

GRASSHOPPER-PLANT COMMUNITY ASSOCIATIONS IN IDAHO
IN RELATION TO THE NATURAL AND ALTERED ENVIRONMENT¹

By

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¹Research supported in part by USDA Cooperative Research Grant No. 12-14-100-9725(33). Portion of a dissertation. Published with the approval of the Director of the Idaho Agricultural Experiment Station as Research Paper No. 935.

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INTRODUCTION

Grasshopper investigations in Idaho have revealed remarkable affinities of many grasshopper species with certain plant communities. In some cases these affinities are restrictive; i.e., a species may be consistently associated with one or a few major plant communities, while others occur in widely diverse plant communities. This permits the establishment of ecological inferences about the community. These inferences can greatly aid understanding of communities by broadening the scope of study to include not only the basic plant community, but a variable poly-specific group of herbivores. It is the contention of the authors that only by broadening ecological studies to include producers and consumers can we gain a more accurate understanding of the broad concept of biotic communities. Furthermore, understanding the economic implications of species interactions within communities has an important practical aspect with respect to management.

Relating grasshopper species to plant communities involves the interaction of two vastly different groups operating as producers and consumers. The plant community is determined by various physical features, e.g., soil type, moisture, exposure and climate, and by the biotic forces of competition. The grasshopper community evolves in response to the same basic forces as govern the plant community, but additionally responds to the vegetation.

Classification of communities is difficult because of the infinite variety of interactions, gradations, transitions, and disturbances. Often communities are described on the basis of "dominant" vegetation, or association of a prominent animal species with a particular plant species or plant complex. The aim of this paper is to evaluate a large number of grasshopper species over broad environmental gradients, establish grasshopper-plant community associations within the framework of current plant community nomenclature, and then subject selected habitat sites to cluster analysis for grouping into more broadly based communities.

Four years (1967-1971) of intensive investigations studying distribution and ecology of grasshoppers (Scoggan and Brusven, 1972; Brusven, 1972; Banfill and Brusven, 1973) coupled with older records (Hewitt and Barr, 1967, and others) provide background for understanding grasshopper plant community associations in Idaho.

Few insects exceed the importance of grasshoppers in grazing areas of Idaho. For this reason, plant communities important for grazing which support native or introduced rangeland vegetation were emphasized. Grasshoppers of economic importance were emphasized in this study; however, numerous common but less damaging species and several uncommon species were included where sufficient

information was available to infer their plant community associations.

METHODS

Information on grasshopper-plant community associations was obtained as a result of over 300 collections of grasshoppers from numerous plant communities in Idaho. The communities studied correspond for the most part with those described by Billings (1940), Daubenmire (1952), Daubenmire (1970), and Tisdale et al. (1969). Collection sites were selected on the basis of being representative of the various plant communities and were periodically sampled during the 4-year period. Information taken on each site included: location, plant community or zone, soil type, slope, exposure, altitude, common plants, percent cover, and grasshopper species and abundance. Plant cover was visually estimated using a 5-rank abundance classification (1=most abundant, 5=rare).

Twenty-four sites were selected for intensive investigation by cluster analysis. Analysis was based on the weighted pair-group method (WPGM) described by Sokal and Sneath (1963) and Estabrook (1967). Dependency between sets of descriptors of different areas was analyzed to give a mathematical "distance," i.e., similarities between sites. Comparisons were based on 87 specific characters including: grasshopper species, common plant species, altitude, soil type, slope, exposure, percent vegetative cover, relative density of grasshoppers, and numbers of grasshopper species. Sites were sampled throughout the growing season in order to record phenological changes. When possible sites "typical" of each zone were selected, if they were inhabited by grasshoppers. In addition, sites representing transitions, replications, or differing altitudes were included to make the analysis broader and more meaningful.

PLANT COMMUNITY CLASSIFICATION

Classification and terminology used in describing plant communities in the intermountain region have not been sufficiently standardized to permit universal acceptance by plant ecologists. However, classifications proposed by Daubenmire (1952, 1968, 1970) and Tisdale et al. (1969) are useful when referring to plant communities in Idaho. Hierarchical classifications involving vegetational zones, series, associations, habitat types, stands etc. have been variously used. Since the intent of this paper is not to revise or propose a new means of classifying plant communities, the term "community" is used to refer to any biotic assemblage, large or small, which is identifiable with respect to dominant species, soil type, and climate. Broad use of the term "community" as we propose it, enables workers to relate various schemes of plant classification to the findings herein with only minor modifications. Only those areas supporting

significant grasshopper numbers were investigated. In forest communities, only open, sparsely treed areas supporting grasshopper populations were sampled.

Zonal terminology, e.g., wheatgrass-bluegrass, ponderosa pine, spruce-fir, etc., proposed by Daubenmire (1952) is extensively used in this paper. We recognize subzonal communities within the traditional intermountain shrub zone and designate them as sagebrush, shadscale, greasewood, and saltsage communities.

Because the plant community connotation used in this paper is broad, communities other than those referred to could be conceived. However, it is our contention, the following are most relevant when relating grasshopper-plant community associations.

