Box 1.1 Common forms of nitrogen. With the exception of dinitrogen, all other forms are considered reactive N (N_r).

Nitrogen Compound	Form
Di-nitrogen: N_2	Gas
Nitrous oxide: N_2O	Gas
Nitrogen oxides: NO, NO_2 (NO_x)	Gas
Ammonia: NH_3	Gas
Ammonium: NH_4^+	Water soluble ion
Nitrite: NO_2^-	Water soluble ion
Nitrate: NO_3^-	Water soluble ion
Organic N: various	Solid ,dissolved, or gas

1013 **Box 1.2 Major steps in the nitrogen cycle**

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Process	Function
Fixation	Process by which atmospheric nitrogen (N_2) is converted into ammonia (NH_3). N_2 is largely inert and does not easily react with other chemicals to form new compounds. Nitrogen fixation can result from biological or industrial activity. In the case of biological activity, the N is fixed by microorganisms that may or may not be symbiotically affiliated with plants. Fixation also can refer to the various physical conversions of N_2 to Nr, such as the production of nitrogen oxides (NO_x) by lightning or fossil fuel combustion.
Ammonification (or mineralization)	Process by which organic forms of N are converted to ammonium during the decomposition of organic matter. When a plant or animal dies, or an animal expels waste, the initial form of N is organic. Bacteria, or in some cases fungi, convert the organic N within the remains back into ammonium (NH_4^+).
Nitrification	Process by which ammonium is oxidized to nitrite and then nitrate by microorganisms under aerobic conditions .
Denitrification	The reduction of nitrate into N_2 via a series of enzymatic reactions by microorganisms in anaerobic environments. Denitrification may also occur under aerobic conditions with (co-respiration) of oxygen and nitrate. Both denitrification pathways involve formation of intermediate gases (NO and N_2O) that may be lost to the atmosphere.
Immobilization	The uptake of Nr by microorganisms or plants from the surrounding environment to meet their metabolic

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Box 1.3 Key characteristics of assessments

- ***Guides decisions*** on complex issues.
- ***Critical evaluation*** of information.
- Conducted in a ***credible, useful, legitimate*** process (open, transparent).
- ***Engages stakeholders and responds to users' needs.***
- ***Adds value by sorting, summarizing, synthesizing, translating, and communicating*** what is known and widely accepted from what is not known (or well published); includes evaluation of uncertainty.
- ***Policy relevant, not policy prescriptive*** (assesses options; "if, then" approach).
- ***Peer reviewed*** (by researchers and stakeholders).

Source: Adapted from: MA 2005

Box 1.4 Examples of well-known assessments

Intergovernmental Panel on Climate Change (IPCC) 1990	Millennium Ecosystem Assessments (MA) 2005	European Nitrogen Assessment (ENA) 2011
• Synthesis of knowledge on climate science and options for mitigation adaptation. • Four assessments reports since 1990. • Methodology reports and guidelines to estimate emissions. • Creates scenarios. • Addresses uncertainty. • Suggests potential actions. • 1250 authors; 195 countries. • Over 2500 reviewers.	• Synthesis of knowledge of trends in earth's ecosystems, including agriculture. • Creates future scenarios. • Addresses uncertainty. • Subsequent 18 MA-approved sub-global assessments. • Builds capacity for conducting scientific assessments. • 1360 authors; 95 countries. • 850 reviewers.	• Synthesis of knowledge of nitrogen sources, impacts, and interactions across Europe. • Creates future scenarios. • Analysis of environmental costs vs economic benefits of nitrogen in agriculture. • Provides recommendations and policy options. • 200 authors; 21 countries. • International peer review.

Box 1.5 Key outcomes from stakeholder engagement

- Indicators and questions that reflect stakeholder concerns.
- Assessment priorities.
- Practical examples of agricultural practices and management options.
- Participatory scenarios of plausible future conditions.
- Shared understanding of nitrogen in California agriculture.
- Strategic partnerships and collaborations.
- Peer review assessment.
- Guidance on products and outreach that meet stakeholder needs.

