USA: California: Forest Restoration in Campgrounds at Kings Canyon National Park

Overview

Intensive campground use at the Grant Grove area of Kings Canyon National Park, California, has compacted the soil and left areas without understory vegetation or tree recruitment. To better inform the restoration of these sites after closure, natural regeneration potential was tested against planting and soil restoration methods. The tested methods included planting with container stock and direct seeding, fencing, and soil treatments of tilling, mulching, and gypsum and humus additions. Container stock showed high survivorship (69 - 100%), while germination and survival from direct seeding was low (0.6 - 4.1%). Wood chip mulch proved beneficial to planting woody species, but detrimental to resident herbaceous species. Plots treated with tilling and gypsum, and humus amendments exhibited the highest growth rates of container stock and the greatest herbaceous species richness and cover. However, tilling without the other soil treatments reduced herbaceous cover and seedling recruitment (natural and sown). In tilled plots, gypsum treatments and humus treatments often had neutral or detrimental effects individually, but their combination greatly increased the success of direct seeding, growth of container stock, and herbaceous cover and richness. Finally, fencing increased volunteer tree recruitment tenfold compared to outside the plots. The data yielded by this study will be used to plan and implement larger restoration projects in area campgrounds.

Project Details

Lead entity types:

- Other

Adaptive management

Describe adaptive management processes and mid-course corrections taken to address unforeseen challenges and improve outcomes in each of the following categories:

Other:

Although the treatments in this study increased the success of some herbaceous and woody species and ameliorated some of the structural soil degradation, the more intensive (expensive) methods may not be necessary to meet restoration and management goals. Human-exclosure fencing alone produced high levels of woody and herbaceous recruitment in many areas. It seems that the campgrounds in the Grant Grove area have not degraded so far that tilling and amendments are necessary to produce an acceptable level of natural recruitment. Nonetheless, some of the more compacted, exposed areas were completely void of natural vegetation after three years even with fencing, tilling, soil amendments, and seed addition. These types of areas will need to be planted with container stock to produce levels of rehabilitation similar to reference site conditions. Although the densities of natural recruitment of some species on control plots were high, planting or seeding still appears to be necessary to reestablish a natural range of species.

State of Progress:

- Planning

Project Start:

2004-04-25

Project End:

2007-04-25

Global Regions:

- Americas
- Northern America
- World

Countries:

- United States of America

Ecosystem Functional Groups / Biomes:

- Temperate-boreal forests and woodlands biome

Extent of project:

- Other

Extent of restoration:

- Other

Degradations:

- Urbanization, Transportation & Industry

Description:

The Grant Grove region of Kings Canyon National Park has three campgrounds, covering approximately 32 ha and containing about 200 campsites. The grass, forb, shrub, and tree seedling understory is largely absent because of high visitor use and associated trampling. Both soil compaction and soil erosion are evident in heavily used areas and have been reducing natural regeneration for many years. In fact, results from comparative surveys of campgrounds in the Grant Grove region revealed that even after being closed for two or three years, these campground areas exhibit very limited recovery of litter depth and herbaceous species richness and no recruitment of woody species, compared to nearby relatively undisturbed sites (Infalt, unpub. data). In addition, from 1997 to 1999, the Grant Grove area experienced an infestation of Douglas fir tussock moths (Orgyia pseudotsugata), part of a much wider infestation in the southern Sierra Nevada, that killed most of the mature overstory trees. Overstory vegetation is now lacking in large areas of the campgrounds. Hazard tree removals and the long-term trampling of the Grant Grove campgrounds have produced a highly degraded and nonsustainable forest structure and have decreased or eliminated wildlife habitat.

Planning and Review

Goals and Objectives

Was a baseline assessment conducted:

unsure

Was a reference model used:

RM5

were_goals_identified:

YES

Goals and objectives:

- Other

Goals Description::

1) To examine the potential for natural regeneration (passive restoration) 2) To test the effectiveness of soil treatments alone at increasing natural regeneration (low-input active restoration) 3) To test the effectiveness of soil treatments at increasing natural regeneration in combination with horticultural planting treatments (high-input active restoration)

