Energy and Water Sector Policies for Drought Mitigation

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Previous SNL Analyses

- **Congressional Report (2007)**
  - **Overview of water & energy interdependencies**
  - **Identified trends in future fresh water demands and consumption for energy**
  - **Identified trends in fresh water use and availability and potential impacts on the energy infrastructure**
  - **Needs and opportunities to improve water use efficiency in energy production**
- **Energy-Water Roadmap**
  - **Regional workshops held to identify issues associated with energy and water needs and development**
  - **Recommendations for S&T R&D efforts**
    - **Improve water use efficiency in EP generation and transportation fuels**
    - **Increase use of non-traditional water supplies**
    - **Improve integrated planning and monitoring of energy and water resources**
- **Strategies recommended will affect *many* energy sectors over *long-term horizon***

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Scope of Analysis

- **Drought Analysis**
  - **Where are the conflicts between energy and water demands likely to occur first?**
  - **Peak energy demand typically occurs in the warmest months, when water supplies are low**
  - **Integrated geo-spatial plant and drought dataset**

- **Policy Options**
  - **Short-term horizon (1-3 years) implementation**
  - **Water policy review**
  - **Energy sector water use review**
  - **Water and energy sector options to reduce demand tensions**

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Water Uses in the Energy Sector

- Electric power generation (coolant and prime mover)
- Energy extraction and fuel production
  - Growing of biofuel feedstocks
  - Coolant and lubrication in drilling and mining
- Refining and processing (oil, gas, etc)
- Transportation and storage
  - Coal via barge
  - Hydrostatic pipeline testing

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Water and Thermoelectric Power Plants: Background

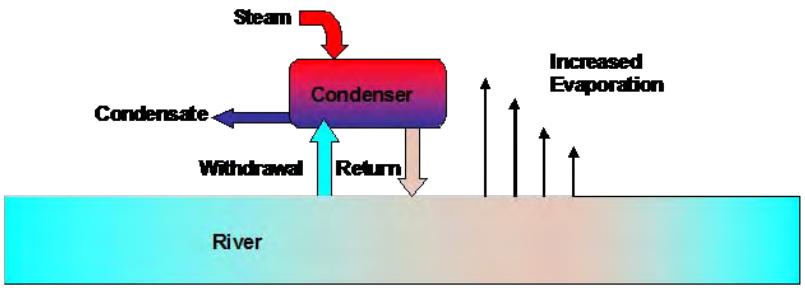
Type of plant affects water requirements and water use efficiency

- **Nuclear and coal-fired plants**
  - **Generally provide baseload electricity and thus run constantly**
  - **Typically have higher EP generating capacities**
  - **These characteristics result in generally higher water needs**
  - **Nuclear plants are least efficient (MWh produced/gal water) used**
- **Natural gas-fired plants**
  - **Typically provide intermediate load, run intermittently**
  - **Relatively smaller capacities**
  - **Combined cycle (CC) plants increase efficiency by a factor of 3 and generally use water most efficiently**
  - **Typically have lower water requirements**

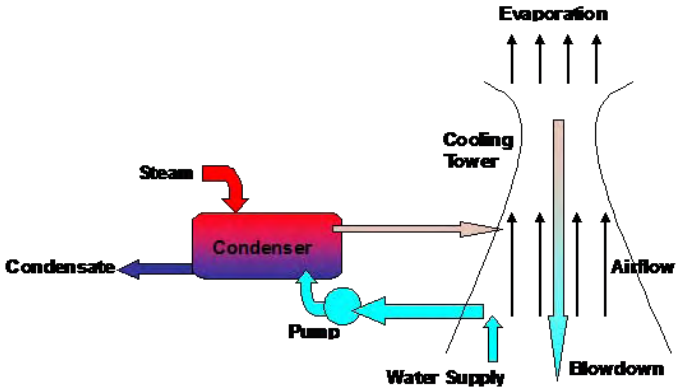
Water is the Primary Coolant for Thermoelectric Power Plants

Type of cooling system affects water requirements and water use efficiency

- Open-loop systems
  - ***Withdraw*** 50-100 times more water than cooling ponds or wet cooling tower systems
  - Generally ***consume*** less water than these closed-loop systems
  - Potential environmental concerns
- Dry cooling towers
  - Neither withdraw nor consume water
  - Can reduce plant efficiency (in terms of fuel consumed) by 25% in hot climates
  - Expensive cooling option



Open-loop cooling



Closed-loop cooling

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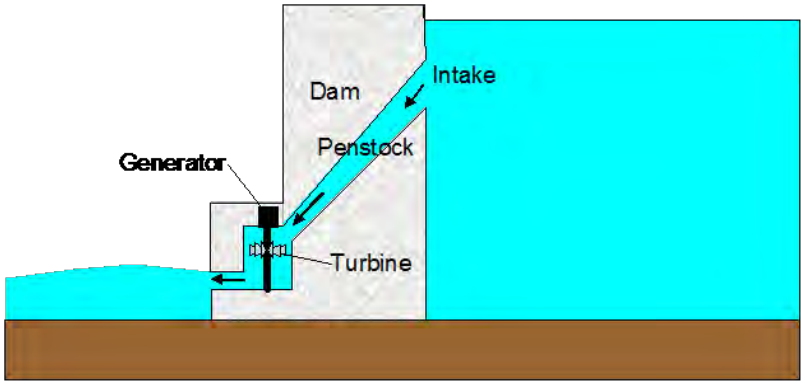
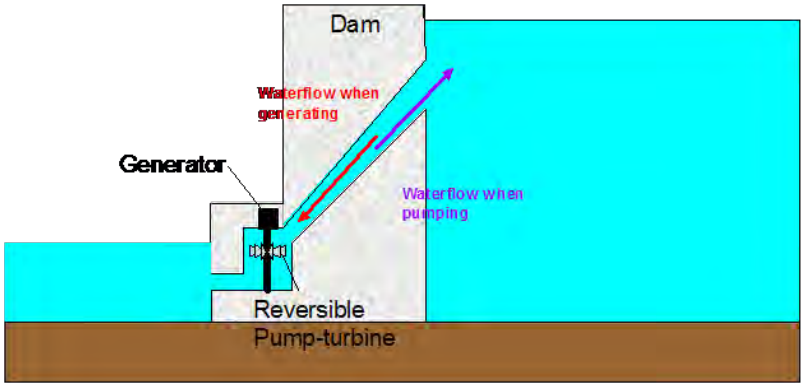
Water is Source of Energy for Hydroelectric Power Plants

- "Once through" use of water by impoundment and run-of-river facilities make them more sensitive to drought conditions
  - Requirements to release additional quantities of water to municipalities in times of drought can further exacerbate water levels at impoundment facilities
- Pumped storage facilities have capability to "reuse" water
  - Facility uses some of its own electricity to pump water to upper reservoir
  - This capability makes them more resistant to drought effects
  - Facilities can be expensive and difficult to site



Impoundment facility



Pumped storage facility

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Drought Assessment

- **Palmer Hydrological Drought Index (PHDI)**
  - **balance of moisture demand and supply for climate division**
  - **not including man-made changes – for example, increased irrigation, new reservoirs**

Drought Category	Possible Impacts
Moderate	Streams, reservoirs, or wells low, some water shortages developing or imminent.
Severe	Water shortages common; water restrictions imposed
Extreme	Widespread water shortages or restrictions

