WYOMING'S CLOUD SEEDING PROGRAM

A summary of weather modification efforts

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Western States Water Council

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WHY?

- One cubic mile of air = 18,000 tons of water (23.7 acre feet)
- Approximately 0.44 inches of water over the entire state
- Equates to ~ 1.4 million acre feet of water over Wyoming

Orographic Cloud Seeding (snow augmentation over mountains)

WHY?

Winter clouds contain lots of water, however, they are **naturally inefficient** at producing snowfall.

<u>The reason for this?</u>

- Water droplets in a cloud do not freeze < 32F ("supercooled water")
- Supercooled water droplets need a "dust" particle in order to freeze into an ice crystal
- There is not enough natural geometrically-appropriate dust particles in the atmosphere

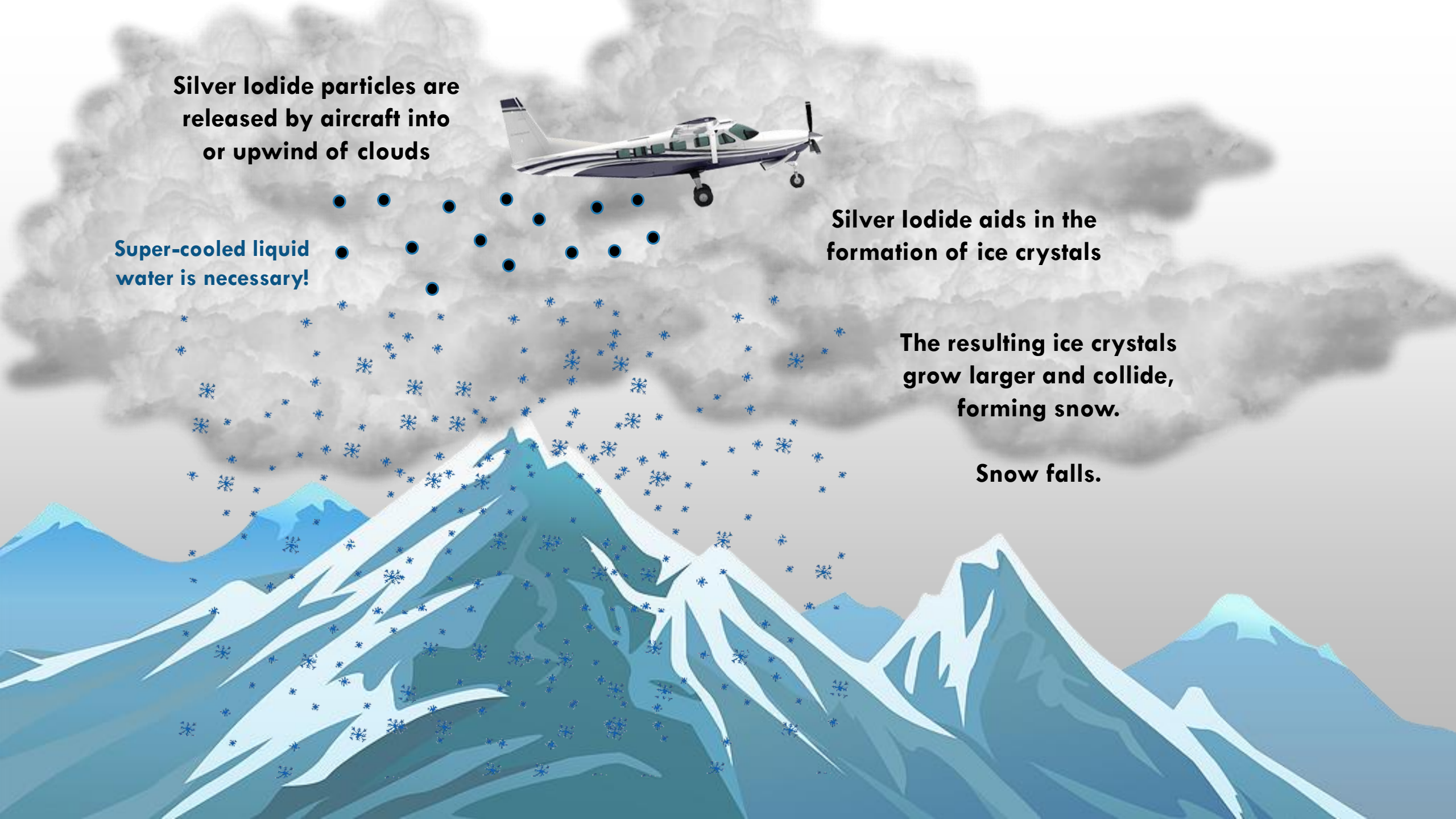
WHAT IS CLOUD SEEDING?

