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Trifolium thompsonii Stand Conditions Following a Wildfire Event in the Entiat Mountains of Central Washington

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Abstract. *Trifolium thompsonii* (Thompson's clover) is listed as a threatened legume of the Eastern Cascades where wildfire is the dominant disturbance agent. Previous research suggested fire supression adversely impacts populations of this species. Recent fires in parts of Thompson's clover range indicate that Thompson's clover responds favorable to fire disturbance. Four areas of Thompson's clover habitat were sampled for vegetation composition and structure. Thompson's clover stands were evaluated for species density and morphological expression. In areas of recent fire, Thompson's clover individuals were significantly taller (means of range 32-25 cm) and had greater numbers of flowerheads (means of range 4 to 1 per plant) than on sites with no recent fire activity, suggesting a Thompson's clover response to fire caused resource release. This information combined with a species density ranging 0.6 to 4.8 plants m^{-2} suggests that Thompson's clover appears to achieve optimum stand conditions on sites where perodic grass-shrub eliminating fires occur. Re-establishment of historical fire effects may be a key to improved management of landscapes in which fire responsive species such as Thompson's clover are components.

Introduction

Trifolium thompsonii (Thompson's clover) is one of 12 plant species listed as threatened along the east slope of the Washington Cascades (WNHP 1994). Within its range it is a dominant forb, first reported by J.W. Thompson in 1933 on the slopes of Swakane canyon at the edge of *Pinus ponderosa* forests and into the *Artemisia tridentata* shrub steppe adjacent to the western shores of the Columbia River (Hitchcock et. al.1969). Work by Canfield (1977) and Tiedemann et.al. (1977) expanded knowledge of this species and documented 10 additional stands, the largest located within the 80 ha Thompson's Clover Research Natural Area. Survey work reported by Gamon and Sprague (1988) further extended the Chelan county occurrences of *Trifolium thompsonii* to canyons near the Entiat River and added information of a stand east of the Columbia River, about 6 km southeast of the Thompson's Clover Research Natural Area.

These new sightings suggest even wider range potentials and perhaps a different ecological amplitude than previously described (Kennison and Taylor 1979). The purpose of this study was to clarify the habitat characteristics of *Trifolium thompsonii* and seek evidence which might indicate the successional role of this species among the different plant communities where it is found. The objectives of this research were: 1. to document the vegetative communities and site factors associated with *Trifolium thompsonii*; and 2. to compare morphological features and plant density of *Trifolium thompsonii* populations among these vegetative communities.

Methods

Study Area

Climate of the area is typical of eastern flank of the Cascade range. Summers are warm and dry and winters are moderatly cold. Precipitation occurs mostly as snow between November and April. The nearest climate station at Wenatchee, WA., has a mean January temperature of -3 °C and a mean July temperature of 22 °C. Annual precipitation is about 220 mm. This species occurs at elevations of 345 to 1146 m (Canfield 1977). Using the normal lapse rate of 2 °C per 300 M the mean temperature on the study sites would be -8 °C for January and 17 °C for July. At these elevations winter snowpack may be expected to remain for up to 60 days longer in the spring; delaying bud emergence for *Trifolium thompsonii* and other species (Gamon and Sprague 1988).

Disturbance History

In general, fire has been an historical disturbance agent in this region and was evident on a portion of the *Trifolium thompsonii* study area. Figure 1 shows the pattern of wildfire within the known range of *Trifolium thompsonii*

since 1930 (WNF 1990, Canfield 1977). The most recent fire occurrence was July 1988. Landscapes within this area were grazed by domestic sheep and cattle until 1965 (Tiedemann et.al.1977). No known fires have occurred on the Douglas county study sites but the area is presently under seasonal grazing impact by domestic cattle and portions of the area are cultivated for wheat crops (Gamon and Sprague 1988, E. Gutzwiler 1993, pers. comm.).

Field Sampling

Sampling sites were selected by reviewing maps of known *Trifolium thompsonii* locations from the Wenatchee National Forest Thompson's Clover Management Guideline (Gamon and Sprague 1988). Criteria for sample site selection was: The appearance of distinct patches of *Trifolium thompsonii* in the overall mosaic of vegetation coverage and patch size greater than 50 M diameter.

Vegetative sampling was done by systematically placing a 50cm x 20cm sampling frame in a 4 X 5, 20 frame matrix at three positions (0, 30, 50M) along 50 meter tape transect running trough *Trifolium thompsonii* patches. The polygonal cover class of each species encountered in the plot frame was recorded (Daubenmire 1959). Taxonomic nomenclature follows Hitchcock and Cronquist (1973). At the same time, soil surface condition was recorded at 10 points on the plot frame as either litter, bare ground, plant basal area, cryptogamic crust, wood pieces, or rocks. At each sampled community the density of *Trifolium thompsonii* was measured by counting individuals within ten $1M^2$ plot frames in the same 4 X 5 vegetation sampling matrix. From each sampled community 10 to 30 *Trifolium thompsonii* individuals were randomly selected and measured for height, leaf number, shoot number, flowerhead number and root crown diameter.

