Appendix VI

Climate Change and California Ecosystems: Potential Impacts and Adaptation Options

Joel Smith
Stratus Consulting Inc.
Boulder, Colorado

and

Hector Galbraith
Galbraith Environmental Sciences, LLC
Boulder, Colorado

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1. Introduction

On January 11 and 12, 2001, a workshop organized by Stratus Consulting and Galbraith Environmental Sciences and hosted by the California Energy Commission (Commission) and the Electric Power Research Institute (EPRI) was held at the Commission offices in Sacramento, California. As part of its Public Interest Energy Research program, the Commission is undertaking a major study of the potential impacts of climate change on California and the effectiveness of adaptation responses. The study described here, which was coordinated by EPRI, examined climate change implications for water supplies, agriculture, coastal areas, vegetation, timber, and energy in the state. This workshop was part of the Commission study, using an analysis of impacts of climate change on California vegetation being conducted by Drs. Ron Neilson of the U.S. Forest Service and Jim Lenihan of Oregon State University and predictions of urbanization patterns in California conducted by Dr. John Landis of the University of California at Berkeley.

The main objectives of this workshop were to:

- Identify the potential effects of future climate change and human development (land use for urban and agricultural purposes) on the status and distribution of California's main terrestrial ecosystems.

- Identify and evaluate potential adaptation options that might offset or mitigate terrestrial ecosystem impacts.

Approximately 30 participants from the Commission, EPRI, academia, state agencies, federal agencies, nongovernmental organizations, and private institutions attended the workshop (see Attachment A for a list of attendees).

Attachment B is the final agenda for the workshop. After welcoming remarks from Kelly Birkenshaw and Guido Franco of Commission and Tom Wilson of EPRI, presentations were given on the following topics:

- The objectives of the workshop and climate change scenarios (Joel Smith, Stratus Consulting).

- The current state of California ecosystems and their conservation challenges (Frank Davis, the University of California, Santa Barbara).

- Current and potential future patterns of development in California (John Landis, the University of California, Berkeley).

- Modeling results of how future climate change scenarios might affect vegetation in California (Ron Neilson, U.S. Forest Service).

- Combining the potential vegetation change results with projected human development patterns and current agriculture in an integrated evaluation of how California vegetation communities may be altered in the future by these stressors (Hector Galbraith, Galbraith Environmental Sciences).

- Types of adaptation options that could be used to offset the effects of climate change on ecological resources (Adam Markham, Clean Air-Cool Planet).

- The potential effects of climate change and development on one Southern California vegetation community, coastal sage scrub (Hector Galbraith). This presentation explored the utility and feasibility of some adaptation options for this community.

- A description of other projects being conducted as part of the Commission /EPRI work (Robert Mendelsohn, Yale University). These studies are examining impacts on market sectors, including agriculture, water resources, timber, coastal resources, and energy.

The workshop was designed to generate discussion about these issues among the attendees. The presentations were interspersed with extensive group discussion on the potential ecosystem effects of climate change and human land use; the strengths and weaknesses of the methods; and the feasibility, opportunities, and constraints associated with conserving affected resources. Much of the latter part of the first day and most of the second day were devoted to these discussions, including the development of a matrix to begin evaluating adaptation options. Finally, the workshop closed with the attendees being asked to identify data and research needs.

The results from many of the presentations are reported in other appendices:

- Climate change scenarios are reported in Appendix I.

- Urbanization scenarios are reported in Appendix III.

- Changes in terrestrial ecosystems resulting from climate change are reported in Appendix IV.

- The analysis of combined effects or urbanization and climate change impacts on ecosystems is reported in Appendix V.

The presentations given at the workshop were all preliminary and some results (e.g., projections of urbanization) changed.

The workshop addressed two topics not addressed in the other appendices: adaptation and future research needs. The following sections summarize the adaptation discussion and identify future research projects that could, potentially, reduce important uncertainties.

2. Adaptation

The workshop participants discussed adaptations that generally could protect biodiversity in the Los Angeles basin area and that specifically could protect coastal sage. Some participants noted that should coastal sage become forest, many people might not object, leading the attendees to recognize that any conclusions about how people would react to changes in ecosystem types would be speculative.

The discussion on adaptation options identified a number of potential adaptation options (Table 1). The participants also identified policy objectives that the options should achieve (Table 2).

Table 1. Adaptation options

Current policy/no change
Allow for relocation
Secure edge areas
Migration corridors
Protect new areas
Protect current areas
Reduce existing stresses
Restoration
Create or transplant habitats
Take new approaches
Active management
Adaptive management
Integrated use management
Bioengineering
Management to minimize catastrophe
Monitor
Educate public
Increase density of urban development
Practice ex situ conservation

Table 2. Policy objectives

Maintain ecological and evolutionary dynamics at multiple scales
Support ecological structure
Resist invasives
Avoid catastrophe
Maintain/enhance ecosystem services
Create win-win situations
Assess technical feasibility[a]
Determine institutional feasibility
Evaluate cost

a. Note that technical feasibility overlaps with the first five objectives, so it was not listed as a separate objective in the adaptation decision matrix.

