate Change Initiative in 2007. The initiative is focused on climate change mitigation, but will allocate some funding for wildlife adaptation. DDCF has also begun exploring the issue under its ongoing Habitat Conservation Initiative. For example, DDCF has supported research efforts to create a framework for management information needs for adaptation, develop an index of wildlife sensitivity in the U.S., and survey planning and action by states on wildlife and climate change. As part of their ongoing explorations, Wilburforce, Kendall, and DDCF jointly hosted a meeting of 14 NGO and government scientists on wildlife adaptation to climate change. A summary of the wildlife adaptation-related activities of selected U.S.-based foundations appears in Table 6.

It bears noting that while there are many foundations supporting work on climate change mitigation, this study found no grantmakers in the U.S. funding both mitigation and wildlife adaptation. An important caveat is the Packard Foundation which is considering a major investment in climate change mitigation and a climate dimension to its new western landscapes initiative. The Packard board meets in mid-March to decide.

[12] The Surdna Foundation also made a $50,000 grant to the project.

IV. Opportunity Areas

A. Overview

As has already been discussed, over the many conversations conducted in the course of this study conservation scientists and practitioners identified a number of future needs. In addition to these needs, several logical, conservation-related implications (mostly indicated in the interviews and the literature reviewed for this work) flow from the fact of a warming planet. The gap between the current state of conservation science and practice on the one hand, and the needs and logical implications which result from climate change on the other, offers potentially productive areas of opportunity for foundation investment.

Implications of Climate Change

The needs that surfaced in project interviews are summarized in Table 7. Several important implications of climate change for wildlife conservation bear highlighting:

1. Species are moving. This means that to ensure their chances of survival the barriers to wildlife movement must become more permeable. Softening what is referred to as the ecological "matrix" around and between protected areas will require softening the institutional matrix that governs the landscape. In fact, a whole slew of boundaries, both virtual and real, will need to be bridged. Chances are that this will not happen with the necessary speed or success in all cases. An increase in species-survival crises is therefore probable.

2. We have entered a world of uncertainty. Perhaps no single word characterizes the current state of wildlife conservation practice better than uncertainty. It is both an articulated need and an unarticulated source of anxiousness. What will the climate be in 10, 50 or 100 years? How will wildlife respond? Will we be able to set and meet the necessary limits on GHG pollution?

3. In light of these two implications, many fundamental aspects of the field are challenged. What is the rationale for conservation in a climate changed world? What is the conservationist's objective? How to frame, plan for, and tackle specific problems in specific places? Perhaps practitioners have had so much difficulty answering this last question because so many aspects of the current approach must be rethought and revitalized. The term paradigm shift is worn to the point of meaningless, and yet, it applies in this case. Table 8 offers a sampling of challenges to the current conservation paradigm.

Major Areas of Opportunity

Bringing together the needs identified by the field and the implications described above, five major areas of opportunity emerge: 1) Refresh thinking; 2) Advance knowledge and forecasts; 3) Develop/refine tools; 4) Test/implement tools and practices, and 5) Invest in leadership. (See Figure 2.) These areas, and a range of ideas within each of them, are discussed in the next section.

B. Motivation for Action

As a point of departure, it is worth emphasizing a central finding of this study, namely, that there is at present a singular opportunity for funders to support emerging efforts to help wildlife adapt to climate change. The general conditions that can currently be found in this area would make this a rare moment in any field. The stakes are of enormous consequence, the thinking and plans of major actors are, generally speaking, still coming together, a range of fundable gaps exist between conservation action and articulated needs and under-articulated implications, the universe of major players is relatively small and, thus, relatively manageable for grantmaking, and, finally, there exists a once-in-decades federal funding opportunity.

C. Possible Approach and Sample Ideas

Framework

So, given the state of the field and the basic areas of opportunity, how can funders invest in wildlife adaptation to climate change with greatest impact? Figure 3 offers a framework to organize and guide investment. The framework has six blocks of action. It begins with investments to help refresh the basic thinking of the field. This is followed by grants that relate to four areas of day-to-day field activity: advance knowledge and forecasts, develop/refine tools, test/implement tools and practices, invest in leadership. Lastly, given the amount of work to take place and the rapidity with which the area is developing, foundations should take stock of progress and assess future options in three to three-and-a-half years.

Ideally, the results of investments in refreshing thinking would influence the nature of grants in the four areas of day-to-day activity. However, due to the urgency of the issue, grants along these two vectors probably need to proceed in a parallel, rather than a linear, fashion. To the extent mechanisms can be developed to foster interactions between these "parallel" lines, overall grantmaking is likely to have a greater impact. Each of these six major blocks of action will be discussed in the rest of this section, with sample grantmaking ideas appearing in Table 9.

