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UNDERSTORY RESPONSE TO TREE HARVESTING OF SINGLELEAF PINYON AND UTAH JUNIPER

Richard L. Everett¹ and Steven H. Sharrow²

ABSTRACT—Fifteen widely separated sites within the pinyon-juniper woodlands of the Great Basin were cleared of trees. Understory response was recorded for 2 to 4 years. The array of postharvest plant assemblages were classified into one of four phytosociological groups using discriminant analysis. Pre- and postharvest plant assemblages from the same site appeared in the same phytosociological group, which indicates postharvest response could be predicted from the preharvest plant assemblage. Initial postharvest response appears cyclic in nature, and cycles are controlled by both residual plants and the rapid immigration of shrub species. Perennial plant density generally declined following tree harvest, but the fewer remaining plants produced significantly more cover than in preharvest stands.

Wood harvesting in pinyon-juniper woodlands of the Great Basin has a long and colorful history. In the late 1800s, the harvesting of trees for charcoal used in the smelting of ore and as heating fuel had decimated tree populations for an 80-km radius around many mining camps. An estimated 1600 to 2000 ha of woodland were cleared annually to fuel this burgeoning mining industry (Young and Budy 1979). Concurrently, livestock numbers, including the numerous draft animals used in wood harvesting, were increasing and indiscriminate burning of woodlands was common (Tausch et al. 1981, J. A. Young, pers. comm.). These perturbations left an array of depleted disclimax understory communities (Tueller 1973) upon which the current woodlands would become established. Trees reestablished rapidly in the Great Basin (currently 7.1 million ha, Tueller et al. 1979), and understory cover and productivity was reduced (Tausch et al. 1981, West 1983).

Rising fossil fuel costs have recently increased the demand for cord wood (Meeuwig and Cooper 1981). Thus, widespread tree harvesting is once again a major use of these woodlands. With appropriate management based on a knowledge of probable understory response, wood harvesting could provide a cost effective means of utilizing the wood resource and increasing the forage base.

Understory response to tree harvest is closely linked to the type and number of residual plants (MacMahon 1980, Clary 1974;

Dryness 1973, Arnold 1964). Grass and shrub production increases following tree harvesting in the Southwest if these plants are numerous and capable of capturing released resources (Clary 1974, Arnold and Schroeder 1955). But floristically impoverished sites with low site potential for understory production can remain static for several years following tree removal (O'Rourke and Ogden 1969).

Our study tests the hypothesis that postharvest response in fully stocked singleleaf pinyon (*Pinus monophylla*)–Utah juniper (*Juniperus osteosperma*) woodlands of the Great Basin is "site specific cyclic." We hypothesize that a linear replacement series of plant forms does not often occur following tree harvest. If mid-to-late successional understory plants or their immigrating seeds are available to the site, they control the character of postharvest response and negate early successional stages. Rapid reinvasion of trees in the central core of the woodland also truncates midsuccessional shrub dominance. This hypothesis is limited to the midelevation of the woodland and may not be viable at either upper or lower ecotones.

METHODS

In 1977, 1978, and 1979 study sites were established in 15 singleleaf pinyon–Utah juniper stands across the Nevada portion of the Great Basin (Fig. 1). Stands selected for tree