- Fescue-wheatgrass community
- Wheatgrass-bluegrass community
- Shadscale community
- Saltsage community
- Greasewood community
- Sagebrush community
- Juniper woodland community
- Mountain mahogany community
- Ponderosa pine community
- Douglas fir community
- Arborvitae-hemlock community
- Spruce-fir community
- Mountain-meadow community

Douglas fir, arborvitae-hemlock and spruce-fir communities are forest zones and only limitedly important as grasshopper habitats. Grasshoppers occur in them where there are open expanses, meadow intrusions or natural or man-caused disturbances, e.g., road building, logging, fires, etc. Mountain-meadow community is considered part of the spruce-fire zone by some plant ecologists (Daubenmire, 1952). Because of the absence or sparseness of trees, preponderance of herbaceous growth and excellent habitat for some species of grasshoppers, it is here given specific community status.

Semi-desert rangeland supports the largest grasshopper populations. It also serves as one of the principal grazing areas, and consequently, receives greatest attention in this paper.

RESULTS AND DISCUSSION

Community Analysis by Clustering

Analysis based on the weighted pair-group method (WPGM) described by Sokal and Sneath (1963) and Estabrook (1967), in which dependency between sets of

descriptors of different areas are analyzed, gave a mathematical expression of similarity between sites. Locations and ecological characteristics of the sites used in cluster analysis are listed in Table 1. Community sites were selected because of minimum habitat alteration by man; one exception was a logged-over area located in the Douglas fir zone (Site 11). Substantial regrowth of perennial herbs made it somewhat similar to natural forest parks found in that community.

Clustering pattern generated from computer analysis of the data is shown by dendrogram (Fig. 1). Sites exhibiting significant similarities are those which join above the dashed transverse line at the weighted similarity value of .7549 (98% confidence interval) or above. Those joining below this line are below the level of significant similarity. None of the clustered sites joined below the 95% confidence limit (.6254), which indicates significant difference. As expected, several of the individual sites were significantly different from other individual sites. This difference in levels of clustering arises from the establishment of clustered pairs where mean similarity values were used for all sites in each cluster. Using these mean similarity values raised the values above the level of significant difference. The upper level was not as affected by average values because fewer values were used to compute similarities in earlier matrices. Higher similarity values indicate closer relationships.

Five significant clusters are apparent from the dendrogram and consist of the following site groupings: sites 1, 2, 3; sites 6, 13, 14, 18, 19, 22, 23; sites 8, 11, 20, 24; sites 7, 10; sites 5, 9, 15, 16 and 17. One shadscale, one sagebrush, and a transition area between sagebrush and wheatgrass-bluegrass failed to cluster with other communities at a significant level.

The shadscale community of Custer County (site 4) failed to cluster at a significant level with the shadscale community of Owyhee County (site 3) probably because of differences in successional stage site factors and grasshopper composition. Although many plant species were common to both areas, site 3 was much more varied in shrub composition, vigor, and cover. The number of grasshopper species and their respective densities was greater in site 4. Site 4 occupied a narrow band between irrigated hayland and a sagebrush community. Site 3 was not similarly bounded by farmland and sagebrush. The large diversity of grasshopper species and high density at site 4 probably resulted from an "edge effect" caused by close proximity with adjoining communities.

The sagebrush community of Custer County (site 21) failed to cluster with the remainder of the sagebrush community sites, probably because of altitudinal differences, soil differences and depleted condition. This site, nearly 1000 feet higher than other sagebrush sites studied, was along a

Table 1. Location and ecological characterization of community sites in Idaho analyzed by cluster analysis.

