Economic Issues and Challenges of Groundwater Resources

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MODESTO
WATER WEALTH CONTENTMENT HEALTH
9TH Street
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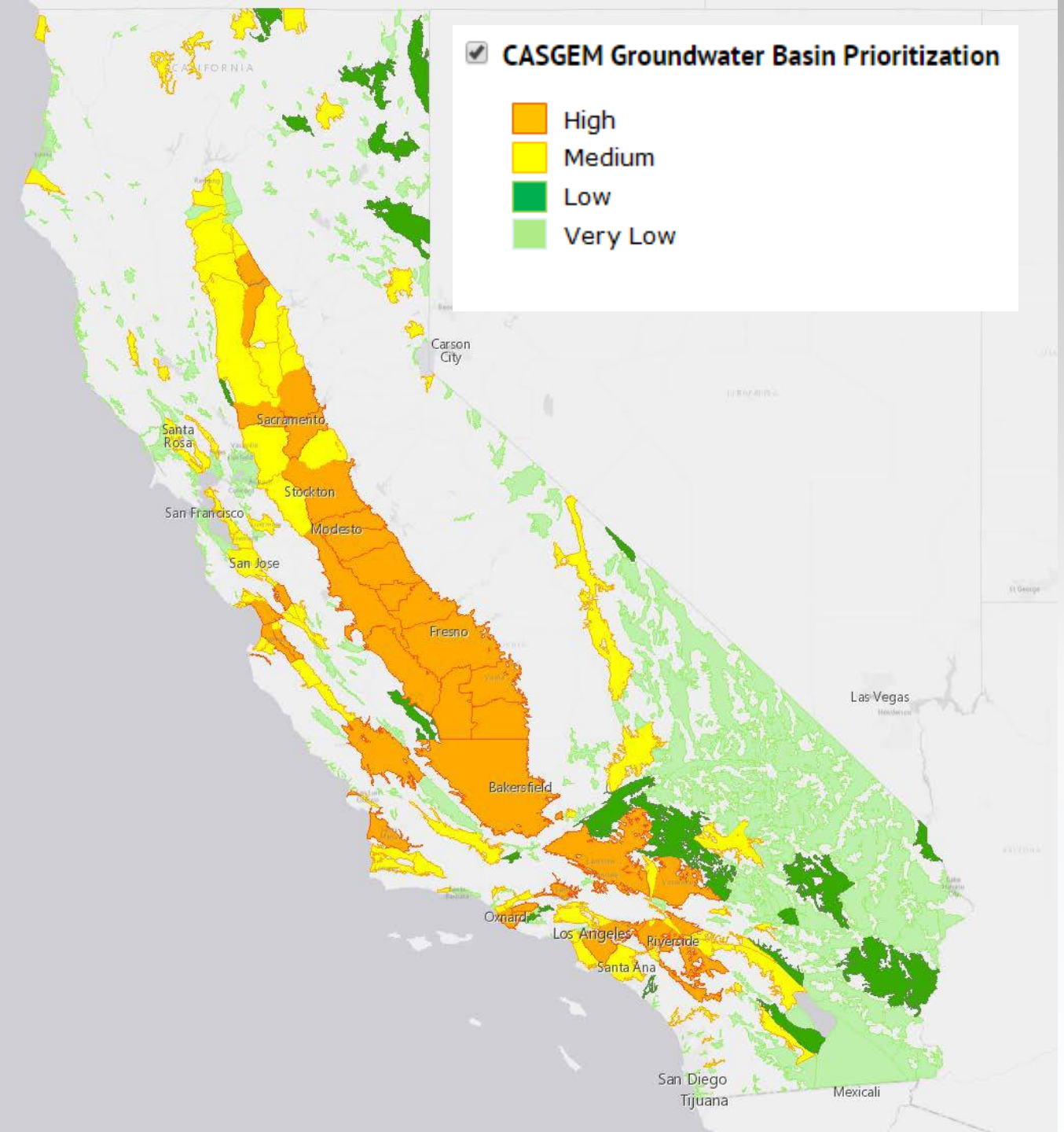
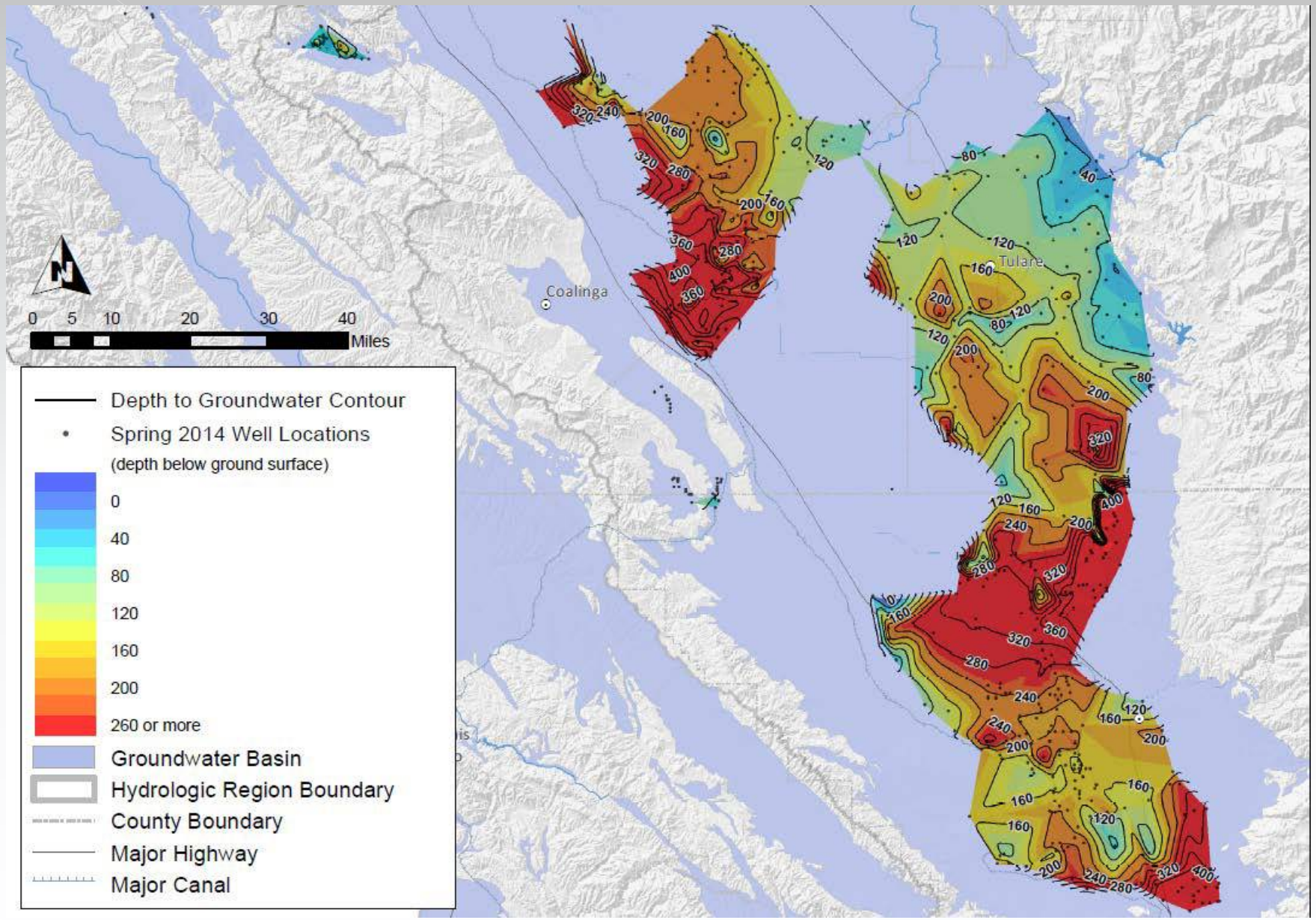
Reasons to stabilize California Groundwater

