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The Influence of Cow Age on Botanical Composition of Diets in Mountain Riparian Areas in Eastern Oregon of the United States

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Abstract

The objective of this study was to evaluate the effect of cow age on botanical composition of diets in mountain riparian areas. Treatments consisted of 30 first-calf heifers, and 30 mature cows randomly assigned to four pastures (2 pastures/treatment, average 21.5 ha) in a 2-year study with a cross-over design. Botanical composition of diets was determined in fecal samples obtained from 10 animals in each treatment (5 per pasture) on the fourth week of 35 to 42-days grazing periods using the microhistological technique. Crude protein (CP) content and *in vitro* dry matter digestibility (IVDMD) were determined, and correction factors were calculated for 22 major plant species. In digested samples, grasses were overestimated, whereas, all forbs but northern bedstraw (*Galium boreale* L.), were underestimated, and all shrub species were overestimated except common snowberry (*Symphoricarpos albus* L.). Ponderosa pine (*Pinus ponderosa* Dougl.) was highly overestimated after digestion. There was no difference between cattle age class in the total number of plant species found in the diets ($p > 0.10$) averaging in 41 species. Most individual grass and grasslike species made up more than 5% of the diets, while all individual forb, shrub, and tree species were minor components, not exceeding 5%, except ponderosa pine. Western wheatgrass (*Agropyron smithii* Rybd.) and tufted hairgrass (*Deschampsia caespitosa* (L.) Beauv.) accounted for over 10% of the diets. Heifers consumed more ($p < 0.05$) grasses and fewer ($p < 0.10$) shrubs and trees compared to mature cows. The diet of heifers contained more western wheatgrass, Baltic rush (*Juncus balticus* Willd.), and pinegrass (*Calamagrostis rubescens* Buckl.) ($p < 0.10$), but less Kentucky bluegrass (*Poa pratensis* L.) ($p < 0.01$), than the diet of mature cows. The proportion of ponderosa pine needles was higher in the diet of mature cows ($p < 0.10$), than in the diet of first calf heifers. In summary, mature cows appeared to have selected a diet that contained less grasses and more shrubs and trees compared to younger cows.

Keywords: cow age, diet selection, foraging behavior, microhistological analysis, riparian area management, sustainable grazing

1. Introduction

Information regarding diet selection of herbivores has become an increasingly important tool in resource management. Milne (1991) noted that grazing animals have the opportunity to select their diet and in many cases the composition of the diet selected simply reflects the species and plant parts present in the horizon of the canopy being grazed. Knowledge of species consumed by grazing animals tells what the key species are, and is essential in determining "when" and "how much" of each plant is consumed, evaluating the availability and the digestibility of the plant, and explaining changes in diet quality and animal performance (Free, Hansen, & Sims, 1970; Holechek, Vavra, & Skovlin, 1981). On the other hand, deciding which season(s) of the year is most appropriate to use the range, what the proper kind(s) of grazing animals should be, or when the animal's diet is most likely to need a nutrient supplement requires knowledge of food habits (Scott & Dahl, 1980; Darambazar, DelCurto, & Damiran, 2013). There have been studies in which differences were observed in diet selection between young ruminants and older animals (Grings, Adams, & Short, 1995; Mohammad, Ferrando, Murray, Pieper, & Wallace, 1996; Winder, Walker, & Bailey, 1996; DelCurto, Porath, Parsons, & Morrison, 2005). Grings et al. (1995) concluded that suckling calves selected diets of higher quality than did mature steers early in the summer, but not at later times. Similarly, diets of calves and heifers generally had greater crude protein concentrations than cows and steers, but differences decreased as the season progressed (Grings, Short, Haferkamp, & Heitschmidt, 2001). They further noted that dietary crude protein between heifers and cows did not consistently differ across years, and digestibility did not differ among these age classes for August of a 2-year study. Winder et al. (1996) observed calves were often grazing substantial distances from their dams, increasing dietary variation and reducing the relationship between the diets of cows and their calves. Few studies, however, have directly addressed cattle diet selection of different age classes in riparian areas. The overall study, of which this research comprised a part, was designed to evaluate the influence of cow age on grazing distribution relative to mountain riparian areas (Morrison, DelCurto, Parsons, Pulsipher, & Vanzant, 2002). The objective of this study was to evaluate the effect of cow age on botanical composition of diets with cattle grazing mixed conifer mountain riparian areas and adjacent uplands.

