

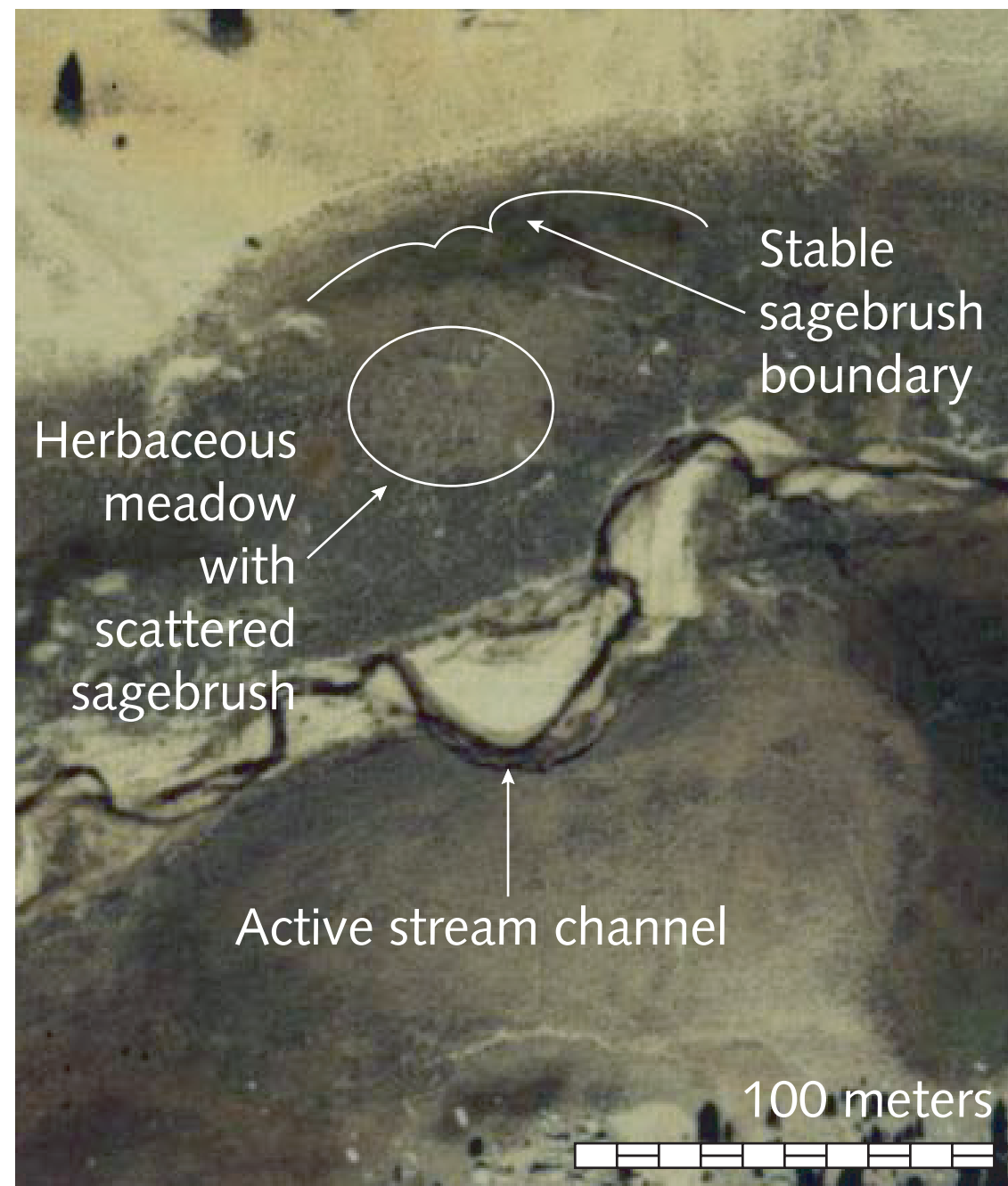
MONTANE MEADOWS found on the Kern Plateau are the largest in the Sierra Nevada – up to 30 km<sup>2</sup>. The meadows are 2,500-3,200 m in elevation and receive most of their precipitation from winter snow. Snow melts and plants grow from late May until August. The meadows endured heavy grazing 100 years ago, and some are still grazed at moderate levels during the summer. Ranchers value the meadows economically, hikers value them aesthetically, and they are home to a diverse assemblage of native plants and associated wildlife. Sagebrush is native but was historically restricted to the dry meadow edges. Expansion into the meadows appears to have begun in the late 1900s. Repeat aerial photographs (see below) and analysis of sagebrush growth rings show that sagebrush invasion continues today. Large stands of sagebrush have formed, displacing native plants and rendering the meadows useless for grazing.



