Nongame Bird Responses to Type Conversion of Sagebrush Communities

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ABSTRACT: When degraded sagebrush communities are converted to grasslands to improve forage production for livestock, impacts on nongame birds occur. Removal of sagebrush results in displacement of the shrub-nesting species which are dominant in degraded sagebrush habitat. However, seeding with perennial grasses results in habitat more suitable for some ground-nesting species which may increase accordingly. When successional invasion by sagebrush reaches the point where a "sagebrush-grass" community is established, relative abundance of bird species may change, resulting in a well-balanced mixture of both shrub and ground-nesting species. This diverse bird community in a shrub-invaded seeding is a result of the more diverse vegetation structure compared to the single-layered stands of either grasses or shrubs. The time required to reach this point depends on several factors, including extent of sagebrush control, success of seeding establishment, and livestock management.

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INTRODUCTION

Beginning in the 1930's, vast acreages of sagebrush-dominated rangelands in the West were treated to increase forage production for domestic livestock, and to improve range condition and prevent erosion. Sagebrush "control" efforts peaked in the late 1950's and 1960's, resulting in the conversion of thousands of acres to grass and croplands. Approximately 10% of the sagebrush rangelands have been converted to cropland or altered to increase livestock production (Braun et al. 1976). Many of the sites where sagebrush cover was removed or reduced were seeded with desirable livestock forage, primarily perennial grasses. Because little success was obtained with native grasses, introduced species were used. Varieties of the alien crested wheatgrass (Agropyron cristatum, A. desertorum) were among the most successfully seeded grasses in the Intermountain West (Blaisdell et al. 1982), and are recognized by range managers and livestockmen as being good livestock forage.

Concern for the effects of sagebrush community alteration on nongame birds was expressed in the 1950's by Carhart (1954), and concern has intensified in recent years (Braun et al. 1976). There have been few studies on the response of nongame birds to sagebrush control (Scott et al. 1966, Best 1972, Pyrah and Jorgensen 1974, Schroeder and Sturges 1975, Castrale 1982). Still fewer have been conducted on the combined effects of sagebrush control and single-species seeding of crested wheatgrass. In this paper we attempt to draw from available literature and our own research experience to show the sequence of bird responses to sagebrush habitat changes: from the pristine sagebrush-grass habitat through eventual degradation by overgrazing, to conversion to grassland and eventual sagebrush reinvasion.

BIRD COMMUNITIES IN PRISTINE SAGEBRUSH-GRASSLAND

It has been estimated that sagebrush covers up to 109 million ha (270 million acres) of western rangeland, with big sagebrush (Artemisia tridentata) comprising more than half of this area (Beetle 1960). It is not possible to know the exact composition of bird communities during presettlement times. Even today bird communities in sagebrush habitats are highly variable by location (Wiens and Rotenberry 1981). However, we can speculate on historical conditions based on descriptions of sagebrush communities by early explorers and settlers.

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According to Vale (1975), the early travelers in the Intermountain West encountered a landscape that was largely shrub dominated, with sagebrush being particularly common. There are indications that although grass coverage was variable, much of the sagebrush range had a vigorous understory of perennial grass and forbs (Harniss and Murray 1973).

Over 100 species of birds are known to forage and nest in sagebrush communities (Brown et al. 1976). The pristine sagebrush-grassland community probably had a diverse mixture of both shrub-nesting and ground-nesting birds. Shrub-nesters such as Brewer's sparrows (Spizella breweri), sage sparrows (Amphispiza belli), sage thrashers (Oreoscoptes montanus), gray fly-catchers (Empidonax wrightii), and loggerhead shrikes (Lanius ludovicianus) are among those common today in sagebrush communities (Braun et al. 1976, Reynolds and Trost 1980, Wiens and Rotenberry 1981, Castrale 1982). These species were probably abundant in pristine vegetation with its reported shrub component. Ground-nesters in sagebrush communities include horned larks (Eremophilus alpestris), western meadowlarks (Sturnella neglecta), vesper sparrows (Poecetes gramineus), and lark sparrows (Chondestes grammacus). Densities of ground-nesting birds, especially the latter three species, were probably higher in presettlement vegetation because of the greater herbaceous cover available. Wiens and Rotenberry (1981) refer to these birds as "grassland" species, and mention particularly that western meadowlarks and lark sparrows are more abundant where perennial grass cover is greater. Castrale (1982) pointed out that vesper sparrows nest both under sagebrush and at the base of grass tussocks.