At each sampled community the following site factors were recorded: elevation, slope, aspect, slope position, and a microterrain feature (flat, convex, concave). The soil depth was measured and a soil sample of the upper 20cm was collected at each sample matrix and analyzed for bulk density and % soil moisture. The soils data were compared and supplemented with SCS Soil survey laboratory information available on the study area (Beiler 1969, 1978).

Analysis

Mean coverage and frequency values were calculated for all species in each sample unit and used to construct a species list of cover and a table of plant communities with species cover and constancy (Table 1). Dendograms produced by cluster analysis (Wilkinson 1992) were used to identify relationships among *Trifolium thompsonii* sampling clusters based on species composition and cover. Site factor data on soil moisture, surface cover and terrain features were tabulated for comparison by plant community (Table 2). Data on density of *Trifolium thompsonii* and measurements of morphological features were tabulated by plant community and analysis of variance was used to test for differences among the community types.

Results

Trifolium thompsonii occurred in three broad vegetative settings: forest patches, steppe-like parklands, and semiarid shrub steppe. The forest patches consisted of a multilayered community of trees, shrubs, grasses and forbs dominated by *Pseudotsuga menziesii* occurring on mesic topographic settings such as gullies and northerly slopes. Steppe parklands were grass dominated landscapes with occasional mature *Pinus ponderosa* individuals. The shrub steppe was the extensive drought tolerant tall shrub-bunchgrass (*Artemisia tridentata/ Agropyron spicatum*) vegetative associations typical of the central Columbia basin.

Within these three settings four plant communities were identified using cluster analysis of species composition and cover values within stands. These four community types probably represent various successional stages of four plant associations as described by Franklin and Dyrness (1973) and Daubenmire (1970). They are *Pseudotsuga menziesii/Calmagrostis rubescens* (PSME/CARU) of the forest setting, *Pinus ponderosa/Agropyron spicatum* (PIPO/AGSP) and *Artemisia tridentata-vaseyana/Agropyron spicatum* (ARVA/AGSP) of the steppe setting and *Artemisia tridentata-tridentata/Agropyron spicatum* (ARTR/ AGSP) of the shrub steppe zone. Physiognomic differences between the community types were distinctive and easily recognizable. These four community types are described below with reference to vegetative composition and site factor data in Tables 1 and 2.

Plant Community Descriptions

The PSME/CARU community occurred on north facing steep slopes (40-60 %) at mid to upper elevations (> 1060 m) in Chelan county. This was the wettest and coolest environment with estimated annual precipitation ranging 508 to 1016 mm and estimated annual temperature of 5-6 °C. *Pseudotsuga menziesii* was the overstory dominant with *Pinus ponderosa* a codominant in some sample units. *Spiraea betulifolia* and *Penstemon fruticosus* were prominent shrub layer components. The grass, *Calmagrostis rubescens* was a significant co-dominant of this community type. *Balsamorhiza sagittata*, *Achellia millefolium* and *Trifolium thompsonii* were the most prominent forb species. Other important herbaceous species were *Festuca idahoensis*, *Bromus tectorum*, *Poa secundi*, *Collensia parviflora*, *Crypthantha affinis*, *Epilobium paniculata*. In this community fire recently

Table 1. Constancy and mean canopy cover of species in four *Trifolium thompsonii* community types. Tr= % cover less than 0.1. N=number of sample units. Con= constancy. Cov= % canopy cover.

