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Abstract

Members of 3 families of Orthoptera (Acrididae, Gryllacrididae, Tettigoniidae) were sampled in clearcuts, burned forest, and undisturbed forest in a coniferous forest ecosystem in northern Utah, USA. Sampling was conducted during July and August, 1995 to 1997, by use of pitfall traps. The camel cricket *Ceuthophilus fusiformis* (Gryllacrididae: Rhaphidophorinae) was the most commonly trapped species in forested plots, where otherwise very few orthopterans were collected. Many more orthopterans were taken in clearcuts and burns and these had equal species richness and total orthopteran abundance. However, the orthopteran assemblages differed between these two treatments. Band-winged grasshoppers (Acrididae: Oedopodinae) tended to be trapped more frequently in clearcuts, especially *Camnula pellucida*. Burned plots provided greater numbers of *Ceuthophilus fusiformis* and *Steiroxys pallidipalpus* (Tettigoniidae: Decticinae).

Key words

Species composition, disturbance, fire, habitat change, succession, colonization, species richness, abundance

Introduction

Orthopterans are capable of rapid response to habitat disturbance, due in part to their high vagility and rapid rate of increase (Parmenter *et al*. 1991). Given this, and the preference of many orthopterans for open areas, they can be used to evaluate the short-term impact of disturbance on a variety of habitats. Previous authors found orthopterans to be good indicators of the degree of disturbance to an area (Samways & Moore 1991, Báldi & Kisbenedek 1997). Knowledge of grasshopper and cricket recolonization and successional patterns after habitat change, can be useful to land managers and ecologists attempting to understand the effects of disturbance, whether natural or human-induced, to a variety of ecosystems.

Much of the previous work regarding the response of orthopterans following disturbance focused on the effects of grazing (Welch *et al*. 1991, Fielding & Brusven 1993), mine reclamation (Parmenter *et al*. 1991), or fire. The studies assessing the effect of fire on orthopterans were most often conducted in grasslands (Evans 1988, Bock & Bock 1991, Porter & Redak 1996, Chambers & Samways 1998). However, research involving the effects of forest fire or timber harvesting on orthopteran communities is lacking.

This study examines the colonization by grasshoppers and camel crickets of newly created habitat in a coniferous forest after 2 disturbance types, clearcutting and wildfire. The new orthopteran assemblages were characterized in terms of relative abundance, spe-cies richness, dominance structure (or rank-abundance), and species composition. Orthopteran numbers trapped within the undisturbed forest are reported as well.

Materials and Methods

Study area.—The study area was located in the Bear River mountain range on the border of Cache and Rich Counties, Utah (lat 41°50′N, long 111°30′W, elevation 2300 - 2400 m), USA. Vegetation of the study area was dominated by mixed coniferous forest. The dominant trees were lodgepole pine (*Pinus contorta*) and subalpine fir (*Abies lasiocarpa*). Engelmann spruce (*Picea engelmannii*), Douglas-fir (*Pseudotsuga menziesii*), and quaking aspen (*Populus tremuloides*) formed a lesser portion of the canopy.

The study area consisted of two primary sites, Temple Canyon and Log Cabin Ridge, approximately 3 km from each other and separated by no more than 110 m in elevation. Three burned plots were located at Temple Canyon where a crown-fire occurred in the summer of 1994 and burned approximately 250 ha of forest. The 3 burned plots were matched with 3 nearby control plots (unburned forest). At Log Cabin Ridge, 3 plots were located within 3 separate clearcuts of approximately 4 ha each. These sites were cut in 1993 and 1994 as a part of the Log Cabin Ridge timber sale. Three control plots (uncut forest) were located nearby. Prior to wildfire or clearcut-ting, the forest canopy of the disturbed sites was composed of the same forest type as that found on the undisturbed sites. All clearcut, burn, and control plots had a northernly aspect and slopes of less than 30°.

Vegetation on the 3 regenerating burned plots during the sampling period (1 to 3 y post-burn) was composed of herbaceous regrowth and, secondarily, tiny conifer seedlings (primarily subalpine fir but also lodgepole pine). The 3 clearcuts (2-4 y post-cut) were dominated by lodgepole pine seedlings, grasses, and scattered forbs. Subalpine fir seedlings occurred in the understory of all control plots. (See Clayton 2002 for a more detailed description of plot characteristics.)

