Weather and Climate Considerations for Rangeland Planting
– Literature Review and Synthesis –

An Extract from “Assessment of Range Planting as a Conservation Practice” NRCS 2010 (In Press)

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Gross climatic variability generally determines the historical complement of native species at a site, but also the suitability of introduced plant materials *(Shown et al. 1969; Shiflet 1994; Vogel et al. 2005; Natural Resources Conservation Service 2006)*. Seedbed preparation and planting methods are designed to optimize microclimatic conditions for planted species, to increase the number of favorable microsites for germination and establishment, and to mitigate or control competition from undesirable species *(Roundy and Call 1988; Call and Roundy 1991; Sheley et al. 1996; Krueger-Mangold et al. 2006; Sheley et al. 2006)*. In addition to a general review of weather/climate/microclimate impacts on restoration, this study surveyed 188 individual studies in the rangeland planting literature to summarize different conservation-practice effects. The studies included in the survey are preceded by an asterisk in the Literature Cited.

Climate and Species Distribution

Weather and climate patterns in western North America are highly variable in space and time *(Wernstedt 1960; Currie and Peterson 1966; Carder 1970; Michaud et al. 1995; Balling 1996; Mock 1996; Higgins et al. 1997, 1999; Rajagopalan and Lall 1998; Camargo and Hubbard 1999; Simpson and Colodner 1999; Akinremi et al. 2001; Sheppard et al. 2002; Gershunov and Cayan 2003; Harmel et al. 2003; Hu 2003; Leung et al. 2003a,b; Schubert et al. 2004; Hereford et al. 2006)*, and the relationships between climate and both vegetation distribution and production on western rangelands are well documented *(Daubenmire 1956; Smoliak 1956, 1986; Sneva and Hyder 1962; Cooper and Hyder 1958; Murphy 1970; Shiflet and Dietz 1974; Duncan and Woodmansee 1975; Eck et al. 1975; Sneva 1977; Bartolome et al. 1980; Fetcher and Trlica 1980; Newbauer et al. 1980; Wight and Hanks 1981; Hanson et al. 1982, 1983; Kindschy 1982; Wight et al. 1984; Hart and Samuel 1985; Olson et al. 1985; White 1985; Powell et al. 1986; Bittman and Simpson 1987; George et al. 1989; Cook and Irwin 1992; Lauenroth and Sala 1992; Sheaffer et al. 1992; Haferkamp et al. 1993; Milchunas et al. 1994; Barbour and Billings 2000; Bork et al. 2001; Mitchell and Csillag 2001; Gillen and Sims 2004; Khumalo and Holechek 2005; Andales et al. 2006;*

Bradford et al. 2006; Hereford et al. 2006; Natural Resources Conservation Service 2006; Nippert et al. 2006; Rehfeldt et al. 2006; Patton et al. 2007; Smart et al. 2007).

The general importance of climate is acknowledged in seeding guides in the form of tables that list species and cultivar suitability as a function of mean annual precipitation *(Jordan 1981; Jensen et al. 2001; Lambert 2005; Ogle et al. 2008a,b)*. Seeding guides often cite climatic thresholds below which active seeding practices are not recommended *(Anderson et al. 1957; Jordan, 1981)*. Unfortunately, the microclimatic requirements for germination, emergence and seedling establishment are much more restrictive than the longer-term climatic requirements for maintenance of mature plant communities *(Call and Roundy 1991; Peters 2000; Hardegree et al. 2003)*. Current state-and-transition models acknowledge that there are perhaps a limited set of potential trajectories for moving between undesirable and desirable vegetation states *(Westoby et al. 1989; Batabyal and Godfrey 2002; Bestelmeyer et al. 2003; Briske et al. 2003, 2005, 2006, 2008; Bashari et al. 2008)*. Westoby et al. *(1989)* noted that many transition pathways between alternative states require the occurrence of a specific and perhaps infrequent series of climatic events.

The strongest evidence for plant materials suitability for a given climatic region is derived from observation of historical relationships between species and climate, experience-based observation, and long-term assessment of persistence of planted species *(Stewart 1950; Hull and Klomp 1966, 1967; Smoliak et al. 1967; Cable 1971; Hull 1971a, 1972b, 1973; Heady and Bartolome 1977; Rogler and Lorenz 1983; Eck and Sims 1984; Harris and Dobrowolski 1986; Miller et al. 1986; Cox et al. 1988; Heady 1988; McClaran and Anable 1992; Shiflet 1994; Barbour and Billings 2000; Vogel et al. 2005; Natural Resources Conservation Service 2006; Schussman et al. 2006; Bock et al. 2007; Vaness and Wilson 2007)*.

Climate and Plant Materials Development

Relatively specific and detailed recommendations for suitability of plant materials exist for different site conditions, climatic zones, and management objectives *(Ogle et al. 2008a,b)*. Plant material recommendations for both native and introduced species are based primarily on plant materials discovery, screening, and breeding programs by NRCS Plant Materials Centers, and other government research and agricultural experiment station programs *(Hafenrichter 1948; Stewart 1950; Schwendiman 1956, 1958; Anderson et al. 1957; Harlan 1951, 1960; Roundy and Call 1988; Alderson and Sharp 1994; Asay et al. 2003; Erickson et al. 2004)*. Selected or bred plant materials deemed to have superior productivity, vigor, establishment, disease resistance and/or seed production characteristics, are then cultivated and released for development as commercial varieties *(Kneebone and Cremer 1956; Schwendiman 1956, 1958; Hafenrichter 1948; Anderson et al. 1957; Harlan 1951, 1960; Trupp and Carlson 1971; Booth et al. 1980; Asay and Johnson 1980; Johnson et al. 1981; Asay and Johnson 1983a; Berdahl and Barker 1984; Asay et al. 1985a, 1985b; Asay et al. 1986; Asay et al. 1991; Berdahl et al. 1992a, 1992b; Johnson and Asay 1993; Asay et al. 1995a, 1995b; Johnson and Asay 1995; Asay et al. 1996; Asay et al. 1997; Jensen et al. 1998; Jones et al. 1998; Jensen et al. 2002; Jensen et al. 2003; Smart et al. 2004; Coulman 2006a,b)*. More recent efforts in plant materials development and evaluation focus on selection for, or comparison of, specific ecological and physiological traits *(Wright and Jordan 1970; Johnson and Asay 1978; Asay and Johnson 1980; Pitman and Jaymes 1980; Asay and Johnson 1983b; Frank et al. 1987; Asay and Johnson 1990; Aguirre and Johnson 1991b; Johnson and Asay 1993, 1995; Kitchen and Monsen 1994; Asay et al. 1996; Arredondo et al. 1998; Bakker and Wilson 2001; Vogel and Jensen 2001; Jones et al. 2003; Erickson et al. 2004; Jensen et al. 2005)*. These efforts incorporate and report more detailed experimental design information, but are often based on relatively controlled experimental conditions in the laboratory, greenhouse, or an agricultural field environment *(Wright and Jordan 1970; Trupp and Carlson 1971; Johnson and Asay 1978; Asay and Johnson 1980; Pitman and Jaymes 1980; Asay and Johnson 1983b; Berdahl and Barker 1984; Asay and Johnson 1990; Aguirre and Johnson 1991b; Kitchen and Monsen 1994; Asay et al. 1996; Arredondo et al. 1998; Bakker and Wilson 2001; Vogel and Jensen 2001; Jones et al. 2003; Jensen et al. 2005)*. The majority of current plant material recommendations are based on evaluations of field performance that are not accessible through refereed journal publications *(Stewart 1950; Schwendiman 1956; Anderson et al. 1957; McGinnies et al. 1963; Great Plains Council 1966; Booth et al. 1980; Asay et al. 1985a, 1985b; Asay et al. 1991; Berdahl et al. 1992a, 1992b; Alderson and Sharp 1994; Asay et al. 1995a 1995b; Asay et al. 1997; Jones et al. 1998; Jensen et al. 2001; Lambert 2005; Coulman 2006a,b; Ogle et al. 2008a,b)*.

The literature documenting management-scale range planting is dominated by studies in which few inferences can be made relative to performance of alternative plant materials *(Casler 1999)*. Very few studies are replicated in such a way that within- or between-species variability can be assessed *(Kneebone and Cremer 1956; Pitman and Jaymes 1980; Asay and Johnson 1983b; Rumbaugh and Johnson 1986; Burner et al. 1988; Asay and Johnson 1990; Kitchen and Monsen 1994; Asay et al. 1996; Casler 1999; Asay et al. 2001; Vogel and Jensen 2001; Jones et al. 2003; Robins et al. 2007)*.

Seeding and Seedbed Microclimate

The following conservation practices are directly or indirectly related to microclimatic management: surface soil modification, microsite improvement, seeding depth, seeding rate, timing of seeding and weed control. Seedbed microsite improvement can consist of operations designed to reduce water loss and/or adverse thermal conditions in the seed zone by improving infiltration into the soil, improving water availability to the seed, reducing the impact of water loss to the atmosphere or reducing plant competition for moisture. This is accomplished through initial mechanical disturbance, soil firming and surface modification, control of seeding depth, application of soil surface amendments, and weed control *(Roundy and Call 1988; Sheley et al. 1996)*.

Surface Modification. Soil surface modification is often justified by expectations of increased water availability to the seed, either by improving seed-soil contact, reducing the amount of surface area subject to evaporation, increasing infiltration and water holding capacity, or by creating specific microsites that either receive or retain water more effectively *(Anderson and Swanson 1949; Hubbard and Smoliak 1953;*

Hyder et al. 1955; Hyder and Sneva 1956; McGinnies 1959; Slayback and Cable 1970; Fisser et al. 1974; Tromble 1976; Eckert et al. 1986; Haferkamp et al. 1987; Roundy et al. 1990; Winkel and Roundy 1991; Winkel et al. 1991a; Roundy et al. 1992; Whisenant 1999). In some situations, cultivation without surface firming can increase the surface area subject to evaporation, reduce effective seed-soil contact and seeding depth control, decrease hydraulic conductivity from deeper soil layers, and stimulate weed establishment if seeds are not effectively buried *(McGinnies 1962; Kyle et al. 2007)*. Subsequent soil firming from press wheels or cultipackers improves hydraulic conductivity to the seed by reducing soil surface area and soil macroporosity *(Hyder and Sneva 1956; McGinnies 1962)*. The bulk of range planting literature does not separate out treatment effects of soil-firming procedures which are usually performed in conjunction with specific cultivation and planting procedures *(Bement et al. 1965; McGinnies 1972; Slayback and Renney 1972)*. Studies that compare multiple seedbed preparation methodologies often find differences in relative seeding success with different equipment and techniques, but specific inferences can only be made at the treatment level for a given site and year *(Hubbard and Smoliak 1953; Hyder et al. 1955; Hyder and Sneva 1956; Bement et al. 1965; Eckert and Evans 1967; Young et al. 1969a; Hull 1970; Klomp and Hull 1972; McGinnies 1972; Slayback and Renney 1972; Lavin et al. 1973; Gonzalez and Dodd 1979; Mueller et al. 1985; Haferkamp et al. 1987; Ott et al. 2003)*. Few studies of this type have been replicated adequately in multiple years or on multiple sites *(Bement et al. 1965; Eckert and Evans 1967; Klomp and Hull 1972; Wood et al. 1982; Young et al. 1990; Bakker et al. 2003)*.

Animal trampling, land imprinting, pitting, furrowing and rolling treatments have all been used in conjunction with broadcasting to capture or preserve moisture, and to press surface-applied seed into the soil *(Hyder et al. 1955; Hyder and Sneva 1956; McGinnies 1959, 1962; Houston 1965; Haferkamp et al. 1987; Roundy et al. 1990; Winkel and Roundy 1991; Winkel et al. 1991a; Roundy et al. 1992; Ethridge et al. 1997)*. Animal ingestion and subsequent deposition of seeds in dung has also been used as a mechanism to disperse seeds into favorable microsites *(Akbar et al. 1995; Andrews 1995; Ocumpaugh et al. 1996; Auman et al. 1998; Traba et al. 2003; Gokbulak and Call 2004)*. Differential establishment success relative to position of soil surface features has been noted and is generally attributed to differences in microclimatic conditions *(Anderson and Swanson 1949; Hyder and Sneva 1956; McGinnies 1959; Hull 1970; Bragg and Stephens 1979; Hauser 1982; Eckert et al. 1986; Roundy et al. 1992)*. Surface modification treatments have also been noted to push small seeds too far into the soil or to fill with soil from wind and water erosion resulting in seed burial *(Hyder and Sneva 1956; Kincaid and Williams 1966; McGinnies 1972; Slayback and Renney 1972; Winkel et al. 1991a)*. Positive effects of these surface features may be less relevant in very wet years when water is generally available, regardless of surface treatment, or in very dry years when plantings are unsuccessful regardless of seedbed preparation technique *(McGinnies 1968; Stuth and Dahl 1974; Wood et al. 1982; Eckert et al. 1986; Roundy et al. 1990; Winkel and Roundy 1991; Roundy et al. 1992; Romo and Grilz 2002)*.

Mulch Application. Application of mulch to improve range seeding success is frequently advocated as a mechanism to reduce water loss and moderate soil surface temperatures, although with the caveat that it is probably not cost-effective for most rangeland applications *(Lavin et al. 1981; McGinnies 1987; Ethridge et al. 1997)*. Relatively expensive soil surface amendments such as mulch are generally applied only after high impact disturbance such as mine reclamation, or for mitigation of erosion after wildfire on topographically-complex terrain *(Jacoby 1969; Meyer et al. 1970; Lavin et al. 1981; Pinchak et al. 1985; Schuman et al. 1985; McGinnies 1987; Schuman et al. 1998; Whisenant 1999; Kruse et al. 2004; Groen and Woods 2008)*. An exception may be mulch production as a byproduct of mechanical shredding for control of juniper and other woody species *(Brockway et al. 2002)*. Establishment of a cover crop to create standing-stubble mulch is usually limited to relatively small areas of major disturbance, or higher precipitation zones where grazing lands are being reclaimed from cultivation *(Stroh and Sundberg 1971; Stubbendieck et al. 1973; Pinchak et al. 1985; Schuman et al. 1985; Hart and Dean 1986)*. Justification for mulching practices on rangelands is derived from greenhouse, laboratory and modeling studies, all of which confirm general benefits of moisture conservation and mitigation of high temperature near the soil surface as a function of relative coverage *(Hopkins 1954; Bond and Willis 1970; Chung and Horton 1987; Bristow and Albrecht 1989; Jalota 1993; Brar and Unger 1994; Bussiere and Cellier 1994; Gill and Jalota 1996; Novak et al. 2000a, 2000b, 2000c; Giminez and Govers 2008)*; and field studies, most of which have been conducted after tillage or on severely disturbed, or otherwise extreme, sites *(Dudeck et al. 1970; Meyer et al. 1970; Stubbendieck et al. 1973; Schuman et al. 1985; Hart and Dean 1986; Ethridge et al. 1997; Ji and Unger 2001; Dahiya et al 2007; Groen and Woods 2008)*. Moisture conservation effects of mulch on range seeding success may not be ecologically significant in very high or very low precipitation years or on some extreme rangeland sites *(Gates 1962; Ludwig and McGinnies 1978; Lavin et al. 1981; Berg and Sims 1984; McGinnies 1987; Bristow 1988; Cione et al. 2002; Fulbright et al. 2006)*. In studies surveyed for this review that evaluated mulch treatments, 62% concluded that mulch application improved establishment success. Regardless of the effect of mulch on seeding success, application of mulch for effective erosion control and soil stabilization is well documented *(Meyer et al. 1970; Bautista et al. 1996; Fulbright et al. 2006; Groen and Woods 2008)*.

Seeding Depth. Successful germination and establishment is dependent upon placement of seeds in favorable soil microsites *(Hyder et al. 1955; Harper et al. 1965; Young et al. 1990; Call and Roundy 1991; Winkel and Roundy 1991, Winkel et al. 1991b; Roundy et al. 1992; Chambers and MacMahon 1994; Sheley et al. 1996; Ott et al. 2003)*. A major assumption of many site preparation treatments is that they increase the number of potential safe sites for germination and establishment either by covering the seed, reducing soil water loss from around the seed, or by redistributing and concentrating resources *(Anderson and Swanson 1949; Hubbard and Smoliak 1953; Hyder et al. 1955; Hyder and Sneva 1956; McGinnies 1959; Hull 1970; Slayback and Cable 1970; Fisser et al. 1974; Tromble 1976; Bragg and Stephens 1979; Hauser 1982; Eckert et al. 1986; Haferkamp et al. 1987; Roundy et al. 1990; Winkel and Roundy 1991; Winkel et al. 1991a; Roundy et al. 1992; Call and Roundy 1991; Whisenant 1999; Ott et al. 2003)*.