	PSME N=2		PIPO N=7		ARTR N=9		ARVA N=3	
	Con	Cov	Con	Cov	Con	Cov	Con	Cov
Tree								
Pinus ponderosa	100	29.0	P	P	0	0.0	0	0.0
Pseudotsuga menziesii	100	32.0	0	0	0	0.0	0	0.0
Shrub								
Artemisia tridentata-tr	0	0.0	14	Tr	77	8.5	0	0.0
Artemisia tridentata-va	0	0.0	0	0.0	0	0.0	67	1.2
Artemisia tripartita	0	0.0	0	0.0	11	1.0	67	14.0
Ceanothus velutinus	50	6.0	0	0.0	0	0.0	0	0.0
Chrysothamnus viscidiflorus	0	0.0	0	0.0	11	0.2	0	0.0
Erigeron linearis	0	0.0	14	0.7	0	0.0	0	0.0
Eriogonum heracleoides	0	0.0	43	2.2	55	2.6	100	8.5
Eriogonum niveum	0	0.0	14	0.4	0	0.0	0	0.0
Eriogonum strictum	0	0.0	0	0.0	22	0.2	0	0.0
Haplopappus stenophyllus	0	0.0	14	Tr	55	1.2	0	0.0
Penstemon fruticosus	100	11.5	28	0.5	0	0.0	0	0.0
Phlox longifolia	100	1.8	57	1.7	100	3.3	34	0.8
Purshia tridentata	0	0.0	0	0.0	66	4.9	0	0.0
Ribes cereum	50	0.4	0	0.0	22	0.6	0	0.0
Spiraea betulifolia	100	12.7	0	0.0	0	0.0	0	0.0
Symphoricarpos albus	50	1.6	14	0.4	0	0.0	0	0.0
Vaccinium occidentale	50	2.3	0	0.0	0	0.0	0	0.0
Grass								
Agropyron cristatum	0	0.0	0	0.0	11	Tr	0	0.0
Agropyron spicatum	50	0.1	100	26.4	100	44.1	100	26.7
Bromus occidentalis	0	0.0	0	0.0	11	Tr	0	0.0
Bromus tectorum	100	0.4	57	2.0	88	1.4	67	4.4
Calmagrostis rubescens	100	37.0	0	0.0	0	0.0	0	0.0
Festuca idahoensis	100	3.7	100	7.5	88	14.5	34	4.2
Festuca rubrua	0	0.0	28	Tr	0	0.0	0	0.0
Koeleria cristata	50	0.1	71	2.3	0	0.0	100	4.3
Melica bulbosa	50	0.0	14	Tr	33	1.3	34	Tr
Poa secunda	100	1.2	85	4.1	100	7.1	100	5.0
Forb								
Achillea millefolium	100	7.1	100	7.3	77	2.0	100	2.4
Agoseris grandiflora	0	0.0	57	1.5	88	6.0	100	1.8
Allium acuminatum	0	0.0	0	0.0	77	10.7	0	0.0
Angelica arguta	0	0.0	14	Tr	0	0.0	0	0.0
Antennaria rosea	0	0.0	85	17.6	0	0.0	34	2.5
Astragalus purshii	0	0.0	43	1.3	0	0.0	0	0.0
Balsamorhiza sagittata	100	9.9	100	11.7	100	17.6	67	3.8
Brodiaea douglasii	0	0.0	0	0.0	11	Tr	34	0.3
Castelleja lutescens	50	0.1	28	0.5	22	0.1	0	0.0
Collinsia parviflora	100	0.5	100	3.1	66	1.0	100	0.9
Cryptantha affinis	100	0.9	85	1.5	22	0.0	67	0.8
Epilobium paniculatum	100	1.6	100	3.2	44	TR	100	1.2
Geum triflorum	50	1.6	28	1.3	0	0.0	34	0.9
Helianthus petiolaris	0	0.0	28	2.4	0	0.0	0	0.0
Hieracium albiflorum	50	0.8	57	1.5	11	Tr	34	0.9
Lactuca serriola	0	0.0	14	0.4	11	0.3	0	0.0
Linanthus liniflorus	0	0.0	14	Tr	0	0.0	0	0.0
Lithospermum ruderale	0	0.0	0	0.0	11	Tr	0	0.0
Lomatium nudicale	50	0.4	57	1.6	77	3.5	0	0.0
Lupinus leucophyllus	0	0.0	0	0.0	44	1.3	0	0.0
Lupinus sericeus	0	0.0	71	1.4	66	2.8	34	Tr
Microsteris gracilis	100	0.4	57	0.2	77	1.6	100	1.0
Polemonium micranthum	0	0.0	57	0.2	100	0.6	34	0.2
Sisymbrium altisimum	50	0.4	0	0.0	22	0.0	67	1.2
Trifolium thompsonii	100	6.5	100	20.7	100	21.2	100	11.6

Table 2. Range of values for site factors in all sample units of four community types associated with of *Trifolium thompsonii*.

	PSME	PIPO	ARTR	ARVA
Site Varibles				
Elevation (m)	1115-1060	810-899	890-1096	816-1071
Slope (%)	40-50	30-60	15-50	30-40
Aspect (deg)	360	360-235	045-270	360-235
Precipit (mm)	508-1016	304-406	208-620	304-406
Temp (C)	5 - 6	8 - 10	8 - 10	8 - 10
Soil Surface				
Litter (%)	44-63	40-60	19-69	37-69
Bare Ground (%)	11	8-34	13-58	8-40
Rock (%)	1	0	0-26	0
Wood (%)	4-11	1	0-10	0
Basal Area (%)	18	11-29	7-27	71-27
Cryptogams (%)	1-4	1-4	5	0-1.5
Soil Profile				
Depth (cm)	35-48	25-55	24-75	48-56
BulkDensit (g/cc)	1.22-1.40	1.10-1.30	1.05-1.30	1.21-1.29
Available Water (cm-cm)	0.38-0.43	0.43-0.50	0.15-0.53	0.30-0.35
pH	6.5	6.4	7.1	6.4
Organic Matter (%)	2.5- 4.5	2.8- 6.4	1.5- 4.5	2.6-3.0
CEC (meq)	10-20	9-15	8-18	8.4 -12.0
Coarse Fragments (%)	10- 40	10-20	5- 45	10-20
Sand (%)	72-83	65- 79	33-59	67- 68
Silt (%)	15-21	19 -31	36- 53	25-32
Clay (%)	1- 3	1- 4	2- 13	1- 6