- Uses a natural compound (Silver Iodide, AgI) to initiate ice crystal formation (snowfall) in specific types of clouds that already has a high potential of producing snow.
- Silver Iodide acts as the “dust” particle allowing supercooled water to freeze into ice crystals (and collide into snowflakes)

WHAT IS CLOUD SEEDING?

- Winter cloud efficiency increases
- Ice from seeding collides with natural ice inside the cloud (snow)

Better efficiency means a great fraction of cloud water gets converted into precipitation and makes it to the ground where it might be used.


Silver Iodide particles are released by aircraft into or upwind of clouds
Super-cooled liquid water is necessary!
Silver Iodide aids in the formation of ice crystals
The resulting ice crystals grow larger and collide, forming snow.
Snow falls.

UNDERSTANDING
WEATHER MODIFICATION & CLOUD SEEDING

The term "cloud seeding"

- Refers to small-scale seeding of clouds to augment snow or mitigate hail, etc.
- Scientifically proven science to "boost" the snowfall process in clouds
- Essentially "cloud physics" or "cloud modification"

The term "weather modification" can sometimes be associated with large scale weather manipulation, climate change, geoengineering, etc.

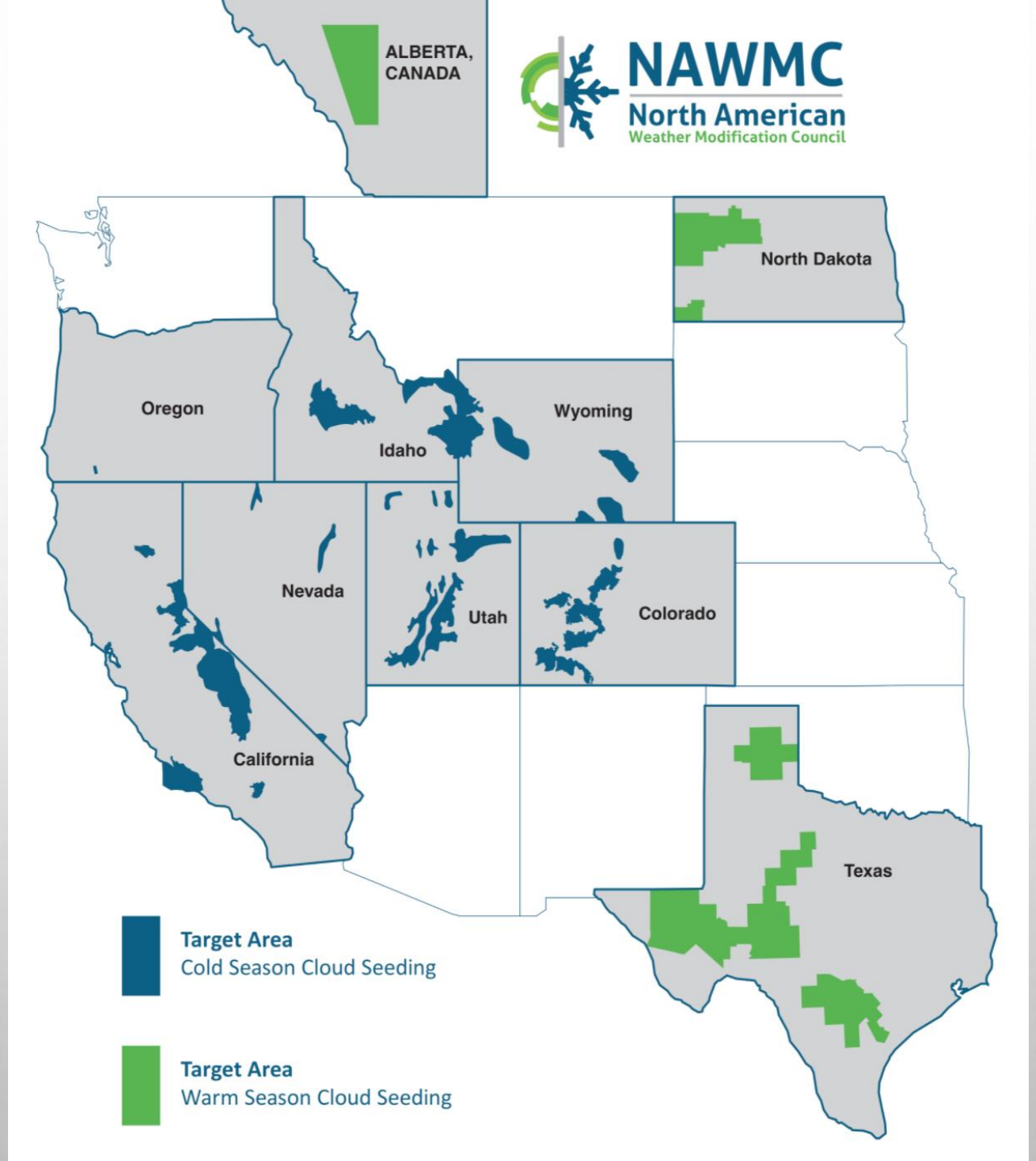
WHAT CLOUD SEEDING CANNOT DO

- Break droughts
- Create clouds
- Move clouds
- Change cloudiness, winds or temperature

WHAT CLOUD SEEDING CAN DO

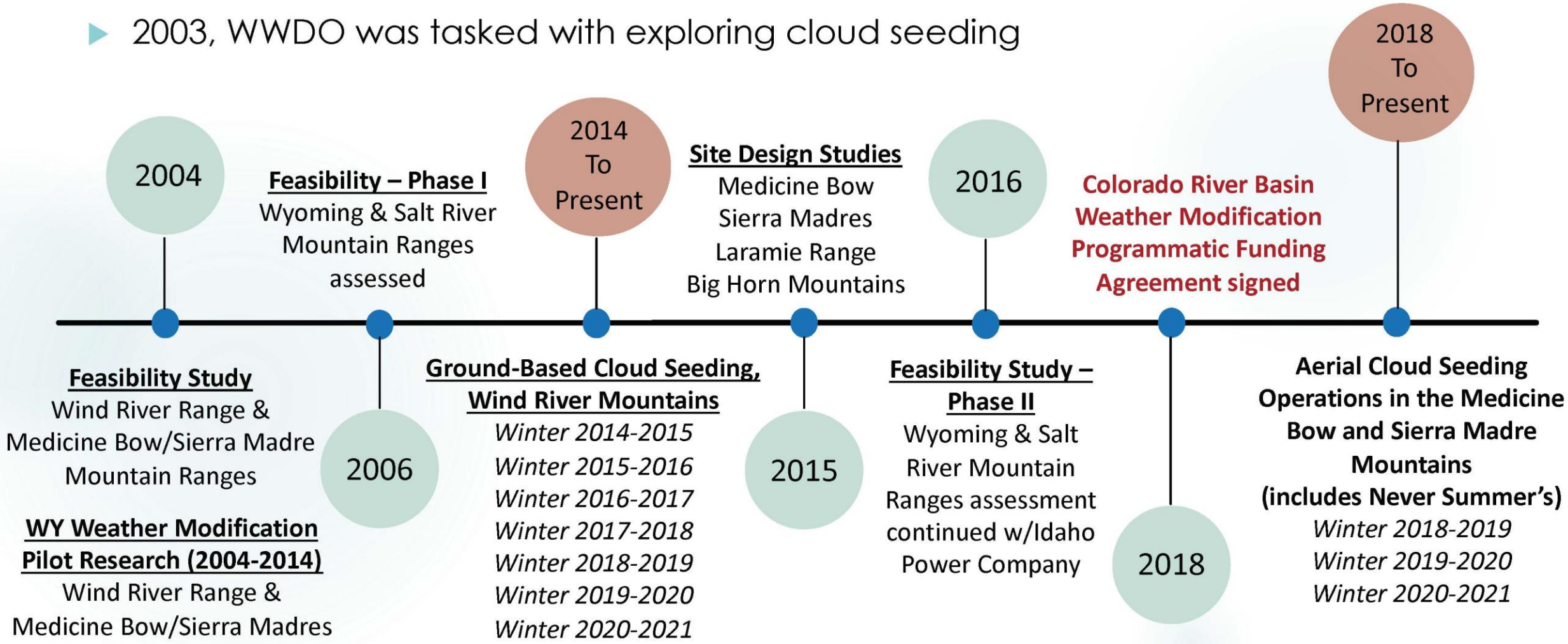
- Safe and effective way to increase snowpack incrementally over time, above what nature can give us (high elevation water storage)
- Assist with drought mitigation (WY's Drought Contingency Plan)
- Inexpensive tool for water resource management

