Hydroeconomic Modeling and GSP Development

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2018 Western Groundwater Conference
Groundwater Resources Association

Sacramento, CA
September 27, 2018

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Topics

- Costs and benefits of sustainable yield
- Options to achieve sustainability: New supplies, reoperation, recharge, demand management
- Phasing-in sustainability requirements to minimize economic impacts
- Simple example to show benefit of flexibility
- Hydroeconomic modeling example

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Costs and Benefits of Achieving Sustainable Yield

- Benefits
  - Avoid impacts from undesirable effects
    - Higher pumping lifts; subsidence; depletion of connected streams; stranded wells; poor water quality
  - Avoid state intervention
- Costs
  - Costs to the implementation agency (and recovery of the costs)
  - Costs imposed on water users
- Distribution of costs and benefits

Options to Achieve Sustainable Yield

- Options to bring basins into a sustainable balance by 2040 include
  - Develop new sources of supply or recharge
  - Better utilize existing supplies
  - Reduce demand
- Developing new supply is politically preferable
- If affordable new supplies are limited, demand management (reducing water use) will fill the gap

Demand Management

- Key GSP evaluation criteria (Article 6. § 355.4.b.(5)):
  - The GSP must specify feasible projects and management actions that are likely to prevent undesirable results and ensure that the basin is operated within its sustainable yield

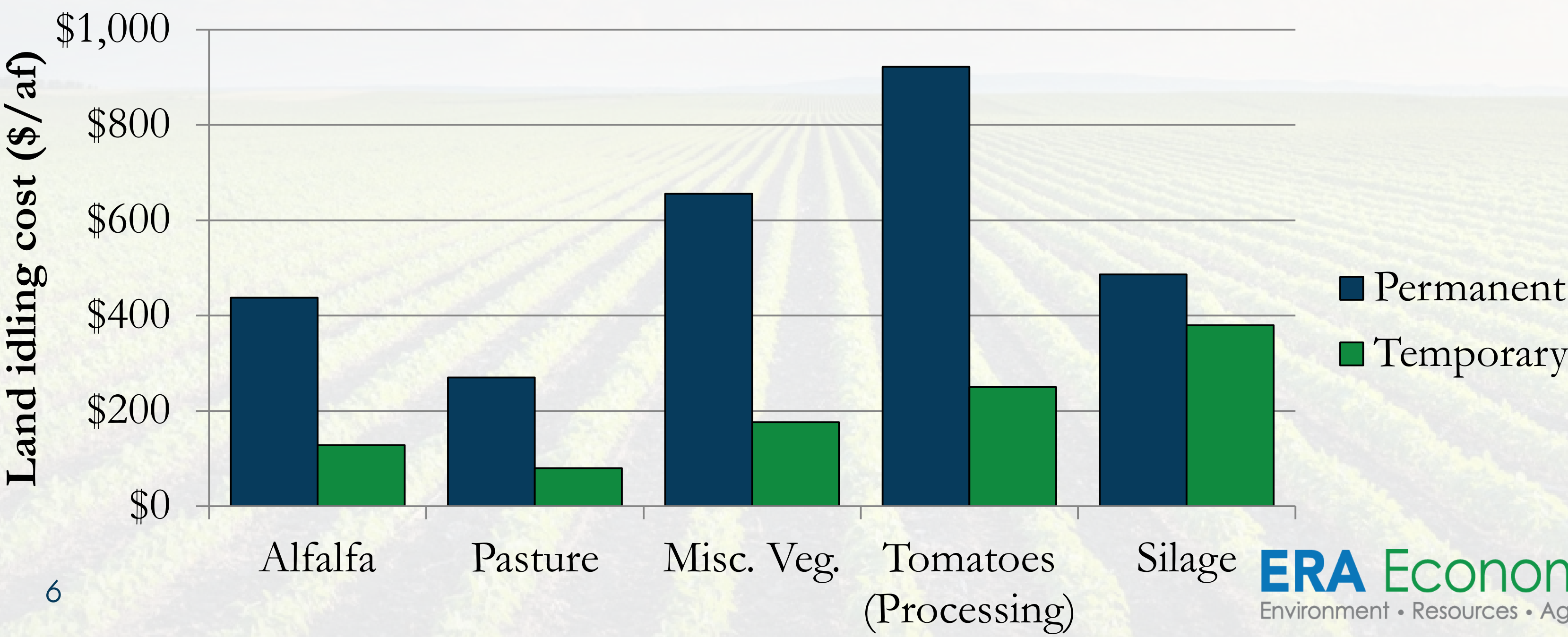
- Demand management (reducing water use) program
  - Scalable over time, depending on affordable supply augmentation projects
  - Ensure subbasin meets sustainable yield, and GSP is approved

