California Department of Food and Agriculture
CANNELLA ENVIRONMENTAL FARMING ACT SCIENCE ADVISORY PANEL

MEETING AGENDA

2800 Gateway Oaks Drive, Room 101
Sacramento, CA 95833
(916) 654-0433

November 7, 2011
1:00 PM to 4:00 PM

Jeff Dlott, PhD, Chairman

Mike Tollstrup, Member **Ann Thrupp, PhD, Member**
Brian Leahy, JD, Member **Don Cameron, Member**
Louise Jackson, PhD, Subject Matter Expert
Daniel Mountjoy, PhD, Subject Matter Expert

Amrith Gunasekara, PhD, CDFA Liaison

1. Introductions – Jeff Dlott
2. The Cannella Act – Amrith Gunasekara
3. Consideration of Draft Bylaws – Amrith Gunasekara
4. Bagley-Keene Open Meeting Act and Public Requests Act – Michele Dias, General Counsel
5. Ecosystem Services
    i. Amrith Gunasekara – Intro Presentation
    ii. Dr. Thrupp – Presentation
    Panel Discussion – Panelist noted below
        Eric Holst or Belinda Morris (EDF)
        Cynthia Cory (CA Farm Bureau)
        Paul Buttner (CA Rice Commission)
        Mark Kramer (Nature Conservancy)
    CRAE Update
        Casey Cady (CRAE)
    Discussion
6. FREP Database update – Amrith Gunasekara
    Discussion
7. Future focus of panel
    Discussion
8. Public Comment
9. Next meeting – Jeff Dlott
10. Adjournment

All meeting facilities are accessible to persons with disabilities. If you require reasonable accommodation as defined by the American with Disabilities Act, or if you have questions regarding this public meeting, please contact Tammy Sulli at (916) 654-0433.

PROCEDURES FOR THE
CANNELLA ENVIRONMENTAL FARMING ACT SCIENCE ADVISORY PANEL

The following will guide the activities of the Cannella Environmental Farming Act Scientific Advisory Panel, created under the Food and Agricultural Code, Division 1, Chapter 3, Article 8.5, Sections 560-568.

PANEL STRUCTURE

1.1 Membership

As provided by Section 568, the Panel shall: 1) consist of five members, 2) three members shall be appointed by the Secretary of Food and Agriculture, at least one of these members shall have a minimum of five years of training and experience in the field of agriculture and shall represent production agriculture; one member shall be appointed by the Secretary of the Environmental Protection Agency with a minimum of five years of training and experience in the field of human health or environmental science; one member shall be appointed by the Secretary of the Resource Agency with a minimum of five years of training and experience in the field of resource management; and 3) be highly qualified and professionally active or engaged in the conduct of scientific research.

1.2 Terms

Of the members first appointed to the Panel, two shall serve for a term of two years and three shall serve for a term of three years, as determined by lot. Thereafter, members shall be appointed for a term of three years. Any variances which occur shall be filled for the remaining unexpired term.

1.3 Vacancies

Any vacancy that occurs during an unexpired term shall be filled by the appointing agency for the remainder of the unexpired term, in accordance with the requirements set for in section 1.1.

1.4 Officers

The permanent officers of the Committee shall be: Chairperson and Vice Chairperson. The Committee may from time to time create additional officers with such titles and duties as it may assign.

1.5 Chairperson

The Chairperson shall preside over meetings of the Committee, and shall serve as the principal spokesperson for the Committee.

1.6 Vice Chairperson

The Vice Chairperson shall serve as Chairperson in the absence of the Chairperson.

1.7 Election of Panel Officers

Panel officers shall be elected for a term of two or three years as specified in section 1.2, commencing with the October 2011 meeting. An office may be held for two consecutive terms, but not more than two consecutive terms.

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CANNELLA ENVIORNMENTAL FARMING ACT SCIENCE ADVISORY PANEL

November 7, 2011
CDFA
Sacramento, CA

Amrith Gunasekara
Science Advisor to the Secretary

INTRODUCTION TO THE CANNELLA ACT

- Section 560-568 of Food and Agricultural Code.
- Authored by Assembly member Cannella in 1995.
- Named the Cannella Environmental Farming Act of 1995.

- Recognizes the following [Food and Economy - 561 (a)];
  - CA Ag helps feed the world and fuels the economy.
  - Ag provided 1 out of 10 jobs.
  - State leads nation in total farm production since 1948.
  - CA farms contribute billions in economic activity.

INTRODUCTION TO THE CANNELLA ACT

- Recognizes the following [Environmental – 561 (b),(c),(d),(e)];
  - Farms have practices that contribute to e-“well-being”.
  - Farms contribute to wildlife as habitats and food sources.
  - Environmental law based on “best scientific evidence”.
  - Both “public and private” sources used for data collection.
  - Science should include net e-impact provided by ag.
  - More research is needed to “inventory” the impact that agriculture has on the environment (agriculture’s net benefit for the environment).

THE CANNELLA ACT MANDATES

- Creation of a Scientific Advisory Panel on E-Farming;
  - Advice/assist - air, water, and wildlife issues [568 (a)1].
  - Compile net e-impact ag has on environment [568 (a)2].
  - Research, review, and comment on data upon which proposed e-policies and programs are based [568 (a)3].
  - Ensure that the e-impacts of ag activities are accurately portrayed and identify incentives [568 (a)3].
  - Review “data on the impact that agriculture has on the environment and recommend to state agencies data that the panel approves as scientifically valid.” [568 (a)1].
  - Assist governmental agencies to incorporate benefits [568 (a)4].

THE SCIENCE ADVISORY PANEL

- Composition;
  - Three by Secretary of Agriculture
    - Dr. Jeff Dlott (Chair) – CEO SureHarvest
    - Dr. Ann Thrupp – Fetzer Winery – Manager of Sustainability
    - Don Cameron, BS - General Manager of Terranova Ranch Inc
  - One by Secretary of Environmental Protection Agency
    - Mike Tollstrup, BS – ARB – Chief – Project Assessment Branch
  - One by Secretary of the Resource Agency
    - Brian Leahy, JD - Assistant Director - Div. Land Resource Protection
  - Subject Matter Experts
    - Dr. Louise Jackson – UC Davis – Chair in EPS (LAWR)
    - Dr. Daniel Mountjoy – USDA NRCS – Assistant State Conservationist

OTHER

- Environmental Farming Program;
  - If existing resources are available, the department shall create a program to provide incentives to farmers whose practices promote the well-being of ecosystems, air quality, and wildlife.
  - Department may assist in compilation of scientific evidence from public and private sources (e.g., science community, industry, conservation organizations) indentifying the net environmental impacts that agriculture creates for the environment.
  - Department will serve as depository of this information.

QUESTIONS

Thanks

http://asymptotia.com/2008/07/10/science-cartoon-contest/

CALIFORNIA CODES
FOOD AND **AGRICULTURAL CODE**
SECTION 560-568

560. This article shall be known as the **Cannella** Environmental Farming Act of 1995.

561. The Legislature finds and declares the following:

(a) California agriculture helps to feed the world and fuel our economy. Agriculture provides one out of every 10 jobs in California, and our state has led the nation in total farm production every year since 1948. During 1993, California's 76,000 farms generated nearly $20 billion in cash receipts and another $70 billion in economic activity.

(b) Many farmers engage in practices that contribute to the well-being of ecosystems, air quality, and wildlife and their habitat. Agriculture plays a pivotal role in preserving open space that is vital to the environment. Seventy-five percent of the nation' s wildlife live on farms and ranches. Freshwater streams and stockponds on farms and ranches provide habitat to millions of fish. Corn, wheat, rice, and other field crops provide bountiful food and habitat for deer, antelope, ducks, geese, and other wildlife.

(c) Environmental laws should be based on the best scientific evidence gathered from public and private sources.

(d) Best scientific evidence should include the net environmental impact provided by agriculture.

(e) Additional research is necessary to adequately inventory the impact that agriculture has on the environment. Recognition should be afforded to **agricultural** activities that produce a net benefit for the environment, which is consistent with the growing trend of providing incentives for the private sector to undertake economic activities that benefit the environment.

564. Unless the context otherwise requires, the following definitions govern the construction of this article:

(a) "**Agricultural** activities" means those activities that generate products as specified in Section 54004.

(b) "Department" means the Department of Food and Agriculture.

(c) "Panel" means the Scientific Advisory Panel on Environmental Farming.

(d) "Secretary" means the Secretary of Food and Agriculture.

566. (a) The department shall establish and oversee an environmental farming program. The program shall provide incentives to farmers whose practices promote the well-being of ecosystems, air quality, and wildlife and their habitat.

(b) The department may assist in the compilation of scientific evidence from public and private sources, including the scientific community, industry, conservation organizations, and federal, state, and local agencies identifying the net environmental impacts that agriculture creates for the environment. The department shall serve as the depository of this information and provide it to federal, state, and local governments, as needed.

(c) The department shall conduct the activities specified in this article with existing resources, to the extent they are available.

568. (a) The secretary shall convene a five-member Scientific Advisory Panel on Environmental Farming to advise and assist federal, state, and local government agencies on issues relating to air, water, and wildlife habitat to do the following:

(1) Review data on the impact that agriculture has on the environment and recommend to appropriate state agencies data that the panel approves as scientifically valid. A state agency that receives data recommended by the panel may adopt and incorporate the data into the appropriate program. If a state agency does not utilize the data recommended by the panel, it shall provide the panel with a written statement of reasons for not utilizing the data. The reasons, at a minimum, shall specify the scientific basis for not utilizing the data. The reasons shall be provided within 180 days of receiving the data from the panel.

(2) Compile the net environmental impacts that agriculture creates for the environment, identified pursuant to paragraph (1).

(3) Research, review, and comment on data upon which proposed environmental policies and regulatory programs are based to ensure that the environmental impacts of **agricultural** activities are accurately portrayed and to identify incentives that may be provided to encourage **agricultural** practices with environmental benefits.

(4) Assist government agencies to incorporate benefits identified pursuant to paragraph (1) into environmental regulatory programs.

(b) Members of the panel shall be highly qualified and professionally active or engaged in the conduct of scientific research. Of the members first appointed to the panel, two shall serve for a term of two years and three shall serve for a term of three years, as determined by lot. Thereafter, members shall be appointed for a term of three years. The members shall be appointed as follows:

(1) Three members shall be appointed by the secretary. At least one of these members shall have a minimum of five years of training and experience in the field of agriculture and shall represent production agriculture.

(2) One member, who has a minimum of five years of training and experience in the field of human health or environmental science, shall be appointed by the Secretary of the Environmental Protection Agency.

(3) One member, who has a minimum of five years of training and experience in the field of resource management, shall be appointed by the Secretary of the Resources Agency.

(c) The panel may establish ad hoc committees, which may include professionals or scientists, to assist it in performing its functions.

(d) The panel shall be created and maintained with funds made available from existing resources within the department to the extent they are available.

1.8 Ad Hoc Committees
As defined in Section 568 (c), the panel may establish ad hoc committees, which may include professionals or scientists, to assist it in performing its functions.

II. AD HOC COMMITTEES

2.1 Membership
The Panel may establish ad hoc committees, which may include professionals or scientists, to assist it in performing its functions, and Panel members. The Chairperson and membership of these committees shall be determined by the Panel Chairperson or Panel.

2.2 A quorum for the conduct of ad hoc committee business shall be a majority of the members, plus one. A majority of the quorum shall be entitled to adopt recommendations constituting committee action.

Once a quorum has been established and a meeting has commenced, a committee may continue to meet and take action even if, as a result of early retirement of some members, less than a quorum of the subcommittee are in attendance.

2.3 Minutes
Ad Hoc Committees shall keep meeting minutes and shall make approved minutes available to the public in a timely manner.

III. PANEL MEETINGS

3.1 Meetings
Meetings of the Panel shall be scheduled as needed and shall be noticed according to the provisions of the Bagley-Keene Open Meeting Act (Government Code Sections 11120 et seq.). A copy of the Bagley-Keene Act shall be provided to each Committee member.

3.2 Notice of Meetings
Written notice of all meetings shall be sent to all interested persons entitled to notice under the provisions of the Bagley-Keene Open Meeting Act.

3.3 Public Meetings
All meetings of the Panel shall be open to the public and in other respects shall conform to requirements of the Bagley-Keene Open Meeting Act.

3.4 Panel Action
A quorum for the conduct of Panel business shall be a majority of Panel members plus one [four of the five-member Panel].

3.5 Place of Meetings
Meetings shall be held as specified in the official meeting notice.

3.6 Minutes

The Panel shall keep meeting minutes and shall make approved minutes available to the public in a timely manner.

IV. PANEL COMMUNICATIONS

4.1 Public Communications

The Science Advisor to the Secretary of the Department of Food and Agriculture shall be official spokesperson for the Panel.

4.2 Communications with the Department

While any Panel member may communicate with the Department, official communications from the Panel shall be sent by the Science Advisor.

4.3 Communication to Panel Members

In recognition of the Panel's broad responsibilities, each member of the Panel shall have the responsibility to maintain lines of communication with his/her appointing agency.

4.4 Reports to Committee from Department

The Department will furnish the Panel with information and reports reasonably necessary to allow the Panel to perform its advisory role.

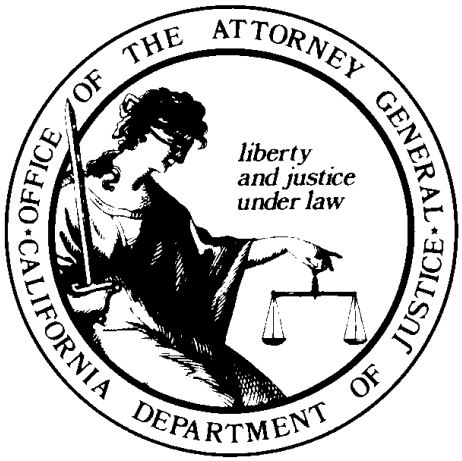
V. FUNCTION OF THE PANEL

5.1 Enumeration of Functions

The Panel shall perform to the best of its ability the advisory functions on all matters pertaining to Chapter 3 of Division 1 including making recommendations regarding incentives for the private sector to undertake economic activities that benefit the environment.

VI. REIMBURSEMENT OF EXPENSES

6.1 The members of the Panel shall serve without compensation, but shall be reimbursed for reasonable expenses incurred attending meetings approved by the department.



A Handy Guide to The Bagley-Keene Open Meeting Act 2004

California Attorney General's Office

INTRODUCTION

The Bagley-Keene Open Meeting Act ("the Act" or "the Bagley-Keene Act"), set forth in Government Code sections 11120-11132[1], covers all state boards and commissions. Generally, it requires these bodies to publicly notice their meetings, prepare agendas, accept public testimony and conduct their meetings in public unless specifically authorized by the Act to meet in closed session. Following is a brief summary of the Act's major provisions. Although we believe that this summary is a helpful road map, it is no substitute for consulting the actual language of the Act and the court cases and administrative opinions that interpret it.

If you wish to obtain additional copies of this pamphlet, they may be ordered or downloaded via the Attorney General's Home Page, located on the World Wide Web at http://caag.state.ca.us. You may also write to the Attorney General's Office, Public Inquiry Unit, P.O. Box 944255, Sacramento, CA 94244-2550 or call us at (800) 952-5225 (for callers within California), or (916) 322-3360 (for callers outside of California); the TTY/TDD telephone numbers are (800) 952-5548 (for callers within California), or (916) 324-5564 (for callers outside of California).

PURPOSE OF THE ACT

Operating under the requirements of the Act can sometimes be frustrating for both board members and staff. This results from the lack of efficiency built into the Act and the unnatural communication patterns brought about by compliance with its rules.

If efficiency were the top priority, the Legislature would create a department and then permit the department head to make decisions. However, when the Legislature creates a multimember board, it makes a different value judgment. Rather than striving strictly for efficiency, it concludes that there is a higher value to having a group of individuals with a variety of experiences, backgrounds and viewpoints come together to develop a consensus. Consensus is developed through debate, deliberation and give and take. This process can sometimes take a long time and is very different in character than the individual-decision-maker model.

Although some individual decision-makers follow a consensus-building model in the way that they make decisions, they're not required to do so. When the Legislature creates a multimember body, it is mandating that the government go through this consensus building process.

When the Legislature enacted the Bagley-Keene Act, it imposed still another value judgment on the governmental process. In effect, the Legislature said that when a body sits down to develop its consensus, there needs to be a seat at the table reserved for the public. (§ 11120.) By reserving this place for the public, the Legislature has provided the public with the ability to monitor and participate in the decision-making process. If the body were permitted to meet in secret, the public's role in the decision-making process would be negated. Therefore, absent a specific reason to keep

[1]All statutory references are to the Government Code.

the public out of the meeting, the public should be allowed to monitor and participate in the decision-making process.

If one accepts the philosophy behind the creation of a multimember body and the reservation of a seat at the table for the public, many of the particular rules that exist in the Bagley-Keene Act become much easier to accept and understand. Simply put, some efficiency is sacrificed for the benefits of greater public participation in government.

BODIES COVERED BY THE ACT: **General Rule**

The general rule for determining whether a body is covered by the Act involves a two part test (§ 11121(a)):

First, the Act covers multimember bodies. A multimember body is two or more people. Examples of multimember bodies are: state boards, commissions, committees, panels, and councils. Second, the body must be created by statute or required by law to conduct official meetings. If a body is created by statute, it is covered by the Act regardless of whether it is decision-making or advisory.

■ **Advisory Bodies**

The Act governs two types of advisory bodies: (1) those advisory bodies created by the Legislature and (2) those advisory bodies having three or more members that are created by formal action of another body. (§11121(c).) If an advisory body created by formal action of another body has only two members, it is not covered by the Bagley-Keene Act. Accordingly, that body can do its business without worrying about the notice and open meeting requirements of the Act. However, if it consists of three people, then it would qualify as an advisory committee subject to the requirements of the Act.

When a body authorizes or directs an individual to create a new body, that body is deemed to have been created by formal action of the parent body even if the individual makes all decisions regarding composition of the committee. The same result would apply where the individual states an intention to create an advisory body but seeks approval or ratification of that decision by the body.

Finally, the body will probably be deemed to have acted by formal action whenever the chair of the body, acting in his or her official capacity, creates an advisory committee. Ultimately, unless the advisory committee is created by staff or an individual board member, independent of the body's authorization or desires, it probably should be viewed as having been created by formal action of the body.

- **Delegated Body**

The critical issue for this type of body is whether the committee exercises some power that has been delegated to it by another body. If the body has been delegated the power to act, it is a delegated committee. (§ 11121(b).) A classic example is the executive committee that is given authority to act on behalf of the entire body between meetings. Such executive committees are delegated committees and are covered by the requirements of the Act.

There is no specific size requirement for the delegated body. However, to be a body, it still must be comprised of multiple members. Thus, a single individual is not a delegated body.

- **Commissions Created by the Governor**

The Act specifically covers commissions created by executive order. (§ 11121(a).) That leaves open two potential issues for resolution with respect to this type of body. First, what's an executive order as opposed to other exercises of power by the Governor? Second, when is a body a "commission" within the meaning of this provision? There is neither case law nor an Attorney General opinion addressing either of these issues in this context.

- **Body Determined by Membership**

The next kind of body is determined by who serves on it. Under this provision, a body becomes a state body when a member of a state body, in his or her official capacity, serves as a representative on another body, either public or private, which is funded in whole or in part by the representative's state body. (§ 11121(d).) It does not come up often, but the Act should be consulted whenever a member of one body sits as a representative on another body.

In summary, the foregoing are the general types of bodies that are defined as state bodies under the Bagley-Keene Act. As will be discussed below, these bodies are subject to the notice and open meeting requirements of the Act.

MEMBERS-TO-BE

The open meeting provisions of the Act basically apply to new members at the time of their election or appointment, even if they have not yet started to serve. (§ 11121.95.) The purpose of this provision is to prevent newly appointed members from meeting secretly among themselves or with holdover members of a body in sufficient numbers so as to constitute a quorum. The Act also requires bodies to provide their new members with a copy of the Act. (§ 11121.9.) We recommend that this Handy Guide be used to satisfy that requirement.

WHAT IS A MEETING?

The issue of what constitutes a meeting is one of the more troublesome and controversial issues under the Act. A meeting occurs when a quorum of a body convenes, either serially or all together, in one place, to address issues under the body's jurisdiction. (§ 11122.5.) Obviously, a meeting would include a gathering where members were debating issues or voting on them. But a meeting also includes situations in which the body is merely receiving information. To the extent that a body receives information under circumstances where the public is deprived of the opportunity to monitor the information provided, and either agree with it or challenge it, the open-meeting process is deficient.

Typically, issues concerning the definition of a meeting arise in the context of informal gatherings such as study sessions or pre-meeting get-togethers. The study session historically arises from the body's desire to study a subject prior to its placement on the body's agenda. However, if a quorum is involved, the study session should be treated as a meeting under the Act. With respect to pre-meeting briefings, this office opined that staff briefings of the city council a half hour before the noticed city council meeting to discuss the items that would appear on the council's meeting agenda were themselves meetings subject to open meeting laws.[2] To the extent that a briefing is desirable, this office recommends that the executive officer prepare a briefing paper which would then be available to the members of the body, as well as, to the public.

■ Serial Meetings

The Act expressly prohibits the use of direct communication, personal intermediaries, or technological devices that are employed by a majority of the members of the state body to develop a collective concurrence as to action to be taken on an item by the members of the state body outside of an open meeting. (§ 11122.5(b).) Typically, a serial meeting is a series of communications, each of which involves less than a quorum of the legislative body, but which taken as a whole involves a majority of the body's members. For example, a chain of communications involving contact from member A to member B who then communicates with member C would constitute a serial meeting in the case of a five-person body. Similarly, when a person acts as the hub of a wheel (member A) and communicates individually with the various spokes (members B and C), a serial meeting has occurred. In addition, a serial meeting occurs when intermediaries for board members have a meeting to discuss issues. For example, when a representative of member A meets with representatives of members B and C to discuss an agenda item, the members have conducted a serial meeting through their representatives acting as intermediaries.

[2] 42 Ops.Cal.Atty.Gen. 61 (1963); see also 32 Ops.Cal.Atty.Gen. 240 (1958).

In the *Stockton Newspapers* case, the court concluded that a series of individual telephone calls between the agency attorney and the members of the body constituted a meeting.[3] In that case, the attorney individually polled the members of the body for their approval on a real estate transaction. The court concluded that even though the meeting was conducted in a serial fashion, it nevertheless was a meeting for the purposes of the Act.

An executive officer may receive spontaneous input from board members on the agenda or on any other topic. But problems arise if there are systematic communications through which a quorum of the body acquires information or engages in debate, discussion, lobbying, or any other aspect of the deliberative process, either among themselves or between board members and the staff.

Although there are no cases directly on point, if an executive officer receives the same question on substantive matters addressed in an upcoming agenda from a quorum of the body, this office recommends that a memorandum addressing these issues be provided to the body and the public so they will receive the same information.

This office has opined that under the Brown Act (the counterpart to the Bagley-Keene Act which is applicable to local government bodies) that a majority of the board members of a local public agency may not e-mail each other to discuss current topics related to the body's jurisdiction even if the e-mails are also sent to the secretary and chairperson of the agency, posted on the agency's Internet website, and made available in printed form at the next public meeting of the board.[4]

The prohibition applies only to communications employed by a quorum to develop a collective concurrence concerning action to be taken by the body. Conversations that advance or clarify a member's understanding of an issue, or facilitate an agreement or compromise among members, or advance the ultimate resolution of an issue, are all examples of communications that contribute to the development of a concurrence as to action to be taken by the body. Accordingly, with respect to items that have been placed on an agenda or that are likely to be placed upon an agenda, members of state bodies should avoid serial communications of a substantive nature that involve a quorum of the body.

In conclusion, serial meeting issues will arise most commonly in connection with rotating staff briefings, telephone calls or e-mail communications among a quorum of board members. In these situations, part of the deliberative process by which information is received and processed, mulled over and discussed, is occurring without participation of the public.

Just remember, serial-meeting provisions basically mean that what the body can not do as a group it can not do through serial communications by a quorum of its members.

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[3] *Stockton Newspapers, Inc.* v. *Redevelopment Agency* (1985) 171 Cal.App.3d 95, 105. See also, 65 Ops.Cal.Atty.Gen. 63, 66 (1982); 63 Ops.Cal.Atty.Gen. 820, 828-829 (1980).

[4] Cal.Atty.Gen., Indexed Letter, No. IL 00-906 (February 20, 2001).

■ Contacts by the Public

One of the more difficult areas has to do with the rights of the public to contact individual members. For example, a communication from a member of the public to discuss an issue does not violate the Act. (§ 11122.5(c)(1).) The difficulty arises when the individual contacts a quorum of the body.

So long as the body does not solicit or orchestrate such contacts, they would not constitute a violation of the Bagley-Keene Act. Whether its good policy for a body to allow these individual contacts to occur is a different issue.

■ Social Gatherings

The Act exempts purely social situations from its coverage. (§ 11122.5(c)(5).) However, this construction is based on the premise that matters under the body's jurisdiction will not be discussed or considered at the social occasion. It may be useful to remind board members to avoid "shop talk" at the social event. Typically, this is difficult because service on the body is their common bond.

■ Conferences and Retreats

Conferences are exempt from the Act's coverage so long as they are open to the public and involve subject matter of general interest to persons or bodies in a given field. (§ 11122.5(c)(2).) While in attendance at a conference, members of a body should avoid private discussions with other members of their body about subjects that may be on an upcoming agenda. However, if the retreat or conference is designed to focus on the laws or issues of a particular body it would no be exempt under the Act.

■ Teleconference Meetings

The Act provides for audio or audio and visual teleconference meetings for the benefit of the public and the body. (§ 11123.) When a teleconference meeting is held, each site from which a member of the body participates must be accessible to the public. [Hence, a member cannot participate from his or her car, using a car phone or from his or her home, unless the home is open to the public for the duration of the meeting.] All proceedings must be audible and votes must be taken by rollcall. All other provisions of the Act also apply to teleconference meetings. For these reasons, we recommend that a properly equipped and accessible public building be utilized for teleconference meetings. This section does not prevent the body from providing additional locations from which the public may observe the proceedings or address the state body by electronic means.

NOTICE AND AGENDA REQUIREMENTS

The notice and agenda provisions require bodies to send the notice of its meetings to persons who have requested it. (§ 11125(a).) In addition, at least ten days prior to the meeting, bodies must

prepare an agenda of all items to be discussed or acted upon at the meeting. (§ 11125(b).) In practice, this usually translates to boards and commissions sending out the notice and agenda to all persons on their mailing lists. The notice needs to state the time and the place of the meeting and give the name, phone number and address of a contact person who can answer questions about the meeting and the agenda. (§ 11125(a).) The agenda needs to contain a brief description of each item to be transacted or discussed at the meeting, which as a general rule need not exceed 20 words in length. (§ 11125(b).)

The agenda items should be drafted to provide interested lay persons with enough information to allow them to decide whether to attend the meeting or to participate in that particular agenda item. Bodies should not label topics as "discussion" or "action" items unless they intend to be bound by such descriptions. Bodies should not schedule items for consideration at particular times, unless they assure that the items will not be considered prior to the appointed time.

The notice and agenda requirements apply to both open and closed meetings. There is a tendency to think that agendas need not be prepared for closed session items because the public cannot attend. But the public's ability to monitor closed sessions directly depends upon the agenda requirement which tells the public what is going to be discussed.

REGULAR MEETINGS

The Act, itself, does not directly define the term " regular meeting." Nevertheless, there are several references in the Act concerning regular meetings. By inference and interpretation, the regular meeting is a meeting of the body conducted under normal or ordinary circumstances. A regular meeting requires a 10-day notice. This simply means that at least 10 days prior to the meeting, notice of the meeting must be given along with an agenda that sufficiently describes the items of business to be transacted or discussed. (§§ 11125(a), 11125(b).) The notice for a meeting must also be posted on the Internet, and the web site address must be included on the written agenda. In addition, upon request by any person with a disability, the notice must be made available in appropriate alternative formats, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the applicable federal rules and regulations. The notice must contain information regarding the manner in which and the deadline by which a request for any disability-related modification or accommodation, including auxiliary aids or services, may be made by a person requiring these aids or services in order to participate in the meeting.

In two special situations, items may be added to the agenda within the 10-day notice period, provided that they are added and notice is given no later than 48 hours prior to the meeting. (§ 11125.) The first such situation is where the body concludes that the topic it wishes to add would qualify for an emergency meeting as defined in the Act. (§ 11125.3(a)(1).) The second situation is where there is a need for immediate action and the need for action came to the attention of the body after the agenda was mailed in accordance with the 10-day notice requirement. (§ 11125.3(a)(2).) This second situation requires a two-thirds vote or a unanimous vote if two-thirds of the members are not present.

Changes made to the agenda under this section must be delivered to the members of the body and to national wires services at least 48 hours before the meeting and must be posted on the Internet as soon as practicable.

SPECIAL MEETINGS

A few years ago, special meetings were added to the Act to provide relief to agencies that, due to the occurrence of unforeseen events, had a need to meet on short notice and were hamstrung by the Act's 10-day notice requirement. (§ 11125.4.) The special meeting requires that notice be provided at least 48 hours before the meeting to the members of the body and all national wire services, along with posting on the Internet.

The purposes for which a body can call a special meeting are quite limited. Examples include pending litigation, legislation, licencing matters and certain personnel actions. At the commencement of the special meeting, the body is required to make a finding that the 10-day notice requirement would impose a substantial hardship on the body or that immediate action is required to protect the public interest and must provide a factual basis for the finding. The finding must be adopted by two-thirds vote and must contain articulable facts that support it. If all of these requirements are not followed, then the body can not convene the special meeting and the meeting must be adjourned.

EMERGENCY MEETINGS

The Act provides for emergency meetings in rare instances when there exists a crippling disaster or a work stoppage that would severely impair public health and safety. (§ 11125.5.) An emergency meeting requires a one-hour notice to the media and must be held in open session. The Act also sets forth a variety of other technical procedural requirements that must be satisfied.

PUBLIC PARTICIPATION

Since one of the purposes of the Act is to protect and serve the interests of the general public to monitor and participate in meetings of state bodies, bodies covered by the Act are prohibited from imposing any conditions on attendance at a meeting. (§ 11124.) For example, while the Act does not prohibit use of a sign-in sheet, notice must be clearly given that signing-in is voluntary and not a pre-requisite to either attending the meeting or speaking at the meeting. On the other hand, security measures that require identification in order to gain admittance to a government building are permitted so long as security personnel do not share the information with the body.

In addition, members of the public are entitled to record and to broadcast (audio and/or video) the meetings, unless to do so would constitute a persistent disruption. (§ 11124.1.)

To ensure public participation, the Legislature expressly afforded an opportunity to the public to speak or otherwise participate at meetings, either before or during the consideration of each agenda item. (§11125.7.) The Legislature also provided that at any meeting the body can elect to consider comments from the public on any matter under the body's jurisdiction. And while the body cannot act on any matter not included on the agenda, it can schedule issues raised by the public for consideration at future meetings. Public comment protected by the Act includes criticism of the programs, policies and officials of the state body.

ACCESS TO RECORDS

Under the Act, the public is entitled to have access to the records of the body. (§ 11125.1.) In general, a record includes any form of writing. When materials are provided to a majority of the body either before or during the meeting, they must also be made available to the public without delay, unless the confidentiality of such materials is otherwise protected. Any records provided to the public, must be available in appropriate alternative formats, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the applicable federal rules and regulations, upon request by a person with a disability.

Notwithstanding the foregoing, the Act makes Government Code section 6254, the most comprehensive exemption under the California Public Records Act, applicable to records provided to the body. That is, if the record that is being provided to the board members is a record that is otherwise exempt from disclosure under section 6254 of the Government Code, then the record need not be disclosed to members of the public. (§ 11125.1(a).) However, the public interest balancing test, set forth in Government Code section 6255, is expressly made inapplicable to records provided to members of the body.

If an agency has received a request for records, the Public Records Act allows the agency to charge for their duplication. (§ 11125.1(c).) Please be aware that the Public Records Act limits the amount that can be charged to the direct cost of duplication. This has been interpreted to mean a pro-rata share of the equipment cost and probably a pro-rata share of the employee cost in order to make the copies. It does not include anything other than the mere reproduction of the records. (See,§ 6253.9 for special rules concerning computer records.) Accordingly, an agency may not recover for the costs of retrieving or redacting a record.

ACCESSABILITY OF MEETING LOCATIONS

The Act requires that the place and manner of the meeting be nondiscriminatory. (§ 11131.) As such, the body cannot discriminate on the basis of race, religion, national origin, etc. The meeting site must also be accessible to the disabled. Furthermore, the agency may not charge a fee for attendance at a meeting governed by the Act.

CLOSED SESSIONS

Although, as a general rule, all items placed on an agenda must be addressed in open session, the Legislature has allowed closed sessions in very limited circumstances, which will be discussed in detail below. Closed sessions may be held legally only if the body complies with certain procedural requirements. (§ 11126.3)

As part of the required general procedures, the closed session must be listed on the meeting agenda and properly noticed. (§ 11125(b).) Prior to convening into closed session, the body must publically announce those issues that will be considered in closed session. (§ 11126.3.) This can be done by a reference to the item as properly listed on the agenda. In addition, the agenda should cite the statutory authority or provision of the Act which authorizes the particular closed session. (§11125(b).) After the closed session has been completed, the body is required to reconvene in public. (§ 11126.3(f).) However, the body is required to make a report only where the body makes a decision to hire or fire an individual. (§ 11125.2.) Bodies under the Bagley-Keene Act are required to keep minutes of their closed sessions. (§ 11126.1.) Under the Act, these minutes are confidential, and are disclosable only to the board itself or to a reviewing court.

Courts have narrowly construed the Act's closed-session exceptions. For example, voting by secret ballot at an open-meeting is considered to be an improper closed session. Furthermore, closed sessions may be improperly convened if they are attended by persons other than those directly involved in the closed session as part of their official duties.

■ Personnel Exception

The personnel exception generally applies only to employees. (§ 11126(a) and (b).) However, a body's appointment pursuant to subdivision (e) of Section 4 of Article VII of the California Constitution (usually the body's executive director) has been designated an employee for purposes of the personnel exception. On the other hand, under the Act, members of the body are not to be considered employees, and there exists no personnel exception or other closed session vehicle for board members to deal with issues that may arise between them. Board elections, team building exercises, and efforts to address personality problems that may arise between members of the board, cannot be handled in closed session.

Only certain categories of subject matter may be considered at a closed session authorized under the personnel exception. (§ 11126(a)(1).) The purpose of the personnel exception is to protect the privacy of the employee, and to allow the board members to speak candidly. It can be used to consider appointments, employment, evaluation of performance, discipline or dismissal, as well as to hear charges or complaints about an employee's actions. Although the personnel exception is appropriate for discussion of an employee's competence or qualifications for appointment or employment, we do not think that discussion of employee compensation may be conducted in closed

session in light of an appellate court decision interpreting a similar exception in the Brown Act, (the counterpart to the Bagley-Keene Act which is applicable to local government bodies).[5]

The Act requires compliance with specific procedures when the body addresses a complaint leveled against an employee by a third person or initiates a disciplinary action against an employee. Under either circumstance, the Act requires 24-hour written notice to the employee. (§ 11126(a)(2).) Failure to provide such notice voids any action taken in closed session.

Upon receiving notice, the employee has the right to insist that the matter be heard in public session. (§ 11126(a)(2).) However, the opposite is not true. Under the Act, an employee has no right to have the matter heard in closed session. If the body decides to hold an open session, the Bagley-Keene Act does not provide any other option for the employee. Considerations, such as the employee's right to privacy, are not addressed under the Bagley-Keene Act.

If an employee asserts his or her right to have the personnel matter addressed in open session, the body must present the issues and information/evidence concerning the employee's performance or conduct in the open session. However, the body is still entitled to conduct its deliberations in closed session. (§ 11126(a)(4).)

- **Pending Litigation Exception**

The purpose of the pending litigation exception is to permit the agency to confer with its attorney in circumstances where, if that conversation were to occur in open session, it would prejudice the position of the agency in the litigation. (§ 11126(e)(1).) The term "litigation" refers to an adjudicatory proceeding that is held in either a judicial or an administrative forum. (§11126(e)(2)(c)(iii).) For purposes of the Act, litigation is "pending" in three basic situations. (§11126(e)(2).) First, where the agency is a party to existing litigation. Secondly, where under existing facts and circumstances, the agency has substantial exposure to litigation. And thirdly, where the body is meeting for the purpose of determining whether to initiate litigation. All of these situations constitute pending litigation under the exception.

For purposes of the Bagley-Keene Act, the pending litigation exception constitutes the exclusive expression of the attorney-client privilege. (§ 11126(e)(2).) In general, this means that independent statutes and case law that deal with attorney-client privilege issues do not apply to interpretations of the pending litigation provision of the Bagley-Keene Act. Accordingly, the specific language of the Act must be consulted to determine what is authorized for discussion in closed session.

Because the purpose of the closed session exception is to confer with legal counsel, the attorney must be present during the entire closed session devoted to the pending litigation. The Act's pending litigation exception covers both the receipt of advice from counsel and the making of

[5] *San Diego Union v. City Council* (1983) 146 Cal.App.3d 947.

litigation decisions (e.g., whether to file an action, and if so, what approach should be taken, whether settlement should be considered, and if so, what the settlement terms should be.

What happens in a situation where a body desires legal advice from counsel, but the Act's pending litigation exception does not apply? In such a case, legal counsel can either (1) provide the legal advice orally and discuss it in open session; or (2) deliver a one-way legal advice memorandum to the board members. The memorandum would constitute a record containing an attorney-client privileged communication and would be protected from disclosure under section 6254(k) of the Public Records Act. (11125.1(a).) However, when the board members receive that memorandum, they may discuss it only in open session, unless there is a specific exception that applies which allows them to consider it in closed session.[6]

- **Deliberations Exception**

The purpose of the deliberations exception is to permit a body to deliberate on decisions in a proceeding under the Administrative Procedures Act, or under similar provisions of law, in closed session. (§ 11126(c)(3).)

- **Real Property Exception**

Under the Act, the real-property exception provides that the body can, in closed session, advise its negotiator in situations involving real estate transactions and in negotiations regarding price and terms of payment. (§ 11126(c)(7).) However, before meeting in closed session, the body must identify the specific parcel in question and the party with whom it is negotiating. Again, the Act requires that the body properly notice its intent to hold a closed session and ~~to~~ cite the applicable authority enabling it to do so.

- **Security Exception**

A state body may, upon a two-thirds vote of those present, conduct a closed session to consider matters posing a potential threat of criminal or terrorist activity against the personnel, property, buildings, facilities, or equipment, including electronic data, owned, leased, or controlled by the state body, where disclosure of these considerations could adversely affect their safety or security. (11126(c)(18).) After such a closed session, the state body must reconvene in open session prior to adjournment and report that a closed session was held along with a description of the general nature of the matters considered, and whether any action was taken in closed session.

Whenever a state body utilizes this closed session exception, it must also provide specific written notice to the Legislative Analyst who must retain this information for at least four years. (11126(c)(18)(D).) This closed session exception will sunset in 2006. (11126(h).)

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[6] *Roberts* v. *City of Palmdale* (1993) 5 Cal.4th 363, 381.

REMEDIES FOR VIOLATIONS

The Act provides for remedies and penalties in situations where violations have allegedly occurred. Depending on the particular circumstances, the decision of the body may be overturned (§ 11130.3), violations may be stopped or prevented (§ 11130), costs and fees may be awarded (§11130.5), and in certain situations, there may be criminal misdemeanor penalties imposed as well. (§ 11130.7.)

Within 90 days of a decision or action of the body, any interested person may file suit alleging a violation of the Act and seeking to overturn the decision or action. Among other things, such suit may allege an unauthorized closed session or an improperly noticed meeting. Although the body is permitted to cure and correct a violation so as to avoid having its decision overturned, this can be much like trying to put toothpaste back in the tube. If possible, the body should try to return to a point prior to when the violation occurred and then proceed properly. For example, if the violation involves improper notice, we recommend that the body invalidate its decision, provide proper notice, and start the process over. To the extent that information has been received, statements made, or discussions have taken place, we recommend that the body include all of this on the record to ensure that everyone is aware of these events and has had an opportunity to respond.

In certain situations where a body has violated the Act, the decision can not be set aside or overturned; namely, where the action taken concerns the issuance of bonds, the entering into contracts where there has been detrimental reliance, the collection of taxes, and, in situations where there has been substantial compliance with the requirements of the Act. (11130.3(b).)

Another remedy in dealing with a violation of the Act involves filing a lawsuit to stop or prevent future violations of the Act. (§ 11130.) In general, these legal actions are filed as injunctions, writs of mandates, or suits for declaratory relief. The Legislature has also authorized the Attorney General, the District Attorney or any other interested person to use these remedies to seek judicial redress for past violations of the Act.

A prevailing plaintiff may recover the costs of suit and attorney's fees from the body (not individual members). (§ 11130.5.) On the other hand, if the body prevails, it may recover attorney's fees and costs only if the plaintiff's suit was clearly frivolous and totally without merit.

The Act provides for misdemeanor penalties against individual members of the body if the member attends a meeting in violation of the Act with the intent to deprive the public of information to which he or she knows, or has reason to know, the public is entitled to receive. (§ 11130.7.)

THE BAGLEY-KEENE OPEN MEETING ACT

Government Code Sections 11120-11132
(January 2004)

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THE BAGLEY-KEENE OPEN MEETING ACT

Government Code Sections 11120-11132

§ 11120. Policy statement; requirement for open meetings

11120. It is the public policy of this state that public agencies exist to aid in the conduct of the people's business and the proceedings of public agencies be conducted openly so that the public may remain informed.

In enacting this article the Legislature finds and declares that it is the intent of the law that actions of state agencies be taken openly and that their deliberation be conducted openly.

The people of this state do not yield their sovereignty to the agencies which serve them. The people, in delegating authority, do not give their public servants the right to decide what is good for the people to know and what is not good for them to know. The people insist on remaining informed so that they may retain control over the instruments they have created.

This article shall be known and may be cited as the Bagley-Keene Open Meeting Act.

§ 11121. State body

11121. As used in this article, "state body" means each of the following:

(a) Every state board, or commission, or similar multimember body of the state that is created by statute or required by law to conduct official meetings and every commission created by executive order.

