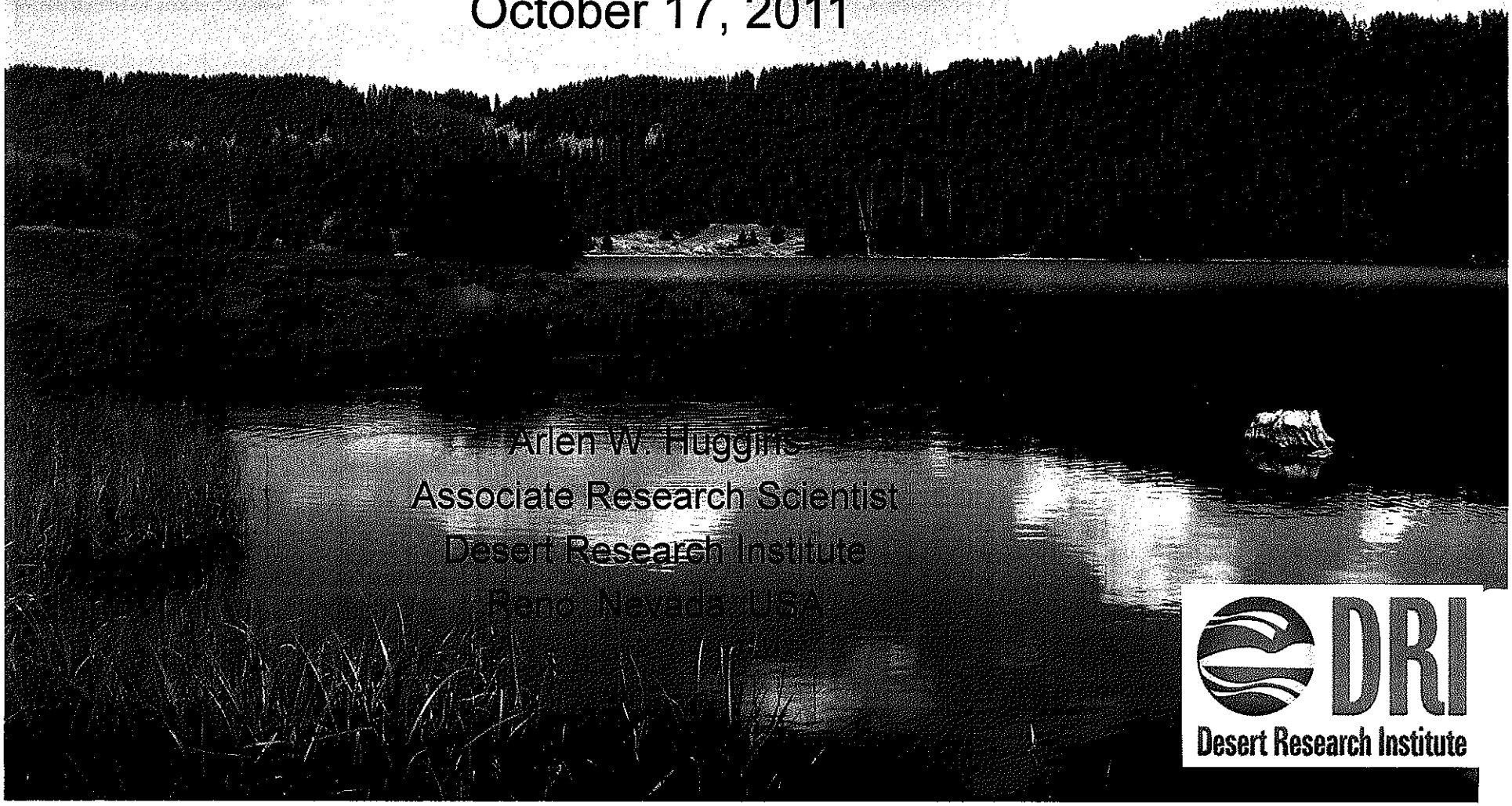
Briefing on the Benefits/Impacts of Weather Modification