- Demand management options may include:
  - Groundwater pumping limits,
  - Groundwater extraction fees
  - Assignment of pumping "credits," and a mechanism for trading those credits
  - Different mixes of extraction fees, pumping limits, and trading can achieve sustainability target

Demand Management Costs

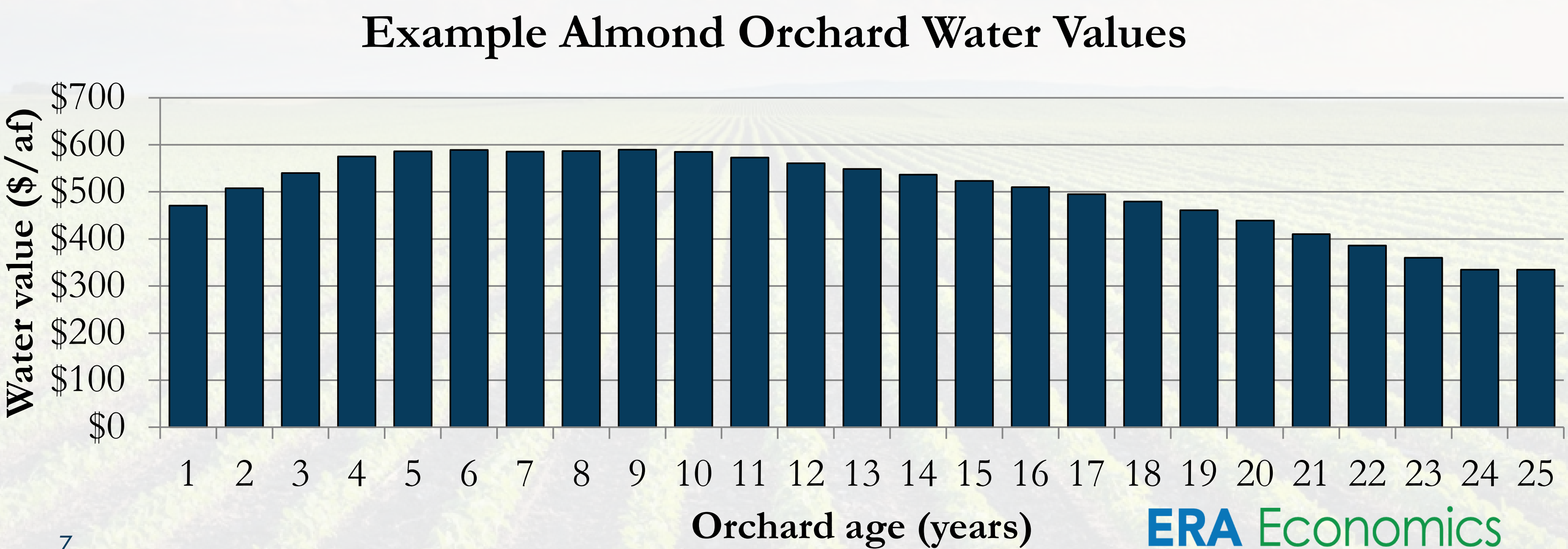
- The cost of idling land varies by crop
  - Permanent land retirement includes significant capital costs
  - Groundwater extraction fees water market prices, have be greater than water values in crop production

Example Crop Water Values



Demand Management Costs (cont.)

