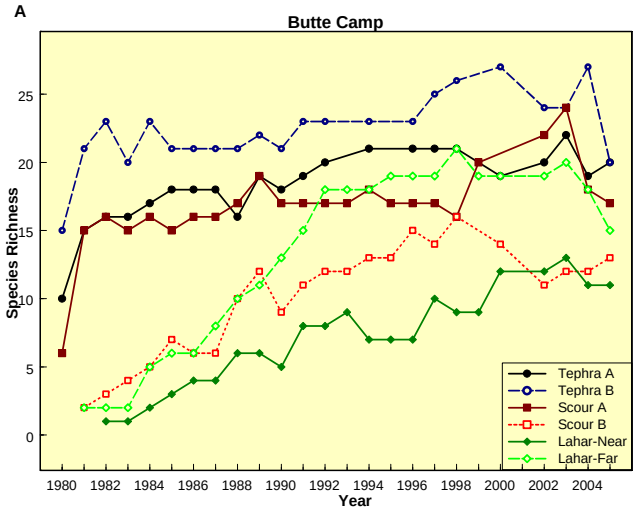
Permanent Plots

PERMANENT PLOTS

Changes in community structure. I continued to monitor permanent plots at Butte Camp, Pine Creek, Pumice Plain, Abraham Plain and Studebaker Ridge. These plots provide insight into mechanisms of community assembly and offer the ecological community large sets of data to test models (see below). Richness has stabilized in most sites, and has declined in a few. (Examples are shown in *Fig. 1*). Tephra A sites recovered quickly after the eruption, and have fluctuated. Changes are due to rare species not being located in some cases. Tephra B is may be losing rare species. Scours have been invaded by many species, a process that occurred quickly in Scour A, which was near intact vegetation, and more slowly in Scour B. In the latter case, richness has declined after a peak in 1998. Lahar plots were situated on Lahar 1, near conifer forest, and Lahar 2, distant from forests. Richness has increased steadily in both, but the isolated plot has more species. The recent decline may be a function of dry summers. The low level in Lahar 1 is related to dense conifer cover that developed quickly.

Scour and Pumice Plots (Fig. 1B) include those with little to no survivorship. The Pine Creek Scours were devastated, but a few remnants survived, especially in Scour A. These plots assembled species slowly, but both peaked in the early 1990s. Since then, richness has declined as a few dominants have prevailed. The four Pumice Plain Plots are on an elevation gradient. Prior to1989 there was very scant vegetation and observations indicated that the first species did not establish until 1986. However, species invaded quickly and, though sparse, the richness of these plots is among the highest. The dips in 2004 are correlated with dense lupines in that year. The Abraham Plain was even sparser (the grid started in 1988) was virtually empty. Plots started in 1995. There was an initial increase in species, but the numbers have declined to about their original numbers.

The Studebaker Ridge provides a direct measurement of the effects of elevation. The ridge received a traumatic blast in 1980, and a minor dusting of tephra in late 2004. These plots are arrayed up the ridge, and structure has developed first at low elevation and progressively up the ridge. However, periodic bursts of *Lupinus lepidus* make the progression episodic, not smooth. All plots have accumulated species, so that by 2005 they have similar values. SR1 stabilized by 2000. SR6 declined in 2004-2005, perhaps due to the dominance of *Lupinus*. SR20, though the highest site has substantial heterogeneity and supports a variety of species.