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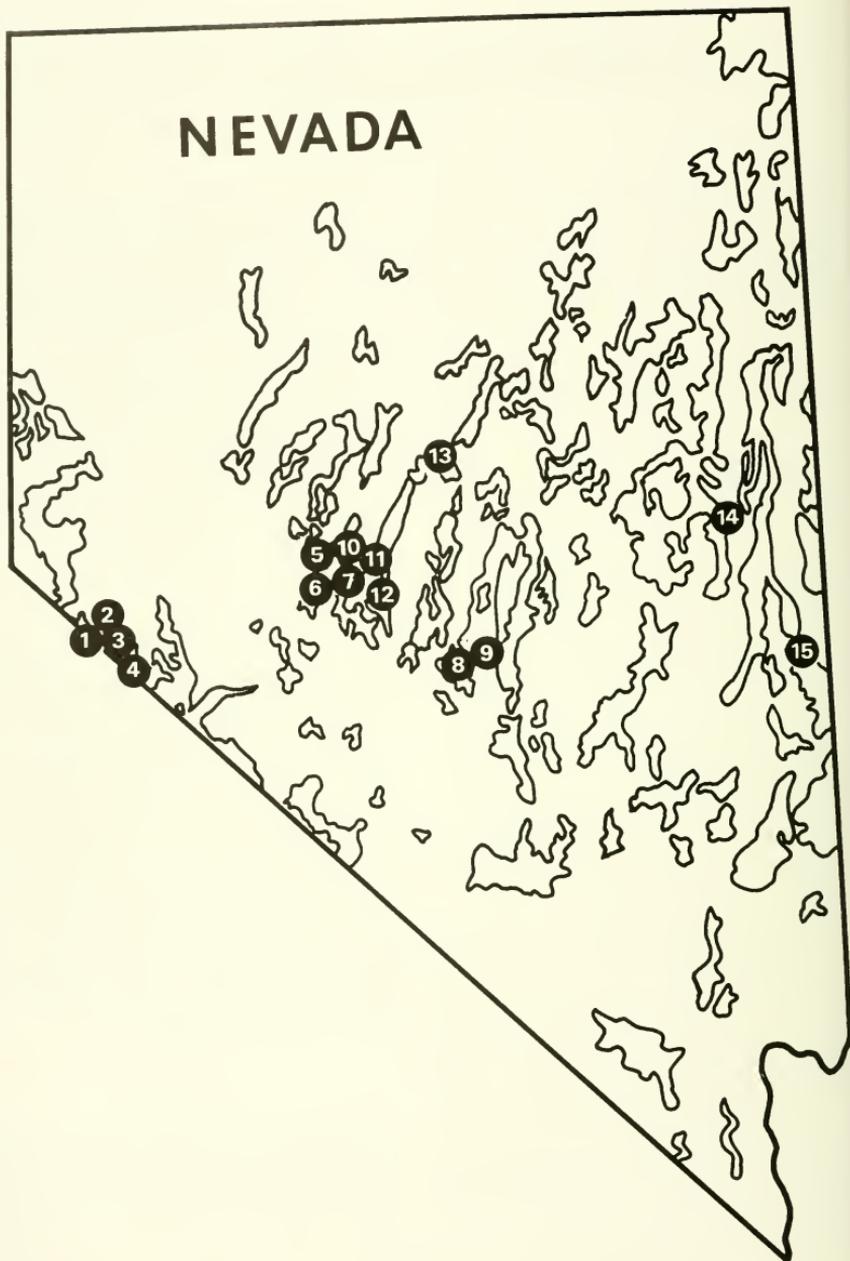


Fig. 1. Location of study sites in the pinyon-juniper woodlands of the Great Basin. Woodland distribution patterns taken from Tueller et al. (1979).

harvest were fully stocked with trees and had minimal understory. Plots (0.1 ha) were selected for site uniformity in microtopography and understory composition. Trees greater than 1 m in height were hand cut, sectioned, and removed from the plots with minimal disturbance to the soil surface.

A series of five parallel transects 20 m in length were laid out on 5-m intervals parallel to one another across the slope. Tree cover was estimated using line intercept (Canfield 1941) along each transect. A series of frames (50 x 50 cm) were laid down at every meter mark, and plant species cover and density were recorded. Understory response on the harvested sites and on adjacent uncut areas were monitored for 2 to 4 years following tree removal. Predominant preharvest understory species, tree cover (%), elevation, aspect, and year of harvest are given for each site in Table 1.

Discriminant analysis was used to group the array of pre- and postharvest plant assemblages (30 total) based on nine phytosociological parameters. Phytosociological parameters used were areal species richness, "evenness" in cover among plant forms (Brilouin's [H] measure of diversity divided by maximum diversity in distribution of cover possible [$J = H/H \max$]: Poole 1974), aggregation of perennial plants (Morisita's Index of Aggregation: Poole 1974), total plant cover, and proportion of cover by shrub, perennial

grass, perennial forb, annual grass, and annual forb. Postharvest data were run using the preharvest groupings to test if postharvest plant assemblages could be predicted from preharvest data.