- Permanent crops typically have a negative cash flow for 3-5 years after establishment
  - The value of water is significantly higher for young orchards
  - Expanding orchard acreage across the state means many subbasins have a greater proportion of young orchards



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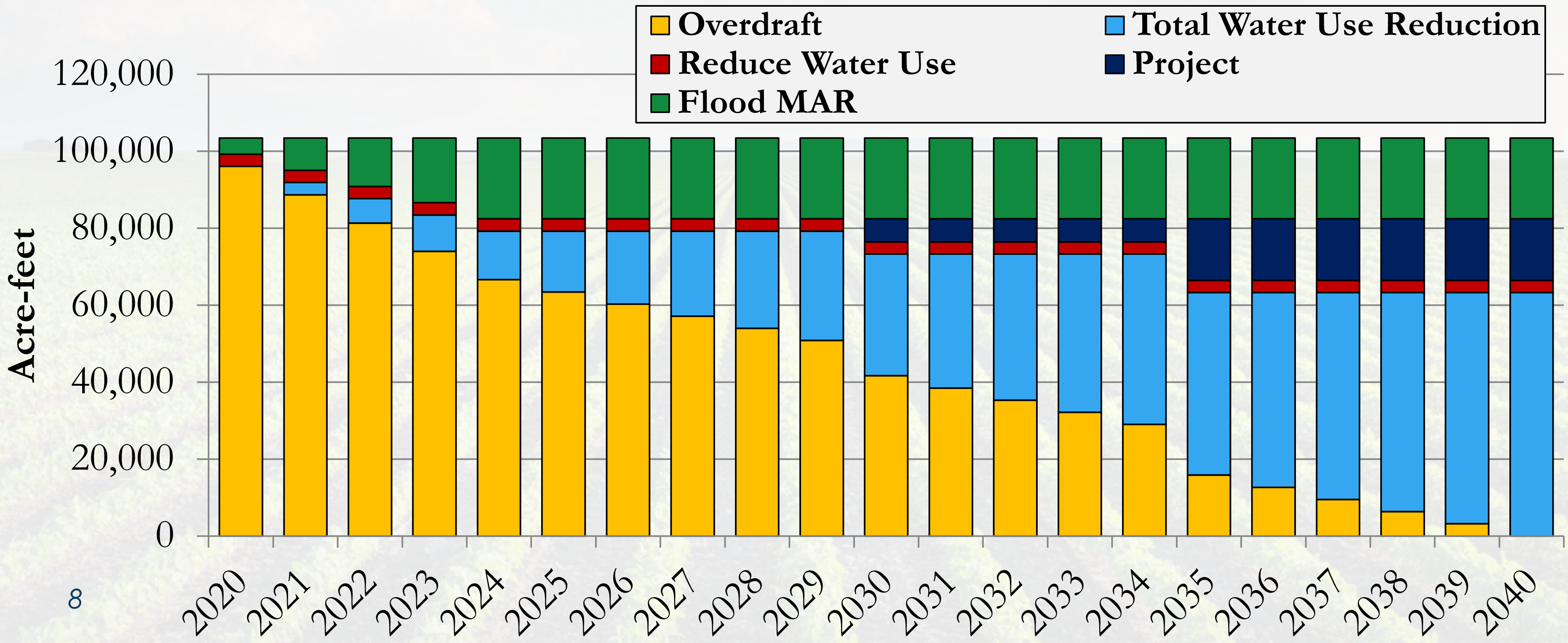
Example of Phased Demand Management

- Assume100 taf of current overdraft, uniform reduction
  - Phasing affects cost and undesirable results
  - Delaying demand management means planned depletion of storage, tradeoff between pumping depths and early land retirement



