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Mapping Seeps, Springs, Ponds, and Streams on Santa Rosa Island, CA

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Abstract

In September 2014, during the driest period of the year, park staff and volunteers mapped surface water on Santa Rosa Island by physically walking all 2nd, 3rd, and 4th order streams. Mappers hiked more than 325 kilometers in 19 major basins and 7 lesser basins, and mapped 1,117 water features. These data have broad application across many disciplines, and will provide a baseline for long-term trends in surface water (Turner and Richter 2011), a better understanding of geologic, hydrologic, and biologic interactions (Schmidt, Minor, and Bedford 2015; Minor, Schmidt, and Bedford 2013), and characterize areas for ecological research (Turner and List 2007).

Introduction

Santa Rosa Island (217 km^2 (84 mi^2)), located 50 km southwest of Santa Barbara, California, is the second largest island in Channel Islands National Park (CINP). It is characterized by highly incised canyons, marine terraces, sandy beaches, and three more or less centrally located peaks: Radar Mountain (484 m (1,589 ft)), Soledad Mountain (480 m (1,574 ft)), and Black Mountain (395 m (1298 ft)).

Santa Rosa Island is characterized by cool, wet winters, and warm, dry summers. Fog drip contributes to the hydrologic cycle during summer months (Williams, Burnette, and Clarke 2008). Springs, seeps, pools, and surface water are critical natural resources to Santa Rosa Island, where 95% of annual precipitation occurs between November and April, and precipitation, averaging about 14 inches per year, is highly variable and unpredictable.

Spring discharge, influenced by geologic and topographic features, occurs in response to hydrologic activity of a much larger area, likely influenced by fog input, recovering vegetation, and precipitation. Springs and seeps provide base flow to the island's 20 major creeks, supports valuable riparian habitats for Santa Rosa Island fox (*Urocyon littoralis* ssp. santarosae), birds (Collins 2011), herpetofauna, island residents, and park visitors. The island's creeks are often the location

Citation: Weber, Samantha, ed. 2016. *Engagement, Education, and Expectations—The Future of Parks and Protected Areas: Proceedings of the 2015 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites*. Hancock, Michigan: George Wright Society.

of exceptional beauty and may hold cultural significance to Native Americans who occupied the island for more than 12,000 years (Johnson et al. 2000).

The mid-1800s ushered in the ranching era. Non-native ungulates, including cattle, sheep, pigs, deer, and elk, were brought to the island and intensively grazed the island for more than 150 years, negatively impacting native coastal sage scrub, island chaparral, grassland, and scattered oak and pine woodland plant communities. The park removed all non-native grazers between 1993 and 2011 (Lombardo and Faulkner 1999) and recovery of plants and wildlife, including the Santa Rosa Island fox and Torrey pine (*Pinus torreyana* ssp. insularis), is occurring.

With rapid change taking place following removal of all non-native ungulates, there was a need to better characterize Santa Rosa Island's hydrologic attributes. During two weeks in September, 2014, following a historic three-year drought, park staff and volunteers mapped all seeps, springs, ponds, and streams by systematically walking 335 stream km along all 2nd, 3rd, and 4th order steams (Strahler 1957; Fitzpatrick et al. 1998). We chose to physically walk tributaries rather than relying on digital datasets or aerial photos to determine the extent of surface water. Although time-consuming and labor-intensive, this approach resulted in accurate mapping of hydrologic features, and eliminated inaccuracies inherent in digital datasets of different resolutions (Vance-Borland, Burnett, and Clarke 2009). All water features were marked using consumer-grade GPS units. These data have broad application across many disciplines, and will provide a baseline for long-term trends in surface water (Turner and Richter 2011), a better understanding of geologic, hydrologic, and biologic interactions (Schmidt, Minor, and Bedford 2015; Minor, Schmidt, and Bedford 2013), and characterize areas for ecological research (Turner and List 2007).

