



Evaluation of Climate Monitoring Needs in Southwestern National Parks: The Saguaro National Park Pilot Study

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Natural Resource Inventory and Monitoring in the National Parks

A major part of protecting resources is knowing what they are, where they are, how they interact with their environment and what condition they are in.
- U.S. Congress, 2000

The goal of the National Park Service's Natural Resource Inventory and Monitoring Program is to acquire the information and expertise needed by park managers in their efforts to maintain ecosystem integrity in the approximately 270 National Park System units that contain significant natural resources.

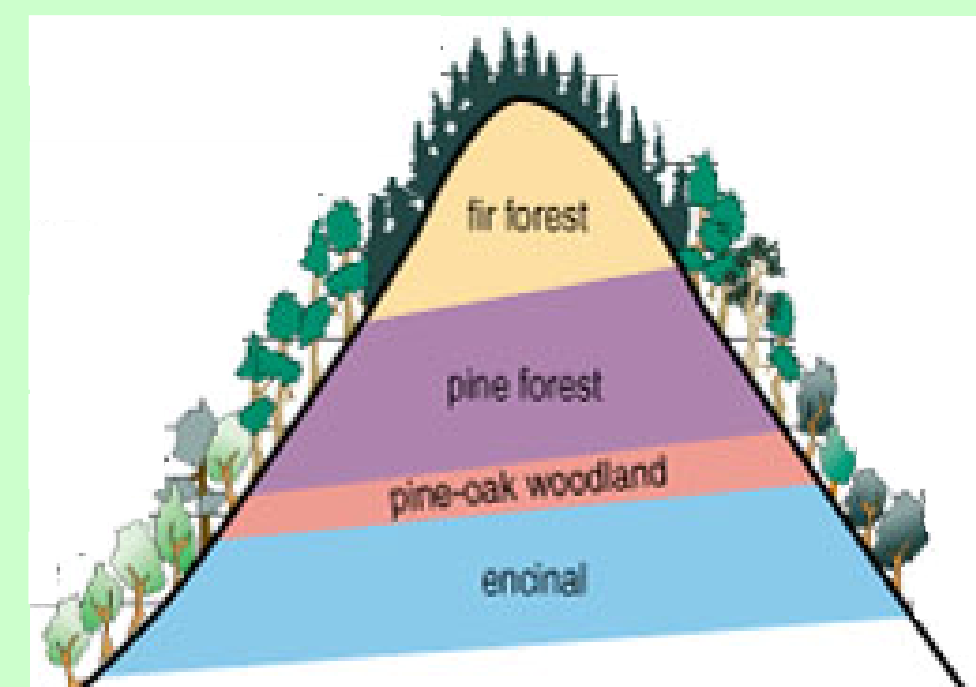
Inventory & Monitoring

A natural resource **inventory** is an extensive, point-in-time survey of the location and condition of plants, animals, and abiotic environment (water, soils, and air). It forms the basis for **monitoring**, which adds the dimension of time. The goal of the NPS Inventory and Monitoring Program is to identify trends in resources that potentially direct management actions or trigger new lines of inquiry.

Sonoran Desert Network I&M

The Sonoran Desert Network covers a geologically and biologically diverse region. The basin and range topography is characterized by lower desert and grasslands and "sky islands", isolated mountain ranges.

Sky islands are composed of many biological communities organized along an elevation gradient. Increasing in elevation is biologically similar to increasing in latitude; conifer forests found on mountain tops in the southwest are similar to those occurring in the northwest and Canada.



Adapted from Warshel 1995

The great diversity in habitats results in remarkable biological diversity. This region contains:

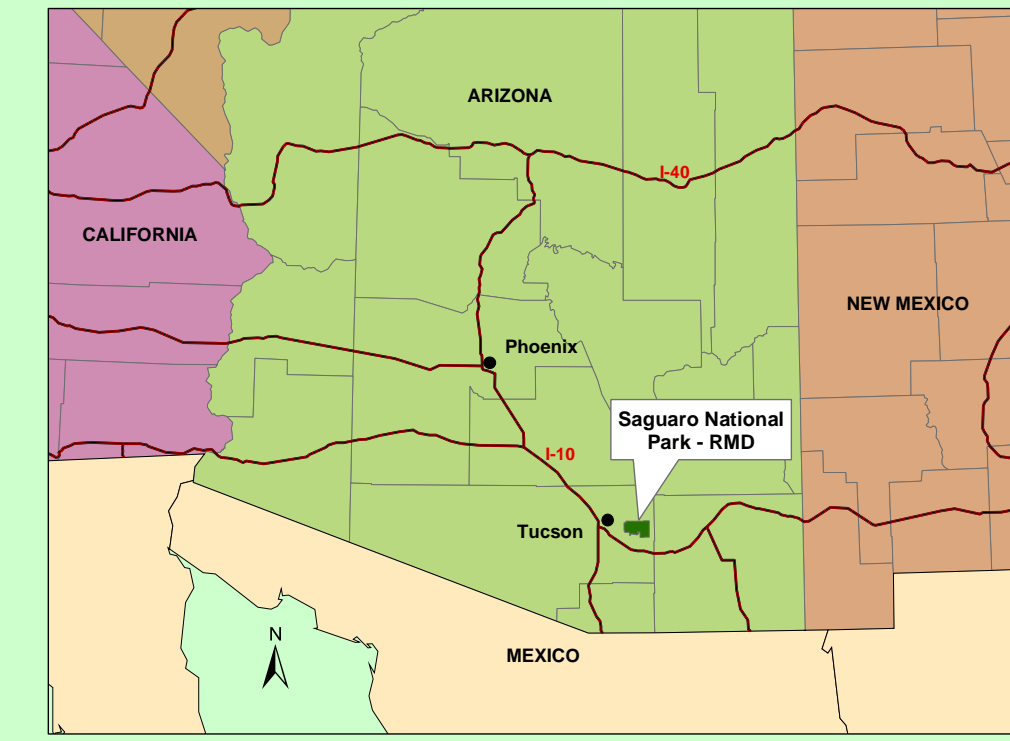
- at least 60 species of mammals
- more than 350 bird species
- 20 amphibians
- over 100 reptiles
- about 30 species of native fish
- more than 2,000 species of plants

Importance of Climate Monitoring in National Parks

Climate variability is strongly linked to ecosystem function. Spatial and temporal patterns in precipitation can limit or promote the growth of different plant species while patterns in temperature can induce mortality in vegetation and wildlife during hard freezes. Current climate monitoring systems capture variability at scales too coarse to be utilized in park level natural resource and ecosystem management. Many different management activities would benefit greatly from climate information collected at much higher spatial and temporal resolutions within park management units. Such activities include:

- **Wildlife studies:** Predicting amphibian movement patterns based on high-resolution precipitation data.
- **Hydrological monitoring:** Addressing water rights issues and maintaining baseflows in critical riparian habitats.
- **Wildfire Management:** Monitoring spatially explicit fuel moisture conditions and predicting fine fuel accumulations.
- **Invasive Species Management:** Establishing links between climatically induced disturbances and invasions of non-native species.
- **Air Quality Management:** Monitoring airflow patterns from urban airsheds carrying harmful pollutants; understanding smoke dispersion during prescribed burns for fuel management.
- **Education:** Providing the opportunity for park visitors to learn about the importance of climatic variability on different ecosystem processes and about coupled ecosystem-climate monitoring.