Mechanical disturbance is generally necessary in order to incorporate seeds into the soil, thus, reducing the risk of either desiccation or adverse thermal effects near the surface. Seeding depth recommendations from commonly referenced seeding guides and technical references are relatively specific but mostly based on rules of thumb regarding seeding depth as a function of seed size *(Hull and Holmgren 1964; Plummer et al. 1968; Jordan 1981; Roundy and Call 1988; Jensen et al. 2001; Monsen and Stevens 2004; Lambert 2005; Ogle et al. 2008a,b)*. The physical rationale for depth recommendations usually assumes a tradeoff between increased water availability and increased energy requirements for emergence as a function of depth *(Hyder et al. 1955; Kinsinger 1962; Mutz and Scifres 1975; Jordan 1981; Carren et al. 1987a,b; Jacobson et al. 1987; Roundy and Call 1988; Call and Roundy 1991; Winkel et al. 1991a, Winkel and Roundy 1991; Roundy et al. 1993; Johnson and Asay 1995; Grundy et al. 2003)*. In some cases, light or diurnal temperature fluctuation may regulate dormancy to ensure that the seeds germinate at an appropriate depth for a given species *(Call and Roundy 1991; Ghersa et al. 1992; Traba et al. 2004)*. Seed predation has also been noted for negative impacts on surface sown seeds *(Nelson et al. 1970)*.

Evidence for depth effects is generally limited to studies conducted in a controlled environment, or over very small spatial scales in the field *(Kinsinger 1962; Vogel 1963; Hull 1964; Mutz and Scifres 1975; Evans et al. 1977; Cox and Martin 1984; Fulbright et al. 1985; Carren et al. 1987a,b; Jacobson et al. 1987; De Alba-Avila and Cox 1988; Newman and Moser 1988; Young et al. 1990; Zhang and Maun 1990a; Charles et al. 1991; Lawrence et al. 1991; Winkel et al. 1991a; Winkel and Roundy 1991a; Redmann and Qi 1992; Roundy et al. 1993; Kitchen 1994; Aiken and Springer 1995; Limbach and Call 1995b; Ries and Hofmann 1995; Heckman et al. 2002; Sanderson and Elwinger 2004; Traba et al. 2004)*. A major exception is for studies comparing the success of broadcast vs. planted seeds. Of the field studies surveyed for this review, 73% of studies that included this specific comparison determined that drill-seeding treatments outperformed broadcast seeding treatments (see Summary and Conclusions). These studies, however, do not generally include quantification of the specific depth distribution after planting *(Stewart 1950; Hyder et al. 1955; Douglas et al. 1960; Gomm 1964; Bement et al. 1965; Statler 1967; Shown et al. 1969; Nelson et al. 1970; McGinnies 1972; Drawe et al. 1975; Wood et al. 1982; Haferkamp et al. 1987; Ott et al. 2003)*. Relative seeding depth in field studies is often reported in the context of depth band settings on mechanical seeding equipment, but there are very few studies in which actual seeding depth has been quantified post-planting *(Winkel et al. 1991a; Winkel and Roundy 1991a,b)*. Laboratory, greenhouse and field comparisons of surface-sown vs. planting methodologies generally confirm that very small seeds establish more frequently from near-surface seed placement, larger seeds require soil cover for maximal performance, and seed performance drops dramatically below some threshold depth *(Hull 1948; Stewart 1950; Douglas et al. 1960; Gomm 1964; Bement et al. 1965; Currie 1967; Springfield and Bell 1967; Robertson and Box 1969; McGinnies 1972, 1973, 1974; Drawe et al. 1975; Mutz and Scifres 1975; Wood et al. 1982; Cox and Martin 1984; Haferkamp et al. 1987; Newman and Moser 1988; Marietta and Britton 1989; Young et al. 1990; Zhang and Maun 1990a; Winkel and Roundy 1991; Roundy et al. 1993; Young et al. 1994; Ries and Hofmann 1995; Ott et al. 2003; Grundy et al. 2003; Cox and Anderson 2004; Sanderson and Elwinger 2004)*. Indian ricegrass

[(*Achnatherum hymenoides* (Roem. & Schulte.) Barkworth] has been extensively documented for its ability to germinate and emerge from relatively deep sowing depths, especially in sandy soils *(Kinsinger 1962; Jones 1990; Young et al. 1994)*.

Broadcast vs. planting recommendations are generally not discretionary as topographic complexity and economic considerations may preclude the use of planting equipment. Broadcast seeding rates for seeds that are not normally recommended for surface placement are generally recommended at 2-3 times the rates for seed that can be incorporated into the soil *(Stewart 1950; Hyder et al. 1955; Douglas et al. 1960; Gomm 1964; Bement et al. 1965; Statler 1967; Shown et al. 1969; Nelson et al. 1970; McGinnies 1972; Drawe et al. 1975; Wood et al. 1982; Haferkamp et al. 1987; Ott et al. 2003)*.

Seeding Rate. General seeding rate recommendations from many technical sources appear to be based on a general standard for what could be considered a hypothetical dominant bunchgrass, planted at optimal depth, in a uniform, well-prepared, weed-free seedbed, in a favorable establishment year. The standard seeding rate for this hypothetical scenario seems to be roughly equal to a seed density of 1 million seeds per acre and approximately 20 seeds/ft^{-2} using historical, non-SI units of measure *(Jordan 1981; Jensen et al. 2001; Monsen and Stevens 2004; Lambert 2005; Ogle et al. 2008a,b)*. The most commonly recommended deviation from this hypothetical standard is to increase seeding rate by a factor of 2 to 5 for seeds smaller than some threshold size, or for potential location-specific problems due to inadequate weed control, lack of site preparation, surface application of seeds, probability of drought, non-optimal seeding season, or high levels of seed dormancy *(Jordan 1981; Monsen and Stevens 2004; Thompson et al. 2006)*. Seeding rate recommendations are also generally adjusted to reflect the total seed mix ratio, and ideal expectations for composition of the future mature plant community *(Pyke and Archer 1991; Ogle et al. 2008a,b)*. It is often difficult to assess numerical seeding rates as the bulk of the literature reports rate in terms of weight of seed planted per unit land area. Weight-based recommendations in the technical literature, however, are generally supplemented by bulk seed density information *(Plummer et al. 1968; Jensen et al. 2001; Monsen and Stevens 2004; Lambert 2005; Ogle et al. 2008a,b)*.

Seeding rate recommendations are linked to microclimatic considerations as increased seed numbers increase the probability of seeds reaching safe microsites, irrespective of active depth management *(Harper et al 1965; Call and Roundy 1991; Roundy et al. 1992; Chambers 1995)*. Relatively few studies reporting effects of seeding rate on establishment success are replicated in such a way to survey annual and seasonal variability in seedbed microclimate *(Schultz and Biswell 1952; Mueggler and Blaisdell 1955; Hull and Holmgren 1964; Launchbaugh and Owensby 1970; Hull 1972a, 1974b; Papanastasis and Biswell 1975; Vogel 1987; McMurray et al. 1997; Masters 1997; Williams et al. 2002)*. Some studies that include variable seeding rates were primarily designed to evaluate competition relative to weed seed numbers, but in general, the literature supports the concept that higher seeding rates may enhance the likelihood of successful initial establishment *(Vogel 1987; Sheley et al. 1999; Wiedemann and Cross 2000; Williams et al. 2002)*. Seeding rate impacts remain highly dependent upon threshold requirements for moisture availability in the early stages of establishment, however, and individual seedling growth can suffer from both inter- and intra-specific competition later in development. The majority of the literature pertaining to seeding rate effects is derived either from controlled environment and greenhouse studies, or field studies conducted in years where reported rainfall conditions were either average or above average *(Francis and Pyke 1996; Sheley and Half 2006)*. Eiswerth and Shonkwiler *(2006)* evaluated a large number of range seeding sites and years in Nevada and determined that increased seeding rates led to higher seedling densities for non-native grasses up to some maximum treatment effect. This study, however, did not analyze or report negative seeding results, and did not consider weather and climate conditions during seeding years.

Planting Season. Most studies of planting season effects on establishment success show seasonal patterns that can be linked to climatic variability, and often to specific germination and dormancy syndromes of various seeded, non-seeded, and weedy species *(Angevine and Chabot 1979)*. General recommendations for seeding season require getting the seed planted in time to take advantage of the most favorable season for plant establishment *(Hull 1948; Stoddart and Smith 1955; Plummer et al. 1968; McGinnies 1972; Vallentine 1979; Jordan, 1981; Roundy and Call 1988; Ries and Hoffman 1996; Monsen and Stevens 2004; Stevens 2004)*. In some cases, dormant-fall seeding is recommended well in advance of the optimal growing season to take advantage of all opportunities for potential establishment in a highly variable, and often arid or semi-arid environment *(Hull 1948; Stewart 1950; Douglas et al. 1960; Plummer et al. 1968; Young et al. 1969b; Nelson et al. 1970; Klomp and Hull 1972; Hart and Dean 1986; Young et al. 1994; Monsen and Stevens 2004)*. Dormant-fall seeding is also recommended when there are logistical concerns for use of mechanical equipment during wet-spring planting conditions, or to mitigate effects of unpredictable spring weather *(Stewart 1950; Douglas et al. 1960; McGinnies 1973; Hart and Dean 1986)*. Seasonal timing of seeding may also be dependent on seasonality of weed competition and/or optimal timing of weed control measures *(Bement et al. 1965; Robocker et al. 1965; Hull 1972a; Klomp and Hull 1972)*. The most favorable season for establishment varies regionally *(Hatfield 1990)*: spring in Mediterranean-coastal and Intermountain-western locations *(Douglas et al. 1960; Nord et al. 1971; Hull 1972a; Harris and Dobrowolski 1986)*, during the summer monsoon in the southwestern desert *(Jordan 1981; Abbot and Roundy 2003; Hereford et al. 2006)*, late-spring through early summer in the Great Plains states *(Robertson and Box 1969; Hyder et al. 1971; McGinnies 1973; Hart and Dean 1986; Ries and Hoffman 1996; Frank et al. 1998; Romo and Grilz 2002)*, and late-spring through early fall in some higher elevation mountain sites *(Hull 1966; Currie 1967; Lavin et al. 1973; Hull 1974a,b)*. Post-planting microclimate must be favorable for growth, but also needs to remain favorable during the vulnerable period of seedling establishment (*Hyder et al. 1971; McGinnies 1973; Frasier et al. 1987; Abbot and Roundy 2003)*. Eiswerth and Shonkwiler *(2006)* confirmed the relative benefits of fall/winter-dormant seeding on Intermountain rangelands in Nevada using meta-analysis of long-term Bureau of Land Management fire rehabilitation monitoring data. Very few experimental studies of seeding-season effects are replicated in more than one or two years *(Hull 1948; Douglas et al. 1960; Robocker et al. 1965; Hull 1974b; Ries and Hoffman 1996)*. Fall-dormant planting was found to be superior to spring planting in

73% of Great Basin studies evaluated in this review when season of planting was included in the experimental design.

Weed Control. Seedbed preparation and planting method recommendations are designed to improve microclimatic conditions for desirable species, but also to reduce competition from undesirable plants *(Lavin et al. 1973; Gonzalez and Dodd 1979; Ott et al. 2003; Mangold et al. 2007)*. Chemical or mechanical weed control, prior to the early stages of establishment, are generally required for establishment success of both native and non-native plant materials *(Evans et al. 1970; Nelson et al. 1970; Klomp and Hull 1972; Stuth and Dahl 1974; Evans and Young 1978; Humphrey and Schupp 2002; Mangold et al. 2007)*. Of 52 studies surveyed for this review that included mechanical or chemical weed control, all but two concluded that weed control was either necessary, or at least beneficial to successful establishment

Justification for Current Conservation Practice Recommendations

General management recommendations, and associated NRCS technical references *(e.g. Ogle et al. 2008a,b)*, are consistent with current rangeland planting technical guidance and authorities *(Valentine 1979; Jordan 1981; Sours 1983; Redente and DePuit 1988; Roundy and Call 1988; Roundy 1996; Sheley et al. 1996; Whisenant 1999; Jensen et al. 2001; Monsen and Stevens 2004; Stevens 2004; Sheley et al. 2006)*. These recommendations and guidelines do not fundamentally differ from earlier cited works that pre-date current standards for hypothesis testing, statistical inference, and experimental design norms *(Stoddart and Smith 1943, 1955; Stewart 1950; Anderson et al. 1957; Plummer et al. 1968; Valentine 1971)*. This review was specifically constrained to focus on the refereed journal literature. Many of the historical references used to justify range planting practices, however, come from Agricultural Experiment Station reports, internal agency documents, and syntheses of unpublished field trials *(McGinnies et al. 1963; Great Plains Council 1966; Plummer et al. 1968; Gomm, 1974; Cox et al. 1984; Call and Roundy 1991)*. With the exception of some specific plant materials selection and development programs, the underlying principles of these earlier recommendations were primarily based on previously established agricultural concepts, and a probabilistic assessment of best management practices derived from the practical experience and personal observations of land management professionals. The scientific literature from the more recent 40-50 year era has attempted to refine and experimentally validate these commonly recommended practices. The more-recent literature, however, is dominated by empirical studies that individually provide examples of field success, but are insufficiently replicated for general inferences *(Call and Roundy 1991)*.

We surveyed 188 range planting field studies to draw some general inferences about a number of assumptions inherent in commonly used technical references and range planting conservation practice documents. These references are preceded by an asterisk in the Literature Cited.

- Few inferences can be made from the range planting literature relative to performance of alternative plant materials. Very few studies are replicated in such a way that within- or between-species variability can be assessed. Over

35% of studies evaluated only one seed lot or a unique seed mix and 24% compared relative establishment among unique seed mixes. Of the 86 studies in which individual seedlots were compared, only 6% were fully replicated, and 19% were partially replicated at the species level. Almost half of the studies used at least some named varieties, but only 4 specifically evaluated within-species variability. The strongest evidence for plant materials suitability is derived from observation of historical relationships between species and climate, experience-based observation, long-term assessment of persistence of planted species, and field trials conducted during the process of plant materials selection and development.

- General recommendations supported by the aggregate literature must be prefaced by an acknowledgement that climatic conditions during the establishment year must be favorable. Ninety percent of the range planting papers surveyed report at least one successful treatment. Of the 57% that reported relative climatic conditions during the study, however, 89% claimed average or above-average precipitation in the year of establishment for the successful treatments. Over half of the studies that report successful establishment in a below-average precipitation year note that the seasonal distribution of precipitation was favorable during the critical establishment phase.
- General recommendations regarding site preparation and seeding methodology are generally supported from the aggregate literature. Drill-seeding treatments outperformed broadcast seeding treatments in 73% of the studies that included a direct comparison. Application of mulch improved establishment success in 62% of the studies where there was a direct comparison. Increasing seeding rate was found to improve establishment success in 79% of the 24 studies where this was directly tested. Of the 52 studies that included mechanical or chemical weed control treatments, all but two concluded that weed control was either necessary, or at least beneficial to successful establishment. Fall-dormant planting was determined to be superior to spring planting in 73% of the Great Basin studies where planting season was evaluated. Seedbed preparation, seeding depth, planting season and seeding rate recommendations may be irrelevant in very-dry and perhaps very-wet years.
- The majority of range-planting field studies are un-replicated in either space or time. Only 47% replicate planting years and 41% replicate site locations. The predominant form of treatment replication was within-site with 69% of studies having at least 2, and 61% having at least 3 within-site treatment replicates. Meta-analysis of studies that are individually under-replicated for general inferences is hampered by the fact that negative results are usually not published, and plant materials selection is often based on *a priori* assumptions about suitability of plant materials.

