ENHANCING UNDERSTANDING OF EVAPOTRANSPIRATION FROM NATURAL SURFACES IN THE UPPER KLAMATH BASIN

KLAMATH FALLS, OREGON, FEBRUARY 4, 2004

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EVAPOTRANSPIRATION

- The vaporization and gaseous transfer to the atmosphere of H_2O from any of various water (or ice) sources at or near the surface of the earth.
- Often the greatest water loss from terrestrial ecosystems.
- Understanding evapotranspiration helps for understanding water balances and ground-water recharge.

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EVAPOTRANSPIRATION: A SIMPLE EQUATION

$$E = \frac{\rho_{vs} - \rho_{va}}{r_v}$$

ρ_{vs} - Water vapor density at the source.

ρ_{va} - Water vapor density at the atmospheric reference.

r_v - Transfer resistance to water vapor.

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ESTIMATING EVAPOTRANSPIRATION I: MODELING

Any technique that computes evapotranspiration using equations employing environmental variables and empirically valuated, surface-specific coefficients.

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ESTIMATING EVAPOTRANSPIRATION I: MODELING

$$E_t = k_c \bullet E_{tr}$$

k_c - Empirically valuated coefficient.

E_{tr} - Reference evapotranspiration, a function of environmental variables.

Some techniques for computing E_{tr} :

- Blaney-Criddle
- Pan evaporation techniques
- Penman
- Penman-Monteith

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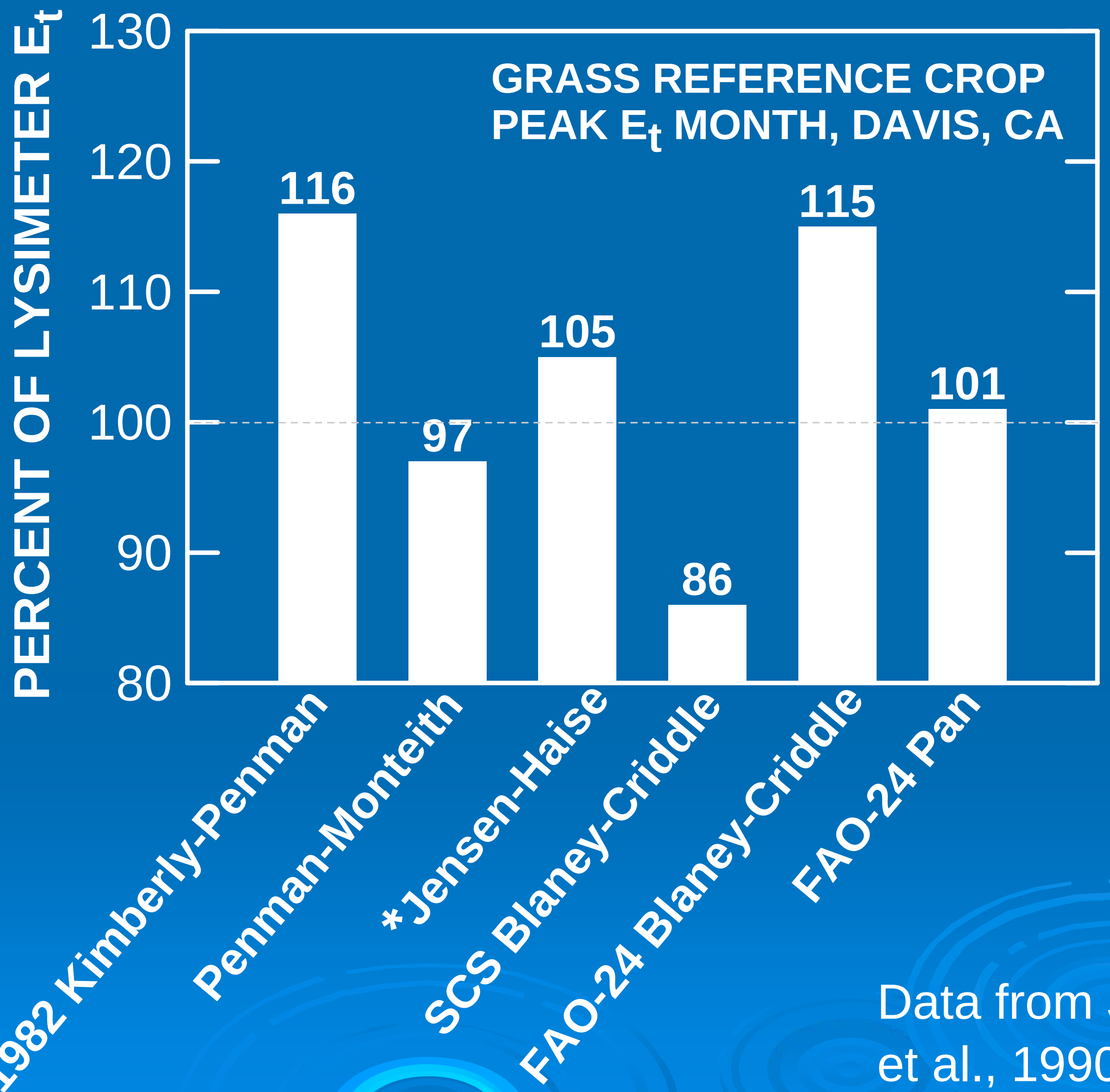
COMPUTED REFERENCE E_t IS METHOD DEPENDENT