Pre- and postharvest data sets from the same site are not independent. Thus, data was compared by t-tests of differences. Multivariate matched pair t-tests of differences (Timm 1975) were conducted for closely related parameter pairs, woody and herbaceous cover, annual and perennial cover, total cover and evenness in cover distribution, and perennial plant density and perennial plant aggregation. The test statistic used was Hotelling's t at the 0.05 significance level.

A correlation matrix of the phytosociological variables was used to identify parameters that varied together ($P = 0.05$) in pre- and postharvest plant assemblages. Proportion of species common to pre- and postharvest plots were included with those variables already mentioned.

RESULTS AND DISCUSSION

LACK OF CLIMATIC EFFECTS ON PLANT RESPONSE TO TREE HARVEST.—Precipitation during the final year of postharvest measurement was less than occurred during the year of preharvest measurement. Mean precipitation from six official weather stations closest to the 15 study sites averaged 28.5 cm

TABLE 1. List of study sites, dominant understory, percent tree cover, elevation, aspect, and harvest year.

Preharvest understory	Study site	Percent cover	Elevation	Aspect	Year
ANNUAL FORB DOMINANT					
<i>Phacelia humilis</i>	4	36	2030	N	78
<i>Collinsia parviflora</i>	9	26	2220	E	79
<i>Collinsia parviflora</i>	15	56	2200	E	79
SHRUB DOMINANT					
<i>Purshia tridentata</i>	1	60	2300	E	77
<i>Artemisia arbuscula</i>	2	49	2200	N	77
<i>Artemisia arbuscula</i>	8	41	2070	W	79
<i>Ribes veltianum</i>	3	64	2100	E	77
PERENNIAL GRASS DOMINANT					
<i>Poa sandbergii</i>	5	56	2040	E	78
<i>Poa sandbergii</i>	6	52	2060	N	78
<i>Poa sandbergii</i>	7	58	2190	E	78
<i>Poa sandbergii</i>	11	54	2300	W	79
<i>Poa sandbergii</i>	12	54	2280	S	79
<i>Poa sandbergii</i>	13	43	2200	N	78
<i>Festuca idahoensis</i>	10	28	2340	N	79
PERENNIAL FORB DOMINANT					
<i>Penstemon pachyphyllus</i>	14	50	2200	N	79

(September to August) the year of preharvest measurement and 21.1 cm the year of final postharvest measurement. The initial preharvest plant cover ($X = 2.71 \text{ dm}^2/\text{m}^2$) was not significantly different ($P = 0.1$) from plant cover on nonharvested plots ($X = 2.57 \text{ dm}^2/\text{m}^2$) the final year of postharvest measurements. Understory response to tree release was not confounded by precipitation levels following tree harvest.

PLANT RESPONSE TO TREE HARVEST.—Semi-arid pinyon-juniper woodlands are characteristically low to moderate in species richness, but this varies with site heterogeneity (Harner and Harper 1976). There was no increase in areal species richness following tree harvest. Preharvest plant assemblages averaged 14 species ($\pm 4 \text{ SD}$), and postharvest plant assemblages averaged 11 species ($\pm 6 \text{ SD}$). On 10 of 15 sites, species numbers were lower after tree harvesting.

The proportion of species common to pre- and postharvest plant assemblages averaged 57% ($\pm 21 \text{ SD}$) among sites. The proportion was lowest on the more depauperate sites (1, 3, and 15) and highest when preharvest cover was more evenly divided among several plant forms (sites 8, 9, 10, 11, and 14).

DISCRIMINANT ANALYSIS OF PLANT RESPONSE.—The array of pre- and postharvest plant assemblages (30 total) were

classified by discriminant analysis into (1) annual forb, (2) shrub, (3) perennial grass, and (4) perennial forb phytosociological groups. Pre- and postharvest plant assemblages were intermingled within the groups. The four groups were significantly ($P = 0.001$) different from each other. Aside from plant form dominance, groups differed significantly ($P = 0.001$) in areal species richness, perennial plant aggregation, perennial plant density, total cover, and "evenness" in the distribution of cover among plant forms. Figures 2A and B separate pre- and postharvest plant assemblages for ease of interpretation.