Orthoptera sampling.— In the course of a study of ground-dwelling beetles (Clayton 2002), it became apparent that the pitfall traps were also capturing orthopterans in significant numbers. Although pitfall traps are not conventionally used for actively flying species, grasshoppers walk along the surface as well and are susceptible to pitfall trapping. Pitfall traps work reasonably well for surface-active species such as the flightless crickets caught during this study. At each plot 15 traps were placed in a 3- by 5-trap grid with 5-m

spacing. Each trap consisted of a steel can (8-cm diameter, 11-cm deep) sunk into the ground. Traps were equipped with funnels and wooden rain covers elevated 2.5 cm above the ground on nails. A smaller can partially filled with 15% ethanol was placed inside the outer can for ease of removal and preservation of specimens. Pitfall traps remained open for 9 d during each sampling period and were closed in between.

At high elevation sites in the Bear River Range the snow-free growing season occurs from June through September. The timing of the 9-d sampling periods at Log Cabin Ridge were seasonally adjusted so that trapping occurred at approximately the same phenologically-based time period as at Temple Canyon. The adjustment was made according to Hopkins Bioclimatic Law (Hopkins 1919), which states, for example, that spring comes 4 d later for each increase of 1° in latitude or each increase of 400 ft (122 m) in elevation. Thus, due to a lag in the timing of snow melt, early season pitfall trapping commenced 3 d later at Log Cabin Ridge, which is higher in elevation, than at Temple Canyon. The Temple Canyon plots were sampled in July and August of 1995, 1996, and 1997; plots at Log Cabin Ridge were sampled in July and August of 1996 and 1997.

Orthopterans were identified using the keys found in Barnum (1954), Otte (1984), and Helfer (1987) and with the assistance of Dr. J. A. MacMahon at Utah State University. Representative specimens have been deposited in the insect collection of Utah State University.

Data analysis.— Orthopteran abundance and species richness were measured on each plot. Rank-abundance curves were generated for the clearcuts and burns; species composition was also examined. Differences in abundance and richness values between clearcuts and burns were analyzed statistically in an ANOVA using the Proc Mixed procedure in SAS. Abundance values were $\log_{10}$ transformed prior to analysis to ensure that the residual error was normally distributed.

Results and Discussion

Representatives from three orthopteran families were taken during the study: Acrididae (Oedopodinae), Gryllacrididae (Rhaphidophorinae), and Tettigoniidae (Decticinae) (Table 1). Very few orthopterans were trapped in the control plots. Of these, most were taken in small forest gaps or openings within the plot. The camel cricket *Ceuthophilus fusiformis* (Scudder) was the most common species taken in controls and constituted roughly two thirds of the orthopterans sampled in these forested plots.

The species trapped in both Temple Canyon burns and Log Cabin Ridge clearcuts were essentially the same [except for the band-winged grasshopper *Trimerotropis cincta* (Thomas), which was trapped twice in one clearcut (Table 1)]. The proportions in which they were taken in these different treatments, however, differed (Fig. 1). On average, more band-winged grasshoppers (Oedopodinae) were trapped in clearcuts than burns, especially in 1997, although the difference was not quite significant (F = 6.84, P = 0.059). This potential difference may relate to the greater proportion of bare ground observed in the clearcuts. Band-winged grasshoppers are common in areas of sparse vegetation and bare ground (Otte 1984, Welch *et al.* 1991). Like the orthopterans, the beetles trapped during this study showed a very different species composition among clearcuts, burns, and controls (Clayton 2002).

Camnula pellucida (Scudder), the most injurious of all Orthoptera in Utah according to Henderson (1924), was the most commonly trapped species in clearcuts, but was only taken twice in burns (Fig. 1). Areas of sparse vegetation are favored for egg deposition by *C. pellucida* (Jones 1995), a possible explanation for its abundance in

Table 1. Orthoptera species captured during July and August, 1995-1997.

