

Nursery and Landscape Performance of Ornamental Junipers in the Southern Rocky Mountains

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ADDITIONAL INDEX WORDS: xeriscape, *Juniperus*, landscaping

SUMMARY. Supplying landscape plants for expanding urban centers in the southern Rocky Mountains provides a solution to limited-resource producers wishing to convert from traditional agricultural crops to higher value horticultural crops in this region. Thirty-five cultivars of ornamental junipers (*Juniperus* sp.) were planted in an abandoned agricultural field in Mora, N.M., to evaluate their suitability for nursery production in this region. The plantings were measured after 4 years, and cultivars were ranked for nursery suitability. The planting was then grown for an additional 16 years to examine landscape performance. Nineteen cultivars were considered suitable for nursery production with five cultivars being highly recommended based on survival and growth. Twenty-five of the cultivars were considered suitable for landscape use in the foothill region of the southern Rocky Mountains based on the 20-year measurements. Nine cultivars were classified as highly recommended. Production of ornamental junipers provides an economical alternative to traditional agricultural production systems.

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This research was funded, in part, through grant from McIntire-Stennis and the New Mexico Agricultural Experiment Station. The cost of publishing this paper was defrayed, in part, by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked advertisement solely to indicate this fact.

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The southern Rocky Mountain region has experienced significant population growth since the mid 1970s. Most growth has been in the foothill and lower slope portions of the region in an elevation range of 1,650 to 2450 m (5400 to 8000 ft). In New Mexico, much of this growth has occurred in Rio Arriba, San Miguel, Santa Fe, and Taos counties of north central New Mexico. Population increases in these four counties from 1980 to 1990 ranged from 13.2% in San Miguel County to 31.3% in Santa Fe County (University of New Mexico, 1995). Urban and suburban centers in this region accounted for most of this growth (University of New Mexico, 1994, 1995). The growth trend is expected to continue in these counties over the next several decades with a projected population increase from ≈183,000 to >284,000 in 2020 (University of New Mexico, 1994).

These municipalities have expanded into semiarid regions with limited supplies of underground and surface water. To satisfy the increasing demands on these water supplies, most municipalities have employed various water conservation measures, including the required use of xeriscape designs for new residential and commercial developments. Enforcement of these xeriscape ordinances has challenged landscapers and homeowners to design and establish species-diverse landscapes. Many native plants from the lower elevation Chihuahuan and Sonoran Deserts used in xeriscapes elsewhere in the southwest United States are not suited to the colder climates found at these higher elevations.

Juniper has been characterized as one of the toughest groups of evergreen landscape plants (Dirt, 1983). Juniper species are ideally suited for landscaping in the foothill region of the southern Rocky Mountains because of their ability to tolerate prolonged drought and wide temperature extremes. Junipers, with a wide range of growth forms, can be used in numerous ways in a landscape, from a ground cover to a solitary tree.

In contrast to population growth in urban areas, rural populations of these and adjacent counties have stagnated, and in some cases decreased, over the past three decades (University

of New Mexico, 1995). The economy of these rural regions remains largely based in agricultural enterprises, primarily ranching and small agricultural production systems. The marginal profitability of these enterprises has contributed to the overall downturn in these rural economies and the efflux of their residents.

The Mora Valley, in north central New Mexico, is typical of many of these rural agricultural communities in the southern Rocky Mountains. Traditionally an agricultural valley, the Mora Valley is currently characterized by small family owned farms. One opportunity to offset the overall economic downturn characteristic of small agricultural enterprises throughout the country is to change from traditional crops such as alfalfa to high value horticultural crops. However, the short, 105-d growing season, the cool night temperatures, a limited water supply, and the distance from large commercial markets combine to exclude most alternative horticultural crops that can be produced economically in these areas. One solution is to produce Christmas trees, which for decades have been harvested from native forests and have provided a significant and ongoing economic enterprise in the Mora Valley (Harrington, 1994).

