A Report on the Results and Recommendations of the International Summit on

# Evolutionary Change in Human-altered Environments

*Sponsored by the Institute of the Environment*
*University of California, Los Angeles*
*February 8-11, 2007*

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November 5, 2007

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# I. Background

## A. Purpose of the Summit

On February 8 – 11th, 2007, the University of California, Los Angeles (UCLA) Institute of the Environment convened an international summit on "Evolutionary Change in Human-altered Environments." The summit brought together recent research by scientists from all over the world, examining how human activities are altering evolutionary processes. This was the first international gathering that included both evolutionary scientists and policymakers to examine recent research on this topic. The goals of the summit were:

- To bring together scientists from all over the globe who are using the latest technologies to investigate how human activities are affecting evolutionary processes.
- To examine the effects and implications of these effects with regard to:
    - climate change
    - habitat degradation
    - invasive species
    - captive breeding
    - exploitation
    - pathogens
- To examine the "added value" that understanding evolutionary impacts could have in improving wildlife management and conservation policy, planning, and practice by initiating a dialogue between the scientific researchers and conservation policymakers and practitioners.
- To synthesize the findings of the summit through panel discussions and through a small group convened to outline a series of steps that should be taken to follow up on the summit, including ways to integrate knowledge about the evolutionary impacts of human activities into efforts to conserve and protect habitats and manage plant and animal populations.
- The results of the scientific sessions are available on line at http://www.blackwell-synergy.com/toc/mec/0/0 and will be published as a Special Issue in the journal *Molecular Ecology*.[1]

## B. Funding

The costs of preparing for the science to policy work at the summit and the direct costs of the summit were underwritten with grants and sponsorships. Major grantors were:

- Blackwell Publishing
- Frankel Foundation
- National Science Foundation
- Southern California Edison

[1]Special Issue: Evolutionary Change in Human-altered Environments. 2008 (in press). Smith, T.B. and Bernatchez, L. (eds.). *Molecular Ecology*.

Smaller grants and sponsorships were provided by:

- Amgen
- Applied Biosystems
- California Department of Fish and Game
- California Department of Parks and Recreation
- Genetic Resources Conservation Program, University of California, Davis
- Gresser Family
- The Nature Conservancy
- U.S. Fish and Wildlife Service
- U.S. Geological Survey Biological Resources Division

In addition, the California Water Resources Control Board and the San Francisco Estuary Institute provided their mailing lists to help reach applied conservation biologists and environmental scientists working in key state and federal agencies. The array of private foundations, public agencies, research and conservation organizations, and private businesses supporting this summit enhanced our efforts to have a diverse audience and participants in the program.

## C. Contents of this Report

The report has two major sections. Part II of the report describes the process and resources that the organizers and policy advisors used before the summit to provide the most up-to-date science for policymakers participating in the summit. The report discusses how the organization of the summit itself was designed to make it possible to build the results of one session onto the next in order to maximize fruitful policy discussions. This section of the report also evaluates how this preparation and summit structure succeeded, and where it could be improved. It includes specific recommendations for how to improve science to policy linkage in a future meeting of this kind.

Part III of the report contains the substantial ideas generated at the summit to use evolutionary science for making informed policy and management decisions. It starts with the broad recommendations emanating from the White Paper Session.

# II. Structuring the Meeting for Successful Science to Policy Communication

## A. Bridging the Gap Between Evolutionary Science and Conservation Decisionmaking

While conservation policymakers and practitioners increasingly look to science for guidance on conservation policy, planning, and management, there are few rapid mechanisms by which the most recent scientific findings inform conservation policy or practice. The flow of information from specialized researchers doing basic and applied research is typically informal, somewhat idiosyncratic, and dependent on key intermediaries with expertise in both basic science and policymaking.

Academic researchers in the rapidly expanding fields of molecular ecology, conservation genetics, landscape ecology, and restoration ecology have developed a variety of links with the conservation community. For example, the National Academy of Sciences has symposia and working groups that invite the participation of the policy community as well as science and policy publications and scientific society meetings that draw conservation practitioners and scientists together. The National Center for Environmental Analysis and Synthesis (NCEAS) in Santa Barbara and some of the national and international grant-making foundations and nonprofit organizations regularly engage scientists to work with policymakers in order to translate scientific findings into policy.

However, with a few exceptions, such as captive breeding, human effects on evolutionary processes have not been an issue fully considered in most of the conservation policy and practice arenas. While many conservation scientists are also evolutionary biologists, the effects of humans on evolutionary processes, while well recognized within the scientific community, have received very limited coverage within the conservation policymaking and decisionmaking communities.[2]

As evolutionary scientists began to apply new molecular genetic tools, the possibility of examining evolutionary changes in populations with much greater precision over shorter time periods has become a reality. It is now possible to document how humans are changing evolutionary processes in both terrestrial and marine environments.

Scientists are now utilizing molecular genetic techniques to address consequential questions in ecology, evolution, behavlor, and conservation. The results of the February 2007 summit will be published as a Special Issue of *Molecular Ecology*, a journal that did not exist before 1992. This year also debuts the new journal, *Evolutionary Applications,* whose mission is "to formalize the field of 'applied evolutionary biology' and to accelerate progress in this dynamic and relevant research area."[3]

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[2]One notable exception is the Evolutionary Hot Spots Project, sponsored by the California Department of Parks and Recreation and the Resources Legacy Fund Foundation and carried out by scientists at the University of California, Berkeley and UCLA. Another exception has been work by the National Park Service to restore the population of mountain lions in the Santa Monica Mountains with the goal of restoring genetic variability and gene flow between populations.

[3]Bernatchez, L. and Tseng, M. 2007. An Editorial. *Evolutionary Applications.* Blackwell Publishing: http://www.blackwellpublishing.com/pdf/evaeditorial.pdf

Scientific advances, particularly in the field of molecular genetics, set the stage for developing the summit and convening evolutionary scientists from all over the world to both share their research on how humans are affecting evolutionary change and to bring together key conservation policymakers and practitioners to begin to build the bridge between evolutionary science and practice.

## B. Linking Evolutionary Science to Conservation Policy and Practice

The current approach for science to inform policy is for key decisionmakers involved in making policy and setting best practices to ask for advice. In the United States, the establishment of the National Environmental Quality Act 1970, the Endangered Species Act (1966), Section 401 and 404 of the Clean Water Act (1977), and similar regulatory environmental protection legislation in California and other states have impelled decisionmakers and conservation planners to ask key questions about the distribution of species, the ecosystems that they depend on, and the impacts of human activities upon those species and ecosystems. Efforts to expand protected public lands have led to questions about which land and water areas should be protected, and how to link protected areas.

However, these same decisionmakers have not been asking scientists to address the evolutionary impacts of human activities. With numerous recent scientific studies showing that humans are dramatically altering evolution processes, disseminating this information to decisionmakers was an important goal of the summit.

### *Organization of the Summit for Linking Science to Policy*

Summit organizers, Thomas Smith (UCLA) and Louis Bernatchez (Université Laval), identified six areas where humans are having substantial effects on evolutionary processes affecting species and ecosystems. They then identified leading researchers on the various topics that would be willing to present their research at the summit and submit articles for a Special Issue of the journal *Molecular Ecology*.

Forty-three researchers were invited to participate. Their presentations were organized into three sessions: (1) Habitat Degradation and Environmental and Climate Change, (2) Captive Breeding and Exploitation, and (3) Invasive Species and Pathogens. Working sessions were held after each of these sessions to synthesize the implications of the combined research. At the end of the science presentations, policymakers were asked to examine the implications of the research for conservation and wildlife management policy, planning, and practice.

After the scientific presenters and working sessions were organized, the effort to involve policymakers in the summit began. The organizers established a Policy Advisory Committee (PAC), chaired by Mary Nichols, Executive Director of the Institute of the Environment, who worked with the organizers in establishing the role of the PAC, and participated in inviting members.

The central goal set for the PAC was to help to create the optimal conditions at the summit to enable scientists and policymakers to succeed in: (1) starting to address the ramifications of human-induced evolutionary change, (2) exploring mitigation approaches that would allow species and ecosystems to successfully adapt to rapid evolutionary change, and (3) beginning

to discuss strategies for moving information and recommendations into the conservation policy and practice arena.