Data from Jensen et al., 1990

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ESTIMATING EVAPOTRANSPIRATION II: MEASUREMENT

Any technique that computes evapotranspiration using measurements and fundamental principles (e.g. conservation of mass) without reliance on empirically valuated, surface-specific coefficients.

ESTIMATING EVAPOTRANSPIRATION II: MEASUREMENT

ENERGY BALANCE TECHNIQUES

- Bowen ratio energy balance technique

MASS BALANCE TECHNIQUES

- Lysimeters, *in situ* canopy and soil water balance techniques

TECHNIQUES BASED ON TURBULENCE MEASUREMENTS

- Eddy correlation (covariance) techniques

BOWEN RATIO ENERGY BALANCE

Equation for the surface energy balance

$$R_n - G - H - \lambda E = 0$$

R_n - Net radiation

G - Soil heat flux

H - Sensible heat flux

λE - Latent heat flux

E - Evapotranspiration

λ - Latent Heat of vaporization for water

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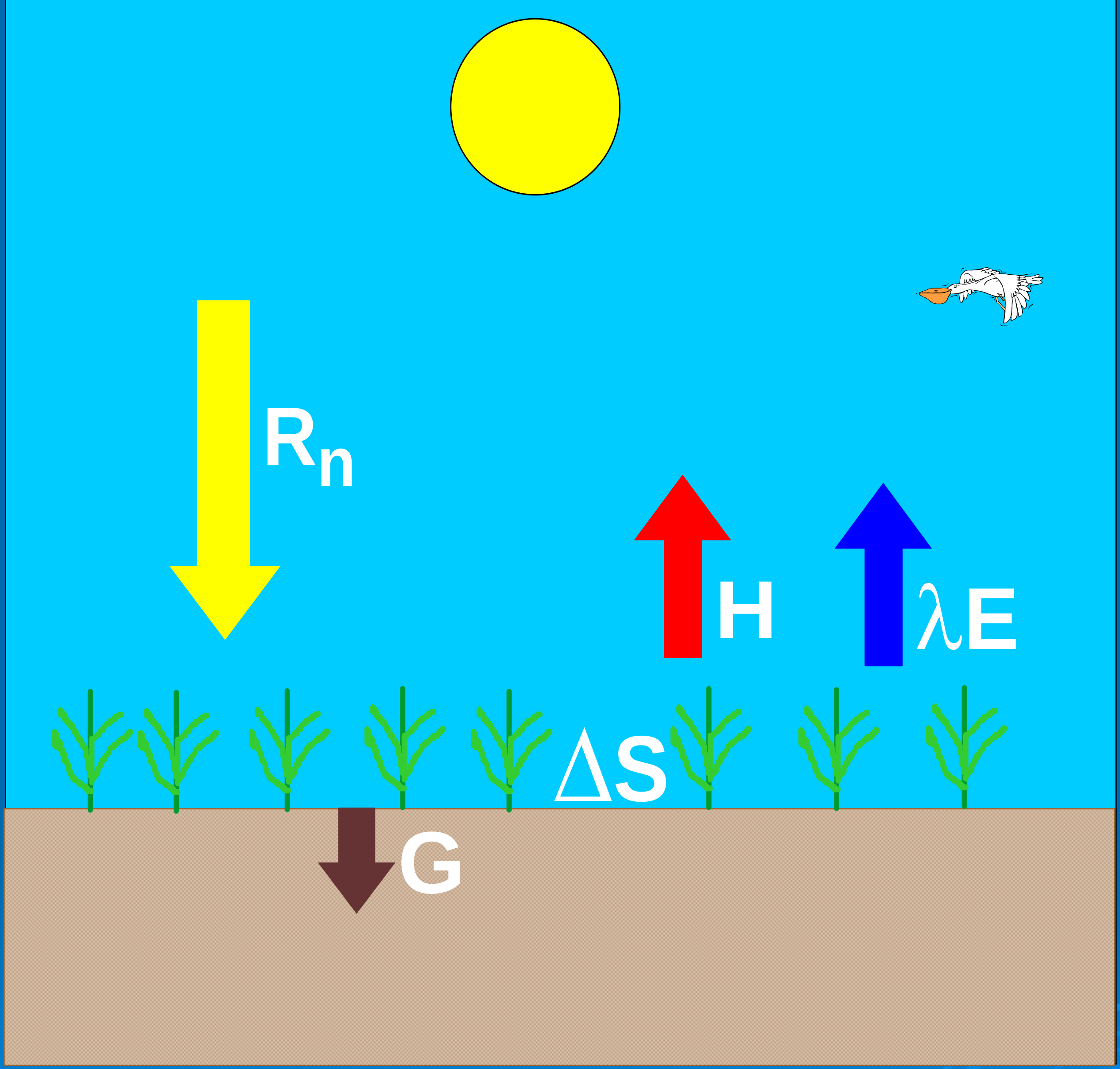