Water Resources Review Committee
Colorado State Legislature
October 17, 2011



Arlen W. Huggins
Associate Research Scientist
Desert Research Institute
Reno, Nevada, USA

DRI
Desert Research Institute

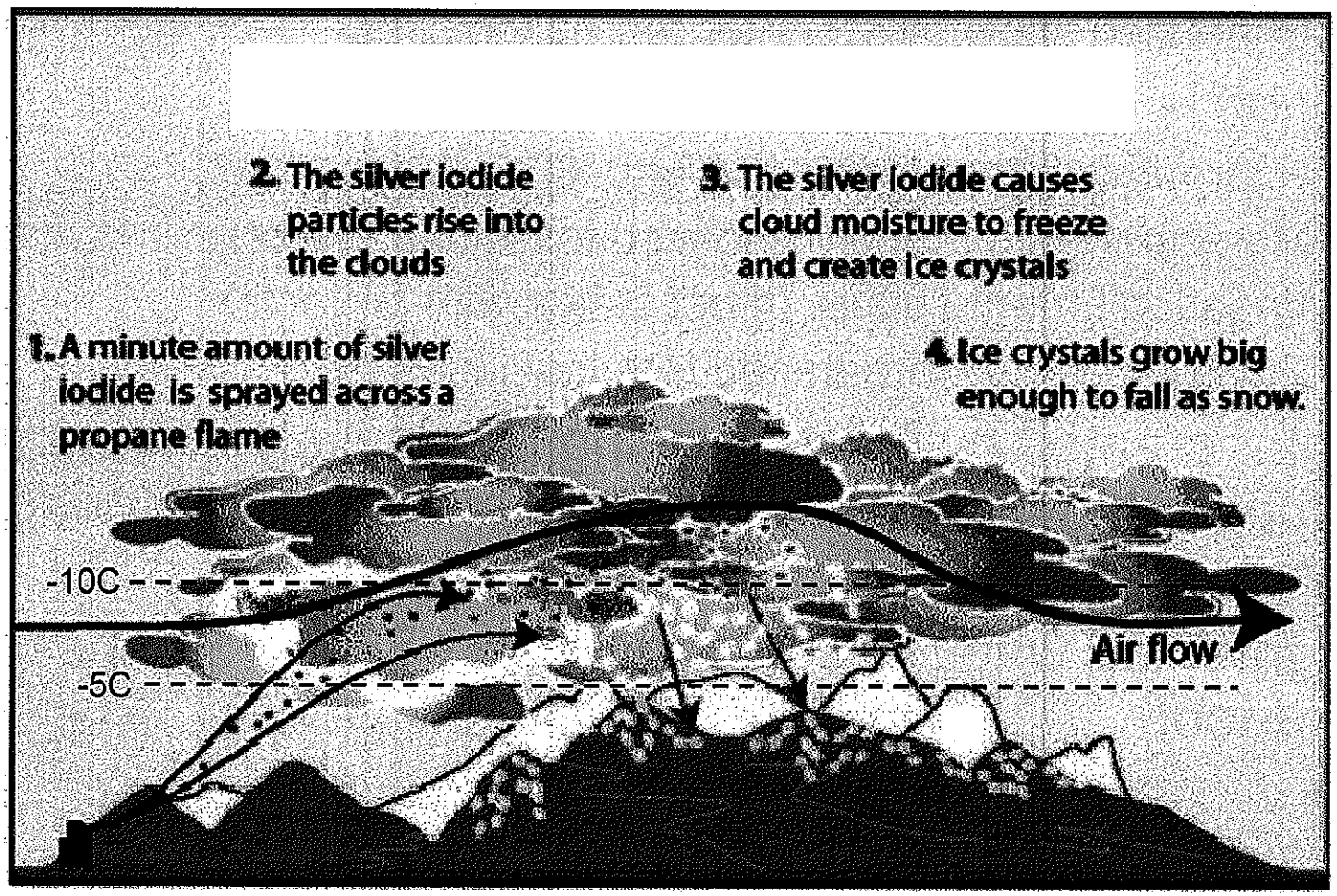
Attachment I

Two Main Types of Cloud Seeding

- Wintertime seeding to enhance snowfall
  - Practiced in mountainous areas of six western states
  - Intended impact is mainly increased runoff to enhance water supplies
  - Recreational benefit to ski areas
  - Seeding period is generally November through March
  - Evaluations have shown snowfall increases up to 15% are possible
  - Environmental impacts have been shown to be insignificant
  - No detrimental downwind effects have been observed
- Spring - Summer seeding of convective storms
  - Current projects in ND, KS and TX
  - Goal to either increase rainfall or decrease hail in support of agriculture