Stakeholder Engagement

Were Stakeholders engaged?:

unsure

Ecosystem Activities and Approaches

General Activities: Twenty-five 6 m x 6 m plots were located around Crystal Springs campground in areas with moderate degradation between individual campsites. Plots were enclosed with post and rope fencing to exclude humans. Five soil treatments were applied in five randomly selected replicates: 1) control; 2) soil tilling; 3) soil tilling and gypsum addition; 4) soil tilling and humus addition; and 5) soil tilling with gypsum and humus additions. Plots receiving the tilling treatment were cultivated to a depth of 10 cm with a small rototiller. Gypsum was applied to plots at a rate of 225 g/mÂ² and tilled in to a depth of 10 cm. For humus treatments, decomposed bark (ground fir and pine bark, (6 mm particle size, 0.2 - 0.4% nitrogen, 4.0 - 5.0 pH) was spread to a depth of 5 cm and tilled. Each plot was divided into 36 1 m x 1 m subplots. In each plot, nine treatment combinations were assigned to each of four tree species: Jeffrey pine, incense cedar, white fir, and sugar pine. Subplots were assigned one of three planting-stock treatments: control (no planting), 1-gallon container stock, and direct seeding. The control plots were used to

monitor background levels of seed rain/natural recruitment, as well as an area off the southeast corner outside of each plot of the same size and shape. The container stock was produced as bare-root seedlings at the USDA Forest Service Nursery in Placerville, California, with seeds collected from the Grant Grove area. After one year, the bare-root stock was then shipped to the park and immediately potted by the Sequoia and Kings Canyon nursery. Plants were 2 - 5 years old (depending on species) at the time of planting. Seeds for direct seeding treatments were also supplied by the USDA Forest Service Nursery from seeds collected in Grant Grove. Each subplot was also assigned a mulch treatment: control (no mulch), wood chip mulch, or native litter/duff mulch. Wood chips produced on site from the tussock moth logging operation were used for the woodchip treatment subplots. Native litter was collected from outside the campground boundary for the native mulch treatments. Mulch was applied to the entire subplot area to a depth of 5 cm. Plots were established in August and September 2004 after collecting baseline measurements of soil and vegetation conditions. First, plots were delineated and fenced, and then the soil treatments were added. Container stock was planted over a two-week period in September of 2004. Six liters of water were added to the planting hole. After the water percolated into the soil profile, the container stock was planted, the holes were backfilled with native soil, small berms were created around the trees, and an additional 6 L of water per tree were provided. Two additional bi-weekly waterings were carried out until the rainy season began. Directly seeded subplots received either 10 Jeffrey pine seeds, 10 white fir seeds, or 9 sugar pine seeds in a grid pattern (to aid in later identification as either directly seeded germinants or volunteers). No incense cedar seed of local genetic stock was available at the time of seeding, and a limited number of sugar pine seeds were available. Plots with the direct seed and mulch treatment were first mulched, then holes were poked through the mulch bed and seeds were placed on bare mineral soil. Seeds were covered with soil to a depth twice their diameter. Plots were surveyed after one year for growth (height and caliper) of planted trees, germination and survival of planted seed, seedling establishment from natural seed rain, herbaceous and shrub species richness and cover, and soil penetration resistance. We visually estimated cover on each subplot aided by a 1-m2 quadrat with 10-cm grid. In September 2007 (three years after initiating the experiment), the plots were resurveyed. All planted container stock was assessed for survivorship and height growth. Plots were surveyed for percent herbaceous cover, number of herbaceous species, and number of woody species.