Saguaro National Park Climate Monitoring Pilot Study



Location of Saguaro NP in Arizona



View of Mica Mountain in Saguaro NP

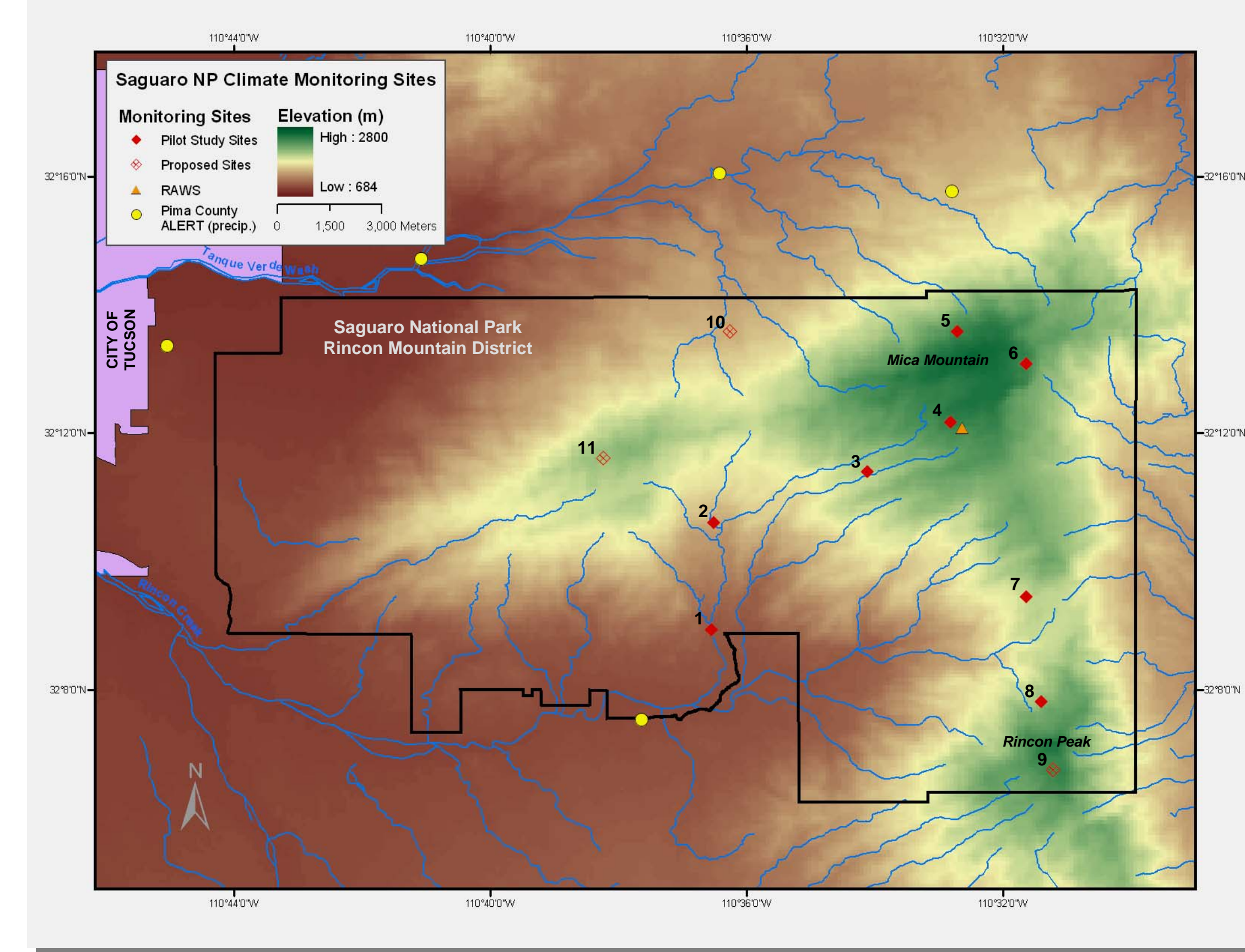
The east park unit of Saguaro National Park encompasses one of the unique 'sky islands' that characterize the landscape of southern Arizona. The Rincon Mountains make up most of the 27,000 ha east unit with elevations ranging from 800 to over 2,700 meters. This range in elevation produces a steep gradient of climatic conditions and ecological community types. The broad floral and faunal diversity in the park poses unique natural resource management challenges that are strongly tied to climatic variability. Activities from prescribed burning to wildlife tracking depend on the local scale variability in climatic conditions in a specific ecological community type. Climate monitoring is fundamentally important to resource management at Saguaro National Park, making this an ideal setting to introduce and evaluate new and higher resolution monitoring techniques.

Field setup of Station #2 at 1400 meters.

All monitoring locations are in backcountry wilderness requiring equipment to be brought in by non-motorized means. This station was carried up in several backpacks.



Monitoring Sites



Monitoring sites were chosen to satisfy several different research and resource management needs. Stations 1 through 5 represent a transect through the dominant ecological community types found in the park. They are also in an important watershed that supplies water to Rincon Creek and recharges local groundwater sources used by communities adjacent to the park.