Current Knowledge Limitations and Research Needs

Development and Utilization of Weather and Forecasting Tools. Weather and climatic limitations require definition of realistic goals when establishing rehabilitation and restoration planning objectives *(Call and Roundy 1991, Hobbs and*

Norton 1996; Ehrenfeld 2000; Jones 2003). Asay et al. *(2001)* argue that the relatively harsh climatic conditions on many rangelands may preclude the realistic use of many native plant materials in favor of adapted non-native species. Biodiversity and restoration planning objectives may require multiple-year strategies for replacement of non-native species only after they have stabilized the site, and suppressed annual weed competition *(Bakker et al. 2003; Cox and Anderson 2004)*. In some years, and on some sites, it may be prudent to plant more easily established non-native species, particularly after wildfire or other disturbance when the principal objective of rangeland planting may be soil stabilization. Biodiversity and restoration objectives could then be addressed in years when climatic conditions are amenable *(Holmgren and Scheffer 2001; Bakker et al. 2003; Hardegree et al. 2003; Cox and Anderson 2004; Hardegree and Van Vactor 2004)*.

The stochastic nature of weather variability will require adoption of new concepts for evaluating revegetation and restoration success. Expectations for success need to be explicitly linked to the probability of favorable conditions for seed germination, emergence, and establishment *(Krzysztofowicz 2001; Bakker et al. 2003)*. New technologies will need to be developed and utilized in order to use weather information to inform rangeland planting management decisions *(Workman and Tanaka 1991; Peters 2000; Rayner et al. 2005; Andales et al. 2006)*. The most useful potential technology for enhancing establishment success lies in development and utilization of relatively-long-range weather forecast technology specific to rangeland planting applications *(Barnston et al. 1994, 2005; Briggs and Wilks 1996; Goddard et al. 2001, 2003; Hartmann et al. 2002; Leetmaa 2003; Zebiak 2003; Klopper et al. 2006; Garbrecht and Schneider 2007; Power et al. 2007; Schubert et al. 2008)*. Long-term weather forecasts in large portions of the Intermountain west are often merely synoptic descriptions of historical weather patterns and not based on physical or empirical prediction of future weather conditions. It may be possible, however, to utilize historical weather and seeding data to construct economic models to assess the potential long-term benefits of adopting forecast/modeling technology in rangeland restoration planning *(Batabyal and Godfrey 2002; Schneider and Garbrecht 2003; 2006; Bashari et al. 2008)*. Similar technology is in relatively common use for more traditional agricultural applications and for some rangeland applications *(Abawi et al. 1995; Fox et al. 1999; Mjelde et al. 2000; Ogallo et al. 2000; Hammer et al. 2001; Schneider et al. 2003, 2006; Doblas-Reyes et al. 2006; Garbrecht et al. 2006a; Hansen and Sivakumar 2006; Sivakumar 2006; Hansen et al. 2006; Ash et al. 2007; Hayman et al. 2007; Meinke et al. 2007; Baigorria et al. 2008; O'Lenic et al. 2008)*. Even low-resolution weather forecasts would increase the probability of successful native plant establishment if seeding decisions in the fall could be based on the anticipation of favorable conditions of seedbed microclimate in the subsequent winter and spring *(Hardegree et al. 2003; Hardegree and Van Vactor 2004)*. Weather forecasts could be used to initiate contingency plans in areas that have been previously identified for restoration, and for which pre-management logistics of equipment, personnel and plant materials are in place *(Bakker et al. 2003; Westoby et al. 1989)*. Separation of restoration planning objectives from the wildfire cycle would also simplify the problem of predicting management needs for native germplasm *(Richards et al. 1998)*. Historical climate records could provide a relatively stable estimate of the probability of favorable establishment years that could be used to predict acquisition and storage requirements for native seed over the long term.

Plant Materials Program Development and Testing. Previous plant materials development has focused on productivity, vigor, establishment, disease resistance, seed production, and specific ecological and physiological traits deemed to confer superior performance or adaptation. Establishment, persistence and invasion resistance of seeded plant communities may be enhanced by identification and selection of plant materials with functional traits similar to the various highly competitive invasive species *(Arredondo et al. 1998; Pokorny et al. 2005; Funk et al. 2008)*. Functional traits common to many weedy invaders include high relative growth rate, specific leaf area, leaf nitrogen content and resource use efficiency *(Aguirre and Johnson 1991a,b; Fogarty and Facelli 1999; Grotkopp et al. 2002; Pokorny et al. 2005; Grotkopp and Rejmanek 2007; James and Drenovsky 2007; Funk et al. 2008)*.

Adoption of Standard Protocols for Evaluating Success and to Facilitate Meta-Analysis of Field Trials. The majority of range planting studies do not measure critical environmental factors affecting success but only measure relative treatment effects *(Call and Roundy 1991; Vargas et al. 2001)*. Range planting studies also tend to extrapolate results obtained from atypical sites and conditions over larger areas *(Cox et al. 1984)*, and are seldom replicated in multiple seeding years (*Douglas et al. 1960; Bement et al. 1965; Eckert and Evans 1967; Klomp and Hull 1972; Hull 1974b; Wood et al. 1982; Young et al. 1990; Casler 1999; Bakker et al. 2003)*. Generally high variability in experimental procedures often produce unique individual studies from a complex combination of unique site preparation, plant materials, seeding rate, soil conditions, and weather during perhaps only one or two establishment years. One recommendation for the future is to adopt minimum experimental design requirements for publication of range planting studies relative to specific inferences that are of principal interest *(Casler 1999; Vargas et al. 2001)*.

Another problem with synthesizing range planting research results is the relatively high variability in metrics used to evaluate "success". Relatively few authors have directly evaluated alternative criteria for quantification of success *(Ries and Svejcar 1991)*. The majority of range planting studies use arbitrary, relative, criteria for judging success, and only consider planting year or first-year effects. Studies that are monitored for longer periods were usually not replicated at the level of planting-year *(Casler 1999)*. Many studies that have monitored range planting results in the very long-term have noted significant changes from what would have been measured only 1-3 years post-planting *(Bleak et al. 1965; Hull 1971a; Hull 1973; Lavin and Johnson 1977; Eck and Sims 1984; Harris and Dobrowolski 1986)*.

In general, most individual studies within the range planting literature are insufficiently replicated to extract valid inferences about weather and climate effects, site effects, plant materials effects, and seeding rate. The dominant level for validation in the currently available literature derives from interspersion and within-location replication of seedbed preparation treatments. These studies, and a large amount of data contained in conference proceedings, technical reports and internal-agency documents, might be subject to valuable meta-analysis of treatment effects that are difficult or impossible to replicate in the context of a stand-alone journal publication *(Durlak and Lipsay 1991; Gurevitch et al. 1992, 2001; Gurevitch and Hedges 1999; Adams et al. 1997; Michener 1997; Osenberg et al. 1999a,b; Johnson 2006)*. Much of this information may only be suitable for low-level meta-analysis similar to the summary statistics used here to document gross treatment effects. It may be possible, however, to develop guidelines for establishing some common experimental design features for future studies that may be amenable to more sophisticated meta-analysis.

Another underutilized research resource is the incorporation of extensive management-level monitoring information into a scientific database format *(Pastorok et al. 1997)*. Eiswerth and Shonkwiler *(2006)* used a Bureau of Land Management dataset to evaluate post-fire management treatment effects on seeded non-native grasses, sagebrush and annual weeds as a function of range site, soil type and seeding prescription. Unfortunately, this dataset did not evaluate impacts of weather and climate variability. Effective utilization of this type of data may also require some degree of coordination within and between management agencies to adopt similar monitoring protocols. Conservation practice recommendations can be improved by establishing standard monitoring requirements to assess both the effectiveness of specific management recommendations, and conservation effects of successful practices. Monitoring requirements, however, should be based on an explicit experimental design that would facilitate future meta-analysis.

LITERATURE CITED

Abawi, G.Y., R.J. Smith and D.K. Brady. 1995. Assessment of the value of long range weather forecasts in wheat harvest management. Journal of Agricultural Engineering Research 62:39-48.

*Abbott, L.B. and B.A. Roundy. 2003. Available Water Influences Field Germination and Recruitment of Seeded Grasses. Journal of Range Management 56:56-64.

Adams, D.C., J. Gurevitch and M.S. Rosenberg. 1997. Resampling tests for meta-analysis of ecological data. Ecology 78:1277-1283.

Aguirre, L. and D.A. Johnson. 1991a. Influence of temperature and cheatgrass competition on seedling development of two bunchgrasses. Journal of Range Management 44:347-354.

Aguirre, L. and D.A. Johnson. 1991b. Root morphological development in relation to shoot growth in seedlings of four range grasses. Journal of Range Management 44:341-346.

Aiken, G.E. and T.L. Springer. 1995. Seed size distribution, germination, and emergence of 6 switchgrass cultivars. Journal of Range Management 48:455-458.

Akbar, G., C.A. Call and R.D. Wiedmeier. 1995. Cattle dungpat microenvironmental effects on germination and establishment of crested wheatgrass. Arid Soil Research and Rehabilitation 9:409-422.

Akinremi, O.O., S.M. McGinn and H.W. Cutforth. 2001. Seasonal and spatial patterns of rainfall trends on the Canadian prairies. Journal of Climate 14:2177-2182.

Alderson, J. and W.C. Sharp. 1994. Grass varieties in the United States. USDA Agricultural Handbook No 170, Washington D.C. 296 pp.

Andales, A.A., J.D. Derner, L.R. Ahuja and R.H. Hart. 2006. Strategic and tactical prediction of forage production in northern mixed-grass prairie. Rangeland Ecology and Management 59:576-584.

*Andersen, M.R., E.J. DePuit, R.H. Abernethy and L.H. Kleinman. 1992. Value of mountain rye for suppression of annual bromegrasses on semi-arid mined lands. Journal of Range Management 45:345-351.

*Anderson, D. and A.R. Swanson. 1949. Machinery for seedbed preparation and seeding on southwestern ranges. Journal of Range Management 2:64-66.

Anderson, D., L.P. Hamilton, H.G. Reynolds and R.R. Humphrey. 1957. Reseeding desert grassland ranges in southern Arizona. Arizona Agricultural Experiment Station Bulletin 249, 32pp.

Andrews, T.S. 1995. Dispersal of seeds of giant *Sporobolus* spp. after ingestion by grazing cattle. Australian Journal of Experimental Agriculture 35:353-356.

Angevine, M.W. and B.F. Chabot. 1979. Seed germination syndromes in higher plants. In: Topics in Plant Population Biology, Solbrig, O.T., S. Jain, G.B. Johnson and P.H. Raven (eds.), Columbia University Press, New York, 188-206.

Arredondo, J.T., T.A. Jones and D.A. Johnson. 1998. Seedling growth of Intermountain perennial and weedy annual grasses. Journal of Range Management 51:584-589.

Asay, K.H. and D.A. Johnson. 1980. Screening for improved stand establishment in Russian wild ryegrass. Canadian Journal of Plant Science 60:1171-1177.

Asay, K.H. and D.A. Johnson. 1983a. Breeding for drought resistance in range grasses. Iowa State Journal of Research 57:441-455.

Asay, K.H. and D.A. Johnson. 1983b. Genetic variability for characters affecting stand establishment in crested wheatgrass. Journal of Range Management 36:703-706.

Asay, K.H. and D.A. Johnson. 1990. Genetic variances for forage yield in crested wheatgrass at six levels of irrigation. Crop Science 30:79-82.

Asay, K.H., D.A. Johnson, K.B. Jensen, W.M. Sarraj and D.H. Clark. 1996. Potential of new tetraploid germplasm in Russian wildrye. Journal of Range Management 49:439-442.

Asay, K.H., D.R. Dewey, F.B. Gomm, D.A. Johnson and J.R. Carlson. 1985b. Registration of "Bozoisky-select' Russian wildrye. Crop Science 25:575-576.

Asay, K.H., D.R. Dewey, F.B. Gomm, D.A. Johnson and J.R. Carlson. 1985a. Registration of "Hycrest" crested wheatgrass. Crop Science 25:368-369.

Asay, K.H., D.R. Dewey, F.B. Gomm, W.H. Horton and K.B. Jensen. 1986. Genetic progress through hybridization of induced and natural tetraploids in crested wheatgrass. Journal of Range Management 39:261-263.

Asay, K.H., D.R. Dewey, W.H. Horton, K.B. Jensen, P.O. Currie, N.J. Chatterton, W.T. Hansen and J.R. Carlson. 1991. Registration of 'NEWHY" RS hybrid wheatgrass. Crop Science 31:1184-1185.

Asay, K.H., N.J. Chatterton, K.B. Jensen, R.R.C. Wang, D.A. Johnson, W.H. Horton, A.J. Palazzo and S.A. Young. 1997. Registration of 'CD-II' crested wheatgrass. Crop Science 37:1023.

Asay, K.H., N.J. Chatterton, K.B. Jensen, T.A. Jones, B.L. Waldron and W.H. Horton. 2003. Breeding improved grasses for semiarid rangelands. Arid Land Research and Management 17:469-478.

Asay, K.H., W.H. Horton, K.B. Jensen and A.J. Palazzo. 2001. Merits of native and introduced Triticeae grasses on semiarid rangelands. Canadian Journal of Plant Science 81:45-52.

Asay, K.H., D.A. Johnson, K.B. Jensen, N.J. Chatterton, W.H. Horton, W.T. Hansen and S.A. Young. 1995a. Registration of Vavilov Siberian crested wheatgrass. Crop Science 35:1510.

Asay, K.H., K.B. Jensen, D.A. Johnson, N.J. Chatterton, W.T. Hansen, W.H. Horton and S.A. Young. 1995b. Registration of Douglas crested wheatgrass. Crop Science 35:1510-1511.

Ash, A., P. McIntosh, B. Cullen, P. Carberry and M.S. Smith. 2007. Constraints and opportunities in applying seasonal climate forecasts in agriculture. Australian Journal of Agricultural Research 58:952-965.

Auman, B.S., C.A. Call and R.D. Wiedmeier. 1998. Crested wheatgrass establishment in livestock dung deposited on degraded rangeland vegetation types in the Intermountain west, USA. Arid Soil Research and Rehabilitation 12:317-333.

*Bahler, C.C., L.E. Moser, T.S. Griffin and K.P. Vogel. 1990. Warm-season grass establishment as affected by post-planting atrazine application. Journal of Range Management 43:421-424.

Baigorria, G.A., J.W. Jones and J.J. O'Brien. 2008. Potential predictability of crop yield using an ensemble climate forecast by a regional circulation model. Agricultural and Forest Meteorology 148:1353-1361.

*Bakker, J.D., J. Christian, S.D. Wilson and J. Waddington. 1997. Seeding blue grama in old crested wheatgrass fields in southwestern Saskatchewan. Journal of Range Management 50:156-159.

Bakker, J. and S. Wilson. 2001. Competitive abilities of introduced and native grasses. Plant Ecology 157:119-127.

*Bakker, J.D., S.D. Wilson, J.M. Christian, X.D. Li, L.G. Ambrose and J. Waddington. 2003. Contingency of grassland restoration on year, site, and competition from introduced grasses. Ecological Applications 13:137-153.

Balliette, J.F., K.C. McDaniel and M.K. Wood. 1986. Infiltration and sediment production following chemical control of sagebrush in New Mexico. Journal of Range Management 39: 160-165.

*Banerjee, M.J., V.J. Gerhart and E.P. Glenn. 2006. Native plant regeneration on abandoned desert farmland: Effects of irrigation, soil preparation, and amendments on seedling establishment. Restoration Ecology 14:339-348.

Barbour, M.G. and W.D. Billings. 2000. North American Terrestrial Vegetation. Cambridge University Press, 708 pp.

Barnston, A.G., A. Kumar, L. Goddard and M.P. Hoerling. 2005. Improving seasonal prediction practices through attribution of climate variability. Bulletin of the American Meteorological Society 86:59-72.

Barnston, A.G., H.M. Vandendool, S.E. Zebiak, T.P. Barnett, M. Ji, D.R. Rodenhuis, M.A. Cane, A. Leetmaa, N.E. Graham, C.R. Ropelewski, V.E. Kousky, E.A. O'Lenic and R.E. Livezey. 1994. Long-lead seasonal forecasts - Where do we stand? Bulletin of the American Meteorological Society 75:2097-2114.