2. Materials and Methods

2.1 Study Site

The study was conducted on the Hall Ranch of the Eastern Oregon Agricultural Research Center, 15 km southeast of Union, Oregon, USA. The pastures used in the study comprised 86 ha along Milk Creek. Mean annual precipitation for the study area is 60.4 cm, with the majority falling between November and May. Elevation of the study area averages 1,018 m. (Ballard & Krueger, 2005). Average July and August rainfall, as reported by Porath et al. (2002), totals 3.94 cm. Historically, the riparian pasture along Milk Creek was grazed heavily under a season long grazing regime (Laliberte, Johnson, Harris, & Casady, 2001; Ballard & Krueger, 2005; Darambazar et al., 2013). The area was divided with electric fence into four pastures, each containing roughly 22 ha and a 560 m stretch of Milk Creek. The study was conducted from late July through early September of 2000 and 2001. Dominant grasses in riparian grass communities included timothy (*Phleum pratensis* L.), Kentucky bluegrass (*Poa pratensis* L.), meadow foxtail (*Alopecurus pratensis* L.), wheatgrasses (*Agropyron* spp.) and bromes (*Bromus* spp.). Sedges (*Carex* spp.) and rushes (*Juncus* spp.) were also present in the wetter portions of the meadow. Numerous forbs, including cinquefoil (*Potentilla* spp.), asters (*Aster* spp.), western yarrow (*Achillea millefolium lanulosa* L.), and lupines (*Lupinus* spp.) occurred in these communities. The overstory typically consisted of hawthorn (*Crataegus douglasii* Lindl.), ponderosa pine (*Pinus ponderosa* Dougl.), snowberry (*Symphoricarpus albus* L.), wild rose (*Rosa gymnocarpa* Nutt.), alders (*Alnus* spp.) and willows (*Salix* spp.) (Porath et al., 2002). The herbaceous species dominating the uplands included timothy, brome spp., Kentucky bluegrass, orchardgrass (*Dactylis glomerata* L.), needlegrasses (*Stipa* spp.), blue wildrye (*Elymus glaucus* Buckl.), Idaho fescue (*Festuca idahoensis* Elmer), bluebunch wheatgrass (*Agropyron spicatum* Scribn.&Smith), pinegrass (*Calamagrostis rubescens* Buckl.), and elk sedge (*Carex geyeri* Boott) (Porath et al., 2002). Several forb species occurred in the uplands, including lupine, cinquefoil and wild iris (*Iris* spp.). Snowberry, wild rose, and maple (*Acer* spp.) comprised the majority of the shrub component in the uplands. Ponderosa pine was the dominant tree species. Nomenclature for the species was listed in accordance with Hitchcock, Cronquist, Ownbey, & Thompson (1966).

2.2 Animal and Pasture Management

Sixty cow/calf pairs each year were stratified by age into the following treatments: 1) thirty first calf heifers (2 years of age; 442 kg, BCS = 4.4) and 2) thirty mature cows (5, 6, and 7 years of age; 569 kg, BCS = 4.9). Each treatment group was then randomly divided to create a total of four groups of 15 pairs each. In Year 1, treatments were randomly assigned to the four pastures. For Year 2, treatment assignments from the previous year were reversed. Thus, every pasture was grazed by each age class during the two-year study. In Year 2, mature cows from Year 1 that were still in the herd and within the age requirements, were used again. A new group of 2-year old first calf heifers was used each year (Morrison et al., 2002). The pastures were stocked at 1.5 ha per animal unit month (AUM) to achieve light to moderate utilization. The trial lasted 42 days in Year 1, but was reduced to 35 days in Year 2 due to drought conditions (Morrison et al., 2002).

2.3 Sampling for Diet Analysis

Ten animals per age class (5 per pasture) were selected randomly and sampled for diet composition analysis. Fresh fecal samples were collected immediately after defecation by following the sampling animals in the pasture. A composite sample was taken from four fecal samples obtained from each sampling animal for 4 days during week four of the trial. Samples were dried in a forced-air oven at 50 ºC for at least 72 hours and stored for subsequent analysis.

