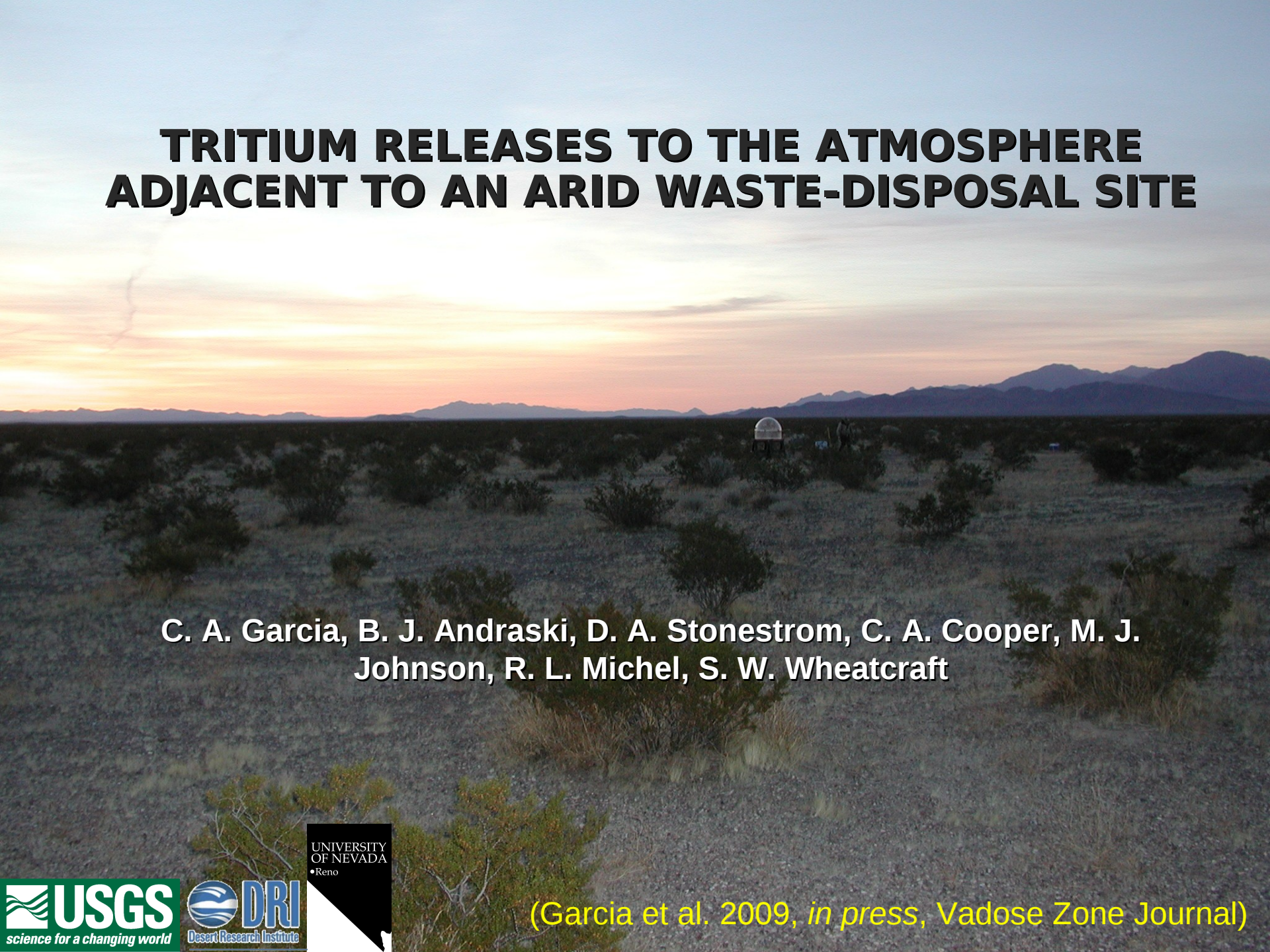
TRITIUM RELEASES TO THE ATMOSPHERE ADJACENT TO AN ARID WASTE-DISPOSAL SITE



C. A. Garcia, B. J. Andraski, D. A. Stonestrom, C. A. Cooper, M. J. Johnson, R. L. Michel, S. W. Wheatcraft

USGS science for a changing world

DRI Desert Research Institute

UNIVERSITY OF NEVADA •Reno

(Garcia et al. 2009, *in press*, Vadose Zone Journal)

