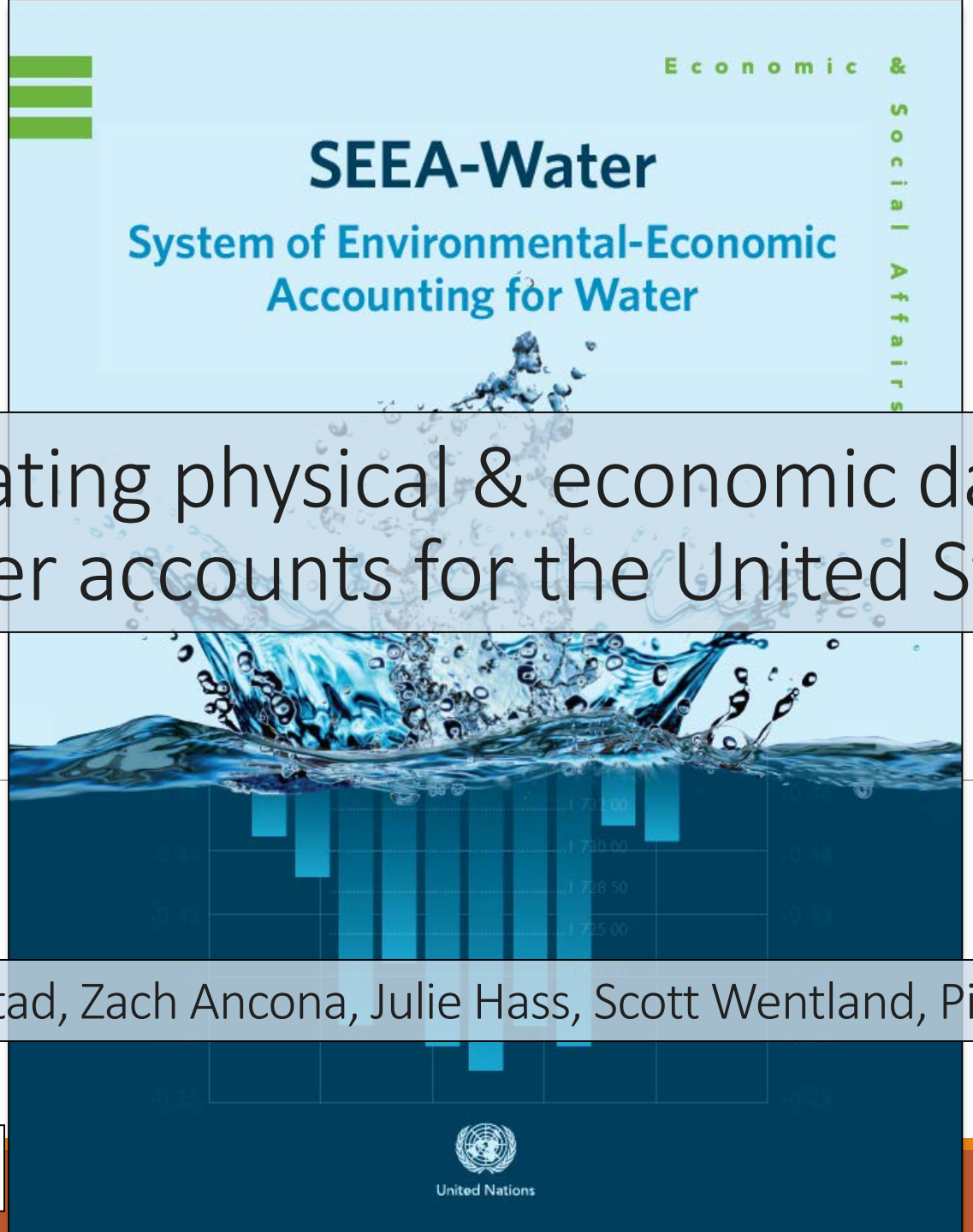

Integrating physical & economic data into water accounts for the United States

Ken Bagstad, Zach Ancona, Julie Hass, Scott Wentland, Pierre Glynn

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USGS science for a changing world

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https://powellcenter.usgs.gov/view-project/57741607e4b07657d1a9910c

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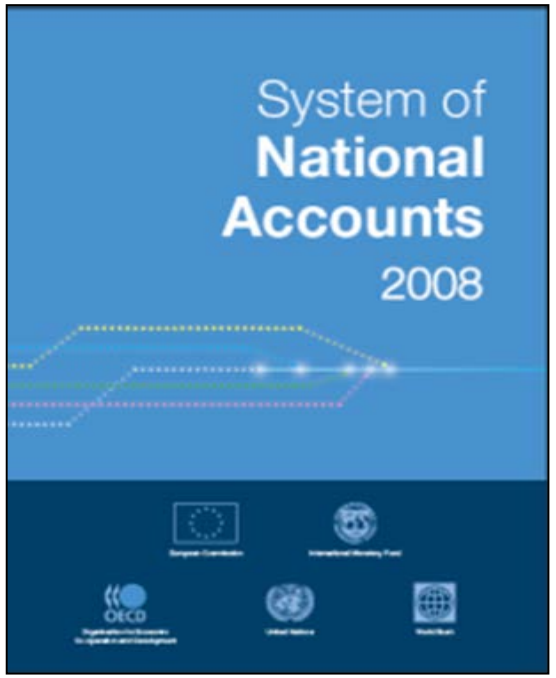
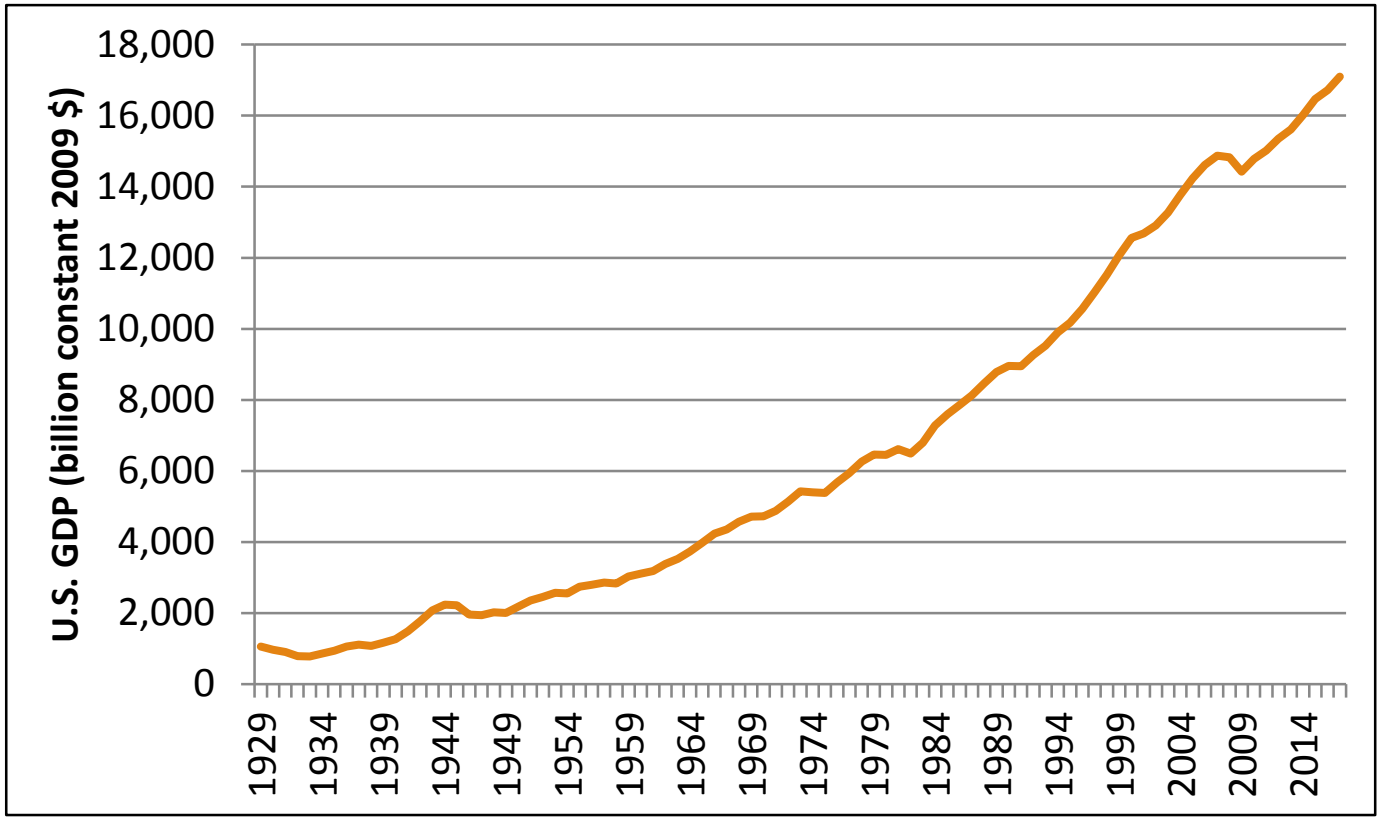
Natural capital accounting: statistical standards

System of
National Accounts



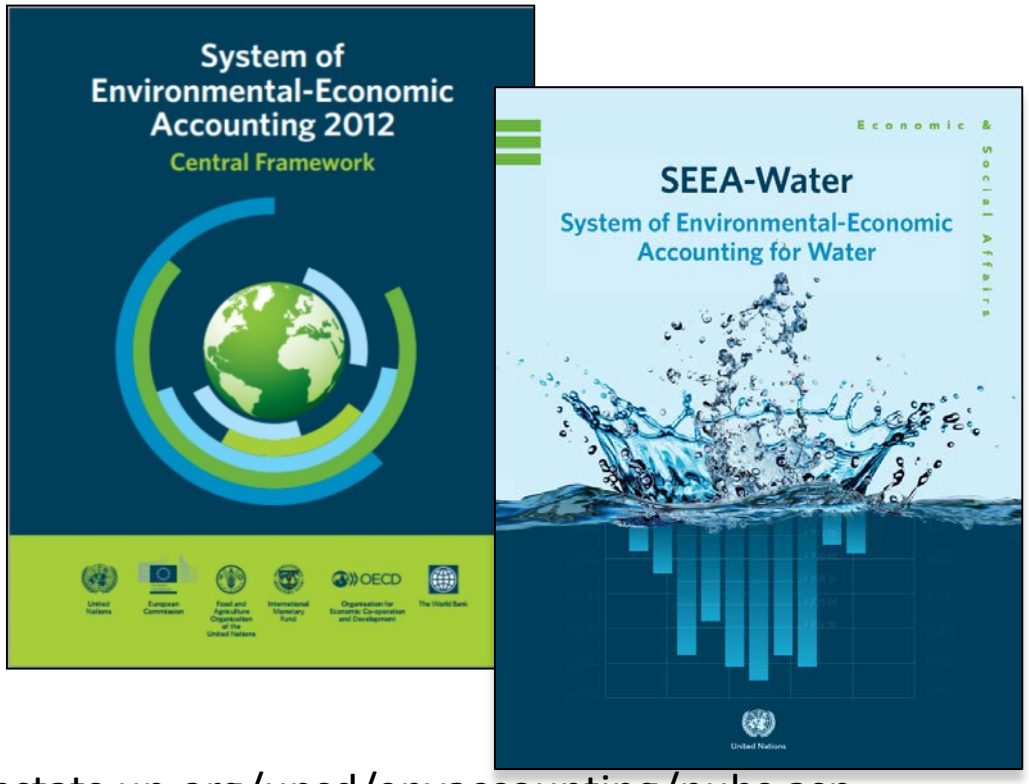


http://unstats.un.org/unsd/envaccounting/pubs.asp

Source: Bureau of Economic Analysis

Natural capital accounting: statistical standards

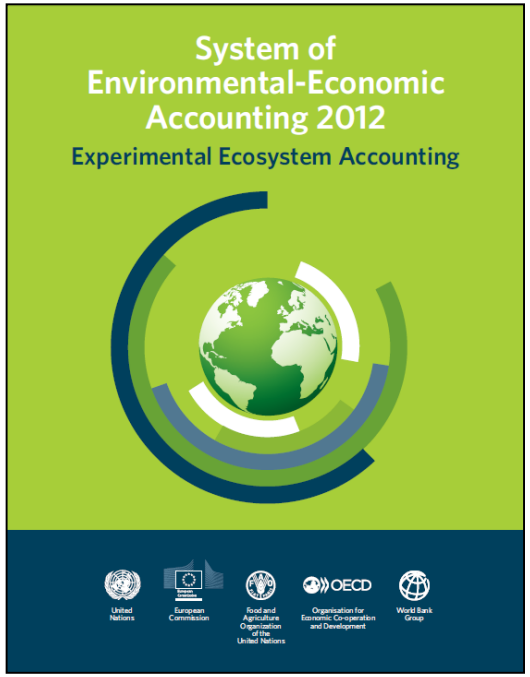
SEEA – Central Framework



http://unstats.un.org/unsd/envaccounting/pubs.asp

Natural capital accounting: statistical standards

SEEA - Experimental Ecosystem Accounting



(Not yet a statistical standard)

http://unstats.un.org/unsd/envaccounting/pubs.asp

USGS science for a changing world

Initial U.S. accounts: state & national, ca. 2000 to 2015

Land accounts

- Land cover
- Land use
- Land value

Water accounts

- Water use by industry
- Water productivity
- Water quality
- Water emissions
- Expert elicitation of water quality – water use linkages

Ecosystem accounts

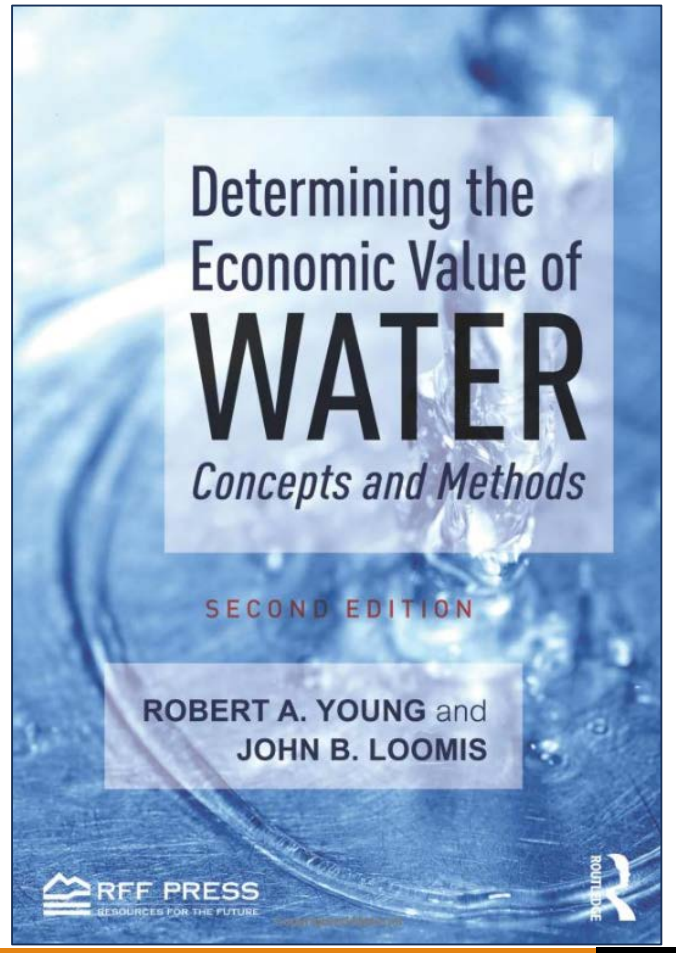
- Crop pollination
- Water filtration
- Avian biodiversity
- Recreational birdwatching
- Air filtration
- Urban heat island mitigation
- Stormwater mitigation
- Wildfire mitigation

Why use natural capital accounts?