The first discriminant function (axis) ordinated plant assemblages along a gradient of increasing perennial grass cover and evenness in distribution of cover among plant forms. The second discriminant function (axis) ordinated plant assemblages along a gradient of increasing species richness, shrub cover, and perennial forb cover. The third discriminant function (axis) emphasized increasing total cover, species richness, and cover of annual forbs. These discriminant functions explained 80% of the variance in the data.

Postharvest response was not unidirectional in phytosociological change. Vectors drawn from pre- and postharvest plant assemblages varied in length and direction (Fig. 1C). Annuals invaded shrub sites, shrubs in-

TABLE 2. Differences between pre- and postharvest phytosociological parameter pairs (multivariate paired t-test of difference).

Preharvest group	Site	Phytosociological Pair 2			
		Total cover (dm^2/m^2)	Evenness in cover (-1 to +1)	Annuals (dm^2/m^2)	Perennials (dm^2/m^2)
Annual forb	4	-5.66**	-0.27**	-42.26**	13.56**
Annual forb	9	0.78**	0.13**	0.78	3.67
Annual forb	15	2.92**	0.12	13.94**	0.70
Shrub	1	3.5*	0.47**	9.28**	8.28
Shrub	2	4.9**	0.33*	9.69	9.75*
Shrub	3	1.83**	0.05	0	3.35
Shrub	8	1.03**	0.04	0.16†	4.97†
Perennial grass	5	0.61	0.08†	-1.67**	-1.14
Perennial grass	6	-0.44**	-0.25**	-0.51	1.71
Perennial grass	7	3.39**	-0.34**	16.85**	0.27**
Perennial grass	10	1.57	0.19	2.62†	5.23†
Perennial grass	11	2.74**	-0.26	2.22	11.29**
Perennial grass	12	0.65**	0	1.26	2.03
Perennial grass	13	1.33**	0	0.17	6.09**
Perennial forb	14	3.19**	0.18**	1.29	14.66**

Significant at 0.1 or 0.05**. †Hotelling's t value.

†Significant at 0.05, but difference cannot be ascribed to any one parameter.

vaded annual sites, and plant forms already present were differentially favored by tree release, causing intragrouping shifts.

Site membership in postharvest groups was similar to preharvest groups, indicating potential predictability of postharvest response. Discriminant analysis was run again using the postharvest plant assemblages grouped according to the preharvest plant assemblages. We found 80% of the postharvest vegetation transects were placed in the correct preharvest group. Thus opportunities exist for a qualitative prediction of postharvest response from the preharvest plant assemblage.

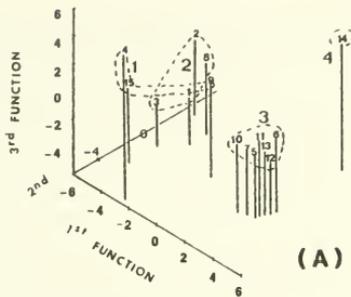
In only three instances were postharvest assemblages classified in groups different from their associated preharvest plant assemblage (Fig. 2C). In two of these instances the difference could be traced to allogenic factors. Site 4 in the annual forb group was invaded and rapidly dominated by mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), shifting it to the shrub group. Site 7 in the perennial grass group was subjected to severe grazing pressure, shifting the plant assemblage to the annual forb group. Site 9 was shifted from the annual forb group to the perennial grass group by the rapid response of on-site perennial grasses.