2.4 Botanical Composition of Diets

Botanical composition of cow diets was determined analyzing the fecal samples through the microhistological technique described by Sparks & Malechek (1968). Each sample was prepared by soaking it in 50% ethanol for overnight, blending, washing under running water over a 200 mesh screen. Samples were dried in a forced-air oven at 50 to 55 ºC, ground in a Wiley mill (Wiley Mill, Model 4, Arthur H. Tomas Co., Philadelphia, PA, USA) through a #20 screen, and a small portion of the ground material was used to make a microscopic slide. Five slides were prepared for each animal and examined in 20 systematically located microscopic fields per slide. Identification was based on epidermal tissue characteristics, such as guard cells, stomata, cell shape, and trichomes (Darambazar & Damiran, 2006). Diet percent by weight was obtained by the following steps: the total number of frequency observations for all species is obtained by adding the species, and the number of frequency observations of each species is divided by the total number of frequency observations for all species. This number multiplied by 100 is used as the percent by weight composition of the diet (Holechek, Vavra, Skovlin, & Krueger, 1982a).

2.5 Correction Factors

To improve the accuracy of fecal analysis it is recommended to develop correction factors specific to forage species, study areas, and season (Dearden, Pegau, & Hansen, 1975; Vavra & Holechek 1980; Leslie, Vavra, Starkey, & Slater, 1983; Holechek et al., 1982a). Correction factors were determined following the approach of Dearden et.al. (1975), modified by Leslie et al. (1983). Each plant species was part of 5 hand-mixed diets and occurred in known relative densities (i.e. percentages by weight) in those mixtures. A known percentage of elk sedge was included in each mix as a standard. Each mix was digested *in vitro* (Tilley & Terry, 1963) for 48 hours using inoculum from steers, and analyzed microscopically as described by Vavra & Holechek (1980). The observed density of each plant species (X) was calculated from frequency of identifiable epidermis according to Sparks & Malechek (1968). The actual density (Y) was calculated from relative weights and the observed density of the standard, assuming the latter equaled its relative weight in the hand-mixed diet.

2.6 Nutritive Quality Analysis

Samples (whole plant) from 22 individual forage species, commonly occurred in the Milk Creek area were collected during late August by hand clipping and were dried in a forced-air oven at 50 ºC. Dried sample was ground to pass through a 1 mm screen (Wiley Mill, Model 4, Arthur H. Tomas Co., Philadelphia, PA, USA). Once ground, sample's dry matter (DM; AOAC method # 930.15), ash (AOAC method # 942.05), and CP (AOAC method # 984.13) concentrations were analyzed according to the procedure of AOAC (1990). *In vitro* dry matter digestibility (IVDMD) was determined by Tilley and Terry (1963) technique, described in details by Damiran, DelCurto**,** Bohnert**,** and Findholt (2008). All data on nutritive quality are reported on DM basis.

2.7 Statistical Analysis

The study was conducted as a randomized complete block design. Data were analyzed using the GLM procedures of SAS (2001) as two treatments, replicated, cross-over design with pasture being experimental unit and cow age being treatment. Treatment means were separated using least squares means procedures and were considered significant at the ($p < 0.10$) level.

3. Results and Discussion

3.1 Chemical Composition and Digestibility of Forage

Heady (1964) stated that as grasses and broad-leaved herbs mature, they decrease in crude protein and increase in crude fiber, lignin, cellulose, and hemi-cellulose. In our study, crude protein levels of grass and grasslike species in the study pasture were relatively low during the late-summer grazing period and ranged from 2.3 to 7%, as contrasted to those of forbs and shrubs and trees, which ranged 4.8 to 9.2% and 7.9 to 16.4%, respectively (Table 1). It was determined that among grasses and grasslikes; redtop, Baltic rush, pinegrass, and elk sedge contained over 5% CP. Among forbs; fleabane (*Erigeron spp.*) was the highest in protein content (9.2%), while among shrubs and trees; willow and alder were higher, containing 15.2 and 16.4% CP, respectively. The IVDMD of forages was in the range of 34.4 to 57.1% for grasses and grasslikes, 45.8 to 79.4% for forbs, and 35.8 to 67.3% for shrubs and trees. Heartleaf arnica was the highest in digestibility (79.4%), whereas blue wildrye, meadow foxtail, and ponderosa pine were the lowest (34.4, 35.6, and 35.8%, respectively).

