Post-fire herbivory of *Pediocactus nigrispinus* in Central Washington

Ron Bockelman

ron.bockelman@hotmail.com
(Photos by the author unless otherwise indicated.)

Pediocactus nigrispinus (Hochstätter) Hochstätter is a regionally endemic cactus found only in Washington, Oregon, and Idaho. It is the only native ball cactus in Washington and is easily distinguished from the two other native species, *Opuntia fragilis* (Nutt.) Haw. and *O.* ×*columbiana* Griffiths (Bockelman 2020). It occurs on shallow rocky soils derived from basalt bedrock along and between the Columbia and Yakima rivers in the western portion of the Columbia Plateau.

In Washington, *Pediocactus nigrispinus* is considered a Vascular Plant of Conservation Concern (Fertig 2021) because its distribution is very limited and its populations face several threats or limiting factors. These include wildfires, habitat conversion/loss, and over collection (Washington Natural Heritage Program 2024).

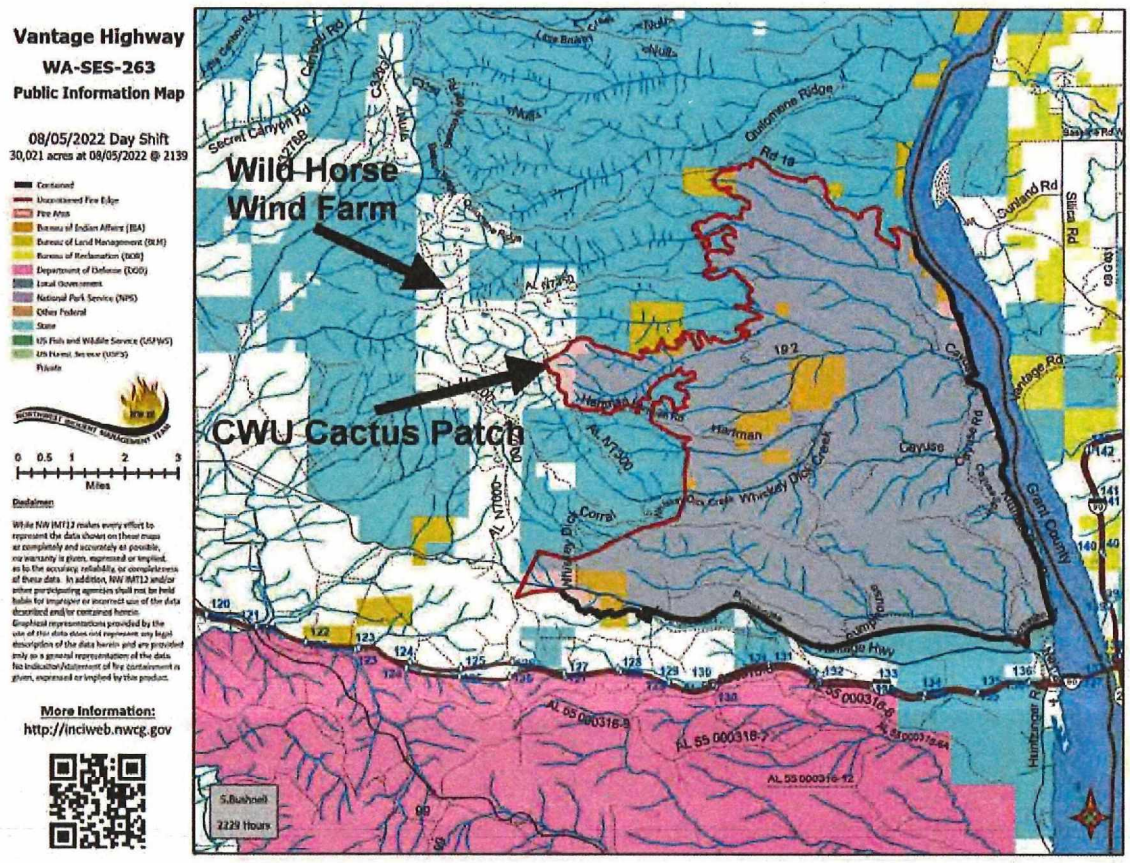
Rangeland wildfires currently are the greatest threat. Their frequency, size, and intensity have increased over the past decade. There are few anecdotal observations of fire effects on *Pediocactus nigrispinus* populations, and no studies focused on individual plants or specific cactus patches. A 2022 wildfire in Kittitas County provided an opportunity for me to address this study need.