Notes: Community type abbreviations are: PSME= *Pseudotsuga menziesii/ Calmagrostis rubescens*; PIPO= *Ponderosa pine/ Agropyron spicatum*; ARTR= *Artemisia tridentata/ Agropyron spicatum*; ARVA= *Artemisia tridentata-vasayana/ Agropyron spicatum*.

destroyed the crown foliage of nearly all *Pseudotsuga menziesii* and *Pinus ponderosa*.

The dominant vegetation in PIPO/ AGSP was an *Agropyron spicatum- Festuca idahoensis* grass understory (Table 1). *Pinus ponderosa* was present as solitary mature individuals in mesic topographic settings with cover rarely exceeding 2 % on the entire study area of the Research Natural Area. Only a few low shrubs, *Eriogonum heracleoides, Phlox longifolia, Haplopappus stenophyllus*, were present with less than 5% overall cover. No tall shrubs were recorded. The most prominent species in the forb component were *Antennaria rosea, Balsamorhiza sagittata, Trifolium thompsonii* and *Achillea millefolium*. The annuals *Collensia parviflora, Epilobium paniculata, Crypthantha affinis* were nearly ubiquitous in the samples but with small cover values. Fire disturbance was generally in the grass shrub understory with no tree crown damage.

The ARVA/ AGSP was located on the Thompson's Clover Research Natural Area (Figure 1) and was adjacent to PIPO/ AGSP. Individuals of *Artemisia tridentata-vasayana* and *Artemisia tripartita* represented the overstory cover of this community type. The grass species *Agropyron spicatum, Poa secunda, Festuca idahoensis* ranging in mean cover from 4-27 % were vegetative dominants. *Trifolium thompsonii, Balsamorhiza sagittata, Antennaria rosea, Achellia millefolium* were the major forb components. Annuals were not prominent in this community, except for a *Bromus tectorum* coverage of 4 %, the highest of this study. Charred bunchgrass clumps and shrub skeletons indicated recent (1988) fire disturbance.

In the ARTR/ AGSP community type the overstory is dominated by the tall shrubs *Artemisia tridentata-tridentata* and *Purshia tridentata*, with mean coverage values of 9% and 5%. The herbaceous dominants were represented by *Agropyron spicatum, Festuca idahoensis*, and *Poa secunda* with up to 44% mean cover. This community was rich in forbs with nearly 20 recorded. The most important were *Trifolium thompsonii, Balsamorhizza sagittata, Allium acuminatum, Agoseris grandiflora, Lomatium nudicale, Achellia millefolium*, and *Lupinus sericeus*. There was no evidence of recent fire in this community. However, some forbs and bunch grasses appeared to have been grazed.

Community Structure

Table 3 shows the structure of the four communities by life form. Grasses and forbs were prominent in the communities of PIPO, ARTR, and ARVA with forbs nearly equal in presence but more variable in cover and species composition among the groups. Tree cover was clearly distinctive in the PSME/ CARU community but almost of no importance in the three others. Noteworthy, was a low value of shrub cover but high value of forb cover in PIPO/ AGSP, suggesting recent disturbance in those layers; likely by fires, since tree boles were charred but crown foliage was mostly unharmed. The structure data shows a decline in shrub and tree components and increase in grass and forb components from the mesic forests to the arid shrub steppe.

Plant density- Trifolium thompsonii

Density of *Trifolium thompsonii* ranged from 0 to 16 plants-m^{-2} on 258 plots from within the four community types. There were significant differences in the mean density of *Trifolium thompsonii* among all the community types. Generally, *Trifolium thompsonii* densities were greater in the steppe-like settings than those in the PSME setting and specifically they were highest in the ARTR shrub- steppe of Douglas County where individual plot frame samples contained as many as 16 plants m^2. By contrast, plot samples in the forested (PSME) had high vegetative coverage in trees, shallow soil depths, and modest available water (Table 2 and Figure 2). These forest like features suggest quite different site conditions for *Trifolium thompsonii* occupancy, which may be the cause of its low density value of 0.6 plants $meter^2$.