(b) A board, commission, committee, or similar multimember body that exercises any authority of a state body delegated to it by that state body.

(c) An advisory board, advisory commission, advisory committee, advisory subcommittee, or similar multimember advisory body of a state body, if created by formal action of the state body or of any member of the state body, and if the advisory body so created consists of three or more persons.

(d) A board, commission, committee, or similar multimember body on which a member of a body that is a state body pursuant to this section serves in his or her official capacity as a representative of that state body and that is supported, in whole or in part, by funds provided by the state body, whether the multimember body is organized and operated by the state body or by a private corporation.

§ 11121.1. State body; exceptions

11121.1. As used in this article, "state body" does not include any of the following:

(a) State agencies provided for in Article VI of the California Constitution.

(b) Districts or other local agencies whose meetings are required to be open to the public pursuant to the Ralph M. Brown Act (Chapter 9 (commencing with Section 54950) of Part 1 of Division 2 of Title 5).

(c) State agencies provided for in Article IV of the California Constitution whose meetings are required to be open to the public pursuant to the Grunsky-Burton Open Meeting Act (Article 2.2 (commencing with Section 9027) of Chapter 1.5 of Part 1 of Division 2 of Title 2).

(d) State agencies when they are conducting proceedings pursuant to Section 3596.

(e) State agencies provided for in Section 109260 of the Health and Safety Code, except as provided in Section 109390 of the Health and Safety Code.

(f) State agencies provided for in Section 11770.5 of the Insurance Code.

(g) The Credit Union Advisory Committee established pursuant to Section 14380 of the Financial Code.

§ 11121.9. Requirement to provide law to members

11121.9. Each state body shall provide a copy of this article to each member of the state body upon his or her appointment to membership or assumption of office.

§ 11121.95. Application to persons who have not assumed office

11121.95. Any person appointed or elected to serve as a member of a state body who has not yet assumed the duties of office shall conform his or her conduct to the requirements of this article and shall be treated for purposes of this article as if he or she has already assumed office.

§ 11122. Action taken; defined

11122. As used in this article "action taken" means a collective decision made by the members of a state body, a collective commitment or promise by the members of the state body to make a positive or negative decision or an actual vote by the members of a state body when sitting as a body or entity upon a motion, proposal, resolution, order or similar action.

§ 11122.5. Meeting defined; exceptions

11122.5. (a) As used in this article, "meeting" includes any congregation of a majority of the members of a state body at the same time and place to hear, discuss, or deliberate upon any item that is within the subject matter jurisdiction of the state body to which it pertains.

(b) Except as authorized pursuant to Section 11123, any use of direct communication, personal intermediaries, or technological devices that is employed by a majority of the members of the state body to develop a collective concurrence as to action to be taken on an item by the members of the state body is prohibited.

(c) The prohibitions of this article do not apply to any of the following:

(1) Individual contacts or conversations between a member of a state body and any other person.

(2) The attendance of a majority of the members of a state body at a conference or similar gathering open to the public that involves a discussion of issues of general interest to the public or to public agencies of the type represented by the state body, provided that a majority of the members do not discuss among themselves, other than as part of the scheduled program, business of a specified nature that is within the subject matter jurisdiction of the state body. This paragraph is not intended to allow members of the public free admission to a conference or similar gathering at which the organizers have required other participants or registrants to pay fees or charges as a condition of attendance.

(3) The attendance of a majority of the members of a state body at an open and publicized meeting organized to address a topic of state concern by a person or organization other than the state body, provided that a majority of the members do not discuss among themselves, other than as part of the scheduled program, business of a specific nature that is within the subject matter jurisdiction of the state body.

(4) The attendance of a majority of the members of a state body at an open and noticed meeting of another state body or of a legislative body of a local agency as defined by Section 54951, provided that a majority of the members do not discuss among themselves, other than as part of the scheduled meeting, business of a specific nature that is within the subject matter jurisdiction of the other state body.

(5) The attendance of a majority of the members of a state body at a purely social or ceremonial occasion, provided that a majority of the members do not discuss among themselves business of a specific nature that is within the subject matter jurisdiction of the state body.

(6) The attendance of a majority of the members of a state body at an open and noticed meeting of a standing committee of that body, provided that the members of the state body who are not members of the standing committee attend only as observers.

§ 11123. Requirement for open meetings; teleconference meetings

11123. (a) All meetings of a state body shall be open and public and all persons shall be permitted to attend any meeting of a state body except as otherwise provided in this article.

(b) (1) This article does not prohibit a state body from holding an open or closed meeting by teleconference for the benefit of the public and state body. The meeting or proceeding held by teleconference shall otherwise comply with all applicable requirements or laws relating to a specific type of meeting or proceeding, including the following:

(A) The teleconferencing meeting shall comply with all requirements of this article applicable to other meetings.

(B) The portion of the teleconferenced meeting that is required to be open to the public shall be audible to the public at the location specified in the notice of the meeting.

(C) If the state body elects to conduct a meeting or proceeding by teleconference, it shall post agendas at all teleconference locations and conduct teleconference meetings in a manner that protects the rights of any party or member of the public appearing before the state body. Each teleconference location shall be identified in the notice and agenda of the meeting or proceeding, and each teleconference location shall be accessible to the public. The agenda shall provide an opportunity for members of the public to address the state body directly pursuant to Section 11125.7 at each teleconference location.

(D) All votes taken during a teleconferenced meeting shall be by rollcall.

(E) The portion of the teleconferenced meeting that is closed to the public may not include the consideration of any agenda item being heard pursuant to Section 11125.5.

(F) At least one member of the state body shall be physically present at the location specified in the notice of the meeting.

(2) For the purposes of this subdivision, "teleconference" means a meeting of a state body, the members of which are at different locations, connected by electronic means, through either audio or both audio and video. This section does not prohibit a state body from providing members of the public with additional locations in which the public may observe or address the state body by electronic means, through either audio or both audio and video.

§ 11123.1. Compliance with the ADA

11123.1. All meetings of a state body that are open and public shall meet the protections and prohibitions contained in Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof.

§ 11124. No conditions for attending meetings

11124. No person shall be required, as a condition to attendance at a meeting of a state body, to register his or her name, to provide other information, to complete a questionnaire, or otherwise to fulfill any condition precedent to his or her attendance. If an attendance list, register, questionnaire, or other similar document is posted at or near the entrance to the room where the meeting is to be held, or is circulated to persons present during the meeting, it shall state clearly that the signing, registering, or completion of the document is voluntary, and that all persons may attend the meeting regardless of whether a person signs, registers, or completes the document.

§ 11124.1. Right to record meetings

11124.1. (a) Any person attending an open and public meeting of the state body shall have the right to record the proceedings with an audio or video tape recorder or a still or motion picture camera in the absence of a reasonable finding by the state body that the recording cannot continue without noise, illumination, or obstruction of view that constitutes, or would constitute, a persistent disruption of the proceedings.

(b) Any tape or film record of an open and public meeting made for whatever purpose by or at the direction of the state body shall be subject to inspection pursuant to the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), but may be erased or destroyed 30 days after the taping or recording. Any inspection of an audio or video tape recording shall be provided without charge on an audio or video tape player made available by the state body.

(c) No state body shall prohibit or otherwise restrict the broadcast of its open and public meetings in the absence of a reasonable finding that the broadcast cannot be accomplished without noise, illumination, or obstruction of view that would constitute a persistent disruption of the proceedings.

§ 11125. Required notice

11125. (a) The state body shall provide notice of its meeting to any person who requests that notice in writing. Notice shall be given and also made available on the Internet at least 10 days in advance of the meeting, and shall include the name, address, and telephone number of any person who can provide further information prior to the meeting, but need not include a list of witnesses expected to appear at the meeting. The written notice shall additionally include the address of the Internet site where notices required by this article are made available.

(b) The notice of a meeting of a body that is a state body shall include a specific agenda for the meeting, containing a brief description of the items of business to be transacted or discussed in either open or closed session. A brief general description of an item generally need not exceed 20 words. A description of an item to be transacted or discussed in closed session shall include a citation of the specific statutory authority under which a closed session is being held. No item shall be added to the agenda subsequent to the provision of this notice, unless otherwise permitted by this article.

(c) Notice of a meeting of a state body that complies with this section shall also constitute notice of a meeting of an advisory body of that state body, provided that the business to be discussed by the advisory body is covered by the notice of the meeting of the state body, provided that the specific time and place of the advisory body's meeting is announced during the open and public state body's meeting, and provided that the advisory body's meeting is conducted within a reasonable time of, and nearby, the meeting of the state body.

(d) A person may request, and shall be provided, notice pursuant to subdivision (a) for all meetings of a state body or for a specific meeting or meetings. In addition, at the state body's discretion, a person may request, and may be provided, notice of only those meetings of a state body at which a particular subject or subjects specified in the request will be discussed.

(e) A request for notice of more than one meeting of a state body shall be subject to the provisions of Section 14911.

(f) The notice shall be made available in appropriate alternative formats, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof, upon request by any person with a disability. The notice shall include information regarding how, to whom, and by when a request for any disability-related modification or accommodation, including auxiliary aids or services may be made by a person with a disability who requires these aids or services in order to participate in the public meeting.

§ 11125.1. Agenda; writings provided to body; public records

11125.1. (a) Notwithstanding Section 6255 or any other provisions of law, agendas of public meetings and other writings, when distributed to all, or a majority of all, of the members of a state body by any person in connection with a matter subject to discussion or consideration at a public meeting of the body, are disclosable public records under the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), and shall be made available upon request without delay. However, this section shall not include any writing exempt from public disclosure under Section 6253.5, 6254, or 6254.7 of this code, or Section 489.1 or 583 of the Public Utilities Code.

(b) Writings that are public records under subdivision (a) and that are distributed to members of the state body prior to or during a meeting, pertaining to any item to be considered during the

meeting, shall be made available for public inspection at the meeting if prepared by the state body or a member of the state body, or after the meeting if prepared by some other person. These writings shall be made available in appropriate alternative formats, as required by Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof, upon request by a person with a disability.

(c) In the case of the Franchise Tax Board, prior to that state body taking final action on any item, writings pertaining to that item that are public records under subdivision (a) that are distributed to members of the state body by board staff or individual members prior to or during a meeting shall be:

(1) Made available for public inspection at that meeting.

(2) Distributed to all persons who request notice in writing pursuant to subdivision (a) of Section 11125.

(3) Made available on the Internet.

(d) Prior to the State Board of Equalization taking final action on any item that does not involve a named tax or fee payer, writings pertaining to that item that are public records under subdivision (a) that are prepared and distributed by board staff or individual members to members of the state body prior to or during a meeting shall be:

(1) Made available for public inspection at that meeting.

(2) Distributed to all persons who request or have requested copies of these writings.

(3) Made available on the Internet.

(e) Nothing in this section shall be construed to prevent a state body from charging a fee or deposit for a copy of a public record pursuant to Section 6253, except that no surcharge shall be imposed on persons with disabilities in violation of Section 202 of the Americans with Disabilities Act of 1990 (42 U.S.C. Sec. 12132), and the federal rules and regulations adopted in implementation thereof. The writings described in subdivision (b) are subject to the requirements of the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), and shall not be construed to limit or delay the public's right to inspect any record required to be disclosed by that act, or to limit the public's right to inspect any record covered by that act. This section shall not be construed to be applicable to any writings solely because they are properly discussed in a closed session of a state body. Nothing in this article shall be construed to require a state body to place any paid advertisement or any other paid notice in any publication.

(f) "Writing" for purposes of this section means "writing" as defined under Section 6252.

§ 11125.2. Announcement of personnel action

11125.2. Any state body shall report publicly at a subsequent public meeting any action taken, and any rollcall vote thereon, to appoint, employ, or dismiss a public employee arising out of any closed session of the state body.

§ 11125.3. Exception to agenda requirements

11125.3. (a) Notwithstanding Section 11125, a state body may take action on items of business not appearing on the posted agenda under any of the conditions stated below:

(1) Upon a determination by a majority vote of the state body that an emergency situation exists, as defined in Section 11125.5.

(2) Upon a determination by a two-thirds vote of the state body, or, if less than two-thirds of the members are present, a unanimous vote of those members present, that there exists a need to take immediate action and that the need for action came to the attention of the state body subsequent to the agenda being posted as specified in Section 11125.

(b) Notice of the additional item to be considered shall be provided to each member of the state body and to all parties that have requested notice of its meetings as soon as is practicable after a determination of the need to consider the item is made, but shall be delivered in a manner that allows it to be received by the members and by newspapers of general circulation and radio or television stations at least 48 hours before the time of the meeting specified in the notice. Notice shall be made available to newspapers of general circulation and radio or television stations by providing that notice to all national press wire services. Notice shall also be made available on the Internet as soon as is practicable after the decision to consider additional items at a meeting has been made.

§ 11125.4. Special meetings

11125.4. (a) A special meeting may be called at any time by the presiding officer of the state body or by a majority of the members of the state body. A special meeting may only be called for one of the following purposes where compliance with the 10-day notice provisions of Section 11125 would impose a substantial hardship on the state body or where immediate action is required to protect the public interest:

(1) To consider "pending litigation" as that term is defined in subdivision (e) of Section 11126.

(2) To consider proposed legislation.

(3) To consider issuance of a legal opinion.

(4) To consider disciplinary action involving a state officer or employee.

(5) To consider the purchase, sale, exchange, or lease of real property.

(6) To consider license examinations and applications.

(7) To consider an action on a loan or grant provided pursuant to Division 31 (commencing with Section 50000) of the Health and Safety Code.

(b) When a special meeting is called pursuant to one of the purposes specified in subdivision (a), the state body shall provide notice of the special meeting to each member of the state body and to all parties that have requested notice of its meetings as soon as is practicable after the decision to call a special meeting has been made, but shall be delivered in a manner that allows it to be received by the members and by newspapers of general circulation and radio or television stations at least 48 hours before the time of the special meeting specified in the notice. Notice shall be made available to newspapers of general circulation and radio or television stations by providing that notice to all national press wire services. Notice shall also be made available on the Internet within the time periods required by this section. The notice shall specify the time and place of the special meeting and the business to be transacted. The written notice shall additionally specify the address of the Internet site where notices required by this article are made available. No other business shall be considered at a special meeting by the state body. The written notice may be dispensed with as to any member who at or prior to the time the meeting convenes files with the clerk or secretary of the state body a written waiver of notice. The waiver may be given by telegram, facsimile transmission, or similar means. The written notice may also be dispensed with as to any member who is actually present at the meeting at the time it convenes. Notice shall be required pursuant to this section regardless of whether any action is taken at the special meeting.

(c) At the commencement of any special meeting, the state body must make a finding in open session that the delay necessitated by providing notice 10 days prior to a meeting as required by Section 11125 would cause a substantial hardship on the body or that immediate action is required to protect the public interest. The finding shall set forth the specific facts that constitute the hardship to the body or the impending harm to the public interest. The finding shall be adopted by a two-thirds vote of the body, or, if less than two-thirds of the members are present, a unanimous vote of those members present. The finding shall be made available on the Internet. Failure to adopt the finding terminates the meeting.

§ 11125.5. Emergency meetings

11125.5. (a) In the case of an emergency situation involving matters upon which prompt action is necessary due to the disruption or threatened disruption of public facilities, a state body may hold an emergency meeting without complying with the 10-day notice requirement of Section 11125 or the 48-hour notice requirement of Section 11125.4.

(b) For purposes of this section, "emergency situation" means any of the following, as determined by a majority of the members of the state body during a meeting prior to the emergency meeting, or at the beginning of the emergency meeting:

(1) Work stoppage or other activity that severely impairs public health or safety, or both.

(2) Crippling disaster that severely impairs public health or safety, or both.

(c) However, newspapers of general circulation and radio or television stations that have requested notice of meetings pursuant to Section 11125 shall be notified by the presiding officer of the state body, or a designee thereof, one hour prior to the emergency meeting by telephone. Notice shall also be made available on the Internet as soon as is practicable after the decision to call the emergency meeting has been made. If telephone services are not functioning, the notice requirements of this section shall be deemed waived, and the presiding officer of the state body, or a designee thereof, shall notify those newspapers, radio stations, or television stations of the fact of the holding of the emergency meeting, the purpose of the meeting, and any action taken at the meeting as soon after the meeting as possible.

(d) The minutes of a meeting called pursuant to this section, a list of persons who the presiding officer of the state body, or a designee thereof, notified or attempted to notify, a copy of the rollcall vote, and any action taken at the meeting shall be posted for a minimum of 10 days in a public place, and also made available on the Internet for a minimum of 10 days, as soon after the meeting as possible.

§ 11125.6. Emergency meetings; Fish and Game Commission

11125.6. (a) An emergency meeting may be called at any time by the president of the Fish and Game Commission or by a majority of the members of the commission to consider an appeal of a closure of or restriction in a fishery adopted pursuant to Section 7710 of the Fish and Game Code. In the case of an emergency situation involving matters upon which prompt action is necessary due to the disruption or threatened disruption of an established fishery, the commission may hold an emergency meeting without complying with the 10-day notice requirement of Section 11125 or the 48-hour notice requirement of Section 11125.4 if the delay necessitated by providing the 10-day notice of a public meeting required by Section 11125 or the 48-hour notice required by Section 11125.4 would significantly adversely impact the economic benefits of a fishery to the participants in the fishery and to the people of the state or significantly adversely impact the sustainability of a fishery managed by the state.

(b) At the commencement of an emergency meeting called pursuant to this section, the commission shall make a finding in open session that the delay necessitated by providing notice 10 days prior to a meeting as required by Section 11125 or 48 hours prior to a meeting as required by Section 11125.4 would significantly adversely impact the economic benefits of a fishery to the participants in the fishery and to the people of the state or significantly adversely impact the sustainability of a fishery managed by the state. The finding shall set forth the specific facts that

constitute the impact to the economic benefits of the fishery or the sustainability of the fishery. The finding shall be adopted by a vote of at least four members of the commission, or, if less than four of the members are present, a unanimous vote of those members present. Failure to adopt the finding shall terminate the meeting.

(c) Newspapers of general circulation and radio or television stations that have requested notice of meetings pursuant to Section 11125 shall be notified by the presiding officer of the commission, or a designee thereof, one hour prior to the emergency meeting by telephone.

(d) The minutes of an emergency meeting called pursuant to this section, a list of persons who the president of the commission, or a designee thereof, notified or attempted to notify, a copy of the rollcall vote, and any action taken at the meeting shall be posted for a minimum of 10 days in a public place as soon after the meeting as possible.

§ 11125.7 Opportunity for public to speak at meeting

11125.7. (a) Except as otherwise provided in this section, the state body shall provide an opportunity for members of the public to directly address the state body on each agenda item before or during the state body's discussion or consideration of the item. This section is not applicable if the agenda item has already been considered by a committee composed exclusively of members of the state body at a public meeting where interested members of the public were afforded the opportunity to address the committee on the item, before or during the committee's consideration of the item, unless the item has been substantially changed since the committee heard the item, as determined by the state body. Every notice for a special meeting at which action is proposed to be taken on an item shall provide an opportunity for members of the public to directly address the state body concerning that item prior to action on the item. In addition, the notice requirement of Section 11125 shall not preclude the acceptance of testimony at meetings, other than emergency meetings, from members of the public, provided, however, that no action is taken by the state body at the same meeting on matters brought before the body by members of the public.

(b) The state body may adopt reasonable regulations to ensure that the intent of subdivision (a) is carried out, including, but not limited to, regulations limiting the total amount of time allocated for public comment on particular issues and for each individual speaker.

(c) The state body shall not prohibit public criticism of the policies, programs, or services of the state body, or of the acts or omissions of the state body. Nothing in this subdivision shall confer any privilege or protection for expression beyond that otherwise provided by law.

(d) This section is not applicable to closed sessions held pursuant to Section 11126.

(e) This section is not applicable to decisions regarding proceedings held pursuant to Chapter 5 (commencing with Section 11500), relating to administrative adjudication, or to the conduct of those proceedings.

(f) This section is not applicable to hearings conducted by the State Board of Control pursuant to Sections 13963 and 13963.1.

(g) This section is not applicable to agenda items that involve decisions of the Public Utilities Commission regarding adjudicatory hearings held pursuant to Chapter 9 (commencing with Section 1701) of Part 1 of Division 1 of the Public Utilities Code. For all other agenda items, the commission shall provide members of the public, other than those who have already participated in the proceedings underlying the agenda item, an opportunity to directly address the commission before or during the commission's consideration of the item.

§ 11125.8. Closed session; Board of Control; crime victims

11125.8. (a) Notwithstanding Section 11131.5, in any hearing that the State Board of Control conducts pursuant to Section 13963.1 and that the applicant or applicant's representative does not request be open to the public, no notice, agenda, announcement, or report required under this article need identify the applicant.

(b) In any hearing that the board conducts pursuant to Section 13963.1 and that the applicant or applicant's representative does not request be open to the public, the board shall disclose that the hearing is being held pursuant to Section 13963.1. That disclosure shall be deemed to satisfy the requirements of subdivision (a) of Section 11126.3.

§ 11125.9. Regional water quality control boards; additional notice requirements

11125.9. Regional water quality control boards shall comply with the notification guidelines in Section 11125 and, in addition, shall do both of the following:

(a) Notify, in writing, all clerks of the city councils and county boards of supervisors within the regional board's jurisdiction of any and all board hearings at least 10 days prior to the hearing. Notification shall include an agenda for the meeting with contents as described in subdivision (b) of Section 11125 as well as the name, address, and telephone number of any person who can provide further information prior to the meeting, but need not include a list of witnesses expected to appear at the meeting. Each clerk, upon receipt of the notification of a board hearing, shall distribute the notice to all members of the respective city council or board of supervisors within the regional board's jurisdiction.

(b) Notify, in writing, all newspapers with a circulation rate of at least 10,000 within the regional board's jurisdiction of any and all board hearings, at least 10 days prior to the hearing. Notification shall include an agenda for the meeting with contents as described in subdivision (b) of Section 11125 as well as the name, address, and telephone number of any person who can provide further information prior to the meeting, but need not include a list of witnesses expected to appear at the meeting.

§ 11126. Closed sessions

11126. (a)(1) Nothing in this article shall be construed to prevent a state body from holding closed sessions during a regular or special meeting to consider the appointment, employment, evaluation of performance, or dismissal of a public employee or to hear complaints or charges brought against that employee by another person or employee unless the employee requests a public hearing.

(2) As a condition to holding a closed session on the complaints or charges to consider disciplinary action or to consider dismissal, the employee shall be given written notice of his or her right to have a public hearing, rather than a closed session, and that notice shall be delivered to the employee personally or by mail at least 24 hours before the time for holding a regular or special meeting. If notice is not given, any disciplinary or other action taken against any employee at the closed session shall be null and void.

(3) The state body also may exclude from any public or closed session, during the examination of a witness, any or all other witnesses in the matter being investigated by the state body.

(4) Following the public hearing or closed session, the body may deliberate on the decision to be reached in a closed session.

(b) For the purposes of this section, "employee" does not include any person who is elected to, or appointed to a public office by, any state body. However, officers of the California State University who receive compensation for their services, other than per diem and ordinary and necessary expenses, shall, when engaged in that capacity, be considered employees. Furthermore, for purposes of this section, the term employee includes a person exempt from civil service pursuant to subdivision (e) of Section 4 of Article VII of the California Constitution.

(c) Nothing in this article shall be construed to do any of the following:

(1) Prevent state bodies that administer the licensing of persons engaging in businesses or professions from holding closed sessions to prepare, approve, grade, or administer examinations.

(2) Prevent an advisory body of a state body that administers the licensing of persons engaged in businesses or professions from conducting a closed session to discuss matters that the advisory body has found would constitute an unwarranted invasion of the privacy of an individual licensee or applicant if discussed in an open meeting, provided the advisory body does not include a quorum of the members of the state body it advises. Those matters may include review of an applicant's qualifications for licensure and an inquiry specifically related to the state body's enforcement program concerning an individual licensee or applicant where the inquiry occurs prior to the filing of a civil, criminal, or administrative disciplinary action against the licensee or applicant by the state body.

(3) Prohibit a state body from holding a closed session to deliberate on a decision to be reached in a proceeding required to be conducted pursuant to Chapter 5 (commencing with Section 11500) or similar provisions of law.

(4) Grant a right to enter any correctional institution or the grounds of a correctional institution where that right is not otherwise granted by law, nor shall anything in this article be construed to prevent a state body from holding a closed session when considering and acting upon the determination of a term, parole, or release of any individual or other disposition of an individual case, or if public disclosure of the subjects under discussion or consideration is expressly prohibited by statute.

(5) Prevent any closed session to consider the conferring of honorary degrees, or gifts, donations, and bequests that the donor or proposed donor has requested in writing to be kept confidential.

(6) Prevent the Alcoholic Beverage Control Appeals Board from holding a closed session for the purpose of holding a deliberative conference as provided in Section 11125.

(7) (A) Prevent a state body from holding closed sessions with its negotiator prior to the purchase, sale, exchange, or lease of real property by or for the state body to give instructions to its negotiator regarding the price and terms of payment for the purchase, sale, exchange, or lease.

(B) However, prior to the closed session, the state body shall hold an open and public session in which it identifies the real property or real properties that the negotiations may concern and the person or persons with whom its negotiator may negotiate.

(C) For purposes of this paragraph, the negotiator may be a member of the state body.

(D) For purposes of this paragraph, "lease" includes renewal or renegotiation of a lease.

(E) Nothing in this paragraph shall preclude a state body from holding a closed session for discussions regarding eminent domain proceedings pursuant to subdivision (e).

(8) Prevent the California Postsecondary Education Commission from holding closed sessions to consider matters pertaining to the appointment or termination of the Director of the California Postsecondary Education Commission.

(9) Prevent the Council for Private Postsecondary and Vocational Education from holding closed sessions to consider matters pertaining to the appointment or termination of the Executive Director of the Council for Private Postsecondary and Vocational Education.

(10) Prevent the Franchise Tax Board from holding closed sessions for the purpose of discussion of confidential tax returns or information the public disclosure of which is prohibited by

law, or from considering matters pertaining to the appointment or removal of the Executive Officer of the Franchise Tax Board.

(11) Require the Franchise Tax Board to notice or disclose any confidential tax information considered in closed sessions, or documents executed in connection therewith, the public disclosure of which is prohibited pursuant to Article 2 (commencing with Section 19542) of Chapter 7 of Part 10.2 of the Revenue and Taxation Code.

(12) Prevent the Board of Corrections from holding closed sessions when considering reports of crime conditions under Section 6027 of the Penal Code.

(13) Prevent the State Air Resources Board from holding closed sessions when considering the proprietary specifications and performance data of manufacturers.

(14) Prevent the State Board of Education or the Superintendent of Public Instruction, or any committee advising the board or the superintendent, from holding closed sessions on those portions of its review of assessment instruments pursuant to Chapter 5 (commencing with Section 60600) of, or pursuant to Chapter 8 (commencing with Section 60850) of, Part 33 of the Education Code during which actual test content is reviewed and discussed. The purpose of this provision is to maintain the confidentiality of the assessments under review.

(15) Prevent the California Integrated Waste Management Board or its auxiliary committees from holding closed sessions for the purpose of discussing confidential tax returns, discussing trade secrets or confidential or proprietary information in its possession, or discussing other data, the public disclosure of which is prohibited by law.

(16) Prevent a state body that invests retirement, pension, or endowment funds from holding closed sessions when considering investment decisions. For purposes of consideration of shareholder voting on corporate stocks held by the state body, closed sessions for the purposes of voting may be held only with respect to election of corporate directors, election of independent auditors, and other financial issues that could have a material effect on the net income of the corporation. For the purpose of real property investment decisions that may be considered in a closed session pursuant to this paragraph, a state body shall also be exempt from the provisions of paragraph (7) relating to the identification of real properties prior to the closed session.

(17) Prevent a state body, or boards, commissions, administrative officers, or other representatives that may properly be designated by law or by a state body, from holding closed sessions with its representatives in discharging its responsibilities under Chapter 10 (commencing with Section 3500), Chapter 10.3 (commencing with Section 3512), Chapter 10.5 (commencing with Section 3525), or Chapter 10.7 (commencing of Section 3540) of Division 4 of Title 1 as the sessions relate to salaries, salary schedules, or compensation paid in the form of fringe benefits. For the purposes enumerated in the preceding sentence, a state body may also meet with a state conciliator who has intervened in the proceedings.

(18) (A) Prevent a state body from holding closed sessions to consider matters posing a threat or potential threat of criminal or terrorist activity against the personnel, property, buildings, facilities, or equipment, including electronic data, owned, leased, or controlled by the state body, where disclosure of these considerations could compromise or impede the safety or security of the personnel, property, buildings, facilities, or equipment, including electronic data, owned, leased, or controlled by the state body.

(B) Notwithstanding any other provision of law, a state body, at any regular or special meeting, may meet in a closed session pursuant to subparagraph (A) upon a two-thirds vote of the members present at the meeting.

(C) After meeting in closed session pursuant to subparagraph (A), the state body shall reconvene in open session prior to adjournment and report that a closed session was held pursuant to subparagraph (A), the general nature of the matters considered, and whether any action was taken in closed session.

(D) After meeting in closed session pursuant to subparagraph (A), the state body shall submit to the Legislative Analyst written notification stating that it held this closed session, the general reason or reasons for the closed session, the general nature of the matters considered, and whether any action was taken in closed session. The Legislative Analyst shall retain for no less than four years any written notification received from a state body pursuant to this subparagraph.

(d)(1) Notwithstanding any other provision of law, any meeting of the Public Utilities Commission at which the rates of entities under the commission's jurisdiction are changed shall be open and public.

(2) Nothing in this article shall be construed to prevent the Public Utilities Commission from holding closed sessions to deliberate on the institution of proceedings, or disciplinary actions against any person or entity under the jurisdiction of the commission.

(e) (1) Nothing in this article shall be construed to prevent a state body, based on the advice of its legal counsel, from holding a closed session to confer with, or receive advice from, its legal counsel regarding pending litigation when discussion in open session concerning those matters would prejudice the position of the state body in the litigation.

(2) For purposes of this article, all expressions of the lawyer-client privilege other than those provided in this subdivision are hereby abrogated. This subdivision is the exclusive expression of the lawyer-client privilege for purposes of conducting closed session meetings pursuant to this article. For purposes of this subdivision, litigation shall be considered pending when any of the following circumstances exist:

(A) An adjudicatory proceeding before a court, an administrative body exercising its adjudicatory authority, a hearing officer, or an arbitrator, to which the state body is a party, has been initiated formally.

(B)(i) A point has been reached where, in the opinion of the state body on the advice of its legal counsel, based on existing facts and circumstances, there is a significant exposure to litigation against the state body.

(ii) Based on existing facts and circumstances, the state body is meeting only to decide whether a closed session is authorized pursuant to clause (i).

(C) (i) Based on existing facts and circumstances, the state body has decided to initiate or is deciding whether to initiate litigation.

(ii) The legal counsel of the state body shall prepare and submit to it a memorandum stating the specific reasons and legal authority for the closed session. If the closed session is pursuant to paragraph (1), the memorandum shall include the title of the litigation. If the closed session is pursuant to subparagraph (A) or (B), the memorandum shall include the existing facts and circumstances on which it is based. The legal counsel shall submit the memorandum to the state body prior to the closed session, if feasible, and in any case no later than one week after the closed session. The memorandum shall be exempt from disclosure pursuant to Section 6254.25.

(iii) For purposes of this subdivision, "litigation" includes any adjudicatory proceeding, including eminent domain, before a court, administrative body exercising its adjudicatory authority, hearing officer, or arbitrator.

(iv) Disclosure of a memorandum required under this subdivision shall not be deemed as a waiver of the lawyer-client privilege, as provided for under Article 3 (commencing with Section 950) of Chapter 4 of Division 8 of the Evidence Code.

(f) In addition to subdivisions (a), (b), and (c), nothing in this article shall be construed to do any of the following:

(1) Prevent a state body operating under a joint powers agreement for insurance pooling from holding a closed session to discuss a claim for the payment of tort liability or public liability losses incurred by the state body or any member agency under the joint powers agreement.

(2) Prevent the examining committee established by the State Board of Forestry and Fire Protection, pursuant to Section 763 of the Public Resources Code, from conducting a closed session to consider disciplinary action against an individual professional forester prior to the filing of an accusation against the forester pursuant to Section 11503.

(3) Prevent an administrative committee established by the California Board of Accountancy pursuant to Section 5020 of the Business and Professions Code from conducting a closed session to consider disciplinary action against an individual accountant prior to the filing of an accusation against the accountant pursuant to Section 11503. Nothing in this article shall be construed to prevent an examining committee established by the California Board of Accountancy pursuant to

Section 5023 of the Business and Professions Code from conducting a closed hearing to interview an individual applicant or accountant regarding the applicant's qualifications.

(4) Prevent a state body, as defined in subdivision (b) of Section 11121, from conducting a closed session to consider any matter that properly could be considered in closed session by the state body whose authority it exercises.

(5) Prevent a state body, as defined in subdivision (d) of Section 11121, from conducting a closed session to consider any matter that properly could be considered in a closed session by the body defined as a state body pursuant to subdivision (a) or (b) of Section 11121.

(6) Prevent a state body, as defined in subdivision (c) of Section 11121, from conducting a closed session to consider any matter that properly could be considered in a closed session by the state body it advises.

(7) Prevent the State Board of Equalization from holding closed sessions for either of the following:

(A) When considering matters pertaining to the appointment or removal of the Executive Secretary of the State Board of Equalization.

(B) For the purpose of hearing confidential taxpayer appeals or data, the public disclosure of which is prohibited by law.

(8) Require the State Board of Equalization to disclose any action taken in closed session or documents executed in connection with that action, the public disclosure of which is prohibited by law pursuant to Sections 15619 and 15641 of this code and Sections 833, 7056, 8255, 9255, 11655, 30455, 32455, 38705, 38706, 43651, 45982, 46751, 50159, 55381, and 60609 of the Revenue and Taxation Code.

(9) Prevent the California Earthquake Prediction Evaluation Council, or other body appointed to advise the Director of the Office of Emergency Services or the Governor concerning matters relating to volcanic or earthquake predictions, from holding closed sessions when considering the evaluation of possible predictions.

(g) This article does not prevent either of the following:

(1) The Teachers' Retirement Board or the Board of Administration of the Public Employees' Retirement System from holding closed sessions when considering matters pertaining to the recruitment, appointment, employment, or removal of the chief executive officer or when considering matters pertaining to the recruitment or removal of the Chief Investment Officer of the State Teachers' Retirement System or the Public Employees' Retirement System.

(2) The Commission on Teacher Credentialing from holding closed sessions when considering matters relating to the recruitment, appointment, or removal of its executive director.

(h) This section shall remain in effect only until January 1, 2006, and as of that date is repealed, unless a later enacted statute, which is enacted before January 1, 2006, deletes or extends that date.

§ 11126.1. Minutes; availability

11126.1. The state body shall designate a clerk or other officer or employee of the state body, who shall then attend each closed session of the state body and keep and enter in a minute book a record of topics discussed and decisions made at the meeting. The minute book made pursuant to this section is not a public record subject to inspection pursuant to the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1), and shall be kept confidential. The minute book shall be available to members of the state body or, if a violation of this chapter is alleged to have occurred at a closed session, to a court of general jurisdiction. Such minute book may, but need not, consist of a recording of the closed session.

§ 11126.3. Required notice for closed sessions

11126.3. (a) Prior to holding any closed session, the state body shall disclose, in an open meeting, the general nature of the item or items to be discussed in the closed session. The disclosure may take the form of a reference to the item or items as they are listed by number or letter on the agenda. If the session is closed pursuant to paragraph (2) of subdivision (d) of Section 11126, the state body shall state the title of, or otherwise specifically identify, the proceeding or disciplinary action contemplated. However, should the body determine that to do so would jeopardize the body's ability to effectuate service of process upon one or more unserved parties if the proceeding or disciplinary action is commenced or that to do so would fail to protect the private economic and business reputation of the person or entity if the proceeding or disciplinary action is not commenced, then the state body shall notice that there will be a closed session and describe in general terms the purpose of that session. If the session is closed pursuant to subparagraph (A) of paragraph (2) of subdivision (e) of Section 11126, the state body shall state the title of, or otherwise specifically identify, the litigation to be discussed unless the body states that to do so would jeopardize the body's ability to effectuate service of process upon one or more unserved parties, or that to do so would jeopardize its ability to conclude existing settlement negotiations to its advantage.

(b) In the closed session, the state body may consider only those matters covered in its disclosure.

(c) The disclosure shall be made as part of the notice provided for the meeting pursuant to Section 11125 or pursuant to subdivision (a) of Section 92032 of the Education Code and of any order or notice required by Section 11129.

(d) If, after the agenda has been published in compliance with this article, any pending litigation (under subdivision (e) of Section 11126) matters arise, the postponement of which will prevent the state body from complying with any statutory, court-ordered, or other legally imposed deadline, the state body may proceed to discuss those matters in closed session and shall publicly announce in the meeting the title of, or otherwise specifically identify, the litigation to be discussed, unless the body states that to do so would jeopardize the body's ability to effectuate service of process upon one or more unserved parties, or that to do so would jeopardize its ability to conclude existing settlement negotiations to its advantage. Such an announcement shall be deemed to comply fully with the requirements of this section.

(e) Nothing in this section shall require or authorize a disclosure of names or other information that would constitute an invasion of privacy or otherwise unnecessarily divulge the particular facts concerning the closed session or the disclosure of which is prohibited by state or federal law.

(f) After any closed session, the state body shall reconvene into open session prior to adjournment and shall make any reports, provide any documentation, and make any other disclosures required by Section 11125.2 of action taken in the closed session.

(g) The announcements required to be made in open session pursuant to this section may be made at the location announced in the agenda for the closed session, as long as the public is allowed to be present at that location for the purpose of hearing the announcement.

§ 11126.5. Removal of disruptive persons

11126.5. In the event that any meeting is willfully interrupted by a group or groups of persons so as to render the orderly conduct of such meeting unfeasible and order cannot be restored by the removal of individuals who are willfully interrupting the meeting the state body conducting the meeting may order the meeting room cleared and continue in session. Nothing in this section shall prohibit the state body from establishing a procedure for readmitting an individual or individuals not responsible for willfully disturbing the orderly conduct of the meeting. Notwithstanding any other provision of law, only matters appearing on the agenda may be considered in such a session. Representatives of the press or other news media, except those participating in the disturbance, shall be allowed to attend any session held pursuant to this section.

§ 11126.7. Charging fees prohibited

11126.7. No fees may be charged by a state body for providing a notice required by Section 11125 or for carrying out any provision of this article, except as specifically authorized pursuant to this article.

§ 11127. State bodies covered

11127. Each provision of this article shall apply to every state body unless the body is specifically excepted from that provision by law or is covered by any other conflicting provision of law.

§ 11128. Time restrictions for holding closed sessions

11128. Each closed session of a state body shall be held only during a regular or special meeting of the body.

§ 11128.5. Adjournment

11128.5. The state body may adjourn any regular, adjourned regular, special, or adjourned special meeting to a time and place specified in the order of adjournment. Less than a quorum may so adjourn from time to time. If all members are absent from any regular or adjourned regular meeting, the clerk or secretary of the state body may declare the meeting adjourned to a stated time and place and he or she shall cause a written notice of the adjournment to be given in the same manner as provided in Section 11125.4 for special meetings, unless that notice is waived as provided for special meetings. A copy of the order or notice of adjournment shall be conspicuously posted on or near the door of the place where the regular, adjourned regular, special, or adjourned special meeting was held within 24 hours after the time of the adjournment. When a regular or adjourned regular meeting is adjourned as provided in this section, the resulting adjourned regular meeting is a regular meeting for all purposes. When an order of adjournment of any meeting fails to state the hour at which the adjourned meeting is to be held, it shall be held at the hour specified for regular meetings by law or regulation.

§ 11129. Continuation of meeting; notice requirement

11129. Any hearing being held, or noticed or ordered to be held by a state body at any meeting may by order or notice of continuance be continued or recontinued to any subsequent meeting of the state body in the same manner and to the same extent set forth in Section 11128.5 for the adjournment of meetings. A copy of the order or notice of continuance shall be conspicuously posted on or near the door of the place where the hearing was held within 24 hours after the time of the continuance; provided, that if the hearing is continued to a time less than 24 hours after the time specified in the order or notice of hearing, a copy of the order or notice of continuance of hearing shall be posted immediately following the meeting at which the order or declaration of continuance was adopted or made.

§ 11130. Legal remedies to stop or prohibit violations of act

11130. (a) The Attorney General, the district attorney, or any interested person may commence an action by mandamus, injunction, or declaratory relief for the purpose of stopping or preventing violations or threatened violations of this article or to determine the applicability of this

article to past actions or threatened future action by members of the state body or to determine whether any rule or action by the state body to penalize or otherwise discourage the expression of one or more of its members is valid or invalid under the laws of this state or of the United States, or to compel the state body to tape record its closed sessions as hereinafter provided.

(b) The court in its discretion may, upon a judgment of a violation of Section 11126, order the state body to tape record its closed sessions and preserve the tape recordings for the period and under the terms of security and confidentiality the court deems appropriate.

(c) (1) Each recording so kept shall be immediately labeled with the date of the closed session recorded and the title of the clerk or other officer who shall be custodian of the recording.

(2) The tapes shall be subject to the following discovery procedures:

(A) In any case in which discovery or disclosure of the tape is sought by the Attorney General, the district attorney, or the plaintiff in a civil action pursuant to this section or Section 11130.3 alleging that a violation of this article has occurred in a closed session that has been recorded pursuant to this section, the party seeking discovery or disclosure shall file a written notice of motion with the appropriate court with notice to the governmental agency that has custody and control of the tape recording. The notice shall be given pursuant to subdivision (b) of Section 1005 of the Code of Civil Procedure.

(B) The notice shall include, in addition to the items required by Section 1010 of the Code of Civil Procedure, all of the following:

(i) Identification of the proceeding in which discovery or disclosure is sought, the party seeking discovery or disclosure, the date and time of the meeting recorded, and the governmental agency that has custody and control of the recording.

(ii) An affidavit that contains specific facts indicating that a violation of the act occurred in the closed session.

(3) If the court, following a review of the motion, finds that there is good cause to believe that a violation has occurred, the court may review, in camera, the recording of that portion of the closed session alleged to have violated the act.