Methods

In September of 2014, park staff and volunteers systematically mapped all surface water features during the driest time of year to establish baseline hydrologic data (see Turner and Richter 2011). This involved identifying all basins and 1st, 2nd, 3rd, and 4th order streams (Horton 1945); creating a unique identifier for each basin and tributary; and assigning tributaries to teams of two mappers armed with Garmin, camera, radio, paper data sheets, and paper maps to locate and record UTMs for all water features. Basins were given the same name as the major creek draining the basin. Small, adjacent watersheds without a major creek name were given the same name as the neighboring basin followed by a sequential number (e.g., Garanon 1).

Each day began with a morning briefing and stream mapping assignment. Teams were transported by vehicle along single track dirt roads to a point closest to their assigned tributary. The team proceeded to their start point at the beginning of a 2nd order tributary. The team walked the creek bottom and recorded UTMs for each spring, seep, pond, and surface water feature. Ponds were defined as any pool of surface water less than 3 meters in length. Seeps and springs were defined as a point where water clearly emerged from the ground but water remained on the surface for less than 3 meters (10 ft). If surface water was present for 3 meters (10 ft) or more, UTMs were recorded where surface water started and where surface water stopped. Stream width was not a factor in start/stop determinations. In addition to recording UTMs with the Garmin, all data were recorded on paper data sheets. Teams were instructed to record the location of significant cultural finds, specific invasive species populations, significant bird sightings or any other unusual sightings. Significant features were photographed with GPS-enabled cameras.

At the end of each day, team members submitted paper data sheets, Garmin and other equipment to the data manager. The data manager then downloaded and checked the data against hand-recorded data from the paper data sheets, which served as the first level of data quality assessment and quality control.

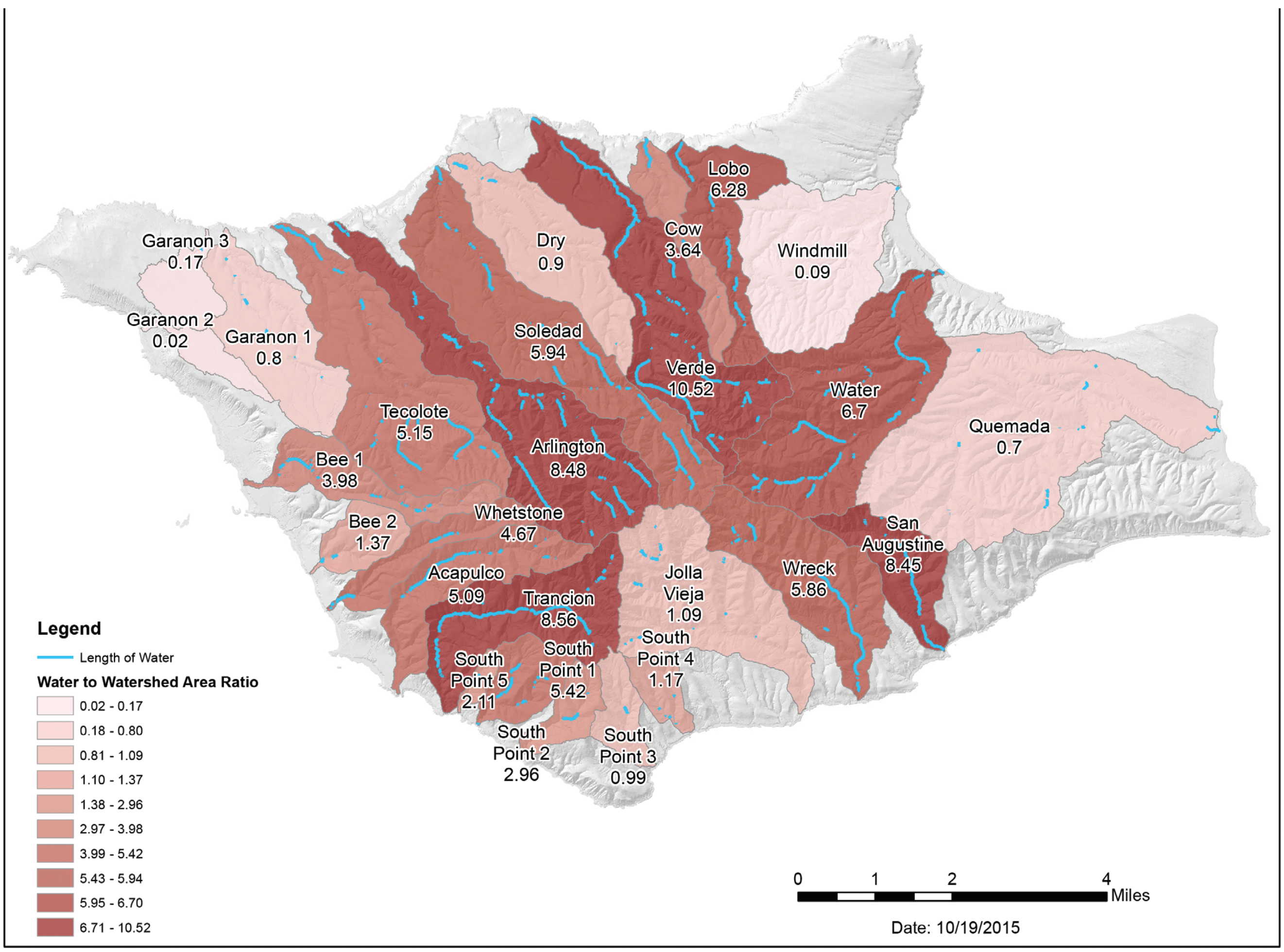
Personal safety and biosecurity (preventing the spread of invasive species) were important components of the project. All teams were instructed in personal risk analysis and the proper use of radios. At the end of the day each team member was responsible for cleaning their equipment, boots, and clothes and emptying their backpack to reduce the risk of unintentionally spreading weed seeds from one canyon to the next.

