THE SAG POND STORY – INTERPRETIVE TRAIL GUIDE

Please respect these fragile habitats, stay away from edge of ponds and *__keep dogs on leash__*. The Sea Ranch Trails Map is available at The Sea Ranch Association Office at 975 Annapolis Road, Two Fish Bakery at 35590 Verdant View, or the Lodge near mile marker 50.59 on Highway 1. Please stay off private property when visiting these sag ponds. Binoculars are helpful for viewing distant plants, small insects, and birds.

Sag ponds are created by earthquakes along the San Andreas Fault (see Interpretive Guide at Post 305). The Fault Zone is ½ mile wide here at Sea Ranch, with parallel strands or breaks. When there is a quake, the Pacific Plate you are standing on moves northwest, and the North American plate on the east side of the Gualala River moves southeast. The ground stretches, creating gaps or depressions. Rocks along the fault lines are pulverized, creating a fine clay sediment that forms a hardpan which water can't penetrate. Rain pools in these depressions, or "sags," forming a "sag pond." Much of San Francisco Bay, Bolinas Lagoon and Tomales Bay are long and deep sag basins, trending northwesterly.

Sea Ranch has at least eight sag ponds, associated with ridges along the northwesterly trending San Andreas Fault. These ponds are miles apart in our mixed evergreen forests of Redwood, Grand Fir, Douglas Fir, Bishop Pine, Tan Oak and California Bay. Each pond is unique as a pH neutral, fresh water "ecological island". During the fall/winter rainy season and just after, the ponds are at their fullest. When the rains end and the warm, dry spring/summer months arrive, there is evaporation and the surrounding vegetation uses moisture in the soil around the ponds, drawing the water level down.

Sag ponds in other parts of California along the San Andreas Fault are mostly in more open woodlands and grasslands. They have usually been disturbed by grazing, conversion to stock reservoirs, or other human activities. Here our ponds have survived as relatively hidden and undisturbed fresh water ecosystems with an interesting variety of aquatically adapted plants and animals. They are worthy of exploring, understanding and appreciating!

As you visit each pond, use all your senses:

LISTEN – how many different sounds can you hear

LOOK –how many different colors? Different shades of green?

SMELL – humus has a rather pleasant, sweet odor; bay can be pungent; evergreen needles have a distinctive aroma

FEEL – how many different textures of leaf surfaces? Angular stems of sedges, round stems of rushes?

IMAGINE what is going on out of sight, underwater or at night, as well as other seasons of the year.

Each pond has a unique habitat with distinctive species:

Submerged

- microscopic unicellular organisms, e.g. bacteria, fungi, algae
- macroscopic organisms, like mosquito larvae and aquatic beetles
- eggs and tadpoles of amphibians such as California Newt and Pacific Tree Frog (the newts have gills and legs right after hatching, the frog tadpoles do not).

Water Surface (note spring sheen of conifer pollen)

- Water Striders (Figure 3)
- Filamentous green algae
- Lemna (Duckweed) (Figure 8)
- Azolla, a tiny aquatic fern (Pond Lily Pond) (Fig 8)

Emergent, including half submerged old logs, providing terrestrial "islands" for mosses and ferns

- Salamanders, including California Newt
- Frogs – Pacific Tree Frogs
- Water Parsley (Figure 1)
- Veronica (Speedwell) (Figure 4)
- Water Starwort (Figure 5)
- Rushes (Figure 2)
- Yellow Pond Lily (Pond Lily Pond only) (Figures 6,7)

Edge – Marsh – transitional to terrestrial vegetation

- Sedges (Figure 2)
- Reed grasses (Figure 2)
- Fringed Corn Lily
- Horsetails
- Deer Fern and Sword Fern
- Willows
- Animals needing drinking water: birds, skunks, squirrels, rabbits, badgers, ring-tailed cats, bobcats, foxes, coyotes, bears and mountain lions

Area 1

There are two ponds at Area 1 shown on the map above, accessed from either the end of Schooner Drive or Longmeadow/Timber Ridge intersection and parking.

How many features described above can you find here?