1117 **Box 1.6 Communicating uncertainty**

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Quantitative Analyses – the following reserved wording was used for statements that lent themselves to formal statistical treatment, or for judgments where broad probability ranges could be assigned:

Virtually certain	Greater than 99% chance of being true or occurring
Very likely	90-99% chance of being true or occurring
Likely	66-90% chance of being true or occurring
Medium likelihood	33-66% chance of being true or occurring
Very unlikely	1-33% chance of being true or occurring
Exceptionally unlikely	Less than 1% chance of being true or occurring

Qualitative Analyses – the following reserved wording was used for more qualitative statements:

		Amount of Evidence		
		Limited	***Medium***	***High***
Level of Agreement	***High***	Agreed but unproven	Agreed but incompletely documented	Well-established
	Medium	Tentatively agreed by most	Provisionally agreed by most	Generally accepted
	Low	Suggested but unproven	Speculative	Alternate explanations

1119 Source: Ash et al 2010

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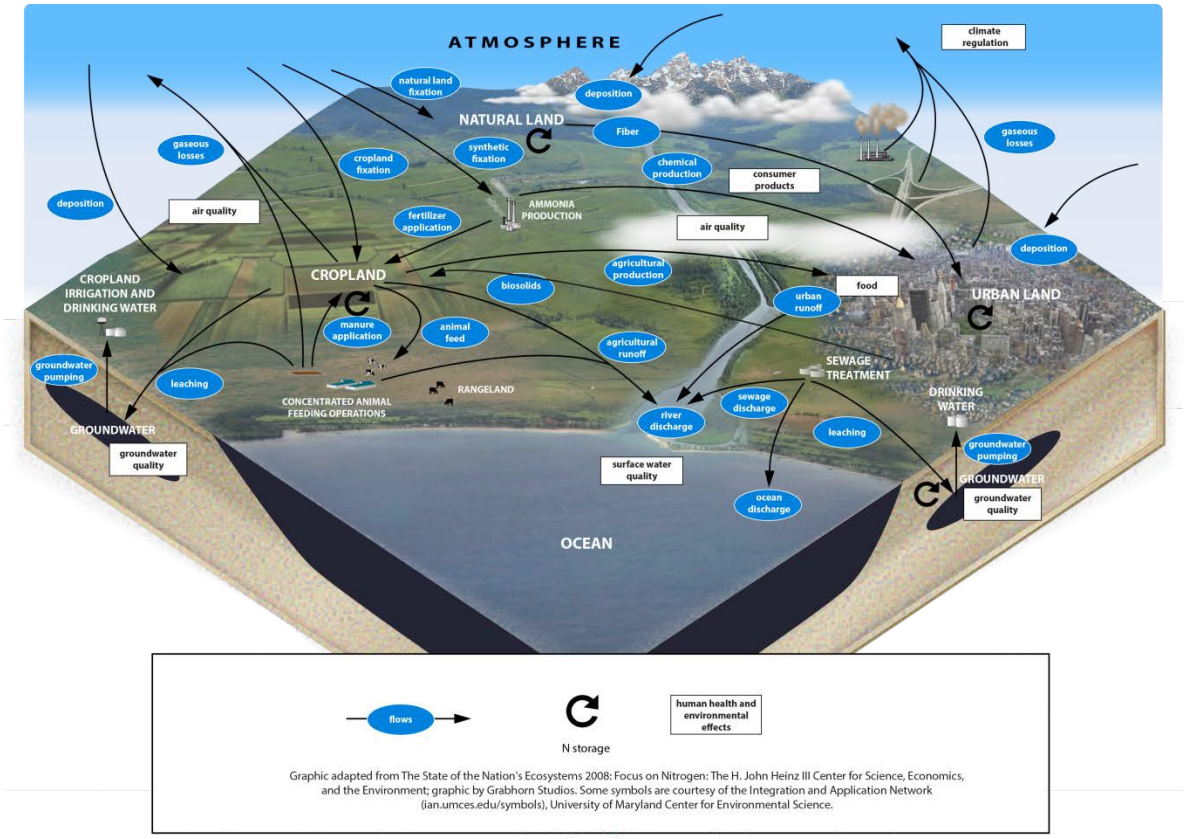
Figure 1.1 Nitrogen pools and flow pathways in the environment



Graphic adapted from The State of the Nation's Ecosystems 2008: Focus on Nitrogen: The H. John Heinz III Center for Science, Economics, and the Environment; graphic by Grabhorn Studios. Some symbols are courtesy of the Integration and Application Network (ian.umces.edu/symbols), University of Maryland Center for Environmental Science.

