WEATHER MODIFICATION PROGRAMS IN THE WESTERN UNITED STATES

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Medora, ND
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A division of the NDSWC

Outline

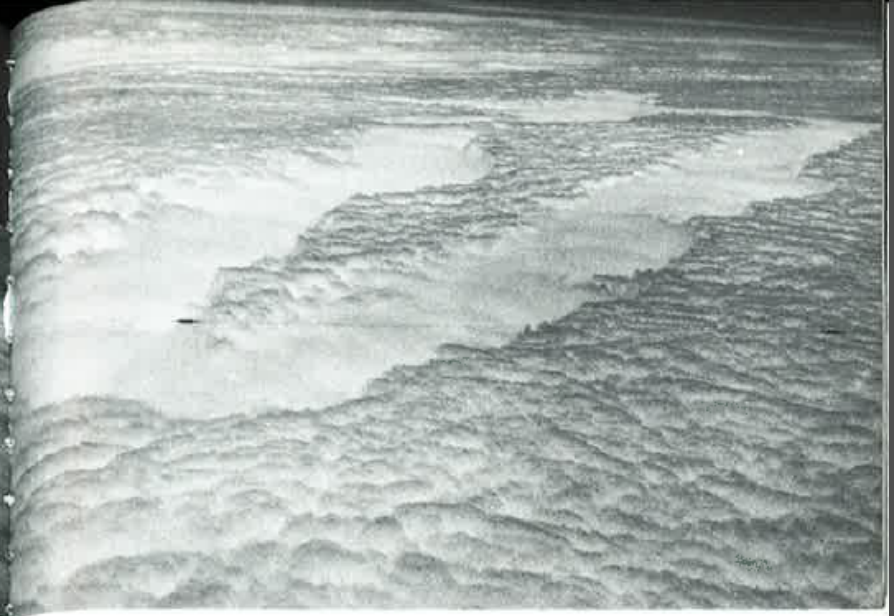
- Brief history of weather mod
- Why seed clouds?
- Project evaluations/benefits
- State specific projects and sponsors
- ASCE standard practice documents
- Conclusions

Early History of Weather Mod

- Seminal discoveries at GE Research Lab in Schenectady, NY under direction of Nobel Laureate Dr. Irving Langmuir, 1946
  - Dr. Vincent Schaefer discovered dry ice as an ice nucleating agent
  - Dr. Bernard Vonnegut discovered silver iodide as an effective ice nucleant
- Began Project Cirrus in 1947
  - Collaboration of GE, US Army Signal Corps, Office of Naval Research and US Air Force

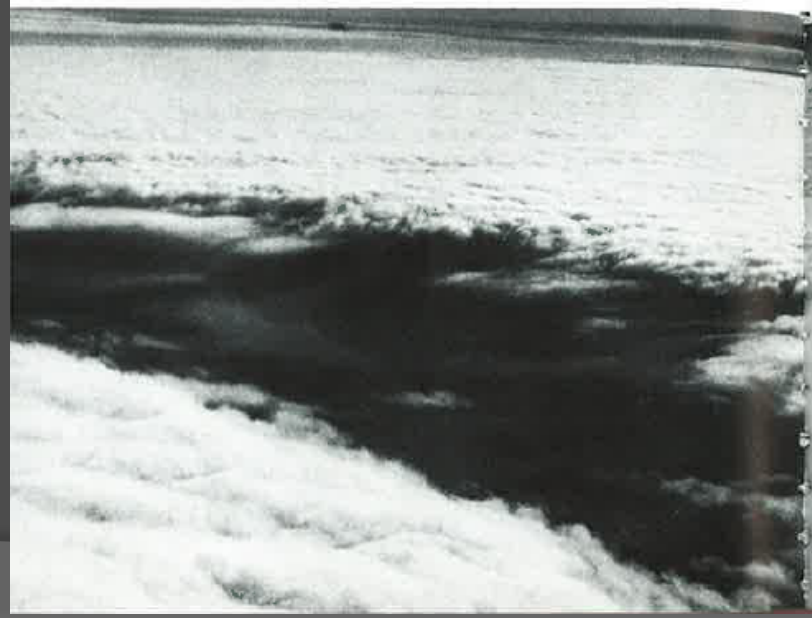
Pl.259 Two lines cut through a deck of supercooled clouds, using dry ice fragments dispensed at rate of about 1 kg/km. Thin veils of ice crystals remain in seeded area but most have fallen.

Pl.260 An extensive hole cut through cloud deck shown above. This opening developed in about 40 minutes and remained open for several hours. New clouds are starting to form in cleared area.



Pl.261 A solid deck of supercooled clouds seeded with burning pellets of charcoal containing silver iodide. The nuclei in the smoke converted mile-wide strips of cloud to ice crystals.

Pl.262 The same area as shown on Plate 261, from the other end of the seeded field about 10 minutes later as the ice crystals settled out of the cloud to produce lines of virga below cloud base.



Why seed clouds?

- Weather modification (a.k.a. cloud seeding) is practiced for three general purposes
  - Rain/Snow enhancement
  - Hail Suppression
  - Fog Dispersal
- Sponsors include counties, cities, states, irrigation districts, ski resorts, and public utilities to name a few