INTERPRETATION OF DISCRIMINANT RESULTS.—Most pre- and postharvest plant

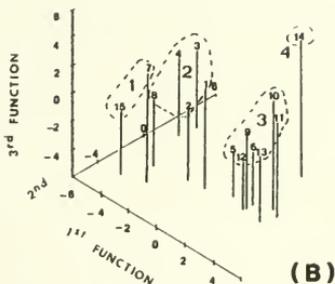
assemblages are found in the same phytosociological groups. This supports the hypothesis that early succession was dominated by species on site at the time of disturbance ("initial floristics": Egler 1954). Postharvest response was "site specific cyclic." The complete successional replacement series of plant forms from annuals to grasses to shrubs to trees (Eardman 1970) could not often occur. This was most apparent where (1) mid-to-late understory successional species immediately predominate the postharvest sites, or (2) where invading trees truncate shrub dominant midsuccessional stages. In the first case, shrubs or grasses rapidly became dominant following tree removal and precluded earlier successional stages (sites 1, 2, 3, 4, and 8). In the second case, perennial grasses or forbs were dominant in both pre- and postharvest understory. This demonstrates the incomplete replacement of herbaceous species by shrubs. We speculate the replacement of grasses and forbs by shrubs is truncated by increasing competition between tree and shrub species (sites 5, 6, 9, 10, 11, 12, 13, and 14). Understory response on the annual forb site (site 15) is the anomaly to the "cyclic response" hypothesis. The lack of on-site perennial species provides increased opportunities for establishment of invading species.

TABLE 2. Continued.

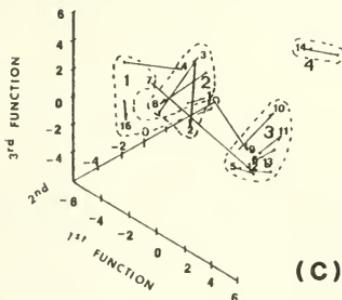
pairs	Pair 3		Pair 4	
	Woody (dm ² /m ²)	Herbaceous	Perennial plant density (plants/m ²)	Aggregation (Morisita's Index) (I)
	13.52**	-41.74**	16.6**	16.9**
	0.92	2.95	0.73	0.1
	0	14.61**	0.4	15.6**
	5.21	8.31	0	-12.0**
	4.93	9.74	- 2.5	- 7.3**
	8.99*	0.16	1.8**	5.6**
	0.47	0.40**	0.50*	0.8**
	0.4	- 3.43**	- 6.4	6.6**
	0	- 2.24	- 5.5	1.2**
- 0.20		24.8*	- 3.8	2.7**
- 3.06		20.87**	- 4.8	0
0.57		14.29**	- 1.3	0.1
0.66		2.63	- 0.3	0.3
1.03		5.17**	3.8	0.3
0.33		18.69**	2.9	0



PREHARVEST



POSTHARVEST



VECTORS OF CHANGE

Fig. 2. Discriminant ordination of preharvest (A) and postharvest (B) plant assemblage. Vectors of change (C) within and among groups. From Klecka (1975).

PHYTOSOCIOLOGICAL CHARACTERISTICS OF PLANT RESPONSE.—Total understory cover significantly ($P = 0.1$ or 0.05) increased following tree harvest on sites not subjected to grazing (sites 5 and 6) or remaining dominated by annual forbs (site 4) (Table 2). The

mean increase in cover across sites was $1.48 \text{ dm}^2/\text{m}^2$, with a high coefficient of variation ($\text{CV} = (S/X \cdot 100) = 61\%$). Mean postharvest understory cover was approximately 200% greater than preharvest understory cover.

Depauperate annual forb sites with few species and unoccupied microsites (loose species packing, Terborgh 1973) were rapidly colonized by herbaceous pioneer species or by shrub seedlings from one of the *Artemisia* taxon. Postharvest response on shrub sites was characterized by increased aggregation of perennial plants, lower species richness, and a less even distribution of cover among the plant forms. Ungrazed grass sites were best characterized by their lack of change in evenness, perennial plant density, and aggregation. Grass sites had high initial species richness, perennial plant density, and evenness in cover distribution among plant forms. Livestock grazing of grass sites altered phytosociological parameters significantly and in one instance caused regression to the annual forb stage.

Evenness in cover distribution among plant forms was low ($J \text{ max} = 1.0$), and the overall mean was numerically the same in both pre- and postharvest plant assemblages ($X = 0.40 \pm 0.26$). Changes in the evenness value for a plant assemblage occurred from such a wide array of circumstances that the value itself had little meaning unless the cause was understood.

Perennial plant cover increased on all sites not subjected to severe grazing, but annual cover was more variable. Woody cover increase was dependent upon remnant shrubs, shrub seed sources, and lack of competing grass species. Herbaceous cover increased following tree harvest unless sites were grazed (site 4).