- Environmental impacts
- Intergenerational Equity
- Subsidence and infrastructure
- Economics of Pumping and reserve stocks
- Water quality dangers



Groundwater Basin Priorities

Depth to Groundwater



Why stabilize California groundwater ?

- Nearly all basins designated as “High priority” have over 60 foot drawdown.
- Direct environmental impacts of further drawdown are negligible
- Opposition to SiGMA comes largely from concern about the economic cost of stabilization
- For most of the central valley its all about the economics

Since its all Economics- Let's start with the standard Hamiltonian specification

$$\max \int_0^T e^{-rt} p_a f(g,x) - p_e e(d,g) - p_k k(\dot{d})\ \mathrm{dt}$$

$$\dot{d} = d + \phi(d,g) + c$$

$$d(0) = d_0$$

$$H = p_a f(g,x) - p_e e(d,g) - p_k k(\dot{d}) + \lambda\left(d + \phi(d,g) + c\right)$$

$$\frac{p_a}{p_e}\frac{\partial f/\partial \bar{g}}{\partial \phi/\partial \bar{g}} = \frac{e\left(d_{ss},\bar{g}\right)}{\partial \phi/\delta \bar{g}} - \frac{1}{1-\beta}\frac{\partial e}{\partial g_{ss}}\bar{g}$$

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Just Kidding!

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Law and Property Rights

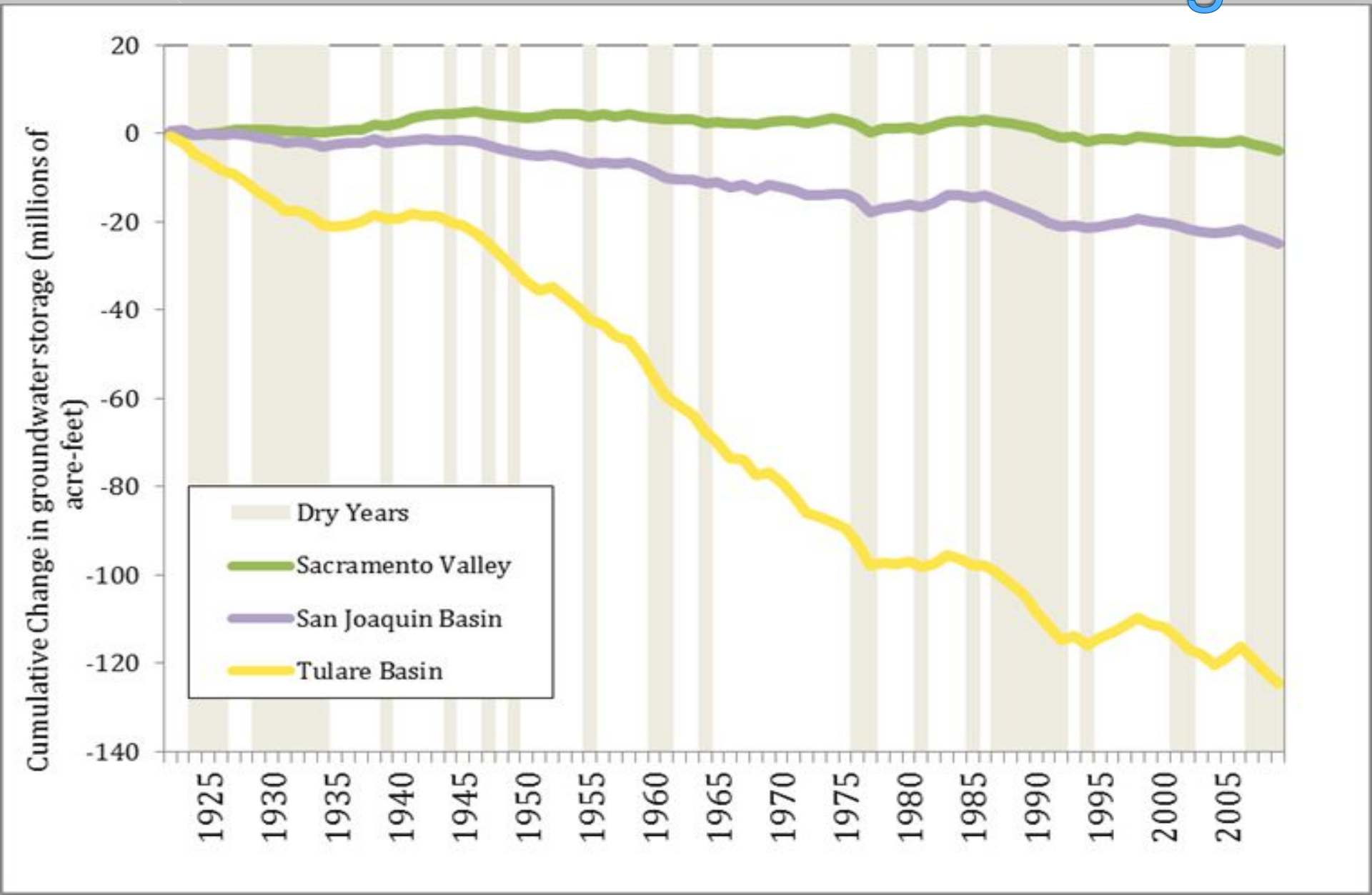
- Law defining and enforcing western resource property rights evolves as resource scarcity justifies increasing complexity of rights.