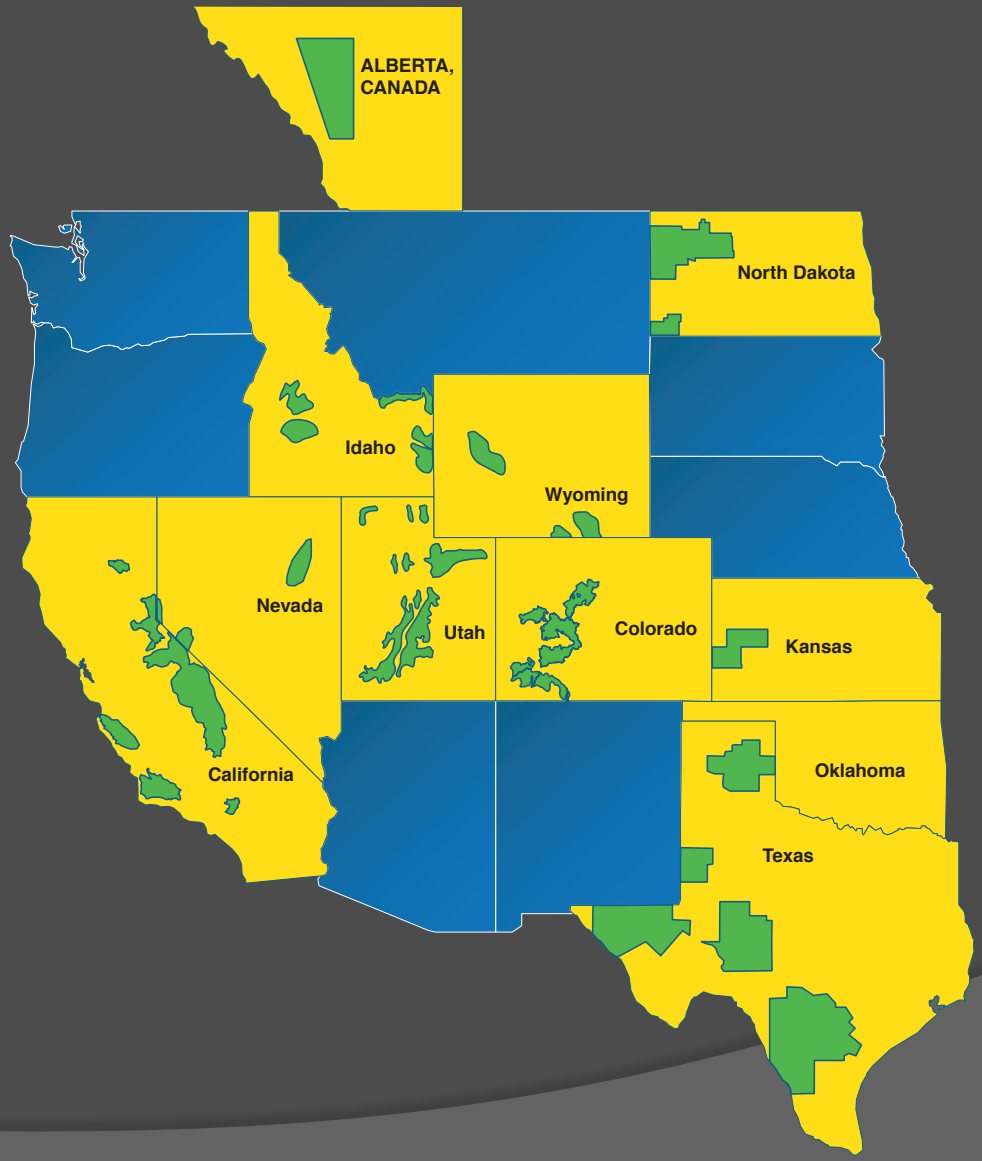
Evaluations/Benefits

- Winter snow enhancement
  - 5-15% increases in effectively targeted programs
  - Produced water costs ~$2-$10 per acre/ft.
- Summer rain enhancement
  - Up to ~10% target/downwind increases
  - 50% increase in rain volume from individual seeded clouds (TX)