Perennial plants were significantly ($P = 0.01$) aggregated ($I > 1$: Morisita's Index) in all pre- and postplant assemblages, with the exception of the regular dispersion of plants ($I = 0$) on preharvest sites 3, 4, and 15. At least two scales of aggregation were visible on most sites. Understory and tree cover were heterogeneous across the ground surface, causing general patchiness. Within a given patch, understory was generally excluded from the duff areas adjacent the tree,

resulting in understory aggregation in the interspace.

Perennial plant density was low in pre- and postharvest plant assemblages: $X = 11.45$ plants/m² vs. $X = 11.31$ plants/m², respectively. Perennial plants increased on sites initially dominated by annuals (sites 3, 4, and 15) and perennial forbs (site 14), and on a single grass site (site 13), but decreased on all others. Physical damage during tree harvesting, altered microclimate following tree harvest, and postharvest grazing effects (sites 5, 6, and 7) probably contributed to this loss of perennial plants.

CORRELATION MATRIX OF PHYTO-SOCIOLOGICAL PARAMETERS.—As perennial grass and forb cover increased, so did species richness, evenness in cover distribution, and perennial plant density (Table 3). High shrub cover was associated with high plant aggregation, low evenness, and low grass cover. The proportion of species common to pre- and postharvest plant assemblages was inversely related to total cover, aggregation,

and the shrub-annual forb cover. On sites subject to immigrating shrubs or annual forbs, a sharp change in species composition occurred but species numbers remained less than in grass or forb dominated understory. Diversity of understory increased spatially (aggregation) on shrub sites. Diversity increased floristically (species richness) and structurally (evenness) on grass sites.

CONCLUSIONS

Postharvest response was cyclic and could be predicted from preharvest plant assemblages barring outside perturbations. Postharvest response was best explained by Egler's (1954) "Initial Floristics" model where residual plants and rapidly immigrating species dominate response. Predictability of postharvest response with its high proportion of preharvest species (57%) is consistent with this hypothesis. Predictability of response is increased under this system. Unfortunately, some plant forms may be excluded from the

TABLE 3. Correlation matrix of phytosociological parameters.

Preharvest										
SR ¹	PD	TC	EV	AG	π S	π G	π F	π AG	π AF	
1.	0.66 ²	0.0	0.49	-0.11	-0.05	0.37	0.14	0.39	0.36	
	1.	-0.07	0.56*	-0.18	-0.18	0.52*	0.48	0.07	-0.43	
		1.	-0.06	-0.13	-0.03	-0.27	-0.18	-0.07	0.36	
			1.	-0.28	-0.53*	0.64*	0.42	0.29	-0.09	
				1.	0.52*	-0.21	-0.17	-0.05	-0.33	
					1.	-0.66*	-0.36	-0.25	-0.49	
						1.	0.45	0.28	-0.28	
							1.	-0.07	-0.28	
								1.	0.015	
									1.	
Postharvest										
SR	PD	TC	EV	AG	π S	π G	π F	π AG	π AF	π CS
1.	0.72	0.14	0.48	-0.49	-0.48	0.48	0.58*	-0.23	-0.05	0.26
	1.	0.19	0.32	-0.27	-0.28	0.57*	0.43	-0.16	-0.37	0.35
		1.	0.0	-0.07	0.19	-0.44	0.17	-0.48	0.32	-0.52*
			1.	-0.59*	-0.41	0.39	0.23	0.34	-0.18	0.26
				1.	0.22	-0.45	-0.29	0.15	0.29	-0.41
					1.	-0.63*	-0.27	-0.18	-0.36	-0.30
						1.	0.13	0.09	-0.37	0.72*
							1.	-0.15	-0.19	0.18
								1.	-0.20	0.23
									1.	-0.47
										1.

¹SR = areal species richness; PD = plant density; TC = total cover; EV = evenness; AG = aggregation; π S, π G, π F, π AG, π AF = proportional cover of shrub, perennial grass, perennial forb, annual grass, and annual forb. π CS = proportion of species common to pre- and postharvest assemblages.