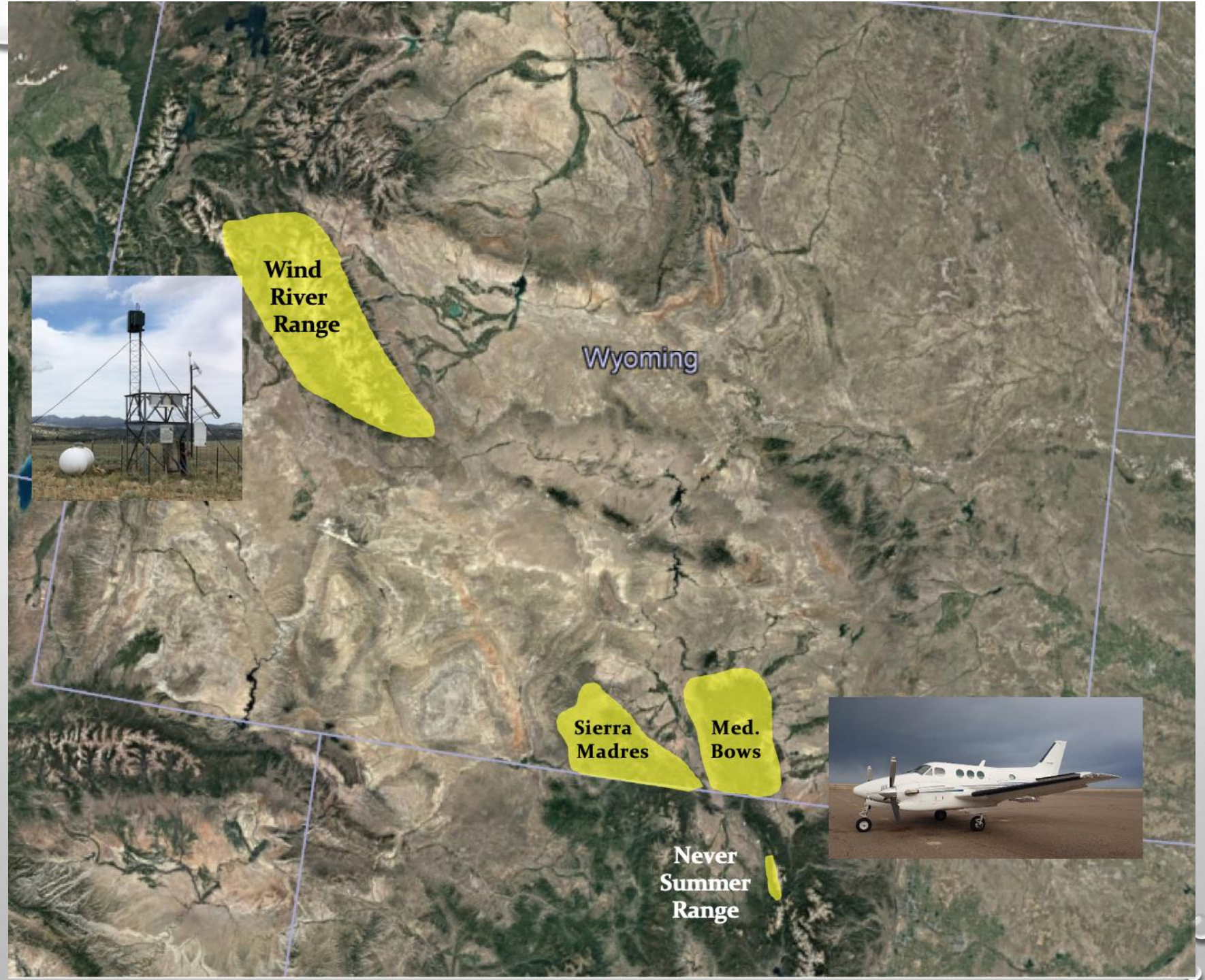
After recent years of science/research, the question is no longer "does it work", the new question is "how well?"


ALBERTA, CANADA
NAWMC
North American
Weather Modification Council
North Dakota
Oregon
Idaho
Wyoming
Nevada
Utah
Colorado
California
Texas
Target Area
Cold Season Cloud Seeding
Target Area
Warm Season Cloud Seeding