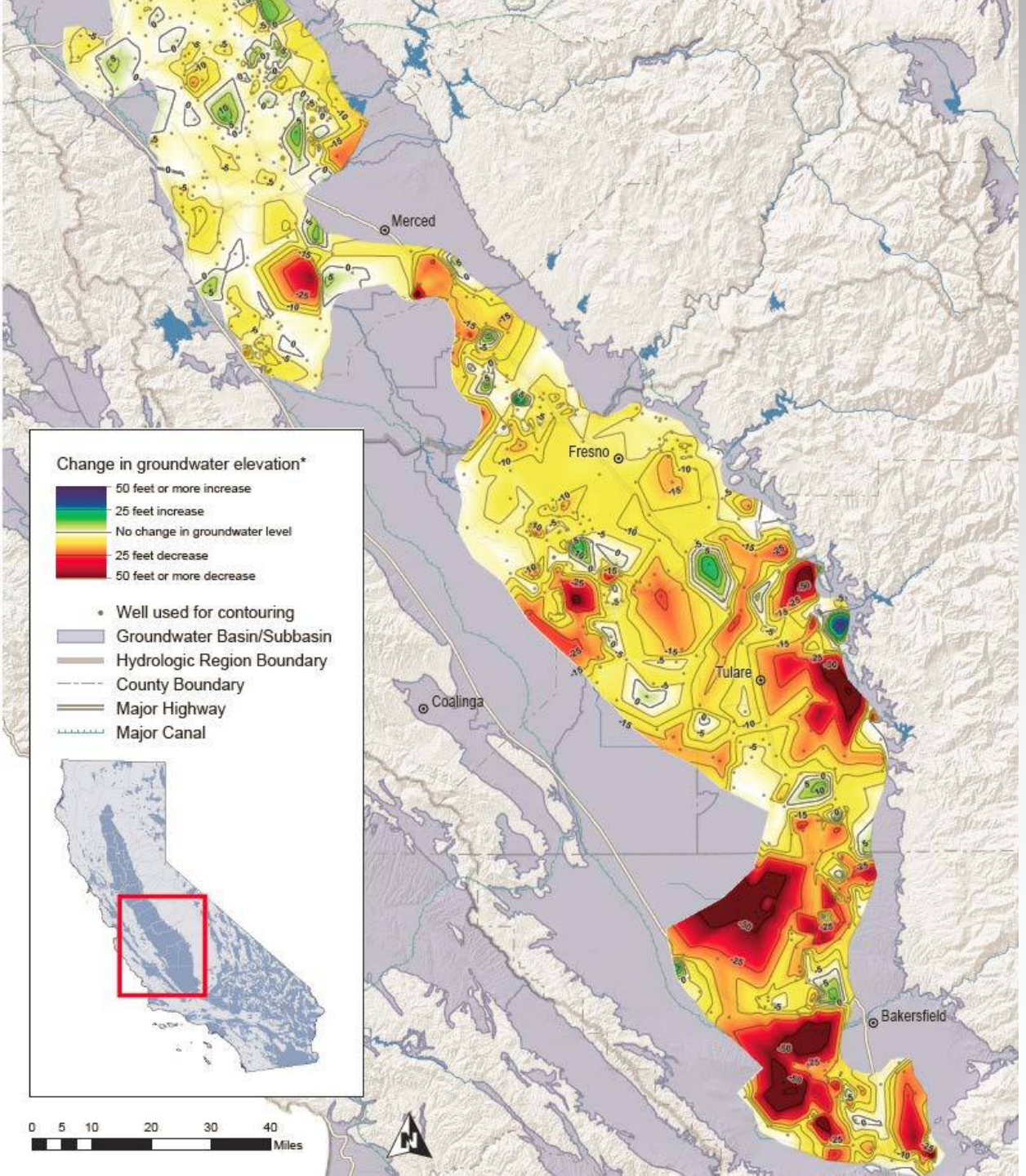
- Current groundwater correlative rights are an example of the tragedy of the commons.

- Groundwater exceptions in California, only where there are external threats- Seawater intrusion (OCWD) – Subsidence (SCVWD)- Connected Nevada pumpers (Long valley) .

