Climate change and water in California: the state of adaptation

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Some context

- California is a semi-arid region whose economic history has been intimately connected with water.
  - The first large scale use of water was for hydraulic mining starting in the 1850's, the first pillar of California's economy.
  - The next large scale use of water for irrigation in the San Joaquin valley, starting in the 1880's, which became the richest farming area in the US.
  - Until ~1940, California's economy was founded on water, agriculture, and oil. California was the first western state to develop. It created the *appropriative right to water*, which became the standard water right in the West.

California's unique history

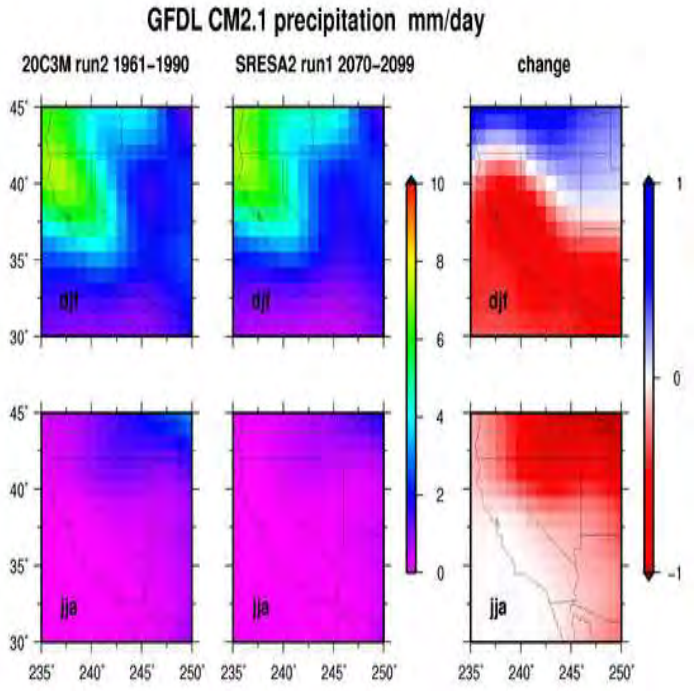
- California has a unique history, unlike that of any other state in the US, with regard to:
  - controlling air pollution from automobiles
  - regulating energy efficiency
- In both cases, California pioneered regulatory approaches that were later copied by the federal government and applied to other states.
- This experience provided the foundation for California's climate mitigation policies.

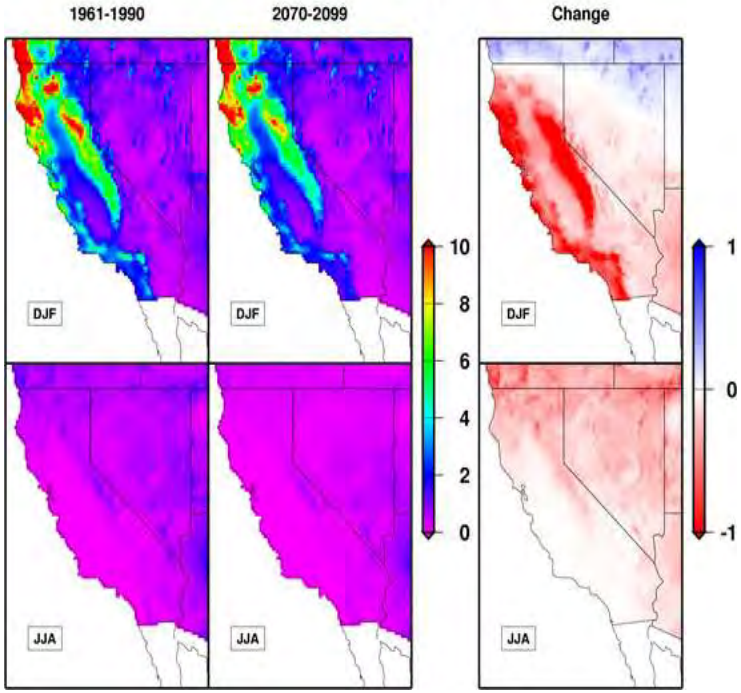
Climate change in California – mitigation policies

