# Further Studies of Natural Reforestation in the Donner Ridge Burn

JANE H. BOCK AND CARL E. BOCK
*Biology Department, University of Colorado*
*Boulder, Colorado 80302*
and
VERNON M. HAWTHORNE
*Sagehen Creek Field Station, University of California*
*Truckee, California 95734*

## INTRODUCTION

We reported to the Tall Timbers Fire Ecology Conference in 1969 about natural reforestation on the 39,000 acre Donner Ridge Burn which occurred in 1960 (Bock and Bock, 1969). In 1965 two permanent study areas of 8 hectares (20 acres) each were established. One study area was located in the burn, and one in the adjacent unburned pine-fir forest. Each study area was subdivided into 91 study plots, 30.5 m (100 ft.) on a side. In the mid-1960's several young trees and seedlings of known age were tagged with permanent markers. The principle tree species of the area are *Abies concolor* (Gord. and Glend.) Lindl., *A. magnifica* A. Murr., *Pinus jeffreyi* Grev. and Balf., and *P. murrayana* Grev. and Balf..

In June, 1974, we revisited the burned study plots, measured the tagged trees and counted living trees. This paper reports on the growth and survival of the tagged trees between 1965 and 1974, and on changes in stand composition over the same period.

## RESULTS

The burned study area has changed dramatically in appearance between 1965 and 1974 (Figs. 1 and 2). This is due primarily to the growth of the young pines. The mean height of the tagged trees in 1965 was 31.82 cm (Standard Deviation=13.61; n=105). In 1974 those trees of the original sample which were still tagged averaged 172.84 cm (S.D.=86.02; n=81).

In 1967, 92 of the original 105 tagged trees were still tagged. Those 92 were retagged with stainless steel tags at that time. This past summer (1974) 83 of those 92 tagged trees were located. Of those 83 trees, 81 were still alive, suggesting a very high survival rate.

Seventy of the tagged trees were Jeffrey pines. They had been aged and their heights measured in 1965 at the initial tagging. These 70 trees were singled out for further studies of growth rate by age class (Fig. 3). An exponential curve was fitted to these data ($y=14.7e^{.20x}$).

Fig. 1. Photograph of the burned study plot, Sagehen Creek, California, taken in October, 1966. Note young trees and standing dead timber.

Species composition of the burned area in 1967 and 1974 was compared with that of the adjacent unburned forest (Table 1). The species compositions for a typical burned plot in 1967 and in 1974 were calculated from data obtained on 14 study plots. These were compared with the species composition of a typical unburned plot based on a census of 10 unburned study plots (Table 1). These data show that there are far more trees per plot on the unburned plots than on the burned ones, and that fir trees on the unburned plots are the primary cause of this difference. Fir seedling recruitment on the unburned plot was high (68.2 seedlings per plot) while it was almost nonexistant on the burn in 1974 (0.1 seedling per plot). On the other hand, pine seedling recruitment on the unburned plot was very low (0.1 seedlings per plot) while recruitment for pines on the burned plots was higher (3.4 seedlings per plot). However, pine seedling recruitment on the burn has dropped from 32.5 seedlings per plot in

Fig. 2. Photograph of the burned study plot, Sagehen Creek, California, taken in June, 1974.

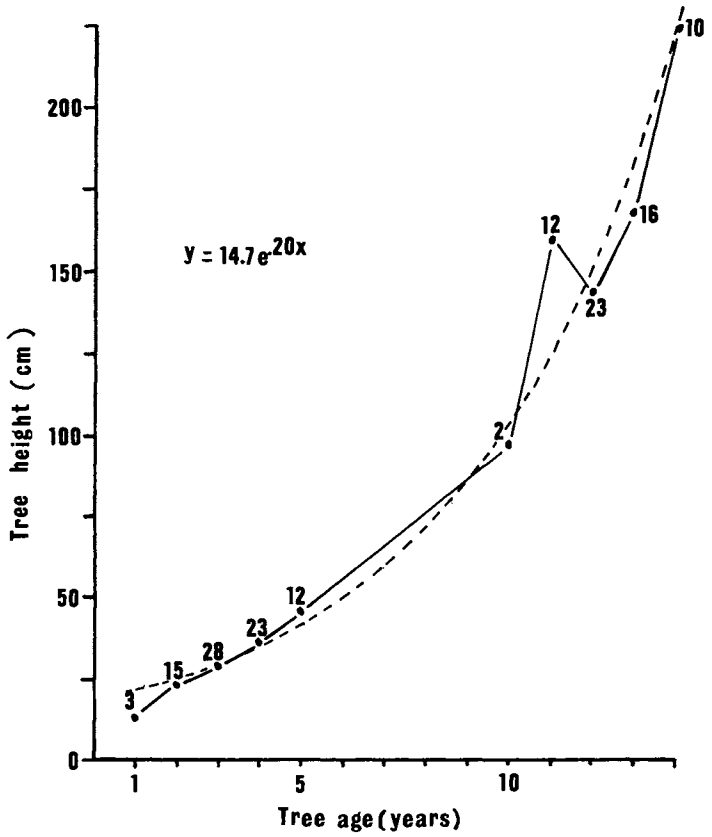


Fig. 3. Pattern of growth in *Pinus jeffreyi*. The 15 year old trees germinated in 1960, the summer of the burn. Numbers above graph points are numbers of trees of that particular age. Dashed line=fitted exponential curve with formula shown in graph.