Station	Installation	Elevation	Aspect	Ecotone/Community Type
1	Sept. 2003	1052 m (3450 ft.)	S	Upper Sonoran Desert Scrub
2	Dec. 2003	1402 m (4599 ft.)	S	Madrean Evergreen Woodland/Chaparral
3	Jan. 2004	1980 m (6500 ft.)	S	Pinyon/Juniper Woodland
4	Jan. 2004	2417 m (7929 ft.)	Level Area	Ponderosa Pine Forest
5	Jan. 2004	2430 m (7972 ft.)	N	Mixed Conifer Forest
6	Jan. 2004	2325 m (7627 ft.)	E	Broadleaf Deciduous Woodland
7	Feb. 2004	1923 m (6309 ft.)	W	Pinyon/Juniper Woodland
8	Feb. 2004	2166 m (7106 ft.)	N	Mixed Conifer Forest
9 (proposed)	Spring/Summer 2004?	2450 m (8038 ft.)	S	Chaparral
10 (proposed)	Spring/Summer 2004?	1450 m (4757 ft.)	N	Pinyon/Juniper Woodland
11 (proposed)	Spring/Summer 2004?	2027 m (6650 ft.)	W	Ponderosa Pine Forest

Weather Stations

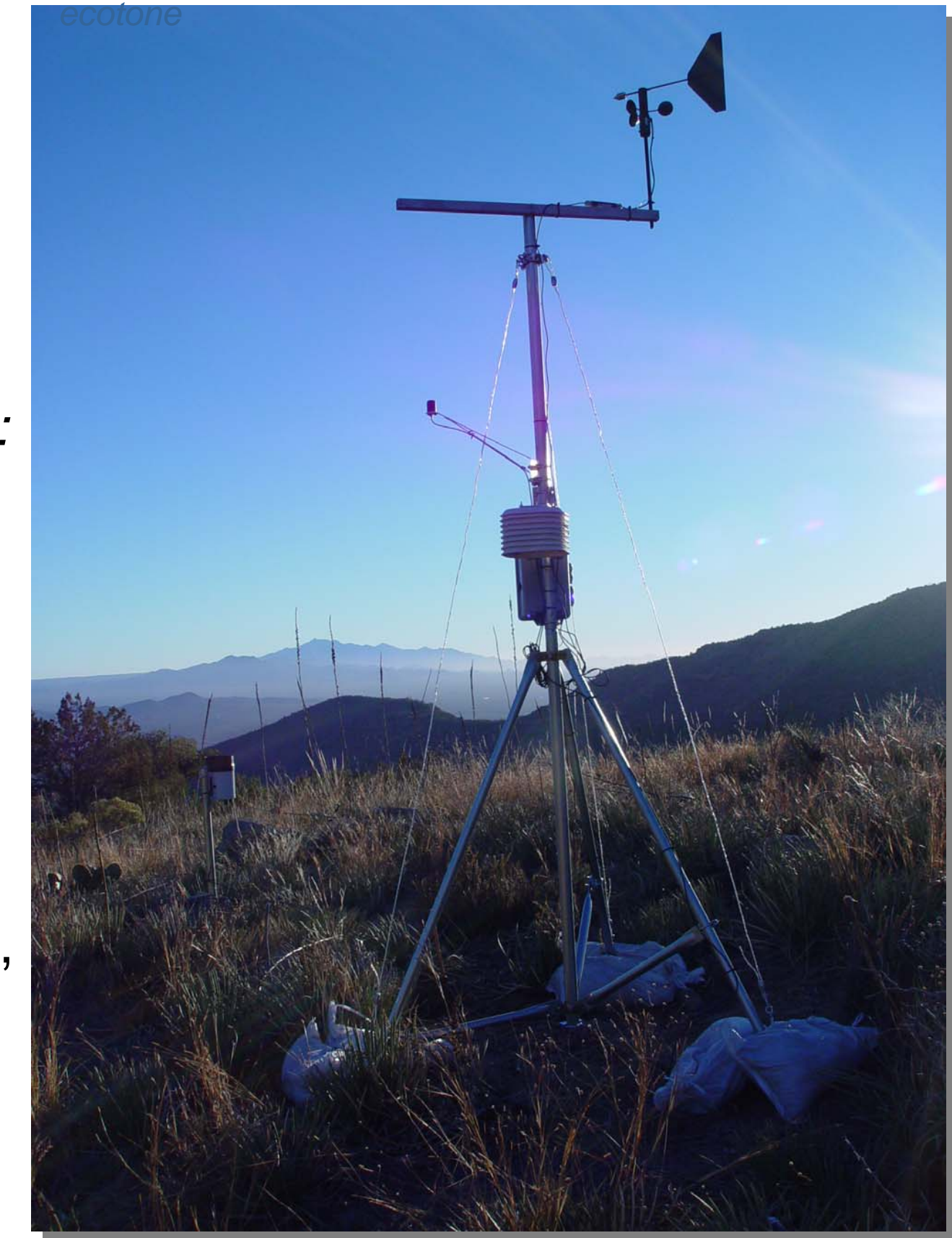
Inexpensive, data-logging weather stations are being used in the first phase of this pilot study. Stations will be temporarily installed at locations agreed upon by the research team and park personnel.