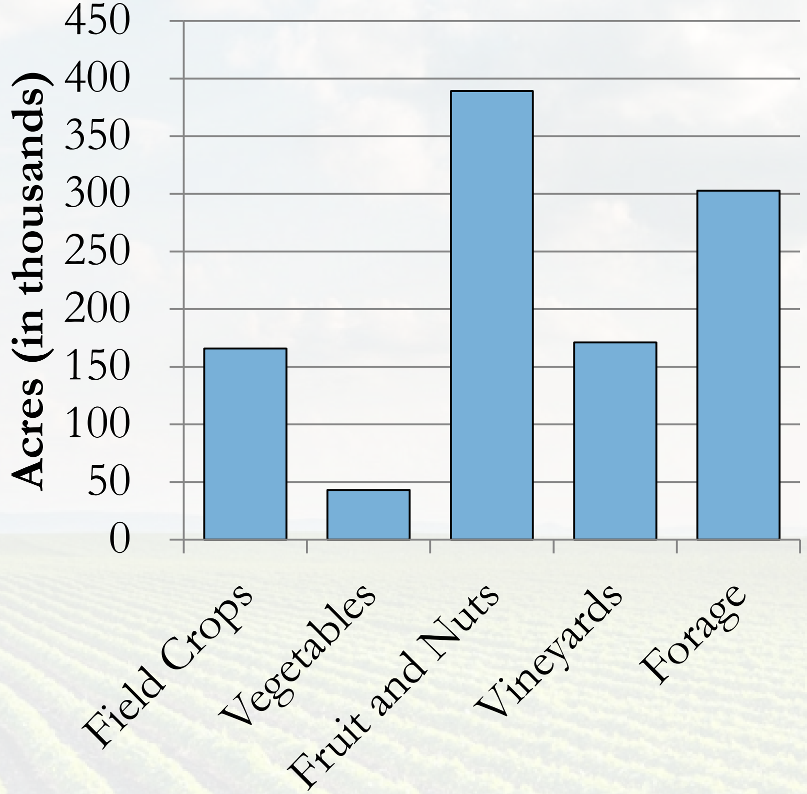
Goals of Sustainable Yield

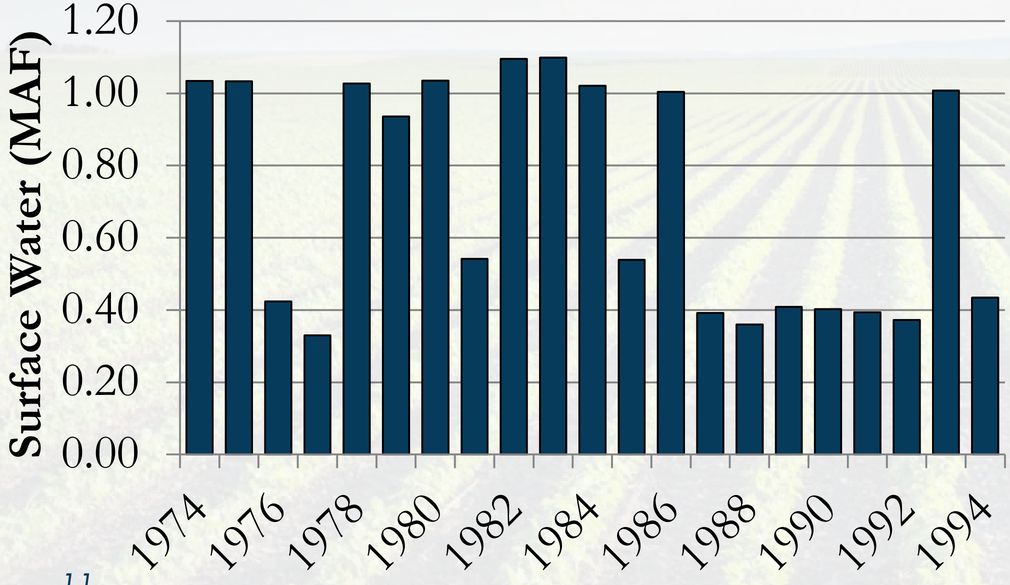
- Sustainable yield considerations include
  - Avoiding undesirable results (GSP regulations)
  - Minimizing the economic adjustment costs
- As an example, should the sustainable yield (and corresponding demand management) be fixed every year, or vary across years?
  - The value of water increases during dry/critical years
  - Variability in total water supply increases adjustment costs

SIMPLE COMPARISON: CONSTANT PUMPING LIMIT VS. VARIABLE THAT REDUCES ANNUAL ADJUSTMENT COSTS

Example Analysis for Kings and Tulare Lake Subbasins

Annual Gross Value	$4.55 billion
Applied water	3.13 MAF
Surface water supply	0.71 MAF
Safe yield (est. for example)	2.03 MAF