Twenty-two individuals (Attachment A) were recruited as members of this PAC to work with Madelyn Glickfeld, Principal Policy Advisor, and Benjamin Wang (UCLA Ph.D. candidate). These advisors were requested to:

- identify specific applied scientists, policymakers, and practitioners who should be invited to participate in the summit, either as observers, speakers, or panelists.
- organize the working sessions, the final panels and the follow-up half-day White Paper session to maximize the productivity of participants in linking science with policy.
- review the abstracts of the science presentations in at least one session to give feedback on the usefulness of the research for policy and practice.
- prepare the science and policy attendees to communicate effectively with each other to synthesize the research findings presented and identify the policy implications of their research.
- attend the summit as observers in the science sessions, participants in the working group sessions with the scientists, policy speakers, and policy panelists, or participants in the White Paper session.

The PAC was initially designed to give advice as a body, in meetings preceding the summit. However, because of the difficulty and expense of convening the group, information was solicited by email and by telephone interview in October and November 2006. Interviews and email responses were recorded, and then the responses compiled. Attachment B includes a copy of the interview form used in this process.

***Advice and Input Received from the Policy Advisors***

Identifying potential participants and outreach strategies

The PAC gave us names of many organizations and particular people involved in conservation management, invasive species control, pathogen response and conservation/restoration of natural resources that might have an interest in attending the meeting. They also suggested candidates for each of the working sessions after each set of presentations, with expertise on the kinds of human impacts involved. The edited list of potential summit participants is attached to this report (Attachment C). Some of our policy speakers were found through this list, or through people on the list.

Advising about how to organize the working sessions, the final panels and the follow-up half-day white paper session to maximize the productivity of participants in linking science with policy

There was excellent advice offered by the members of the PAC on how to organize the summit to maximize the productivity of participants in linking science with policy. Here are some of the major points made:

- Many made the point that the program schedule should have been designed after, not before focusing on policy participation and making the science to policy link.
- Many made the point that it would be very difficult to engage many policymakers and practitioners without more discussion of policy and practice on the summit agenda.

- Many PAC members suggested that the working sessions would need to be very organized to both synthesize the scientific findings in each session and recommend policy actions.
- Some PAC members suggested that the White Paper session would require some preparatory work in advance. Some members suggested that a Draft White Paper be prepared and given to the Working Session chairs and White Paper session participants in advance of the summit, to give them something to work from.
- Other members suggested that the sessions be chaired by policy experts, and that the working sessions be supported by facilitators and notetakers who could assist in preparation of presentations out of the working session.
- Some PAC members suggested that communications would be hindered if policymakers did not have a better understanding of the terminology of evolutionary science, and that we needed to take steps to make the presentations at the summit more accessible to non-scientists.

Reviewing the abstracts of the science presentations in at least one session to give feedback on the usefulness of the research for policy and practice:

All PAC members reviewed the presenter's abstracts for at least one of the three major scientific sessions in advance of the summit. By and large, those PAC members with a science background understood the abstracts and were able to see some of the implications of the specific presentations for policy and practice.

Those PAC members who had a legal, administrative, or public policy background were unable to understand many of the abstracts because of language issues, and were unable to use the descriptions in the abstracts to determine the implications for policymakers or practitioners. In general, non-scientist PAC members found this true for most of the individual research abstracts, as well as for the implications of all of the studies in each session.

Neither group was able to use the scientists' presentation abstracts to synthesize the findings of studies in the same session to the point where policy and practice implications were clear. One PAC member said that the studies were never designed to answer a common conservation policy question, were particularistic in nature (captive breeding in wolves, fisheries), and specific to the geography studied. Thus while some patterns could be seen, the larger policy implications were difficult to draw from reading the abstracts.

***Actions Taken in Response to PAC Recommendations***

Questions to scientists

With this range of understanding and reactions from the PAC, we decided that the best approach would be to ask the scientists to clarify the implications of their research and tell us whether they thought it provided new information for decisionmaking. The questionnaire in Attachment D was sent to all of the scientific presenters several weeks before the summit. The results were added to their abstracts and significantly improved both the ability of non-scientists to understand the research and analyze the implications of the research for practical use.

Science presentations to conclude with policy implications

We also asked every scientist to use the last three minutes of a fifteen-minute presentation at the summit to focus on the policy implications. There were significant changes in the content and style of the presentations as the scientists responded to this request.

Policy expert presentations on current policy, planning, and management

When the responses to the questions were received, the following conclusions were drawn:

First, the questions we asked helped the scientists to bridge the gap between scientific findings and conclusions and policy/planning implications. Their answers helped the PAC to better understand their findings and why they might be important to consider.

Second, the answers scientists gave demonstrated that a significant majority of them, particularly those who were not directly participating in on-the-ground wildlife management and conservation projects, were not familiar with current policy, planning, and management approaches. This meant that they could either only give very general recommendations about how their findings should be used (i.e., stop sprawl). Some gave recommendations for changes in policy that had already been considered, adopted, or put into practice.

This result was unexpected, but not surprising. Academic evolutionary scientists doing field research and laboratory analysis, reporting their findings in academic journals, might be interested in the implications of their research for policy purposes. However, many have little time or opportunity in the pursuit of their work to learn about how conservation and impacts on ecosystems are being addressed and how current policy is, or is not, working.

We concluded that it would be extremely helpful to engage policy experts to conclude each session of presentations at the summit with a presentation to educate the scientists on current policy, practice, and management, and the success and failings in relation to each presentation session. This would happen just prior to having the presenting scientists adjourn with other invitees to synthesize the implications of their combined research and make recommendations for next steps.

Finding the most informed policy experts in each of these issues was a major challenge. We needed people with experience bringing science into policy and with detailed knowledge of current policy, practice, and management to make these presentations. What is more, we needed them to review all of the scientific abstracts for their session, as well as the scientist's responses to questions about the policy implications of their individual research. They only had fifteen minutes to provide the overview--a huge challenge.

The organizers, PAC chair, Policy Advisor, and PAC spent much time identifying these key speakers and providing them with information and support while they worked on their presentations. These presentations would be a critical step towards enabling the scientists to understand current policy, practice, and constraints to change. They were meant to improve the ability of scientists to think about the implications of their work and to give all of the working session participants a common knowledge base for their discussions.

Organization of the working sessions

The PAC had told us about their concerns that the time for the working sessions was short and had to be very well organized in advance to give the working session participants the framework to succeed.

The following steps were taken to provide the framework and environment for successful collaboration.

First, we asked two PAC members, Dr. Tom Lacher and Dr. Ray Sauvajot, to prepare a summary and synthesis of the scientific abstracts and their responses to the questionnaire about implications of their research for each presentation session. This summary and synthesis were given to the policy speakers at the end of each session, and to the Chairs/Facilitators of each working session, as well as the White Paper session participants. We did not ask for a "Draft White Paper," as suggested by a PAC member, because such a paper could constrain discussion at the working sessions and white paper session in a way that the summary and synthesis did not.

We also asked Lacher and Sauvajot to observe all of the presentations throughout the summit, participate in all of the working sessions, and be part of the reporting panel after the working sessions. The work they did before and during the summit was instrumental in helping the discussions link the scientific conclusions with policy implications during and after the working sessions.

Second, we carefully invited a limited number of policy experts to participate in the working sessions. We made a significant effort to get experts on the issues addressed in each session, as well as inviting the more general policy experts on the PAC.

Third, we chose working session chairs and facilitators carefully, and worked with them to prepare for the sessions. We asked them to be present at all of the presentations made prior to their working session. We recruited doctoral students and postdoctoral fellows to be note takers for the working sessions and helped them prepare for this work. Putting together these teams, giving them the summary and synthesis ahead of time, and helping them plan their sessions all proved helpful to getting good results in the working sessions.

Organization of the policy panels in the context of the overall program

The program schedule is included as Attachment E. This program shows how the policy expert presentations concluded each session, and identifies the working session chairs and facilitators. The transition from scientific presentations, policy overviews by subject areas, and working sessions to the final plenary policy discussions was done in two steps.

First there was a panel of session chairs reporting out of the working sessions, and Lacher/Sauvajot reporting their summary and synthesis. While the chairs were the reporters of recommendations and ideas of the working group, Lacher and Sauvajot integrated their reactions to the presentations and the working group discussion in the context of the summary and synthesis they drafted before the summit. There was moderated discussion and questions/comments from the audience after the presentations to help crystallize the findings from both sources.