Focus on severe or extreme – restrictions necessary, impacts likely

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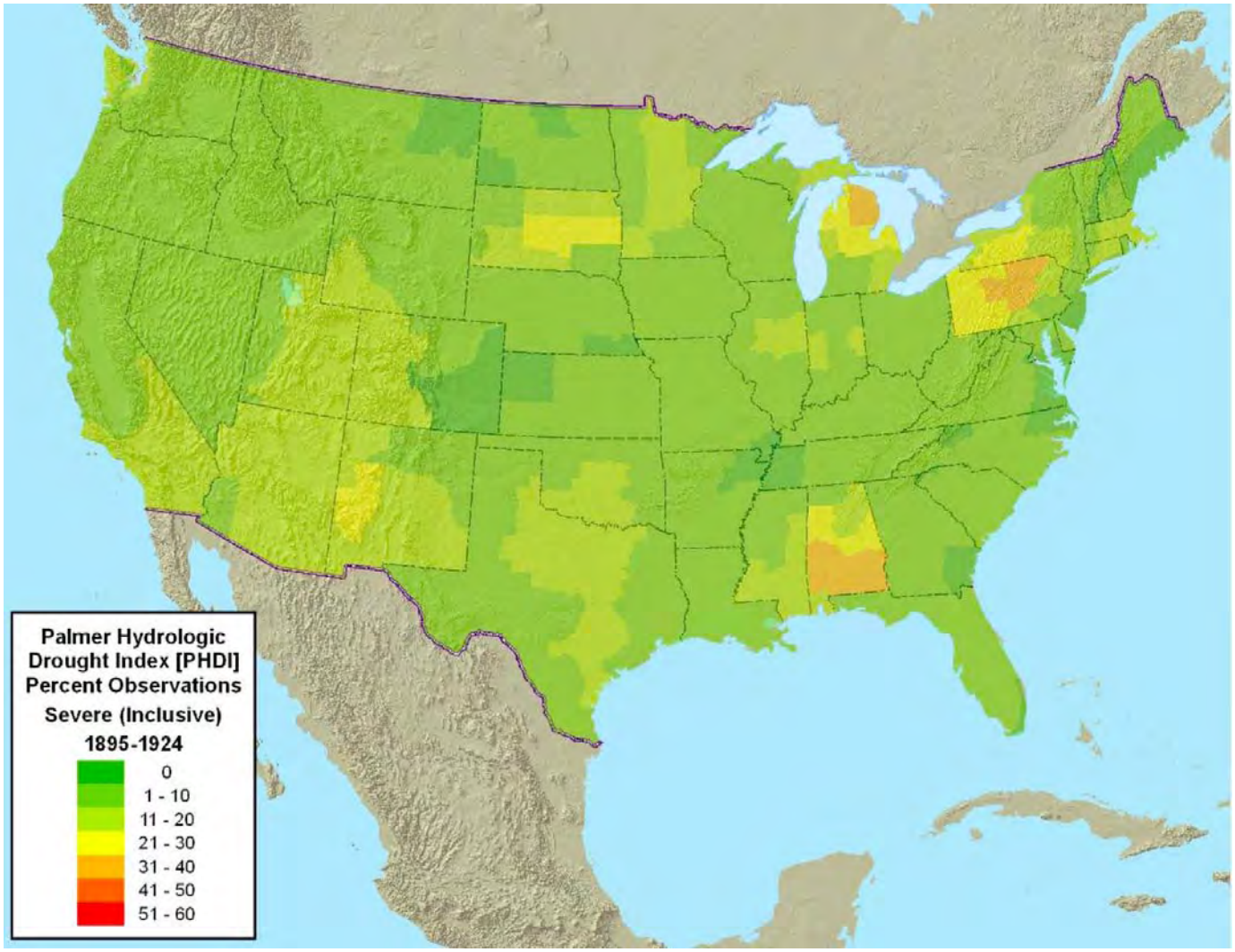
Severe or Worse Drought 1895-1924



Source Data: National Climatic Data Center

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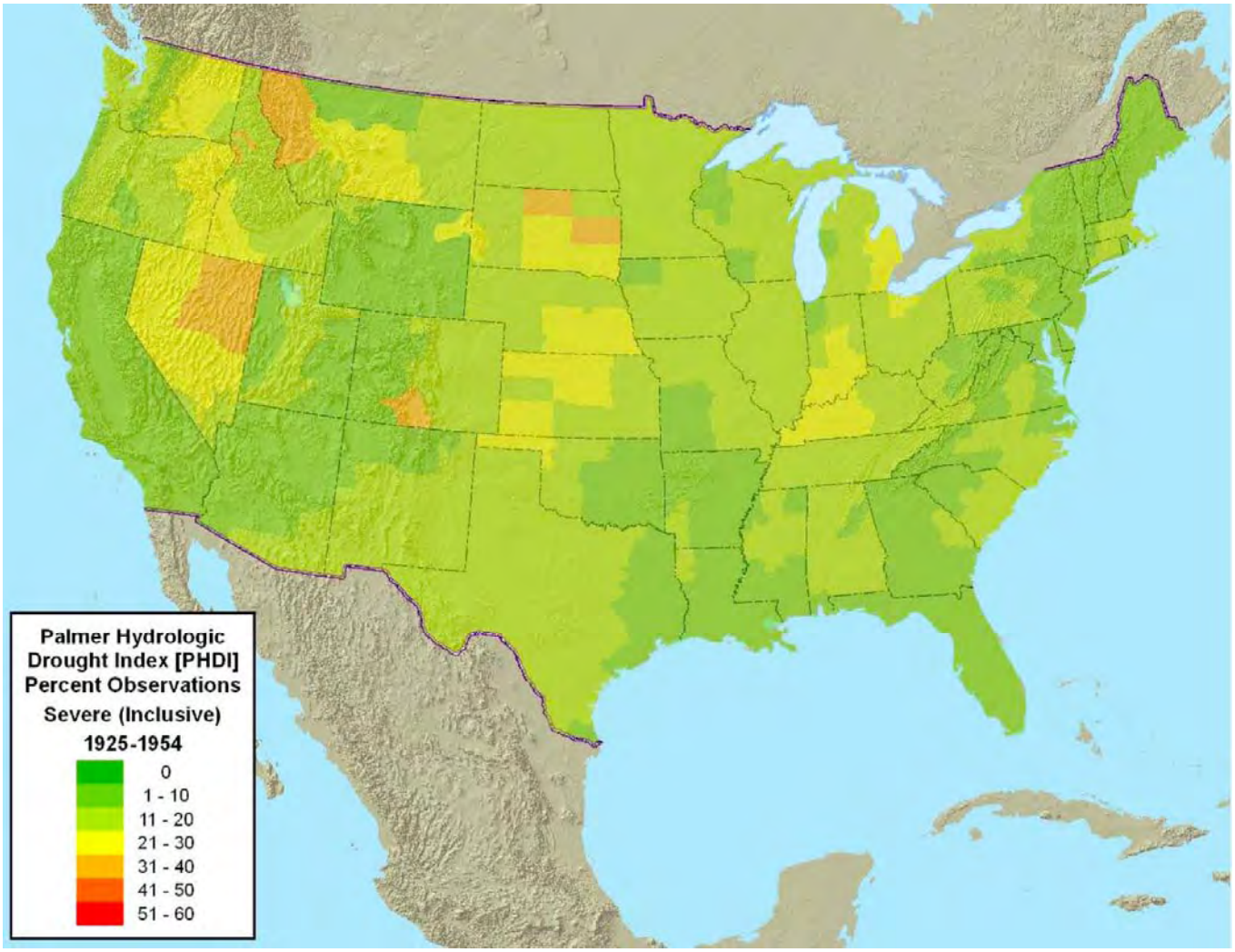
Severe or Worse Drought 1925-1954