- Assigning safe yield property rights will incentivize trade in groundwater safe yield and optimal allocation over time

Trends in Groundwater Storage





- Change in groundwater elevation:
  - Spring 2013 – Spring 2014
- Levels dropped by more than 50 feet in some regions

Effect of Groundwater on 2014 Drought Impacts

Impact	Quantity
Water supply, 2014 drought	
Surface water reduction	6.6 Million acre feet
Groundwater pumping increase	5.0 Million acre feet
Net water shortage	1.6 Million acre feet
Statewide Economic Impacts	
Crop revenue loss	$810 million
Additional pumping cost	$454 million
Livestock and dairy revenue loss	$203 million
Total direct costs	$1.5 billion
Total economic costs	$2.2 billion
Total job losses	17,100

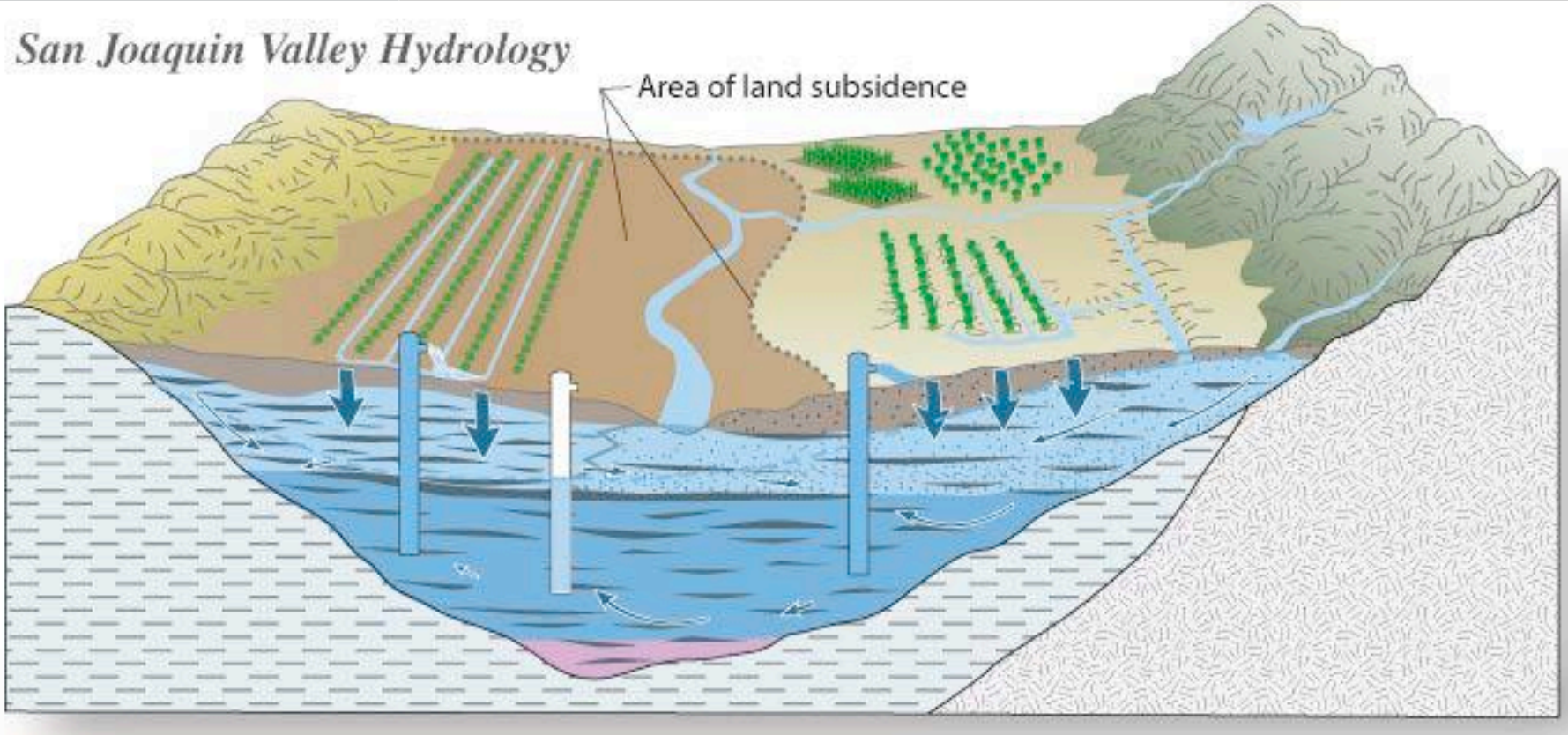
Concept of Groundwater Common Property

- Assume simple “bath tub” hydrology and lateral flows
- Current correlative rights

- Current groundwater correlative rights are essentially tragedy of the commons

- For the standard agricultural or urban groundwater basin
  - At what depth is it economically beneficial to stabilize groundwater
  - Given a target depth, what is the cost minimizing trajectory to reach this depth ?

Common Property Groundwater

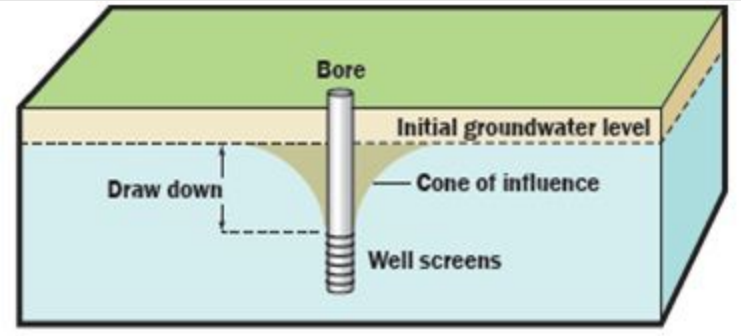


Optimal Groundwater Pumping: Depth

- Marginal private benefit of pumping
  - Value marginal product of the least valuable crop grown with ground water
- Marginal social cost of pumping
  - Present value of pumping from a deeper depth
- Marginal cost depends on
  - Storativity of aquifer
  - Average rate of future pumping
  - Discount rate
- Optimal depth is where:
  - Marginal Private benefit = Marginal Social cost

