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PLANT MATERIALS TECHNICAL NOTE

A Summary of the Results of the Mill Creek Woody Comparative Evaluation Planting

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Integration of Selected Native Plant Materials for Enhanced Restoration Activities in the UCFRB
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1999

2001

2007

2013

Introduction

This report summarizes the performance of seven woody species consisting of 19 different accessions planted in a study plot called the Mill Creek Woody Comparative Evaluation Planting (CEP). The Mill Creek area was severely impacted by past smelter emissions fallout containing heavy metal and sulfur compounds.

The Mill Creek Woody CEP was established to test the performance of local (indigenous) sources versus non-local sources of woody germplasm when grown in low pH and heavy metal contaminated soil. The results would be the basis for future plant selections, as well as determining if off-site seed sources were appropriate for use on metal-affected sites in the Anaconda area.

The local stock used in the study originated from seed collected at the Anaconda Smelter Superfund Site in Deer Lodge County, Montana. The non-local stock originated from seed collected in various counties in Montana, Colorado, South Dakota, Utah, and Wyoming, depending on species and nursery stock availability. Based on the concept that plants able to survive in acidic soil contaminated with heavy metals possess heritable genetic traits for tolerance to those conditions (Sainger et al., 2011), we believed the local stock would have better survival than non-local stock.

Materials and Methods

The CEP was established in the fall of 2000 at the Anaconda, Montana Superfund Site. The 0.4-acre study site is located two miles southeast of the town of Anaconda, approximately 200 yards east of Mill Creek at an elevation of 5,140 feet. The 30-year average annual precipitation at the site is 13.9 inches and the average frost-free period is 90 to 105 days. The parent material is alluvium; the soil is classified as Beaverell cobbly loam, 1 to 4 percent slopes, severely impacted.

The test plot was prepared using a 6-foot wide chisel plow. Three perpendicular passes were made across the plot to a depth of 6 inches. After plowing, exposed rocks were handpicked and placed outside the test plot. Subsequently, the plot was tilled with a 5-foot wide tiller, packed, and harrowed. The test plot was not amended with lime or fertilizer.

Laboratory analysis of four composite soil samples taken after tilling from 0 to 6 inches indicated an average pH of 4.53. Average heavy metal concentrations in the four soil samples were arsenic - 423 ppm; cadmium - 6 ppm; copper - 510 ppm; lead - 233 ppm; and zinc - 308 ppm. Average arsenic and zinc concentrations exceeded EPA phytotoxicity standards (see Table 1).

Table 1. Acid extractable heavy metal levels (EPA Method 3050) and pH of 0 to 6-inch composite samples.

Sample	pH S.U.	As ppm	Cd ppm	Cu ppm	Pb ppm	Zn ppm
A.T. 0-6” NE	4.00	610.0	7	620	320.0	370
A.T. 0-6” NW	4.90	360.0	5	340	120.0	222
A.T. 0-6” SE	4.60	530.0	5	340	150.0	200
A.T. 0-6” SW	4.60	190.0	7	740	340.0	440
Average	4.53	422.5	6	510	232.5	308
Phytotoxic Criteria†	< 5.0	136-315	5.1-20	236-750	94-250	196-240

† EPA phytotoxicity standards (CDM Federal 1997)

Nineteen accessions of seven woody species, including common snowberry (*Symphoricarpos albus*); western snowberry (*Symphoricarpos occidentalis*); silver buffaloberry (*Shepherdia argentea*); wax currant (*Ribes cereum*); lodgepole pine (*Pinus contorta*); ponderosa pine (*Pinus ponderosa*); and Woods’ rose (*Rosa woodsii*), were transplanted as seedlings that were grown in 10-in^3 Cone-tainers™ containing Sunshine Mix #1™ growing (see Table 2). Vispore™ (3-ft x 3-ft) tree mats were installed the spring following planting on all entries to suppress weeds and retard soil moisture evaporation.

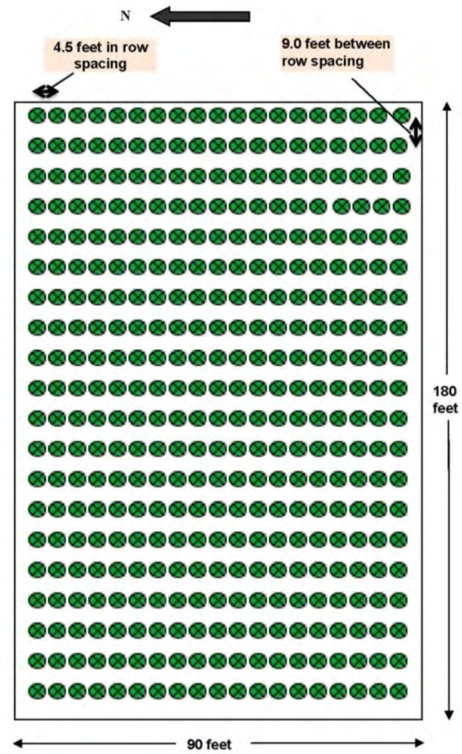
Materials and Methods (continued)

Table 2. Seed Origin and Elevation of Entries in the Woody Comparative Evaluation Planting.

Family/Species	Common Name	Source I.D.	Seed Origin	Elevation
Pinaceae:				
Pinus contorta (PICO) Dougl. ex Loud.	Lodgepole pine	9078320	Deer Lodge Co., MT	6400 ft
P. contorta (PICO) Dougl. ex Loud.	Lodgepole pine	m039ID0002	Custer Co., ID	6300 ft
P. contorta (PICO) Dougl. ex Loud.	Lodgepole pine	m038WY0002	Albany Co., WY	9500 ft
P. ponderosa (PIPO) P. & C. Lawson	Ponderosa pine	9081318	Deer Lodge Co., MT	5850 ft
P. ponderosa (PIPO) P. & C. Lawson	Ponderosa pine	m04CO0002	San Juan Co., CO	8000 ft
P. ponderosa (PIPO) P. & C. Lawson	Ponderosa pine	m020SD9903	Lawrence Co., SD	5500 ft
Grossulariaceae:				
Ribes cereum (RICE) Dougl.	Wax currant	9081329	Deer Lodge Co., MT	5700 ft
R. cereum (RICE) Dougl.	Wax currant	m024CO0003	Chaffee Co., CO	8000 ft
Rosaceae:				
Rosa woodsii (ROWO)	Woods' rose	9081638	Deer Lodge Co., MT	5168 ft
R. woodsii (ROWO)	Woods' rose	m076CO0003	Pueblo Co., CO	6000 ft
R. woodsii (ROWO)	Woods' rose	m07MT0003	Ravalli Co., MT	3400 ft
Elaeagnaceae:				
Shepherdia argentea (SHAR) (Pursh) Nutt.	Silver buffaloberry	9081334	Deer Lodge Co., MT	6000 ft
S. argentea (SHAR) (Pursh) Nutt.	Silver buffaloberry	m022WY0005	Sweetwater Co., WY	6000 ft
S. argentea (SHAR) (Pursh) Nutt.	Silver buffaloberry	m015UT9901	UT Seed Source	unknown
Caprifoliaceae:				
Symphoricarpos albus (SYAL) (L.) Blake	Common snowberry	9078388	Deer Lodge Co., MT	6000 ft
S. albus (SYAL) (L.) Blake	Common snowberry	m045MT003	Ravalli Co., MT	3500 ft
S. occidentalis (SYOC) Hook.	Western snowberry	9081639	Deer Lodge Co., MT	5559 ft
S. occidentalis (SYOC) Hook	Western snowberry	m021WY0004	Weston Co., WY	5000 ft
S. occidentalis (SYOC) Hook	Western snowberry	m018CO09904	CO Seed Source	unknown

The study was arranged in a randomized complete block design replicated 20 times (see Figure 1). Plant entries were spaced 4.5 ft. apart within rows and 9 ft. apart between rows. Plant height and vigor ratings were assessed each year from 2001 to 2010 and in 2013. Height was measured in centimeters to the top of live foliage. Vigor was rated on a scale of 1 to 9 (1 = best, 9 = nearly dead) based on a visual assessment of plant health and robustness. A plant was considered dead when the cambium tissue was no longer green and plant parts were brittle. Percentage survival was calculated by dividing the number of live replications by the total of 20 replications. To test if survival differed among species, and if survival differed among accessions within a species, multiple-sample survival tests and a Kaplan-Meier product limit estimate of the survival function was performed (Statistix 8, 2003, see Addendum 1 for details).

Figure 1. Layout of Woody Comparative Evaluation Planting Near Anaconda.



Results

Survival

The multiple-sample survival tests found species differed in survival over the 14 years of the study (p-values for Gehan-Wilcoxon, Logrank, and Peto-Wilcoxan tests < 0.0001). The survivorship of ponderosa pine was greater than lodgepole pine, Woods' rose, silver buffaloberry, and common snowberry at each time interval and greater than wax currant over the first six years. Western snowberry had greater survivorship than lodgepole pine at each time interval, greater than Woods' rose over the first 10 years, greater than silver buffaloberry over the first five years, and greater than common snowberry over the first three years. Wax currant had greater survivorship than lodgepole pine at each time interval, and greater than Woods' rose over the first three years (see Figures 2 & 3 in Addendum 1). Lodgepole pine and Woods' rose each had greater than 50% mortality during the first three years of the study, and silver buffaloberry had greater than 50% mortality after 4 years. The results support a recommendation of planting ponderosa pine, western snowberry, wax currant, and common snowberry on this site. Averaged over all accessions, their survivorship, after 14 years, was 49%, 37%, 48% and 52%, respectively. Averaged over all accessions the survivorships of silver buffaloberry, Woods' rose, and lodgepole pine were 25%, 18% and 1%, respectively, after 14 years.

With the exception of wax currant (p-values >0.1), survivorship differed among accessions within each species (p-values for Gehan-Wilcoxon, Logrank, and Peto-Wilcoxan tests < 0.04). Two accessions of wax currant were tested, the local accession and one from Colorado. Values for the survivorship function S (t) (see Figure 6 in Addendum 1) for the local accession ranged from 0.75 after three years to 0.60 at year 14, and 0.70 to 0.35 for the Colorado accession. The confidence intervals overlap at each timing indicating no significant difference between the two accessions. At year 14, of the 20 seedlings planted for each accession, 13 of the local accession remained alive compared to 8 of the Colorado accession. The height growth rate (see Table 5) and vigor rating (see Table 6) of the local accession was greater than the Colorado accession. The survival results support a recommendation of either accession for reclamation on this site, however the local accession's growth rate suggests it may be better adapted to the edaphic conditions.