What is the Vantage Highway Fire? This fire started along Vantage Highway about 8 miles west of the Columbia River around noon on August 1, 2022. Driven by strong southwesterly winds, it quickly spread along the highway and to the northeast. After burning farther northward for a couple days, one arm on the fire started burning westward up the Bryant Creek drainage. When the wind switched to easterly, the fire burned all the way to Wild Horse Wind Farm, where I have been studying *Pediocactus nigrispinus* since 2018 as a retirement project.

The fire containment line eventually enclosed 30,000 acres (Fig. 1), but only about 19,000 acres actually burned. The fire first spread through the canyons and draws where riparian vegetation fueled it. From there it spread up the slopes, but sometimes died out when reaching rocky areas, especially those near the tops of knobs and ridges. Also, some slopes that burned in a 2018 fire did not burn again.

What cactus patch burned? I call it the CWU patch because biology students at Central Washington University measure cacti there as part of a class in field techniques. It is one of the patches where I studied cactus phenology in 2019 and 2020 (Bockelman 2021). There are more large cacti, both single and multi-stem plants, than elsewhere at Wild Horse. It also differs by having bluebunch wheatgrass (*Pseudoroegneria spicata* (Pursh) Á.Löve) in addition to the Sandberg bluegrass (*Poa secunda* J. Presl.) which typically occurs in cactus patches elsewhere in Washington. It is the only patch where I have seen rock lupine (*Lupinus saxosus* Howell) as a prevalent plant associate.

How did fire impact cacti? Photos by wind farm staff soon after the fire (Fig. 2), and my own reconnaissance about a week later, showed that only the western portion of the CWU patch burned. Apparently, the main fire stopped just short of the ridgeline, but burning embers blown by the easterly wind must have landed near the center of the patch. As a



1. Map of the Vantage Highway Fire containment line.

2. Only part of the CWU patch at Wild Horse Wind Farm burned, as shown in this photo from August 8, 2022. Photo by Andrea Crawford.

3. Examples of fire damaged cacti on August 11, 2022: a) some spines singed but most not burned, b) spines burned to short stubs but tubercles still greenish, c) tubercles tawny but apical spines still intact, 4) whitish desiccated epidermis at apex with apical spines burned to stubs. Photo by Mary Poulson

result, the western portion of the patch burned but the eastern part was spared.

Most fire injuries were substantial with the epidermis appearing tawny and many spines burned to short stubs (Fig. 3). Injuries to a few cacti appeared minor with the tips of some spines slightly singed but most spines looking normal. Although some plants were black, this seemed to be soot from adjacent vegetation that burned rather the cacti themselves burning until black. None of the blackish cacti were split open like I sometimes saw in patches elsewhere that were severely burned.

Cacti with the greatest damage in the CWU patch tended to be those immediately adjacent to bluebunch wheatgrass. It is easy to imagine these dense clumps of grass, mostly dry by August, fueled very intense flames.

How were fire impacts and cactus recovery studied? I rely heavily on photo-documentation because the 5-hour roundtrip drive from home limits my

time in the field each day. My initial reconnaissance in August suggested taking photos of burned cacti with a numbered marker and surrounded by a 0.25-m x 0.25-m PVC frame for scale. I also decided to install a time-lapse camera taking daily photos in hopes of documenting habitat recovery.

In September 2022 I marked and photographed all 99 burned cacti that I found in the CWU patch. I planned to take repeat photos quarterly, however, when I asked Jim Mauseth for feedback on my study plan, he recommended monthly instead. This proved to be very sage advice when herbivory became evident.

What were the first indications of herbivory? While getting the study started in September, I noticed that the epidermis on a few burned cacti had been breached, showing white tissue inside the stem. Closer examination revealed small discs or chips scattered around the cacti. These turned out to be dried tubercle tips with an areole of burned spines (Fig. 4).

The fire often burned the cactus spines to short basal stubs. It also scorched the epidermis, making it brittle. It appears that herbivores were able to break off the dried tubercles, with spine areoles attached, to gain access into the cactus stem.

Thus, the spines which normally protect the cactus from herbivory, after they were burned short, probably gave the rodent something easy to pick away, letting it get through the epidermis and gnaw inside the stem. And once the epidermis was breached, even tubercles with unburned spines became vulnerable.

How did we determine the culprit? When I bemoaned to friends the lack of a motion-activated camera to determine what was eating the cacti, Mary Poulson replied that CWU might have a couple wildlife cameras. Not only did she arrange use of the cameras, but Mary also volunteered to deploy and service four. Then she reviewed the 1000+ photos, nearly all of which apparently were triggered by plants moving in the wind or by spinning wind turbine blades, to ferret out those few showing critters.