1. Refresh Thinking

A range of elements form the enabling thinking and relationships behind conservation. Most of these elements need to be challenged and refreshed in light of climate change. Five areas are highlighted here.

> ***Reinvent basic propositions.*** Investment is needed in how to think about conservation in a climate-changed world. Basic premises should be challenged. Does habitat conservation still make sense? If so, why? In what ways must it change? Should the very idea of conservation survive these challenges a set of powerful, logical arguments needs to be developed that present a convincing rationale for why wildlife habitat conservation remains important under climate

change. Within this, conservationists need to revisit and update the objectives of wildlife conservation. "We're going to have to re-evaluate what our mandates are for conservation," commented one practitioner.

For example, in many cases, species mobility poses a potential challenge to the perceived value of parks and permanent land protection activities. Given the large capital investments in land protection by government, foundations and nonprofits, it will be important to assess and re-articulate the role and value of land protection work under climate change. Practitioners may intuit that protected land will remain important for preserving evolutionary options, for habitat for the species that do not move far, and for other reasons, but funders and politicians, among others, may need their understanding and commitment renewed.

Explore/expand old limits. In practice and in policy many of the tools and laws that are central to conservation will beg re-examination and innovation. Conservationists would be wise to get out in front of the need to do so, pressing to the logical limits where possible. "'Perpetuity,' what does this mean in the context of climate change?" asked one land conservation practitioner. Permanent acquisition and easements will remain essential, however, time-limited land protection arrangements, and other tools, might also emerge as important options. The basis of land stewardship will also need to be examined, given that most landscapes are no longer static in a human timeframe. What is the object of stewardship now?

On the policy side, the need for a more permeable landscape suggests a need to reexamine, reinterpret, and possibly revise land use laws and regulations. What are the implications of climate change for federal and state and local laws and ordinances that touch upon habitat? Stream setbacks, wetlands mitigation requirements, the standard of assessment under the National Environmental Policy Act, and the Endangered Species Act (ESA) are just a few areas that might be examined.

The ESA is one area with an especially large number of associated issues. Should ESA critical habitat designations include historical range that goes farther back in time? If so, how far back? Should regulators tie coal-fired power plants in Texas to the problem of the polar bear? Can ESA experimental population provisions be an avenue for testing assisted migration? Even more fundamentally, will the pressure of increased endangered species listings pose a critical challenge to the viability of the act itself? If the 2008 election yields a reasonably favorable Congress and president, would the time have arrived to seek the long-overdue reauthorization of ESA? What are the risks in pursuing this? What are the risks in not pursuing it?

Forge new links across boundaries. The implications of climate change raise the importance of building bridges across – or eliminating – a range of boundaries. In habitat protection, management and policy, these include geographic boundaries (state, international), institutional boundaries (local-state-

federal; within a given level of government, especially federal, boundaries across agencies), mission boundaries (in particular, between land conservation and land use planning/smart growth groups), and sectoral boundaries (between government, nonprofit, private sector organizations). In science there are boundaries to cross between climate change modelers and ecological modelers, and between modelers and conservation practitioners. Finally, there is work to be done across the boundary between mitigation and adaptation.

At the highest level, mitigation has enormous implications for wildlife and those working on adaptation should remain closely connected to mitigation discussions. "Even the best designed approaches to increasing resistance and resilience to climate change will work only for changes of a few degrees at most," WWF-US writes in its climate change planning handbook. "A 650 world is very different from a 450 world," observes a conservationist, referring to the implications of different CO2 levels.

In addition to its fundamental implications for wildlife, mitigation interacts with adaptation in at least two direct ways, sequestration and alternative energy development. "Good carbon management is not necessarily good wildlife habitat," said one scientist interested in the use of forests for both mitigation and biodiversity conservation. The impacts on wildlife habitat of various forms of alternative energy (e.g., biofuels, wind) makes dialogue with those influencing mitigation strategies essential.

Shape public opinion. Decision makers and the general public understand the vivid images of the plight of the polar bear. But what do they really think about the impacts of climate change on wildlife? Which audiences will play the biggest role in shaping action on the issue? What messages do they respond to? What words? How can people be motivated to connect effectively with solutions such as funding in the pending climate legislation?

Advance funder perspectives. Most funders do not have fully evolved ways of thinking about wildlife and climate change. The potential exists for funders to learn from one another, and, perhaps, ultimately, to act in reinforcing ways. International funders with established initiatives, such as MacArthur and Christensen, would be valuable participants in a funder convening on the issue.

2. Advance knowledge and forecasts

This area of investment would seek to build knowledge about the response of critical species and ecosystems to climate change, support the development of enhanced models of future species distribution and dynamics, and accelerate the production of climate forecasts at a fine scale.

