Draft -- Strategic Plan for Sustainable Natural Ecosystems Initiative
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Authors: SNE Advisory Panel (Mike Allen, James Bartolome, Morgan Doran, Val Eviner, and Maggi Kelly)

1. Goal:

Our overall goal is to justify, define, prioritize, and recommend for implementation the portions of the ANR Strategic Vision related to Sustainable Natural Ecosystems using a five-year planning horizon.

2. Background and Introduction

We used the ANR *Strategic Vision 2025* (UC ANR 2009) and two of its commissioned supporting documents (Paine et al. 2008; Battles et al. 2008) as the bases for our strategic planning. The ANR strategic vision states that ANR can use its strengths, which are people, programs, and science-based solutions to "…connect and deliver resources… forming integrated teams to work on [these] complex issues and develop innovative multidisciplinary solutions." The general goals are healthy food systems, environments, communities, and Californians (UC ANR 2009).

Five teams contributed to development of *Strategic Vision 2025* by focusing on the future for: 1) demographics and infrastructure of California; 2) agriculture and food production; 3) natural resources; 4) health and nutrition; and 5) human development.

Those five teams helped ANR propose nine new initiatives, including one in the area of Sustainable Natural Ecosystems. The term "Natural Ecosystems" refers collectively to the less intensive land uses characteristic of forests, rangelands, and wetlands. A Sustainable Natural Ecosystems Initiative needs to assess the predictable changes affecting those regions in California and prioritize focal issues and solutions for these changes. In the document *Natural Resource Systems 2025,* Battles et al. (2008) focused on issues of biodiversity, coastal and marine resources, forests, land use, rangeland watersheds, and water resources. Several of the issues that were identified were common across several of the resources, but others were specific to a given resource.

Issues that are common across many of our natural resources include:

1. Population growth. The changing number, age, and distribution of Californians affect all natural resource systems. For example, both water quality and quantity will be affected by increased and competing demands for water.

2. Climate change. Climate change will also affect water quality and quantity, as there are expected to be more weather extremes and changes in the patterns and kinds of precipitation. Climate change is also anticipated to affect the risk of wildfire due to changes in temperature and precipitation patterns. Invasive species are likely to increase in range and impact on natural resources, as climate change creates new habitats and niches and eliminates existing ones.

3. Land use change and fragmentation. Changes in land cover and the more fragmented nature of many of the systems that regulate California's natural resources were also identified as a factor that will make it increasingly difficult to manage for change.

4. Education. The final cross-cutting issue identified as affecting our ability to respond to issues facing our natural resources is the education and literacy of California's population. This is an area in which ANR can have a significant beneficial impact (Battles et al. 2008).

In addition to the cross-cutting themes discussed above, there were a number of issues that were identified as having large impacts on California's natural resource ecosystems. Introduction of invasive species was identified as an issue that will impact biodiversity – this may be animals or plants, and it may occur in any environmental setting – marine, freshwater, forest, rangeland, etc. Most ecosystems also are vulnerable to disruptions in the sustainability of the ecosystem goods and services, particularly coastal and marine systems, forests, wetlands, and rangeland watersheds. Management of fuels and wildfire risk will continue to be an important issue facing the state. In the area of water, the aging of the delivery infrastructure was seen as an issue that will become increasingly important in the future.

Below we identify and justify key areas of inquiry for the SNE Initiative: a) land change science, b) biodiversity, c) water supply, d) energy, e) climate change, and f) understanding and valuing working landscapes and ecosystem services. Next we discuss programs under categories of: a) academic positions; b) interactions with other programs; c) work groups; d) internal grants programs; e) leveraging outside funds; and f) outreach and communications. Finally, we propose a key area of inquiry for action and prioritize key program elements for implementation. The current draft document is a revision based on extensive discussions at the June 2010 Natural Resources Continuing Conference, comments received in August 2010 and March 2011, and discussion among the authors in September and October 2010, and March 2011.

3. Key areas of inquiry

We initially selected seven key areas of inquiry for the draft SNE Strategic Initiative. These were developed from the ANR report *Natural Resource Systems 2025* (Battles et al. 2008). We have since combined the two areas of "Land Use" and "Habitat Fragmentation" into a new category of "Land change science" and retitled the section on "Ecosystem services" as "Understanding and valuing working landscapes and ecosystem services" to better reflect revised content.

3.a. Land Change Science

California is characterized by a complex physical geography, tremendous natural biodiversity, and an intricate ownership pattern that juxtaposes private, municipal, state, tribal and federal land parcels across the state. Land use and human development as implemented across this diverse ecological and social landscape can lead to increasing fragmentation which in turn threatens the ecological integrity of vital natural resources. Rapid increases in human population density and changes in climate only accentuate the need to coordinate regional planning efforts to promote conservation while also meeting the needs of all Californians.

The broad social goals of maintaining economic growth and public health, protecting natural systems and ecosystem services, sustaining healthy environments and communities, and supporting agricultural systems, increasing scientific literacy, and encouraging working landscapes can be complementary, but when they coincide in space, they are often conflicting. Just as each parcel of land is influenced by local environmental and ecological processes and its social, economic, cultural, and political setting, over large scales it is the multifaceted feedbacks between natural and human drivers that shape the complex spatial configuration of land use in California. Any prediction for California's future needs to consider those patterns. The study of this interplay is increasingly described as "land change science:" an interdisciplinary field of research that spans the social, spatial and biophysical sciences and seeks to understand the dynamics of land cover and land use as a coupled human–environment system. It addresses theory, concepts, models, and applications relevant to linked environmental and societal challenges across scales (Rindfuss et al. 2008; Turner et al. 2007). California -- diverse, dynamic and growing -- is at the extreme end of biophysical and social complexity, and thus faces the immediate consequences of land use change. We have an urgent need for academic research and outreach excellence in this important area, to help California plan for future growth and land use change so that people can live in liveable communities while maintaining connected and functioning natural and agricultural communities.

The state has a complex ownership pattern, with land owned and managed by a range of federal, state, local and municipal entities, along with private landowners (see Table 1.). Each parcel of land faces a number of competing uses, and the competition will likely increase in the future as the population increases and cities grow; and habitats, plants and

animals all respond to climate changes.