Thanks to Mary, we know that cottontail rabbits are responsible for most of post-fire herbivory. The locally native mountain cottontail (*Sylvilagus nuttallii* Bachman 1837), based on feedback from CWU mammologist Kris Ernest, seems to be the prime culprit (Fig. 5). There also are a couple night photos of a rabbit bent over a cactus stem, which was noticeably shorter in the light of day.

Bushy-tailed woodrat (*Neotoma cinerea* Ord 1815) is another critter that might be eating burned cacti. Night photos show this "packrat" spending time around some of the same cacti eaten by the rabbit(s). Although packrats are known to protect their nests with spiny prickly pear pads, I am not aware of any reports that they eat globose cacti like *Pediocactus nigrispinus*.

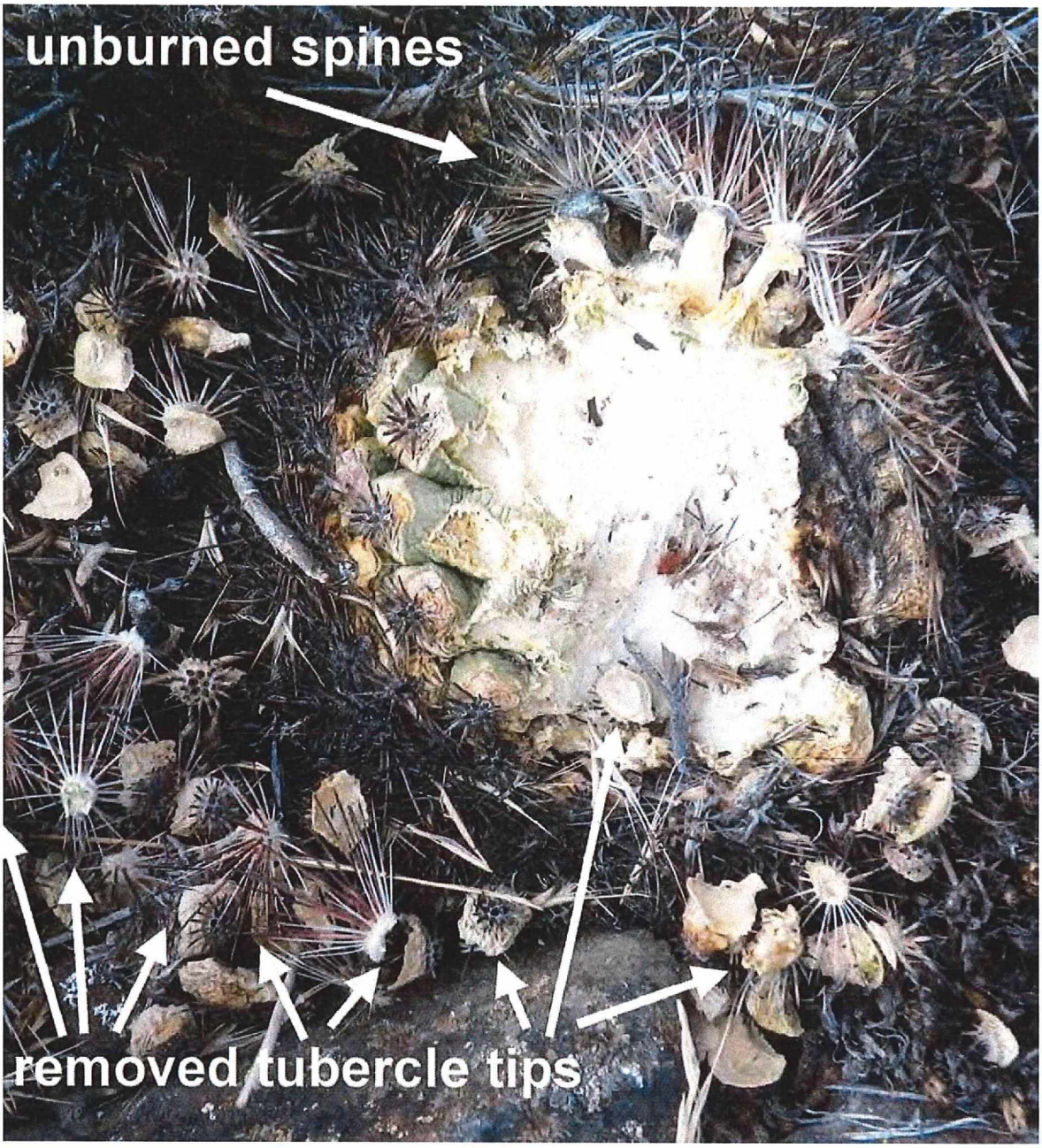
Did the herbivory continue? Yes, more cacti showed damage each month into November (Table 1). By November, 46% of the 99 burned plants and 30% of their 235 stems had been damaged.

