Chapter 6: Scenarios for the future of nitrogen management in California agriculture

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What is this chapter about?

Scenarios can help stakeholders deal with controversy and complexity, and they are particularly useful in cases where there is a large amount of uncertainty, as is the case in this assessment. This chapter describes the process (overview in section 6.1 and details in section 6.4) and results (sections 6.2 and 6.3) of a scenarios development workshop involving a diverse group of stakeholders who were asked to creatively think about the following question: *How will we manage nitrogen (N) in California agriculture over the next 20 years?* Although the starting perspectives were quite diverse, the stakeholders collectively identified two areas of high uncertainty and great influence: future profitability of California agriculture and the future course of agricultural policy and mechanisms for implementation. This exercise led to the stakeholders developing four plausible futures of how N-relevant technologies and policies might unfold and how these would affect N management and impacts, based on different possible profitability and policy trajectories.

Stakeholder questions

The California Nitrogen Assessment engaged with industry groups, policy makers, non-profit research and advocacy organizations, farmers, farm advisors, scientists, and government agencies. This outreach generated more than 100 N-related questions which were then synthesized into five overarching research areas to guide the assessment (Figure 1.4). While this chapter presents possible 'scenarios' of the future of N in California, it provides some insights related to the following stakeholder questions[1]:

- To what extent would policies designed to reflect the public health and environmental costs of nitrogen pollution affect food prices and farm revenues?

[1] These questions will be addressed in more detail in other chapters based on historical evidence, trends, and analysis of current conditions in California.

- How can policies account for the trade-offs between costs and benefits of N use?
- How might policy be used more effectively to both monitor and address non-point source agricultural pollution?

Main messages

Participants in the scenarios workshops identified the profitability of farming and environmental regulations as two of the most uncertain forces and important drivers affecting N management in California over the next two decades.

Based primarily on variations in these two attributes of profitability and regulation, stakeholders determined four potential futures for N in California. The four scenarios are the following:

1. *End of agriculture:* Rising cost and declining competitiveness for California farmers, with mandates and regulation running ahead of technological capabilities to address N issues.
2. *Regulatory Lemonade:* Good prices and strong competitiveness for California farmers, with strict mandates and regulations to control N tempered by flexible implementation to allow technological capabilities to catch up.
3. *Nitropia:* Farming economics are favorable, and technological innovation spurs controls of N before there is need for regulation.
4. *Complacent agriculture:* Rising costs and declining competitiveness for California farmers, with incentives and regulation lagging behind technological capabilities to address N issues.

The four scenarios show that the environmental and human health impacts of agricultural N use could vary substantially depending on regulatory responses and the competitiveness of California's

agriculture industry in the global context. The worst-case scenario, from the perspective of outcomes for agriculture, the environment, and human health, evolves from a combination of low agricultural competitiveness and low regulatory pressure to adopt better management practices and technologies, which leads to poor outcomes for the agricultural sector and mixed outcomes for the environment and human health. The two best-case scenarios in terms of outcomes, involve high agricultural profitability, which stimulates investment in better management options, and either strict regulations that are rolled out in a flexible and timely manner, or government policies and consumer-driven certification schemes that provide incentives for adoption, resulting in better environmental and human health outcomes.

The four scenarios collectively suggest that multiple pathways could lead to positive environmental and human health outcomes around N. On the one hand, strict regulations can force more monitoring, information management, and technology adoption, as happens in Scenarios 1 and 2, while on the other hand, agricultural profitability, often driven by consumer demand and possibly price premiums for best management practices, can also drive industry investment in development and adoption of better practices, as in Scenario 3.

The scenarios suggest that the manner in which regulations are implemented can be as important as the actual extent of regulations, and that farm profitability can be both an enabler of better N management as well as an outcome of N management policies. In Scenario 2, regulations are implemented with flexibility and with more advance notice and involvement from agricultural producers, allowing producers to maintain profitability while changing practices. In Scenario 1, rapid imposition of regulations decrease profitability and farmer buy-in, resulting in good environmental outcomes but poor economic outcomes for the farm sector. Differences in scenarios suggest that pro-active industry participation may help agriculture to adapt successfully to a highly regulatory environment. Moreover, the scenarios suggest that farm profitability can also be an important driver or at least a critical precursor to innovation in N management, suggesting multiple feedback loops between regulatory policies, farm profitability and N management.

None of these scenarios by themselves lead to sufficient improvement in groundwater quality to fully address human health concerns by 2030. This shortcoming is primarily due to the fact that N leaches through the soil profile at very slow rates, often taking decades to reach the groundwater. Therefore, even if all agricultural N inputs were 100% ended in 2010, the N that had already been added in prior years would continue to accrue in groundwater in 20 years' time. For this reason, regulation of agricultural N management alone is unlikely to fully address human health concerns in only 20 years, although it could improve the condition of groundwater over a longer timeframe.

An historic drought affected water supply across the entire state for several years immediately following the creation of these scenarios in 2010. That extreme weather event – combining low rainfall with historic high average temperatures, has raised awareness of prospects for extreme fluctuations in climate going forward, particularly among the agricultural communities of California's Central Valley. **While these prospects for greater uncertainty about climate and water supply accentuate their importance, recent events do not significantly affect how these scenarios would be formulated.**

6.1 Using scenarios to establish a common understanding around N in California

This chapter describes a set of four scenarios developed by a diverse group of stakeholders, representing a wide range of perspectives in California agriculture, public health, and environmental advocacy (see Appendix 6.1 for a complete list of participants). These scenarios represent plausible alternative futures for the “story” of N in California, stemming from stakeholder workshops in June and September 2010, in which participants were asked to think creatively about the following question: *How will we manage nitrogen in California agriculture over the next 20 years?*

6.1.1 The logic behind the scenarios

Environmental scenarios are "plausible, provocative, and relevant stories of how the future may unfold" (Bennett et al. 2005) based on an internally consistent set of assumptions about how key driving forces will interact. The use of formalized scenarios development and analysis to deal with uncertainties in future trends and events began more than 50 years ago and has increasingly been used for addressing environmental uncertainties since the 1980s and 1990s. A formalized scenarios development process offers multiple benefits to stakeholders facing complex, uncertain, and potentially nonlinear changes in the environment. With uncertainty, it becomes imperative to develop adaptive decision-making that is flexible to unexpected changes, and scenarios can be an effective tool to facilitate that process (Aggarwal 2010). They play a useful role in raising awareness and educating people about the dynamics of environmental problems, they provide scientists opportunities to explore the inter-connectedness of information from different disciplines (social and biophysical sciences), and they support strategic planning by stakeholders and decision-makers by providing insight into possible future developments (Alcamo and Henrichs 2008).

The primary objectives for constructing scenarios as part of the California Nitrogen Assessment were to foster creative interaction and to build a common understanding around the dynamics and consequences of nitrogen management among diverse stakeholders who often hold very different views on the subject. The scenario construction process itself can enable negotiation on different views and can also build competencies in recognizing potential consequences of different driving forces and stakeholders’ own actions and responses (Wiek et al. 2006). Secondarily, the objectives of this exercise were to create scenario storylines that could inform policy thinking on strategies to effectively address nitrogen-related problems.

The California Nitrogen Assessment scenarios are grounded in consideration of the many driving forces that are likely to shape the future use of N in California agriculture. During the June 2010 scenarios workshop, participants developed a list of driving forces that were grouped into seven main categories (additional details are provided in section 6.4). Participants then selected two driving forces as simultaneously highly uncertain and highly important—1) changes in farming profitability and economic competitiveness and 2) shifts in the public policy of N management. These two attributes were used to populate four quadrants in which the horizontal axis represents external forces that drive changes in farming profitability, and the vertical axis represents the response of California's agricultural industry to shifts in public policy (Figure 6.1). The four scenarios reside within these four quadrants, differing in their driving forces and their subsequently divergent outcomes. Building the scenarios on two critical uncertainties that influence most or all of the others follows a model employed by other scenario exercises, notably the Intergovernmental Panel on Climate Change (IPCC 2000)and the Millennium Ecosystem Assessment (MA)(Bennett et al. 2005; see also Henrichs et al. in Ash et al. 2010, Schwartz 1991).