Source Data: National Climatic Data Center

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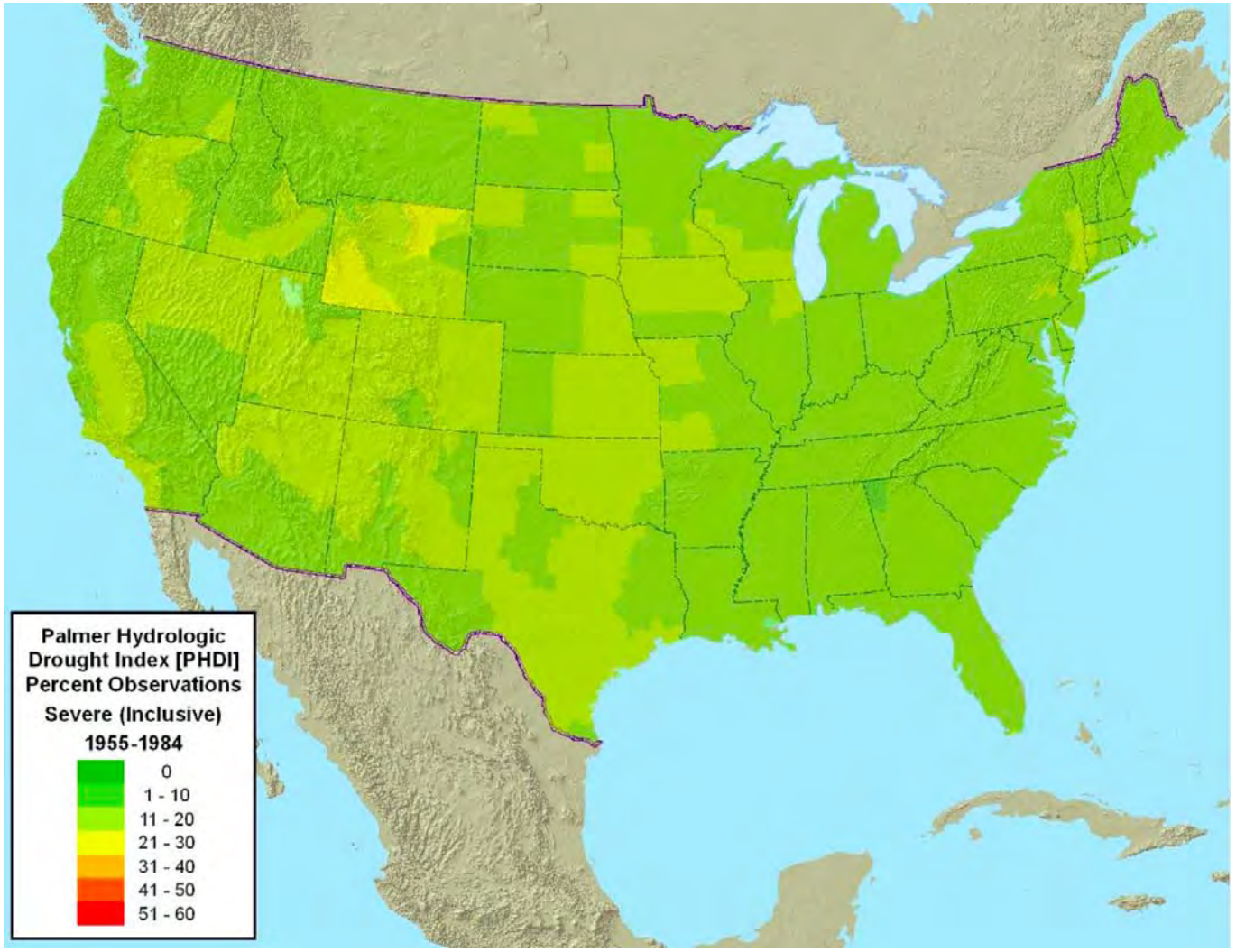
Severe or Worse Drought 1955-1984



Source Data: National Climatic Data Center

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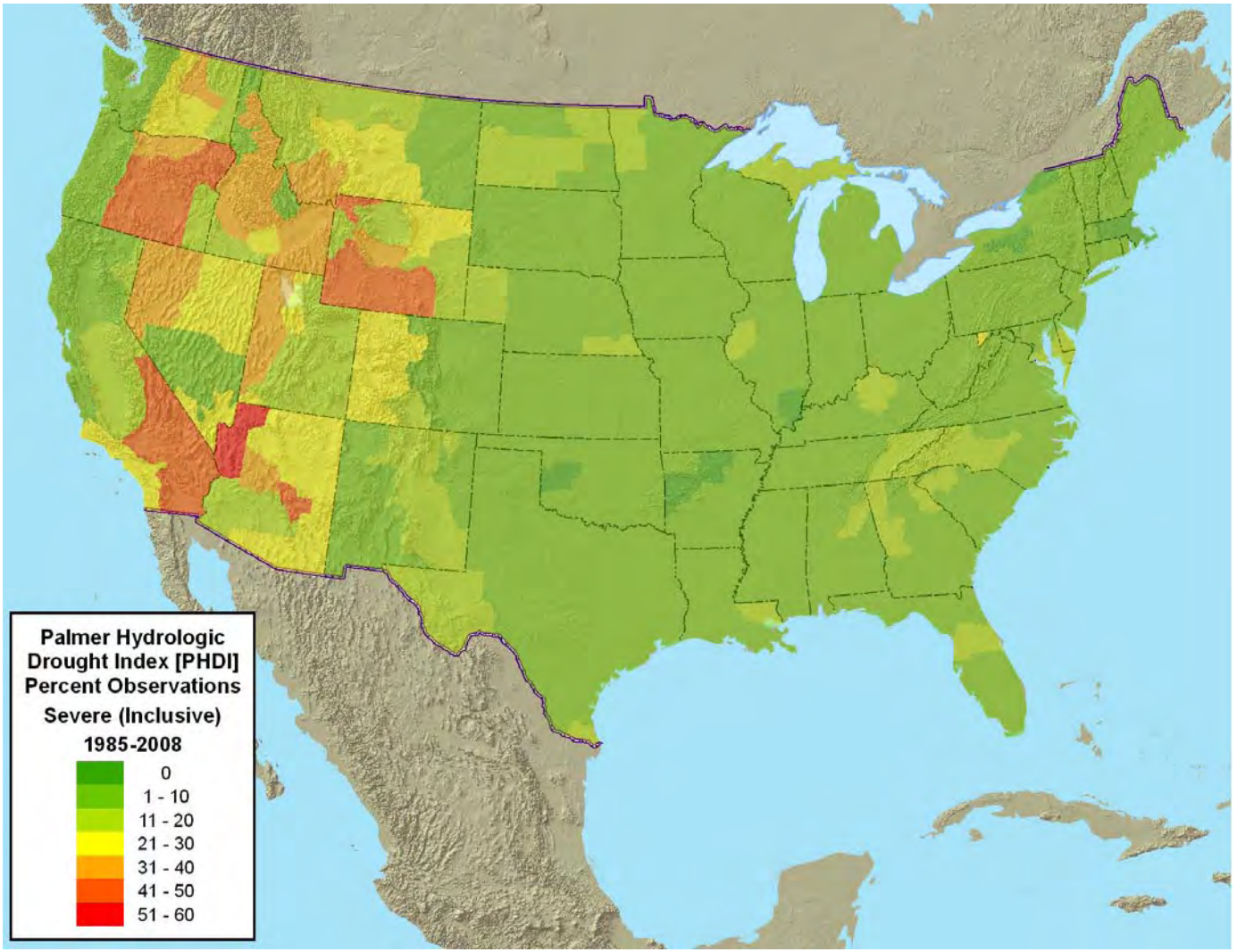
Severe or Worse Drought 1985-2008