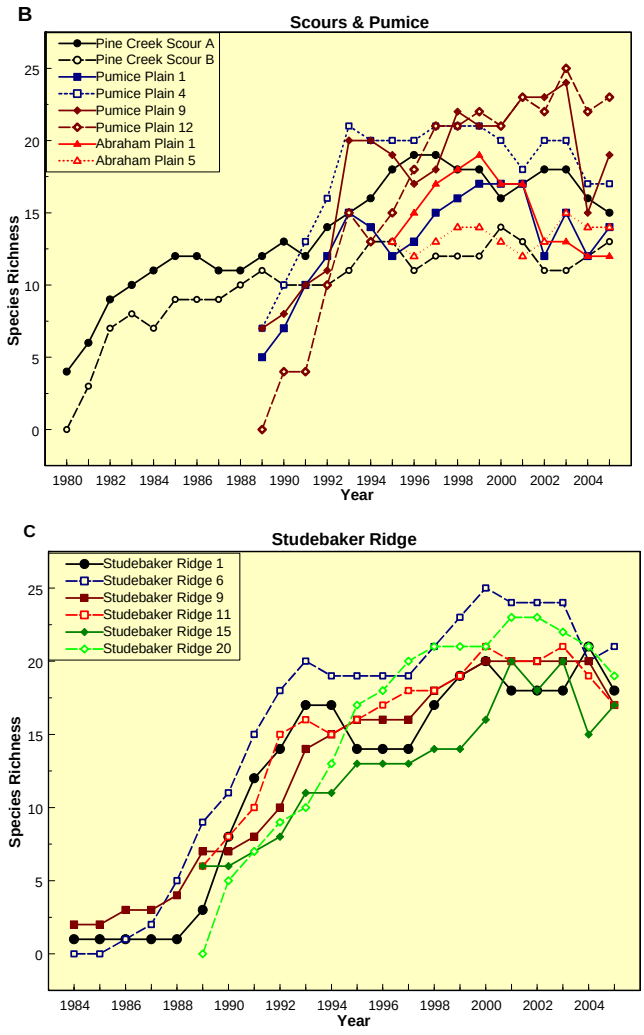


Fig. 1. Richness in selected permanent plots.

The plot cover in these permanent plots is shown in *Fig. 2*. Tephra impacted sites are stable, with the large *fluctuations* due primarily to seasonal drought variations. The low scour has developed vegetation much more quickly than the high one, which remains barren. The lahars show different patterns. Both appear to be continuing to expand, but the Near Lahar, due to conifers, continues to expand. The distant lahar remains with sparse vegetation, though the long-term trend appears upward.

On the Pumice Plain, *Lupinus* increases strongly affected many once *barren* sites (*Fig. 2B)*. In 2005, lupine density decline precipitously when sampling occurred, though it made a minor recovery by the end of the season. The long-term development of all sites is to increase, but some specie turnover may be occurring where lupines have been dense.

The *blasted* ridge (Studebaker) experienced a *Lupinus* invasion that has slowly moved up the slope, showing how the rate of succession must be gauged by *relative* time, indexed by rates of biomass accumulation (*Fig. 2C*). This pattern has been observed elsewhere on Mount St. Helens.