BIRD COMMUNITIES IN DEGRADED "MONOTYPIC" SAGEBRUSH HABITATS

Sagebrush-grass communities on rangelands were severely overgrazed by livestock near the beginning of this century. This overgrazing destroyed much of the understory vegetation and, combined with fire suppression, resulted in heavy overstory dominance by sagebrush (Stewart 1941). The present condition of sagebrush rangelands probably bears minimal resemblance to the pristine potential (Young et al. 1979). Assuming the sequence of understory degradation followed by shrub dominance, bird populations in today's near-monoculture sagebrush habitats should not be considered as "natural" or "pristine" bird communities, especially in terms of species composition. On the other hand, since the rangelands in question were apparently sagebrush dominated (although with a better herbaceous understory), type conversion of these areas to pure stands of grass (e.g., crested wheatgrass) cannot be justified in terms of reestablishing "natural" plant cover (Vale 1975). Rather, the primary justification for such conversions has been (and remains) to increase forage production for livestock.

Bird communities in today's degraded sagebrush habitats probably include most if not all of the species present in the pristine environment. However, the relative abundance of many species may be markedly different. In a Nevada study, Page et al. (1978) found that grass-nesting species such as vesper sparrows and western meadowlarks decreased when livestock grazing reduced herbaceous vegetation cover in sagebrush habitat. If indeed livestock grazing has also resulted in an increase in shrub (e.g., sagebrush) density over the years in some areas, then some of the shrub-nesting bird species might have increased accordingly. Grassland studies under the International Biological Program have shown that where grazing produced marked changes in vegetation, there were accompanying major shifts in the avian community (Wiens and Dyer 1975). We would therefore like to reemphasize that the bird communities in today's degraded sagebrush stands are probably very different (in terms of relative abundance) than those in presettlement vegetation.

EFFECTS OF SAGEBRUSH HABITAT CONVERSION ON PASSERINE BIRDS

Sagebrush Control

Big sagebrush rangelands with depleted understory vegetation are those which are typically chosen for sagebrush control and seeding (Evans et al. 1979). The most immediate effects on the avifauna of the treated areas are brought about by this removal or reduction of shrub cover (Rotenberry and Wiens 1978). Sagebrush is most often removed by burning, spraying, or mechanical means. Basically, all of these methods result in the elimination of the necessary stratum for shrub-nesting species, and an increse in openness of the habitat. Food habitats of passerine birds (perching songbirds) in sagebrush habitats may also be affected by changes in plant and animal (insect) abundance and composition brought about by sagebrush control, and the accompanying damage to herbaceous vegetation (Best 1972). According to Rotenberry and Wiens (1978), there is a real lack of information on how the food base of birds is affected by habitat manipulation.

Burning.--Fire is a natural component of many sagebrush-grass rangelands, and any site with vegetation dense enough to carry a fire has probably burned many times in its history. The use of fire as a management tool in sagebrush communities has been thoroughly reviewed by Britton and Ralphs (1979). In a Utah study, Castrale (1982) found that the effects of burning were much more pronounced four years after treatment than the effects of mechanical control (chaining). He also stated that, compared to herbicide spraying and chaining, burning causes the most immediate and persistent changes in sagebrush habitat because whole shrubs are consumed by fire and ground litter is reduced. However, intensity of the burn may affect the outcome as well. When fires burn in a mosaic pattern, some sagebrush plants which are left unburned provide suitable nesting cover for birds (Castrale 1982). Also, Harniss and Murray (1973) stated that sagebrush will sometimes invade an area immediately following a burn.

Studying bird communities in rangelands of the Pacific Northwest, Rotenberry and Wiens (1978) found no change in total density and biomass of birds during the first year after fire removed nearly all shrubs (primarily sagebrush) on a study plot. However, they did note some significant changes in relative abundance of species. In particular, horned larks (ground-nesters) replaced the shrub-nesting sage sparrows as the dominant breeding

species. The authors concluded that this phenomenon reflected the differing relationships of these species to the presence of shrub cover. Although there was a reduction in biomass diversity, species composition remained unchanged.