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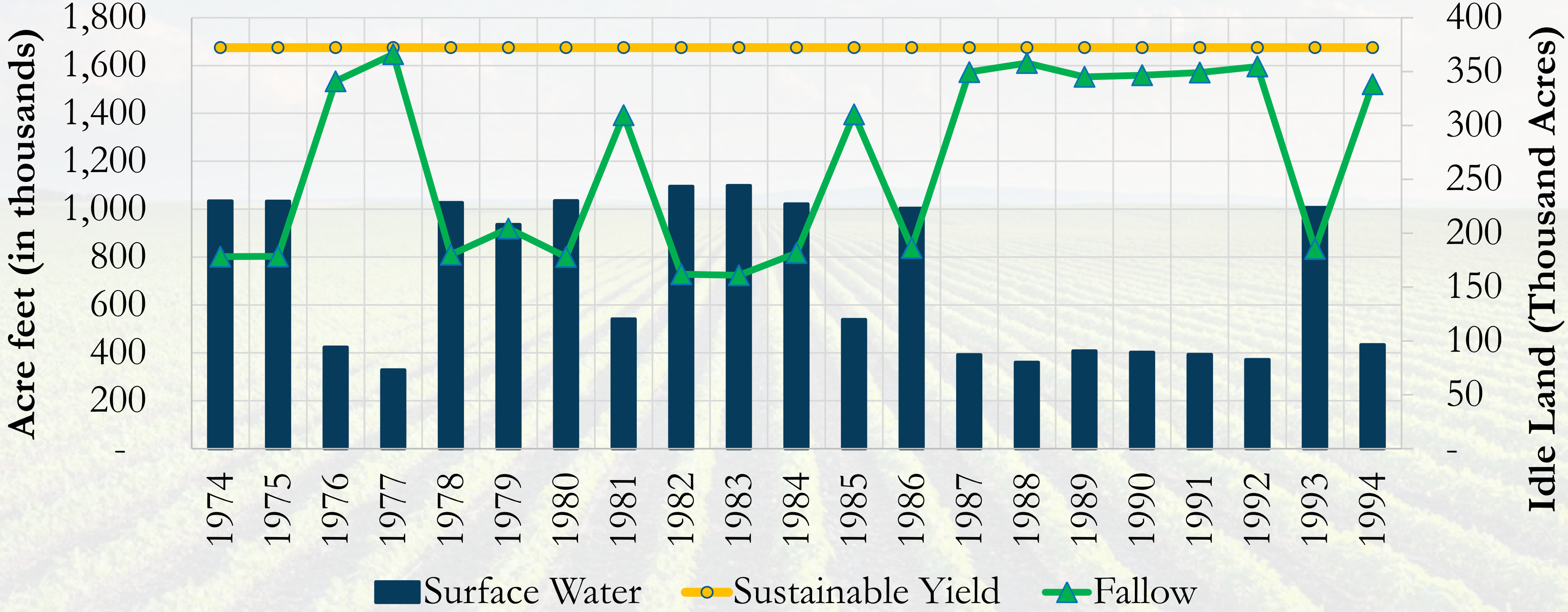