Source Data: National Climatic Data Center

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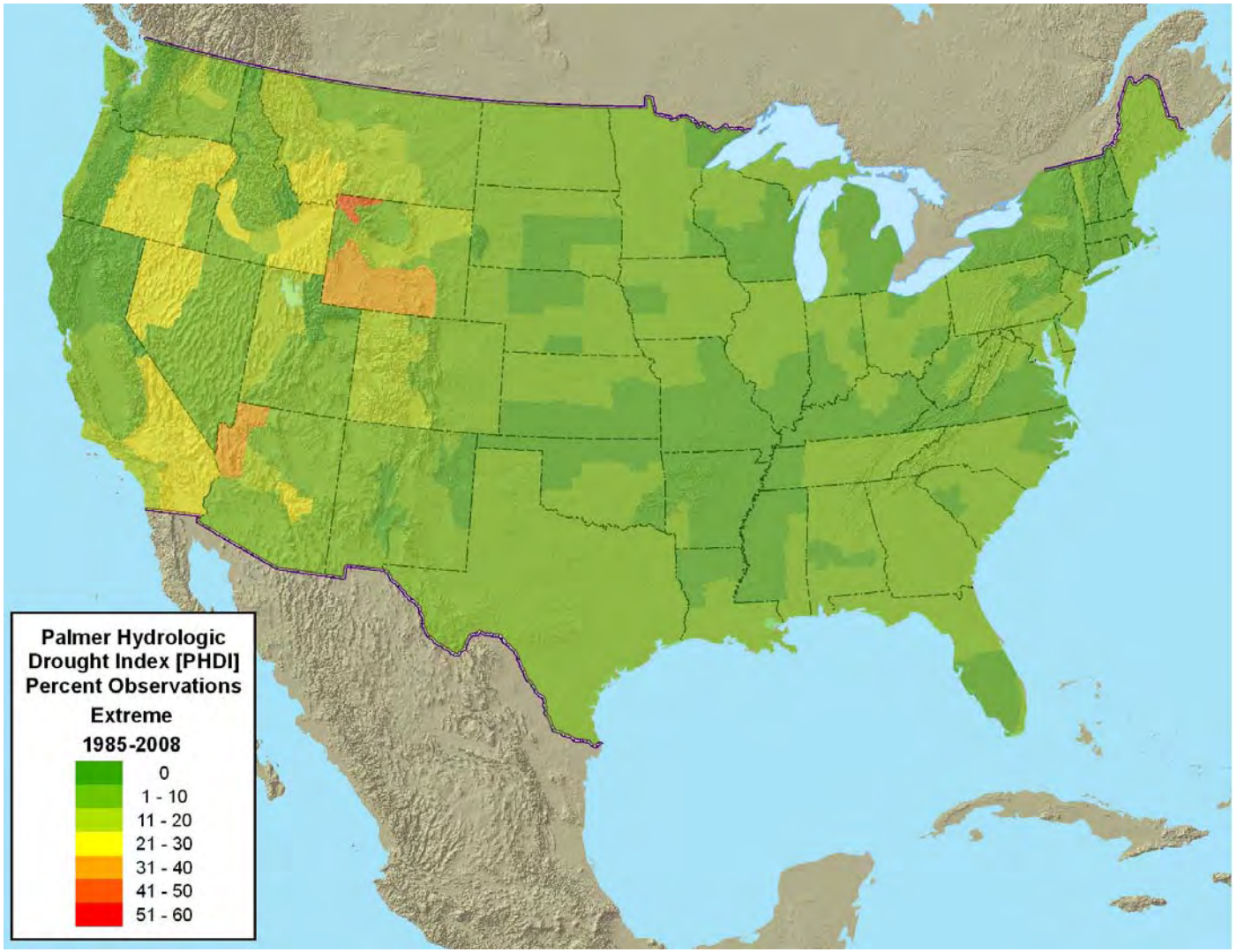
Extreme Drought, 1985-2008



Source Data: National Climatic Data Center

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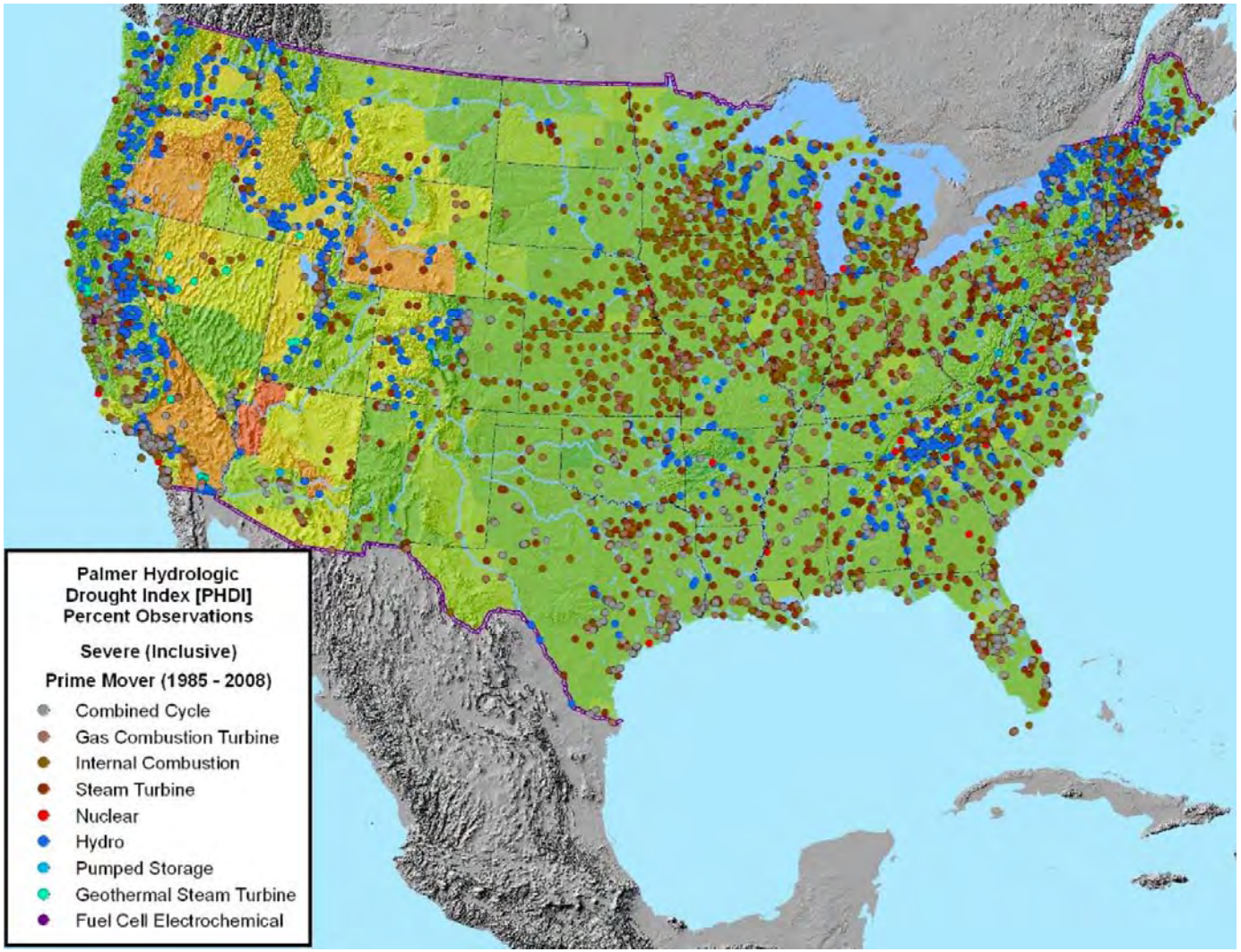
Power Plants by Prime Mover



Source Data: National Climatic Data Center and Platts (2008)