|	Temple Canyon						Log Cabin Ridge			
	Controls			Burns			Controls		Clearcuts	
	1995	1996	1997	1995	1996	1997	1996	1997	1996	1997
Acrididae (Oedopodinae)										
Camnula pellucida (Scudder)	0	0	0	0	0	2	0	0	28	88
Circotettix rabula Rehn & Hebard	0	0	0	0	2	0	0	0	3	3
Cratypedes lateritius (Saussure)	0	0	0	0	1	0	0	0	1	0
Cratypedes neglectus (Thomas)	0	0	0	0	0	1	0	0	0	6
Trimerotropis cincta (Thomas)	0	0	0	0	0	0	0	0	0	2
Trimerotropis pallidipennis (Burmeister)	0	0	0	1	1	4	0	0	3	2
Trimerotropis suffusa Scudder	0	0	0	8	11	8	0	0	29	26
unidentified oedopodine nymph	0	2	0	3	27	14	1	0	30	45
Gryllacrididae (Rhaphidophorinae)										
Ceuthophilus fusiformis Scudder	9	0	4	30	9	33	0	0	1	1
Tettigoniidae (Decticinae)										
Steiroxys pallidipalpus Thomas	1	0	2	2	2	30	0	0	0	1
Total number of individuals	10	2	6	44	53	92	1	0	95	174
Species richness	2	1	2	5	7	7	1	0	7	9
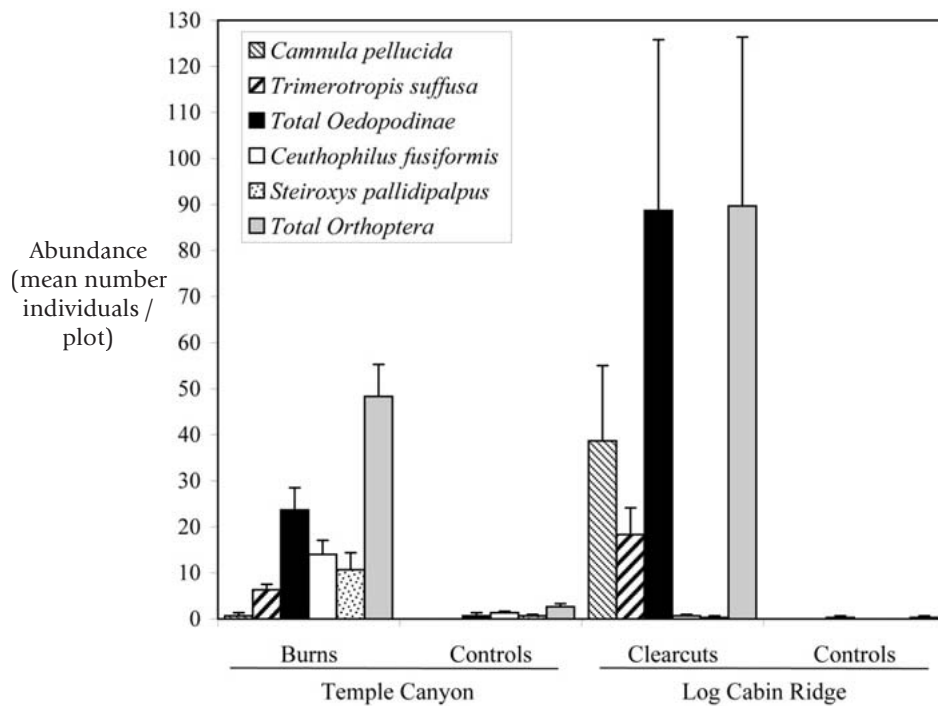
Fig. 1. Abundance of selected orthopterans. Columns show plot means of the total catch from July and August, 1996 and 1997. Bars show 1 standard error.
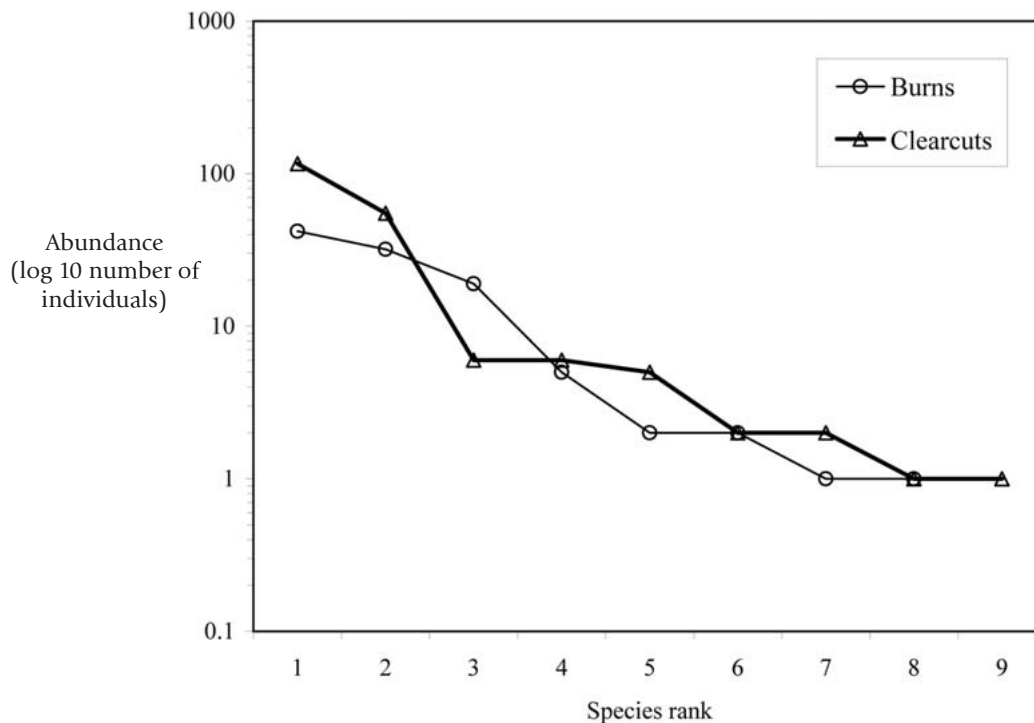