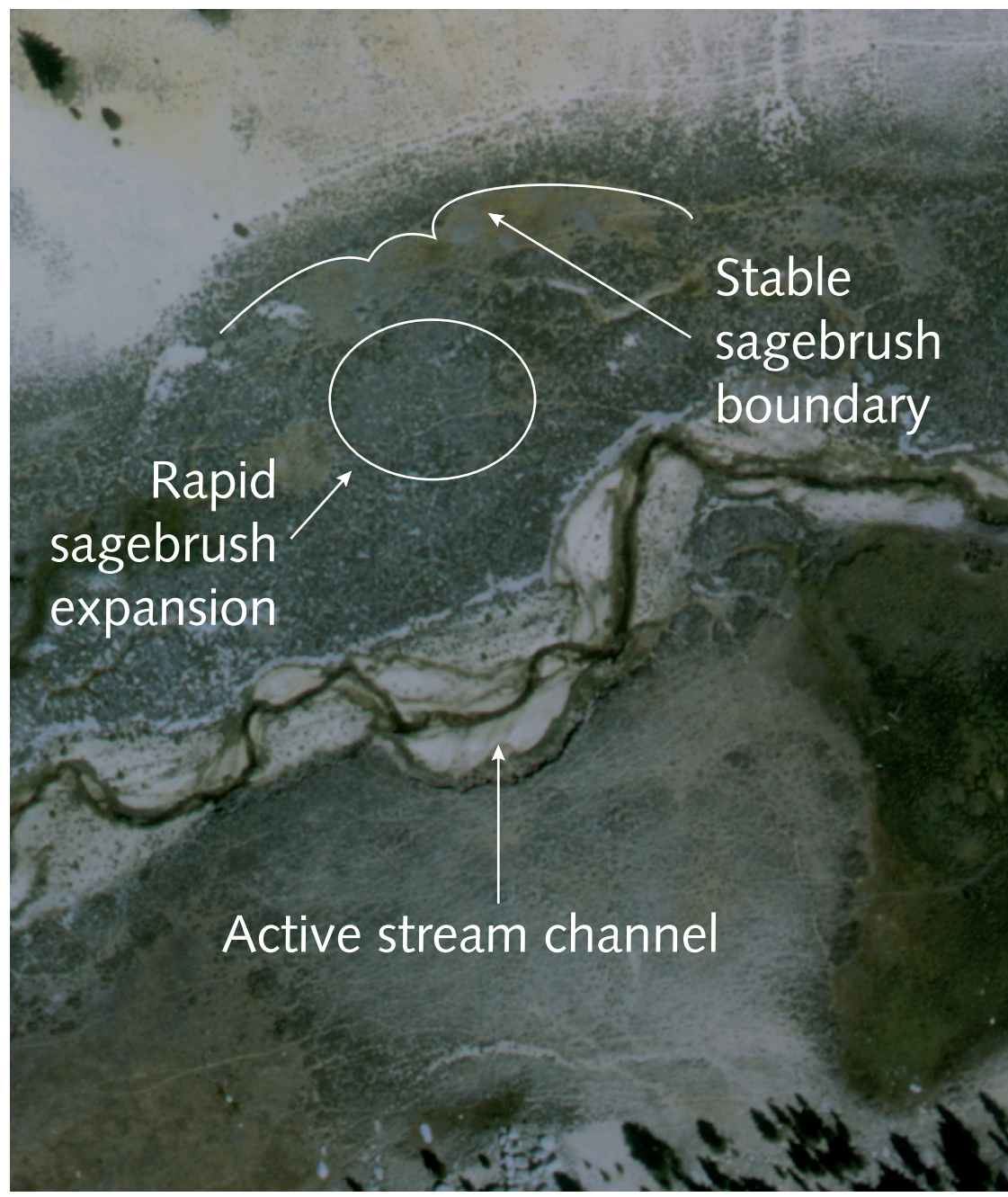
A young sagebrush shrub

## INTRODUCTION

Rothrock sagebrush (*Artemisia rothrockii*) invades montane meadows on the Kern Plateau in the southeastern Sierra Nevada. This semiarid region receives less than 50 cm annual precipitation. Thus, water is an important limiting resource for meadow plants — grasses, forbs, and shrubs. In Sierran meadows, and other systems, invading woody shrubs are frequently associated with soil aridification. This pattern probably occurs because shrubs have deeper roots that allow them to live in drier areas. On the Kern Plateau, grazing by livestock has been associated with stream incision, which lowers the water table and dries out soils, presumably allowing sagebrush invasion. However, this simple explanation cannot account for the whole invasion pattern because Rothrock sagebrush also invades wet areas with shallow water tables. This anomaly led to an alternative hypothesis to explain woody shrub invasion and soil aridification in the meadows. >>



10 September 1974



8 August 1994

AERIAL PHOTOGRAPHS show that within 20 years, a patch of herbaceous meadow was invaded by sagebrush. By contrast, sagebrush on the edge of the meadow has maintained a sharp boundary. The active stream channel is the dark line in the center of the white gravel bar.

# THE EFFECTS OF INVADING YOUNG SAGEBRUSH (*ARTEMISIA ROTHROCKII*) ON AN HERBACEOUS MONTANE MEADOW IN THE EASTERN SIERRA NEVADA

Anthony Darrouzet-Nardi · Carla D'Antonio · Eric Berlow · Heather Swartz

University of California, Berkeley  
Department of Integrative Biology

University of California, Berkeley  
Department of Integrative Biology

University of California, San Diego  
White Mountain Research Station

University of California, Berkeley  
Department of Environmental Science, Policy, & Management