[Figure 6.1]

6.2 Our four scenarios: an overview

Below is a brief summary of the core ideas in each of the four scenarios developed by the stakeholder groups – (1) End of agriculture; (2) Regulatory Lemonade; (3) Nitropia; and (4) Complacent agriculture. The full scenarios, describing plausible futures extending over the next twenty years, can be found in section 6.3 of this chapter. Each of these scenarios were assessed along common characteristics that affect the nature of future conditions – these include key drivers such as the economic and regulatory landscapes and public opinion and consumer behavior, and outcomes to the agricultural sector, human health, and the environment (Table 6.1). It should be noted that, in terms of regulatory policies, the scenario-building groups focused more heavily on the outcomes of different regulatory directions and did not delve very deeply into describing the specific types of regulations that might be enacted within each scenario. More details about different possible policy approaches to managing N and an assessment of their potential effectiveness can be found in Chapter 8.

[Table 6.1]

6.2.1 Scenario 1: End of agriculture

Scenario 1 is a world in which California agriculture becomes significantly less competitive over the next twenty years, as farmers incur higher production costs driven by tighter regulations being implemented faster than farmers are able to adapt to them. Due to growing environmental and public health concerns, policy makers and regulators mandate changes in agricultural practices to reduce N applications in California. The technology to do so proves costly as technological solutions develop slowly, with few if any clear incentives for technological innovation being offered. As scientific knowledge of health impacts becomes clearer, regulations address water quality and the buildup of greenhouse gases in the atmosphere. As the state's total farm gate revenue declines, farmers are unable to invest in new technology and innovative farming methods. Small farmers struggle to afford the cost of compliance. These developments trigger rounds of consolidations, a decline in crop diversity, rising unemployment for farm workers, and a rise in the number of larger farms. Many dairies leave California, and move to states with weaker regulatory environments. Total N use declines in California agriculture as farming acres and crops decrease in number, and the state's air and water quality have improved.

6.2.2. Scenario 2: Regulatory lemonade

Scenario 2 is a world in which California agriculture benefits from higher global food prices and growing demand for the diverse and environmentally "clean" foods grown in the state over the next twenty years. Advances in N science and public awareness drive agricultural policy, but California farmers remain competitive – with ample public investment and incentives for research and development and a favorable regulatory implementation schedule to reduce N applications that takes a long-term approach to address environmental and health impacts. New regulations also make it possible for costs to be shared by consumers, and farmers are able to meet requirements with new investments that stimulate innovation in farming practices. In this sense, they are successful in turning the "lemons" of a strong regulatory environment into the "lemonade" of new innovations that keep them competitive and their products in demand. Issues of water scarcity, population growth, and continued monitoring of N in the environment are balanced so that California agriculture is protected as a resource vital to the state's long term economy. Nitrogen is used more efficiently and with improved scientific understanding of smart use, leading to a long term decline in the total amount of N leaked into the environment. A form of precision agriculture expands in California farming. In the short term, excess N remains in the environment, but specific interventions increasingly protect public health and reduce greenhouse gas emissions.

6.2.3. Scenario 3: Nitropia

Scenario 3 is a world in which California agriculture benefits from two complementary trends over the next two decades: higher global demand and prices for its production, and the private and public development of new technologies and farming methods that result in sustainable N management. Regulators as well as strong consumer interest and willingness to pay provide farmers with incentives to make adjustments and invest in effective monitoring and management tools, which lead to efficient use of N and cost reductions. California farmers maintain their diverse base of crops and keep up with shifting market demand for sustainably grown and high-end foods. Rational approaches are used to address the costs and benefits of environmental concerns, and public health projects are evaluated based on feasibility and their potential for positive impact. Air and water quality have improved due to the precision management of N fertilizer and advanced N management on dairies. While some N issues persist over the long-term, policy and investment establish a clearly positive path to improve the efficiency of N management.

6.2.4. Scenario 4: Complacent agriculture

Scenario 4 is a world in which California agriculture is unable to offset growing international price competition and high production costs with innovative farming practices. New farming technology, although available, proves expensive to farmers, which reduces the global competitiveness of California agriculture. Lacking incentives to adopt new technology and practices, many farmers leave the state or sell to larger players, resulting in higher levels of consolidation. Dairies also increasingly leave California in search of more industry-friendly regulatory environments. Marketing agreements and private branding agreements emerge as a way for farmers to promote their sustainable practices, and these agreements later become the template for public policy. But policy later in this scenario is guided by three dominant themes: a worldwide focus on low prices and high quantities, protective government policy, and the consolidation of agriculture which leads to consolidation of political power among a handful of large operations. While these developments prevent the implementation of punitive regulations around N, they also fail to spur creation of adequate positive financial or other incentives for on-farm adoption of practices to address excess N application. With cheap food being the primary societal concern, farm gate revenue is low, suppressing interest and capacity to develop new practices.

Water availability and land use issues continue to cause shifts in the state, affecting where and how food is grown, the most visible impacts being a reduction in the diversity of crops grown in the state. With California (and US) farming less competitive, imported food has a significant place on the American dinner plate.

6.3 Alternate futures for nitrogen in California agriculture 2010-2030

Here, each of the four scenarios is described in greater detail, covering three distinct time periods from 2010 to 2030. Each of the four scenarios has distinct outcomes regarding the economic health of the agricultural sector and environmental and human health impacts of N (Figure 6.2). Outcomes for the agricultural sector include factors such as crop value, crop diversity, and technology development. These economic and technological outcomes affect the flows of N in California, which in turn affect environmental and human health outcomes, including groundwater quality, air quality, and GHG emissions, among others.

[Figure 6.2]

6.3.1 Scenario 1: End of agriculture

Abstract: Costs are rising and competitiveness is declining for California farmers, with mandates and regulation preceding technological capabilities to address N issues.

6.3.1.1. Early years: 2010 to 2017

The shape of things to come: environmental regulations and farm consolidation

Scenario 1 is a world where trends that emerge in 2010 gather momentum and eventually lead to a significant restructuring of California agriculture. Those emerging trends include growing competition from abroad, intense pricing pressure from the distribution and marketing end of food-related products, and tighter environmental restrictions to address concerns for excess N in the environment and lack of voluntary adoption of better N management practices. As these trends develop, farmers are forced out of the most N-intensive production systems, such as dairy, and those crops that face the most foreign competition, such as fresh-market tomatoes and other vegetables, and are pushed into consolidating.

During the early years of this scenario, California agriculture is caught up in the larger adjustments occurring in the global economy. These include economic policies to address the recession following the credit crisis of 2008 and 2009. Some of those policies are highly deflationary, and along with higher unemployment, dampen overall demand and put downward price pressure on most services and products, including food. The US, as the world's largest economy, stands by a more open trading policy and keeps import barriers low, thereby allowing agricultural products to flow freely into the country.

The data is in: nitrogen's dangers are quantified and the public pushes for change

California plays a leading role in the US in addressing environmental issues, and, based on consumer activism, pays increased attention to the impacts of excess N in the environment. The effects of N on groundwater and air quality are more heavily monitored, and research based on these data increasingly points to negative health and environmental impacts. Over time, increased activism to protect the environment leads to increasing mandates for agriculture in the state to aggressively reduce N leakage and clean up its effects. One of the new initiatives is a tax on N inputs, levied across the board on farms and ranches. Increased expenditures for monitoring equipment are also mandated, and various other environmental taxes are imposed to fund clean-up projects. Policies tend to favor punitive regulations over innovation incentives, thus driving up operating costs for producers. These increased costs make it harder for California farmers to compete and prosper with the intense competitive pressures they face, and smaller operations increasingly consolidate or are bought out by larger farmers who can bear the costs over the long term. California's agricultural industry begins to shrink as operations move out of state, many to Mexico and Central America, where land is cheaper, labor costs are lower, regulations are fewer, and transportation into the US market is easy.