Figure 1.2 Location of stakeholder outreach events in California. In the design phase of the assessment, the assessment engaged with organizations, groups, and individuals from a broad range of perspectives through stakeholder forums, grower consultations, and field visits. This map does not include numerous additional meetings held at UC Davis, national and international nitrogen meetings, and stakeholder engagement via telephone interviews and email surveys.

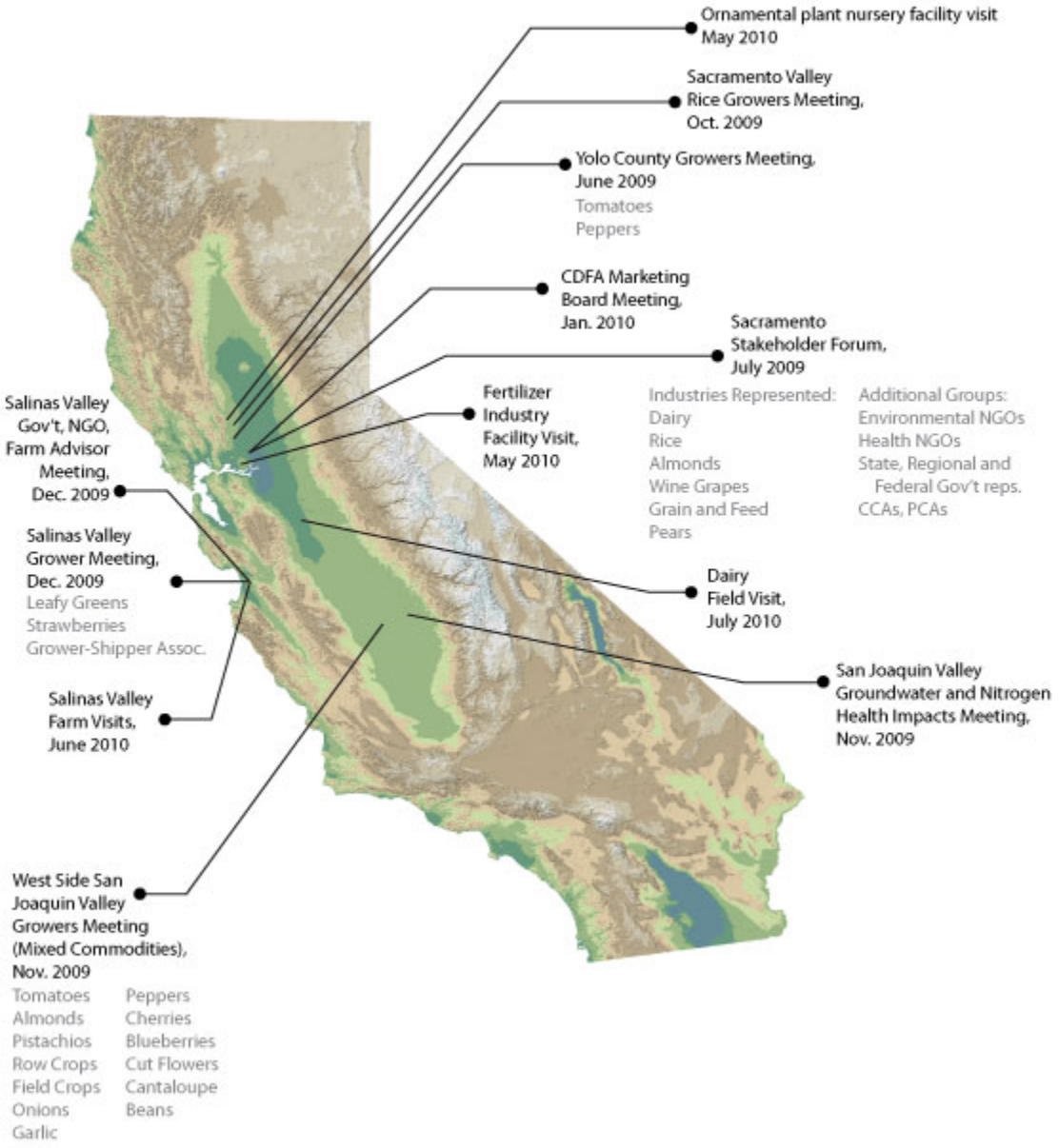


Figure 1.3 Stakeholder engagement. Includes participants at 12 stakeholder forums, grower consultations, and field visits between June 2009 and July 2010, as well as individuals contacted by phone or email. In addition to these activities, the assessment engaged with 151 farm advisors and extension specialists with University of California Cooperative Extension and the members of the Stakeholder Advisory Committee (SAC).