A young sagebrush shrub

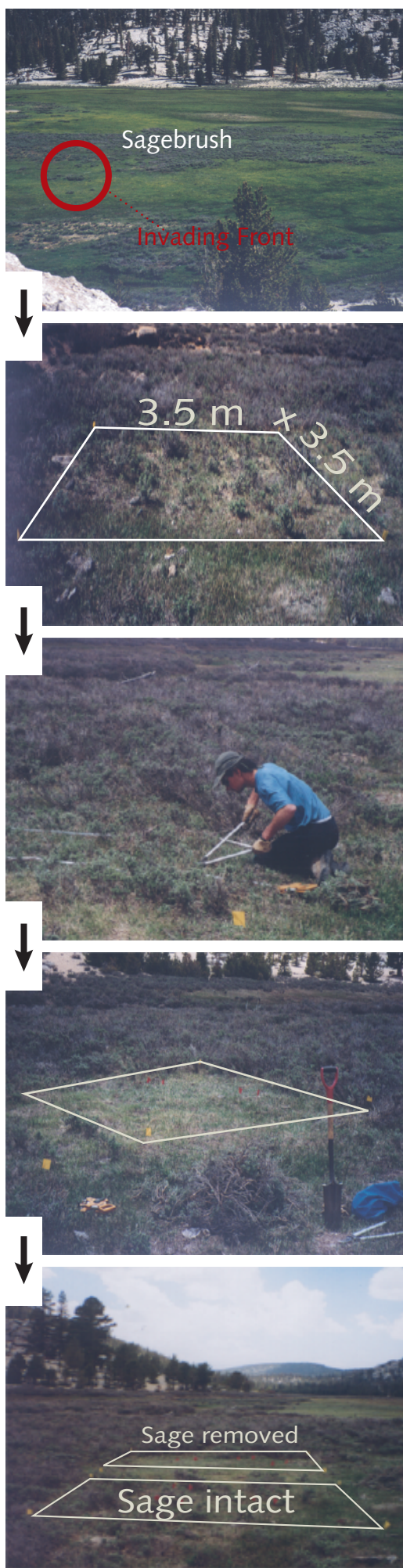
## METHODS

**Question**  
Do young sagebrush shrubs contribute to a net negative water balance or otherwise modify physical conditions in herbaceous montane meadows when they invade?