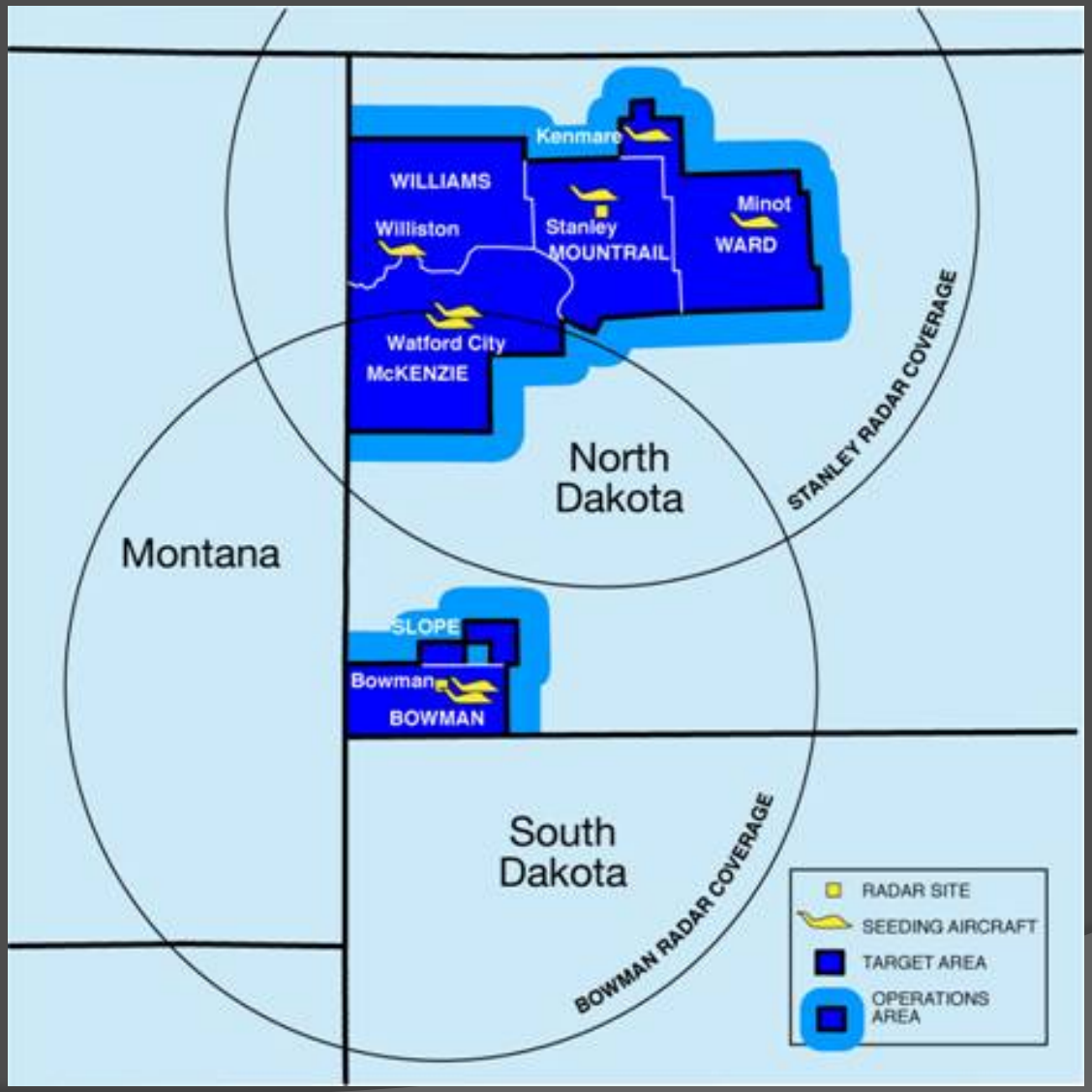
Evaluations/Benefits

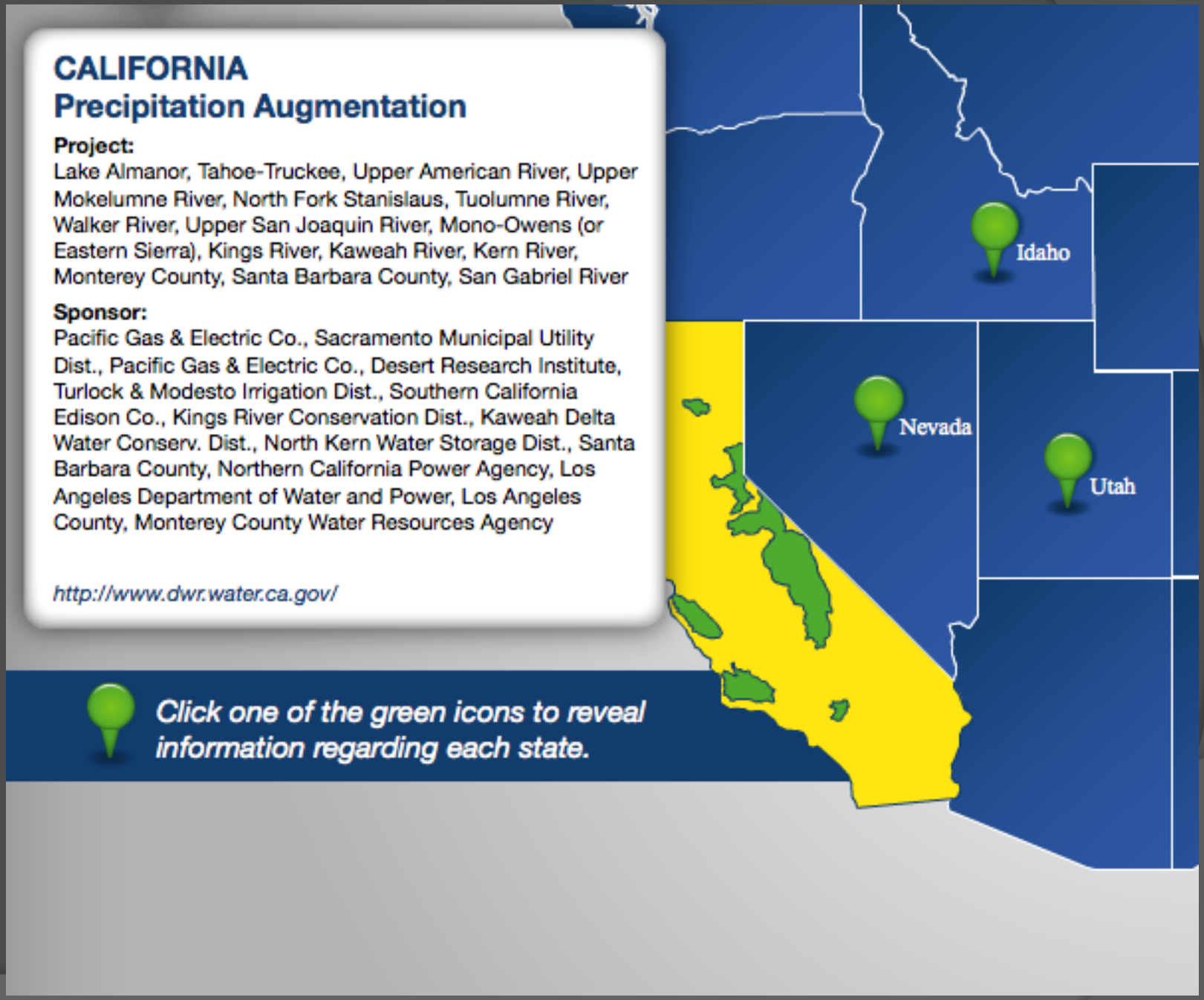
- Hail suppression
  - 27-45% (KS, ND) reduction in crop-hail losses
- Benefit/Cost ratios
  - Snowpack programs better than 10:1
  - Rain enhancement/hail suppression programs for ag production in the range of 37:1 (KS), 13-22:1 (direct) and 41-67:1 (gross) (ND)