Desert Soil-Plant-Atmosphere Interactions

- Strongly influence subsurface water movement (liquid & vapor) (Gee et al. 1994; Andraski 1997)
- Little known about
  - Effect on release of water-borne contaminants to atmosphere
  - Remediation potential of native plants

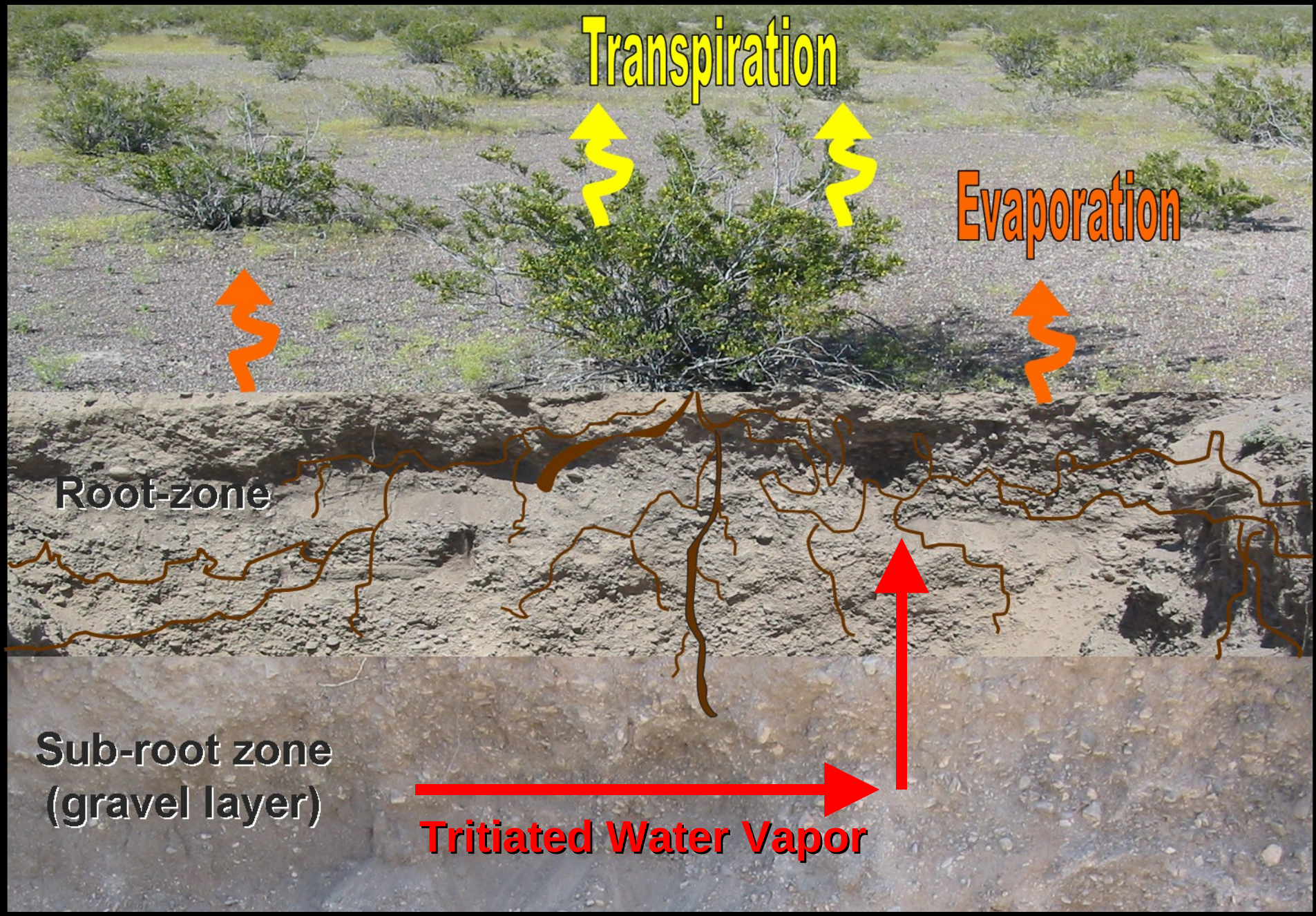
Objective

- Estimate the magnitude and spatio-temporal variability of tritium transport from the shallow unsaturated zone to the atmosphere