6.3.1.2. Middle years: 2017 to 2024

Reaping what they've sown: policies lead to farm shut-downs

During these years, there is considerable frustration in the California agriculture industry across all stakeholders. Farmers and dairy operators are upset over rising costs, many of them related to attempts to address environmental issues, and find it difficult to pay for adoption of the monitoring and N management practices required by new regulations. Regulators are unhappy that despite the changes made on farms and dairies, N issues are not showing dramatic improvement, essentially because it is impossible to erase over a century of synthetic N use in such a short time. Activists are unhappy because they are still seeing the public health and environmental impacts continue. Farm workers are experiencing rising rates of unemployment as farms are closed and sold to developers. Many dairies leave California and move to states with more favorable regulatory environments. Pockets of poverty increase in Central Valley communities formerly dependent on the farm economy. Consumers are also unhappy as imported food is sometimes of lower quality and lacking in freshness. When food safety issues arise, it is often impossible to trace distribution chains and clearly identify problems.

Past the point of no return: land is re-purposed and crop diversity suffers

The factors driving the changes leading to the frustration, however, are now firmly in place and in fact are gathering momentum during these years. Foreign investments into US farms outside of California are now producing returns. Federal policy supporting open trade is now locked into international agreements. Prime farmland in California is being developed into solar power stations, suburban subdivisions, and in some cases, protected habitats. Farm workers have also migrated out of the state. Larger farms have emerged and rely on policy instruments such as incentives for conservation practices to lower some of their taxes and make ends meet. California's crop diversity has dropped significantly as production of some fruits and vegetables disappear from the state.

The writing on the wall: regulations aimed at big farms also hurt small-scale farms, and technological solutions develop too slowly to help

California's attempt to address the N issue also runs into some challenges during these years as original cost estimates prove overly optimistic. Technological challenges also emerge as some of the hoped-for innovation proves less effective than forecast, and other precision agriculture solutions arrive too late, due at least in part to a lack of clear incentives for faster and more far-reaching innovation, and lack of sufficient public or private sector investment in research and development. Policy makers push ahead and find ways to put additional pressure on what are now larger farms, who they believe can handle the increased costs and seek federal assistance. Activists continue to point to "big Ag" as the problem and continue to lobby for more regulation, such as design standards for dairy lagoons and manure handling systems, and performance standards that restrict the amount and seasonal timing of fertilizer applications and require time-consuming documentation (for a description and assessment of design and performance standards, refer to Chapter 8). These new regulatory pressures have the unintended consequence of squeezing small farms that can't afford the cost of compliance. Because of this, many of the small-scale farmers still in business see the writing on the wall, and most of them rush to sell their land.

6.3.1.3. End years: 2024 to 2030

The new order: only large-scale farms with select crops have survived

In urban areas, some people will be growing fruits and vegetables in home or community gardens. These will make up an insignificant amount of the food most people consume. But even those gardens will be restricted in their use of chemical fertilizers; consumers will be heavily urged to use compost. On the other hand, both the conventional and organic farms that remain in California will be mostly large-scale.

Better living, at a cost: high-tech agriculture, reduced greenhouse gas emissions, and improved human health

California will also be a national leader in the implementation of environmental technologies, some which have met their promise and some which have not. The environmental technologies that failed will be seen as wasteful experiments and painful lessons learned. However, total use of N in California agriculture will have declined significantly. In most cases, California's production costs for agriculture will be among the highest in the nation, due in large part to the high costs of mandatory monitoring and precision agriculture technologies to reduce N use, and the additional fees and taxes levied on agriculture to help fund N pollution clean-up projects.

In its long term fight to reduce the impacts of excess N in the environment, California will be able to claim some important victories. A large portion of California agriculture's greenhouse gas emissions will have been mitigated, and transportation and energy sources in the state will also contribute less to atmospheric and ground-level N pollution.

Was it worth it?

Looking back over the past two decades, California farmers and state officials will wonder whether the big changes they have gone through were all worth the results. Food may be affordable for consumers, but food quality and safety will not have improved much, and in many cases will have declined. On the other hand, with a smaller agricultural base and some of the former cropland going into solar power generation and protected habitat, statewide water use has declined, easing some of the urban versus rural, and north versus south conflicts over water allocations. However, the diversity of crops grown in California will be much lower, and many small and medium-sized farms will be lost to consolidation. Fertilizer usage on a global basis will be much larger – but outside of California. Years of intensive scientific study has resulted in a clear understanding of nitrogen's effects on human health and the environment, but it's unclear if the responses have been proportional to the problem.

6.3.2 Scenario 2: Regulatory lemonade

Abstract: California farmers benefit from strong prices and competitiveness, while mandates and regulation lead technological capabilities to address N issues.

6.3.2.1. Early years: 2010 to 2017

Setting the standard: healthy people and healthy farms

Scenario 2 is a world in which California agriculture continues to set the standards for the nation in terms of environmental safety, food quality and the integration of technology into farming. Just as the state was the leader in setting standards for automobiles to address environmental concerns, it will also be a leader in moving the nation to precision agricultural practices. The state will combine tougher regulatory oversight, advanced technology and consumer supported standards to lead to a competitive, more specialized and high-value agricultural sector. This sector feeds a population that is increasingly concerned about healthy food and is willing to pay for higher costs.

Farmers ride the wave of regulation: public interest drives policy changes that the agricultural industry helps to shape

Indications of the emerging future for California agriculture during these years include the drive for more monitoring and measuring of N. Public awareness of the health and environmental effects of excess N leakage is a key driver for policy change. Regulators take a long-term view to address problems connected to N, and believe that more work needs to be done to thoroughly understand the science of nitrogen's effects on human and environmental health. They are careful to build some flexibility and feedback loops into new regulations and set up monitoring and analysis procedures within a long-term strategy.

Farmers get a sense of what might be emerging and increase their level of understanding and sophistication in N management. In many cases, the steps needed can be readily implemented, based on already proven best management practices that until now have been poorly adopted. Farmers who are already specializing in high-value crops are taking the initiative. They take the risks that higher prices and growing markets will bear out in the long term. Larger farm operators see long-term advantages in proprietary processes that allow them to out-compete others, so some private investment is also supporting the evolving new standards. The agricultural industry stays involved in shaping new regulations, and it pays off with an implementation schedule that allows farmers plenty of lead time to make changes. Collaboration and advance notice of new regulations means there are opportunities to prepare for the changes and compete more effectively.

6.3.2.2. Middle years: 2017 to 2024

Forging a national and global model: California defines sustainable agriculture

During these years it becomes increasingly clear how strong California's influence in agricultural innovation is. The fact that the state serves such a large consumer base, has such a diversity of crops, and has the scientific and educational resources to apply to agricultural innovation and improvement becomes a dominant factor for the nation. California standards are copied by other states that do not have its advantages but want the benefits of its know-how. Global companies also take note of California's innovation and its ability to make the state's products more competitive internationally. The state's practices begin to define what sustainable agriculture is. It is information intensive, science based, and comprehensive.

The keys to success: an easy-to-use reporting system, engagement and collaboration with farmers, and integrated policies based on smart science

California takes a big step in implementing an easy-to-use online nutrient-use reporting system that contains high levels of integrated information. This is used to enforce new rules as well as reward those who comply. Over time, the system weeds out poor performing or non-complying farming operations and leads to some consolidation. Outreach to farmers and ranchers increases as funding flows into University of California Cooperative Extension. Cooperative Extension Specialists also interact more with the public to increase public awareness of critical agricultural needs and trends in use of better nutrient management practices. Although efforts are made to ease in new requirements with sensitivity and flexibility to address the needs within different crops and regions of the state, changes are still mandatory. Consumers also play an important role. New food labeling rules allow California-produced products that meet or exceed stringent new nutrient reporting and management requirements to bear "eco-California" labels that enhance consumer interest and willingness to pay higher prices. Alternative energy technologies are favored in tax policies so as to reduce energy costs.

