

# A Possible Symptom of the Die Off

David Perasso May 17, 2019

Since April 15 of this year, I have been monitoring 9 sword ferns in an active die off area at Seward Park. The purpose of the monitoring is to document the progression of the die off by tracking changes in ferns as they die. It is hoped that a set of definitive symptoms will be found that can help identify die off sites.

Already there are some observations which, taken together, seem to be a significant symptom of the Seward die off syndrome:

- Fronds from the previous growing season appear to be healthy. Their color is >80% green and degradation of the fronds is well within the degradation seen on ferns in non-die off areas of Seward Park. Severely shriveled fronds, if they exist on these ferns, have mechanically damaged or broken stipes.
- Though all Seward Park ferns outside the die off have multiple, fully expanded croziers as of May 10, no new fronds had emerged from these ferns<sup>1</sup>.
- Any croziers that formed during the previous growing season are smaller than normal, possibly malformed, and have not expanded into fronds.

These characteristics are observable in late spring, when all non-infected sword ferns have expanded their new fronds. It may also be possible to observe this symptom during summer and fall if it is possible to differentiate between fronds from the current and previous years.

I want to stress that this is a preliminary conclusion and it should be verified by others and tested at other die off locations before we conclude that this is a symptom of the Seward die off syndrome.

## Normal Crozier Emergence

When I began the monitoring on April 15, I noted and photographed many ferns along Squebeqed trail. Until I came to ferns opposite the die off area, ALL of the ferns had large, robust croziers emerging. On May 12 I walked the trail again and carefully looked to see if any ferns had few or no expanded new fronds. All ferns along the trail had fully or nearly fully expanded new fronds. In all cases the number of new fronds was roughly equal to the number of old fronds, if not larger. I counted the fronds on 10 ferns and the number of new fronds was never less than the number of fronds from the previous year.

I also noted the state of the old fronds. In most cases at least 90% of the fronds were green and healthy looking, but there were several ferns where the old fronds were in terrible condition. Some were broken, some non-existent (perhaps pruned away?), some had curled, crisp pinnae, some were mostly brown or black. Yet all these ferns had produced abundant, healthy looking new fronds.

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<sup>1</sup> One fern, not among the 9 under monitoring, was observed with one new frond. This fern had 20+ green fronds from the previous year. So it's possible that "very few new fronds" is also a symptom of the die off.

This is not unexpected. During summer and fall a sword fern energy into the production of croziers for the following year and the storage of energy in the rhizome. In dry, warm areas (e.g. California redwood forests), it is common for all or nearly all of the fronds to completely die back by the end of their first year. As long as a sword fern has created croziers for the following year and stored enough energy to support them, the sword fern is in good condition despite how the current year's fronds may look.

This does not mean that there cannot be some particular frond symptom that indicates that a fern is infected with the Seward die off syndrome, but we need to be very specific about what that symptom is.

In summary:

- By April 15 most, if not all, the croziers of normal ferns began to expand. By May 12, all fronds of normal sword ferns had fully or nearly fully expanded.
- Even though the fronds from the previous year show significant signs of stress, croziers emerge and expand.

Below are photos taken along Squebeqed trail, in unaffected area, showing ferns with healthy expanded new fronds and fronds from previous year in varying states of damage/stress:



## The 9 Monitored Ferns

The ferns selected for monitoring are in the active die off area to the north of the hatchery trail and east of Squebeqed trail. Ferns were selected whose fronds (previous year) were still at least 80% green. Many fronds were close to 100% green and showed little, if any, signs of stress. Fronds that were severely shriveled proved to have broken or bent stipes.

For example, here is fern # 8, which had fronds that were close to 100% green. Note that no new fronds have emerged from fern #8 despite an abundance of healthy looking fronds from the previous year.



The following table shows the number of new fronds that have emerged from each of the monitored ferns as of May 10:

monitored fern #	count of expanded croziers
1	0 on one head, 8 on the other
2	8
3	0
4	0
5	16
6	6
7	15
8	0
9	0

On May 12 I did an informal check of ferns in the same area. Standing next to fern 8 I could see, without moving, 7 other ferns that had mostly green fronds from last year but no new fronds. There was also one fern which had 20+ fronds from the previous year which had only 1 new frond. Clearly this symptom is common in the active die off area.

## Observations of Rhizome Tips

The next photo is of fern 2, which has 8 new fronds. This was taken on April 15, when the croziers were just starting to expand. If this photo had been taken a week or two earlier, before the croziers started expanding, the croziers would have been tightly bunched in the center<sup>2</sup>.

Note the size of the croziers relative to the approximate cross section of the rhizome -- their total cross section is comparable to the cross section of the rhizome.



Now look at the rhizome tips of some ferns whose croziers did not expand.

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<sup>2</sup> A beer to anyone with a good picture of sword fern croziers before expansion.

Fern 4 is typical. Few croziers have formed and they are smaller than normal (see fern 2 above). As of May 12, no croziers have expanded into fronds. Ferns 1, 8 and 9 were similar.