We prepared a matrix to evaluate the effectiveness of the adaptation options in meeting the policy objectives, assuming that climate will change. There was insufficient time to work through the entire matrix; partial results are displayed in Table 3. We considered four options. The first three addressed facilitating migration (or transplantation) of coastal sage to new, more suitable locations. The fourth, reducing existing stresses, addressed ways to maintain coastal sage in its current locations. A "+" means an option is likely to meet an objective, a "-" means it is unlikely, and a "?" means the participants were uncertain. Double pluses or minuses indicate higher levels of certainty.

There is no objective way to sum up the results of the matrix. Although it appears that reducing existing stresses is more likely to satisfy more objectives than the other adaptation alternatives, these results are quite preliminary and need further analysis.

In addition to the work on the matrix, general discussion covered several topics, including:

- **Policy issues**. Some participants argued that current planning and conservation policies might not allow us to most effectively address the new problems that climate change will introduce. Faced with the uncertainty about future climates, it might be most effective to adopt more flexible planning policies and regulations than those that are already in place. Management for single-species or fixed-site reserves may not be the optimal solutions to these new challenges. Also, policy is typically set at the local level and climate change occurs at a far larger scale. How do we integrate these two scales?

Table 3. Adaptation decision matrix

Options	Maintain ecological and evolutionary dynamics	Support ecological Structure	Resist invasives	Minimize catastrophe	Maintain ecosystem services	Create win-win situations	Determine institutional feasibility	Evaluate cost
Secure range margins	+	?	-	?	+	Not sure	- (+ along immediate margins) (+ in government-controlled areas)	-
Provide migration corridors	++ (depends on predictability)	+/?	-	?/+	+	+ (note invasives)/ uncertainty of CC impacts; lower Santa Clara River Valley	- (+ in government-controlled areas)	-
Protect new habitat areas	+	+	-	?/+	+	Not sure	- (+ in government-controlled areas)	-
Reduce existing stresses	++	+	++	+	+	Depends: invasives yes; some others not clear	Depends	-

- **Conservation values**. Perhaps climate change will put pressure on us to look more closely at our conservation goals and the flexibility with which we identify them. Under climate change, it may not be possible to manage so that our valued resources remain unchanged. Perhaps the best we can do is to direct this change through actively managing sites.

- **Land ownership**. Implicit in most of our discussions about managing natural resources is the assumption that the valued resources will be on "reserves." Much of California, however, is privately owned. How do we ensure that conservation planning can be applied to these areas? Would a system of incentives or disincentives work? Also, might it be possible to encourage conservation within already developed areas by facilitating "reconciliation ecology?" The political boundaries that inform current policy may also be a problem; setting policy at a state rather than a county level may facilitate more effective conservation.

3. Future Research Objectives

The final session of the workshop focused on identifying possible future research activities that could improve our ability to plan adaptation to climate change in California. A number of activities were proposed, and these are listed in Table 4. In the descriptions below we grouped these proposals in terms of their potential immediate applicability to the continuing analysis. The two categories are projects that could be immediately applicable and produce valuable results in a relatively short time frame, and projects that are valuable but may be longer term.

3.1 Immediately Applicable Projects

- **Modeling potential vegetation change using a drier future climate scenario**. The climate scenarios that have been the basis of the vegetation modeling thus far postulate either a higher soil moisture content (HadCM2) or little change from current conditions (T3P0, T5P0, and T3P18). However, there is not, as yet, a consensus that future climate change will meet these assumptions — it could result in reduced soil moisture. For this reason, it would be useful to re-run the model using a future climate scenario that would result in a significantly reduced soil moisture content.[1]

1. A relatively dry run of a second GCM, the parallel climate model (PCM), estimates reduced precipitation throughout the state.

Table 4. Research priorities

Perform higher resolution analysis of key areas
Incorporate slope and aspect
Use actual vegetation and land use data
Improve understanding of vegetation dynamics and non-native species
Foster better understanding and modeling of ecosystem services, such as:
Water
Endangered species
Productivity
Carbon sequestration
Improve valuation of ecosystem services
Integrate paleoecological information
Include richer representation of urbanization
Incorporate long-term population and land use scenarios
Improve science within models
Examine coastal habitats
Assess water inflows
Examine institutional design to cope with impacts
Investigate ways to make risk communication digestible for policy makers and public
Better integrate urbanization impacts on ecosystems such as the heat island
Incorporate fog
Better understand impacts on wildlife
Use mesoscale climate models
Better incorporate fire effects
Increase interaction and communication among researchers

- **Estimating urbanization beyond 2020**. California's population is projected to grow to at least 45 million by 2020 and could reach 100 million by 2100. Such increases in population are likely to result in more conversion of land to urban and suburban uses, which could lead to further losses of biodiversity. Estimating urbanization patterns out to 2100 will put these projections on the same time scale as the vegetation estimations.