- 2002: AB1493 passed to reduce GHG emissions from motor vehicles in California.
- September 2004: California Air Resources Board approves regulations to implement AB 1493.
- 2005 Governor Schwarzenegger announces GHG emissions reduction targets:
  - Reduce to 1990 level by 2020 (a 15% reduction compared to 2005)
  - Reduce 80% below 1990 by 2050
- 2005 Low carbon fuel standard enacted
- 2006: Legislature passes AB 32 to implement the 2020 target; SB 375 requires land use planners to account for GHG emissions.
- 2010 AB 32 regulations take effect
- 2013 Emission trading commences

Climate change impact assessment in California

- 1991 California Energy Commission (CEC) funds study of climate change impact on California water.
- 2000-2002 CEC funds first assessment study of climate change impacts on California
- 2003 CEC establishes California Climate Change Center; second assessment launched.
- 2005 Schwarzenegger calls for impact assessment to be released by early 2006.
- 2007 Third impact assessment initiated, completed 2010.
- 2015 Fourth impact assessment initiated, results in late 2018
- The impact assessments employ downscale climate change projections on fine spatial scale





Global Climate Models compute Climate on a coarse grid

So, a "downscaling" procedure was used to provide temperature and precipitation over a finer mesh that is more commensurate with the California landscape

Climate change and water

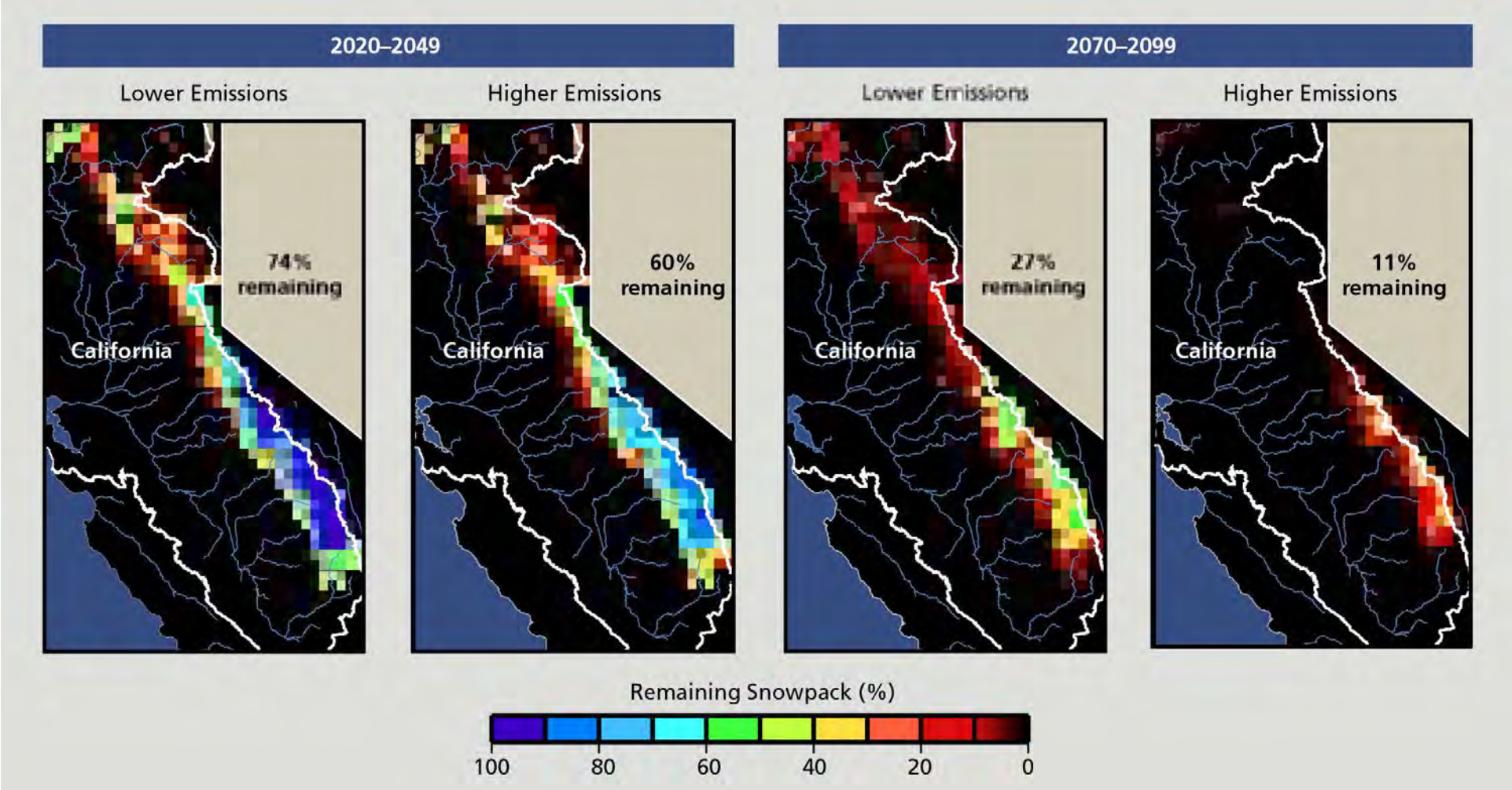
- Impacts on water supply and demand are a major pathway by which climate change will harm California.
- Other impact areas include agriculture, forestry, fire, energy, coastal resources, air quality and public health.