- Current economic accounts are incomplete
- Link physical & monetary information in a systematic way
- Link information needed to assess water sustainability
- Integrated information for decision making:
  - Public sector: management & tradeoff analysis across diverse resource types
  - Private sector: identify supply chain liabilities, risk, opportunities for current & future investors
- Synthesize available information and improves data coherence and coordination
- Updated periodically - ideally annually - like economic accounts (GDP)

Basic accounting principles

- Assets combine to produce economic value
- The extent and condition of those assets matters:
  - A large, brand-new factory vs. a smaller factory with years of deferred maintenance
  - A stock of water, its quality, and the timing of flows (+ how well these mesh with needed uses)
- Assets can be valued using net present value (discounted flow of benefits into the future)
  - Water is notoriously tricky to place an economic value on (natural monopoly, water rights, subsidies, etc.)



Accounting rules

- Fundamentally, are *tables governed by rules*, e.g.:

  Total supply = Outputs + Imports

  Total use = Intermediate consumption + Final consumption + Gross capital formation + Exports

  Gross value added = Gross operating surplus + Compensation of employees + Taxes – Subsidies

- In water accounts:

  Total abstraction + Water received from other economic units = Supply of water to other economic units + Total returns + Water consumption

Water & the economy: System of Environmental & Economic Accounts-Water

Figure II.1
Flows between the economy and the environment

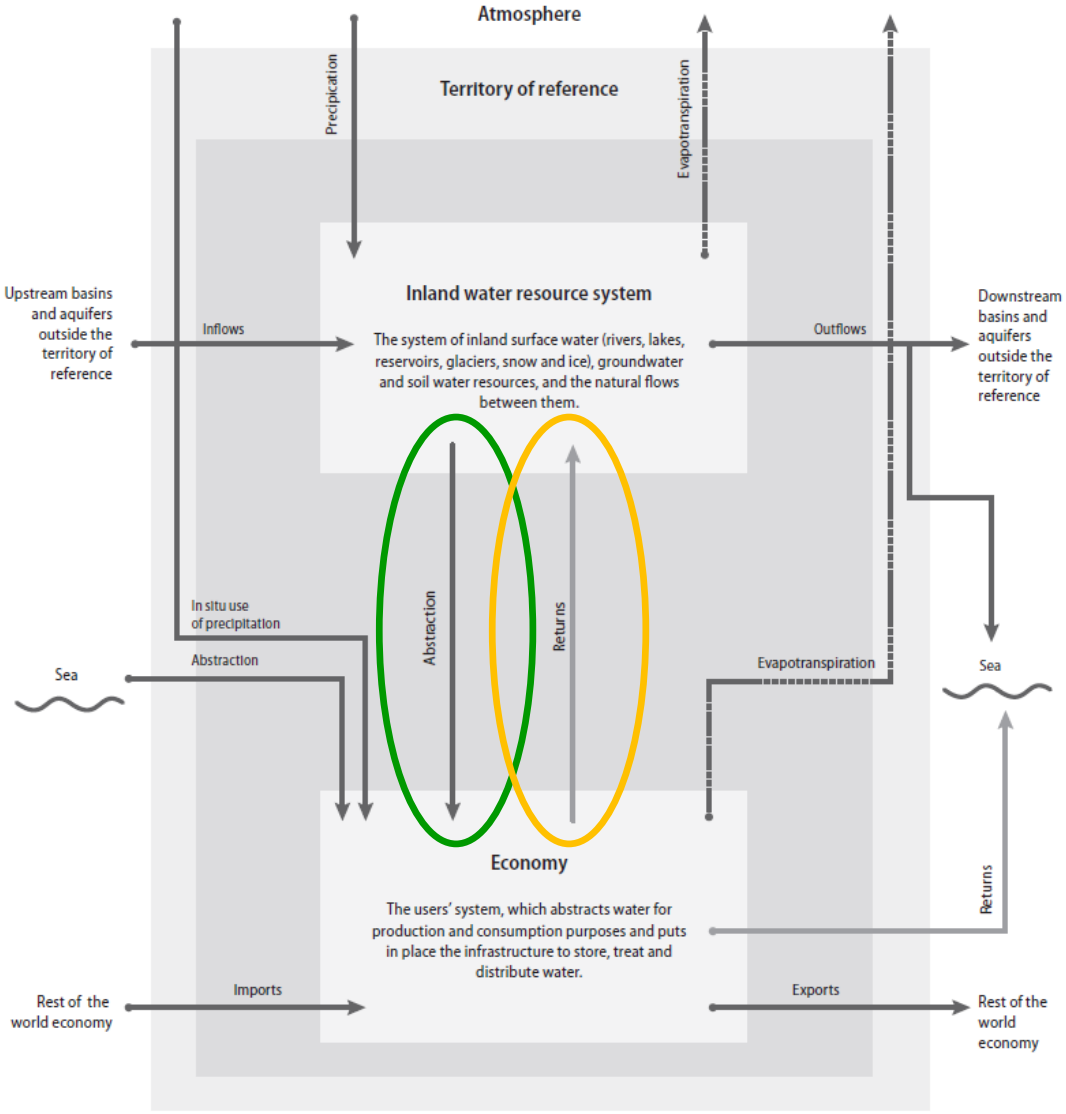
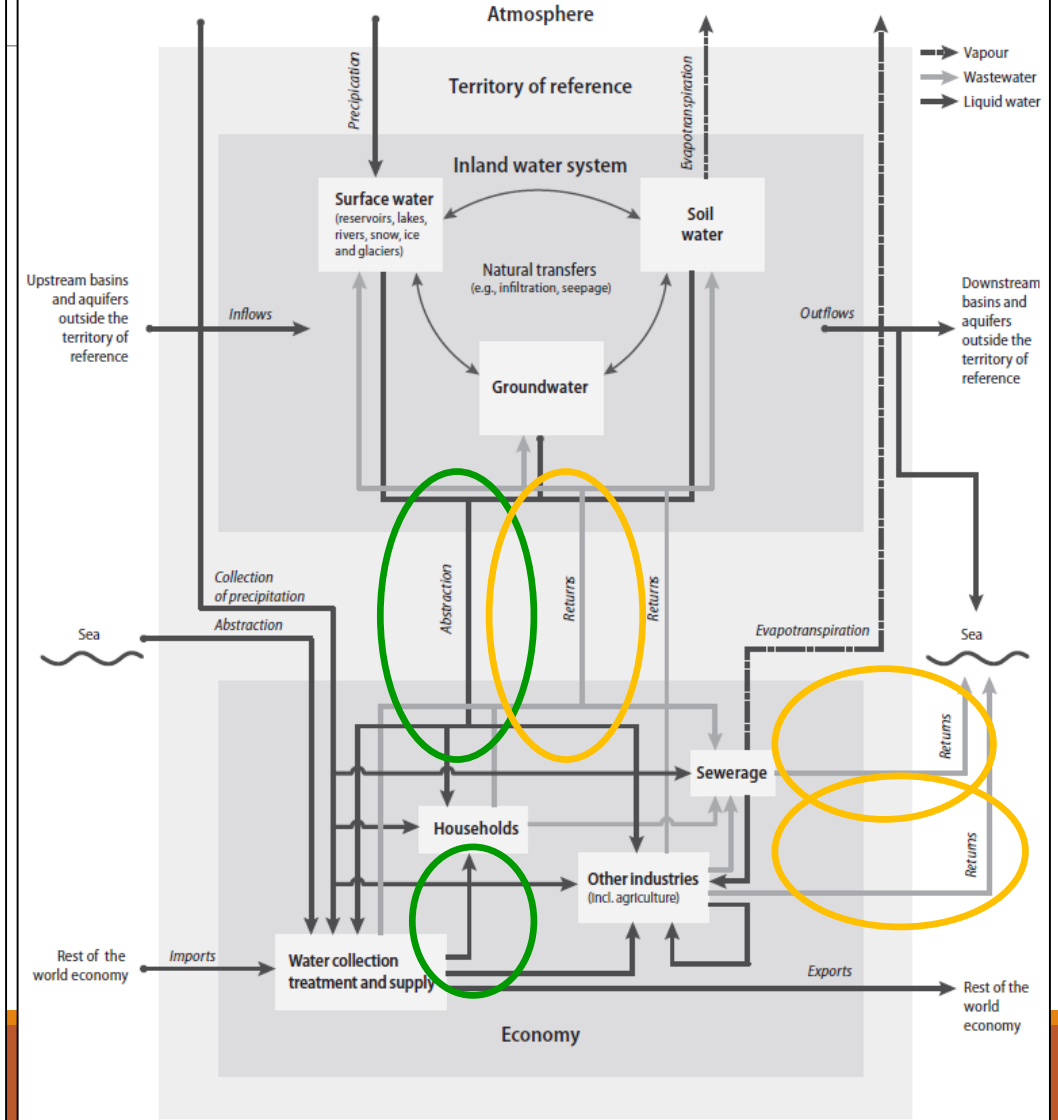


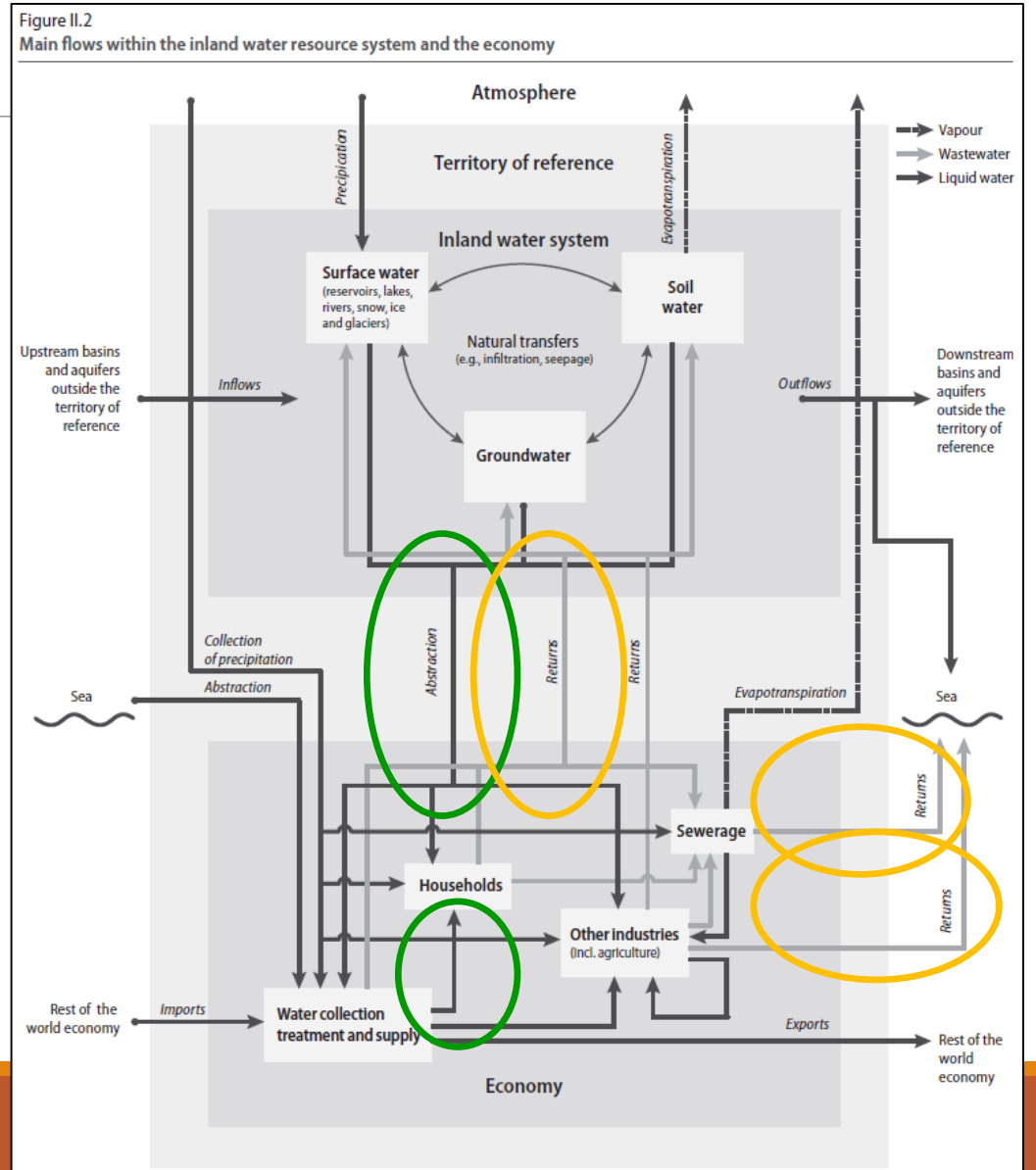
Figure II.2
Main flows within the inland water resource system and the economy



SEEA Water at a glance

Typical challenges:

- Reconciling physical & political boundaries
- Quantifying the stock of water (asset)
- Disaggregated/inconsistent reporting
- Incomplete/no reporting (water returns, intra-economy flows, pollutant emissions, wastewater treatment)



Types of water accounts

Flow accounts

- **Physical supply & use tables** – flows from environment to economy & within economy
- **Emission accounts** – discharge back into environment
- Hybrid & economic accounts – water-related products & industries; gov't expenditures on water supply & infrastructure

Asset accounts

- Produced assets – stocks of built infrastructure to supply & treat water
- Water resources – volume of water resources in different asset categories (surface/ground; fresh/saline) plus natural & human-caused changes
- **Quality accounts** – stocks & their change

"the SEEA (pp. 70 – 79) recommends starting by setting up a physical supply and use table… for different water sources, showing domestic water abstraction and distribution, domestic water use disaggregated by different users, return flows into the environment, as well as water trade (if any) with neighboring countries. More advanced water accounts could also include physical and monetary asset accounts for water bodies such as lakes and groundwater"

Our work

- Best first estimates for U.S. & state level, for:
  - Physical supply & use accounts
  - Water quality accounts
  - Water emissions accounts
  - Water productivity accounts
  - Expert elicitation of water quality-economic linkages (connect above accounts)
- Evaluate data gaps these and for other accounts (esp. asset accounts)
- Lay groundwork for future accounts, including new accounts & continuation of ongoing time series