Mechanical shrub removal.--The most commonly employed mechanical shrub removal methods are plowing or disking, beating or shredding, railing, and chaining (Blaisdell et al. 1982). These methods differ somewhat in their effectiveness as sagebrush control measures and in the extent to which understory vegetation is harmed. Beating and railing produce only light kills of sagebrush and sprouting shrubs, and damage to understory vegetation is minimal. Plowing (or disking) and modified chaining result in more thorough shrub removal and also prepare a good seedbed where revegetation is planned. Shrub removal by mechanical methods is considered by some to be less permanent than that achieved by other methods (Parker 1979).

Plummer et al. (1968) recognized that chaining did not completely kill sagebrush and that native grasses and forbs were retained in the treated area. However, plow and seed treatments account for most of the crested wheatgrass seedings in the Great Basin and Northwest (Heady and Bartolome 1977). Urness (1979) suggested that crested wheatgrass seedings would not differ materially whether done on a burned, sprayed, or plowed seedbed. However, he pointed out that a big advantage of mechanical control methods was their potential for partial control and interspersion of native range.

Castrale (1982) studied bird populations in sagebrush habitats that were mechanically controlled (by plowing and chaining). Basically, he concluded that the more thorough removal of sagebrush and accompanying understory damage by plowing are more detrimental to bird populations the first few years after control than are the vegetation changes which result from chaining.

Spraying with herbicides.--The use of herbicides in sagebrush control became common in the 1950's with the use of 2,4-D (Evans et al. 1979). Other chemicals have also been used successfully since then, but 2,4-D has received the most widespread use because of its effectiveness, low cost, low toxicity to humans and animals, and degradability (Blaisdell et al. 1982).

In addition to killing shrubs, 2,4-D kills some species of forbs as well, but seldom damages perennial grasses. The loss of some forb species in the understory may be of consequence to birds because of a resulting loss of food items such as seeds and insects (Best 1972). However, this forb loss through spraying is partially offset by the more gradual loss of shrub cover (compared to other control methods). Schroeder and Sturges (1975) reported that, during the year of herbicide application, nesting success of Brewer's sparrows was not affected by spraying with 2,4-D. However, they found that use of sagebrush decreased greatly after the leaves had dropped from the plants. Bird densities were 67% lower one year after spraying and 99% lower 2 years afterward. Best (1972) reported a 54% decrease in breeding pairs of Brewer's sparrows one year after spraying. Vesper sparrow pairs on his study area were not affected because of their ground-nesting habits.

In comparing sagebrush control methods, Castrale (1982) suggested that effective control by herbicide application continues to offer cover and suitable nest sites for a few years after treatment. The dead shrubs then eventually deteriorate, leaving the habitat unsuitable for shrub-nesters until sagebrush becomes reestablished. Kindschy (1978) also mentions the same phenomenon. Rotenberry and Wiens (1978) suggest that this adaptability of sagebrush dependent birds shows they are at least moderately resistant to small scale habitat alteration (i.e., if the basic vegetation structure is not altered markedly).

Seeding Stages After Brush Control

After shrubs have been controlled by one of the methods mentioned above, the treated area is then usually seeded with perennial grass (typically some variety of crested wheatgrass) or some mixture of grasses, forbs, and possibly even important forage shrubs (Keller 1979). Sometimes, in habitats where remnant understory vegetation is sufficient, sagebrush is controlled for the purpose of "releasing" the existent understory by reducing competition with shrubs (Braun et al. 1976). However, since crested wheatgrass is the focus of this symposium, we will primarily address conversion to crested wheatgrass seedings. There are many parallels between bird response to seedings and bird response to understory release, and these will be pointed out. We will consider seedings as having four basic stages, though obviously seedings change slowly and continually as secondary succession proceeds.

Stage one-immediately after seeding.--The initial effects of the seeding will be variable, related primarily to the method and effectiveness of brush control, and the resulting extent of damage to the understory vegetation. Another influence on bird populations in the early stages of the seeding is the relative "barrenness" of the area until crested wheatgrass becomes established. This stage is often compounded by the invasion of alien weeds. On some sites, cheatgrass (Bromus tectorum) can be a serious deterrent to successful range seeding (Harris 1967). In southern Idaho, Rickard (1981) reported that horned larks and western meadowlarks were common in cheatgrass monocultures, while other species resident in adjacent sagebrush-grass habitat were seldom observed. Horned larks nest on the ground or in open areas, and are most common in disturbed grassland habitats in the West (Kendeigh 1941). Because western meadowlarks are considered closely tied to perennial grass cover, their utilization of annual cheatgrass is apparently a suboptimal situation.