$$R_n - G - \Delta S - H - \lambda E = 0$$

BOWEN RATIO ENERGY BALANCE

The Bowen ratio

$$\beta = H/\lambda E = \gamma \Delta T/\Delta e$$

- γ - Psychrometer constant
- ΔT - Vertical air-temperature difference
- Δe - Vertical vapor-pressure difference

Latent heat flux

$$\lambda E = (R_n - G - \Delta \mathbf{S})/(1+\beta)$$

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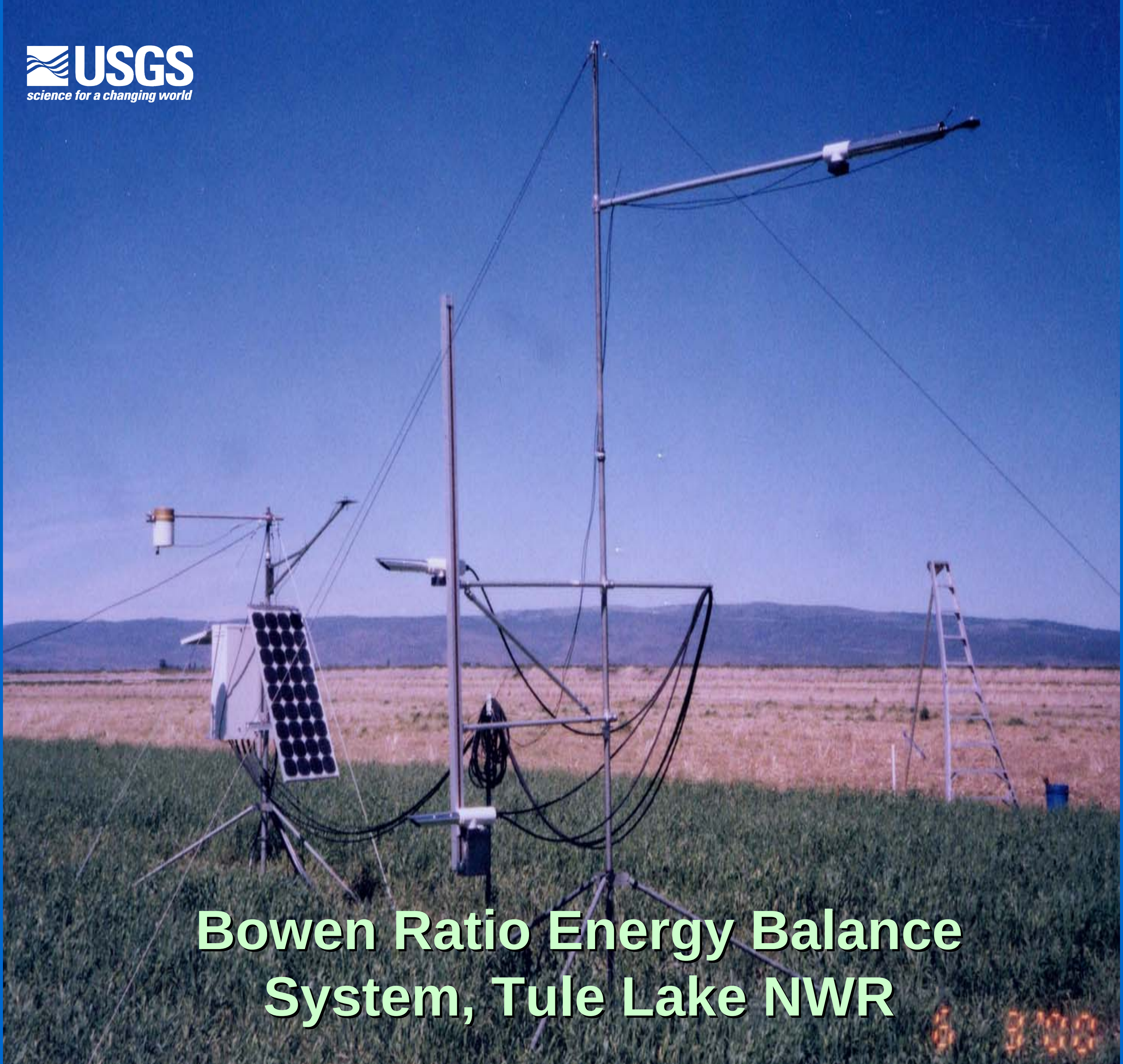
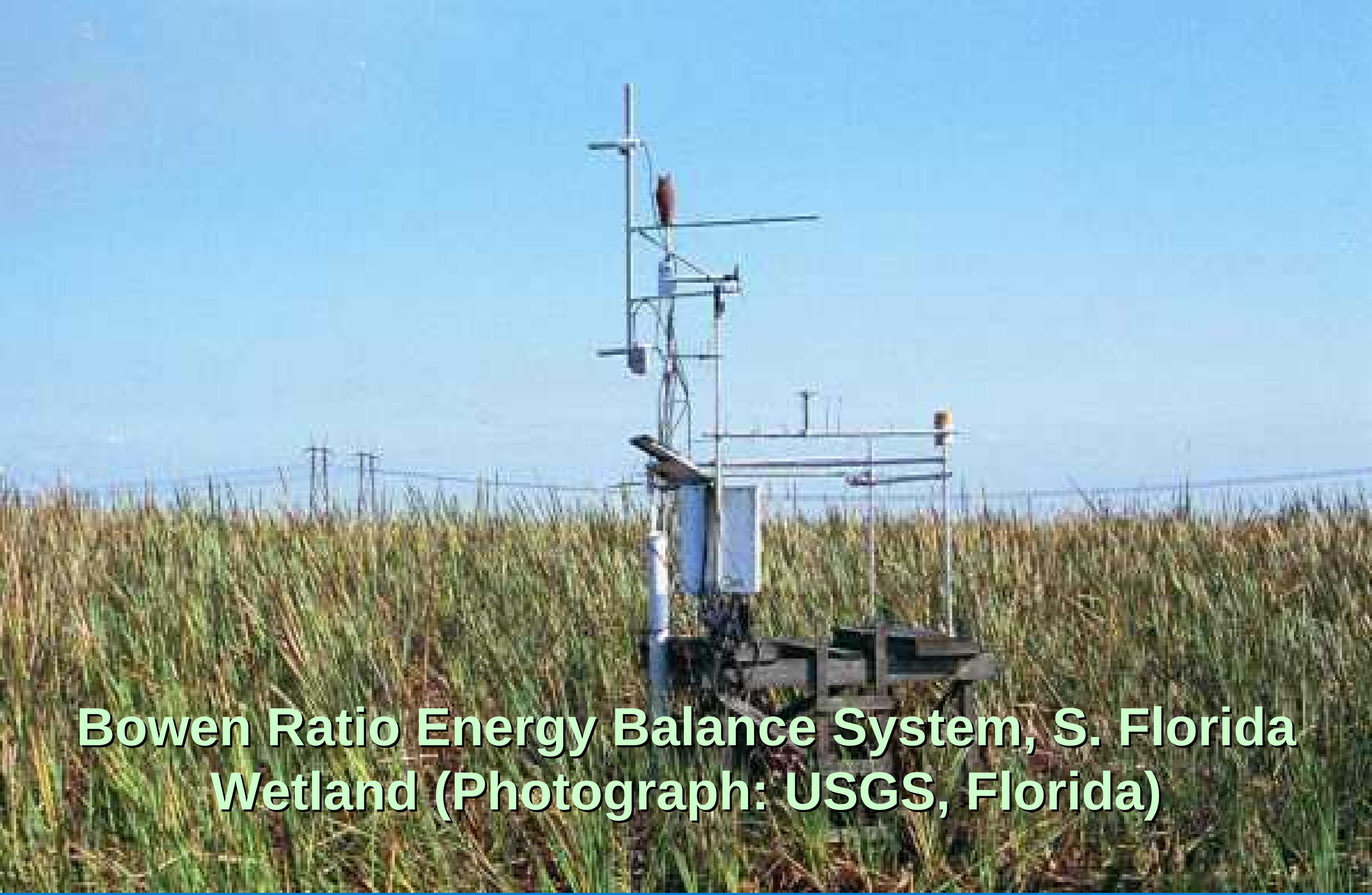
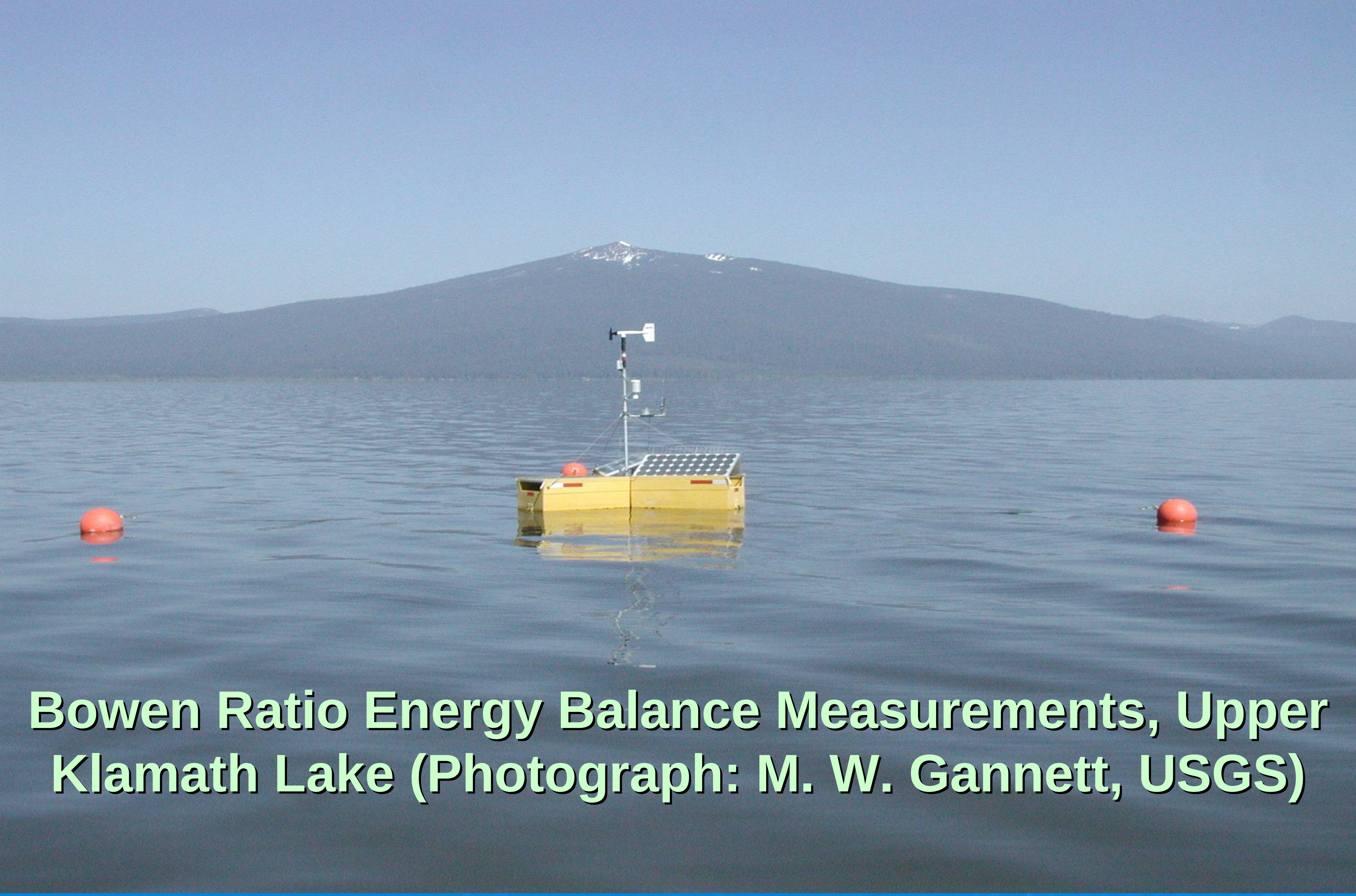