Impacts on water

- Reduced runoff.
- Reduced streamflow in summer.
- Reduced storage in snow pack.
- Surface water becomes more variable, less reliable (shift to groundwater).
- More frequent drought events, more extreme drought.
- Higher ET (crop water demand).
- Flooding from more intense rain events.
- Flooding from sea level rise.

Diminishing Sierra Snowpack

% Remaining, Relative to 1961-1990



Climate change in California - Adaptation

- First California climate adaptation strategy adopted in 2009.
- Focuses on adaptation by state agencies and assistance to local government.
- Encourages planning through dissemination of downscale climate projections.
- The impetus for adaptation is now coming bottom-up from individual cities and counties.
  - Since ~2009, local elected officials have started to put climate change on their list of things to pay attention to.

A contrast: mitigation vs adaptation

- With mitigation, California has been highly pro-active and has achieved some significant success.
- Far less progress, so far, with adaptation.
- Adaptation is harder than mitigation.
  - Mitigation is primarily energy and transportation.
  - Adaptation is *much more* than that including where you live.
  - Mitigation is global – total emissions matter.
  - Climate is highly varied spatially, and so adaptation is local.

Climate adaptation and water in California

- Since water is such a key pathway for harm from climate change, one might imagine that there has been the most success with adaptation there.
- This is not what has happened.
- Water in California has a greater legacy of unresolved conflicts and unsolved problems than any other sector.
- Water is inherently more difficult to manage and allocate than any other resource or commodity.
- In California, therefore, we are still grappling with the past more than adapting for the future.

My key message – the California lesson

- The first step in adaptation is to resolve the existing, difficult problems
  - that impede the effective functioning of the economy and society,
  - that arise from institutional and group conflict, and
  - that have stubbornly persisted because of the lack of sufficient (political) will to solve them.
- Dealing with the past is the first step to preparing for the future.
- It may take a crisis – several crises – to make progress.
  - In the case of California, the 2014-2016 drought.

Water: an exceptionally difficult commodity

- Compared to other things (e.g., land), water is exceptionally difficult (i) to conceptualize and (ii) to manage/allocate.
- This is because it has some distinctive physical and economic features that make it different.
  - It moves around – it flows.
  - The same molecule of water can be used sequentially by different people.
  - The same molecule can be used simultaneously for multiple purposes by multiple people.
  - It functions as both a private good and a public good.
  - Its quantity is variable .
  - Its use – especially agriculture – is intermittent.
  - It is essential for life and, often, for economic production.
  - Water supply is highly fragmented.
    - ~7 agencies supply electricity to 85% of the California population
    - ~200 agencies supply water to 85% of the California population
- These features make water difficult in rich countries, not just poor ones.