This session led directly into the final policy presentation of the summit. This panel, which included the session chairs, Lacher and Sauvajot, and other PAC members, was asked to address the topic "Integrating Science and Policy: Using Evolutionary Science in Conservation Policy, Planning, Practice, and Management. The moderator interviewed the panelists and did so by putting herself into the role of the Governor of California, and the panelists into the role of Cabinet Members that had just attended the summit. She asked the panelists questions that a governor engaged in this topic would likely ask, and asked them to make recommendations to her as to how she should lead the state in using the findings from the summit. This discussion presented a very real example to the entire audience of how policy decisions are made, and fostered much discussion about the role of scientists in this process.

The White Paper session following the summit

A half-day session with key scientists and policymakers followed the summit. As shown in Attachment F, the goal of this session was to develop an outline, assignments, and a timeline for writing a commentary that discussed the threats, challenges, and potential solutions of the findings on the evolutionary impacts of human activities on the natural world, both in an international context and a California-specific context. In addition, the White Paper session participants were to start to develop a strategy for the next steps to begin to apply what was learned to conservation and wildlife management. Finally, assignments were made to follow through with specific activities.

***How Did the Preparation for Science to Policy Communications at the Summit Work?***

In general, everything described above contributed to our success in synthesizing common implications and management recommendations from the presented research. Each step that we took helped to reinforce our other efforts. This process encouraged the presenting scientists to think about policy implications in their initial questionnaires and in the way that paid off greatly when they made their presentations at the summit.

While the discussions at the working sessions were still very challenging, given the wide divergence of scale, location and topics studied, the methods that we used to help people better understand each other before and during the presentations helped considerably. In two of the three cases, the end of session policy speakers did a brilliant job of "setting the table" for the working session discussions. The Lacher/Sauvajot summary and synthesis aided the chairs of the Working Sessions and the White Paper session participants in organizing their discussions. Having facilitators and notetakers helped working session participants to organize their thoughts and develop some consensus on recommendations with very short time frames available. Having a written record of the sessions helped the chairs to faithfully report the findings, and to use their own expertise to take them further.

With the large number of specifically-focused scientific presentations, discussing across-the-board implications was very challenging. While it was not entirely successful, the ideas coming from the presentations to the policy panels would have never been as clear without engaging in the preparatory process and in the agenda and organization followed at the summit.

That said, it should be noted that our limited perusal of the literature did not provide examples or studies of successful environmental science-to-policy processes to guide us. So it is difficult to tell what would have further improved our results in comparison to other similar efforts. We hope that documenting the process that we used and the results we obtained may be used by others as a starting point in their efforts to connect new science with environmental policy.

### *How Could Another Summit Improve the Science to Policy Connection?*

Because of the success of the summit, another international summit had been proposed for 2008 and will tentatively be hosted by Georgina Mace, one of the keynote speakers at the UCLA summit. Given the experience we have had here, there is an opportunity to take other steps to integrate science and policy.

The remainder of this report details research findings and policy recommendations that scientists and policymakers could work together to address. It also includes thoughtful questions raised by the discussants that could be the starting point for new, policy-relevant research on evolutionary changes in human-altered environments.

# III. Science to Policy Recommendations

## A. Overall Recommendations of the White Paper Group

### *Conclusions*

The conclusions drawn from the research need to be organized, along with policy implications and management recommendations. These ideas should be organized and communicated through a commentary in a major scientific journal and through other means to draw attention from key public and private conservation actors and decisionmakers. Some of the key conclusions are as follows:

- Human activities are impacting evolutionary process and the scientific community has not adequately incorporated this into conservation planning. Evolution precipitated by human activities is occurring in years and decades rather than centuries and has "disrupted" evolutionary processes in recent times. Adaptation of species through evolution cannot keep pace with the rate of change.
- The research presented at the summit demonstrates that evolutionary processes are important to ensuring the future of biodiversity and functioning ecosystems. Conservation of natural resources cannot be successfully accomplished without considering and addressing the evolutionary impacts of human-altered environments. Conservation strategies that take into account evolutionary processes and human alteration of those processes would be significantly different than contemporary conservation strategies that do not integrate evolutionary processes.
- The evolutionary science community needs to clearly define relationship of this emerging science to existing work on ecology and ensure complementarity.
- The tools needed to understand and consider evolutionary processes in real time have only recently been developed and, as a result, regular use of these tools for incorporating evolutionary process into conservation and wildlife management efforts has not yet occurred. Putting these research tools and methods into use in policy evaluation and practice is something that evolutionary scientists and conservation experts can collaborate on.
- These tools cannot help us to "manage" evolution. Evolution is too complex and we do not know how to manage it actively. We can only use these tools and methods to design conservation and wildlife management strategies that work in parallel with natural processes. We can consider and protect evolutionary processes by maximizing opportunities for species to adapt and to protect the evolutionary processes that help maximize adaptation.

### *Why Does Evolution Matter?*

The scientific and conservation policy communities need to provide examples of how understanding evolutionary processes is important to trying to address the impacts of human change on the rest of the natural world. There are plenty of examples where underlying evolutionary processes play a key role. Many past and present examples, involving climate change, invasives species or spread of pathogens, or ecosystem collapse, would serve the purpose of demonstrating the importance of evolutionary processes to a wider conservation audience.

***How Should the Importance of Human-caused Evolution be Illustrated to Different Audiences?***

Written materials should include the following:

- At least three case studies should be prepared and published to illustrate the importance of considering the evolutionary processes set into motion by climate change, invasives and/or pathogen spread, and ecosystem collapse (e.g., fisheries).
- The Special Issue of *Molecular Ecology* that will carry the articles generated by presenters at the summit.
- A book that:
    - Illustrates the importance of evolutionary processes in conservation and wildlife management,
    - Discusses where conservation and wildlife management policy and practice need to change to account for evolutionary processes, and
    - Discusses how to move forward towards conservation and wildlife management that considers evolutionary processes.

***What Other Strategies Should be Used to Build Institutional and Public Awareness, Support, and Dialogue about Human Impacts on Evolutionary Processes?***

Some ideas to start this dialogue and build awareness and support are:

- Refine the ideas and information above into a slide show presentation to distribute to policy advisors and present to target policy/conservation groups. (Volunteers: Ray Sauvajot, Ellie Cohen, Tom Lacher, Louis Bernatchez, Thomas Smith)
- Formalize a post-meeting working group to lead in carrying out these actions or find other ways of networking to accomplish these goals.
- Look at the possibility that the National Center for Ecological Analysis and Synthesis could play a role in convening and coordinating follow-up efforts.
- Deliver the slide show to the Board and CEO of Conservation International and other NGOs. (Tom Lacher)
- Invite and convene key international conservation non-profit organizations: (e.g., World Wildlife Fund, Wildlife Conservation Society, Conservation International, The Nature Conservancy) to develop a joint statement about how to proceed in considering evolutionary processes in conservation and wildlife management.
- Consider asking the Natural Resources Defense Council to do the same with national NGOs with an emphasis on California as a state with high biodiversity, endemicity, and the legal and financial infrastructure to conserve natural resources.
- Submit opinion pieces to newspapers. (Tom Smith, Paul Bunje, Mary Nichols).
- Ask the Resources Legacy Fund Foundation to host a meeting of big conservation funding foundations and their directors of conservation science to discuss why and how to increase awareness of human impacts on evolution and how to support and incorporate evolutionary process into conservation on a global level and more specifically in California.
- Build on the experience of this summit to organize a follow-up meeting.
    - National Science Foundation (NSF) workshop (Jim Collins and Tom Smith)
    - National Center for Evolutionary Synthesis (Robert Wayne)
    - National Parks (Ray Sauvajot)
    - National Forest Service (Robert Mangold)

    - NABCI (Ellie Cohen)
    - Presidents Office of Science
    - Council on Environmental Quality
- Engage the Canadian government through:
    - Environment Canada (André Talbot)
    - Strong relationship between Canadian government with California and UCLA
- Engage international agencies through:
    - Convention on Biological Diversity (CBD) through the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). The twelfth meeting of this group will take place from July 2-6, 2007 at UNESCO headquarters in Paris
    - United Nations Development Program
    - International Mechanism of Scientific Expertise on Biodiversity

***Strategies for Integrating Consideration of Evolutionary Impacts and Processes into Policy and Practice***

The White Paper Session participants developed some consensus around the concept of "Evolutionary Impact Statement or Analysis" as a way to move evolutionary science from research to application.