(4) If, following the in-camera review, the court concludes that disclosure of a portion of the recording would be likely to materially assist in the resolution of the litigation alleging violation of this article, the court shall, in its discretion, make a certified transcript of the portion of the recording a public exhibit in the proceeding.

(5) Nothing in this section shall permit discovery of communications that are protected by the attorney-client privilege.

§ 11130.3. Cause of action to void action

11130.3. (a) Any interested person may commence an action by mandamus, injunction, or declaratory relief for the purpose of obtaining a judicial determination that an action taken by a state body in violation of Section 11123 or 11125 is null and void under this section. Any action seeking such a judicial determination shall be commenced within 90 days from the date the action was taken. Nothing in this section shall be construed to prevent a state body from curing or correcting an action challenged pursuant to this section.

(b) An action shall not be determined to be null and void if any of the following conditions exist:

(1) The action taken was in connection with the sale or issuance of notes, bonds, or other evidences of indebtedness or any contract, instrument, or agreement related thereto.

(2) The action taken gave rise to a contractual obligation upon which a party has, in good faith, detrimentally relied.

(3) The action taken was in substantial compliance with Sections 11123 and 11125.

(4) The action taken was in connection with the collection of any tax.

§ 11130.5. Court costs; attorney's fees

11130.5. A court may award court costs and reasonable attorney's fees to the plaintiff in an action brought pursuant to Section 11130 or 11130.3 where it is found that a state body has violated the provisions of this article. The costs and fees shall be paid by the state body and shall not become a personal liability of any public officer or employee thereof. A court may award court costs and reasonable attorney's fees to a defendant in any action brought pursuant to Section 11130 or 11130.3 where the defendant has prevailed in a final determination of the action and the court finds that the action was clearly frivolous and totally lacking in merit.

§ 11130.7. Violation; misdemeanor

11130.7. Each member of a state body who attends a meeting of that body in violation of any provision of this article, and where the member intends to deprive the public of information to which the member knows or has reason to know the public is entitled under this article, is guilty of a misdemeanor.

§ 11131. Prohibited meeting facilities; discrimination

11131. No state agency shall conduct any meeting, conference, or other function in any facility that prohibits the admittance of any person, or persons, on the basis of race, religious creed, color, national origin, ancestry, or sex, or that is inaccessible to disabled persons, or where members of the public may not be present without making a payment or purchase. As used in this section,

"state agency" means and includes every state body, office, officer, department, division, bureau, board, council, commission, or other state agency.

§ 11131.5. Required notice; exemption for name of victim

11131.5. No notice, agenda, announcement, or report required under this article need identify any victim or alleged victim of crime, tortious sexual conduct, or child abuse unless the identity of the person has been publicly disclosed.

§ 11132. Closed sessions; express authorization required

11132. Except as expressly authorized by this article, no closed session may be held by any state body.

CANNELLA ENVIRONMENTAL FARMING ACT SCIENCE ADVISORY PANEL (CEFA SAP)

November 7, 2011
CDFA
Sacramento, CA

Amrith Gunasekara
Science Advisor to the Secretary

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

ECOSYSTEM SERVICES

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

It will be useful for CDFA to define ecosystems services in relation to agriculture

- The definition should be;
  - Easy to comprehend by the general public
  - Applicable to field/grower level so the benefits offered by agriculture can be recognized
  - Thoughtful and meaningful so that it can be used in public policy including public incentives and the regulatory arena
- ES definition is broadly defined as valued services people get from nature (Daily, 1997; Swinton, 2008)
- There are numerous applications of Ecosystem Services (ES).

Daily, G., ed. 1997. Nature's Services. Washington, DC: Island Press.
Swinton, S. M. 2008. Reimagining Farms as Managed Ecosystems. Choices. 23: 28-31.

ECOSYSTEM SERVICES

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

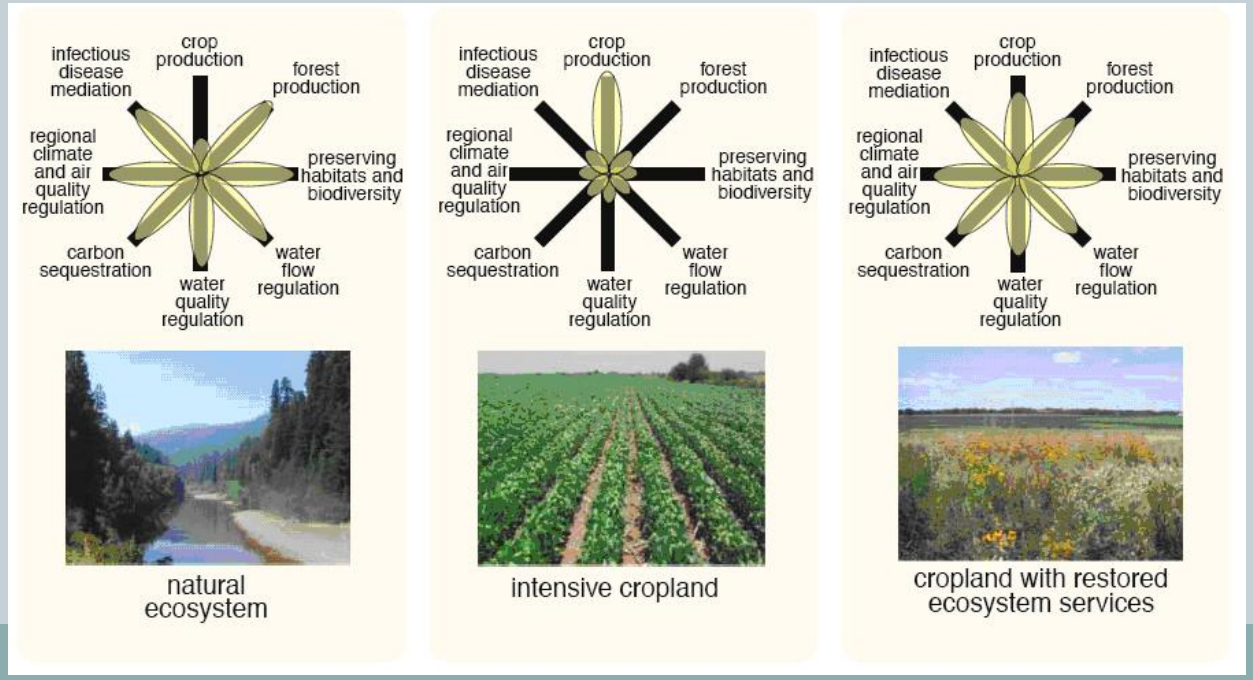
- According to Swinton (2008), "Farming began as a means to;
  - produce food more reliably than hunting and gathering
  - Over time, the scope of farming expanded to fiber and fuel crops
  - The historic focus on producing goods has led most farmers to view themselves as "producers"
  - While this role will not change, new roles are becoming available as providers of more diverse ecosystem services than food, fiber and fuel"

- Who is using it and how is Ecosystem Services (ES) being used to date?
  - Will provide some basic information gathering in next few slides
  - Presentation by Panel Member Dr. Ann Thrupp
  - Panel discussion with EDF, CA Rice Commission, Nature Conservancy, and Farm Bureau

ECOSYSTEM SERVICES

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

- Ecosystems Services initiatives/research/pilots are already underway. Some examples:
  - Government (e.g., USDA)
  - Academia
  - NGO's (e.g., WWF, NFWF)
  - Private Sector



ECOSYSTEM SERVICES - GOV

- Defined as benefits people obtain from ecosystems. The Millennium Ecosystem Assessment categorizes ecosystem services as:
  - Provisioning Services
  - Regulating Services
  - Supporting Services
  - Cultural Services

ECOSYSTEM SERVICES - ACADEMIA

"Agriculture" defined as an Ecosystem Service;

Eigenbrod et al. 2011. The impact of projected increases in urbanization on ecosystem services. Proc. R. Soc. B. 3201-3208.

Methods

- "Our study takes advantage of a national-scale hydrological model for Britain, and of spatially explicit population projections for the period 2006 – 2031, together with existing high-quality datasets available for two ecosystem services (agricultural production and stored carbon)."

Results

- "Even a 1.1 percent reduction in agricultural production combined with a 16 percent increase in the population will mean that self-sufficiency will drop from approximately 57 to 48 % by 2031 in Britain."

ECOSYSTEM SERVICES - NGO

- Payment for Environmental Services, or PES.
- Multiple benefits that people receive from nature, such as water purification and flood control by wetlands.
  - PES scheme developed on the island of Lombok, Indonesia
  - Conserve the forests of Mt. Rinjani.
  - Forests vital to the $50 million per year agricultural sector of the region, and supply domestic water worth $14 million.
  - Bring tourist dollars into the economy
  - Study indicated that nearly all 43 thousand households in the area would agree to pay up to US$0.60 per month in special charges
  - Funds collected will help pay for conserving the watershed forests at the head of the Segara River and improving social conditions in neighboring communities.

ECOSYSTEM SERVICES - PRIVATE

MUDFORD FARM | Chesapeake Bay, Maryland

Mudford Farm is a 274-acre farm on the Eastern Shore of Maryland in the Chesapeake Bay region. In addition to growing corn, wheat, and soybeans, Mudford's owners have diversified their farm by restoring marginal farmland to wetlands, grass meadows, and riparian buffers, hoping to reap greater financial returns from the restored ecosystem services.

Restored marginal farmland to include:
Grass meadows and filter buffer strips (40 acres)
Wetland bank (10 acres)
Water quality protection (36 acres)
Several restored wetlands, together with vegetated buffer strips, serve to reduce runoff from nitrogen, phosphorus, and sediment into nearby waterways.

December 2010 – "Biophilia Foundation sold an easement to the State of Maryland that will allow for the adaptive management of the habitat practices in perpetuity. The easement will allow one new home site, and will restrict future farming on the property to the remaining 90 acres of agricultural land possessing the most productive soils."

?

CHOICES
The magazine of food, farm, and resource issues

A publication of the
American Agricultural
Economics Association

Reimagining Farms as Managed Ecosystems

Scott M. Swinton

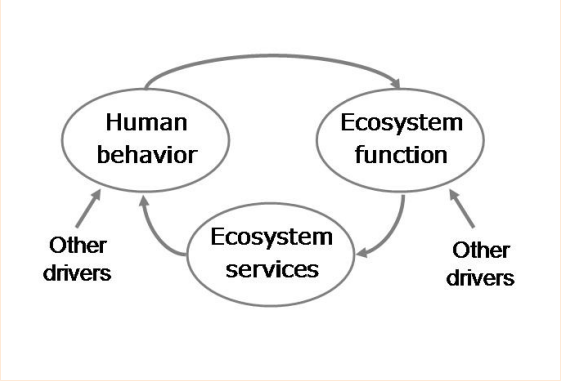
JELclassifications: Q57, Q51, Q12

How scientists perceive people and nature to interact is changing. These changes will likely transform how we perceive farming. Along the way, they are reshaping the research agenda for agricultural and environmental economists. In short order, farmers will be faced with dramatically different management opportunities.

Farming began as a means to produce food more reliably than hunting and gathering. Over time, the scope of farming expanded to fiber and fuel crops. The historic focus on producing goods has led most farmers to view themselves as "producers." While this role will not change, new roles are becoming available as providers of more diverse ecosystem services than food, fiber and fuel.

Broadly speaking, "ecosystem services" are the valued services that people get from nature (Daily, 1997) (Figure 1). They encompass four broad areas (Millennium Ecosystem Assessment, 2005):

Figure 1. Ecosystem services link people and ecosystems



- Provisioning services include food, fiber, wood, fuel and fresh water that provide for human subsistence.
- Regulating services maintain the balance of the Earth's systems at levels that enable human survival. These services include climate, flood, water quality and disease regulation. Examples include vegetation that buffers the effects of natural flooding, or predator–prey systems that limit the spread of pathogens.
- Cultural services include the spiritual, inspirational, aesthetic, heritage, recreational and tourism benefits.
- Supporting services include the myriad natural systems that enable the three tiers above. For example, organic matter cycling contributes to soil creation, which makes food provisioning possible. Photosynthesis transforms solar energy into plant matter, enabling provisioning services, carbon cycling, and various other services.

The idea of ecosystem services transforms the way we think about nature in three ways. First, when viewed as a web of ecosystems, nature is no longer a background resource, but rather a system that can malfunction. Second, the idea of service flows implies a need to maintain the capital base that produces those services. Last, and most important, "ecosystem service" expresses a link between people and ecosystems whereby people enjoy benefits from ecosystems—but also influence their functioning.

Agriculture as Managed Ecosystem

From an ecological perspective, agriculture is an ecosystem that is frequently disturbed to favor desired products. Tillage and herbicides prevent competition from undesired weeds. Veterinary care and housing protect livestock from pathogens and predators. What ecologists call "human disturbance" agriculturalists call "management." But farmers who manage those ecosystems influence flows of many ecosystem services, whether they think about it or not. Herein lie opportunities for farmers and society at large, by perceiving the larger role of agricultural ecosystems. The opportunities are many, for crops and pasture already

occupy roughly half the Earth's land area that is not barren rock, desert or permafrost (Millennium Ecosystem Assessment, 2005), and farmland is expanding.

New opportunities for farmers to manage for ecosystem services are emerging from recent research (Swinton, Lupi, Robertson and Landis, 2006). Two specific examples come from pest regulation and climate regulation.

Managing habitat for pollinators and the natural enemies of agricultural pests can enhance farm food, fiber and fuel production. Pollination and the regulation of pests and diseases are two natural ecosystem services. Like food production, they can be enhanced by management. While many farmers rely on the European honey bee for commercial pollination, native bees and other pollinators also play important roles (National Research Council, 2006). Habitat essentials typically involve a nearby landscape with suitable nesting sites and a sequence of flowering plants for food to keep the pollinators from migrating elsewhere. The natural enemies of agricultural pests have shown the ability to suppress potentially damaging populations of such invasive pests as soybean aphid. Their habitat needs are similar, though their food requirements are not.

Farming can play a major role in climate regulation, both by limiting emissions of greenhouse gases and by sequestering carbon in plants and soil (Robertson, 2004). Agriculture generates two particularly potent greenhouse gases. Methane, from rice paddies, manure and livestock digestion, has a global warming potential of 21 CO2 carbon equivalents. Nitrous oxide has over 300 times the global warming potential of CO2. It is generated by excess mineral nitrogen, particularly from heavily fertilized crop fields. More livestock waste management, fertilizer application and efficient machinery use can mitigate these ecosystem disservices. Sequestration of carbon into agricultural soils through no–till farming and production of biofuel crops that remove CO2 from the atmosphere as they grow can directly reduce global warming potential.

Other opportunities abound for farmers to manage for ecosystem services, from wildlife habitat to water quality to aesthetic landscapes.

Value of Ecosystem Services

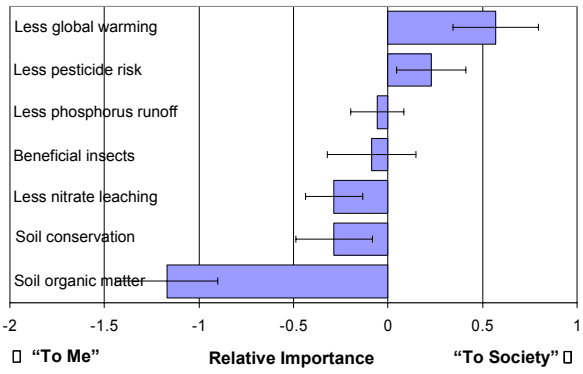
Why would farmers bother to provide ecosystem services that lack markets? To be sure, certain ecosystem services contribute to private profitability, but others do not. In 2007 focus group interviews, Michigan crop farmers identified increased soil organic matter as offering private benefits to their farms, but found reduced global warming to chiefly benefit society at large (Figure 2).

Of course, if there are clear benefits to society at large from ecosystem services that lack markets, then policymakers have justification to create incentives that stimulate more supply. In order to make such incentives operational, four steps are needed, 1) understand how humans can affect the production process for ecosystem services, 2) find cost–effective ways to measure those services, 3) estimate the value of ecosystem services to humans, and 4) design policies that fit both the environmental setting and existing legal institutions.

Agricultural ecosystems offer special opportunities to generate other ecosystem services as joint products along with food, fiber or fuel production (Wossink and Swinton, 2007). Hence, costs of providing joint ecosystem services can be much lower than if they were produced alone. Understanding how agricultural practices affect ecosystem functioning and generate ecosystem services is highly complex. For management purposes, performance indicators are needed that track high–priority ecosystem service in a cost–effective way across space and time (Dale and Polasky, 2007).

The valuation of ecosystem services that lack markets can be viewed from two perspectives: what consumers would be willing to pay for it, or what producers would be willing to accept to supply it. Many techniques exist to estimate consumer willingness to pay, including responses to questions about hypothetical purchases and calculations based on what consumers already spend. In the latter category, for example, expenses made to travel to a distant site for fishing or hiking can be used to estimate the value of the

Figure 2. Farmer ratings of the relative importance of the environmental benefits "to me" (negative) versus "to society" (positive), 34 Michigan farmers, 2007. (Likert scale paired difference t–test error bars = 1 std error).



fishery or the aesthetic ecosystem services. Land prices can be analyzed to infer the values of ecosystem services in the vicinity. Producers' willingness to accept payment in exchange for providing ecosystem services can be estimated from the implied costs due to changes in farming costs and foregone crop revenues. Because farm locations vary in potential commercial productivity and potential abundance of ecosystem services, farmers' willingness to supply ecosystem services will vary from place to place (Antle and Valdivia, 2006). These methods are discussed in greater detail in a recent special section of the journal, Ecological Economics, devoted to the topic, "Ecosystem Services and Agriculture" (Swinton, Lupi, Robertson and Hamilton, 2007).

Incentives for Farmers to Provide Ecosystem Services

If we understand how ecosystem services are produced, how to measure them, and what they are worth to consumers and producers, then incentives for their provision can be designed. Incentive programs can be divided between government programs and private sector ones. U.S. farm policy has a history of cost–share support for clearly observable practices, such as soil conservation investments, and land retirement policies, such as the Conservation Reserve Program. In the 2002 farm bill, the Conservation Security Program created payments for environmental stewardship.

Private sector activities include business–to–business payments and markets for pollution credits (Kroeger and Casey, 2007). One rapidly developing example of a market for pollution credits is the global carbon market. The Chicago Climate Exchange has developed rules for buying "carbon management offsets" from U.S. farmers whose use of reduced tillage practices can sequester atmospheric carbon in soil (Chicago Climate Exchange (CCX), 2007). Payment levels are very modest at present ($2–3/acre/year for 5–year commitments on the most productive lands). Related offset payments are available for livestock farmers who collect and burn methane, so that it is not released into the atmosphere. If international agreements to limit global warming become more binding—especially if the United States joins in—then opportunities for farmers to profit by providing climate regulation services are likely to grow in number and value.

Business–to–business payments for environmental services are also developing, particularly linked to water markets (Pagiola, Bishop and Landell–Mills, 2002). In most successful programs, such payments have compensated farmers or foresters for maintaining vegetative cover so as to protect drinking water supplies. More recent efforts are underway to pay for more diverse ecosystem services, such as biodiversity and soil conservation.

Biodiversity conservation is particularly challenging for policy design, because it often calls for coordinated action among multiple landowners. Many large mammals and migratory species require contiguous habitat over large areas. Recent research involving experimental games has shown that land owners can rapidly learn to cooperate if offered policy incentives that favor cooperating by agglomerating contiguous habitat (Parkhurst and Shogren, 2007).

Demand for Research on Economics of Ecosystem Services

Because so many ecosystem services have intrinsic value yet lack markets, scientists and policy makers are keen to see economic measures of their value. The twin challenges of lucid communication and sound economic methodology are formidable. Scientists and policy makers would like clear numbers, while economists want to explain that "it depends" on various parameters. Can economists meet these twin challenges? Ecosystem services pose broad, complex valuation problems, but the benefit transfer literature has progressed impressively in recent years (Wilson and Hoehn, 2006).

Research opportunities on the economics of ecosystem services are proliferating. A growing consensus among science research administrators seeks to fill a perceived void in research efforts on multidisciplinary problems, notably those associated with global change. The National Science Foundation has just converted a temporary initiative into a permanent program in Coupled Natural and Human Systems—its first such multidisciplinary program. It is currently evaluating follow–on ideas for its successful initiative in Human and Social Dynamics. New opportunities in these areas involve multidisciplinary teams, especially focused on socioecological research.

Rethinking farming as ecosystem management offers fresh and promising ways to imagine contributions from agriculture. Agriculture's history as a managed ecosystem and its scale, coupled with society's growing needs for a broad mix of ecosystem services, create a formidable research and policy agenda. That agenda calls for multidisciplinary research into how farmers can produce a wider range of ecosystem services, what those services are worth, and what policy designs could effectively induce more such services to be provided. Successful answers will capitalize on the unique productive potentials of diverse ecosystems using incentives tailored to fit farmers' objectives, resources and property rights. The challenge is great, the rewards as well.

For More Information

Antle, J.M., & Valdivia, R. (2006). Modeling the supply of ecosystem services from agriculture: a minimum data approach. Australian Journal of Agricultural and Resource Economics 50(1),1–15.

Chicago Climate Exchange (CCX). (2007). Soil carbon management offsets. Available online: http://www.chicagoclimatex.com/docs/offsets/CCX_Soil_Carbon_Offsets.pdf.

Daily, G., ed. 1997. Nature's services. Washington, DC: Island Press.

Dale, V.H., & Polasky, S. (2007). Measures of the effects of agricultural practices on ecosystem services. Ecological Economics 64(2), 286–296.

Kroeger, T., & Casey, F. (2007). An assessment of market–based approaches to providing ecosystem services on agricultural lands. Ecological Economics 64(2), 321–332.

Millennium Ecosystem Assessment. (2005). Ecosystems and human well–being: synthesis. Washington, DC: Island Press.

National Research Council. (2006). Status of pollinators in North America. Washington, DC: National Academies Press.

Pagiola, S., Bishop, J. & Landell–Mills, N., eds. (2002). Selling forest environmental services: marked–based mechanisms for conservation and development. London: Earthscan.

Parkhurst, G.M., & Shogren, J.F. (2007). Spatial incentives to coordinate contiguous habitat. Ecological Economics 64(2), 344–355.

Robertson, G.P. (2004). Abatement of nitrous oxide, methane and other non–CO2 greenhouse gases: the need for a systems approach." In Field, C.B. & Rapauch, M.R., eds., The global carbon cycle. Washington, DC: Island Press, pp. 493–506.

Swinton, S.M., Lupi, F., Robertson, G.P. & Hamilton, S.K. (2007). Ecosystem services and agriculture: cultivating agricultural ecosystems for diverse benefits. Ecological Economics 64(2), 245–252.

Swinton, S.M., Lupi, F., Robertson, G.P. & Landis, D.A. (2006). Ecosystem services from agriculture: looking beyond the usual suspects. American Journal of Agricultural Economics 88(5), 1160–1166.

Wilson, M.A., & Hoehn, J. P. (2006). Valuing environmental goods and services using benefit transfer: the state–of–the art and science. Ecological Economics 60(2), 335–342.

Wossink, A., & Swinton, S.M. (2007). Jointness in production and farmers' willingness to supply non–marketed ecosystem services. Ecological Economics 64(2), 297–304.

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PROCEEDINGS OF THE ROYAL SOCIETY B

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The impact of projected increases in urbanization on ecosystem services

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Alteration in land use is likely to be a major driver of changes in the distribution of ecosystem services before 2050. In Europe, urbanization will probably be the main cause of land-use change. This increase in urbanization will result in spatial shifts in both supplies of ecosystem services and the beneficiaries of those services; the net outcome of such shifts remains to be determined. Here, we model changes in urban land cover in Britain based on large (16%) projected increases in the human population by 2031, and the consequences for three different services—flood mitigation, agricultural production and carbon storage. We show that under a scenario of densification of urban areas, the combined effect of increasing population and loss of permeable surfaces is likely to result in 1.7 million people living within 1 km of rivers with at least 10 per cent increases in projected peak flows, but that increasing suburban 'sprawl' will have little effect on flood mitigation services. Conversely, losses of stored carbon and agricultural production are over three times as high under the sprawl as under the 'densification' urban growth scenarios. Our results illustrate the challenges of meeting, but also of predicting, future demands and patterns of ecosystem services in the face of increasing urbanization.

Keywords: agricultural production; carbon storage; densification; flood risk; natural capital; urban ecology

1. INTRODUCTION

Alteration in land use is likely to be a major driver of global changes in the distribution of vital ecosystem services before 2050 [1]. Large increases in urbanization (conversion of land to residential and industrial areas) are in turn projected to be a key driver of these alterations in land use in many regions, and probably the main one in Europe [2]. These increases in urbanization are a consequence of growth both in the human population and in the percentage of that population living in urban areas—while globally only 220 million people (13%) lived in urban areas in 1900, this increased to 3.2 billion (49%) by 2005 and is projected to reach 4.9 billion (60%) by 2030 [3].

Urbanization will not only influence the potential supply and use of ecosystem services, but also the number, behaviour and distribution of potential beneficiaries of those services. For one, conversion of non-urban areas to urban areas is likely to reduce the supplies of many services. Secondly, increasing human populations could lead to shortages in some ecosystem goods and services (e.g. provisioning services such as agricultural production; [4]), even if there was no reduction in the overall quantity of service available, by decreasing the amount available *per capita*. In addition, urbanization changes the distribution of beneficiaries: human populations are increasingly located in small dense patches (urban areas) that are frequently far away from where services are generated. This change in the distribution of populations relative to the locations of ecosystem service supplies could further reduce the *per capita* supply or increase the costs of service provision (e.g. dams and water transfers, transport of food from rural areas to urban areas). Finally, these multifaceted interactions between urbanization and ecosystem service provision are likely to alter trade-offs between services in an area (e.g. [5]). However, analyses of such interactions have been lacking to date.

While many ecosystem services will be affected by urbanization, mitigation of the impact of freshwater flood events by the landscape (through storage and slow release of rain water from the soil and aquifers) is a vital ecosystem service that can be particularly severely affected by increases in urbanization. This is because (i) urban development can lead to larger and more frequent floods owing to increases in impervious surfaces (reviewed in [6]), and (ii) the increasing population of growing urban areas leads to more people being affected by floods.

Here, we provide the first study mapping the impacts of projected increases in urbanization on a range of ecosystem services at a national scale by assessing the effects of two contrasting urbanization scenarios on

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freshwater flood mitigation services, carbon storage and agricultural production for Britain. Specifically, we link spatially explicit urbanization projections for the period 2006–2031 with estimates of peak river flows from a high-resolution hydrological model, and with existing spatial models of stored carbon and agricultural production. We chose Britain as a case study because of (i) the availability of the high-resolution, national-scale datasets required for this sort of analysis and (ii) the high (16%) projected increase in the human population by 2031 (http://www.statistics.gov.uk/pdfdir/pproj1007.pdf).

We compare two urbanization scenarios in our analyses that reflect opposite ends of the spectrum of urban growth scenarios that are likely to occur in Britain as a result of projected increases in population growth. Under one strategy, expansion of future urban areas is minimized by increasing the density of existing dense urban areas (hereafter the 'densification' scenario), while under the other, overall urban area increases by favouring future urban growth at the same densities as existing suburban areas in Britain (hereafter the 'sprawl' scenario). There has been a policy of increasing densification in the UK since 2000 [7], which has led to increased housing density [8], suggesting that densification is a realistic scenario. However, patterns of urbanization are sensitive to both economic conditions and planning policy [8], and growth similar to the sprawl scenario is in line with one of the (non-spatial) housing scenarios developed for England by the UK government [9].

2. METHODS

Our study takes advantage of a national-scale hydrological model for Britain [10], and of spatially explicit population projections for the period 2006–2031, together with existing high-quality datasets available for two ecosystem services (agricultural production and stored carbon; [11]).

(a) *Ecosystem services*

(i) *Flood mitigation*

While mapping areas at a high risk of flooding (currently and in the future) is relatively straightforward and often carried out by national governments (e.g. the Foresight Future Flooding study for Britain; [12]), actually identifying which portions of a landscape provide flood mitigation services is a much more complex undertaking. This is both because of the need spatially to link upstream locations where the service is being provided with downstream beneficiaries, and because of the difficulties in linking specific land cover types to flooding. A spatial hydrological model is required to link changes in run-off upstream caused by changes in natural land cover to changes in peak flows downstream. This in turn needs to be linked to the number of people who would be affected by changes in peak flows—if there are no direct or indirect beneficiaries of landscape flood mitigation, there is no ecosystem service. However, while maintenance of natural land-cover types such as forests or wetlands can lead to reduced peak flows further downstream through direct use (e.g. [13]) and by facilitating infiltration (e.g. [14,15]), the link between different types of land cover and flooding is very difficult to quantify at anything other than a local scale [16].

A number of studies have mapped flood mitigation/flood control within the ecosystem service framework, but these have in the main been restricted to mapping land-cover types that *can* reduce flooding (e.g. [17,18]), or to simple models that map flood risk based on biophysical factors such as slope and elevation (e.g. [19]). A few studies combine multiple factors in identifying key areas for flood mitigation in large-scale studies (see e.g. [20,21] globally), but no large-scale study to date has used a hydrological model explicitly to link upstream changes in flows to downstream beneficiaries.

Here, we used an existing grid-based hydrological model (Grid-to-Grid (G2G) [10]) of Britain to map the impacts of projected changes in dense urban and suburban land cover between 2006 and 2031 on freshwater flood mitigation services provided by the landscape. We quantify loss of flood mitigation provided by the landscape that the hydrological model predicts will occur through the conversion of non-urban land to urban land by calculating the change in flood risk (percentage increase in peak flow at the 2 year return period) for 1×1 km UK grid squares containing a significant river component (grid squares with a drainage area greater than 20 km^2 or for which the observed river length is greater than 500 m). A 2 year return period peak flow denotes the magnitude of flow that would be exceeded on average every 2 years and corresponds to the median annual flood. This value will typically be slightly higher than bankfull flow, which is the maximum amount of discharge that a river channel can accommodate without overflowing. For a 2 year return period of flow (*without* any additional increase), we would expect some localized flooding of natural river reaches that have no artificial flood defences. Preliminary analyses (electronic supplementary material) showed that using a 20 year return period rather than a 2 year return period did not qualitatively affect our findings.

The G2G model is a grid-based hydrological model whose main output is time-varying grids of river flow across a large region, in this case Britain. The model requires gridded estimates of precipitation and potential evaporation (PE) as input, and has previously been used to assess how climate change may impact river flows [10] and to estimate real-time river flows for operational flood-forecasting [22]. G2G relies on digital datasets of landscape and soil properties to provide the spatial differentiation in landscape response to rainfall, and a recent evaluation comparing modelled and observed river flows at sites across Britain indicated relatively good model performance [10]. More accurate simulations can be obtained by model calibration to individual catchment conditions (e.g. abstractions, presence of reservoirs), but the emphasis here is to study large-scale hydrological changes, for which this model is ideally suited. Further details of the G2G model formulation and a map of peak flows across Britain (see electronic supplementary material, figure S1) are available in the electronic supplementary material.

(ii) *Agricultural production*

Following Anderson *et al.* [11], we measured agricultural production as the summed gross margins of all major crops and livestock, at the 1×1 km grid resolution (see electronic supplementary material, figure S3). We obtained raw yields in relevant units (e.g. animals per hectare) from agricultural census data from England [23], Scotland [24] and Wales [25]. We then converted these yields into gross margins using estimates obtained from the Farm Management Handbook 2007/2008 [26]. Gross margins (value of output − variable costs excluding subsidy payments) provide the best estimate

of yield that the ecosystem can provide by allowing us to exclude human-applied inputs such as fertilizer. See the electronic supplementary material for detailed methods.

(iii) *Carbon storage*

Also following Anderson *et al.* [11], we obtained estimates of the total above and below ground (vegetation and soil) stored carbon per 1 × 1 km grid cell (see electronic supplementary material, figure S4). Vegetation carbon data were obtained from Milne & Brown [27], while soil carbon data were estimated from extensive field, soil parameter, land-use and soil series data. Detailed methods can be found in the electronic supplementary material.

(b) *Future urbanization models*

We created simple models of projected urbanization in 2031 for Britain that highlight opposite ends of the spectrum of urban growth scenarios that are likely to occur as a result of projected increases in population growth—the densification and sprawl scenarios. We could not use existing models of future land-use change as even the most spatially resolved of these for Britain as a whole [28] does not give the percentage of each 1 × 1 km grid square that is covered by dense urban and suburban land cover required by our hydrological model [10]. Our urbanization models take advantage of recent district-level projections of population growth for Britain combined with land-cover data (Land Cover 2000: [29]). These population projections are available online through the Office of National Statistics for England (http://www.statistics.gov.uk/statbase/product.asp?vlnk=997), the General Register Office for Scotland (http://www.gro-scotland.gov.uk/statistics/publications-and-data/popproj/index.html) and StatsWales (http://www.statswales.wales.gov.uk/ReportFolders/reportfolders.aspx?IF_ActivePath=P,345,1851,2048,5954). The districts (or local authorities) range from small, densely populated areas (e.g. the London borough of Westminster) to moderately sized cities with intermediate population densities (e.g. Sheffield) to large, sparsely populated rural districts (e.g. the Scottish Highlands). Note that our urbanization model also calculates the projected number of people in each 1 × 1 km grid square, in addition to the percentage of each grid square that is covered by dense urban and suburban land cover.

Under the densification scenario, the housing demands of the projected increases in the population in each district are preferentially met by converting existing suburban housing to dense urban housing. Suburban housing has approximately 65 per cent of the population density of dense urban housing (3298 versus 5052 km^{-2}, as calculated for England, which has approx. 85% of the population of Britain), so 35 per cent more people can be accommodated in dense urban areas than in suburban housing. New housing (also at dense urban and not suburban population densities) is only added under the densification scenario once all suburban housing in a district has been converted to dense urban housing, therefore minimizing the need for new urbanization.

Under the sprawl scenario, the opposite occurs—housing demands are preferentially met by creating new housing at suburban housing densities, with conversion of suburban to dense urban housing only occurring when no space is available in the district for new urbanization (e.g. parts of London). In both scenarios, new housing is preferentially located near existing urban areas, and is restricted to 'realistic' locations; that is, not in National Parks, biodiversity reserves, nationally important historic sites, large city parks, wetlands or montane areas.

We also modified both the densification and sprawl scenarios to minimize the losses of stored carbon and agricultural production, respectively, by preferentially placing new urban areas in 1 × 1 km grid cells with low levels of the respective service; similar analyses minimizing losses of flood mitigation services were not undertaken as they are beyond the scope of this manuscript (see electronic supplementary material). We then evaluated the effects that these 'minimization of loss' scenarios had on flood mitigation. All GIS analyses were carried out in ArcGIS/ArcInfo 9.2 (ESRI, Redlands, CA, USA), and urbanization modelling and all statistical analyses were carried out in R 2.10 [30]. Detailed methods about the creation of and the assumptions within the future urbanization model are available in the electronic supplementary material, along with a map of the distribution of the current cover of suburban and urban land cover (see electronic supplementary material, figure S5).

(c) *Integration of ecosystem service and urbanization models*

(i) *Flood mitigation*

The extent of impervious urban cover is an important factor determining the effect of urban development on peak river flows. Impervious urban surfaces (e.g. roads and buildings) reduce the infiltration of rainfall to soil/groundwater stores and increase fast surface run-off. In the G2G model, urban extent is divided into two categories, urban and suburban, for which relatively simple differences in hydrological behaviour are assumed. For grid cells containing an urban or a suburban fraction (based on the 25 × 25 m resolution LCM2000 land-cover map; [29]), the amount of water stored by soils is reduced to a value below that specified by national soil datasets, with the greatest reduction applied in urban areas. The specific reduction factors used in the G2G model for dense urban and suburban pixels (70 and 30%, respectively) have been determined through a combination of model assessment and calibration for catchments containing a significant urban fraction [10], and literature recommendations. For example, assuming the same soil type, conversion of 50 per cent of a 1 × 1 km grid cell to dense urban or suburban land cover would result in a loss of 35 and 15 per cent of the water storage capacity of the grid cell, respectively. Typically, rivers with large projected increases in flooding are those that are located downstream from clusters of urbanized cells for which the water storage capacity has been reduced.

(ii) *Agricultural production*

We assumed that agricultural production would be reduced at a rate directly proportional to the amount of new urbanization (dense urban or suburban) in a 1 × 1 km grid cell. For example, if agricultural production in a grid cell was originally estimated to be £1000, and 25 per cent of the cell was then projected to urbanized, then this would result in production in the square being reduced to £750; this assumption may not always be true because of economies of scale. This approach also assumes that urban areas have no agricultural production, that new urban areas will primarily occur on agricultural land and that agricultural prices, preferences and productivity are static. The first assumption is likely to be broadly correct, given that agriculture in Britain

Table 1. Number of people residing within 1 × 1 km^2 that have projected increases in peak flows (2 year return period) under the densification and sprawl scenarios of urban growth by 2031.

minimum percentage increase in peak flow	densification		sprawl	
	people	percentage of population	people	percentage of population
10	1 736 000	2.5	11 000	0
20	774 000	1.1	1000	0
50	180 000	0.3	0	0

Table 2. Losses in carbon storage and agricultural production (percentages of total for Britain) under the densification and sprawl urbanization scenarios.

	densification scenarios			sprawl scenarios		
service	base	minimize losses of agricultural production	minimize losses of stored carbon	base	minimize losses of agricultural production	minimize losses of stored carbon
carbon storage	0.20	0.22	0.16	0.71	0.77	0.61
agricultural production	0.32	0.15	0.42	1.12	0.60	1.36

is heavily mechanized and dominated by large-scale operations that do not occur in urban areas. The second assumption is probably also broadly correct in Britain, given that most areas that are suitable for urbanization (i.e. not wetlands or moorland) are also farmlands (only 12% of Britain is forested; [8]). The third assumption of static prices, preferences and productivity is clearly not true, but is unavoidable given (i) the complexities of predicting future shifts in agricultural prices and preferences and (ii) the lack of availability of such data for Britain as a whole.

(iii) *Carbon storage*

We assumed that new urbanization would affect stored carbon exactly as for agricultural production—stored carbon would decrease at a rate directly proportional to the amount of new urbanization (dense urban or suburban). Again, this approach assumes that urban areas have no stored carbon. This is almost certainly an underestimate of true carbon stores, but is in line with many current national estimates of soil [31] and vegetation [27] carbon for Britain, owing to a paucity of data on carbon stores in urban areas.

3. RESULTS

The high (16%) projected growth in the British population by 2031 will have a considerable impact on the three ecosystem services considered here. However, which services will be most affected will depend critically on whether future urbanization patterns are closer to densification or to sprawl scenarios of urban growth—there is a much greater negative effect on natural flood mitigation services under the former, while carbon storage and agricultural production see larger reductions under the latter (tables 1 and 2).

There are large differences in the amount of land converted to new urbanization (figure 1), and differences in the increased amount of dense urbanized areas (figure 2), between the two scenarios. The total amount of land converted to new urbanization is 948 km^2 (0.4% of Britain) and 3302 km^2 (1.4% of Britain) under the densification and sprawl scenarios, respectively. Dense urban area is projected to increase by 94 per cent (from 4170 to 9161 km^2) under the densification scenario, but only by 2 per cent (4170–4787 km^2) under the sprawl scenario. Modification of the densification and sprawl scenarios to minimize losses of stored carbon or agricultural production, respectively, had no effect on the amount of land converted to new urbanization or in the amount of dense urban land. This is because these 'minimization' scenarios primarily shifted where new urbanization occurred, and not the total amount of land converted to new urban areas or the areas converted to dense urban.

The densification scenario has a much greater effect on increases in flood risk caused by a loss of natural flood mitigation services than the sprawl scenario (figure 2). The *mean* change in peak (2 year return period) flows across all British rivers is relatively small in both, but over three times higher under the densification scenario (1.4%; s.d. of 6.3 percentage points) than under the sprawl scenario (0.3%; s.d. of 0.65 percentage points). However, much higher changes are projected to occur near or downstream of many urban areas under the densification scenario (figure 2). The difference between the scenarios is even more pronounced when the beneficiaries of flood mitigation services are considered. Under the densification scenario, approximately 1.7 million people (as calculated from the urbanization model) would reside within the same 1 × 1 km^2 for which peak river flows are projected to increase by at least 10 per cent, whereas under the sprawl scenario, a much smaller number of people (approx. 11 000) would be affected in this way (table 1).