Stage two-established seeding.--Degree of seeding establishment depends on a variety of factors, including site potential, weather (especially precipitation), reduction of plant competition (e.g., with cheatgrass), method and timing of seeding, and adequate early protection from grazing (Keller 1979). Most seedings are left ungrazed until at least the latter part of the second growing season, and up to two or more years later.

Braun et al. (1976) and Kindschy (1978) acknowledged that reduction of sagebrush cover can benefit such bird species as horned larks, western meadowlarks, vesper sparrows, lark sparrows, and mourning doves. Wildlife response to such understory "release" is widely accepted by wildlife managers as being positive (Buttery and Shields 1975, Urness 1979). When areas require seeding due to lack of an understory, a mixed species seeding (as opposed to single species seeding) would undoubtedly be more beneficial to a variety of wildlife. In particular, a rangeland seeding with native grasses and forbs is largely beneficial to bird habitat (Buttery and Shields 1975). However, single-species seeding of crested wheatgrass was the usual practice in past habitat conversions. Fortunately, the ecological distribution of nesting birds is controlled by life form of vegetation rather than species composition (Johnsgaard and Rickard 1957, MacArthur and MacArthur 1961). This being the case, "grassland" bird species may be expected to respond favorably when an introduced grass such as crested wheatgrass becomes well established.

There have been few studies which specifically dealt with bird populations in older, well established crested wheatgrass seedings. Reynolds and Trost (1980) reported on breeding bird populations in 21- to 22-year-old crested wheatgrass seedings in southern Idaho. They found nests of horned larks, western meadowlarks, and vesper sparrows in an ungrazed seeding, but horned larks were the only nesting species in a seeding grazed by sheep. No nests of shrub-nesting species were discovered in either of the seedings. They also reported that total bird density, species diversity, and species richness were lower in both the grazed and ungrazed seedings than in either grazed or ungrazed sagebrush habitats. However, nesting densities of both horned larks and meadowlarks were higher in the ungrazed crested wheatgrass than in either the grazed or ungrazed sagebrush communities, and ungrazed seeding habitat was the only area where a vesper sparrow nest was located. Similarly, both meadowlarks and vesper sparrows have been observed to be more abundant where native perennial grass cover is greater (Wiens and Rotenberry 1981), and where a mixture of native grass/crested wheatgrass cover is greater (Castrale 1982).

Rickard (1981) investigated bird populations on established crested wheatgrass seedings in southern Idaho and found likewise that vesper sparrows, western meadowlarks, and horned larks nested in these man-made communities. He stated that crested wheatgrass seedings were suitable habitat for the latter two species. Although horned larks were most abundant in the seedings, communities with sagebrush harbored more meadowlarks. Once again, the missing component in crested wheatgrass seedings was shrub-nesting species.

In an ongoing study in central Nevada[1], ground-nesting species (primarily horned larks and meadowlarks) comprised 91% of the nesting avifauna in a 26-year-old crested wheatgrass seeding. Comparatively, in unconverted sagebrush habitat with 21% shrub cover, only 30% of the birds were ground-nesters. Both the seeding and surrounding sagebrush habitat were grazed by cattle. Although total number of bird species nesting in the seeding was lower than that in the untreated sagebrush, total abundance was nearly the same. This finding conflicts with what Reynolds and Trost (1980) reported for total bird abundance on both grazed and ungrazed seedings in Idaho. Variables which might explain this difference include livestock class, season and intensity of grazing, and success of original seeding establishment in terms of perennial grass cover. Where brush control for understory release is practiced there may or may not be changes in total abundance, although those species closely tied to shrub cover may be nearly eliminated (Rotenberry and Wiens 1978).

Stage three-reinvasion by sagebrush.--Little mention has been made in the literature of passerine bird population responses to the reinvasion of sagebrush into areas of sagebrush control. Sneva (1972) recognized that shrub invasion of treated range in the Intermountain area was to be expected. Fifteen years after chemical control of sagebrush on his study area, the number of sagebrush plants 6 in (15 cm) or less in height on the treated area was similar to the number of mature sagebrush on untreated areas. He also maintained that even when treated areas are managed for minimal ecological impact, shrubs will return.