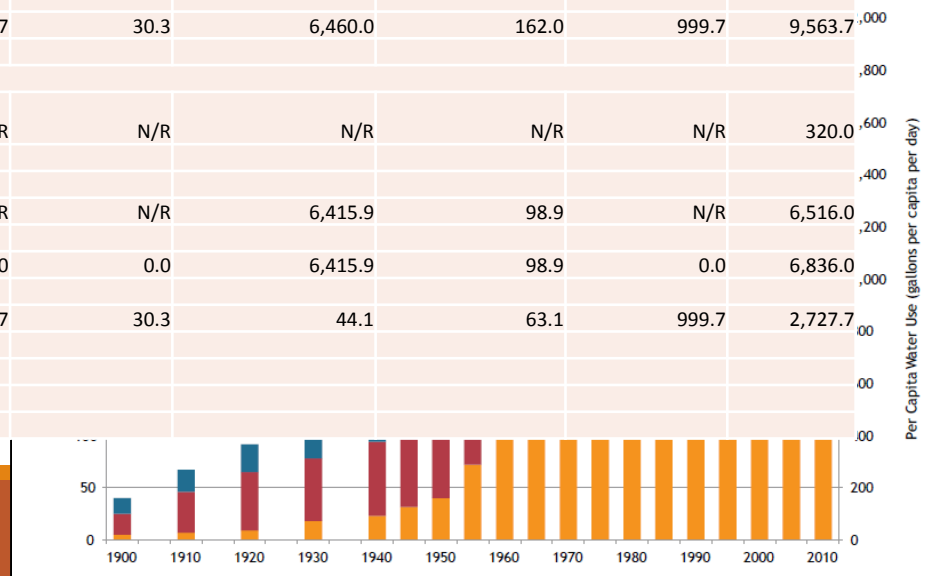
Water supply & use

	2213. Water, Sewage & Other (Irrigation)			Irrigation						2211. Electric Power Generation, Transmission and Distribution			
Physical supply & use of water, Alabama, 2015	Industries (by NAICS 2017 category)												Across all Industries
	2213. Water, Sewage & Other (Irrigation)		Households (Domestic)	Irrigation		112. Animal Production (Livestock)	1125. Aquaculture	31-33. Industrial	21. Mining	2211. Electric Power Generation, Transmission and Distribution			Total Across all Industries
	221310 Water supply (Public supply)	221320 Sewage treatment facilities (Wastewater)		111. Crop Production (Irrigation Crop)	713910. (Golf Courses and Country Clubs)					Thermoelectric Power (Once-through cooling)	Thermoelectric Power (Closed-loop cooling)	Hydroelectric (Evaporative Use)[a]	
A. Water Use													
1. Total abstraction	762.0	N/R	36.7	180.9	43.0	26.2	49.4	493.7	30.3	6,460.0	162.0	999.7	9,243.7
1.i.1. Surface Water, of which is	490.0	N/R	0.0	81.1	43.0	14.7	22.2	461.0	8.5	6,460.0	162.0	999.7	8,742.0
Fresh	490.0	N/R	0.0	81.1	43.0	14.7	22.2	461.0	8.5	6,460.0	162.0	999.7	8,742.0
Saline	0.0	N/R	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.i.2. Ground Water, of which is	272.0	N/R	36.7	99.8	0.0	11.5	27.2	32.7	21.8	0.0	0.0	0.0	501.7
Fresh	272.0	N/R	36.7	99.8	0.0	11.5	27.2	32.7	21.8	0.0	0.0	0.0	501.7
Saline	0.0	N/R	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. Use of water from other economic units	N/R	N/R	320.0	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	320.0
Reclaimed wastewater	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0.0
3. Total use of water	762.0	0.0	356.7	180.9	43.0	26.2	49.4	493.7	30.3	6,460.0	162.0	999.7	9,563.7
B. Water supply													
4. Supply of water to other economic units	320.0	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	320.0
Wastewater to sewerage													
5. Total returns	N/R	N/R	N/R	1.2	0.0	N/R	N/R	N/R	N/R	6,415.9	98.9	N/R	6,516.0
6. Total supply of water	320.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	6,415.9	98.9	0.0	6,836.0
7. Consumption	442.0	0.0	356.7	179.7	43.0	26.2	49.4	493.7	30.3	44.1	63.1	999.7	2,727.7

N/R: Not reported

[a]Coefficient-based estimate

[b]Relative surface and groundwater use unknown; assigned as 50/50



Water use classification vs. NAICS

USGS: 8 categories

North American Industrial Classification System (NAICS): Hierarchical industry classification

2017 NAICS 2, 3, and 4-digit codes		
11. Agriculture, forestry, fishing, and hunting	111. Crop production	1111. Oilseed & grain farming
		1112. Vegetable & melon farming
		1113. Fruit & tree nut farming
		1114. Greenhouse, nursery, & floriculture production
		1119. Other crop farming
	112. Animal production & aquaculture	1121. Cattle ranching & farming
		1122. Hog & pig farming
		1123. Poultry & egg production
		1124. Sheep & goat farming
		1125. Aquaculture
		1129. Other animal production
	113. Forestry & logging	1131. Timber tract operations
		1132. Forest nurseries & gathering of forest products
		1133. Logging
	114. Fishing, hunting & trapping	1141. Fishing
		1142. Hunting & trapping
	115. Support activities for agriculture & forestry	1151. Support activities for crop production
		1152. Support activities for animal production
		1153. Support activities for forestry
21. Mining, quarrying, and oil and gas extraction	211. Oil & gas extraction	2111. Oil & gas extraction
	212. Mining (except oil & gas)	2121. Coal mining
		2122. Metal ore mining
		2123. Nonmetallic mineral mining & quarrying
	213. Support activities for mining	2131. Support activities for mining
22. Utilities	221. Utilities	2211. Electric power generation, transmission and distribution
		2212. Natural gas distribution
		2213. Water, sewage, and other systems
23. Construction	236. Construction of buildings	2361. Residential building construction
		2362. Nonresidential building construction
	237. Heavy & civil engineering construction	2371. Utility system construction

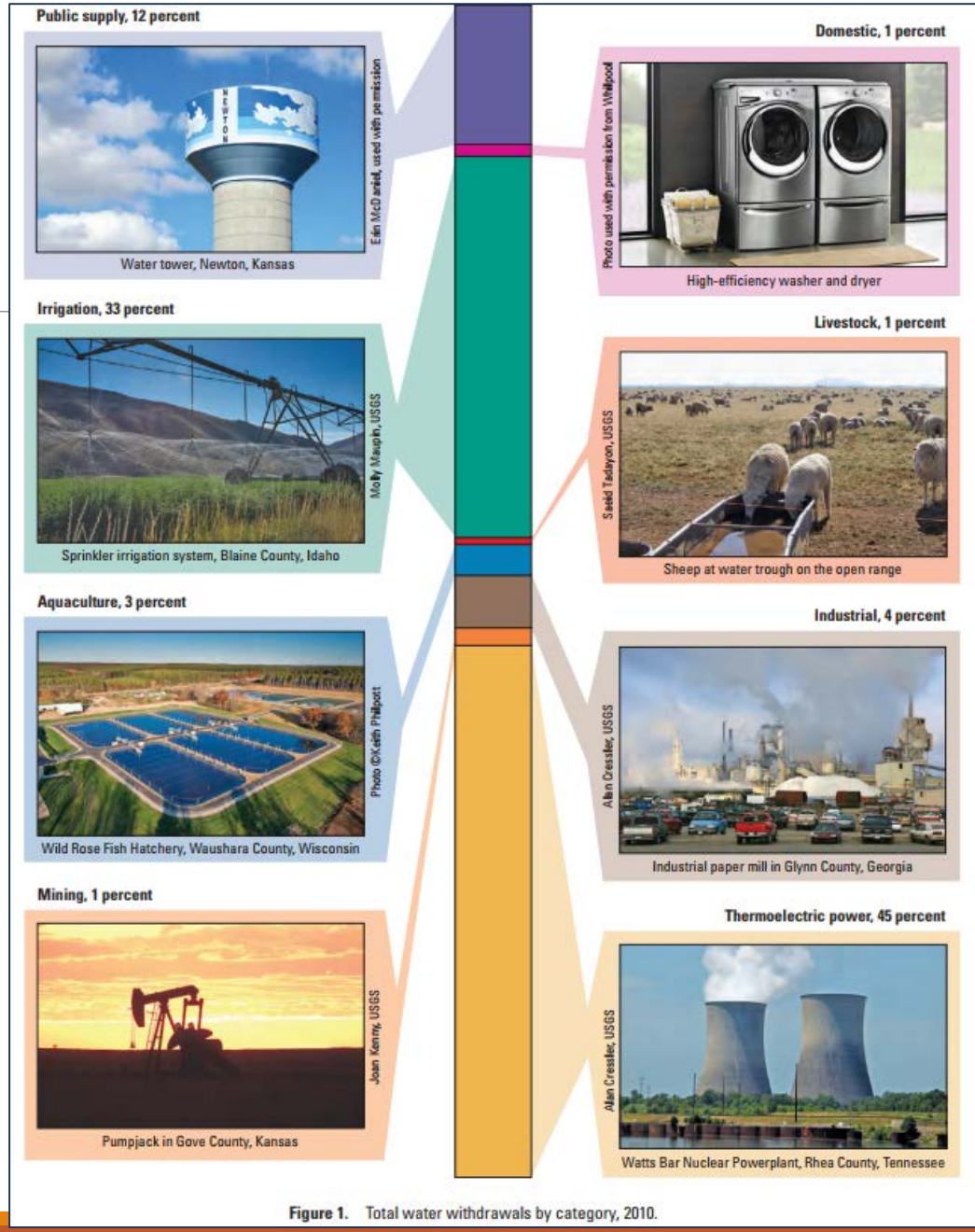
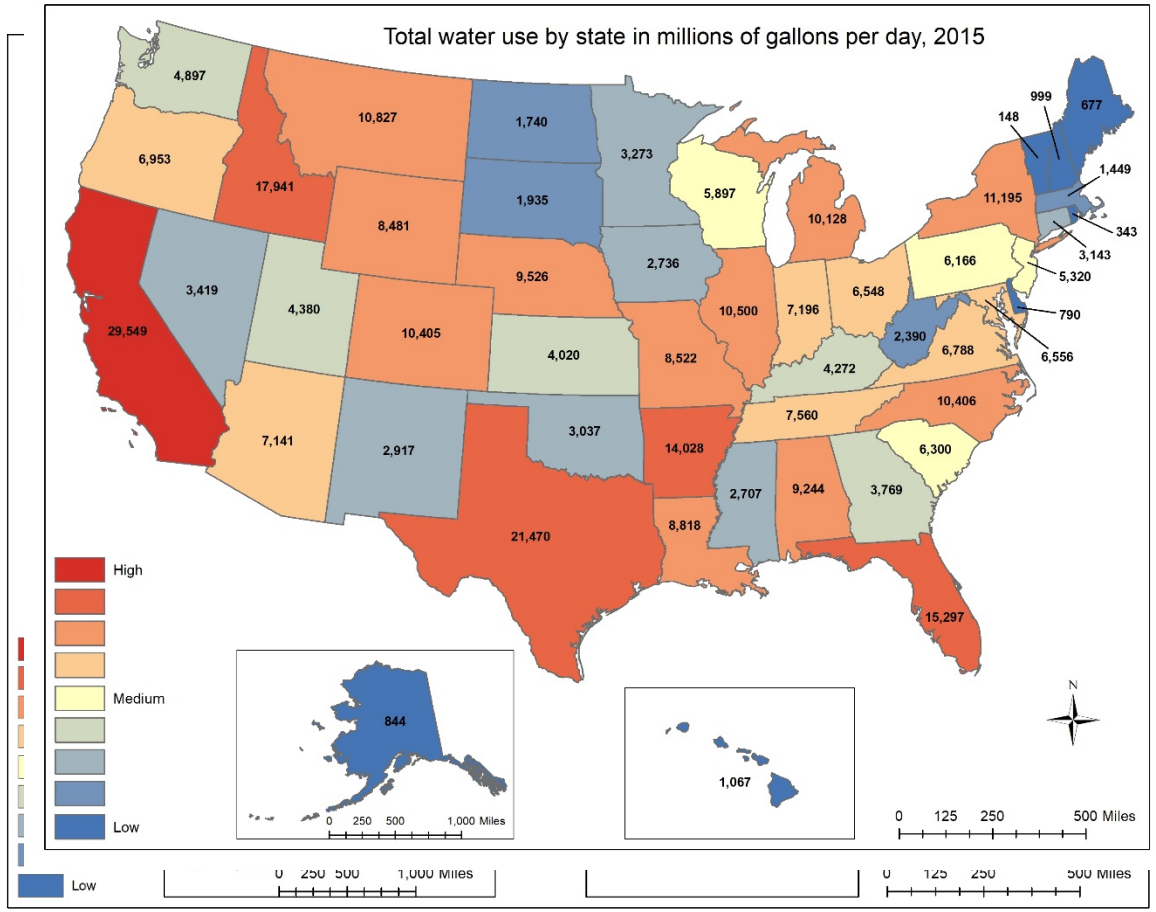
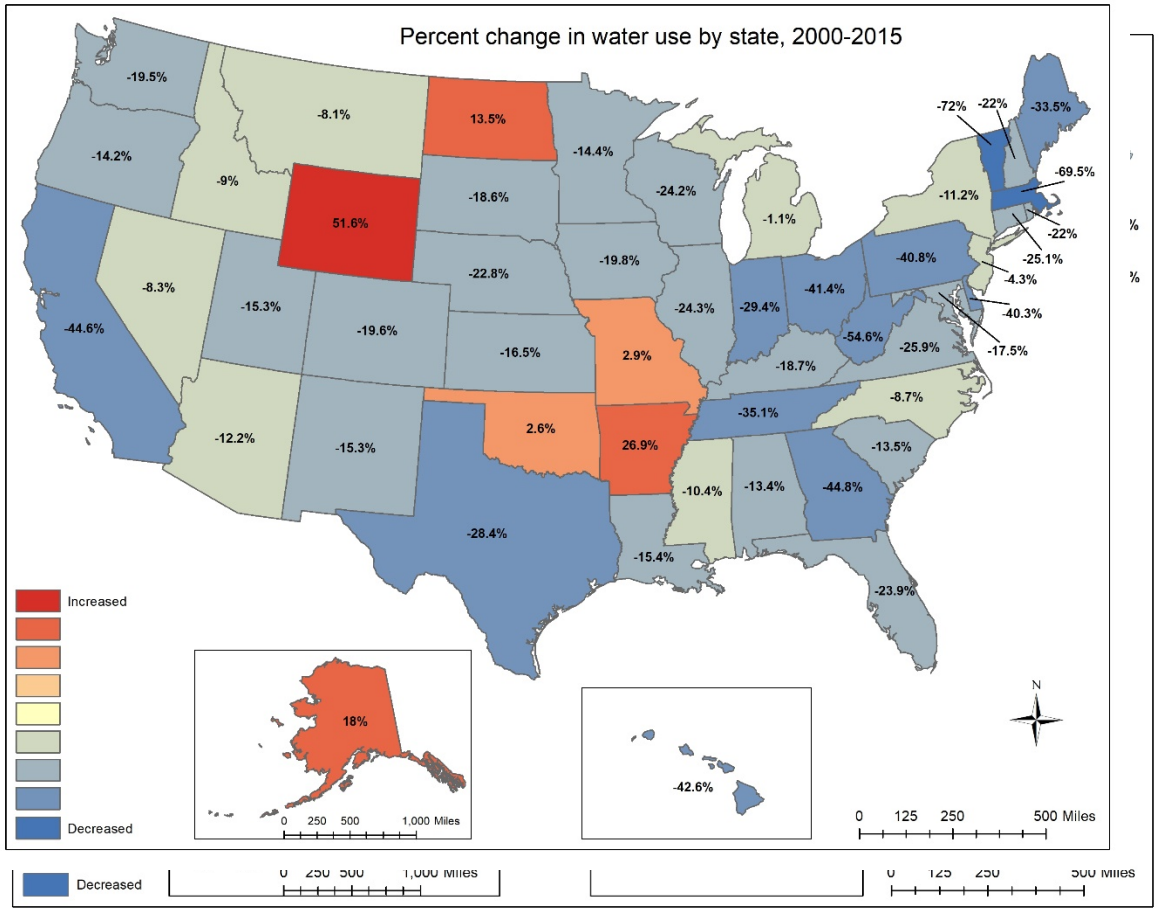