Water is an *entangled* commodity

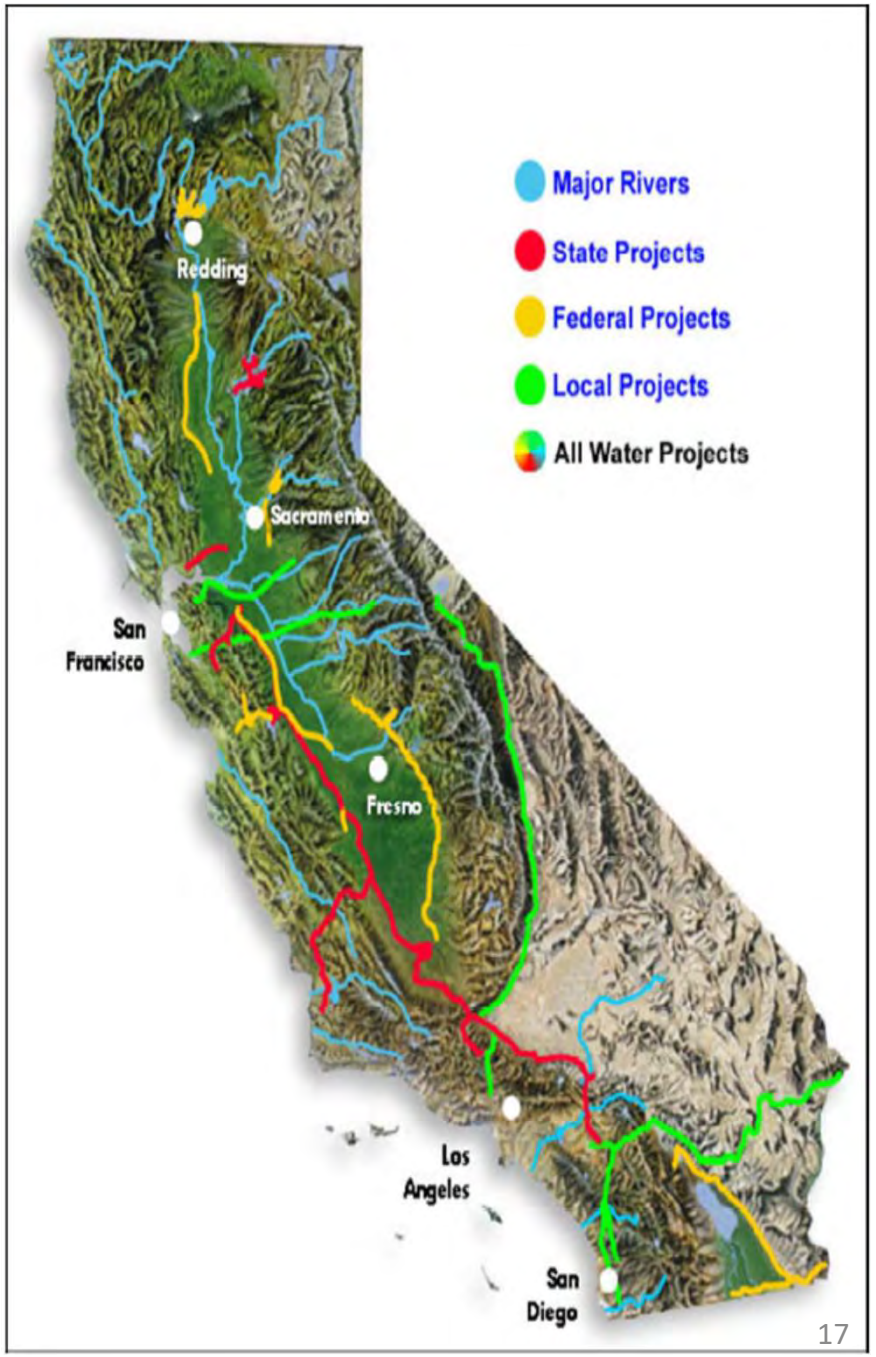
- The entanglement occurs because of externalities associated with the use of water.
  - E.g., return flow; downstream pollution; aquatic habitat; multiple-use reservoirs.
- It occurs because of the nature of the legal property right to water.
  - "Unlike almost every other form of property, water has always been vied as something in which the community has a stake and which no one can fully own." (Sax, 2008)
- It occurs because the supply of water (especially surface water) involves shared infrastructure with joint costs that are collectively financed.

Water as a source of contention

- The fact that multiple uses, and multiple users, can benefit from the same stream is an abundant source of conflict.
- Also, over time, new uses of water emerge. Often, the population that would like to exploit a water resource grows over time.
- Conflict over water, and property rights to water, is endemic in human society.
  - Conflict is more endemic with water than with land.
- Much of the disagreement over water is disagreement over what the property rights are, or what they should be.
- Resolving these property rights dispute is often politically fraught.

California Water

- 2/3 of precipitation occurs north of Sacramento.
- About 2/3 of all water use occurs south of Sacramento.
- 80% of precipitation occurs October-March.
- 75% of all water use occurs April – September.