3.2 Correction Factors

Correction factors were developed in 22 common forages, which included 10 grass, 2 grasslike, 5 forb, and 4 shrub and 1 tree species that occur in the study area, to adjust for the effects of differential digestibility of ingested forages (Table 1).

Table 1. Chemical composition and digestibility of the major forage species and the correction factors during late summer grazing season in Milk Creek riparian area, Hall Ranch in northeastern Oregon, USA

	Chemical Composition (% DM)			Correction Factor (b)*
Forage Species	Ash	CP	IVDMD	
Grasses & Grasslikes				
Blue Wildrye	8.6	3.5	34.4	0.657
Kentucky Bluegrass	8.6	3.2	45.6	0.639
Meadow Foxtail	8.5	2.3	35.6	0.779
Orchardgrass	10.0	3.2	42.5	1.213
Pinegrass	15.4	6.7	46.2	0.433
Redtop	8.8	5.6	57.1	0.469
Timothy	5.7	2.9	48.7	0.759
Tufted Hairgrass	8.0	4.0	42.4	0.411
Western Needlegrass	—†	2.8	—	0.640
Western Wheatgrass	8.8	2.9	43.7	0.838
Elk Sedge	9.4	7.0	51.6	1.001
Baltic Rush	4.3	6.0	45.9	1.133
Forbs				
Western Yarrow	8.5	7.2	45.8	2.613
Fleabane	7.9	9.2	59.9	1.443
Heartleaf Arnica	10.1	7.7	79.4	1.838
Yellow Salsify	—	4.8	—	2.482
Northern Bedstraw	—	6.6	—	1.001
Shrubs & Trees				
Common Snowberry	12.3	9.3	62.4	2.613
Firmleaf Willow	7.8	15.2	67.3	0.656
Alder	5.4	16.4	56.9	0.838
Low Oregongrape	3.4	9.7	59.3	0.635
Ponderosa Pine	2.7	7.9	35.8	0.495

*b = Degree of underestimation (b > 1.0) or overestimation (b < 1.0).

†—, data not collected.

All grasses, except orchardgrass, were overestimated, while all forbs, but northern bedstraw, were underestimated. Orchardgrass was slightly underestimated, while northern bedstraw was neither over- or underestimated. Most shrubs were overestimated, except that common snowberry was highly underestimated in digested diets (Darambazar, 2003). Similarly, several researchers have reported that forbs were underestimated and some grass and browse species were overestimated by fecal analyses, while others were underestimated (Dearden et al., 1975; Vavra & Holechek, 1980). Vavra and Holechek (1980), also, have noted that common snowberry was identified in only small amounts in some digested samples and was totally absent in others. Our results were consistent with these researchers. Ponderosa pine was highly overestimated after digestion.

3.3 Diet Botanical Composition

Composition of the cow diets was dominated by grasses, accounting for up to 75% in the diets, the next greater diet constituents were shrubs and trees (to 13%), and grasslikes made up lesser portion (to 12%) with forbs occurring only in minor amounts (to 5%) (Table 2). This pattern in the rankings of forage classes in diet composition remained similar over the study years ($p > 0.10$). Heady (1964) implied that grazing animals change their preference with growth stage as plants in mixed vegetation do not mature at the same rate. Holechek & Vavra (1983) found that in the early summer (July 19 to August 15) the cattle diet was dominated by shrubs, while grasses dominated the diet in the late summer (August 16 to September 12) in the Blue Mountains of northeastern Oregon. They further reported that during the drought year in their study, forbs were lower in cattle diets because most forb species had reached maturity and dried by early July.

Table 2. Diet botanical composition by forages (% dry weight) of cows during late summer grazing season in Milk Creek riparian area, Hall Ranch in northeastern Oregon, USA

Forages	Cow Age Heifer	Mature Cow	SEM*	*p*-values
Grasses	74.7	70.8	0.17	0.01
Grasslikes	11.8	11.0	1.74	0.79
Forbs	4.3	4.8	0.44	0.47
Shrubs & Trees	9.2	13.4	0.69	0.05

*Standard error of mean (Pooled) ($n = 20$).