²* denotes significant correlation coefficient ($P < 0.05$).

postharvest plant assemblage. When tree harvesting is done to increase the forage base for livestock or wildlife, the desired species should already be in the understory. Understory species richness was reduced following tree harvest on 10 out of 15 sites as suggested by Loucks (1970) for more mesic forests. Understory diversity increased spatially on shrub sites (aggregation) and increased floristically (species richness) and structurally (evenness) on grass sites.

Total plant cover increased following tree harvest on all sites not subjected to severe livestock grazing. Preharvest understory in the fully stocked stands was severely suppressed. Mean increase in postharvest cover was 1.48 dm²/m² and represented a 200% increase in cover over preharvest conditions.

LITERATURE CITED

- ARNOLD, F. 1964. Zonation of understory vegetation around a juniper tree. *Journal of Range Management* 17:41-42.
- ARNOLD, J. F., AND W. L. SCHROEDER. 1955. Juniper control increases production on the Fort Apache Indian Reservation. Station Paper 18. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 35 pp.
- CANFIELD, R. H. 1941. Measurement of grazing use by the line interception method. *Journal of Forestry* 42:192-194.
- CLARY, W. P. 1974. Response of herbaceous vegetation to felling of alligator juniper. *Journal of Range Management* 27:357-389.
- DYBNESS, C. T. 1973. Early stages of plant succession following logging and burning in the western Cascades of Oregon. *Ecology* 54:57-69.
- EGLER, F. E. 1954. Vegetation science concepts. I. Initial floristic composition a factor in old-field vegetation development. *Vegetatio* 4:412-417.
- ERDMAN, J. A. 1970. Pinyon-juniper succession after natural fires on residual soils of Mesa Verde, Colorado. *Brigham Young University Science Bulletin, Biological Series*, 11(2): 24 pp.
- HARNER, R. E., AND K. T. HARPER. 1976. The role of area heterogeneity and favorability in plant species diversity of pinyon-juniper ecosystems. *Ecology* 57:1254-1263.
- KLECKA, W. R. 1975. Discriminant analysis. Pages 434-467 in H. Nie, C. Hull, J. Jenkins, K. Steinbrenner, and D. Bent, eds., *Statistical package for the social sciences*. McGraw-Hill, New York.
- LOUCKS, O. L. 1970. Evaluation of diversity, efficiency, and community stability. *American Zoology* 10:17-25.
- MACMAHON, J. A. 1980. Ecosystems over time: succession and other types of change. Pages 27-55 in R. H. Waring, ed., *Forests: fresh perspectives from ecosystem analysis*. Proceedings Biology Colloquium, 40th. Oregon State University, Corvallis.
- MEEUWIG, R. O., AND S. V. COOPER. 1981. Site quality and growth of pinyon-juniper stands in Nevada. *Forest Science* 27(3):593-601.
- O'ROURKE, J. T., AND P. R. OGDEN. 1969. Vegetative response following pinyon-juniper control in Arizona. *Journal of Range Management* 22:416-418.
- POOLE, R. W. 1974. An introduction to quantitative ecology. McGraw-Hill, New York. 532 pp.
- TAUSCH, R. J., N. E. WEST, AND A. A. NABI. 1981. Tree age and dominance patterns in the Great Basin pinyon-juniper woodlands. *Journal of Range Management* 34:259-264.
- TERBORGH, J. 1973. On the notion of favorableness in plant ecology. *American Naturalist* 107:481-500.
- TIMM, N. H. 1975. Multivariate analysis with applications in education and psychology. Wadsworth Publishing Company, Belmont, California. 689 pp.
- TUELLER, P. T., C. BEESON, R. J. TAUSCH, N. E. WEST, AND K. H. REY. 1979. Pinyon-juniper woodlands of the Great Basin: distribution, flora, vegetal cover. USDA Forest Service Research Paper INT-229. Intermountain Forest and Range Experiment Station, Ogden, Utah. 22 pp.
- YOUNG, J. A., AND J. D. BUDY. 1979. Historical use of Nevada's pinyon-juniper woodland. *Journal of Forest History* 23(3):112-121.