Onset Corporation Weather Station Specifications*:

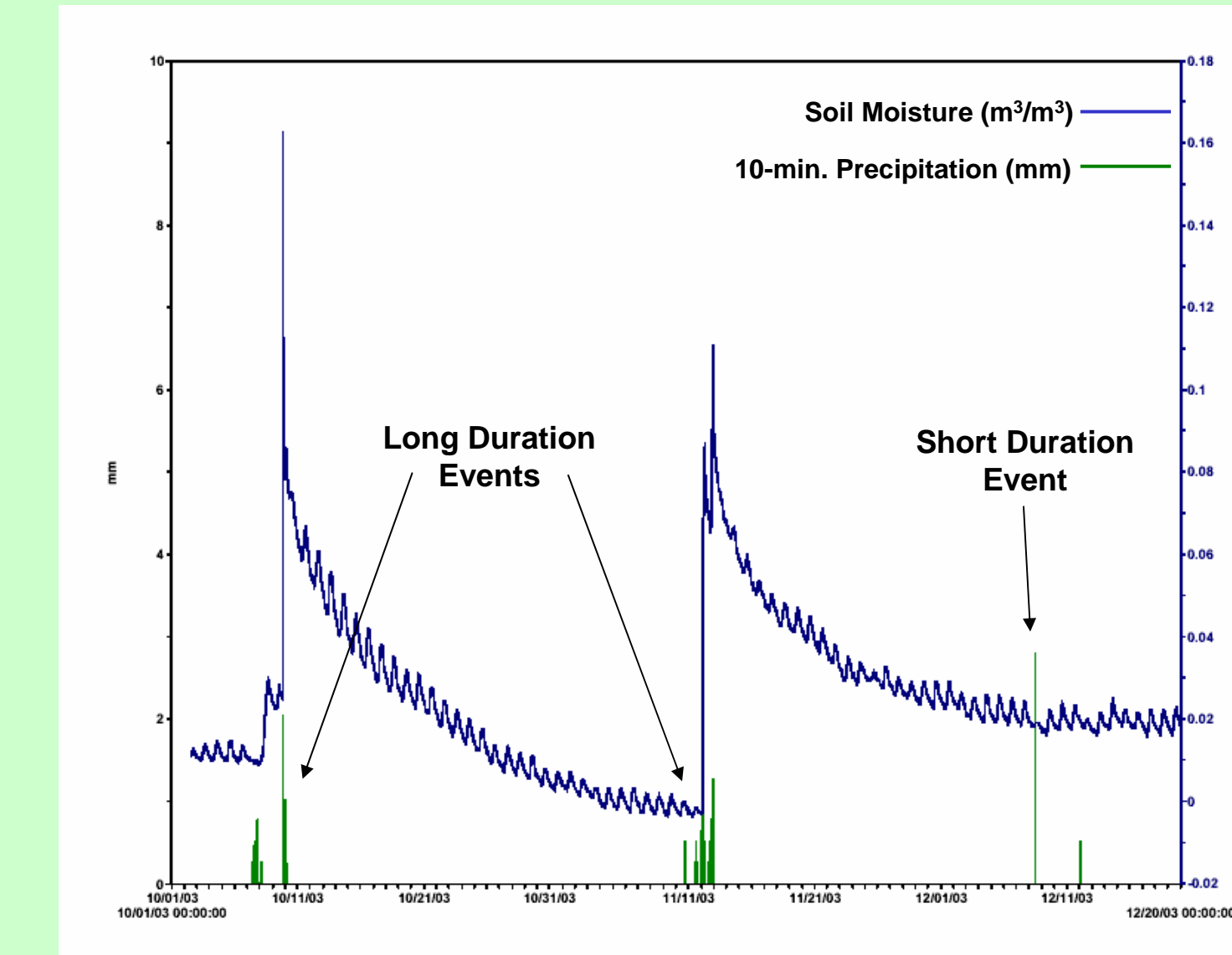
- 15 channel, 512K logger (1 minute sampling)
- Wind speed/direction (10 minute average speed, gust)
- Rainfall (0.01 tip)
- Temperature (10 minute average)
- Dew Point (10 minute average)
- Atmospheric Pressure (10 minute average)
- Solar Radiation (10 minute average, 300-1100 nm, watts/m²)
- Photosynthetically Active Radiation (10 minute average, 400-700 nm, umol/m²/sec)
- Soil Moisture (10 minute average, m³/m³)