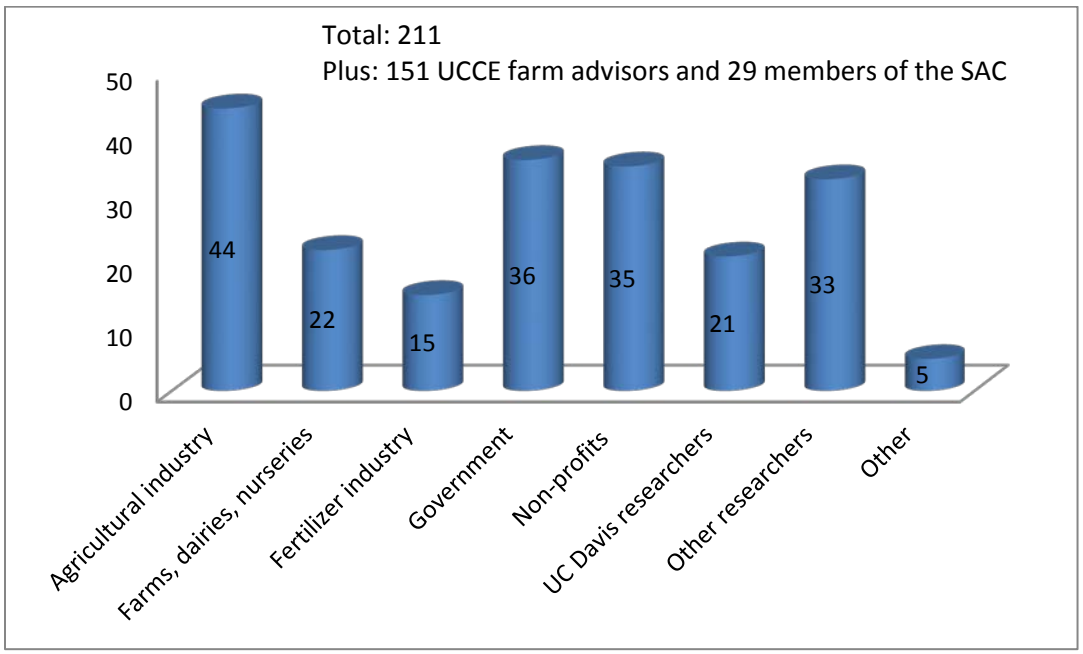


Figure 1.4 Major categories of stakeholder-generated questions about nitrogen. Consolidated from over 100 questions generated by stakeholders. These five overarching thematic areas represent the major issues identified as most important for nitrogen in California agriculture; these synthesized questions were used to guide the assessment's research priorities.