A comprehensive view of agricultural activity in California emerges in a way that allows detailed analysis and "smart" public decision-making. An integrated approach to public policy has also taken shape, with regulatory silos consolidating and allowing for elimination of contradictory regulations and more streamlined enforcement and compliance. Measuring and monitoring instruments blanket the state leading to real-time, in-the-field management information across a wide range of variables. This allows new guidelines and applications to be developed and used wisely. Some private firms invest profitably in the new technology and systems. Air and water quality are also monitored and integrated into local land use and transportation policies. For farmers, a new world of nutrient management is technologically enabled, implemented, and enforced. It is worth noting that this will also require an educated and trained workforce that can develop and operate the technologies and systems described.

Public backing for environmental stewardship: strong consumer support for California-grown products

The net environmental impact of much of this change has yet to show big results at this stage. Still, the true costs of cleaning up the environment are better understood and communicated to the public through increased Cooperative Extension and industry outreach to the public. Clean water infrastructure is under construction in many places and new practices are taking hold. The historical use of N remains an issue and a public health concern. Voters give a groundswell of support to the notion of California as a national leader in environmentally-friendly agriculture. New policies level the playing field in California as all producers are required to meet the new nitrogen monitoring and management standards. Consumers respond with a willingness to pay more for California-grown products. Legislators pass bonds to finance the provision of water treatment infrastructure in underserved communities to address nitrate accumulated in drinking water from prior decades of agricultural N applications, and approve funding increases to UC Cooperative Extension.

6.3.2.3. End years: 2024 to 2030

Staying ahead of the curve: California begins developing the next-generation in precision agriculture and other technology innovation

California agriculture is widely recognized as the leader in precision farming practices and in high-quality food products. Industry and public sector investments pay off in strengthening a world-class food industry. Other states and countries are working to catch up with California. The state begins movement into the next-generation of technology and systems which it believes will lead to a long-term reduction of excess N in the environment and reduce public health risks. Next-generation technologies have the potential to reduce the cost of, expand the use of, and improve the effectiveness of nutrient management systems.

Reaping the rewards: good food at reasonable prices

The changes in California farming have delivered substantial benefits to the state's consumers. Even though there has been some reduction in numbers of crops and producers who could not keep up with the changes, on balance the food choices remain high and quality and availability are unsurpassed. Jobs in the state's agricultural sector have been sources of steady employment and the state's positive trade balance in agricultural products has supported economic growth. Highly-trained agricultural "knowledge workers" are well paid and are in high demand.

Storm clouds on the horizon: population growth, land use tensions, and competition for water can't be ignored

Environmental challenges remain for California, despite its progress. The overall growth in population puts growing pressure on the state's infrastructure. Water is in higher demand, its allocation is contentious, and land prices and land use tensions increase as the state's population nears 50 million. Meeting the state's energy demand has also put pressure on land use if alternative energy technologies require large amounts of land. Removing excess N from ground water remains a challenge, even though new technology and practices are moving in the right direction. Furthermore, while some of the technologies that have improved N management in agriculture have involved increased irrigation efficiency, increasing impacts from climate change place even more pressure on water supplies and on agricultural producers to adapt. Political activism on the N issue remains strong, and policymakers have a larger body of science to draw upon for decision making.

6.3.3 Scenario 3: Nitropia

Abstract: Farming economics are favorable, and technological innovation spurs control of N before there is need for regulation.

6.3.3.1. Early years: 2010 to 2017

Building Nitropia: innovative technology, a thriving farm economy, and smart policy

Scenario 3 is a world in which innovative technology, smart agricultural policy, and strong consumer demand for high quality food and environmentally sound production practices combine to usher in a new age of food production in California. Key positive trends lead to a more modern, efficient, and higher quality food system for the nation, where N is efficiently used and well monitored.

If agriculture is to be re-invented in the US, there is no better place for it to begin than California. The state has a combination of all of the key factors: a research and technological base in its great universities; a diverse crop base from which to learn and experiment; consumers interested in food quality and willing to pay enough to encourage growers to respond; private venture capital constantly searching for new innovation; and highly qualified regulators with the desire and capability to use science-based interventions and incentives to achieve objectives. All of these factors combine into a vibrant and innovative environment where agriculture is moved onto a more sustainable path.

A shared goal with a shared cost: consumers pay higher prices while incentives and regulations take shape

An indicator of things to come occurs in the early years, as both the state government - in response to public concern - and the agricultural sector - in response to consumer demand as well as to internal concerns about long-term business viability - invest in research focused on improving N management and N use efficiency. This investment meets with some early successes as management, monitoring, measurement, and information sharing technologies lead to better farming methods and reduced economic and environmental costs. Consumer demand for high-quality food keeps California's farmers economically competitive. New policy focuses on incentives by offering cost-share arrangements for farmers to adopt new technologies for monitoring crop N needs and applying fertilizer and irrigation water. Rather than mandating the use of any one technology that may not work in all cropping systems, these incentives give farmers a range of choices and enable continued diversity among the crops grown in California. Incentives are also focused most strongly in areas where public health impacts are most acute and where technical interventions are likely to be the most successful. Policy makers also invest in new water system projects where needed, but cost effectiveness and public health and safety issues are kept in balance. High-cost projects promising high-end results are studied closely and their risks are identified. Many high-end projects are rejected for lower-cost approaches. In addition, early research results show that urban uses of N need to be managed as much as farm-based uses, which in turn opens the eyes of consumers to N management issues and increases support for remediation projects.

6.3.3.2. Middle years: 2017 to 2024

Even better than expected: technology greatly improves N management

Innovative energy efficient technologies, new genetic research, and improved information technologies lead to a revolution in food production and consumption. The new technologies and methods exceed expectations because they are able to combine with existing processes that lead to new efficiencies and capabilities. Farmers are increasingly able to target markets, improve quality and safety, and manage their whole enterprise on a real-time basis. Biotechnology results in crops with better nutritional content and drought and pest resistance, which will allow crops to grow better under adverse conditions and recover applied N more reliably. Information and monitoring systems also allow farmers to use fertilizers more precisely by adjusting the rate and timing so that the exact quantity is applied only when needed according to the development stage of the crop. Changes in equipment also improve placement of fertilizer and expansion of minimum tillage techniques, for a combined effect of lower N applications, less N leakage into water and air, and cost savings to producers. Livestock systems, especially dairies, also benefit from cost-share policies that assist producers in adoption of more efficient manure management technologies. Advances in information technologyenable consumers to know which crops and producers achieve the highest levels of N efficiency, thereby enabling those producers to be rewarded with customer loyalty and higher profits. These practices begin to define sustainable agriculture for the 21st Century.

Better living through science: establishing the idea of a sustainable N balance

A concept of sustainable N balance emerges in California agriculture. This idea becomes practical as information and monitoring systems are designed with a deeper understanding of the N cycle in the environment and nature's ability to recycle N. Policies and plans emerge that over the long-term will slow and eventually reverse the contamination of groundwater. Better understanding of N use emerges from the science, and with the right economic incentives, the proper changes can be made in agricultural practices. Farmers have so much information on the state of their crops that they are able to manage N much more efficiently with lower costs and improved food quality. Soil management also improves significantly based on research conducted in earlier years. Farmers are increasingly able to manage both soil quality and plant health.

The will of the people: public health concerns over N continue to drive consumer choice, and farmers respond to the changing tastes of consumers

Progress in managing N, not only in agriculture but also in energy and transportation, proceeds as public health concerns continue to drive policy and consumption patterns. Just as people are driving more hybrid and electric vehicles during this time, they are also opting for more organic, high-quality, and resource-conserving food. Farmers are responsive to those demands because food prices allow them to succeed in meeting the changes.