USGS science for a changing world

DRI Desert Research Institute

UNIVERSITY OF NEVADA •Reno


Transpiration
Evaporation
Root-zone
Sub-root zone
(gravel layer)
Tritiated Water Vapor

EXPERIMENTAL APPROACH

Tritium flux to the atmosphere ...

product of tritium concentrations and ET fluxes

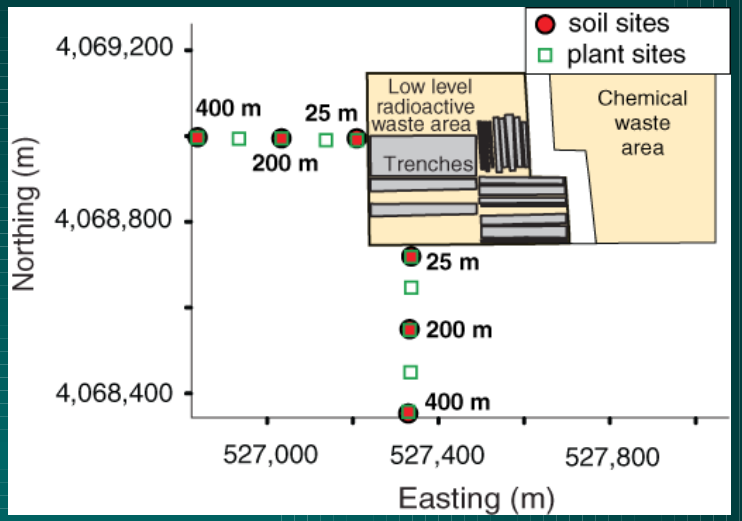
- **Tritium measured in**
  - **Soil – vapor extraction**
  - **Plants – toluene extraction**

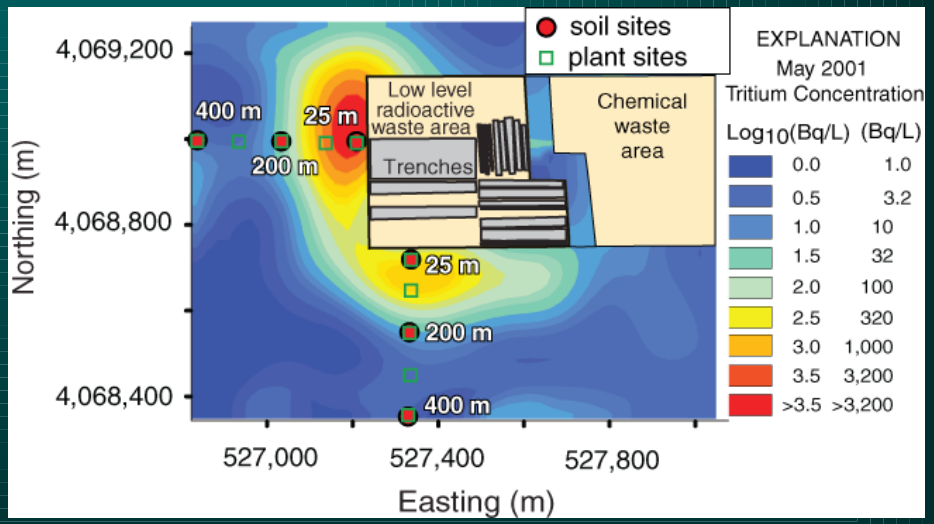
- **ET partitioned into bare-soil E and plant T**

EXPERIMENTAL APPROACH

- Tritium Concentrations
  - Sampled quarterly
    - August 2003–05
  - Spatially extrapolated
    - 0.76 km² study area
    - Base map May 2001

      (Andraski et al. 2005)
  - Temporally interpolated
  - Converted to mass fraction (X)





EXPERIMENTAL APPROACH CONT.