For carbon storage and agricultural production, losses in the current stock of both services will be 3.5 times higher under the sprawl than the densification scenario (table 2). Modification of the scenarios to minimize losses of agricultural production approximately halves losses of agricultural production at the expense of an 8–10% increase in the amount of carbon lost. However, minimizing losses of carbon only leads to a 15–20%

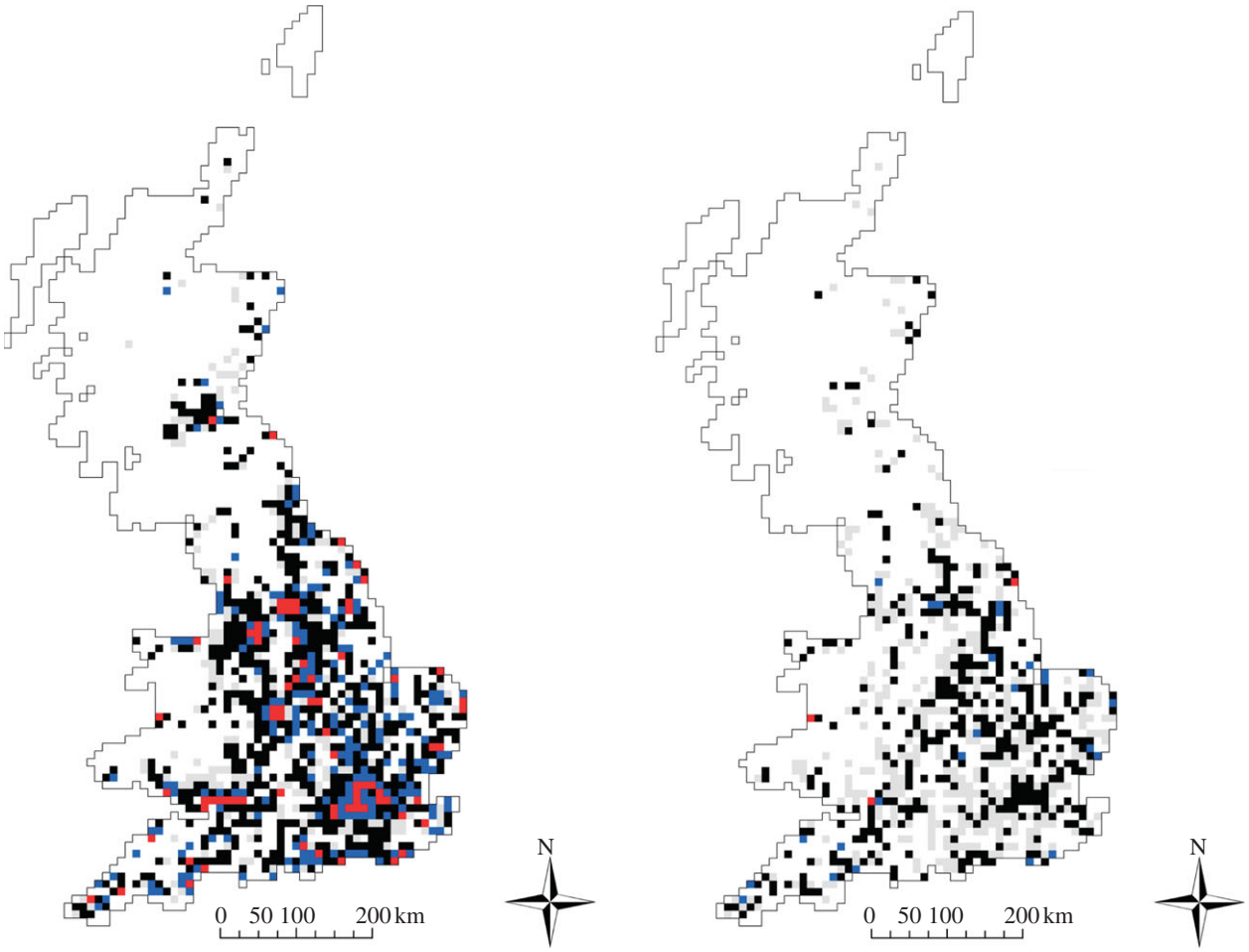

Figure 1. The percentage of each 1 × 1 km grid cell (mean value per 10 × 10 km cell) projected to be converted from non-urban to urban (dense urban + suburban) by 2031 in Britain under the densification and sprawl scenarios (unshaded area, 0; grey-shaded area, 0–1; black-shaded area, 1–5; blue-shaded area, 5–10; red-shaded area, 10–22.

reduction in the amount of carbon lost at the expense of a 20–25% increase in losses in agricultural production (table 2). Minimization of losses of stored carbon or agricultural production also leads to small increases in the number of people predicted to be affected by peak flows under the densification scenario (approx. 2% more people affected by at least 10% increases in peak flows). Under the sprawl scenario, the absolute number of people likely to be affected is still very small (approx. 16 000 affected by at least 10% increases in peak flows under the minimization of losses in agricultural production/sprawl scenario versus 11 000 under the base sprawl scenario). However, these small changes in numbers can translate to large (up to 100%) percentage increases in the number of people likely to be affected by changes in peak flows when minimizing losses of stored carbon or agricultural production under the sprawl scenario (see electronic supplementary material, table S2).

4. DISCUSSION

The results of our models suggest that the best type of urban development in terms of maintaining ecosystem services will depend on the service considered, highlighting the challenge both of predicting and sustainably managing ecosystem services under changing land-use patterns. For example, future shifts in both the amount and distribution of ecosystem service supplies and beneficiaries could alter current patterns of covariation between ecosystem services (e.g. [11,20]) and existing 'ecosystem service bundles' [32]. Indeed, the complexity of the relationships between just three ecosystem services under just two land-use scenarios presented here emphasizes the importance of understanding the drivers of relationships between different ecosystem services [5].

A key finding of this study is that increasing sprawl-type, suburban development potentially has less of an effect on flood mitigation services than increasing the amount of dense urban housing, but that the opposite is true for stored carbon and agricultural production. The much greater increase in risk of flooding was due to the doubling of dense urban areas (mostly through conversion of suburban areas to dense urban areas) under the densification scenario. In the hydrological model applied here, high-density housing (dense urban) development leads to a greater reduction in subsurface water storage than low-density (suburban) housing, and to increases in river routing speed. This decreases the residency time of water, and leads to a faster release into rivers, which in turn increases peak flows and downstream flooding [14]. Losses of stored carbon and agricultural production were predicted to be higher in the sprawl scenario than in the densification scenario because over three times as much non-urban land was converted to urban in the

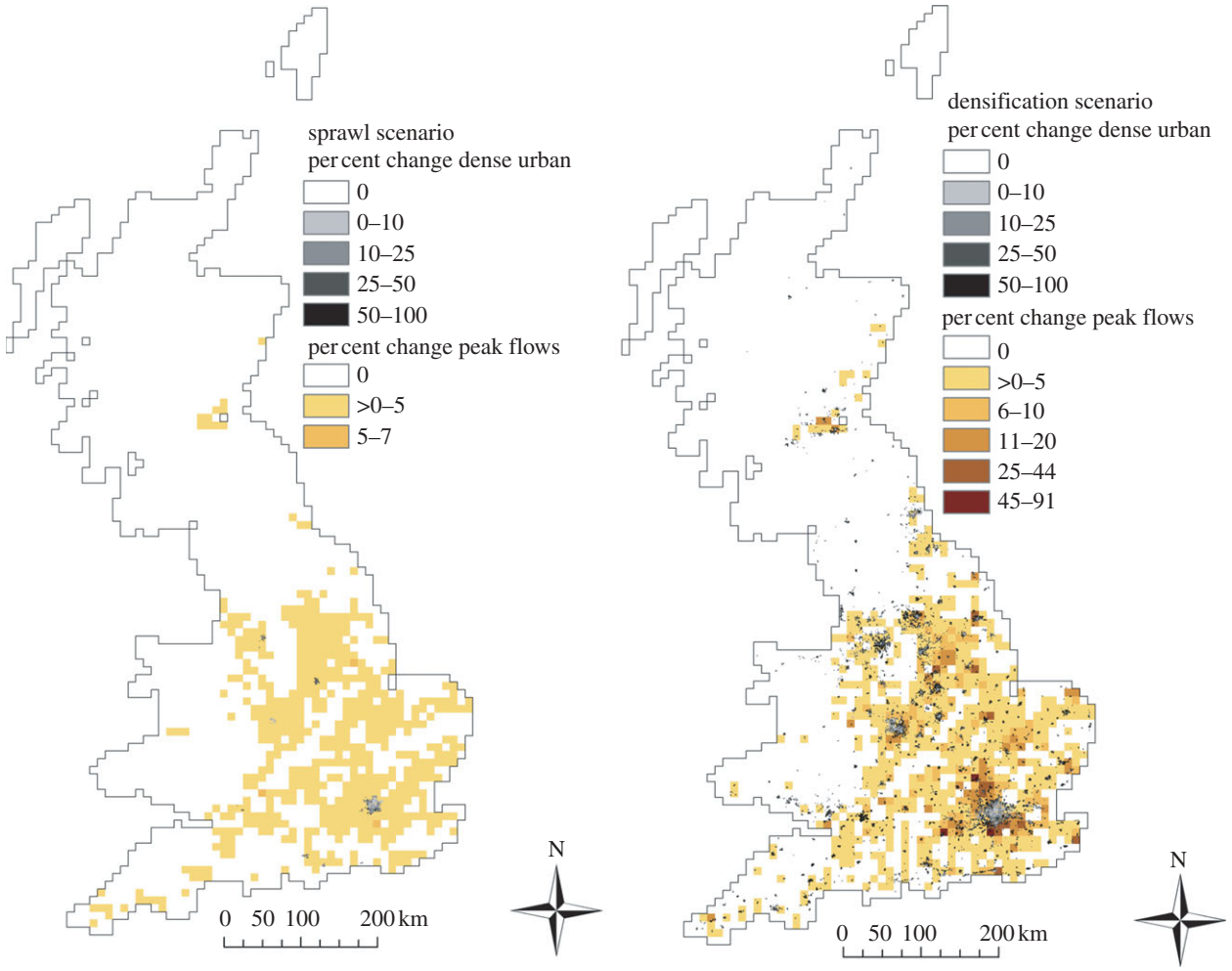

Figure 2. Projected changes in peak flows at the 2 year return period (10 × 10 km grid cell resolution) by 2031 for Britain under the densification and sprawl scenarios. The percentage of dense urban land cover (1 × 1 km resolution) is shown for reference.

former than in the latter. It is important to note that our models assume static societal preferences for the ecosystem services we consider, which is unlikely to be true. For example, increases in the risk of flooding may lead to some areas no longer being considered suitable for housing. This would reduce the number of people affected by increased flooding, but would inevitably increase development pressure on other areas.

More generally, this study highlights the challenges in predicting future impacts of urbanization on ecosystem services in general, and on hydrological services in particular. Our study uses the state of the art in large-scale hydrological modelling—the G2G model [10]—explicitly to link upstream changes in flows to downstream beneficiaries, but nonetheless we were forced to make a number of pragmatic simplifying assumptions owing to the lack of research on the effects of urban development on large-scale hydrology. The most important assumption—that dense urbanization results in a 70 per cent reduction in soil storage while suburban housing only reduces soil storage by 30 per cent (assuming the same underlying soils)—is in line with current hydrological understanding, but clearly future changes to urban drainage systems or developments in large-scale urban modelling could lead to significantly different findings from what we report here.

If methods can be found for increasing urban densities without compromising flood mitigation services, then the advantages of increasing densification are considerable. Indeed, if it were possible to accommodate the projected population growth in Britain by increasing the population density of urban areas by 50 per cent beyond the densities currently found in dense urban areas, then only 56 km^2 of land would need to be converted to new urban areas (versus 948 and 3302 km^2 under the densification and sprawl scenarios, respectively) (see electronic supplementary material). Densification also leads to more efficient energy and resource use [2,33]. Technological innovations such as increased use of sustainable urban drainage systems (e.g. permeable pavements, urban storage ponds) encouraged by building regulations could potentially mitigate the loss of subsurface storage in new urban developments, leading to lower increases in peak flows, while improved flood defences could minimize the damage caused by such flows. As such innovations may be particularly cost-effective in dense urban development, they could allow high levels of urban densification, while still reducing the impact of flooding in dense urban relative to low-density urban development. Innovative planning solutions such as green roofs [34] could also offset the losses of urban green space currently associated with high urban housing densities in Britain [35]; urban green space can provide direct positive effects on the health of local human populations (e.g. [36]) in addition to providing other ecosystem services (e.g. [35,37]). However, recent experience suggests that

such low-impact densification is likely to be challenging; the recent policy of densification [7] in England has meant that the proportion of new dwellings built on previous residential land in England has risen from 12 to 27 per cent between 1999 and 2009, leading to considerable public concern about the conversion of residential gardens to housing—'garden grabbing' (http://www.communities.gov.uk/news/newsroom/1665648).

Careful selection of where new urbanization occurs may also offer some solutions to the trade-offs between ecosystem services under different types of urban growth. Indeed, we show that by shifting the locations of new urban areas, losses in agricultural production can be halved at the cost of only a 10 per cent increase in losses of stored carbon, with relatively little effect on flood risk. However, reliably to inform policy, models such as ours should include a much wider set of services, or risk potentially catastrophic losses of vital services whose spatial distribution is currently unknown.

Our analysis also illustrates that linking future supplies of ecosystem services to changes in the number and distribution of beneficiaries is vital to making informed policy decisions. In our study, the actual percentage of the total supply of ecosystem services that is affected by projected increases in urbanization is relatively small. This is because even under the sprawl scenario, a 16 per cent increase in human population only translates into an extra 1.5 per cent of Britain being converted from non-urban to urban land cover. However, these small percentage changes can have major socioeconomic impacts, particularly because of the projected increase in the human population.

For example, we show that despite the relatively low mean increases in peak flows across all rivers, under the densification scenario, 1.8 million people could be living in areas with projected increases of at least 10 per cent in peak river flows at the 2 year return period. While it is very unlikely that all these people would actually be affected by flooding (given that we only have data at the 1×1 km grid resolution, and not all areas would flood), even if flooding affected an extra 18 000 people (1% of this total) every 2 years, this would have very high human and economic costs. The total economic cost of flooding in England in 2007, which affected between 46 000 and 48 000 households, was estimated to be £3.2 billion [38].

The increasing human population also increases the potential policy impact of even small losses in agricultural production, as such production actually needs to increase to maintain current levels of self-sufficiency. Even a 1.1 per cent reduction in agricultural production combined with a 16 per cent increase in the population will mean that self-sufficiency will drop from approximately 57 to 48 per cent by 2031 in Britain (electronic supplementary material). Until recently, self-sufficiency has not been a major UK government priority, based on the argument that the financial wealth of the country means that it is well placed to import food as needed. However, this policy could potentially change quickly [39], and indeed the financial crisis of 2009 has already led to suggestions that arguments against increasing self-sufficiency are no longer politically or economically credible (e.g. [40]).

The policy implications of any losses of stored carbon are magnified by the UK's legally binding targets under the 2008 Climate Change Act (http://www.opsi.gov.uk/acts/acts2008/pdf/ukpga_20080027_en.pdf) to reduce annual carbon emissions by 2020 by 34 per cent from 1990 levels, and 80 per cent by 2050. A loss of 0.7 per cent of the total carbon stock of Britain is approximately equal to 17 per cent of the total carbon emitted in Britain in 2008 (electronic supplementary material), and, even if it occurs over 25 years, such extra releases of carbon would make difficult overall reductions in carbon emissions yet more so.

More generally, these first projections of the interactions between land-use change and human population growth we describe for Britain have major implications for conserving ecosystem services globally. The combination of an increasing number of human beneficiaries of ecosystem services and increasing competition for the land that provides these services is a worldwide phenomenon for which the policy implications are only now beginning to be considered. Quantifying the impacts on both the supply and demand side of ecosystem services under realistic future land-use change scenarios is urgently needed to identify those services for which future shortages are most likely; and whether and where strategies can be devised to minimize losses of ecosystem services. Such work will require innovative collaborative efforts between physical, ecological and social scientists to develop the new models that will be required to reliably model the ecosystem service impacts of both an increasing human population and changes to ecosystems driven by land use and climate change.

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REFERENCES

1 Millennium Ecosystem Assessment. 2005 In *Ecosystems and human well-being: scenarios: findings of the scenarios working group*. The Millennium Ecosystem Assessment. Washington, DC: Island Press.
2 Reginster, I. & Rounsevell, M. 2006 Scenarios of future urban land use in Europe. *Environ. Plann. B Plann. Design* **33**, 619–636. (doi:10.1068/b31079)
3 United Nations. 2006 *World urbanization prospects: the 2005 revision*. New York, NY: United Nations.
4 Alcamo, J., van Vuuren, D., Ringler, C., Cramer, W., Masui, T., Alder, J. & Schulze, K. 2005 Changes in nature's balance sheet: model-based estimates of future worldwide ecosystem services. *Ecol. Soc.* **10**, 19. [Online] URL: http://www.ecologyandsociety.org/vol10/iss2/art19/
5 Bennett, E. M., Peterson, G. D. & Gordon, L. J. 2009 Understanding relationships among multiple ecosystem

services. *Ecol. Lett.* **12**, 1394–1404. (doi:10.1111/j.1461-0248.2009.01387.x)
6 Chin, A. 2006 Urban transformation of river landscapes in a global context. *Geomorphology* **79**, 460–487. (doi:10.1016/j.geomorph.2006.06.033)
7 Dixon, T. & Adams, D. 2008 Housing supply and brownfield regeneration in a post-Barker world: is there enough brownfield land in England and Scotland? *Urban Stud.* **45**, 115–139. (doi:10.1177/0042098007085104)
8 Bibby, P. 2009 Land use change in Britain. *Land Use Policy* **26**, S2–S13. (doi:10.1016/j.landusepol.2009.09.019)
9 ODPM. 2005 *A sustainability impact study of additional housing scenarios in England*. London, UK: Office of the Deputy Prime Minister.
10 Bell, V. A., Kay, A. L., Jones, R. G., Moore, R. J. & Reynard, N. S. 2009 Use of soil data in a grid-based hydrological model to estimate spatial variation in changing flood risk across the UK. *J. Hydrol.* **377**, 335–350.
11 Anderson, B. J., Armsworth, P. R., Eigenbrod, F., Thomas, C. D., Gillings, S., Heinemeyer, A., Roy, D. B. & Gaston, K. J. 2009 Spatial covariance between biodiversity and other ecosystem service priorities. *J. Appl. Ecol.* **46**, 888–896. (doi:10.1111/j.1365-2664.2009.01666.x)
12 Evans, E., Ashley, R., Hall, J., Penning-Rowsell, E., Sayers, P., Thorne, C. & Watkinson, A. 2004 *Foresight future flooding, Volume I and Volume II*. London, UK: Office of Science and Technology.
13 Jones, J. A. & Post, D. A. 2004 Seasonal and successional streamflow response to forest cutting and regrowth in the northwest and eastern United States. *Water Resour. Res.* **40**, W05203. (doi:10.1029/2003WR002952)
14 Brauman, K. A., Daily, G. C., Duarte, T. K. & Mooney, H. A. 2007 The nature and value of ecosystem services: an overview highlighting hydrologic services. *Annu. Rev. Environ. Resour.* **32**, 67–98. (doi:10.1146/annurev.energy.32.031306.102758)
15 Darby, S. E. 1999 Effect of riparian vegetation on flow resistance and flood potential. *J. Hydraul. Eng. Asce* **125**, 443–454. (doi:10.1061/(ASCE)0733-9429(1999)125:5(443))
16 O'Connell, P. E., Ewen, J., O'Donnell, G. & Quinn, P. 2007 Is there a link between agricultural land-use management and flooding? *Hydrol. Earth Syst. Sci.* **11**, 96–107. (doi:10.5194/hess-11-96-2007)
17 Eade, J. D. O. & Moran, D. 1996 Spatial economic valuation: benefits transfer using geographical information systems. *J. Environ. Manage.* **48**, 97–110. (doi:10.1006/jema.1996.9990)
18 Turner, W. R., Brandon, K., Brooks, T. M., Costanza, R., da Fonseca, G. A. B. & Portela, R. 2007 Global conservation of biodiversity and ecosystem services. *Bioscience* **57**, 868–873. (doi:10.1641/B571009)
19 Phua, M. H. & Minowa, M. 2005 A GIS-based multicriteria decision making approach to forest conservation planning at a landscape scale: a case study in the Kinabalu Area, Sabah, Malaysia. *Landsc. Urban Plann.* **71**, 207–222. (doi:10.1016/j.landurbplan.2004.03.004)
20 Chan, K. M. A., Shaw, M. R., Cameron, D. R., Underwood, E. C. & Daily, G. C. 2006 Conservation planning for ecosystem services. *PLoS Biol.* **4**, 2138–2152.
21 Luck, G. W., Chan, K. M. A. & Fay, J. P. 2009 Protecting ecosystem services and biodiversity in the world's watersheds. *Conserv. Lett.* **2**, 179–188. (doi:10.1111/j.1755-263X.2009.00064.x)
22 Moore, R. J., Cole, S. J., Bell, V. A. & Jones, D. A. 2006 Issues in flood forecasting: ungauged basins, extreme floods and uncertainty. In *Frontiers in flood research, 8th Kovacs Colloquium, UNESCO* 305 (eds I. Tchiguirinskaia, K. N. N. Thein & P. Hubert), pp. 103–122. Paris, France: IAHS Publication.
23 DEFRA. 2004 *June agricultural survey*. London, UK: Department for Environment Food and Rural Affairs.
24 SEERAD. 2006 *Agricultural survey*. Edinburgh: Scottish Executive Environment and Rural Affairs Department.
25 Welsh Assembly Government. 2006 *Agricultural small area statistics*. Cardiff, UK: Welsh Assembly Government.
26 Beaton, C., Catto, J. & Kerr, G. 2007 *The farm management handbook 2007/2008*. Edinburgh, UK: Scottish Agricultural College.
27 Milne, R. & Brown, T. A. 1997 Carbon in the vegetation and soils of Great Britain. *J. Environ. Manage.* **49**, 413–433. (doi:10.1006/jema.1995.0118)
28 Verburg, P. H., Eikhout, B. & Meijl, H. 2008 A multiscale, multi-model approach for analyzing the future dynamics of European land use. *Ann. Region. Sci.* **42**, 57–77. (doi:10.1007/s00168-007-0136-4)
29 Fuller, R. M., Smith, G. M., Sanderson, J. M., Hill, R. A. & Thomson, A. G. 2002 The UK Land Cover Map 2000: construction of a parcel-based vector map from satellite images. *Cartograph. J.* **39**, 15–25.
30 R Development Core Team. 2009 *R: a language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.
31 Bradley, R. I., Milne, R., Bell, J., Lilly, A., Jordan, C. & Higgins, A. 2005 A soil carbon and land use database for the United Kingdom. *Soil Use Manage.* **21**, 363–369. (doi:10.1079/SUM2005351)
32 Raudsepp-Hearne, C., Peterson, G. D. & Bennett, E. M. 2010 Ecosystem service bundles for analyzing tradeoffs in diverse landscapes. *Proc. Natl Acad. Sci. USA* **107**, 5242–5247. (doi:10.1073/pnas.0907284107)
33 Johnson, M. P. 2001 Environmental impacts of urban sprawl: a survey of the literature and proposed research agenda. *Environ. Plann. A* **33**, 717–735. (doi:10.1068/a3327)
34 Grant, G., Engleback, L. & Nicholson, B. 2003 *Green roofs: existing status and potential for conserving biodiversity in urban areas* (English Nature Research Report No. 498). Peterborough, UK: English Nature.
35 Tratalos, J., Fuller, R. A., Warren, P. H., Davies, R. G. & Gaston, K. J. 2007 Urban form, biodiversity potential and ecosystem services. *Landsc. Urban Plann.* **83**, 308–317. (doi:10.1016/j.landurbplan.2007.05.003)
36 Maas, J., Verheij, R. A., Groenewegen, P. P., de Vries, S. & Spreeuwenberg, P. 2006 Green space, urbanity, and health: how strong is the relation? *J. Epidemiol. Commun. Health* **60**, 587–592. (doi:10.1136/jech.2005.043125)
37 Brack, C. L. 2002 Pollution mitigation and carbon sequestration by an urban forest. *Environ. Pollut.* **116**, S195–S200. (doi:10.1016/S0269-7491(01)00251-2)
38 Chatterton, J., Viavattene, C., Morris, J., Penning-Rowsell, E. & Tapsell, S. 2010 *The costs of the summer 2007 floods in England*. Bristol, UK: Environment Agency.
39 Pratt, A. C. 2009 Social and economic drivers of land use change in the British space economy. *Land Use Policy* **26**, S109–S114. (doi:10.1016/j.landusepol.2009.09.006)
40 Sustainable Development Commission 2009 *Food security and sustainability: the perfect fit*. London, UK: Sustainable Development Commission.

Forest and rangeland owners value land for natural amenities and as financial investment

by Shasta Ferranto, Lynn Huntsinger, Christy Getz, Gary Nakamura, William Stewart, Sabrina Drill, Yana Valachovic, Michael DeLasaux *and* Maggi Kelly

Forty-two percent of California's forests and rangelands are privately owned (34 million acres). These lands provide important ecosystem services such as carbon sequestration, pollination and wildlife habitat, but little is known about the people who own and manage them. We surveyed forest and rangeland owners in California and found that these long-time landowners value their properties for their natural amenities and as a financial investment. Owners of large properties (500 or more acres) were significantly more likely to use their land for income production than owners of smaller properties, and they were also more likely to carry out or be interested in environmental improvements. Many forest and rangeland owners reported they had been previously approached to sell their land for development. Only about one-third had participated in conservation programs; few had conservation easements. This survey can help guide outreach and education efforts, and the development of information, policies, programs and financial incentives for landowners.

A survey of forest and rangeland property owners in California found that the vast majority value their land for its natural beauty, and they voluntarily undertook environmental improvements and management practices. *Above,* an exurban development in coastal California.

Over the last 20 years, an "in-migration" of new landowners has occurred in California's forests and rangelands. Rural housing trends in California mirror similar trends in the nation: between 1940 and 2000, 10% of private forests and rangelands were fragmented into areas with more than one house per 20 acres (CDFFP 2003). The ecological and management impacts of exurban parcelization include decreased biodiversity (Hansen et al. 2005; Maestas et al. 2003; Parmenter et al. 2003), fragmentation of wildlife habitat (Hobbs et al. 2008) and more-difficult wildfire management (Moritz and Stephens 2008).

Changes in land ownership can also bring changes in social values and demographic characteristics. In-migrants seeking a better quality of life may more strongly support protection of amenity values, such as scenery and recreation, and more often participate in environmental activism (Jones et al. 2003). These values may conflict with more traditional views held by long-time residents (Walker and Fortmann 2003; Yung and Belsky 2007). New residents may also have less expertise in land management (Kendra and Hull 2005) or different views than long-term landowners on how undeveloped landscapes should be managed (Gosnell et al. 2006). These changes raise questions: As properties become fragmented into smaller management units, how do the goals and needs of landowners change? Do they use or manage their land differently? And what do these changes imply for future environmental sustainability?

Several studies have examined the physical patterns of fragmentation in the United States (Brown et al. 2005), and many predict future patterns of increased parcelization (Alig and Plantinga 2004; Nowak and Walton 2005; Theobald 2005; White et al. 2009). Few studies, however, have examined the social changes associated with fragmentation or the ecological implications of these changes. These issues are especially pertinent to California forests and rangelands, where fragmentation is predicted to continue (CDFFP 2003). Limited knowledge of the landowner population in California has made it difficult to assess this population and to establish a baseline for understanding how it might change over time, or with interventions of information, policy or financial resources. To improve outreach and education programs geared

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to landowners, a team of UC Cooperative Extension and UC Berkeley researchers surveyed California forest and rangeland owners in 2008.

Survey design and analysis

There are approximately 34 million acres of privately owned forest and rangeland in California, concentrated in the Sierra Nevada and coastal regions (CDFFP 2003). Forest and rangeland owners with parcels greater than 3 acres from 10 California counties were mailed a questionnaire. Eight of the state's 10 bioregions contain forests or rangelands, as defined by the California Department of Forestry and Fire Protection (CDFFP, now known as Cal Fire) for natural resources assessment purposes. A minimum of one county was selected from each. Together, these eight bioregions contain 89% of the state's private forests and rangelands (CDFFP 2003). We sampled counties representative of each bioregion: Contra Costa, El Dorado, Humboldt, Mendocino, Plumas, San Diego, Santa Barbara, Shasta, Sierra and Sonoma (fig. 1). Because they have small populations, Sierra and Plumas counties, which are adjacent to one another, were treated as a single sampling unit.

Within each county, survey recipients were selected using a stratified random sampling design. The sample was drawn from a statewide land parcel database created in 2003 by CDFFP for the Forest and Range Assessment (CDFFP 2003). The database contains information on parcel size derived from county assessor tax records, and vegetation type at the parcel center derived from satellite imagery. Parcel vegetation type was categorized into either forest, including conifer and hardwood, or rangeland, including oak woodlands, grassland and shrubland.

Parcel size was then subcategorized into four groups: 3 to 9 acres, 10 to 49 acres, 50 to 499 acres, and 500 or more acres. A random sample of up to 30 parcels was drawn from each subcategory, for a total of approximately 240 parcels per county. All duplicate landowner addresses were dropped, so that landowners received only one survey regardless of how many parcels they owned.

We mailed the survey and follow-ups to 1,730 landowners in spring 2008, following a modified version of the Dillman Total Design Method (Clendenning et al. 2004; Dillman 2007). The questionnaire was a 17-page booklet with 38 questions, many of which contained multiple parts. Most questions were close-ended, with either categorical or Likert scale response choices. Respondents were also offered the option of taking an identical online survey. Questionnaires were returned by 670 people, with 8% answering online. After adjusting for undeliverable questionnaires and those sent to people who were not forest or rangeland owners, the final response rate was 42.5%.

A stratified sampling design ensured the inclusion of owners from all property sizes but created a sample disproportionate to true population ratios. Unless otherwise indicated, all data was weighted proportionally to sampling intensity to adjust for a disproportionate sampling intensity between different sampling strata. Proportional survey weights were calculated by multiplying the reciprocal sampling ratio (i.e., the total number of landowners in each sampling strata compared to the number of landowners sampled from each strata) by the overall sampling ratio (the overall sample size compared to the overall population) (Maletta 2007). Reported results are thus representative of true landowner population ratios.

All data analysis was done with SPSS 17.0 statistical software. Results are reported as percentages of the total number of respondents to each question. Several questions were based on a Likert scale from 1 to 5, ranging from "not at all important" (value = 1) to "highly important" (value = 5). Results for all Likert scale questions were grouped so that a response of "not important" included values 1 and 2, and a response of "important" included values 4 and 5. Comparisons between property sizes were based on the same size categories as used in the sampling (3 to 9 acres, 10 to 49 acres, 50 to 499 acres, and 500 or more acres), but respondents were reclassified based on the reported size of all the parcels owned and managed as a single property, rather than on assessor parcel records. (We use the term "property" when referring to the full property, and "parcel" when referring to a single parcel.) Differences in responses by property size were calculated using either Pearson's chi-square analysis for categorical data or analysis of variance (ANOVA) for continuous data.

Profile of landowners

Respondents were mostly male, over 60 and predominantly married or living with a partner. Few had children living at home, and they tended to be well educated and relatively affluent, with just over half earning more than $100,000 and just under one-third earning more than $200,000 per year (table 1). These results did not vary substantially based on property size, with the exception that property owners with 50 to 499 acres were significantly more likely to have a bachelor's degree, more likely to have children living at home and more likely to earn over $200,000 per year than landowners in other property size categories.

The most common careers, with about one-third of landowners in each category, were professional or management

Fig. 1. The study was conducted in 10 counties, within eight of California's 10 bioregions that contain forests or rangelands.

positions, retired and self-employed, with only slight variation between property sizes. Only 14% of respondents reported production-oriented enterprises (timber, agriculture or range) as their profession.

Ownership demographics. On average, respondents had owned their land or the land had been in their family for 31 years. The average length of ownership increased with property size; the most notable increase in land tenure was in the largest property size category (500 or more acres) (table 2). Most owned their land as private individuals (the landowner's name is on the deed). Owners of the largest properties (500 or more acres) were significantly more likely to be in corporate ownership — often a family corporation (table 2). The majority of respondents were primary residents. Owners were less likely to be primary residents as property size increased, with an almost equal ratio of primary to nonprimary residents in the largest property size category. Of the nonprimary residents, 46% used the land as a second, seasonal or vacation home, with no significant variation based on property size (table 2). Nonprimary residents tended to live fairly far from the property — 77% lived more than 20 miles away, and 44% lived more than 100 miles away.

Reasons for ownership. A variety of reasons were reported for owning land. To "live near natural beauty" was the objective ranked by most landowners as important (fig. 2). Other popular reasons included "land value appreciation," "escape from city crime and pollution," "financial investment" and "live in a small community." In general, amenity values and financial investment objectives were important to the most landowners.

When broken down by property size, several notable differences became evident. All property sizes ranked living near natural beauty and financial appreciation of the land as important. Only a small percentage of small property owners (less than 50 acres) considered family tradition or business as important; about half of landowners with 50 to 499 acres marked it as important; but this was the single most important objective for owners of large properties (500 or more acres) (fig. 3). Income source was not considered important to most owners of small properties but was important to over three-fourths of large property owners. In contrast, owners of large properties were less concerned than owners of small properties about escaping from the city, living in a small community or having a simpler lifestyle (fig. 3).

TABLE 1. Demographic profile of California forest and rangeland owners based on property size, 2008

		All landowners	3 to 9 acres	10 to 49 acres	50 to 499 acres	500 or more acres	*P* value*	*n*
Age (years)	Mean age	62	63	61	60	64	0.02	516
Gender (%)	Male	65	67	65	62	65	0.62	578
	Female	35	32	33	38	35		
Education (%)	At least some college	90	92	86	92	90	0.19	568
	Bachelor's degree or higher	65	56	65	75	61	0.01	568
Marital status (%)	Married	81	77	81	84	83	0.48	576
Children (%)	< 18 years, living in household	22	14	19	35	15	0.00	515
Income (%)	> $100,000	56	55	48	64	56	0.06	523
	> $200,000	30	23	22	39	36	0.00	523

* Differences between property sizes, chi-square analysis.

TABLE 2. Ownership demographics among California forest and rangeland owners based on property size, 2008

		All landowners	3 to 9 acres	10 to 49 acres	50 to 499 acres	500 or more acres	*P* value*	*n*
Land tenure (years)	Mean length of ownership	31	19	21	29	60	0.00	629
	Std. deviation	29	12	15	23	41		
Ownership type (%)	Private individual(s)	70	80	79	67	45	0.00	596
	Trust	19	16	18	24	17		
	LLC	3	0	0	0	18		
	Partnership	2	1	2	1	7		
	Other	5	3	2	7	13		
Residency (%)	Primary	60	72	63	55	49	0.00	600
Nonresident property uses (% of nonprimary residents)	Vacation or second home	46	43	54	35	54	0.09	218
	Rental unit	7	2	7	15	0	0.01	218

* Differences between property sizes, chi-square analysis.

Resource use

Overall, landowners were more likely to utilize their land's resources such as timber, livestock forage or game for personal use than for income production (fig. 4). Only one-third reported earning income in one of the provided ways, while almost three-fourths used their land's natural resources for personal use.

As property size increased, landowners were more likely to use their land

for income (fig. 4A). Over half of landowners with the largest properties (500 or more acres) harvested timber for income, and just under 40% raised livestock (fig. 4A). Hunting and fishing for personal use also increased with property size, but raising food crops or livestock, and harvesting timber for personal use all remained constant or decreased slightly as property size increased (fig. 4B). Harvesting fuelwood for personal use increased with property size until the 50-to-499-acre category, then dropped substantially in the 500-or-more-acres category (fig. 4B).

Land management practices

California forest and rangeland owners implemented a variety of land management practices for environmental

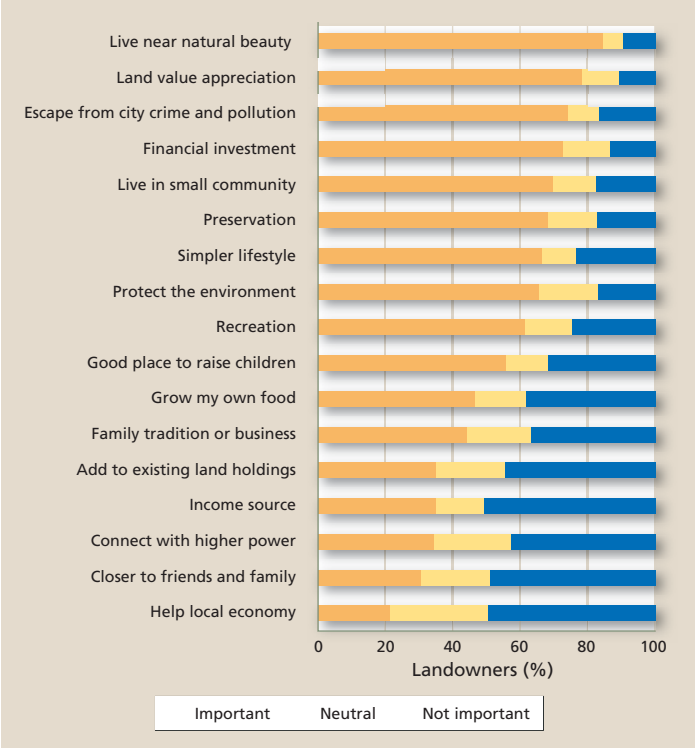

Fig. 2. California forest and rangeland owners' reasons for owning land (*n* = 578), 2008.

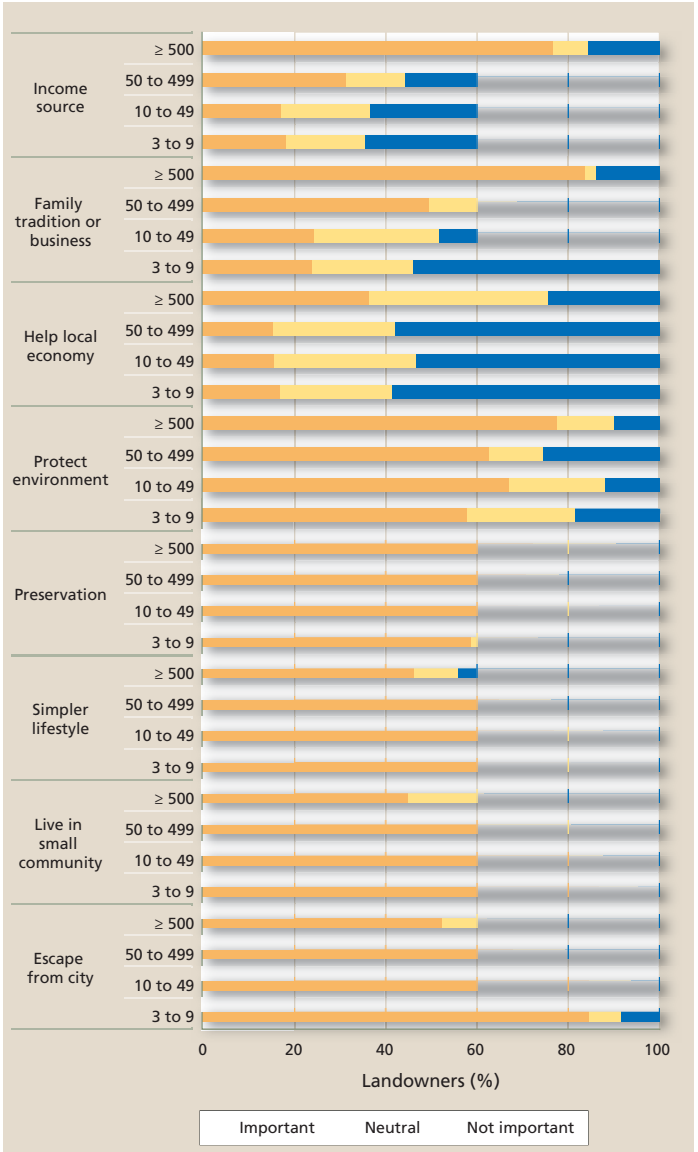

Fig. 3. California forest and rangeland owners' reasons for owning land based on property size, 2008. Ownership objectives with significant differences between property sizes are shown (chi-square analysis, *P* < 0.01, *n* = 566).

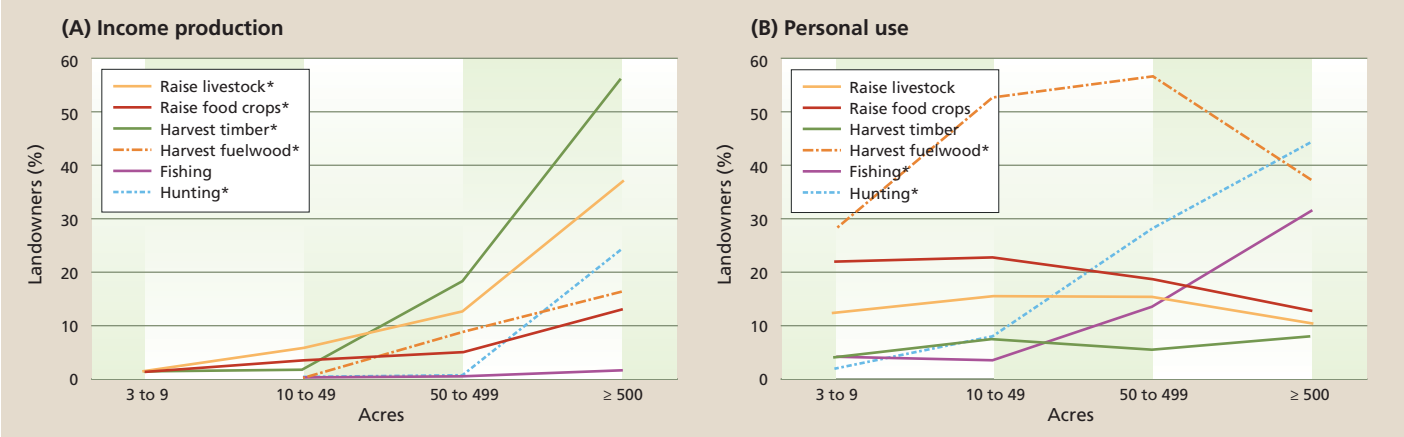

Fig. 4. (A) Income production from and (B) personal use of natural resources based on property size for California forest and rangeland owners, 2008; 80% of owners use resources in one of the ways shown (* = significant difference between property sizes, chi-square analysis, *P* < 0.01, *n* = 627).

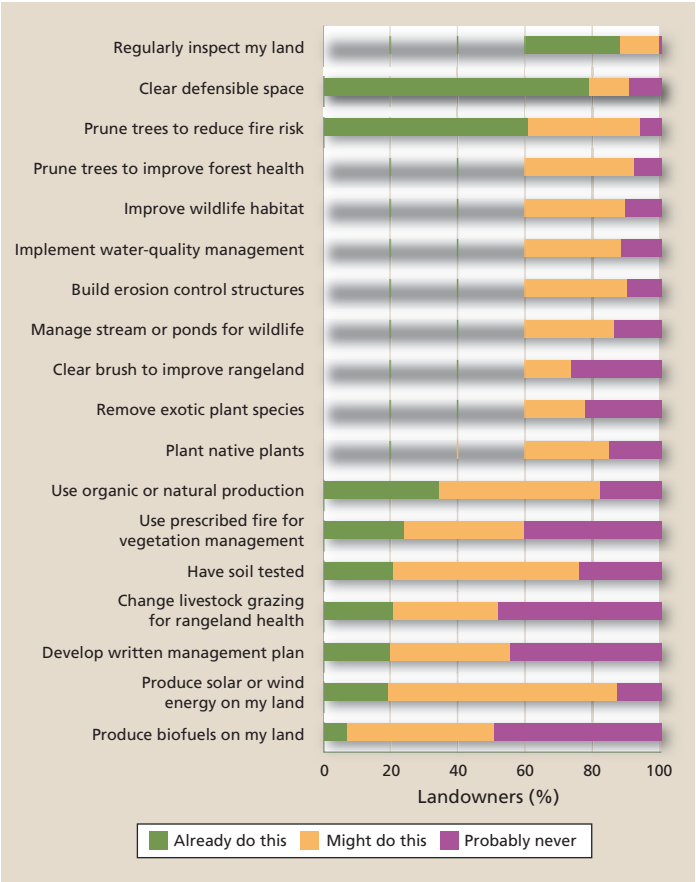

Fig. 5. Management practices used by California forest and rangeland owners (*n* = 615), 2008.