Bowen Ratio Energy Balance System, Tule Lake NWR



Bowen Ratio Energy Balance System, S. Florida Wetland (Photograph: USGS, Florida)



Bowen Ratio Energy Balance Measurements, Upper Klamath Lake (Photograph: M. W. Gannett, USGS)

EDDY CORRELATION

Turbulent flux of water vapor:

$$E = \overline{w'\rho_v'}$$

w' - Instantaneous vertical wind speed

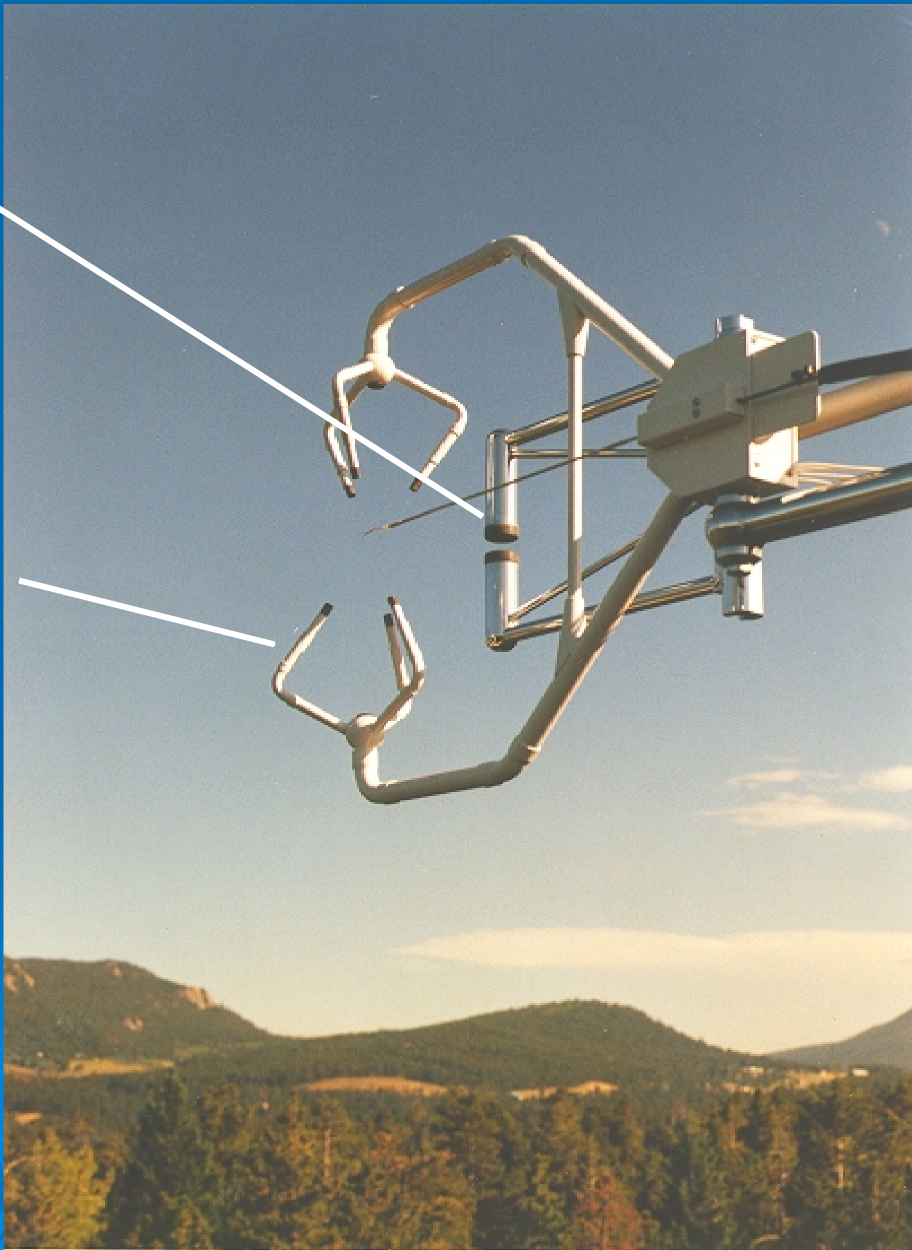
ρ_v' - Instantaneous vapor density

$\overline{\quad}$ - Indicates time averaging

EDDY CORRELATION SYSTEM

Fast-response hygrometer

Fast-response anemometer



Photograph: D. I. Stannard, USGS

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MEASURING FOREST E_t, COLORADO