For example, in the case of invasive species, incorporate phylogenetic considerations into determination of policy (relationship to native species and likelihood of hybridization) and contemporary evolutionary/population genetics from native range. A strategy to apply evolutionary science to understanding the full range of human impacts on the natural environment would require a strategy itself. Such a strategy might be:

- Identify large-scale projects with evolutionary implications that might provide case studies to use to understand how to apply evolutionary scientific tools and methods in a time- and cost-sensitive way. This would help to demonstrate whether it is feasible to do applied science at a scale and on a time schedule and cost that would make widespread application in conservation and wildlife management possible. One such large-scale test project would the current National Marine Fisheries Service proposal to significantly expand Eastern Pacific aquaculture in the waters off the U.S. Pacific Coast. Dam impacts or dam removal impacts are another such project. Reintroduction or intentional introduction of fish or wildlife species into an ecosystem where they have been absent for a long time would be another such project.
- Approach these projects as test cases for research and reporting. Seek research funding from federal agencies to university researchers to adapt current research techniques to apply to environmental impact analysis on these projects to assess whether the state of the science and techniques are operable at a scale ready for more formalized use.
- Use these test cases to formalize links between universities and government and private agencies that generate impact reports to successfully integrate evolutionary analyses into a large environmental impact framework.
- Define test cases to include post-analysis monitoring for evolutionary effects as part of adaptive management.
- If the studies have useful results and if they can be executed within a reasonable time frame and cost that would allow these studies to be done as a matter of law, then develop a legislative strategy to expand the environmental analysis of evolutionary impacts. Consideration should be given to pursuing this at a national level (National Environmental Policy Act - NEPA) or more narrowly for specific kinds of projects, and in

California, where the California Environmental Quality Act (CEQA) process is well developed.

- Prioritize the importance of recommendations for practitioners: As results of evolutionary impact studies accumulate, provide a mechanism to share the analysis and key recommendations with practitioners, both in the areas of the activities that are causing evolutionary impacts (climate change, international trade in invasive species, aquaculture) and in the mitigation to allow successful adaptation of species and ecosystems to the human activities causing these impacts.
- A suggested legal framework might apply to a specific set of actions on the environment that have "foreseen" evolutionary impacts. Some are identified above. Positive projects to improve habitat, species health and ecosystem health could be subjected to this framework to insure that evolutionary processes have been considered in their design. Such positive projects include restoration, mitigation, endangered species, rapid risk assessment, and acquisition and management of protected lands. In the latter case, fundamentally different approaches and criteria would be used to define protected areas, including hot spot analysis and gradient analysis.

## B. Summary and Synthesis of Research Findings (Drs. Thomas Lacher and Ray Sauvajot)

As noted above, we asked Drs. Lacher and Sauvajot to write a brief summary and synthesis of the research findings, including general observations and specific policy recommendations, based on the abstracts and questionnaire results available prior to the summit. At the summit, they observed all research presentations and all three working sessions, and modified/updated their draft. This section provides their summary and synthesis after participating in the summit.

### *Captive Breeding and Exploitation: General Findings and Observations*

- Human-imposed selective pressures impact "evolutionary sustainability" of economically, socially, and politically important species. (Frankham, Leberg and Firmin, Coltman, Roy and Fenberg)
- Captive-reproduced species can impact "evolutionary sustainability" of wild populations. (Randi, Frankham, Waples, Hutchings and Fraser, Bernatchez)
- Evolutionary principles are often not considered in management or policy decisions. (Baker et al., Frankham, Roy, and Fenberg)
- Evolutionary biologists have tools that help measure evolutionary impacts, develop management recommendations, or measure the effectiveness of management actions. (Baker et al., Randi, Wayne et al., Bernatchez)

### *Captive Breeding and Exploitation: Management Recommendations*

- Recognize and incorporate "evolutionary sustainability" into policy and mgmt decisions (e.g., no size-selective harvesting, avoid introduction of captive-bred individuals).
- Evolutionary consequences of policy and management decisions must be understood; evolutionary biologists must communicate concerns.
- Tools developed by evolutionary biologists should be used by policymakers and managers.

***Climate Change Effects on Evolution: General Observations***

- Species may not adapt as quickly as the climate might change. (Merilä and Gienapp)
- Genetic effects of climate change can occur over very short time frames. (Garant et al.)
- Rates of microevolution must match the rate of change in environmental conditions. Conservation policy can aid by increasing the rate of adaptation via corridors for gene flow. (Visser)
- Organisms key their phenology more to day length than to climate. Mismatches between light keys and appropriate climatic and resource conditions may occur. Mismatches could be severe for plant-pollinator, predator-prey, and plant-herbivore interactions. (Bradshaw and Holzapfel)

- Species tolerant of human disturbance might also be tolerant of climate change, yet many of these species are undesirable. (Hellman et al.)

***Climate Change Effects on Evolution: Management Observations***

- The rate of climate change is a policy decision; evolutionary biology can inform policy decisions by addressing the specific scientific and evolutionary consequences of alternative rates of change. (Visser)
- As the climate changes, crop belts will move northward, requiring new crops. Disjunctions between pollinators and plants could result in declines of crop productivity. Disjunctions between timing of events due to light and climate could be significant. (Bradshaw and Holzapfel)
- Management actions could include the active displacement of certain species (assisted migration) to overcome barriers of dispersal. This could be important for keystone-like species, or habitats could be heavily managed to remain suitable to the evolutionary history of species. (Hellmann et al.)

***Habitat Degradation Effects on Evolution: General Observations and Management Recommendations***

- The acoustic environment brought about by urbanization may impact species which rely on acoustic communication. (Slabbekoorn)
- We must understand the response of organisms to fragmentation, particularly over evolutionary time. This understanding is crucial for assessing the potential for disrupted gene flow, increased genetic bottlenecks, and loss of genetic variation. (Sork and Grivet)
- Large reserves can help reduce homogenizing effects of gene flow from disturbed habitats. Fragments may be under differing selection pressures, whether fragments are natural or human caused. These impacts need to be incorporated into reserve design. (Smith et al.)
- Focus on communities and ecosystem process to buffer communities from invasives and other impacts; intact and undisturbed communities are more resistant to invasives. (Gillespie)

***Invasive Species and Pathogens: General Observations***

- Early detection and discovery, and rapid control and eradication are critical for managing impacts related to invasives. Delays can foster the selection for and evolution of greater invasiveness. (Kinnison et al., Barrett et al., Parker and Dlugosch, Suarez and Tsutsui)
- Care should be taken in the reintroduction of strongly interacting species (especially large mammals), particularly in areas where these species have been long extirpated. (Benkman et al.)
- Evolutionary biologists must determine the role of phenotypic plasticity in responses to human-induced changes. (Hendry et al.)
- Non-natives that are closely related to natives can hybridize, forming aggressive weedy and invasive plants. (Whitney et al.)
- One result of disturbance can be the creation of "invasive genotypes" due to selection for traits that facilitate coexistence with disturbance. (Pergams and Lacy)
- Be exceptionally vigilant about the introduction of novel vectors and diseases into systems, because the immune systems of native species may be less robust to novel pathogens. (Fleischer)
- More attention must be directed to understanding the evolution of emerging diseases, especially how control programs and human disturbances such as habitat fragmentation and degradation direct evolution in pathogens. (Lebarbenchon et al.,Day and Read)

***Invasive Species and Pathogens: Management Recommendations***

- Focus on rapid detection and immediate eradication of invasive plants and animals, including founder populations. More care should be given to importation and quarantine of exotics for horticulture. National policy and infrastructure are needed to collect information on non-native species and to coordinate action and funding. (Barrett et al., Parker and Dlugosch, Kinnison et al.)
- Transgenic crops might pose unexpected risks to wild populations, especially when these have closely related wild relatives. Hybridization may create aggressive invasives. Quarantine procedures of imported species should carefully examine phylogenetic relatedness to natives. (Whitney et al.)
- Researchers need to explore links between evolutionary biology of invasives and emerging diseases, and investigate these issues in the context of policy and management implications. (Fleischer)

***Translating Science into Policy***

While having knowledge and data to solve a problem is the first step towards a solution, the data itself is not policy. Bridging the gap from data and knowledge to policy is a familiar task for most involved in conservation policy, planning, and management. It is not as apparent to the scientists who develop the knowledge and data that this is the case.