Table 1. Area of land cover classes by major ownership (thousand acres)

Land cover class	Private	USFS	BLM	NPS	Other public	Total
Conifer Forest	6,432	10,644	394	1,108	426	19,004
Conifer Woodland	458	1,051	482	220	151	2,363
Hardwood Forest	2,901	1,287	176	134	193	4,691
Hardwood Woodland	4,292	310	239	36	309	5,188
Shrub	5,433	5,673	2,261	319	878	14,565
Grassland	9,621	233	496	43	526	10,919
Desert Woodland	42	3	55	22	12	134
Desert Shrub	4,256	197	10,198	4,656	4,106	23,414
Wetland*	145	69	11	20	23	268
Forest and Rangeland Total	33,582	19,468	14,312	6,558	6,626	80,545
Wetland*	189	(L)	1	2	80	272
Agriculture	11,201	4	42	(L)	174	11,421
Barren/ Other	229	918	203	680	254	2,283
Urban	4,606	17	29	8	250	4,909
Water**						1,486
Statewide total	49,805	20,406	14,587	7,247	7,384	100,915

*Only the Wet Meadow CWHR habitat type is considered forests and rangelands.

**Areas classified as water are not assigned an ownership.
(L) - less than 500 acres; BLM-U.S. Bureau of Land Management; NPS-National Park Service; USFS-U.S.Forest Service; F&R-forest and rangelands
FRAP, 1999; FRAP, 2002

California's forests and rangelands have undergone extensive transformation over the past two centuries. Timber removal, agricultural intensification and stream channelization, are only a few examples of the changing landscape. Much of the state has shifted from a wildland matrix, with urban patches, to an urban or agricultural matrix, with wildland resource patches. New conceptual approaches to measuring, understanding, and managing of natural resources are needed.

Fragmentation of the landscape means that biodiversity will change, resources such as water shift spatially and are used (or lost) differently (channeling versus meandering in streams), and ecological mechanisms affecting management strategies change. These approaches need to be scaling-based. We can no longer just focus on farm field-size perspectives. Global climate change will affect a constrained biota in small patches differently than in a large matrix where organisms can move in response to climate shifts. Invasive species can migrate along corridors created in a disturbed landscape, and can use the increasing edges as invasion points to spread into agricultural or wildland areas. Greater emphasis is needed to understand the micro- to state-wide impacts of our changing environment, and understanding the shifting spatial structure and fragmentation of wildland and agricultural lands is a critical step.

Land change science, which embraces aspects of global environmental change, resource economics, land management, planning and policy, geospatial sciences, and sustainability research, is crystallizing around several themes:

> understanding the causes, contexts, consequences, and future trajectories of coupled human-environmental systems;
> examining the changing spatial and temporal interactions at the human natural land interface. In particular, the impacts of changing human land uses on natural ecosystems, and changing conditions of natural ecosystems on human land use will produce unexpected outcomes and consequences.
> earth observation and monitoring, including the use of innovative geospatial tools and hyperspectral, optical and active remote sensing technologies across multiple scales;
> modeling: including spatially explicit, econometric, ecological, cellular automata, and agent-based models as well as novel statistical approaches; and
> synthesis issues involving linkages across themes and with other disciplines (Aspinall, 2006; Rindfuss et al. 2008; Turner et al. 2007).

Land use and fragmentation are critical issues in sustaining natural ecosystems. Our focus for all SNE issues (e.g. biodiversity, climate change, working landscapes) must go beyond considering just a single landuse patch type, but consider local-to regional scale patterns and processes that consider not only multiple types of natural ecosystems, but how they, and managed ecosystems, are arranged and interact across a working landscape. Helping clientele build and use better tool kits for quantitatively evaluating changes in the Californian landscape is an appropriate role for ANR and the SNE.

3.b. Biodiversity

Because of our unique and highly variable topography, geology, and climate, California is a global biodiversity hotspot. The distribution and stresses imposed with increasing urbanization, global climate change, and air pollution will impact California's biodiversity, and understanding and predicting these impacts is a priority. Conservation and restoration of diversity will be challenging, particularly due to land use changes and climate change, and will require an understanding of the distribution of ecosystem types, species, and species interactions, across space and time. These components of diversity are among the critical factors that maintain resilient systems and ecosystem services.

While much attention is paid to the diversity of flowering plants and wildlife; archea, bacteria, fungi, and invertebrate animals represent the greatest unknowns in characterizing biodiversity of the state. Just as importantly, we know little about how to manage both beneficial and detrimental effects of these organisms for agriculture and for natural resources management. Mutualisms abound among plants, animals and microbes, but remain poorly characterized both taxonomically and functionally. The potential for disease outbreaks and spread through California's managed and natural systems has been highlighted by oak decline (due to Sudden Oak Death) and presence of a number of fungi previously reported from Mediterranean ecosystems (not just the spotted golden oak borer), and the rapid spread of the Asian citrus psyllid potentially carrying the Huanglongbing disease.

The impacts of invasive species have been and remain potentially devastating to California's biodiversity and natural resources. Biodiversity and the mechanisms sustaining biodiversity should be a priority need in protecting and managing California's natural resources. Issues of biodiversity cross over the several ANR initiatives and are not restricted to any state or region, requiring a high degree of cooperation and strength in research and outreach. An additional issue is identification of what is a diverse potential clientele. A critical role for the SNE Initiative is to help bridge and integrate the gaps between research and application.

3.c. Water Supply

Californians built and maintain the largest water redistribution system in the world. Moving water from sources, such as the Sierras and the Rocky Mountains, to agricultural and urban sinks, through wetlands, deserts, and wildlands consumes energy at unprecedented rates. Global climate change models suggest that warmer temperatures will decrease water supply generally, and increase the occurrence of mega-droughts. Warming will lead to decreased water storage as snowpack, leading to faster runoff and significant challenges to managing the amount and timing of water supply. Land use patterns will also decrease water availability (e.g. increasing tree density leads through

fire suppression and forest management will increase transpiration losses). Calls for more dams are challenged by their associated environmental problems, including fisheries management.