  - Seeding periods vary, but mostly April through August
  - Use aircraft since cloud locations vary and seeding must focus on specific clouds

Conceptual Diagram of Orographic Cloud Seeding (the only type of seeding currently done in CO)

Ground-based seeding with silver iodide



Benefits of seeding for snowfall augmentation

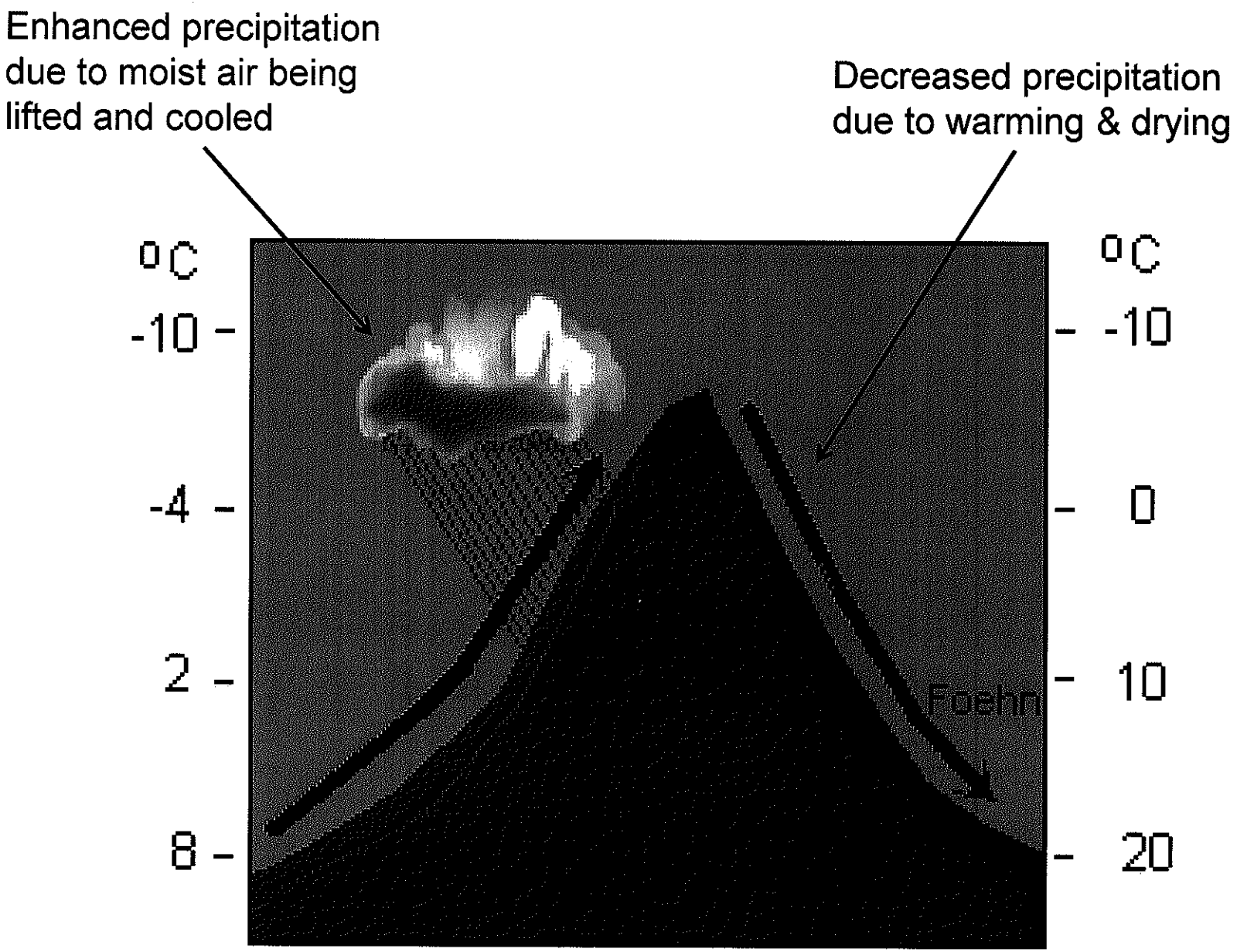
- Potential to add tens of thousands of acre-feet of snow water to a basin
  - Enhanced snowfall at winter recreation sites
- Runoff is enhanced for downstream use
  - Hydropower generation (CA and ID)
  - Municipal water supply (most states with projects)
  - Irrigation for agriculture (most states with projects)
  - Environmentally threatened terminal lakes (NV)
- Water created by cloud seeding is relatively inexpensive compared to alternative methods of adding or storing water
- Augmented water costs range from <$8 to ~$20 per acre-foot