3. Develop/refine tools

In each major area of habitat conservation activity – planning, protection, stewardship, monitoring – new tools likely will have to be developed and/or old tools revised. For example, uncertainty-based tools, such as scenario planning, need to be integrated into conservation planning frameworks. These revised frameworks need to be responsive to questions about what land to purchase and how best to take care of it. "We need practical decision support tools that are easy to use and express their results in clear terms," said one conservation practitioner.

4. Test/implement tools and practices

Funding will be needed for testing and deploying new and/or refined tools. As part of this, there will be a need for capital grants that advance emerging notions of the role of permanently protected land under climate change.

5. Invest in leadership

While broad-based, competitive re-grant programs offer an effective avenue for bringing the best thinking to bear on a problem, given the fluidity of the conservation field at present on the question of wildlife adaptation to climate change, investments in the capability of leading players can offer a complementary means of shaping the field at large.

Two opportunities seem relatively compelling. On the policy side, funding the capacity of the National Wildlife Federation, Defenders of Wildlife, and others whose involvement is pivotal, to educate key players about wildlife adaptation needs could contribute to the ultimate success of efforts to secure funding for wildlife in pending climate legislation. Of course this would need to be designed carefully, with limits on foundation funding for lobbying in mind.

On the practice side, there are a number of instances where substantial investment in particular institutions could be leveraged into field-wide advance.

One example is The Nature Conservancy. TNC remains a massive, nationwide force in land conservation, and, as such, it is an important point of leverage in the land conservation system. Investments that accelerate the reworking of TNC's planning, protection, and stewardship techniques in light of climate change, and that facilitate their dissemination to other land conservation practitioners (e.g., land trusts, government agencies), could put forward momentum into wildlife adaptation efforts at multiple scales across the country.

6. Convene and take stock

In three to three-and-a-half years, convene the field to discuss what is working, what is not, and what additional work is needed.

Table 1. What Scientists Say is Needed

Area	Need
Applied Science	– More basic biological and behavioral information on species – Better understanding of corridors – butterflies and birds use even small corridors very effectively – Long-term monitoring targeted to complex, uncertain areas – More information about thresholds, especially at a regional scale. Significant habitat destruction has resulted from modest climate change. When and why do systems collapse? In the case of Pinion Pines in the Southwest and Black Spruce on the Kenai Peninsula, pests came in with a 1 degree warming.
Species/Systems Modeling	– Frameworks for thinking about which species will be fine or able to move and which will not be able to move fast enough, and specific forecasts – Estimates of where future biological hotspots will be – Better methods for forecasting species abundance within a probable range – Better understanding of competitive dynamics of new species combinations and better methods for integrating inter-species competition into species distribution models – Integrate land use into range/distribution models

Table 1. What Scientists Say is Needed (cont'd)

Area	Need
Climate Modeling	– Downscaled climate information on the scale of kilometers, not 10s or 100s of kilometers – A set of standard, well-vetted, readily accessible scenarios other researchers can use at a more local scale – Integration of land use scenarios into climate models – Regional impact studies, such as for California and Puget Sound. These give useful information for scientists
Decision Support/ Planning Tools	– Tools to help managers decide where to put resources – Scenario models for conservation planning, and a mobile scenario planning team – Planning based on a broader range of natural variability for species range, perhaps looking back 6,000 – 15,000 years
Coordination/ Connections	– Input from managers on the questions they need answered by science and climate modeling – Communication between climate modelers and conservation scientists