Figure 1. Total water withdrawals by category, 2010.

https://www.census.gov/eos/www/naics/

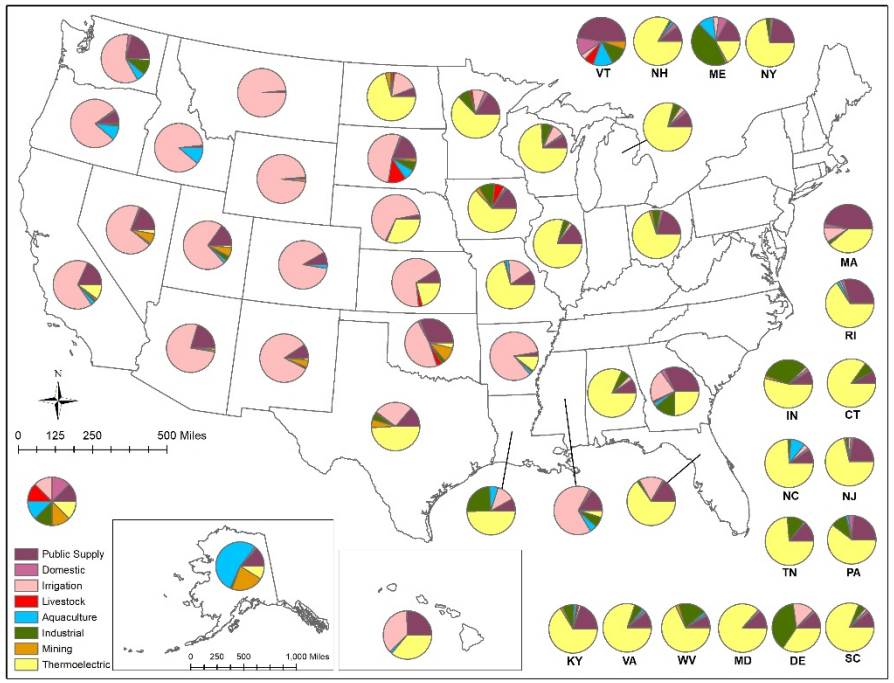
Water use - 2015



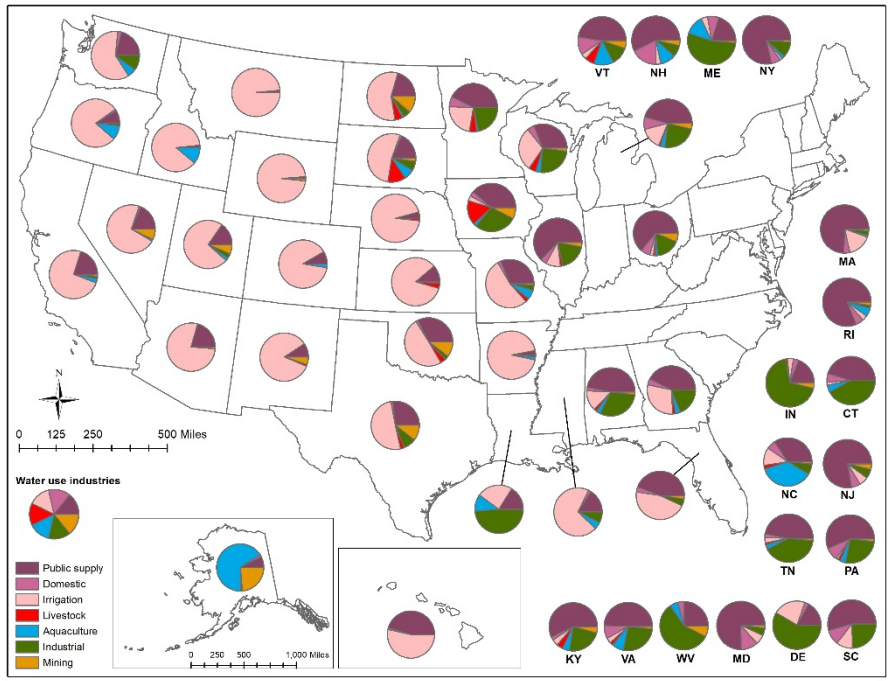


Water use

Total water use by industry including thermoelectric, 2015



Total water use by industry excluding thermoelectric, 2015



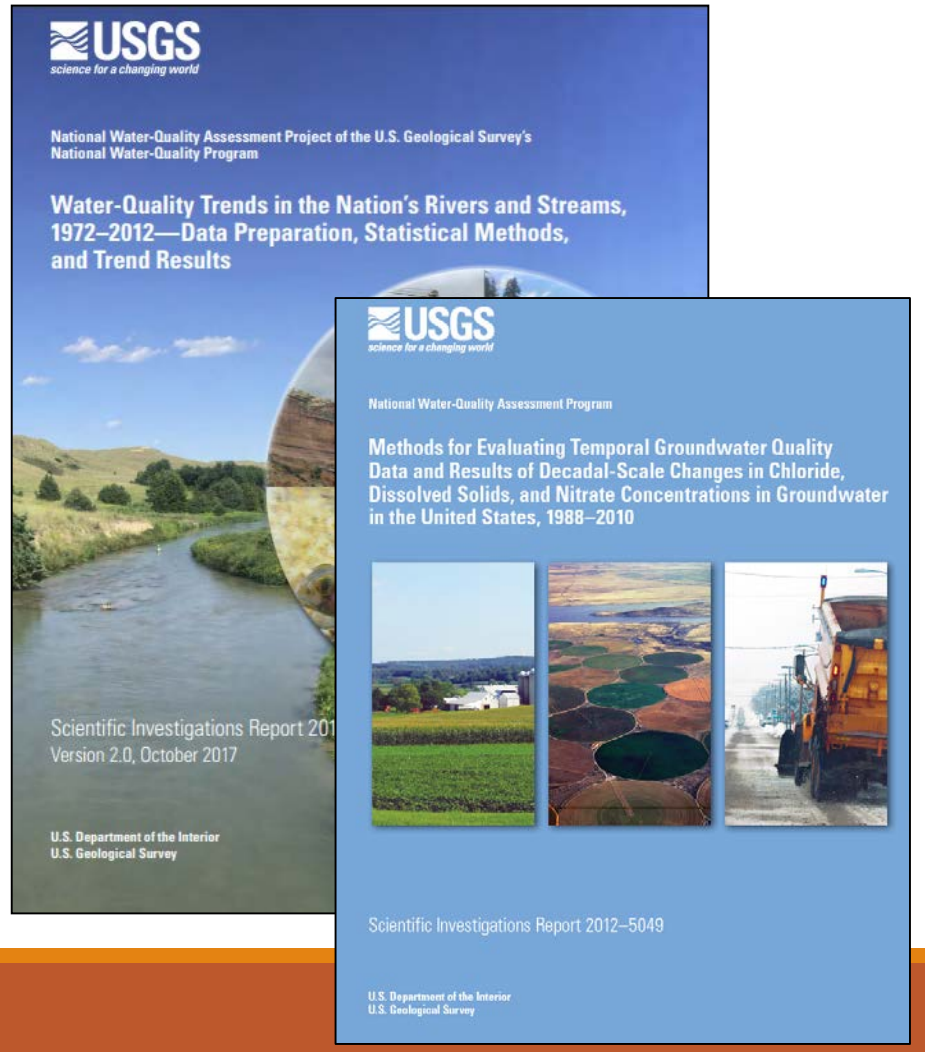
lues in Mgal/day)

c))	All other uses	Total, excl. hydroelectric	Total, incl. hydroelectric
2	48,404	77,696	544,624
3	193,408	351,991	366,795**

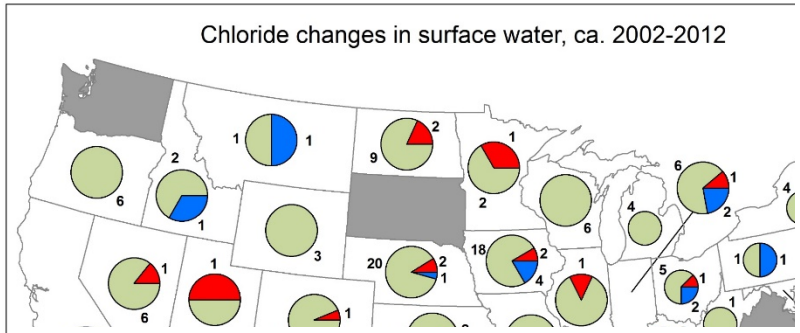
OK, SD

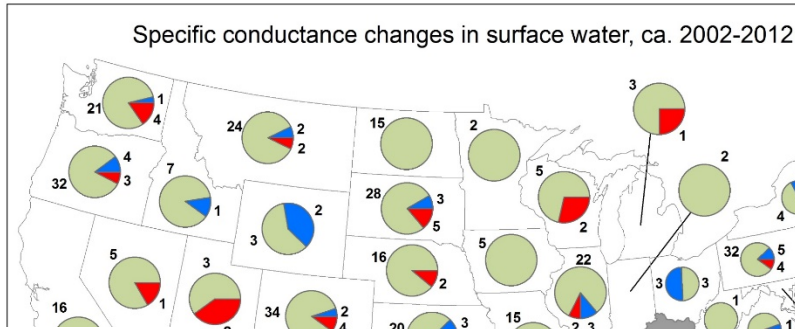
Water quality accounts (ca. 2002-2012)

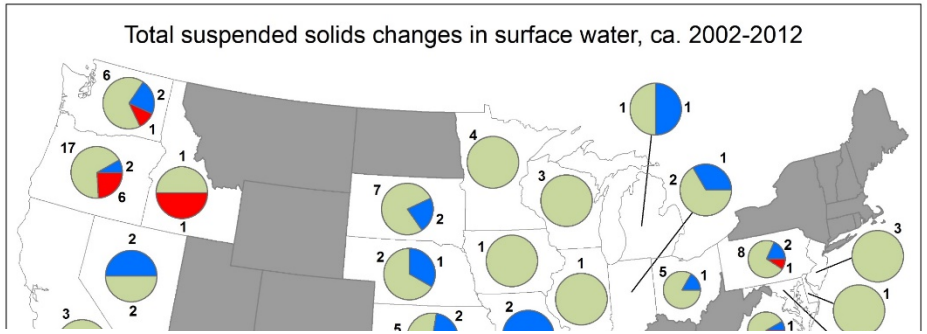
Region		CONUS	Southeast	Northeast	Midwest	Plains	Southwest	Northwest
Chloride	Decreased	25	7	1	8	6	2	1
	No Change	245	59	16	50	81	31	8
	Increased	29	7	0	6	13	3	0
Nitrate	Decreased	31	12	7	5	4	2	1
	No Change	307	86	44	94	38	20	25
	Increased	44	16	3	8	10	1	6
Specific Conductance	Decreased	55	15	7	6	15	6	6
	No Change	527	136	63	62	138	68	60
	Increased	62	15	9	5	17	9	7
Total Nitrogen	Decreased	29	9	6	6	3	4	1
	No Change	222	71	58	55	21	9	8
	Increased	19	14	0	2	2	1	0
Total Phosphorous	Decreased	30	6	6	6	8	4	0
	No Change	281	73	50	68	66	15	9
	Increased	48	19	4	7	12	5	1
Total Suspended Solids	Decreased	27	6	3	5	7	2	4
	No Change	122	39	15	18	21	5	24
	Increased	28	12	3	0	5	0	8