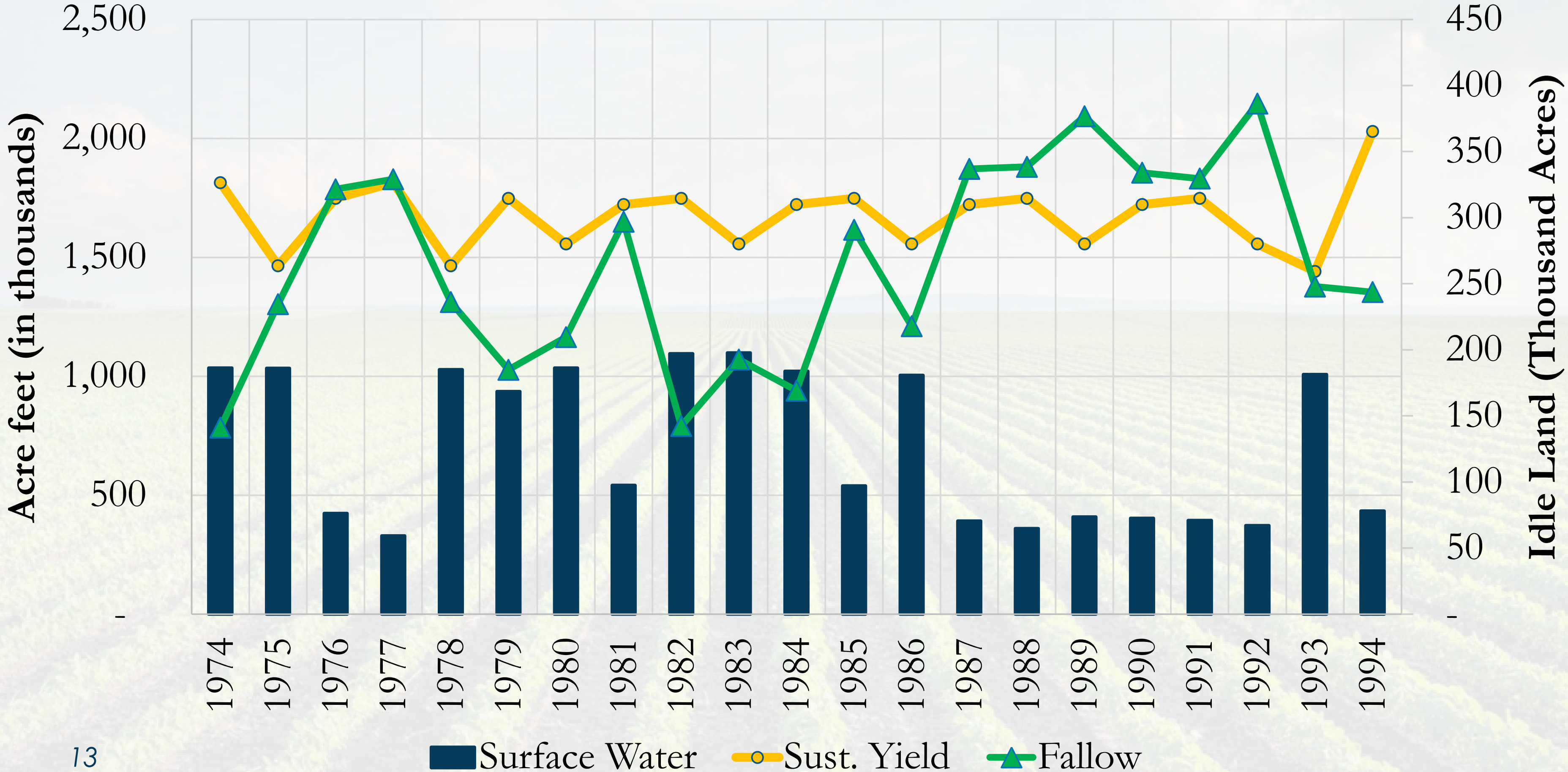
Fixed-Rule Pumping