Continuous ET partitioned: ET = E + T

- ET: measured eddy-covariance
- E = E_s x %soil cover
  - E_s - Chamber measurements
    - Priestley-Taylor model
- T: computed as ET - E

- % soil cover interpolated from quarterly plant-&-soil transect data

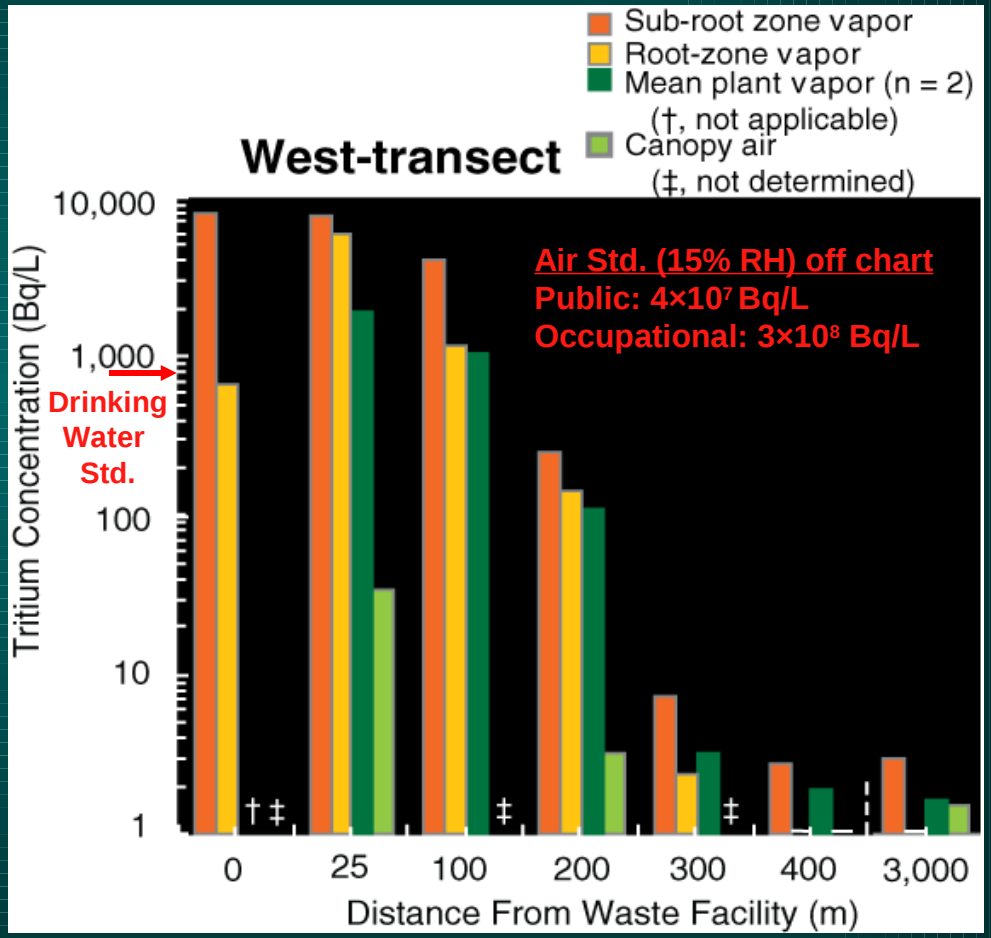
USGS science for a changing world

DRI Desert Research Institute

UNIVERSITY OF NEVADA •Reno

RESULTS – Tritium Concentrations Spatial Distributions