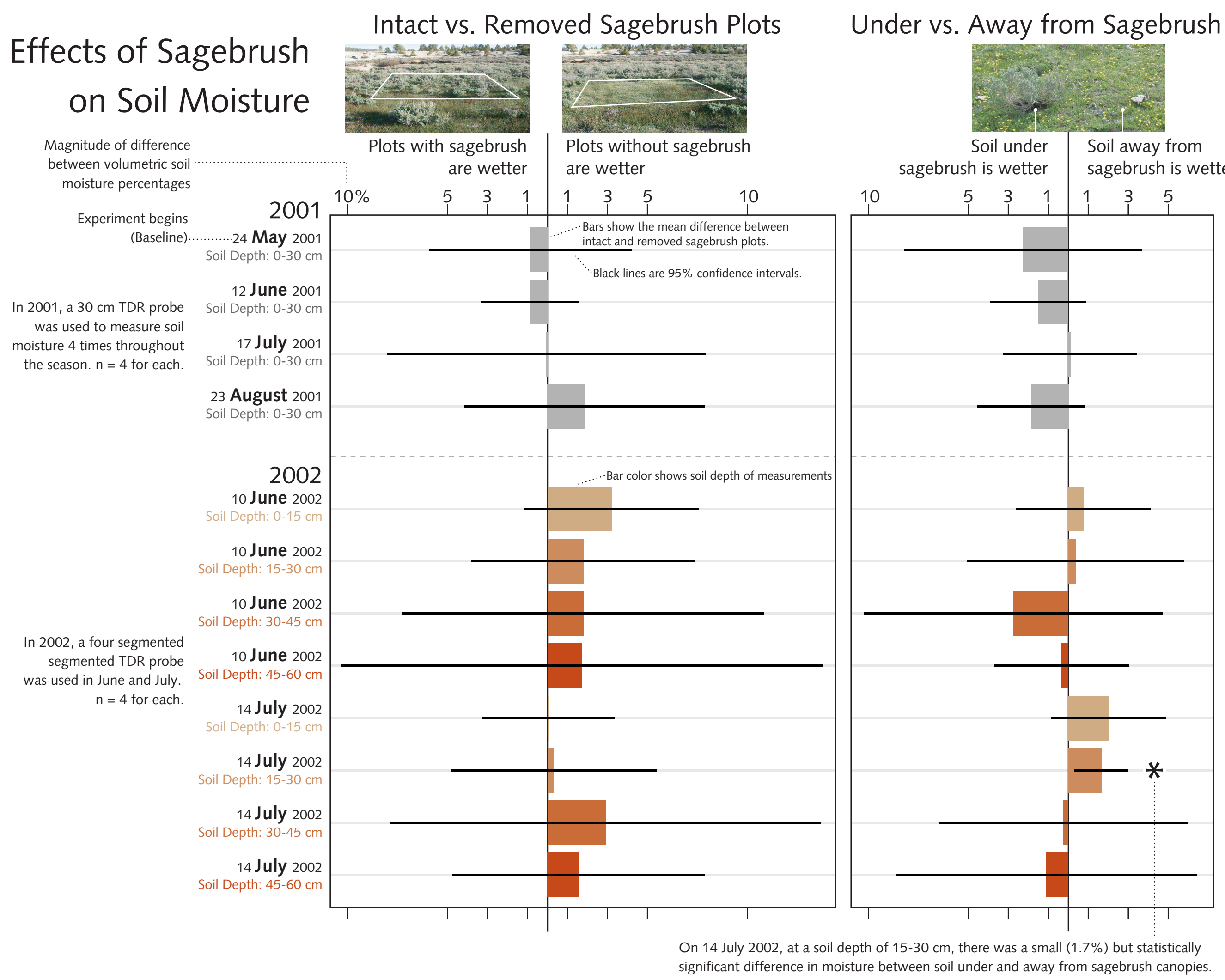
**Hypothesis**  
When young sagebrush shrubs invade herbaceous meadows, they transpire large amounts of water to the disadvantage of resident herbs, thereby creating conditions favoring further sagebrush expansion.