<u>Stakeholders must be a part of translating science into policy.</u>

- Stakeholders are essential, because any policy solution will require some combination of legislative and regulatory action.
- Any policy has costs, both political and economic, so policy action in the absence of unidentified stakeholders is unlikely.

The following conditions are important when engaging stakeholders to bring science into policy:

- Stakeholders must be affected by the problem. It has to be *their* problem, however, not just any problem. Otherwise they won't engage.
- They must understand the science, at a conceptual level, particularly the contribution of the application of the science to solving the problem.
- Scientists must understand how to collaborate with communication specialists to convey conceptual importance to stakeholders.

An example: The Convention on Biological Diversity (CBD) and development of the 2010 targets.

- The stakeholders at one level are the signatories - the Council of Parties (COP) or member nations who have agreed to the conceptual principles of the CBD.
- They also have a representative scientific body, Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). Thus, there is a mechanism for translating science into a conceptual framework for action on policy decisions by the member states
- Positive result of stakeholder involvement in this case: parties understand their obligations as signatories to the CBD and know what they need to do.
- Negative ramifications: poor translation of science into concepts can lead to misguided policy. Plus, if some science is not part of the CBD, stakeholders are unlikely to be interested in using it.
- In any circumstance, other social, political, and economic pressures can make other stakeholder demands (local government, corporate interests, etc.) more important to a party than their fellow signatories. This can occur at all scales.
- You can do everything right and still not get consensus for the intended policy impact!

## C. Conclusions and Recommendations from each Working Session

***Captive Breeding and Exploitation (Dr. André Talbot)***

The research presented in this session demonstrated phenotypic and genetic effects on species across a range of human actions:

- Exploitation. (Hutchings, Coltman, Roy, Baker)
- Rescue of small populations by captive breeding. (Frankham, Hutchings, Leberg, Randi, Hedrick, Wayne, Bernachez)
- Rescue of domesticated populations. (Taberlet)
- Evolutionary consequences of altered ecosystems. (Waples)

Implications that can be drawn from the presented research include:

- Managed exploitation of fish and wildlife can lead to genetic bottlenecks, changes in life history characteristics (phenotypic and genetic), and reduced productivity (recovery).
- Strong adverse effects of genetic adaptation to captivity reduce survival and reproductive success of animals returned to the wild.
- Loss of genetic diversity from domestic animal husbandry practices.
- Ability of fish and wildlife to adapt to altered environments and the nature of adaptation will have unknown impacts on restoration and conservation measures.

What is at risk?

- Species-level variability.
  - variability should be maintained as general principle
  - variability is the fundamental element of evolutionary potential
- Erosion of the genetic diversity of wild populations.
- Long-term sustainability of biodiversity.
- Possible loss of evolutionary options, loss of ecosystem resilience, and risk of ecological collapse.

Recommendations for management of fish and wildlife exploitation that accounts for evolutionary effects:

- Tighter controls on size/age selective fishing/hunting mortality.
- Maintenance of large, complex populations.

Recommendations for management of captive breeding programs that accounts for evolutionary effects:

- Improve controls on the containment capabilities of domesticated animals (including feral mammals/birds).
- Improve approaches to avoid introduction of non-native individuals.
- Minimize use of captive animals in recovery programs.
- Minimize number of generations in captivity.
- Use strict breeding population protocols to minimize inbreeding, loss of diversity, and adaptations, drift, unwanted hybridization, etc.

More general policy considerations and recommendations:

- It is critical to keep evolutionary options for adaptation open, especially in light of the rapid change occurring because of climate change, etc.
- Tractable policy goals for conservation and fish and wildlife management must incorporate elements of evolutionary conservation.
- Clear and simple evolutionary concepts are necessary to keep evolutionary options open and incorporate elements of evolutionary conservation into current policy.
- It is necessary to build a communication strategy to help the public, decisionmakers and fish and wildlife managers to understand why evolutionary conservation principles matter.
- Communicate by demonstrating key examples of human-induced evolution and disseminate at places like “shiftingbaseline.org.”
- Develop a strategy for keeping the issues and concepts on the table.
- Burden of Proof - The burden of proof on environmental and evolutionary impact must be shifted in favor of a precautionary approach akin to Bayesian inference.
- Beyond integrating evolutionary concepts into conservation and wildlife management decisions, they must also be integrated into economic decision-making. In this case, evaluation of economic options must meet evolutionary criteria.
- Evolutionary concepts must be integrated into decision-making economic structures. Evaluations of economic options must meet evolutionary criteria such as abundance, productivity, spatial structure, and genetic variability.

Some questions for further consideration and debate:

- Is evolution of fish and wildlife species caused by human activity reversible?
- Can we conserve evolutionary fitness in species by conserving ecological functions and services, or are other interventions necessary?
- What is it we need to conserve to address evolutionary impacts of human activities: Should high priority be placed on animal abundance, hotspots of diversity, and habitat transition areas?
- Does all diversity need to be conserved?
- Is the public ready to accept evolutionary concepts? How do academic researchers communicate with the lay public about human-induced evolutionary changes in species?
- Can researchers maintain lines showing human-induced evolution (polluted sites)?
- Are economic and evolutionary conservation values compatible? Can industry tradeoffs be understood?

***Habitat Degradation and Climate Change (Dr. Jerry Schubel)***

Setting the context

- The rates of global climate change and habitat change are compromising ecosystems because the rates of natural evolution cannot keep up.
    - Corollary: Human activities are decreasing genetic diversity and changing the course of evolution.
- We can do little to affect the natural rate of evolution, but we can affect the rates of global climate change and habitat degradation. These should be our priority.
    - Corollary: Slow them down; give nature a chance.
- Evolutionary sustainability is a prerequisite to maintaining biodiversity and ecosystem services.

Draft policies and strategies: strategic conservation planning

- The primary and most frequently used criterion in acquiring and/or designating areas for conservation is the degree of threat to those areas. The more threatened, the more likely to be selected. A better criterion would be future conservation potential which is a function of evolutionary potential.
- In designating areas for protection, in general, the bigger the better. The value of these areas can be further enhanced by providing linkages/corridors and by encompassing environmental/habitat gradients. These measures would contribute to conservation of evolutionary processes.
- Take a futuristic look. Design the ecological and evolutionary landscape of the future--one that captures processes important to providing qualities, values, uses, and services important to society and that is coherent with prevailing environmental conditions at some future date.
- The importance of enforcement should not be underestimated in realizing the potential of protected areas.
- In designating areas for protection, traditional ecological criteria should be supplemented by ecological processes and evolutionary processes.
- To promote genetic diversity, keep populations as large as possible, maintain the natural heterogeneity of their habitats, provide linkages to other populations, and allow animals to move among local cells.

    - Corollary: Maintaining genetic diversity is a good hedge against global climate change and habitat degradation. Captive breeding programs in zoos and aquariums are "bit players."
- Focus more on conserving communities and ecosystems and ecosystem functions and less on conserving individual species.
- Promote policies and practices that conserve natural habitat heterogeneity and that minimize habitat homogenization.
- Control early morning traffic in parks, preserves, and reserves.

Draft policies and strategies: Fish and wildlife management

- Keep some big, old guys and gals around.
- "Re-wilding" efforts need to be integrated into comprehensive restoration efforts. In advance of the reintroduction of predators, clues need to be given - sounds, smells- along with introductions of gene flow in prey.

Draft policies and strategies: How to get these issues into the public realm

- Encourage the Society for Conservation Biology to create a Working Group on "The Roles of Evolutionary Biology in Conservation."
- Set up a workspace on "Conserve Online" and begin a dialogue to refine the policy case.
- Engage the public in exploring the importance and implications of the effects of global climate change and habitat degradation on the future course of evolution.
- Get rid of the jargon.
- Use networks of aquariums, zoos, science centers, and NGOs to reach a broad cross-section of the general public. Small traveling exhibits might be helpful.

Questions to ponder:

- Human evolutionary strategies have served us well, at least up until recently. Do we need a new set of human evolutionary strategies?
- Conservation reserves are important, but perhaps not as important as figuring out strategies to accommodate other forms of life in human altered systems since that is the prevailing state of the planet.
- We need new and better institutional mechanisms to engage our best scientists in dialogues with key decision-makers on specific policy questions/issues.