A transition from traditional land uses to Christmas tree production would create a more sustainable and profitable enterprise than is attainable with trees harvested from the forest, but such a transition faces many obstacles. A primary difficulty with conversion to Christmas tree production is its slow return on investment (Gorman et al., 1989). Production of marketable Christmas trees in this valley requires 6 to 9 years, depending on the species and management (Gorman et al., 1989; Harrington, 1994). A potential solution is to produce an interim high value crop, such as ornamental junipers, marketable in the expanding urban and suburban centers of the region. The junipers could be interplanted with the Christmas trees, providing an interim return on investment in 3 to 4 years. Investment in land would remain unchanged, however, plant material costs would be increased. Irrigation costs would remain similar, as most of this area is flood irrigated from surface water sources.

The objectives of this study were to 1) examine the feasibility (based on survival and growth) of commercial production of junipers in north central New Mexico for landscape applications and 2) evaluate the performance of these juniper cultivars over 20 years in the landscape.

Materials and methods

Thirty-five cultivars of junipers, representing seven species, were evaluated (Table 1). Plants, originally rooted into 6.25-cm³ (0.4-inch³) rose pots, were transplanted at the end of the

growing season (August 1976) into 3.8-L (1-gal) pots containing a (by volume) mixture of 1 composted sawdust (mixed fir and pine) : 1 soil : 1 sand. Plants were grown and overwintered in a lath house through the spring and transplanted into the field in June 1977. Plants were fertilized weekly through the end of the growing seasons with liquid fertilizer (75N-21P-29K). At the end of September, plants were fertilized with one application of 10N-12P-15K.

The planting site, New Mexico State University's Mora Research Cen-

ter, is located at ≈2,200 m (7200 ft) and has an average frost-free period of 105 d. The soils of the planting site are a Brycan loam (fine, loamy, mixed cumulic haploboroll). Following planting, plants were irrigated once every month for the first three growing seasons. To examine landscape performance (survival and growth), no further irrigation was provided from the 4th through 18th growing seasons.

The experimental design was a randomized complete block design with six blocks. Each cultivar was represented by 13 plants per block. Tree

Table 1. Survival, mean height and mean spread of field grown ornamental juniper cultivars after three growing seasons at Mora, N.M., from 1977 through Spring 1980 (±standard error).

Species	Cultivar	Survival		Mean ht (cm) ±SE	Mean spread (cm) ±SE
		(%)	(LSD ^a)		
Spreading					
<i>J. chinensis</i>	'Armstrong'	45	d-g	33 ± 2.8	18 ± 1.0
	'Mint Julep'	88	a-c	30 ± 1.0	15 ± 1.9
	'Pfitzeriana Glauca'	58	b-g	35 ± 4.8	19 ± 3.8
	var sargentii 'Glauca'	78	a-f	18 ± 1.9	16 ± 0.2
<i>J. horizontalis</i>	'Bar Harbor'	60	a-g	18 ± 2.6	16 ± 3.4
	'Emerald Spreader'	77	a-d	15 ± 1.3	19 ± 1.6
	'Turquoise Spreader'	40	g	20 ± 1.5	18 ± 3.7
	'Emerson's Creeper'	83	a-c	18 ± 0.3	14 ± 2.6
<i>J. procumbens</i>	'Hughes'	90	a-b	13 ± 2.1	11 ± 0.6
	'Nana'	77	a-d	23 ± 1.1	15 ± 4.7
<i>J. sabina</i>	'Arcadia'	78	a-c	40 ± 1.5	18 ± 5.7
	'Broadmoor'	75	a-c	15 ± 2.1	17 ± 0.6
	'Buffalo'	85	a-c	20 ± 2.0	19 ± 2.7
	'Skandia'	60	a-g	20 ± 1.5	20 ± 1.0
	var tamariscifolia	82	a-c	20 ± 2.5	18 ± 0.7
<i>J. scopulorum</i>	'Tabletop Blue'	92	a	30 ± 1.1	13 ± 1.3
<i>J. flaccida</i>	'Expansa'	92	a	20 ± 0.9	10 ± 1.1
<i>J. virginiana</i>	var prostrata 'Silver Spreader'	42	f-g	20 ± 1.7	19 ± 0.2
Semiprostrate/Semierect					
<i>J. chinensis</i>	'Fruticandii'	73	a-f	33 ± 0.7	18 ± 3.9
	'Hetzi Glauca'	63	b-f	30 ± 1.0	12 ± 1.9
	'Pfitzeriana'	68	a-g	30 ± 1.7	18 ± 1.0
	'Pfitzeriana Aurea'	75	a-c	23 ± 1.7	16 ± 0.9
	var sargentii 'Viridis'	82	a-c	18 ± 2.1	17 ± 1.4
<i>J. sabina</i>	'Blue Danube'	68	a-g	33 ± 1.4	21 ± 0.4
Pyramidal/Upright					
<i>J. chinensis</i>	'Gold Coast'	58	b-g	23 ± 1.6	14 ± 2.7
	'Blaauw'	55	b-g	40 ± 2.5	8 ± 6.2
	'Blue Point'	88	a-b	38 ± 1.6	14 ± 3.3
	'Spartan'	43	a-f	70 ± 1.3	15 ± 4.2
	'Keteleeri'	77	a-c	68 ± 1.3	16 ± 3.4
<i>J. scopulorum</i>	'Moffettii'	70	a-c	55 ± 1.2	18 ± 5.3
	'Pathfinder'	80	a-c	83 ± 0.9	15 ± 2.7
<i>J. virginiana</i>	'Manhattan Blue'	42	f-g	53 ± 1.4	15 ± 4.8
Columnar					
<i>J. virginiana</i>	'Sky Rocker'	65	a-g	53 ± 2.8	16 ± 5.6
Globe					
<i>J. scopulorum</i>	'Lakewood Globe'	60	a-g	33 ± 1.6	17 ± 4.6