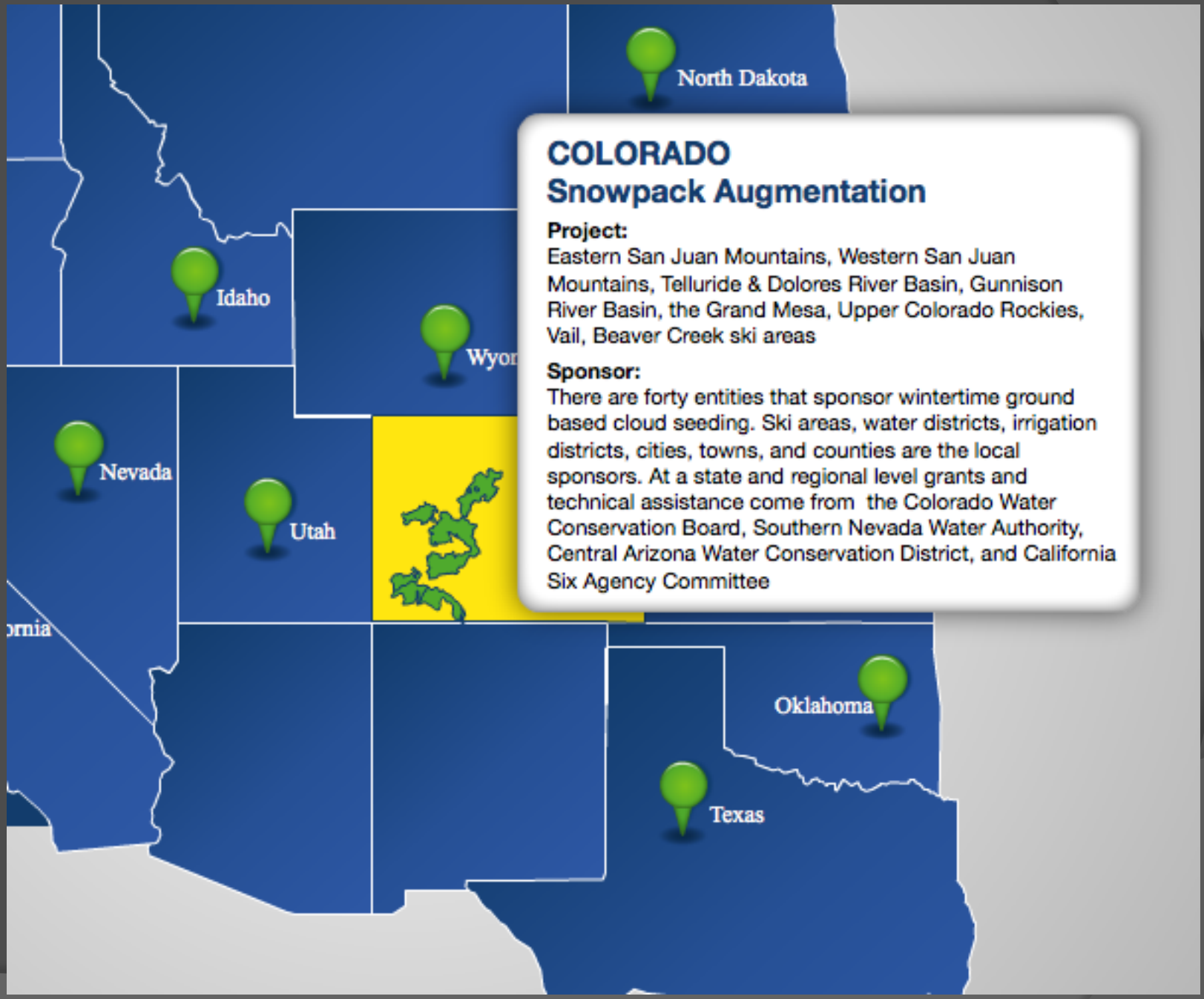
Western US Programs - 2012

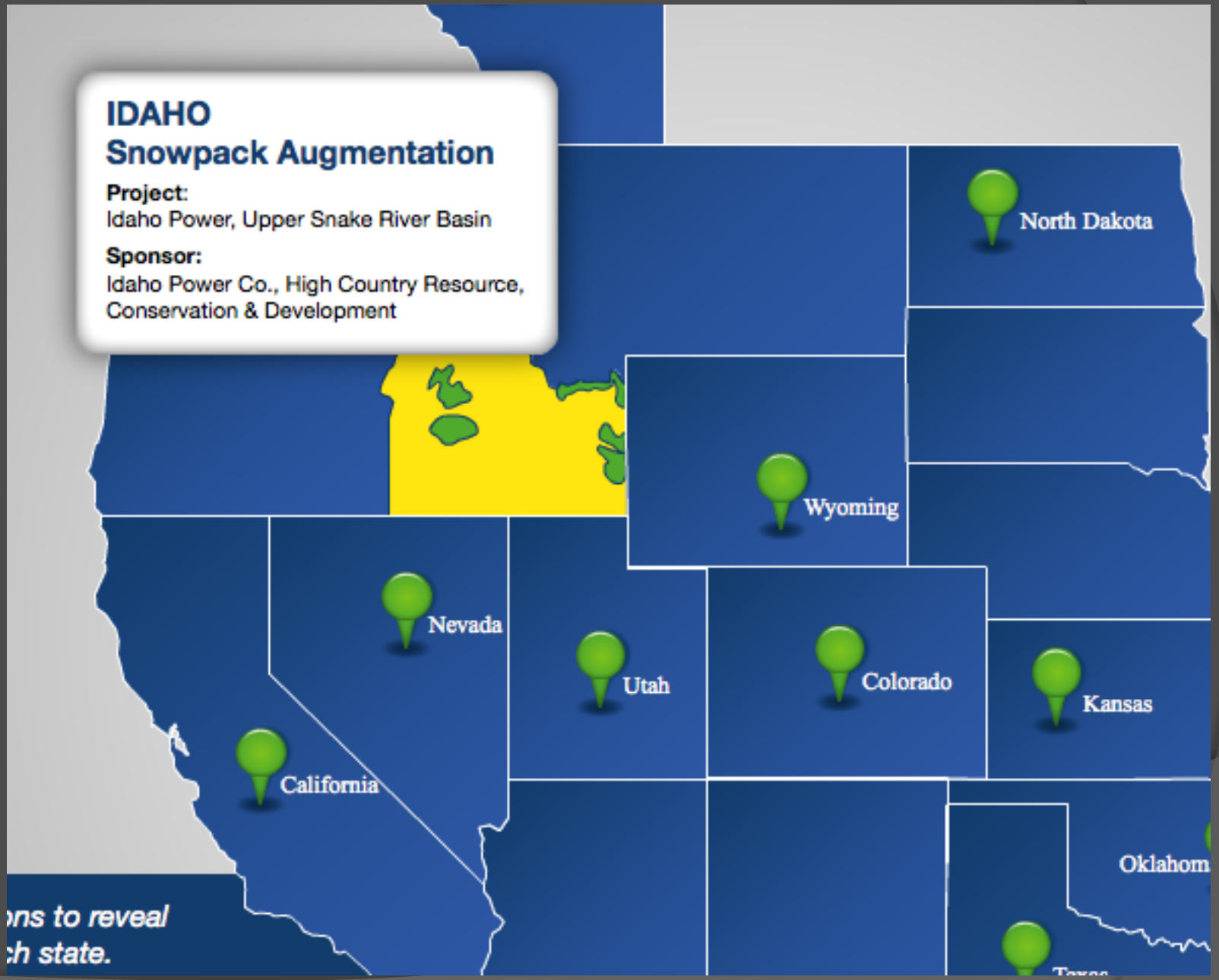


NDCMP


Kenmare
WILLIAMS
Williston
Stanley
MOUNTRAIL
Minot
WARD
Watford City
McKENZIE
North
Dakota
STANLEY RADAR COVERAGE
Montana
SLOPE
Bowman
BOWMAN
South
Dakota
BOWMAN RADAR COVERAGE
RADAR SITE
SEEDING AIRCRAFT
TARGET AREA
OPERATIONS AREA


CALIFORNIA
Precipitation Augmentation
Project:
Lake Almanor, Tahoe-Truckee, Upper American River, Upper Mokelumne River, North Fork Stanislaus, Tuolumne River, Walker River, Upper San Joaquin River, Mono-Owens (or Eastern Sierra), Kings River, Kaweah River, Kern River, Monterey County, Santa Barbara County, San Gabriel River
Sponsor:
Pacific Gas & Electric Co., Sacramento Municipal Utility Dist., Pacific Gas & Electric Co., Desert Research Institute, Turlock & Modesto Irrigation Dist., Southern California Edison Co., Kings River Conservation Dist., Kaweah Delta Water Conserv. Dist., North Kern Water Storage Dist., Santa Barbara County, Northern California Power Agency, Los Angeles Department of Water and Power, Los Angeles County, Monterey County Water Resources Agency
http://www.dwr.water.ca.gov/
Idaho
Nevada
Utah
Click one of the green icons to reveal information regarding each state.


North Dakota
Idaho
Wyo
Nevada
Utah
Oklahoma
Texas
COLORADO
Snowpack Augmentation
Project:
Eastern San Juan Mountains, Western San Juan Mountains, Telluride & Dolores River Basin, Gunnison River Basin, the Grand Mesa, Upper Colorado Rockies, Vail, Beaver Creek ski areas
Sponsor:
There are forty entities that sponsor wintertime ground based cloud seeding. Ski areas, water districts, irrigation districts, cities, towns, and counties are the local sponsors. At a state and regional level grants and technical assistance come from the Colorado Water Conservation Board, Southern Nevada Water Authority, Central Arizona Water Conservation District, and California Six Agency Committee