Many entities within California are involved in water, including UC inside and outside of ANR. Water needs to be an integral part of any ANR initiative. There is a clear need for objective research into the changing conditions, and new management strategies for water which include how land use and management regulate the water cycle. Translation of information to clientele as appropriate for natural ecosystems should be a specific component of the initiative.

3.d. Energy

Climate change will likely result in increased demand for electricity, especially electricity for air conditioning in the summer, and more frequent future peak electricity demand periods. In addition, changes to the hydrologic cycle (timing, type and quantity of peak flow) may affect the supply of electricity through alterations to hydropower generation capacity in the state. Finally, there are also likely to be direct impacts of climate change on electricity supply through physical impacts to thermoelectric generation in California and demand. This includes impacts of temperature increase on the efficiency of thermoelectric generation, impacts from sea level rise to energy infrastructure along the coast, and increased threats to energy infrastructure from fires. Energy issues will likely have significant impacts on sustainability through changes in land use and resource economics. Identification of appropriate clientele, integration of diverse information, and accurate information for decision-making are potentially important initiative tasks.

3.e. Climate Change

Compared with the past 50 years, California's mean annual temperature is projected to increase by 1-2^{O}C by mid-century (whether or not there are changes to greenhouse gas emission rates). Depending on greenhouse gas emissions, by the end of the century, temperatures are expected to rise by 1.5-4.5 ^{O}C. While warming over the past 50-100 years has largely resulted in increased spring and winter temperatures, by mid- to late-century, the most rapid temperature increases will occur in the summer (1.6-6.4 ^{O}C increase in mean daily summer temperature by end of the century). More of this warming will occur during the night, decreasing the amount of daily cool-down. Warming is expected to be greater in inland than coastal regions, although this warming trend has so-far been buffered in areas adjacent to intensively irrigated agriculture.

Projections of precipitation change are far more variable than temperature changes, and it is expected that regional and annual variability in precipitation amounts and timing will continue to be critical controllers of ecosystem structure and function. Modeling efforts

project a range from no change in annual precipitation, to a 15-20% reduction. Even in the scenarios with little overall change in total annual precipitation, a change in seasonality of rainfall is expected, with large decreases in the summer, and moderate decreases in the winter. Winter storms are projected to be less frequent and more intense, with a proportional decrease in snowfall compared to rainfall. Large annual fluctuations in precipitation are expected, with a 1.5-2.5-fold increase in the frequency of critically dry years, as well as a potential increase in the frequency of wet El Nino years.

Changes in temperature and the amount and seasonality of precipitation will have large impacts on the distribution, composition, and function of most California ecosystems. The projected climate changes are likely to result in a decrease in native species, and an increase in invasive species. Predicted changes in habitat distribution include: a decrease in the extent of subalpine and alpine forests, a replacement of evergreen coniferous forests with mixed evergreen forests, and an expansion of grassland (largely at the expense of woodlands and shrublands). Some species are already moving northward and up in elevation, and/or displaying a phenological shift in their activities. Coastal and marine systems will be threatened with sea-level rise (18-89 cm by end of century) and increases in the intensity and frequency of storm surges. Freshwater systems will be threatened by salt water intrusion, increased water temperatures (particularly a threat to species such as salmon), decreases in water quality and quantity, and alterations in the seasonality/flashiness of water inputs.

In terms of ecosystem services, there is substantial concern over a 30-90% projected decrease in Sierra snowpack- the state's major reservoir of freshwater. This will not only alter water availability to humans and natural ecosystems, but will also alter the timing and variability of hydropower availability. Air quality is also expected to deteriorate with climate change, with increased fine particulate matter levels, and a 25-85% projected increase in the number of days conducive to ozone formation. The risk of large wildfires is expected to increase by 10-55%, with increases in the duration, size and frequency of these fires. Net primary productivity is expected to substantially decrease in water-limited systems (e.g. grasslands and many forests), and increase in temperature-limited systems.

In addition to climate change, there are a number of other global changes occurring that are of concern for sustainable natural ecosystems, including: nitrogen deposition, increased levels of atmospheric greenhouse gases, land use change, and the spread of invasive species. Predicting ecosystem response to change using fully integrated data-driven models is a critical need for sustaining natural systems.

3.f. Understanding and Valuing Working Landscapes and Ecosystem Services

California's growing population will require an increased utilization of the natural resources that are principally responsible for the ecological and economic well-being of our state. The degradation and loss of these natural resources reduces the benefits or services provided by our natural ecosystems with consequences to our society such as poorer health, less productive agricultural systems and forests, fewer jobs, higher costs to provide clean drinking water, increasing flood damage in coastal and riparian communities, less outdoor recreation, degraded natural aesthetics and the loss of genetic diversity in our flora and fauna that could harbor enormous, but yet undiscovered benefits. A list of some important services provided by our natural ecosystems is found in Table 1. Sustaining these services under a changing environment and increased human pressure on the land will require increased understanding of the mechanisms that control ecosystem services, and how those controls can be managed. This requires a careful understanding within and across patches on the landscape- understanding how each contributes to a service, and how neighboring parcels interact to enhance or diffuse these effects. The emphasis needs to be not only on the "natural" ecosystems, but on the "working landscape"—incorporating the patchwork of land use types across local to regional scales. This will be one of the most critical foci of SNE, incorporating all of the other subjects and priority areas mentioned.

Beyond an ecological understanding of these services, attributing a monetary value to each service enables policy makers to quantitatively understand the societal impacts of specific land use decisions that degrade our natural ecosystems, which can lead to better land use and mitigation decisions. By attaching a monetary value to ecosystem services policy makers can quantitatively understand the societal impacts of specific land use decisions that degrade our natural ecosystems, which may lead to better land use and mitigation decisions. Ecosystem service values can also help evaluate societal benefits and return on costs from conservation and restoration projects.

Table 1. Important services provided by our natural ecosystems.