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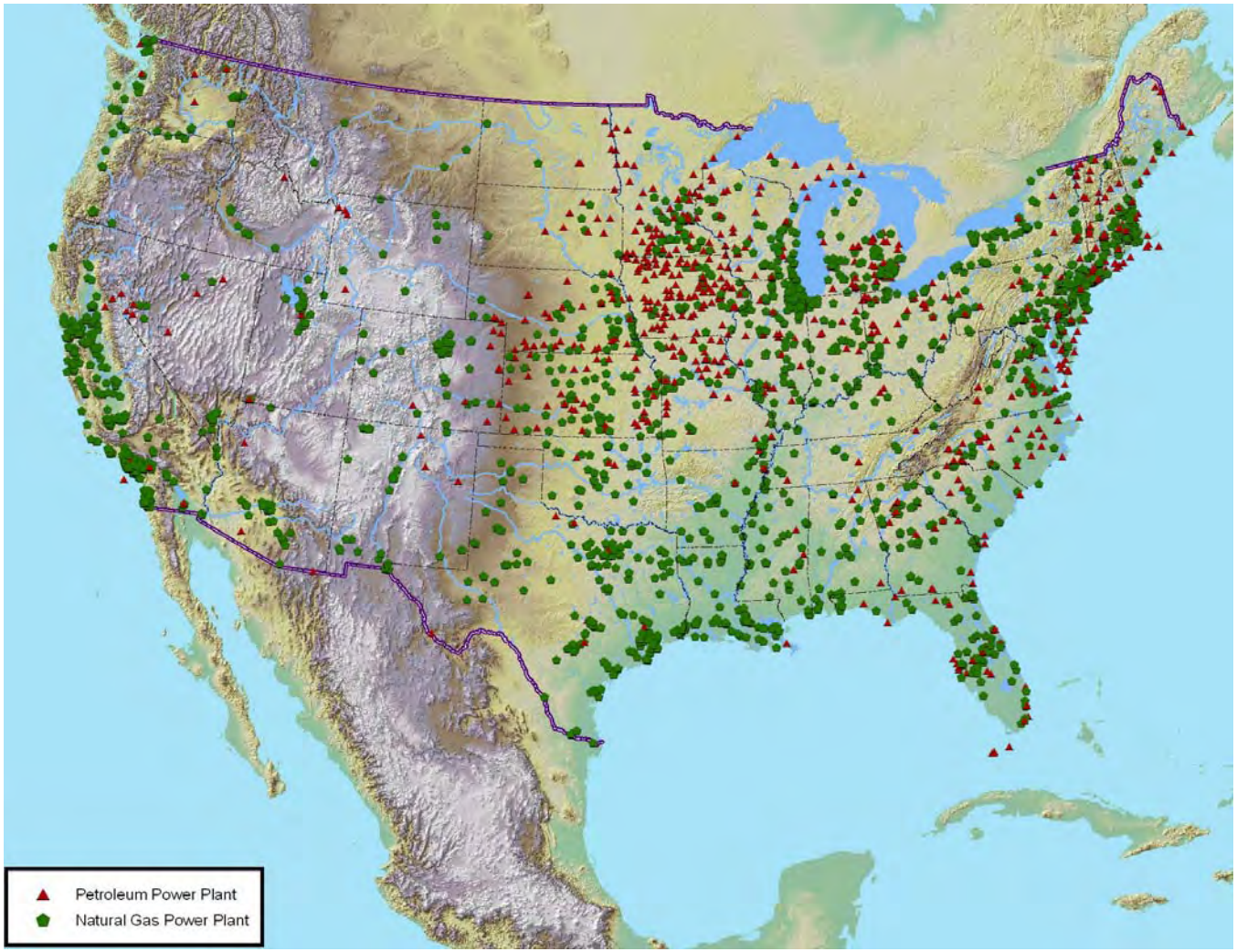
Petroleum and Natural Gas Fired Plants



Source Data: Platts (2008)

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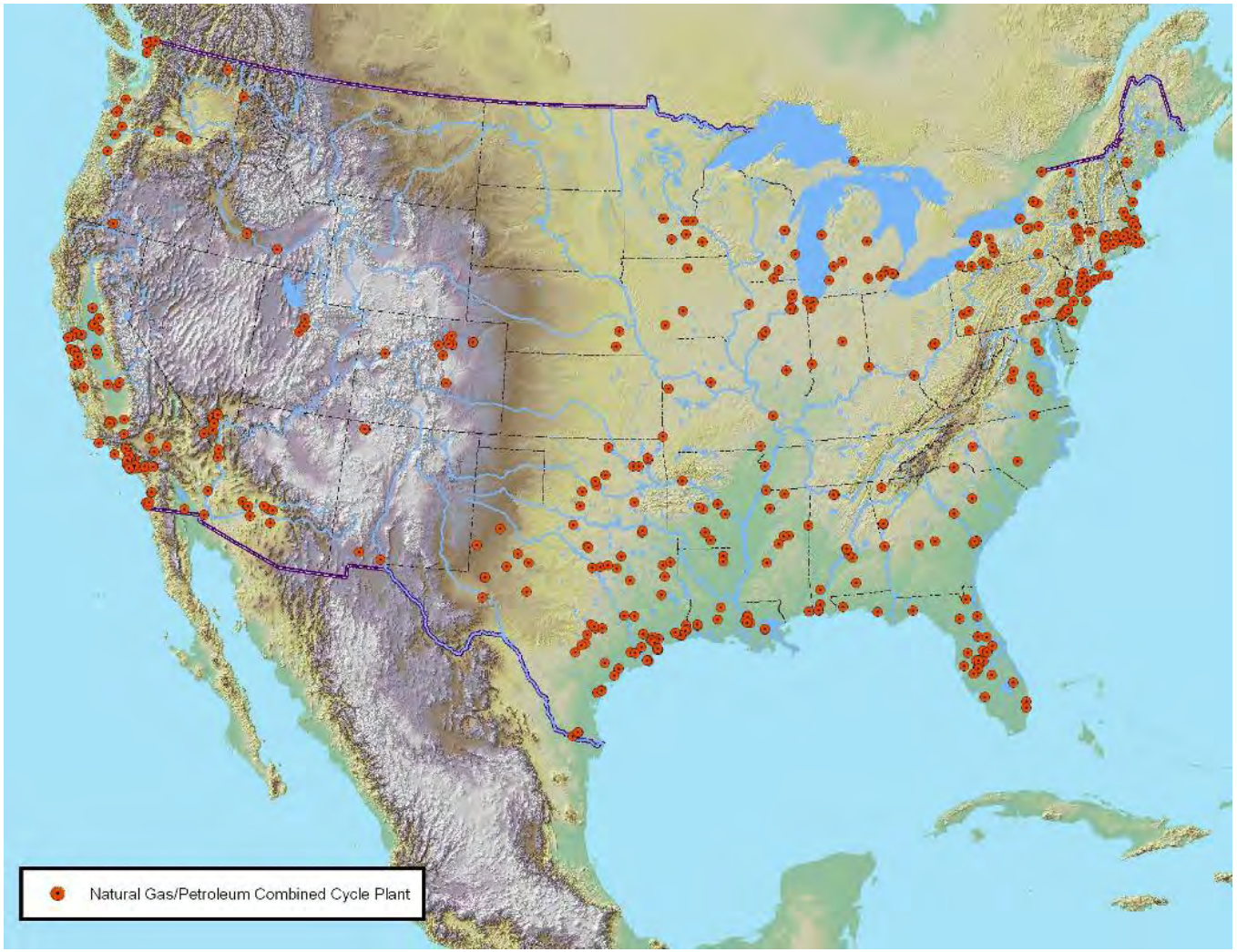
Combined Cycle Plants



Source Data: Platts (2008)