Site	Location	Effective Community	Dominant Plants	Percent Slope	Exposure	Soil Type	Altitude
1	Owyhee Co. 6.3 Mi. E. Oreana	Salt Sage (Depleted)	<i>Atriplex nuttallii</i> <i>Bromus tectorum</i>	5	S.E.	Silty-clay	3100
2	Owyhee Co. 8.7 W. Murphy	Greasewood (Depleted)	<i>Sarcobatus vermiculatus</i> <i>Bromus tectorum</i>	5	N	Silty-sand	2250
3	Owyhee Co. 4.6 W. Murphy	Shadscale	<i>Atriplex confertifolia</i> <i>Oryzopsis hymenoides</i>	1	S	Sandy-loam	3000
4	Custer Co. 2 S. Ellis	Shadscale (Seral)	<i>Atriplex confertifolia</i> <i>Bromus tectorum</i>	10	W	Stony-loam	4500
5	Elmore Co. 20 N. Mtn. Home	Sagebrush (Seral)	<i>Artemisia tridentata</i> <i>Bromus tectorum</i>	5	E	Gravelly-loam	3200
6	Lemhi Co. 16 SE Salmon	Wheatgrass- bluegrass (Seral)	<i>Agropyron spicatum</i> , <i>Poa</i> sp. <i>Artemisia tridentata</i>	15	W	Loam	7500
7	Nez Perce Co. 5 S. Lewiston	Fescue-wheatgrass	<i>Agropyron spicatum</i> <i>Festuca idahoensis</i>	10	S	Sandy-loam	800
8	Idaho Co. 14 W. Riggins	Mountain meadow	<i>Festuca idahoensis</i> <i>Carex</i> sp.	35	E	Stony-loam	8000
9	Bannock Co. 5 W. McCammon	Juniper	<i>Juniperus</i> <i>Bromus tectorum</i>	35	S	Talus-loam	4800
10	Latah Co. 5 N. Moscow	Ponderosa Pine	<i>Pinus ponderosa</i> <i>Agropyron spicatum</i>	20	S.W.	Loam	2700
11	Fremont Co. 9.5 W. Macks Inn	Douglas Fir	<i>Pseudotsuga menziesii</i> <i>Festuca idahoensis</i>	5	W	Stony-loam	6000
12	Clark Co. 2 N. Blue Dome	Sagebrush- wheatgrass- bluegrass (Transition)	<i>Artemisia tridentata</i> <i>Agropyron spicatum</i> , <i>Poa</i> sp.	1	S	Stony-gravel	6400
13	Clark Co. 3.4 E. Blue Dome	Wheatgrass- bluegrass (Seral)	<i>Agropyron spicatum</i> , <i>Poa</i> sp. <i>Artemisia tridentata</i>	20	S.W.	Stony-gravel	7200
14	Clark Co. 5.4 E. Blue Dome	Fescue-wheatgrass (Seral)	<i>Festuca idahoensis</i> <i>Artemisia tridentata</i> <i>Agropyron spicatum</i>	5	W	Stony-loam	8000
15	Cassia Co. 4.5 W. Malta	Sagebrush- shadscale (Transition)	<i>Artemisia tridentata</i> <i>Atriplex confertifolia</i>	5	S.W.	Sandy-loam	4300
16	Cassia Co. 6 E. Oakley	Sagebrush- wheatgrass (Seral)	<i>Artemisia tridentata</i> <i>Agropyron spicatum</i>	10	N	Stony-loam	4700
17	Cassia Co. 4 N. Elba	Juniper	<i>Juniperus</i> sp. <i>Artemisia tridentata</i>	15	W	Stony-loam	5000
18	Cassia Co. 7.5 SW Albion	Wheatgrass- sagebrush (Transition)	<i>Agropyron spicatum</i> <i>Artemisia tridentata</i>	15	N	Stony-Gravel	6600
19	Cassia Co. 10 SW Albion	Fescue-wheatgrass	<i>Festuca idahoensis</i> <i>Agropyron spicatum</i>	20	N	Stony-loam	7800
20	Cassia Co. 15 SW Albion	Mountain meadow	<i>Festuca idahoensis</i> <i>Carex</i> sp.	5	W	Loam	8100
21	Custer Co. 2 S. Chilly	Sagebrush (Depleted)	<i>Artemisia tridentata</i> <i>Salsola kali-tenuifolia</i>	1	E	Stony-gravel	5800
22	Custer Co. 7 N. Chilly	Fescue-wheatgrass stand in sagebrush community	<i>Agropyron spicatum</i> <i>Festuca idahoensis</i>	10	S.W.	Gravelly-loam	7000
23	Custer Co. 10 N. Chilly	Mountain mahogany	<i>Cercocarpus ledifolius</i> <i>Festuca idahoensis</i>	30	W	Loamy-gravel	7400
24	Custer Co. 15 N. Chilly	Mountain meadow	<i>Carex</i> sp. <i>Festuca idahoensis</i>	10	S	Gravel	8300