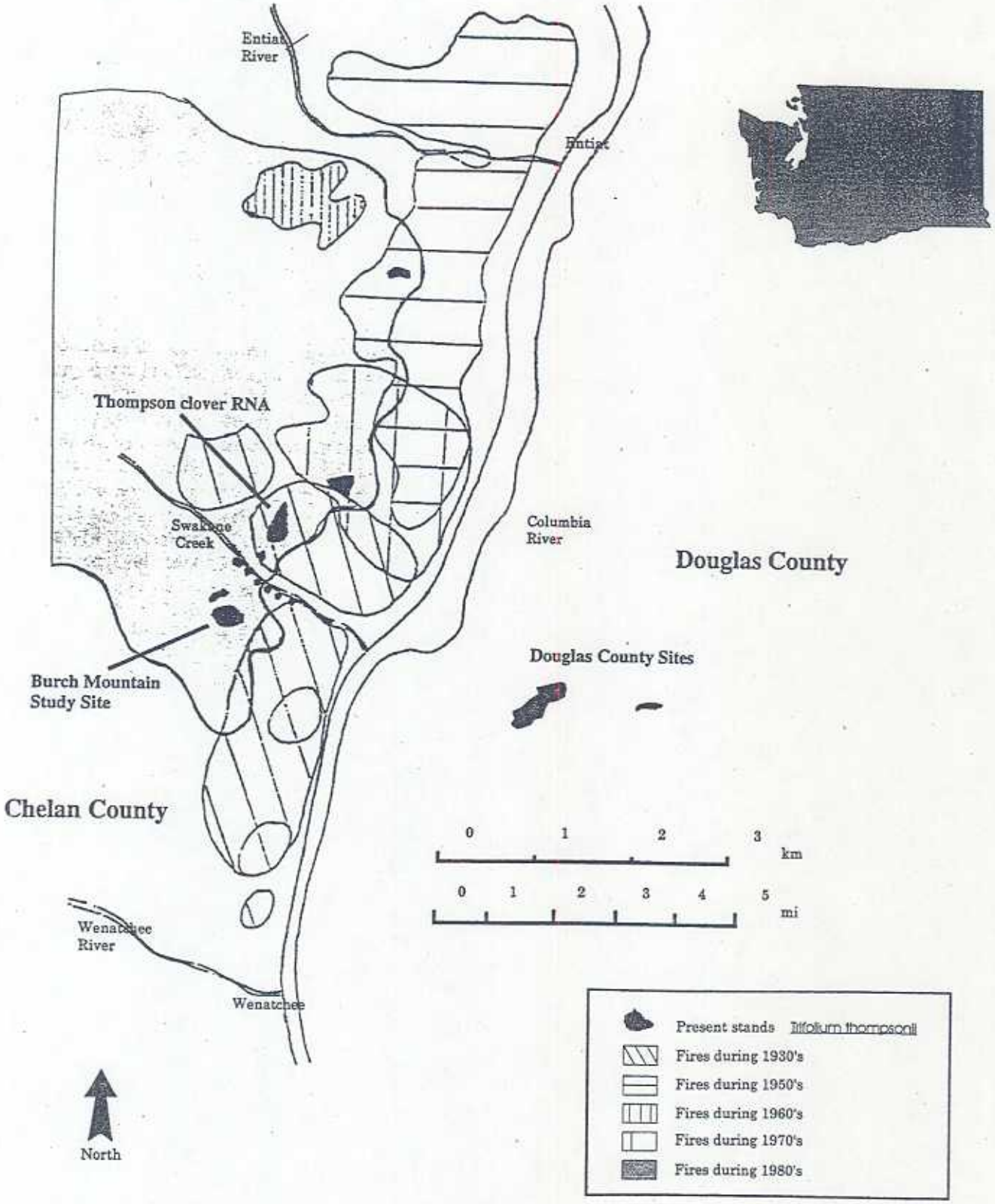


Figure 1. Present known stands of *Trifolium thompsonii* in Chelan and Douglas counties Washington with known areas of fire disturbance in *Trifolium thompsonii* range since 1930 (adapted from Canfield 1977 and Wenatchee National Forest 1990).

Table 3. Proportion of cover by life form in four community types associated with *Trifolium thompsonii*.

	PSME	PIPO	ARTR	ARVA
Forb (%)	17.7	61.4	28.3	40.8
Grass (%)	25.1	34.4	46.0	43.5
Shrub (%)	21.3	4.2	25.5	14.5
Tree (%)	35.9	1	0	0
Total	100	100	99.8	98.8

Notes: Community type abbreviations are: PSME= *Pseudotsuga menziesii/ Calmagrostis rubescens*;PIPO= *Ponderosa pine/ Agropyron spicatum*; ARTR= *Artemisia tridentata/ Agropyron spicatum*; ARVA= *Artemisia tridentata-vasayana/ Agropyron spicatum*.