Bartolome, J.W., M.C. Stroud and H.F. Heady. 1980. Influence of natural mulch on forage production on differing California annual range sites. Journal of Range Management 33: 4-8.

Bashari, H., C. Smith and O.J.H. Bosch. 2008. Developing decision support tools for rangeland management by combining state and transition models and Bayesian belief networks. Agricultural Systems 99:23-34.

Batabyal, A.A. and E.B. Godfrey. 2002. Rangeland management under uncertainty: A conceptual approach. Journal of Range Management 55:12-15.

Bautista, S., J. Bellot and V.R. Vallejo. 1996. Mulching treatment for postfire soil conservation in a semiarid ecosystem. Arid Soil Research and Rehabilitation 10:235-242.

*Bement, R.E., R.D. Barmington, A.C. Everson, C.L. Hylton and E.E. Memmenge. 1965. Seeding of abandoned croplands in the central great plains. Journal of Range Management 18:53-59.

*Benz, L.J., K.G. Beck, T.D. Whitson and D.W. Koch. 1999. Reclaiming Russian knapweed infested rangeland. Journal of Range Management 52:351-356.

Berdahl, J.D. and R.E. Barker. 1984. Selection for improved seedling vigor in Russian wild ryegrass. Canadian Journal of Plant Science 64:131-138.

Berdahl, J.D., R.E. Barker, J.F. Karn, J.M. Krupinsky, R.J. Haas, D.A. Tober and I.M. Ray. 1992a. Registration of Mankota Russian wildrye. Crop Science 32:1073.

Berdahl, J.D., R.E. Barker, J.F. Karn, J.M. Krupinsky, R.J. Haas, D.A. Tober and I.M. Ray. 1992b. Registration of 'Reliant" intermediate wheatgrass. Crop Science 32:1072.

*Berg, W.A., C.L. Dewald and P.L. Sims. 1996. Seedbed and seeder options for old world bluestem establishment. Journal of Range Management 49:179-181.

*Berg, W.A. and P.L. Sims. 1984. Herbage yields and water-use efficiency on a loamy site as affected by tillage, mulch and seeding treatments. Journal of Range Management 37:180-184.

Bestelmeyer, B.T., J.R. Brown, K.M. Havstad, R. Alexander, G. Chavez and J. Herrick. 2003. Development and use of state-and-transition models for rangelands. Journal of Range Management 56:114-126.

*Biedenbender, S.H. and B.A. Roundy. 1996. Establishment of native semidesert grasses into existing stands of *Eragrostis lehmanniana* in southeastern Arizona. Restoration Ecology 4:155-162.

Bittman, S. and G.M. Simpson. 1987. Soil water deficit effect on yield, leaf area, and net assimilation rate of three forage grasses: crested wheatgrass, smooth bromegrass, and altai wildrye. Agronomy Journal 79:768-774.

*Bleak, A.T., N.C. Frischknecht, A.P. Plummer and R.E. Eckert. 1965. Problems in artificial and natural revegetation of the arid shadscale vegetation zone of Utah and Nevada. Journal of Range Management 18:59-65.

*Bleak, A.T. and A.C. Hull. 1958. Seeding pelleted and unpelleted seed on four range types. Journal of Range Management 11:28-33.

*Bleak, A.T. and W. Keller. 1974. Emergence and yield of six range grasses planted on four dates using natural and treated seeds. Journal of Range Management 27:225-227.

Bond, J.J. and W.O. Willis. 1970. Soil water evaporation: first stage drying as influenced by surface residue and evaporation potential. Soil Science Society of America Proceedings 34:924-928.

*Booth, D.T. 1980. Emergence of bitterbrush seedlings on land disturbed by phosphate mining. Journal of Range Management 33:439-441.

*Booth, D.T. 2002. Seed longevity and seeding strategies affect sagebrush revegetation. Journal of Range Management 55:188-193.

Bork, E.W., T. Thomas and B. McDougall. 2001. Herbage response to precipitation in central Alberta boreal grasslands. Journal of Range Management 54:243-248.

*Bovey, R.W., V.L. Houser and R.E. Meyer. 1990. Establishment of kleingrass with annual ryegrass and other cultural treatments. Agronomy Journal 82:210-215.

Bradford, J.B., W.K. Lauenroth, I.C. Burke and J.M. Paruelo. 2006. The influence of climate, soils, weather, and land use on primary production and biomass seasonality in the US Great Plains. Ecosystems 9:934-950.

*Bragg, T.B. and L.J. Stephens. 1979. Effects of agricultural terraces on the re-establishment of bluestem grasslands. Journal of Range Management 32:437-441.

*Brahim, K. and S.E. Smith. 1993. Annual medic establishment and the potential for stand persistence in southern Arizona. Journal of Range Management 46:21-25.

Brar, G.S. and P.W. Unger. 1994. Soil temperature simulation with varying residue management. Journal of Agronomy and Crop Science 172:1-8.

Briggs, W.M. and D.S. Wilks. 1996. Estimating monthly and seasonal distributions of temperature and precipitation using the new CPC long-range forecasts. Journal of Climate 9:818-826.

Briske, D.D., S.D. Fuhlendorf and F.E. Smeins. 2003. Vegetation dynamics on rangelands: a critique of the current paradigms. Journal of Applied Ecology 40:601-614.

Briske, D.D., S.D. Fuhlendorf and F.E. Smeins. 2005. State-and-transition models, thresholds, and rangeland health: A synthesis of ecological concepts and perspectives. Rangeland Ecology and Management 58:1-10.

Briske, D.D., S.D. Fuhlendorf and F.E. Smeins. 2006. A unified framework for assessment and application of ecological thresholds. Rangeland Ecology and Management 59:225-236.

Briske, D.D., B.T. Bestelmeyer, T.K. Stringham, and P.L. Shaver. 2008. Recommendations for development of resilience-based state-and-transition models. Rangeland Ecology and Management 61:359-367.

Bristow, K.L. 1988. The role of mulch and its architecture in modifying soil temperature. Australian Journal of Soil Research 26:269-280.

Bristow, K.L. and D.G. Abrecht. 1989. The physical environment of two semi-arid tropical soils with partial surface mulch cover. Australian Journal of Soil Research 27:577-587.

Brockway, D.G., R.G. Gatewood and R.B. Paris. 2002. Restoring grassland savannas from degraded pinyon-juniper woodlands: effects of mechanical overstory reduction and slash treatment alternatives. Journal of Environmental Management 64:179-197.

Burner, D.M., J.A. Balasko and P.M. O'Brien. 1988. Attributes of tall fescue germplasm of diverse geographic origin. Crop Science 28:459-462.

Bussiere, F. and P. Cellier. 1994. Modification of the soil temperature and water content regimes by a crop residue mulch - experiment and modelling. Agricultural and Forest Meteorology 68:1-28.

Cable, D.R. 1971. Lehmann lovegrass on the Santa Rita experimental range 1937-1968. Journal of Range Management 24:17-21.

*Cable, D.R. 1972. Fourwing saltbush revegetation trials in southern Arizona. Journal of Range Management 25:150-153.

*Cable, D.R. 1976. Twenty years of changes in grass production following mesquite control and reseeding. Journal of Range Management 29:286-289.

Call, C.A. and B.A. Roundy. 1991. Perspectives and processes in revegetation of arid and semiarid rangelands. Journal of Range Management 44:543-549.

Camargo, M.B.P. and K.G. Hubbard. 1999. Spatial and temporal variability of daily weather variables in sub-humid and semi-arid areas of the United States high plains. Agricultural and Forest Meteorology 93:141-148.

*Canode, C.L. and J.K. Patterson. 1961. Grass seed production from seeded range lands. Journal of Range Management 14:88-92.

Carder, A.C. 1970. Climate and the rangelands of Canada. Journal of Range Management 23:263-267.

Carren, C.J., A.M. Wilson and R.L. Cuany. 1987a. Caryopsis weight and planting depth of blue grama. II. Emergence in marginal soil moistures. Journal of Range Management 40:212-216.

Carren, C.J., A.M. Wilson, R.L. Cuany and G.L. Thor. 1987b. Caryopsis weight and planting depth of blue grama. I. Morphology, emergence and seedling growth. Journal of Range Management 40:207-211.

Casler, M.D. 1999. Repeated measures vs. repeated plantings in perennial forage grass trials: an empirical analysis of precision and accuracy. Euphytica 105:33-42.

Chambers, J.C. 1995. Relationships between seed fates and seedling establishment in an alpine ecosystem. Ecology 76:2124-2133.

Chambers, J.C. and J.A. MacMahon. 1994. A day in the life of a seed: Movements and fates of seeds and their implications for natural and managed systems. Annual Review of Ecology and Systematics 25:263-292.

Charles, G.W., G.J. Blair and A.C. Andrews. 1991. The effect of soil temperature, sowing depth and soil bulk density on the seeding emergence of tall fescue (*Festuca arundinacea* Schreb.) and white clover (*Trifolium repens* L.). Australian Journal of Agricultural Research 42:1261-1269.

Chung, S.O. and R. Horton. 1987. Soil heat and water flow with a partial surface mulch. Water Resources Research 23:2175-2186.

*Cione, N.K., P.E. Padgett and E.B. Allen. 2002. Restoration of a native shrubland impacted by exotic grasses, frequent fire, and nitrogen deposition in southern California. Restoration Ecology 10:376-384.

*Cluff, G.J., J.A. Young and R.A. Evans. 1983. Edaphic factors influencing the control of Wyoming big sagebrush and seedling establishment of crested wheatgrass. Journal of Range Management 36:786-792.

*Cook, C.W. 1965. Grass seedling response to halogeton competition. Journal of Range Management 18:317-321.

*Cook, C.W. and C.E. Lewis. 1963. Competition between big sagebrush and seeded grasses on foothill ranges in Utah. Journal of Range Management 16:245-250.

Cook, J.G. and L.L. Irwin. 1992. Climate-vegetation relationships between the Great Plains and Great Basin. American Midland Naturalist 127:316-326.

Cooper, C.S. and D.N. Hyder. 1958. Adaptability and yield of eleven grasses grown on the Oregon high desert. Journal of Range Management 11:235-237.

Coulman, B. 2006a. Goliath crested wheatgrass. Canadian Journal of Plant Science 86:743-744.

Coulman, B. 2006b. Success hybrid bromegrass. Canadian Journal of Plant Science 86:745-747.

*Cox, J.R. and G.L. Jordan. 1983. Density and production of seeded range grasses in southeastern Arizona (1970-1982). Journal of Range Management 36:649-652.

Cox, J.R. and M.H. Martin. 1984. Effects of planting depth and soil texture on the emergence of four lovegrasses. Journal of Range Management 37:204-205.

Cox, J.R., H.L. Morton, T.N. Johnson, G.L. Jordan, S.C. Martin and L.C. Fierro. 1984. Vegetation restoration in the Chihuahuan and Sonoran deserts of North America. Rangelands 6:112-115.

Cox, J.R., M.H. Martin, F.A. Ibarra-F., J.H. Fourie, N.F.G. Rethman and D.G. Wilcox. 1988. The influence of climate and soils on the distribution of four African grasses. Journal of Range Management 41:127-139.

*Cox, J.R., M.H. Martin, R.F.A. Ibarra-F. and H.L. Morton. 1986. Establishment of range grasses on various seedbeds at creosotebush (*Larrea tridentata*) sites in Arizona USA and Chihuahua, Mexico. Journal of Range Management 39:540-546.

*Cox, M.L. and M.K. McCarty. 1958. Some factors affecting establishment of desirable forage plants in weedy bluegrass pastures of eastern Nebraska. Journal of Range Management 11:159-164.

*Cox, R.D. and V.J. Anderson. 2004. Increasing native diversity of cheatgrass-dominated rangeland through assisted succession. Journal of Range Management 57:203-210.

*Currie, P.O. 1967. Seeding Sherman big bluegrass. Journal of Range Management 20:133-136.

Currie, P.O. and G. Peterson. 1966. Using growing-season precipitation to predict crested wheatgrass yields. Journal of Range Management 19:284-288.

*Currie, P.O. and R.S. White. 1982. Drought survival of selected forage grasses commonly seeded in the northern Great Plains. Canadian Journal of Plant Science 62:949-955.

Dahiya, R., J. Ingwersen and T. Streck. 2007. The effect of mulching and tillage on the water and temperature regimes of a loess soil: Experimental findings and modeling. Soil and Tillage Research 96:52-63.

Daubenmire, R. 1956. Climate at a determinant of vegetation distribution in eastern Washington and northern Idaho. Ecological Monographs 26:131-154.

De Alba-Avila, A. and J.R. Cox. 1988. Planting depth and soil texture effects on emergence and production of three alkali sacaton accessions. Journal of Range Management 41:216-220.

*Depuit, E.J., C.L. Skilbred and J.G. Coenenberg. 1982. Effects of two years of irrigation on revegetation of coal surface-mined land in south-eastern Montana. Journal of Range Management 35:67-74.

Doblas-Reyes, F.J., R. Hagedorn and T.N. Palmer. 2006. Developments in dynamical seasonal forecasting relevant to agricultural management. Climate Research 33:19-26.

*Doerr, T.B., E.F. Redente and T.E. Sievers. 1983. Effect of cultural practices on seeded plant communities on intensively disturbed soils. Journal of Range Management 36:423-428.

*Douglas, D.S., A.L. Hafenrichter and K.H. Klages. 1960. Cultural methods and their relation to establishment of native and exotic grasses in range seedings. Journal of Range Management 13:53-57.

*Drawe, D.L., J.B. Grumbles and J.F. Hooper. 1975. Establishment of Russian wildrye on foothill ranges in Utah. Journal of Range Management 28:152-154.

Dudeck, A.E., N.P. Swanson, L.N. Meilke and A.R. Dedrick. 1970. Mulches for grass establishment on fill slopes. Agronomy Journal 62:810-812.

Duncan, D.A. and R.G. Woodmansee. 1975. Forecasting forage yield from precipitation in California's annual rangeland. Journal of Range Management 28:327-329.

Durlak, J.A. and M.W. Lipsay. 1991. A practitioner's guide to metaanalysis. American Journal of Community Psychology 19:291-332.

Eck, H.V. and P.L. Sims. 1984. Grass species adaptability in the southern high plains - a 36-year assessment. Journal of Range Management 37:211-217.

Eck, H.V., W.G. McCully and J. Stubbendieck. 1975. Response of shortgrass plains vegetation to clipping, precipitation, and soil water. Journal of Range Management 28:194-197.

*Eckert Jr., R.E., J.E. Asher, M.D. Christensen and R.A. Evans. 1974. Evaluation of the atrazine-fallow technique for weed control and seedling establishment. Journal of Range Management 27:288-292.

*Eckert, R.E. 1974. Atrazine residue and seedling establishment in furrows. Journal of Range Management 27:55-56.

*Eckert, R.E. and R.A. Evans. 1967. A chemical-fallow technique for control of downy brome and establishment of perennial grasses on rangeland. Journal of Range Management 20:35-41.

*Eckert, R.E., A.D. Bruner, G.J. Klomp and F.F. Peterson. 1973. Mountain meadow improvement through seeding. Journal of Range Management 26:200-203.

*Eckert, R.E., F.F. Peterson, M.S. Meurisse and J.L. Stephens. 1986. Effects of soil-surface morphology on emergence and survival of seedlings in big sagebrush communities. Journal of Range Management 39:414-420.

*Eckert, R.E., G.J. Klomp, R.A. Evans and J.A. Young. 1972. Establishment of perennial wheatgrasses in relation to atrazine residue in the seedbed. Journal of Range Management 25:219-224.

Ehrenfeld, J.G. 2000. Defining the limits of restoration: the need for realistic goals. Restoration Ecology 8:2-9.

*Eiswerth, M.E. and J. Scott Shonkwiler. 2006. Examining post-wildfire reseeding on arid rangeland: A multivariate tobit modelling approach. Ecological Modelling 192:286-298.

Erickson, V.J., N.L. Mandel and F.C. Sorensen. 2004. Landscape patterns of phenotypic variation and population structuring in a selfing grass, *Elymus glaucus* (blue wildrye). Canadian Journal of Botany 82:1776-1789.

Ethridge, D.E., R.D. Sherwood, R.E. Sosebee and C.H. Herbel. 1997. Economic feasibility of rangeland seeding in the arid southwest. Journal of Range Management 50:185-190.