IDAHO
Snowpack Augmentation
Project:
Idaho Power, Upper Snake River Basin
Sponsor:
Idaho Power Co., High Country Resource, Conservation & Development
North Dakota
Wyoming
Nevada
Utah
Colorado
Kansas
California
Oklahom
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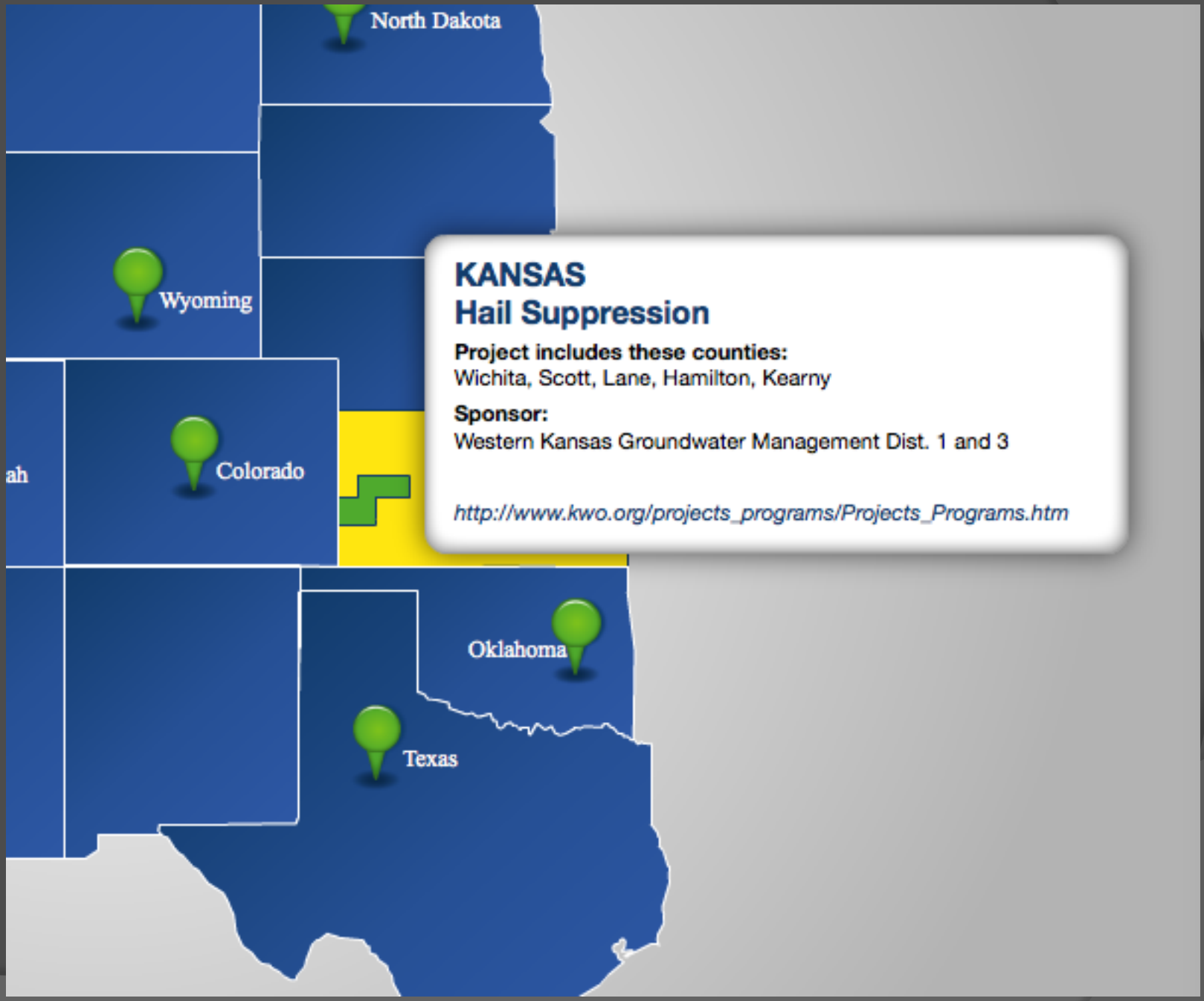
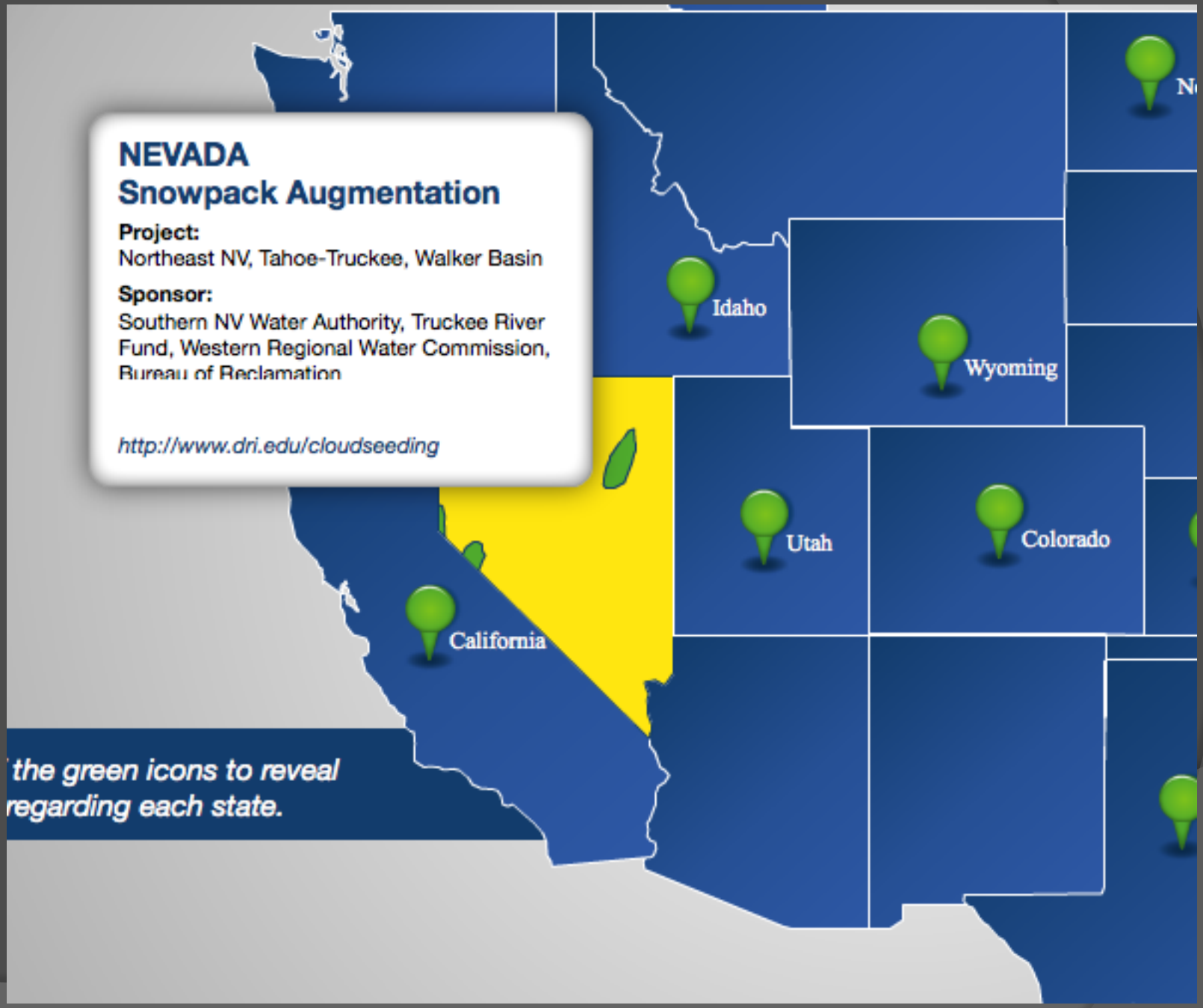
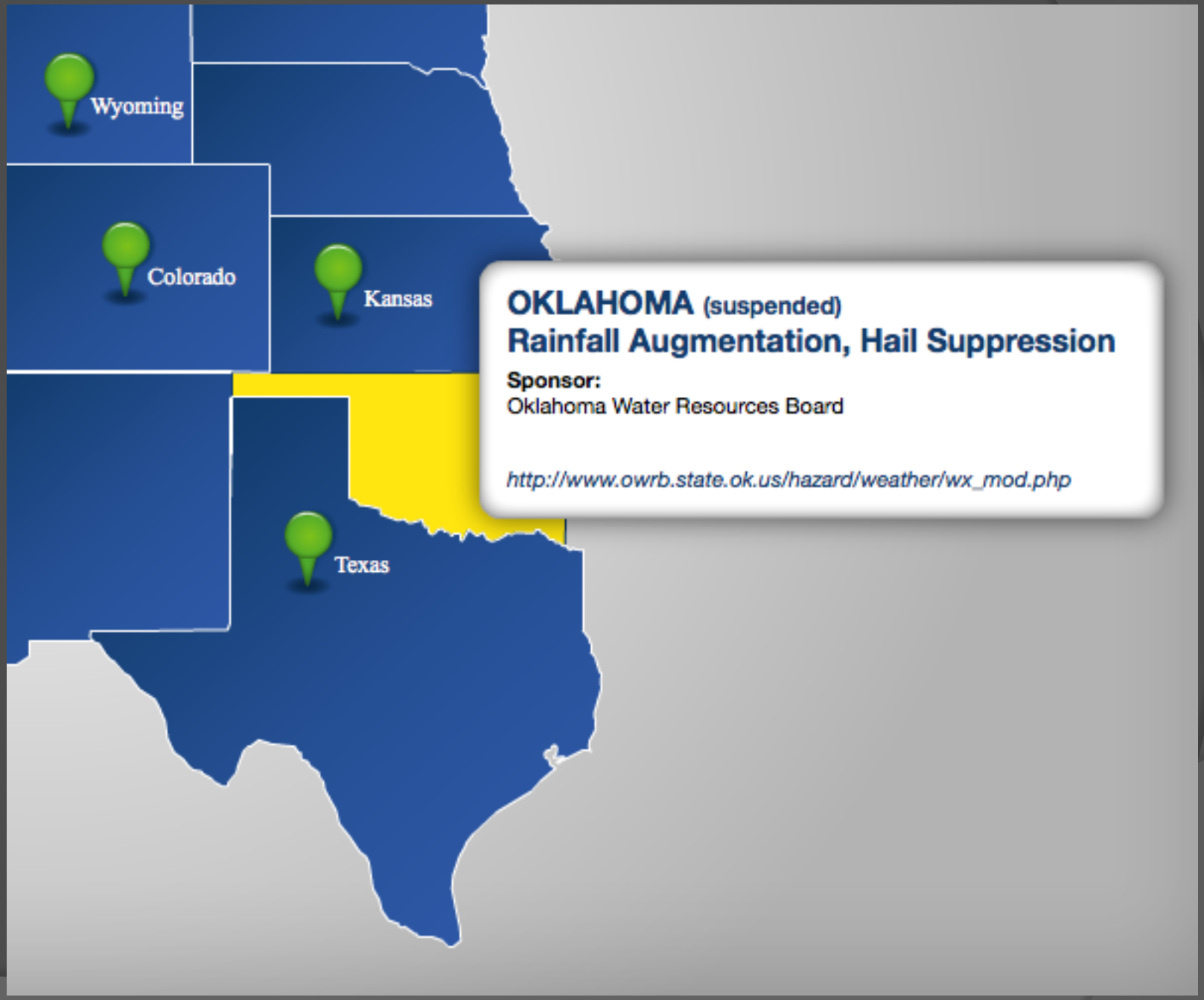
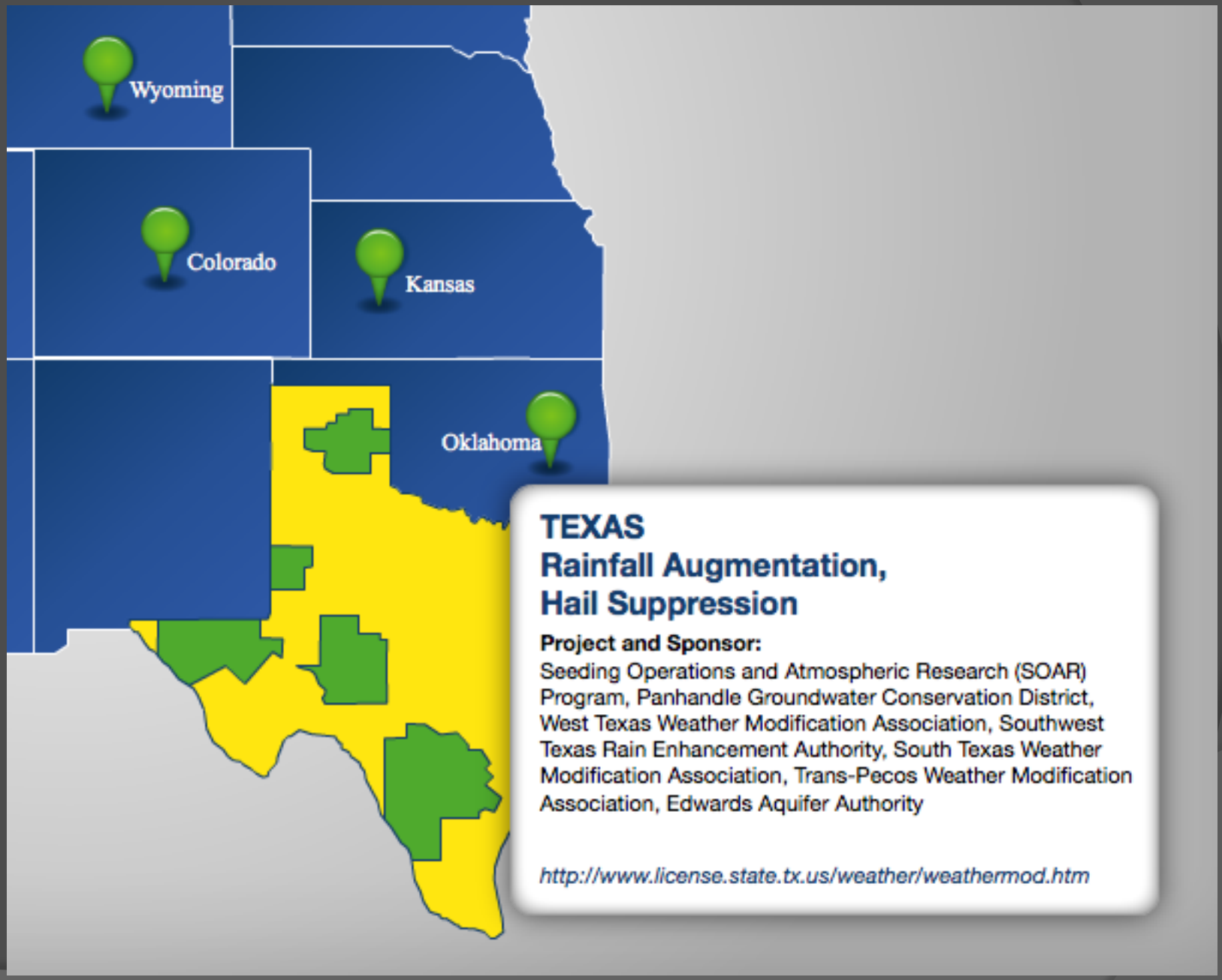