Morphological characteristics- Trifolium thompsonii

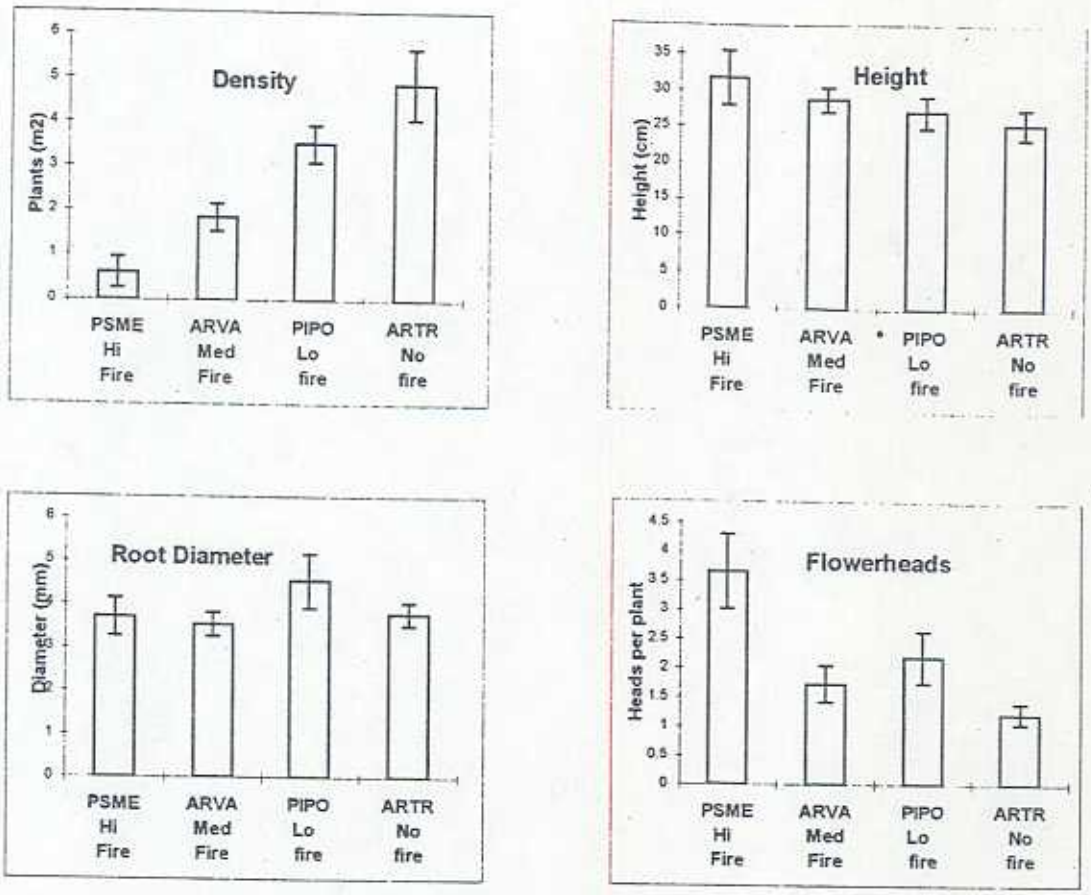
Approximately 350 specimens of *Trifolium thompsonii* were measured for the five morphological features of height, leaf number, shoot number, flowerhead number, and root crown diameter. Because of plant density differences there were varying sample sizes from each of the community types. Based on mean values, a "typical" *Trifolium thompsonii* specimen was 27.6 cm in height, a three shoot plant with five leaflet per leaf, two flowerheads and root diameter of four mm. Data presented in Figure 2 show relationships of *Trifolium thompsonii* height, root diameter and flowerhead numbers in each community aligned in order by high fire intensity to low fire intensity. This information suggests that *Trifolium thompsonii* achieves significant plant height and flowering potential on sites affected by wildfire, such as PSME and PIPO. Flowerhead numbers on PSME were significantly greater ($p < 0.05$) than those of the other communities. However, as the confidence interval bars suggest, there were no significant differences in the height or root diameter data among the other communities. We note the trend comparison of *Trifolium thompsonii* plant density rising to ARTR-no fire side and the height/ flowerhead counts measures declining in the same direction, but presently offer no explanation for this pattern.

Discussion

Steep rocky slopes with deep valleys and open pine-shrub-grass communities are the most distinctive landscape features of the semi-arid foothills on each side of the Columbia River north of Wenatchee, WA. It is an ecotonal area where dry climate species of the *Pinus ponderosa /Agropyron spicatum* association loses landscape influence to even more drought tolerant *Artemisia tridentata /Agropyron spicatum* communities (Franklin and Dyrness 1973). Topographic influences here create intergrade variations in the vegetative mosaic such as *Pinus ponderosa* communities giving way to *Pseudotsuga menziesii* associations in north facing ravines and at elevations of 800M or more (Daubenmire and Daubenmire 1968). This landscape is part of a larger eastside area that is subjected regularly to lightning ignited wildfire disturbances (Agee 1992). The results of this were observed in the physiognomy of the vegetative mosaic as scorched trunks of *Pinus ponderosa*, fire-killed pole size *Pseudotsuga menziesii*, burned skeletons of *Artemisia tridentata* (or large areas of none at all), and charred clumps of bunch grasses of *Agropyron spicatum* and *Festuca idahoensis*. Amidst this regularly disturbed landscape condition, *Trifolium thompsonii* appears as a dominant forb but in discontinuous patches of up to 70 ha in size over some 80 km² of this area. The patchiness of habitats along this ecotone is particularly characteristic of the part of its range west of the Columbia River in Chelan county.