*Evangelista, P., T.J. Stohlgren, D. Guenther and S. Stewart. 2004. Vegetation response to fire and postburn seeding treatments in juniper woodlands of the Grand Staircase-Escalante National Monument, Utah. Western North American Naturalist 64:293-305.

*Evans, R.A. and J.A. Young. 1978. Effectiveness of rehabilitation practices following wildfire in a degraded big sagebrush-downy brome community. Journal of Range Management 31:185-188.

Evans, R.A., H.R. Holbo, R.E. Eckert and J.A. Young. 1970. Functional environment of downy brome communities in relation to weed control and revegetation. Weed Science 18:154-162.

Evans, R.A., J.A. Young and B.A. Roundy. 1977. Seedbed requirements for germination of Sandberg bluegrass. Agronomy Journal 69:817-820.

*Evans, R.A., R.E. Eckert and B.L. Kay. 1967. Wheatgrass establishment with paraquat and tillage on downy brome ranges. Weeds 15:50-55.

Fetcher, N. and M.J. Trlica. 1980. Influence of climate on annual production of seven cold desert forage species. Journal of Range Management 33:35-37.

*Fisser, H.G., M.H. Mackey and J.T. Nichols. 1974. Contour-furrowing and seeding on Nuttall saltbush rangeland in Wyoming. Journal of Range Management 27:459-462.

Fox, G., J. Turner and T. Gillespie. 1999. The value of precipitation forecast information in winter wheat production. Agricultural and Forest Meteorology 95:99-111.

Francis, M.G. and D.A. Pyke. 1996. Crested wheatgrass cheatgrass seedling competition in a mixed-density design. Journal of Range Management 49:432-438.

Frank, A.B., R.E. Barker and J.D. Berdahl. 1987. Water-use efficiency of grasses grown under controlled and field conditions. Agronomy Journal 79:541-544.

Frank, K.W., R.E. Gaussion, T.P. Riordan and E.D. Miltner. 1998. Date of planting effects on seeded turf-type buffalograss. Crop Science 38:1210-1213.

Frasier, G.W., J.R. Cox and D.A. Woolhiser. 1987. Wet-dry cycle effects on warm-season grass seedling establishment. Journal of Range Management 40:2-6.

*Frischknecht, N.C. 1951. Seedling emergence and survival of range grasses in central Utah. Agronomy Journal 43:177-182.

*Frischknecht, N.C. and A.T. Bleak. 1957. Encroachment of Big Sagebrush on seeded range in northeastern Nevada. Journal of Range Management 10:165-170.

*Frischknecht, N.C. and A.P. Plummer. 1955. A comparison of seeded grasses under grazing and protection on a mountain brush burn. Journal of Range Management 8:170-175.

Fulbright, T.E., A.M. Wilson and E.F. Redente. 1985. Green needlegrass seedling morphology in relation to planting depth. Journal of Range Management 38:266-270.

*Fulbright, T.E., J.A. Ortega-Santos, A. Lozano-Cavazos and L.E. Ramirez-Yanez. 2006. Establishing vegetation on migrating inland sand dunes in Texas. Rangeland Ecology and Management 59:549-556.

Funk, J.L., E.E. Cleland, K.N. Suding, and E.S. Zavaleta. 2008. Restoration through reassembly: plant traits and invasion resistance. Trends in Ecology and Evolution 23:695-703.

Garbrecht, J.D. and J.M. Schneider. 2007. Climate forecast and prediction product dissemination for agriculture in the United States. Australian Journal of Agricultural Research 58:966-974.

Garbrecht, J.D., J.M. Schneider and M.W. Van Liew. 2006a. Monthly runoff predictions based on rainfall forecasts in a small Oklahoma watershed. Journal of the American Water Resources Association 42:1285-1295.

*Gates, D.H. 1962. Revegetation of a high-altitude, barren slope in northern Idaho. Journal of Range Management 15:314-318.

*Gates, D.H. and W.C. Robocker. 1960. Revegetation with adapted grasses in competition with dalmatian toadflax and st. johnswort. Journal of Range Management 13:322-326.

George, M.R., W.A. Williams, N.K. McDougald, W.J. Clawson and A.H. Murphy. 1989. Predicting peak standing crop on annual range using weather variables. Journal of Range Management 42:508-513.

Gershunov, A. and D.R. Cayan. 2003. Heavy daily precipitation frequency over the contiguous United States: Sources of climatic variability and seasonal predictability. Journal of Climate 16:2752-2765.

Ghersa, C.M., R.L.B. Arnold and M.A. Martinez-Ghersa. 1992. The role of fluctuating temperatures in germination and establishment of *Sorghum halepense* - regulation of germination at increasing depths. Functional Ecology 6:460-468.

Gill, B.S. and S.K. Jalota. 1996. Evaporation from soil in relation to residue rate, mixing depth, soil texture and evaporativity. Soil Technology 8:293-301.

Gillen, R.L. and P.L. Sims. 2004. Stocking rate, precipitation, and herbage production on sand sagebrush-grassland. Journal of Range Management 57:148-152.

Gimenez, R. and G. Govers. 2008. Effects of freshly incorporated straw residue on rill erosion and hydraulics. Catena 72:214-223.

*Giunta, B.C., D.R. Christensen and S.B. Monsen. 1975. Interseeding shrubs in cheatgrass with a browse seeder-scalper. Journal of Range Management 28:398-402.

Goddard, L., A.G. Barnston and S.J. Mason. 2003. Evaluation of the Iri's "net assessment" seasonal climate forecasts 1997-2001. Bulletin of the American Meteorological Society 84:1761-1781.

Goddard, L., S.J. Mason, S.E. Zebiak, C.F. Ropelewski, R. Basher and M.A. Cane. 2001. Current approaches to seasonal-to-interannual climate predictions. International Journal of Climatology 21:1111-1152.

Gokbulak, F., and C.A. Call. 2004. Grass seedling recruitment in cattle dungpats. Journal of Range Management 57:649-655.

*Gomm, F.B. 1964. A comparison of two sweetclover strains and ladak alfalfa alone and in mixtures with crested wheatgrass for range and dryland seeding. Journal of Range Management 17:19-23.

Gomm, F.B. 1974. Forage species for the northern intermountain region. a summary of seeding trails, Tech Bulletin No 1479, USDA ARS 307 pp.

*Gonzalez, C.L. and J.D. Dodd. 1979. Production response of native and introduced grasses to mechanical brush manipulation, seeding, and fertilization. Journal of Range Management 32:305-309.

*Gonzalez, C.L. and G.V. Latigo. 1981. Rootplowing, front-end stacking, and seeding effects on herbaceous plant species composition. Journal of Range Management 34:460-465.

*Great Plains Council. 1966. A Stand Establishment Survey of Grass Plantings in the Great Plains. Great Plains Council Report no. 23, University of Nebraska Agricultural Experiment Station, Lincoln, NE. 60 pp.

Groen, A.H. and S.W. Woods. 2008. Effectiveness of aerial seeding and straw mulch for reducing post-wildfire erosion, north-western Montana, USA. International Journal of Wildland Fire 17:559-571.

Grotkopp, E. and M. Rejmanek. 2007. High seedling relative growth rate and specific leaf area are traits of invasive species: Phylogenetically independent contrasts of woody angiosperms. American Journal of Botany 94:526-532.

Grotkopp, E., M. Rejmanek and T.L. Rost. 2002. Toward a causal explanation of plant invasiveness: Seedling growth and life-history strategies of 29 pine (*Pinus*) species. American Naturalist 159:396-419.

Grundy, A.C., A. Mead and S. Burston. 2003. Modelling the emergence response of weed seeds to burial depth: Interactions with seed density, weight and shape. Journal of Applied Ecology 40:757-770.

Gurevitch, J. and L.V. Hedges. 1999. Statistical issues in ecological meta-analyses. Ecology 80:1142-1149.

Gurevitch, J., L.L. Morrow, A. Wallace and J.S. Walsh. 1992. A meta-analysis of competition in field experiments. American Naturalist 140:539-572.

Gurevitch, J., P.S. Curtis and M.H. Jones. 2001. Meta-analysis in ecology. Advances in Ecological Research 199-247.

*Haas, R.H., H.L. Morton and P.J. Torell. 1962. Influence of soil salinity and 2,4-D treatments on establishment of crested wheatgrass and control of halogeton and other annual weeds. Journal of Range Management 15:205-210.

Hafenrichter, A.L. 1948. Getting new range plants into practice. Journal of Range Management 1:9-18.

*Haferkamp, M.R., D.C. Ganskopp, R.F. Miller and F.A. Sneva. 1987. Drilling versus imprinting for establishing crested wheatgrass in the sagebrush-bunchgrass steppe. Journal of Range Management 40:524-530.

Haferkamp, M.R., J.D. Volesky, M.M. Borman, R.K. Heitschmidt and P.O. Currie. 1993. Effects of mechanical treatments and climatic factors on the productivity of northern Great Plains rangelands. Journal of Range Management 46:346-350.

*Halliday, B.O. 1957. Nineteen years of range improvement on the crystal springs range demonstration area in Nevada. Journal of Range Management 10:203-207.

Hammer, G.L., J.W. Hansen, J.G. Phillips, J.W. Mjelde, H. Hill, A. Love and A. Potgieter. 2001. Advances in application of climate prediction in agriculture. Agricultural Systems 70:515-553.

Hansen, J.W. and M.V.K. Sivakumar. 2006. Advances in applying climate prediction to agriculture. Climate Research 33:1-2.

Hansen, J.W., A. Challinor, A. Ines, T. Wheeler and V. Moron. 2006. Translating climate forecasts into agricultural terms: Advances and challenges. Climate Research 33:27-41.

Hanson, C.L., J.R. Wight, J.P. Smith and S. Smoliak. 1982. Use of historical yield data to forecast range herbage production. Journal of Range Management 35:614-616.

Hanson, C.L., R.P. Morris and J.R. Wight. 1983. Using precipitation to predict range herbage production in southwestern Idaho. Journal of Range Management 36:766-770.

Hardegree, S.P. and S.S. Van Vactor. 2004. Microclimatic constraints and revegetation planning in a variable environment. Weed Technology 18:1213-1215.

Hardegree, S.P., G.N. Flerchinger and S.S. Van Vactor. 2003. Hydrothermal germination response and the development of probabilistic germination profiles. Ecological Modelling 167:305-322.

Harlan, J.R. 1951. New grasses for old ranges. Journal of Range Management 4:16-18.

Harlan, J.R. 1960. Breeding superior forage plants for the Great Plains. Journal of Range Management 13:86-89.

Harmel, R.D., K.W. King, C.W. Richardson and J.R. Williams. 2003. Long-term precipitation analyses for the central Texas blackland prairie. Transactions of the ASAE 46:1381-1388.

Harper, J.L., J.T. Williams and G.R. Sagar. 1965. The behavior of seeds in soil I. The heterogeneity of soil surfaces and its role in determining the establishment of plants from seed. Journal of Ecology 53:273-286.

Harris, G.A. and J.P. Dobrowolski. 1986. Population dynamics of seeded species on northeast Washington semiarid sites 1948-1983. Journal of Range Management 39:46-51.

*Hart, M., S.S. Waller, S.R. Lowry and R.N. Gates. 1985. Discing and seeding effects on sod bound mixed prairie. Journal of Range Management 38:121-125.

*Hart, R.H. and J.G. Dean. 1986. Forage establishment: weather effects on stubble vs. fallow and fall vs. spring seeding. Journal of Range Management 39:228-230.

Hart, R.H. and M.J. Samuel. 1985. Precipitation, soils and herbage production on southeast Wyoming range sites. Journal of Range Management 38:522-525.

Hartmann, H.C., R. Bales and S. Sorooshian. 2002. Weather, climate, and hydrologic forecasting for the US southwest: a survey. Climate Research 21:239-258 .

Hatfield, J.L. 1990. Agroclimatology of semiarid lands. Advances in Soil Science 13:9-26.

Hauser. V.L. 1982. Punch planting to establish grass. Journal of Range Management 35:294-297.

Hayman, P., J. Crean, J. Mullen and K. Parton. 2007. How do probabilistic seasonal climate forecasts compare with other innovations that Australian farmers are encouraged to adopt? Australian Journal of Agricultural Research 58:975-984.

*Heady, H.F. 1952. Reseeding, fertilizing, and renovating in an ungrazed mixed prairie. Journal of Range Management 5:144-149.

Heady, H.F. 1988. The Vale Rangeland Rehabilitation Program: An evaluation. USDA USFS PNRS Resource Bulletin PNW-RB-157 151 pp.

*Heady, H.F. and J. Bartolome. 1977. The Vale rangeland rehabilitation program: the desert repaired in southeastern Oregon. USDA FS Res. Bull PNW-70, NWFRES 139 pp.

Heckman, N.L., G.L. Horst and R.E. Gaussoin. 2002. Planting depth effect on emergence and morphology of buffalograss seedlings. HortScience 37:506-507.

*Herbel, C.H., G.H. Abernathy, C.C. Yarbrough and D.K. Gardener. 1973. Rootplowing and seeding arid rangelands in the southwest. Journal of Range Management 26:193-197.

*Hessing, M.B. and C.D. Johnson. 1982. Early secondary succession following restoration and reseeding treatments in northern Arizona. Journal of Range Management 35:667-669.

Higgins, R.W., Y. Chen and A.V. Douglas. 1999. Interannual variability of the North American warm season precipitation regime. Journal of Climate 12:653-680.

Higgins, R.W., Y. Yao and X.L. Wang. 1997. Influence of the North American monsoon system on the US summer precipitation regime. Journal of Climate 10:2600-2622.

Hobbs, R.J. and D.A. Norton. 1996. Towards a conceptual framework for restoration ecology. Restoration Ecology 4:93-110.

*Holechek, J.L. 1981. Initial establishment of four species on a mine spoils. Journal of Range Management 34:76-77.

*Holechek, J.L., E.J. Depuit, J.G. Coenenberg and R. Valdez. 1982a. Legume establishment on strip mined lands in southeastern Montana. Journal of Range Management 35:298-300.

*Holechek, J.L., E.J. Depuit, J. Coenenberg and R. Valdez. 1982b. Long-term plant establishment on mined lands in southeastern Montana. Journal of Range Management 35:522-525.

*Holechek, J.L., R.E. Estell, C.B. Kuykendall, R. Valdez, M. Cardenas and G. Nunez-Hernandez. 1989. Seeded wheatgrass yield and nutritive quality on New Mexico big sagebrush range. Journal of Range Management 42:118-122.

Holmgren, M. and M. Scheffer. 2001. El Nino as a window of opportunity for the restoration of degraded arid ecosystems. Ecosystems 4:151-159.

Hopkins, H.H. 1954. Effects of mulch upon certain factors of the grassland environment. Journal of Range Management 7:255-258.

*Houston, W.R. 1957. Seeding crested wheatgrass on drought depleted range. Journal of Range Management 10:131-134.

Houston, W.R. 1965. Soil moisture response to range improvement in the northern Great Plains. Journal of Range Management 18:25-30.

*Houston, W.R. and R.E. Adams. 1971. Interseeding for range improvement in the northern Great Plains. Journal of Range Management 24:457-461.

Hu, Q. 2003. A multidecadal variation in summer season diurnal rainfall in the central United States. Journal of Climate 16:174-178.

Hubbard, W.A. and S. Smoliak. 1953. Effect of contour dykes and furrows on short-grass prairie. Journal of Range Management 6:55-62.

*Huber-Sannwald, E. and D.A. Pyke. 2005. Establishing native grasses in a big sagebrush-dominated site: An intermediate restoration step. Restoration Ecology 13:292-301.

Hull, A.C. 1948. Depth, season and row spacing for planting grasses on southern Idaho range lands. Journal of the American Society of Agronomy 40:960-969.

*Hull, A.C. 1959. Pellet seeding of wheatgrasses on southern Idaho rangelands. Journal of Range Management 12:155-163.

*Hull, A.C. 1963. Seeding salt-desert shrub ranges in western Wyoming. Journal of Range Management 16:253-258.

Hull, A.C. 1964. Emergence of cheatgrass and three wheatgrasses from four seeding depths. Journal of Range Management 17:32-35.