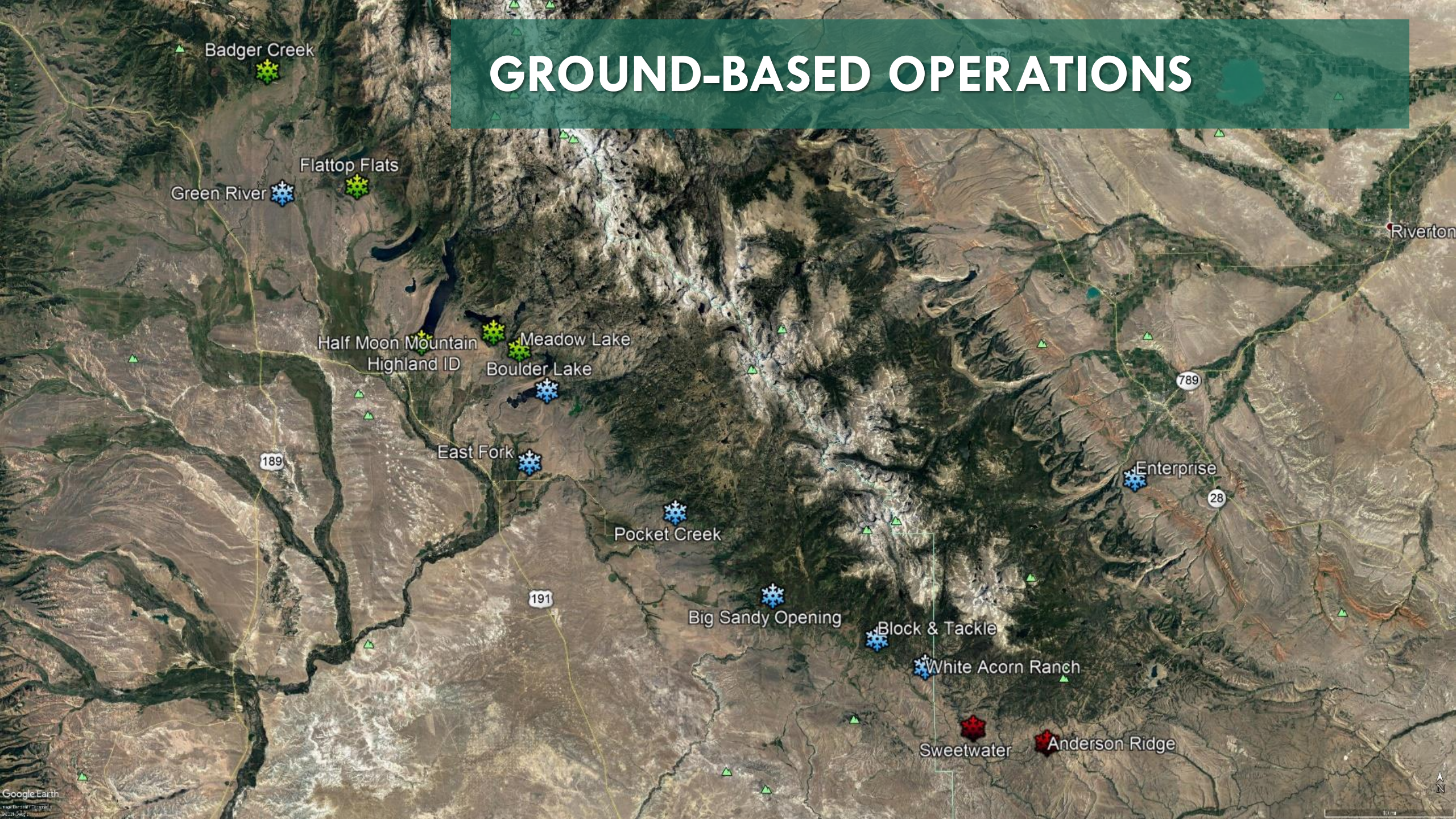
Wyoming's Cloud Seeding Timeline

- Prior to 2003, WY Assoc. of Conservation Districts inquired about cloud seeding
- 2003, WWDO was tasked with exploring cloud seeding




Wind
River
Range
Wyoming
Sierra
Madres
Med.
Bows
Never
Summer
Range

GROUND-BASED OPERATIONS



GROUND-BASED OPERATIONS

GROUND-BASED OPERATIONS

Legislation requires this project be a cost-share:

37% (State of Wyoming), 63% (other funding partners)

Regional funding partners (Colorado River Basin entities)

Local funding partners (Trona Mining Industry, energy)