Figure 1. Process of Sense-Making and Action

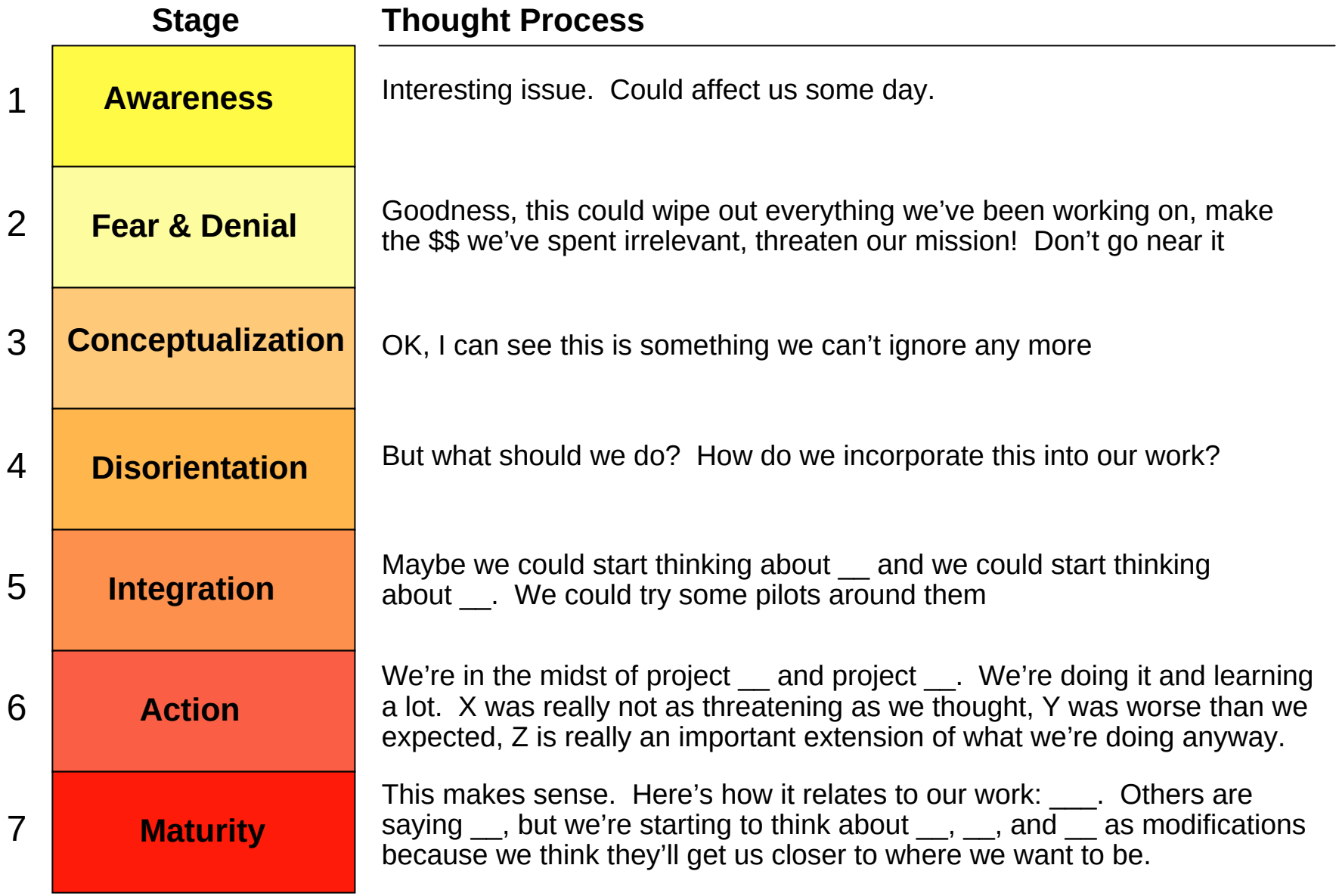

Table 2. Selected Habitat Conservation Organizations and Wildlife Adaptation to Climate Change

Organization	Current Situation
World Wildlife Fund-US	– Published handbook in 2003 – 7 scientists in Epicenter of Climate Adaptation and Resilience Building – Working with 24 of 30 WWF-US priority ecoregions – Annual Climate Camp – Looking to grow relationships with universities and other international conservation and development organizations – New head of climate program
The Nature Conservancy	– 8 climate change scientists + regional and other science staff, including modelers – Numerous assessments and projects at state level, e.g., New Mexico, California, Puget Sound, and Albemarle Sound – Considering implications for site and ecoregional planning – New planning hire charged with revising TNC planning frameworks in light of CC – New climate team head
Land Trust Alliance	– Convened leading land trust directors on climate in October 2007 – Efforts underway to develop multi-faceted approach

Table 3. What Habitat Conservationists Say is Needed

Area	Need
Applied Science	– Observations/monitoring of how the biological community is changing – Better understanding about species tolerance to changing temperature, moisture, etc. – Better understanding of what factors make an ecosystem resilient, what ecosystems are more resilient – Better coastal elevation data – Know more about water, keystone issue – Better understanding of restoration under climate change. Ecosystems may not regenerate as previously expected
Species/Systems Modeling	– What sorts of species and communities are most likely susceptible to climate change impacts – The geographic areas that are most sensitive to climate change – Connectivity. What sorts are helpful? When? – How to adapt existing protected areas to help species that will move
Climate Modeling	– Finer spatial downscaling of projected climate impacts

Table 3. What Habitat Conservationists Say is Needed (cont'd)

Area	Need
Decision Support/ Planning Tools	– For planning, acquisition, and stewardship – Tools to integrate uncertainty – Tools to aid in priority setting – Scenario building/modeling tools
Pilot Projects	– Demonstrate different approaches, then synthesize and adjust – Pilot assisted migration
Coordination/ Connections	– Across agencies on an ecological scale that makes sense – Across planners, managers, and scientists – Across wildlife practitioners and climate modelers
Messaging & Communications	– Get smarter about how to talk about this, need a communications strategy