*Hull, A.C. 1966. Emergence and survival of intermediate wheatgrass and smooth brome seeded on a mountain range. Journal of Range Management 19:279-283.

*Hull, A.C. 1970. Grass seedling emergence and survival from furrows. Journal of Range Management 23:421-424.

*Hull, A.C. 1971a. Grass mixtures for seeding sagebrush lands. Journal of Range Management 24:150-152.

*Hull, A.C. 1972a. Seeding rates and row spacings for rangelands in southeastern Idaho and northern Utah. Journal of Range Management 25:50-53.

Hull, A.C. 1972b. Growth characteristics of crested and fairway wheatgrasses in southern Idaho. Journal of Range Management 25:123-125.

*Hull, A.C. 1973. Duration of seeded stands on terraced mountain lands, Davis County, Utah. Journal of Range Management 26:133-136.

*Hull, A.C. 1974a. Species for seeding arid rangeland in southern Idaho. Journal of Range Management 27:216-218.

*Hull, A.C. 1974b. Seedling emergence and survival from different seasons and rates of seeding mountain rangelands. Journal of Range Management 27:302-304.

*Hull, A.C. 1974c Species for seeding mountain rangelands in southeastern Idaho, northeastern Utah and western Wyoming. Journal of Range Management 27:150-153.

Hull, A.C. and R.C. Holmgren. 1964. Seeding southern Idaho rangelands. Research Paper INT-10, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station 31p.

*Hull, A.C. and G.J. Klomp. 1966. Longevity of crested wheatgrass in the sagebrush-grass type in southern Idaho. Journal of Range Management 19:5-11.

Hull, A.C. and G.J. Klomp. 1967. Thickening and spread of crested wheatgrass stands on southern Idaho ranges. Journal of Range Management 20:222-227.

*Hull, A.C. and H. Cox. 1968. Spraying and seeding high elevation tarweed rangelands. Journal of Range Management 21:140-144.

*Humphrey, L.D. and E.W. Schupp. 1999. Temporal patterns of seedling emergence and early survival of Great Basin perennial plant species. Great Basin Naturalist 59:35-49.

Humphrey, L.D. and E.W. Schupp. 2002. Seedling survival From locally and commercially obtained seeds on two semiarid sites. Restoration Ecology 10:88-95.

*Hyder, D.N. and F.A. Sneva. 1956. Seed and plant-soil relations as affected by seedbed firmness on a sandy loam rangeland soil. Soil Science Society of America Proceedings 20:416-419.

*Hyder, D.N., A.C. Everson and R.E. Bement. 1971. Seedling morphology and seeding failures with blue grama. Journal of Range Management 24:287-292.

*Hyder, D.N., F.A. Sneva and W.A. Sawyer. 1955. Soil firming may improve range seeding operations. Journal of Range Management 8:159-163.

Jacobson, T.L.C. and B.L. Welch. 1987. Planting depth of Hobble Creek mountain big sagebrush seed. Great Basin Naturalist 47:497-499.

Jacoby, P.W. 1969. Revegetation treatments for stand establishment on coal spoil banks. Journal of Range Management 22:94-97.

Jalota, S.K. 1993. Evaporation through a soil mulch in relation to mulch characteristics and evaporativity. Australian Journal of Soil Research 31:131-136.

James, J.J. and R.E. Drenovsky. 2007. A basis for relative growth rate differences between native and invasive forb seedlings. Rangeland Ecology and Management 60:395-400.

Jensen, K.B., K.H. Asay and B.L. Waldron. 2003. Registration of RS-H hybrid wheatgrass germplasm. Crop Science 43:1139-1140.

Jensen, K.B., K.H. Asay, D.A. Johnson, W.H. Horton, A.J. Palazzo and N.J. Chatterton. 1998. Registration of RWR-Tetra-1 tetraploid Russian wildrye germplasm. Crop Science 38:1405.

Jensen, K.B., K.H. Asay, N.J. Chatterton and D.R. Dewey. 2002. Registration of *Leymus* Hybrid-1 wildrye germplasm. Crop Science 42:675-676.

Jensen, K.B., M.D. Peel, B.L. Waldron, W.H. Horton and K.H. Asay. 2005. Persistence after three cycles of selection in NewHy RS-Wheatgrass (*Elymus hoffmannii* K.B. Jensen & Asay) at increased salinity levels. Crop Science 45:1717-1720.

Jensen, K.B., W.H. Horton, R. Reed and R.E. Whitesides. 2001. Intermountain Planting Guide. Utah State University Extension Publication AG510 104 pp.

*Jessop, B.D. and V.J. Anderson. 2007. Cheatgrass invasion in salt desert shrublands: Benefits of postfire reclamation. Rangeland Ecology and Management 60:235-243.

Ji, S.N. and P.W. Unger. 2001. Soil water accumulation under different precipitation, potential evaporation, and straw mulch conditions. Soil Science Society of America Journal 65:442-448.

Johnson, D.A. and K.H. Asay. 1978. A technique for assessing seedling emergence under drought stress. Crop Science 18:520-522.

Johnson, D.A. and K.H. Asay. 1993. Viewpoint - selection for improved drought response in cool-season grasses. Journal of Range Management 46:194-202.

Johnson, D.A. and K.H. Asay. 1995. Breeding and selection of grasses for improved drought response: A review. Annals of Arid Zone 34:163-178.

Johnson, D.A., M.D. Rumbaugh and K.H. Asay. 1981. Plant improvement for semi-arid rangelands: possibilities for drought resistance and nitrogen fixation. Plant Soil 58:279-303.

Johnson, D.H. 2006. The many faces of replication. Crop Science 46:2486-2491.

*Johnson, T.N. and F.B. Gomm. 1981. Forage plantings on six Arizona pinyon-juniper subtypes. Journal of Range Management 34:131-136.

*Johnson, W.M. 1959. Grazing intensity trials on seeded ranges in the ponderosa pine zone of Colorado. Journal of Range Management 12:1-7.

Jones, T.A. 1990. A viewpoint on Indian ricegrass research. Its present status and future prospects. Journal of Range Management 43:416-420.

Jones, T.A. 1998. Viewpoint: The present status and future prospects of squirreltail research. Journal of Range Management 51:326-331.

Jones, T.A. 2003. The restoration gene pool concept: beyond the native versus non-native debate. Restoration Ecology 11:281-290.

Jones, T.A., D.C. Nielson, D.G. Ogle, D.A. Johnson and S.A. Young. 1998. Registration of sand hollow squirreltail germplasm. Crop Science 38:286.

Jones, T.A., D.C. Nielson, J.T. Arredondo and M.G. Redinbaugh. 2003. Characterization of diversity among 3 squirreltail taxa. Journal of Range Management 56:474-482.

Jordan, G.L. 1981. Range seeding and brush management on Arizona rangelands. Agricultural Experiment Station University of Arizona College of Agriculture Bulletin T81121:

*Judd, B.I. 1966. Range reseeding success on the Tonto National Forest, Arizona. Journal of Range Management 19:296-301.

*Judd, B.I. and L.W. Judd. 1976. Plant survival in the arid southwest 30 years after seeding. Journal of Range Management 29:248-251.

*Kay, B.L. and J.E. Street. 1961. Drilling wheatgrass into sprayed sagebrush in northeastern California. Journal of Range Management 14:271-273.

Khumalo, G. and J. Holechek. 2005. Relationships between Chihuahuan Desert perennial grass production and precipitation. Rangeland Ecology and Management 58:239-246.

*Kilcher, M.R. 1961. Fall seeding versus spring seeding in the establishment of five grasses and one alfalfa in southern Saskatchewan. Journal of Range Management 14:320-322.

*Kilcher, M.R. and D.H. Heinrichs. 1968. Rates of seeding rambler alfalfa with dryland pasture grasses. Journal of Range Management 21:248-249.

*Kilcher, M.R. and J. Looman. 1983. Comparative performance of some native and introduced grasses in southern Saskatchewan, Canada. Journal of Range Management 36:654-657.

Kincaid, D.R. and G. Williams. 1966. Rainfall effects on soil surface characteristics following range improvement treatments. Journal of Range Management 19:346-351.

Kindschy, R.R. 1982. Effects of precipitation variance on annual growth of 14 species of browse shrubs in southeastern Oregon. Journal of Range Management 35:265-266.

*King, M.A., S.S. Waller, L.E. Moser and J.L. Stubbendieck. 1989. Seedbed effects on grass establishment on abandoned Nebraska sandhills cropland. Journal of Range Management 42:183-187.

Kinsinger, F.E. 1962. The relationship between depth of planting and maximum foliage height of seedlings of Indian ricegrass. Journal of Range Management 15:10-13.

Kitchen, S.G. and S.B. Monsen. 1994. Germination rate and emergence success in bluebunch wheatgrass. Journal of Range Management 47:145-150.

*Klomp, G.J. and A.C. Hull Jr. 1972. Methods for seeding three perennial wheatgrasses on cheatgrass ranges in southern Idaho. Journal of Range Management 25:266-268.

Klopper, E., C.H. Vogel and W.A. Landman. 2006. Seasonal climate forecasts - Potential agricultural-risk management tools? Climatic Change 76:73-90.

Kneebone, W.R. and C.L. Cremer. 1956. Breeding for seedling vigor in sand bluestem (*Andropogon hallii* Hack.) and other native grasses. Agronomy Journal 48:37-40.

*Kocher, E. and J. Subbendieck. 1986. Broadcasting grass seed to revegetate sandy soils. Journal of Range Management 39:555-557.

Krueger-Mangold, J.M., R.L. Sheley and T.J. Svejcar. 2006. Toward ecologically-based invasive plant management on rangeland. Weed Science 54:597-605.

Kruse, R., E. Bend and P. Bierzychudek. 2004. Native plant regeneration and introduction of non-natives following post-fire rehabilitation with straw mulch and barley seeding. Forest Ecology and Management 196:299-310.

Krzysztofowicz, R. 2001. The case for probabilistic forecasting in hydrology. Journal of Hydrology 249:2-9.

Kyle, G.P., K.H. Beard and A. Kulmatiski. 2007. Reduced soil compaction enhances establishment of non-native plant species. Plant Ecology 193:223-232.

Lambert, S. 2005. Guidebook to the seeds of native and non-native grasses, forbs and shrubs of the Great Basin. Idaho BLM Technical Bulletin 2005-04 134 pp.

Lauenroth, W.K. and O.E. Sala. 1992. Long-term forage production of North American shortgrass steppe. Ecological Applications 2:397-403.

*Launchbaugh, J.L. and C.E. Owensby. 1970. Seeding rate and first-year stand relationships for six native grasses. Journal of Range Management 23:414-417.

Lavin, F. and T.N. Johnson. 1977. Species adapted for planting Arizona pinyon-juniper woodland. Journal of Range Management 30:410-415.

*Lavin, F., F.B. Gomm and T.N. Johnson. 1973. Cultural, seasonal, and site effects on pinyon-juniper rangeland plantings. Journal of Range Management 26:279-285.

*Lavin, F., T.N. Johnsen and F.B. Gomm. 1981. Mulching, furrowing, and fallowing of forage plantings on Arizona pinyon-juniper ranges. Journal of Range Management 34:171-177.

*Lawrence, B.K., S.S. Waller, L.E. Moser, B.E. Anderson and L.L. Larson. 1995. Weed suppression with grazing or atrazine during big bluestem establishment. Journal of Range Management 48:376-379.

Lawrence, T., C.D. Ratzlaff and P.G. Jefferson. 1991. Emergence of several Triticeae range grasses influenced by depth of seed placement. Journal of Range Management 44:186-187.

*Leckenby, D.A. and D.E. Toweill. 1983. Response of forage species seeded for mule deer in western juniper types of south-central Oregon. Journal of Range Management 36:98-103.

Leetmaa, A. 2003. Seasonal forecasting - innovations in practice and institutions. Bulletin of the American Meteorological Society 84:1686-1691.

Leung, L.R., Y. Qian and X.D. Bian. 2003a. Hydroclimate of the western United States based on observations and regional climate simulation of 1981-2000. Part I: seasonal statistics. Journal of Climate 16:1892-1911.

Leung, L.R., Y. Qian, X.D. Bian and A. Hunt. 2003b. Hydroclimate of the western United States based on observations and regional climate simulation of 1981-2000. Part Ii: mesoscale ENSP anomalies. Journal of Climate 16:1912-1928.

Limbach, W.E. and C.A. Call. 1995b. Establishment of *Psathyrostachys juncea* (Fisch.) Nevski seedlings on a foothill range site in central Utah. Journal of Arid Environments 31:33-44.

*Ludwig, J.R. and W.J. McGinnies. 1978. Revegetation trials on a saltgrass meadow. Journal of Range Management 31:308-311.

Mangold, J.M., C.L. Poulsen and M.F. Carpinelli. 2007. Revegetating Russian knapweed (*Acroptilon repens*) infestations using morphologically diverse species and seedbed preparation. Rangeland Ecology and Management 60:378-385.

*Marietta, K.L. and C.M. Britton. 1989. Establishment of seven high yielding grasses on the Texas High Plains. Journal of Range Management 42:289-294.

*Masters, R.A. 1995. Establishment of big bluestem and sand bluestem cultivars with metolachlor and atrazine. Agronomy Journal 87:592-596.

Masters, R.A. 1997. Influence of seeding rate on big bluestem establishment with herbicides. Agronomy Journal 89:947-951.

*Masters, R.A., D.D. Beran and R.E. Gaussoin. 2001. Restoring tallgrass prairie species mixtures on leafy spurge-infested rangeland. Journal of Range Management 54:362-369.

*Masters, R.A. and S.J. Nissen. 1998. Revegetating leafy spurge (*Euphorbia esula*)-infested rangeland with native tallgrasses. Weed Technology 12:381-390.

*Masters, R.A., K.P. Vogel, P.E. Reece and D. Bauer. 1990. Sand bluestem and prairie sandreed establishment. Journal of Range Management 43:540-544.

*Masters, R.A., S.J. Nissen, R.E. Gaussoin, D.D. Beran and R.N. Stougaard. 1996. Imidazolinone herbicides improve restoration of Great Plains grasslands. Weed Technology 10:392-403.

*Mathis, G.W., M.W. Kothmann and W.J. Waldrip. 1971. Influence of rootplowing and seeding on composition and forage production of native grasses. Journal of Range Management 24:44-46.

McClaran, M.P. and M.E. Anable. 1992. Spread of introduced Lehman lovegrass along a grazing intensity gradient. Journal of Applied Ecology 29:92-.

McGinnies, W.J. 1959. The relationship of furrow depth to moisture content of soil and to seedling establishment on range soil. Agronomy Journal 51:13-14.

*McGinnies, W.J. 1960. Effects of planting dates, seeding rates, and row spacings on range seeding results in western Colorado. Journal of Range Management 13:37-39.

*McGinnies, W.J. 1962. Effect of seedbed firming on the establishment of crested wheatgrass seedlings. Journal of Range Management 15:230-234.

*McGinnies, W.J. 1968. Effect of post-emergence weed control on grass establishment in north-central Colorado. Journal of Range Management 21:126-128.

*McGinnies, W.J. 1972. An alternate-furrow system for seeding northern Colorado rangeland. Journal of Range Management 25:450-452.

McGinnies, W.J. 1973. Effects of date and depth of planting on the establishment of three range grasses. Agronomy Journal 65:120-123.

McGinnies, W.J. 1974. Effect of planting depth on seedling growth of Russian wildrye (*Elymus junceus* Fisch.). Journal of Range Management 27:305-307.

McGinnies, W.J. 1987. Effects of hay and straw mulches on the establishment of seeded grasses and legumes on rangeland and a coal strip mine. Journal of Range Management 40:119-121.

*McGinnies, W.J., D.F. Hervey, J.A. Downs and A.C. Everson. 1963. A summary of range grass seeding trials in Colorado. Tech Bulletin 73, Colorado State University Agricultural Experiment Station.

*McKell, C.M., J.R. Goodin and C. Duncan. 1969. Chaparral manipulation affects soil moisture depletion patterns and seedling establishment. Journal of Range Management 22:159-165.

*McLean, A. and S.J. Wikeem. 1983. Effect of time of seeding on emergence and long-term survival of crested wheatgrass in British Columbia. Journal of Range Management 36:694-700.