Sadly, the devastation continued over winter and by April 2023, 87% of the burned plants and 85% of their stems appeared impacted by herbivory. The time lapse photos in winter show periods of snow cover interrupted by occasional days of warmer weather when the snow melted. The burned cacti probably were one of the few food sources available to the rabbit(s) during the lean winter months.

Extensive damage can occur overnight (Fig. 6). Seven large cactus stems are seen on the afternoon of December 19. All of them look eaten nearly to the ground the next morning. Having so many large stems disappear so quickly has me wondering how many rabbits were eating them.

Table 1. Increase in the frequency of herbivore damage to burned cacti.

DATE	PLANTS (N=99)	STEMS (N=235)
11-Aug-2022	0	0
8-Sep-2022	10	14
6-Oct-2022	35	50
10-Nov-2022	46	70
6-Apr-2023	86	199



4. Loose tubercles with spine stubs around cacti and partially eaten stems were obvious indications of herbivory on October 6, 2022.

How bad was the damage? After seeing the extent of damage in April, I wondered how best to measure it. I decided to score the damage using an ordinal scale from zero to five, in increasing amounts of damage. To make sure that for multi-stem plants I didn't miss any stems or score a stem twice, I first labeled each stem on the plant condition photos from September.

A major benefit of repeatedly photo-documenting the burned cacti is that I could go back and score the damage from the beginning (Table 2). When herbivory was first noticed in September, the damage was relatively minor, mostly tubercle removal and damaged epidermis on only 24 stems.

Not only did the number of damaged stems increase over the next two months, but so did the severity, with the average score climbing to 2.5 per damaged stem. Whereas only a single stem was eaten across its entire diameter in September, over 40% were by November. To me, this level of damage is especially noteworthy because not only was the stem interior exposed to desiccation and

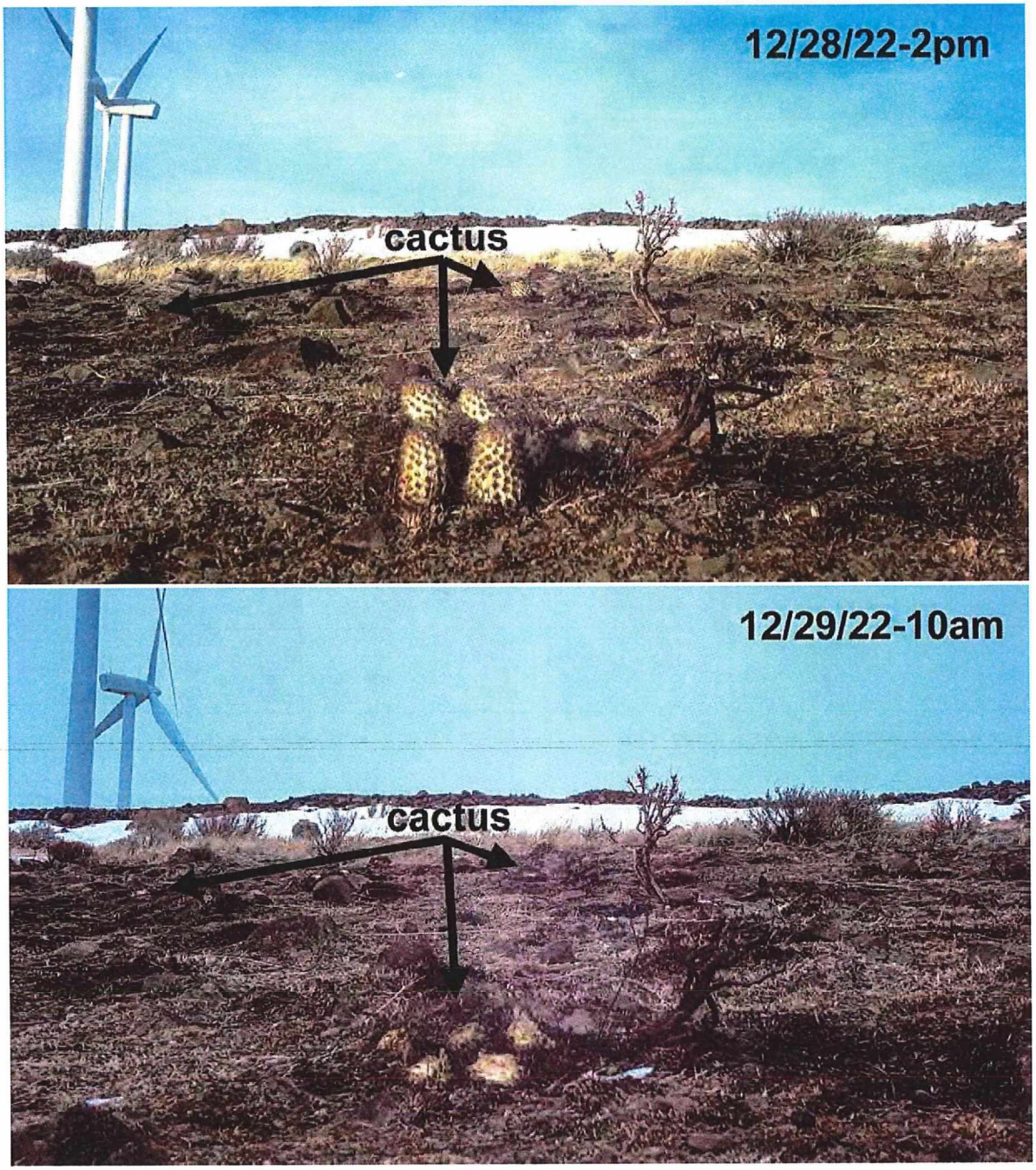
5. Wildlife cameras documented a cottontail rabbit eating a burned cactus on October 19, 2022 at 7:18 a.m. Photo by Mary Poulson