1967 to 3.4 in 1974. The large number of pine seedlings on the burned plots in 1967 is reflected in the large number of immature pine trees per plot (42.4 trees per plot) observed in 1974.

## DISCUSSION

As can be seen in Table 1 there are sufficient mature pine and fir

Table 1. Trees per plot on the Burned Study Area in 1967 and 1974 and trees per plot on the Unburned Study Area. SDL=Seedlings 0-5 years of age. Imm=Immature trees older than 5 years, but less than 20 cm DBH, Mat=Mature trees 20 cm or larger DBH.

| | BURN '67 | BURN '74 | UNBURN |
|---|---|---|---|
| *ABIES* | | | |
| MAT. | 0.4 | 0.4 | 8.9 |
| IMM. | 1.0 | 1.1 | 121.8 |
| SDL. | 1.2 | 0.1 | 68.2 |
| *P. JEFF.* | | | |
| MAT. | 0.5 | 0.6 | 10.1 |
| IMM. | 5.4 | 36.6 | 38.1 |
| SDL. | 28.6 | 3.3 | 0.1 |
| *P. MURR.* | | | |
| MAT. | – | – | – |
| IMM. | 1.0 | 5.8 | 0.6 |
| SDL. | 3.9 | 0.1 | – |
| TOTALS | 42.0 | 48.0 | 247.8 |
| PINES ONLY: | 39.4 | 46.4 | 48.9 |

trees in the adjacent unburned forest to offer copious seed sources for seedling recruitment on the burn. However, pine seedlings have far outnumbered fir seedlings on the burn since the fire. The natural pattern of post-fire reforestation in this part of the Sierra Nevada appears to be PINE $\geq$ PINE+FIR $\geq$ FIR (Bock and Bock, 1969). The pure fir forest stage of this succession pattern is seldom, if ever, reached due to interruption of the pattern by fire. It is difficult for us to reconcile this fire-regulated successional pattern with the classical climax community classification schemes of plant ecology.

Survivorship of seedlings that were tagged in 1965 and retagged in 1967 was found to be very high in 1974 (see Results). We feel that this high survivorship (98%) is evidence that the pine trees in this part of the Sierra Nevada are adapted to post-fire succession. The pattern of pine recruitment and its confinement to the burn offers further evidence of adaptation to fire. A third line of evidence comes from the growth patterns of the 70 tagged Jeffrey pine trees. We feel that this remarkably regular growth curve is a strong indication of a spe-

cies that is well adapted to its environment, in this case a burn. The climatic features in this area have not been constant in the 14 years since the burn, but the height increase of the trees has been. Such uniform exponential growth would not be expected in a species growing under abnormal or stressful growing conditions for that species.

One of the most intriguing aspects of our work is the similarity of numbers of pines per plot on unburned plots and burned plots in 1974 (Table 1). There are two possible explanations for this that merit discussion. One is that pine recruitment may continue on the burn for a few more decades until the forest canopy closes. At that time fir recruitment will commence and will continue concomitant with pine attrition until the next burn. If this hypothosis is accurate, then the similarity of pine density on our burned and unburned plots is due to chance; pines are still increasing on the burn, while they are declining in the unburned forest. Evidence of pine mortality on the unburned plot supports this hypothesis (Bock and Bock, 1969). Another possibility is that numbers of pines on a burn will stay more or less constant until the canopy closes. At this time fir recruitment will commence and the existing shrubby and herbaceous vegetation on the burn will be displaced with time by fir trees. This second hypothesis implies that pine reproduction occurs almost entirely during the first few years after a fire. This hypothesis is supported by our data (Table 1) which indicate a drastic decline in pine seedling recruitment on the burn between 1967 and 1974. Further research will be needed to determine which pattern or combination of patterns best describes this post-fire succession.

## ACKNOWLEDGMENTS

We are grateful to Mr. Larry Lepthien for assistance with data analysis. We wish to thank Prof. A. Starker Leopold, University of California, for his encouragement and for use of the facilities of the Sagehen Creek Field Station which he directs.

### LITERATURE CITED

Bock, Jane H. and Carl E. 1969. Natural reforestation in the northern Sierra Nevada-Donner Ridge burn. Proc. Annual Tall Timbers Fire Ecology Conf. 9:119-126.