More questions for scientists (Dr. Mark Reynolds):

Dr. Reynolds is an evolutionary scientist and a senior scientist for emerging projects at The Nature Conservancy. He spends a good deal of his time trying to bring the best science possible into the work of The Nature Conservancy in deciding where and how to protect global biodiversity. In giving the policy expert overview for this session of presentations, he proposed three big questions for scientists to examine in future research:

- 'Irreplacibility' estimates are one of the most important criteria used in most systems to identify high priority conservation investments. However, most studies of species-based and vertebrate- and plant-based Irreplacibility do not address variability within species. How much does this matter?

- Scientists and practitioners do not have adequate metrics to define geography critical to protection of evolutionary process to use now in trying to prioritize conservation investments on a global, regional, national, or smaller level,. Can metrics of evolutionary process be developed and incorporated into current state-of-the-art conservation investment strategies?
- What if we view 'threats' as 'selection'?

The common denominator in all conservation planning is spatial data that describes the attributes of land, water, plants, and wildlife that characterize "space." Given that, how are the following questions answered?

- How can transition areas and range edges be incorporated?
- How should breeding and non-breeding areas be considered?
- To what extent does incorporating these kinds of areas into conservation plans address evolutionary processes?
- Do protecting larger and better-connected areas subsume evolutionary processes?
- Are conservation plans accounting for these issues durable to climate change and habitat shifts? What about adaptation?

Given the degree of human impact on natural areas, those high priority conservation areas that are protected from development must still be managed.

- Endangered species must be managed, with restoration of habitat for recovery
- Ecological and evolutionary processes such as predator-prey balances and wildland fire must be managed.
- Both prevention and eradication of invasive species and pathogens that can cause disease must be addressed
- Human activities on reserves and use of resources from reserves (e.g. water) must be managed
- With this in mind, how can we manage micro-evolution in conservation landscapes (e.g. Wildland Urban Interface (WUI), core-buffer transitions, and habitat transitions)?

***Invasive Species and Pathogens (Dr. Gabriella Chavarria and Ellie Cohen, Executive Director PRBO Conservation Science)***

Policy and management priorities for invasives and pathogens

- Fund and Promote Prevention: Reduce introductions of exotics and improve quarantine methods by establishing a "white list" approach with universal guidelines of what you can bring in versus current black list approach (too few species on black list and too easily influenced by agricultural and horticultural interests).
- Increase funding to institute eradication programs on public and private lands; apply approaches used successfully in other countries to engage public's assistance.
- Incorporate parasite issues into conservation policy and practice - parasites are small in size but have a strong effect on the ecosystem.

Public education priorities to bring attention to the evolutionary implications of human activities for the spread of invasives and pathogens

- Educate the public and encourage/fund scientific literacy at all ages; focus on integrating ecology and evolutionary biology at the high school and undergraduate level.
- Link evolutionary ecology issues to public health including invasion of pathogens and other issues to which the public can relate.
- Teach awareness of native versus exotic versus invasive in the landscape - if they don't know, it isn't a problem.

Transfer of evolutionary science into conservation policy and practice

- Establish ways to speed up transfer and translation of scientific findings to policymakers and conservation practitioners to guide more effective conservation.
    - For example: online information-sharing tools, establishing science advisory committees to local, state, and federal decisionmakers, and participation in existing conservation partnerships across disciplines, locally, regionally, nationally, and internationally, on land and in the marine realm.
    - Increase access to and sharing of scientific data that can be used for conservation; increase links and scale of diversity data bases.
    - Map evolutionary processes with climate change processes onto landscapes - if you can map it, you can conserve it.
    - Map endemism richness for species versus lineages - use to prioritize conservation. Identify what other data we have or need to map biodiversity hotspots for protection.
- Increase incentives to encourage scientists to engage in policy and application:
    - For example, professional societies, statewide grants programs, academic fellowships for "applied" scientists and practitioners, field fellowships for academics, participation in existing on-the-ground and at-sea conservation partnerships, and developing online, real-time communication tools to encourage information flow between scientists, conservation practitioners, and policymakers
    - Eliminate the false dichotomy of "pure" vs. "applied" science to use in determining research funding. Sometimes what appears to be pure or basic science ends up having significant application. The false dichotomy slows or impedes the flow of information from what appears to be basic science (evolutionary science) to real life conservation and public health applications.
- Establish incentives to help evolutionary biologists redirect and/or expand research priorities in the context of a quickly changing global environment (e.g., climate change) to ensure applicable findings, models, tools and applications for timely use by public and private conservation practitioners.
- Participate in adaptive management cycles; engage conservation and wildlife management practitioners in helping to develop research questions to ensure useful and practical research outputs and outcomes.

Increase sampling and monitoring to understand what aids invasives and pathogens in replacing native species, and how to design effective prevention and eradication approaches.

- Increase sampling to document change in genetic structure and presence of parasites; establish more documentation of shifting baselines.

- Increase funding for existing monitoring and evaluation efforts on public lands, restoration sites (riparian, in particular), marine food webs, and private lands to incorporate sampling.
- Expand monitoring and sampling sites to already identified evolutionary hotspots and projected hotspots with climate change.

Apply evolutionary science to conservation planning

- Institute (or join/expand existing) large-scale, coordinated partnerships to protect ecological connectedness across gradients and large heterogeneous [areas?????] to successfully protect evolutionary hotspots.
- In California and the West: Understand the effects of water diversions and allocation of uses outside stream changes in ecosystem function evolution and adaptation of species in rivers and riparian corridors. The evolutionary effects of water diversions are critical to ensuring freshwater supplies in streams and to support riparian biodiversity conservation.

Concluding thoughts:

- Al Gore's next movie: "Another Inconvenient Truth - Invasive Species and Pathogens."
- To the Secretary of the Treasury: There is no such thing as free trade.
- To the Secretary of Defense: Fortress America (modeled after New Zealand).

Research questions from the policy expert (Dr. Robert Mangold)

Dr. Robert Mangold is the Director of Forest Health Protection for the United States National Forest Service and is a plant geneticist. As the policy expert for the session on invasive species and pathogens, Dr. Mangold identified areas where more research would help in addressing invasives and pathogen control:

- Invasiveness:
  - How can we better understand the spread rate potentials (dispersal mechanisms and rates, life cycle, climatic limits, colonizing ability)?
  - Why do some species become invaders? Studies on genetic variation, hybridization, adaptation, and founder effects can lead to answers.
- Locations:
  - What are current and future geographic locations of invasive species?
  - Especially helpful are studies that predict which environments will be invaded.
- Pathways:
  - How does it get here? What anthropogenic factors are involved?
  - Controls for import/export, disposal techniques, etc. These are crucial for management programs.
- Management:
  - How do we better detect, prevent, control, mitigate?

# Attachment A
# Policy Advisory Committee

***Scientific Organizers:***
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***Members*:**

1. Michael Bean, Attorney, Chair, Wildlife Program, Environmental Defense, USA
2. Ryan Broddrick, Director, California Department of Fish and Game, USA
3. Gabriela Chavarria, Director, Natural Resources Defense Council Science Center, USA
4. Ellie Cohen, Executive Director, PRBO Conservation Science, USA
5. Frank Davis, Professor, Landscape Ecology and Conservation Planning, Donald Bren School of Environmental Science & Management, University of California, Santa Barbara
6. Sylvia Fallon, Conservation Genetics Fellow, Natural Resources Defense Council, USA
7. David Hayes, Global Chair of the Environment, Land & Resources Department, Latham and Watkins, USA
8. Terri Kempton, California Invasive Species Project Manager, Sustainable Conservation, USA
9. Charles Kennel, Distinguished Professor, Center for Atmospheric Sciences, Scripps Institute, University of California, San Diego, USA
10. Tim King, United States Geological Survey-Biological Resources Division (USGS-BRD), Leetown Science Center, Aquatic Ecology Branch, USA
11. Tom Lacher, Senior Vice President and Executive Director, Center for Applied Biodiversity Science, Conservation International, USA
12. Robert Mangold, Director, Forest Health Protection, United States Department of Agriculture (USDA) National Forest Service, USA
13. Felicia Marcus, Executive Vice President and Chief Operating Officer, Trust for Public Land, USA
14. David Olson, Director of Science and Stewardship, Irvine Ranch Land Reserve Trust, USA
15. Richard Rayburn, Chief of Resource Management, California Department of Parks and Recreation, USA
16. Mark Reynolds, Senior Ecologist for Emerging Projects, The Nature Conservancy, California Program, USA
17. John Robinson, Executive Vice President for Conservation and Science, Wildlife Conservation Society, USA
18. Deborah L. Rogers, Director of Conservation Science, Center for Natural Lands Management, and Conservation Geneticist, Genetic Resources Conservation Program, University of California, Davis, USA
19. Ray Sauvajot, Chief of Planning, Science and Resource Management, Santa Monica Mountains National Recreation Area, USA

20. Jerry Schubel, Chief Executive Officer and President, Long Beach Aquarium of the Pacific, USA
21. André Talbot, Section Head, Fluvial Ecosystems Research, Aquatic Ecosystem Protection Research Division, Environment Canada/Environnement Canada
22. Woody Turner, Program Scientist, National Aeronautics and Space Administration (NASA), USA

Attachment B

## Policy Advisory Committee Interview Form

Interview with _____ Date_____

1. Who are some individuals/groups that might be part of an audience for this summit?

2. Do you know of lists, or people with mailing/email lists that include appropriate marketing targets, or do you know people who we can talk with about lists of groups? If yes, please describe:

3. The central goal of the Policy Advisory Committee is to create the optimal conditions at the summit that will enable scientists and policymakers to succeed in starting to address the ramifications of human-induced evolutionary change and explore mitigation approaches that will allow species and ecosystems to successfully adapt to rapid evolutionary change.