Table 2. Increase in the severity of herbivore damage to burned cactus stems.

STEMS SCORING	AUG	SEP	OCT	NOV	APR
1	0	4	8	7	1
2	0	9	21	27	3
3	0	1	18	29	18
4	0	0	3	7	156
5	0	0	0	0	18
Total Stems	0	14	50	70	199
Total Score	0	25	116	176	775
Average Score	0	1.8	2.3	2.5	3.9

Stem Damage Scoring

0 – no evidence of herbivory
1 – some tubercle(s) removed, epidermis not breached
2 – epidermis breached less than stem diameter
3 – major damage across entire stem diameter
4 – only stem base remains
5 – no stem or base apparent



6. Time lapse photos from December 2022 showed that considerable herbivory can occur overnight during winter.

disease, but also because it removed the apical meristem responsible for normal stem growth.

In April the average score was 3.9 and 174 of the 199 damaged stems had been eaten to the ground or else withered away after the stem contents were exposed by herbivory. Thus in the eight months following the fire, herbivores had damaged 85% of the stems burned in the fire, and of these, 87% had been lost entirely. What a tragic and sudden ending for these robust cacti, many of which probably required several decades to grow so large.

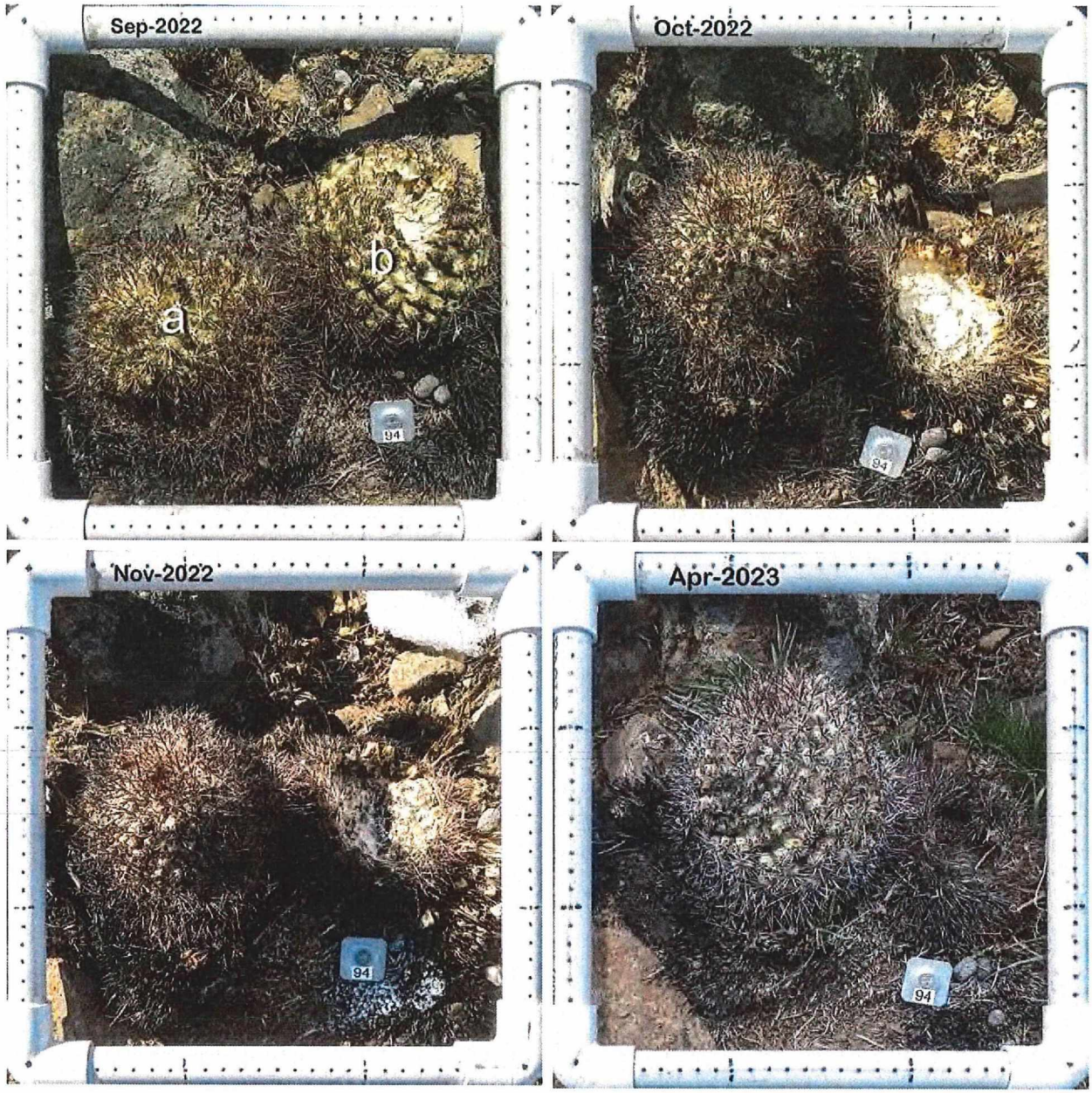
Is what happened at the wind farm typical? Thankfully the post-fire herbivory observed at the Wild Horse Wind Farm seems to be the exception

7. Plant condition photos for burned cactus #5, with stem assignments shown on the Sep-2022 photo. Herbivory scores are 2 for stem d in Oct- and Nov-2022, 3 for stem e in Nov-2022, 3 for stems b and f in Apr-2023, and 4 for stems a and c-e in Apr-2023.

rather than the rule. I have been able to check on burned cacti in three other patches and have only seen one single-stem plant that looked partially eaten.