*McMurphy, W.E. 1969. Pre-emergence herbicides for seeding range grasses. Journal of Range Management 22:427-429.

McMurray, M.H., S.H. Jenkins and W.S. Longland. 1997. Effects of seed density on germination and establishment of a native and an introduced grass species dispersed by granivorous rodents. American Midland Naturalist 138:322-330.

*McWilliams, J.L. and P.E. Van Cleave. 1960. A comparison of crested wheatgrass and native grass mixtures seeded on rangeland in eastern Montana. Journal of Range Management 13:91-94.

Meinke, H., M.V.K. Sivakumar, R.P. Motha and R. Nelson. 2007. Climate predictions for better agricultural risk management. Australian Journal of Agricultural Research 58:935-938.

Meyer, L.D., W.H. Wischmeier and G.R. Foster. 1970. Mulch rates required for erosion control on steep slopes. Soil Science Society of America Proceedings 34:928-931.

Michaud, J.D., B.A. Auvine and O.C. Penalba. 1995. Spatial and elevational variations of summer rainfall in the southwestern United States. Journal of Applied Meteorology 34: 2689-2703.

Michener, W.K. 1997. Quantitatively evaluating restoration experiments: Research design, statistical analysis, and data management considerations. Restoration Ecology 5:324-337.

Milchunas, D.G., J.R. Forwood and W.K. Lauenroth. 1994. Productivity of long-term grazing treatments in response to seasonal precipitation. Journal of Range Management 47:133-139.

*Miller, H.W., O.K. Hoglund and A.L. Hafenrichter. 1953. Reseeding to aid conservation of annual forage range. Journal of Range Management 6:414-422.

Miller, R.F., J.M. Seufert and M.R. Haferkamp. 1986. The ecology and management of bluebunch wheatgrass (*Agropyron spicatum*): a review. Agricultural Experiment Station, Oregon State University Bulletin 669. 39 pp.

Mitchell, S.W. and F. Csillag. 2001. Assessing the stability and uncertainty of predicted vegetation growth under climatic variability: northern mixed grass prairie. Ecological Modelling 139:101-121.

Mjelde, J.W., J.B. Penson and C.J. Nixon. 2000. Dynamic aspects of the impact of the use of perfect climate forecasts in the corn belt region. Journal of Applied Meteorology 39:67-79.

Mock, C.J. 1996. Climatic controls and spatial variations of precipitation in the western United States. Journal of Climate 9:1111-1125.

Monsen, S.B. and R. Stevens. 2004. Seedbed preparation and seeding practices. In: Restoring Western Ranges and Wildlands, V. 1, USDA Forest Service General Technical Report RMRS-GTR-136, 121-154.

*Mueggler, W.F. and J.P. Blaisdell. 1955. Effect of seeding rate upon establishment and yield of crested wheatgrass. Journal of Range Management 8:74-76.

*Mueller, D.M., R.A. Bowman and W.J. McGinnies. 1985. Effects of tillage and manure on emergence and establishment of Russian wildrye in a saltgrass meadow. Journal of Range Management 38:497-500.

Murphy, A.H. 1970. Predicted forage yield based on fall precipitation in California annual grasslands. Journal of Range Management 23:363-365.

Mutz, J.C. and C.J. Scifres. 1975. Soil texture and planting depth influence buffelgrass emergence. Journal of Range Management 28: 222-224.

Natural Resources Conservation Service. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. USDA NRCS Agricultural Handbook, 296, 669 pp.

*Nelson, J.R., A.M. Wilson and Goebel C.J. 1970. Factors influencing broadcast seeding in bunchgrass range. Journal of Range Management 23:163-170.

Newbauer, J.J., L.M. White, R.M. Moy and D.A. Perry. 1980. Effects of increased rainfall on native forage production in eastern Montana. Journal of Range Management 33:246-250.

Newman, P.R. and L.E. Moser. 1988. Grass seedling emergence, morphology, and establishment as affected by planting depth. Agronomy Journal 80:383-387.

*Newman, G.J. and E.F. Redente. 2001. Long-term plant community development as influenced by revegetation techniques. Journal of Range Management 54:717-724.

Nippert, J.B., A.K. Knapp and J.M. Briggs. 2006. Intra-annual rainfall variability and grassland productivity: Can the past predict the future? Plant Ecology 184:65-74.

*Nord, E.C., P.F. Hartless and W.D. Nettleton. 1971. Effects of several factors on saltbush establishment in California. Journal of Range Management 24:216-223.

Novak, M.D., W.J. Chen and M.A. Hares. 2000. Simulating the radiation distribution within a barley-straw mulch. Agricultural and Forest Meteorology 102:173-186.

Novak, M.D., W.J. Chen, A.L. Orchansky and R. Ketler. 2000. Turbulent exchange processes within and above a straw mulch. Part I: mean wind speed and turbulent statistics. Agricultural and Forest Meteorology 102:139-154.

Novak, M.D., W.J. Chen, A.L. Orchansky and R. Ketler. 2000. Turbulent exchange processes within and above a straw mulch. Part II: thermal and moisture regimes. Agricultural and Forest Meteorology 102:155-171.

*Ocumpaugh, W.R., S. Archer and J.W. Stuth. 1996. Switchgrass recruitment from broadcast seed vs seed fed to cattle. Journal of Range Management 49:368-371.

Ogallo, L.A., M.S. Boulahya and T. Keane. 2000. Applications of seasonal to interannual climate prediction in agricultural planning and operations. Agricultural and Forest Meteorology 103:159-166.

Ogle, D., L. St. John, J. Cornwell, M. Stannard and L. Holzworth. 2008a. Pasture and range seedings: planning-installation-evaluation-management. USDA NRCS Technical Note, PM-TN-10, 36 pp.

Ogle, D., L. St. John, M. Stannard and L. Holzworth. 2008b. Grass, grass-like, forb, legume, and woody species for the Intermountain west. USDA NRCS Technical Note, TN Plant Materials No. 24, 43 pp.

*Oldfather, S., J. Stubbendieck and S.S. Waller. 1989. Evaluating revegetation practices for sandy cropland in the Nebraska Sandhills. Journal of Range Management 42:257-259.

O'Lenic, E.A., D.A. Unger, M.S. Halpert and K.S. Pelman. 2008. Developments in operational long-range climate prediction at CPC. Weather and Forecasting 23:496-515.

Olson, K.C., R.S. White and B.W. Sindelar. 1985. Response of vegetation of the northern Great Plains to precipitation amount and grazing intensity. Journal of Range Management 38:357-361.

Osenberg, C.W., O. Sarnelle and D.E. Goldberg. 1999b. Meta-analysis in ecology: concepts, statistics, and applications. Ecology 80:1103-1104.

Osenberg, C.W., O. Sarnelle, S.D. Cooper and R.D. Holt. 1999a. Resolving ecological questions through meta-analysis: goals, metrics, and models. Ecology 80:1105-1117.

*Ott, J.E., E.D. McArthur and B.A. Roundy. 2003. Vegetation of chained and non-chained seedings after wildfire in Utah. Journal of Range Management 56:81-91.

*Owensby, C.E. and K.L. Anderson. 1965. Reseeding "go-back" land in the Flint Hills of Kansas. Journal of Range Management 18:224-225.

*Papanastasis, V. and H.H. Biswell. 1975. Seeding rate-cover relationships of annual ryegrass seeded on burned brushlands. Journal of Range Management 28:402-406.

*Passey, H.B. and D.S. Winn. 1953. Management of reseeded range and its place in ranch operation. Journal of Range Management 6:11-15.

Pastorok, R.A., A. MacDonald, J.R. Sampson, P. Wilber, D.J. Yozzo and J.P. Titre. 1997. An ecological decision framework for environmental restoration projects. Ecological Engineering 9:89-107.

Patton, B.D., X. Dong, P.E. Nyren and A. Nyren. 2007. Effects of grazing intensity, precipitation, and temperature on forage production. Rangeland Ecology and Management 60:656-665.

Peters, D.P.C. 2000. Climatic variation and simulated patterns in seedling establishment of two dominant grasses at a semi-arid-arid grassland ecotone. Journal of Vegetation Science 11:493-504.

*Pinchak, B.A., G.E. Schuman and E.J. Depuit. 1985. Topsoil and mulch effects on plant species and community responses of revegetated mined land. Journal of Range Management 38:262-265.

Pitman, W.D. and C.C. Jaymes. 1980. Strains of blue grama and sideoats grama evaluated for the southern great plains. Journal of Range Management 33:381-384.

Plummer, P.A., D.R. Christensen and S.B. Monsen. 1968. Restoring big-game range in Utah. Utah Division of Fish and Game Publication No. 68-3 183 pp.

Pokorny, M.L., R.L. Sheley, C.A. Zabinski, R.E. Engel, T.J. Svejcar and J.J. Borkowski. 2005. Plant functional group diversity as a mechanism for invasion resistance. Restoration Ecology 13:448-459.

Powell, J., S.J. Stadler and P.L. Claypool. 1986. Weather factors affecting 22 years of tallgrass prairie hay production and quality. Journal of Range Management 39:354-361.

*Powell, K.B., R.B. Vincent, E.J. Depuit, J.L. Smith and F.E. Parady. 1990. Role of irrigation and fertilization in revegetation of cold desert mined lands. Journal of Range Management 43:449-455.

Power, S.B., N. Plummer and P. Alford. 2007. Making climate model forecasts more useful. Australian Journal of Agricultural Research 58:945-951.

Pyke, D.A. and S. Archer. 1991. Plant-plant interactions affecting plant establishment and persistence on revegetated rangeland. Journal of Range Management 44:550-55.

Rajagopalan, B. and U. Lall. 1998. Interannual variability in western US precipitation. Journal of Hydrology 210:51-67.

*Ralphs, M.H. and F.E. Busby. 1979. Prescribed burning: vegetative change, forage production, cost, and returns on six demonstration burns in Utah. Journal of Range Management 32:267-270.

*Ratzlaff, T.D. and J.E. Anderson. 1995. Vegetal recovery following wildfire in seeded and unseeded sagebrush steppe. Journal of Range Management 48:386-391.

Rayner, S., D. Lach and H. Ingram. 2005. Weather forecasts are for wimps: why water resource managers do not use climate forecasts. Climatic Change 69:197-227.

Redente, E.F. and E.J. Depuit. 1988. Reclamation of drastically disturbed rangelands. In: P.T. Tueller (ed.) Vegetation Science Applications for Rangeland Analysis and Management 559-589.

*Redente, E.F., T. McLendon and W. Agnew. 1997. Influence of topsoil depth on plant community dynamics of a seeded site in northwest Colorado. Arid Soil Research and Rehabilitation 11:139-149.

Redmann, R.E. and M.Q. Qi. 1992. Impacts of seeding depth on emergence and seedling structure in 8 perennial grasses. Canadian Journal of Botany 70:133-139.

Rehfeldt, G.E., N.L. Crookston, M.V. Warwell and J.S. Evans. 2006. Empirical analyses of plant-climate relationships for the western United States. International Journal of Plant Sciences 167:1123-1150.

Richards, R.T., J.C. Chambers and C. Ross. 1998. Use of native plants on federal lands: Policy and practice. Journal of Range Management 51:625-632.

*Riegel, D.A., F.W. Albertson, G.W. Tomanek and F.E. Kinsinger. 1963. Effects of grazing and protection on a twenty-year-old seeding. Journal of Range Management 16:60-63.

Ries, R.E. and L. Hofmann. 1995. Grass seedling morphology when planted at different depths. Journal of Range Management 48:218-223.

*Ries, R.E., F.M. Sandoval and J.F. Power. 1988. Irrigation water for vegetation establishment. Journal of Range Management 41:210-215.

*Ries, R.E. and L. Hofmann. 1996. Perennial grass establishment in relationship to seeding dates in the northern Great Plains. Journal of Range Management 49:504-508.

*Ries, R.E. and T.J. Svejcar. 1991. The grass seedling: When is it established? Journal of Range Management 44:574-576.

*Robertson, J.H., R.E. Eckert and A.T. Bleak. 1966. Responses of grasses seeded in an *Artemisia tridentata* habitat in Nevada. Ecology 47:187-194.

*Robertson, J.H. and C.K. Pearse. 1945. Artificial reseeding and the closed community. Northwest Science 19:58-66.

*Robertson, T.E. and T.W. Box. 1969. Interseeding sideoats grama on the Texas high plains. Journal of Range Management 22:243-245.

Robins, J.G., B.L. Waldron, K.P. Vogel, J.D. Berdahl, M.R. Haferkamp, K.B. Jensen, T.A. Jones, R. Mitchell and B.K. Kindiger. 2007. Characterization of testing locations for developing cool-season grass species. Crop Science 47:1004-1012.

*Robocker, W.C. and R.D. Schirman. 1976. Reseeding trails on Columbia Basin rangelands dominated by winter annual grasses. Journal of Range Management 29:492-497.

*Robocker, W.C., D.H. Gates and H.D. Kerr. 1965. Effects of herbicides, burning, and seeding date in reseeding an arid range. Journal of Range Management 18:114-118.

Rogler, G.A. and R.J. Lorenz. 1983. Crested wheatgrass-early history in the United States. Journal of Range Management 36:91-93.

*Romo, J.T. and R.W. Grilz. 2002. Establishment of silver sagebrush in the northern mixed prairie. Journal of Range Management 55:217-221.

*Rose, K.K., A.L. Hild, T.D. Whitson, D.W. Koch and L. Van Tassell. 2001. Competitive effects of cool-season grasses on re-establishment of three weed species. Weed Technology 15:885-891.

*Roundy, B.A. 1985. Emergence and establishment of Basin wildrye and tall wheatgrass in relation to moisture and salinity. Journal of Range Management 38:126-131.

Roundy, B.A. 1996. Revegetation of Rangelands for Wildlife - Chapter 21. Rangeland Wildlife, Paul R. Krausman (ed.), p. 355-368.

Roundy, B.A. and C.A. Call. 1988. Revegetation of arid and semiarid rangelands. In: Tueller, P.T. (ed.), Vegetation Science Applications for Rangeland Analysis and Management, Kluwer Academic Publishers, Dordrecht, 607-635.

Roundy, B.A., R.N. Keys and V.K. Winkel. 1990. Soil response to cattle trampling and mechanical seedbed preparation. Arid Soil Research and Rehabilitation 4:233-242.

Roundy, B.A., V.K. Winkel, H. Khalifa and A.D. Matthias. 1992. Soil water availability and temperature dynamics after one-time heavy cattle trampling and land imprinting. Arid Soil Research and Rehabilitation 6:53-69.

Roundy, B.A., V.K. Winkel, J.R. Cox, A.K. Dobrenz and H. Tewolde. 1993. Sowing depth and soil water effects on seedling emergence and root morphology of three warm-season grasses. Agronomy Journal 85:975-982.

Rumbaugh, M.D. and D.A. Johnson. 1986. Annual medics and related species as reseeding legumes for northern Utah pastures. Journal of Range Management 39:52-58.

*Rumbaugh, M.D. and M.W. Pedersen. 1979. Survival of alfalfa in five semiarid range seedings. Journal of Range Management 32:48-51.

*Rumbaugh, M.D. and T. Thorn. 1965. Initial stands of interseeded alfalfa. Journal of Range Management 18:258-261 .

Sanderson, M.A. and G.F. Elwinger. 2004. Emergence and seedling structure of temperate grasses at different planting depths. Agronomy Journal 96:685-691.

Schneider, J.M. and J.D. Garbrecht. 2003. A measure of the usefulness of seasonal precipitation forecasts for agricultural applications. Transactions of the ASAE 46:257-267.

Schneider, J.M. and J.D. Garbrecht. 2006. Dependability and effectiveness of seasonal forecasts for agricultural applications. Transactions ASABE 49:1737-1753.

Schubert, S.D., M.J. Suarez, P.J. Pegion, R.D. Koster and J.T. Bacmeister. 2004. Causes of long-term drought in the US Great Plains. Journal of Climate 17:485-503.

Schubert, S.D., M.J. Suarez, P.J. Pegion, R.D. Koster and J.T. Bacmeister. 2008. Potential predictability of long-term drought and pluvial conditions in the U.S. Great Plains. Journal of Climate 21:802-816.