Table 4. Selected Policy Organizations and Wildlife Adaptation to Climate Change

Organization	Current Situation
National Wildlife Federation	– Major commitment to CC mitigation last several years – 60-80 staff – Wildlife adaptation efforts initiated in 2007 – Hiring staff to focus on federal land management agencies, sea level rise – flood insurance reform, and western water issues – Focus is cap and trade $$ for wildlife adaptation and fostering discussion among federal land managers of policy and land management implications
Defenders of Wildlife	– Hosted major symposium on wildlife and climate change in fall of 2007 – Took up CC within last 18 months, decided to integrate into existing programs rather than start new program – Major focus on Congress/cap and trade $$ for wildlife adaptation – Examination of other policy areas on individual basis
Environmental Defense Fund	– Internal discussion around forging connections between mitigation work and EDF biodiversity program in process

Table 5. What Policy Specialists Say is Needed

Area	Need
Intellectual Groundwork	– Enhancements to arguments for why wildlife needs $$ from CC legislation, what the $$ can do
Species/Systems Modeling	– Impacts of mitigation on wildlife (e.g., alternative energy, sequestration, etc.)
Climate Modeling	– Standard methodology for what a regional climate is going to look like
Messaging & Communications	– New terminology to replace “range shift”, “adaptation”, etc.
Legal, Policy & Mgmt Reviews	– Review CC implications for federal land management agency practices and policies – Better understanding of CC implications for critical laws, such as ESA, water law, and the organic laws of the Forest Service and the Park Service
Conservation Tools	– Innovative protection mechanisms – Means of monetizing mitigation, e.g., payments for carbon sequestration to increase economic benefit of CRP land

Table 6. Summary of Selected U.S.-Based Funder Activity

International Funders

MacArthur Foundation

Wildlife adaptation program launched 2005

8 grants, Sept 2007:

1) Existing MacArthur regions: impact assessments, science refinements, specific issues