Use the Summit Concept Paper, the Presentation Abstracts and the Draft Program as context for answering the questions below. You have already received the Concept Paper and the Draft Summit Program. The Research Abstracts are on the web at http://www.ioe.ucla.edu/CTR/Speakersabstracts.html. Please review all of the abstracts in at least one of the three scientific presenting sessions, and then answer the following questions.

3a. Which group of abstracts did you review?

3b. Are these abstracts understandable to conservation policymakers, planners and practitioners who are not also scientists? Which are not?

3c. Do the abstracts provide information necessary to allow understanding of policy implications?

3d. Which abstracts are research that is too basic to be applicable to conservation policy, planning or practice in conservation? Use the attached "Schedule for web" for easy access to the list of speakers and research titles to respond.

3e. Can common policy implications be drawn across abstracts on the same human impact in different places, and different circumstances (i.e. all presentations on the evolutionary impact of climate change on species and ecosystems) or are the individual research studies too unique and idiosyncratic to synthesize?

3f. Do you have other comments on the abstracts?

4. What should we ask scientists and invited policy/planning practice people to do to *prepare in advance* so that we maximize communication at the summit?

5. What specific applied scientists, policymakers, and practitioners should be invited to participate in the summit, in the presentation sessions, the working sessions or the policy panel?

5a. General Science to Policy Synthesizers?

5b. Specific expert in human impacts and protection of resources? (e.g. effects of habitat degradation on biodiversity?

6. Who comes to mind as an appropriate participant for these different kinds of applied scientists, policymakers and practitioners?

6a. As policy speakers in specialized science sessions to give overview of findings and relevant policy?

6b. As policy, planning, practitioner participant in working sessions after each presentation session on Thursday, Friday, Saturday morning with policy, planning or conservation practice experience?

6c. As reporters and panelists for the policy session on Saturday?

7. How should we organize the working sessions at the end of each presentation section to maximize effect communication and positive results?

8. How should we use the Sat. 1:20 to 5:00 pm time available for the summary output of work sessions and policy discussion that lead us to recommendations for policy applications at the end of the summit?

# Attachment C
## Conservation Policy Expert Participants for Working Sessions
### (Recommended by Policy Advisory Committee)

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# Attachment D

## Key Policy Questions for Science Presenters: Implications of their Evolutionary Science Research for Conservation

1. Do the findings of your research indicate a positive or negative secondary effect from evolutionary impacts on biological composition or the functionality of ecosystems[1]? Explain.

2. Do the findings of your research indicate that the human activities you are linking to evolutionary effect need to be further controlled or changed? (For example, an implication of your research might be that further controls on importation or distribution of invasive species should be considered. You may or may not have specific suggestions about how this can or should be done; for purposes of this discussion, we only need to know whether or not some change in current practice could change the effect.)

3. Do you think that the findings of your research indicate that changing conservation practices could reduce the negative evolutionary effects of the human activities you studied? (For example, providing more long-term management and restoration to conservation reserves would address the impacts of invasives.)

4. IF you answered 'no' to Question 3, are most of the negative evolutionary impacts on natural resources you found already addressed by current efforts to conserve the functionality of ecosystems and maintain diverse species populations and habitats?

5. Can you briefly describe any further research that you think might build on your findings to would in answering the questions above?

[1] As defined in Callicott et al; "Current Normative Concepts in Conservation"; **Conservation Biology**; Pgs 22-35; Vol 13, No. 1, February, 1999. Biologic composition is represented by the biological diversity and integrity of ecosystems, while the functionality of ecosystems is about the way that ecosystems function to support life for both humans and other life Secondary impacts can be of either type.,

# Attachment E
## Summit Agenda and Speakers

**Thursday, February 8**

| | | |
|---|---|---|
| 7:00 AM | *Registration and Continental Breakfast* | |
| 9:00 AM | **Welcome** | |
| | Thomas Smith, Summit Co-organizer | |
| | Mary Nichols, Director, Institute of the Environment | |
| | Norman Abrams, Acting Chancellor, UCLA | |
| | Roberto Peccei, Vice Chancellor for Research, UCLA | |
| | Louis Bernatchez, Summit Co-organizer | |
| | **Keynote Addresses** | |
| 9:20 AM | Georgina Mace | Evolutionary biology and practical conservation: bridging a widening gap |
| 9:50 AM | Loren Rieseberg | The speed of adaptation |
| 10:20 AM | *Coffee Break* | |
| | **Session I - Captive Breeding and Exploitation** | |
| 10:40 AM | Richard Frankham | Genetic adaptation to captivity in species conservation programs |
| 11:00 AM | C. Scott Baker | How few whales were there after whaling? |
| 11:20 AM | David Coltman | Consequences of selective harvesting |
| 11:40 AM | Robin Waples | Evolutionary consequences of anthropogenic changes on long-term viability of Pacific salmon and steelhead |
| 12:00 PM | *Lunch* | |
| 1:20 PM | Jeffrey A. Hutchings | Fishing, farming, and their evolutionary consequences to fishes |
| 1:40 PM | Paul Leberg | Purging of inbreeding depression and the management of captive populations |

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| 2:00 PM | Ettore Randi | Detecting hybridization between wild species and their domesticated relatives |
| 2:20 PM | Kaustuv Roy | Downsizing nature: ecological and evolutionary consequences of size-selective harvesting |
| 2:40 PM | Phil Hedrick | Captive breeding and the recovery of Mexican and red wolves |
| 3:00 PM | *Coffee Break* | |
| 3:20 PM | Robert Wayne | The effect of extirpation and reintroduction on genetic variability of the gray wolf |
| 3:40 PM | Pierre Taberlet | Conservation genetics of domestic Bovidae (cattle, sheep, goats) |
| 4:00 PM | Louis Bernatchez | The functional genomics of rapid evolutionary changes between domesticated and wild populations |
| 4:20 PM | Ryan Broddrick<br>*Policy Presentation* | Implications of research findings for fish and wildlife management |
| 4:40 PM | Questions and Discussion | |
| 5:00 PM | **Speaker Working Session I - Captive Breeding and Exploitation**<br>Co-chairs: André Talbot and Ray Sauvajot | |
| 6:00 PM | *Adjourn* | |

**Friday, February 9**

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|---|---|---|
| 7:00 AM | *Registration* | |
| | *Posters and Continental Breakfast* | |
| | **Session II - Habitat Degradation and Environmental and Climate Change** | |
| 8:00 AM | Juha A. Merilä | Environmental change and evolution: disentangling environmental and genetic responses |
| 8:20 AM | David Reznick | Experimental studies of evolution in guppies – a model for understanding the role of predators in structuring natural communities |