The diet of heifers comprised significantly more grasses and less shrubs and trees than that of mature cows ($p < 0.10$). In contrast, no differences between age classes was found in percentages of grasslikes and forbs ($p > 0.10$). Morrison et al. (2002), who studied distribution and utilization patterns of these cows, reported that the mature cows had utilized more forage in the riparian grass communities than did first calf heifers at the end of the trial. Their findings indicated also, that early in the grazing period the mature cows did appear to select upland areas, while the first calf heifers appeared to prefer riparian vegetation type, though as the grazing continued, the distribution and utilization patterns of the different age classes converged. Considering that the first calf heifers spent more time in riparian vegetation, it is possible that differences in diet composition reflect differences in distribution and forage utilization patterns.

A total of 41 species was found in the composition of the cow diets (39 identified and 2 unidentified). No differences were found between age classes in the number of species in the diets across the study years ($p > 0.10$). The most consistently occurring species throughout examining the diets were 8 grass, 2 grasslike, 5 forb, and 4 shrub and 1 tree species, and data presented in Table 3 demonstrate the percentages of these species by weight composition of the diet and correction factors developed for them.

Most of the individual grass and grasslike species made up between 5 to 10% of the diets with an exception of few species (Table 3). The highest dietary proportions were estimated for western wheatgrass and tufted hairgrass, which accounted for more than 10% of the diet. In a study on forested ranges in northeastern Oregon, Holechek, Vavra, and Pieper (1982b) reported that only six of a total 29 graminoids occurred in greater than trace amounts (i.e. 5% or more to the overall diet), which was comprised of Idaho fescue, bluebunch wheatgrass, pinegrass, elk sedge, western fescue, and Kentucky bluegrass.

Although some of the individual species were similar to those found by these researchers, the number of graminoids that occupied more than 5% of the diet in our findings was higher. Forb species occurred in the amounts near or less than 2%, while all shrub and tree species were found under 5% of the diets except ponderosa pine. The two most preferred grasses, western wheatgrass and tufted hairgrass, were selected for reason other than protein density, since their CP contents were very low (2.9% for western wheatgrass and 4.0% for tufted hairgrass, respectively). Dietary selection may be dependent, therefore, on palatability (Damiran, 2005), availability, or the desire to maximize nutrient intact per bite (Clark, DelCurto, Vavra, & Dick, 2013). Cattle selections for the grass and grasslike species such as western wheatgrass, Kentucky bluegrass, pinegrass, and Baltic rush were different between age classes ($p < 0.10$) with mature cows consuming more Kentucky bluegrass, but less western wheatgrass, Baltic rush, and pinegrass than first calf heifers. Higher portion of Kentucky bluegrass, but lesser portion of Baltic rush in the diet of mature cows may have related to the distribution (Walburger et al., 2009) and utilization patterns of these cows, in that they spent more time in the uplands than their counterparts (Morrison et al., 2002; Morrison, 2002). Shrub and tree species were found in trace amounts in the diets and did not differ among age classes with an exception of ponderosa pine. The proportion of ponderosa pine in the diet of mature cows was higher ($p < 0.10$) as compared to that of first calf heifers. Values on shrub consumption in our study were lower than those reported by Holechek et al. (1981; 1982a) where cattle in the Blue Mountains consumed shrubs continually from late spring to fall with an average of 23%, and a low of 10% and a high of 47% being observed in late summers, but were closer to those in a New Mexico study, where shrubs contributed small amounts to both cow and steer diets during the summers decreasing from 10% during spring to 2% in summer (Mohammad et al., 1996), although the study was from a different ecological zone.

Table 3. Diet botanical composition by the major forage species (% dry weight) of cows during late summer grazing season in Milk Creek riparian area, Hall Ranch in northeastern Oregon, USA