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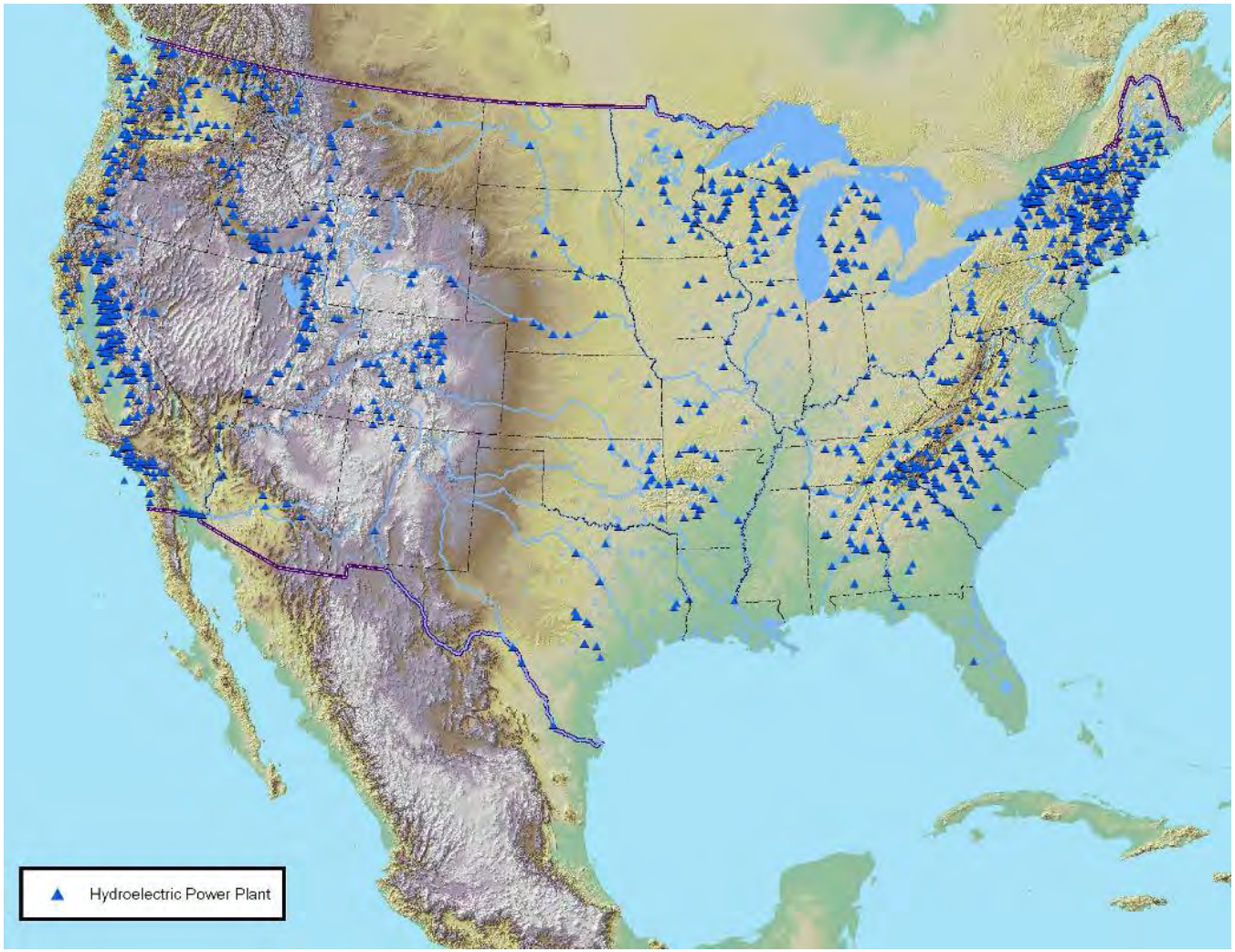
Hydroelectric Plants



Source Data: Platts (2008)

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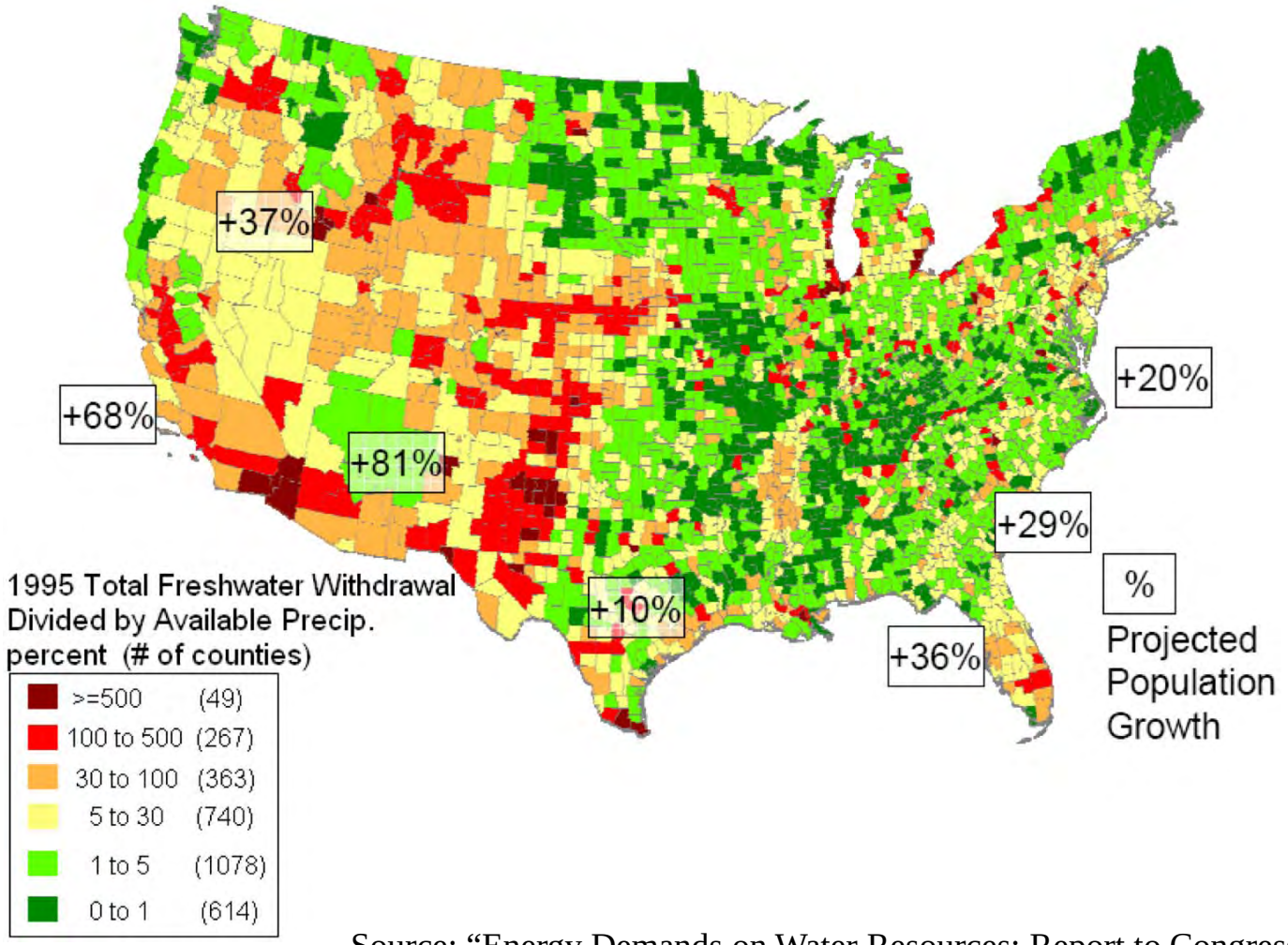
Population Growth and Water Usage



Source: "Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water", DOE 2007

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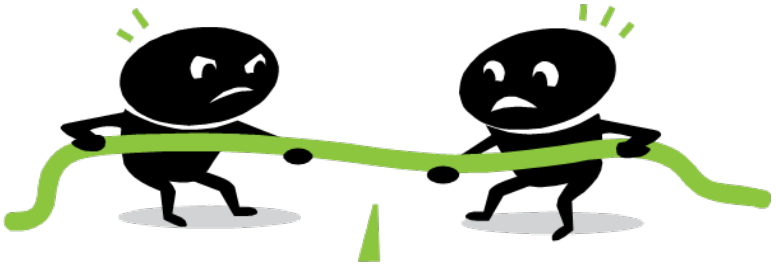
Goal

- **Minimize the conflict between power generation and water usage**
- **Peak power demand, and peak water demand occur at times of lower water availability (ie, typically summer months)**



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Policy Considerations

- **Difficulties are at the confluence of times of peak water demand and peak power demand**
  - **Reduce energy consumption**
  - **Reduce water consumption**
- **Policies that are implementable in the short term (1-3 year time horizon)**
- **Not tied to any specific region of the country**

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Policy Actions that Reduce Energy Consumption