- California expanded its water supply system with the federal government's Central Valley Project (CVP) starting ~1949 and with a second round of expansion around 1970; and the State Water Project (SWP) starting around 1970.
- The major droughts in California since World War II occurred in:
  - 1976-77 Governor Brown (youngest governor in California history)
  - 1987-92
  - 2007-09
  - 2012-16 Governor Brown (oldest governor in California history)
- What made the recent drought distinctive was the presence of Governor Brown, not the hydrologic conditions per se.

The property right to water in California

- Before proceeding, some distinctions are in order.
- Distinguish the property right to divert water from the *contractual right* to receive water from a water supply organization.
  - About 20% of the water used in California is obtained through supply contracts with the two large water projects in California, the federal Central Valley project and the State Water Project.
- Distinguish surface water from groundwater, since they are subject to different legal regimes.
- The right is a usufructuary right. It is a right to use (divert) water from a water source. It does not convey ownership of the water resource.
  - The water in California is owned by the state of California in the interest of the people of California.

Two types of surface water right: riparian, appropriative

Riparian right

- Adopted by all eastern states, taken from English common law. Also adopted by California.
- Riparian rights entitle the owner of land bordering a surface water body ("riparian" land) to use the water flowing past his property.
- It does not allow the water to be put to use on any *non-riparian* land.
  - Riparian rights remain with the riparian land regardless of changes in ownership.
  - Nonuse does not terminate the right.
- It thus combines ownership of (riparian) land with access to water.
- No specific quantity attaches to a riparian right. If a riparian originally applied *X*, this does not preclude him from applying 5*X* later.
  - There is no recording of the volume diverted.
- No institution administers the riparian right.
  - Riparian right requires the issuance of no permit or license.
- Disputes are resolved through litigation among the riparians – including at a time of drought.

- The riparian doctrine was logical where it originated, in a humid region with plentiful streamflow.
- It is ill-suited to an arid region like California, where rivers can run dry by the late summer and annual streamflow can vary by an order of magnitude.
  - There needs to be a specific mechanism for allocating limited streamflow. The riparian right lacks this.
- It was ill-suited to hydraulic mining in the gold country of California.
  - The land was not owned by water users – it was owned by the federal government.
  - In many cases, they were using the water to mine at some distance from the stream (i.e., not on riparian land).
- Starting around 1851, a new type of water right emerged in California known as an *appropriative* water right, adapted from the rules developed by miners for the right to a mining claim.

Appropriative water right (the right of first possession)

- The right to divert water is based on the time and quantity of the initial diversion creating that right.
- As with a mining claim, one obtained the right by posting a sign at the point of diversion stating the details (date, volume, identity of diverter).
  - This would be posted on a stick in the ground, or a nearby tree.
- The locations of water diversion and application can be different. The link between ownership of land and ownership of water is severed.
- If there is too little streamflow, the senior appropriators divert their full quantity until the stream is exhausted, while the remaining (junior) appropriators receive nothing.
- To perfect the right, the water user has to initiate the diversion with diligence and the water must be applied to beneficial use.
- Disagreements are resolved through litigation

- The point to note: riparian rights and appropriative rights are, in principle, *not* self-enforcing.
  - In the riparian system, and originally in the appropriative system, there are no water police.
- What, then, is the enforcement mechanism?
- Answer: At least in the beginning, private litigation offers the only mechanism for resolving disputes among property owners, as with other types of property (e.g., land).

While the appropriative water right was modeled after the right to a mining claim, there were some crucial differences which made the appropriative right problematic for water.

1. Different spatial interaction among rival claimants.
   - Rival miners would be seeking to explore the same piece of land. You would know it if someone else had posted a claim there.
   - Rival water users diverting water from the same river could be 100 miles apart and they would not see the claim posted by other users.
2. Different use of the resource
   - Miners primarily interested in determining whether the claim was valuable. Most claims weren't, and the miner would move on. The focus was not so much on regular production, as with irrigation.
3. No mechanism for enforcing rights and resolving conflicts
   - The miners relied on local mining camps as a forum to resolve differences. There was no analog for water claims. Instead, disputes resolved by litigation.