	Cow age			
Forage Species	Heifer	Mature Cow	SEM*	*p*-values
Grasses & Grasslikes				
Baltic Rush	6.5	5.2	0.13	0.02
Blue Wildrye	10.0	8.4	0.54	0.17
Elk Sedge	5.3	5.9	1.67	0.82
Kentucky Bluegrass	6.3	7.5	0.03	0.01
Meadow Foxtail	4.0	6.0	1.19	0.35
Orchardgrass	7.3	7.6	0.47	0.67
Pinegrass	8.0	6.4	0.34	0.08
Redtop	5.2	4.8	0.40	0.44
Timothy	1.8	1.9	0.39	0.89
Tufted Hairgrass	11.1	10.2	0.37	0.21
Western Needlegrass	8.7	7.6	0.80	0.45
Western Wheatgrass	12.6	11.2	0.25	0.06
Forbs				
Heartleaf Arnica	0.3	0.5	0.12	0.27
Northern Bedstraw	0.2	0.2	0.07	0.51
Western Yarrow	1.6	1.8	0.41	0.71
Yellow Salsify	2.1	1.8	0.37	0.71
Shrubs & Trees				
Common Snowberry	2.4	2.5	0.33	0.84
Low Oregongrape	0.2	0.3	0.09	0.82
Ponderosa Pine	5.8	9.5	0.76	0.07
Firmleaf Willow	0.6	0.8	0.12	0.33

*Standard error of mean (Pooled) (n = 20).

Forbs comprised a minor component of diets with the amounts not exceeding 2.1% of the diet. Similarly, research findings reported elsewhere indicate that forbs are a minor portion of the cattle diet and/or forb consumption declines as the grazing season advanced (Hurd & Pond, 1958; Holechek et al., 1982b; Uresk & Paintner, 1985). Although the number of forb species found in diets by Holechek et al. (1982b) and by Damiran, DelCurto, Findholt, Johnson, and Vavra (2013) was more than it was in our study, only western yarrow, heartleaf arnica, and lupine comprised 1% or more of the overall diet, which was partly, in agreement with our findings. Holechek and Vavra (1983) also, determined that western yarrow in cattle diets declined from 4% in early summer to 1% in late summer. Researchers report smaller number of forb species identified and/or forbs being found in very little amounts in the feces which may be accounted for the almost complete digestion of some forbs, by the low abundance in the diet, or disintegration during grinding for slide preparation (Free et al., 1970; Rees, 1982; Samuel & Howard, 1983).

On the other hand, Hirschfeld, Kirby, Caton, Silcox, and Olson (1996) who investigated cattle diets in central North Dakota, reported a higher portion of forbs in diets ranging from 1.1% in fall to 27% in late summer, but this study was done in a different climatic and ecological zone. The greater proportion of ponderosa pine found in the diets of mature cows may have been related, in part, to mature cows spending more time (much of it foraging) in the uplands early in the grazing period (Morrison et al., 2001).This is likely to have happened under the canopy of ponderosa pine, which increases the chances of incidental consumption of pine needles. Thus, Karl and Doescher (1998) in determining cattle removal of terminal tissue of ponderosa pine seedlings in May and August found that August tissue removal was severe, as both current-year needles and stem tissue were consumed. Estimates in our study were closer to those of Uresk & Paintner (1985), who found greater ponderosa pine in cattle diets later in the summer grazing season, which averaged 8.7% in August in ponderosa pine forest of South Dakota and those of Mitchell & Rodgers (1985) on summer forest and pasture ranges in northern Idaho, where up to 8% of ponderosa pine needles was recovered in cattle diets, which they explained by possible inadvertent ingestion and by the morphological characteristics of pine needles in the diet.

4. Conclusions

Sustainable management of beef cattle involves balancing the nutrient needs of the animal with the nutritional opportunities of the rangeland resource. In addition, forest grazing must demonstrate that the impact of the herbivore is compatible with the long-term diversity of vegetation and wildlife. Understanding how age class and/or experience influences landscape distribution patterns and diets is important in designing sustainable grazing strategies. In our study, the diets of first calf heifers and mature cows grazing in a mixed conifer mountain riparian area differed in that mature cows consumed less in the amount of grasses and more in the amount of shrubs and trees as compared to younger cows. These differences could be explained by the distribution patterns of the cows. Diet species composition varied between age classes in that mature cows had more Kentucky bluegrass and ponderosa pine, but fewer Baltic rush, western wheatgrass, and pinegrass in their diet than first calf heifers. Our research suggests that cow age/experience does relate to modest changes in diet composition of beef cattle grazing mountain riparian areas. To better understand the nutritional needs and preferences of different age classes of cattle, we need to continue the evaluation of dietary selection as the forage composition of the range changes with use and season.

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