SITE NUMBER

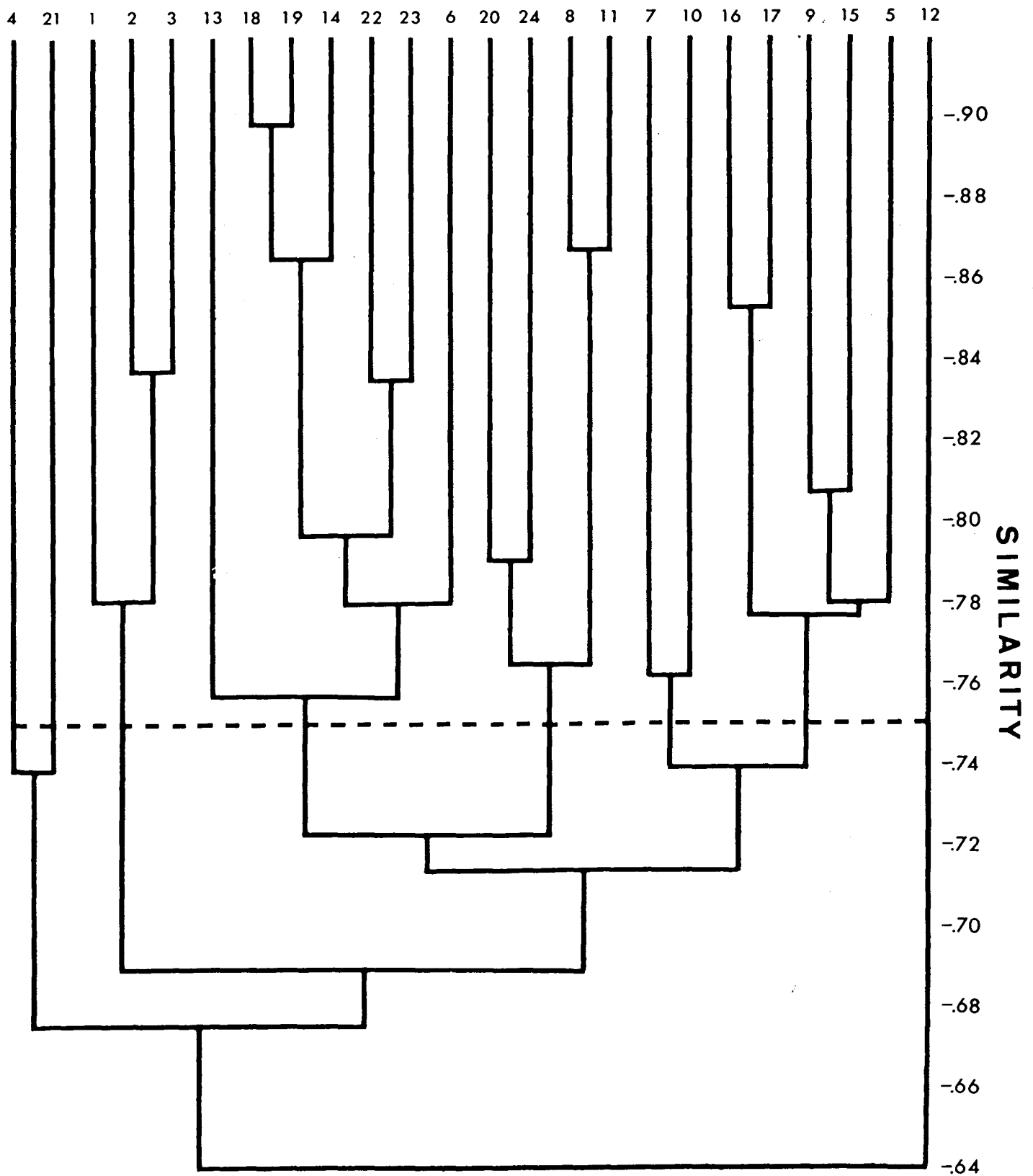


Fig. 1. A dendrogram depicting similarity values and clustering of 24 community sites in Idaho. Numbered sites correspond to sites referred to in Table 1.

valley floor receiving cold air drainage from the Lost River Mountains, the highest range in Idaho. Its depleted condition, reflected by differences in plant and grasshopper composition, was sufficient to prevent clustering with other sagebrush sites. This site clustered most closely with the Custer County shadscale community (site 4) discussed previously, although it was not similar enough to cluster significantly.

Finally, site 12, which failed to cluster at a significant level, represented a sagebrush wheatgrass-bluegrass transition. It was completely unrelated to other sites as indicated by its position in the dendrogram. Grasshopper composition and, to some degree, vegetation were distinct from the other sites studied. Some grasshopper species found here were rare or absent in other areas of the state.

These non-clustering areas demonstrate the difficulties involved with delimiting communities. In Idaho, there are extensive areas that have certain similarities but can neither be grouped nor are they deserving of separate community status. These may well represent either seral or transitional communities.

While some sites failed to cluster at a significant level, others clustered in a somewhat unexpected manner. Unexpected clustering occurs when subjective evaluations of community uniqueness are based on dominant aspect criteria, e.g. plant dominants, without giving full regard to the multitude of lesser components, both physical and biotic. Greater insight into the infrastructure of communities permits greater acceptance of similarity (i.e. clustering) of superficially different communities.

The juniper community (sites 9 and 17) clustered with the sagebrush community (sites 5, 15 and 16). They differed primarily in the presence or absence of juniper. Understory of juniper communities ranged from mostly annual cheatgrass (*Bromus tectorum* L.) to perennial bunchgrasses (*Agropyron spicatum* (Pursh) Scribn. and Smith and *Poa secunda* Presl.) and big sagebrush (*Artemisia tridentata* Nutt.).

The ponderosa pine community (site 10) paired with the fescue-wheatgrass community for two apparent reasons. First, site 10 had an open canopy and grassy understory suitable for grasshopper habitation; the understory vegetation was similar to dominants in the fescue-wheatgrass community. This type of area is found only in drier parts of the ponderosa pine community. In moister areas, denser canopies and shrub growth reduce or eliminate grasshoppers.

The mountain mahogany community (site 23) clustered with sagebrush wheatgrass-bluegrass (sites 6, 14, 18, 19 and 22). Similarities between these communities include ground cover vegetation and physical features of the environment. Similar findings were reported by Scheldt and Tisdale

(1970). Grasshopper density and diversity were lower in the mountain mahogany site than in wheatgrass-bluegrass sites, but species present were common to both areas.

The Douglas fir community (site 11) clustered with mountain-meadow community (sites 8, 20 and 24). It had been previously logged, and had an open canopy with only scattered trees remaining. The site was well within the Douglas fir zone, but was much more suitable for grasshopper habitation than densely canopied areas. Here again, important similarities existed in physical factors, ground cover vegetation, and grasshopper composition.

Greasewood and shadscale communities (sites 2 and 3) showed a clustering relationship to saltsage community (site 1), differing primarily in dominant shrub composition.

Analysis of, and comparisons between, computer clustering and ecological knowledge of areas indicated that the computer is a useful tool for community analysis. The computer can provide a more complete understanding of communities through simultaneous analyses of many variables. It is important, however, that appropriate data are available for analysis.

Characteristics of Clustered Communities

Interjecting animal species into the classical plant-community physical-environment complex considerably changes the traditional community classification of plant ecologists. Since many animals are motile and adaptive to a wide variety of habitats, it is not surprising that cluster analysis results in fewer communities than when plants alone are considered. Instead of 10 or more communities (sometimes referred to as zones) only 5 are significant when the grasshopper complex is introduced.

Five clustered communities are described in relation to traditional plant communities and/or zones (e.g. Daubenmire 1952; Tisdale et al., 1969) and their grasshopper composition.

Community Type I. This complex consists of dry, alkaline or saline vegetation communities, e.g., shadscale, saltsage and greasewood communities. Some authors (Tisdale et al., 1969) collectively refer to these as the salt-desert shrub vegetation type. This community is of limited distribution in Idaho, occurring almost exclusively in the southwestern part. Principal shrub species include *Atriplex confertifolia* (Torr.) Wats., *A. nuttallii*, S. Wats., *Sarcobatus vermiculatus* (Hook.) Torr., *Crayia spinosa* (Hook.) Moq., and *Artemisia spinescens* D. C. Eat. *Bromus tectorum*, *Oryzopsis hymenoides* (R. & S.) Richer, *Sitanion hystrix* (Nutt.) J. G. Smith and *Hordeum jubatum* L. are the major grasses.