In order to describe basin characteristics, surface water between stop and start points was categorized as a perennial stream. We assumed surface water was perennial because mapping took place during the driest time of year in an extreme three-year drought. Each basin was characterized further using the following geomorphic descriptors. Drainage area for a specific basin was measured in a horizontal plane, enclosed by a drainage divide (Horton 1945). The cumulative perennial stream length was the sum of the length of all perennial streams within a drainage basin (Horton 1945). Drainage density was the ratio of the cumulative perennial stream length to drainage basin area (Leopold, Wolman, and Miller 1964).

Results

Thirty-one mappers walked 335 stream kilometers in 19 major basins and 7 lesser basins, and mapped 1,117 water features (Figure 1). All named basins on Santa Rosa Island had surface water, except Old Ranch Canyon. Old Ranch Canyon and smaller, unnamed or dry watersheds are dropped from further analysis and discussion.

Figure 1. Santa Rosa Island, CINP, with drainages and drainage densities.



All creeks were intermittent, fed by seeps and springs. The largest spring, San Augustine, emerges at an elevation of 287 m (944 ft) and flows to the ocean, with one short break. Canyons with the greatest cumulative stream length were Verde (12,446 m), Arlington (10,016 m), Water (8,176 m), Soledad (7,286 m), and Trancion (6,299 m; Table 1).

Table 1. Surface water features and basin characterizations in 19 named basins and 7 lesser basins on Santa Rosa Island, Channel Islands National Park (CINP).

Basin	Drainage Area (ha)	Cumulative Stream Length (m)	Drainage Density (m:ha)	Total seeps, springs, ponds
Verde	1183.04	12446	10.52	21
Trancion	735.92	6299	8.56	21
Arlington	1181.61	10016	8.48	58
San Augustine	367.85	3110	8.45	1
Water	1219.63	8176	6.70	27
Lobo	470.34	2953	6.28	6
Soledad	1225.83	7286	5.94	34
Wreck	741.81	4344	5.86	10
South Point 1	248.16	1344	5.42	34
Tecolote	1183.90	6095	5.15	20
Acapulco	474.67	2417	5.09	1
Whetstone	276.10	1289	4.67	27
Bee 1	366.05	1458	3.98	5
Cow	278.77	1014	3.64	5
Garanon 2	136.82	496	3.62	2
South Point 2	168.54	499	2.96	-
South Point 5	48.51	102	2.11	2
Bee 2	198.01	271	1.37	4
South Point 4	134.64	158	1.17	2
Jolla Vieja	930.80	1011	1.09	31
South Point 3	176.42	175	0.99	-
Dry	686.22	616	0.90	16