- Impose a firm pumping limit = sustainable yield, every year
  - Average annual land idling cost: $630 million
  - Present value of land idling cost: $9.1 billion



Variable Pumping

- Achieve sustainable yield, but
- Allow pumping to vary and "smooth" total supply
  - Average annual land idling cost: $603 million
  - Present value of land idling cost: $8.7 billion



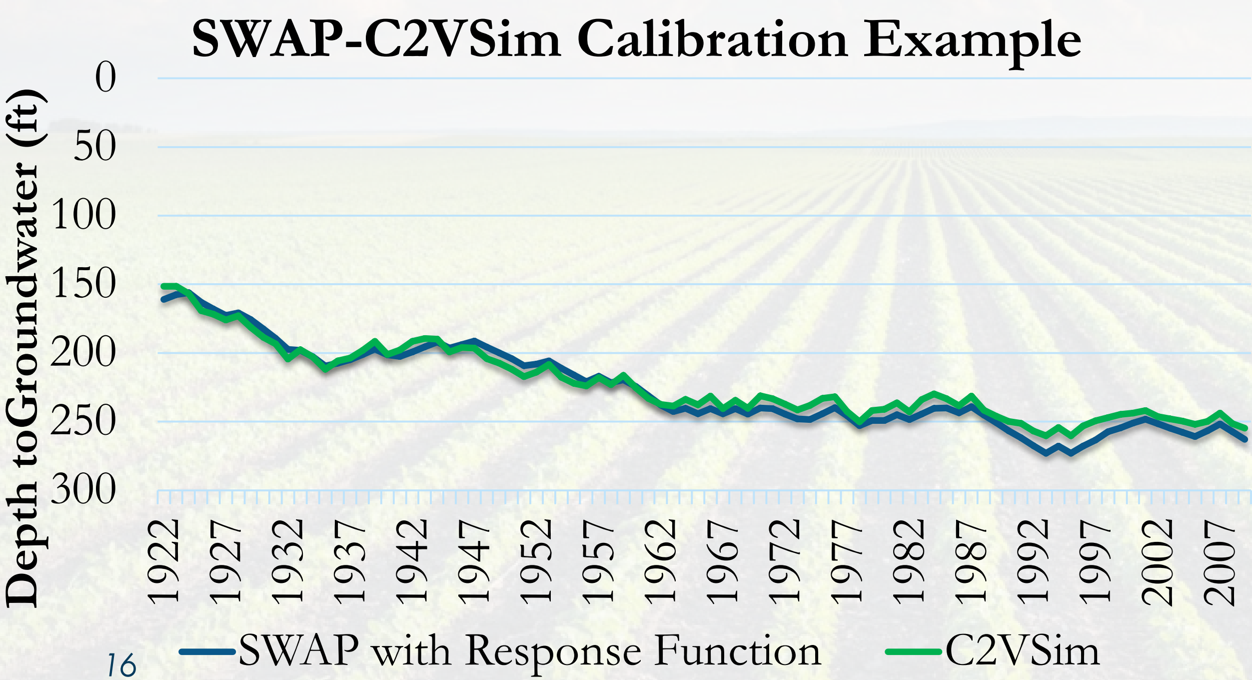
INTEGRATED HYDROECONOMIC ANALYSIS

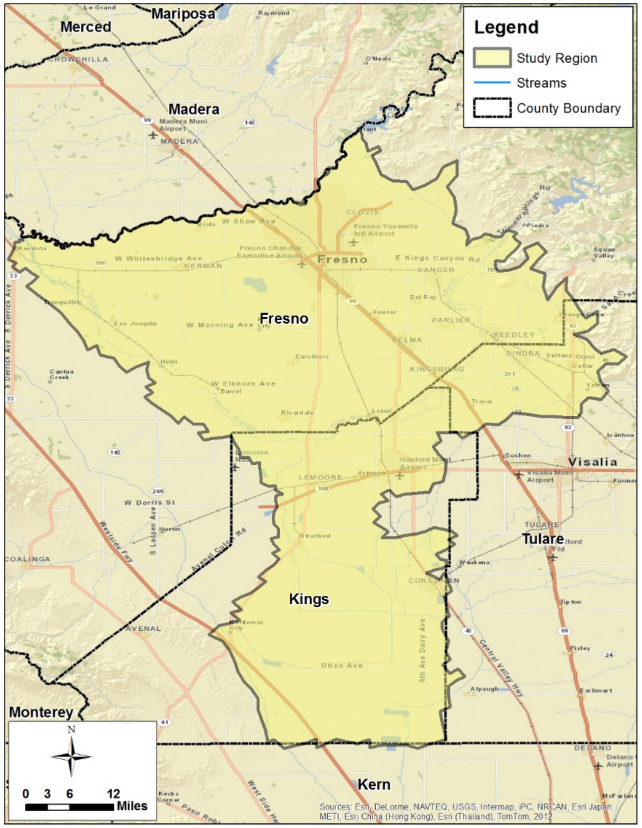
Integrate Groundwater Analysis (C2VSim) and Economic Analysis (SWAP)