Tower-Based Eddy Correlation System

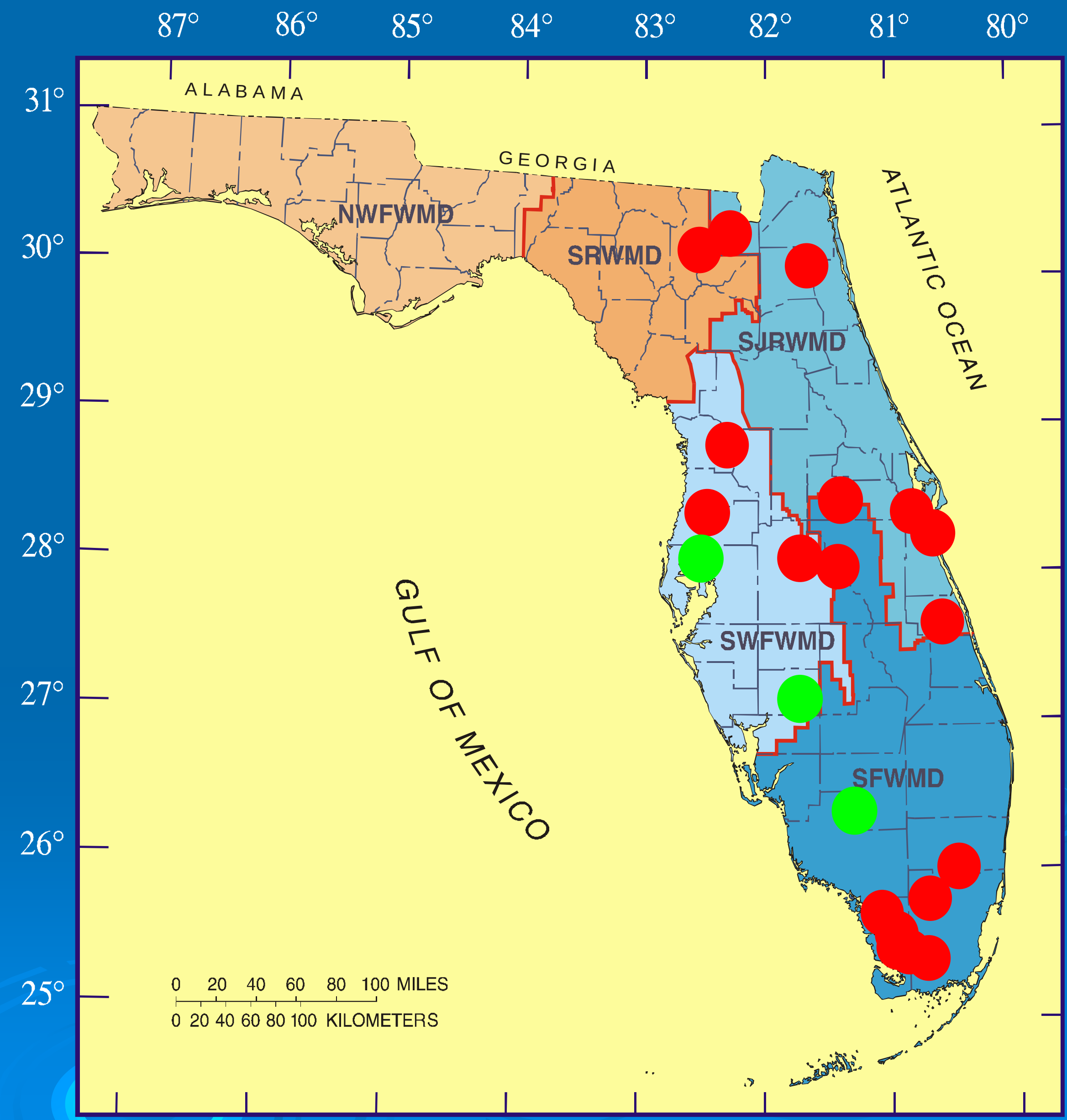
Photograph: D. I. Stannard, USGS

EDDY CORRELATION MEASUREMENTS AT UPPER KLAMATH NWR

MEASURING FOREST INTERCEPTION LOSS

FLORIDA E_t NETWORK 2004

- ● PLANNED
- ● INSTALLED



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ADVANTAGES AND DISADVANTAGES OF EVAPOTRANSPIRATION MODELING AND MEASUREMENT

TECHNIQUES	ADVANTAGES	DISADVANTAGES
MODELING	MODEST DATA REQUIREMENTS RELATIVELY EASY TO APPLY	UNCERTAINTY ABOUT COEFFICIENTS AND E_{tr} LOCAL CALIBRATION MIGHT BE NEEDED
MEASUREMENT	NO CALIBRATION NEEDED	DIFFICULT AND EXPENSIVE LACK OF DATA CONTINUITY

STRATEGY TO COMBINE E_t MEASUREMENT AND MODELING

- Make intermittent E_t measurements at suitable sites.
- Evaluate data and use it to calibrate empirically based E_t models.
- Use calibrated E_t models for time and space extrapolation.
- Test models using additional intermittent E_t measurements, if possible.