Fig. 2. Orthopteran rank-abundance curves for clearcuts and burns.

the clearcuts that had much exposed soil. Growth and development of *C. pellucida* is also favored by extended warm weather (Pfadt 1988); the warmest average soil temperatures recorded during the study were in the clearcuts. Additionally, *C. pellucida* is primarily a grass feeder (Pfadt 1988). Over half of these grasshoppers were taken in the plot, one of the clearcuts with the greatest coverage of grass. (One of the burns also had a fair coverage of grass, about one third of the plot, but no *C. pellucida* were trapped there.) Thus, a significant amount of exposed soil, warm soil temperatures, and the availability of grass may help explain the abundance of *C. pellucida* in clearcuts.

Although numbers of *C. pellucida* differed between clearcuts and burns, when all orthopteran species were included in the analysis, orthopteran abundance did not differ between clearcuts and burns. The decticid *Steiroxys pallidipalpus* (Thomas) was taken in higher numbers in all 3 burned plots the third year after burning, but was rare in clearcuts. *C. fusiformis* was also only taken once in the clearcuts but was the most commonly trapped species in the burns. Given that *C. fusiformis* is a scavenger, consuming plant detritus and a variety of dead animal materials (Hubbell 1936), it is perhaps not surprising that it was found in larger numbers in burned than control plots; its relative scarcity in clearcuts is unexplained, however.

In both clearcuts and burns, orthopterans constituted a major portion of the total arthropod biomass collected in the pitfall traps (personal observation). Abbott (1984) is the only other study found which addresses changes in orthopteran numbers after fire in a forested ecosystem. In that Australian study, where arthropods were also collected in pitfall traps, crickets were found in greater numbers in the unburned forest. This contrasts with the results for decticids and camel crickets from this study.

The number of orthopterans trapped in burns and clearcuts increased with time since the disturbance. This is likely due to an increase in vegetation on the regenerating plots, but the possibility that the observed increase was influenced by a difference in trapping dates could not be ruled out. The 1997 trapping periods occurred towards the end of July and August, whereas the 1996 periods were closer to the beginning of July and August.

Orthopteran species richness did not differ between clearcuts and burns (Table 1). Rank-abundance curves for clearcuts and burns were also very similar (Fig. 2). As a comparison, the study done by Chambers and Samways (1998) in a South African grassland, found burning and mowing to be equally suited in managing for grasshopper diversity, but annual burning resulted in somewhat higher grasshopper species richness than annual mowing.

Possible differences in abundance and species composition could be due to different source pools at the two sites where these treatments occurred. However, grasshoppers are highly vagile insects and the few kilometers separating the Temple Canyon and Log Cabin Ridge sites, along with numerous sagebrush meadows intermixed with forest in this area, make significant source pool differences perhaps unlikely, at least for members of the Oedopodinae. Additionally, by the third and fourth year of regeneration, response to plant species composition, habitat structure, and other internal population dynamics have certainly become important in shaping the local orthopteran assemblages of these disturbed plots. Many studies have shown correlations between plant species diversity and composition and orthopteran diversity (Otte 1976, Evans 1988, Kemp *et al.* 1990, Quinn *et al.* 1991, Samways & Moore 1991, Fielding & Brusven 1993).

Observed differences between the grasshopper fauna on clearcuts and burns could also relate to the difference in regeneration age—two of the clearcut plots were 1 y older than the burned plots. However, the plant species composition in the clearcuts and burns indicated that regeneration in these 2 treatments was proceeding along different trajectories. Additionally, orthopteran species composition on the clearcut plot that was the same age as all burned plots, was more similar to the other clearcut plots rather than to burned plots of the same age.

In this forest, clearcutting and burning resulted in somewhat different orthopteran assemblages. If wildfire were completely suppressed and clearcutting became the dominant initiating factor in forest succession, changes to local orthopteran assemblages would likely result. Populations of both the camel cricket, *C. fusiformis*, and the decticid, *S. pallidipalpus*, could decline without the habitat provided by regenerating burned forest. *C. pellucida* has potentially benefited from clearcutting. Changes to orthopteran assemblages such as these might be considered when managing for ecosystem health along with timber harvesting. Further research is needed to confirm the results presented in this study and to determine how broadly these findings might be applied to other forested regions.

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