- **Analyzing adaptation policies**. One of the insights that emerged from the workshop was that current state planning policies might not be adequate to effectively address the conservation problems that climate change may introduce. The policies are designed to protect ecosystems where they currently exist, not to facilitate migration or transplantation to new locations. An important step forward would be to review federal, state, and local policies to identify impediments to planning for future climate change and opportunities and synergies that may aid such planning.

3.2 Longer Term Projects

- **Investigating exotic plant species and predicting the effects of climate change on future vegetation distributions.** In California, 20% of the plant species are exotics (i.e., introduced by people or their livestock). In many areas these invasives are the dominating force in vegetation communities. For example, large areas are dominated by yellow starthistle or ice plant rather than native communities. From what is understood thus far about the ecology of these invasives, they are likely to gain even more of a competitive advantage over native species under future changes in climate. As a result, they could be a major factor that determines the likelihood of modeled changes in vegetation. Although we know a great deal about the biology of these invasive plants, their potential effects under climate change have not been evaluated. In this project, the biology of the main species would be reviewed to determine which of those would have the greatest impacts under climate change and where these effects might occur, and to identify the environmental conditions under which these impacts would be greatest (and where the model projections would have to be modified).

- **Do higher resolution potential vegetation mapping.** The modeled projections of California vegetation are currently made at a 10 km^2 scale. However, expressing them at a larger scale (e.g., 1 km^2) would make the modeled results more ecologically accurate and facilitate their use in planning.

Appendix VI — Attachment A

Commission/EPRI Climate Change Adaptation Workshop Participant List and Contact Information

Marc Beyeler
Senior Program Manager
California State Coastal Conservancy
1330 Broadway, Suite 1100
Oakland, CA 94612
Phone: (510) 286-4172
Fax: (510) 286-0470
mbeyeler@scc.ca.gov

Joe Carboni
Wildlife and Habitat Data Analysis Branch
California Department of Fish & Game — Habitat Conservation Division
1416 Ninth St.
Sacramento, CA 95814
Phone: (916) 324-1414
Fax: (916) 324-0475
jcarboni@dfg.ca.gov

Frank Davis
University of California at Santa Barbara
Donald Bren School of Environmental Sciences & Management
Room 109 Bldg. 489
Santa Barbara, CA 93106
Phone: (805) 893-3438
Fax: (805) 893-7612
fd@geog.ucsb.edu

Pierre DuVair, Ph.D.
Resource Economist — Scientific Program, State of California
Department of Fish and Game
1700 K Street, Suite 250
P.O. Box 944209
Sacramento, CA 94244-2090
Phone: (916) 327-0911
Fax: (916) 323-4407
pduvair@ospr.dfg.ca.gov

Chris Field
Carnegie Institution of Washington
Department of Plant Biology
260 Panama Street
Stanford, CA 94305
Phone: (650) 325-1521 ×213
Fax: (650) 325-3748
chris@jasper.stanford.edu

Guido Franco, P.E.
Associate Mechanical Engineer
California Energy Commission
Energy Facilities Siting and Environmental Protection Division
1516 Ninth Street, MS 40
Sacramento, CA 95814-5504
Phone: (916) 654-3940
Fax: (916) 654-3882
gfranco@energy.state.ca.us

Hector Galbraith
Galbraith Environmental Sciences
633 Furman Way
Boulder, CO 80303
Phone: (720) 304-8764
Fax: (720) 304-8765
hgalbraith2@home.com

Madelyn Glickfeld
UCLA Institute of the Environment
1652 Mira Hershey Hall
Box 951496
Los Angeles, CA 90095-1496
Phone: (310) 825-7755
Fax: (310) 825-9663
mglickfeld@aol.com

Russell Jones
Stratus Consulting Inc.
P.O. Box 4059
Boulder, CO 80306-4059
Phone: (303) 381-8000
Fax: (303) 381-8200
rjones@stratusconsulting.com

John Landis
Professor, Department of City and Regional Planning
University of California at Berkeley
228 Wurster Hall #1850
Berkeley, CA 94720-1850
Phone: (510) 642-5918
Fax: (510) 642-1641
jlandis@uclink4.berkeley.edu

James Lenihan
Oregon State University
Research Associate
Forestry Sciences Lab
3200 SW Jefferson Way
Corvallis, OR 97330
Phone: (541) 750-7432
Fax: (541) 750-7329
lenihan@fsl.orst.edu