Common grasshoppers include the spurthroats *Melanoplus sanguinipes* F. and *Oedaleonotus enigma* (Scud.) and the bandwings *Trimerotropis bilobata* Rehn & Hebard, *T. pallidipennis* (Burm.), and *T. strenua* McNeill. Slantfaced grasshoppers are sparse, and represented primarily by *Psoloessa delicatula* (Scud.), *Ageneotettix deorum* (Scud.) and *Cordillacris occipitalis* (Thos.).

Community Type II. This is a major community in Idaho, both in area and importance. It contains most of the sagebrush grassland and Juniper communities as well as several transitional areas. It encompasses primarily low intermediate elevation areas in the Snake River Plains of southern Idaho. The area is extensively grazed and often serves as an infestation source for migrating grasshoppers moving into cropland. Two species of Juniper, *Juniperus osteosperma* and *J. occidentalis* Hook., and the shrubs, *Artemisia tridentata*, *Purshia tridentata* (Pursh) D.C., *Chrysothamnus nauseosus* (Dall.) Britt. and *C. viscidiflorus* (Hook.) Nutt. are common. Grasses include *Bromus tectorum*, *Poa secunda* and *Agropyron* spp. Many species of annual forbs are present. This community has been greatly altered by fire, overgrazing and range renovation. Major economic grasshopper species included the spurthroats *Melanoplus sanguinipes*, *M. bivittatus* (Say), *M. foedus* Scud., *M. infantilis* Scud. and *Oedaleonotus enigma*. Slantfaces are best represented by *Aulocara ellioti* (Thos.) which often reaches outbreak proportions. Common bandwings include *Trimerotropis pallidipennis*, *Conozoa wallula* (Scud.), *Dissosteira carolina* (L.) and in southwestern Idaho, *D. spurcata* Saussure.

Overall physical features and vegetation are the most important factors affecting grasshopper composition in this community. Even in areas with fairly dense stands of juniper, grasshopper-plant relationships were not sufficiently different to cause independent clustering of the juniper community. Herbaceous understory of the juniper community is remarkably similar to much of the extensive sagebrush-grass community (zone).

Community Type III. This is an intermediate community in the moisture-altitude gradient. It comprises much of the traditional ponderosa pine and a large portion of the fescue-wheatgrass and wheatgrass-bluegrass communities of northern Idaho, often referred to as the Palouse Prairie. In addition to the prairie areas it includes the Lower Salmon, Middle Snake and Clearwater River canyons.

Vegetation in this area consists of numerous grasses and forbs. *Agropyron spicatum* (Pursh) Scribn. & Smith and *Festuca idahoensis* Elmer are the most important grasses. Open stands of ponderosa pine, lacking dense shrubby understory, are also suitable for grasshopper habitation and form an important part of this community. Grasshoppers common to this community include *Camnula pellucida* (Scud.),

Trimerotropis suffusa Scud., *Melanoplus sanguinipes* and *Chorthippus curtippennis* (Harris). In drier, more marginal habitats, *Trimerotropis pallidipennis* (Burm.), *T. fontana* (Thos.), and *Ageneotettix deorum* may be found.

Community Type IV. This is a broad and somewhat intermediate community. Generally speaking, it lies above community type II in elevation and south and southeast of community type III. It is generally marginal to the Snake River Plains of southern Idaho. Sagebrush is usually present and some authors (Tisdale et al., 1969) include it in sagebrush grasslands. It differs from lowland sagebrush-grassland as discussed in community type II in relative vigor of plants and plant and grasshopper composition. Although elevation is only a relative criterion for community delineation, sites clustering in this community type ranged from 6600-8000 feet in elevation. Slope and soil also differ from its lower sagebrush-grassland counterpart, with slopes generally steeper and soils much stonier. The grass, *Agropyron spicatum* is usually prominent. At lower elevations of traditional sagebrush-grassland this species has been largely replaced by *Bromus tectorum*. Sagebrush is often quite vigorous, but does not compete with grasses to the extent it does at lower elevations. Competitive vigor is evidenced in part by the distribution of different species and subspecies of sagebrush (Winward, 1970).

Grasshopper species common to this community type include the bandwings *Circotettix undulatus* (Thos.) and *Camnula pellucida*, and the spurthroats *Melanoplus sanguinipes* and *M. bruneri* Scud. Slantfaces are less common but include *Aulocara ellioti*; though not abundant, *Amphitornus coloradus* (Thos.) is frequently encountered.

Community Type V. This is a high-elevation, mesic community, which we designate as the "mountain-meadow community." Sagebrush is absent, confined to small isolated patches, or forms an abrupt ecotone with this community. "Forest park" applies to large parts of this community type. Open, uncanopied areas in timber zones from the Douglas fir to the spruce-fir zone are also included. Sedges (*Carex* spp.) are prevalent. *Festuca* spp. and *Poa* spp. are common grasses. The forbs *Penstemon*, *Delphinium* and *Potentilla* are common. Grasshoppers such as *Chorthippus curtippennis* reach maximum development in this habitat. Other common species include *Bruneria sordida* (McNeill), *Arphia conspersa* Scud., *Trimerotropis suffusa*, *Bradynotes obesa* (Thos.), *Melanoplus alpinus* Scud. and *M. indigenus* Scud.