Groundwater Overdraft: Well Capital Cost

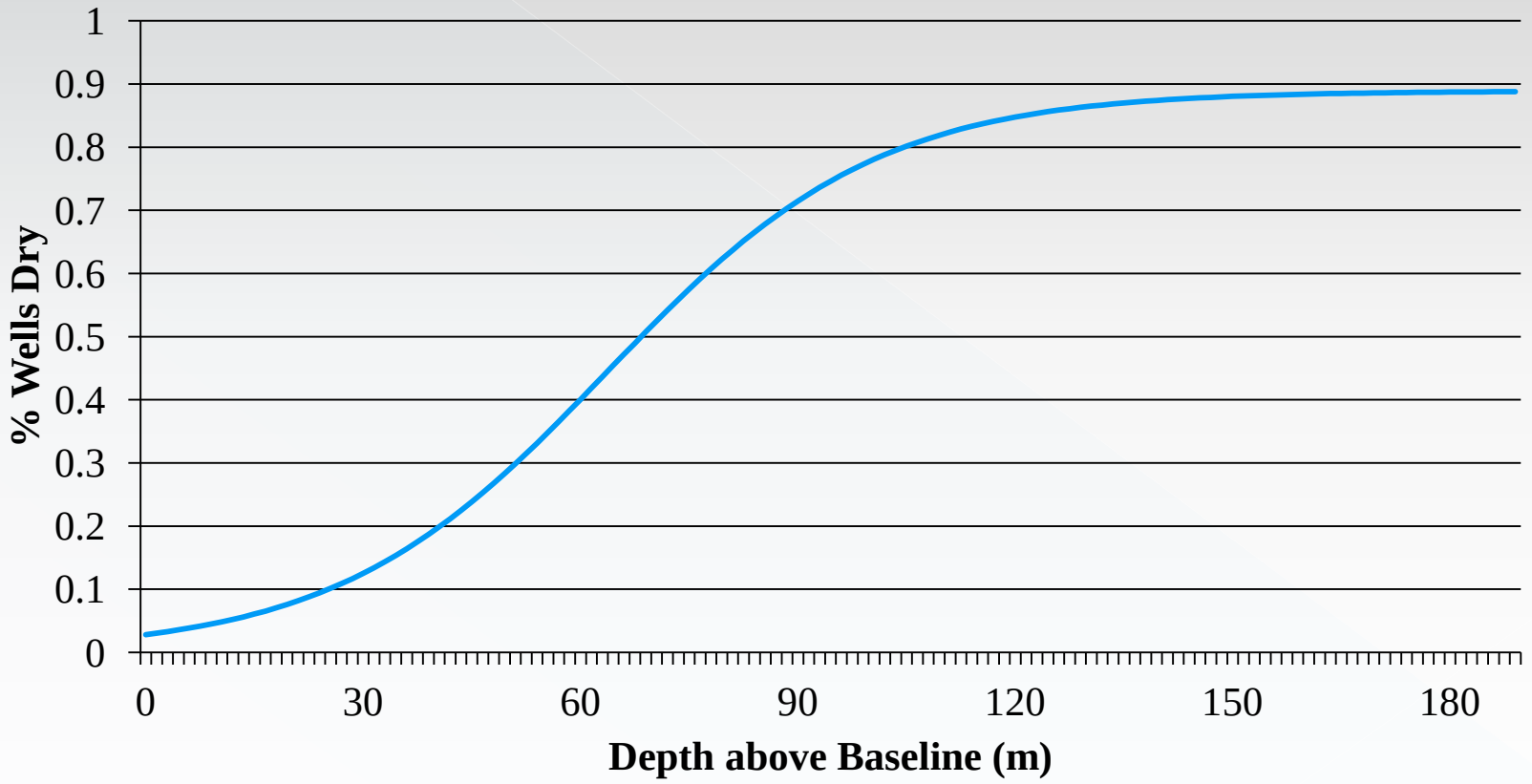
- Fogg's estimate of up to 1 million wells in California
  - Capital cost--$40-50 billion
- Average expected well life of 50 years
  - 10% loss = $4 billion cost
- Well screen depth



- If groundwater depth is falling faster than envisaged when the well was drilled then wells will go dry in drought years.
  - Often a permanent loss of sunk capital.
- Short term drought crop losses can be very costly

Well depth distribution

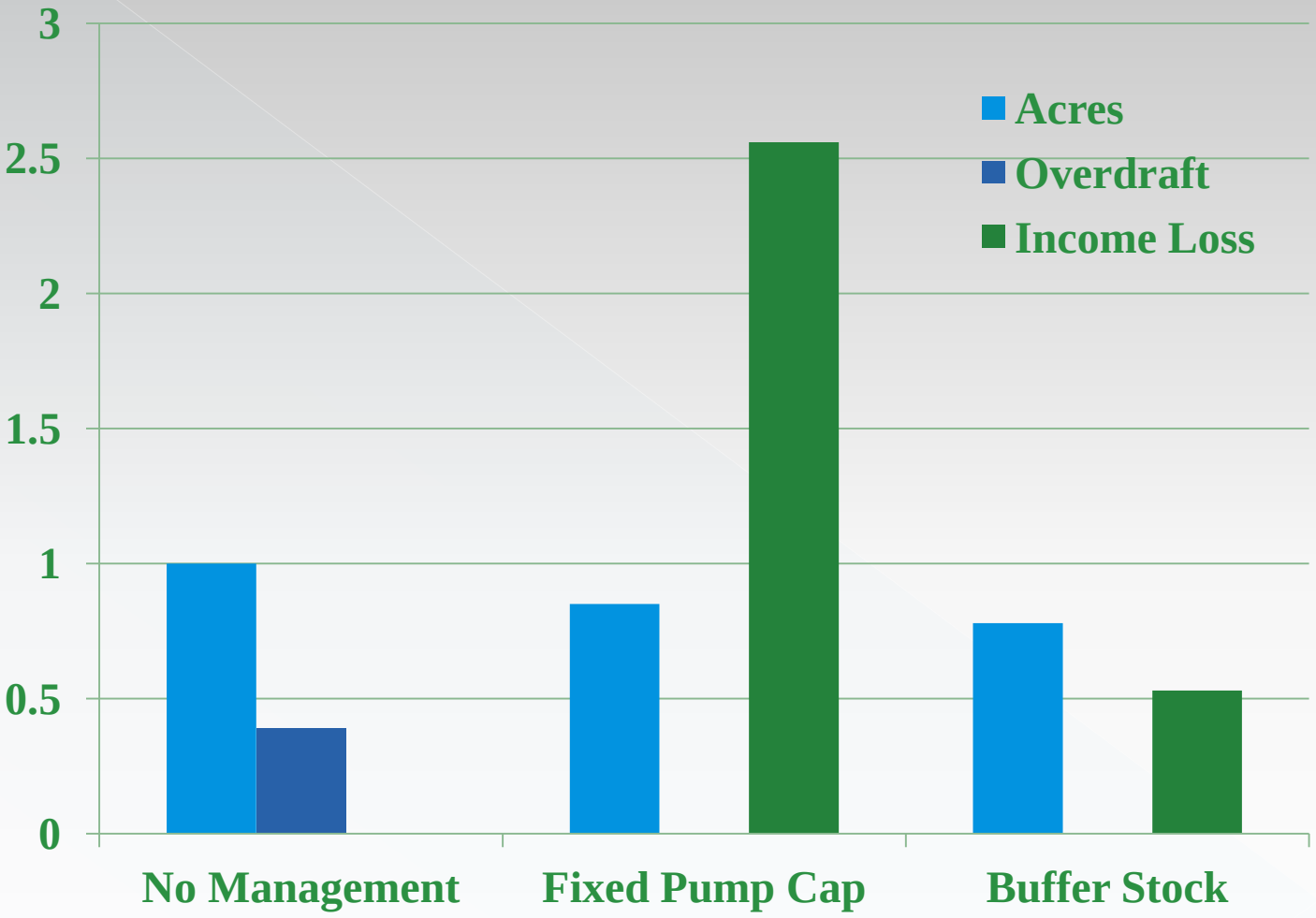
- Fitted function for depth to top screen for each region
- 50 foot drop in groundwater can strand 10% of wells