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EVAPOTRANSPIRATION FROM CALIBRATED DAILY PRIESTLEY-TAYLOR MODEL

Selected Klamath Basin Wetlands, May 1 to October 31

WETLAND SITE / YEAR	INUNDATION	VEGETATION	E_t feet
KLAMATH MARSH NWR / 1996	SEASONAL	GRASSES, SEDGES, BULRUSH	2.3
KLAMATH MARSH NWR / 1996	SEASONAL	BULRUSH, CATTAIL	2.2
LOWER KLAMATH NWR / 1996	SEASONAL	BULRUSH, CATTAIL	2.3
KLAMATH MARSH NWR / 1997	SEASONAL	BULRUSH, CATTAIL	3.0
UPPER KLAMATH NWR / 1997	PERENNIAL	BULRUSH, CATTAIL	2.3

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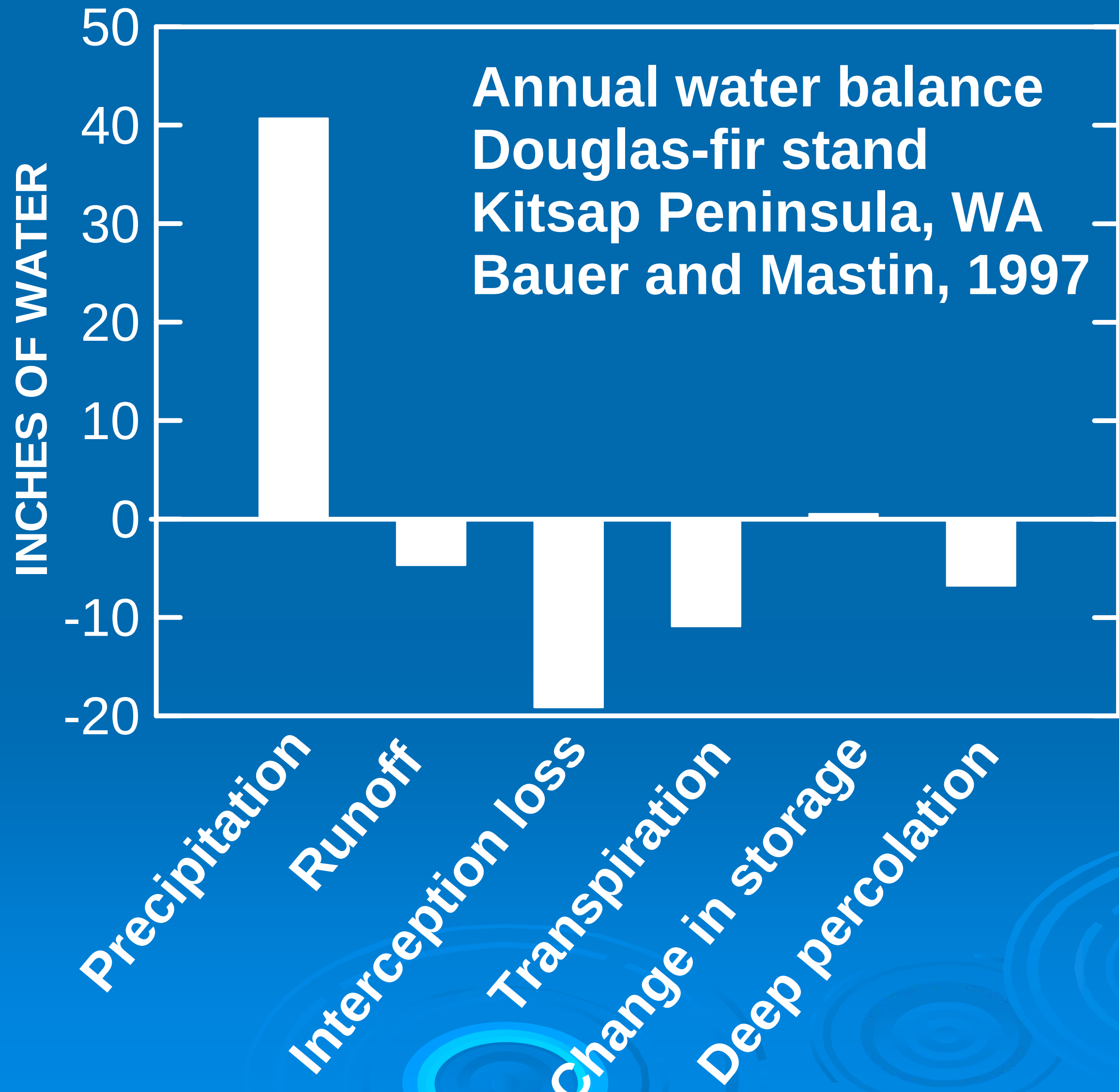
FORESTS AFFECT THE WATER BALANCE



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SUMMARY

- Better estimates of E_t from wetlands, waters, forests, and other natural surfaces will improve understanding of water balances and ground-water recharge in the Upper Klamath Basin.
- E_t measurement techniques are applicable to many types of natural surfaces.
- E_t modeling and measurement can be complementary.

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END