

## Survival of *Veratrum viride*, a Robust Herbaceous Plant, when Buried by Volcanic Tephra

### Abstract

*Veratrum viride* plants that survived burial by 12-18 cm of tephra from Mount St. Helens in 1980 were experimentally buried 20-50 cm deeper in 1982. Burial of dormant plants by an additional 40 cm of tephra prevented most shoot development, but only reduced survival by half when shoots were already emerging at the time of burial.

### Introduction

Burial of plants by volcanic tephra elicits a variety of plant responses (Antos and Zobel 1985a, 1985b). Where tephra does not erode, buried plants must grow up through the tephra to survive. Most perennial herbs moved their underground perennating structures into the tephra, but shoots of a few species grew up through the tephra each year, retaining the original position of their overwintering buds in the buried soil. The most robust herbaceous species we encountered, and the most successful at this latter strategy, was American false hellebore, *Veratrum viride* Ait. (Liliaceae). Shoots of *V. viride*, which can exceed 2 m tall when flowering, pushed up through 15 to 18 cm of tephra, including a hard 1 cm surface crust, with no evident difficulty.

The purpose of the experiments described here was to determine how deep a tephra deposit would be required to prevent the emergence of shoots of *Veratrum viride*.

### Study Area and Methods

A *Veratrum viride* population was chosen at 1200 m elevation, 22 km NE of Mount St. Helens, Washington, in an area covered by 12-18 cm of tephra on 18 May 1980 (described by Antos and Zobel 1985b). The plants grew among scattered *Abies amabilis*, *Tsuga mertensiana*, and *Alnus sinuata*. They showed no adverse effects of the 1980 eruption at the time they were chosen in 1982.

Experiment 1. On 30 June 1982, six clumps were chosen with 3 to 5 shoots each just emerging (0-15 cm tall) from the tephra. Two clumps were randomly assigned to each treatment, treat-

ments being 20, 30, or 40 cm of additional burial. Clumps were buried by shoveling tephra from the surrounding area carefully over the shoots. Emergent shoots were counted, measured, and checked for damage on 15 September 1982, 14 September 1983, and 5 September 1984. On the last sampling date, all mounds were excavated and the buried parts of all shoots measured and examined.

Experiment 2. On 15 September 1982, ten additional clumps with 3-6 shoots each were chosen, and shoot heights measured. Clumps were assigned randomly to one of two treatments, of 40 and 50 cm additional burial, and buried on 1 October 1982, after the shoots had died. Observations were made in 1983-4 as for Experiment 1.

Experiment 3. Four mounds from Experiment 2 with no emerging shoots were excavated 14 September 1983. Shoots were measured and then reburied to 30 cm deeper than natural tephra. Observations were made in 1984 as in Experiment 1.

The experiment terminated when the stand was logged late in 1984.

### Results

#### Shoot Emergence from Tephra

Aerial shoots developed from all clumps buried in Experiment 1 (Table 1). All shoots visible at burial grew through 20 cm of added tephra (as did several shoots not visible at burial), but about half failed to escape burial by 30 and 40 cm. In 1983 and 1984, shoots emerged from the same points as 1982 shoots, presumably following the same path through the mound.

The ten clumps buried in the fall after shoot senescence (Experiment 2) produced 43 shoots

TABLE 1. Experiment 1: Responses of shoots buried by 20, 30, and 40 cm tephra after emergence from the natural tephra in June 1982. Values in parentheses are standard deviations. Measurements were all in September except the "before" shoot number.

Burial Depth (cm)	Actual Depth (cm)	Number of shoots				No. Flowering			Shoot Heights (cm)			No. Leaves 1984
		before	1982	1983	1984	1982	1983	1984	1982	1983	1984	
20	33.0 (1.4)	7	11	12	11	0	2	0	45 (9)	67 (31)	65 (9)	9.0 (2.1)
30	38.5 (2.1)	8	3	4	3	0	1	0	31 (15)	67 (47)	55 (19)	9.0 (2.5)
40	48.0 (1.4)	10	5	5	8	0	3	0	37 (11)	110 (59)	45 (23)	6.5 (2.1)

the season before burial. After burial only one clump, buried by 40 cm, produced emergent shoots, two in 1983 and three in 1984. No shoots emerged in 1984 from four clumps reburied less deeply in 1983 (Experiment 3).