North Dakota
Wyoming
Colorado
Oklahoma
Texas
KANSAS
Hail Suppression
Project includes these counties:
Wichita, Scott, Lane, Hamilton, Kearny
Sponsor:
Western Kansas Groundwater Management Dist. 1 and 3
http://www.kwo.org/projects_programs/Projects_Programs.htm


NEVADA
Snowpack Augmentation
Project:
Northeast NV, Tahoe-Truckee, Walker Basin
Sponsor:
Southern NV Water Authority, Truckee River Fund, Western Regional Water Commission, Bureau of Reclamation
http://www.dri.edu/cloudseeding
Idaho
Wyoming
Utah
Colorado
California
the green icons to reveal
regarding each state.

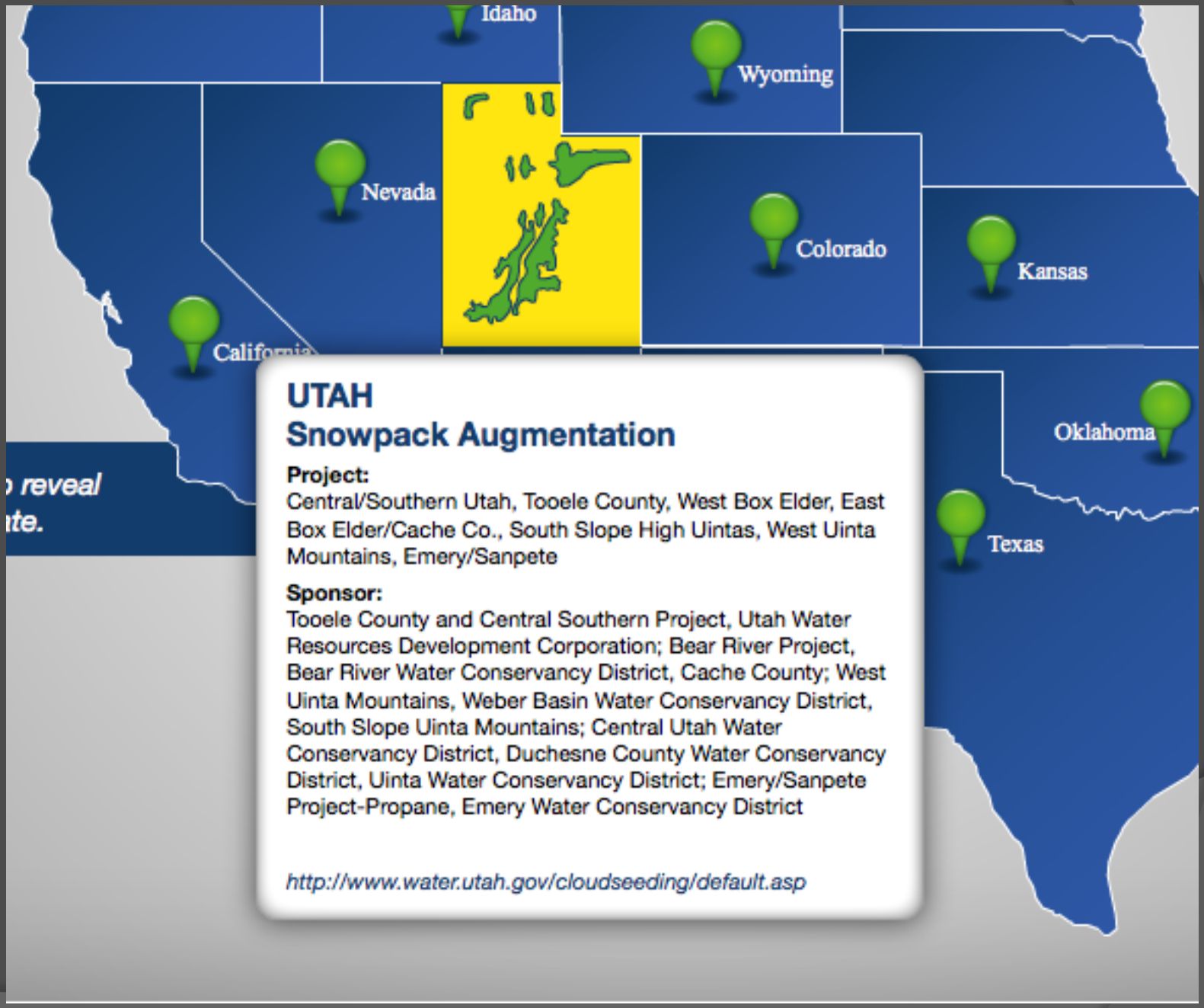

Wyoming
Colorado
Kansas
Texas
OKLAHOMA (suspended)
Rainfall Augmentation, Hail Suppression
Sponsor:
Oklahoma Water Resources Board
http://www.owrb.state.ok.us/hazard/weather/wx_mod.php