Living genetic repository	
Productivity (Forage, timber, etc.)	Carbon sequestration
Surface water retention, delivery and storage	Recreation
Groundwater recharge	Hunting and fishing
Water filtration Flood control Fire control Local climate control	Wildlife habitat
Native pollinators	Natural viewscape

Management and valuation of ecosystem services and translation of that information for an appropriate clientele within and outside of ANR is a critical role for the SNE initiative, with potential for lasting impacts on sustainability of both natural and intensively

management systems. This will not be easy because of the complexity of these issues, and in a five year plan, the most appropriate SNE focus may be on education. The general novelty of ecosystem service valuation to the general public warrants a step-wise approach beginning with clientele engagement, education outreach, and building the foundations for an ecological understanding of these services. The education component works towards communicating the purpose and mechanics of using ecosystem services to policy makers and communicating policy makers' perspectives of ecosystem service values to researchers. Valuing ecosystem services is a relatively new field of study and will require careful research to quantify services and monetary values, to develop models that estimate levels of services provided in various natural systems and to develop recommendations on how to ensure continuation of services and mitigate for the loss of services. Eventual adoption and application of ecosystem service valuation will require stakeholder participation from the beginning of the process so that stakeholder input is used to guide pertinent research questions and realistic expectations.

4. SNE program components

Within the areas of inquiry, the SNE initiative has several overlapping programmatic options, which are briefly discussed and summarized below.

4.a. Academic positions

Understanding the complexity of natural ecosystems, their interactions with humans, and solving problems for the benefit of Californians requires diverse, adaptable, well-trained, and dedicated academics. Within ANR the magnitude of core issues and needed programs has not been matched by recent hiring of academic personnel. The inexorable pressures of institutional demography are resulting in a smaller and more aged workforce, an undesirable change which will be difficult to reverse even with significantly increased resources. It is clear that new academics will be needed very soon to make natural resource programs viable.

Given the scarce resources available and the potentially changing problem areas in natural resources, new strategies will be needed to provide adequate academic personnel coverage. The traditional mechanism for hiring, with its preferences for in kind replacements, selection from a diverse proposed slate of positions, ad hoc justifications, and funding from permanent funds will be difficult to reconcile with strategic needs for the next 5 or more years. Although preference should be for permanently funded career positions, new ways to create academic capability by using term positions, outside or temporary funds, unusual combinations of jobs for specialists and advisors, and retraining of some positions will be required. The optimal mix of specialist and advisor positions, and maintaining CE presence in small offices will need attention. With a more streamlined county structure, some resources may be available to be redirected away from administrative functions.

Timely development and filling of academic position within ANR is the key to making programs like the SNE SI work. All the other program elements are important, but without new positions the capacity in some areas of inquiry and overall for natural resources is stretched too thin. The SNE SI has identified areas for academic hires that are needed to support the strategic plan and will need to work closely with other ANR units (campuses, counties, workgroups, other SIs and statewide programs) to develop good position descriptions and justifications. In discussions of the objectives for the SNE SI we quickly identified (unranked in this section) critical needs for CE Specialists in the areas of air quality, forestry, restoration ecology, resource economics, and land change science; and for NR Advisors in central and southern California to fill important gaps in regional coverage. In section 5 we propose specific positions needed in support of the SNE SI.

4.b. Interactions with other programs

ANR's mission is to undertake the highest quality research into understanding of California's natural resources, and to develop management alternatives based on the best research. Addressing the diversity of natural resource issues in California requires an inclusive approach in creating collaborative partnerships among our UC and California State University colleagues and our stakeholders that include landowners, land managers and a broad spectrum of State agencies, municipalities, agricultural support organizations and environmental groups. While it is important to use information and structures in other states as examples to build on, California has many unique ecological, economic and social issues that need to be incorporated into policies and management. ANR should be working more closely with State Agencies our stakeholders to define the topic areas that we understand, identify those where knowledge and techniques are lacking, and to balance and improve the links between basic and applied research needs. ANR leaders need to work closely with State agencies to direct funding towards those needs and pursue research and outreach through focused funding.

ANR programs have a successful history of forming collaborative partnerships and this strategy will continue to be encouraged and supported by the Sustainable Natural Ecosystems Initiative. A collaborative funding structure is very effective at encouraging broad participation and will be an important mechanism in the future. External partnerships depend on the relationships our researchers have with clientele groups and could be further enhanced by strategic communications and marketing of ANR to appropriate agencies and organizations and by including external partners in work groups. Internal partnerships are largely created and maintained through work groups, but can be strengthened through changes in the merit and promotion system, closer ties between county advisors and departments, faculty orientations that highlight CE programs and conferences that encourage cross-disciplinary participation. These mechanisms will require deliberate actions by individuals as well as ANR and department

leaders. Some examples that deserve mention are the excellent opportunities to increase science literacy through the participation of ANR natural resource academics in 4-H SET (Science, Engineering and Technology; HYPERLINK "http://groups.ucanr.org/Cal4HSET/" http://groups.ucanr.org/Cal4HSET/) and the newly formed California Naturalist program (HYPERLINK "http://ucanr.org/sites/UCCNP/" http://ucanr.org/sites/UCCNP/). Both are relatively new programs within ANR designed to teach and inspire science learning and application.

The priority issues identified in the ANR Strategic Vision are socially, agriculturally, ecologically and environmentally complex and require integrated approaches that ANR is well equipped to handle. Although some ANR programs are now divided among the strategic initiatives, collaboration between programs and stakeholders will be necessary to our future success. Most, if not all, Sustainable Natural Ecosystem priorities are intrinsically linked to those in other initiatives, other statewide programs, the campuses, and the counties. Therefore a key function of our initiative is to identify, link and encourage collaborative opportunities that will effectively address the complexity in the issues our initiative shares with others.

4.c. Work Groups

ANR workgroups are and will continue to be integral in organizing academics around specific research topics and well functioning workgroups will provide significant contributions to all facets of creating and implementing the Sustainable Natural Ecosystems strategic plan. Because the SIs addresses focused components of ANR SV, not the entire SV, the workgroups will need to play a more important role in ensuring depth and breadth to the work of ANR academics. The Sustainable Natural Ecosystems leader will work with workgroups to explore the best options to support productive workgroup functions with available resources. This may require a restructuring of existing workgroups to fit programmatic priorities as described in the Sustainable Natural Ecosystems strategic plan and the ANR Strategic Vision. Workgroups should be supported to provide an important interdisciplinary role supplementing the shorter-term goals of the SIs and helping to provide a regional and disciplinary focus for advisor and specialists and for justifying new positions.