During these years, momentum gathers from the positive results in new technology and farming methods. These new approaches expand rapidly in the state and throughout the nation. California becomes a world leader in innovative agricultural technology and sustainable practices. The state benefits by having continued high crop diversity, more choice for consumers, and higher food quality. California's economy benefits as agriculture, jobs, and food exports expand. The cycle of research and innovation, venture capital investment, and new business development continues to thrive in the state, with agricultural innovation playing an important role.

6.3.3.3. End years: 2024 to 2030

Toward sustainable N use: combining monitoring, management, and technology helps improve air and water quality

California moves to more efficient N management during these years. The combination of increased N use monitoring, more efficient use of fertilizers and organic N sources across the board, improved N management on dairies, reformulated fertilizers, and reduced urban use of fertilizers have begun to have an impact. Just as air quality was greatly improved with technology and changed behaviors, water quality is following suit and quality is no longer degrading. However, a few important targets remain – such as addressing rural septic systems and water treatment systems in small communities that cannot afford to finance advanced treatment on their own.

Over the previous twenty years, California agriculture has been restructured into a more high-technology, high-quality, and market-interconnected sector. Farming proves to be both profitable and innovative. The consumer market is diverse and demand is strong with both national and international sales. Demand for organic food grows so sharply that organics now account for one-third of the market share, but conventional crops also perform well by meeting increasing global demand.

Farming even further out on the cutting edge

New technology allows a balance to be achieved in keeping food costs low, while making farming more profitable in many ways. Quick-response information systems at every stage, operated by an educated and trained workforce, help direct behavior and activity. Fertilizer is applied more precisely, with application of excess N reduced by at least 50 percent, saving farmers money and resulting in positive environmental impacts. As a result, the total amount of synthetic N fertilizer sold in California decreases. With better information technology food waste is reduced at the production, processing and wholesale stages, resulting in less unharvested N staying in crop fields and less food N being sent to landfills. A sustainable food system has emerged as a balance of smart farming methods, environmental monitoring and distribution efficiency.

6.3.4 Scenario 4: Complacent agriculture

Abstract: Costs are rising and competitiveness is declining for California farmers, with incentives and regulation lagging behind technological capabilities to address N issues.

6.3.4.1. Early years: 2010 to 2017

A swiftly tilting marketplace: high in-state production costs and slim margins keep California farmers from changing quickly enough to compete globally

Scenario 4 is a world in which slim economic margins drive how N is used in California agriculture. Few new regulations are written, and those that do emerge are paired with increasingly capable technology to monitor the environment. Despite a relatively lax regulatory landscape, rising production costs keep many California crops from competing on a national and global basis. Farmers must change their crop mixes, leave the state, and/or sell-out to larger players. Federal trade and agricultural policies allow increasing imports and competition to keep food costs low.

Slow response time: policy is focused on helping the industry tread water

During these years, policymakers shelve talks on incentives that would take aim at N management. Instead, policy is focused on sustaining a farm industry that maintains crop diversity and produces a wide range of products that consumers want. There is hope among agricultural leaders that a science-based approach will allow the state to maintain a thriving farm economy – one which will develop more sustainable methods of farming. This approach to agriculture relies on sound science, data collection, monitoring, and enforcement of existing standards. The scientific understanding of the full N cycle is progressing, but many significant questions remain. The first stages of technological research are primarily focused on monitoring and measuring, but new tools to improve N management are slow to develop and farmers lack incentives to adopt best management practices already identified. The public has an increasing interest in the monitoring of groundwater and surface water quality as it relates to N, and policymakers again discuss incentives as a possible key to mitigation.

6.3.4.2. Middle years: 2017 to 2024

A reluctance to change: most farmers maintain the status-quo because of competition from imports

These are the years when new tools and techniques are demonstrated and adopted by some farmers. Some attempts are made to encourage farmers to implement some of the new approaches. Where farmers see cost, marketing, or other competitive advantages, they quickly make changes accordingly. But other farmers are reluctant to change, due to their concern about higher costs which they are unable to pass on to consumers because of competition from imports. Farmers who are especially sensitive to environmental and public health concerns adopt the new approaches on long-term sustainability grounds and trust that the economics will work out. A limited pool of federal funding and regional pilot projects help support the limited spread of new farming techniques, but most farmers are unwilling and unable to change their practices without effective incentives.

Setting a private standard: some farmers develop private marketing agreements to promote their sustainable practices

While the pace of progress moves slowly for some, other farmers look for opportunities to innovate and compete. They also seek public acceptance of new technologies such as genetically modified crops that might be more efficient and better for the environment. Farmers who want to stay on the leading edge of farming practices forge ahead without policy makers, and in the absence of regulations or incentives, these farmers develop private marketing agreements to promote their sustainable practices. These private standards later become the template for public policy.

The importance of global forces: a world focus on low prices and high quantity puts continued pressure on California farmers

Meanwhile, price and cost competition continue to drive the global food business. While the state features prominently in the world market for select crops, farmers in those crops find it increasingly difficult to compete in the global marketplace. Food distributors increasingly view all food products as a commodity, and strive to keep food prices as low as possible. Even though some consumers are dedicated to more costly organic and specialty foods, the majority of people on the planet are not. Most consumers are unwilling to pay premium prices for food, especially if they are not sure it has health or nutritional benefits worthy of the higher price. Government policy largely supports this consumer paradigm, with a policy focus on maintaining high quantities and low prices.

Testing the market: farmers grasp for opportunities to target limited markets

A pattern emerges during these years of targeting new technologies and practices to limited markets where they might be most readily accepted. This extends from biotechnology to alternative fuels and N management practices. Crops benefitting the most from these approaches and those able to pass on the higher costs are selected first for innovations. Time and testing will tell whether innovation might expand to other areas or find limited applications only in select crops.

Fewer farms, less N: a shrinking agricultural sector means less pollution

Land use patterns shift in the state due to population growth and to loss of farms and crops that were unable to compete effectively on the world market. California agriculture contracts during this period, leading to lower demand for N. Additionally, dairies begin to leave the state in search of more favorable economic environments in which to operate. In the short-term however, ground water quality does not improve significantly because of historical accumulation of N that continues to flow downward. Pressure on regulators to address excess N remains and drives expansion of monitoring of both surface and groundwater. Air quality issues are also a hot area of activism and public health impacts are becoming better understood.

6.3.4.3. End years: 2024 to 2030

Bigger, faster, stronger: the consolidation of agricultural power results in a weak regulatory landscape

During these years, the dominance of the food industry by food retailers increases. The industrialization of food is global, and all crops are essentially commodities outside of small protected local areas where specialized quality and features command a premium price. The diversity of crops grown in the state has greatly declined and larger industrial farms, with long term contracts and real-time information systems tied to big distributors, govern the way food is grown. Only a few small scale farms and ranches remain viable in the state, capitalizing on their ability to exploit niche markets.

Having significant economic power, large farmers wield significant political and market power as well, and as a result, regulatory changes are negotiated to fit the needs of dominant players. Regulatory mandates are rare. Instead, incentive-based systems that leave lots of room for choice are the predominant approach. Only major health-related issues can invigorate public discourse and dramatically change the rules that govern agriculture. In this arena, food safety and availability are more powerful considerations than concerns over long-term environmental damage.

Eating out: food imports now play a major role in consumer diets

With the changes that have occurred, N use in California agriculture has significantly declined, driven primarily by the overall decline in farming activity in the state. In-state crop diversity has declined and imported food has increased in market share. Food products from China, Mexico, and South America have significant places on the American dinner plate.

A silver lining to a cloudy economic outlook: some gains in agricultural technology and N science, although progress has been slow

Nevertheless, some technological advances have emerged in California's farming sector. Nitrogen is being better managed in the soil and in crops. The N cycle is better understood and its lessons applied in areas where the impacts are the greatest and where they help manage production costs. An incentive-based regulatory regime exists in the state and it is working well in many locations. There is real-time monitoring and a continuous flow of information about N application and management. However, few scientists would argue that what has been achieved is a model of environmentally sustainable agriculture. Public health risks also remain to be addressed completely. More scientific research is also needed to improve and deepen the understanding of the effect N has on human and environmental health. The political will for this additional work is yet to emerge. Complacency is reinforced by low food costs.