*All instruments meet or exceed World Meteorological Organization monitoring standards (WMO 1983)

Station #2 at 1400m in chaparral-pinyon/juniper



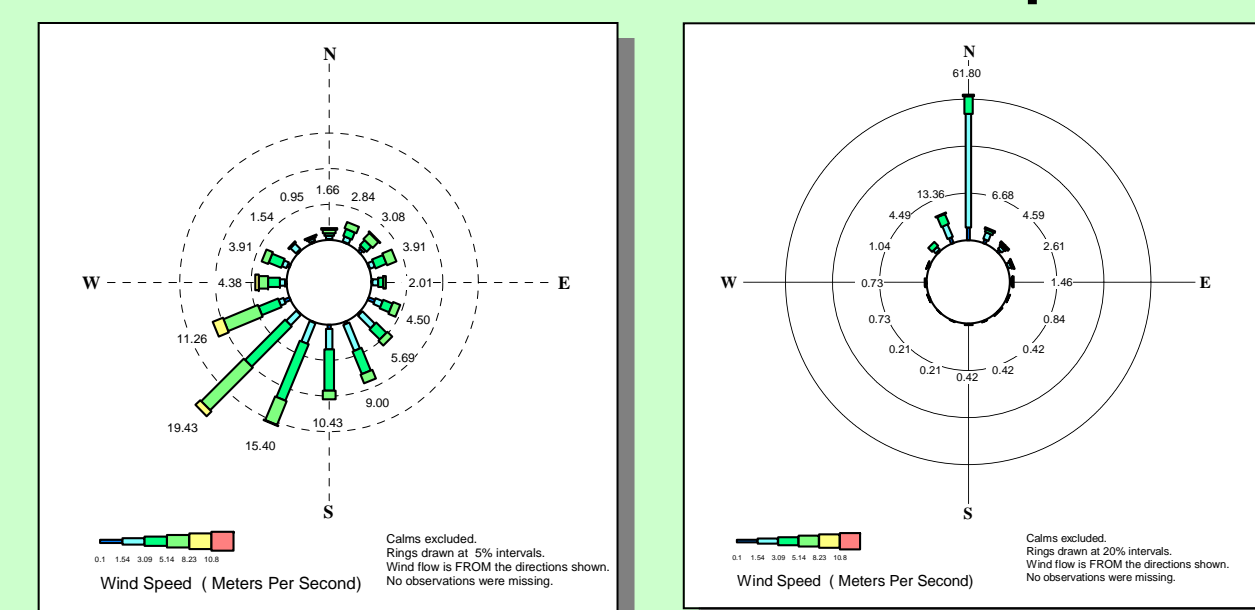
Preliminary Data



Soil Moisture and Precipitation at Station #1

Two low-intensity/long duration events occurred during October and November with subsequent rises in soil moisture. A high-intensity/short duration event occurred in December producing mostly runoff and little infiltration. The character of precipitation events and accompanying soil moisture changes are important in understanding local climate-vegetation dynamics.

October 2004 Wind Direction/Speeds



Day Night

Wind Regime at Station #1

A previously undocumented nocturnal drainage flow has been identified at station #1. This is an important finding for managing smoke during prescribed burns.

Pilot Study Strategy

Phase 1 (Sept. 2003-Sept. 2005)

- Evaluate existing climate monitoring strategies at the 11 Sonoran Desert Network national parks.
- Interview park personnel to assess how climate information is used and the limitations of current monitoring systems.
- Collect high resolution (spatial and temporal) climate data at Saguaro National Park in support of existing management activities.
- Evaluate utility of new climate data and target new parks for monitoring

Phase 2 (Begins Spring 2005)

- Use spatial and temporal information from initial monitoring to establish long-term climate monitoring sites within park.
- Install high-quality, permanent monitoring equipment at these locations with real-time data access capabilities.
- Institute new ecological monitoring (e.g. vegetation, wildlife, wildfire) in conjunction with permanent climate monitoring sites.