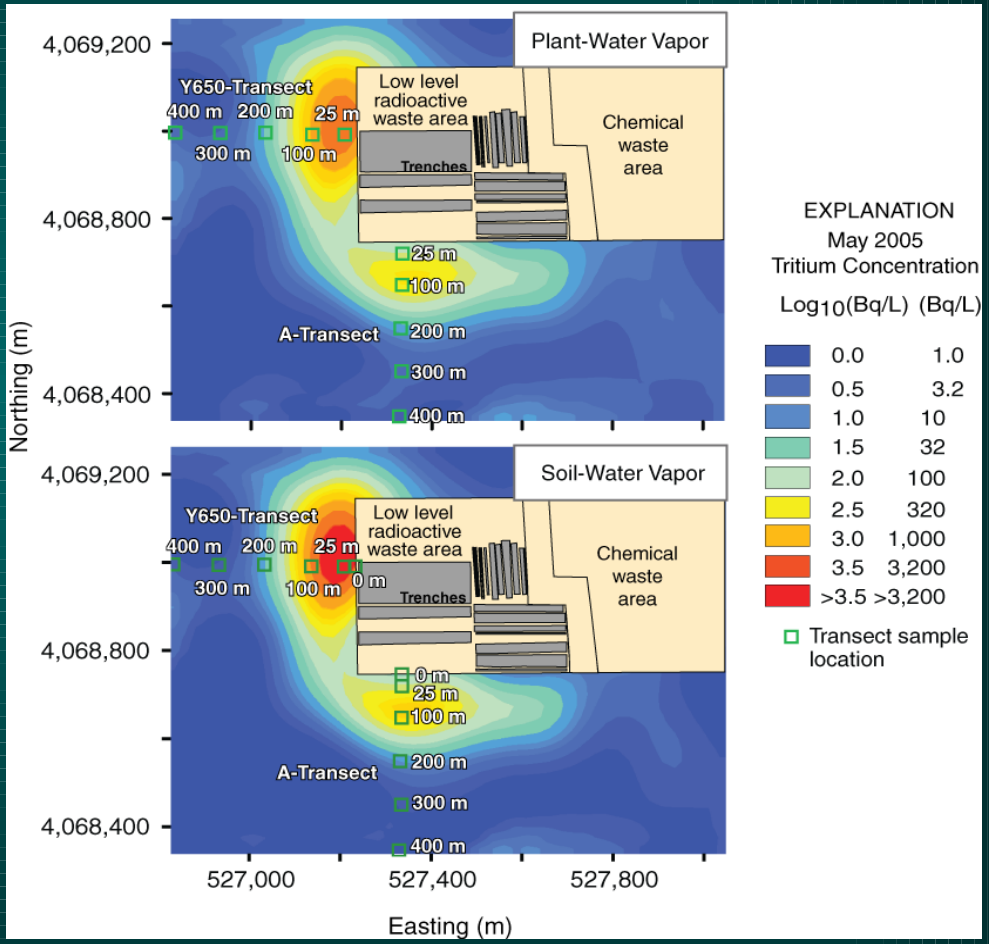
- **Measured Concentrations**
  - **Decrease from sub-root zone to canopy**
  - **Decrease with distance from facility**
  - **Background at >300 m**



(Garcia et al. 2009, *in press*)

RESULTS – Tritium Concentrations Spatial Distributions

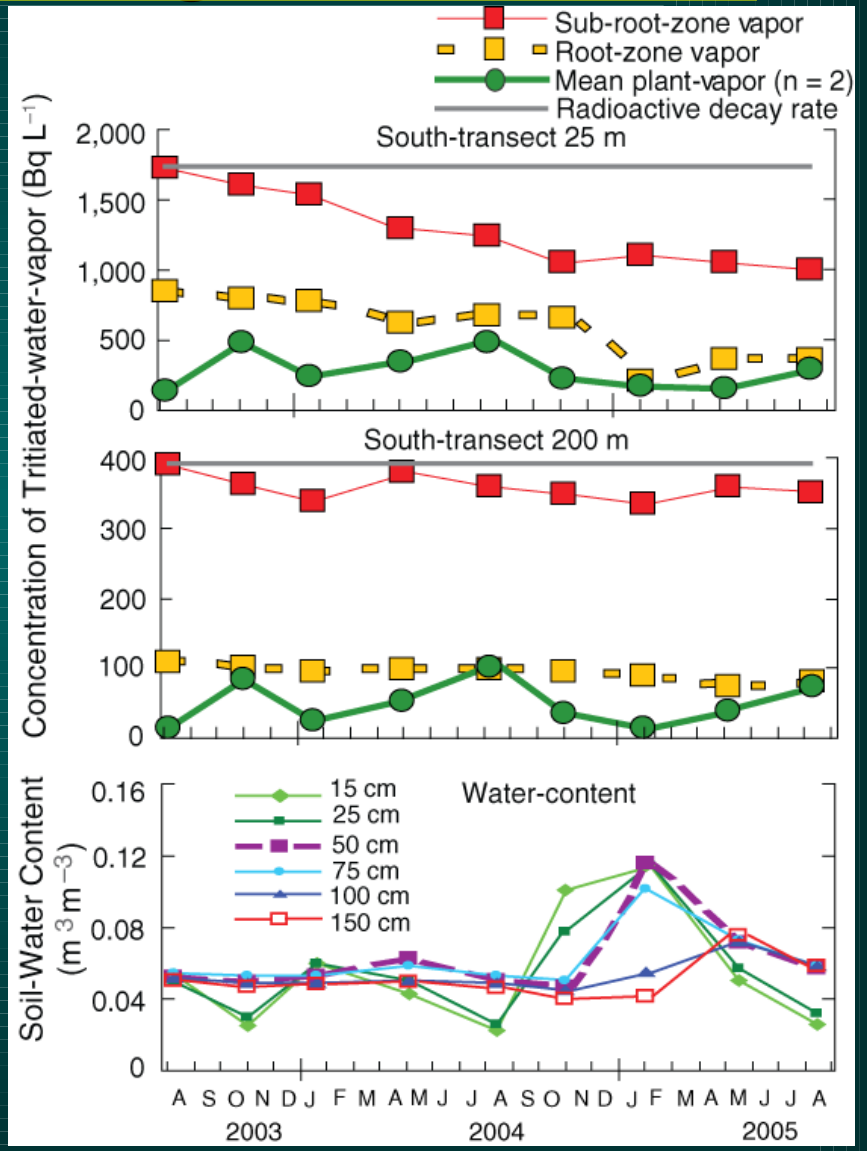
- Concentration Distributions
  - Reflect measurements
  - Pattern consistent for all quarters