#### Shoot Size and Flowering

The shallowest burial produced the tallest shoots in 1982 and 1984 (Table 1) but differences were non-significant. Shoots buried the deepest had significantly fewer leaves in 1984 (leaves were not counted in 1983). In 1983, flowering occurred but did not appear to be related to depth of burial (Table 1). In 1984, however, no experimental shoots produced flowers; in contrast, about 40 percent of unburied shoots near the experiment flowered.

#### Damage to Emergent Shoots

In 1982, all leaves of shoots emerging from 40 cm deep burial were torn, except for the top two leaves on 2 of the 5 shoots; in contrast, those buried with 20 cm of tephra had only slight abrasion damage on the lower leaves. Plants buried 30 cm had intermediate levels of leaf damage. Damage to deeply buried shoots was less in later years.

#### Condition of Buried Shoots

Excavation in September 1984 revealed only one buried shoot that had not emerged from the six tephra mounds in Experiment 1. In contrast, the ten clumps buried in the fall had 32 buried shoots, averaging 16 to 37 cm long (except for clump 15 at 59 cm). Since total tephra depth was 40 to 68 cm, most shoots were too short to emerge

even if they had grown straight up. In clump 15, one shoot grew nearly to the surface and then downward, and another grew twisted through the mound.

There was no difference in buried shoot length among the treatments in Experiments 2 and 3 in 1984, nor any significant correlation between length of buried shoots and shoot height of the clump before burial. Buried shoots were significantly taller in 1984 than in 1983 in the four mounds excavated both years (31 vs. 14.5 cm).

All buried shoots were abraded and dying back from the tip, which was often rotten. In 1983, most buried shoot tissue was dead in mid-September. Shoots usually grew vertically near the base but bent or twisted farther into the mounds. Shoots lost vigor as they grew into the mound, the apical parts being of much smaller diameter than below.

Almost all emergent shoots grew vertically, their buried length equal to (or for a few up to 3 cm greater than) the depth of the tephra. Many followed the same route through the mound as shoots of previous years.

#### Discussion

*Veratrum viride* copes more successfully with burial after shoots begin growth in the spring than with burial while plants are dormant. Forty cm of additional tephra was fatal to most shoots when dormant, but to only half those buried while shoots were growing. The difference may result because, in the spring, the emergent shoots are closer to the surface, tissue is "hardened" by exposure at the time of burial, and the tephra is less compact. In subsequent years, spring-buried

shoots face the same problems as fall-buried ones, except that there are pathways through the mound followed by shoots the year before.

The effect of burial appears to occur after shoots begin growth. Leaf abrasion and tearing appeared to be caused by friction as the shoots pushed up through the coarse, rough tephra. Gas exchange beneath the tephra potentially could be a problem, but with the loose, coarse tephra in the mounds, and the initial vigorous vertical growth, it seems unlikely to be important here. Reduced gas exchange is more likely to be critical in a natural deep tephra deposit, however. There, deep tephra would not be in isolated mounds, and the fine layers as produced from the 1980 eruption (Waitt and Dzurisin 1981) would be intact, offering a more effective barrier to gas exchange.

The 1980 tephra deposit was shallow enough to allow most or all *Veratrum viride* to survive, although it eliminated all except isolated individuals of other forest herbs near the study area (Antos and Zobel 1985c). Earlier deposits in the area have been substantially deeper (Waitt and Dzurisin 1981). A deposit twice as deep, falling on dormant plants, could kill most *V. viride*. If *Veratrum* shoots were above the soil, still in the

compact form in which they penetrate it, the effect would probably be much less severe. The shoots retain this less susceptible form, however, for only about two weeks. When the leaves are spread, as during most of the growing season, damage is again likely to be great; the weight of even a few mm of fallen tephra trapped in the expanded leaves toppled shoots of *Veratrum californicum* (Mack 1981). Except when flowering, the aerial "stem" of *Veratrum viride* is composed only of concentric, elongated, sheath-like leaf bases, with the meristem remaining below ground. Thus the plant may be more susceptible to toppling or abrasion damage than shoots of a similar size that include stem tissue. Even so, its very large size and robust shoots give *Veratrum* an advantage over most other species.

The effect of tephra on a particular organism or other natural system varies drastically with the condition of that system (for example, see Antos and Zobel 1982). In our case, *Veratrum*, singled out as being particularly vulnerable to falling tephra while mature (Mack 1981), proved to be the herb best able to cope with burial of its perennial organs by much deeper tephra, in areas where shoots had not yet developed.

#### Literature Cited

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