Area 1: Water Parsley Pond (on the west side of the trail between posts 108 and 109A): In addition to abundant Water Parsley (Figure 1) and Duckweed (Figure 8), there are Fringed Corn Lilies edging the pond.

Area 1: Sedge Pond (on the east side of trail near post 109A): This pond has filled in with sedges on the way to becoming a meadow. "Sedges have edges, and rushes are round, and grasses are hollow right down to the ground."

Figure 1 - **Water Parsley** (photo by Linda Keir)

Figure 2 - **Rush, Reed Grass, Sedge** (l. to r.)
(photo by Marge Anthony)

Area 2: Rush Pond (on the west side of Timber Ridge, between Drovers Close and Sorcerer's Wood): At the trail's end are colonies of stiff-stemmed rushes about 20" high, which spread underground by rhizomes (underground stems). At the northwest end are clumps of reed grass, a bunchgrass with leaves clustered at the base and stems up to 30" high. Figure 2 shows how the three most common marsh plants, all native perennials, differ in flower arrangement.

The water at Rush Pond is usually shallow and clear enough to see some aquatic insects and tadpoles in season. Look for Water Striders (Figure 3) which are uniquely adapted to live on the surface. Each pair of legs is of noticeably different lengths and is adapted for different functions. The short front legs act as sensors for vibrations produced by ripples in the water from struggling prey, such as spiders and insects that have dropped onto the surface. Striders also feed on mosquito larvae which come to the surface for air. The middle and back pair of long and slender legs distribute their body weight over a much larger surface area. Legs and body are densely covered with velvety short hairs which entrap air bubbles, preventing them from sinking. The much longer middle legs are used for rowing. The slightly shorter hind legs are used for steering and brakes. Striders can move up to a yard per second! Striders grow up to ½ inch in length, with adults showing obvious dimpled water at the end of each leg supported by surface tension of the water. These remarkable insects have been studied to design water walking robots which could be used for water pollution monitoring.

Figure 3 - **Water Strider** (note water dimples at end of legs) (photo by Rebecca Smith)

Area 3: Long Pond (along the San Andreas Interpretive Trail between posts 305 and 307): Pick up a San Andreas Fault Interpretive Guide to learn more about the geology as you enjoy the rest/contemplation bench with a fine view of the pond. Look for Water Striders and Ducks.

Area 4: Frog Chorus Pond (on the west side of Timber Ridge Road just north of Indian Close): Early spring brings a very loud frog chorus. Pacific Tree Frogs live mostly on ground or in water, not on trees. They can change color from green to brown or black in a few minutes, camouflaging themselves from predators such as herons, snakes, and raccoons. On the south side this pond has a stand of August blooming Veronica (Figure 4) with tiny ¼ inch wide blue flowers. In August, on the northwestern side of the pond, beyond the emergent log, Water Starwort rosettes appear on the surface, with 1 mm inconspicuous flowers (Figure 5).

Figure 6 - **Closeup of Yellow Pond Lily Flower** (photo by Molly Engelbrecht)

Figure 4 - **Veronica** (photo by Linda Keir)

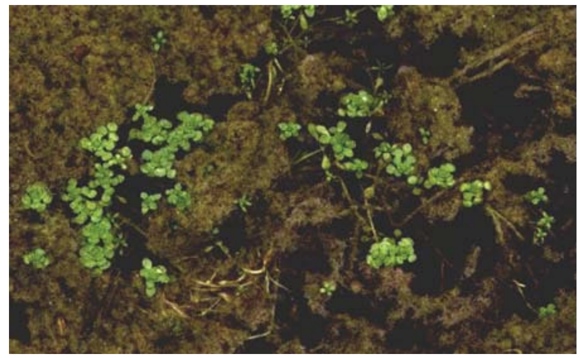

Figure 5 - **Water-starwort** emergent rosettes (photo by Marge Anthony)

Area 5: Pond Lily Pond: (on the east side of Timber Ridge Road between Annapolis Road and River Beach Road): Yellow Pond Lily and Azolla are found only in this pond. Dormant in winter, the yellow pond lily blooms in summer (Figures 6 and 7). Leaves are more vertical than horizontal and grow up to 15" wide and flowers 2-4" diameter; this plant provides food and shelter for a number of aquatic species.