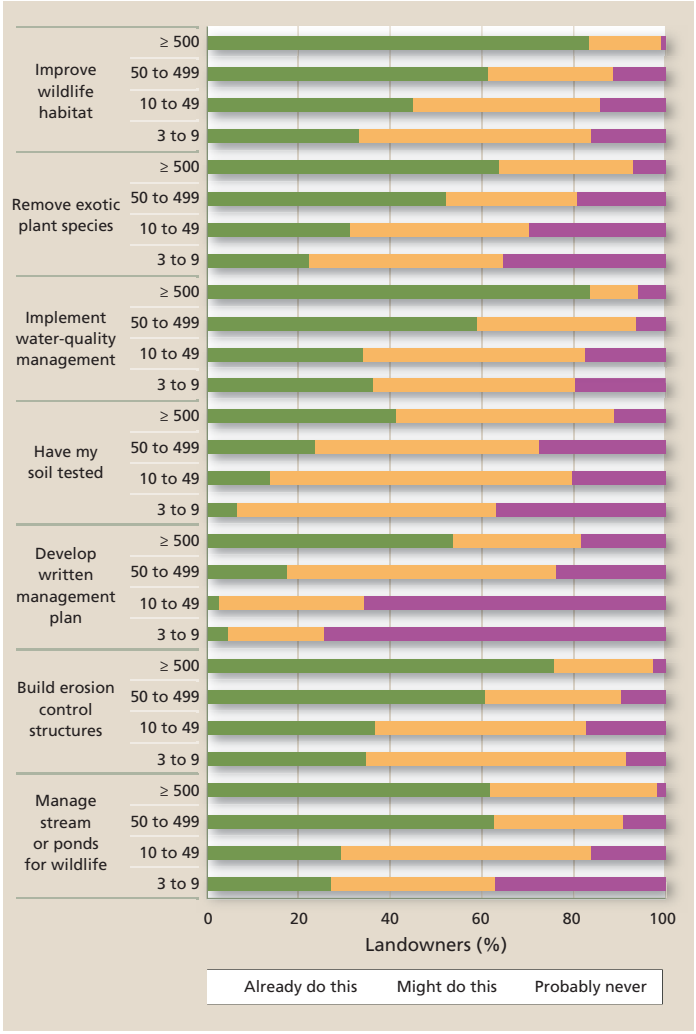

Fig. 6. Management practices commonly used by owners of larger properties (in acres) than owners of smaller properties (*P* < 0.01, *n* = 596), 2008.

improvement (fig. 5). Almost all respondents regularly inspected the condition of their land. Over half (for whom the question was applicable) cleared defensible space to reduce fire risk; pruned or cut trees to reduce fire risk or improve forest health; improved wildlife habitat; implemented water-quality management practices; or built erosion control structures (fig. 5). Of those who did not use these practices, many would consider using them in the future. For all of the management practices surveyed, over half of all respondents either currently implemented or would consider the practice in the future. Some practices, such as generating solar or wind energy, or testing the soil, although not currently implemented by many, were of interest to many landowners and may be areas where outreach could improve implementation.

Overall, owners of large properties were more likely to carry out or be interested in environmental improvements than owners of smaller properties. In particular, as the property size increased, landowners were notably more likely to improve wildlife habitat, remove exotic plants, implement water-quality management practices, have their soil tested, develop a written management plan, build erosion control structures or manage streams for wildlife (fig. 6). Practices such as clearing defensible space or pruning or cutting down trees to reduce fire risk were as common on small properties as they were on large ones.

Conservation programs

Only one-third of all respondents had participated in one of the land management or conservation programs identified in our survey (see box, page 189). The Williamson Act (California Land Conservation Act) program had the most participants, followed by the Timberland Production Zone (TPZ) program. These programs provide property tax reductions to eligible participants to encourage agricultural land (Williamson Act) or forest (TPZ) conservation. The Environmental Quality Incentives Program (EQIP) and the California Forest Improvement Program (CFIP) had the next highest participation (fig. 7).

These programs provide technical and financial assistance to landowners to address natural resource concerns on private land. Less than 5% of landowners reported that they had a written rangeland water-quality management plan; participated in the Wildlife Habitat Incentives Program (WHIP) under the U.S. Forest Service, which provides technical and financial assistance; had forest certification, a third-party certification of sustainable forest management operations; had a conservation easement limiting development on their property; had organic certification, ensuring that food is grown according to organic standards; or had received a grant from the California State Water Resources Control Board to

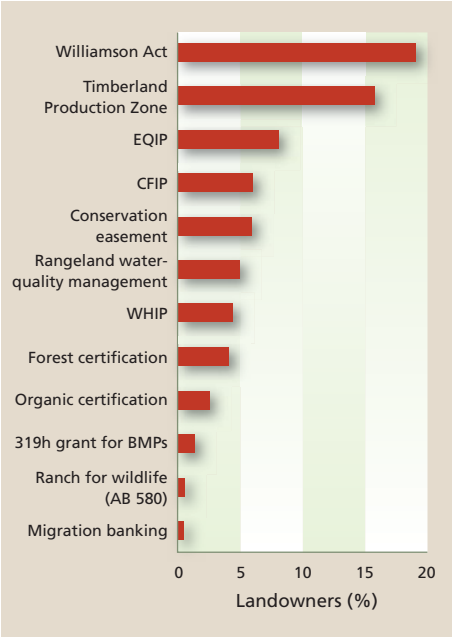

Fig. 7. California forest and rangeland owners participating in land management or conservation programs (*n* = 624), 2008.

implement water-quality improvements (319h grant for BMPs). Less than 1% of landowners reported participating in the Ranch for Wildlife Program (AB 580, now known as the Private Land Management Program of the California Department of Fish and Game), which offers increased fee-hunting opportunities in exchange for habitat improvements on private land; or participated in mitigation banking, a third-party system in which landowners protect or restore wetlands or streams on their property to compensate for impacts to wetlands and streams elsewhere.

Participation varied only slightly based on property size, and in most instances owners of the largest properties (500 or more acres) were no more likely to participate in land management or conservation programs than owners of smaller properties.

Future intentions for land use

When asked about their long-term plans, almost two-thirds of respondents reported that they planned to pass their land on to children or other family members, while one-sixth planned to sell their land. Few landowners were undecided or had never thought about it. Owners of large properties (500 or more acres) were more likely to plan to pass their land to children and less likely to sell than owners with other property sizes (table 3).

The role of land conservation programs

Land conservation programs can reward landowners for not fragmenting or developing their land, but only a small percentage of landowners participate in these programs (fig. 7), and most are tailored toward production-oriented ownership. We asked about three land conservation programs in the survey.

Williamson Act (California Land Conservation Act) enrollment. The program with the highest participation (19%) was the Williamson Act. This program reduces property taxes on agricultural properties through a rolling 10-year contract between landowners and counties, while the state provides funding to compensate counties for all or a part of the property tax losses. The 45-year-old Williamson Act is widely supported by agricultural groups, landowners, county governments and environmentalists as a method to restrict the conversion of farms and ranches to urban uses, but its fate is tenuous due to recent state budget cuts (Sokolow 2010). The program is also not accessible to all landowners. The specifications for enrolling include having a property large enough for commercial use and located within a county-designated "agricultural preserve," as well as other requirements set by each county. To change the land use without penalty, a landowner must stop renewing the contract and wait 9 years while property taxes gradually increase to normal levels. About 15 million acres were enrolled in 2010, with 9 million on "nonprime" sites typical of rangelands.

Timberland Production Zone (TPZ) designation. The TPZ program had the second highest participation (16%). County governments initially classified lands as TPZs in the 1970s, but landowners can petition to change the county zoning. Lands zoned as TPZs have larger minimum parcel sizes and limitations on residential uses. Similar to the Williamson Act, TPZs have specific acreage and site requirements that vary by county. The landowner receives a lower tax assessment based on timber production rather than development potential. A successful petition for rezoning and a 10-year period of gradually increasing property taxes are needed to remove land from a TPZ without penalties. About 4.3 million of the 5.6 million acres in TPZ designation in 2010 are owned by forestry businesses, and the rest are owned by families.

Conservation easement establishment. Conservation easements, in contrast, can be implemented on any type of landscape with conservation value. A landowner voluntarily gives up the development rights for a property in return for a monetary payment and/or tax reductions (Gustanski and Squires 2000). The development rights are then held by a land trust or agency and recorded in the property title. The easement may also have other provisions such as limitations on particular practices, but these are individually negotiated for each property. Over the last decade, conservation easements have become an increasingly important conservation tool, but like other conservation programs, they are limited by the level of private donations to land trusts and the availability of public funds. Only 6% of the landowners surveyed had conservation easements on all or part of their property.

Mitigation easements. Mitigation easements are another form of environmentally oriented easement; although they were not asked about in the survey, some respondents may have treated them as conservation easements. Mitigation easements are similar to conservation easements in that they change the property title to restrict certain activities. However, they are funded when a developer has to mitigate, for example, habitat loss for a particular species. The landowner agrees to provide that habitat, and anything that might harm it is permanently restricted from the area.

Limitations of land conservation programs. Limitations in available funding and the high transaction costs per project make these programs inaccessible to the vast majority of landowners (fig. 7). Programs for large properties can preserve the greatest number of acres with the least logistical overhead. Still, with continuing fragmentation in California's forests and rangelands, it will become increasingly important to consider the ecosystem services provided by moderate- to small-sized properties and adopt more comprehensive strategies to preserve these services.

TABLE 3. California forest and rangeland owners' future intentions for their land (n = 595), 2008*

Future intentions	All landowners	3 to 9 acres	10 to 49 acres	50 to 499 acres	500 or more acres
			%		
Pass to children or family member	62	48	63	61	79
Sell	16	26	13	18	6
Undecided	11	12	14	11	5
Other	6	7	5	5	9
Never thought about	3	7	3	2	0
Donate	2	1	2	2	1

*P < 0.01, differences between property sizes, chi-square analysis.

Landowners were also asked what reasons would influence a hypothetical future decision to sell their land. Almost 20% reported that none of the reasons applied to them because they would never sell. Of the remaining 80%, just over half chose "it is too much work to maintain," followed by "can't afford to keep it," "property taxes too expensive," "to finance retirement" and "inheritance taxes too expensive" (fig. 8).

Development pressure. A high percentage (43%) of landowners reported that they had been previously approached to sell their property for development. As property size increased, landowners were significantly more likely to have been approached (χ^2 = 86.4, P < 0.0005). Of the owners of large properties (500 or more acres), 73% had been approached, compared with 49% for 50 to 499 acres, 32% for 10 to 49 acres and 21% for the smallest properties.

Conservation easements. Conservation easements are voluntary contracts between a landowner and land trust or agency that restrict real estate development, certain land-use practices, and other relevant activities on private property in exchange for payment or tax relief for the owner. Of the landowners surveyed, 41 had a conservation easement on their property (unweighted data), or 6% of all landowners from the weighted sample. Because of this small number, all subsequent statistics on easement holders are unweighted. There were no significant differences in easements based on property size. Together, the 41 easements covered approximately 41,000 acres and represented 3% of the total acres reported. Of the 41 landowners, 30% indicated that they sold the easement, 30% donated the easement, 13% reported a combination of selling and donating, and 28% purchased the property with an existing easement.

Easements were sold or donated to more than 23 different land trusts. Pacific Forest Trust, a regional land trust focused on protecting private working forests, held seven easements from our sample. Two-thirds of the easements were obtained since 2000. The most popular reasons for selling or donating the easement were "to conserve the land," "for tax benefit" and "to preserve land for heirs." When asked whether they would sell or donate the easement again, 92% of landowners said they would.

Although most respondents did not have a conservation easement, there was general interest: 33% of owners without easements indicated that they would consider selling one in the future, and 9% would consider donating an easement. Another 34% indicated that they did not know enough about easements to make a decision.

Ownership trends, fragmentation

Although a small percentage of the surveyed forest and rangeland owners earned income from their land, the majority earned little to no income; they predominantly benefited from its amenity and investment value. Only landowners with the largest properties ranked ownership objectives such as "family tradition or business" and "income source" as important reasons for owning their land and reported income-generating land uses (figs. 3 and 4A).

These results are consistent with other studies of California landowners. In a study of California oak woodland owners with more than 20 acres, Campos et al. (2009) found that landowners were willing to forgo significantly greater income from using their land equity for alternate investments in order to keep their land and enjoy its amenities. Drawing on the same population of oak woodland owners, Huntsinger et al. (2010) found that while the acreage grazed by livestock has remained relatively consistent since 1992, the number of owners selling livestock declined, reliance on other income sources increased and the number of owners with small parcels increased.

These findings imply an overall shift from production-oriented owners to amenity and investor ownership in California forests and rangelands. The shift is more pronounced among smaller properties. How this shift might influence the ecological integrity of California's forests and

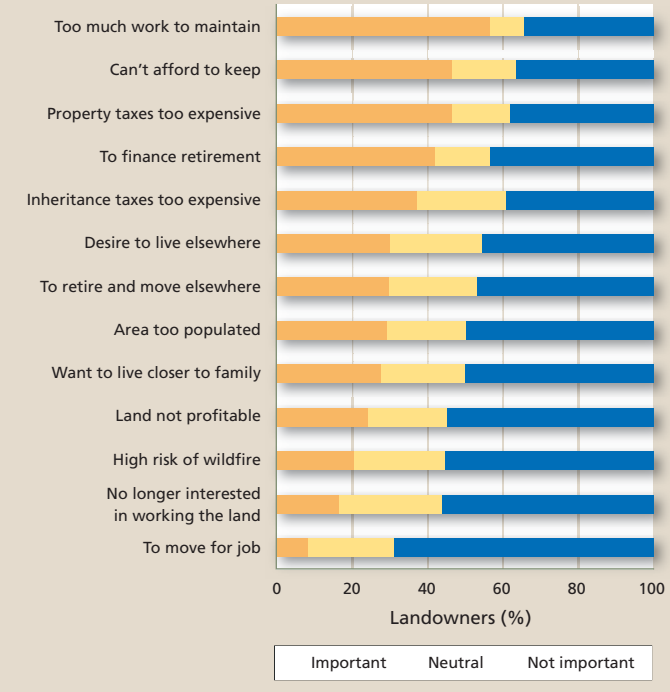

Fig. 8. Reasons California forest and rangeland owners stated they might sell their land someday (n = 552), 2008.

rangelands is not clear. Rural landowners clearly value the scenic qualities of their land — the most common reason chosen for owning land was to "live near natural beauty." "Preservation" and "protecting the environment" were also important to a strong majority of landowners of all property sizes (figs. 2 and 3), indicating that many feel a sense of stewardship and want to preserve their land's scenic and environmental qualities. Many of these qualities provide ecosystem services that are shared by society and benefit the public (Huntsinger et al. 2010).

However, owners of large properties, the category with the longest land tenures, were more likely than smaller landowners to implement environmental management or improvement practices (fig. 6). These results raise the question of whether fragmentation may affect environmental health by facilitating an in-migration of landowners less likely to implement environmental practices. Addressing this question will be an important challenge for conservation in California. The fact that landowners from all property sizes expressed widespread interest in implementing environmental management practices in the future gives cause for optimism, and it highlights the importance of outreach and assistance designed to help landowners better manage their properties.

Landowners face land management costs as well as liquidity challenges when a major portion of their assets is tied up in forest and rangeland. Four of the five most popular reasons why respondents might someday sell their land were related to financial concerns (fig. 8). California has some of the highest land values in the country (Kroll 2009), and landowners can tap into this monetary value only if they choose to sell land or some of the associated development, timber harvesting, mineral or other rights. Since landowners obtain significant amenity benefits from moderate to small properties (Campos et al. 2009), owners of large properties can capture considerable monetary value by selling off parcels, while still maintaining the quality of life they value on their remaining, slightly smaller, property. In fact, this is a tradition among cash-poor livestock producers.

Future of privately owned lands

What will happen when privately owned forests and rangelands change ownership — either through generational transfer of land or sale — is unknown. Family land transfers across the United States are expected to be substantial in the next 10 to 20 years (Butler and Leatherberry 2004). California forest and rangeland owners are 62 years old on average, with a high proportion retired, and many more nearing retirement. The majority of these landowners, especially owners of large properties, plan to pass ownership on to their children or family members. Without proper estate planning, inheritance taxes and disagreements among heirs could make it difficult for many families to keep their properties. Without technical knowledge on environmental management and improvement practices, it may be difficult to maintain the desired amenities.

New owners, through inheritance or in-migration, may bring a new set of ownership goals and objectives, or the current trend toward valuing amenities more than revenue generation may continue. It will be important to update knowledge of these landowners so that forestry and range professionals can effectively provide advice, assistance and outreach, and encourage protection of the ecosystem services that support quality of life for all Californians.

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References

Alig RJ, Plantinga AJ. 2004. Future forestland area: Impacts from population growth and other factors that affect land values. J Forest 102:19–24.

Brown DG, Johnson KM, Loveland TR, Theobald DM. 2005. Rural land-use trends in the conterminous United States, 1950–2000. Ecol Appl 15:1851–63.

Butler BJ, Leatherberry EC. 2004. America's family forest owners. J Forest 102:4–9.

Campos P, Oviedo JL, Caparros A, et al. 2009. Contingent valuation of woodland-owner private amenities in Spain, Portugal and California. Rangeland Ecol Manag 62:240–52.

[CDFFP] California Department of Forestry and Fire Protection. 2003. The Changing California: Forest and Range 2003 Assessment. Sacramento, CA. http://frap.cdf.ca.gov/assessment2003.

Clendenning G, Field DR, Jensen D. 2004. A survey of seasonal and permanent landowners in Wisconsin's Northwoods: Following Dillman and then some. Soc Natur Resour 17:431–42.

Dillman DA. 2007. *Mail and Internet Surveys: The Tailored Design Method* (2nd ed.). New York: Wiley. 464 p.

Gosnell H, Haggerty JH, Travis WR. 2006. Ranchland ownership change in the greater Yellowstone ecosystem, 1990–2001: Implications for conservation. Soc Natur Resour 19:743–58.

Gustanski JA, Squires RH (eds.). 2000. *Protecting the Land: Conservation Easements Past, Present and Future*. Washington, DC: Island Pr. 566 p.

Hansen AJ, Knight R, Marzluff JM, et al. 2005. Effects of exurban development on biodiversity: Patterns, mechanisms and research needs. Ecol Appl 15:1893–905.

Hobbs NT, Galvin KA, Stokes CJ, et al. 2008. Fragmentation of rangelands: Implications for humans, animals and landscapes. Global Env Chang 18:776–85.

Huntsinger L, Johnson M, Stafford M, Fried J. 2010. California hardwood rangeland landowners 1985 to 2004: Ecosystem services, production and permanence. Rangeland Ecol Manag 63:325–34.

Jones RE, Fly JM, Talley J, Cordell HK. 2003. Green migration into rural America: The new frontier of environmentalism. Soc Natur Resour 16:221–38.

Kendra A, Hull B. 2005. Motivations and behaviors of new forest owners in Virginia. Forest Sci 51:142–54.

Kroll CA. 2009. California Housing in the Subprime/Credit Crisis — Overview and a Forward Look at Recovery. UC Berkeley Fisher Center for Real Estate and Urban Economics. http://escholarship.org/uc/item/9h1898m1.

Maestas JD, Knight RL, Gilgert WC. 2003. Biodiversity across a rural land-use gradient. Conserv Biol 17:1425–34.

Maletta H. 2007. Weighting. www.spsstools.net/Tutorials/WEIGHTING.pdf.

Moritz MA, Stephens SL. 2008. Fire and sustainability: Considerations for California's altered future climate. Clim Change 87:265–71.

Nowak DJ, Walton JT. 2005. Projected urban growth (2000–2050) and its estimated impact on the U.S. forest resource. J Forest 103:383–9.

Parmenter AW, Hansen A, Kennedy RE, et al. 2003. Land use and land cover change in the greater Yellowstone ecosystem: 1975–1995. Ecol Appl 13:687–703.

Sokolow A. 2010. Outlook: Budget cuts threaten the Williamson Act, California's longstanding farmland protection program. Cal Ag 64:118–20.

Theobald DM. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecol Soc 10:32.

Walker P, Fortmann L. 2003. Whose landscape? A political ecology of the "exurban" Sierra. Cult Geogr 10:469–91.

White EM, Morzillo AT, Alig RJ. 2009. Past and projected rural land conversion in the U.S. at state, regional and national levels. Landscape Urban Plan 89:37–48.

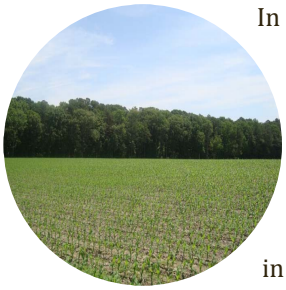
Yung L, Belsky JM. 2007. Private property rights and community goods: Negotiating landowner cooperation amid changing ownership on the Rocky Mountain Front. Soc Natur Resour 20:689–703.

FARM OF THE FUTURE

Working lands for ecosystem services

MUDFORD FARM | Chesapeake Bay, Maryland

Mudford Farm is a 274-acre farm on the Eastern Shore of Maryland in the Chesapeake Bay region. In addition to growing corn, wheat, and soybeans, Mudford's owners have diversified their farm by restoring marginal farmland to wetlands, grass meadows, and riparian buffers, hoping to reap greater financial returns from the restored ecosystem services.



In 2005 Mudford Farm was like many other farms in the Chesapeake region. The land was rented to farm managers who cultivated any land that wasn't forested. But almost half of the cropland was marginally productive. An environmental assessment of the property concluded that significant areas of the farm contained poorly drained, anaerobic or "hydric" soils. Using a combination of private financing, USDA Farm Bill conservation programs, and state funding, its new owner, the Biophilia Foundation, remodeled the working farm to include the production of ecosystem services, creating a more economically viable enterprise in the process.

The new farm. Biophilia Foundation reserved the most productive 80 acres on Mudford Farm for continued cultivation and set about creating habitat and implementing new management practices to generate a net positive environmental impact. Five years later, the farm continues to produce corn, wheat, and soybeans under a conservation management strategy that also involves:

Grass meadows and filter strips (40 acres)

Strategically placed buffer strips along field borders, including 25 acres of warm season grasses, provide habitat for waterfowl, quail, wild turkey, and other wildlife. The subsequent increase in waterfowl populations improves Mudford's hunting revenue. Additionally the farm now receives a Conservation Reserve Enhancement Program (CREP) rental payment of $12,000 per year.

Wetland bank (10 acres)

A portion of the restored wetland was put now under permanent easement so that wetlands credits could be sold to the State of Maryland in 2009 for $8,000 per acre.

Water quality protection (36 acres)

Several restored wetlands, together with vegetated buffer strips, serve to reduce runoff from nitrogen, phosphorus, and sediment into nearby waterways. Verified nutrient reductions from these practices created water quality credits that the Biophilia Foundation registered with a credit trading platform for sale to private or public parties on a voluntary basis or to regulated entities in anticipation of a future compliance market. Recently, Biophilia sold a CREP easement to the State of Maryland to permanently protect the entire farm, including the cropland, wetlands, forest, and buffers; water quality credits resulting from the protective actions were retired. If sold on the voluntary market, Biophilia expected the nutrient credits to generate at least $18,500 per year.

The business model. The Biophilia Foundation utilized USDA Farm Bill conservation programs to restore marginal agricultural land and produce measurable water quality, habitat, and wetlands benefits while keeping the most productive soils in farming. The Mudford story illustrates Biophilia's unique conservation approach. The non-profit organization buys farm properties, restores the land for conservation and continued agricultural production, and sells the restored farms with permanent land use restrictions to secure conservation benefits. Profits at Mudford from the wetland bank, the sale of nutrient credits, and the future sale of the encumbered property will be reinvested in similar future projects. The next owner of Mudford Farm will receive CREP rental payments, which will continue on an annual basis for the next 12 years.

Farm Revenue Sources (Gross), 2009

Source	Revenue	Customer
Corn, soy and wheat revenue	45%	Poultry companies
CREP rental payment	35%	The state of MD
Wildlife hunting leases	20%	Sportsmen

Revenue calculations and all financial information provided by the landowner.

LESSONS LEARNED

Public programs jumpstart innovation. Two USDA Farm Bill programs, the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP), helped Mudford Farm finance its restoration activities. Public programs can provide start-up funding for conservation activities and help landowners overcome financial barriers to environmental market access.

Local partnerships are a win-win. The Biophilia Foundation relied on local partners to design and implement its restoration plan, measure and verify wildlife population increases and nutrient runoff reductions, and bring nutrient credits to market. Involving regional expertise builds ecological credibility into the conservation plan and supports small businesses, employment, and workforce training in the community.

Voluntary markets can prime the pump. Mudford Farm serves as a demonstration site for measuring nutrient reductions produced by restoration activities. Voluntary, trial-and-error activity is already taking place on the ground and can inform the development of compliance-based nutrient trading markets.

One size does not fit all. Mudford's experience is unique, involving a nontraditional landowner and a land purchase model that is not easily replicable. Landowner involvement in emerging markets is currently on a case-by-case basis and an entrepreneurial endeavor. However, as different payment for ecosystem markets develop, examples such as this one should evolve and become easier to replicate.

USDA

Farm of the Future case studies were produced by EcoAgriculture Partners with support from the USDA Office of Environmental Markets. Funding was provided through a cooperative agreement with the USDA Natural Resources Conservation Service.

ecoagriculturepartners

Chesapeake Bay Stewardship Fund

www.nfwf.org/chesapeake

Chesapeake Bay Program
A Watershed Partnership

Project Fact Sheet

Project Title: The Chesapeake Nutrient Neutral Fund (aka The Chesapeake Fund)
Organization: Chesapeake Bay Foundation
Project Partners: Forest Trends, World Resources Institute (WRI), Water Stewardship Inc. (WSI), Environmental Defense Fund
Grant Award: $ 500,000
Matching Funds: $ 500,000

Project Description.

The purpose of the Chesapeake Fund is to attract and invest private capital in projects (initially in the agricultural sector) that reduce nitrogen pollution flowing into the Chesapeake Bay and its tributaries. We believe that we will not solve the Bay's problems without the direct engagement of businesses and key industries. To do this, the Fund offers four basic services: 1) Onsite nitrogen accounting: We estimate the nitrogen "footprint" of businesses that results from day to day activities. Sources include: stormwater runoff; air deposition from energy use; transportation; and, wastewater management. 2) On-Site Corporate Pollution Reduction Planning: The Fund works with its partners to develop nitrogen reduction strategies that will minimize this footprint. 3) Watershed Stewardship and Restoration Projects: The Chesapeake Fund invests in nitrogen reduction stewardship projects that are financed by private entities wishing to "offset" their nitrogen footprint. 4) Measurement and Reporting: As partners and investors take action to reduce nitrogen pollution, the Fund measures and tracks their success, transparently reporting the results for all to see and evaluate.

Goals and Outcomes.

Our goal (to be accomplished within 5 years) is to facilitate the annual reduction of one million pounds of nitrogen flowing to the Chesapeake Bay. Within the time period of the grant, we have committed to investing $ 150,000 of private dollars in agricultural projects that will reduce roughly 15,000 pounds of nitrogen. We will update and revise NutrientNet so that we can use it to estimate nitrogen credits (i.e., pounds of nitrogen reduced) in VA. MD and PA. We will build upon CBF's household nitrogen footprint calculator and develop a prototype for use with small businesses and work with 4 different businesses, including one developer, to estimate their nitrogen footprint and develop strategies to reduce or offset it, or both.

Status.

The Director of the Chesapeake Fund, Dan Nees, was hired by Forest Trends in August 2008. The web page for the Chesapeake Fund (www.chesapeakefund.org) went live in spring 2009. We have secured our first corporate donor to the Fund, Pepco Holdings, Inc. who agreed to invest $ 200,000 in pollution reduction projects on agricultural lands. We developed ranking and scoring criteria for projects (based primarily on cost-effectiveness) and currently have a request for project proposals in the Tuckahoe watershed, MD, to invest these dollars. We will use WRI's NutrientNet to estimate the nitrogen offset credits for the projects and WSI will conduct the verification and monitoring. We expect the selected projects to go on-the-ground in spring 2010. As the Fund grows, we plan to continue to invest in the Tuckahoe and to expand to the Little Conestoga watershed in PA and tributaries of the North River watershed in the Shenandoah Valley in VA.

We have established an advisory committee composed of a diverse array of stakeholders, including developers, those with experience in environmental markets and finance, EPA, Chesapeake Bay Commission, credit aggregators, and the energy sector to help guide the Fund's activities. We are working with the environmental registry "Markit" (the same registry being used by the Bay Bank) to develop a registry platform that could be used to track the credits generated from our offset projects, as well as those from the practices and activities implemented by businesses as part of a their onsite nitrogen reduction strategy.

We have developed a draft business plan and marketing strategy that we are continuing to refine based on the results of the market survey conducted by MacWilliams, Kirchner, Sanders and Partners (MKSP). This survey of consisted of hour long interviews with 20 regional business leaders and **these interviews indicate that a real opportunity exists to establish and grow the Fund.** Two key findings of the study that have influenced our marketing and outreach strategy are that: most business leaders wanted help with assessing how, and how much, nitrogen their businesses generated. This service, helping businesses assess their nitrogen footprint, was highly valued and sought after. Many business leaders also wanted help with determining how to take direct action to reduce the nitrogen emissions identified by accounting.

Currently, we are working with two local restaurants, a developer and are in discussions with several other organizations to assess their nitrogen footprint and develop a nitrogen reduction strategy. WRI is working to "scale up" CBF's household nitrogen calculator for use with small businesses.

Challenges and Lessons Learned.

As noted above, our marketing survey indicated that businesses were very interested in learning about their nitrogen footprint and ways they could reduce it, but needed a bit more time before they take the next step of purchasing offsets. In hindsight, this approach makes complete sense: before a business commits to offsetting, they need to have an estimate of what it will cost. As a result we have revised our business plan to focus on the footprint and accounting services of the Fund – these too, will result in quantifiable, measurable nitrogen reductions to the Bay from the implementation of on-site practices e.g., through stormwater controls, energy conservation, reduced water use. Unfortunately, our grant did not include funds for this aspect of the Fund (beyond the development of a prototype small business calculator), so we are currently seeking other funding sources to help develop the accounting protocols.

Readiness for Scale Up.

Our initial vision for the Chesapeake Fund was that it would operate watershed-wide. We have engaged with businesses and organizations in MD, VA, PA and D.C. At the moment, we are investing in on-the-ground projects in MD, but the intent is to expand those efforts to VA and PA.

Ecosystem Services in Agriculture

(Draft background for discussion with Cannella Panel - CDFA)

October 2011

Ann Thrupp, Fetzer Vineyards,
With some slides borrowed from Andrew Arnold - SureHarvest

Topics

- What are ecosystem services in agriculture?
- Payment for Ecosystem Services in farming: The concept and applications
- Potential and Questions for the future

CALIFORNIA
SUSTAINABLE WINEGROWING
ALLIANCE

Ecosystem Services - An Overview

Basic definitions of Ecosystem Services (ES):

"**Benefits provided by ecosystems to humans**" (FAO, 2010)

OR: "The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life." (Daily, 1997)

ES are usually classified in 4 main categories:

- Provisioning
- Supporting
- Cultural
- Regulating (*Millenium Assessment, 2005)*

Ecosystem Services: The Concept

Ecosystems services = *benefits people obtain from ecosystems*

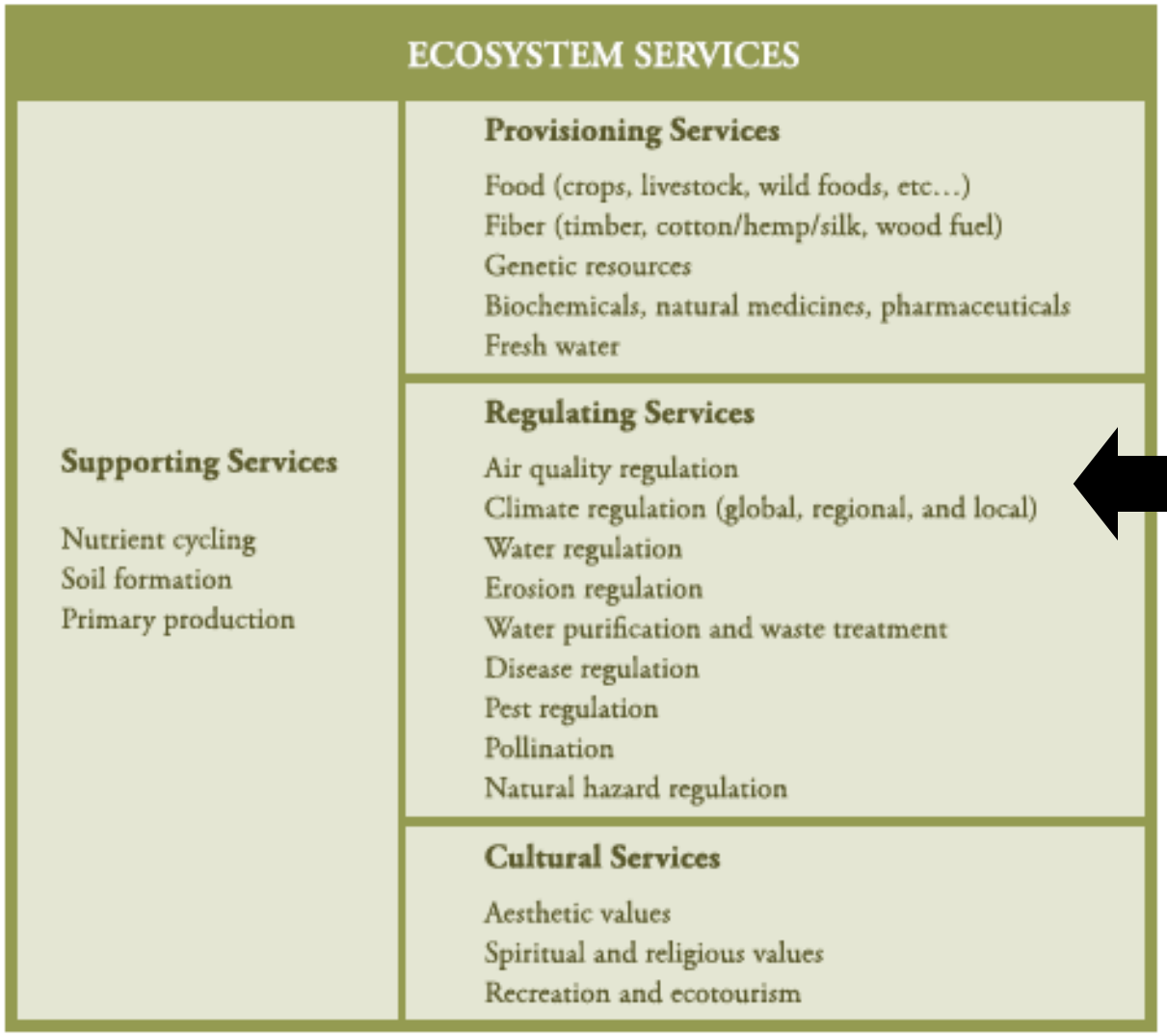
Adapted From the Millenium Assessment

Ecosystem services in Agriculture (examples)

- **Food, Fiber, and Fuel**
  ("The most important service provided by agriculture is provision of food, fuel, and fiber." - Swinton et al, 2007)
- **Soil structure and Fertility**
  - **Soil Carbon - carbon sequestration**
- **Beneficial Insects -**
  - **Pest control, pollination services, & decomposition**
- **Climate/air regulation**
- **Biodiversity conservation**
- **Water provision and purification**
- **Water & watershed conservation**

Ecosystem Services: The Concept

Ecosystems services = *benefits people obtain from ecosystems*



The role of the farmers

In climate change mitigation

Carbon storage

Carbon sequestration in biomass

Carbon sequestration in the soil

In watershed protection services

Land management

Water quantity

Water quality

In biodiversity conservation

Preserving biodiversity

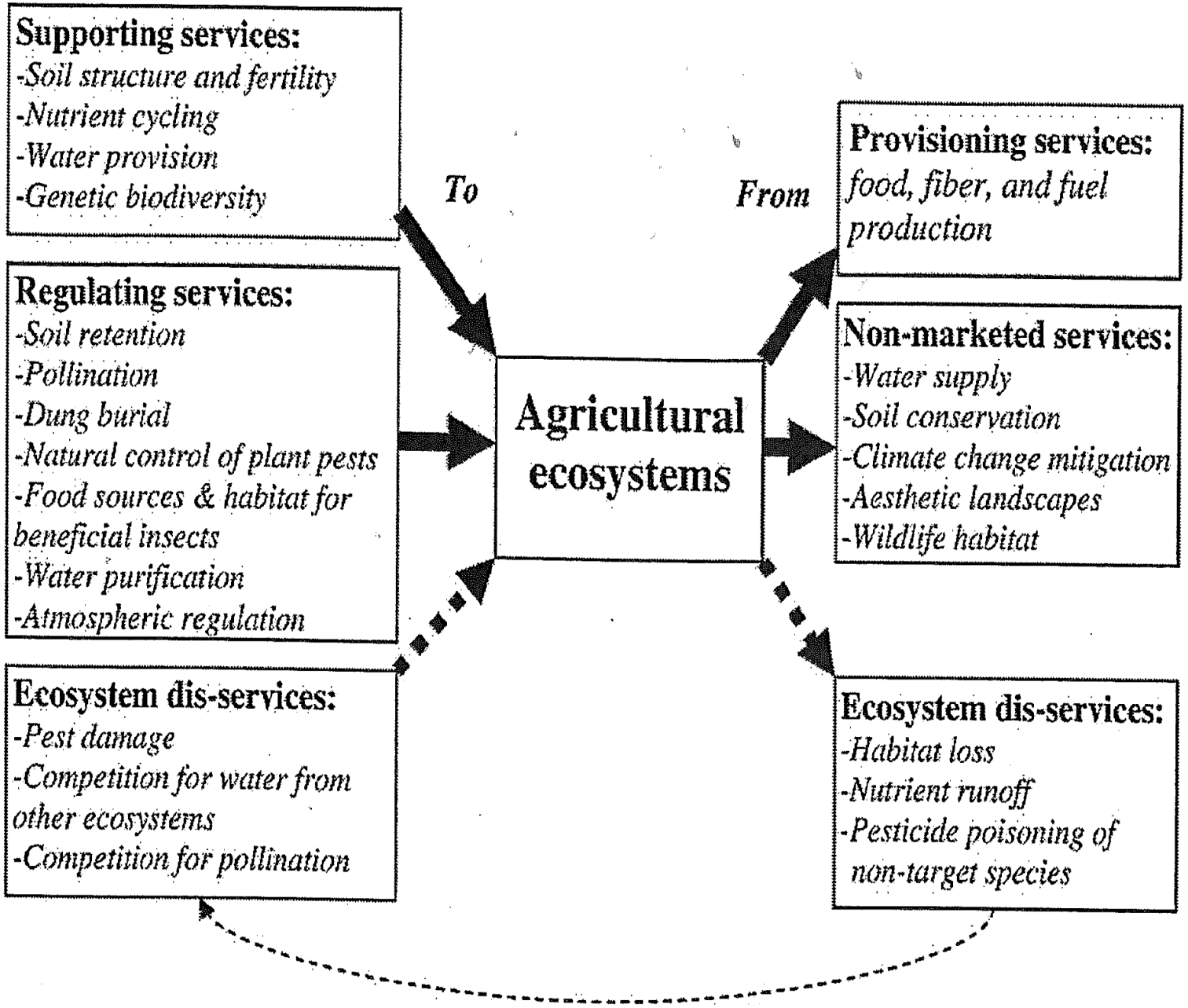
Reducing agricultural expansion

Enhancing on-farm wild biodiversity

Conserving agricultural biodiversity

Preserving agriculture landscape

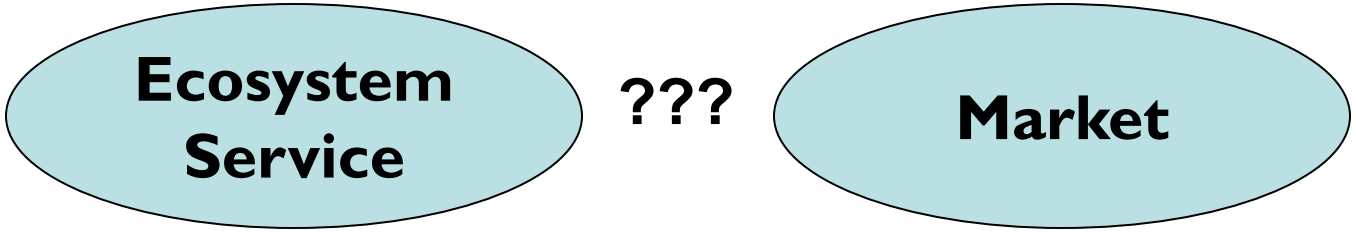
Adapted party From Millenium Assessment



Feedback effect of dis-services from agriculture to agricultural input (e.g., removal of natural enemy habitat can encourage pest outbreaks)

Zhang et al, 2007

Payment for Ecosystem Services: The Concept



Is there a market for a specific ecosystem service?