Parameters for a Simple Cropping example

	Revenue/Ac-ft	CU/Acre	Crop-Proportion	Revenue	Water Use
Almonds	1173	3	0.5	1,759	1.5
Tomatoes	519	3	0.25	389	0.75
Wheat	135	2	0.25	67	0.5
Average/ Acre				2,216	2.75
Year Type	Wet/Normal Year	Dry year	Drought		
Probability	0.4	0.4	0.2		
Surface Water	1.25	0.65	0		
Safe Yield	1.25	1.25	1.25		
Water Supply	2.5	1.9	1.25		2.01

Effect of Alternative Management



Economic Tools for Implementing SiGMA

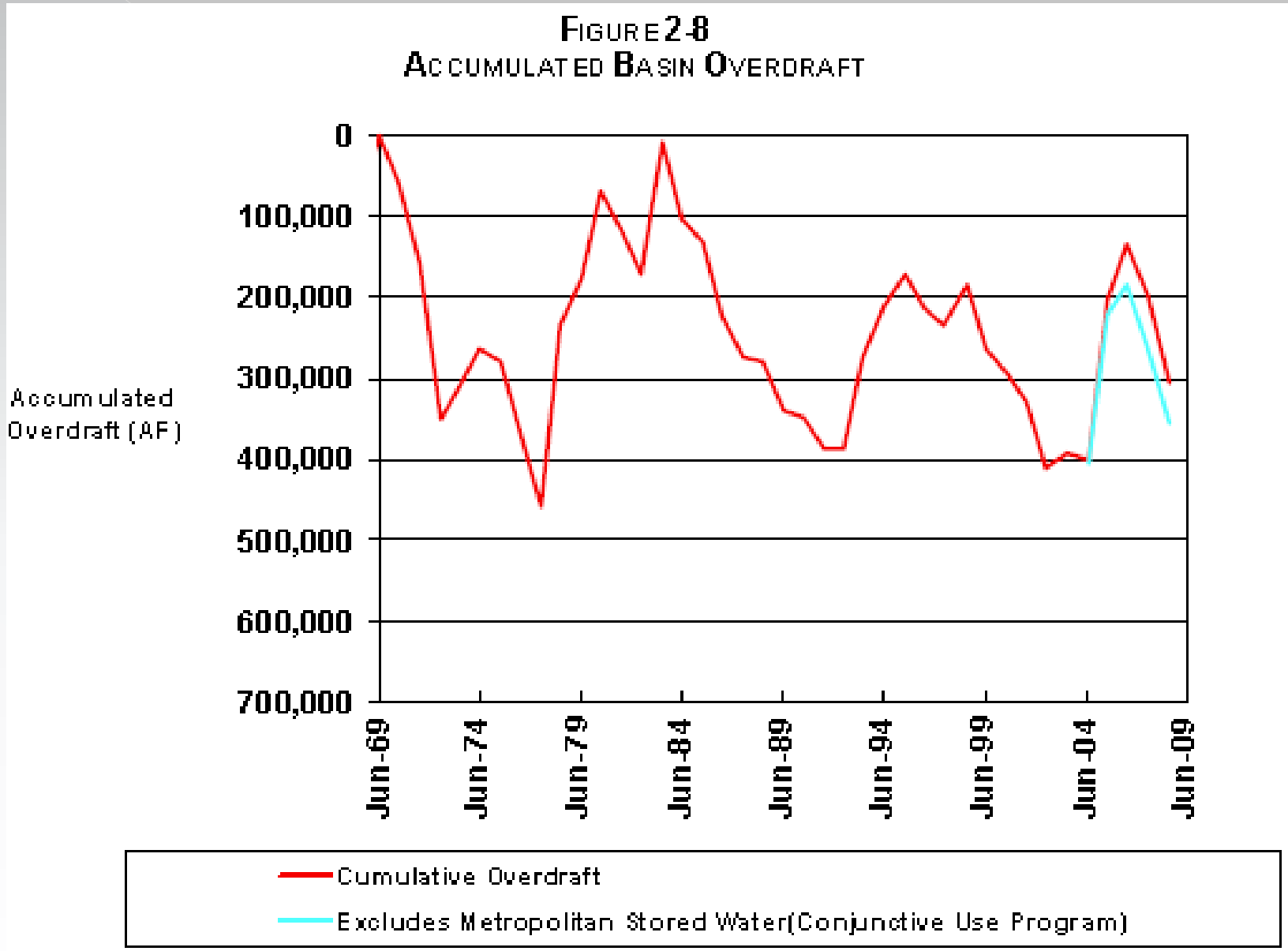
- Try to avoid adjudication costs
- Enable local management at minimum cost
- Have a system that can be seen as equitable
- Avoid punitive fees and taxes
- Working examples in Orange County Water District and Santa Clara Valley Water District