Trifolium thompsonii east of Columbia River in Douglas county occurred in a more uniform physiognomy of *Artemisia tridentata/ Agropyron spicatum* zonal association with an area of *Pinus ponderosa* forest to the north on the summit ridge of Badger mountain (Daubenmire 1970). On a long term basis, this area has experienced similar landscape disturbances as the west side but with less regularity in recent years, probably due to greater agricultural activity such as fruit orchards, wheat farming and cattle ranching (E. Gutzwiller 1993, pers comm). Shrub-grass vegetation was typical cover in all but thinly soiled scab patches on knolls, ridges, basalt cliffs and talus screes. *Trifolium thompsonii* appears in this landscape in patches up to about 3 ha. on modest slopes and terraces of all aspects but not necessarily as a dominant forb evenly dispersed among the *Artemisia tridentata / Agropyron spicatum* communities.

The present successional condition of the *Pinus ponderosa /Agropyron spicatum* association on the Thompson's Clover Research Natural Area in Chelan county can be described as seral because of clear evidence of a recent (1988) wildfire which involved much of this landscape (WNF1990). The species composition of PIPO of this study (Table 1), however, suggests that this community may still be near its most successionally advanced stage. The composition nearly matches the established *Pinus ponderosa /Agropyron spicatum* habitat type documented by Daubenmire and Daubenmire (1968). There may be some argument on the authenticity of the PIPO community of this study because of the presence of *Festuca idahoensis*, a grass species not normally found in the *Pinus ponderosa /Agropyron spicatum* habitat type. Higher elevations and slightly more mesic conditions on northerly aspects of PIPO probably explains this. Vegetative evidence of fire disturbance is revealed by the persistent presence of *Antennaria rosea* and *Epilobium paniculatum* and significant cover values of such annuals as *Crypthantha affinis*, *Helianthus petiolaris*, *Microsteris gracillis*, and *Bromus tectorum* (Wright 1984). Presence of these species in the understory are clues of an early



Community type abbreviations are: PSME= Pseudotsuga menziesii/ Calmagrostis rubescens
PIPO= Ponderosa pine/Agropyron spicatum; ARTR=Artemisia tridentata/ Agropyron spicatum
ARVA= Artemisia tridentata/ Agropyron spicatum

Figure 2. *Trifolium thompsonii* plant density and morphological features in four community types. Vertical bars are 95% confidence intervals.

seral stage in this landscape. If this community is seral, then the vigor of *Trifolium thompsonii* individuals sampled here may support the proposition that this species is a seral opportunist in response to disturbance.

It was in the PSME community, however, that *Trifolium thompsonii* appeared to be most opportunistic. Individuals here were tallest and had the greatest floral-seed potential. This PSME community resembled the *Pseudotsuga menziesii / Symphoricarpus albus* habitat type as described by Daubenmire and Daubenmire (1968) largely because of the presence of the shrubs *Spirea betulifolia*, *Ceanothus velutinus* and *Vaccinium* spp. This comparison, though, is confounded by the presence of *Calmagrostis rubescens* that was sampled on slightly drier parts (ridges) of this community. The shrubs were located in slightly wetter gully locations. It is important to note that the *Pseudotsuga menziesii* was burned in the tree crowns by the 1988 wildfire. This lack of tree crown permitted considerable light penetration to the understory and surface. With these openings and reduced competition, light tolerant heliophytes such as *Trifolium thompsonii* may have opportunity to develop particularly vigorous individuals. Of course, this strategy depends on a taxon being present in the community, either in the soil seed reserves or in a reduced vegetative form prior to the event of disturbance. The low density value of *Trifolium thompsonii* recorded in the PSME community suggests that its presence was probably limited in the predisturbance phase.

The ARTR community of this study appeared to have the least disturbance, certainly from fires. A nearby rancher grazes cattle in the area. Grazing was observed on the bunch grasses and on *Trifolium thompsonii*. There was no indication of recent fires, indeed with such exten-

sive coverage of fire intolerant *Artemisia tridentata-tridentata*, fire probably has not been a disturbance factor for decades (Table 1). This community is thoroughly described in Daubenmire (1970) as a major climax association of the Columbia Basin area. *Trifolium thompsonii* is present here in substantial densities and coverages (Table 1). The individuals, however, were significantly shorter than those of the other community types of this study. Because this well established ARTR community was so successionally advanced, we argue that *Trifolium thompsonii* is also an important climax community forb. Since this study did not accurately identify the severity of previous grazing on this landscape, *Trifolium thompsonii* probably should be considered a seral forb in this community until more information is available on its ecological life history at this new location east of the Columbia River, particularly with the broad influence of agricultural disturbances.