- WE SET UP A REMOVAL EXPERIMENT in Bullfrog Meadow on the Kern Plateau (see map above, left) during summer 2001 to examine the effect that young sagebrush shrubs have on the soil. We manually removed young sagebrush shrubs from 3.5 × 3.5 m plots and compared the plots to adjacent control plots.
- Plots without sagebrush will have higher volumetric soil moisture percentages than plots with sagebrush, especially in surface soil.
- Soil under sagebrush canopies will have higher volumetric soil moisture percentages than soil away from sagebrush canopies.
- These differences will be large enough to negatively affect resident herbs.

- WE USED TIME DOMAIN REFLECTOMETRY (TDR) probes to measure volumetric soil moisture. Measurements were made under and away from three random shrubs in intact sagebrush plots and at three random locations in removed sagebrush plots. In 2001, we used a TDR probe with a single 30 cm segment. In 2002, we used a TDR probe with four 15 cm segments. >>



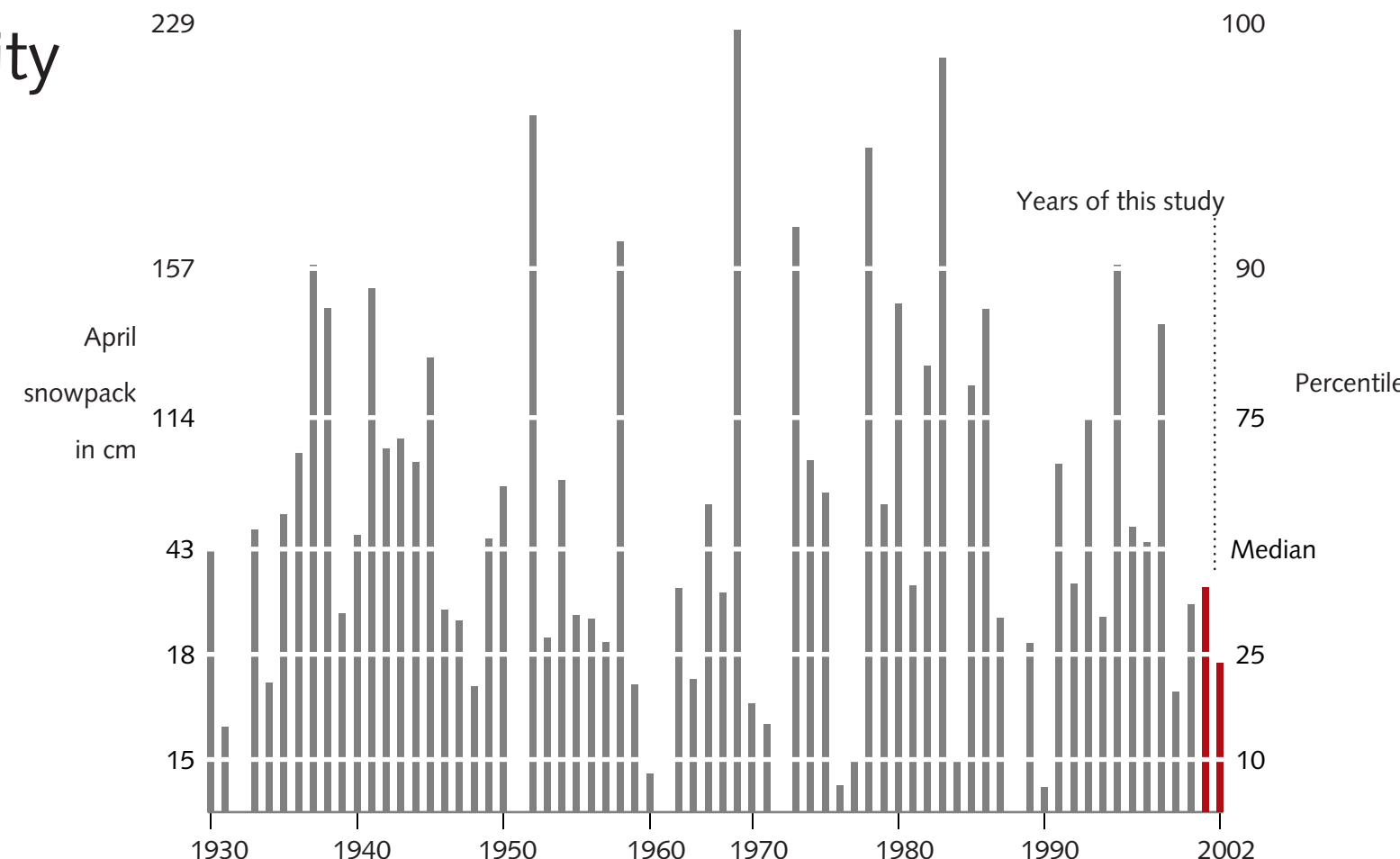
## RESULTS



- SAGEBRUSH DID NOT DRY OUT THE SOIL in plots with intact sagebrush at any time during the season or at any soil depth. It also did not dry out soil under its canopy except during July 2002 at 15-30 cm deep. Even then, the difference in soil moisture created by sagebrush (1.7%) was much smaller than the average variability *within* 3.5 × 3.5 m plots (2-8%) or *among* them (5-29%). It is also much less than seasonal variability. Both years of this study were relatively dry, but still there was a difference of 12% in volumetric soil moisture between June 2001 and June 2002 and a difference of 16% between July 2001 and July 2002. Invading young sagebrush does not transpire enough water to have a large impact on available water in the meadow. >>