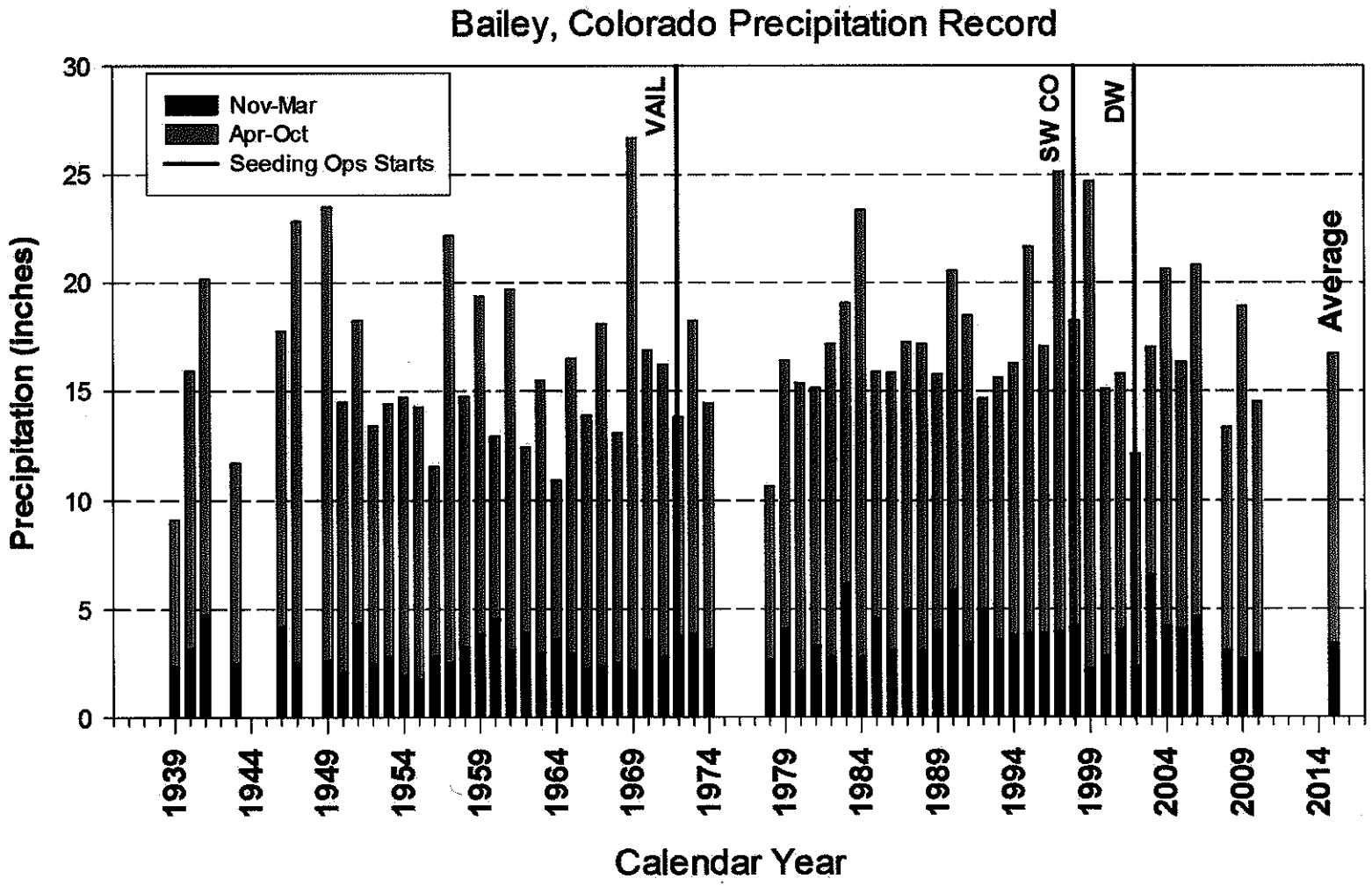
Benefits of summertime seeding

- Potential to increase rainfall
  - Research indicates rainfall increase mainly due to increasing storm area and rainfall duration
  - Water added directly to farmland areas (ND, KS, TX)
  - Aquifer recharge (TX)
- Potential to decrease hailfall
  - Specific counties or water districts in ND and KS
  - Large economic impact in decreased crop losses
  - Evaluations of insurance losses show drastic loss reduction over seeded regions
- Water created by cloud seeding is relatively inexpensive compared to alternative methods of adding or storing water