GROUND-BASED OPERATIONS

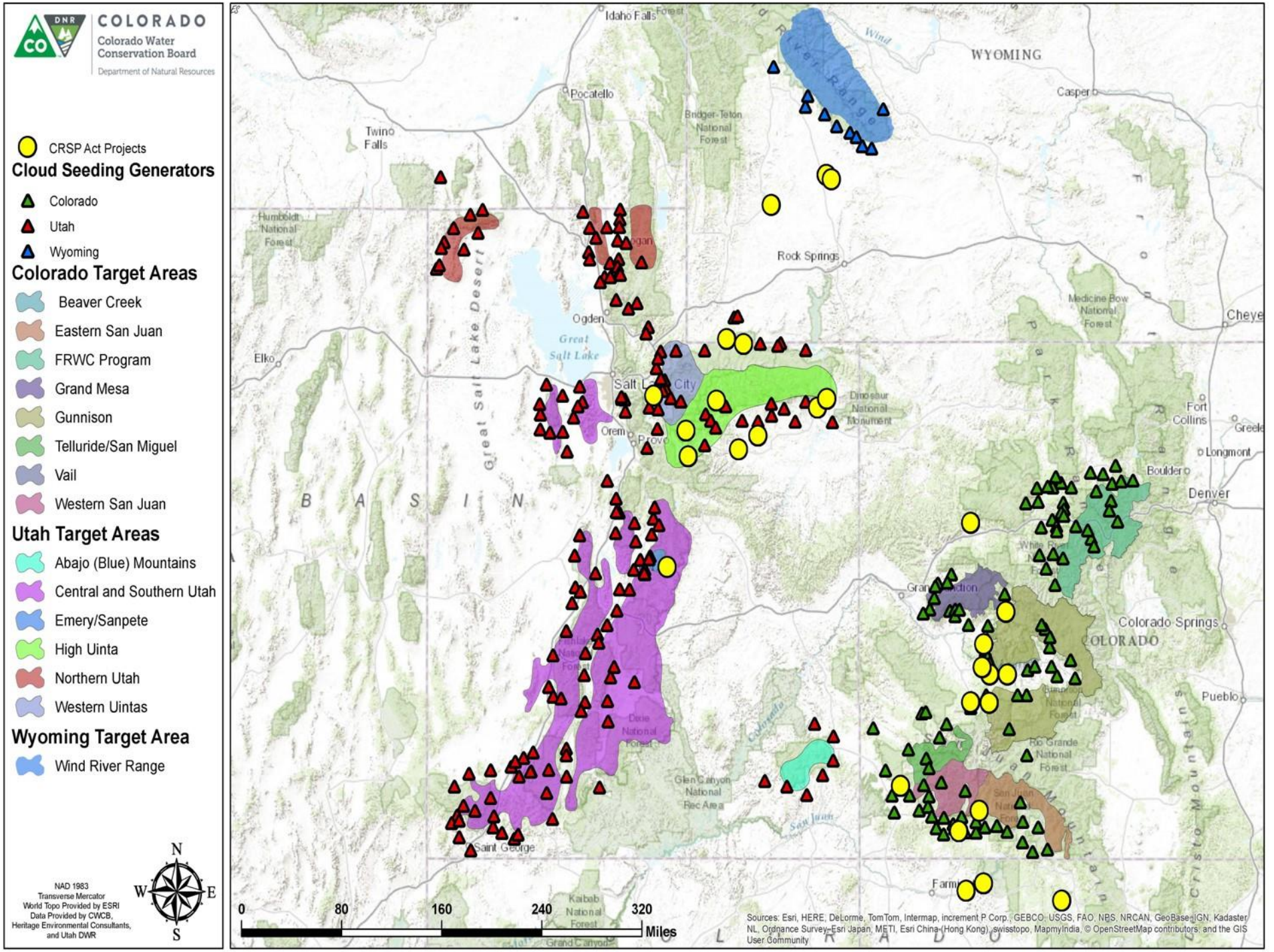
Colorado River Basin Weather Modification Activities Programmatic Funding Agreement

- Upper Basin and Lower Basin partnership, signed in 2018
- Continue the use of weather modification efforts as a way to contribute additional water into the system for CRB users
- Proposals submitted every summer, to be approved prior to operations
- Collective contributions can reach $1.5 million in a single water year
- Funding allows us to opportunities to expand the program