6.4 Background and process

Scenario analysis is a widely used process to create plausible stories despite uncertainties about the future. The process allows decision makers to better see and understand the implications of decisions that have or could have long term effects on their organizations or other interests. It also creates opportunities for different stakeholders to learn from an informative negotiation process among their diverse perspectives, and to suggest strategies for addressing problem issues.

The scenarios for this project were focused on the issue of N management in California agriculture. While N plays a central and critical role in crop and livestock production, N use has led to unintended consequences, among which are greenhouse gas emissions and ground water pollution. Stakeholder participants devised a set of scenarios as a means to create a big-picture view leading to a more comprehensive understanding of response options regarding California's N management and how these responses might affect farm profitability as well as environmental and human health outcomes over time.

Once a set of scenarios is created, it can be used to brainstorm and test potential responses to emerging conditions. Scenarios allow a proactive approach to planning; they allow stakeholders to consider options and prepare for actions in advance of a future event or situation. Further, scenarios can help identify early indicators and significant outliers.

In addition to the role scenarios can play in looking at the future, the California Nitrogen Assessment scenario process was designed to increase awareness and understanding across the assessment's diverse stakeholder groups, and to ensure that a wide variety of perspectives were heard. This process was facilitated by Gerald Harris and Jeff Barnum of Reos Partners, who began working with the assessment team in April 2010. Stakeholders were contacted that same month regarding their availability for future workshops, and given the opportunity to participate in pre-workshop interviews. Those interviews were conducted face-to-face and via telephone by Harris and Barnum in May 2010, and input from those interviews was used to shape the workshops.

During the first workshop session (June 9 and 10, 2010), stakeholder participants identified a number of important drivers that would be likely to influence the future use of N in California agriculture. The facilitation team captured a list of these factors and grouped them into seven major categories:

- *Technological change*
- *Changes in farming economics (profitability)*
- *Advances in N cycle understanding*
- *Awareness of the impact of N on human health and the environment*

- *Changes in the energy system aspects of agriculture*
- *Shifts in public policy related to managing N impacts in California*
- *Information creation and dissemination*

Through group discussion, participants then jointly agreed on two driving forces from this list of categories to serve as the primary variables for the four scenarios stories, following a general model from other scenario development efforts (Henrichs et al. in Ash et al. 2010; Schwartz 1996, van 't Klooster and van Asselt 2006). The two attributes were chosen because they were simultaneously highly uncertain and highly important—changes in farming profitability and shifts in the public policy of N management. Participants agreed by a wide margin that these two factors are most uncertain and most important, and will thus most significantly affect how N-use decisions will be made in California agriculture over the next twenty years. Participants identified economic conditions that affect the viability of farms as vitally important, especially because of the wide diversity of different crops grown in California. They also agreed that public policy and regulation are central because they directly affect operating decisions and allow issues important to both government and consumers to be incorporated into agriculture. The extreme ranges of uncertainty of these two drivers help to differentiate the four possible scenarios from one another. The scenarios reside within the four quadrants created by these two drivers, with external forces driving changes in farming profitability representing the horizontal axis and shifts in public policy representing the vertical axis.

Many of the drivers discussed by the scenarios workshop group are similar to the drivers identified by the nitrogen assessment (see chapters 2 and 3). These include: global food systems, population and economic growth, regulations and incentives, land value, development of new technology, fossil fuel combustion, land-use conversion, and farm management (for both plant and animal systems).

After selection of drivers, the workshop participants were divided into four groups, with attention to representation of different stakeholder categories in each group. One or two members of the assessment project team were also present in each group as equal participants (i.e. they did not adopt particular leadership roles within the groups). Each group was assigned one of the four quadrants to use as a basis for developing a scenario storyline. Through group discussions, participants developed storylines in seven-year increments that were captured in notes written by one or two group-selected members on flip charts. At the end of the multi-hour session, each group took a turn to orally present its scenario storyline to the entire workshop group, with workshop facilitators taking notes. The facilitators, with input from the assessment team, then used their own notes plus each group's notes to write out scenario storylines in text form. Members of the assessment team checked the storylines for plausibility and consistency.

In September 2010, stakeholders reconvened at a second workshop to review the core ideas of the four scenarios previously developed, discuss any disagreements or alternative interpretations for the scenario storylines written by the facilitators and assessment team, identify gaps and additional drivers and outcomes, and suggest any necessary revisions. The group also discussed how the scenarios affect policy and agricultural practices (see Section 6.6 of this chapter) and possible research topics for the assessment which would provide needed information for varying audiences.

Members of the assessment team made final edits to the storylines based on the second workshop and re-checked all storylines for plausibility and consistency. This process led to some simplification and small changes in specific details contained within the storylines, but did not result in any fundamentally different outcomes for any of the four scenarios.

6.5 Discussion

6.5.1. Climate change and water availability

One issue notably absent in any detail from these scenarios is the potential future effect of climate change on agriculture. Climate change is already affecting California—with sea levels on the California coast having risen by as much as seven inches over the last century, and the state's snow pack and water supply shrinking under even the most conservative climate change scenario (CARB, 2009). Although neither the possible future effects of further climate change on possibilities for extreme events (both droughts and floods) nor the plausible impacts on water supply in California received detailed attention by our stakeholder group in these scenarios exercises, these topics are covered in Chapter 2 (Section 2.3).

Although competition for water resources was mentioned as a future concern in scenarios 2 and 4, the details of this competition and the related issues of water scarcity were not described. Legislation already in place (the "20x2020" plan, formally enacted as Senate Bill x7-7 2009) requires that state agencies must implement strategies to achieve a statewide reduction of 20 percent in per capita urban water use by 2020, and requires agriculture to implement efficient water management practices. The economic impact of this or future legislation on agriculture is unclear.

Additionally, other factors make the full effect of climate change on the state's agricultural system hard to predict (Jackson et al. 2009). Agriculture may experience some benefit from higher levels of CO_2, as well as longer growing seasons and the related decrease in the occurrence of freezing temperatures for sensitive crops. However, higher average temperatures may also increase pest, weed, and invasive pressures on agriculture, disturb winter dormancy in tree and vine crops, and disrupt the timing of crop pollination. Rising temperatures can also increase livestock mortality and/or decrease their productivity (CARB, 2009).

While the effect of climate change on agriculture is not detailed in these scenarios, the scenarios suggest that agriculture may have some positive effects on climate change mitigation efforts. Most of the scenarios make some mention of a reduction in greenhouse gas (GHG) emissions, but exactly how this happens—beyond the generic development of new technologies that increase N use efficiency and improve overall N management—is unclear. Presumably, such a reduction would allow agricultural GHG emissions to remain below the regulatory radar. Currently, agriculture is an unlikely regulatory target for future GHG emissions (Jackson et al. 2009) because it accounts for only 6% of the state's total emissions (CARB 2008)—although agriculture contributes more than any other economic sector to GHG emission relative to its contribution to the economy (UCAIC 2006). Moreover, agriculture may stand to benefit from climate change mitigation efforts, by sequestering carbon (C) and reducing methane (CH_4) or nitrous oxide (N_2O) emissions (CARB 2008).

6.5.2. Trigger point analysis: What could move our future from one scenario to another?

To get the most benefit from these scenarios as "thought tools", it is useful to consider what specific trigger points or conditions would result in a hypothetical future shift from one scenario to another. Identifying such triggers builds our understanding of the defining features of each scenario, and also helps us to consider what types of real-world trends or events might be most likely to lead to substantially different future conditions.

Several participants expressed the opinion that, from among the four scenarios presented here, Scenario 2, Regulatory Lemonade, at its starting point, seemed to be the closest to current conditions in California, and therefore could serve as a useful baseline for comparisons. While the details may differ substantially, what Scenario 2 shares with the current situation is a combination of a comparatively strict regulatory environment and an agricultural industry that has by and large succeeded in innovating and adapting to regulations and has maintained its global competitiveness. Therefore, we use Scenario 2 as the starting point in the following analysis, in which we examine the key trigger points that would move conditions from one scenario to another.