Harniss and Murray (1973) reported a similar occurrence for burned sagebrush range. According to Pechanec and Stewart (1944), good grazing management will not prevent sagebrush invasion, but heavy grazing and poor brush control will accelerate such invasion. Frischnecht (1968) observed that in wet years sagebrush will invade grazed or ungrazed stands of crested wheatgrass. Time lapse before invasion is highly variable (Urness 1979). According to Evans et al. (1979), some seedings are invaded almost immediately after establishment, while others remain shrub-free for years. Unkilled mature sagebrush in the seeding is a source of reinvasion (Parker 1979).

According to Urness (1979), wildlife research has tended toward all-or-none comparisons (i.e., intact sagebrush stands vs. crested wheatgrass monocultures). He also suggests that there has been a tendency to deny stand dynamism and what it means to specific wildlife forms. Black and Thomas (1978) noted in general that type conversions without maintenance tended to revert to the original plant community.

Best (1972) pointed out that the duration of changes in bird food habits resulting from chemical control of sagebrush would depend upon future grazing practices, the return of forb species, and reinvasion of sagebrush. He also mentioned that the duration of compensatory cover (for birds) provided by dead sagebrush would depend on the rate of deterioration of these dead plants and the rapidity and extent of sagebrush reinvasion (our emphases).

Castrale (1982) studied a 17-year-old seeding in Utah which had been plowed and seeded with a mixture of perennial grasses, including crested wheatgrass as well as native species. He found that this site had greater sagebrush density (apparently form

[1] McAdoo, J.K. Data obtained from research at the Gund Research and Demonstration Ranch and presently being analyzed for publication.

reinvasion) than 4-year-old sites in the same area which had been either chained or burned. However, size of the shrubs was considerably less than those in islands of the burned site and the remaining sagebrush in the chained area. Brewer's sparrow densities varied directly with percent cover and density of sagebrush, being highest on the oldest (chained) site and lowest on the burned site. Sage thrasher densities were low on all sites, but were highest on islands in the burn, due to the larger size of the shrubs there. Thrashers apparently require larger shrubs for nesting (Reynolds 1981), and therefore might be expected to respond more slowly to sagebrush reestablishment in seedings. Ground-nesting western meadowlarks were slightly more abundant on the younger treatments where grass cover was the greatest.

In our ongoing study in central Nevada[1], we have been sampling breeding bird populations of seedings in various successional stages of sagebrush reinvasion, as well as of degraded sagebrush communities. The seedings vary in age from 17 to 27 years. All sites were originally plowed to control sagebrush and seeded with crested wheatgrass. Preliminary results of first year data indicate that sagebrush reinvasion of seedings results in some obvious changes in the bird community.

We found that shrub-nesters (especially sage sparrows and Brewer's sparrows) were more abundant on seedings with the greatest extent of sagebrush invasion (as measured by percent canopy cover). Similarly, Rotenberry and Wiens (1978) reported a strong correlation between sage sparrow density and shrub cover in unseeded sagebrush habitat. The dependence of sage sparrows and Brewer's sparrows on shrubs (especially sagebrush) for nesting has been widely reported (Best 1972, Schroeder and Sturges 1975, Wiens and Rotenberry 1981, Castrale 1982). Other shrub-nesting passerine birds (e.g., gray flycatchers, loggerhead shrikes, and sage thrashers) could also conceivably be benefited by sagebrush reinvasion of seedings.

The most obvious ground-nesting responder in the central Nevada study was the horned lark. Abundance of this species varied inversely with sagebrush canopy cover in seedings. Horned larks were most abundant in near-monoculture seedings ($\leq$ 5% shrub cover) and least abundant in unconverted sagebrush habitat ($\geq$20% shrub cover). Rotenberry and Wiens (1978) also found that horned lark abundance was inversely correlated with percent shrub cover in unconverted sagebrush habitat.

For the western meadowlark, another ground-nesting species, total cover seems to be an important factor influencing abundance. In central Nevada, meadowlarks were abundant in near-monoculture seedings with high grass cover, but also in invaded seedings which had moderate grass cover, and in unconverted sagebrush habitat with only 1% herbaceous cover. On a depleted 17-year-old seeding which had both low herbaceous cover (3%) and low shrub cover (5%), nesting western meadowlarks were not found. In unconverted native sagebrush communities, Wiens and Rotenberry (1981) found that meadowlark densities varied directly with grass and litter cover, total cover, and some measures of vertical vegetation structure.