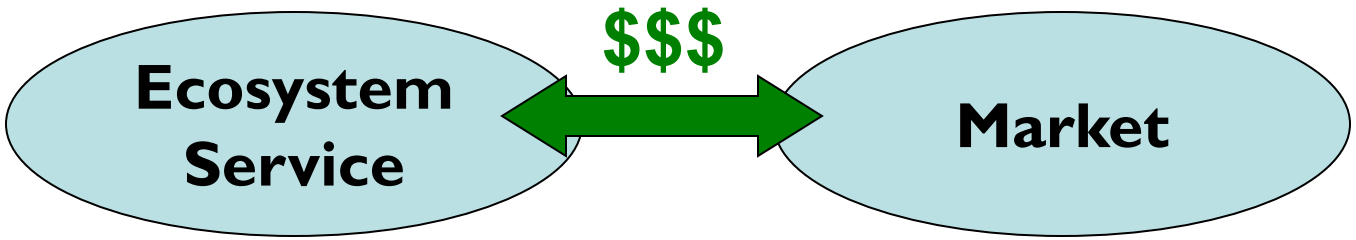
How big?

How does a grower provide "added value" & participate?

How does a grower quantify his "product?"

How much $$$ can a grower earn in this process?

Payment for Ecosystem Services (PES): The Concept



- **Quantify**
- **Register**
- **Verify**

Types of markets and payment mechanisms

- Public payments and support services
- Private contracts or deals
- Tax incentives and subsidies
- Trading of rights or credits under a regulatory cap
- Eco-labeling

The largest payment program in the United States is the NRCS' Conservation Reserve Program (CRP). Pays growers to:

- Reduce soil erosion & sedimentation
- Improve water quality
- Establish wildlife habitat
- Enhance forest/wetland resources

Ecosystem Services & Markets

USDA Office of Environmental Markets

The **Office of Environmental Markets (OEM)** is a new office created within the U.S. Department of Agriculture to catalyze the development of markets for ecosystem services. OEM has a unique role in the federal government's efforts to develop uniform standards and market infrastructure that will facilitate market-based approaches to agriculture, forest, and rangeland

"Environmental markets leverage private investments that result in cleaner air, improved water quality, restored wetlands, and enhanced wildlife habitat," said Vilsack. "These markets have the potential to become a new economic driver for rural America, exactly what we need to support a bold, creative future for America's farmers, ranchers and rural communities."

PES - Agriculture Industry Initiatives

Ranchlands provide habitat for many wading and migratory birds

- No-till/conservation tillage farming
- Commitment to a time frame
- Carbon credits (sequestering carbon)

- Revise water mgmt practices
- Capture water (wildlife)
- Reduce phosphorous runoff
- Payment to farmers

PES- Agriculture Industry Initiatives (cont.)

Willamette Partnership

- Pay-for-performance concept
- Water quality pilots
- Measure – improve – get paid

Water Quality Issue	Performance Measure
Phosphorus (P)	Iowa Phosphorus Index
Nitrogen	End-of-season Cornstalk Nitrate Test

World Resources Institute

WRI Main Site...

NUTRIENT NET reducing watershed nutrient runoff

WELCOME to NutrientNet - first on-line market for improving water quality through nutrient trading

project of the World Resources Institute

PES - Broad Ag Industry Initiatives (cont.)

Watson Partners Farm receives payments for planting a cover crop with its sugar beets as part of a phosphorus trading program within its cooperative. Cover cropping sequesters phosphorus and offsets discharge from the cooperative's wastewater treatment facility.
Brief | Diagram

Buck Island Ranch is one of eight ranches in the Lake Okeechobee watershed supplementing its cattle sales with payments for water retention as part of an ecosystem services pilot project.
Brief | Diagram

- Creative payment schemes
- Credits/offsets
- Additional revenue for beneficial land management practice changes

Eco-agriculture Partners

Measuring & Valuing Ecosystem Services

Example:
Winegrape Growers

- **Practices**
- **Technologies**
- **Innovation**

Incentivize

Environmental Services
& Markets

Early stages for:

- Water quality trading
- Nutrient trading
- Carbon offsets
- Biodiversity valuation
- ???

Tools & Calculators?

Quantify services to participate in markets

Farm & Ranch Possibilities in California?

Farmscape services?
(beyond the farm footprint)

No/minimum till and cover crop

Buffer areas & riparian restoration

Composting

Insectary vegetation

Cover crops and their effects in vineyards

Cover Crops

- Prevent erosion
- Improve soil structure
- Retain soil moisture
- Increase organic material and soil fertility
- Absorb carbon
- Increase diversity of soil organisms
- Attract beneficial insects

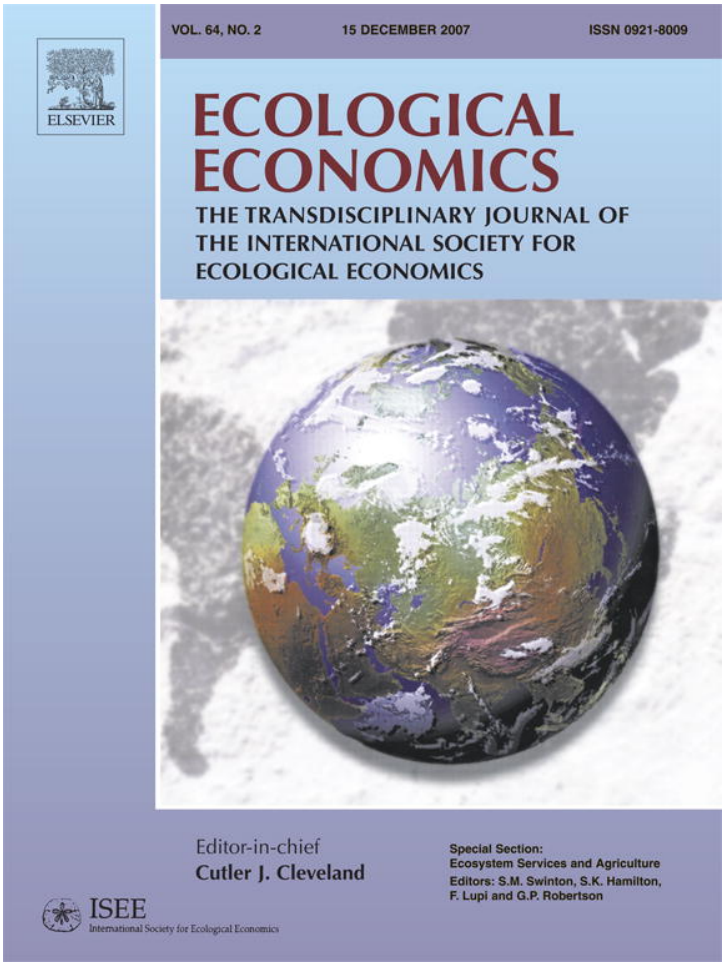
Thrupp, 1999

Ecosystem Services in California Agriculture: Prospects and Questions?

Are there really are prospects for California farmers to gain significant added value from ecosystem services?

- If so, how?
- What are barriers?
- What are steps to leverage support?

Critical perspective: Norgaard... Does this market-based approach really create adequate valuation for these important "services" ? Are they actually non-quantifiable in monetary terms?



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INTRODUCTION

Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits☆

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ABSTRACT

Crop and rangelands are over 25% of the Earth's land area, and they are expanding. Agricultural ecosystems rely on a suite of supporting ecosystem services to provide food, fiber and fuel as well as a range of accompanying but non-marketed ecosystem services (ES). Ecosystem services from agriculture include regulation of water and climate systems, aesthetic and cultural services, as well as enhanced supporting services (such as soil fertility). Many of these ES are appreciated by people, but they lack markets, so they lack the incentives for provision that come with prices. For public policy decisions to take them into account, non-market valuation techniques are needed, such as travel cost, contingent valuation, hedonic valuation, and cost-based or factor-income approaches. This article offers an overview of ES from agriculture and non-market valuation methods as it introduces the articles in this special section on "Ecosystem Services and Agriculture." Understanding how ecological functions generate ES is fundamental to management, but so too is understanding how humans perceive and value those services. Research is required both to design cost-effective incentives to provide ES and to measure which kinds of ES could provide the greatest overall welfare benefits to society. Agricultural ecosystems offer newly recognized potential to deliver more diverse ecosystem services and mitigate the level of past ecosystem disservices. This special section of *Ecological Economics* conveys both how these are becoming possible and the challenges to science and public policy design of turning that potential into reality.

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1. Introduction

Agricultural ecosystems are managed by people chiefly to meet food, fiber and fuel needs. Estimates of agricultural crop and pasture land area range from 24 to 38% of the Earth's land area (Millennium Ecosystem Assessment, 2005; Wood et al., 2001) or roughly half of all land not classified as desert, rock or permafrost. Extrapolating global trends from 1960 onward, Tilman et al. (2001) predict that by 2050, cropland will increase by 23% and pasture land by 16%. Hence, agriculture accounts for a massive and growing share of the Earth's surface.

Agriculture is a recent development in geological and even human history. The Neolithic Revolution of farming occurred in the Middle East sometime between 11,000 and 18,000 years ago (Boyden, 1987; Mann, 2006). In the brief span of time since then, humans have come to dominate the Earth, covering much of it with farmed plants and animals.

The clearing of native ecosystems such as forest or prairie for farming or grazing constitutes a major disturbance of existing ecosystems. Importing water to support agriculture in arid or semi-arid landscapes is an even more fundamental change in the biophysical environment. Indeed, crop farming represents a continuing disturbance regime whose purpose is to favor preferred plants, most of which are vigorous annuals grown in monocultures to rapidly transform solar energy into biomass (Boyden, 1987). Continuous farming has become the norm over vast areas. Parts of Asia have been farmed for millennia. Where farming has become established, it has permanently transformed ecosystems to the point that cultivated farmland is now widely recognized as a distinct kind of ecosystem (Heinz Center, 2003; Millennium Ecosystem Assessment, 2005).

Among the Earth's major ecosystems, agriculture is the one most directly managed by humans to meet human goals. Food, fiber, and fuel production is the overwhelmingly dominant goal of agriculture. Yet as a managed ecosystem, agriculture plays unique roles in both supplying and demanding other ecosystem services. Agriculture supplies all three major categories of ecosystem services — provisioning, regulating and cultural services — while it also demands supporting services that enable it to be productive. Here we elucidate the nature of agriculture as provider and recipient of ecosystem services, with special focus on services that lack formal markets. We then discuss how those services can be valued economically, and how changed management and policy incentives can induce farmers to offer a broader range of ecosystem services. Along the way, we introduce articles from this special section on "Ecosystem Services and Agriculture" that offer greater conceptual or empirical depth. We close by reflecting on the state of ecosystem services available from agriculture and challenges ahead for science and policy.

2. Agriculture as provider and recipient of ecosystem services (ES)

Agriculture both provides and receives ecosystem services that extend well beyond the provision of food, fiber, and fuel. Some are planned, but most are indirect, unmanaged, underappreciated, and unvalued — in effect, serendipitous. Only in their absence do most become apparent. Pollination services, which have recently become threatened by honeybee colony collapse disorder, contribute to fruit, nut, and vegetable production worth $75 billion in 2007 (USDA, 2007) — five times the cost of expected U.S. farm subsidies. The soybean aphid, a pest new to the U.S. since 2000, is capable of lowering grain yields by over 25% when unchecked, but in many landscapes populations are kept low by coccinellid beetles that are naturally present when sufficient natural habitat is nearby (Costamagna and Landis, 2006). Wetlands and streams in agricultural watersheds can transform leached nitrate into a non-reactive form that keeps it from harming downstream ecosystems (Whitmire and Hamilton, 2005). Wetland drainage and stream channelization in the Mississippi River basin have diminished this water quality regulating service, and as a result nitrate pollution contributes to hypoxia in the Gulf of Mexico, producing a significant economic impact on the coastal shrimp fisheries (NRC, 2000). The broad and diverse dimensions of ES to agriculture are explored more fully in Zhang et al., (this volume).

These sorts of services (and disservices, in the case of effects that are deemed undesirable) place agriculture in a web of other services provided by ecosystems to society, a web formed by linkages within and inherent to the agricultural landscape (Fig. 1). In fact we now recognize that agriculture is not so much

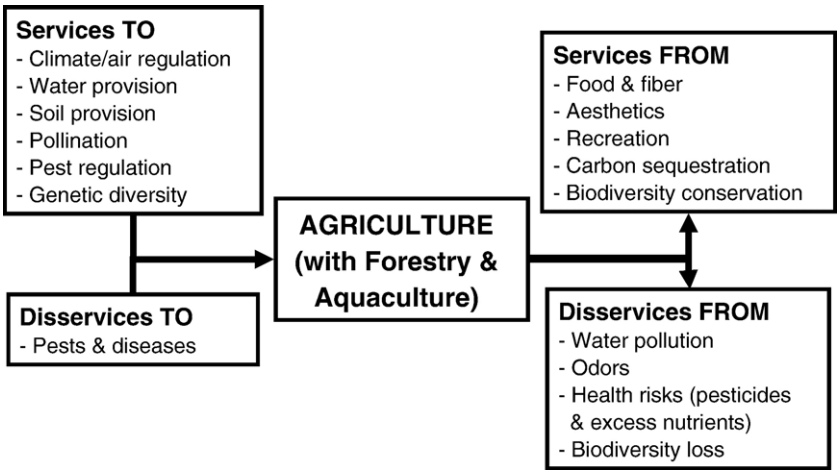


Fig. 1 – Ecosystem services to and from agriculture.

a field-based enterprise as a landscape-based enterprise: Crops in individual fields are dependent on services provided by nearby ecosystems, whether native or managed, and nearby ecosystems are often influenced by their agricultural neighbors. Neighboring ecosystems provide food, refugia, and reproductive habitat for pollinators and biocontrol agents; they provide wildlife habitat; and they help to attenuate some of the unwelcome effects of agricultural production, including the escape of nitrogen, phosphorus, and pesticides into non-agricultural ecosystems where they may produce undesirable impacts.

These unwanted effects of agriculture — agriculture's ecosystem disservices — are not minor. Land use change associated with agricultural development results in habitat loss, cropland irrigation leads to the diversion of rivers and groundwater depletion, overgrazing results in rangeland erosion and can initiate desertification, invasive pests are introduced with the movement of agricultural commodities, accelerated nitrogen and phosphorus loading of surface waters results in aquatic and marine eutrophication — the list goes on and is well known. But ecosystems in agricultural landscapes can also ameliorate these problems, as can changes in agricultural management per se. Cropland can be managed to be more nutrient and water efficient, riparian zones can be managed to effectively remove nutrients and sediments before runoff reaches surface water bodies, and native communities and wetlands can be restored within a matrix of agricultural lands to provide habitats for beneficial insects and birds (Robertson et al., 2007). To the extent that agricultural ecosystems can be managed or placed to abate harm that would otherwise be more severe, these ecosystems are also providing mitigation services.

While conversion of native ecosystems to agricultural use often results in profound environmental impacts, agricultural ecosystems do still retain many features common to native ecosystems, and thus the consideration of ecosystem services provided by agriculture has to be viewed in the context of what they replace, and what they might be replaced with. For example, conversion of agricultural lands to urban development may diminish certain ecosystem services, such as groundwater recharge, that may have functioned as well in the agricultural ecosystem as in the native one it replaced. On the other hand, restoration of native ecosystems on abandoned agricultural lands can restore lost ecosystem services, and to some extent so can changes in agricultural practices. Thus agricultural land use lies somewhere in the middle of a human-impact continuum between unmanaged native ecosystems (e.g., wilderness) and human domination (e.g., built-up landscapes), and of course different kinds of agriculture vary in their relative positions on that continuum.

2.1. *Services provided by agriculture*

Unquestionably the most important service provided by agriculture — in fact its main rationale — is its provision of food, fuel, and fiber. Grain, livestock, fuel, forage, and other products are used to meet subsistence or market needs, usually without regard to the provision of other services. Nevertheless, a number of other services are also provided.

Among these services are those classified by the Millennium Ecosystem Assessment (2005) as supporting services. Arguably, the most important of these is the maintenance of soil fertility, which is fundamental to sustain agricultural productivity. Agronomic management that maintains or improves soil fertility, when employed in place of less sustainable practices, can be viewed as providing a mitigation service. A number of factors comprise soil fertility, and all of these are potentially influenced by agronomic practices. Soil organic matter (SOM) provides many of the mineral nutrients essential for crop growth. Even in intensively fertilized grain crops, SOM provides about 50% of the crop's nitrogen needs. About 50% of SOM is carbon, which provides the chief source of energy for microbes, invertebrates, and other heterotrophic organisms that form the complex soil food web (Barrios, this volume). In most ecosystems more energy flows along the soil decomposer pathway than through the aboveground grazing or harvest pathway, and agricultural systems are no exception. This energy flow has a huge impact on soil biodiversity and the provision of plant-available nutrients to the soil solution.

Soil carbon also plays a major role in soil structure, another major component of soil fertility. Soil aggregates are formed by mineral particles held together by decomposition products such as polysaccharides. Aggregates ranging in size from 50 μm to 2 mm form the basis for a soil structure that enhances infiltration, soil water retention, porosity, and aeration — qualities that in turn enhance microbial activity and plant growth, and thus provide a valuable service to the cropping system.

Regulating services are among the most diverse class of services provided by agriculture. Agricultural landscapes have the capacity to regulate the population dynamics of pollinators, pests, pathogens and wildlife, as well as fluctuations in levels of soil loss, water quality and supply, and greenhouse gas emissions and carbon sequestration.

Insect pests — those that feed on crop or rangeland plants or that transmit livestock or other disease — are commonly kept in check by other organisms in the food web. However, the presence of these other organisms, mostly carnivores and parasitoids, largely depends on the availability of appropriate habitat and prey during portions of the year when crop pests are not available. Managing agricultural landscapes to allow this regulation can be an important way to deliver this service.

Soil loss can also be regulated by agricultural management. Conservation tillage and the maintenance of plant cover year-round can reduce runoff and associated soil, nutrient, and pesticide loss. The reduction of runoff also serves to increase infiltration, which increases the water available to plants and can improve groundwater recharge. And the retention of soil carbon — in croplands via tillage and cover crop management, in rangelands via management of plant cover and species composition — can store carbon that would otherwise be emitted to the atmosphere as CO_2, and thus help to regulate climate change (Caldeira et al., 2004). Havstad et al. (this volume) suggest that rangelands may be particularly valuable for sequestering carbon and simultaneously enhancing biodiversity.

Additional services provided by agricultural landscapes include cultural benefits whose valuation can be especially difficult. These include open-space, rural viewscapes, and the cultural heritage of rural lifestyles. The relationship of agriculture to other cultural services — recreational hunting (e.g. Knoche and Lupi, this volume) and tourism — are also largely unvalued in the market economy.

3. Valuation of ecosystem services that lack markets

Being able to place values on ecosystem services is fundamental to designing policies to induce agricultural land managers to provide (or maintain) ES at levels that are desirable to society. Of course, food, fiber and fuel have markets that provide both incentives to produce those ES as well as measures of their value to society. But many other ES lack markets. The value of those ES may differ between farmers and the consumers of the ES. Farmers (or producers in general) would often lose income by changing production practices to generate more ES. In such cases, the value of ES to them can be estimated from their willingness to supply those ES in exchange for minimal compensation (referred to as "willingness to accept" [WTA]). On the other hand, consumers would gain satisfaction from the availability of more ES, so values to them can be estimated from their willingness to pay (WTP) for additional ES. A variety of methods exist to estimate consumer WTP and producer WTA from observed behavior or survey responses to hypothetical questions.

3.1. *Travel cost*

One of the ways to value recreational ES from agriculture uses the cost of travel to destinations where recreational ES such as wildlife viewing, hunting, and fishing are available. Travel costs reveal information about WTP for outdoor recreation. Observations on the relationship between people's recreation activity and their travel costs are used to estimate recreation demand functions. If the demand can also be related to levels of ES provision, then changes in ES will shift the demand functions and can be used to value changes in the ES. This approach has been used to estimate values associated with agricultural conservation programs that affect water quality (Baylis et al., 2002) and pheasant hunting (Hansen et al., 1999). In this issue, Knoche and Lupi develop a travel cost model for deer hunting in an agricultural region and provide estimates of possible deer hunting values associated with agriculture.

3.2. *Contingent valuation and stated preference approaches*

The contingent valuation approach involves directly surveying people to elicit their willingness to pay or accept payment for a change in ES. The contingent valuation method allows researchers to specify the exact scenario to be valued. Unlike other methods, the contingent valuation method is capable of measuring passive use values that people may hold regardless of whether or not they will directly use the ES (Mitchell and Carson, 1989; Freeman, 2003). The contingent valuation method has been used to estimate values for various ES associated with agriculture including visual amenities (Ready et al., 1997), wildlife habitat (Brouwer and Slangen 1998), and water quality impacts (Colomboa et al., 2006).

Brey et al. (this volume) present the results of a contingent valuation study for forest land preservation. In addition to estimating willingness to pay for the program, Brey et al. use an attribute-based contingent valuation method that can identify the effect of several forest policy attributes on willingness to pay. In light of the multidimensional nature of ES to and from agriculture, and the fact that many policies of interest involve trade-offs among ES (Lupi et al., 2002), the attribute-based contingent valuation methods are likely to be of increased importance in the field of ES valuations.

3.3. *Hedonics*

Hedonic valuations use relationships between land property prices and property characteristics to value changes in the characteristics. In essence, hedonic approaches can measure values that get capitalized into the asset value of property. If agricultural ES can be linked to property values, then their value can be estimated using these methods. ES effects on farmland prices are of interest at two distinct scales: the direct effect on the price of farmland itself and the indirect effect on prices of surrounding properties. The surrounding land could be residential and the amenity effect could be positive (Ready et al., 1997) or negative (Ready and Abdalla, 2005). Alternatively, the surrounding land might be working agricultural lands with values that are affected by the land use of their neighbors (for example, due to refugia that support desirable insects).

The hedonic approach can also be used to measure the value of ES *to* agriculture that get capitalized into land values because they increase incomes from the land. For example, land with vital soil microbial communities that can provide higher crop yields might fetch a higher price. For this to occur, (1) the ES must vary across space and (2) market participants must have knowledge about how the ES influences agricultural profitability. If buyers and sellers are unaware of the effect relevant ES have on the agricultural earning potential of the land, then such ES will not be reflected in market prices. The scientific knowledge to support enhanced awareness of the linkage between ES and agricultural earnings is a key area for future research.

3.4. *Approaches based on cost*

Cost-based approaches can in some cases be used to infer the value of an ES based on the cost of mitigating or replacing the services. For example, if soil fertility is reduced and yields are maintained by using increased inputs of fertilizer, then the cost of increased fertilizer usage provides information on the value of the reduced soil fertility supporting service. Similarly, if soil erosion leads to sediment build-up off-farm, for example in waterways, then the observed added costs for dredging will provide information on the disservice values (i.e., costs). In some situations these defensive expenditures (or avoided costs) can be considered a lower bound on the value of the change in ES (Dickie, 2003, Farber et al., 2002). However, these defensive expenditure approaches are sometimes confused with replacement costs.

Measures of what it costs to replace an ES are not generally viewed by economists as appropriate measures of value (Barbier 1998; Bockstael et al., 2000) because people might not be willing to replace an ES at the replacement cost (Freeman, 2003). Thus, the replacement cost technique generally only

reveals economic value if we observe a service being replaced (Chichilnisky and Heal, 1998).

3.5. *Factor-income approaches*

On-farm values of ES to agriculture commonly can be measured with the factor-income approach (Farber et al., 2002), which in our case refers to a variety of valuation approaches that aim to link ES to incomes from agriculture. A common way to identify the effect of an ES on income would be to identify its effect on yields or costs. For example, when ES to agriculture enhance yield without altering costs, the increased yields directly translate into increased income (Ricketts et al., 2004).

More generally, when ES to agriculture affect agricultural outputs or the need for various inputs, one can use a production function approach to value the ES. A production function relates the quantity of output (e.g., agricultural yields) to various levels and combinations of inputs (Wossink and Swinton, this volume). One approach to documenting the value of ES to agriculture is to estimate a production function and then use it to compute how the expected present value of agricultural profits will change when an ES changes. The production function method has long been applied to estimate crop and livestock production response to externally applied inputs (Dillon and Anderson, 1990; Just and Antle, 1990). However, most classical agricultural production functions include an intercept term to describe output achieved without external inputs. This base yield level is largely due to natural ES, as shown by recent precision agriculture research (Liu et al., 2006). Hence, a challenge for future research is to describe ES inputs sufficiently thoroughly to estimate agricultural production functions that show no output if there is no input (naturally or externally provided).

Both on-farm and off-farm ES values need to be included to account for total value. While the on-farm effects can often be measured using factor-income approaches including production or cost function approaches (Wossink and Swinton, this volume) and econometric analyses of opportunity costs (Antle and Valdivia 2006), some of the above mentioned valuation techniques typically used for off-farm effects can also be applied to on-farm effects. Examples include the use of stated preference approaches to measure willingness to supply off-farm (Cooper and Osborn, 1998), or hedonic techniques that measure the value of ES to agriculture that get capitalized into land values (Petrie and Taylor, 2007, Schlenker et al., 2005). Even the travel cost method could be used for on-farm benefits if the application involved fee-based hunting where the farmer could capture the fees as income. Indeed in some parts of the United States, there are long histories of fee-based hunting access or leases tied in part to agriculture (Rasker et al., 1992) and especially rangelands (Butler and Workman, 1993).

A useful economic approach related to the factor-income techniques involves quantifying the on-farm effects on income of different ES levels. The combined effects are used to produce a trade-off frontier that facilitates assessment of the cost-effectiveness of providing differing levels of off-farm ES. By measuring the profitability of different farming practices in relation to changes in levels of off-farm ES that affect the farm (Coiner et al., 2001), one can elucidate the ES trade-offs and their relation to agricultural incomes without directly valuing the ES outcomes.

3.6. *Consumers*

When ES to agriculture affect agricultural profitability, they have the potential to affect the well-being of the consumers of food, fiber and fuel products. The well-being of consumers is affected by any changes in product prices or quality as a result of a change in the ES to agriculture. In such cases, the well-being of consumers ought to be quantified as a part of the value of the change in ES. In some cases very small changes in prices to millions of consumers can yield substantial values.

3.7. *General considerations in valuation of ES*

Agricultural ES will vary across space, and the provision of ES occurs within a landscape context. Consequently, spatial interdependence is expected for many ES to agriculture. For example, the value of refugia for beneficial insects will depend on the scarcity of that service from surrounding landscapes. Likewise, the value of ES from agriculture will depend on the location and spatial context of the service. For example, recreational services from agricultural lands will generally be greater the closer the lands are to population centers due to the reduced travel and access costs for users of those services, as is the case for the deer hunting services examined by Knoche and Lupi (this volume). This spatial dependence of values can pose a challenge for valuation of agricultural ES and for the generalization of findings and transfer of values.

When considering alternative approaches to managing agricultural lands, many practices will involve changes in the levels of ES from or to agriculture rather than the total elimination of the ES. Moreover, some ES being considered may have substitutes outside of agriculture. In these situations, the relevant valuation concepts will measure *changes* in the values of the ES when management *changes*. This is conceptually challenging for ES that are important, in fact life sustaining, yet are not currently scarce (e.g., the ecological paradox that diamonds are highly priced but water is not) (Heal, 2000). Put differently, some ES will have modest values for marginal (small) changes yet have values that may well be infinite for larger scale changes (Bockstael, et al., 2000). Because scarcity of an ES affects its value on the margin, it is important to understand the scale of changes, and any cumulative impacts relative to ecological thresholds, when assessing values.

Implicit in any attempt to value ES to and from agriculture is sufficient understanding of the linkage between management of the agricultural ecosystem and the resultant flows of ES (Fig. 1). The need for understanding this linkage was illustrated above by the dependence of market values for agricultural land on buyer and seller recognition of how supporting ES affect agricultural earnings. Likewise, properly valuing recreational deer hunting services related to agriculture calls for quantifying the linkage between agricultural management and deer populations Knoche and Lupi (this volume). As such, continued enhancement of our scientific understanding of the

linkage between *changes* in agricultural management and *changes* in resulting ES flows is a key element of the research agenda on ES valuation and agriculture.

4. Opportunities for management of ecosystem services

People clearly appreciate the economic value of many ecosystem services that are not currently traded in markets, and the methods outlined above offer means to estimate those values. Conventional environmental economic wisdom suggests the need for incentives to ensure greater provision of ES that are undersupplied due to incomplete markets. In theory, a subsidy on the provision of non-marketed ecosystem services could induce producers to supply more. In practice, many of these services are difficult or costly to measure (Kroeger and Casey, 2007-this volume). Cost-effective indicators must often be chosen as proxy variables for measuring the state of some true underlying ecological process whose measurement would otherwise be prohibitively costly. Moreover, farmers often do not understand well the relationship between input-use practices and ecosystem service outputs. In their accompanying article, Dale and Polasky (this volume) explore these challenges, defining criteria for selection of indicators, reviewing measurement approaches in use, and characterizing the challenges that remain. A common approach is to measure change relative to a "conventional" baseline, yet what is "conventional" may differ in space (pristine forest or parking lot) as well as in time (due to technological changes in production processes).

If ES outcomes can be measured effectively, it becomes possible to manage for them. There are two broad ways to conceptualize management for ES, via biophysical practices or economic trade-offs. Biophysical practices divide between applications on cultivated lands and on non-crop areas. Agronomic practices on cultivated lands include management of soil structure, soil fertility and microbial activity, weeds, crop pests, and pollinators. The management tools range from mechanical to chemical to genetic. In industrialized country settings, where agriculture has focused on efficient output of marketed products, the emphasis of biophysical management for ES is often on mitigating "off-farm" ecosystem impacts from agriculture (e.g., agrochemical leaching and runoff, aerial pesticide drift, soil erosion).

Management of non-crop areas may focus on ES that link to agricultural production or ES that are valued for their own sake. Management for ES linked to agricultural production include habitat for native pollinators of crops, natural enemies of crop pests, and mitigation of ecosystem disservices, such as vegetative buffers to capture eroded soil before it enters waterways. Non-crop areas of farms may also be managed for directly valued ES, such as desirable wildlife or plant species, open-space views or carbon sequestration.

The economic trade-offs (or lack thereof) between marketed products and non-marketed ES determine the need for incentives to produce non-market ES from agriculture. Wossink and Swinton (this volume) present the production possibility frontier as a means of illustrating two-dimensional trade-offs. When the output of two products can be jointly increased from the same resource base (complementary products), the producer has a private incentive to produce the non-marketed ES. For example, a small area of land devoted to habitat for crop pollinators or natural enemies of crop pests might increase the value of crop production by more than the opportunity cost of the production foregone from not planting the habitat area in crops. However, when production of agricultural products and non-marketed ES have a win–lose trade-off relationship (competitive products), the profit-maximizing farmer has no private incentive to produce the non-marketed ES. To motivate such farmers, external incentives are required that suit the farmer and the farm setting.

5. Designing incentives for ES provision by agriculturalists

Designing incentives for voluntary ES provision by farmers is both important and difficult. Kroeger and Casey (2007-this volume) identify three broad areas: 1) direct business-to-business payments for environmental services, 2) government payment programs, and 3) markets for pollution mitigation ("cap and trade" markets). Noting that markets are human constructions, they survey the criteria for effective markets for ES, emphasizing the importance of measuring ES quality, accommodating spatial uniqueness ("non-fungibility") of many ES, and establishing clear property rights that allow exclusion of non-payers. Along the way, they highlight why government payment programs may be the most effective incentive mechanisms, given the particularities of most ES that agriculture can provide.

Although voluntary incentives programs all aim to make provision of non-marketed ES financially attractive, the financial outcomes are especially important for impoverished farmers. Both Pagiola et al. (2007-this volume) and Börner et al. (this issue) explore how government programs to induce ES provision affect outcomes for both ecosystem services and poverty alleviation. Pagiola et al. focus on efforts to restore degraded pastures in Nicaragua. They report on the use of government payments to encourage Nicaraguan farmers to incorporate tree planting and other practices to restore degraded pastures, conserve biodiversity, and sequester carbon. The evolving lessons highlight the distinctions between viable government payment programs and true business-to-business "payment for environmental services (PES)" programs. Börner et al. focus on protection of rainforest remnants in northeastern Brazil. Using a bioeconomic mathematical programming model, they explore several policy scenarios, identifying trade-offs among the objectives of food production, carbon sequestration, forest protection, and income generation.

The site specificity of many ES implies a need for incentive policies that account for both scale and configuration of ES provision. Goldman et al. (this volume) review appropriate spatial scales and configurations for a range of different ES types. They propose three policy alternatives to induce cooperation among different landowners, discussing the strengths and weaknesses of each policy based on property rights, likely ES outcomes, and the social fabric among the landowners involved. Parkhurst and Shogren (this volume) look specifically at the question, if government program incentives were

introduced for wildlife habitat conservation, could they be structured to induce landowners to set aside contiguous habitat parcels? Having designed an incentive policy to reward retirement of adjacent parcels, they test its performance using an experimental economic game to investigate whether land owners would cooperate and how readily they would learn the advantages of coordinating retirement of contiguous land parcels in a wildlife habitat conservation program.

6. Ecosystem services to and from agriculture: retrospect and prospect

6.1. What has been learned

Among managed ecosystems, agriculture offers special potential to diversify the suite of ecosystem services it generates. That potential arises from both its broad spatial extent and human management objectives focused on biotic productivity. At the same time, agriculture offers potential to diminish its reliance on external agrochemical inputs by reliance on enhanced management of supporting ecosystem services. Both of these potentials have been fueled by growing scientific understanding of how agricultural ecosystems function. With our growing grasp of how biogeochemical cycles and ecological interactions operate, it is becoming more feasible to manipulate ecosystem processes in subtler and more beneficial ways. For example, instead of heavy fertilizer applications, much of which will fail to benefit the targeted crop while contributing the greenhouse gas nitrous oxide to the atmosphere (McSwiney and Robertson, 2005), scientific knowledge is becoming available to nurture soil nitrogen fixation where and when needed while sequestering atmospheric carbon in soil and plants (Robertson and Grandy, 2006). Likewise, with emerging knowledge of how agricultural systems depend upon and contribute to biotic structure of the surrounding landscape, it is becoming possible to manipulate habitats in that landscape to enhance the productivity of agricultural systems (Landis et al., 2000).

Not only is scientific knowledge creating unimagined potential to manage agricultural systems for more diverse ecosystem services, but also scientific advances are leading to the recognition of new services. Today's explosion of research into moderating global warming follows on relatively recent establishment of how biogeochemical cycles affect climate. Recognition of how human actions affect climate has led to understanding not only of how the process occurs, but also of how it could be mitigated, including by ecosystem management. New ES that are unrecognized today will continue to be discovered.

Understanding how ecological functions generate ES is fundamental to management, but so too is understanding how humans perceive and value those ES. Over the past forty years, the rapid evolution of non-market valuation methods in environmental economics has contributed an important set of new tools to estimate the value to society of ES that lack markets. At the same time, a parallel literature has developed that identifies cost-effective policy designs to create flexible incentives to induce provision of ES by agricultural managers and others (Casey et al., 1999). Both of these developments depend on and build on scientific understanding of the linkages between agricultural management actions and ES.

6.2. Challenges ahead

Agricultural ES tend to be spatially and temporally heterogeneous. So tracking the performance of attempts to generate more diverse ES is costly (Dale and Polasky, this volume). Cost-effective monitoring via sensing technologies and other indicators shows promise, and presents a new set of challenges to estimate the patterns of correlation of a particular metric with the underlying ES of interest. But advances in this area are essential if the performance of management for enhanced ES provision is to be measured against private and public policy objectives.

Scientific knowledge of how agricultural ecosystems generate ES remains insufficient on many fronts, making improved understanding of this linkage a key part of the agricultural and ES research agenda. To pick one area, knowledge of soil microbial taxonomy and community functioning is especially incomplete, yet these communities play major roles in biogeochemical transformations that sustain ecosystem productivity (Robertson and Groffman, 2007). To pick another, astonishingly little is known about how the multitude of native species that provide pollination ES, nor about their effects on genetic evolution of pollination dependent plant species (NRC, 2006).

Cost-effective public policy incentives for farmers to provide ES from agriculture require estimates of how society can maximize returns on such investments. The current non-market valuation methods can provide estimates of the costs to farmers of supplying these ES as well as the amount that consumers would be willing to pay to receive them. Research is required both to design cost-effective incentives to provide ES and to measure which kinds of ES could provide the greatest overall welfare benefits to society (measured as economic surplus, the difference between consumer benefits and producer costs). As Kroeger and Casey (2007-this volume) observe, tailoring incentives for farmers to provide non-market ES in ways that succeed will require nuanced policies that can adapt to the scale and configuration of specialized socio-ecological settings as well as extant property rights regimes. And if generating effective incentives is challenging in a domestic setting, it is dauntingly difficult in an international context where nations compete to provide attractive trade and investment climates that may place little weight on the value of agricultural ecosystems and the services that they use and provide.

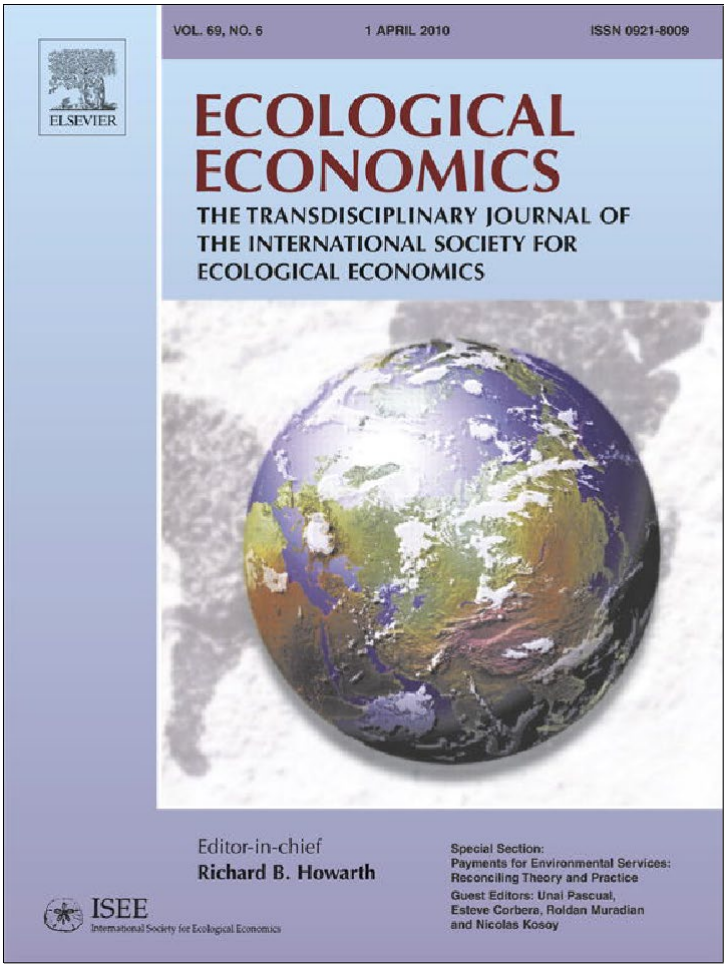
In sum, agricultural ecosystems offer newly recognized potential to deliver more diverse ecosystem services and mitigate the level of past ecosystem disservices. This special section of *Ecological Economics* conveys both how these are becoming possible and the challenges to science and public policy design of turning that potential into reality.

REFERENCES

Antle, J., Valdiva, R.O., 2006. Modeling the supply of ecosystem services from agriculture: a minimum data approach. Australian Journal of Agricultural and Resource Economics 50, 1–15.

Barbier, E., 1998. The economics of soil erosion: theory, methodology, and examples. In: Barbier, E. (Eds.), The Economics of Environment and Development: Selected Essays. Edward Elgar, Cheltenham, UK, pp. 281–307.