Project Outcomes

Eliminate existing threats to the ecosystem: --Planting Treatments-- Although the four planted tree species differed significantly in first-year (2004 - 2005) survivorship rates in the one-gallon planting stock, all exhibited high survivorship (69% - 100%). Survivorship between 2005 and 2007 was also high (73%-94%). First-year diameter growth did not differ significantly among species, but incense cedar and Jeffrey pine grew in height twice as fast as sugar pine, with white fir being intermediate. Between 2005 and 2007, Jeffrey pine grew significantly more in height (9.8 cm) than the other three species, which exhibited no net growth overall, mostly because of shoot-tip herbivory. Germination establishment success differed significantly among species, but was very low overall. On average, 2.5% of all seeds sown into the plots had germinated and survived to the end of the first year (4.1% of Jeffrey pine, 2.9% of sugar pine, and 0.6% of white fir). Subplots with a planting treatment (container stock or seed addition) had slightly lower average herbaceous species cover than subplots that were assigned no planting treatment (9% vs. 11%). This difference is small, but it does suggest that either the disturbance at the time of planting or seeding or the competition from the woody species additions will slightly reduce herbaceous cover, at least initially. --Mulch Treatments-- Woodchip mulching increased first-year survivorship of container stock compared to the control and native litter mulching, but not survivorship between 2005 and 2007. Similarly, volunteer tree seedling recruitment was greatest on subplots with woodchip mulch, followed by subplots without mulch, then subplots with native litter mulch. In contrast, herbaceous species cover and species richness were greater in the absence of mulch, and the woodchip mulch was more detrimental than the native litter mulch. --Tilling, Gypsum, and Humus Soil Treatments-- Tilling was successful at reducing soil compaction. Plots that additionally received humus had the greater reductions in penetration resistance, changing the average from 339 psi before plot installations to 300 psi for plots without humus, and from 355 psi before treatment application to 223 psi for plots with humus. Tilling generally reduced herbaceous cover, unless it was associated with both humus and gypsum. Year 1 height growth (and diameter increase) of container stock was greatest in plots that received all three amendments (tilling, gypsum, and humus) and plots that received tilling and humus. Between 2005 and 2007, many planted seedlings experienced considerable shoot-tip herbivory that negated positive growth in some treatments. Herbaceous species richness and cover were greatest in plots with all three treatments and (in 2005) control plots. Total seedling recruitment (natural seed rain and sown seeds) was greater in untilled plots than in tilled plots (0.6 vs. 0.4 seedlings/m2). Container stock in the humus addition plots increased in height 75% more between 2004 and 2005 than trees planted in non-humus plots (2.8 cm vs. 1.6 cm), and increased in trunk caliper 55% more (1.5 mm vs. 0.97 mm). Herbaceous cover in plots with humus was 24% greater than plots without humus (10.9% vs. 8.8%), and herbaceous species richness was 12% higher in plots with humus (1.9 species/m2 vs. 1.7 species/m2). A significant tilling-by-mulch interaction revealed that tilling was more detrimental to herbaceous cover when mulch was also applied. There were fewer seedlings from sown and volunteer seeds in humus-treated plots. --Interactions between Humus and Gypsum Treatments-- There was a set of interesting interactions between humus and gypsum treatments. Although gypsum alone or humus alone often had neutral or detrimental effects, the combination of both soil treatments substantially increased herbaceous species cover and richness and the growth of container stock. --Volunteer Seed Rain-- There was ten times more volunteer tree recruitment inside the fenced plots than in areas directly outside the plots (0.53 seedlings/m2 vs. 0.04 seedlings/m2 outside). Of the volunteer tree seedlings, 79% were incense cedar, 15% were sugar pine, 4% were white fir, and 1% were Jeffrey pine; there were a negligible number of unidentified seedlings. There were fewer volunteer seedlings in plots that were tilled (0.32 vs. 0.51 seedlings/m2) and in humus plots that were also tilled (0.26 vs. 0.42 seedlings/m2). Although there was some shrub recruitment, there were no detectable differences among treatments. Factors limiting recovery of the ecosystem: --Planting Treatments-- The direct seeding treatment had very low success rates. Recruitment rates from directly sown seeds averaged 2.5%, while laboratory germination tests yielded an average of over 95% viability from the same seed lots. It is suspected that this difference was due to seed predation, but planting sites were not examined for such herbivory. --Mulch Treatments-- It is intuitive that wood chip mulch would increase the success of container stock and decrease the success of herbaceous species, compared with controls. It is less clear why native litter mulch would have intermediate effects. It was initially suspected that native litter mulching treatments might increase recruitment success of woody species via viable seeds

present in the native litter. However, native litter had a negative impact on volunteer recruitment of woody species. It is possible that the adult litter had allelopathic effects on seeds (Bai et al. 2000). Native litter mulching may be useful in areas that managers wish to keep clear of woody vegetation, but further studies would be needed to determine the cause of the reduction in germination and the long-term effects of native mulch. --Tilling, Gypsum, and Humus Soil Treatments-- Tilling alone was detrimental to the first-year success of herbaceous species and germinating seedlings. This negative effect was overcome on plots that received the tilling, gypsum, and humus treatment. As with the mulching treatments, it is clear that objectives must be identified before treatments are applied, since the treatments in this study were often detrimental to species of one group (forbs) while being beneficial to another (tree seedlings). If herbaceous species or natural woody recruitment is the management target, the high-input tilling, gypsum, and humus treatments are no better than installing protective fencing only, and would not be worth the extra time and expense. If management goals are aimed at higher growth rates of container stock, then the tilling, gypsum, and humus treatment and the tilling and humus treatment might be worthwhile, though tilling alone does not seem to provide any appreciable benefit to sites with the moderate level of compaction found in the campgrounds of the Grant Grove area. --Volunteer Seedlings-- Although there was an abundance of volunteer seedlings on control plots (Infalt, unpub. data), the species composition was not proportional to that of the mature or sapling overstory. Incense cedar is extremely prolific and seedlings were observed in all microsites (shaded areas, full sun areas, bare mineral soil, and areas with a duff layer). White fir seedlings were nearly absent because most mature white fir in the area were killed during the moth infestation, but it is not clear why Jeffrey pine and sugar pine seedlings were not more abundant.

Monitoring and Data Sharing

Does the project have a defined monitoring plan?:

NO

Open Access URL:

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Long Term Management

STAPER