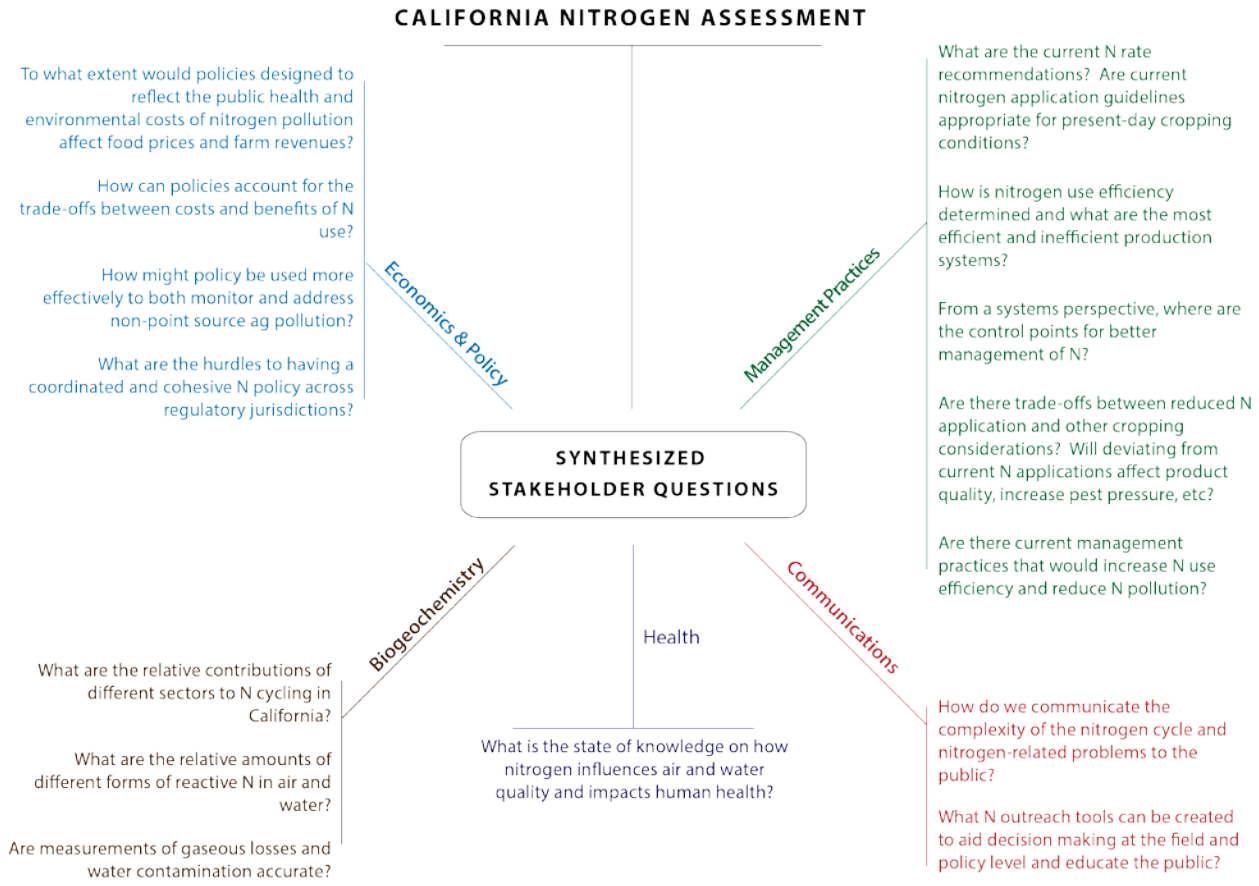
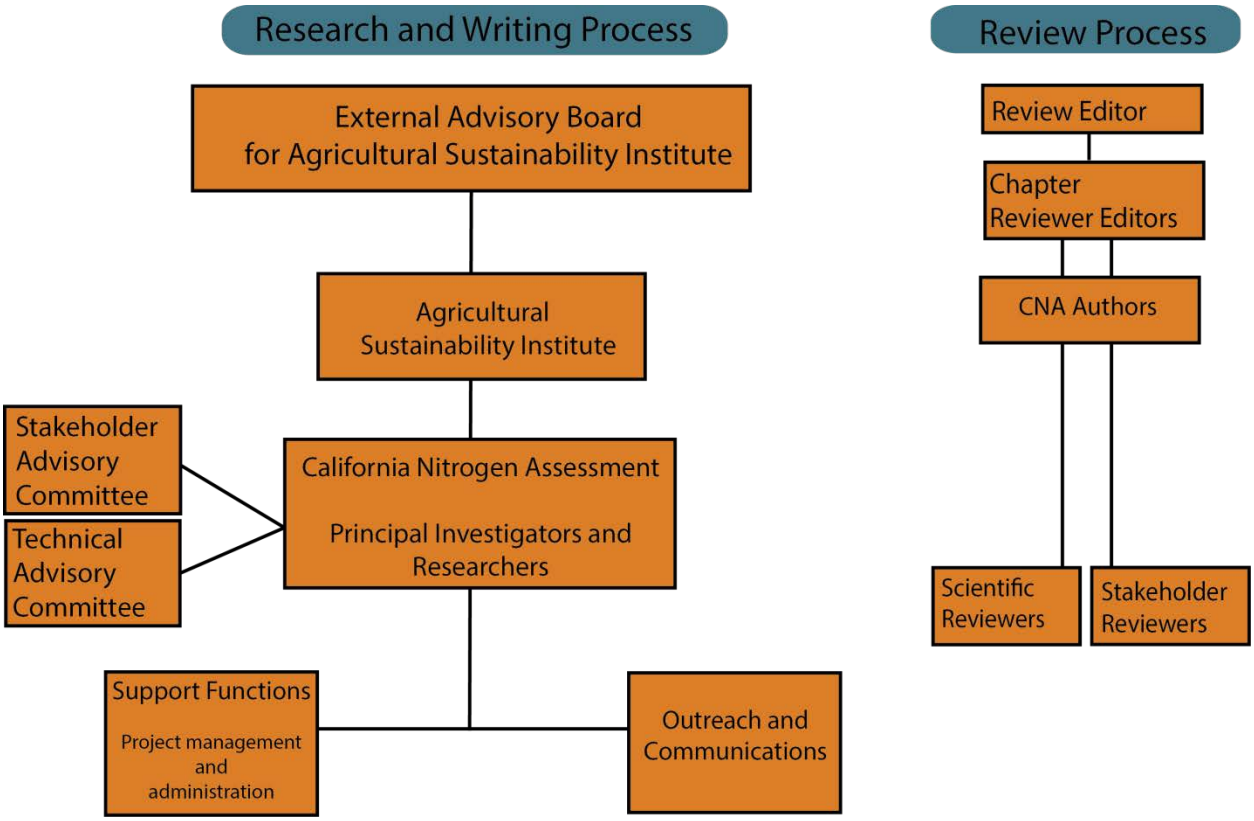