^aLSD refers to pairwise comparisons of survival with cultivars having the same letter not being significantly different.

spacing was 1 m (3 ft) within rows and 1.2 m (4 ft) between rows. Survival, height, and crown spread were measured in the field in the spring of the fourth growing season (May 1980).

The plants were kept in the original planting for the next 16 years, to examine suitability for use in the landscape. During this time, no supplemental water or fertilizers were applied. Twice each year, weeds growing within plot borders were mowed. Three times during the 16 years, pocket gophers had to be removed to prevent damage to the junipers. Pocket gophers were removed before any visible aboveground effects.

After 16 years, survival, height and crown spread were measured. Crown spread measurements were taken perpendicular to the planting row. For spreading varieties with irregular crown perimeters, crown spread was measured to outermost line parallel to the row of plants where a continuous canopy existed.

Survival data were analyzed using analysis of variance followed by a means separation procedure (PROC GLM (LSD) of SAS (SAS Institute, Cary, N.C.). All analyses were conducted at the 5% significance level. The large variability in crown form of the cultivars negated the utility of traditional statistical analysis. Therefore, height and crown spread are reported as mean values with an associated standard error.

Results

NURSERY SUITABILITY. Overall, early (4-year) study-wide survival was variable both within and between species (Table 1). The large variability associated with blocking restricted the utility of the mean comparison procedure used. Early survival ranged from 40% for *J. horizontalis* (Moench.) 'Turquoise Spreader' to 92% for *J. davurica* (Parl.) 'Expansa' (note this cultivar is also referred to as *J. squamata* (Lamb.) 'Parsoni' Whitcomb, 1983) and *J. scopulorum* (Sarg.) 'Table Top Blue' (Table 1). The *J. chinensis* (L.) cultivars had the greatest range of survival of any species tested, with survival ranging from 43% for the 'Spartan' cultivar to 88% for the 'Blue Point' cultivar.

Five spreading cultivars evaluated had high (>85%) survival, including *J. scopulorum* 'Table Top Blue', *J. davurica* 'Expansa', and *J. horizontalis*

'Hughes', all having survival in excess of 90% (Table 1). Four of the remaining spreading cultivars evaluated had extremely poor survival, with the worst survival being 40% for *J. horizontalis* 'Turquoise Spreader.'

Crown width of spreading cultivars after three growing seasons ranged from 10 to 20 cm (4 to 8 inches) and was not related to survival (Table 1). *Juniperus sabina* (L.) 'Skandia' had the greatest crown growth, but poor survival. In contrast, the three spreading cultivars with the highest survival had the smallest crown width after 3 years in the field. Overall, all spreading cultivars of *J. chinensis*, *J. procumbens* [(Endl.) Sieb. et Zucc.], *J. sabina*, and *J. virginiana* (L.) had good lateral crown growth after three growing seasons in the field.