Probably the most interesting response to sagebrush invasion of crested wheatgrass seedings in central Nevada was that of lark sparrows. This ground-nesting species was either absent or present in very low numbers in both unconverted sagebrush habitat and near-monoculture seedings. However, it was found regularly in moderate abundance in invaded seedings with approximately 10 to 12% shrub cover. At this point in our analysis, the most important variable influencing lark sparrow abundance appears to be the interaction between herbaceous cover and shrub cover. Similarly, Wiens and Rotenberry (1981) found that lark sparrows were correlated with both grass and shrub cover.

The combination of shrub-nesting and ground-nesting species which nested in invaded seedings (10-12% shrub cover) in central Nevada resulted in greater species richness than in either near-monoculture seedings or unconverted sagebrush habitat. Birds were also more evenly distributed (by nesting guild) in terms of relative abundance in the invaded seedings, with 60% ground-nesters and 40% shrub-nesters (compared to 91% ground-nesters in near-monoculture seedings and 30% ground-nesters in unconverted sagebrush). Total abundance (all species combined) was nearly the same among uninvaded seedings with good grass cover, areas of unconverted sagebrush, and seedings with 10 to 12% sagebrush cover.

Stage-four-sagebrush-dominance.--As secondary succession proceeds, sagebrush may eventually outcompete crested wheatgrass to the point where perennial grass cover is minimal once again as it was in the degraded sagebrush community before seeding. Vale (1975) stressed that shrubs were an integral component of presettlement sagebrush-grass communities. Their competitive advantage over grasses under livestock grazing is obvious from the history of understory depletion and shrub dominance in the sagebrush ecosystem (Young et al. 1979). Therefore improper grazing management of livestock could accelerate the occurrence of this sagebrush dominance "stage". In a review of the literature, Keller (1979) noted that sagebrush invasion of seedings is inversely proportional to the density of grass cover, and that sagebrush increases more slowly under light grazing use.

We found no available information concerning the effects of this stage on nongame bird populations. However, it seems reasonable to assume that the avifauna in a grass depleted, shrub-dominated seeding would be very similar to that in a degraded sagebrush stand before seeding, i.e., dominated by shrub-nesting species.

EFFECTS OF SAGEBRUSH HABITAT CONVERSION ON RAPTORS

Use of Sagebrush Rangelands by Raptors

Sagebrush habitat is used by a wide variety of raptorial bird species (birds of prey). These include the golden eagle (Aquila chrysaetos), red-tailed hawk (Buteo jamaicensis), rough-legged hawk (B. lagopus), ferruginous hawk (B. regalis), Swainson's hawk (B. swainsoni), marsh hawk (Circus cyaneus), prairie falcon (Falco mexicanus), American kestrel (F. sparverius), short-eared owl (Asio flammeus), long-eared owl (A. otus), great horned owl (Bubo virginianus), and burrowing owl (Speotyto

cunicularia). Although many of these species nest in habitats other than sagebrush, their large hunting territories often include portions of sagebrush range.

Direct Effects of Habitat Conversion

Occasionally, sagebrush control may result in the loss of nesting habitat for some raptors. For example, ferruginous hawks in parts of their range nest primarily in juniper trees (Howard and Wolfe 1976), with lone or peripheral trees being preferred (Woffinden 1975). Type conversion of sagebrush habitat adjacent to juniper stands where lone trees might be destroyed could thus have potential for nest-site elimination. Swainson's hawks occasionally nest in tall sagebrush plants, and could also suffer directly from shrub control. However, some ground-nesting species may utilize the open areas created by brush removal and seeding. Reynolds and Trost (1980) discovered evidence of short-eared owls nesting in crested wheatgrass seedings in Idaho, and we have seen burrowing owls nesting in recently burned sagebrush habitat in central Nevada.

Indirect Effects of Habitat Conversion

The indirect effects of sagebrush habitat conversion on raptors are potentially of more consequence than the direct effects. Several authors have mentioned that raptors can be affected by habitat conversion (Snyder and Snyder 1975, Call 1979, McAdoo and Klebeneow 1979, Olendorff et al. 1980, and Craighead and Mindell 1981), primarily through changes in prey base. This potential change in prey base can affect not only distribution of raptors, but also their breeding density and productivity (Howard and Wolfe 1976).