I rarely see herbivory of unburned *Pediocactus nigrispinus*, but it does occur. Most often one sees empty "exoskeletons" of spines with a hole in the top of the stem. Local cactus enthusiast Dixie Dringman tells me that this results when rodents burrow underground to begin eating the stem from below. I also know of a patch of rescued and replanted cacti at the wind farm that disappeared after Townsend's ground squirrels (*Urocitellus townsendii* subsp. *townsendii* Bachman 1839) established a colony in it. Finally, last summer two of my favorite rescued/replanted cacti in a raised bed at Wild Horse were partially eaten, in much the manner of the burned ones I was studying.

What's next? My field time is too valuable to continue monthly studies of burned cactus recovery, now that so many plants and stems are



8. Plant condition photos for burned cactus #94, with stem assignments shown on the Sep-2022 photo. Herbivory scores for stem b are 2 in Sep-2022, 3 in Oct- and Nov-2022, and 4 in Apr-2023.

essentially missing. Although it seems unlikely, I am curious if new stems might grow from the roots of cacti eaten to the ground. So, I plan to check on this for the next couple of years before removing my markers.

I am going to continue using plant condition photos to monitor about 20 burned cacti that weren't damaged by the rabbit(s), but I will only take photos once per year, probably when cactus fruits are ripe. I plan to compare the results from Wild Horse to those from two other patches burned by the Vantage Highway Fire.

Literature cited

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