U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: DESERT ECOSYSTEM WATER DYNAMICS UNDER VARIOUS THERMAL SCENARIOS

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Presentation Outline

- Delineation of impact
- Significance of impact
- State-of-knowledge on significance
- Uncertainties in state-of-knowledge
- Resolution of uncertainties
- Residual uncertainties
- Conclusions

Delineation of Impact

Increased soil temperature

- Most probable increase is 1.0-1.5°C
- Maximum temperature increase expected is <6°C
- Increased surface temperature to be seen on 2.3-3.0 sq. mi.
- Temperature increase to begin about 1,000 years after initial emplacement
- Temperature maximum obtained 2,000-3,000 years after initial emplacement
- Temperature to gradually reduce 2,000-3,000 years after initial emplacement

Significance of Thermal Loading on Biological Resources

- Dependent on magnitude of temperature increase
  - < 2°C = minimal impact
  - 2-6°C = moderate to large impact
- Altered water-mass balance
- Altered timing of biological processes
- Destabilization of system

Significance of Thermal Loading on Biological Resources

(Continued)

Altered water-mass balance

- Evaporation
- Transpiration
- Available water for biological processes

Significance of Thermal Loading on Biological Resources

(Continued)

Altered timing of biological processes

- Species use environmental cues to initiate phases

- Asynchrony of processes
  - Breaking seed dormancy
  - Emergence from hibernation
  - Pollination

- Insufficient time to complete processes
  - Reduced growing season/activity period
  - Reduced resources

Significance of Thermal Loading on Biological Resources

(Continued)

Destabilization of system

- Limiting factors/threshold limits
- Enhancement of other detrimental processes
  - Decomposition of organic matter
  - Enhance pathogens/pests

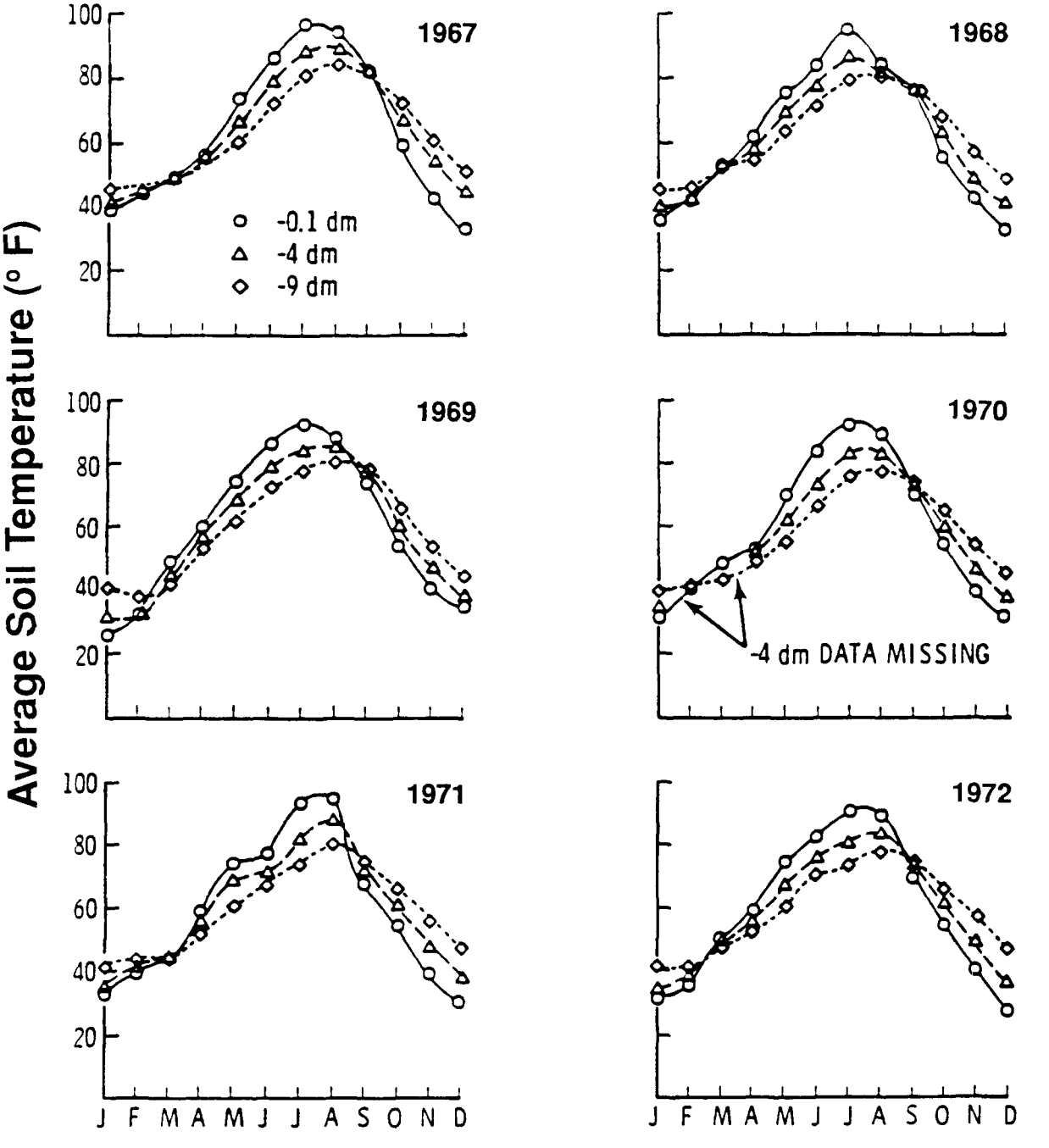
State-of-Knowledge on Significance of Thermal Loading on Biological Resources