2) Field wide – support for new technology and tools

Christensen Fund

2002, examined needs for preservation of their focus areas

Interest is connections between cultural and biological diversity

Large numbers of grants (150 in 2007) focused on local actors

Domestic Funders

Kendall Foundation

Began to assess the issue in 2007

Water emerged as significant issue

Legacy of investment in Y2Y and 2C1F

$60K grant to WCS-NCEAS project

Wilburforce Foundation

Existing priorities are connectivity & species

Surveying field, do not see need to change at present

Recently funded a forum in BC for policy and science specialists

Doris Duke Charitable Foundation

Mitigation-oriented initiative launched 2007

Support for several adaptation-related research efforts

Assessing field

Table 7. Summary of Field Needs

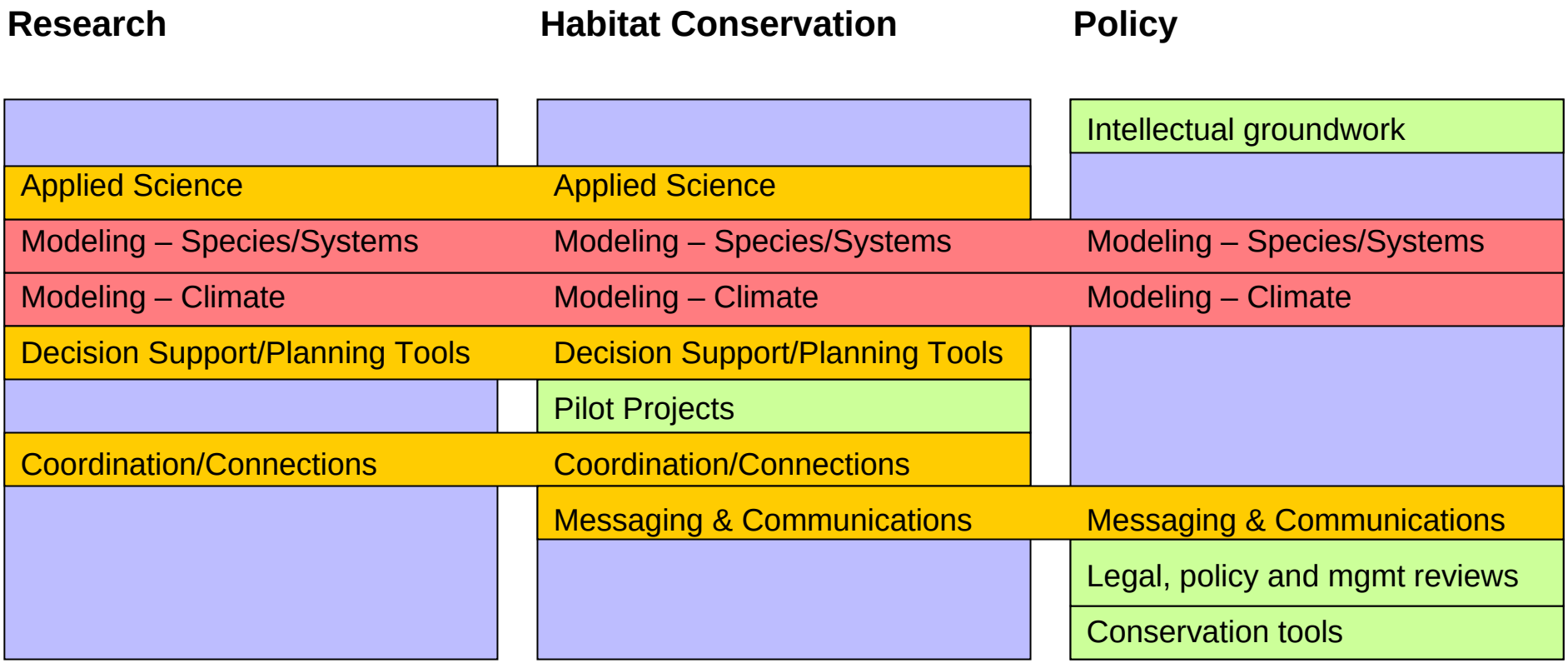

Table 8. Paradigm Challenges

Selected Element	Past	Future
Conservation target	Species static within human time scale Species, communities, landscapes	Mobile/dynamic and accelerating within human time scale Species, biogeographic features, refugia
Climate	"Normal," stable/predictable within bounds	Warming/changing, more extremes, less predictable, dependent upon mitigation
Planning horizon	5 – 10 years	5 – 10 years and 50 – 100 years
Threats	Habitat fragmentation/conversion Invasive species	Increased import – species moving Re-think some dimensions of invasives Weather extremes and disturbances
Tools **Planning** **Protection**	CAP, Ecoregional planning Permanent/acquisition Reserves	Uncertainty tools – Scenarios These plus… Time-based legal arrangements Corridors – increased import Assisted migration