The differences in survival among the three accessions of lodgepole pine (p-values <0.02, see Figure 4 in Addendum 1) were evident during the first four years of the study. Over that time, the local accession had fewer deaths (6 of 20 seedlings) than the accessions from Idaho and Wyoming (15 and 16 of 20 seedlings, respectively). Growth rates were low (see Table 5) and vigor ratings (see Table 6) less than average for all accessions suggesting poor adaptation to the site. These results support not recommending using lodgepole pine for reclamation of this site.

Accessions of ponderosa pine differed in survivorship (P-values <0.0001, see Figure 5 in Addendum 1). Both the local accession and the accession from South Dakota had greater survival than the accession from Colorado after 14 years. The South Dakota accession also had greater survivorship than the Colorado accession at all time intervals after three years. Growth rates of the local and South Dakota accessions were greater than the Colorado accession (see Table 5), but after five years the vigor ratings of all three accessions were below average (see Table 6). These results support recommending ponderosa pine over lodgepole pine for reclamation of a conifer species on this site.

The survivorship of the local accession of Woods' rose was greater than the accessions from Ravalli County Montana and from Colorado at each time interval (p-values <0.001, see Figure 7 in Addendum 1). By year three, 16 Colorado accession plants and 17 Ravalli accession plants had died whereas only 5 of the local accession were dead. By the 14th year, 10 local accession plants survived compared to one from Colorado and two from Ravalli. The height growth of the surviving local and Ravalli accessions were similar, but the growth rate of the Colorado accession was slow (see Table 5). All three accessions had good vigor ratings during the first year, but the vigor of the Colorado accession deteriorated in year two, was below average for the Ravalli accession after three years, and below average for the local accession after year five (see Table 6). The survival analysis of the three accessions combined showed low survivorship. However, the analysis of the local accession combined with the height results support recommending it for reclamation of this site.

The survivorship of the local accession of silver buffaloberry was greater than the survivorship of the Utah accession at all time intervals, and was greater than the Wyoming accession at time intervals after year six (p-values <0.0003, see Figure 8 in Addendum 1). At year 14, 14 local accession plants remained alive compared to 2 each for the Utah and Wyoming accessions. In addition, the local accession grew taller than the other two (see Table 4) and generally had average or better vigor ratings compared to the below average rating of the Utah and Wyoming accessions (see Table 6). The survival analysis of the three accessions combined showed low survivorship. However, the analysis of the local accession combined with the height results support recommending it for reclamation of this site.

The local accession of common snowberry had greater survivorship than the accession from Ravalli Montana at each time interval (p-values <0.0003, see Figure 9 in Addendum 1). There were 16 living local accession plants at year 14 compared to 5 plants of the Ravalli accession. The Ravalli accession had high mortality over the first three years. However, the growth rates of the surviving Ravalli plants were greater (see Table 5), and the vigor ratings generally better (see Table 6), than the local accession suggesting plants that survived were equally or better adapted to the edaphic conditions of the site than the local accession.

The Wyoming and Colorado accessions of western snowberry had greater survivorship than the local accession at time intervals after six years (p-values < 0.04, see Figure 10 in Addendum 1). Twelve plants of both the Wyoming and Colorado accessions were alive at year 14 compared to two of local source plants. Heights (see Table 4) and vigor ratings (see Table 6) were generally greater for the Wyoming and Colorado plants compared to the local plants. The results support recommending the Wyoming source for reclamation on this site.

Table 3. Percentage Survival: DATR Woody Comparative Evaluation Planting, 2001 through 2013.

Percentage Survival %											
Year of Recording	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2013**
Accession											
PICO 9078320	**100**	**85**	**40**	**25**	**25**	**25**	**20**	**15**	**15**	**15**	**15**
PICO m039ID0002	95	30	15	10	10	10	0	0	0	0	0
PICO m038WY0002	70	20	15	12	10	10	10	10	10	10	10
PIPO 9081318	**100**	**100**	**100**	**95**	**95**	**95**	**80**	**80**	**75**	**73**	**70**
PIPO m04CO0002	90	85	85	85	75	50	30	25	20	20	10
PIPO m020SD9903	100	100	100	95	95	95	90	75	70	70	70
RICE 9081329	**80**	**75**	**65**	**63**	**60**	**60**	**60**	**60**	**60**	**60**	**60**
RICE m024CO0003	65	65	50	50	40	40	40	40	40	35	35
ROWO 9081638	**80**	**75**	**65**	**65**	**55**	**50**	**50**	**50**	**50**	**50**	**45**
ROWO m076CO0003	30	15	5	5	0	0	0	0	0	0	0
ROWO m07MT0003	20	20	10	10	10	10	10	10	10	10	10
SHAR 9081334	**95**	**80**	**80**	**80**	**75**	**75**	**70**	**65**	**63**	**60**	**60**
SHAR m022WY0005	95	60	35	35	35	20	15	15	10	8	5
SHAR m015UT9901	95	25	20	10	10	10	10	10	10	10	10
SYAL 9078388	**95**	**95**	**95**	**95**	**90**	**90**	**90**	**90**	**85**	**83**	**80**
SYAL m045MT003	95	30	30	30	30	30	25	25	25	25	25
SYOC 9081639	**90**	**85**	**80**	**65**	**30**	**20**	**20**	**20**	**20**	**20**	**15**
SYOC m021WY0004	100	90	75	70	65	55	55	55	55	55	55
SYOC m018CO9904	95	90	85	75	70	65	65	55	50	46	40
Composite Average of all Accessions	84	64	55	51	46	43	39	37	35	34	32

The bolded accessions are the local accessions.

Table 4. Average Height: DATR Woody Comparative Evaluation Planting, 2001 through 2013.

Average Height, *inches*											
Year of Recording	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2013**
Accession											
PICO 9078320	**3.6**	**4.0**	**4.0**	**4.7**	**5.5**	**6.9**	**8.3**	**9.9**	**10.4**	**14.8**	**14.2**
PICO m039ID0002	5.4	5.1	6.4	6.3	6.5	6.3	0.0	0.0	0.0	0.0	0.0
PICO m038WY0002	5.4	5.7	6.2	7.1	8.1	7.9	7.5	8.5	9.1	9.7	9.1
PIPO 9081318	**8.4**	**9.7**	**10.8**	**10.2**	**12.3**	**12.7**	**12.1**	**12.5**	**13.6**	**18.8**	**21.3**
PIPO m04CO0002	4.9	5.6	5.8	5.4	5.6	4.7	6.7	5.4	4.3	6.9	4.7
PIPO m020SD9903	9.1	10.6	12.7	12.4	15.1	16.4	18.5	24.0	26.0	31.6	38.6
RICE 9081329	**8.3**	**10.1**	**18.6**	**20.5**	**31.0**	**37.0**	**35.2**	**45.0**	**43.9**	**46.4**	**50.7**
RICE m024CO0003	5.5	4.9	9.5	10.1	18.5	22.4	22.5	30.8	28.2	32.1	39.3
ROWO 9081638	**8.9**	**10.3**	**14.1**	**15.5**	**22.6**	**22.7**	**23.1**	**25.6**	**25.5**	**27.6**	**25.1**
ROWO m076CO0003	5.2	3.6	2.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROWO m07MT0003	5.3	4.7	11.2	8.5	19.9	18.1	21.0	19.9	19.3	24.8	27.0
SHAR 9081334	**9.9**	**11.8**	**14.9**	**16.4**	**29.1**	**31.5**	**33.2**	**38.7**	**33.6**	**41.5**	**37.8**
SHAR m022WY0005	5.3	2.2	3.1	5.0	7.9	13.1	17.3	18.1	15.8	21.3	25.2
SHAR m015UT9901	5.9	3.6	5.2	5.9	12.4	9.5	15.0	22.7	26.4	38.8	31.1
SYAL 9078388	**6.1**	**7.4**	**9.9**	**11.2**	**12.0**	**11.4**	**10.7**	**12.0**	**11.3**	**12.0**	**11.2**
SYAL m045MT003	4.5	7.2	12.0	13.3	16.0	18.0	19.6	21.5	22.5	24.8	21.3
SYOC 9081639	**7.6**	**7.1**	**6.3**	**7.3**	**10.4**	**10.7**	**11.8**	**12.5**	**11.0**	**15.6**	**10.8**
SYOC m021WY0004	5.0	9.8	16.0	14.8	21.9	23.5	23.5	26.8	30.2	29.1	23.9
SYOC m018CO9904	4.9	6.5	9.0	9.3	14.2	14.3	16.3	15.6	17.6	19.9	16.6

The bolded accessions are the local accessions.

Table 5. Average Annual Height Growth, DATR Woody Comparative Evaluation Planting, 2001 through 2013.

	Average Annual Height Growth *inches*											13-Year Average Growth, *inches*
Year of Recording	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2013**	
Accession												
PICO 9078320	**0.3**	**0.4**	**-0.3**	**0.7**	**0.9**	**1.3**	**1.4**	**1.6**	**0.5**	**6.7**	**-0.7**	**1.0**
PICO m039ID0002	0.2	0.0	0.1	-0.1	0.2	-0.2	dead	dead	dead	dead	dead	dead
PICO m038WY0002	0.2	0.4	0.4	0.9	1.0	-0.2	-0.4	1.0	0.6	0.6	-0.6	0.3
PIPO 9081318	**1.9**	**1.2**	**1.1**	**-0.6**	**2.2**	**0.4**	**-0.7**	**0.4**	**1.1**	**5.2**	**2.5**	**1.2**
PIPO m04CO0002	1.2	0.4	0.8	-0.4	0.2	-0.9	2.0	-1.3	-1.0	2.7	-2.3	0.1
PIPO m020SD9903	1.0	1.6	2.5	-0.3	2.7	1.3	2.1	5.5	1.6	5.9	7.0	2.4
RICE 9081329	**-0.4**	**1.6**	**6.6**	**1.9**	**10.5**	**6.0**	**-1.8**	**9.8**	**-1.1**	**2.5**	**4.3**	**3.1**
RICE m024CO0003	-0.2	-0.4	4.3	0.6	8.4	3.9	0.1	8.3	-2.6	3.8	7.2	2.6
ROWO 9081638	**0.7**	**2.4**	**4.9**	**1.4**	**7.0**	**0.1**	**0.5**	**2.5**	**-0.2**	**2.1**	**-2.5**	**1.5**
ROWO m076CO0003	0.0	-0.8	0.0	-0.4	-1.6	dead	dead	dead	dead	dead	dead	dead
ROWO m07MT0003	0.2	0.1	4.9	-2.7	11.4	-1.8	2.9	-1.1	-0.6	5.5	2.2	1.7
SHAR 9081334	**0.6**	**2.4**	**5.2**	**1.5**	**12.7**	**2.4**	**1.7**	**5.6**	**-5.1**	**7.8**	**-3.6**	**2.4**
SHAR m022WY0005	-0.3	-2.0	1.0	1.9	2.9	5.2	4.2	0.8	-2.4	5.5	3.9	1.6
SHAR m015UT9901	-0.1	-1.2	3.7	0.7	6.5	-3.0	5.6	7.6	3.7	12.4	-7.7	2.2
SYAL 9078388	**-0.25**	**1.6**	**2.5**	**1.4**	**0.8**	**-0.6**	**-0.8**	**-0.7**	**-0.7**	**0.6**	**-0.8**	**0.2**
SYAL m045MT003	-0.30	3.9	5.9	1.3	2.7	2.0	1.6	1.0	1.0	2.3	-3.6	1.4
SYOC 9081639	**0.2**	**0.4**	**0.4**	**1.0**	**3.1**	**0.3**	**1.0**	**0.7**	**-1.5**	**3.4**	**-4.9**	**0.3**
SYOC m021WY0004	1.0	3.9	6.3	-1.2	7.2	1.5	0.1	3.2	3.5	-1.1	-5.2	1.5
SYOC m018CO9904	0.4	3.9	3.7	0.4	4.8	0.2	2.0	-0.7	2.0	2.3	-3.3	1.2