### Seasonal Variability

APRIL SNOWPACK for nearby Ramshaw meadow is shown from 1930 to the present. Seasonal variability in water availability is high: 2001 and 2002 both had below average snowpacks (45th and 25th percentiles).



## CONCLUSIONS

- MEADOW SOIL MOISTURE LEVELS are highly variable seasonally and on the spatial scale of this study (3.5 meters within blocks and 50-100 meters among them). The effect that young sagebrush has on soil moisture is small compared to this variability. Sagebrush is not accelerating its own invasion by drying out the soil. Large-scale hydrological changes such as descending water tables and smaller-scale fluctuations in underground water sources and flow rates are more significant factors than sagebrush transpiration in determining water availability.
- THIS STUDY UNDERSCORES the importance of hydrology in understanding woody shrub invasions in semiarid grasslands. Berlow et al. (2002) show that sagebrush cannot establish in dense herbs. Because invading sagebrush fronts will not reduce herb density by competing for water, hydrological processes which reduce water availability and thin herbs are very important for sagebrush establishment. Gophers and alluvial deposits also thin herbs which probably accounts for the anomalous invasion of sagebrush in wet meadows with high water tables. But this study suggests that sagebrush will not dry out those sites if hydrology stays constant.
- MANY INVADING SHRUBS modify conditions and resource levels in areas that they invade. However this may or may not accelerate the rate of the invasion. In this system, sagebrush does not reduce soil water availability early enough to accelerate its own invasion. Even if mature sagebrush stands can reduce water availability it would only allow sagebrush to maintain its dominance. Determining at what stage invaders modify conditions and resource levels is important in understanding the rate of an invasion. ■

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