Some examples of differing prey base responses to habitat alteration of sagebrush communities are available from the literature. Baker and Frischknecht (1973) reported in Utah that chaining to remove juniper from sagebrush-grass habitats, followed by reseeding, resulted in higher rodent populations during the first two years following treatment. Larrison and Johnson (1973) found that certain grass-adapted rodent species in Idaho were more numerous in crested wheatgrass seedings, but total rodent abundance was about the same as in depleted sagebrush sites. In a northern Nevada study, Jenkins (1978) concluded that although there was no significant difference in densities of Richardson's ground squirrel (Spermophilus richardsonii) between sagebrush habitat and a crested wheatgrass seeding, the seeding provided comparatively more food for the squirrels.

Negative responses of prey species to alteration of sagebrush communities have also been recorded. In Idaho, Reynolds and Trost (1980) found lower total rodent and reptile densities in crested wheatgrass seedings, compared to sagebrush-dominated areas. Working in Colorado, Johnson and Hansen (1969) found that the density of least chipmunks (Eutamias minimus) was lower after shrub reduction. Chipmunks are dependent on shrubs for food and cover.

The literature also contains conflicting information concerning the effects of type conversion on lagomorphs. According to Call (1979), conversion of brushland to grass can be disruptive to production of both jackrabbits (Lepus spp.) and cottontails (Sylvilagus spp.) that survive best in shrub-grass mixtures. But Westoby and Wagner (1973) reported that abundance of jackrabbits (L. californicus) in shrub habitat adjacent to a crested wheatgrass seeding was much the same as that in similar habitat 900 m away. Use of open areas (like seedings) by prey species makes them more vulnerable to predation (Olendorff et al. 1980).

Whether the initial result of a crested wheatgrass seeding is an increase or decrease in prey abundance, or an increase in prey vulnerability, the successional reinvasion of sagebrush into these areas results in further change. According to Howard and Wolfe (1976), the presence of crested wheatgrass seedings in various stages of "reversion" to original vegetation (reinvasion by sagebrush) may increase the probability that ferruginous hawks will produce young in years of low jackrabbit densities, due to greater vulnerability of prey in these areas than elsewhere. They also concluded that past crested wheatgrass seedings did not adversely affect reproduction of the hawks. The authors stated that reversion to native vegetation in these seedings created suitable prey base habitat within 6 to 8 years following treatment.

SUMMARY

Passerine bird populations in pristine sagebrush-grass communities probably consisted of more ground-nesting species, in addition to shrub-nesters, than we see in degraded sagebrush habitats today. Overgrazing by livestock at the turn of the century apparently resulted in depletion of the herbaceous understory which these birds require. However, most attempts to revegetate "degraded" sagebrush habitat are aimed at conversion to grassland rather than restoration to sagebrush-grassland.

It is generally assumed, and correctly so, that passerine birds in sagebrush habitats would be more benefitted by improvement of native understory vegetation or by mixed species seeding than by shrub removal and seeding to crested wheatgrass. However, type conversion of sagebrush habitat is typically justified by the goal of increased forage for livestock production, and derived wildlife responses are often coincidental.

Wildlife trade-offs occur when sagebrush cover is removed or greatly reduced and crested wheatgrass is planted. Specifically, shrub-dependent species are displaced or reduced dramatically, and some ground-nesting species may then increase on the seeding in response to improved herbaceous cover. Although crested wheatgrass is non-native, ground nesting birds are adapted to its life form or structure and therefore can live in this man-made habitat successfully. Total bird abundance in the seeding may be similar to that of unconverted sagebrush habitat, but total number of species is lower and relative abundance of species is much different in the monoculture seeding.

After several years, sagebrush invasion of a crested wheatgrass seeding may reach the point where a well-balanced mixture of both ground-nesting

species and shrub-nesting species is present. If and when this stage occurs depends upon several variables, including grazing management and effectiveness of original sagebrush control and grass seeding. (Indeed, some seedings may never accomodate abundant and diverse bird-life if, for example, low herbaceous cover results from poor grass establishment or overgrazing). As secondary succession continues, the seeding may become sagebrush dominated at the expense of the perennial grass. Good livestock grazing management should help postpone this stage.

Birds of prey are affected primarily in an indirect manner by type conversion of sagebrush communities to grassland. Specifically, the changes in prey species populations (i.e., total abundance, relative abundance of species, and vulnerability) that are brought about by changes in shrub and herbaceous cover may in turn affect raptor distribution, nesting success, etc. In some cases, prey abundance and vulnerability increases after habitat conversion, thus benefitting raptors. Sagebrush-invaded seedings with their diverse vegetation structure may be of even more indirect benefit to some raptors because of the combination of food and cover these areas provide for prey species (especially rabbits and rodents).

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