4.d. Internal grants programs

Within ANR, the strategic initiatives and other existing programs will have access to internal funds. Proposed for the initiatives are internal grants programs in critical areas. It is especially important to provide discretionary funds to facilitate work by ANR academics in the changing UC institutional structure, and to bridge across campuses and regions in order to maximize our understanding of spatial and temporal variability in the controls and management of our natural systems, and to increase the effectiveness of our outreach and education efforts

In the face of multiple environmental changes, it will be particularly challenging to conserve, manage and restore biodiversity, native species, and multiple ecosystem services. This will require strong, integrated research, extension and education programs that synthesize across management goals and regions (within California and across states facing similar challenges and environmental conditions). ANR funding should play a key role in facilitating leadership in the following areas:

Funding activities that synthesize and archive existing datasets across regions, and within and across ecosystem and land use types. Synthesis activities will make the most of existing knowledge and point out key holes to direct new research and management priorities

Funding for new initiatives in research, education, and/or extension- particularly for efforts that need initial support to leverage outside funding including: initial data gathering, planning grants, matching funds, stakeholder group meetings to prioritize needs, initiation of integrated projects

Funding to develop outreach/education programs focused on generating management-decision/policy changes needed to sustain our natural ecosystems

Synthesis across other SI program areas (healthy families and communities, sustainable food systems, endemic and invasive pests and diseases)

4.e. Leveraging outside funds

A key to success for the initiative plan is leveraging outside funding to provide necessary capacity to address critical problems. This is a particular challenge in natural ecosystems because while the total federal outlay for research in health and in the environment is relatively similar, there is much less competitive funding available in natural resources. Specifically, in health research, approximately 80% of the budget is competitively distributed through the NIH, largely to universities and to non-profit or for profit entities focused on solving the problems. In the natural resources, over 80% of the budget is retained internally by federal agencies. Only a small fraction of the total budget is competitively directed towards understanding natural resources.

Federal funding is critical for many of UC's and ANR's research, extension and education programs. Many federally funded research calls are shifting to multi-state scales, and to projects that can be representative across the US. While there is a strong need for addressing environmental issues at this scale, this shift in scale may have detrimental consequences on research programs and management decisions and outreach at the state level. Many UC and ANR programs have been leaders in the types of work emphasized by new federal funding-- broader scale research that integrates management, education and research. California as a state needs to collaborate with federal agencies to provide links between state needs and broader-scale needs for understanding and managing sustainable natural systems. ANR and UC administrators should explore ways to better facilitate and directly support the partnership, and especially develop other public and

private means for support. Means for improving the support for collaborative efforts of extension and campus faculty need to be developed.

4f. Outreach and communications

Continued relevance and support of ANR programs, and specifically the Sustainable Natural Ecosystems Initiative, beyond this five-year plan will depend on the positive impacts created through our efforts. A key practice to achieve positive impacts is effective collaboration with stakeholders in identifying priorities and conducting carrying out research with stakeholders and managers actively involved in all aspects of projects. In addition, it is critical to have strong communication of findings and recommendations to our stakeholders. We must use a mix of traditional (meetings, print publications) and emerging outreach approaches (social media, web-based material and delivery) to reach the diverse people and groups that are our stakeholders.

ANR programs have a long history of successful outreach and clientele collaboration and the Sustainable Natural Ecosystems Initiative will encourage a continuation of those successful models such as a strong campus-county continuum and close clientele engagement in research programs. New and less traditional methods must be incorporated into our outreach efforts in order to successfully reach a broader and more technically savvy audience that comprises California's population. ANR Communication Services offers many resources that enable our division to learn and use new methods of media outreach in addition to our traditional forms of communication. As the communication preferences of our clientele change, so too must our communications toolbox to ensure we do not create self-imposed limits in the way we extend our information. There is a need for broad training in the use of social media and communication tools as well as a need to make these tools readily available to ANR personnel. ANR Communication Services support to outreach efforts will be increasingly critical, which may justify new positions within Communication Services to provide specific media assistance to ANR programs for web site development and maintenance, material creation, social media use, news media contact and information distribution.

As an example, the Sustainable Natural Ecosystems Initiative supports education, research and outreach efforts in order to develop and extend information on understanding and valuing ecosystem services. The education component works towards communicating the purpose and mechanics of using ecosystem services to policy makers and communicating policy makers' perspectives of ecosystem service values to researchers. Valuing ecosystem services is a relatively new field of study and will require careful research to quantify services and monetary values, to develop models that estimate levels of services provided in various natural systems and to develop recommendations on how to ensure continuation of services and mitigate for the loss of services. Eventual adoption and application of ecosystem service valuation will require stakeholder participation from the beginning of the process so that stakeholder input is

used to guide pertinent research questions and realistic expectations.

It is particularly important to move beyond our traditional clientele and make strong efforts to enhance scientific literacy across all Californians. The complexity and significance of the problems required to sustain natural ecosystems will require informed and integrated decisions that affect everyone. The common knowledge base is one protection against polarization of groups and their information sources at a time when we most need to work together to solve the state's problems.

5. Proposed SNE Areas of Inquiry and required program elements

Identification of critical issues and programmatic actions should be an iterative process starting with this draft strategic plan for the next five years. The criteria for specific recommended actions include: a) consistency with the ANR Strategic Vision; b) strong links among basic research, applied research, and outreach; c) capacity and comparative advantage within ANR; d) potential impacts of programmatic action on the critical issues; and e) contribution to the public good.

A list of critical issues was developed based on the ANR Strategic Vision and its supporting documents, then discussed at the NRCC by nearly 80 natural resource professionals in June 2010. Following a comment period ending in August, the authors have made further modifications including additions, deletions, enhanced problem descriptions, and prioritized program elements. The SNE Strategic Plan was updated and presented to the ANR Program Council for their comments in early October 2010 and finalized as a working document for release in early 2011. The SNE Plan will be a working draft, with period updates of goals and recommended actions.