- May be conflict of interest for utilities
- Extend and/or reauthorize federal tax credits for installation of alternative energy technologies
  - Solar and wind power are rapidly becoming more competitive with traditional electric power generation
- Create and promote incentives for electricity conservation
  - Expand and extend programs for window replacement, insulation, and installation of shades and shutters
  - Promote conversion of incandescent to fluorescent light bulbs

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Policy Actions that Reduce Energy Consumption

- Encourage lower thermostat settings in winter and higher settings in summer
  - Shaving the peak demand reduces the marginal capacity requirement for a seasonal peaking system
  - One degree nationwide is the equivalent of 200 power plants 1,000 MW capacity (75% duty cycle)
- Promote and incentivize demand side management
  - Equipment and programs including interruptible load control devices for non-industrial HVAC systems and time-of-use pricing

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Policy Actions that Reduce Water Consumption

- As much as 70% of water used in agriculture never makes it to crops (The Economist, 2008)
  - Abundant and inexpensive water supplies promote inefficiency
- Improve agricultural efficiency through changes in agricultural techniques and new technology
  - Crop mix can be changed, amount of water applied to crops can be adjusted, improved irrigation management
  - Switch from complete reliance on ground and surface water to site produced recycled water

Policy Actions that Reduce Water Consumption

- **Option contracts from agricultural users for use during drought**
  - **Formal contract between agricultural users and an industrial/urban water users to transfer water temporarily from agriculture to industrial/urban use at specified water supply levels**
- **Interruptible water markets would allow irrigation use to give up some water to maintain hydroelectric power supplies**
  - **Contractual commitments would range from 20-25 years**

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Policy Actions that Reduce Water Consumption

- **Non-price restrictions on water use**
  - **Water restrictions on selected uses, education campaigns to encourage voluntary conservation, and subsidies for adoption of water efficient technologies**
- **Price restrictions on water use**
  - **Price policy that would move households from fixed per unit uniform rates to a moderately increasing block price schedule**
  - **Allot each household a specific water allocation with penalties for noncompliance**

Summary

- Population growth occurring in regions where water is scarce
- Water and energy demands continue to increase
- Conservation policies provide near-term benefit for water and energy demands
  - Lessens the impact of droughts
  - Allows for technological adaptation
  - Policies fall out of favor in ‘surplus’ years
- Decoupling of utility power sales from earnings will help
  - States moving to incentivize conservation and renewables

Backup slides

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Thermoelectric Power Plants: Water Withdrawals (gal/MWh)

Cooling Process / Plant Type	Open Loop	Cooling Pond/Wet Cooling Tower	Dry Cooling Tower
Nuclear	25-60k	500-1000	0
Fossil Fuel	20-50k	300-600	0
Combined Cycle	7.5-20k	200	0

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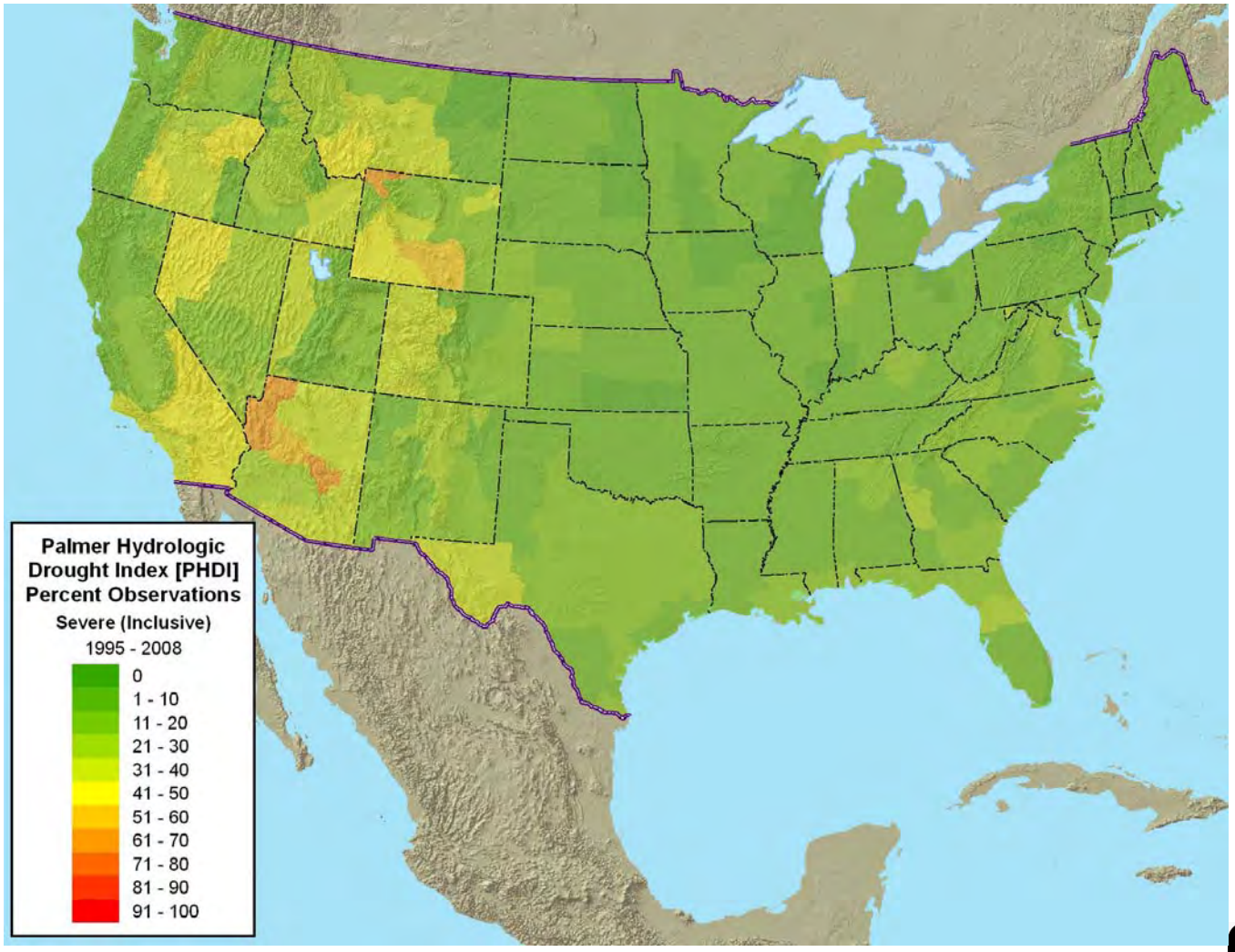
Thermoelectric Power Plants: Water Consumption (gal/MWh)

Cooling Process / Plant Type	Open Loop	Cooling Pond/Wet Cooling Tower	Dry Cooling Tower
Nuclear	~400	400-700	0
Fossil Fuel	~300	300-500	0
Combined Cycle	~100	~200	0