The bolded accessions are the local accessions.

Table 6. Average Vigor Rating: DATR Woody Comparative Evaluation Planting, 2001 through 2013.

	Average Vigor Rating (1-9)*										
Year of Recording	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2013**
Accession											
PICO 9078320	**3.0**	**5.8**	**5.1**	**6.5**	**7.6**	**7.4**	**7.3**	**5.5**	**5.7**	**5.3**	**8.6**
PICO m039ID0002	3.5	5.0	5.0	7.0	8.0	8.0	9.0	9.0	9.0	9.0	9.0
PICO m038WY0002	3.6	4.0	4.5	5.5	6.0	6.5	7.5	7.0	7.0	6.0	8.7
PIPO 9081318	**2.5**	**2.1**	**3.4**	**5.6**	**5.7**	**5.8**	**5.9**	**5.6**	**5.5**	**5.7**	**6.7**
PIPO m04CO0002	3.1	4.2	4.8	7.3	8.0	7.9	8.7	7.4	7.0	7.8	8.9
PIPO m020SD9903	2.6	3.2	2.7	4.8	5.3	5.4	4.7	4.5	4.1	4.7	6.0
RICE 9081329	**2.5**	**4.8**	**2.8**	**3.9**	**3.3**	**3.4**	**3.6**	**3.3**	**4.1**	**3.8**	**4.8**
RICE m024CO0003	3.5	5.4	5.0	5.9	5.4	5.1	5.8	4.5	5.0	4.7	7.2
ROWO 9081638	**2.3**	**4.2**	**4.5**	**4.5**	**4.4**	**5.0**	**5.0**	**5.1**	**5.0**	**5.1**	**7.6**
ROWO m076CO0003	3.0	7.0	7.0	8.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
ROWO m07MT0003	3.3	5.0	4.0	6.0	4.0	7.0	7.0	5.5	6.5	4.7	8.5
SHAR 9081334	**2.0**	**2.5**	**2.5**	**3.9**	**4.0**	**3.7**	**3.6**	**4.4**	**4.9**	**4.3**	**5.8**
SHAR m022WY0005	3.1	6.6	5.2	6.7	7.3	6.3	6.3	5.3	6.5	7.0	8.8
SHAR m015UT9901	3.2	5.8	5.0	5.5	6.0	5.5	5.0	4.5	4.0	4.5	8.6
SYAL 9078388	**2.0**	**3.6**	**4.0**	**4.5**	**5.7**	**6.2**	**6.3**	**6.3**	**7.1**	**5.8**	**6.8**
SYAL m045MT003	2.9	3.6	3.0	4.2	4.8	4.8	3.6	3.8	4.8	4.3	8.3
SYOC 9081639	**2.1**	**4.6**	**5.2**	**6.9**	**6.5**	**6.0**	**4.8**	**5.0**	**6.2**	**5.0**	**8.8**
SYOC m021WY0004	2.3	3.8	2.8	4.6	4.4	4.1	4.0	4.2	3.9	4.0	6.9
SYOC m018CO9904	2.7	4.0	4.5	4.8	5.4	5.4	4.9	5.4	5.6	5.3	7.6

The bolded accessions are the local accessions.

***Vigor rating: 1 = best vigor: 4 = average vigor; 9 = dead**

Discussion and Conclusions

Stand establishment in the acid/heavy metal soil conditions at the Anaconda site was the characteristic of greatest value when evaluating the study. Therefore the survival statistic is of great interest when recommending a particular accession for critical area restoration.

The severe edaphic conditions of the test site have taken their toll over time, as survival has decreased each subsequent year after planting. Several dead test plants were removed and it was observed that their roots had not grown outside of the container media and into the adjacent soil. It seems probable that plants with roots able to tolerate and grow in the low pH and metalliferous surroundings beyond their plug area flourished, while those with roots sensitive to the soil contaminants declined.

The 30-year average annual precipitation at Anaconda, MT, is 13.9 inches (see Table 7). The site was abnormally dry the year of establishment (2000 - 9.6 inches), but subsequent years were near or above normal, as reported by the National Oceanic and Atmospheric Administration climatological station in Anaconda. Precipitation at the site of the CEP, therefore, was not considered a major limiting factor in plant survival as all the species tested are adapted to this precipitation pattern.

Table 7. Annual Precipitation in Anaconda, Montana.

Year	Inches of Precipitation
30-year avg.	13.9
2000	9.6
2001	14.0
2002	16.2
2003	15.4
2004	13.4
2005	15.8
2006	19.0
2007	16.5
2008	16.9
2009	18.8
2010	18.7
2011	17.6
2012	10.2
2013	18.5

A Kaplan-Meier product limit estimate of the survival success between accessions in each species (see Addendum 1) showed a significant difference between the best performing accession and the other accessions of the species. Data collected in the 2013 field evaluation shows accessions originating from seed collected at the Anaconda Smelter Superfund Site had superior survival compared to accessions from other sites in five of the seven species tested. *Symphoricarpos occidentalis* (WY - m021WY0004 - 55%) originating in Weston County, Wyoming, outperformed stock originating from the Anaconda Smelter Superfund Site (*S. occidentalis* - MT - 9081639 - 15%), and *Pinus ponderosa* (SD - m020SD9903 - 70%) originating in South Dakota had the same overall survival as the local ponderosa pine (MT - 9081318 - 70%). The superior accessions for survival included *Symphoricarpos albus* (Deer Lodge, MT - 9078388 - 80%), followed by *Pinus ponderosa* (MT - 9081318 - 70%) and *Pinus ponderosa* (SD - m020SD9903 - 70%), and *Ribes cereum* (9081329 - 60%) and *Shepherdia argentea* (9081334 - 60%), both from Deer Lodge Co., MT. For each of these four species the local accession was the best survivor.

The highest-ranked accession for survival in 2013 was, *Symphoricarpos albus* (Deer Lodge Co., MT - 9078388 - 80%). This accession, released in 2002 as Prospectors Germplasm common snowberry, is an erect, densely branched, deciduous shrub found at various elevations and climatic zones in open or wooded sites. Prospectors is considered important browse for many types of wildlife such as bighorn sheep, moose, and grizzly bears as well as domestic sheep and cattle. It is used in the rehabilitation of disturbed sites due to its large ecological amplitude and densely branched, colony-forming root system.

Of the nineteen accessions tested, two of the three *Pinus ponderosa* accessions (MT - 9081318 and SD - m020SD9903) had the second highest percentage survival (70%) in 2013. *Pinus ponderosa* is a long-lived evergreen, coniferous tree, growing at elevations between 4,000 to 8,000 feet. It provides roosting, nesting, and foraging habitat for a variety of song birds, wild turkeys, and cavity nesting birds such as owls. It also provides good habitat for small mammals, deer, and elk. Compared to other montane conifers, it has the best tolerances to dry, nutrient-poor sites and is widely planted on erodible and other disturbed sites including burns. It is known to be relatively slow growing and upon maturity produces a deep, extensive root system.

Ribes cereum (MT - 9081329) and *Shepherdia argentea* (MT - 9081334) had the third best percentage survival (60%) in 2013. *Ribes cereum* is a native, deciduous, non-rhizomatous shrub growing from 1.5 to 5 feet tall. It occurs in open, coniferous forests, at forest edges, and in mountain shrub communities. *Ribes cereum* provides food and cover for many species of wildlife. *Shepherdia argentea* is a native, deciduous, thicket forming, small tree or large shrub with spreading ascending thorny branches. The roots are shallow, much branched, often sprouting, and are able to fix a moderate amount of nitrogen. It is a valuable forage species for mule deer, pronghorn, and grizzly bear. Sharp-tailed grouse, cedar waxwings, other passerine species, and small mammals eat the fruit.

As discussed earlier a statistical analysis of the data for height growth and vigor does not show a difference between plots planted with seedlings of local origin and plots planted with seedlings from sources obtained outside of Deer Lodge County. Generally, as the years of the study passed, the overall vigor of the plants in the CEP went down. In all species, except the *Symphoricarpos occidentalis* (WY - m021WY0004), the accession that originated from seed of local origin had the highest vigor rating. Although the survival statistic is the most valuable characteristic to consider when choosing a species for a critical area planting, the height and vigor data will be valuable to help decide which accession to use when two accessions have similar survival ratings.

The releases from the Bridger Plant Materials center that were tested at the Mill Creek Woody CEP are listed in the table below. Each of these releases performed well in the acid/heavy metal contaminated soils at the site of the Mill Creek Woody CEP.

Table 8. Woody CEP Releases from Bridger Plant Materials Center.