*Schultz, A.M. and H.H. Biswell. 1952. Competition between grasses reseeded on burned brushlands in California. Journal of Range Management 5:338-345.

*Schuman, G.E., D.T. Booth and J.R. Cockrell. 1998. Cultural methods for establishing Wyoming big sagebrush on mined lands. Journal of Range Management 51:223-230.

Schuman, G.E., E.M. Taylor, F. Rauzi and B.A. Pinchak. 1985. Revegetation of mined land: influence of topsoil depth and mulching method. Journal of Soil and Water Conservation 40:249-252.

Schussman, H., E. Geiger, T. Mau-Crimmins and J. Ward. 2006. Spread and current potential distribution of an alien grass, *Eragrostis lehmanniana* Nees, in the southwestern USA: comparing historical data and ecological niche models. Diversity and Distributions 12:582-592.

Schwendiman, J.L. 1956. Improvement of native range through new grass introduction. Journal of Range Management 9:91-95.

Schwendiman, J.L. 1958. Testing new range forage plants. Journal of Range Management 11:71-76.

*Shaw, N.L., M.R. Haferkamp and E.G. Hurd. 1994. Germination and seedling establishment of spiny hopsage in response to planting date and seed-bed environment. Journal of Range Management 47:165-174.

Sheaffer, C.C., P.R. Peterson, M.H. Hall and J.B. Stordahl. 1992. Drought effects on yield and quality of perennial grasses in the north central United-States. Journal of Production Agriculture 5:556-561.

*Sheley, R.L. 2007. Revegetating Russian knapweed (*Acroptilon repens*) and green rabbitbrush (*Ericameria teretifolia*) infested rangeland in a single entry. Weed Science 55:365-370.

*Sheley, R.L., J.S. Jacobs and T.J. Svejcar. 2005. Integrating disturbance and colonization during rehabilitation of invasive weed-dominated grasslands. Weed Science 53:307-314.

Sheley, R.L. and M.L. Half. 2006. Enhancing native forb establishment and persistence using a rich seed mixture. Restoration Ecology 14:627-635.

*Sheley, R.L., J.S. Jacobs and D.E. Lucas. 2001. Revegetating spotted knapweed infested rangeland in a single entry. Journal of Range Management 54:144-151.

*Sheley, R.L., J.S. Jacobs and R.P. Velagala. 1999. Enhancing intermediate wheatgrass establishment in spotted knapweed infested rangeland. Journal of Range Management 52:68-74.

Sheley, R.L., J.M. Mangold and J.L. Anderson. 2006. Potential for successional theory to guide restoration of invasive-plant-dominated rangeland. Ecological Monographs 76:365-379.

Sheley, R.L., T.J. Svejcar and B.D. Maxwell. 1996. A theoretical framework for developing successional weed management strategies on rangeland. Weed Technol. 10:766-773.

Sheppard, P.R., A.C. Comrie, G.D. Packin, K. Angersbach and M.K. Hughes. 2002. The climate of the US southwest. Climate Research 21:219-238.

Shiflet, T.N. 1994. Rangeland Cover Types of the United States. Society for Range Management, Denver, Colorado 152 pp.

Shiflet, T.N. and H.E. Dietz. 1974. Relationship between precipitation and annual rangeland herbage production in southeastern Kansas. Journal of Range Management 27:272-276.

Shown, L.M., R.F. Miller and F.A. Branson. 1969. Sagebrush conversion to grassland as affected by precipitation, soil, and cultural practices. Journal of Range Management 22:303-311.

Simpson, H.J. and D.C. Colodner. 1999. Arizona precipitation response to the southern oscillation: a potential water management tool. Water Resources Research 35:3761-3769.

Sivakumar, M.V.K. 2006. Climate prediction and agriculture: Current status and future challenges. Climate Research 33:3-17.

*Skousen, J.G., J.N. Davis and J.D. Brotherson. 1989. Pinyon-juniper chaining and seeding for big game in central Utah. Journal of Range Management 42:98-104.

*Slayback, R.D. and C.W. Renney. 1972. Intermediate pits reduce gamble in range seeding in the southwest. Journal of Range Management 25:224-227.

*Slayback, R.D. and D.R. Cable. 1970. Larger pits aid reseeding of semidesert rangeland. Journal of Range Management 23:333-335.

Smart, A.J., B.H. Dunn, P.S. Johnson, L. Xu and R.N. Gates. 2007. Using weather data to explain herbage yield on three great plains plant communities. Rangeland Ecology and Management 60:146-153.

Smart, A.J., L.E. Moser and K.P. Vogel. 2004. Morphological characteristics of big bluestem and switchgrass plants divergently selected for seedling tiller number. Crop Science 44:607-613.

Smoliak, S. 1956. Influence of climatic conditions on forage production of shortgrass rangeland. Journal of Range Management 9:89-91.

Smoliak, S. 1986. Influence of climatic conditions on production of *Stipa-bouteloua* prairie over a 50-year period. Journal of Range Management 39:100-103.

Smoliak, S., A. Johnston and L.E. Lutwick. 1967. Productivity and durability of crested wheatgrass in southeastern Alberta. Canadian Journal of Plant Science 47:539-548.

Sneva, F.A. 1977. Correlations of precipitation and temperature with spring, regrowth, and mature crested wheatgrass yields. Journal of Range Management 30:270-275.

Sours, J.M. 1983. Characteristics and uses of important grasses for arid western rangelands. In: Proceedings - Managing intermountain rangelands - Improvement of range and wildlife habitat. S.B. Monson and N. Shaw (comp.). USDA Forest Service General Technical Report INT-157.

Springfield, H.W. and D.G. Bell. 1967. Depth to seed fourwing saltbrush. Journal of Range Management 20:180-182.

Statler, G.D. 1967. Establishment trials. Journal of Range Management 20:253-255.

Stevens, R. 2004. Basic considerations for range and wildland revegetation and restoration. In: Restoring Western Ranges and Wildlands, USFS General Technical Report RMRS-GTR-136 V.1:19-23.

*Stevenson, B.A., T. Mclendon and E.F. Redente. 2000. Effects of soil fumigation and seeding regimes on secondary succession in a semiarid shrubland. Arid Soil Research and Rehabilitation 14:87-99.

*Stewart, G. 1950. Reseeding research in the intermountain region. Journal of Range Management 3:52-59.

Stoddart, L.A. and A.D. Smith. 1943. Range Management. McGraw-Hill, New York 547 pp.

Stoddart, L.A. and A.D. Smith. 1955. Range Management. McGraw-Hill Book Company, Inc., NY 433.

*Stroh, J.R. and V.P. Sundberg. 1971. Emergence of grass seedlings under crop residue culture. Journal of Range Management 24:226-230.

*Stubbendieck, J. and W.G. McCully. 1972. Factors affecting germination, emergence and establishment of sand bluestem. Journal of Range Management 25:383-385.

*Stubbendieck, J., P.T. Koshi and W.G. McCully. 1973. Establishment and growth of selected grasses. Journal of Range Management 26:39-41.

Stuth, J.W. and B.E. Dahl. 1974. Evaluation of rangeland seedings following mechanical brush control in Texas. Journal of Range Management 27:146-149.

*Thompson, T.W., B.A. Roundy, E.D. McArthur, B.D. Jessop, B. Waldron and J.N. Davis. 2006. Fire rehabilitation using native and introduced species: A landscape trial. Rangeland Ecology and Management 59:237-248.

*Tiedemann, A.R. and E.M. Schmutz. 1966. Shrub control and reseeding effects on the oak chaparral of Arizona. Journal of Range Management 19:191-195.

Traba, J., F.M. Azcarate and B. Peco. 2004. From what depth do seeds emerge? A soil seed bank experiment with Mediterranean grassland species. Seed Science Research 14:297-303.

Traba, J., C. Levassor and B. Peco. 2003. Restoration of species richness in abandoned Mediterranean grasslands: seeds in cattle dung. Restoration Ecology 11:378-384.

Tromble, J.M. 1976. Semiarid rangeland treatment and surface runoff. Journal of Range Management 29:251-255.

Trupp, C.R. and I.T. Carlson. 1971. Improvement of seedling vigor of smooth bromegrass (*Bromus inermis* Leyss.) by recurrent selection for high seed weight. Crop Science 11:225-228.

Vallentine, J.F. 1979. Range Development and Improvements second edition. Brigham Young University Press, Provo, UT 545 pages.

Vaness, B.M. and S.D. Wilson. 2007. Impact and management of crested wheatgrass (*Agropyron cristatum*) in the northern Great Plains. Canadian Journal of Plant Science 87:1023-1028.

Vargas, M., J. Crossa, F. Van Eeuwijk, K.D. Sayre and M.P. Reynolds. 2001. Interpreting treatment X environment interaction in agronomy trials. Agronomy Journal 93:949-960.

Vogel, K.P. 1987. Seeding rates for establishing big bluestem and switchgrass with preemergence atrizine applications. Agronomy Journal 79:509-512.

Vogel, K.P. and K.J. Jensen. 2001. Adaptation of perennial Triticeae to the eastern Central Great Plains. Journal of Range Management 54:674-679.

Vogel, K.P., M.R. Schmer and R.B. Mitchell. 2005. Plant adaptation regions: ecological and climatic classification of plant materials. Rangeland Ecology and Management 58:315-319.

Vogel, W.G. 1963. Planting depth and seed size influence emergence of beardless wheatgrass seedlings. Journal of Range Management 16:273-275.

*Waldron, B.L., T.A. Monaco, K.B. Jensen, R.D. Harrison, A.J. Palazzo and J.D. Kulbeth. 2005. Coexistence of native and introduced perennial grasses following simultaneous seeding. Agronomy Journal 97:990-996.

*Warnes, D.D. and L.C. Newell. 1969. Establishment and yield responses of warm-season grass strains to fertilization. Journal of Range Management 22:235-240.

*Wein, R.W. and N.E. West. 1971. Seedling survival on erosion control treatments in a salt desert area. Journal of Range Management 24:352-357.

Wernstedt, F.L. 1960. "Climatic fluctuations in the Great Basin, 1931-56". Journal of Range Management 13:173-178.

Westoby, M., B. Walker and I. Noy-Meir. 1989. Opportunistic management for rangelands not at equilibrium. Journal of Range Management 42:266-274.

Whisenant, S.G. 1999. Repairing Damaged Wildlands: A Process-Oriented, Landscape-Scale Approach. Cambridge University Press, Cambridge, UK 312 pp.

White, L.M. 1985. Stand age, precipitation, and temperature effects on forage yield. Journal of Range Management 38:39-43.

*Wiedemann, A.T. and B.T. Cross. 2001. Chain diker effects on seeded grass establishment following disk chaining. Journal of Range Management 54:138-143.

*Wiedemann, H.T. and B.T. Cross. 2000. Disk chain effects on seeded grass establishment. Journal of Range Management 53:62-67.

*Wight, J.R. and L.M. White. 1974. Interseeding and pitting on a sandy range site in eastern Montana. Journal of Range Management 27:206-210.

Wight, J.R. and R.J. Hanks. 1981. A water-balance, climate model for range herbage production. Journal of Range Management 34:307-311.

Wight, J.R., C.L. Hanson and D. Whitmer. 1984. Using weather records with a forage production model to forecast range forage production. Journal of Range Management 37:3-6.

*Willard, E.E. and J.L. Schuster. 1971. An evaluation of an interseeded sideoats grama stand four years after establishment. Journal of Range Management 24:223-226.

*Williams, M.I., G.E. Schuman, A.L. Hild and L.E. Vicklund. 2002. Wyoming big sagebrush density: effects of seeding rates and grass competition. Restoration Ecology 10:385-391.

*Wilson, S.D. and A.K. Gerry. 1995. Strategies for mixed-grass prairie restoration: Herbicide, tilling, and nitrogen manipulation. Restoration Ecology 3:290-298.

*Winkel, V.K. and B.A. Roundy. 1991. Effects of cattle trampling and mechanical seedbed preparation on grass seedling emergence. Journal of Range Management 44:176-180.

Winkel, V.K., B.A. Roundy and D.K. Blough. 1991a. Effects of seedbed preparation and cattle trampling on burial of grass seeds. Journal of Range Management 44:171-175.

Winkel, V.K., B.A. Roundy and J.R. Cox. 1991b. Influence of seedbed microsite characteristics on grass seedling emergence. Journal of Range Management 44:210-214.

*Wood, M.K., R.E. Eckert, W.H. Blackburn and F.F. Peterson. 1982. Influence of crusting soil surfaces on emergence and establishment of crested wheatgrass, squirreltail, thurber needlegrass and fourwing saltbush. Journal of Range Management 35:282-287.

Workman, J.P. and J.A. Tanaka. 1991. Economic feasibility and management considerations in range revegetation. Journal of Range Management 44:566-573.

Wright, L.N. and G.L. Jordan. 1970. Artificial selection for seedling drought tolerance in Boer lovegrass (*Eragrostis curvula* Nees.). Crop Science 10:99-102.

*Young, J.A., R.R. Blank, W.S. Longland and D.E. Palmquist. 1994. Seeding Indian ricegrass in an arid environment in the Great Basin. Journal of Range Management 47:2-7.

*Young, J.A., C.D. Clements and R.R. Blank. 1997. Influence of nitrogen on antelope bitterbrush seedling establishment. Journal of Range Management 50:536-540.

*Young, J.A., R.A. Evans and R.E. Eckert. 1969a. Emergence of medusahead and other grasses from four seeding depths. Weed Science 17:376-379.

*Young, J.A., R.A. Evans and R.E. Eckert. 1969b. Wheatgrass establishment with tillage and herbicides in a mesic medusahead community. Journal of Range Management 22:151-155.

Young, J.A., R.A. Evans and D. Palmquist. 1990. Soil surface characteristics and emergence of big sagebrush seedlings. Journal of Range Management 43:358-367.

Zebiak, S.E. 2003. Research potential for improvements in climate prediction. Bulletin of the American Meteorological Society 84:1692-1696.

Zhang, J. and M.A. Maun. 1990a. Effects of sand burial on seed germination, seedling emergence, survival, and growth of *Agropyron psamophilum*. Can. J. Bot. 68:304-310.

84601; 4Research Geneticist, USDA Agricultural Research Service, Forage and Range Research Laboratory, Logan, UT 84322-6300; and 5Range Trend Project Director, Utah Division of Wildlife Resources, 735 N 500 E, Provo, UT 84601. Abstract.Â At the time of research, Thompson was a graduate student, Botany and Range Science, Brigham Young University, Provo, UT 84602. Correspondence: Bruce Roundy, Dept of Integrative Biology, 401 WIDB, Brigham Young University, Provo, UT 84602. Email: bruce_roundy@byu.edu. Manuscript received 11 July 2005; manuscript accepted 22 February 2006. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us /database/feis/plants/graminoid/agrcri/all.html. []. ABBREVIATIONÂ SPECIES: Agropyron cristatum. Importance to livestock and wildlife. Palatability. Nutritional value.Â Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 110-115. [356]. 6. Asay, K. H.; Knowles, R. P. 1985. Current status and future of introduced wheatgrasses and wildrye for rangeland improvement. In: Carlson, Jack R.; McArthur, E. Durant, chairmen. 1Plant and Wildlife Sciences, Brigham Young University, Provo, UT, USA 2USDA Forest Service, Rocky Mountain Research Station, Provo, UT, USA 3U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Boise, ID, USA. Correspondence Lindsay Chaney, Department of Biology, Snow College, Ephraim, UT, USA. Email: lindasy.chaney@snow.edu. Present address Lindsay Chaney, Department of Biology, Snow College, Ephraim, UT, USA. Funding information Great Basin Native Plant Program; USDA Forest Service National Fire Plan. Abstract A genecological approach was used to explore genetic variation Brigham Young Universityâ€“Hawaii is the preeminent international center of learning in the Pacific. Its small campus is a unique laboratory of intercultural leadership development, where a diverse population of 3,000 students representing over 70 countries live, study, and work together.Â Brigham Young Universityâ€“Hawaii Student Life Vice President Jonathan Kala Kau announced the appointment of Alison Whiting as the director of campus life. This is a new position that will oversee the newly envisioned HoÊ»okahua department, which has broad stewardship for the Student Leadership & Service, Seasider Sports & Activities, Residential Life, and the Office of Honor departments. Devotionals. Koau â€˜Eni: It Is Me.