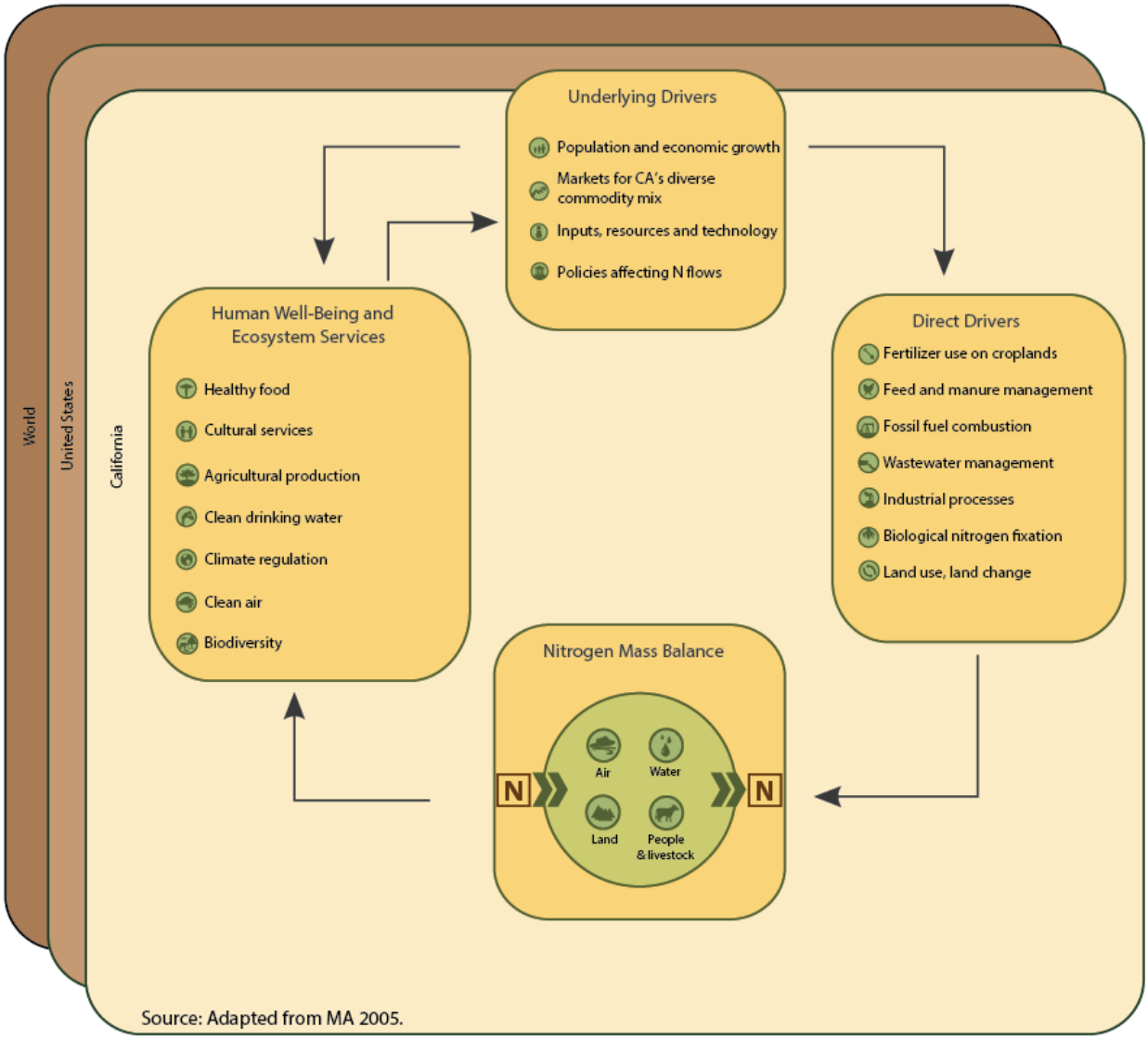