Scientific Name	Common Name	Variety / Accession	Year of Release
Shrubs			
Shepherdia argentea	silver buffaloberry	Mill Creek / 9081334	2010
Symphoricarpos albus	common snowberry	Prospectors / 9078388	2002
Symphoricarpos occidentalis	western snowberry	Trapper / 9081639	2004

The DATR Project has established seed increase fields of all plant species tested at the Mill Creek Woody CEP showing superior establishment and performance on the Anaconda Smelter Superfund Site in Deer Lodge County, Montana. The USDA-NRCS Plant Materials Center, in cooperation with the Deer Lodge Valley Conservation District, plans to continue to release superior plant materials exhibiting tolerance of acid/heavy metal-contaminated sites.

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Addendum 1 Survival Statistical Analysis

The Survival Statistical Analysis used Multi-Sample Survival Tests to compare survival distributions among species and accessions within a species and a Kaplan-Meier product limit estimate of the survival success between accessions in each species (Statistix8, 2003). The Multi-Survival Tests were the Gehan-Wilcoxon test, Logrank test, and the Peto-Wilcoxon test. Each test calculates p-values that when less than 0.05 show significant differences among the species or accessions tested. The Kaplan-Meier survival function estimation is a descriptive method for estimating the distribution of survival times from a sample. It is a non-parametric method used to estimate the probability of survival past given time points (i.e., it calculates a survival distribution). It calculates the survivorship function [S(t)] and 95% confidence intervals at each time interval for each species or accession. It also calculates a hazard function [H(t)] at each time interval. Differences among S(t) of species or accessions can be determined by comparing the confidence intervals around each S(t) at each time interval. Species or accessions differ in S(t) if the confidence intervals do not overlap.

SURVIVAL ANALYSIS BY SPECIES

Multi-Sample Survival Tests by Species
Time Variable: Time
Event Variable: Death

			Gehan-Wilcoxon Test		Logrank Test		Peto-Wilcoxon Test	
Species #	**Species Name**	**N**	**Sum**	**Mean**	**Sum**	**Mean**	**Sum**	**Mean**
1	**lodgepole pine**	60	-7637.0	-127.28	25.567	0.4261	18.731	0.3122
2	**ponderosa pine**	59	8358.0	141.66	-22.705	-0.3848	-21.485	-0.3642
3	**wax currant**	40	2300.0	57.50	-9.2404	-0.2310	-5.6069	-0.1402
4	**Woods' rose**	60	-6721.0	-112.02	17.693	0.2949	18.641	0.3107
5	**silver buffaloberry**	60	-2816.0	-46.933	8.4176	0.1403	4.7256	0.0788
6	**common snowberry**	40	1956.0	48.900	-10.870	-0.2718	-4.2032	-0.1051
7	**western snowberry**	60	4560.0	76.000	-8.8624	-0.1477	-10.802	-0.1800
Chi-Square				81.66		62.08		71.22
DF				6		6		6
P				0.0000		0.0000		0.0000

Kaplan-Meier Product-Limit Survival Distribution by Species
Time Variable: Time
Event Variable: Death
Group Variable: Species

SPECIES 1 - LODGEPOLE PINE

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	33	0	60	0.3681	0.4500	0.5347	0.0642	0.7985
4	4	0	27	0.2786	0.3833	0.5001	0.0628	0.9589
5	13	0	23	0.1137	0.1667	0.2377	0.0481	1.7918
6	1	0	10	0.0836	0.1500	0.2546	0.0461	1.8971
8	3	0	9	0.0535	0.1000	0.1792	0.0387	2.3026
10	1	0	6	0.0388	0.0833	0.1701	0.0357	2.4849
14	0	5	5					

SPECIES 2 - PONDEROSA PINE

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	3	0	59	0.8639	0.9492	0.9821	0.0286	0.0522
5	2	0	56	0.8187	0.9153	0.9627	0.0363	0.0886
6	2	0	54	0.7772	0.8814	0.9406	0.0421	0.1263
7	5	0	52	0.6838	0.7966	0.8764	0.0524	0.2274
8	8	0	47	0.5453	0.6610	0.7603	0.0616	0.4140
10	5	0	39	0.4576	0.5763	0.6868	0.0643	0.5512
14	5	29	34	0.3773	0.4915	0.6066	0.0651	0.7102

SPECIES 3 - WAX CURRANT

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	11	0	40	0.5955	0.7250	0.8252	0.0706	0.3216
5	4	0	29	0.4812	0.6250	0.7496	0.0765	0.4700
6	3	0	25	0.4072	0.5500	0.6850	0.0787	0.5978
10	1	0	22	0.3782	0.5250	0.6676	0.0790	0.6444
14	2	19	21	0.3358	0.4750	0.6182	0.0790	0.7444

SPECIES 4 - WOODS' ROSE

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	38	0	60	0.2967	0.3667	0.4428	0.0622	1.0033
4	2	0	22	0.2316	0.3333	0.4534	0.0609	1.0986
5	3	0	20	0.1915	0.2833	0.3975	0.0582	1.2611
6	4	0	17	0.1399	0.2167	0.3199	0.0532	1.5294
7	1	0	13	0.1208	0.2000	0.3127	0.0516	1.6094
14	1	11	12	0.1081	0.1833	0.2937	0.0500	1.6964

SPECIES 5 - SILVER BUFFALOBERRY

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	27	0	60	0.4565	0.5500	0.6401	0.0642	0.5978
4	5	0	33	0.3551	0.4667	0.5816	0.0644	0.7621
5	3	0	28	0.3064	0.4167	0.5359	0.0636	1.8755
6	1	0	25	0.2878	0.4000	0.5238	0.0632	0.9163
7	3	0	24	0.2478	0.3500	0.4681	0.0616	1.0498
8	2	0	21	0.2174	0.3167	0.4360	0.0601	1.1499
10	3	0	19	0.1779	0.2667	0.3793	0.0571	1.3218
14	1	15	16	0.1601	0.3167	0.3682	0.0559	1.3863

SPECIES 6 - COMMON SNOWBERRY

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	15	0	40	0.5025	0.6250	0.7333	0.0765	0.4700
6	1	0	*25*	0.4490	0.6000	0.7341	0.0775	0.5108
8	1	0	24	0.4250	0.5750	0.7123	0.0782	0.5534
10	2	0	23	0.3812	0.5250	0.6648	0.0790	0.6444
14	0	21	21					

SPECIES 7 - WESTERN SNOWBERRY

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	6	0	60	0.8049	0.9000	0.9515	0.0387	0.1054
4	2	0	54	0.7606	0.8667	0.9300	0.0439	0.1431
5	9	0	52	0.6041	0.7167	0.8074	0.0582	0.3331
6	8	0	43	0.4694	0.5833	0.6890	0.0636	0.5390
7	5	0	35	0.3860	0.5000	0.6140	0.0645	0.6931
8	1	0	30	0.3637	0.4833	0.6050	0.0645	0.7270
10	1	0	29	0.3482	0.4667	0.5890	0.0644	0.7621
14	6	22	28	0.2674	0.3667	0.4787	0.0622	1.0033

Kaplan-Meier Survivorship Percentiles by Species

Time Variable: Time
Event Variable: Death

Kaplan-Meier Survivorship Percentiles for lodgepole pine

Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
90	3.000	3.000	3.000
75	3.000	3.000	3.000
50	3.000	3.000	5.000
25	5.000	5.000	8.000
10	5.000	8.000	M

Kaplan-Meier Survivorship Percentiles for ponderosa pine.

Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
90	3.000	5.900	7.000
75	7.000	8.000	10.000
50	10.000	14.000	M
25	M	M	M
10	M	M	M

Kaplan-Meier Survivorship Percentiles for wax currant.

Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
90	3.000	3.000	3.000
75	3.000	3.000	M
50	5.000	M	M
25	M	M	M
10	M	M	M

Kaplan-Meier Survivorship Percentiles for Woods' rose

Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
90	3.000	3.000	3.000
75	3.000	3.000	3.000
50	3.000	3.000	3.000
25	4.000	6.000	M
10	M	M	M

Kaplan-Meier Survivorship Percentiles for silver buffaloberry

Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
90	3.000	3.000	3.000
75	3.000	3.000	3.000
50	3.000	4.000	7.000
25	M	M	M
10	M	M	M

Kaplan-Meier Survivorship Percentiles for common snowberry

Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
90	3.000	3.000	3.000
75	3.000	3.000	3.000
50	3.000	4.000	7.000
25	M	M	M
10	M	M	M

Kaplan-Meier Survivorship Percentiles for western snowberry

Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
90	3.000	3.000	5.000
75	5.000	5.000	6.000
50	6.000	7.000	14.000
25	M	M	M
10	M	M	M

Figure 2. Kaplan-Meier PL Survivorship Function Graph for Species 1 and 2.