- Extending analysis using a hydroeconomic model
  - **Hydroeconomic Modeling of Sustainable Groundwater Management. *Water Resources Research. 2017. 53(3)***
- Consider all costs and benefits that can be quantified
- Calibration approach and analysis method
  - Economic parameters in GW model or vice-versa?
  - Embedded groundwater response functions in SWAP economic model
  - Evaluated transition paths for sustainability and economic effects

SWAP-C2VSim Analysis

- Kings-Tulare Lake Basin study area
- Regression analysis of C2VSim groundwater pumping – elevation response
  - Close calibration within the economic model (SWAP)





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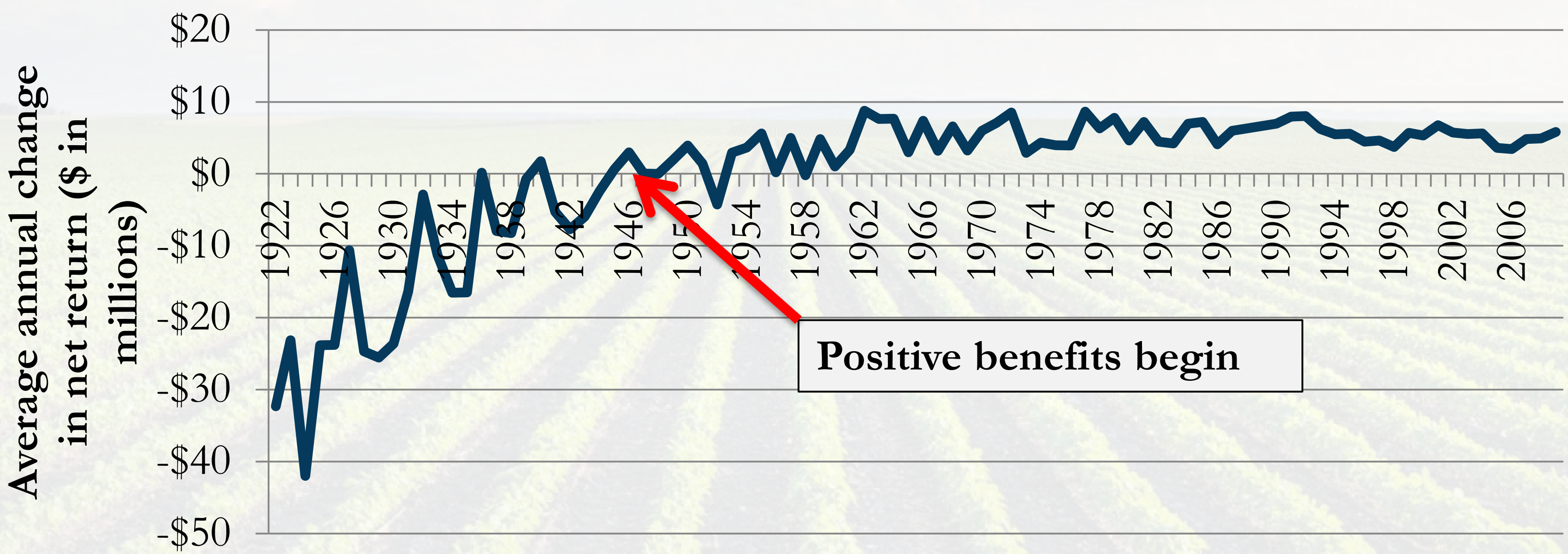
"Optimal" Sustainable Yield

- Simulate scenarios: baseline w/o SGMA, perfect foresight, managed pumping
- Include all relevant costs and benefits, if possible
  - Pumping cost, well replacement cost, crop value
  - Subsidence and water quality benefits are not valued in this example
- Consider value of trading off wet and dry year pumping



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Conclusion and Future Work

- Pumping rules should consider the safe yield, other GSP requirements, and benefits and costs
  - Get the best estimates of hydrology; calibrate groundwater models
  - Evaluate cost and feasibility of alternative supplies
  - Use demand management for the residual reduction
  - Consider all costs and benefits during transition and after
- Flexibility is valuable
  - Adjust to hydrologic year (expected surface supply)
  - Adjust to new information on GW conditions, recharge
  - Adjust to evolving crop market conditions