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| 8:40 AM | Pierre Saumitou-Laprade | Adaptation of *Arabidopsis halleri* (Brassicaceae) to sites recently polluted by high amounts of zinc and cadmium |
| 9:00 AM | Ole Seehausen | Speciation reversal in human-altered environments |
| 9:20 AM | Hans Slabbekoorn | How much acoustic space do we leave to the birds? |
| 9:40 AM | Victoria Sork | Do landscape changes threaten regions of evolutionary interest in California valley oak (*Quercus lobata*)? |
| 10:00 AM | *Coffee Break* | |
| 10:20 AM | Thomas Smith | Microevolutionary consequences of human disturbance in a rainforest species from Central Africa |
| 10:40 AM | Rosemary Gillespie | Natural and human-mediated biodiversity dynamics in isolated island communities: using current patterns towards a general understanding of process |
| 11:00 AM | Dany Garant | Changing climate and changing genetic (co)variance of reproductive traits in a wild bird population |
| 11:20 AM | Marcel Visser | Climate change leads to selection on temperature sensitivity of avian timing of reproduction |
| 11:40 AM | William Bradshaw | Genetic response to rapid climate change |
| 12:00 PM | Jessica Hellmann | Local adaptation as potential constraint on geographic range shifts under climate change: molecular evidence of divergence and field tests of population fitness in two contrasting butterfly species |
| 12:20 PM | Mark Reynolds<br>*Policy Presentation* | Is ignoring evolution intelligent design for conservation? |
| 12:40 PM | **Lunch and Speaker Working Session II - Habitat Degradation and Climate Change**<br>Chair: Jerry Schubel | |
| | **Session III. Invasive Species and Pathogens** | |
| 2:00 PM | Spencer Barrett | The evolution of adaptation during plant invasion |

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| 2:20 PM | Katrina Dlugosch | Founding events in invasions: genetic patterns and evolutionary consequences |
| 2:40 PM | Craig Benkman | Species introductions, the loss of geographic variation, and the elimination of coevolutionary diversification |
| 3:00 PM | *Coffee Break* | |
| 3:20 PM | Scott Carroll | Predicting the forms and foundations of rapid adaptation in persisting populations |
| 3:40 PM | Carol Eunmi Lee | Exploring genomic targets of selection across independent invasions into novel environments |
| 4:00 PM | Andrew Suarez and Neil Tsutsui | The evolutionary consequences of social insect invasions |
| 4:20 PM | Andrew Hendry | Human impacts on rates of phenotypic change in wild animal populations |
| 4:40 PM | Kenneth Whitney | Hybridization as a route to invasion |
| 5:00 PM | **POSTER SESSION and Wine & Cheese Reception** | |
| 8:00 PM | *Adjourn* | |

**Saturday, February 10**

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|---|---|---|
| 7:40 AM | *Registration* | |
| | *Posters and Continental Breakfast* | |
| | **Session III. Invasive Species and Pathogens (continued)** | |
| 8:40 AM | Michael Kinnison | Rapid evolution as an ecological determinant of invasion: experimental evaluation in the wild |
| 9:00 AM | Oliver Pergams | Microevolution in Chicago-area mice |
| 9:20 AM | Craig Moritz | Predicting and protecting evolutionary hotspots in California |
| 9:40 AM | Robert Fleischer | Trouble in Paradise: interactions of invasive vectors, introduced disease and an endangered native avifauna |
| 10:00 AM | *Coffee Break* | |

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| 10:20 AM | Scott Edwards | Host-parasite interactions: evolutionary genetics and gene expression changes in House Finches induced by an expanding bacterial pathogen |
| 10:40 AM | Frédéric Thomas | Human activities and parasite microevolution |
| 11:00 AM | Robert Mangold<br>*Policy Presentation* | Federal policy on forest invasive species and its relationship to evolutionary biology research |
| 11:20 AM | Questions and Discussion | |
| 12:00 PM | **Lunch and Speaker Working Session III - Invasive Species and Pathogens**<br>Co-chairs: Gabriela Chavarria and Ellie Cohen | |
| 1:20 PM | **Discussion Session:**<br>***Reports from the Working Sessions and Synthesis*** | |
| | Moderator: Sylvia Fallon<br>Panelists: | |
| | André Talbot | Conservation implications of evolutionary effects of captive breeding and exploitation |
| | Jerry Schubel | Conservation implications of the evolutionary effects of habitat degradation and climate change |
| | Gabriela Chavarria and Ellie Cohen | Conservation implications of evolutionary effects of invasive species and pathogens |
| | Tom Lacher and Ray Sauvajot | Summary and synthesis |
| 3:00 PM | *Coffee Break* | |
| 3:20 PM | **Integrating Science and Policy:**<br>***Using Evolutionary Science in Conservation Policy, Planning, Practice and Management*** | |
| | Moderator: Mary D. Nichols<br>Panelists:<br>Gabriela Chavarria<br>Ellie Cohen<br>Tom Lacher<br>Felicia Marcus<br>David Olson<br>Richard Rayburn<br>John Robinson | |

Ray Sauvajot
Jerry Schubel
André Talbot

5:00 PM *Adjourn*

**Concluding Reception, Banquet, and Keynote Speech**

6:00 PM Reception

7:00 PM Dinner
Keynote Address: Translating science into policy
Mary Nichols

# Attachment F
## White Paper Session Goals, Agenda, and Participants
## February 11, 2007

### White Paper Session
### Sunday, February 11, 2007, 9:00 AM - noon

Goals:

1. To develop an outline, assignments, and timeline for writing a commentary that discusses the threats, challenges, and potential solutions.
2. To develop an outline, assignments, and timeline for a report on California-specific recommendations.

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8:30–9:00 Continental breakfast

9:00–9:15 Introductions and agreement on goals and agenda

9:15–10:00 Discuss and synthesize the main outcomes from Saturday's afternoon session and others from working sessions that were not discussed on Saturday:

1. Assess whether there are solutions to address the problems identified in the research that can realistically be implemented, in the short- and the long-term.
2. Assess what would be required in order to develop realistic approaches to consideration of evolutionary impacts in conservation policy and practice.
3. Where serious secondary negative impacts from human-caused evolutionary changes have been shown, but where there have been no conservation efforts to mitigate them, *begin* to identify what would need to happen in order to develop realistic approaches to address the problems.
4. Begin to look at ways to institutionalize future communication between evolutionary scientists, conservation biologists, conservation policymakers, practitioners, and managers to improve the linkage between science on the evolutionary impacts of human activities and application in conservation.

10:30–10:45 Break

10:45–11:15 Develop commentary: outline, assignments, and timetable.

11:15–11:45 Develop California recommendations: outline, assignments, and timetable

11:45–12:00 Wrap-up

**White Paper Session Participants**

**Facilitator:** Steve Johnson, Director of Strategic Initiatives, The Nature Conservancy

| **Participants** | **Affiliation** |
|---|---|
| Louis Bernatchez | Summit Co-organizer, Professor, Department of Biology, Université Laval, Québec, Canada |
| Ellie Cohen | Executive Director, PRBO Conservation Science |
| Madelyn Glickfeld | Summit Principal Policy Advisor, Institute of the Environment |
| Tom Lacher | Senior Vice President and Executive Director, Center for Applied Biodiversity Science, Conservation International |
| Georgina Mace | National Environment Research Council Centre for Population Biology, Imperial College London, United Kingdom |
| Robert Mangold | Director of Forest Health, US Department of Agriculture National Forest Service |
| Craig Moritz | Museum of Vertebrate Zoology, University of California, Berkeley |
| Mary Nichols | Director, UCLA Institute of the Environment |
| David Olson | Director of Science and Stewardship, Irvine Ranch Land Reserve Trust |
| John Robinson | Executive Vice President for Conservation and Science, Wildlife Conservation Society |
| Ray Sauvajot | Chief of Planning, Science and Resource Management, Santa Monica Mountains National Recreation Area |
| Jerry Schubel | Chief Executive Officer, Long Beach Aquarium of the Pacific |
| Thomas Smith | Summit Co-Organizer, Professor, Institute of the Environment, Director, Center for Tropical Research, Professor, Ecology and Evolutionary Biology, UCLA |
| Victoria Sork | Professor, Institute of the Environment, Professor and Chair, Ecology and Evolutionary Biology, UCLA |
| André Talbot | Section Head, Fluvial Ecosystems Research, Aquatic Ecosystem Protection Research Division, Environment Canada/Environnement Canada |
| Robin Waples | Northwest Fisheries Science Center, National Marine Fisheries Service |
| Robert Wayne | Professor, Institute of the Environment, Professor, Ecology and Evolutionary Biology, UCLA |
| **Notetakers:** | |
| Jordan Karubian | Associate Director and Latin America Director, Center for Tropical Research, Institute of the Environment, UCLA |
| Benjamin Wang | Ph.D. candidate, Ecology and Evolutionary Biology, UCLA |