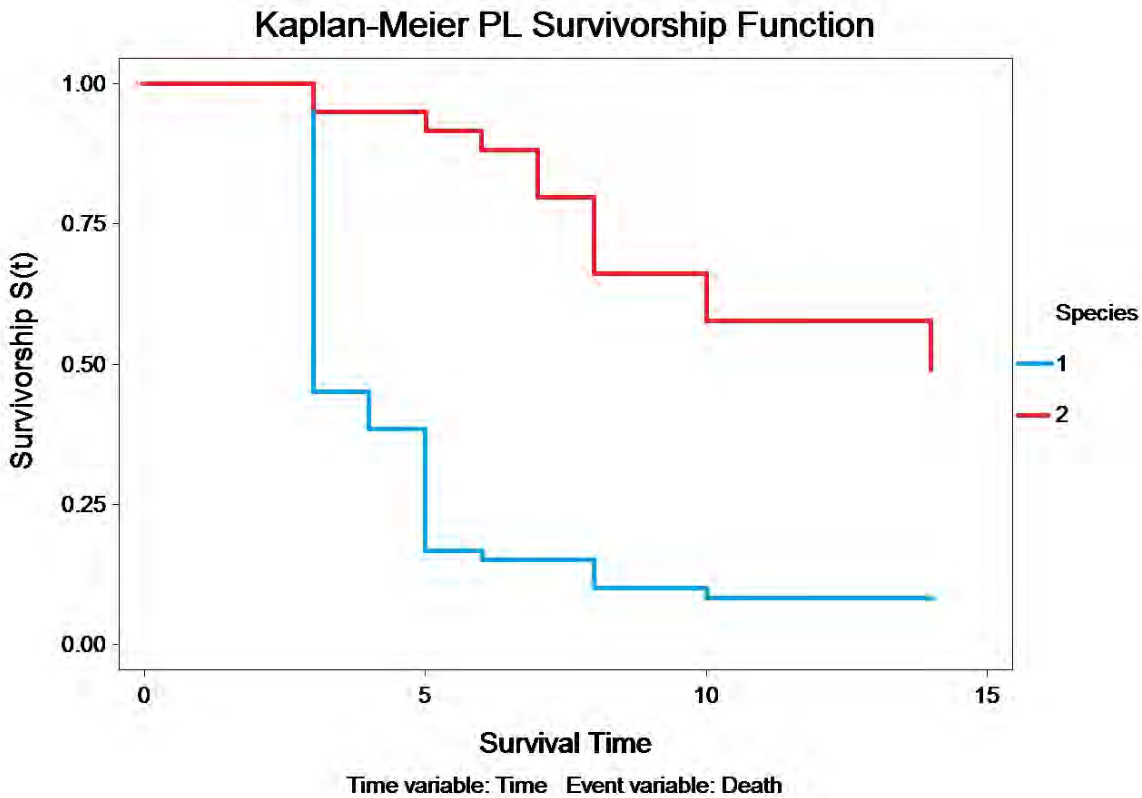
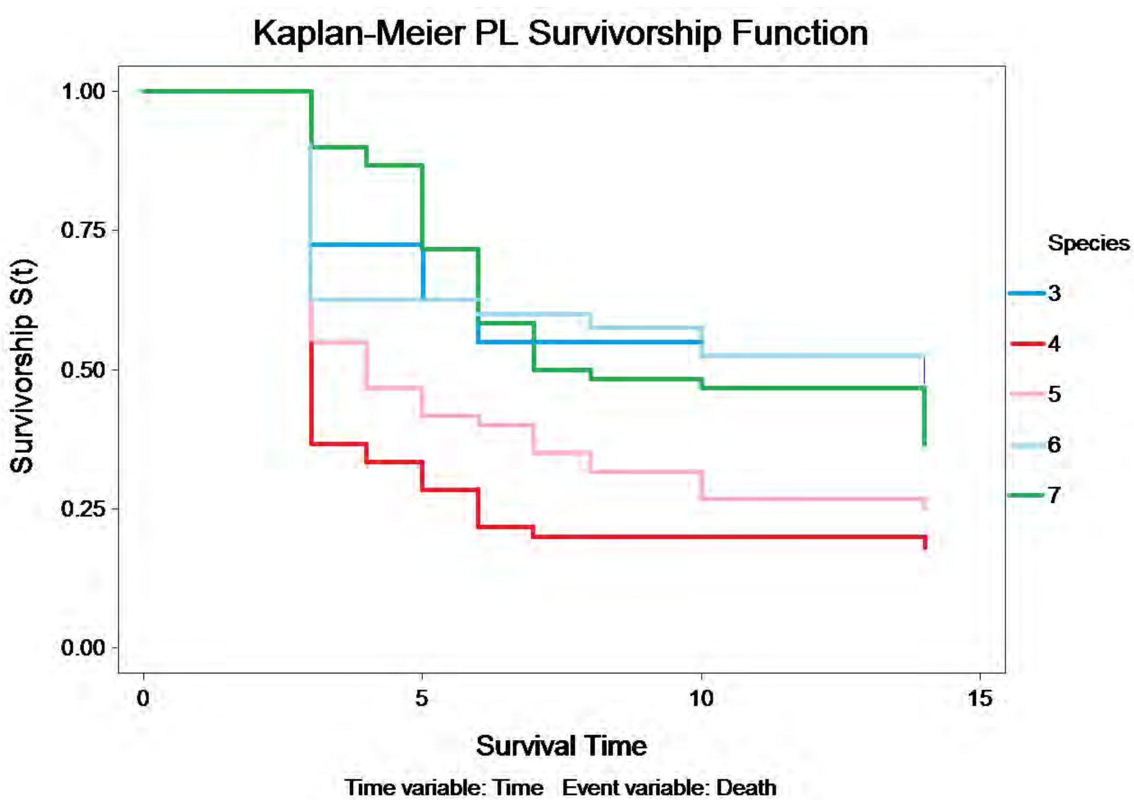


Figure 3. Kaplan-Meier PL Survivorship Function Graph for Species 3 through 7.



SURVIVAL ANALYSIS BY ACCESSION

SPECIES 1 - LODGEPOLE PINE

Multi-Sample Survival Tests for lodgepole pine.
Time Variable: Time
Event Variable: Death

		Gehan-Wilcoxon Test		Logrank Test		Peto-Wilcoxon Test	
Accession	**N**	**Sum**	**Mean**	**Sum**	**Mean**	**Sum**	**Mean**
1	20	465.00	23.250	-7.3682	-0.3682	-7.4333	-0.3717
2	20	-197.00	-9.850	4.4184	0.2209	0.5667	0.0283
3	20	-268.00	-13.400	2.9465	0.1473	6.8667	0.3433
Chi-Square			16.28		8.80		15.16
DF			2		2		2
P			0.0003		0.0123		0.0005

Kaplan-Meier Product-Limit Survival Distribution for lodgepole pine.
Time Variable: Time
Event Variable: Death
Group Variable: Accession

Accession 1 – PICO 9078320

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	3	0	20	0.6584	0.8500	0.9434	0.0798	0.1625
4	3	0	17	0.5011	0.7000	0.8442	0.1025	0.3567
5	8	0	14	0.1879	0.3000	0.4425	0.1025	1.2040
6	1	0	6	0.1200	0.2500	0.4490	0.0968	1.3863
8	1	0	5	0.0886	0.2000	0.3913	0.0894	1.6094
10	1	0	4	0.0599	0.1500	0.3282	0.0798	1.8971
14	0	3	3					

Accession 2 – PICO m039ID0002

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	14	0	20	0.2034	0.3000	0.4184	0.1025	1.2040
4	1	0	6	0.1200	0.2500	0.4490	0.0968	1.3863
5	3	0	5	0.0435	0.1000	0.2136	0.0671	2.3026
8	2	0	2	0.0000	0.0000	0.0000	0.0000	M

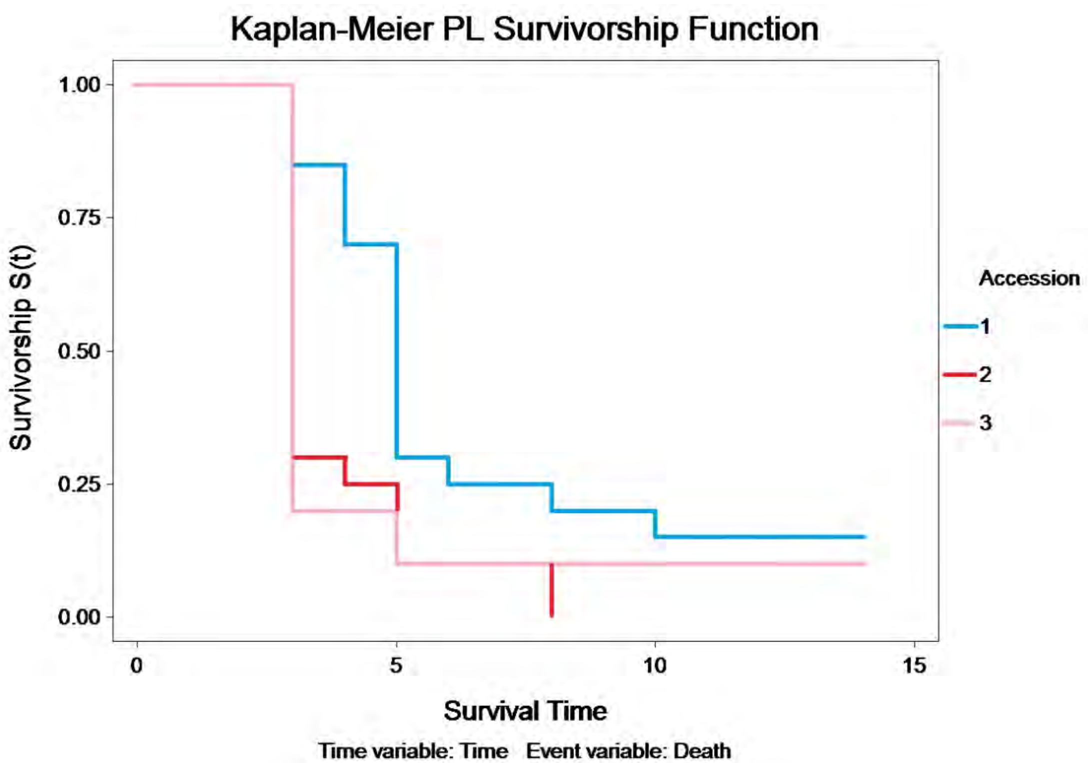
Accession 3 – PICO m038WY0002

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	16	0	20	0.1334	0.2000	0.2888	0.0894	1.6094
5	2	0	4	0.0396	0.1000	0.2305	0.0671	2.3026
14	0	2	2					

Kaplan-Meier Survivorship Percentiles for lodgepole pine
Time Variable: Time
Event Variable: Death

Accession	Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
1	90	3.000	3.000	4.000
	75	3.000	4.000	5.000
	50	4.000	5.000	6.000
	25	5.000	6.000	M
	10	M	M	M
2	90	3.000	3.000	3.000
	75	3.000	3.000	3.000
	50	3.000	3.000	4.000
	25	3.000	4.000	8.000
	10	5.000	5.000	M
3	90	3.000	3.000	3.000
	75	3.000	3.000	3.000
	50	3.000	3.000	3.000
	25	3.000	3.000	M
	10	3.000	5.000	M

Figure 4. Kaplan-Meier PL Survivorship Function Graph for lodgepole pine.



SPECIES 2 - PONDEROSA PINE

Multi-Sample Survival Tests

Time Variable: Time

Event Variable: Death

		Gehan-Wilcoxon Test		Logrank Test		Peto-Wilcoxon Test	
Accession	**N**	**Sum**	**Mean**	**Sum**	**Mean**	**Sum**	**Mean**
1	20	280.00	14.000	-5.9001	-0.2950	-4.8475	-0.2424
2	20	-546.00	-27.300	11.244	0.5622	9.3220	0.4661
3	19	266.00	14.000	-5.3442	-0.2813	-4.4746	-0.2355
Chi-Square			21.79		20.95		22.00
DF			2		2		2
P			0.0000		0.0000		0.0000

Kaplan-Meier Product-Limit Survival Distribution for ponderosa pine.