Baylis, K., Feather, P., Padgitt, M., Sandretto, C., 2002. Water-based recreational benefits of conservation programs: the case of conservation tillage on U.S. cropland. Review of Agricultural Economics 24, 384–393.
Bockstael, N.E., Freeman, A.M., Kopp, R.J., Portney, P.R., Smith, V.K., 2000. On measuring economic values for nature. Environmental Science and Technology 34 (8), 1384–1389.
Boyden, S., 1987. Western Civilization in Biological Perspective: Patterns in Biohistory. Oxford University Press, New York.
Brouwer, R., Slangen, L., 1998. Contingent valuation of the public benefits of agricultural wildlife management: the case of Dutchpeat meadow land. European Review of Agricultural Economics 25, 53–72.
Butler, L., Workman, J., 1993. Fee hunting in the Texas Trans Pecos area. Journal of Range Management 46, 38–42.
Caldeira, K., Morgan, M.G., Baldocchi, D., Brewer, P.G., Chen, C.T.A., Nabuurs, G.-J., Nakicenovic, N., Robertson, G.P., 2004. A portfolio of carbon management options. In: Field, C.B., Raupach, M.R. (Eds.), The Global Carbon Cycle. DC:Island Press, Washington, pp. 103–130.
Casey, F., Schmitz, A., Swinton, S., Zilberman, D., 1999. Flexible Incentives for the Adoption of Environmental Technologies in Agriculture. Kluwer Academic Publishers, Boston.
Chichilnisky, G., Heal, G., 1998. Economic returns from the biosphere. Nature 391 (6668), 629–630.
Coiner, C., Wu, J., Polasky, S., 2001. Economic and environmental implications of alternative landscape designs in the Walnut Creek Watershed of Iowa". Ecological Economics 38 (1), 119–139.
Colomboa, S., Calatrava-Requenaa, J., Hanley, N., 2006. Analysing the social benefits of soil conservation measures using stated preference methods. Ecological Economics 58 (4), 850–861.
Cooper, J., Osborn, C.T., 1998. The effect of rental rates on the extension of Conservation Reserve Program contracts American Journal of Agricultural Economics 80 (1), 184–194.
Costamagna, A.C., Landis, D.A., 2006. Predators exert top-down control of soybean aphid across a gradient of agricultural management systems. Ecological Applications 16, 1619–1628.
Dickie, M., 2003. Defensive behavior and damage cost methods. In: Champ, et al. (Eds.), A Primer on Nonmarket Valuation. Kluwer Academic Publishers, Boston MA, pp. 395–444.
Dillon, J.L., Anderson, J.R., 1990. The Analysis of Response in Crop and Livestock Production, 3rd ed. Pergamon, Oxford.
Farber, S., Costanza, R., Wilson, M., 2002. Economic and ecological concepts for valuing ecosystem services. Ecological Economics 41, 375–392.
Freeman, M., 2003. The Measurement of Environmental and Resource Values: Theory and Methods. Resources for the Future, Washington, DC.
Hansen, L., Feather, P., Shank, D., 1999. Valuation of agriculture's multi site environmental impacts: an application to pheasant hunting. Agricultural and Resource Economics Review 28 (2), 199–207.
Heal, G., 2000. Valuing ecosystem services. Ecosystems 3, 24–30.
Heinz Center, 2003. The state of the nation's ecosystems. H. John Heinz III Center for Science, Economics and the Environment. http://www.heinzctr.org/ecosystems/report.html.
Just, R., Antle, J., 1990. Interaction between agricultural and environmental policies: A conceptual framework. American Economic Review 80, 197–202.
Kroeger, T., Casey, F., 2007. An assessment of market-based approaches to providing ecosystem services on agricultural lands. Ecological Economics 64, 321–332 (this volume).
Landis, D.A., Wratten, S.D., Gurr, G.M., 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. Annual Review of Entomology 45, 175–201.
Liu, Y., Swinton, S.M., Miller, N.R., 2006. Is site-specific yield response consistent over time? Does it pay? American Journal of Agricultural Economics 88 (2), 471–483.
Lupi, F., Kaplowitz, M., Hoehn, J., 2002. The economic equivalency of drained and restored wetlands in Michigan. American Journal of Agricultural Economics 84, 1355–1361.
Mann, C.C., 2006. 1491: New Revelations of the Americas before Columbus. Knopf, New York.
McSwiney, C.P., Robertson, G.P., 2005. Nonlinear response of N_2O flux to incremental fertilizer addition in a continuous maize (*Zea mays* L.) cropping system. Global Change Biology 11, 1712–1719.
Mitchell, R.C., Carson, R.T., 1989. Using Surveys for Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington, DC.
Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.
National Research Council (NRC), 2000. Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution. National Academy Press, Washington, DC.
National Research Council (NRC), 2006. Status of Pollinators in North America. National Academies Press, Washington, DC.
Pagiola, S., Ramírez, E., Gobbi, J., de Haan, C., Ibrahim, M., Murgueitio, E., Ruíz, J., 2007. Paying for the environmental services of silvopastoral practices in Nicaragua. Ecological Economics 64, 374–385 (this volume).
Petrie, R., Taylor, L., 2007. "Estimating the Value of Water Use Permits: A Hedonic Approach Applied to Farmland in the Southeastern U.S.," with Laura Taylor, Land Economics, 84: August.
Rasker, R., Martin, M., Johnson, R., 1992. Economics: theory versus practice in wildlife management. Conservation Biology 6 (3), 338–349.
Ready, R., Berger, M.C., Blomquist, G.C., 1997. Measuring amenity benefits from farmland: hedonic pricing vs. contingent valuation. Growth and Change 28 (4), 438–458.
Ready, R., Abdalla, C., 2005. The amenity and disamenity impacts of agriculture: estimates from a hedonic pricing model. American Journal of Agricultural Economics 87 (2), 314–326.
Ricketts, T., Daily, G., Ehrlich, P., Michener, C., 2004. Economic value of tropical forest to coffee production. Proceedings of the National Academy of Science 101, 12579–12582.
Robertson, G.P., Grandy, A.S., 2006. Soil system management in temperate regions. In: Uphoff, N., Ball, A.S., Fernandes, E., Herren, H., Husson, O., Laing, M., Palm, C., Pretty, J., Sanchez, P., Snanginga, N., Thies, J. (Eds.), Biological Approaches to Sustainable Soil Systems. CRC Press, Boca Raton, FL, pp. 27–39.
Robertson, G.P., Groffman, P., 2007. Nitrogen transformations. In: Paul, E.A. (Eds.), Soil Microbiology, Ecology, and Biochemistry. Elsevier Academic Press, Oxford, UK, pp. 341–364.
Robertson, G.P., Burger, L.W., Kling, C.L., Lowrance, R., Mulla, D.J., 2007. New approaches to environmental management research at landscape and watershed scales. In: Schnepf, M., Cox, C. (Eds.), Managing Agricultural Landscapes for Environmental Quality. Soil and Water Conservation Society, Ankeny, IA, pp. 27–50.
Schlenker, W., Hanemann, W.M., Fisher, A.C., 2005. Will U.S. agriculture really benefit from global warming?: accounting for irrigation in the hedonic approach. American Economic Review 95 (1), 395–406.
Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., Schindler, D., Schlesinger, W.H., Simberloff, D., Swackhamer, D., 2001. Forecasting agriculturally driven global environmental change. Science 292, 281–284 (Apr 13, 2001).
USDA, 2007. Agriculture Secretary Mike Johanns addressed the problem of honeybee colony collapse disorder. USDA Satellite News Feed July 5, 2007. http://w3.usda.gov/agency/oc/bmtc/scripts.htm.
Whitmire, S.L., Hamilton, S.K., 2005. Rapid removal of nitrate and sulfate by freshwater wetland sediments. Journal of Environmental Quality 34, 2062–2071.
Wood, S., Sebastian, K., Scherr, S.J., 2001. Pilot Analysis of Global Ecosystems: Agroecosystems. International Food Policy Research Institute and World Resources Institute, Washington, DC. http://www.ifpri.org/pubs/books/page.htm.



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Ecosystem services: From eye-opening metaphor to complexity blinder

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abstract

What started as a humble metaphor to help us think about our relation to nature has become integral to how we are addressing the future of humanity and the course of biological evolution. The metaphor of nature as a stock that provides a flow of services is insufficient for the difficulties we are in or the task ahead. Indeed, combined with the mistaken presumption that we can analyze a global problem within a partial equilibrium economic framework and reach a new economy project-by-project without major institutional change, the simplicity of the stock-flow framework blinds us to the complexity of the human predicament. The ecosystem services approach can be a part of a larger solution, but its dominance in our characterization of our situation and the solution is blinding us to the ecological, economic, and political complexities of the challenges we actually face.

In an effort to communicate the delusion of economic growth and the essence of environmental sustainability, ecological economists helped advance the metaphor of nature as a fixed stock of capital that can sustain a limited flow of ecosystem services (Costanza and Daly, 1992; Jansson et al., 1994; Prugh et al., 1999). Conservation biologists, joining with environmental economists, also saw this metaphor as a way to help describe our relation to nature and build support for conservation (Daily, 1997; Daily et al., 2000). There was a strong sense that, however revolting for those who intrinsically value nature, the use of market metaphors was necessary to awaken a public deeply embedded in a global economy and distant from natural processes. The eye-opening metaphor, however, soon rose to become a central framework for scientifically assessing ecosystem change (Millennium Ecosystem Assessment, 2003, 2005). The Millennium Assessment, in turn, led to calls for ecologists to direct their research toward developing stronger theory and empirical documentation of how the stock of nature delivers flows of services (Carpenter et al., 2006; Armsworth et al., 2007).

The transition from metaphor to scientific framework was complemented by the search for innovative approaches to reduce environmental degradation in developing countries. Economic services became a paradigm for thinking about development and environment and for designing environmental management programs (Pagiola et al., 2004; Ranganathan et al., 2008; UNEP, 2008; World Bank, 2009). Simultaneously, with the belief in market solutions heavily swaying the national and international politics, plans for capping greenhouse gases and issuing tradable permits initiated a massive market for carbon offsets through the sequestration of carbon in forests and other biomass on a global scale. Many of the same economists and ecologists working on the initial communication and subsequent scientific front participated in the discourse on the possibilities of markets for environmental services. The transition from communication metaphor to scientific and developmental model paralleled an exponential rise in the use of the term "ecosystem services" in academic journals (Fisher et al., 2009).

Over a period of about 15 years, an eye-opening metaphor intended to awaken society to think more deeply about the importance of nature and its destruction through excessive energy and material consumption transformed into a dominant model for environmental policy and management in developing countries and for the globe as a whole. There is now a thriving industry of professionals providing advice on ecosystem services. The metaphor's ties to the problems of continued global economic growth have largely been broken. Indeed, through carbon offsets and optimizing the use of ecosystem services in poor countries, the delusion of continuing consumption along its old path in the rich countries is being sustained.

In this paper, I make three critical points. First, while the stock-flow framework underlying the concept of ecosystem services conceptually links ecological and economic systems, this framework only utilizes one of the many ways ecologists understand ecosystems, leaving out many of the other frameworks. While many ecologists have noted the "limits" of ecology for defining ecosystem services, valuing them, and designing payments for ecosystem services (PES) and related projects, the problem is really with the limits of stock-flow models (Palmer and Filoso, 2009). Ecologists understand the complexity of nature using many different frameworks, each of which helps them understand different aspects of natural systems. By

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focusing on the stock-flow framework, the valuation of ecosystem services and implementation of PES and related projects will have unintended consequences that could have been better foreseen and avoided or adapted to by using additional patterns of thinking. The ecosystem service metaphor now blinds us to the complexity of natural systems, the ecological knowledge available to work with that complexity, and the amount of effort, or transactions costs, necessary to seriously and effectively engage with ecosystem management.

Second, the theoretical literature on ecosystem services, their valuation, and payments for ecosystem services have been framed within a partial equilibrium framework that assumes "other things are equal" (*ceteris paribus*). Similarly, the implementation of the concept of ecosystem services has been on a project-by-project basis within existing national and global institutional structures. Yet the driving motivation, from the initial use of the ecosystem metaphor to the implementation of PES projects, has been to instigate significant institutional and consequent economic change in response to what are perceived to be very serious environmental problems generated by the economy we have. Using a general equilibrium framework, I show that the more significant one thinks our environmental problems are, the more inappropriate has been the partial equilibrium and project-by-project approach for utilizing the concept of ecosystem services.

Third, we need new global institutions and far more resources devoted to environmental governance. The flurry of enthusiasm for optimizing the economy by including ecosystem services has blinded us to the more important question of how we are going to make the substantial institutional changes to significantly reduce human pressure on ecosystems, especially by the rich, and to adapt to and work effectively with the rapid ecosystem changes being driven by existing and foreseeable climate dynamics.

1. The richness of the ecological sciences

Today's ecology does not have the predictive capacity to identify the sustainable use of any particular ecosystem service, to describe the tradeoffs between uses of ecosystem services, and to be able to do this, furthermore, not only in particular contexts but in the face of ecosystem change from climate and other drivers (Norgaard, 2008a; Palmer and Filoso, 2009). Ecologists, even those supportive of the concept of ecosystem services, frequently characterize the ecology as weak and not sufficiently predictive to support the application of the concept (Daily et al., 2000; Carpenter et al., 2006; Armsworth et al., 2007). The hope that ecology will have this predictive ability is pretentious, denies the many other ways that ecologists actually do understand ecosystems that expose the pretentiousness, and is dangerous that the pretense of eventually knowing forecloses our use of the diversity of ways of knowing the ecological sciences that we already have and should continue to broadly support.

The Millennium Ecosystem Assessment (MA) provides critically important insights into this broad concern. The MA was a five-year effort by some 1400 scientists from around the world that assessed the state of ecosystem services, the drivers of ecosystem change, and the implications for human well-being (Millennium Ecosystem Assessment, 2005). In the process of preparing to undertake the MA, general frameworks describing the relationship between ecosystems and human well-being were discussed. A team of over fifty scholars and practitioners settled on and elaborated a dynamic, multi-scale systems view (Fig. 1) within which ecosystems were thought of as natural capital that provided ecosystem services, a stock-flow model (Millennium Ecosystem Assessment, 2003). Note that Fig. 1 effectively incorporates how PES is expected to work. By paying for the services represented by the vertical arrow in the lower left of Fig. 1, those who manage ecosystems will have an incentive to protect the ecological capital represented by the box on the lower left that generates the services. Doing this entails combating or counteracting the direct drivers of change to the ecosystems indicated in the box on the lower right.

The MA framework, however, also reminds us that there is a larger system of concern, that there are different goals we are trying to attain, and that ecological and social phenomena happen on multiple scales and over different time periods that also match with the scalars of different social institutions (Wilson et al., 1999; Folke et al., 2005). Looking at the box on the lower right, an important point becomes immediately clear. While landowners or managers can influence some direct drivers of change listed in this box such as "harvest and resource consumption" and "technological adaptation and use", they have much less influence over species introductions and removals and no influence over climate change or "natural, physical and biological drivers" such as evolution or volcanoes. Similarly, while local institutions may be adapted to better accommodate individual ecosystem service projects, national and global institutions are taken as given.

The stock-flow framework illustrated in Fig. 1 helped the participants in the Millennium Ecosystem Assessment identify critical questions, but the model proved far less useful in the assessment than expected. Fortunately, the assessment was guided but not constrained by this particular framework. The following difficulties arose.

First, certainly the greatest difficulty of using the MA general framework was that very little ecological research has been conducted within an ecosystem service framework. Rather, ecologists think in terms of population dynamics, food webs, energy flows, interactive behaviors, biogeochemical cycles, spatial organization across landscapes, and co-evolutionary processes, among others. Furthermore, most ecological researches do not address human well-being. Similarly, most of the researches on human behavior and social systems neither fit a stock-flow model nor connect to the ecosystem services or to how social systems drive ecosystems. In short, the literatures representing our scientific understanding do not fit neatly into the ecosystem service framework, or even provide information appropriate for any particular quadrant of the MA model.

This is not simply a problem of natural scientists ignoring the social and social scientists ignoring the natural. The major issue is that only some of the ways in which ecologists think, for example food webs or energetics models, can be interpreted as stock-flow models that fit the lower left quadrant of Fig. 1. Most of the ways ecologists think, however, do not fit the stock-flow framework. Evolutionary and behavioral ecology, for example, provide insights into the nature and management of ecosystems, but these frameworks do not reduce to a stock-flow model. Indeed, to the extent that these other frameworks do provide insights, the insights are cautionary rather than complementary to the mechanistic prediction and control facilitated by stock-flow models. Similarly, much of the social science literature cautions against the dominance of the framework of society as individuals linked through markets rather than complements its use.

Scientists see different aspects of complex systems through different models (Norgaard and Baer, 2005a,b) most of which do not fit within a stock-flow meta-framework underlying the concept of ecosystem services. While many ecologists have described the ecology as being very weak, my concern is that ecology in fact is very rich and that much of the ecology we know does not support the ecosystem service perspective. Rather than jettison the multiple patterns of reasoning in ecology and emphasizing stock-flow models, we should be using the richness of ecological ways of knowing to help us see the poverty of thinking predominantly in stock-flow terms. An emphasis on interpreting and responding through a stock-flow framework sets other patterns of understanding off to the side and increases the likelihood of making serious mistakes. The ecosystem service perspective suggests we can achieve gains by further fine-tuning along our current path while the heterogeneity of ecological knowledge questions the current course.

Fully thinking through ecosystem service projects from multiple perspectives means society must establish standing institutional mechanisms for bringing out, sorting through, and using complex, contradictory insights in environmental management. Many more aspects of the environment must be monitored to support multiple

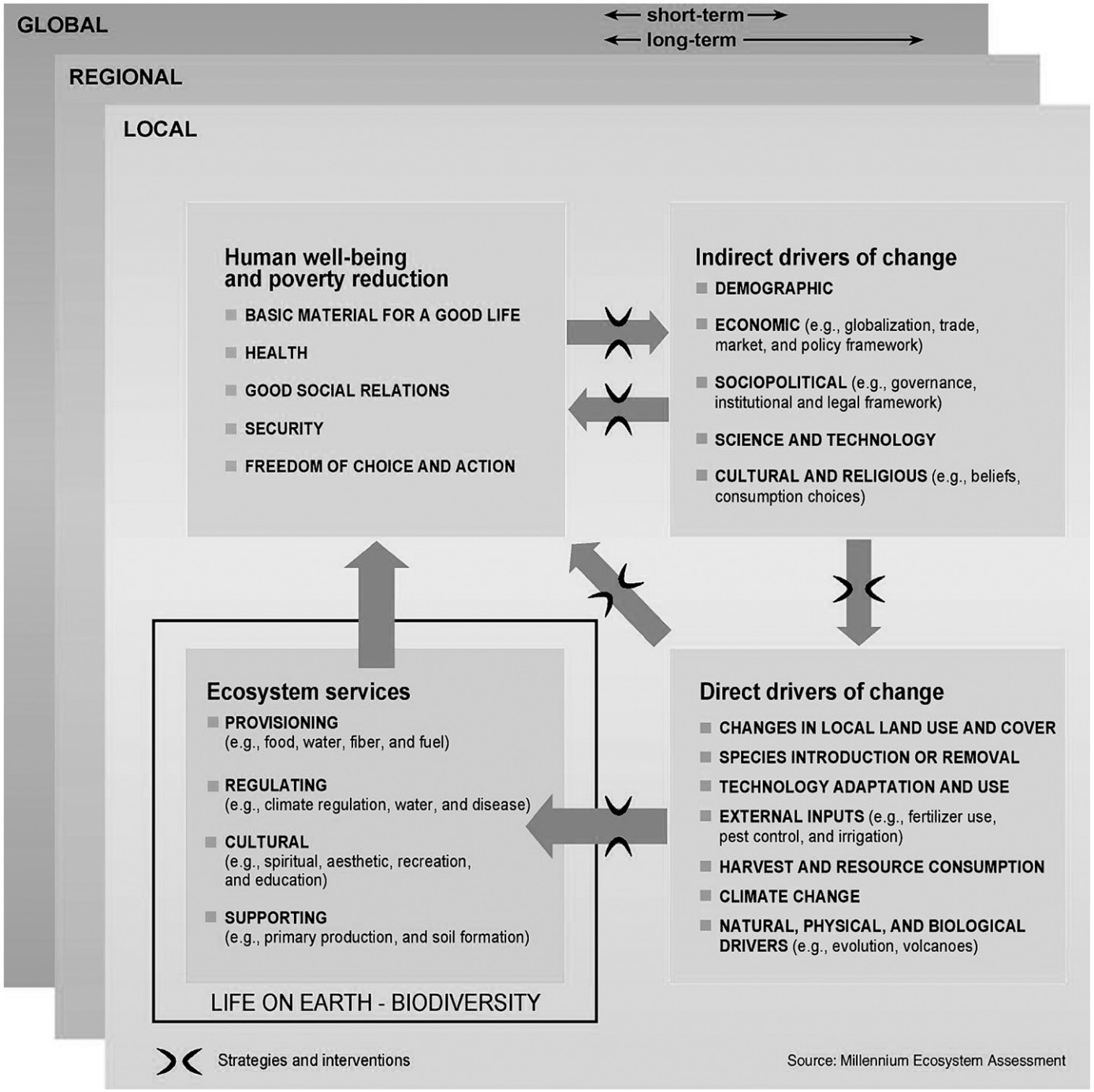

Fig. 1. The Millennium Ecosystem Assessment adapted an ecosystem service framework through which to assess the literature on ecosystem transformation and human well-being.

ways of understanding ecological systems. All of this entails high transaction costs, the bane of fine-tuning systems, whether through markets or other institutions. If the transaction costs were not high, market failure would not be a problem (Coase, 1960). We should always be open to ways of engaging with each other and nature that have lower transaction costs, assuming away the complexity of socio-ecological systems and the diverse ways we understand that complexity will surely lead to lower transaction costs, but it will also lead to ineffective to disastrous outcomes.

Second, in the process of assessing the global significance of ecosystems and their services, participants in the MA were frustrated by two problems. What they had learned in one ecosystem did not easily translate to another ecosystem, even if it seemed to be a quite similar ecosystem. Rather, the literature across seemingly similar ecosystems indicated many more differences than expected, many of them apparently due to different histories of human influence. Other scholars (Daily et al., 2000; Muradian et al., 2010—this issue; Pascual, et al, 2010—this issue; Vatn, 2010—this issue) have noted the contextuality of ecosystem service projects, and how each must be, and to some extent are, designed on their own terms. A closely related problem, however, was that the quality of the background data on key variables such as climate and soil conditions were insufficient to match knowledge gained in one area to another (Biggs et al., 2009). The implication for application of ecosystem service projects is that the relationships between services and ecosystem states need to be determined for each location to assure a realistic connection between payments, services, and approaches to

ecosystem management and conservation (National Research Council, 2007). Furthermore, as the pace of ecosystem change speeds up, ecosystem service projects will have to be followed closely and adjusted frequently. This is an additional reason why the transaction costs for well-designed and well-maintained ecosystem service projects will be high.

Third, participants in the MA discovered that they could say very little about how the provisioning of one service affects the availability of other services or the state of the ecosystem over the medium to long-term. Relationships between ecosystem services as well as the relationships between levels of ecosystem services and the long-term condition of ecosystems are only rarely known. A critical aspect of this knowledge deficit is that the MA scientists were not able to document there ever having been anything approaching a consensus among ecologists that a population was about to crash or that an ecosystem was about to transform from one state to another. Individual ecologists have predicted crashes and state transitions and been proven correct after the fact, but other ecologists had argued at the time to the contrary. Ecologists have only recently advocated developing a database that might assist in developing improved predictive capability with respect to dire changes in populations and ecosystems (Walker and Meyers, 2003). This means that science is far from being able to predict smaller shifts in the delivery of services. This means that research needs to be conducted site by site to understand underlying relationships and continuous monitoring will be necessary to assure that our ecological understanding is correct and adapts as conditions change. And, of course, ecosystem service projects themselves must change as the underlying ecological understanding changes. Again, this is another reason why the transaction costs of well-designed and well-maintained ecosystem service projects will be high.

It is interesting to note that implementing the concept of ecosystem services is primarily being advocated for developing countries while in the developed countries, with a few exceptions, it is much less frequently advocated, let alone implemented. This is curious given that the environmental sciences are far better developed in the rich countries. Similarly, monitoring and applied research are far more extensive in the developed nations. Furthermore, the techniques of environmental valuation originated and are probably most meaningful in developed economies since rich nations are already more monetized. In the developed world where markets flourish, there can be better institutional support for ecosystem service projects. Let me suggest that a significant reason why there are so few ecosystem service projects in the developed world is because scientific disagreement is also rampant where ecological understanding is deeper, *i.e.* heterogeneous. Ecosystem service valuation is not being advocated to resolve California's many environmental problems associated with conflicts over economic development and water scarcity because the controversies stemming from the diversity of ecological ways of knowing make almost any such approach impossible. Furthermore, as environmental scientists increasingly incorporate climate change into their conceptual thinking and applied research on water management and economic development in California, they become less confident of their ability to predict and manage and thereby satisfy expectations for attaining any particular mix of development and environmental goals (Healy et al., 2008; Norgaard et al., 2009). We also know that new, more sustainable, solutions in California will require significant reallocations of property rights between historic users and new public interests (Hanemann and Dyckman, 2009).

As we enter a century or two of rapid ecological change, property rights will need to be redefined and reallocated more frequently to meet social goals most effectively. We are entering a period when the relative advantage of property and markets are probably lower than they have been. In any case, we should expect adaptive governance in times of ecosystem change to entail more transaction costs than more stable governance during times of less change.

The Millennium Ecosystem Assessment provides interesting insights on the issues of equity as well. The MA says very little about the monetary values much less about whether users should pay for ecosystem services or providers should compensate users for the loss of services. This was partly because the valuation literature was not assessed; it was not deemed part of the study from the beginning. Yet at various times in the process of conducting the MA, being able to put monetary values on ecosystem services would have been helpful, for example, in order to aggregate different services across regions or between types. When the possible use of monetary values arose, however, there was typically a modest howl of protest by some of the many participants from developing nations. They expressed concern that the dollars of rich, northern ecotourists, or even the urban rich in developing countries, would dominate and outweigh the values of local poor people who needed access to ecosystems to meet basic needs. Similarly, MA participants recognized that we have the goal of sustaining ecosystem services so that future generations will not suffer. Future generations, however, are not directly in markets and affecting prices, are not affecting the behavior of current people sufficiently if we think ecosystem conservation is insufficient, or available to answer contingent valuation questionnaires (Bromley, 1989; Howarth and Norgaard, 1992). For these reasons, environmental valuation as currently practiced was generally deemed inappropriate.

The frameworks of ecology that can be reduced to stock-flow models will no doubt receive more research funding and scholarly attention. These ways of knowing within ecology will likely improve faster than they would have otherwise while other ways of knowing will wane. The enterprise of science has always coevolved with dominant forms of social organization, available technologies, and the range of social values as well as with nature and environmental problems as perceived at the time (Norgaard, 1994). Of course we want science to advance to support human needs. But we also know that nuclear physics has had a disproportionate share of the scientific budget because of its relation to the need for defense. Environmental toxicology arose as a field largely to establish health thresholds for pollutants. But the thresholds were established independently without considering other pollutants and as if people's ages, nutritional status, or other diseases did not matter (Jasanoff, 1990). The science was distorted because of the need for simple, enforceable, regulatory standards. Scientists in the U.S. Forest Service rationalized how excessive logging rates could be sustained by over-estimating growth rates because public policy mandated sustainability (Hirt, 1994). Ecology will coevolve with the dominance of market thinking and how this dominance affects whose needs are expressed. We should be aware, however, that this will likely lead to dominant ways of thinking in ecology that could substantially reduce scientific and public understanding of the true complexities of ecosystems that will lead to narrow management and future crises. A stronger, broader awareness of how science coevolves in society could help science coevolve more richly to benefit a broader constituency including future generations.

The arguments in favor of sustaining the richness of ecological understanding parallel those for methodological pluralism in ecological economics (Norgaard, 1989; Zellmer et al., 2006; Farrell et al., 2009). There are strong interests that benefit from the status quo who do not want society to dwell on how the dominance of market thinking has transformed society in ways that do not benefit all (Polanyi, 1944). We can expect parallel interests to arise that will favor limited ways of ecological thinking, much as powerful economic interests historically promoted chemical over biological understandings of soil. Grappling with the complexity of combined socio-ecological systems will not be easy, but merely hoping or imagining that they can be reduced, with transaction costs diminishing in the process, would be like putting on blinders.

2. Ecosystem services and sustainability in a general equilibrium framework

The dominant literature on ecosystem services and their valuation in practice follow the tradition of project analysis where the analyst

assumes "all other things are held equal" (*ceteris paribus*) and then proceeds within a partial equilibrium framework. Setting the boundaries of the analysis as a project and doing analyses of ecosystem services project-by-project assuming that the economy as a whole is not affected by the projects might have made sense historically. Yet even under the historic conditions in which project analysis evolved, one could surely argue that water projects, for example, entailed plans for multiple dams along whole river systems and sweeping changes in the use of land with the explicit intention of transforming the regional economy.

It is just such a sweeping economic transformation that is needed now and should be done globally. We are in a global ecological–economic crisis that threatens human well-being through climate change, ecosystem degradation, and species loss driven by our economic choices. Marginal adjustments in the economy will not suffice. Rather we are trying to understand the appropriate speed and extent of what will likely be a significant economic transition around new energy technologies and institutions affecting how we interact with nature, especially biocarbon stocks and flows. The dynamics of ecosystems and the future of biodiversity and their values will be mischaracterized if we simply think of this transition in terms of individual projects from within the economy we have.

At the project level, holding other things, equal implies that the analyst accepts existing regional to global institutions, whether they support sustainability or not. If institutions supported sustainability overall, project structured around the concept of ecosystem services could fine-tune the market to correct a particular inefficiency. But if the broader institutions supporting sustainability are not in place, local fine-tuning will have a little effect. We can move to this broader perspective through general equilibrium analysis. Using an overlapping generations, general equilibrium model, Howarth and Norgaard (1992) found that shifting to a sustainable development path results in both environmental services being more highly valued and the rate of interest being lower. Thus with sustainability, the marginal value of an ecosystem is higher and future values are discounted less because of the lower rate of interest than in an unsustainable economy. Current valuation methods only help us "see" ecosystem services and their values from within our unsustainable economy. We are "seeing" them, and working with them, less favorably than we would be in the economy we are trying to reach. Ironically, we are trying to reach a sustainable economy by invoking the value of ecosystem services but doing so less effectively than needed because our point of view is the economy we have rather than the economy we are trying to attain.

This simple argument is graphically presented in Fig. 2 where we have ecosystem services consumed by the current generation on the *X*-axis and ecosystem services consumed by future generations on the *Y*-axis. Every point on the possibility frontier is efficient in that neither current nor future generations can become better off without hurting the other. At every point on the possibility frontier, there is a different set of efficient prices, including an interest rate that is directly represented by the slope of the frontier showing how ecosystem services are weighted between generations.

Being at different points on the frontier requires different distributions of property rights, regulations, obligations, and other institutions that set the underlying rules of who has what and how individual choices are made in markets. The public choice of where to be on the possibility frontier requires a criterion from outside of economics that economists have referred to as a "social welfare function" that generates curves of equal social well-being analogous to preference curves for individuals choosing between two goods. Since the figure is already pretty busy, the different levels of social welfare are not portrayed. The essential point is that better markets can only move society toward the frontier while social preferences guide society to a point on the frontier. Specific institutions are necessary to reach any particular point and keep the economy at that point rather than being at another on the frontier. Thus the underlying

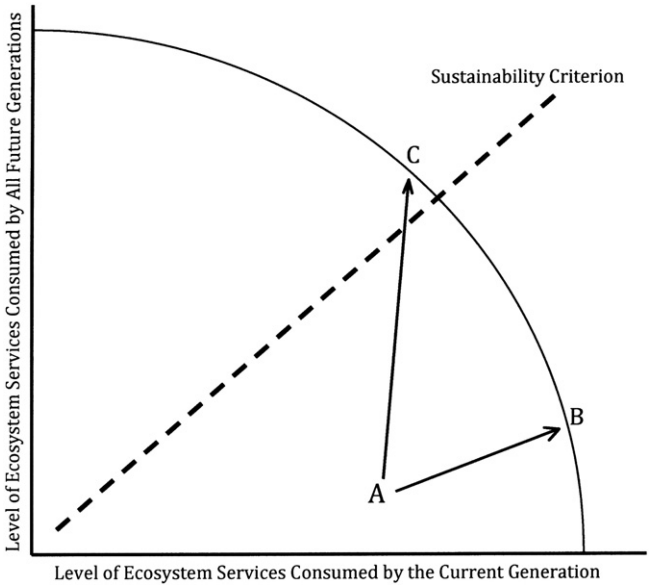

Fig. 2. Unless the overall institutional conditions are in place to support sustainability, incorporating ecosystem services into the economy project-by-project will take the economy to the efficient point B, which is unsustainable, rather than C, which is sustainable.

institutions that help us express our care across generations determine prices and the rate of interest.

Let me assert that the economy is positioned at point A that is inefficient because ecosystem services are not included in the market to the extent that they can be given transaction costs. Within the economy we have, *i.e.* given the existing distribution of rights between present and future generations, internalizing the externalities through PES projects, or including the values of ecosystem services in public projects, might move the economy to a position such as point B where both current and future generations are better off (at least for the medium run) yet the economy is not sustainable.

Note, however, that Fig. 2 also includes a (strong) sustainability criterion above which future generations are able to consume as many or more ecosystem services as current generations. When the economy is operating below the sustainability criterion, current generations are consuming ecosystem services at a rate that is depleting natural capital. Above the sustainability criterion, investments are being made in natural capital. Our concern, documented by the Millennium Ecosystem Assessment (2005), is that our existing environmental governance structure puts the economy at a point such as A, while a sustainable point such as point C is preferred. Though one cannot directly compare values between points on the curve without knowing what prices maintain the different points, the findings of Howarth and Norgaard (1992), and simple logic, indicate that ecosystem services will be more highly valued in a society that sustains them and that the interest rate will be lower, as shown, at point C as compared to point B.

I argue that this underestimation of the importance and value of ecosystem services is further compounded by the rapid transition in scientific understanding, reinforced by the emergence of new evidence of climate change, in the last decade. This transition indicates we are trading off more in future well-being through current consumption than we had thought we were. We have been overly optimistic about the possibilities of new technologies releasing new, or substituting for existing, environmental services and we have thus been consuming natural capital rather than simply living off of services (Millennium Ecosystem Assessment, 2005; Hansen et al., 2008; Barnosky, 2009). I illustrate this in Fig. 3 with an "actual" possibility frontier that is well inward of the "mistaken" frontier we have thought existed. Note that the actual frontier is within the mistaken frontier both because our scientific understanding indicates that the tradeoff between current and future

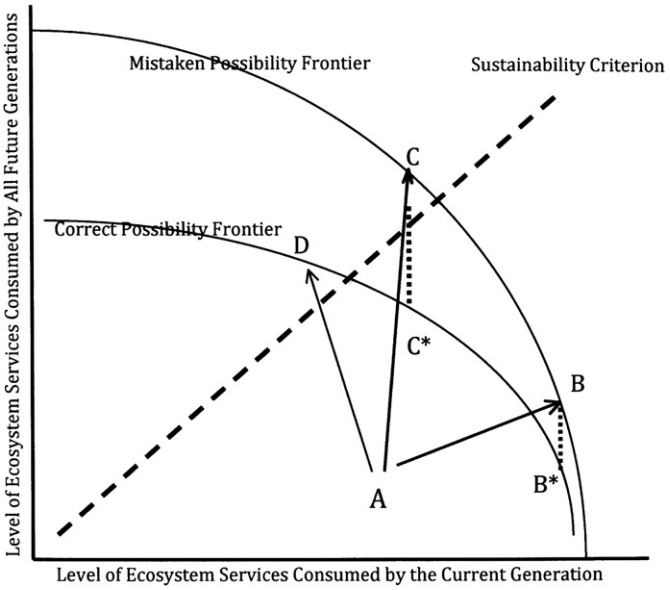

Fig. 3. Given recent climate science and empirical evidence, the possibility frontier has moved inward significantly such that society now needs to move to a point such as point D. This would entail reducing the consumption of ecosystem services by the current generation. Note that attempting to move to point B or C would likely take society to point B* or C*.

consumption is different than previously thought and because past consumption of ecosystem services, mostly by the rich, depleted the natural stock and reduced future options (the two-period, comparative static, illustration emphasizing flows veils the changes in stocks over time illustrated in the work of Howarth and Norgaard, 1992).

The difference between the actual and mistaken frontiers helps us see several important issues. First, trying to move to point B on the premises of the mistaken frontier could leave society at point B* on the actual frontier where future generations are quite possibly worse off than they were at the beginning point A. Similarly, trying to move to point C would actually leave future generations at point C*. The difference between the possibility curves illustrates a substantial correction in our knowledge that also indicates we need a substantial correction in our actions. Given the actual frontier and the preference for sustainability, society needs to move to a position such as point D. Now we see how having fewer possibilities for future generations should affect our choices today, *i.e.* the current generation should consume fewer ecosystem services so that future generations can consume at least as many services as current generations. Indeed, many climate scientists (Mastrandrea and Schneider, 2004; Baer and Mastrandrea, 2006; Hansen et al., 2008) are advocating much more aggressive climate mitigation than most economists (Nordhaus, 2008) or even economists making more effort to address risk and future people (Stern, 2007) have been talking about because of the new understanding of even greater risks of disaster identified by the most recent climate science and emerging evidence. The key point here is that, if we think that our environmental problems are serious, we should not simply be thinking in terms of fine-tuning the direction of development. Rather, we need to completely reassess how we can quickly move to something closer to the path we would have chosen historically had we known earlier what we know now.

In this sense, the IPCC scenarios derived in the early mid 1990s and only now being updated and used in the assessments of possible climate futures until recently do not take the gravity of the new scientific understanding and empirical evidence of the past decade seriously. Rather than presenting alternative transitions to something closer to the path we would have been on if we had been more knowledgeable, the scenarios simply present alternative paths from where our incomplete knowledge brought us. This is comparable to building a house, realizing along the way that the construction project had gone way off course, and then, rather than undoing the mistakes, simply proceeding on top of the mistakes. In Fig. 3, this is comparable to implementing ecosystem service projects as if the prices and behavior observed in a state of delusion at point A were approximately correct rather than totally wrong. This is my sense of what is happening overall. We are ignoring that we want to move to a point such as D where, once fully realized, prices and behavior will be different than at point A, B, or C (the latter two not actually being possible, leaving society at point B* or C*).

Moving from point A to point D will require much stronger governance regimes, from local to global, to monitor and manage environmental services than the ones that have allowed ecosystem deterioration. To reach stronger governance at the much needed global level, the rich will have to acknowledge that the reduction in options for future generations has resulted largely from their activities (Srinivasan et al., 2008), and it is the rich by any reasonable criterion of justice who should be cutting back on their use of environmental services so that we can move to point D. In short, we need a major new global contract between rich nations and poor and between the rich and poor within nations that revamps our relation to nature and the future. To reach that contract, society will have to acknowledge the inequities of past development and environmental change (Baer et al., 2008). Once such institutions are in place, project building on the concept of ecosystem services could then help fine-tune economies to move to the possibilities frontier at point D. In short, it is point D that should provide the design criteria for significant institutional change and, when these changes are in place, the valuation of and payments for ecosystem services can be used for fine-tuning.

Many thoughtful scholars writing on ecosystem services recognize the importance of the institutional context (Grieg-Gran, et al., 2005; Pagiola et al., 2005; Lant, Ruhl and Kraft, 2008; Vatn, 2009, 2010—this issue). The guides to ecosystem service management pay considerable attention to local institutions and questions of equity (Ranganathan et al., 2008; UNEP, 2008). Some scholars are documenting how the dominance of partial equilibrium market analysis in ecosystem service projects has blinded us to how policies will actually turn out, especially with respect to equity, when implemented (McAfee, 1999; Corbera et al., 2007; Shapiro and McAfee, 2008). Nevertheless, few explore the problems with respect to humanity's shriveled ecological options and gross social injustices as starkly or as globally as I have. Yet, none who promotes the concept of ecosystem services, whether in the scientific literature or through practice, argues, to my knowledge, that our environmental problems are few, small and local, that the global institutions needed for sustainability are largely in place, and that the new climate and ecosystem change science is neither important nor alerting us to more rapid change ahead.

We should not let the intricacies of partial equilibrium analysis and project-by-project practice blind us to this bigger picture. Indeed, ecological economists should be acutely aware of and helping policy-makers and the public understand how economists began to uncover this larger picture starting with Cournot (1838), then fully elaborated it over the next century, and then systematically rationalized away its relevance to public understanding and application to policy analysis, ending with Harberger (1971).

Taking off the blinders of partial equilibrium analysis and incorporating the insights from a general equilibrium framework into the necessary politics, local to global, to bring about systemic change will be difficult. The available data, both ecological and economic, are concentrated around point A. Empiricists will plead that we must look for solutions under this lamppost where the light shines. Existing economic interests will support this realist claim as objective. The world we know can be used to help ground macro simulations of the economy and its possible other states in order to shed light on how we can get to where we want to go. The major changes need to be accomplished at the level of national and global politics, not project analysis. Nevertheless,

simulations rooted in the general equilibrium theory of the economy that we want to have could be undertaken by development and environment agencies, from international to local, to help guide individual project analysis and design and update them periodically as appropriate.

3. Becoming serious about environmental governance

The multiple ways ecologists understand aspects of ecological complexity highlighted in Section 1 raise questions about how ecology is being skewed to inform markets rather than being drawn on more fully to inform governance. The general equilibrium framework presented in Section 2 helps us see the relation between markets, governing institutions and the goal of sustainability. We have experienced three decades of free market fundamentalism during which public understanding has been reduced to ideology extolling markets while government agencies have been denigrated and their budgets shrunk. During this period, markets have been guided and regulated more by internal power and market mythology, less through democratic institutions and informed reason, compared to more pragmatic times following the Great Depression and World War II. The shift toward thinking of ecosystems as having services and of conservation through payments for ecosystem services rose to dominance during this period of faith in markets with little public guidance and weakened regulation.

The global economic crisis that arose in 2008 as the U.S. mortgage market bubble burst has reawakened economists and the public at large to how markets depend on effective institutions. This reawakening can, in turn, affect how we think about institutions and markets more broadly for environmental governance. Let me identify and briefly describe some key areas where more serious thinking is needed, both within ecological economics and beyond.

First, economic thought, the ways it has linked with other ways of thinking, and its application in practice have to be understood in historical context. Economics changes with the times as it changes the times; it influences reality, especially the immediate reality within which we live, while broader real forces must also be addressed. We are at a time when the reality of climate change and ecosystem transformation could affect economic thinking significantly. Many ecological economists have been helping keep economics in historical perspective (Martinez-Alier and Schlupman, 1987, Kosoy and Corbera, 2010—this issue), and we need to sustain such efforts. In practice, ecological economists need to resist using current dominate ways of thinking to reach short-run, partial solutions and favor both emerging and the multiplicity of less dominant ways of analyzing problems to promote a rich understanding of the complexities of society and nature.

Second, there needs to be a serious enrichment in the understanding of economists, the scholarly community as a whole, policy-makers, and the public about the interplay between markets and institutions. While institutional economists are very well represented within ecological economics and provide excellent input (see, for example, Söderbaum, 2000; Vatn, 2005; Bromley, 2007), the perspective that markets and institutions, across scales, work together still needs to become more integral for more ecological economists. We also need to strive further to extend the public's understanding of how markets and institutions work together. As the new institutional economists stress, we should be focusing on the combination of markets and institutions that best reach social goals given transaction costs (Coase, 1937; Ostrom, 1990; Williamson, 1996). Taking such a combined view is not easy, but it should be the perspective when framing an environmental issue, designing environmental policy, and assessing analytical or actual outcomes. While we find a stress on transaction costs and institutions in ecological economic analyses (see, for example, Haddad, 2000), this approach needs to be more integral to ecological economics and this framing needs to be spread more broadly.

While we should seek the combination of institutions and markets for reaching social goals with the lowest transaction costs, surely the transaction costs of living sustainably will be considerably higher than we have become accustomed to within the social organization, approaches to understanding, and deployment of technologies that have facilitated high levels of individual and corporate choice with respect to energy and material extraction and consumption, choices that have been destroying the natural system we depend on in common. Sustainability is difficult, *i.e.* transaction costs will be high; working with rapidly changing ecosystems will entail even higher transaction costs and continually rethinking property rights in light of changing ecological dynamics, changing ecological knowledge, and changing social goals as new problems arise.