The SNE SI Advisory Panel proposes combing areas 3.a. Land Change Science with area 3.f. Working Landscapes and Ecosystem Services into a new area of inquiry with the provisional title "Land Change Science for Working Landscapes." This combined area of inquiry will necessarily include some elements from the other four areas of inquiry listed in section 3.0. As described below, the specific goals and actions can be accomplished in the 5 year window and will contribute significantly to the ANR Vision. We propose that the activities described below rely primarily on existing academic units, but incorporate a well-defined coordinating, advisory, and evaluation role for the SNE Advisory Panel.

5.a. New Combined Area of Inquiry -- Land Change Science for Working Landscapes

The interlaced themes of land change and working landscapes with the provision of ecosystem services were identified in Section 3 as important and essential areas of inquiry for the SNE Initiative. As described above in Section 3.a, land change science is an emerging area on inquiry essential to clearly understanding and defining

environmental problems. In order to understand and manage natural systems for multiple goals, and under multiple stressors, it is critical for ANR to play a leading role in developing new and fully integrated conceptual, methodological, and management approaches. It is particularly critical to consider the concept of working landscapes (Section 3.f), the maintenance of healthy and functional ecosystems to provide specific societal goods and services.

Society's dependence on the provision of ecosystem goods and services is acutely evident as natural resources become more limited due to anthropogenic degradation of ecosystems and their functions. A likely contributing factor to ecosystem degradation is climate change while reductions in biodiversity, water quality and water supply are likely consequences, all of which are impacted by our choices in land use policy, energy production and water use and allocation. The goods and services we receive from our ecosystems are the source of monetary income for individuals and families and sustenance for society, which makes the perspective of natural resource economics necessary.

People depend on the use of ecosystems, but that continued use must sustain ecosystem integrity and function. This has to be accomplished through linking approaches for understanding and managing the sustainable provision of multiple ecosystem services and diversity under a changing environment (focusing on a patch, or management unit scale).

Key questions at the scale of management units include:

How will the controls over, and management of a given ecosystem service change across space and time, and due to environmental stressors and alterations in land management/ use?
What are the tradeoffs and potential synergies in managing for multiple services, and how do these change across space and time, and due to environmental stressors and alterations in land management/use?
How effective is management for ecosystem services within a natural ecosystem, depending on different management practices and ecosystem types that occur within that natural system boundary?
How do socio-economic opportunities/constraints affect the balance of managed services (e.g. livestock or timber productivity vs. clean water, flood control, etc.)?

Approaches that move beyond a focus on a given patch/management unit of a natural ecosystem to consider how ecosystem services are provided across a working landscape of various land use types require answers to the following kinds of landscape scale questions:

How effective is management for ecosystem services within a natural ecosystem, depending on its surrounding land use types?

How do the services provided by working landscapes in the vicinity of a natural ecosystem contribute to and/or diminish the resilience/sustainability of that natural landscape? To what extent does this depend on the size, shape, and configuration of landscape patches?
What are the scales at which different ecosystem services are provided? to what extent does the provision of key ecosystem services rely on coordinated efforts across land use types (e.g. fire control, invasive species control)? What are the suite of management practices within and across land use types that can mediate provision of these services across mixed-use working landscapes?
How will our understanding and management of cross-scale controls of ecosystem services vary due to environmental stressors?

ANR has many distinct advantages for addressing the breadth and complexity of issues within the subjects of land use, working landscapes, and ecosystem services. People are our greatest asset and within ANR we have a tremendous diversity of academics working on the issues that create the nexus between natural and managed ecosystems. Our technical expertise combined with the strong working relationships among our natural resource colleagues and the close connections we have to diverse clientele groups make us well positioned to conduct the appropriate research and outreach necessary to achieve positive impacts in this area. A wide diversity of stakeholder groups (agricultural managers, ranchers, restoration managers, conservation managers, timber managers) have already embraced this working landscapes approach by forging unprecedented collaborations across private and public lands to more effectively manage key services (e.g. fire control, invasive species control). Collaboration with these groups provides a unique and compelling opportunity to research these cross-scale questions, and to significantly contribute to the effectiveness of managing for not only individual, but multiple services.

5.b. Academic Positions

We have identified three key specialist positions which complement existing expertise in Natural Resources and are necessary for developing the area of inquiry. Those positions are in: 1) Land Change Science; 2) Natural Resource Economics; and 3) Restoration Ecology. The positions may be thought of in the context of questions about changing land uses. What is happening (Land Change Science)? What does it cost (Natural Resource Economics)? And, what do we do about it (Restoration Ecology)?

These three positions complement an already good capacity within ANR in the Natural Resources field. The SNE SI will support a new Land Change Science specialist position in 2011 (see below) and has already gained support from several workgroups, centers and academic departments. The SNE SI also strongly supports the creation of new positions in Natural Resource Economics and Restoration Ecology and expects that those two

positions will be be proposed and supported by Departments, Workgroups, or other SIs. The SNE SI Advisory Panel recognizes that there are likely to be other new specialist position proposals that will directly or indirectly be allied with the objectives of the new combined area of inquiry.

The SNE SI Advisory Panel recognizes that the new area of inquiry will depend on support for and creation of additional ANR capacity in NR Advisors. In implementing a program of inquiry focused on Land Change and Working Landscapes, the gaps in disciplinary and regional coverage by advisors need to be addressed. New NR advisor positions in Southern and Central California appear particularly needed. The initiative will strongly support such positions.

5.b.1. Land Change Science Cooperative Extension Specialist

California's forests and rangelands have undergone extensive transformation over the past two centuries. Timber removal, agricultural intensification, and stream channelization are only a few examples of the changing landscape. Much of the state has shifted from a wildland matrix, with urban patches, to an urban or agricultural matrix, with wildland resource patches. Just as each parcel of land is influenced by local environmental and ecological processes, management, and its social, economic, cultural, and political setting; over large scales it is the multifaceted feedbacks between natural and human drivers that shape the complex spatial configuration of land use in California.