Grasshopper Composition of Clustered Communities

Grasshopper composition for the clusters shown in the dendrogram (Fig. 1) is listed in Table 2; designation (A) means accidental, i.e., a species generally unable to colonize for any substantial length of time; (R) means a species is

Table 2. Grasshopper composition of communities clustering above 98% confidence level. A = accidental; R = rare; O = occasional; and C = common. *Overwinter in nymphal stage.

SPECIES	Community Type I	Community Type II	Community Type III	Community Type IV	Community Type V
Oedipodinae					
<i>Aerochoreutes carlinianus</i> (Thos.)	O	O			
* <i>Arphia conspersa</i> Scudder			O	O	C
<i>Arphia pseudonietana</i> (Thos.)		A	R	R	
<i>Camnula pellucida</i> (Scudder)		A	C	C	C
<i>Circotettix rabula</i> Rehn & Heb.		R			
<i>Circotettix undulatus</i> (Thos.)		O	R	O	O
<i>Conozoa wallula</i> (Scudder)	C	C	O	R	
<i>Cratypedes neglectus</i> (Thos.)	R	C	R	R	R
<i>Derotmema haydenii</i> (Thos.)	O	O			
<i>Dissosteira carolina</i> (L.)	O	C	C	O	
<i>Dissosteira spurcata</i> Saus.		O	A		
<i>Spharagemon collaris</i> (Scudder)		R		A	
<i>Spharagemon equale</i> (Say)	A	O			
<i>Trachyhrachys kiowa</i> (Thos.)	R	O		R	
<i>Trimerotropis agrestis hewitti</i> Tink.	R	R			
<i>Trimerotropis arenacea</i> Rehn	O	R			
<i>Trimerotropis bilobata</i> Rehn & Heb.	C	O			
<i>Trimerotropis caeruleipennis</i> Brun.	O	R			
<i>Trimerotropis campestris</i> McNeill				O	R
<i>Trimerotropis cyaneipennis</i> Brun.	R	R			
<i>Trimerotropis fontana</i> (Thos.)	R	A	O		R
<i>Trimerotropis gracilis</i> (Thos.)		O		R	
<i>Trimerotropis latifasciata</i> Scudder		O			
<i>Trimerotropis pallidipennis</i> (Burm.)	C	C	C	C	
<i>Trimerotropis strenua</i> McNeill	C				
<i>Trimerotropis suffusa</i> Scudder		A	O	O	C
* <i>Xanthippus corallipes</i> (Haldeman)	O	O	O	O	O
Gomphocerinae					
<i>Aeropedellus clavatus</i> (Thos.)					O
<i>Ageneotettix deorum</i> (Scudder)	C	O	O	O	
<i>Amphitornus coloradus</i> (Thos.)		O		O	
<i>Aulocara elliotti</i> (Thos.)	C	C		O	
<i>Bruneria sordida</i> (McNeill)	R	R		C	C
<i>Chorthippus curtipennis</i> (Harris)				O	C
<i>Chloealtis brachyptera</i> (Scudder)		R	R		
<i>Cordillacris occipitalis</i> (Thos.)	C	O			
<i>Paropomala pallida</i> Bruner	R		R		
<i>Paropomala wyomingensis</i> (Thos.)		O		R	
<i>Pedioscirtetes nevadensis</i> Thos.		R			
* <i>Psoloessa delicatula</i> (Scudder)	O	O		O	
Catantopinae					
<i>Bradynotes obesa</i> (Thos.)					O
<i>Oedaleonotus enigma</i> (Scudder)	C	C			
<i>Melanoplus alpinus</i> Scudder					C
<i>Melanoplus bivittatus</i> (Say)		R	O	O	O
<i>Melanoplus bruneri</i> Scudder					O
<i>Melanoplus foedus</i> Scudder	O	C			
<i>Melanoplus indigenus</i> Scudder					O
<i>Melanoplus infantilis</i> Scudder		O		O	
<i>Melanoplus sanguinipes</i> (F.)	C	C	C	C	O

rare but permanent in that community; (O) means a species is a permanent resident and occasionally reaches high numbers; and (C) means a species is nearly always collected in that particular community and is often abundant and common throughout the community.

Few species range throughout all communities (Table 2). Of those which do, only *Melanoplus sanguinipes* reaches economic numbers. Species permanently inhabiting 4 or 5 clustered communities are alike in having varied periods of nymphal emergence. One of these species, *Xanthippus corallipes*, typically overwinters as the third instar while others vary in their times of spring emergence. Early instars of some of the typical spring-emergent species, e.g. *Trimerotropis pallidipennis* and *Melanoplus sanguinipes*, have been collected during late fall at lower elevations. Emergence of species with broad ecological ranges tends to be delayed with increasing elevation and synchronized with vegetation development of a particular area; e.g. *Cratypedes neglectus* may be collected as an adult from mid-June to mid-September or later depending on elevation. Since variability in nymphal emergence even within a given site is widespread among broad-ranging species, this appears to be a major factor of their adaptability.

All grasshoppers studied characteristically fall into one of 3 classes: 1) species inhabiting low, dry community types, restricted either to the shadscale or sagebrush communities; 2) species restricted to the mountain-meadow or wheatgrass-bluegrass communities; and, 3) the largest class, species restricted only by high and/or low moisture, temperature, and altitude conditions. Species belonging to the two extreme groups become gradually less frequent in both density and occurrence as they approach the midpoint of the altitude-moisture gradient. Species restricted to one community in Idaho may extend into higher, moister, or lower, drier areas in other states; thus, they may not be as limited as their Idaho distribution would indicate.