Survival for the semiprostrate and semierect cultivars ranged from 58% for *J. chinensis* 'Hetzi Glauca' to 82% for *J. chinensis* var. *sargentii* (Henry) 'Viridis' (Table 1). Crown height varied from 18 to 33 cm (7 to 13 inches) after three growing seasons in the field. *Juniperus sabina* 'Blue Danube' achieved the greatest crown size at the end of the nursery trial. *Juniperus chinensis* 'Fruitiandii' and 'Pfitzeriana' achieved the greatest crown size of the five *J. chinensis* cultivars evaluated in this crown form category.

Survival varied considerably for the pyramidal and upright cultivars, ranging from 42% for *J. virginiana* 'Manhattan Blue' to 88% for *J. chinensis* 'Blue Point' (Table 1). Five of the nine cultivars in this category had <60% survival, including four of the six cultivars of *J. chinensis* and the *J. virginiana* cultivar that was evaluated. Final crown heights were acceptable in all but two of the six *J. chinensis* cultivars in this category. *Juniperus scopulorum* 'Pathfinder' and *J. chinensis* 'Spartan' and 'Keteleeri' had the greatest growth, achieving final mean heights of 83, 70, and 68 cm (33, 28, 27 inches), respectively (Table 1).

The columnar cultivar *J. virginiana* 'Sky Rocket' and the globe cultivar *J. scopulorum* 'Lakewood Globe' had poor survival after three growing seasons in the field. Survivors of these two cultivars did achieve marketable size at the end of the nursery portion of this study.

LANDSCAPE SUITABILITY. Survival varied tremendously between cultivars and blocks in this portion of the study.

Again, block variability limited the utility of the means comparison procedure used. For example, a cultivar with 51% survival was considered no different than a cultivar with 74% survival (Table 2). Twenty year cultivar survival ranged from 14% for *J. chinensis* 'Gold Coast' to 74% for *J. sabina* 'Arcadia' (Table 2). Nine cultivars had survival rates of greater than 60%, including 7 cultivars with spreading crown forms, one with a semiprostrate form, and one with an upright crown form (Table 2). Eleven cultivars in three of the four crown categories had between 50% and 59% survival. Species survival differences exhibited no pattern.

As would be expected, 20-year height growth and lateral growth varied widely (Table 2). Overall height growth ranged from <20 cm (8 inches) for *J. horizontalis* 'Emerson's Spreader' to near 3.25 m (10.6 ft) for *J. scopulorum* 'Moffetti' and *J. virginiana* 'Manhattan Blue.' Of the seven pyramidal forms evaluated, *J. chinensis* 'Keteleeri', *J. scopulorum* 'Moffetti' and 'Pathfinder', and *J. virginiana* 'Manhattan Blue' all were ≈3.0 m (9.8 ft) in height after 20 years in the field. *Juniperus chinensis* 'Blue Point' and 'Spartan' were ≈2.5 m (8.2 ft) tall and cultivar 'Gold Coast' was slightly >60 cm (24 inches) tall at the end of the study. Twenty-year height for the semierect juniper cultivars ranged from 1.2 m (3.9 ft) (*J. sabina* 'Blue Danube') to 1.8 m (5.9 ft) (*J. chinensis* 'Hetzi Glauca') with *J. chinensis* 'Pfitzeriana Aurea' falling between. Final height also varied considerably for the semiprostrate cultivars evaluated, ranging from 60 cm (24 inches) for *J. chinensis* var. *sargentii* 'Viridis' to 1.3 m (4.3 ft) for 'Pfitzeriana' (Table 2).

Spreading cultivar height growth ranged from <20 cm (8 inches) for *J. horizontalis* 'Emerald Spreader' to >2.3 m (7.5 ft) for *J. scopulorum* 'Table Top Blue' (Table 2). All *J. horizontalis* cultivars and *J. procumbens* 'Nana' remained <40 cm (16 inches) tall after 20 years in the field. The spreading cultivars of *J. sabina*, *J. davurica*, and *J. virginiana* had 20-year heights ranging from 45 to 100 cm (18 to 39 inches) (Table 2).