(Garcia et al. 2009, *in press*)

RESULTS – Tritium Concentrations Temporal Changes

- Sub-root-zone gravel
  - Long-term decrease near facility
  - Indicate plume movement with time
- Root-zone
  - Similar to sub-root zone
  - Short-term variations
- Plants
  - No long-term trends
  - Variation generally follows inverse of change in soil moisture



(Garcia et al. 2009, *in press*)

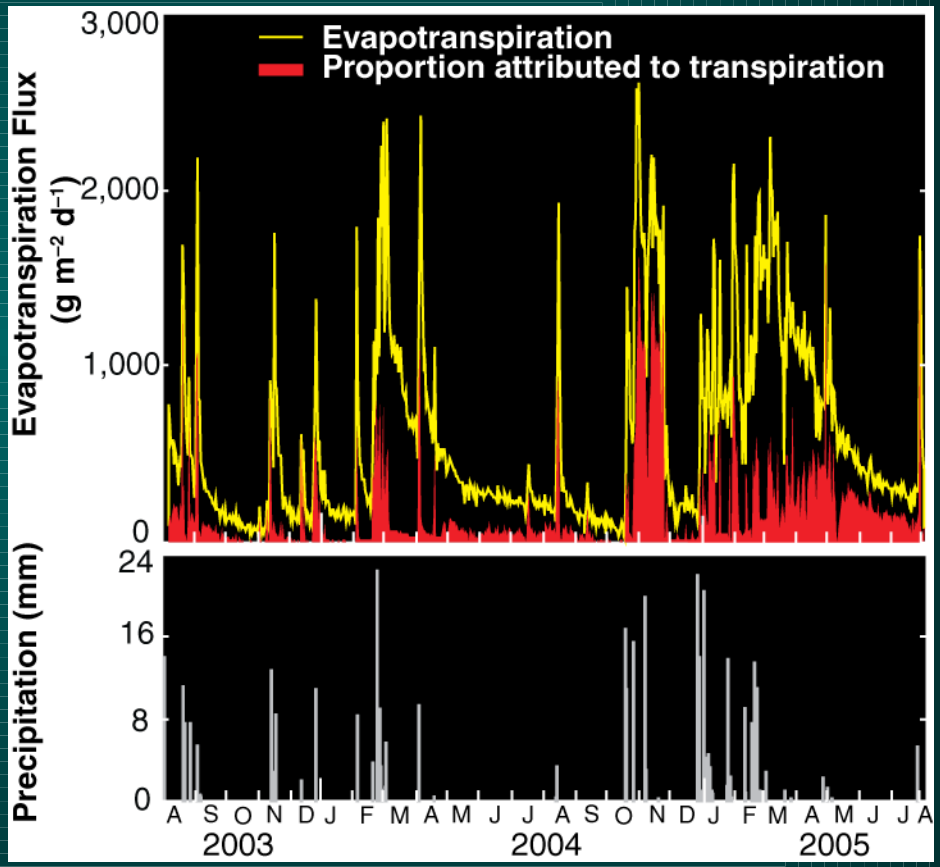
USGS science for a changing world

DRI Desert Research Institute

UNIVERSITY OF NEVADA •Reno

RESULTS – Partitioned Evapotranspiration

- ET
  - Similar to total precipitation
  - Lack of seasonality
  - Large increases with precipitation
  - Year 2 = twice year 1
- Average E:T = 70:30 %
- Proportion of T increased in year 2