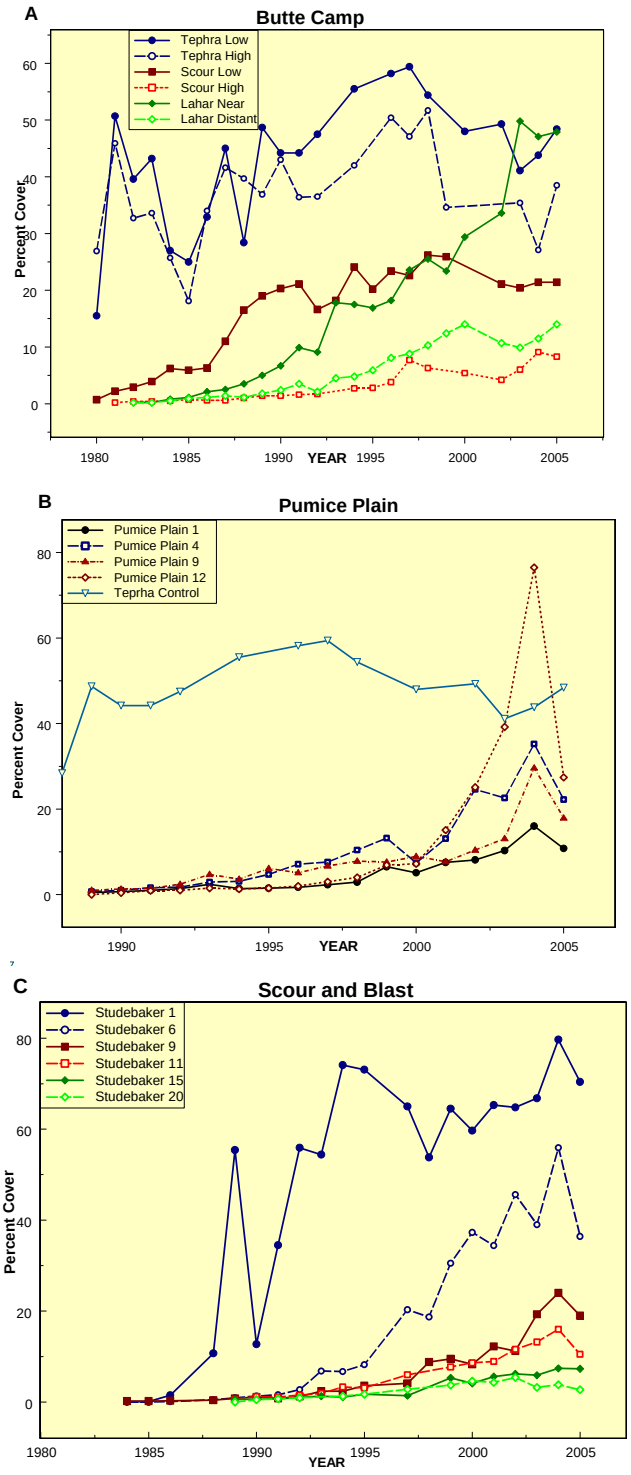


Fig. 2. Mean Percent Cover in selected permanent plots.

The cover of individual quadrats in permanent plots has been produced in EXCEL files so that changes through time can be estimated. Of course, in every case, there have been significant changes, but the magnitude of these changes differs with the nature of the habitat.

Representative data are presented in *Table 1*, in which the habitat, length of the record, range of values, number of homogeneous groups based on the Bonferroni comparison of means, peak year, and overall significance of a one-way ANOVA are shown. The record in primary plots did not normally start in

the first year of observation because in initially sparse sites, no quadrat had any cover, even though plants were recorded in the plot as a whole.

Table 1. Summary of analysis of permanent plot cover, calculated from individual quadrats.

Habitat Type	Range, Years	Lowest Cover (%)	Highest Cover (%)	2005 Cover (%)	Number of Different Groups
Tephra A	1980-2005	15.3	66.9 (1996)	47.7	4
Tephra B	1980-2005	17.8	50.6 (1996)	38.2	3
Scour A	1981-2005	0.71	24.0 (1998)	20.6	2
Scour B	1989-2005	0.46	8.8 (2004)	7.8	3
Lahar - Near	1986-2005	0.88	48.6 (2003)	47.0	7
Lahar - Far	1985-2005	0.42	13.2 (2005)	13.2	7
Pine Creek Scour A	1980-2005	1.54	50.8 (1999)	42.1	10
Pine Creek Scour B	1982-2005	0.29	39.4 (1999)	28.2	5
Pumice Plain 1	1990-2005	0.04	15.5 (2004)	10.4	6
Pumice Plain 4	1990-2005	0.25	34.7 (2004)	21.5	5
Pumice Plain 9	1989-2005	0.42	28.9 (2004)	17.0	4
Pumice Plain 12	1989-2005	0.17	75 (2004)	26.2	4
Abraham Plains 1	1995-2005	1.6	7.9 (2001)	4.8	4
Abraham Plains 5	1995-2005	1.2	6.3 (2004)	5.7	2
Studebaker Ridge 1	1984-2005	0.04	78.5 (2004)	69.6	5
Studebaker Ridge 4	1992-2005	0.04	72.9 (2002)	53.2	5
Studebaker Ridge 6	1991-2005	0.45	54.9 (2004)	35.4	5
Studebaker Ridge 11	1989-2005	0.08	14.4 (2004)	9.6	6
Studebaker Ridge 15	1992-2005	0.12	6.54 (2004)	6.0	2
Studebaker Ridge 20	1992-2005	0.04	3.63 (2002)	1.4	1

Note 1: nomenclature follows that of Fig. 1.

Note 2: all ANOVA are significant at $P < 0.0000$

The permanent plots indicate that succession rates are conditioned on environmental stress. Often this is a direct correlate of elevation, but local factors can override this effect. Species turnover occurs as vegetation becomes denser and dominance hierarchies develop. This is more readily seen where conifers have invaded. Future studies are planned to investigate the effects of willows in wetlands and other shrubs on the Muddy River.