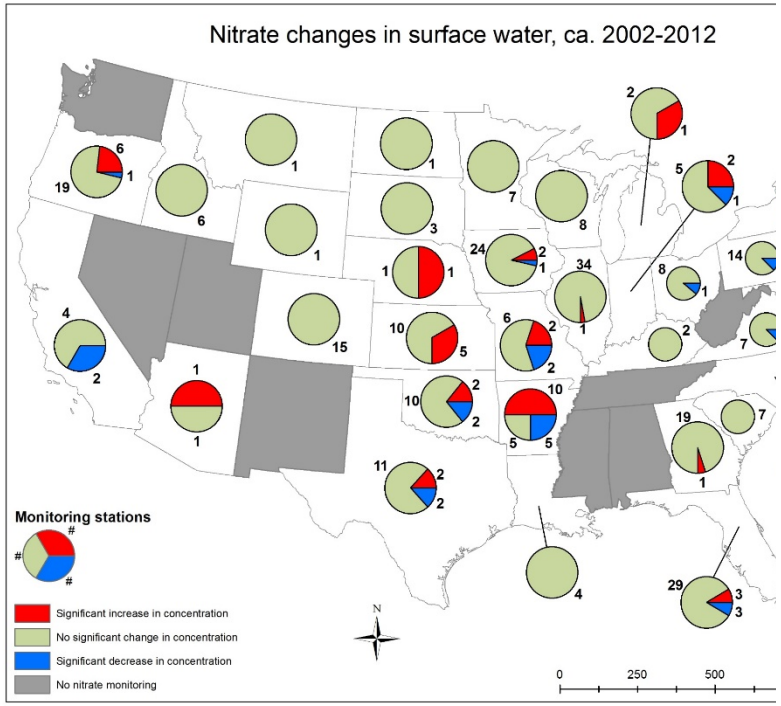


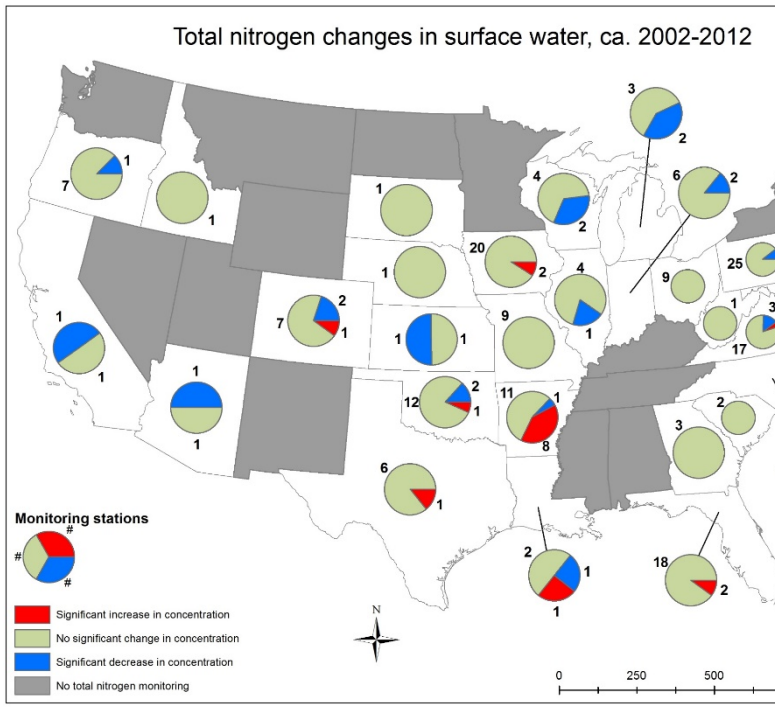
Water quality accounts

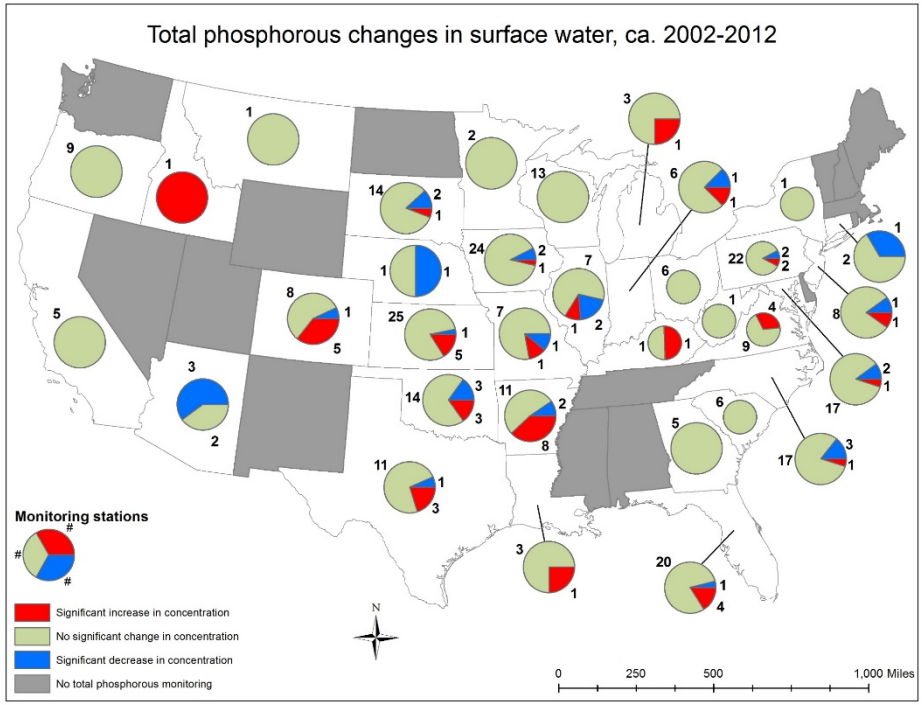






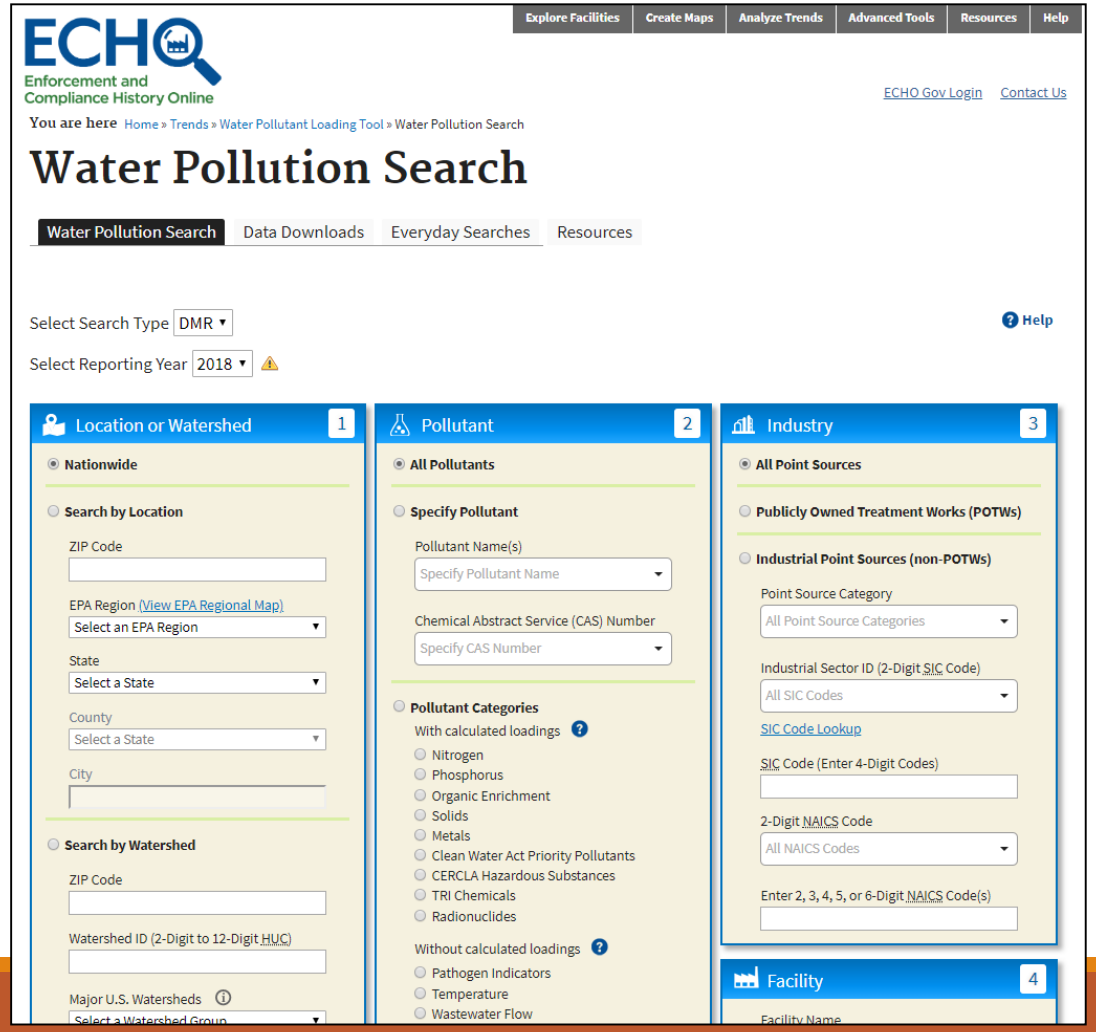






Water emissions accounts

- USEPA Discharge Monitoring Reports – great but some important caveats
  - Only NPDES facilities
  - Self-reported - data gaps & errors (can sometimes be fixed)
  - Tracks by SIC code – messy translation to NAICS
- We initially report only for 2015 at national scale



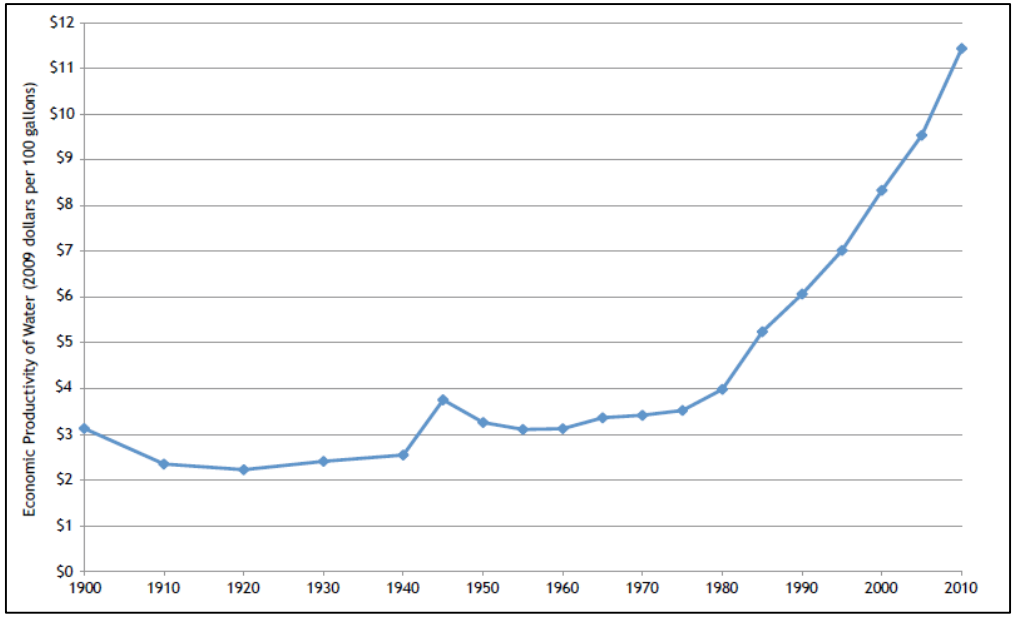
Water emissions accounts

National water emissions accounts: Net emissions from point sources (lbs), 2015												
	Industries (by NAICS 2017 category)[a]											
	211. Oil & Gas Extraction	212. Mining (Except Oil & Gas)	2211. Electric Power Generation	221310. Water supply & irrigation systems	221320. Sewage Treatment Facilities	311. Food Manufacturing	312. Beverage & Tobacco Product Manufacturing	321. Wood Product Manufacturing	322. Paper Manufacturing	325. Chemical Manufacturing	326. Plastics & Rubber Products Manufacturing	488. Support Activities for Transportation
Nitrogen	1,958,753	175,894	30,799,748	4,625,342	1,707,044,049	9,076,309	223,678	2,304,678	4,476,851	11,390,196	689,532	2,745,438
Phosphorus	1,812,670	1,080,377	3,518,434	278,333	229,369,504	46,984,187	482,744	66,860	3,062,443	4,483,287	22,353,375	57,155
Organic enrichment	17,864,431	1,527,739	7,921,047	1,877,695	794,384,600	126,283,081	58,361,620	63,112,102	221,832,247	31,189,631	32,721,806	32,693,096
Solids	31,838,843	47,734,469	815,669,482	1,413,229,518	2,402,701,873	256,619,855	4,365,042	189,360,155	319,345,828	291,293,333	937,320,550	268,138,914
Metals	84,021,720	94,431,196	53,179,422	15,175,581,651	486,175,286	9,730,834	82,041	361,429	1,337,937	4,025,157	8,382	97,100,990

	493. Warehousing & Storage	562. Waste Management & Remediation Services	721. Accommodation	Other industries	Total	% as other industries
Nitrogen	276,071	41,456,922	1,712,585	61,160,117	1,880,116,163	3.3%
Phosphorus	1,115	53,324	7,845,753	2,467,571	323,917,132	0.8%
Organic enrichment	102,962,934	89,413,204	7,770,512	213,201,676	1,803,117,422	11.8%
Solids	5,059,140	305,548,960	15,089,070	3,023,845,194	10,327,160,225	29.3%
Metals	72,625	60,815,915	21,083	184,521,154	16,251,466,822	1.1%

Water productivity ($ GDP/100 gal water used)

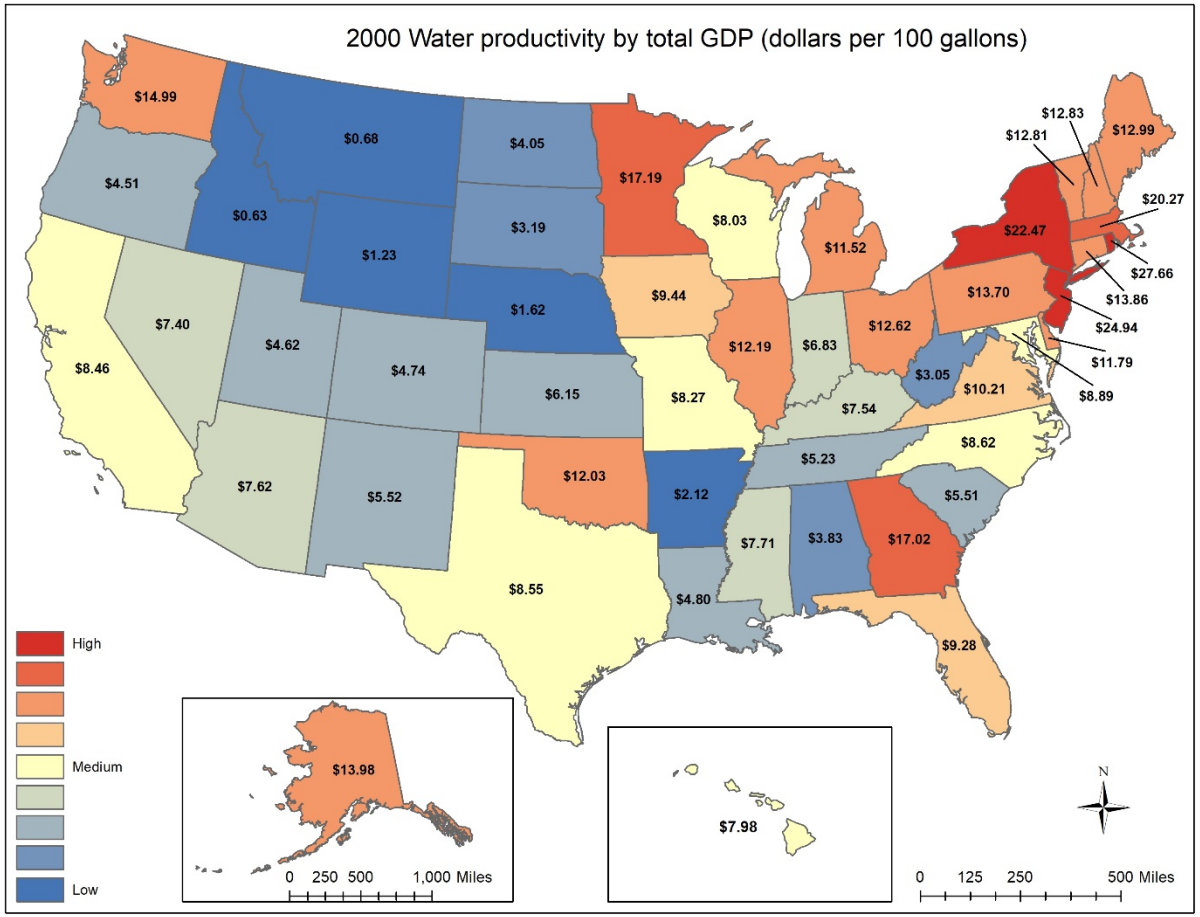
- Limited by thematic resolution of water use & GDP data
- Can't resolve e.g., industries as we lack data on industrial use of public supply