Crown spread for spreading cultivars ranged from 1.4 to nearly 3.7 m (4.6 to 12.1 ft) (Table 2). Crown spread for the four spreading cultivars of *J. chinensis* ranged from 1.7 m (5.6

Table 2. Survival, mean height and mean crown spread after 20 years for cultivars of *Juniperus chinensis*, *J. horizontalis*, *J. procumbens*, *J. sabinna*, *J. scopulorum*, *J. squamata*, and *J. virginiana* examined in this study (\pm standard error).

Species	Cultivar	No. of plants	Survival		Mean ht (cm) \pm SE	Mean spread (cm) \pm SE
			(%)	(LSD ^a)		
Spreading						
<i>J. chinensis</i>	'Armstrong'	19	28	j-l	121.2 \pm 5.6	170.0 \pm 12.6
	'Mini Julep'	28	55	a-l	193.6 \pm 2.7	391.2 \pm 13.1
	'Pfitzeriana Glauca'	25	50	b-j	189.7 \pm 9.5	364.1 \pm 32.0
<i>J. horizontalis</i>	var sargentii 'Glauca'	28	55	a-g	85.0 \pm 7.5	180.1 \pm 18.3
	'Bar Harbor'	23	37	f-l	21.4 \pm 1.9	153.7 \pm 11.6
	'Emerald Spreader'	29	64	a-c	18.8 \pm 1.6	181.1 \pm 11.4
	'Turquoise Spreader'	23	36	f-l	26.4 \pm 6.7	146.3 \pm 7.3
	'Emerson's Creeper'	30	54	a-h	24.3 \pm 4.8	138.1 \pm 8.2
<i>J. procumbens</i>	'Hughes'	30	72	a-b	37.7 \pm 3.3	215.3 \pm 7.0
<i>J. sabinna</i>	'Nana'	20	37	i-l	22.8 \pm 1.8	115.4 \pm 11.0
	'Arcadia'	30	74	a	87.3 \pm 2.9	223.7 \pm 15.4
	'Broadmoor'	30	68	a-c	46.9 \pm 4.1	204.3 \pm 11.2
	'Buffalo'	30	71	a-b	47.3 \pm 2.3	213.7 \pm 9.9
	'Skandia'	25	58	a-g	79.2 \pm 3.0	247.2 \pm 13.4
<i>J. scopulorum</i>	var tamariscifolia	30	64	a-c	65.1 \pm 2.8	143.5 \pm 9.8
<i>J. davurica</i>	'Tabletop Blue'	30	67	a-d	237.5 \pm 13.2	240.3 \pm 12.9
<i>J. virginiana</i>	'Expansa'	22	44	d-k	59.5 \pm 2.4	172.0 \pm 3.6
<i>J. virginiana</i>	var prostrata 'Silver Spreader'	22	29	i-l	99.8 \pm 9.1	198.7 \pm 22.4
Semiprostrate/Semierect						
<i>J. chinensis</i>	'Fruitlandii'	25	41	e-k	106.5 \pm 5.6	267.1 \pm 9.0
	'Hetzi Glauca'	29	59	a-f	186.7 \pm 4.0	432.2 \pm 17.6
	'Pfitzeriana'	28	55	a-g	126.3 \pm 3.9	301.6 \pm 22.5
	'Pfitzeriana Aurea'	21	46	c-k	135.7 \pm 3.4	285.0 \pm 14.0
	var sargentii 'Viridis'	27	62	a-e	62.4 \pm 2.2	211.5 \pm 9.6
<i>J. sabinna</i>	'Blue Danube'	26	54	a-h	117.2 \pm 3.3	276.6 \pm 9.5
Pyramidal/Upright						
<i>J. chinensis</i>	'Gold Coast'	11	14	l	63.6 \pm 5.4	91.8 \pm 11.8
	'Blaauw'	12	15	l	85.5 \pm 5.3	62.7 \pm 5.0
	'Blue Point'	26	56	a-g	234.8 \pm 10.6	171.9 \pm 9.7
	'Spartan'	23	31	h-l	269.8 \pm 12.3	224.4 \pm 10.9
	'Keteleeri'	28	51	a-j	299.2 \pm 4.8	275.2 \pm 9.5
<i>J. scopulorum</i>	'Mcffetii'	27	53	a-i	324.9 \pm 10.3	195.4 \pm 6.9
	'Pathfinder'	25	71	a-b	291.8 \pm 8.6	229.8 \pm 7.1
<i>J. virginiana</i>	'Manhattan Blue'	16	23	k-l	324.6 \pm 14.2	328.8 \pm 12.1
Columnar						
<i>J. virginiana</i>	'Sky Rocket'	25	56	a-g	376.6 \pm 4.8	267.2 \pm 7.4
Globe						
<i>J. scopulorum</i>	'Lakewood Globe'	20	35	g-l	271.6 \pm 5.6	237.8 \pm 6.8