Adam Markham
Clean Air-Cool Planet
100 Market Street, Suite 204
Portsmouth, NH 03801
Phone: (603) 422-6466
amarkham@cleanair-coolplanet.org

Robert Mendelsohn
School of Forestry & Environmental Studies
Yale University
Marsh Hall 38
New Haven, CT 06520
Phone: (203) 432-5128
robert.mendelsohn@yale.edu

Connie Millar
USDA Forest Service
PSW Research Station
800 Buchanen St.
Albany, CA 94710
Phone: (510) 559-6300
cmillar@fs.fed.us

Ron Neilson
U.S. Forest Service
FSL 250
Oregon State University
3200 SW Jefferson Way
Corvallis, OR 97331
Phone: (541) 750-7303
Fax: (541) 750-7329
neilsonr@fsl.orst.edu

Michelle Passero
Policy Manager
The Pacific Forest Trust
416 Aviation Blvd., Suite A
Santa Rosa, CA 95403
Phone: (707) 578-9950
mpassero@pacificforest.org

Lou Pitelka
Appalachian Laboratory
301 Braddock Road
Frostburg, MD 21532-2307
Phone: (301) 689-7101
Fax: (301) 689-7200
pitelka@al.umces.edu

M.A. Sanjayan
Director of Conservation Science
The Nature Conservancy — California Regional Office
201 Mission Street, 4th Floor
San Francisco, CA 94105
Phone: (415) 281-0460
Fax: (415) 777-0244
msanjayan@tnc.org

Joel B. Smith
Stratus Consulting Inc.
P.O. Box 4059
Boulder, CO 80306-4059
Phone: (303) 381-8218
Fax: (303) 381-8200
jsmith@stratusconsulting.com

Andrea Tuttle
California Department of Forestry and Fire Protection
P.O. Box 944246
Sacramento, California 94244-2460
andrea_tuttle@fire.ca.gov

Robert Wilkinson
University of California at Santa Barbara
Environmental Studies Program
2314 Girvetz Hall
Santa Barbara, CA 93106
Phone: (805) 893-2769
Fax: (805) 893-8433
wilkinso@envst.ucsb.edu

Larry Williams
EPRI
3412 Hillview Ave.
Palo Alto, CA 94304-1395
Phone: (650) 855-2695
Fax: (650) 855-2950
ljwillia@epri.com

Tom Wilson
EPRI
3412 Hillview Avenue
P.O. Box 10412
Palo Alto, CA 94303-0813
Phone: (650) 855-7928
Fax: (650) 855-2950
twilson@epri.com

Appendix VI — Attachment B

Agenda for Commission/EPRI Climate Change Adaptation Workshop

This is an agenda for the EPRI/Commission climate change adaptation workshop to be held on 11th and 12th January 2001. The workshop will be held in Hearing Room A of the California Energy Commission offices at 1516 9th St., Sacramento, CA 95814.

January 11

8:30 Welcoming remarks from EPRI and Commission.

8:40 Introduction and reiteration of the aims of the workshop — Joel Smith, Stratus Consulting Inc.

8:50 The current state of Californian ecosystems and the conservation challenges facing them Frank Davis UC Santa Barbara.

9:20 "Traditional" stressors — current and potential future development in California — John Landis, UC — Berkeley.

9:50 Break

10:15 Potential effects of climate change on Californian major vegetation communities: Recent modeling results — Ron Neilson, Oregon State University.

10:45 Integrating impacts of development and climate change on California vegetation — Hector Galbraith, Galbraith Environmental Sciences and University of Colorado.

11:25 Discussion on climate change and urbanization impacts on California ecosystems.

12:00-1:30 Lunch

1:30 Continue discussion on climate change and urbanization impacts on California ecosystems.

2:15 Adaptation as an option — Adam Markham, Clean air — cool planet.

2:45 Identification of Californian adaptation options and case study results (45 minutes) — Hector Galbraith.

3:25 Break

3:40 Drawing conclusions about feasibility of adaptation options — discussion moderated by Joel Smith of Stratus Consulting. In this discussion, the group will address the adaptation options presented by Dr. Galbraith and identify and evaluate additional options. The pros, cons, costs, and uncertainties regarding each option will be identified in a discussion open to all participants.

5:30 Adjourn

January 12

8:45 Presentation on assessment of climate change impacts on California forestry — Robert Mendelsohn, Yale University.

9:00 Moderated discussion on adaptation options, continued. This session will review the results of the final session on the 11th and explore specific options in more detail as necessary.

10:30 Break

10:45 Identification of future research priorities.

11:45 Closing remarks — EPRI/Commission.

12:00 Adjourn