Severe or Worse Drought 1995-2008



Source Data: National Climatic Data Center

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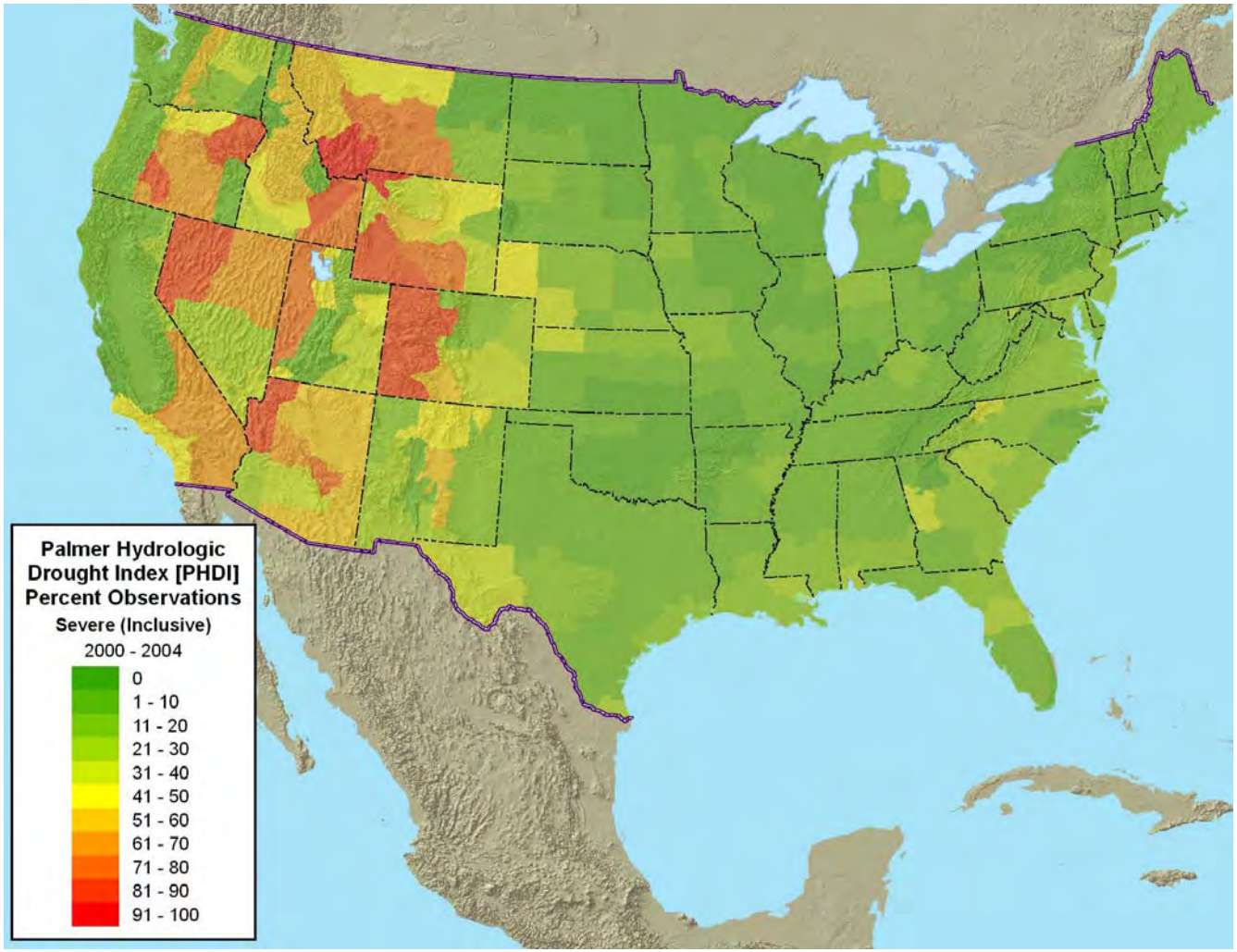
Severe or Worse Drought 2000-2004



Source Data: National Climatic Data Center

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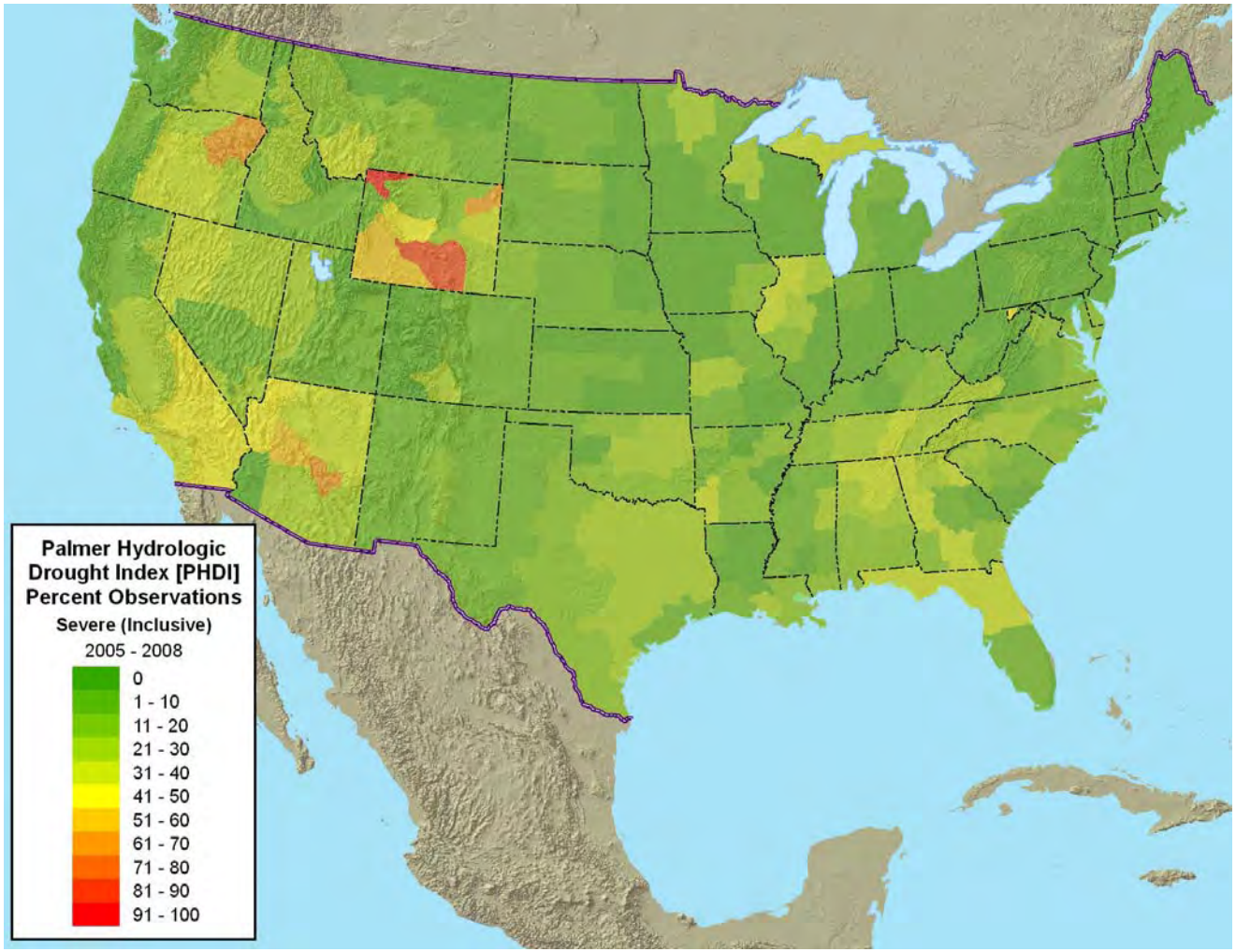
Severe or Worse Drought 2005-2008



Source Data: National Climatic Data Center

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Southeast Climate Regions with 20% Severe or Worse Observations, 1985-2008

NAME	STATE	1995-2008	1995-1999	2000-2004	2005-2008
APPALACHIAN MOUNTAIN	AL	11	0	5	35
NORTHERN VALLEY	AL	11	0	7	35
EASTERN VALLEY	AL	11	0	5	35
UPPER PLAINS	AL	9	0	5	28
PIEDMONT PLATEAU	AL	10	0	7	30
GULF	AL	13	0	22	18
NORTH	FL	15	5	12	35
NORTHWEST	FL	11	2	5	33
NORTH CENTRAL	FL	28	27	25	35
NORTHEAST	GA	16	0	20	35
NORTH CENTRAL	GA	6	0	0	23
NORTHWEST	GA	11	0	5	35
EAST CENTRAL	GA	9	3	20	0
WEST CENTRAL	GA	30	18	35	40
SOUTH CENTRAL	GA	11	0	5	35
EAST CENTRAL	MS	9	0	8	23
COASTAL	MS	13	0	20	20
EASTERN	TN	7	0	0	28
CUMBERLAND PLATEAU	TN	8	0	0	33
MIDDLE	TN	8	0	5	23

Source Data: National Climatic Data Center

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