Using Prices for Groundwater Management

- Orange County Water District has been using a simple pricing system to manage groundwater
  - Define the basin boundaries and the average safe yield
  - Pro-rate the safe yield by adjudication or overlying acres
  - Measure all groundwater pumping in the basin
  - If a pumper uses more than their safe yield they pay the cost of replacing the water (replenishment charge) in later years

- Advantages of the OCWD approach
  - No restrictions on individual pumping- allows drought overdrafts
  - No regulation
  - Simple and equitable system that has been shown to work

Managing Overdraft in Orange County

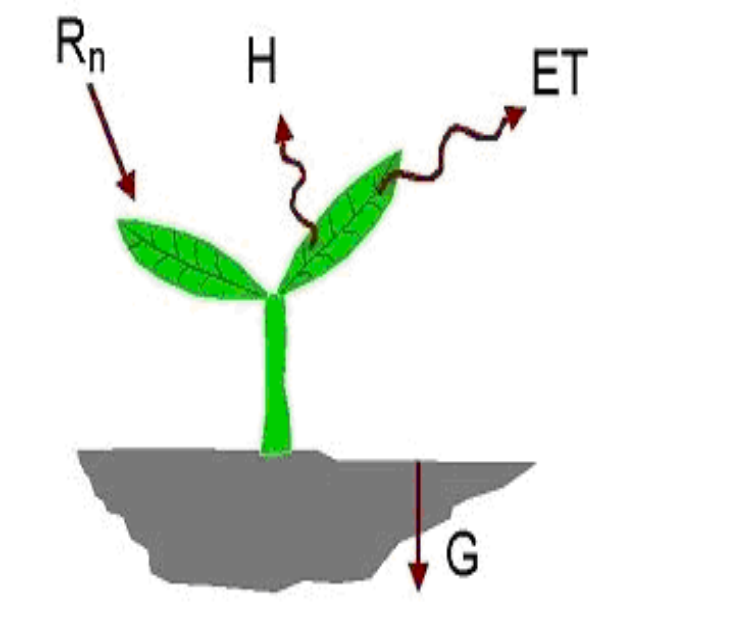


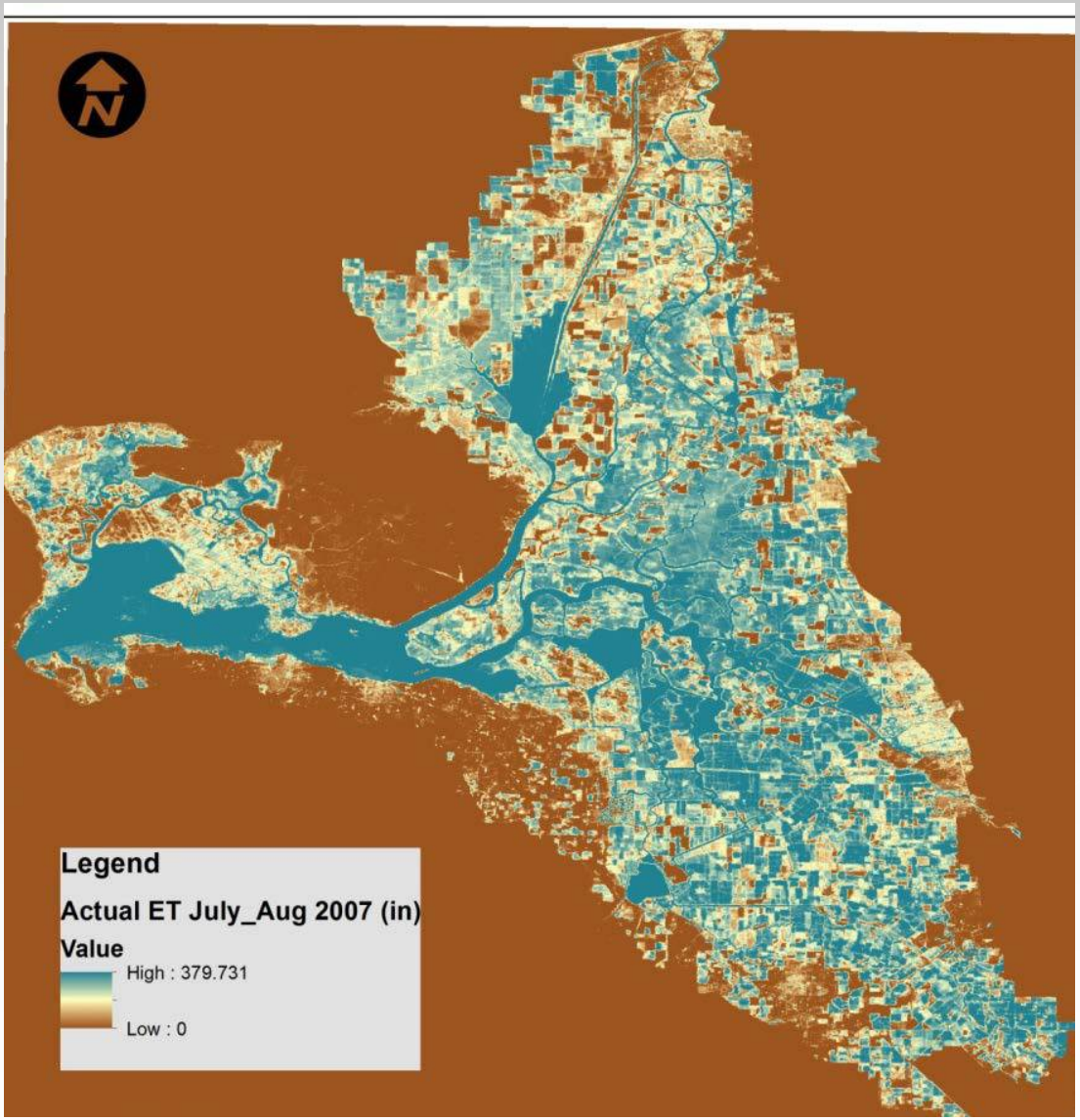
Remotely Measuring Groundwater Use

- Low transaction cost, non-intrusive
- Uniform system over all basins and pumpers
- Easily understood
- Accepted by courts
- Remotely sensed measures of net total water use enables groundwater use to be netted out