Figure 2. Opportunity Areas for Foundation Investment

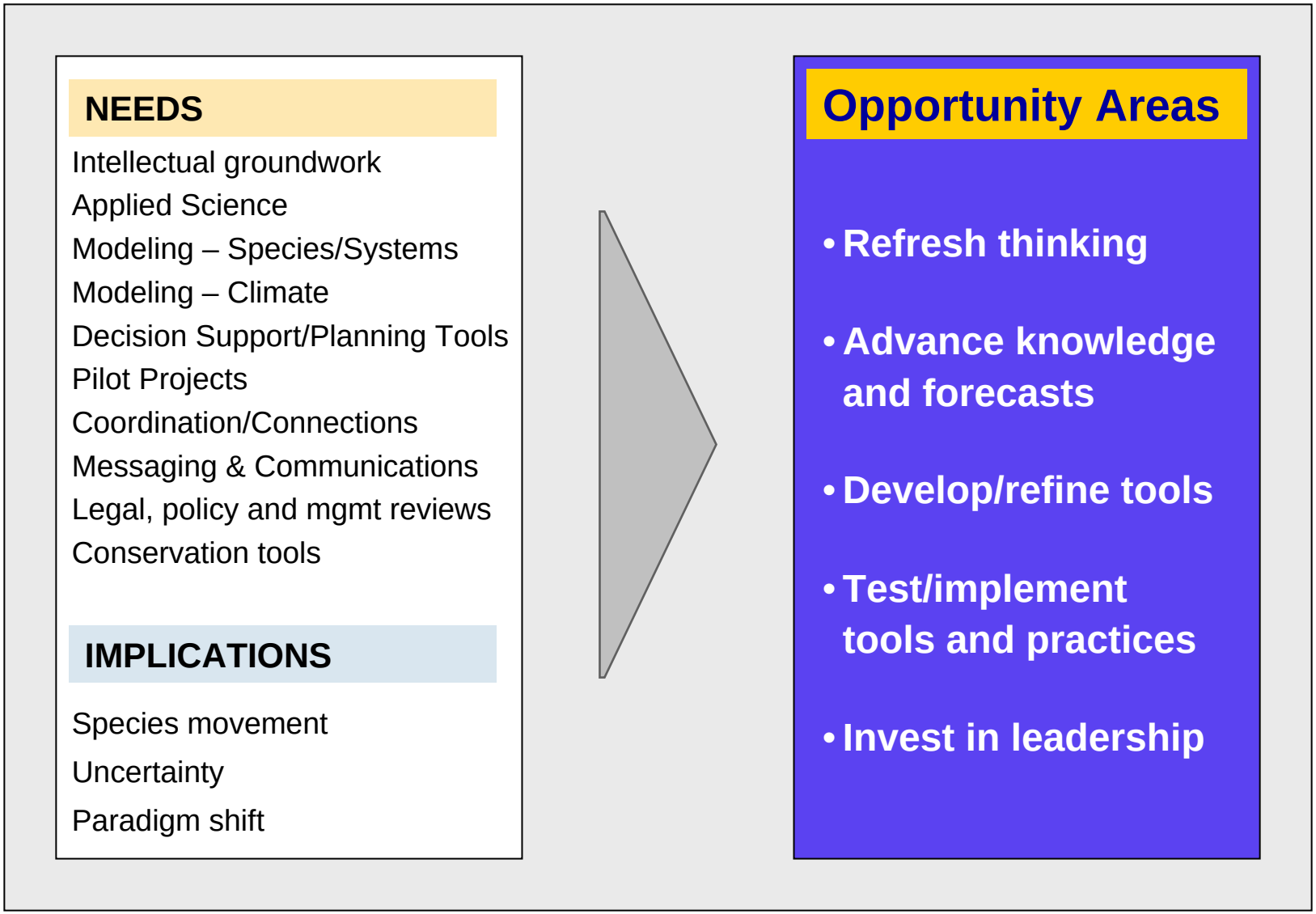

Figure 3. Investment Framework

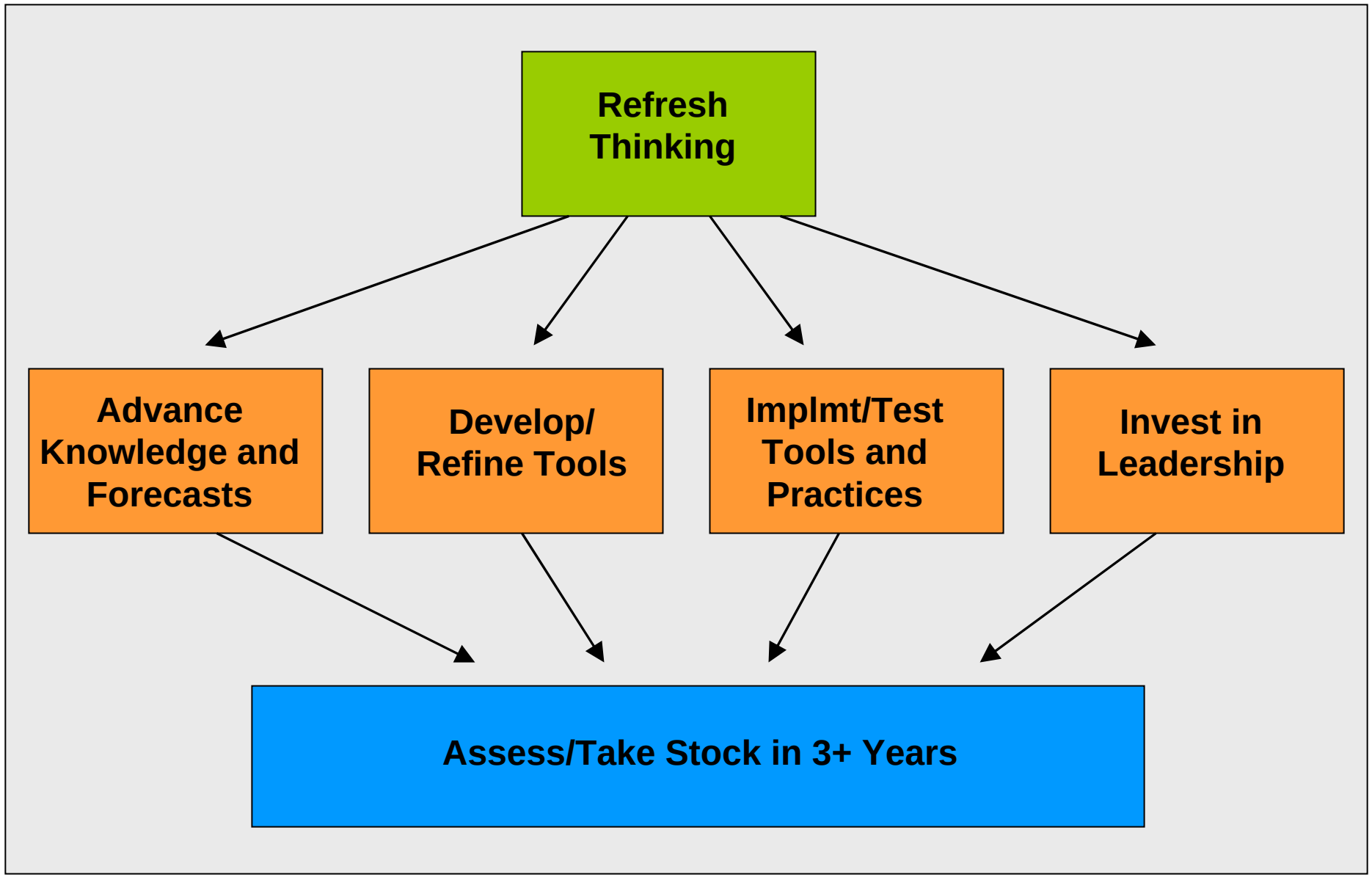

Table 9a. Sample Ideas: Shape Thinking

Avenue	Mechanism	Sample Ideas
Basic propositions	White papers and/or convening*	Commission series of papers on the necessity, relevance and objectives of conservation and the role of protected areas in a climate changed world
Expand limits – practice	White papers and/or convening	Commission series of papers by land protection thinkers on overarching issues facing land protection in conjunction with a convening on land protection under CC which would also cover tools developed under Develop/Refine Tools
Expand limits – policy	White papers, convening, and/or re-grants	Commission series of papers by Environmental Law Institute, Defenders, EDF, NRDC and/or others for convening on policy frontiers under CC
New links – management	Re-grant program or leadership grant Convening	Form/support Regional Climate Collaboratives (RCC) to bring together scientists and practitioners in key U.S. regions to communicate/ collaborate around regional habitat protection and management issues Bring together leaders in land protection and land use planning/smart growth
New links – modeling	Re-grant program	Modeling collaborative or conference
Shape public perception	Grant or re-grants	Commission national poll and messaging strategy on wildlife and CC Commission same at state or regional level, perhaps with advice from/through RCCs
Advance funder perspectives	Convening	Bring major conservation funders together to discuss climate change and wildlife

*Funders could hold convenings or organize them as part of other regular meetings of the field. White papers could be commissioned by funders or in a range of open/competitive/judged forums by panels or collaboratives set up by funders or in conjunction with regular meetings of the field.

Table 9b. Sample Ideas: Advance Knowledge and Forecasts

Avenue	Mechanism	Sample Ideas
Species and systems research	Re-grant program	Research projects – how CC is affecting critical species, systems; paleo questions?
Modeling – species and systems	Re-grant program	Applied research projects. Questions include: how are species likely to move, what are target ecosystems likely to look like, where are "hotspots" likely to be, what is gap between protected areas and future species needs