Time Variable: Time

Event Variable: Death

Group Variable: Accession

Accession 1 - PIPO 9081318

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
5	1	0	20	0.7703	0.9500	0.9908	0.0487	0.0513
8	3	0	19	0.6032	0.8000	0.9132	0.0894	0.2231
14	2	14	16	0.4950	0.7000	0.8474	0.1025	0.3567

Accession 2 – PIPO m04CO0002

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	3	0	20	0.6584	0.8500	0.9434	0.0798	0.1625
6	2	0	17	0.5450	0.7500	0.8825	0.0968	0.2877
7	5	0	15	0.3315	0.5000	0.6685	0.1118	0.6931
8	4	0	10	0.1719	0.3000	0.4694	0.1025	1.2040
10	2	0	6	0.0951	0.2000	0.3731	0.0894	1.6094
14	2	2	4	0.0396	0.1000	0.2305	0.0671	2.3026

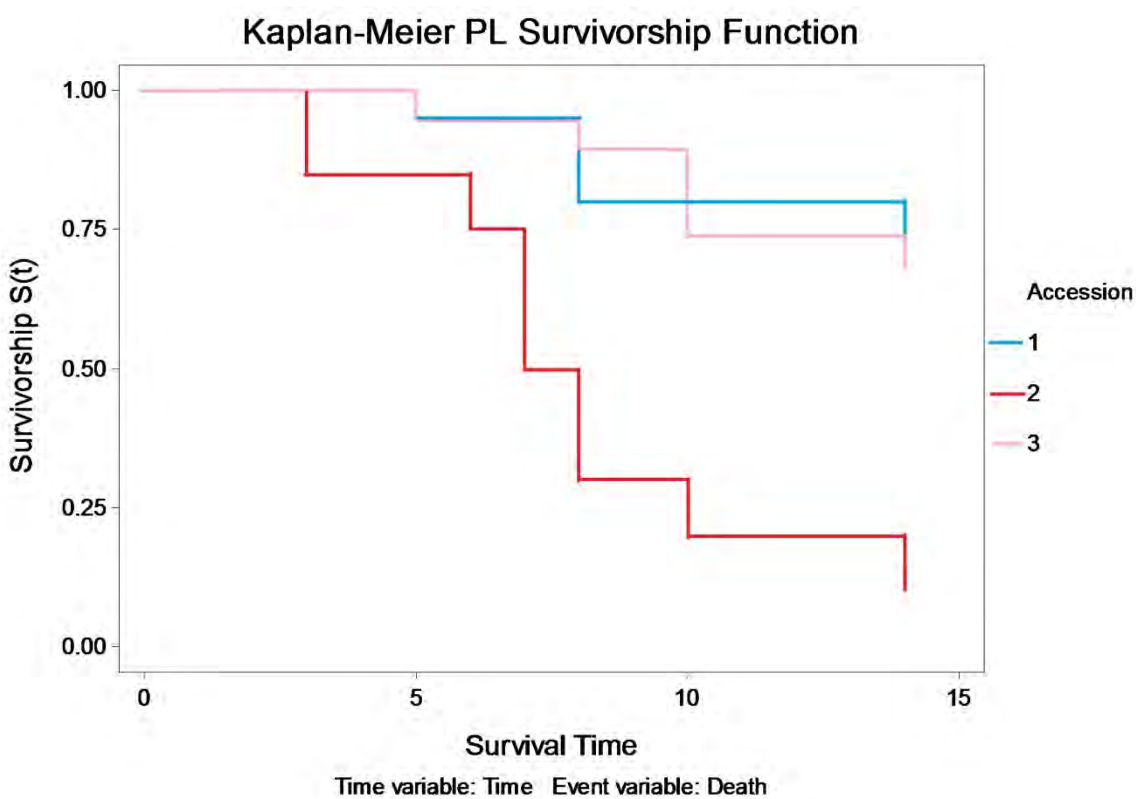
Accession 3 – PIPO m020SD9903

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
5	1	0	19	0.7606	0.9474	0.9903	0.0512	0.0541
8	1	0	18	0.6932	0.8947	0.9697	0.0704	0.1112
10	3	0	17	0.5333	0.7368	0.8728	0.1010	0.3054
14	1	13	14	0.4680	0.6842	0.8422	0.1066	0.3795

Kaplan-Meier Survivorship Percentiles for ponderosa pine.

Accession	Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
1	90	5.000	8.000	14.000
	75	8.000	14.000	M
	50	M	M	M
	25	M	M	M
	10	M	M	M
2	90	3.000	3.000	6.000
	75	3.000	6.000	7.000
	50	7.000	7.000	10.000
	25	8.000	10.000	M
	10	10.000	14.000	M
3	90	5.000	7.700	10.000
	75	8.000	10.000	M
	50	M	M	M
	25	M	M	M
	10	M	M	M

Figure 5. Kaplan-Meier PL Survivorship Function Graph for ponderosa pine.



SPECIES 3 - WAX CURRANT

Multi-Sample Survival Tests
Time Variable: Time
Event Variable: Death

		Gehan-Wilcoxon Test		Logrank Test		Peto-Wilcoxon Test	
Accession	**N**	**Sum**	**Mean**	**Sum**	**Mean**	**Sum**	**Mean**
1	20	86.000	4.3000	-3.0780	-0.1539	-2.1000	-0.1050
2	20	-86.000	-4.3000	3.0780	0.1539	2.1000	0.1050
Chi-Square			1.55		2.20		1.45
DF			1		1		1
P			0.2127		0.1384		0.2293

Kaplan-Meier Product-Limit Survival Distribution for wax currant.
Time Variable: Time
Event Variable: Death
Group Variable: Accession

Accession 1 – RICE 9081329

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	5	0	20	0.5617	0.7500	0.8754	0.0968	0.2877
5	1	0	15	0.4884	0.7000	0.8508	0.1025	0.3567
6	1	0	14	0.4403	0.6500	0.8142	0.1067	0.4308
14	1	12	13	0.3942	0.6000	0.7756	0.1095	0.5108

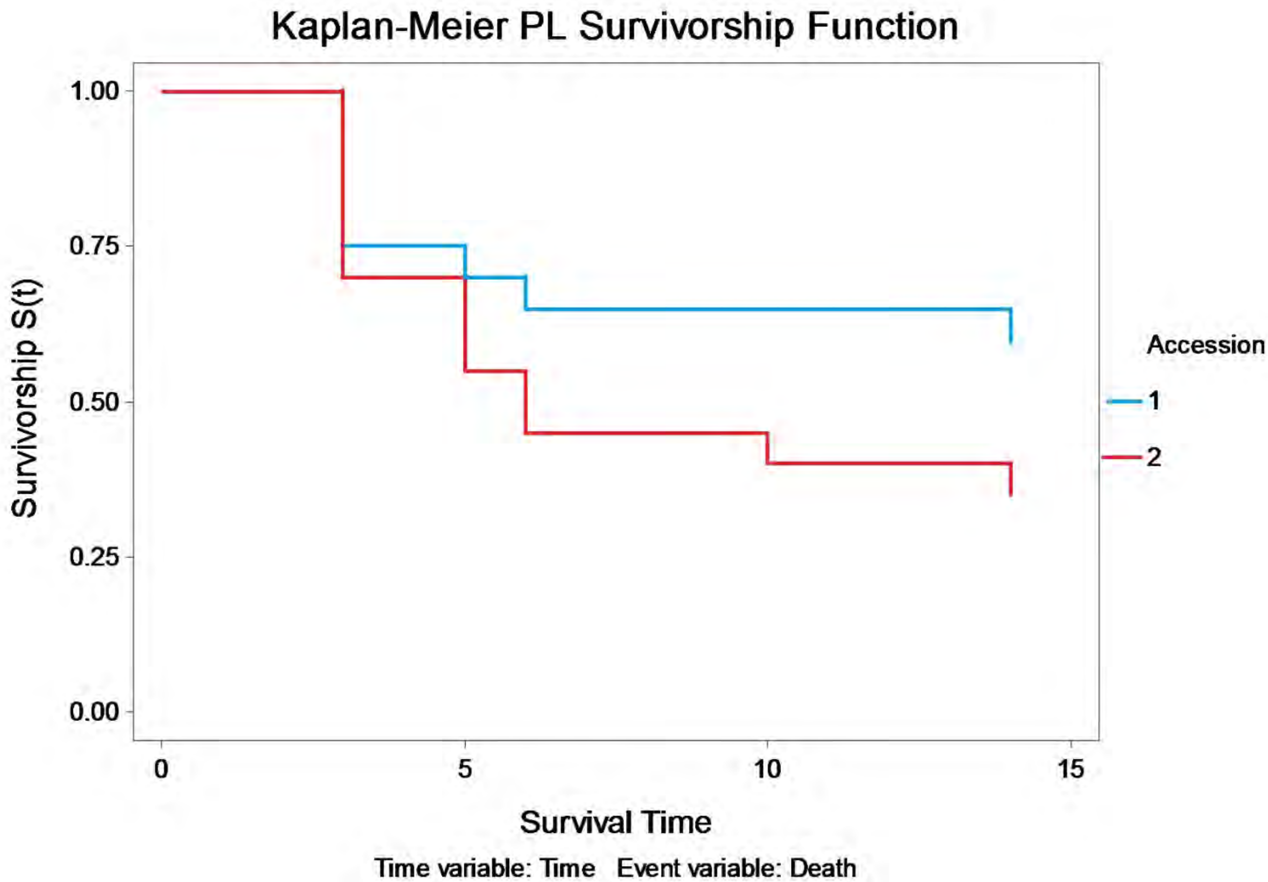
Accession 2 – RICE m024CO0003

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	6	0	20	0.5168	0.7000	0.8358	0.1025	0.3567
5	3	0	14	0.3632	0.5500	0.7237	0.1112	0.5978
6	2	0	11	0.2733	0.4500	0.6403	0.1112	0.7985
10	1	0	9	0.2269	0.4000	0.6022	0.1095	0.9163
14	1	7	8	0.1894	0.3500	0.5538	0.1067	1.0498

Kaplan-Meier Survivorship Percentiles for wax currant.

Accession	Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
1	90	3.000	3.000	3.000
	75	3.000	3.000	M
	50	M	M	M
	25	M	M	M
	10	M	M	M
2	90	3.000	3.000	3.000
	75	3.000	3.000	5.000
	50	3.000	6.000	M
	25	M	M	M
	10	M	M	M

Figure 6. Kaplan-Meier PL Survivorship Function Graph for wax currant.