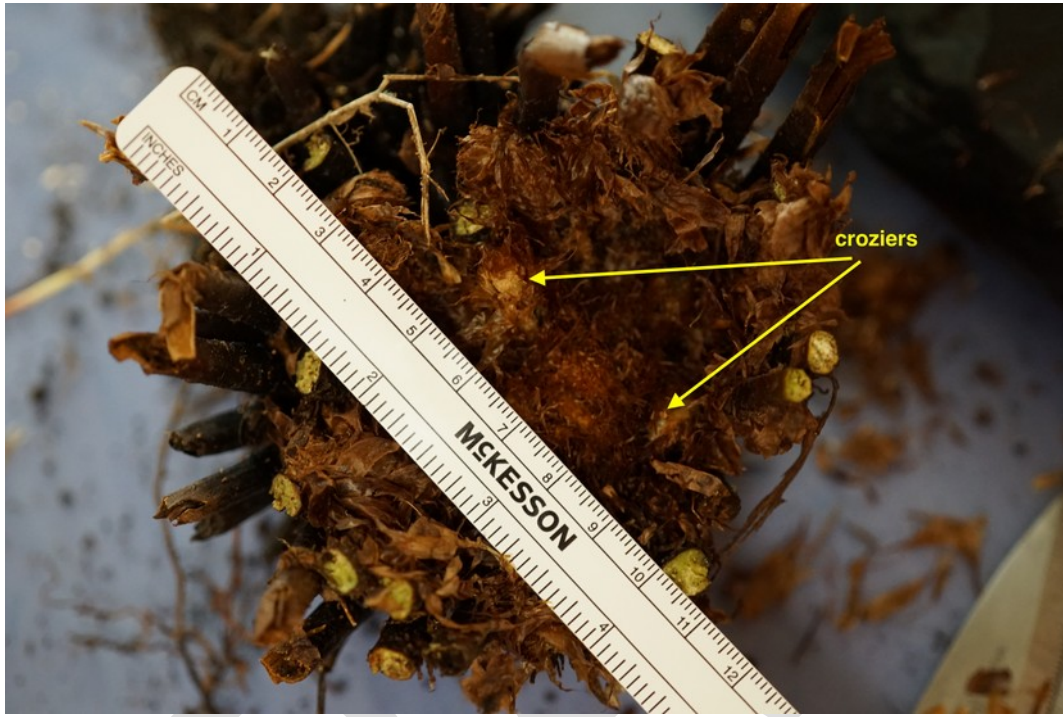


Fern 3 is slightly different. It also had croziers that were tiny and that did not expand, but it also had a crozier that only partially expanded.



## Dissection of Fern 8 Rhizome

On May 8, one rhizome tip of multi branched fern 8 was removed and dissected. Here is a view of the tip of the rhizome before dissection. Notice that the croziers are 1) not expanded, and 2) they are much smaller, relative to the diameter of the rhizome, than the croziers of fern 2 above.



The following is a cross section of the rhizome. It's coloration looks normal.



Here are photos of two croziers of fern 8, one of which is cross sectioned:



And another crozier from fern 8, also cross sectioned:



Now compare the above to a normal crozier<sup>3</sup> on the right.

Notice the spiral of the normal crozier, having several complete turns that are missing in the croziers from fern 8. It's possible that fern 8's croziers had multiple turn spirals in March/April and then expanded to their present shape, but whether or not they are malformed, the croziers on Fern 8, are smaller than normal and, so far at least, they have not expanded into fronds.

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<sup>3</sup> The "normal" crozier was taken from a smaller fern in my front yard. This fern had expanded its croziers at least 3 weeks earlier and this crozier is likely a "summer" frond and it probably not fully developed. Nonetheless it is much more developed than the croziers from fern 8.

## Implications for Fern Survival

Sword ferns (and virtually all ferns) must make new fronds each year. Sword ferns spend the growing season storing energy and forming croziers that emerge the following spring. Sword ferns that do not make new croziers will die.

## Summary, Speculation and Further Work

### Summary:

Between April 15 and May 12 of 2019, 9 closely monitored sword ferns in the active die off area of Seward Park displayed the following:

- 1) Fronds from the previous year are still mostly green. The range of damage to previous year's fronds is not out of line with ferns in other areas of the park, ferns that successfully expanded many new fronds.
- 2) 5 out of 9 of the monitored ferns have rhizome tips that did not expand new fronds.
- 3) The croziers of rhizome tips that did not expand new fronds are smaller than normal and have not expanded into fronds though they may show some sign of having partially expanded.
- 4) Ferns outside the die off area all expanded multiple new fronds.

It is highly likely that this set of characteristics is a symptom of the The Seward die off syndrome.

### Speculation:

I can only think of two possible causes of this phenomenon.

- 1) During the growing season the fern is unable to generate enough energy (sugars, etc.) to support the formation of new croziers. The disease, whatever it is, prevents photosynthesis, or blocks the flow of nutrients to the rhizome tip, or the fern is unable to take up enough water to support crozier formation.
- 2) The fern is producing enough energy, but the disease somehow disrupts crozier formation.

### Further work:

- 1) Continue monitoring the 9 ferns and expand the monitoring to include ferns outside the die off area. Pay special attention to when croziers are formed, both inside and outside the die off area.
- 2) Check other sites to see if the same symptom is present. **This should be done soon while it is still easy to tell new growth from last year's growth.**
- 3) Review studies of frond photosynthetic activity to see if they correlate with crozier formation/non-formation.
- 4) Check healthy ferns to see if they also produce small or malformed croziers.
- 5) Track the percentage of ferns in the active die off areas with the characteristics described in this report.