Figure 1.5 Governance structure of the California Nitrogen Assessment



Source: Adapted from Ash et al. 2010

Figure 1.6 The conceptual framework



Source: Adapted from MA 2005.

1227 **Table 1.1 Key engagement activities**

Assessment stage	Engagement mechanism	Targeted stakeholders	Outcomes
Design: setting the agenda	Stakeholder forums and grower meetings	Growers, agricultural industry, government, environmental and health organizations	Suggestions for research questions; feedback on conceptual framework; network and database of stakeholders invested in N management in California.
	Email and phone consultations	Growers, agricultural industry, government, environmental and health organizations	Suggestions for research questions; network and database of stakeholders invested in N management in California.
	Survey	UCCE Farm Advisors	Data on current cropping practices, opinions and level of awareness.
Implementation: research and dialogue	Field visits	Growers and agricultural industry	Information on agricultural practices and management options; audio and video clips of N management issues and solutions from growers' perspective (available at www.asi.ucdavis.edu/nitrogen).
	Email and phone consultations	Growers, agricultural industry, government, researchers (UC Davis and elsewhere)	Information and data on flows of N, agricultural practices, and management options; suggestions on methodological approaches; network of researchers and stakeholders invested in N management.
	Participatory scenarios workshop	Members of Stakeholder Advisory Committee	Raise awareness of key drivers of N use and brainstorm plausible futures of N in California; identify differences in stakeholder perspectives and build shared understanding; create network of stakeholders invested in N management in California.
	Online comment forum	Members of Stakeholder Advisory Committee	Feedback on selected materials to guide assessment research.
		General public / stakeholders	Comments on assessment (e.g., input on data needs and key issues).
	Seminar class	Students and researchers at UC Davis	Build capacity for assessment methodologies and application of these methods to issues on agriculture, nitrogen, and climate change in California.
	Academic conferences	Researchers, government, environmental and health organizations	Raise awareness of CNA and obtain feedback on research goals, methodologies, and preliminary findings.
	Presentations to commodity boards and government	Government, agricultural industry, growers	Raise awareness of CNA and obtain feedback on research goals, methodologies, and preliminary

Assessment stage	Engagement mechanism	Targeted stakeholders	Outcomes
			findings.
	Speaker series	Students and researchers at UC Davis	Knowledge transfer with seven scientific experts from across the US and internationally; raise awareness of CNA and N management issues in California and elsewhere.
	N symposium	UC researchers and UC Cooperative extension specialists	Knowledge transfer on nitrogen-related issues in California; raise awareness of the CNA and build network of researchers across a range of disciplines.
Review process	*Stage 1: scientific review* – online review template	9 members Technical Advisory Committee	Ensure final assessment report has scientific credibility, reflects the state of knowledge fairly and adequately, and is attentive to varied stakeholder perspectives. Archive of all comments, authors' responses, and editors' feedback posted to www.asi.ucdavis.edu/nitrogen
		40 scientific experts from academia, government, and non-government organizations; 10 review editors	
	Stage 2A: SAC review – preliminary online review	29 members of the Stakeholder Advisory Board; 10 review editors	
	Stage 2B: public review – online review forum	Participants in past CNA meetings/events; general public; 10 review editors	
Dissemination of results	Nitrogen website	Key stakeholder groups involved in assessment; general public; researchers	Raise awareness of CNA process and findings; provide point of access for stakeholders interested in N management in California.
	Targeted summaries, policy briefs, white papers	Policymakers, farmers, educators/students, agricultural industry	Raise awareness of CNA and main messages - key findings presented in easily digestible formats targeted to specific interests/perspectives.
	Stakeholder forum	Growers, agricultural industry, government, environmental and health organizations	Raise awareness of CNA and main messages; develop shared understanding of N issues in California and potential solutions; build network of varied interests to move forward.

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