^aLSD refers to pairwise comparisons of survival with cultivars having the same letter not being significantly different.

ft) for 'Armstrong' to 3.6 m (11.8 ft) for 'Pfitzeriana Glauca.' *Juniperus horizontalis* cultivars were less variable in crown spread, ranging from 1.4 m to nearly 2.3 m (4.6 ft to nearly 7.5 ft). This range in crown spread is comparable to the spreading forms of *J. sabinna*, *J. davurica*, and *J. virginiana*.

Among erect forms evaluated, crown spread ranged from <60 cm (24 inches) (*J. chinensis* 'Blaauw' to >4.0 m (13.1 ft) for *J. chinensis* 'Torulosa' (Table 2). Crown spread for pyramidal forms ranged from <1.0 m (3.3 ft) (*J. chinensis* 'Gold Coast') to >3.2 m (10.5

ft) for *J. virginiana* 'Manhattan Blue.' The semiprostrate forms of *J. chinensis* ('Fruitlandii,' 'Pfitzeriana,' and var. *sargentii* 'Viridis') ranged in crown spread from 2.0 to 3.0 m (6.6 to 9.8 ft). The semierect cultivars evaluated, *J. chinensis* 'Hetzi Glauca,' 'Pfitzeriana Aurea,' and *J. sabinna* 'Blue Danube' had crown spread ranging from 2.7 m to nearly 4.0 m (8.9 ft to nearly 13.1 ft) (Table 2).

Discussion

Overall, 4-year survival and growth were favorable for many of the

cultivars evaluated. The 19 cultivars with adequate survival (>70%) and growth for nursery production in this region include 11 cultivars with spreading growth forms, four cultivars with pyramidal growth forms, three cultivars with semiprostrate growth forms, and one cultivar with a semierect crown form. These ornamental juniper cultivars could provide a basis for a 3-year nursery crop grown exclusively or, possibly as interim crops for Christmas tree producers in this region. If a Christmas tree producer planted trees in rows with a 2 m (6.6 ft) spacing, and

interplanted juniper with a 1 m (3.3 ft) within row spacing, the grower could produce ≈5,000 junipers/ha (2,049 junipers/acre). Given a 70% to 90% survival rate, the producer could harvest between 3,500 and 4,500 junipers after three growing seasons in the field. While not as rapid as containerized production, the proposed production system does provide a potential for increasing the short-term return on investment for a limited resource Christmas tree producer typical of the Mora Valley area. This partial return on investment may provide a sufficient cash flow to allow a grower to convert from a marginally profitable agriculture system to higher value horticultural crops such as Christmas trees. For example, using a budget schedule proposed by Gorman and others (1989) for Christmas tree producers in this region, use of intercropping junipers will provide revenue 2 to 3 years before the first Christmas tree harvest. Revenue generated by the juniper sales could be used to offset a portion of the initial costs of establishing the plantation.

The suitability of junipers for mini-landscapes is demonstrated

through the 20-year life of the study. The research plot from growing seasons four through 20 had no supplemental water or fertilizer applied. In addition, many cultivars were planted at densities much higher than appropriate. These factors provide an evaluation of the cultivars' performance in a poorly managed landscape, common in many urban and suburban areas. This tight spacing resulted in many cultivars with pyramidal, upright, and semierect growth forms failing to achieve normal crown spread. Height growth was as expected in most cultivars. The failure of a given cultivar to achieve design height is likely due to the intense competition for water and nutrients generated by the dense planting.

Twenty-one cultivars had adequate survival (>50%) and growth, under admittedly neglected circumstances, for landscape use in the region. These 21 cultivars represent a wide range of crown forms, size, foliage color, and foliage density. This broad spectrum of suitable juniper cultivars allows landscapers and homeowners to develop landscapes that are acceptable to landowners and consis-

tent with most xeriscape requirements.

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