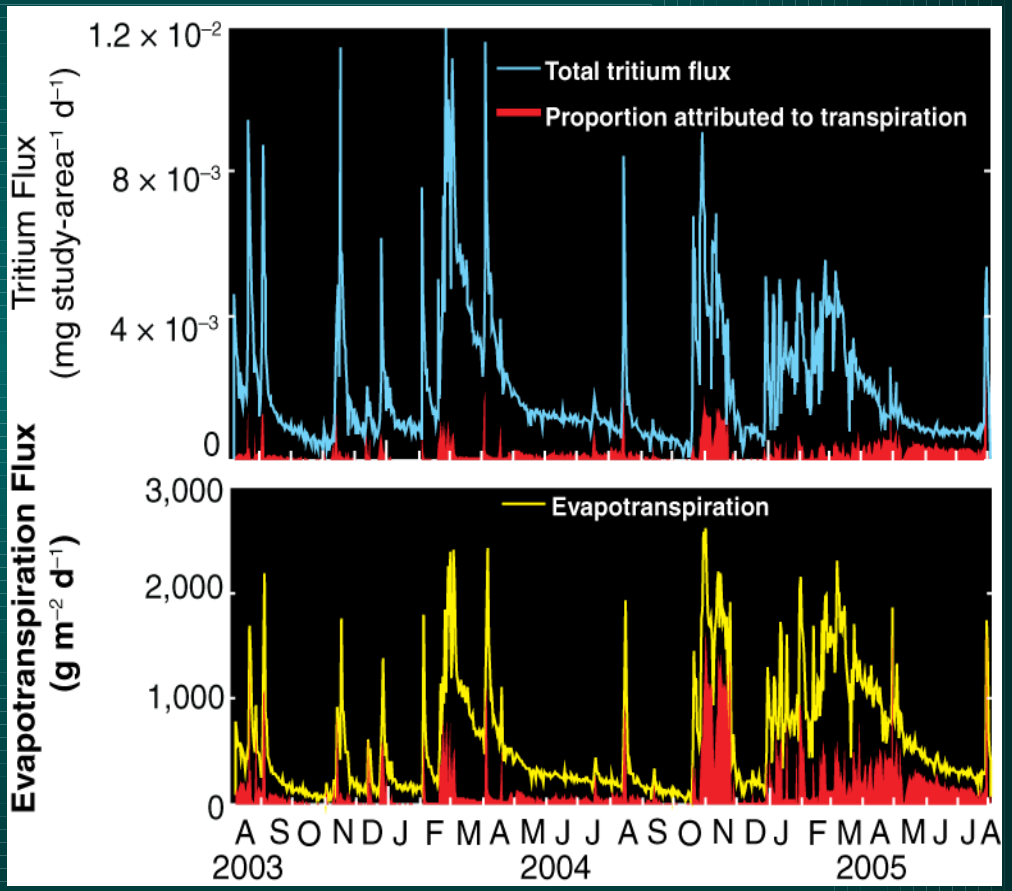
(Garcia et al. 2009, *in press*)

RESULTS – Tritium Flux Temporal Variability

Tritium concentrations × ET fluxes

- Magnitude of tritium flux affected by changes in
  - Soil & plant concentrations
  - Proportioning between soil E & plant T
- Tritium flux on average:
  - 85% attributed to E
  - 15% attributed to T
- Both short- & long-term variations
  - Annual tritium flux:

    Year-1 was 15% > Year-2



(Garcia et al. 2009, *in press*)