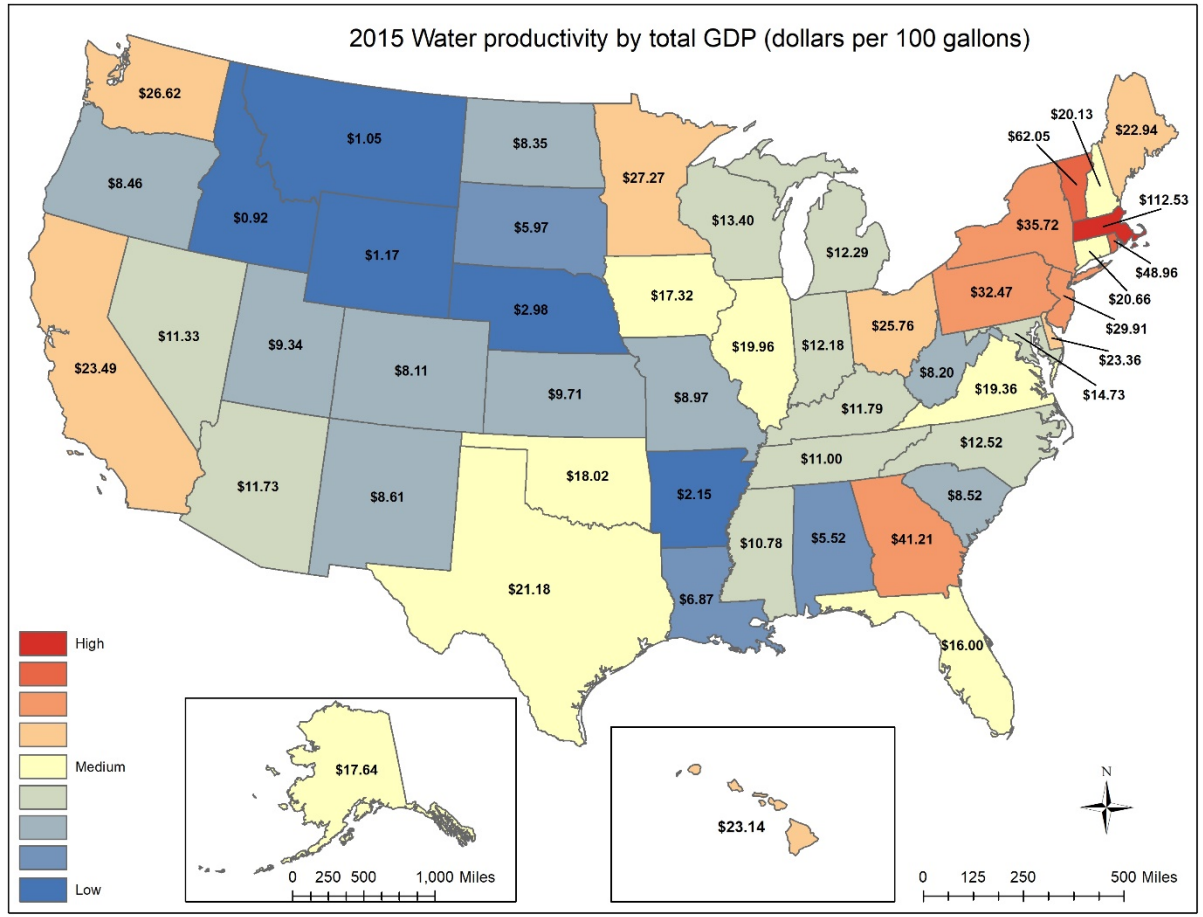


		Water productivity (GDP, 2009 US Dollars/100 gallons of water)			
		Crop Production, Livestock, Aquaculture	Mining	Total (Deducting domestic use, adding golf courses & evaporative loss from hydropower)	Total (USGS Reported)
National	2000	$0.16	$14.17	$8.27	$8.40
National	2005	$0.20	$15.39	$9.83	$9.53
National	2010	$0.24	$19.27	$11.75	$11.39
National	2015	$0.26	$28.16	$14.32	$13.84