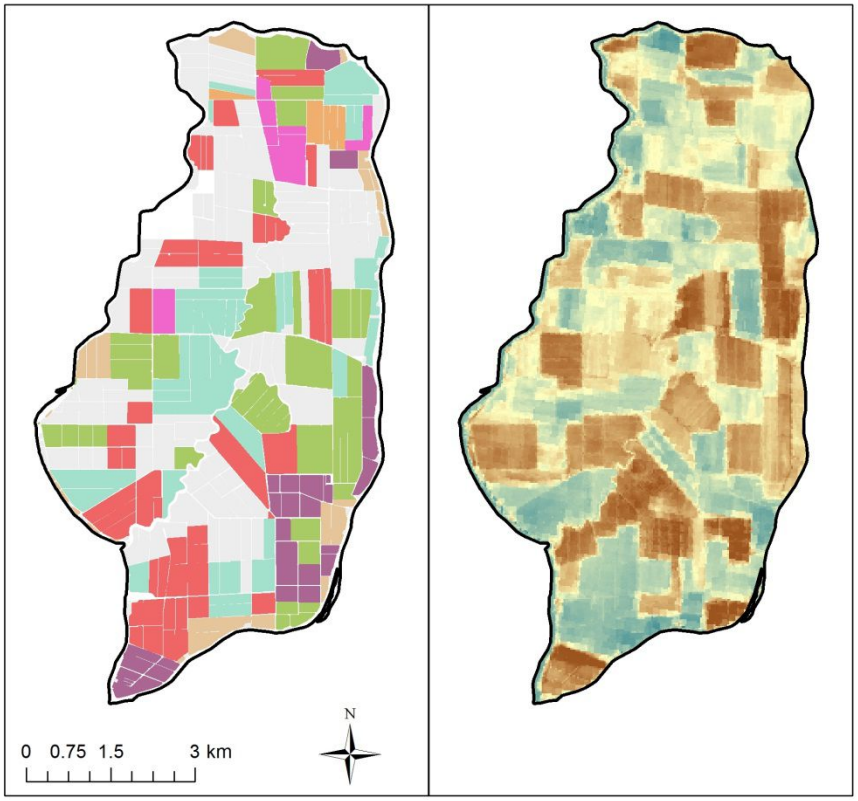
- Established in Idaho courts

ET Estimation by Energy balance methods SEBAL & METRIC





Ryer Island



Land use

- Other land use classes
- Alfalfa
- Almond and Pistachio
- Corn
- Fallow and idle
- Grain
- Grapes
- Orchards
- Field Crops
- Pasture
- Rice
- Subtropical
- Tomatoes

Period Actual ET (mm)

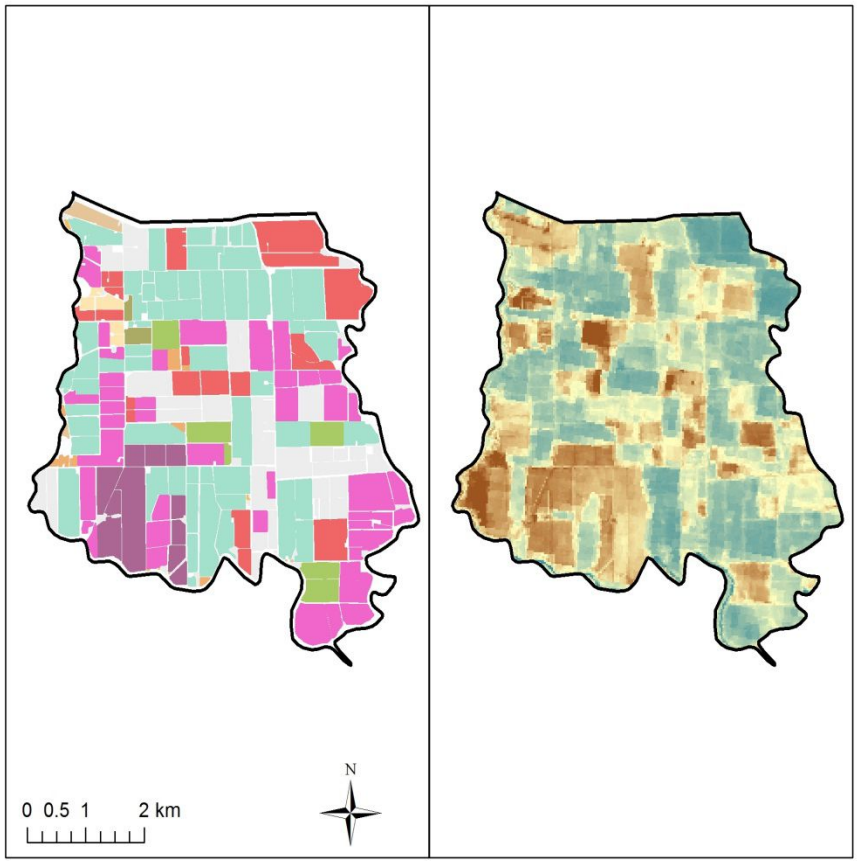
July 16th to July 31st, 2007

High : 220

Low : 0

Data sources:07_Delta_SM_ver3,SEBAL 7.21.07 ETA_per

Upper Roberts Island



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Conclusions

- Economic benefits from management are: Power, Capital and Buffer stock costs
- For many basins it is in the economic interest of agriculture to define property rights and stabilize groundwater.
- Basin stabilization must enable flexible pumping for the drought buffer role.
- Orange County WD pricing system is simple, equitable, and has been shown to work well.
- Remote sensing methods hold promise for low cost consistent water measurement.