SPECIES 4 - WOODS' ROSE

Multi-Sample Survival Tests
Time Variable: Time
Event Variable: Death

		Gehan-Wilcoxon Test		Logrank Test		Peto-Wilcoxon Test	
Accession	**N**	**Sum**	**Mean**	**Sum**	**Mean**	**Sum**	**Mean**
1	20	509.00	25.450	-10.019	-0.5009	-8.6333	-0.4317
2	20	-263.00	-13.150	6.4344	0.3217	0.9667	0.0483
3	20	-246.00	-12.300	3.5842	0.1792	7.6667	0.3833
Chi-Square			21.54		19.66		19.93
DF			2		2		2
P			0.0000		0.0001		0.0000

Kaplan-Meier Product-Limit Survival Distribution
Time Variable: Time
Event Variable: Death
Group Variable: Accession

Accession 1 - ROWO 9081638

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	5	0	20	0.5617	0.7500	0.8754	0.0968	0.2877
5	2	0	15	0.4471	0.6500	0.8100	0.1067	0.4308
6	2	0	13	0.3569	0.5500	0.7292	0.1112	0.5978
7	1	0	11	0.3072	0.5000	0.6928	0.1118	0.6931
14	1	9	10	0.2662	0.4500	0.6485	0.1112	0.7985

Accession 2 - ROWO m076CO0003

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	16	0	20	0.1334	0.2000	0.2888	0.0894	1.6094
4	2	0	4	0.0396	0.1000	0.2305	0.0671	2.3026
5	1	0	2	0.0138	0.0500	0.1650	0.0487	2.9957
6	1	0	1	0.0000	0.0000	0.0000	0.0000	M

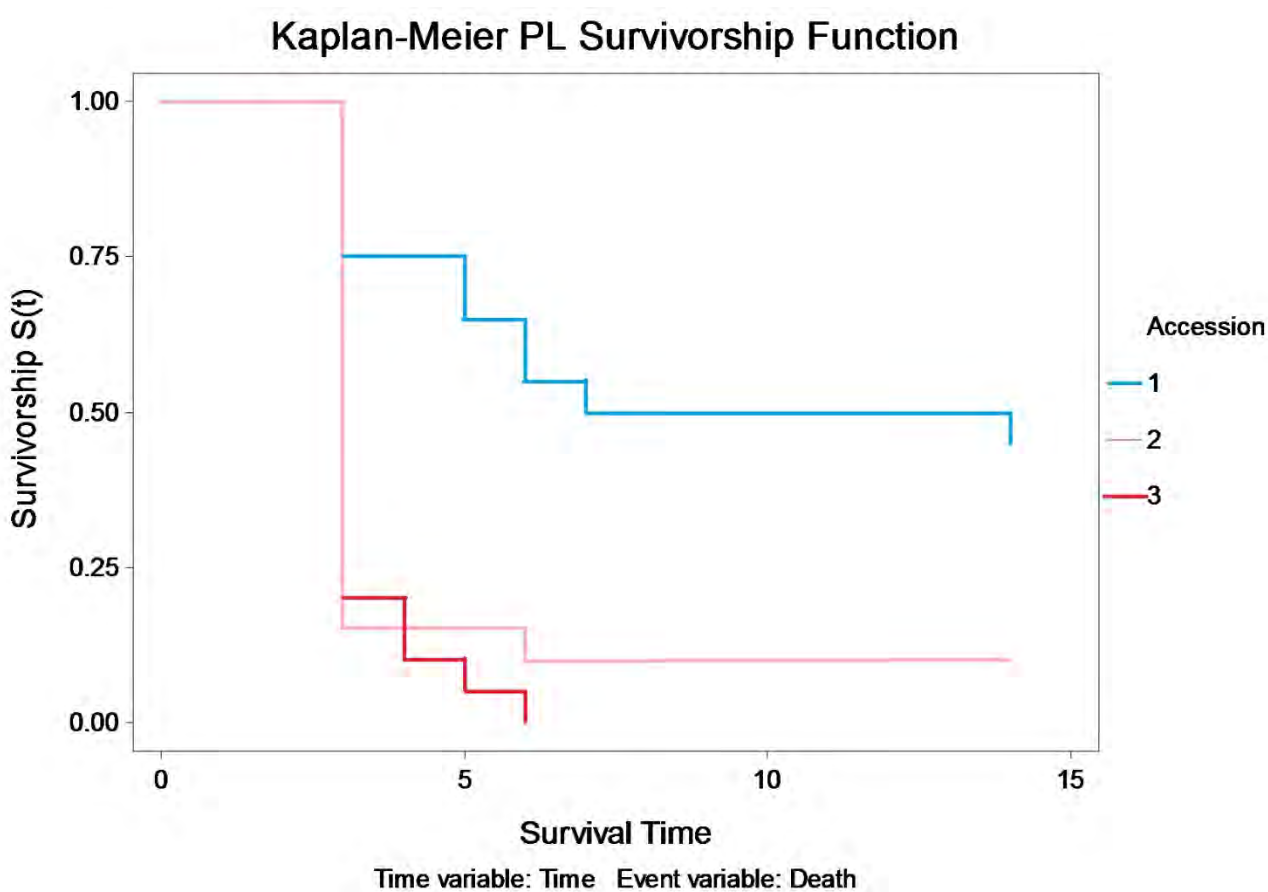
Accession 3 - ROWO m07MT0003

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	17	0	20	0.0992	0.1500	0.2204	0.0798	1.8971
6	1	0	3	0.0346	0.1000	0.2562	0.0671	2.3026
14	0	2	2					

Kaplan-Meier Survivorship Percentiles for Woods' rose

Accession	Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
1	90	3.000	3.000	3.000
	75	3.000	3.000	6.000
	50	5.000	7.000	M
	25	M	M	M
	10	M	M	M
2	90	3.000	3.000	3.000
	75	3.000	3.000	3.000
	50	3.000	3.000	3.000
	25	3.000	3.000	5.000
	10	3.000	4.000	M
3	90	3.000	3.000	3.000
	75	3.000	3.000	3.000
	50	3.000	3.000	3.000
	25	3.000	3.000	M
	10	3.000	6.000	M

Figure 7. Kaplan-Meier PL Survivorship Function Graph for Woods' rose.



SPECIES 5 - SILVER BUFFALOBERRY

Multi-Sample Survival Tests
Time Variable: Time
Event Variable: Death

		Gehan-Wilcoxon Test		Logrank Test		Peto-Wilcoxon Test	
Accession	**N**	**Sum**	**Mean**	**Sum**	**Mean**	**Sum**	**Mean**
1	20	489.000	24.450	-12.0430	-0.6021	-7.9000	-0.3950
2	20	-89.000	-4.450	5.0829	0.2541	1.1667	0.0583
3	20	-400.000	-20.000	6.9597	0.3480	6.7333	0.3367
Chi-Square			18.69		21.12		16.35
DF			2		2		2
P			0.0001		0.0000		0.0003

Kaplan-Meier Product-Limit Survival Distribution
Time Variable: Time
Event Variable: Death
Group Variable: Accession

Accession 1 - SHAR 9081334

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	4	0	20	0.6087	0.8000	0.9114	0.0894	0.2231
6	1	0	16	0.5385	0.7500	0.8852	0.0968	0.2877
8	1	0	15	0.4884	0.7000	0.8508	0.1025	0.3567
10	2	0	14	0.4011	0.6000	0.7706	0.1095	0.5108
14	0	12	12					

Accession 2 - SHAR m022WY0005

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	8	0	20	0.4318	0.6000	0.7475	0.1095	0.5108
4	3	0	12	0.2796	0.4500	0.6329	0.1112	0.7985
5	2	0	9	0.1964	0.3500	0.5426	0.1067	1.0498
7	3	0	7	0.1004	0.2000	0.3589	0.0894	1.6094
8	1	0	4	0.0599	0.1500	0.3282	0.0798	1.8971
10	1	0	3	0.0346	0.1000	0.2562	0.0671	2.3026
14	1	1	2	0.0138	0.0500	0.1650	0.0487	2.9957

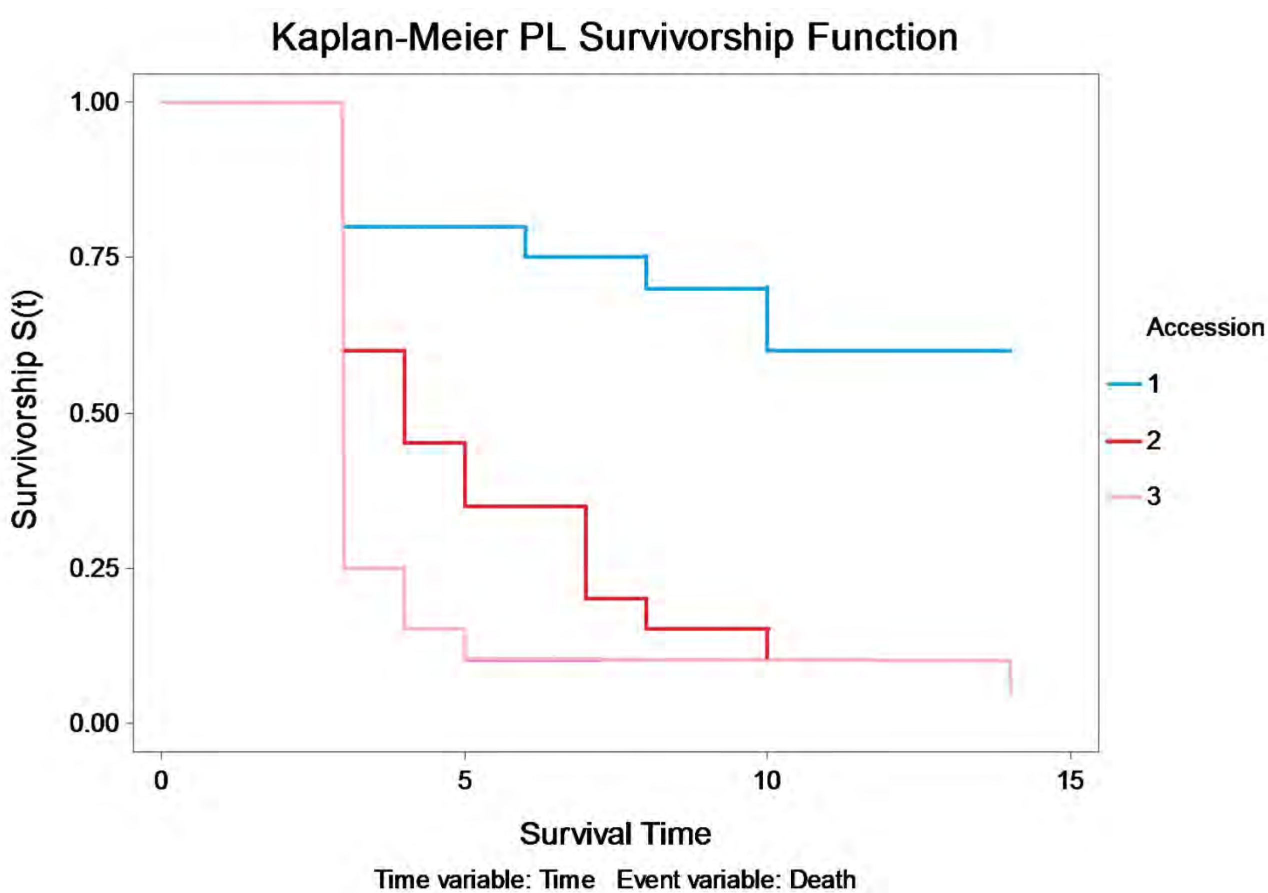
Accession 3 - SHAR m015UT9901

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	15	0	20	0.1681	0.2500	0.3548	0.0968	1.3863
4	2	0	5	0.0658	0.1500	0.3065	0.0798	1.8971
5	1	0	3	0.0346	0.1000	0.2562	0.0671	2.3026
14	0	2	2					