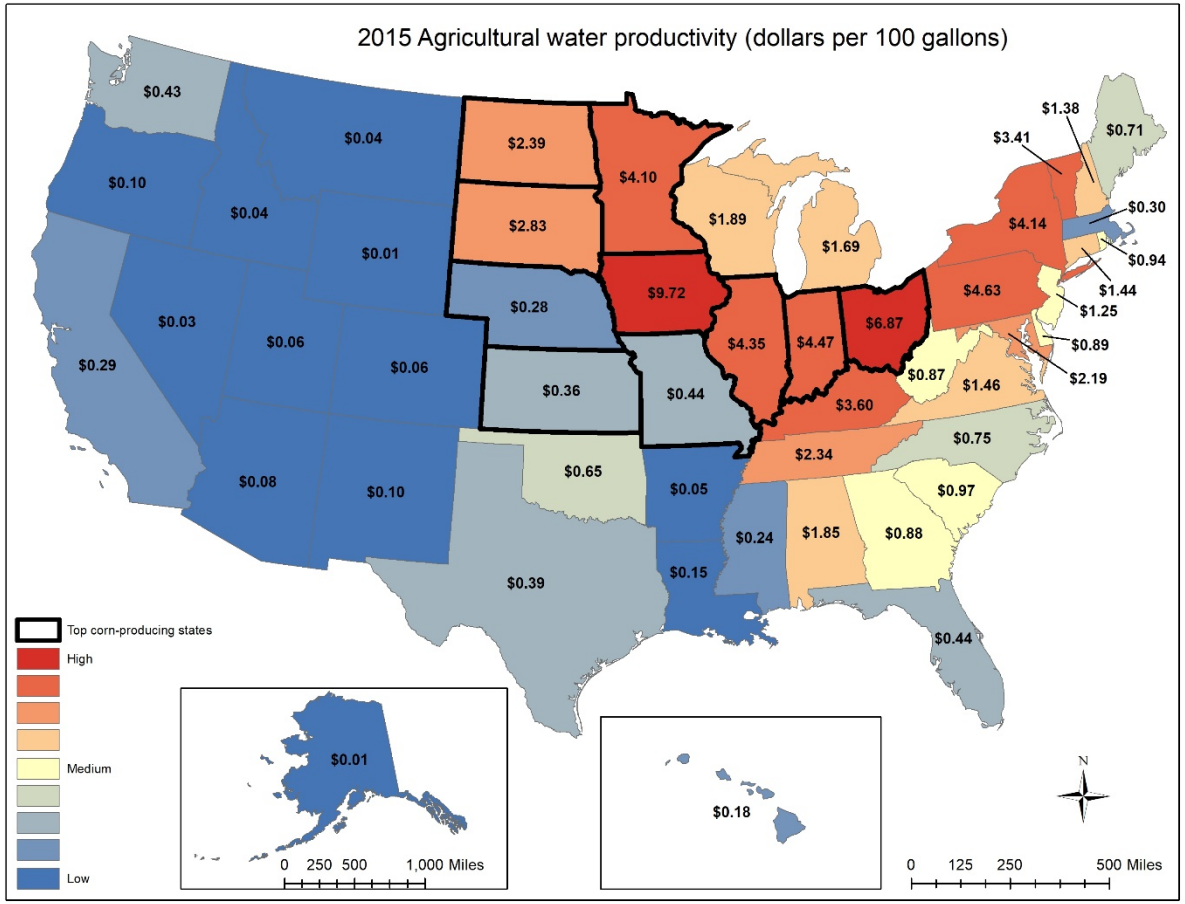
Donnelly and Cooley 2015

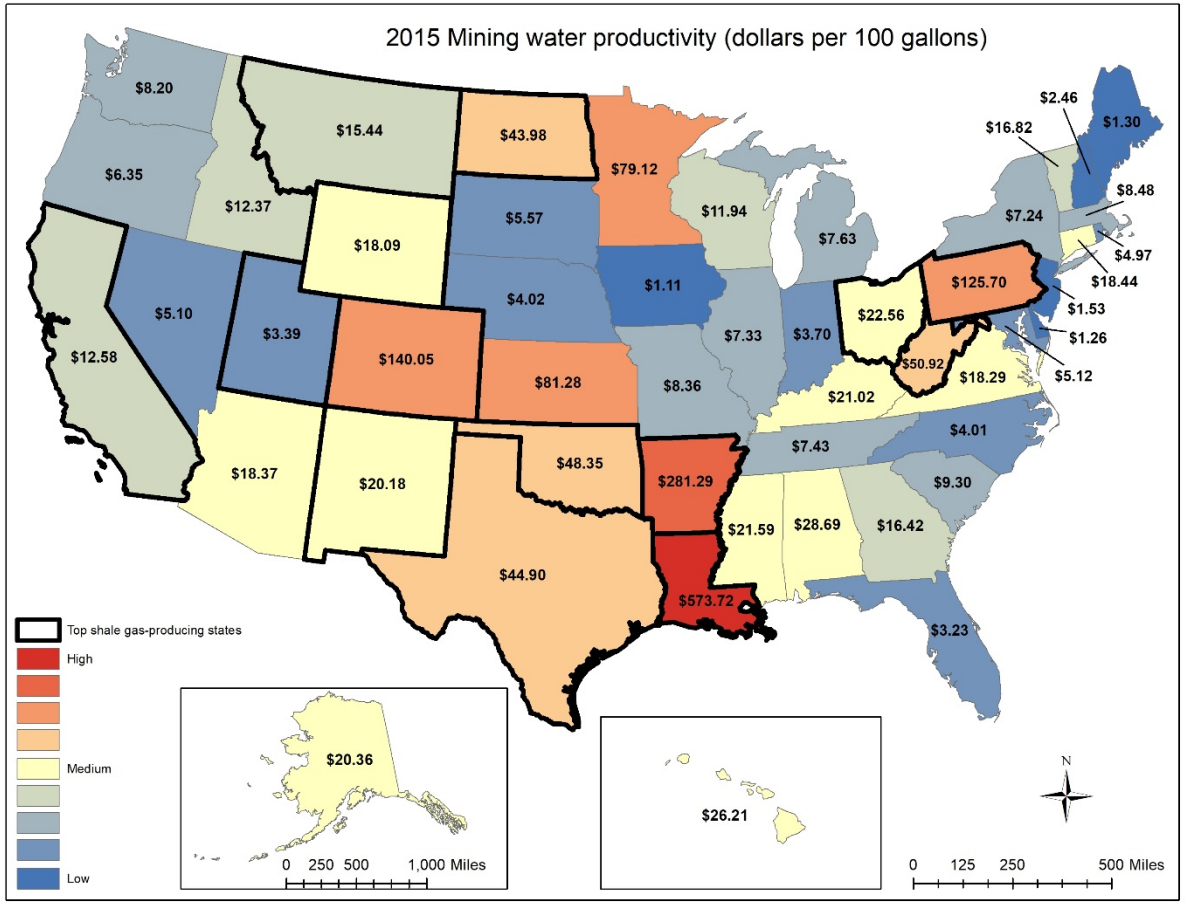
Total water productivity - 2000 & 2015





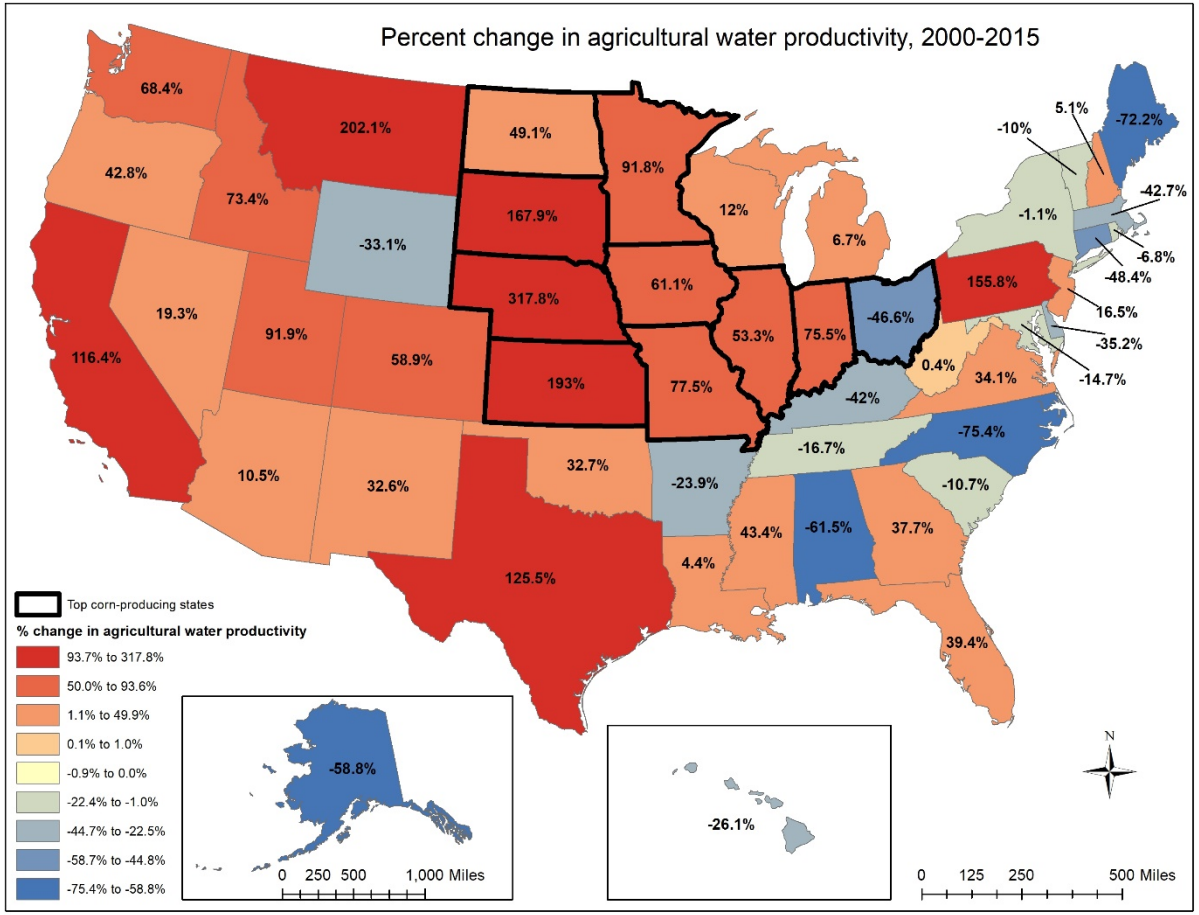
Water productivity by industry - 2015

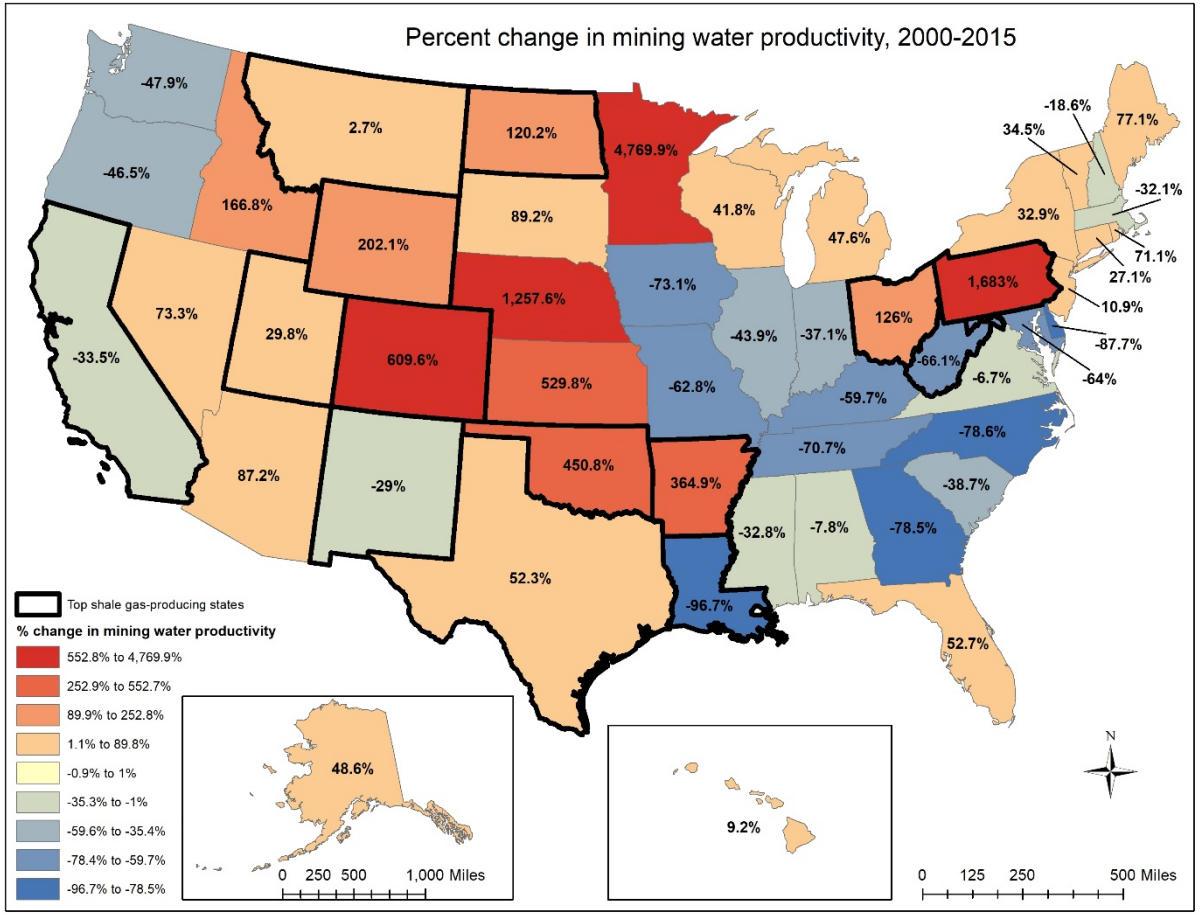




USGS science for a changing world

Changes in water productivity, 2000-2015





Expert elicitation, water quality-economic linkages

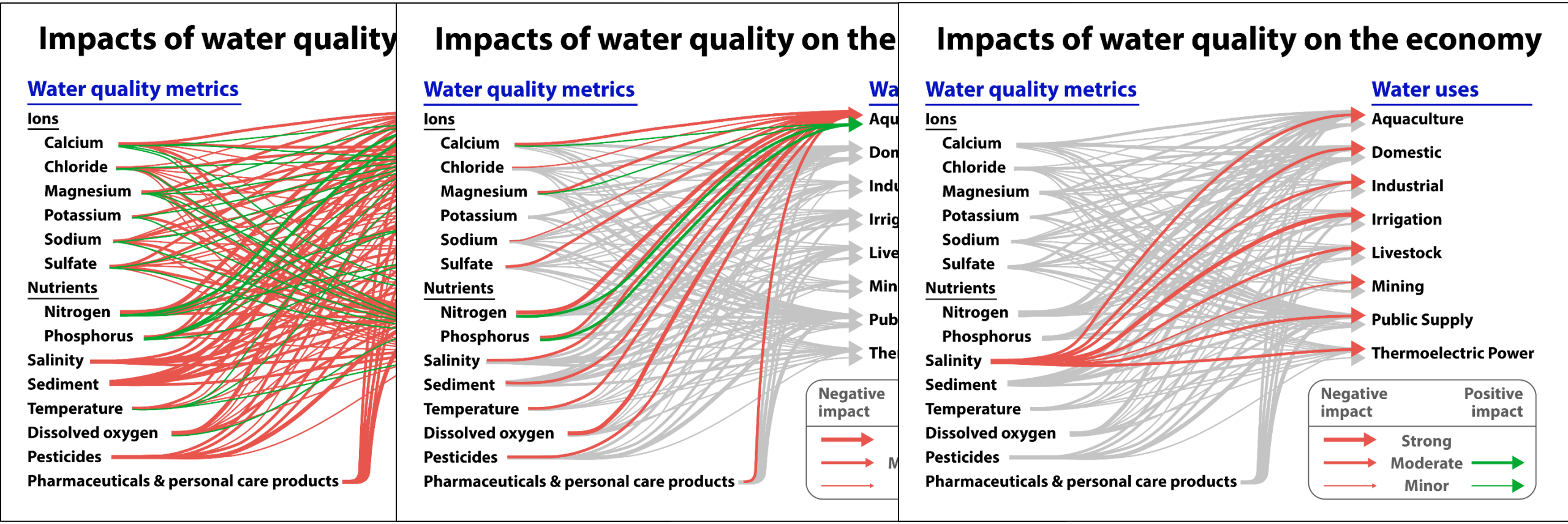
- Q1: What are the effects of changing water quality on the economy?
- Q2: How does economic activity affect water quality?
- Compare, e.g.,:
  - States with water quality changes for key metrics
  - States with high GDP in in industries potentially vulnerable to water quality change

Water quality-economic linkages

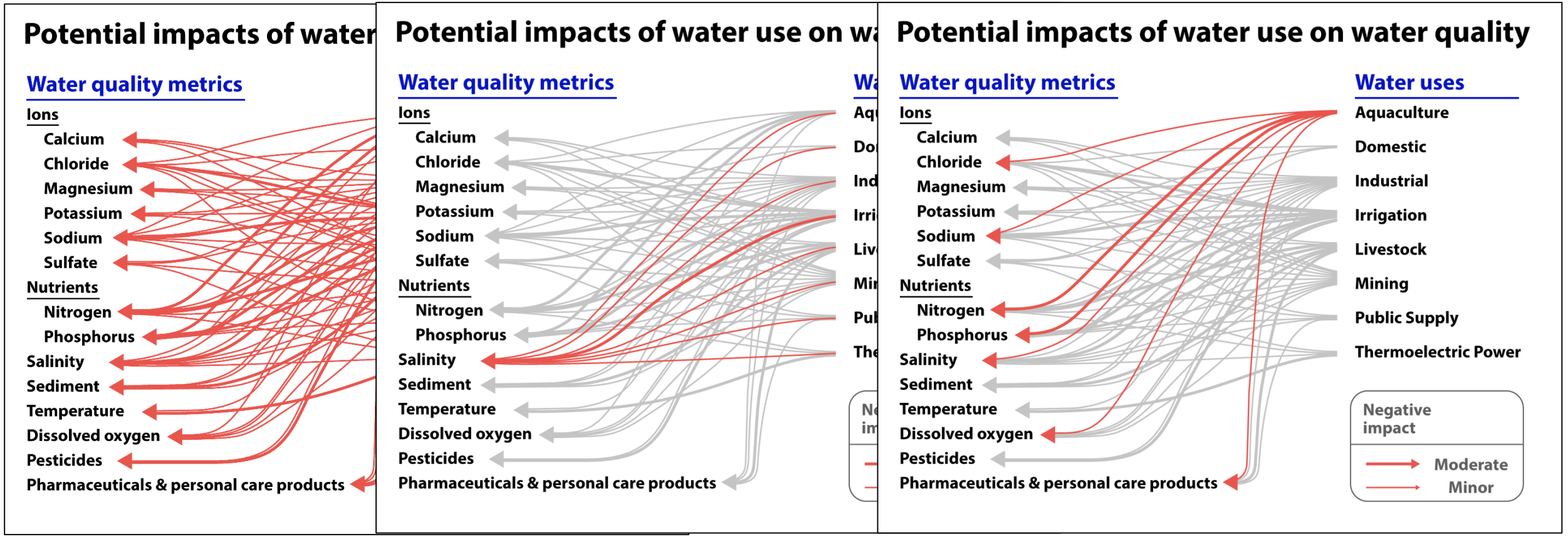
- Elicitation from 15 water/water quality experts from USGS & USEPA
- Effects of 14 water quality parameters (measured nationally or of emerging concern) on 8 water use types

		Water uses/industries							
Water quality metrics		**Aquaculture**	**Domestic**	**Industrial**	**Irrigation**	**Livestock**	**Mining**	**Public Supply**	**Thermoelectric Power**
Ions	Calcium	+/--	+/--	-	+	+	-/+	+/--	-
	Chloride	-	+/--	-	-	-		+/--	-
	Magnesium	+/--	+/--	-	+	+	-/+	+/--	-
	Potassium		+/--					+/--	
	Sodium	-	+/--	-	-	-		+/--	-
	Sulfate	--	+/--	-	-	-	-	+/--	-
Nutrients	Nitrogen	---/++	--		-/+	--/+		--	
	Phosphorus	--/++	--/+		-/+	-/+		--	-
	Salinity	--	--	--	---	--	-	--	--
	Sediment	--	--	--	--	--	--	--	--
	Temperature	--	-/+	-/+				-/+	-/+
	Dissolved oxygen	---	-	-			-	--	-
	Pesticides	--	--	-	--	--		---	
	Pharmaceuticals & personal care products	--	--	-	--	--		---	

Impacts of water quality on the economy



Impacts of economic activity on water quality



Accounts investigated but not compiled

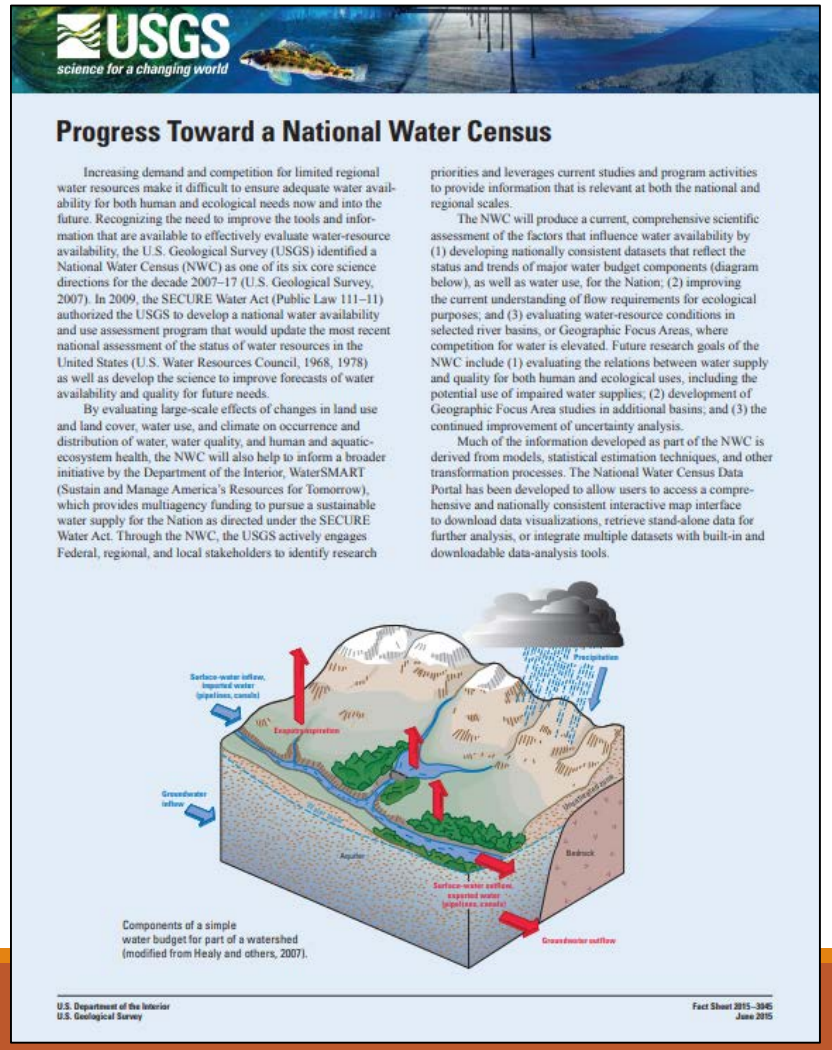
- Water asset accounts - Work underway with USGS National Water Census
  - Watershed-level surface water budgets
  - National-scale groundwater & soil water model

Table VI.1
Asset accounts (*millions of cubic metres*)

	EA.131. Surface water				EA.132 Groundwater	EA.133 Soil water	Total
	EA.1311 Artificial reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, ice and glaciers			
1. Opening stocks	**1 500**	**2 700**	**5 000**	**0**	**100 000**	**500**	**109 700**
Increases in stocks							
2. Returns	300	0	53		315	0	**669**
3. Precipitation	124	246	50			23 015	**23 435**
4. Inflows	1 054	339	20 137		437	0	**21 967**
4.a. From upstream territories			17 650				**17 650**
4.b. From other resources in the territory	1 054	339	2 487	0	437	0	**4 317**
Decreases in stocks							
5. Abstraction	280	20	141		476	50	**967**
6. Evaporation/actual evapotranspiration	80	215	54			21 125	**21 474**
7. Outflows	1 000	100	20 773	0	87	1 787	**23 747**
7.a. To downstream territories			9 430				**9 430**
7.b. To the sea			10 000				**10 000**
7.c. To other resources in the territory	1 000	100	1 343	0	87	1 787	**4 317**
8. Other changes in volume							**0**
9. Closing stocks	**1 618**	**2 950**	**4 272**		**100 189**	**553**	**109 583**

Overlap, challenges, extensions to USGS National Water Census

- Other remaining gaps for water accounts:
  - Water supply & use: 1) Return flows to environment, 2) flows between industries (Marston et al. 2017), 3) timing & thematic resolution
  - Water quality: Finer-scale change than # of gages (national SPARROW model would be ideal – forthcoming 2019 USGS product)
  - Summarize by watersheds or political boundaries?
- Some overlap with ongoing work at USGS & other agencies
  - April 2018 USGS Water Availability & Use Program – Water Use Workshop
  - Census Bureau collecting data on water use by industry in 2017 Economic Census (most recent previous data from 1983, Becker 2016)
- Water accounts offer connections to economic data – value of water resources, multiple ways to inform decision making



USGS
science for a changing world

Progress Toward a National Water Census

Increasing demand and competition for limited regional water resources make it difficult to ensure adequate water availability for both human and ecological needs now and into the future. Recognizing the need to improve the tools and information that are available to effectively evaluate water-resource availability, the U.S. Geological Survey (USGS) identified a National Water Census (NWC) as one of its six core science directions for the decade 2007–17 (U.S. Geological Survey, 2007). In 2009, the SECURE Water Act (Public Law 111–11) authorized the USGS to develop a national water availability and use assessment program that would update the most recent national assessment of the status of water resources in the United States (U.S. Water Resources Council, 1968, 1978) as well as develop the science to improve forecasts of water availability and quality for future needs.

By evaluating large-scale effects of changes in land use and land cover, water use, and climate on occurrence and distribution of water, water quality, and human and aquatic-ecosystem health, the NWC will also help to inform a broader initiative by the Department of the Interior, WaterSMART (Sustain and Manage America's Resources for Tomorrow), which provides multiagency funding to pursue a sustainable water supply for the Nation as directed under the SECURE Water Act. Through the NWC, the USGS actively engages Federal, regional, and local stakeholders to identify research priorities and leverages current studies and program activities to provide information that is relevant at both the national and regional scales.