Grasshoppers which are restricted in distribution often reach higher densities and are more widespread within a given community than those with broader distributions. This is most obvious at higher elevations where loss of flight is a common adaptation. Flightless species inhabiting higher elevations may become locally abundant and widespread within higher community types, but seldom inhabit lower community types. In the same manner, relatively few species from lower elevations become well established in communities at high elevations.

Most species of grasshoppers are community limited with limitations varying from narrow (present in few communities) to broad (present in several communities). Additionally, density and frequency occurrence of species varies in different communities. Broad-ranging species seldom reach

high numbers within a single community (a possible exception is *Melanoplus sanguinipes*), apparently losing some protection of high numbers while gaining flexibility in range.

Effects of Habitat Alteration on Grasshopper Distribution and Abundance

Numerous habitat disturbances were investigated, including the effects of fires, soil tillage, sagebrush abatement, logging, road construction, natural erosion and overgrazing. All have distinct and profound influence on grasshopper distribution and abundance.

Fire. This is a common and widespread natural or man-caused disturbance. The intermountain-shrub region of southern Idaho is especially vulnerable to fires during the dry summer period. Sagebrush is particularly affected with climax often delayed or deterred as a result of it. During the initial years after a fire, cheatgrass and annual forbs prevail, particularly where severe grazing has occurred. Perennial wheatgrasses and bluegrasses are generally present but often contribute little to the over-all cover. Sagebrush is either absent or represented as seedlings. Fires in the sagebrush community and other communities in the intermountain shrub zone may cause major changes in density and composition of grasshopper populations. Overall grasshopper density after sagebrush removal is usually greater. Species particularly favored after fire are *Melanoplus sanguinipes*, *Oedaleonotus enigma*, *Aulocara elliotti* and *Trimerotropis pallidipennis*.

Post-fire evaluations were also made in the fescue-wheatgrass community, particularly where a fescue-wheatgrass-sagebrush transition integrated with the Douglas fir community. Slight increases in grasshopper population were noted once the area had become revegetated. Species apparently enhanced were *Melanoplus sanguinipes*, *Camnula pellucida* and *Trimerotropis suffusa*, the latter often reaching its best development on north exposures.

Grasshopper populations in all of the true forest communities tend to be enhanced during the initial post-fire years when herbaceous and shrubby species prevail. Colonization is usually by species commonly found in the mountain-meadow community, e.g. *Melanoplus indigenus*, *M. sanguinipes*, *Camnula pellucida* and *Trimerotropis suffusa*.

Soil tillage. Tilling was observed only in the fescue-wheatgrass and sagebrush communities. In annually tilled areas, grasshoppers are most common in wastelands and field margins. Species diversity and density are generally low. In the sagebrush community, tilling is done subsequent to sagebrush removal and prior to seeding crested wheatgrass. This procedure causes two changes in grasshopper populations:

(1) enhancement of overall density; (2) tilling favors several species of bandwings and disfavors most spurthroats and slantfaces; however, species diversity is often enhanced. Species most favored are *Dissosteira spurcata* for the extent of its range, *Spharagemon equale* (Say) and *Trimerotropis latifasciata*; if weedy species become established, several spurthroats, e.g. *Oedaleonotus enigma*, *Melanoplus sanguinipes* and *M. foedus*, are enhanced. Conversely, if grasses are prevalent, *Cratypedes neglectus*, *Aulocara elliotti*, and *Ageneotettix deorum* are favored.

Sagebrush abatement. Sagebrush may be removed by burning, tilling or use of herbicides. The results of burning and tilling have been discussed previously. Sagebrush removal by spraying may have somewhat different effects than fire. Coincident with sagebrush removal, perennial grasses are often seeded. Crested wheatgrass is often used and provides excellent forage for many grasshoppers and livestock. After sagebrush removal, herbaceous species increase in vigor and tend to grow later in the summer, thus improving conditions for several grasshopper species. Species most benefited by this type of sagebrush abatement are grass-feeding species which prefer undisturbed soils, e.g., *Aulocara elliotti* at lower elevations and *Camnula pellucida* at higher elevations. These species usually inhabit different community types, but both are favored in their respective habitats. It should be pointed out that even though there may be a denser grasshopper population, there is often no greater forage loss on a relative basis because of the improved range condition.

Logging. Disturbance induced by logging stimulates herbaceous growth, often resulting in increased density of grasshoppers or invasion of areas previously uninhabited by grasshoppers. Species most favored by logging include the slantface *Chorthippus curtipennis*, the bandwings *Trimerotropis suffusa*, *T. fontana* and *Camnula pellucida*, and the spurthroats *Melanoplus sanguinipes* and *M. indigena*.

Road construction. Effects of road construction vary with altitude, soil type, exposure, etc. At elevations below the Douglas fir community, higher numbers of either spurthroats or bandwings often exist along roadsides than in adjacent, undisturbed areas. If vegetation is sparse, bandwings are enhanced; if vegetation is more lush, spurthroats, and to a lesser extent slantfaces, are enhanced. *Dissosteira carolina*, *Melanoplus sanguinipes*, and *M. femurrubrum* (De-Geer) are the 3 most common roadside species in Idaho with *Conozoa wallula* numerous bordering semidesert rangeland in southern Idaho. At elevations above the Douglas fir community, these species are usually absent and bandwings and spurthroats indigenous to the particular area are enhanced.