Kaplan-Meier Survivorship Percentiles for silver buffaloberry

Accession	Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
1	90	3.000	3.000	6.000
	75	3.000	6.000	M
	50	M	M	M
	25	M	M	M
	10	M	M	M
2	90	3.000	3.000	3.000
	75	3.000	3.000	4.000
	50	3.000	4.000	7.000
	25	5.000	7.000	14.000
	10	7.000	10.000	M
3	90	3.000	3.000	3.000
	75	3.000	3.000	3.000
	50	3.000	3.000	3.000
	25	3.000	3.000	M
	10	4.000	5.000	M

Figure 8. Kaplan-Meier PL Survivorship Function Graph for silver buffaloberry.



SPECIES 6 - COMMON SNOWBERRY

Multi-Sample Survival Tests
Time Variable:Time
Event Variable: Death

		Gehan-Wilcoxon Test		Logrank Test		Peto-Wilcoxon Test	
Accession	**N**	**Sum**	**Mean**	**Sum**	**Mean**	**Sum**	**Mean**
1	20	262.00	13.100	-6.5752	-0.3288	-6.8000	-0.3400
2	20	-262.00	-13.100	6.5752	0.3288	6.8000	0.3400
Chi-Square			15.64		12.85		15.82
DF			1		1		1
P			0.0001		0.0003		0.0001

Kaplan-Meier Product-Limit Survival Distribution
Time Variable: Time
Event Variable: Death
Group Variable: Accession

Accession 1 - SYAL 9078388

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	1	0	20	0.7703	0.9500	0.9908	0.0487	0.0513
6	1	0	19	0.7056	0.9000	0.9713	0.0671	0.1054
10	2	0	18	0.5974	0.8000	0.9151	0.0894	0.2231
14	0	16	16					

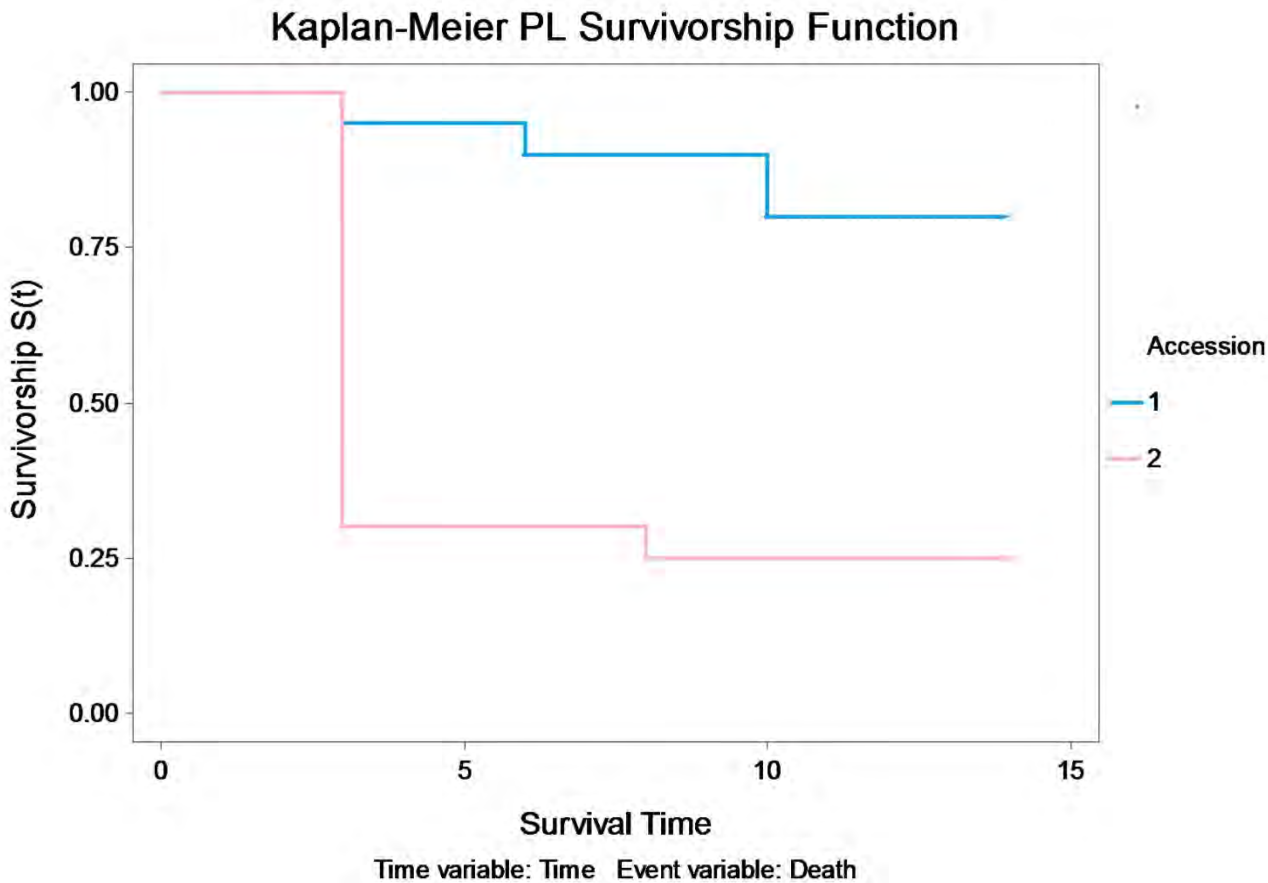
Accession 2 – SYAL m045MT003

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	14	0	20	0.2034	0.3000	0.4184	0.1025	1.2040
8	1	0	6	0.1200	0.2500	0.4490	0.0968	1.3863
14	0	5	5					

Kaplan-Meier Survivorship Percentiles for common snowberry

Accession	Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
1	90	3.000	6.000	M
	75	M	M	M
	50	M	M	M
	25	M	M	M
	10	M	M	M
2	90	3.000	3.000	3.000
	75	3.000	3.000	3.000
	50	3.000	3.000	8.000
	25	3.000	8.000	M
	10	M	M	M

Figure 9. Kaplan-Meier PL Survivorship Function Graph for common snowberry.



SPECIES 7 - WESTERN SNOWBERRY

Multi-Sample Survival Tests
Time Variable: Time
Event Variable: Death

		Gehan-Wilcoxon Test		Logrank Test		Peto-Wilcoxon Test	
Accession	**N**	**Sum**	**Mean**	**Sum**	**Mean**	**Sum**	**Mean**
1	20	-314.00	-15.700	7.0239	0.3512	5.2500	0.2625
2	20	214.00	10.700	-5.1712	-0.2586	-3.3833	-0.1692
3	20	100.00	5.000	-1.8527	-0.0926	-1.8667	-0.0933
Chi-Square			6.71		7.28		6.59
DF			2		2		2
P			0.0349		0.0262		0.0370

Kaplan-Meier Product-Limit Survival Distribution for western snowberry.
Time Variable: Time
Event Variable: Death
Group Variable: Accession

Accession 1 - SYOC 9081639

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	3	0	20	0.6584	0.8500	0.9434	0.0798	0.1625
5	4	0	17	0.4590	0.6500	0.8026	0.1067	0.4308
6	7	0	13	0.1845	0.3000	0.4481	0.1025	1.2040
7	2	0	6	0.0951	0.2000	0.3731	0.0894	1.6094
14	1	3	4	0.0599	0.1500	0.3282	0.0798	1.8971

Accession 2 - SYOC m021WY0004

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	1	0	20	0.7703	0.9500	0.9908	0.0487	0.0513
4	1	0	19	0.7056	0.9000	0.9713	0.0671	0.1054
5	3	0	18	0.5510	0.7500	0.8800	0.0968	0.2877
7	2	0	15	0.4471	0.6500	0.8100	0.1067	0.4308
8	1	0	13	0.3942	0.6000	0.7756	0.1095	0.5108
14	1	11	12	0.3499	0.5500	0.7352	0.1112	0.5978

Accession 3 - SYOC m018CO9904

Time	Died	Censored	At Risk	Lower 95% C.I.	S(t)	Upper 95% C.I.	SE S(t)	H(t)
3	2	0	20	0.7117	0.9000	0.9704	0.0671	0.1054
4	1	0	18	0.6464	0.8500	0.9461	0.0798	0.1625
5	2	0	17	0.5450	0.7500	0.8825	0.0968	0.2877
6	1	0	15	0.4884	0.7000	0.8508	0.1025	0.3567
7	1	0	14	0.4403	0.6500	0.8142	0.1067	0.4308
10	1	0	13	0.3942	0.6000	0.7756	0.1095	0.5108
14	4	8	12	0.2459	0.4000	0.5768	0.1095	0.9163

Kaplan-Meier Survivorship Percentiles for western snowberry

Accession	Percentile	Lower 95% C.I.	Time	Upper 95% C.I.
1	90	3.000	3.000	5.000
	75	3.000	5.000	6.000
	50	5.000	6.000	7.000
	25	6.000	7.000	M
	10	M	M	M
2	90	3.000	4.000	5.000
	75	4.000	5.000	14.000
	50	M	M	M
	25	M	M	M
	10	M	M	M
3	90	3.000	3.000	5.000
	75	3.000	5.000	14.000
	50	6.000	14.000	M
	25	M	M	M
	10	M	M	M

Figure 10. Kaplan-Meier PL Survivorship Function Graph for western snowberry.