Any understanding of California's future needs to consider this interplay of factors, which is increasingly described as "land change science:" an interdisciplinary field of research that spans the social, spatial and biophysical sciences and seeks to understand the dynamics of land cover and land use as a coupled human–environment system. It addresses theory, concepts, models, and applications relevant to linked environmental and societal challenges across scales. California -- diverse, dynamic and growing -- is at the extreme end of biophysical and social complexity, and thus faces the immediate consequences of land use change. We have an urgent need for academic research and outreach excellence in this important area, to help California plan for future growth and land use change so that people can live in liveable communities while maintaining connected and functioning natural and agricultural communities.

Fragmentation of the landscape means that biodiversity will change, resources such as water shift spatially and are used (or lost) differently (channeling versus meandering in streams), and ecological mechanisms affecting management strategies change. These approaches need to be scaling-based. We can no longer just focus on farm field-size perspectives. Global climate change will affect a constrained biota in small patches differently than in a large matrix where organisms can move in response to climate shifts. Invasive species can migrate along corridors created in a disturbed landscape, and can use the increasing edges as invasion points to spread into agricultural or wildland areas.

Greater emphasis is needed to understand the micro- to state-wide impacts of our changing environment, and understanding the shifting spatial structure and fragmentation of wildland and agricultural lands is a critical step. New conceptual approaches to measuring, understanding, and managing of natural resources are needed.

The incumbent is expected to develop a strong program of applied research and education in the emerging area of Land Change Science, which embraces aspects of global environmental change, resource economics, land management, planning and policy, geospatial sciences, and sustainability research. Several areas of investigation might include: a) understanding the causes, contexts, consequences, and future trajectories of coupled human-environmental systems; b) examining the complexity of coupled human-environmental systems, for example emergent spatial or temporal properties, uncertainty and heterogeneity, and feedback mechanisms that can produce nonlinear system behaviors; c) earth observation and monitoring, including the use of innovative geospatial tools and hyperspectral, optical and active remote sensing technologies across multiple scales; d) modeling: including spatially explicit, econometric, ecological, cellular automata, and agent-based models as well as novel statistical approaches; and synthesis issues involving linkages across themes and with other disciplines.

Strong skills in landscape ecology, GIS, remote sensing, modeling, and resource management are required, as is a degree in resource management.

The incumbent will be expected to develop strong collaborative links with other academics in ANR including AES faculty, specialists, and advisors. Interaction through outreach with a varied clientele outside of ANR is important. Because land use and fragmentation are critical issues in sustaining natural ecosystems (e.g. biodiversity, climate change, working landscapes) the position must go beyond considering just a single landuse patch type, but consider local-to regional scale patterns and processes that consider not only multiple types of natural ecosystems, but how they, and managed ecosystems, are arranged and interact across a working landscape. Helping clientele build and use better tool kits for quantitatively evaluating changes in the Californian landscape is an appropriate role for the specialist. In addition, this specialist can play a key role in identifying critical areas where landowners/managers need to collaborate across ownership boundaries and land use types in order to manage at the scales that govern the provision and sustainability of key ecosystem services/goods.

5.b.2. Economics of Working Landscapes Cooperative Extension Specialist

The term “Working Landscapes” implies the maintenance of healthy and functional ecosystems to provide specific societal goods and services. Society’s dependence on the provision of ecosystem goods and services is acutely evident as natural resources become more limited due to anthropogenic degradation of ecosystems and their functions. A likely contributing factor to ecosystem degradation is climate change while reductions in

biodiversity, water quality and water supply are likely consequences, all of which are affected by our choices in land use policy, energy production and water use and allocation. The goods and services we receive from our ecosystems are the source of monetary income for individuals and families and sustenance for society.

Use of ecosystems is necessary for our well being, but continued human use must both maintain the economic viability of practices and sustain ecosystem integrity and function. ANR has many distinct advantages to address the breadth and complexity of issues within the subject of working landscapes. Our general technical expertise combined with the strong working relationships among our natural resource colleagues and the close connections we have to diverse clientele groups make us well positioned to conduct the appropriate research and outreach necessary to achieve positive impacts in this area. Although a number of faculty, specialists, and advisors have expertise in natural resource economics, the complexity and extent of valuation issues require an individual dedicated primarily to analysis, understanding, and communication of results of differing activities on working landscapes.

The incumbent is expected to develop a strong program of applied research and education in the application of resource economics to valuation of working landscapes and associated ecosystem services. Required is expertise and an advanced degree in applied resource economics.

5.b.3. Restoration Ecology

This proposed new CE Specialist would provide an integrated approach to understanding sustainable production and restoration on working landscapes. The incumbent would focus on the identification of relationships among vegetation productivity and sustainability of ecosystem services on rangelands and associated woodlands. Productivity in terrestrial systems depends on natural biological and physical processes as influenced by purchased inputs and associated regulations. These processes or services include outputs of clean water, nutrient and biological cycling in soil, and provision of habitats for plants, animals and people. This specialist will be part of an interdisciplinary land grant team of AES and CE researchers and educators, to improve the success of ecosystem restoration projects statewide by: (1) developing new and enhanced methods for restoration of multiple ecosystem services (e.g. productivity, water supply and quality, soil quality, pollination, etc.), weed and pest control, and promotion of desirable species, and (2) assessing how successful strategies will vary across space (landscape position, local climate, soil type, due to fragmentation, etc.) and time (annual and long-term shifts in environmental conditions) .

The incumbent would approach this area through investigation of rangeland and woodland health, applied genetics, landscape restoration, resource utilization, inventory and monitoring. Required is expertise in ecosystem sustainability as it applies to

productive range and woodland ecosystems. Combinations of strong skills in terrestrial ecology, genetics, silviculture, GIS, remote sensing, modeling, and resource management are required. An advanced degree in a natural resource management field with an emphasis in range, woodland, or forest systems is required.