Verde Canyon, located on the north side of the island, with the 5th largest drainage area, had the greatest drainage density (10.52 (cumulative stream flow:drainage area)), followed by Trancion (8.56), Arlington (8.48), and San Augustine (8.45). Quemada canyon, located on the northeast side of Santa Rosa Island, had the largest basin (1,183.04 ha), and with 1,302 m surface water, had one of the lowest drainage densities (0.70). Windmill canyon, draining adjacent to the historic ranch complex at Beecher's Bay, with only 81 m surface water had the lowest drainage density and was the driest canyon overall.

Discussion

Physically walking all 2nd, 3rd, and 4th order streams was an effective method of obtaining detailed and accurate information about surface water on Santa Rosa Island. Mapping provided several insights that differed from conventional wisdom regarding the island's hydrologic conditions. At the time of data collection, California was experiencing 3 years of extreme drought conditions; yet, every named canyon except Old Ranch Canyon had at least one seep or spring and surface water ranging from shallow (<2 cm) to ankle- or calf-deep riffles.

These data have broad application across many disciplines and will provide a baseline for long-term trends in surface water (Turner and Richter 2011), a better understanding of geologic, hydrologic, and biologic interactions (Schmidt, Minor, and Bedford 2015; Minor, Schmidt, and Bedford 2013), and a characterization of Santa Rosa Island for future ecological research (Turner and List 2007). Cumulative perennial stream length determines the amount of stream habitat within the basin (Fitzpatrick et al. 1998) and is influenced by vegetative cover and geology. With the removal of all non-native ungulates in 2011, vegetation has rapidly changed, after 150 years of intensive grazing, and new occurrences of species native to the Channel Islands have been found. Baseline data from this effort and repeated mapping of key basins will improve our understanding of basic biologic, geologic, and hydrologic processes.

Mappers walking the canyons located priority invasive species, including fennel (*Foeniculum vulgare)* and tamarisk (*Tamarix ramosissima*). The park's invasive species management strategy targets these species for immediate removal. *Helichrysum* spp., a common landscape ornamental and an aggressive weed on nearby Santa Cruz Island, was mapped and treated. Locating and treating these species early in their invasion is critical because, when they invade and expand, they have the potential to alter ecologic processes.

Drainage density represents the amount of stream that drains a basin. Drainage density reflects climate patterns, geology, soils, basin vegetation, and age of stream network, and is perhaps the single most useful index to describe basin processes (Gregory and Walling 1973). Verde, Trancion, Arlington, and San Augustine have the highest drainage density on the island. With abundant surface water and springs, these canyons have the greatest potential for stream habitat recovery following non-native ungulate removal, including recovery of wetland plant and aquatic invertebrate species, in addition to providing surface water for island animals, including the endangered Santa Rosa Island fox and spotted skunk (*Spilogale gracilis*). Drainage density may also have cultural significance. Perennial streams may indicate potentially long-term use by Native Americans. Repeated surface-water mapping will provide data for trend analysis and create an accurate measure of change in biologic and hydrologic resources.

Acknowledgments

The authors would like to thank Ken Niessen for developing a watershed and stream order model, Stacey Osterman-Kelm, NPS Mediterranean Network (MEDN) Inventory and Monitoring (I&M) Coordinator, and Lena Lee MEDN I&M Data Manager for technical support, and the volunteers and park staff who hiked and mapped each canyon. Funding for this project was provided by the NPS MEDN I&M program.

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