Introduction

This paper discusses site- and landscape-level management implications of a long-term study in the high elevation forests of southwestern Colorado (Figure 1) initiated to examine use of different colors of tree shelters (providing variable levels of shading) as a means to improve Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) reforestation success. A description of the project justification, study site (Figure 2), experimental methodology, and results following two growing seasons were presented in Jacobs and Steinbeck (2001). We found that use of lighter-colored tree shelters improved early growth and survival of planted seedlings as compared to the traditional method of relying upon natural shade within the site. This was attributed to decreased animal browse (i.e., gophers) of sheltered seedlings along with positive changes to seedling development associated with shelter microclimatic conditions (Oliet and Jacobs 2007). Seedling responses to subsequent tree shelter removal (vs. not) were then published after 6 (Jacobs 2004) and 11 (Jacobs 2001) growing seasons. Results indicated that control seedlings had lower survival (35%) than any other treatment (ranging from 59 to 78%). In the lightest 2 shelter color treatments, shelter removal did not reduce survival indicating that seedlings can grow in full sun after four years of shading. The best overall response (i.e., survival, absolute height, and root-collar diameter) occurred in the lightest shelter color with shelters removed.
Management Implications

This long-term project has produced encouraging results toward successful restoration of these high-elevation spruce-fir sites where past planting efforts have proven difficult (Figures 3 and 4). Results also help emphasize the importance of long-term monitoring of plantation experiments on harsh restoration sites before issuing management recommendations as results tend to shift over time (Oliet and others 2005). The best general responses after 11 growing seasons occurred in the lightest shelter color (with or without shelter removal) and the second lightest shelter (with shelter removal). Thus, a lighter color shelter (i.e., 24% PAR) is recommended in operation especially if the shelters may not be subsequently removed. Although seedlings without shelter removal in the lightest shelter color had excellent performance, shelter removal resulted in seedlings with significantly larger root-collar diameter. Additionally, growth restrictions for sheltered seedlings could still be observed in the future. Therefore, it is recommended that funding for shelter removal after four years be allocated on these restoration projects. Development of tree shelter design has advanced since the initiation of this study and more rigid models are now available that may allow relatively simple installation, removal, and reliable re-use at another site. This would provide further benefit in minimizing environmental contamination associated with discarded tree shelters. Finally, ability to re-use a tree shelter at multiple sites may help to reduce the cost of incorporating tree shelters into these restoration projects.
In addition to these stand-level management implications, it is interesting to ponder several larger, landscape-level issues related to this research. Efforts to salvage trees infected by the spruce bark beetle (Dendroctonus rufipennis Kirby) resulted in dramatic increases in harvesting in the high-elevation Rocky Mountain forests around 1950. Many of these clearcut sites remain poorly or partially stocked due to subsequent failure of both natural regeneration and plantings (Ronco and Noble 1971; Alexander 1987). Although the US Forest Service has continued with restoration plantings on these sites, the intensity of the program has fluctuated over time and generally declined in recent years partly due to a decline in general funds, especially those generated from timber sales. This brings forth a question regarding the fate of these understocked sites through various time scales (i.e., 100, 1,000, or 10,000 years). In the absence of planting, these sites will likely be invaded by natural regeneration of trees from surrounding stands but the timeframe required will depend on current stocking levels, seed availability, and site conditions. Hundreds of years may be required before full stocking is attained on some sites. Clearly this negatively affects the commercial potential of these sites and, simultaneously, the ecosystem and its ability to provide wildlife habitat, watershed protection, and carbon sequestration is impacted by conversion of these mature forests to non-stocked forestlands. In some cases, the US Forest Service is considering modifying land use designations to re-classify some of these clearcut sites as meadows. Some may argue that conversion of some forest sites to meadow via clearcutting has negligible impacts on these ecosystems at the landscape scale. Nevertheless, the US Forest Service must decide if they have a moral obligation to the public to ensure that these harvested sites are reforested.

References


The content of this paper reflects the views of the authors, who are responsible for the facts and accuracy of the information presented within.