Natural erosion. Blowouts, dunes, and gullies caused by wind and water are the most common types of natural erosion affecting grasshopper species. They occur commonly

in the Snake River Plains of southern Idaho and are most often associated with dry areas. Few examples of true gullies, dunes or blowouts were found above the sagebrush community in Idaho. Eroded areas have shifting soils and scant vegetation and tend to favor bandwings. Slantface species are generally scarce, but when present, are closely associated with sparse perennial bunchgrasses. Spurthroats are generally more common than slantfaces. Bandwings most favored include *Trimerotropis agrestis*, *T. arenacea*, *Spharagemon collaris* and *Conozoa wallula*. *Trimerotropis caeruleipennis* is generally absent in dunes and blowouts, but often favored in gully areas.

Overgrazing. This practice results in exposure of the soil to wind and water, reduction in vegetation, and instability of the area. It is particularly acute in semi-desert areas of southern Idaho. With reduction of vegetation and exposure of soil, bandwings are favored, often becoming more numerous than prior to overgrazing.

An Overview of Grasshopper-Plant Community Associations

The overall community must be considered in light of its biotic composition. With varied ecological requirements and tolerances among grasshoppers, a time-related dynamic equilibrium is established in each community, often allowing a high species diversity except in marginal grasshopper habitats, e.g. marshlands, talus slopes or high altitudes. Shifts in habitat conditions may result in changing grasshopper composition, but diversity is often equal or greater. Original habitat type and nature and severity of change all influence composition and, unless continually disturbed, an area will achieve "stability."

Factors affecting grasshopper numbers and composition are numerous and varied. Much insight can be gained by studying climatic and weather conditions (Pickford, 1966; Edwards, 1960; McCarthy, 1956), particularly as they affect numerical fluctuation. If weather and climate are too severe for permanent survival, a species will be eliminated unless replaced by migrants. If climate is suitable for permanent habitation, a dynamic equilibrium will be established between numbers and climate. Density-related factors adjust numbers to the habitat, acting in response to amount and quality of the food present, predators and parasites and total density. Density-related phenomena prevent extinction by adjusting population numbers to the resources of the environment.

All requisites, functions, locations and phenologies of large numbers of grasshopper species occupying a common area are not known. If they can be defined, grasshopper composition and numbers for a habitat could be modeled. Even with the limited knowledge presently available one can

often predict the outcome or impact of a specific habitat alteration on grasshopper populations. If sagebrush is removed in a sagebrush community, there are a number of possible outcomes. First, removal of a shrub or tree overstory generally results in increased grasshopper numbers, but it also causes greater exposure of herbaceous vegetation. In the sagebrush community, severe overgrazing often results in reduction of plant cover and an increase in weedy plants unpalatable to livestock. This favors bandwing grasshoppers. If grazing has not been severe, perennial grasses increase, and slantfaced grasshoppers will be generally favored. Spurthroated grasshoppers manifest wide ecological diversity with many species adaptable to a variety of habitats.

Successional stages in grasshopper communities can be generalized. Bandwings are the "pioneers," becoming established while the soil is unstable and early seral vegetation sparse. As plants (chiefly annual forbs) become established, spurthroats invade and bandwings decline. With the establishment of perennial grasses, slantfaces become established.

Grasshopper composition is a product of the plant community, suitable host plants, edaphic characteristics, climate, light conditions, and other, often species-specific requirements. Plant community and edaphic characteristics often reflect directly and indirectly conditions of moisture, temperature, elevation, slope, exposure, disturbance factors and other physical features of the environment. Ecological requirements of most grasshoppers, especially the more common species, are fairly broad and can be fulfilled in several communities. In many cases the limiting factor or factors are not fully realized because of interacting and possible synergistic effects of environment and genetic attributes of a population.

SUMMARY

To achieve a better understanding of grasshopper associations with plant communities, over 300 collections of grasshoppers from various plant communities in Idaho were made. In addition, detailed studies of 24 community sites representing a cross-section of grasshopper habitats were selected for cluster analysis. Cluster comparisons were based on 87 descriptors, including grasshopper and plant species, altitude, soil type, slope, exposure, percent vegetative cover, relative density of grasshoppers, and numbers of grasshopper species.

Cluster analysis revealed five significant groupings and corresponds to the following types of areas: xeric shrub areas (intermountain or salt desert shrub type); sagebrush-grassland and juniper areas of the Snake River Plains; the wheatgrass-bluegrass, fescue-wheatgrass and ponderosa pine areas of the Palouse Region and major river canyons of northern and northcentral Idaho; higher elevations of fescue-

wheatgrass containing sagebrush, occurring primarily marginal to the Snake River Plains of southern Idaho; and the high elevation, mesic, untimbered areas of the traditional forest zones.

Ecological ranges of selected species and subfamilies of grasshoppers in Idaho are discussed; information on grasshopper responses to habitat alteration are included. Many wide-ranging species have broad phenologies which enable them to adapt to various environmental conditions.

Habitat alterations and disturbances have profound effects on grasshopper composition. Generally, bandwing species are "pioneers," favored by unstable soils and early and intermediate seral vegetation; spurthroats prefer intermediate seral conditions with moderately stable soils and having a mixture of grasses and forbs; slantface species prefer stable grassy areas.

ACKNOWLEDGEMENTS

The authors extend their appreciation to Dr. E. W. Tisdale, Forestry Range Resources, University of Idaho, for his advice and suggestions regarding the plant community classification referred to in this paper and his critical review of the manuscript.

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