5.c. Interactions with other programs

The proposed focal area of inquiry will require a high degree of collaboration and integration within ANR. Existing and new academic positions will need to be aligned with a portion of the effort devoted to goals of the area of inquiry. We are proposing three new specialist positions that will be affiliated with the area of inquiry. Those positions need not be in the same academic unit and we believe that support from several existing programs will be developed for the different positions. Workgroups will need to be involved in development of white papers, collaborative research, and as a focal point for specialists and advisors. Some funding should be provided via the SNE SI, but other sources inside and outside ANR will likely be involved. Finally, there needs to be a well-structured method for ensuring coordinated communications among participants ant clientele. We recommend that the SNE Advisory Panel develop a proposal for ensuring a role in coordinating activities among existing units and personnel.

5.d. Workgroups

We see several natural resources workgroups as key players in the focal area of inquiry. The existing workgroups with goals and membership key to the Land Change Science and Working Landscapes area of inquiry include the Remote Sensing, Oak Woodland Conservation, Forestry, Fire, and Rangeland Watershed workgroups. We expect that workgroups will be asked to participate as appropriate in development of selected white papers, hosting scientific meetings and continuing conferences, developing research proposals, and coordinating outreach.

5.e. Internal Funding – ANR Competitive Grants

The interlaced themes of land change and working landscapes with the provision of ecosystem services were identified as important and essential areas of inquiry for the SNE Initiative. The SNE Initiative has helped develop, and ANR is currently accepting, proposals for two types of awards: ***Large-scale integrated projects*** are long-term multi-year projects (3-5 years) that must draw on expertise in research, education and extension, as well as expertise from key stakeholders and external partners to accomplish the goals and objectives of the proposed work. Proposals must outline how the project will incorporate extension outreach education and stakeholder partners, describe the potential outcomes of the project, provide a structure, coordination, and implementation plan; and should achieve specific research, education, and extension milestones. Large-scale integrated projects may request up to a maximum of $600,000 USD for the entire

duration of the project (up to five years). ***Targeted short-term projects*** are smaller in scale and short-term (1-2 years). Targeted projects may be research only, education and outreach only, or a combination of both. Activities might include fostering collaborations with key stakeholders, developing and publishing policy briefs and papers, and holding policy conferences as part of the collaborative education and outreach efforts. Research projects may expand an existing innovative/novel research area where ANR expertise and contribution will result in the translation of that research for the public good. Short-term projects may request up to a maximum of $50,000 USD for the entire duration of the project (up to two years).

5.e.1. Large-scale integrated project "Balancing multiple ecosystem services and biotic diversity in California's working landscapes"

Wildland, rangeland, urban, and agricultural managers face increasing pressure to develop management practices that maximize crop/forage yield and quality while conserving native species, increasing soil storage of carbon and water, and minimizing weeds, erosion, flooding, and nutrient leaching. Managing ecosystems for multiple goals involves careful evaluation of tradeoffs, thresholds, and feedbacks associated with multiple ecosystem processes. Despite a few reviews and a significant amount of recent research, there is still little synthesis connecting how to manage for multiple services, or even how managing for one service impacts other services.

Questions in this area may include:
a) How do environment and management interact to control individual ecosystem services and diversity (including patch- to landscape-level, as well as short-term to long-term) options?

b) What are the impacts of any given management practice on multiple services (and how does that depend on site conditions and annual variation in weather)?

c) How can the tradeoffs in managing for multiple services be valued and understood, and how do these tradeoffs vary by site, region, and spatial and temporal scale?

d) How do adjacent land uses affect the provision of individual and multiple ecosystem services?

e) What is the scale at which different ecosystem services are provided? How does the provision of ecosystem services change due to the interactions between climate change, land use change, N deposition, and invasion of exotic species?

5.e.2. Targeted short term project "The shifting spatial structure of California's natural resources under environmental change"

New conceptual approaches to measuring, understanding, and managing of natural resources are needed because fragmentation of the landscape will change the distribution

and abundance of organisms, resources such as water shift spatially and are used (or lost) differently, and ecological mechanisms resulting from management strategies change.

Concentration in this area may include:
a. An overview of the current status and knowledge, known and postulated trends, and currently projected outcomes in land-change science.
b. The development of a clearer framework to evaluate and analyze impacts of fragmentation across scales (local, county, and region), dynamics (temporal dimensions), processes, drivers and systems (working landscapes, wildlands, agriculture, and urban communities).

5.e.3. Targeted short term project "Tools for Land change science"

One aspect of land change science is observation, monitoring and prediction of patterns. There is a range of tools that can be used in support of land change science: understanding change, understanding consequences, predicting futures, and educating decision-makers. There are also a number of tools currently available for citizen science monitoring that could be used by Cooperative Extension to broaden the existing network of monitors.

Concentration in this area may include:
A focus on the inventory of land change tools, and the following questions: Are these tools primarily for data collection; do they have an educational aspect; what are their strengths and weaknesses; what is their adaptability; are they available through UC, ANR, or externally?

5.e.4. Targeted short term project "Promote the understanding and importance of ecosystem services provided by California's working landscapes"

The general novelty of ecosystem services to the general public warrants a step-wise approach beginning with clientele engagement, education outreach, and building the foundations for an ecological understanding of these services. The education component works towards communicating the purpose and mechanics of using ecosystem services to policy makers and communicating policy makers' perspectives of ecosystem services to researchers.

Concentration in this area may include:
a. Education outreach media, an increased understanding by policy makers and the public of ecosystem services, and b. the engagement of policy makers in the development of future ecosystem services research.

5.f. External funding

The Panel will continue to explore and encourage development of external funding

sources.

5.g. Outreach and communications

The Panel will utilize available electronic means for communication with other SI Panels and groups within and outside of ANR. The SNE website will be duly developed and implemented by early 2011.

5.h. Five-year outcomes and deliverables

Academic positions consistent with needs of the area of inquiry

White papers in critical areas

Results from a targeted competitive grants program

Funded collaborative proposals from outside sources producing results directed at critical needs

Engagement of specific clientele groups to assess needs, develop research questions and deliver products

Outreach products/tools on ecosystem services, resource economics, water quality, land use

Effecting natural resource policy changes

The Sustainable Natural Ecosystems Initiative will support and encourage projects designed to meet one or more of the specified outcomes in five years and contribute to longer term outcomes and impacts. Projects should be multi-disciplinary, span the campus-county continuum and engage clientele groups in all project aspects.

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