The Rockies Influence on Colorado Precipitation

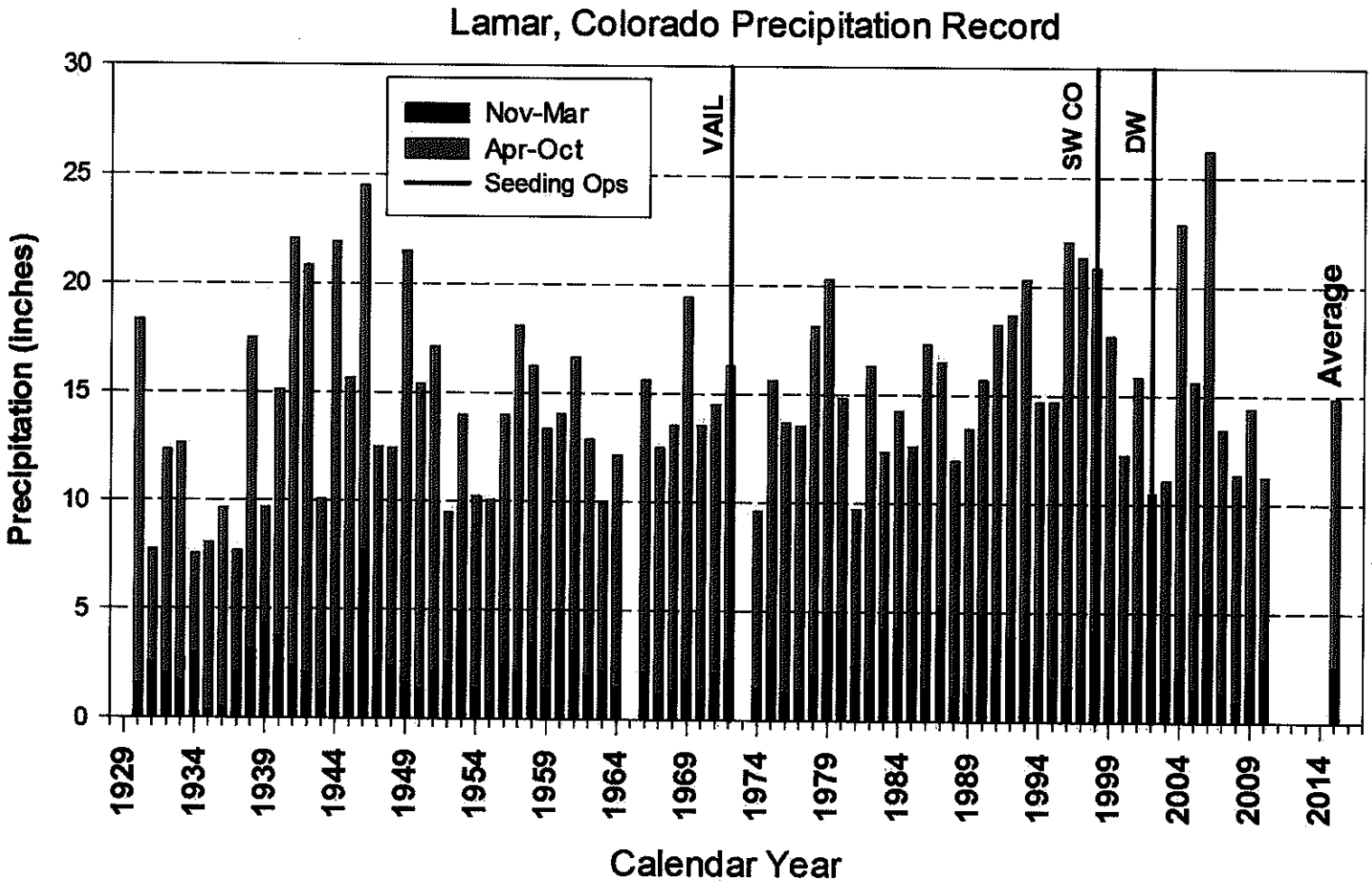
- Snowfall is maximized west of the Divide due to orographic lift with storms coming in from the west
  - Clouds and precipitation form as moist air is lifted over the western slopes
  - Annual precipitation can be 40 inches or more west of the Divide
- Precipitation is limited east of the Divide as air descends and warms
  - Clouds and precipitation evaporate as they descend over the Front Range
  - This is the rain shadow effect noted downwind of all major mountain ranges
  - Annual precipitation will "naturally" decrease to less than half the west slope values
- Front range areas get their best snowfall when low pressure systems are over the southern part of the state
  - Air flow is from the east creating the upslope effect east of the Divide
  - West slope regions are rain shadowed in these situations
  - <u>This storm type is much less frequent</u>, but can dump feet of snow on Denver and the front range when it occurs
- Eastern plains of CO generally get most of their precipitation in the spring and summer months – different type of storm
  - Currently no cloud seeding in CO after March


Enhanced precipitation due to moist air being lifted and cooled
Decreased precipitation due to warming & drying
°C
-10
-4
2
8
°C
-10
0
10
20
Foehn



Front Range Precipitation example:

- Only about 18% of precip Nov through March (seeding period)
- No trend showing a negative impact during seeding months
- Similar trends before and after seeding began



Eastern CO Precipitation example:

- Only about 17% of precip Nov through March (seeding period)
- No trend showing a negative impact during seeding months
- Similar trends before and after seeding began

Summary of Cloud Seeding Effects

- Wintertime cloud seeding has best documented evidence of precipitation enhancement
  - Practiced in many states with a wide variety of sponsors
  - Main benefit is enhanced streamflow for many different purposes
  - Additional water is relatively inexpensive
- Summertime cloud seeding has shown positive effects, but evidence is not as strong
  - Benefit to agriculture during the growing season
  - ND study shows reduction in losses from hail storms
- Colorado wintertime seeding not noticeably impacting front range or eastern plains
  - Natural precipitation decrease east of the Divide due to rainshadow
  - Front range and eastern CO get only a small % of precipitation in winter months when seeding is done
  - No noticeable change in downwind precipitation patterns since seeding began in the 1970s