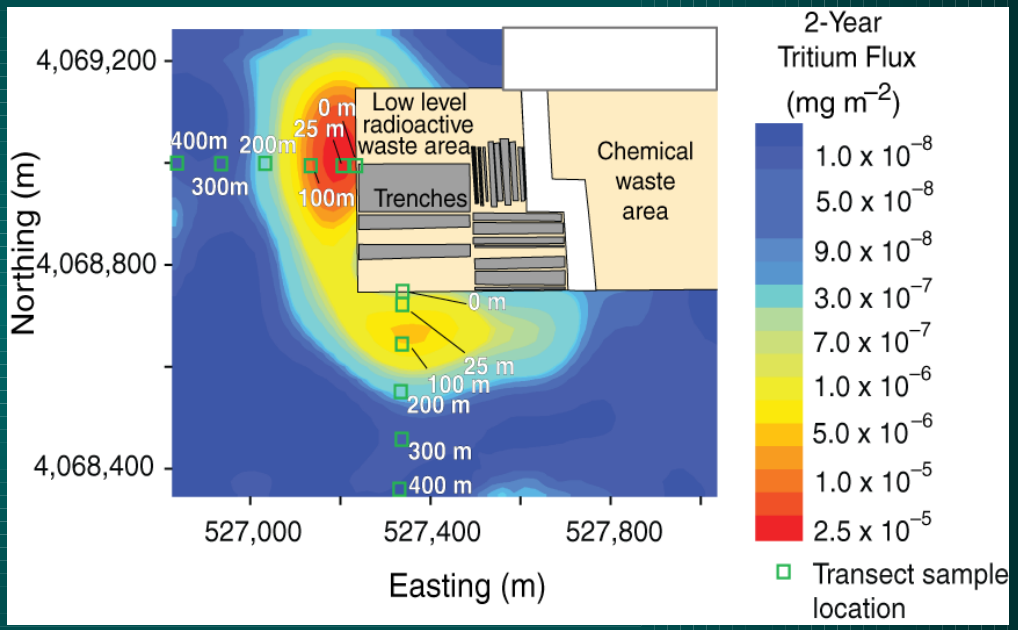
USGS science for a changing world

DRI Desert Research Institute

UNIVERSITY OF NEVADA •Reno

RESULTS – Tritium Flux
Spatial Variability – 2-Year Distribution

- Two "hotspots"
  - Represent 20% of study area
  - Contribute 90% of 2-year tritium flux
- Total mass of tritium released = 1.5 mg
  (8×10^{10} Bq; 2×10^{12} pCi)
  - 0.002% of the residual disposed tritium



(Garcia et al. 2009, *in press*)

IMPLICATIONS – Remediation

- 2-year flux (1.5 mg) ~ 0.002% of disposed tritium
  - Extrapolate into the future
    - 13 mg of tritium over 40 yrs (7×10^{11} Bq; 2×10^{13} pCi)
    - ~0.05% of remaining tritium
    - Total mass of tritium in atmospheric reservoir (Aug. 03 on)
      - Reaches a maximum of 5.6 mg in 2021 (3×10^{11} Bq; 8×10^{12} pCi)
- Plume movement
  - Concentrations nearest the source have reached peak values and are declining
  - Contaminant plumes advancing but decaying

(Garcia et al. 2009, *in press*)

IMPLICATIONS – Waste Disposal

- Devegetated soil covers
  - Enhanced accumulation of precipitation
    - Increases potential for downward tritium transport
    - Hinders upward vapor transport of contaminants
      - May play a role in unexplained long distance, lateral migration of contaminants (Andraski et al. 2005; Mayers et al. 2005)
- Arid site waste isolation – high ET / low precipitation
  - Diminished with
    - Precipitation and runoff into open trenches
    - Disposal of liquid contaminants in unlined trenches

(Garcia et al. 2009, *in press*)

CONCLUSIONS

- Complex soil-plant-atmosphere interactions control tritium release to the atmosphere
- Remediation through desert ET removed 1.5 mg (8×10^{10} Bq; 2×10^{12} pCi) of tritium from the 0.76 km^2 study area in 2 years
- Results improve understanding of near-surface processes controlling subsurface transport and release of contaminants to the atmosphere

USGS science for a changing world

DRI Desert Research Institute

UNIVERSITY OF NEVADA •Reno

(Garcia et al. 2009, *in press*)


THANK YOU
USGS
science for a changing world
DRI
Desert Research Institute
UNIVERSITY
OF NEVADA
•Reno