6.5.2.1. Scenario 2 to Scenario 1: End of Agriculture

Both Scenarios 1 and 2 involve strong regulatory environments, but a key difference between them is that, in Scenario 1, regulations are applied broadly without regard for differences between regions or crops, while in Scenario 2 they are implemented more flexibly, and with more advance-notice and involvement from agriculture, so producers have more time to prepare and contribute to the search for workable solutions. This difference suggests that the manner in which regulations are implemented can be as important as the actual extent or "strictness" of regulations. Important triggers to transform Scenario 2 into Scenario 1 include a refusal or failure of agricultural industry groups and public agencies to work together in shaping regulations and their implementation schedules. A lack of flexibility among government agencies to be able to delegate some implementation decisions to local authorities could also be important in hindering regulations from being better adapted to different regions and crops. Pressure from the public or environmental and health advocates to apply stringent restrictions on a statewide basis could hinder government flexibility. Opposition of industry groups to all regulations, regardless of their scope, or to voluntary self-policing efforts, would also lead to a situation in which agricultural players miss an opportunity to commit to a series of earlier, smaller or easier to implement regulations that might obviate the need for harsher or broader regulations later when environmental conditions have been allowed to deteriorate further.

Consumers can also play important trigger roles. In Scenario 2, consumers are eager to purchase California products, because they understand the environmental advantage of doing so, and are willing to help pay the extra costs incurred by regulations on agriculture. In Scenario 1, cheap food imports compete with California products, and consumers apparently lack awareness, information, and/or motivations and incentives to preferentially purchase California products over imported ones. A downturn in the economy that limits consumers' willingness and ability to spend more, and advertisement that focuses on the low cost of food rather than the public health and environmental advantages of "greener" products, could reduce consumer support for farmers' costs to implement new regulations.

6.5.2.2. Scenario 2 to Scenario 3: Nitropia

A crucial focus in Scenario 3, in which farming remains economically strong, is that early efficiency-related technologies become available that significantly lower net costs to producers, allowing food prices to remain relatively cheap as well. These technologies help producers to remain economically viable even when some regulations do get implemented in later years. In fact, the success of N management in this scenario really hinges on the development of revolutionary new technologies that exceed all prior expectations in their capacity to improve the efficiency of N management. One crucial trigger to attain this situation is strong public- and private-sector investment in agricultural research and development. Additional triggers could include policies that favor establishment of incentive programs, both for the development of efficiency-boosting technologies and practices, as well as for the adoption of those technologies and practices on California farms. Such incentives could be market-based (eco-labeling and branding), or could involve private and public sector competitions that reward technology developers and the producers who adopt them and can document the highest increases in N utilization efficiency. Another important trend to consider is to couple the development and release of N-regulating and monitoring technologies with efficiency-boosting technologies (which may or may not be the same technologies or techniques), so that producers may be able to adopt them as a package and benefit from a boost to their bottom line, while minimizing N pollution. If the implementation of investments and incentives described above were to succeed in spurring development as well as producer adoption of new or existing approaches that significantly increase the efficiency of N management early on, then the highly regulatory approach of Scenario 2 would be unnecessary. If increases in on-farm resource use efficiency alone do not sufficiently compensate producers for costs to implement new approaches, then early and committed consumer buy-in and willingness to pay would also be an essential trigger to attain Scenario 3.

6.5.2.3. Scenario 2 to Scenario 4: Complacent agriculture

In Scenario 4, a complacent California public and its policymakers do not follow through on emerging environmental concerns. Instead, cheap food prices and competition from imports are defining aspects of Scenario 4. Although farm profitability is not hampered by costly environmental regulations, California farmers still face difficulties competing with the large volume of cheap imported food. The trigger point in this case is marked agricultural expansion in other countries with low costs of production, as well as a consumer preference for these imported products and a lack of willingness to pay for any special "California-grown" characteristics. Another key trigger to switch from Scenario 2 to Scenario 4 would be either a cessation of a policy focus on actively incentivizing adoption of the new technologies and practices that are being developed, or implementation of perverse policies that get in the way of incentives for adoption. A shift between scenarios might also hinge on large-scale farm consolidation, which solidifies the political power of a relatively small group of dominant players. Successful alliances between these players and politicians from the powerful and more liberal urban centers of the state would likely be necessary to trigger a shift to lower-intensity agricultural regulation.

As shown by these three analyses, competition from cheap imports but also consumer interests and awareness of distinguishing qualities of California-produced food can be critical trigger points that can affect the nature of future conditions. In addition, the way regulations are implemented - with sensitivity to geographic and crop variability and with adequate time for adaptation - could be just as important as what the regulations specifically require. Finally, the nature of new technology developments can also greatly influence future conditions. If technologies are as effective at increasing farm efficiency as they are in limiting N use, then they may be able to pay for themselves in terms of allowing farmers to adopt them without risking much reduction in overall farm profitability.

Finally, the role of agricultural research and how it is funded merits its own consideration. The fact that the positive aspects of Scenarios 2 (Regulatory Lemonade) and 3 (Nitropia) strongly depend on new technologies becoming available to monitor N status and regulate N management means that such research must be supported by adequate funding, from both public and private sources. Both these scenarios entail strong economic conditions for agriculture, but it is uncertain what the situation in the public sector will be. Currently, agricultural research receives support from private interests, including commodity boards, and the public sector, with the latter's share declining. With a strong farm economy, research funding generated directly from agricultural assessments, or even in-house research by agricultural and food companies, may increase. Public sector funding could also conceivably increase under Scenario 2, which has a consuming public that is highly engaged and interested in agricultural and environmental outcomes. Under Scenario 3, technology development seems to be spurred more from within the agricultural sector, and the role of the public sector funding research is less clear. In the case of an economic downturn that cuts agricultural profits, would research and technology development continue to be funded in this scenario? Even in Scenario 2, significant strains on public coffers might constrain the otherwise good intentions of the public and policymakers. Under such situations, the continued success regarding agricultural AND environmental outcomes might hinge on new public-private partnerships that could engage new or different sources of funding, such as the food industry and private foundations.

6.6 Responses

The differences between the scenarios illustrate contrasting responses from agricultural producers, consumers, public sector research and extension, and private sector technology developers (Table 6.2). In Scenario 3, Nitropia, the positive environmental and human health outcomes that stem from pro-active, market-driven adoption of practices and technologies by farmers minimize the need for strict regulations as the scenario unfolds. In this scenario, farm profits obtained in early years can fund continued private-sector investment in research and development for further improvements in later years. However, continued success in this scenario hinges on consumers continuing to demand, and pay for, increasing levels of environmental and human health protections associated with the food products they buy. In contrast, in Scenario 2, Regulatory Lemonade, environmental regulations are very strong from the beginning but are phased in to allow for adaptation. This scenario spurs technological innovation in the agricultural sector, which may initially need to be led by the public sector. Over time, successful development and adoption of innovations allows farms to remain profitable as the scenario progresses, even within a challenging regulatory environment. Success in this scenario hinges on rapid technology development and effective public and private sector extension.

The lack of profits within the agricultural sector in Scenarios 1 and 4 requires more public sector investment to stimulate progress toward environmental and human health goals. In Scenario 1, however, the emphasis on regulation without accompanying increases in farm profitability means that, in the end, large parts of the agricultural sector are lost from the state. In Scenario 4, agriculture limps along, but without regulation, environmental health outcomes also suffer, and farming operations cannot afford to make needed technical improvements. Obtaining better outcomes in each of these scenarios might hinge on better coupling of regulatory policies with opportunities to increase farm profitability over time, for example, by designing environmental policies that provide more financial incentives for farmers to adopt specific practices or achieve specific measurable environmental outcomes.