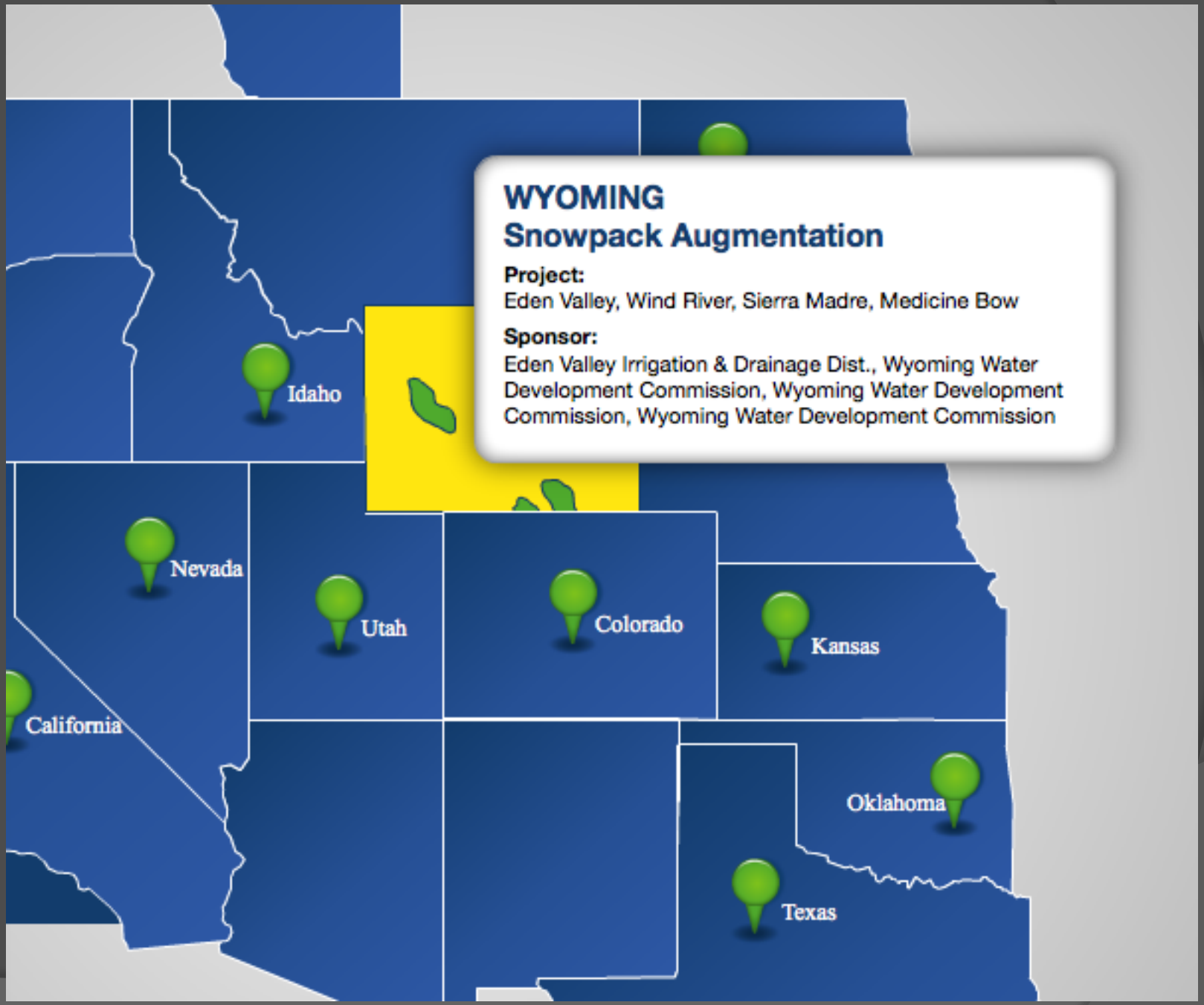


TEXAS
Rainfall Augmentation, Hail Suppression

Project and Sponsor:
Seeding Operations and Atmospheric Research (SOAR) Program, Panhandle Groundwater Conservation District, West Texas Weather Modification Association, Southwest Texas Rain Enhancement Authority, South Texas Weather Modification Association, Trans-Pecos Weather Modification Association, Edwards Aquifer Authority

http://www.license.state.tx.us/weather/weathermod.htm


Idaho
Wyoming
Nevada
Colorado
Kansas
Oklahoma
Texas
UTAH
Snowpack Augmentation
Project:
Central/Southern Utah, Tooele County, West Box Elder, East Box Elder/Cache Co., South Slope High Uintas, West Uinta Mountains, Emery/Sanpete
Sponsor:
Tooele County and Central Southern Project, Utah Water Resources Development Corporation; Bear River Project, Bear River Water Conservancy District, Cache County; West Uinta Mountains, Weber Basin Water Conservancy District, South Slope Uinta Mountains; Central Utah Water Conservancy District, Duchesne County Water Conservancy District, Uinta Water Conservancy District; Emery/Sanpete Project-Propane, Emery Water Conservancy District
http://www.water.utah.gov/cloudseeding/default.asp

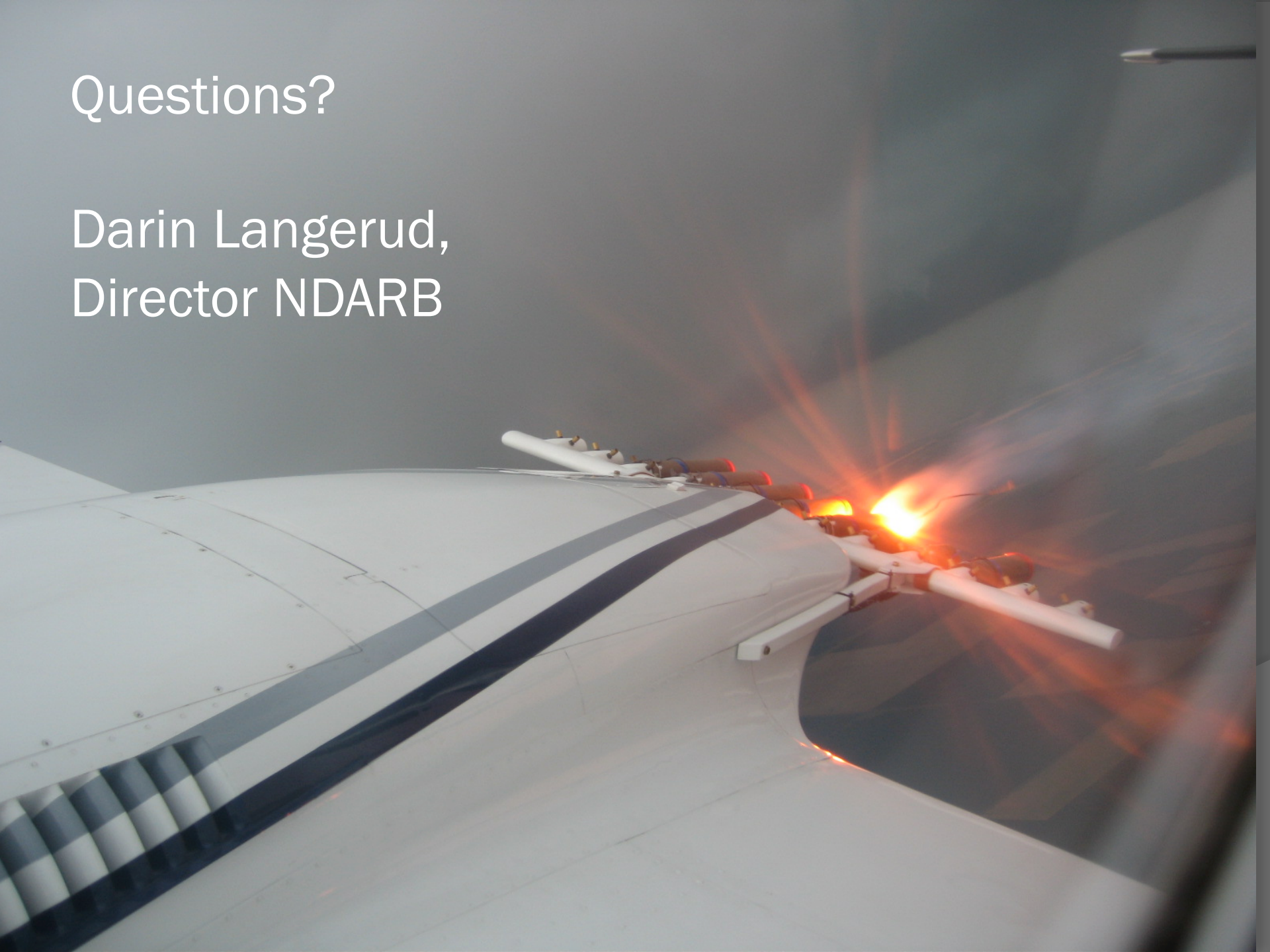

WYOMING
Snowpack Augmentation
Project:
Eden Valley, Wind River, Sierra Madre, Medicine Bow
Sponsor:
Eden Valley Irrigation & Drainage Dist., Wyoming Water Development Commission, Wyoming Water Development Commission, Wyoming Water Development Commission
Idaho
Nevada
Utah
Colorado
Kansas
California
Oklahoma
Texas

ASCE/EWRI Documents

- Standard Practice documents
  - For the Design and Operation of Hail Suppression Projects (39-03)
  - For the Design and Operation of Precipitation Enhancement Projects (42-04)
  - For the Design and Operation of Supercooled Fog Dispersal Projects (44-05)
- ASCE Manual and Report on Engineering Practice #81, Guidelines for Cloud Seeding to Augment Precipitation (2nd edition)

Conclusions

- Active operational programs ongoing in nine western states
- Seeding programs viewed as long-term water resource and risk management tools – not drought busters
- Advancing technology and knowledge continue to improve seeding efficacy


Questions?
Darin Langerud,
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