The NWC will produce a current, comprehensive scientific assessment of the factors that influence water availability by (1) developing nationally consistent datasets that reflect the status and trends of major water budget components (diagram below), as well as water use, for the Nation; (2) improving the current understanding of flow requirements for ecological purposes; and (3) evaluating water-resource conditions in selected river basins, or Geographic Focus Areas, where competition for water is elevated. Future research goals of the NWC include (1) evaluating the relations between water supply and quality for both human and ecological uses, including the potential use of impaired water supplies; (2) development of Geographic Focus Area studies in additional basins; and (3) the continued improvement of uncertainty analysis.

Much of the information developed as part of the NWC is derived from models, statistical estimation techniques, and other transformation processes. The National Water Census Data Portal has been developed to allow users to access a comprehensive and nationally consistent interactive map interface to download data visualizations, retrieve stand-alone data for further analysis, or integrate multiple datasets with built-in and downloadable data-analysis tools.

Components of a simple water budget for part of a watershed (modified from Healy and others, 2007).

U.S. Department of the Interior
U.S. Geological Survey

Fact Sheet 2015–3045
June 2015

Summary

Account	Description	Key data sources	Key limitations
Physical supply & use	Water use & its change over time	USGS National Water Use Information Program	5-year time periods /w 4 years to release; low thematic resolution
Water quality	Key water quality parameters	USGS NAWQA for surface & groundwater	Uneven spatial coverage (national SPARROW model showing annual change would be the ideal)
Water productivity	GDP/unit water use	Bureau of Economic Analysis GDP estimates; USGS water use data	Be sure to tie any improvements in water use thematic resolution to NAICS codes
Water emissions	N, P, organic enrichment, solids, metals emissions to waters	USEPA Discharge Monitoring Reports	Data limited to facilities with NPDES permit; incomplete data & errors more likely prior to 2017; reports using SIC codes; discharges to WWTPs included in TRI but difficult to incorporate
Water quality-economic linkages	Expert elicitation linking water quality change to economic impacts	Expert elicitation led by USGS	Qualitative; provides basis for further quantitative work
Water asset account	Changes in water volume held in different types of water assets (reservoirs, lakes, streams, snow, groundwater, soil)	Not yet attempted; key components underway as part of USGS Water Census	TBD

Application of water accounts to water management elsewhere

Box VIII.5
Marginal value of water in Canada, by industry, 1991

Using a production function approach, the marginal value of raw water was estimated for 58 manufacturing industries in Canada in 1981, 1986 and 1991. Assuming that firms would minimize their costs, the researchers formulated a translog cost function based on the quantity of output; the quantity of water; the price of capital, labour, energy, materials, water recirculation and in-plant water treatment; as well as several dummy variables that took into consideration site-specific and industry-specific characteristics, such as the aridity of provinces and the share of raw water that was used for industrial processes. In the cost function approach, the shadow price of water was estimated as the marginal change in costs resulting from an incremental change in the quantity of raw water intake. The mean shadow value across industries was C$ 0.046 per cubic metre in 1991 prices. In very dry provinces, the shadow value was higher than in water-abundant provinces: C$ 0.098 and C$ 0.032, respectively.

Industry	Shadow price of water (Canadian dollars per cubic metre)	Industry	Shadow price of water (Canadian dollars per cubic metre)
Food	17	Paper and allied products	31
Beverages	38	Basic metals	107
Rubber	6	Fabricated metal	48
Plastic	32	Transport equipment	25
Primary textiles	14	Non-metallic minerals	23
Textile products	5	Refined petroleum/coal	288
Wood	20	Chemicals	72

Table IX.3
Water profile and water productivity in Australia, 2000-2001

	Water consumption (megalitres)	Percentage distribution of water consumption	Percentage of industry gross value added	Value added in Australian dollars per megalitre of water consumption
Agriculture, total	16 660 381	66.9	1.8	0.58
Livestock	5 568 474	22.4	0.3	0.27
Dairy farming	2 834 418	11.4	0.3	0.53
Vegetables	555 711	2.2	0.3	3.27
Fruit	802 632	3.2	0.3	1.98
Grapes	729 137	2.9	0.3	1.86
Sugar cane	1 310 671	5.3	0.1	0.22
Cotton	2 908 178	11.7	0.2	0.42
Rice	1 951 160	7.8	0.1	0.18
Forestry and fishing	26 924	0.1	0.3	57.42
Mining	400 622	1.6	6.3	84.81
Manufacturing	866 061	3.5	13.6	84.70
Electricity and gas supply	1 687 778	6.8	2.1	6.59
Water supply	1 793 953	7.2	0.8	2.35
Other industries	832 100	3.3	75.2	487.65
Households	2 181 447	8.8	n/a	n/a
Environment	459 393	1.8	n/a	n/a
Total	**24 908 659**	**100.0**	**100.0**	

Application of water accounts to water management elsewhere

Figure IX.1
Index of water use, population and GDP in Botswana, 1993-1998

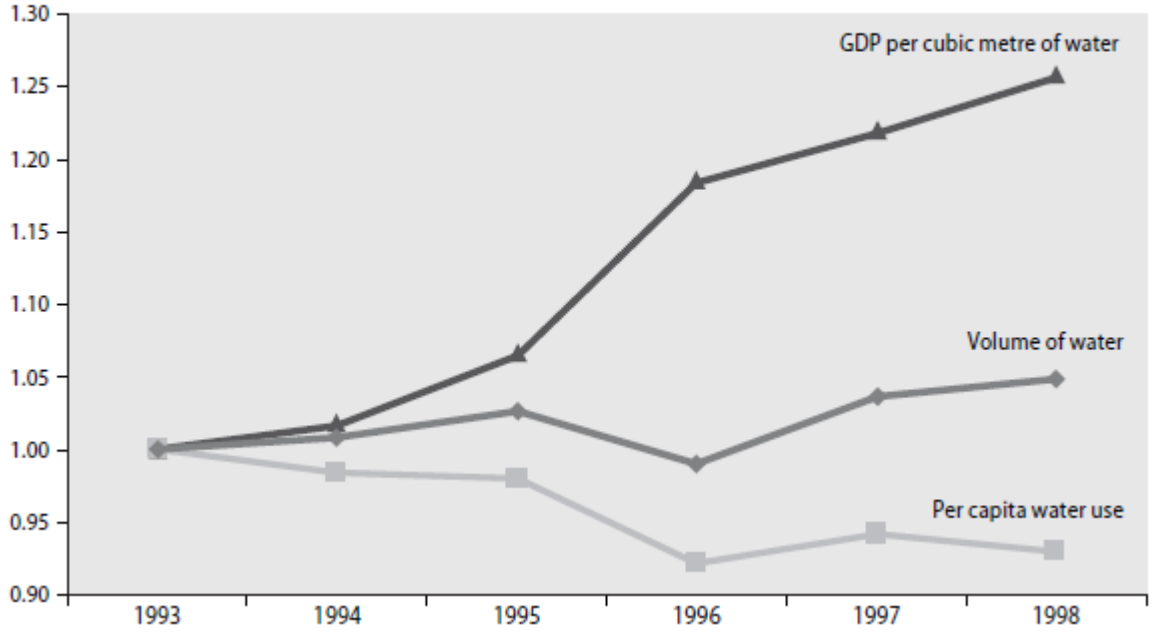
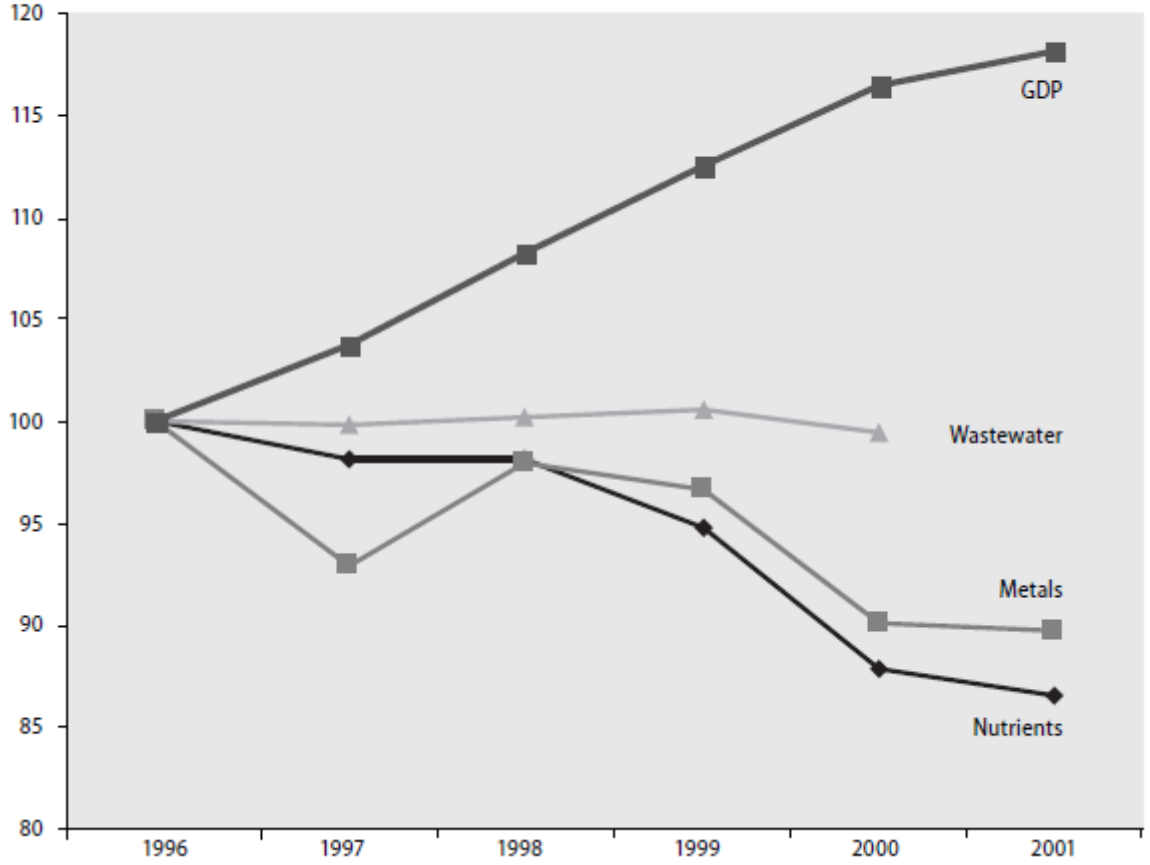


Figure IX.2
Index of growth of GDP, wastewater and emissions of nutrients and metals in the Netherlands, 1996-2001



Box VIII.3
Calculating residual value: an example from Namibia

The residual value technique was applied to agricultural production in the Stampriet region of I where farmers abstract groundwater to raise cattle and irrigate crops, including lucerne, for their li A survey was undertaken in 1999 and data for farm income and costs were obtained for 16 of the 66 in the region. The data on some items are considered reasonably accurate, notably, farm income, i most goods and services, and the compensation of employees. Fixed capital costs, one of the larg components, were difficult to estimate because farmers often did not keep good records. Farmer not always meter their water use; thus, the estimates of water use must be treated with caution. F survey, average farm income and costs were calculated u following formula:

> Gross farm income - inputs of goods and services - compensation of employees - farmer imputed income - capital costs (depreciation, working capital, cost of fixed capital)

Despite the weakness of the data, the results are useful in illustrating the sensitivity of the residual to the assumptions made. The table below shows the costs of production and residual value under different assumptions about the cost of capital. Assuming a 5 per cent cost for capital inve the residual value of water was 19 Namibian cents per cubic metre. However, if the real cost of cap to 7 per cent, farmers would not earn enough to cover even the capital costs and the value of t would be negative.

Farm revenue and costs (in 1999 Namibian dollars)		Data source
Gross farm income	$601 543	Output multiplied by market prices obtained survey
Inputs of goods and services	$242 620	Inputs multiplied by prices obtained from su
Value added, *of which:*	$358 923	
Compensation of employees	$71 964	Wages paid + in kind payments obtained fron
Gross operating surplus, *of which:*	$286 959	
Imputed value of farmers' labour	$48 000	Imputed value based on average salary of hir manager
Depreciation	$66 845	Standard depreciation rates multiplied by far estimated historical cost of capital in survey
Cost of working capital	$17 059	Imputed as percentage of the value of fixed c
Cost of fixed capital including land, 3-7 per cent	$75 739 to $176 724	Based on farmers' estimated historical cost of reported in survey
Residual value of water	$79 316 to -$21 669	
Amount of water used (cubic metres)	154 869	Farmers' "best guess" (water is not metered)
Residual value (Namibian dollars/ cubic metre)	$0.51 to -$0.14	

Box VIII.4
Adjusting the residual value of water for market distortions

The case studies for the United Kingdom and Jordan show the importance of adjusting for market distortions occurring as a result of trade protection. In both cases, the residual value of water is calculated with and without the effective subsidies from trade protection. Substantial differences occur as a result.

Case 1. United Kingdom. Bate and Dubourg estimated the residual value of water used for irrigating five crops in East Anglia from 1987 to 1991, using data from farm budget surveys. However, because data about actual water use were not available, the residual value was calculated for the amount of water needed to cultivate a hectare of a given crop. When the effective subsidies from the European Union's Common Agricultural Programme are taken into account, the residual value is negative for all crops except potatoes.

	British pounds sterling per hectare[a]	
	Not adjusted for Common Agricultural Programme subsidies	Adjusted for Common Agricultural Programme subsidies
Winter wheat	101.12	-176.48
Barley	13.45	-164.70
Oilseed (rape)	220.04	-146.48
Potatoes	1 428.84	880.04
Sugar beet	327.93	-3 565.10

Source: Adapted from Roger N. Bate and W. Richard Dubourg, "A net-back analysis of irrigated water demand in East Anglia", *Journal of Environmental Management* (1997), vol. 49, No. 3, pp. 311-322.

a The actual amount of water used per hectare of a crop is unknown.

Case 2. Jordan. Schiffler calculated residual value for fruit crops (apples, peaches, olives, grapes) and vegetable crops (tomatoes, watermelon, cucumbers, squash and wheat) in 1994 based on data from farm surveys. Values were calculated with and without trade protection. The difference was small (7 per cent) for fruit crops, but nearly 50 per cent for vegetables.

	Jordanian dinars per cubic metre of water input	
	Not adjusted for trade protection	Adjusted for trade protection
Fruit crops	0.714	0.663
Vegetable crops	0.468	0.244

Source: Adapted from Manuel Schiffler, *The Economics of Groundwater Management in Arid Countries* (London and Portland, Oregon, Frank Cass Publishers, 1998).

Possible water management/analysis applications

- Meeting future water demand
- Social & economic gains from water policy changes – e.g., water pricing & allocation
- Trade & environment: water use & pollution
- Transnational water resource management
- Linkages to other environmental accounts (fisheries, forestry, land/soils, ecosystems)
- Value of water to the public & the economy
- Context for value of USGS information studies

Open questions

- What value/use cases do you see for developing water accounts in the U.S.?
- Are we missing any potentially important data sources/databases?
- How can we better collect and manage data to provide more timely, complete, & accurate water accounts information?

Thanks!

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