In summary, several communities have been described where *Trifolium thompsonii* occurred. They are well known plant associations in certain stages of their successional development. *Trifolium thompsonii* showed varying population densities and plant vigor expressions in each of these associations. These variations in expression can be explained, in part, by the different site potentials and degree of resource capture by *Trifolium thompsonii* in each of these communities. The various site potentials are partly explained by the type, severity and recency of disturbances these communities have experienced: from the intensely burned trees of the PSME community, where this species is tall and vigorous but very low in density to the only slightly disturbed community of ARTR where it is significantly shorter but greater in population density.

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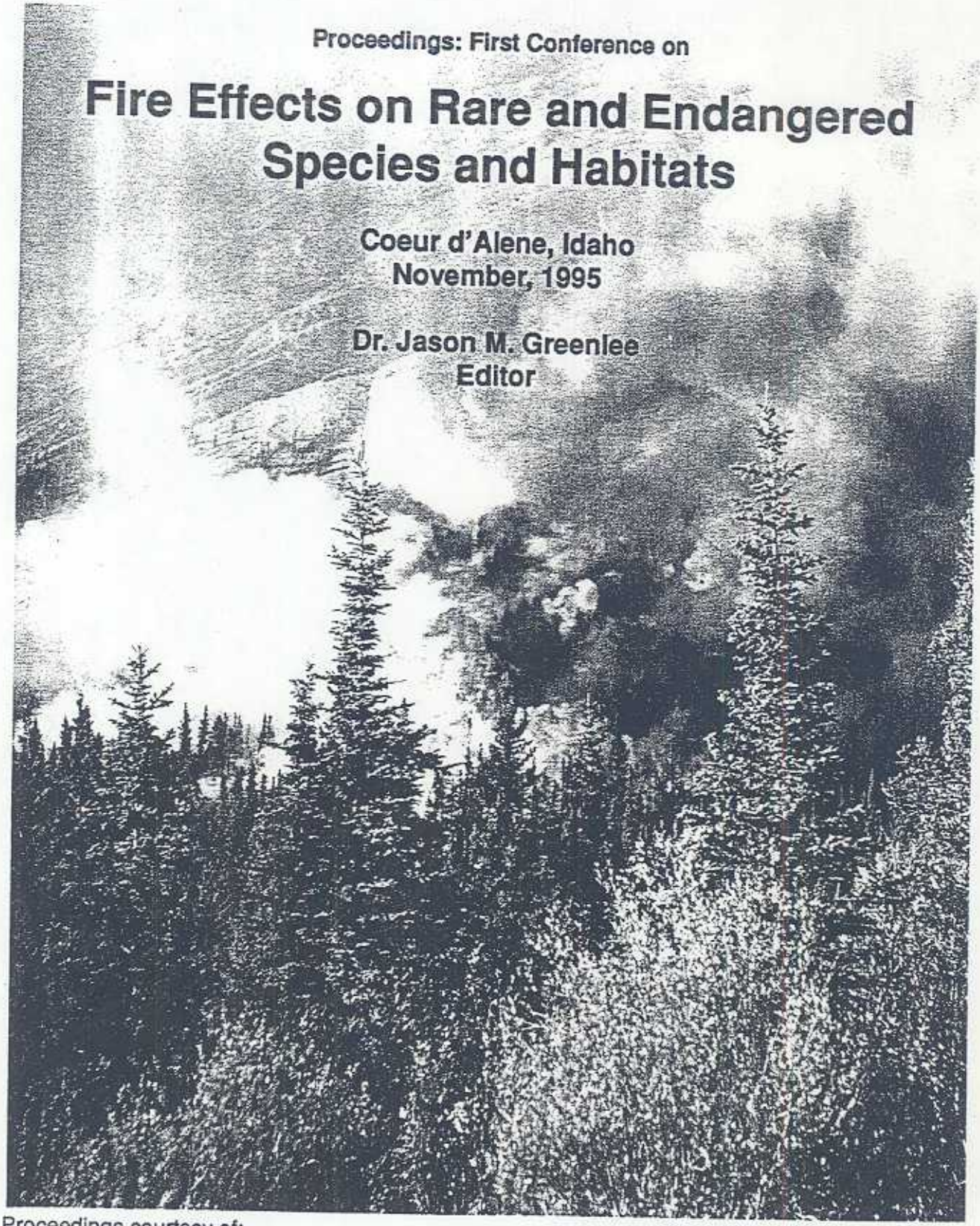

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