Modeling – regional climate at fine scale	Convening and white papers	Commission papers on technical issues; Convene climate and ecological modelers to discuss technical issues, best practice techniques, standard scenarios, etc. Convene modelers, conservation scientists, and practitioners to discuss common outputs practitioners need
	Re-grant program	Support ongoing modeling collaboratives as indicated in initial experiences with them

Table 9c. Sample Ideas: Develop/Refine Tools

Avenue	Mechanism	Sample Ideas
Conservation planning	Re-grants	Develop and test scenario planning tools and integrate into revised conservation planning frameworks
		Help states chart path to revising State Wildlife Action Plans in light of CC
	White papers and convening	Bring conservation planners together to share innovations, best practice under CC
	Leadership grant	Support revisions of TNC Conservation Action Planning (site planning) and Ecoregional Planning
Land protection	White papers and convening	Develop CC-related innovations in fee purchase, easements, and other protection mechanisms; Bring leading practitioners together to discuss
Stewardship	Grant/re-grant	Collaborative or network to share best practices and discuss issues
Monitoring	Re-grant or leadership grant	Regional monitoring collaborative – determines key targets and methods affiliated with/part of RCCs?

Table 9d. Sample Ideas: Test/Implement Tools and Practices

Avenue	Mechanism	Sample Ideas
Testing and deployment	Re-grants and/or leadership grants	Demonstration projects for new planning, stewardship and monitoring tools and practices. Focus on a regional or sub-regional collaborative?
Habitat protection	Land protection capital grants	Capital grants that advance emerging notions of relevance of conservation and role of protected areas under CC, and tests/demonstrates new tools

Table 9e. Sample Ideas: Invest in Leadership

Avenue	Mechanism	Sample Ideas
Policy	Leadership grant	NWF, DoW, TRCP, AFWA, ?? – Capacity to educate key players about wildlife adaptation needs
Practice	Leadership grant	Invest in accelerating development of TNC planning, protection and stewardship approaches (and science?), and in their dissemination to other land conservation practitioners, including land trusts and agencies

Table 9f. Sample Ideas: Assess/Take Stock

Avenue	Mechanism	Sample Ideas
Assess/take stock	Convening, pre-convening white papers and/or assessments	In three to three-and-a-half years, bring NGOs, agencies, and funders together to reflect upon what's working, what's not and what else is needed