- Current environment
  - Regional: seasonal variability: scale of change induced by natural vs repository
  - Site-specific: seasonal variability: scale of change induced by natural vs repository
  - Geothermal areas
- Literature review
  - Effects of increased soil temperature
  - Effects of reduced soil moisture
  - Effects of interaction between increased soil temperature and reduced soil moisture

Average Soil Temperatures Measured at Three Depths

Thomas P. O'Farrell et. al.

Ecological Monograms
Vol. 45, No. 1



Natural Variability in Soil Temperature at Yucca Mountain

Soil temperature (°C) at 45 cm	Vegetation Associations			
	Larrea-Ambrosia	*Larrea-Lycium-Grayia*	*Coleogyne*	*Lycium-Grayia*
January temp. (1991)	8.9	8.6	7.3	7.8
August temp. (1991)	30.9	30.3	28.7	28.0
Range of January temps.	8-10	7-10	6-9	6-10
Range of August temps.	30-33	29-31	26-31	26-31
Difference of September 1990-1991 temps.	-2.8	-2.7	-1.0	-1.8

Impact of Geothermal Heating on Lodgepole Pine in Yellowstone National Park (White, 1978)

- "The actual upper limit of tolerance is probably not set by heat flow as such but by the seasonal maximum soil temperature at the root depths preferred by each form of vegetation"

- Investigated three zones: normal, mixed, stunted

Zone	Near-surface heat flow (W/m^2)
Normal	1.9 - 8.4
Mixed	9.6 - 13.8
Stunted	> 20.9

Uncertainties in State-of-Knowledge

- Species processes
  - Change in phenology/activity periods
  - Change in biomass production/food resource
  - Available water for biological processes
- Ecosystem processes
  - Loss of species from ecosystem
  - Interaction of remaining species
  - Impact on trophic levels
- Limited or no site-specific information

Resolution of Uncertainties

- Measure existing ecosystems along latitudinal/ elevational gradients
- Measure local/regional geothermal areas
- Conduct glasshouse/small field trials
- Develop models/improve existing models

Residual Uncertainties After Completion of Studies and Modeling

- Secondary impacts
  - Indirect impacts to other trophic levels and trophic-level interfaces
  - Effects at a large scale not detectable on small-scale studies
- Evolutionary scale effects
  - Genetic drift
- Climatic change

Conclusions

- High thermal loading should have an impact on biological resources
- The significance of that impact is dependent on actual level of surface temperature increase
- Surface temperature increases of 1-1.5°C over a 1,000-year period should cause minimal impacts
- High thermal loading may cause the loss of some species at the impacted area
- Biological system has tolerance for change
- Uncertainties exist on level of change and impact on the specific biological resources at Yucca Mountain
- Many of these uncertainties could be addressed through a research progam
- Some uncertainties would still exist