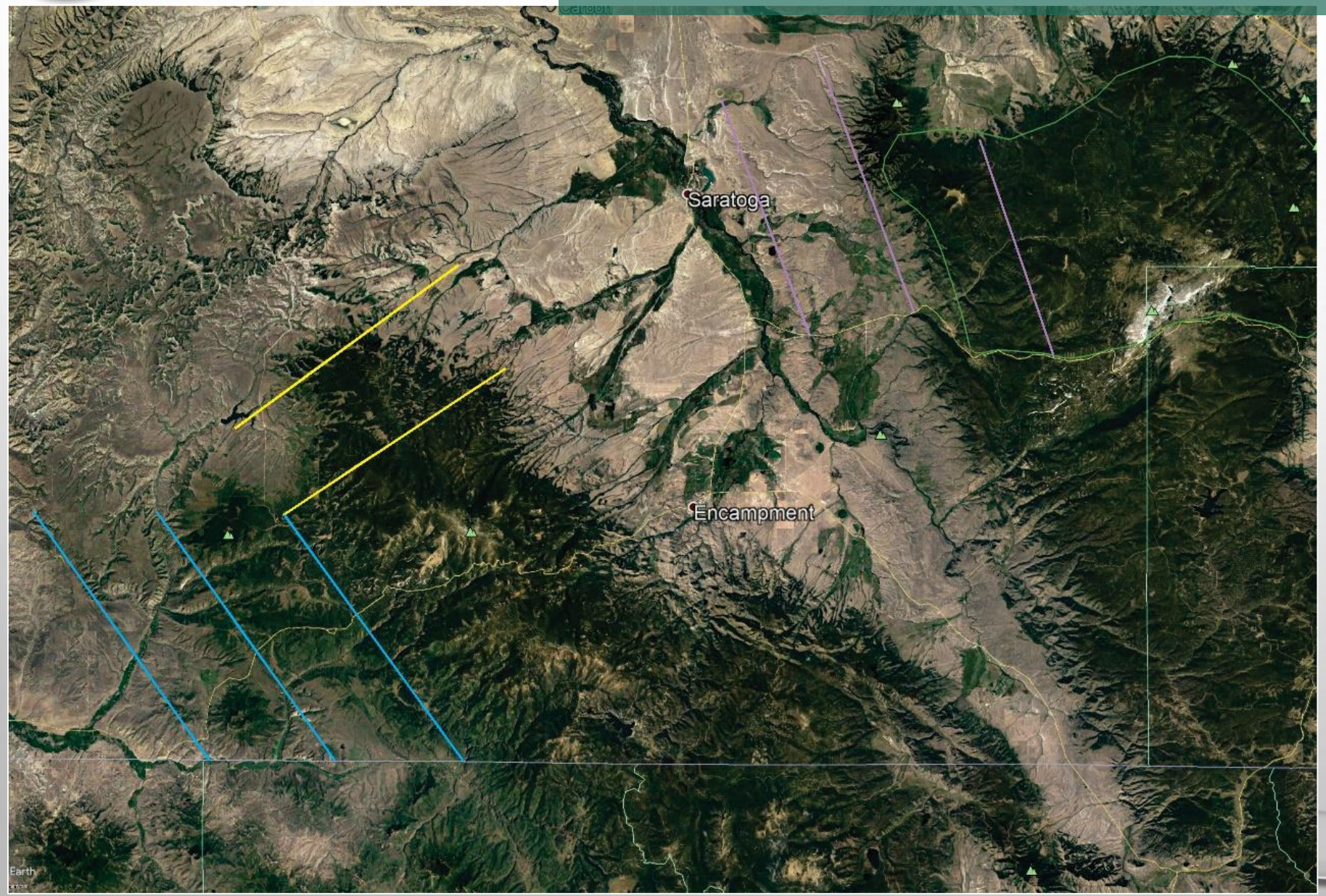
CAP
CENTRAL ARIZONA PROJECT

SOUTHERN NEVADA WATER AUTHORITY™

Colorado River Board of California


COLORADO
Colorado Water Conservation Board
Department of Natural Resources
CRSP Act Projects
Cloud Seeding Generators
Colorado
Utah
Wyoming
Colorado Target Areas
Beaver Creek
Eastern San Juan
FRWC Program
Grand Mesa
Gunnison
Telluride/San Miguel
Vail
Western San Juan
Utah Target Areas
Abajo (Blue) Mountains
Central and Southern Utah
Emery/Sanpete
High Uinta
Northern Utah
Western Uintas
Wyoming Target Area
Wind River Range
NAD 1983
Transverse Mercator
World Topo Provided by ESRI
Data Provided by CWCB,
Heritage Environmental Consultants,
and Utah DWR
N
W
E
S
0
80
160
240
320
Miles
WYOMING
COLORADO
Idaho Falls
Pocatello
Twin Falls
Bridger-Teton National Forest
Wind River Range
Casper
Rock Springs
Humboldt National Forest
Great Salt Lake Desert
Ogden
Great Salt Lake
Elko
Salt Lake City
Orem
Provo
Dinosaur National Monument
Medicine Bow National Forest
Cheyenne
Fort Collins
Greeley
Longmont
Boulder
Denver
Colorado Springs
Pueblo
Rio Grande National Forest
Dixie National Forest
Glen Canyon National Rec Area
Saint George
Kaibab National Forest
Grand Canyon
Sangre de Cristo Mountains
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