What happened in California – Chaos

- There was no central record of water right claims.
- There was no administrative apparatus for limiting the quantity of water diverted or for enforcing seniority.
- A huge number of bogus claims to water developed.
  - For example, while the average flow of the Kings River varied from 5,000 to 10,000 cfs, the claims to Kings River water amounted to 750,000 cfs, exclusive of multiple claims to the entire river flow. On the San Joaquin River, six entities each claimed the entire average flow, and the remaining claims totaled 8 times its maximum flow.
- Private litigation was the only way to resolve any type of disagreement.
  - This was costly and slow. It could not resolve disputes about seniority during the course of a single irrigation season.
  - The judges had little knowledge and could be bamboozled by "experts."
  - For this reason, the results of litigation could be erratic and illogical.

Other states

- Other western states became populated often through mining discoveries - Colorado (1858–1859), Nevada (1859), Idaho (1860), Montana (1862–1864), Arizona (1863).
- They followed California's trajectory. Some first adopted riparian water rights. But (unlike California) these states soon switched to appropriative water rights and eliminated the riparian right to water.
- With the appropriative right to water, the copied California – posting the claim on a stick at the point of diversion, relying on litigation to resolve disagreements, etc. They experienced the same type of chaos as in California.
- Quite soon, they moved to resolve the chaos.

Administrative reforms in other states

- An administrative agency was created to record new claims to an appropriative water right – prior claims were exempted (grandfathered).
- The new agency established an administrative apparatus to ensure that diversions complied with the amount and seniority of a right – district inspectors who would go around checking on local diversions.
- In many states, the water rights agency had the power to resolve disputes about water rights it had granted; in some cases (especially Colorado) disputes other than those dealt with the district inspectors were still resolved in court.
- After some time, the pre-existing water rights that had been exempted were subsequently brought within the purview of the water rights agency.
  - This was often accompanied by the equivalent of a general stream adjudication.

What happened in California

- A codification of appropriative rights in 1872 left the system intact, including the posting of a claim at the point of diversion.
- Following a legal conflict between a riparian and an appropriative water user, the California Supreme Court in 1886 declared that riparian rights were still valid. They coexist with appropriative rights.
- Support grew for water law reform following drought in 1898-99, but this was blocked by water users.
- Finally, over the opposition of water users, California established an administrative system for issuing appropriative rights. It went into effect in December 1914.
- There have been suggestions for a General Stream Adjudication of the Sacramento-San Joaquin River systems, including in 1939, 1942 and 1951. This was opposed by water users, and no such adjudication has been conducted.

California's water rights agency (SWRCB, "the Board") finally created in 1914

- It has no authority over pre-1914 appropriative rights and riparian rights.
- It has no authority over groundwater extraction.
- It has no power to supervise the diversion of water under the right that it created.
- It has no power to manage the right it created (e.g., adjudicate disputes) – this is left to private litigation.
- It has no power to initiate a general stream adjudication. This can occur only if a sufficient number of water users request it.
- These limitations came about at the behest of water users who opposed giving the Board stronger powers.

HOW LONG AFTER THE CREATION OF APPROPRIATIVE WATER RIGHTS DID THE KEY APPURTENANCES OF A PROPERTY RIGHT EMERGE?

	COLORADO	CALIFORNIA
When did appropriative rights start?	1861	1851
Establish centralized recording of new water rights	After 20 years 1881, 1887	After 60 years
Terminate grandfather status for pre-existing water rights	After 20-60 years 1881 1903, 1919	Not yet after 165 years
Establish local apparatus on the ground to monitor diversions and enforce seniority	After 18-38 years 1879 1859	Not yet after 165 years. Since 2012 we have *self-reporting* of water diversions.

California has lived with this flawed system of water rights since 1914

What did the state do in a drought in California?

- Prior to the 1976-1977 drought, the state offered moral suasion to water users to reduce their water use, but did nothing formally to regulate water use.
- The state agency in the limelight was the Department of Water resources, which does water planning but has no water rights authority. The water rights board stayed in the background.
- In the drought of 1976-77, Governor Brown made the water rights board the lead agency for dealing with the right. In the summer of 1977 it announced that it would curtail pre-1914 rights, as well as post-1914 rights, where there was a large enough shortage.
- The drought ended that winter and the matter was dropped.
- In the 1987-1992 and 2007-2009 drought the pattern went back to normal – no formal intervention by the state under water rights authority.

Governor Brown and the drought 2014-2016

- The drought hit home in January 2014. Governor Brown intervened decisively.
- Brown had been governor during the 1976-77 drought. He intervened then in an unusual manner. But that drought ended by the winter 1977-78, and things went back to how they had been before the drought.
- In January 2014, Brown declares a state of emergency and issued an Executive Order.
- As in 1976, Brown makes SWRCB the state's chief actor to manage the drought, instead of DWR as with other governors in other droughts.
- This hints at the water rights authority possessed by SWRCB, not DWR.