[Table 6.2]

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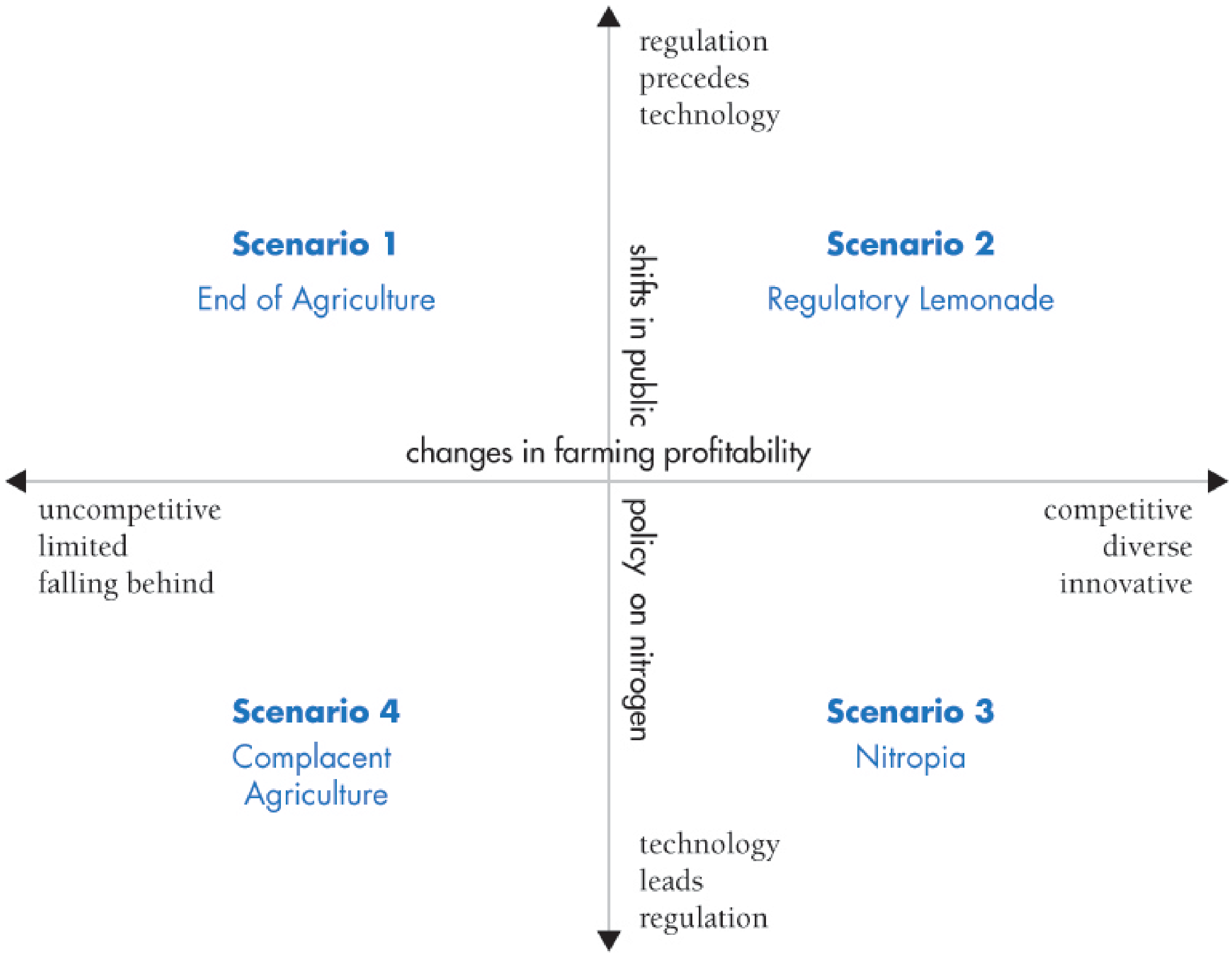
Figure 6.1. Four scenarios for nitrogen in California 2010-2030 [Navigate back to text]



979 **Figure 6.2. Outcomes of the four scenarios affecting changes in nitrogen flows in California by 2030** [Navigate back to text]

	Scenario 1 End of agriculture	**Scenario 2** Regulatory lemonade	**Scenario 3** Nitropia	**Scenario 4** Complacent agriculture
agricultural competitiveness	↓	↑	↑	↓
environmental regulations	↑	↑	↓	↓
Agricultural sector outcomes				
Crop value	N	P	P	N
Livestock value	N	?	P	N
Total farm gate revenue	N	P	P	N
Nitrogen use efficiency in agriculture	?	P	P	?
Public investment in agriculture	?	P	P	?
Private investment in agriculture	N	P	P	N
Agricultural technology development and adoption	N	P	P	N
Environmental and human health outcomes				
Reducing N leakage	P	P	P	M
Groundwater quality	P	P	P	M
Groundwater quality impacts on health	?	?	?	?
Surface water quality	P	P	P	M
Air quality	P	P	P	M
Reducing GHG emissions and ozone depletion	P	P	P	M

Key		**Changes in N flows in this scenario produce**
Positive	P	beneficial impact on agriculture, the environment, or human health
Mixed or neutral	M	mixed or neutral impact on agriculture, the environment, or human health
Negative	N	negative impact on agriculture, the environment, or human health
Uncertain	?	uncertainty about whether impact exists or whether it is positive or negative

Table 6.1. Defining characteristics of nitrogen scenarios [Navigate back to text]

	Scenario 1: End of Agriculture	Scenario 2: Regulatory Lemonade	Scenario 3: Nitropia	Scenario 4: Complacent Agriculture
Economic Landscape	High production costs	Higher global food prices; growing demand for diverse foods	Higher global demand for diverse foods; consumers drive outcomes	Dominated by global drive towards cheap food
Regulatory Landscape	Increasingly strict regulations	Flexible regulatory implementation schedule	Policies are targeted based on economic feasibility	Policy driven by global focus on maintaining cheap food and high quantities; some incentive-based regulations
Public Landscape and Consumer Behavior	Public increasingly interested in environmental and public health issues	Public helps to pay for cost of compliance	Global demand for high-end CA products increases	Consumers eat more imported food; increased public demand for cheap food
Agricultural Sector Outcomes	CA's total farm gate declines; small farms struggle to afford cost of compliance; farm consolidation	Precision agriculture grows; farms remain viable	CA farmers maintain diverse base of crops and keep up with shifting market demand	Increase in food imports; less farming in CA as farmers leave state; farm consolidation
Health and Environmental Outcomes	Improved air and water quality due to fewer farm acres	Emergence of Precision agriculture results in a decline in the total amount of nitrogen leaked into environment	More efficient use of nitrogen results in a decline in the total amount of nitrogen leaked into environment	Some late gains in the understanding of nitrogen science and health impacts; less farming leads to less nitrogen leakage

Table 6.2: Responses of different constituent groups to scenarios, and relative importance of their actions to shaping each scenario in early versus later stages of the scenario timelines

[Navigate back to text]

Key:

C[illegible]uent groups	**Scenario 1: End of Agriculture**	**Scenario 2: Regulatory Lemonade**	**Scenario 3: Nitropia**	**Scenario 4: Complacent Agriculture**
Agricultural Producers	Struggle to adapt to inflexible and strict regulations, or go out of business.	Adapt to regulations by adopting improvements over time; invest in some of their own tech improvements.	Invest strongly in tech improvements throughout.	Driven by import competition to increase production efficiencies over time, but improvements are small.
Consumers	Prefer cheaper food imports over CA products.	Become willing to pay for environmental and health protections over time.	Exert strong demand and willingness to pay for environment and health protections throughout.	Prefer cheaper food imports over CA products.
Public sector research and extension	Develop and extend monitoring and precision ag technologies.	Lead initial innovation development and extension.	Unclear role.	Constituency needed for public investment is lacking.
Private sector technology developers	Largely absent.	Support later tech improvements.	Support later tech improvements.	Inadequate.

: Crucial leading role in shaping this scenario from early years

: Important role in maintaining scenario trajectory in later years

: Passive, non-reactive role in shaping scenarios