AERIAL OPERATIONS

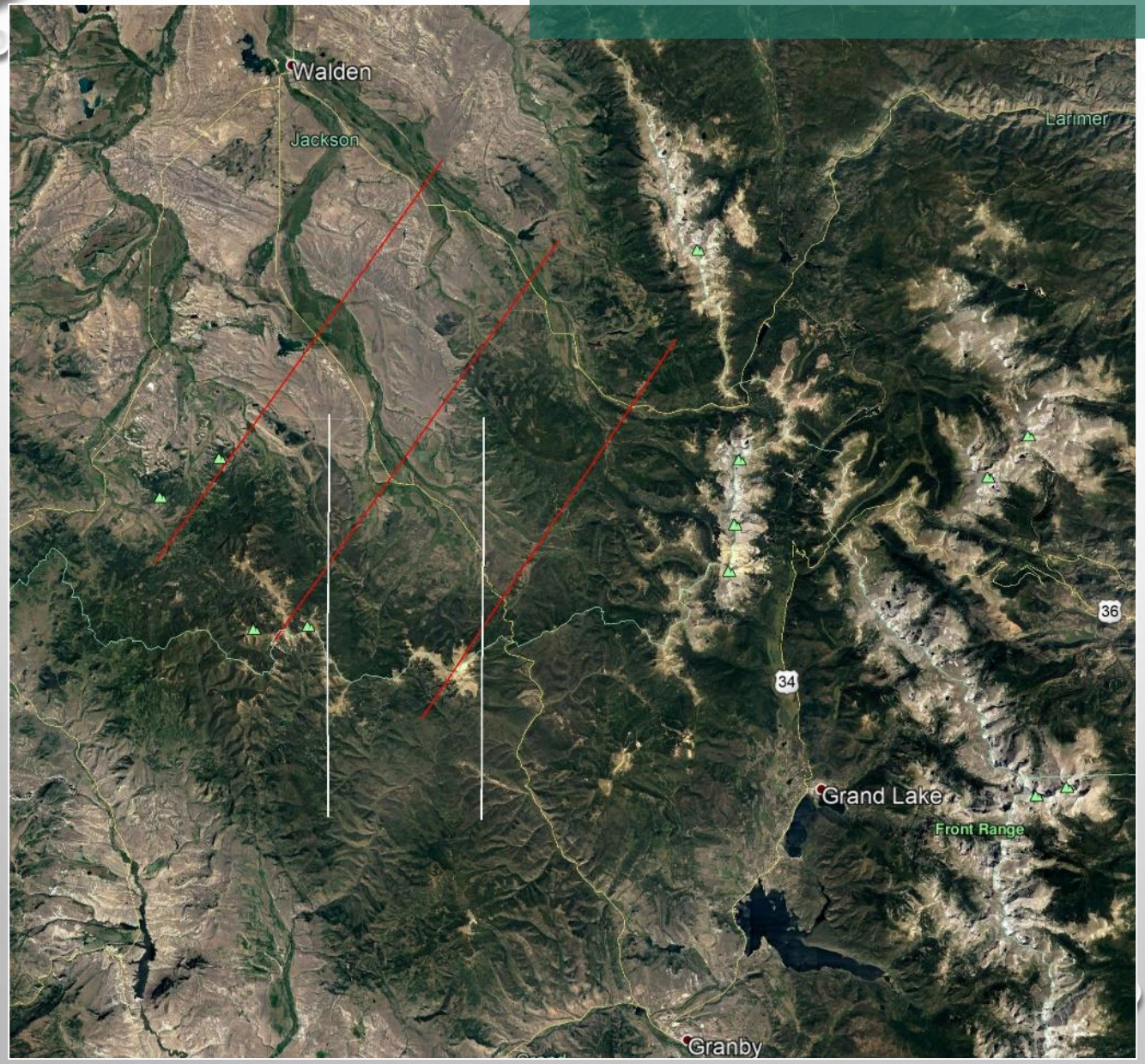


Sierra Madre's

Medicine Bow's

We avoided seeding over the Mullen Fire Burn Scar this past winter.

AERIAL OPERATIONS



"Add-On"

Never Summer Mountains (west side)

Operations paid for by Jackson Co. Water Consevancy District in Walden, CO.

Supports Upper North Platte River Basin in Wyoming.

LOOKING AT THE NUMBERS

Utilizing the results from the WY Weather Mod. Pilot Study (2014) and MBSM Design Study (2017), positive impacts have been estimated:

- Cloud seeding in the Wind River Mountains can generate ~16,000+ acre feet of additional run-off ($24-$28 per acre foot)
- Cloud seeding in Medicine Bow & Sierra Madre Mountains can generate ~30,000 (+/-) acre feet of additional run-off ($24 per acre foot)

***Future Needs**: Robust assessment on cost effectiveness of operations*

THANK YOU FOR YOUR TIME.

Weather Modification/Cloud Seeding Program

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