Third, whatever the appropriate institutional mix of government and markets, environmental governance must be informed in a balanced way, as fully as transaction costs constraints allow, to be effective. Environmental governance can no more succeed around the metaphor of ecosystem services apart from the richness of ecological thinking than mortgage markets can succeed on the myth that housing prices will always rise. The more we learn about the complexity of environmental systems and how phenomena interact across scales, the more we realize that compartmentalized science and specialization in social organization have increased transaction costs and facilitated our unsustainable economy. Somehow, we need to make a significant transition toward richer ways of understanding and governing. The current evidence indicates these ways will be more collective, participatory, and discursive forms of learning, knowing, and governing (Dryzek, 1987; Wilson and Howarth, 2002; Zellmer et al., 2006; Norgaard, 2008b; Jäger, 2009). This is a major challenge that will entail considerable social reorganization and far more collective human effort going into knowing and understanding (Adger and Jordan, 2009). Much as Vatn (2009a) argues that valuation needs to be understood as being integral with the institutional contexts of valuation, we need to think of knowledge and valuation together in a new systemic institutional context to effect change (Nowotny et al., 2001).

Fourth, the current political acceptance of a cap and trade system as the primary approach to managing carbon and other greenhouse gases to mitigate climate change carries with it the presumption that we can monitor and manage to maintain existing net biocarbon stocks throughout the biosphere and, as offsets to fossil hydrocarbon emissions, invest in and monitor new biocarbon stocks. This presumption is girded by the rise in the stock and flow framing of nature and the idea that markets can solve problems apart from broader institutional contexts. Of course, short of physically geoengineering a solution to climate change, to successfully mitigate and adapt to climate change we will have to develop the technology and institutional conditions to substantially improve our ability to monitor and manage existing biocarbon regardless of the institutional framework for sharing the burden of the reduction in emissions from fossil hydrocarbon combustion. It is disturbing, however, that there are now new institutions being proposed under UN-REDD (UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) for the management of biocarbon that largely ignore both the long history of institutional failure in stemming tropical deforestation and the vulnerability of biocarbon stocks themselves to climate change (United Nations, 2008; UNFAO, UNDP, UNEP, 2008). The REDD program appears to be driven by the necessity of its existence to stabilize baseline biocarbon stocks, a requirement for meaningful global carbon markets, along with the desire of rich nations to continue combusting fossil hydrocarbons and the poor to receive compensation for protecting nature. The ecosystem service framework and belief in markets apart from institutions, let alone the limits of institutions, foster this naïveté. Rather than thinking of biocarbon as offsets to fossil hydrocarbon combustion, we should be reducing fossil hydrocarbon combustion even more rapidly than we had previously thought necessary because of the vulnerability of biocarbon stocks under climate change.

Fifth, the idea of natural limits is fundamental to ecological economics (Georgescu-Roegen, 1971; Daly, 1973; Daly and Farley, 2004). The general equilibrium framework inherently expresses limits and allows us to see how new knowledge adjusts these limits. The move from point A to point D would require some current people to use fewer ecosystem services because of limits and our desire for a future for our children. Yet, even as ecological economists we still too rarely argue that turning down the economic drivers and/or decoupling economic activity from environmental consequences should be the first steps toward a solution. As we better acknowledge the higher transaction costs and institutional limits of living sustainably with nature, let alone with rapid socio-ecological change, the need for turning down the economic drivers should be increasingly clear. At the same time, though limits surely exist, we cannot put the burden on ecologists to declare what they are in any detail. Limits are many, contextual, and interrelated. The observable condition of the planet and the collective assessments of scientists (Millennium Ecosystem Assessment, 2005; IPCC, 2007) are as specific as we can be.

Sixth, and lastly, sustainability is ultimately a distributional question, a matter of ethics or environmental justice within and between generations. Designing better environmental governance always entails addressing the question: better for whom? While economists have been unusually successful at averting the ethical questions, and in the process supporting those who currently benefit from the governance structure, this avoidance has become central to the problems we know have in reaching a global accord. Global climate negotiations have been stalled for over a decade because of ethical disagreements with respect to addressing both historical and future responsibility, not the technicalities of economic efficiency. A cap and trade mechanism is preferred to a carbon tax until negotiations over the distribution of emission rights become explicit. Moving from a point such as A in Fig. 3 to one such as D must be an ethical decision, and it will be a difficult one. While economic reasoning has been firmly rooted in weighing likely consequences, the unpredictability of climate change, ecosystem transformation, and their interplay, let alone the uncertainties of social system responses, combined with what is at stake means we need to become more adept with *a priori* ethical reasoning for public decisions as well as move toward new individual virtue ethics (Sachs and Santarius, 2005; Meyer and Roser, 2006; Vanderheiden, 2008).

4. Conclusions

What started as a humble metaphor to help us think about our relation to nature has become integral to how we are addressing the future of humanity, the management of ecosystems, and the course of biological evolution. The metaphor of nature as a stock that provides a flow of services is insufficient for the difficulties we are in or the task ahead. Indeed, combined with the mistaken presumption that we can analyze a global problem within a partial equilibrium economic framework and reach a new economy project-by-project without major institutional change, the simplicity of the stock-flow framework blinds us to the complexity of the human predicament. The ecosystem services approach can be a part of a larger solution, but its dominance in our characterization of our situation and the solution is blinding us to the complexity of the challenges we actually face.

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References

Adger, W.N., Jordan, A., 2009. Governing Sustainability. Cambridge University Press, Cambridge, UK.
Armsworth, P.R., et al., 2007. Ecosystem-service science and the way forward for conservation. Conservation Biology 21 (6), 1383–1384.
Baer, P., Athanasiou, T., Kartha, S., and Kemp-Benedict, E. 2008. The greenhouse development rights framework: the right to development in a climate constrained world. Revised second edition Heinrich Böll Foundation, Christian Aid, EcoEquity and the Stockholm Environment Institute, Berlin.
Baer, P., Mastrandrea, M., 2006. High Stakes: Designing Emissions Pathways to Reduce the Risk of Dangerous Climate Change. Institute for Policy Research, London.
Barnosky, A.D., 2009. Heatstroke: Nature in an Age of Global Warming. Island Press, Washington, D. C.
Biggs, R., Carpenter, S.R., Brock, W., 2009. Spurious certainty: how ignoring measurement error and environmental heterogeneity may contribute to environmental controversies. BioScience 59 (1), 65–76.
Bromley, D.W., 1989. Entitlements, missing markets, and environmental uncertainty. Journal of Environmental Economics and Management 17 (2), 181–194.
Bromley, D.W., 2007. Environmental regulations and the problem of sustainability: moving beyond market failure. Ecological Economics 63 (4), 676–683.
Carpenter, S.R., et al., 2006. Millennium ecosystem assessment: research needs. Science 314, 257–258 13 October.
Coase, R.H., 1937. The nature of the firm. Economica 4, 386–405.
Coase, R.H., 1960. The problem of social *cost*. Journal of Law and Economics 3 (1), 1–44.
Corbera, E., Kosoy, N., Martinez-Tuna, M., 2007. The equity implications of marketing ecosystem services in protected areas and rural communities: case studies from meso-America. Global Environmental Change 17, 365–380.
Costanza, R., Daly, H.E., 1992. Natural capital and sustainable development. Conservation Biology 6, 37–46.
Cournot, A., 1838. The Mathematical Principles of the Theory of Wealth. Irwin Paperback Classics in Economics, Homewood, Illinois. 1963.
Daily, G.C. (Ed.), 1997. Nature's Services: Societal Dependence on Natural Systems. Island Press, Washington, D. C.
Daily, G.C., et al., 2000. The value of nature and nature of value. Science 289 (5478), 395–396.
Daly, H.E., (Ed.), 1973. Toward a Steady-State Economy. W. H. Freeman. San Francisco.
Daly, H.E., Farley, J., 2004. Ecological Economics: Principles and Practice. Island Press, Washington, D.C.
Dryzek, J.S., 1987. Rational Ecology: Environment and Political Economy. Basil Blackwell, Oxford.
Farrell, K, van den Hove, S., Luzzati, T. (Eds.), 2009. Beyond Reductionism: A Passion for Interdisciplinarity. Routledge, London.
Fisher, B., Turner, R.K., Morling, P., 2009. Defining and classifying ecosystem services for decision making. Ecological Economics S 68, 643–653.
Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of socio-ecological systems. Annual Review of Environment and Resources 30, 441–473.
Georgescu-Roegen, N., 1971. The Entropy Law and the Economic Process. Harvard University Press. Cambridge, U.S.
Grieg-Gran, M., Porras, I., Wunder, S., 2005. How can market mechanisms for forest environmental services help the poor? Preliminary lessons from Latin America. World Development 33 (9), 1511–1527.
Haddad, B.M., 2000. Rivers of Gold: Designing Markets to Allocate Water in California. Island Press, Washington, D.C.
Hanemann, W.M., Dyckman, C., 2009. The San Francisco Bay–Delta: a failure of decision-making capacity. Environmental Science and Policy 12 (6), 710–725.
Hansen, J., et al., 2008. Target Atmospheric CO2: Where Should Society Aim? Available at: http://arxiv.org/pdf/0804.1126.
Harberger, A., 1971. Three postulates for applied welfare economics. Journal of Economic Literature IX (3), 785–797.
Healey, M., Dettinger, M., Norgaard, R.B. (Eds.), 2008. The State of Bay–Delta Science, 2008. CALFED science program, Sacramento, California.
Hirt, P.W., 1994. A Conspiracy of Optimism: Management of the National Forests Since World War Two. University of Nebraska Press, Lincoln.
Howarth, R.B., Norgaard, R.B., 1992. Environmental valuation under sustainable development. American Economic Review 82 (2), 473–477.
Intergovernmental Panel on Climate Change, 2007. Climate Change 2007. Three Volumes. Cambridge University Press. Cambridge, UK.
Jansson, A.M., Hammer, M., Folke, C., Costanza, R. (Eds.), 1994. Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Island Press, Washington, D.C.
Kosoy, N., Corbera, E., 2010. Payments for ecosystem services ascCommodity fetishism. Ecological Economics 69 (6), 1228–1236 (this issue).
Jäger, J., 2009. The governance of science for sustainability. In: Adger, W.N., Jordan, A. (Eds.), Governing Sustainability. Cambridge University Press, Cambridge, UK.

Jasanoff, S., 1990. The Fifth Branch: Science Advisors as Policy-Makers. Harvard University Press, Cambridge, MA.
Lant, C.L., Ruhl, J.B., Kraft, S.E., 2008. The tragedy of ecosystem services. BioScience 58 (10), 969–974.
Martinez-Alier, J., Schlupman, K., 1987. Ecological Economics: Energy, Environment and Society. Blackwell, Oxford.
Mastrandrea, M.D., Schneider, S.H., 2004. Probabilistic assessment of "dangerous" climate change. Science 304 (5670), 571–575.
McAfee, K., 1999. Selling nature to save it? Biodiversity and green developmentalism. Environment and Planning D — Society and Space 17 (2), 133–154.
Meyer, L.H., Roser, D., 2006. Distributive justice and climate change: the allocation of emission rights. Analyse and Kritik 28, 223–249.
Millennium Ecosystem Assessment, 2003. Ecosystems and Human Well-Being: A Framework for Assessment. Island Press, Washington, D.C.
Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington, D.C.
Muradian, R., Corbera, E., Pascual, U., Kosoy, N., May, P.H., 2010. Reconciling theory and practice: an alternative conceptual framework for understanding payments for ecosystem services. Ecological Economics 69 (6), 1202–1208 (this issue).
National Research Council, 2007. Understanding multiple environmental stresses. Report of a Workshop held by the Committee on Earth–Atmosphere Interactions, Board on Atmospheric Sciences and Climate. National Academies Press, Washington, D.C.
Nordhaus, W.D., 2008. A Question of Balance: Weighing the Options on Global Warming Policies. Yale University Press, New Haven, Connecticut.
Norgaard, R.B., 1989. The case for methodological pluralism. Ecological Economics 1, 37–57.
Norgaard, R.B., 1994. Development Betrayed: The End of Progress and a Coevolutionary Revisioning of the Future. Routledge, London.
Norgaard, R.B., 2008a. Finding hope in the Millennium Ecosystem Assessment. Conservation Biology 22, 862–869.
Norgaard, Richard B., 2008b. The implications of interdisciplinary scientific assessments for environmental governance. In: Ranganathan, J., Munasinghe, M., Irwin, F. (Eds.), Chapter 8 in Policies for Sustainable Governance of Global Ecosystem Services. Edward Elgar, Cheltenham, U.K.
Norgaard, R.B., Baer, P., 2005a. Collectively seeing complex systems: the nature of the problem. BioScience 55, 953–960.
Norgaard, R.B., Baer, P., 2005b. Collectively seeing complex systems: the limits of formal models. BioScience 55, 961–966.
Norgaard, R.B., Kallis, G., Iparsky, M., 2009. Collectively engaging complex socio-ecological systems: reinvisining science, governance, and the California delta. Environmental Science and Policy 12 (6), 644–652.
Nowotny, H., Scott, P., Gibbons, M., 2001. Re-thinking science: knowledge and the public in an age of uncertainty. Polity, Cambridge, UK.
Ostrom, E., 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge, UK.
Pagiola, S., et al., 2004. Paying for biodiversity conservation services in agricultural landscapes. : Environment Department Paper, vol. 96. The World Bank, Washington, D.C.
Pagiola, S., Arcenas, A., Platias, G., 2005. Can environmental services help reduce poverty? An exploration of the issues and the evidence to date from Latin America. World Development 33 (2), 237–253.
Palmer, M.A., Filoso, S., 2009. Restoration of ecosystem services for environmental markets. Science 325, 575–576 31 July.
Pascual, U., et al., 2010. Exploring the links between equity and efficiency in payments for environmental services: A conceptual approach. Ecological Economics 69 (6), 1237–1244 (this issue).
Polanyi, K., 1944. The Great Transformation: The Political and Economic Origins of Our Time. Rhinehart, New York.
Prugh, T., Costanza, R., et al., 1999. Natural Capital and Human Economic Survival. Lewis Publishers, Boca Raton, Florida.
Ranganathan, J., et al., 2008. Ecosystem Services: A Guide for Decision Makers. World Resources Institute, Washington, D.C.
Sachs, W., Santarius, T. (Eds.), 2005. Fair Future: Resource Conflicts, Security, and Global Justice. Zed Books, London.
Shapiro, E.N., McAfee, K., 2008. To empty the countryside of farmers? Contesting the neoliberal nature of payment for ecosystem services in Mexico. Paper Presented at the Association of American Geographers Annual Meetings, Boston, MA, April 18, 2008.
Söderbaum, P., 2000. Ecological Economics: A Political Economics Approach to Environment and Development. Earthscan, London.
Srinivasan, U.T., et al., 2008. The debt of nations and the distribution of ecological impacts from human activities. Proceedings of the National Academy of Sciences 105 (5), 1768–1773.
Stern, N., 2007. The Economics of Climate Change: The Stern Review. Cambridge University Press, Cambridge, UK.
UNEP, 2008. Payments for Ecosystem Services: Getting Started. A Primer. UNEP, Nairobi.
UNFAO, UNDP, and UNEP, 2008. Framework document. UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD), Rome.
United Nations, 2008. UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries UN -REDD. FAO, UNDP, UNEP Framework Document 20 June 2008.
Vanderheiden, S., 2008. Atmospheric Justice: A Political Theory of Climate Change. Oxford University Press, Oxford.
Vatn, A., 2005. Institutions and the Environment. Edward Elgar, Cheltenham, UK.
Vatn, A., 2009a. An institutional analysis of methods for environmental appraisal. Ecological Economics 68 (8–9), 2207–2215.
Vatn, A., 2010. An institutional analysis of payments for environmental services. Ecological Economics 69 (6), 1245–1252 (this issue).
Walker, B.H., Meyers, J.A., 2003. Thresholds in ecological and social-ecological systems: a developing database. Ecology and Society 9 available at http://www.ecologyandsociety.org/vol9/iss2/art3/.
Williamson, O., 1996. The Mechanisms of Governance. Oxford University Press, Oxford.
Wilson, J., Low, B., Costanza, R., Ostrom, E., 1999. Scale misperceptions and the spatial dynamics of socio-ecological systems. Ecological Economics 31 (2), 243–257.
Wilson, M.A., Howarth, R.B., 2002. Discourse-based valuation of ecosystem services: establishing fair outcomes through group deliberation. Ecological Economics 41 (3), 431–443.
World Bank, 2009. Environment Matters at the World Bank: Valuing Coastal and Marine Ecosystem Services. World Bank, Washington, D.C.
Zellmer, A.J., Allen, T.F.H., Kesseboehmer, K., 2006. The nature of ecological complexity: a protocol for building the narrative. Ecological Complexity 3 (171–182).

A Scientific Web-tool to Assist Growers using FREP Research

Amrith Gunasekara, Ph.D.
Science Advisor to the Secretary

CDFA

- The mission of the department states; “CDFA protects and promotes California’s agriculture……. These commodities are marketed fairly for all Californians and produced with responsible environmental stewardship.”

Question

How has CDFA responded to agricultural environmental stewardship over the years?

FREP

- FREP is a program within the Fertilizer Branch and under the Division of Inspection Services
- Funds research (through a mill assessment) to advance the safe and sound use of fertilizer materials
- It is designed to primarily serve growers and help manage and effectively apply fertilizers at a level that is effective

Concept is…safe and sound use (management) of fertilizers will lead to lower amounts used and thus less environmental impact

FREP

- FREP currently distributes research information by;
  1) an annual FREP conference: technical information is presented to growers and certified crop advisors (CCAs)
  2) FREP conference proceedings report
  3) final technical research documents and abstracts posted online
  4) scientific journal articles

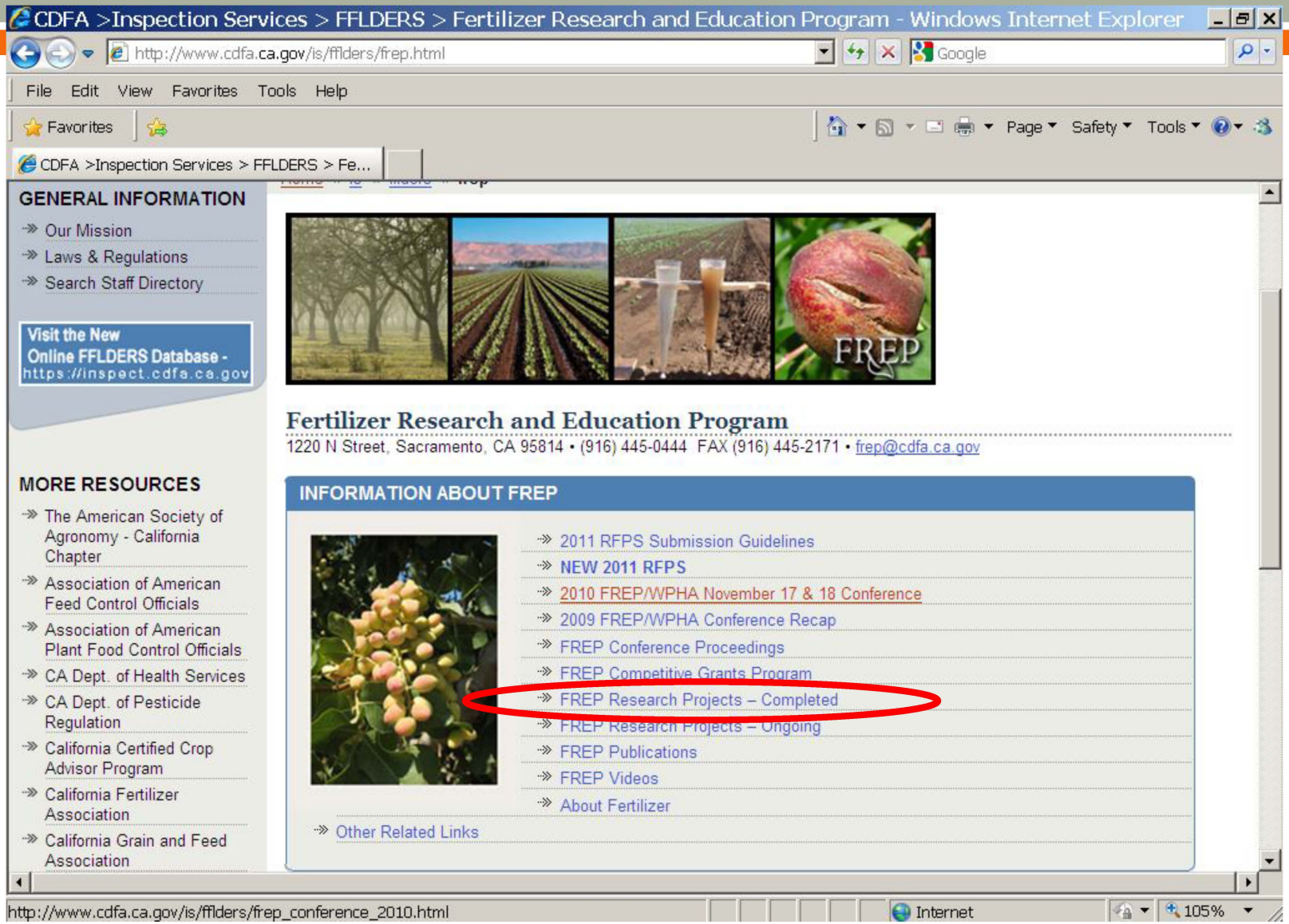
Question

Are these classical methods of information distribution working to promote the 20 years of environmental stewardship?

1. Don't know until we do a survey

2. Need scientific tool using FREP research findings that can have direct practical applications

FREP (the present)



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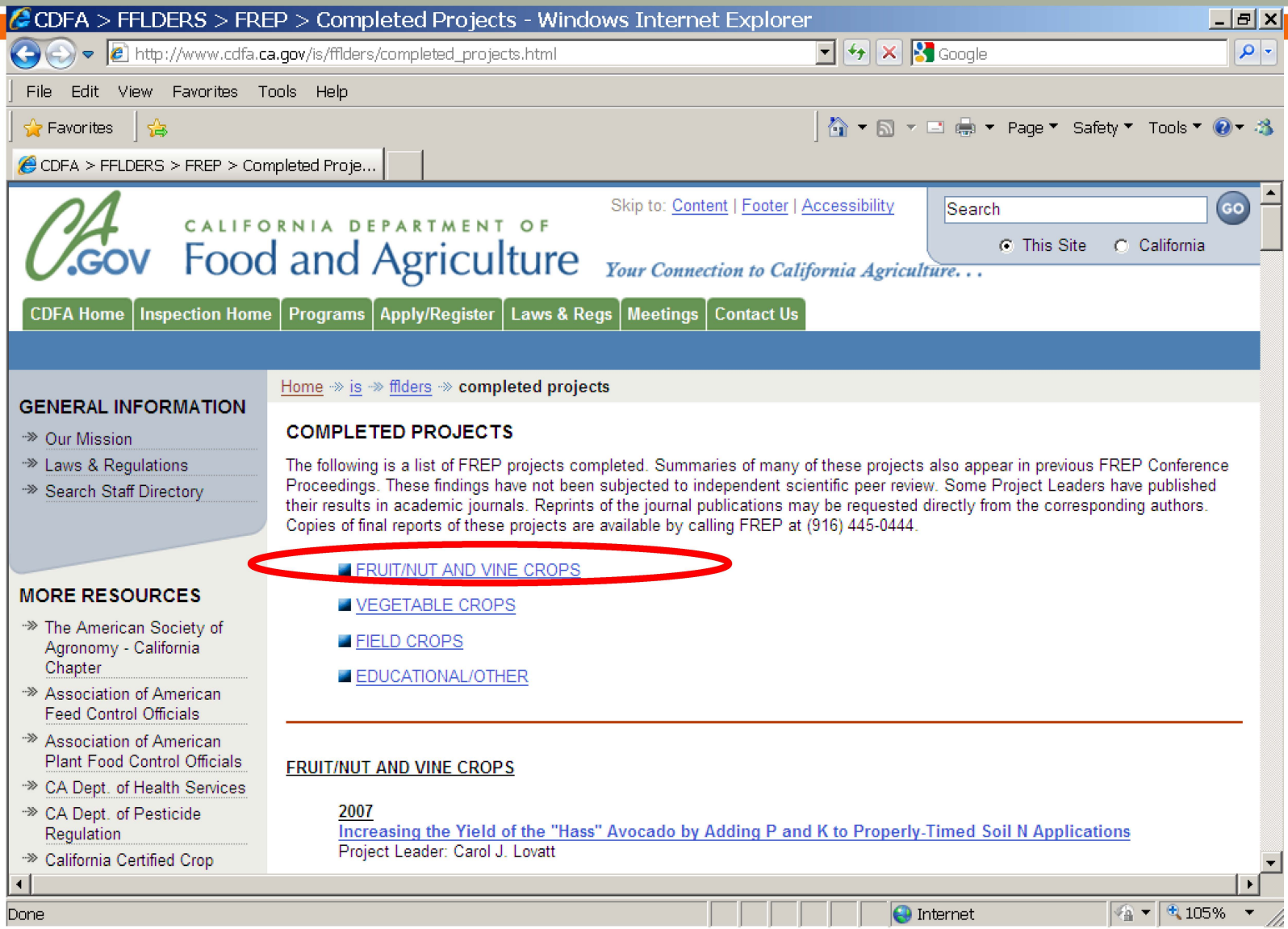

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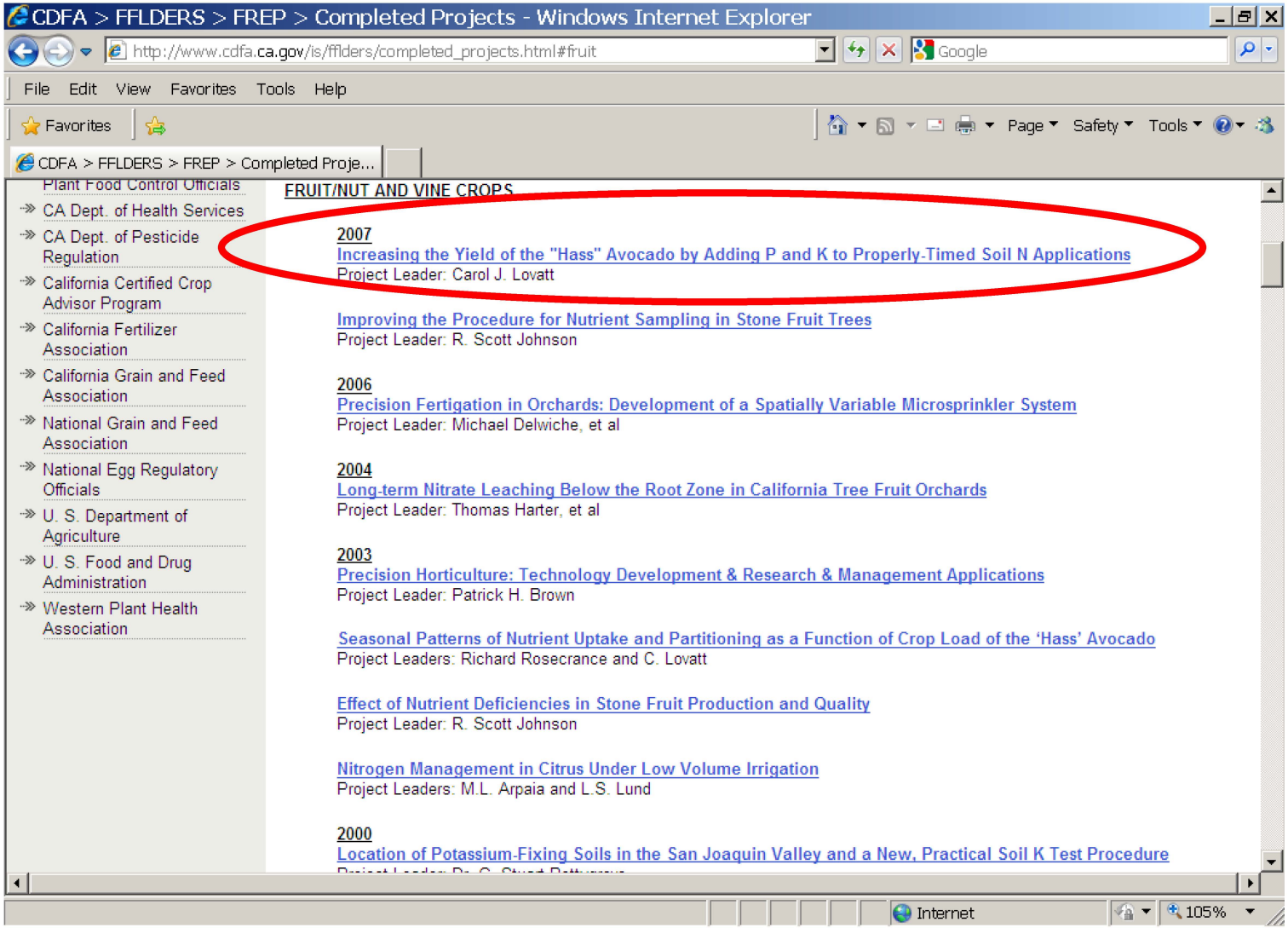

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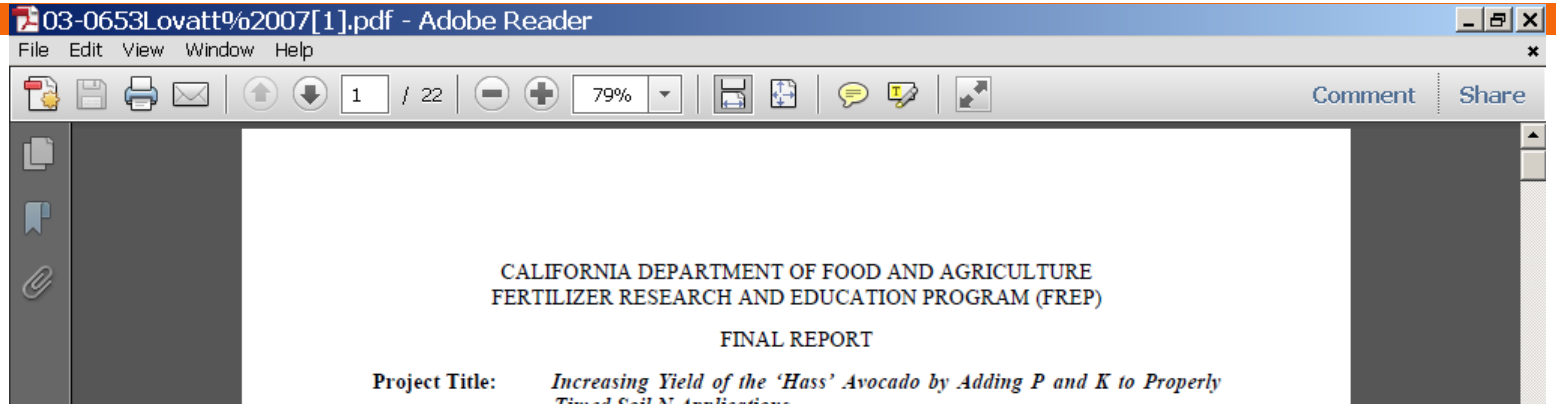
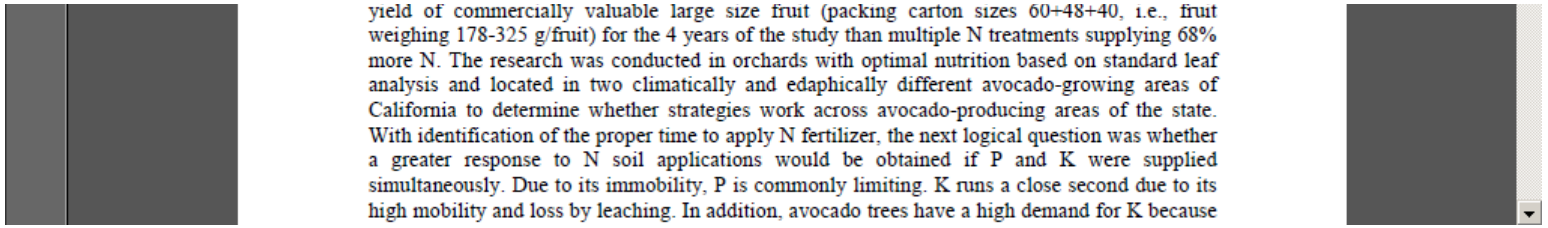


FULL "TECHNICAL" REPORT

22 PAGES

NOT EASY FOR A CCA OR GROWER TO COMPREHEND AND APPLY



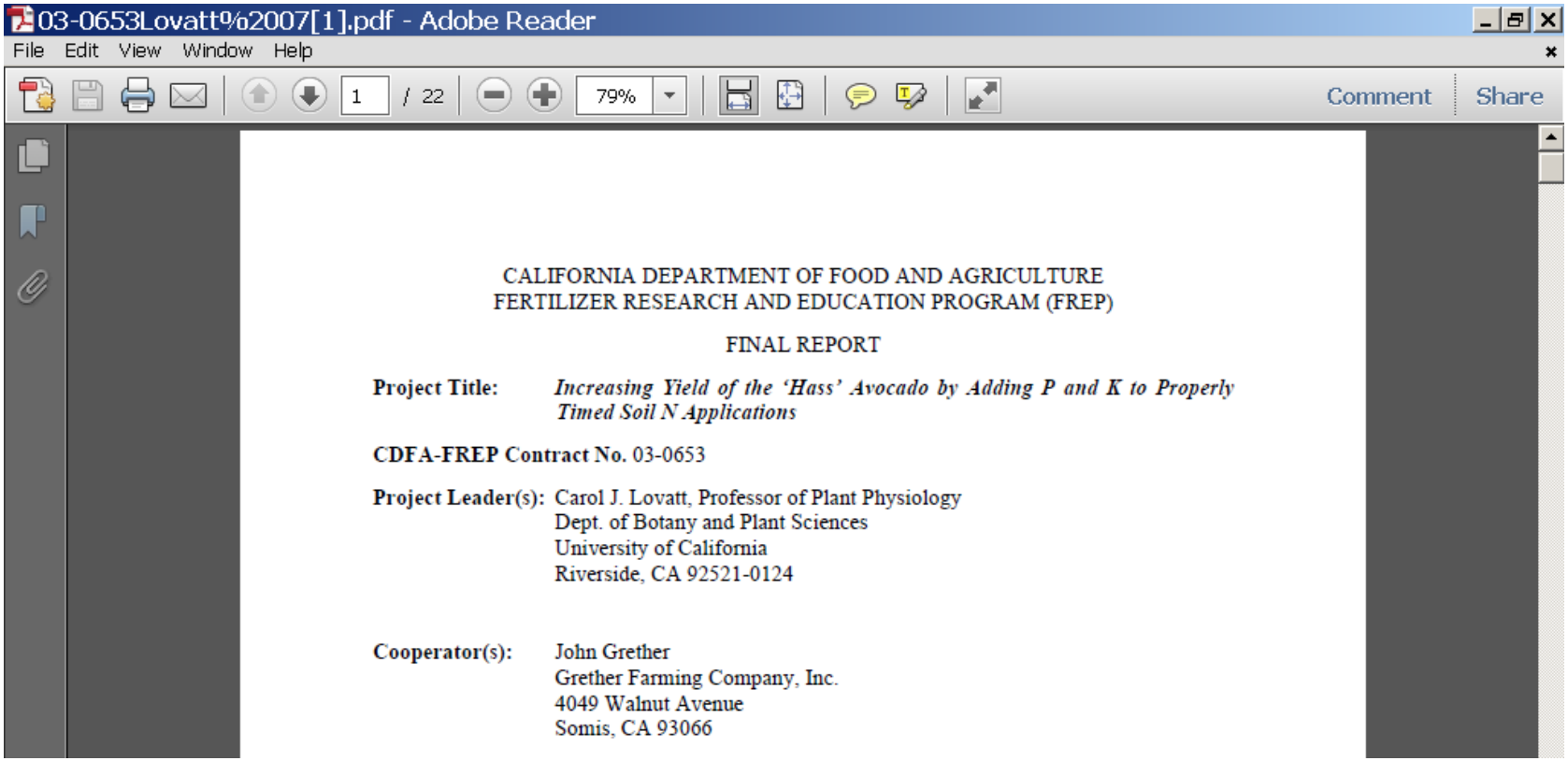
yield of commercially valuable large size fruit (packing carton sizes 60+48+40, i.e., fruit weighing 178-325 g/fruit) for the 4 years of the study than multiple N treatments supplying 68% more N. The research was conducted in orchards with optimal nutrition based on standard leaf analysis and located in two climatically and edaphically different avocado-growing areas of California to determine whether strategies work across avocado-producing areas of the state. With identification of the proper time to apply N fertilizer, the next logical question was whether a greater response to N soil applications would be obtained if P and K were supplied simultaneously. Due to its immobility, P is commonly limiting. K runs a close second due to its high mobility and loss by leaching. In addition, avocado trees have a high demand for K because

FREP (the future)

- Synthesize and summarize each FREP technical research proposal, collected over the past 20 years
- Apply summaries into an online, user-friendly, searchable, database so that growers and agricultural/environmental stakeholders can easily access FREP research findings by crop and plant nutrient
- Work will involve taking each research proposal and determining the major findings as well as the environmental conditions under which those results were obtained
- Currently, there is no other “one-stop-shop” web-based scientific tool in California or the nation (TMK) on plant nutrient requirements and environmental stewardship applications

FREP (the future)

- An example:



FREP (the future)

- An example: a database search for N requirements for Avocados will yield the following information

Required N application rate	40-50 lbs total N/arce
Type of N applied	Ammonium nitrate
Appliation time	July and August
Location of experimental orchard	Somis, CA
Trees	24 year old 'Hass'

Important Notes

This application is better than applying multiple N treatments.
Multiple applications will result in 68% more N than required.
July is period of rapic cell division and signficiant increase of fruit size
August is period of inflorescence initiation (flowering)

Avacado | Almonds | Strawberries

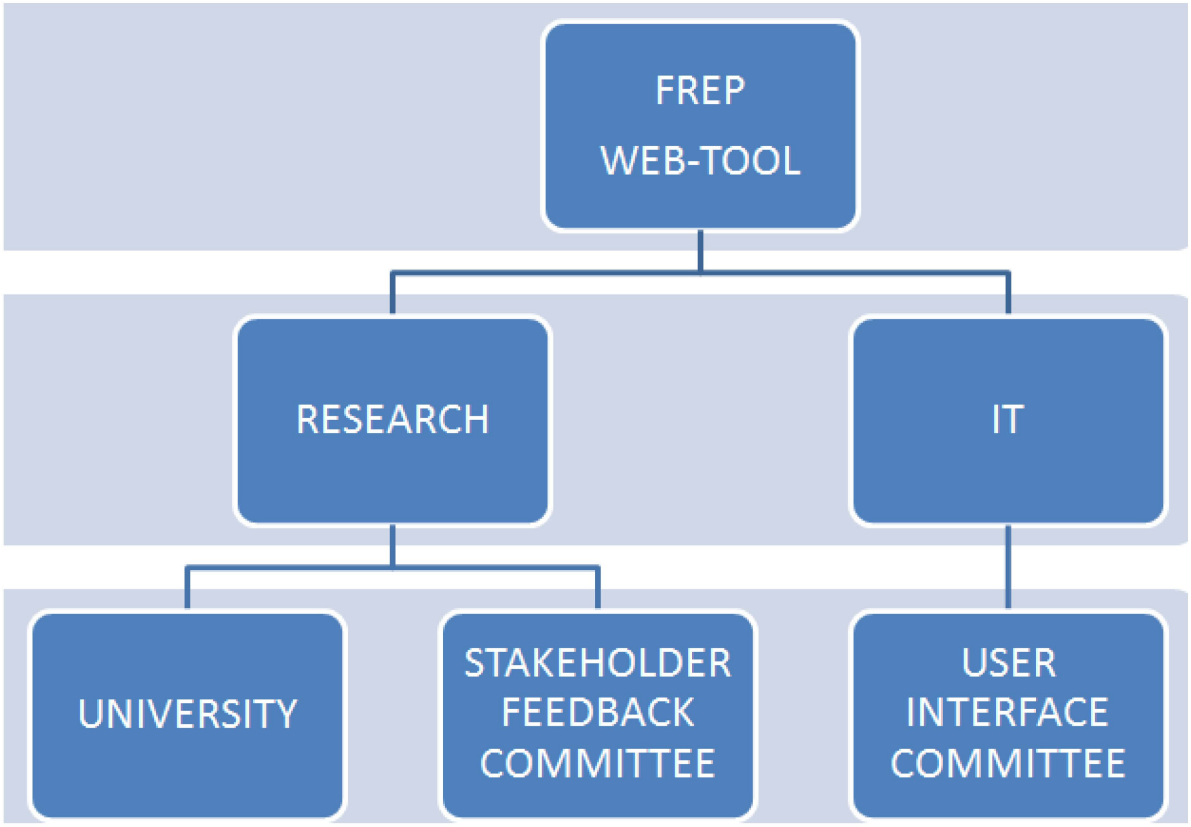
*Other important parameters include soil type and similar environmental variables

FREP (Summary)

- Create a unique web-based scientific tool that is easy to use and apply for growers

  (can find information by nutrient and crop type)
- This tool will lead to a direct impact of FREP research at the grower level and possibly at the regulatory level
- Important tool that can be used to show CDFA is actively involved with environmental stewardship efforts through agricultural BMP (best management practices)
- Build a nutrient management tool that cannot be found at any state, federal, or national level using the extensive scientific knowledge collected from over 20 years of FREP funded research
- Approximate timeline for completion – 1 Year (Nov. 2012)

Summary


FREP
WEB-TOOL
RESEARCH
IT
UNIVERSITY
STAKEHOLDER FEEDBACK COMMITTEE
USER INTERFACE COMMITTEE

Questions

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POTENTIAL FUTURE FOCUS AREAS

Ecosystem services:

- Define (in terms of Agriculture contributions)
- Ensure broad stakeholder feedback
- Contribute to promoting agriculture

Working landscapes (versus non-working landscapes)

- Define (in terms of Agriculture)
- Ensure comprehensibility for the general public
- Ensure definition is strong enough so that a broad spectrum of people understand contributions from a working landscape

Evaluate current regulatory system. Study and suggest alternative regulatory framework (process) and procedures (e.g., regulatory process based on performance based measures). Select one environmental component (e.g., water).

Evaluate and suggest improvements to FREP program. Determine how the data can be best utilized to inform other state agencies of environmental contributions and applicability of research.

Compile publishable papers on several topics;

- Current understanding of ecosystem services and how it relates to agriculture
- Literature review and potential of markets for agriculture ecosystem services
- Listing and discussion of the many benefits from a worked landscape

CANNELLA ENVIRONMENTAL FARMING ACT SCIENCE ADVISORY PANEL

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