Azolla, a small aquatic water fern, produces a reddish pigment which gives this pond surface its distinctive color (Figures 7,8). The azolla plant contains several endosymbionts, which are other organisms living within the plant in a mutually dependent relationship. Each leaf is a microcosm, with a cavity (Figure 9) containing microscopic cyanobacteria (blue-green alga) and other species of bacteria. In exchange for the sugars, shelter, support and distribution by the fern, the endosymbionts fix nitrogen, which makes the azolla a self-fertilizing plant. Azolla has been used as a cheap, renewable and pollution-free source of bio-fertilizer, and has long been used in rice cultivation and as animal feed. In sun, the azolla can double its biomass in a few days, making a thick mat and reducing the amount of oxygen in the pond water, which suppresses mosquito larvae. Azolla has also been used in water purification (possible space applications) and in antifungal agents. Astrobiologists are studying Azolla as a promising biologically-based life support and water/waste recycling component for long space missions.

Figure 7 - **Yellow Pond Lilies in Azolla Mat**
(photo by Molly Engelbrecht)

Azolla often grows in association with the larger and smoother Lemna (duckweed) (Figure 8), the smallest of all flowering plants. Both plants multiply rapidly by fragmentation. Each small piece broken off the plant will propagate a new plant. Since the seeds of many aquatic plants are too heavy for wind dispersal, and water dispersal is not possible where the ponds are disconnected from other water, reptiles, amphibians, birds and mammals must be important in dispersing seeds/fruits to new locations, adhering to mud on their feet or passing through their digestive systems. Pieces of lemna or azolla may also be transported by adhering to animals.

Figure 8 - **Lemna (duckweed) and Azolla**
(Courtesy of Aaron Arthur)

Such symbiotic/mutualistic associations are the focus of many current studies. Research has shown that most species have co-evolved in this way, enabling survival under constantly changing conditions. Symbiosis is thought to have driven the evolution, over millions of years, of the biological diversity we see today.

Think about how many other examples of symbiotic/mutual relationships are present at this pond. Most trees and shrubs have mycorrhizae, symbiotic associations between their roots and soil fungi, facilitating sugar, water, and mineral exchange. Mycorrhizae in the soil beneath your feet provide the fungi with relatively constant and direct access to carbohydrates, which are transferred from sunlit leaves above to roots below, and then to the fungal symbiont. In return, the fungi recycle the forest litter into soluble essential mineral nutrients as well as greatly increasing the surface area for absorbing water.

Of course, we humans are the most familiar example of such co-evolution. Actually, only 10% of our cells are human. The rest are bacteria, which fortunately are very much smaller. The International Human MicroBiome Consortium is working to identify these microbes which we host and to learn whether their function is essential, neutral, beneficial, or parasitic, as well as looking at relationships to human diseases.

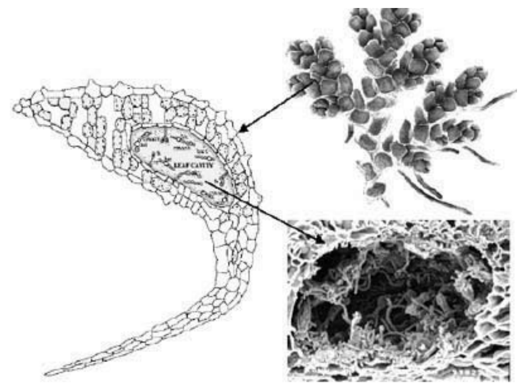

Figure 9 - **Section Through Azolla**, showing enclosed cavity with endosymbiont cyanobacteria and bacteria
(Courtesy of Francisco Carripico, Univ. of Lisbon, Portugal)

Lichens are a very successful plant type resulting from a symbiotic relationship of a fungus and a green alga or cyanobacteria. By growing together, co-symbionts extend their habitat, the fungus storing water and minerals, and the alga providing photosynthesis. There are more than 15,000 species of lichen, with a wide variety of shapes within the three basic forms shown in Figure 10. The branchlet in the picture was found at this pond.

Figure 10 Three Lichens: Crustose, Foliose, and Fruticose
(photo by Marge Anthony)