State interventions in 2014-2016

- Reporting of all surface water diversions on a monthly basis.
- Increased on-the-ground inspection of actual diversions.
- Partial enforcement of seniority in pre- as well-as post-1914 appropriative rights.
  - The curtailment is is being challenged in litigation.
- Starting in June 2015, mandatory reduction in per capita urban water use, ranging from 8% for cities with the lowest per capita use to 36% for those with the highest, compared to water use in July 2014.

What happens next?

- Will SWRCB's intervention to curtail pre-1914 and riparian rights be upheld under its power to ensure reasonable and beneficial use?
- SWRCB is appointed by the governor and serves at his pleasure. Since its formation in 1914, it has always been extremely subservient to the governor's wishes.
- Will future governors follow in the direction set by Brown, or will they revert to what was done by all other governors – non-intervention?
- Will something else emerge?

What should happen in a drought? Two views.

- Water markets can deal with the problem. There is no need for state government (higher level) intervention to deal with drought. Just let the market work.
- There is a role for state government intervention. Considerations of reasonable and beneficial use. The public trust doctrine applies.
  - A once-and-for-all determination of water rights does not adequately cope with economic and physical change occurring over the course of a century or more.
  - What constitutes reasonable use or the public trust may change.
  - There is a need to carve out some water supply for the environment (in-stream flow), which may be short-changed under existing water rights.

Questions about water marketing in California

- Why do some rights holder sell water, but others not? Are the sellers those with the lowest MVP of water?
- Why did some rights holders stay out of the market until a certain point in time, and have sold since then? Water markets have been advocated in California since ~1970, but did not occur much until mid 1990s. Why? Was there a change in the economic value of their water at that time?
- Why do transactions take some forms but not others? Why are transactions predominantly short-term (< 1 year)?
- My view is that the tenuous nature of water rights explains these distinctive features.

The least tenuous water rights in California are those where there have been transfers/long-term leases.

Once there is consensus on water rights, water marketing commences.

Distinguish different types of water market transaction

1. Short-run operational flexibility (within the growing season)
   - Within season sales and swaps
2. Hedging against hydrologic variability
   - One-year leases signed before the irrigation season, but not repeated for multiple years in a row
   - Dry-year contracts
3. Long-run reallocation of water
   - Long term leases
   - Permanent sales
   - Land sales

>50% of what happens is (1); ~ 35% is (2); < 15% is (3).

Also, transfers potentially involving groundwater impacts have proven politically explosive.

Why few long-term transfers?

- Because 1-year transactions do not require solid proof of prior diversions.
  - The fact that appropriative rights are ill-defined and not effectively adjudicated in many cases is an impediment to long-run transfers
- Because 1-year transactions escape review for CEQA environmental impacts and other third-party issues.
  - SWRCB does not have any standardized procedure – each is done on a one-shot basis.
  - Moreover, the larger issue of the environmental impacts of water diversions on water quality and fish in the Delta remain unresolved.

- Does it matter? Yes:
  - While the operational flexibility associated with 1-year exchanges is valuable, this does not help deal with the larger need for long-run reallocation of water.
  - With urban population growth, and with climate change reducing our effective water supply, this becomes all the more important.
  - Also, with climate change making surface water less reliable, the issue of groundwater regulation will have to be addressed.

Conclusion

- Many property rights to water in California remain vague and unquantified.
- You have to fix property rights before the market for water can play a meaningful role.
- Fixing property rights – (re-)allocating water – is not rocket science. But it requires courage and political will.
- The political leadership of California has always lacked this courage and political will.
- If and when property rights are reformed in California, relying entirely on the market to handle shortage at a time of drought won't be adequate.

Inherent limits to water markets as an allocative tool

- Water is a multi-dimensional commodity. Property rights represent at best an incomplete contract.
  - The best type of property right would be a right to a percentage share of flow (as in Australia) rather than a right to a specific quantity of water.
    - It will be impossible to engineer this in the US.
- Environmental concerns/needs will vary over time.
- Water always arouses social concerns that cannot be left completely to the market.
  - Like saving life or providing food during a famine: relying on the market exclusively for allocation will be opposed.