Appendix F: Season of Use Determination

Travel planning on the Beartooth District raised potential issues concerning motorized route impacts to soil, water quality and vegetation, specifically during spring snowmelt periods. Existing and potential impacts occur through displacement or rutting of saturated or soft road surfaces. Travel off-road to bypass snowdrifts or mudholes can impact adjacent soils with subsequent impacts to vegetation. Travel across route drainage features, e.g., water bars or rolling dips, when they are most susceptible to damage, can impair the function of these structures and thereby concentrate route drainage down the route, delivering water and sediment to stream crossing sites. One management option to address these issues involves restricting motorized travel during the period when route surfaces and adjacent soils are most susceptible to impact. In other words, assigning a season of use (SOU) for periods when the risk of impact from motorized travel would be low.

A season of use that restricts travel during late spring or early fall was deemed unnecessary. The risk of impact was considered low during these periods because infiltration during rain events is generally high as the ground has either thawed or has not yet frozen. Additionally, the time frame in late fall between when precipitation turns to snow and when the ground becomes frozen is generally very short, unlike spring snowmelt, when the time frame between the beginning of snowmelt and complete ground thaw is generally much longer.

Determination of the period when soils are most susceptible to impact was problematic due to a lack of site-specific data. The next most scientific approach is to extrapolate data from nearby sites with similar elevation and latitude, and relatively long periods of record. Snowpack telemetry (SNOTEL) data, collected by the USDA Natural Resources Conservation Service (2007) meets these requirements.

F.1 PRYOR MOUNTAINS

Fifteen SNOTEL sites around the Pryor Mountains were used for this analysis; seven are in Montana and eight are in Wyoming. Additional sites are located within this same area, but they were not included in the overall dataset because 1) they were outside the elevation range of the Pryor Mountains (6600’- 8900’), 2) the period of record was short and extrapolation of data from adjacent sites was not highly correlated, and 3) sites locations were outside of an acceptable range of latitude. Table F-1 provides site description information for the sites used in this analysis.

Table F-1. SNOTEL Site Information

NAME	STATE	FOREST	LATITUDE	ELEVATION	PERIOD OF RECORD[1] (SWE)	PERIOD OF RECORD[2] (temperature)
Placer Basin	MT	Gallatin	45.4167	8830	1981-2007	1991-2007*
Box Canyon	MT	Gallatin	45.2667	6670	1979-2007	1990-2007
Monument Peak	MT	Gallatin	45.2167	8850	1981-2007	1991-2007*
Cole Creek	MT	Custer	45.1833	7850	1975-2007	1992-2007*
Silver Run	MT	Custer	45.1500	6630	1977-1998	NA[3]
White Mill	MT	Gallatin	45.1167	8700	1974-2007	1990-2007
NE Entrance	MT	YNP	45.0000	7350	1967-2007	1985-2007
Wolverine	WY	Shoshone	44.8000	7650	1981-2007	1985-2007
Tie Creek	WY	Big Horn	44.8000	6870	1995-2007	1995-2007*

Table F-1. SNOTEL Site Information

NAME	STATE	FOREST	LATITUDE	ELEVATION	PERIOD OF RECORD[1] (SWE)	PERIOD OF RECORD[2] (temperature)
Burgess Junction	WY	Big Horn	44.7833	7880	1981, 1983-2007	1990-2007
Sucker Creek	WY	Big Horn	44.7167	8880	1979-2007	1991-2007*
Dome Lake	WY	Big Horn	44.5667	8880	1979-2007	1990-2007
Big Goose	WY	Big Horn	44.5667	7990	1995-2007	NA[3]
Sylvan Road	WY	Shoshone	44.4667	7120	1988-2007	1990-2007
Sylvan Lake	WY	Shoshone	44.4667	8420	1981-2007	1984-2007

[1]The period of record for the analysis was standardized at 1981-2007.
[2]The period of record for the analysis was standardized at 1990-2007, except for those sites with an asterisk.
[3]Not applicable. Period of record for this site is too short for analysis of temperature data.

Elevation and latitude are two site characteristics that are quantified, but only elevation was used as a predictor in this analysis. Latitude is known to affect snowmelt at a broad continental scale (Stewart, et al., 2004), but it may not be useful at the finer scale as in this analysis. Additional statistical analysis would help to determine if this variable would improve correlations. Other known site characteristics such as aspect, adjacent vegetation and topography cannot be quantified and therefore used for this data extrapolation effort. Additionally, variations in precipitation and climatic patterns between mountain ranges are acknowledged and likely add to the variability that cannot be explained by the regression analyses as described further in this narrative.

The date when routes and adjacent soil **begin** to become susceptible to excessive rutting or displacement was assumed to be the point in time when average daily temperature exceeded 0ºC. As average daily temperature increases above freezing, the amount of time the snowpack is melting exceeds the time under which it is frozen. To establish this date, a three month period (usually 3/1-5/31) of average daily temperature data was averaged across the period of record for each SNOTEL site. This averaged data was then plotted over time to determine the date when average daily temperature reached 1ºC. It is important to note that temperature sensors at most SNOTEL sites are located well above snow levels (16-18 feet above ground) and therefore do no reflect exact the temperature of the snowpack surface. The temperature at snowpack surfaces is generally cooler than at the sensor location, hence the start of snowmelt may be some short period later than the date when average daily temperature reaches 0ºC. To account for this, the date when average daily temperature reached 1ºC was used instead of 0ºC.

Chart F-1 depicts this process for the Cole Creek site on the Custer N.F. The data indicates that April 14 is the date when average daily temperature reaches 1ºC at the Cole Creek site. The R^2 value is 0.89. R^2, otherwise referred to as the coefficient of determination, is the proportion of variability in a dataset that is accounted for by a statistical model. Using Cole Creek as an example, approximately 89 percent of the variation in temperature can be explained by the spring three month time period. The remaining 11 percent can be explained by inherent variability, or other unknown variables.

Chart F-1. Average Daily Temperature for the Cole Creek SNOTEL Site

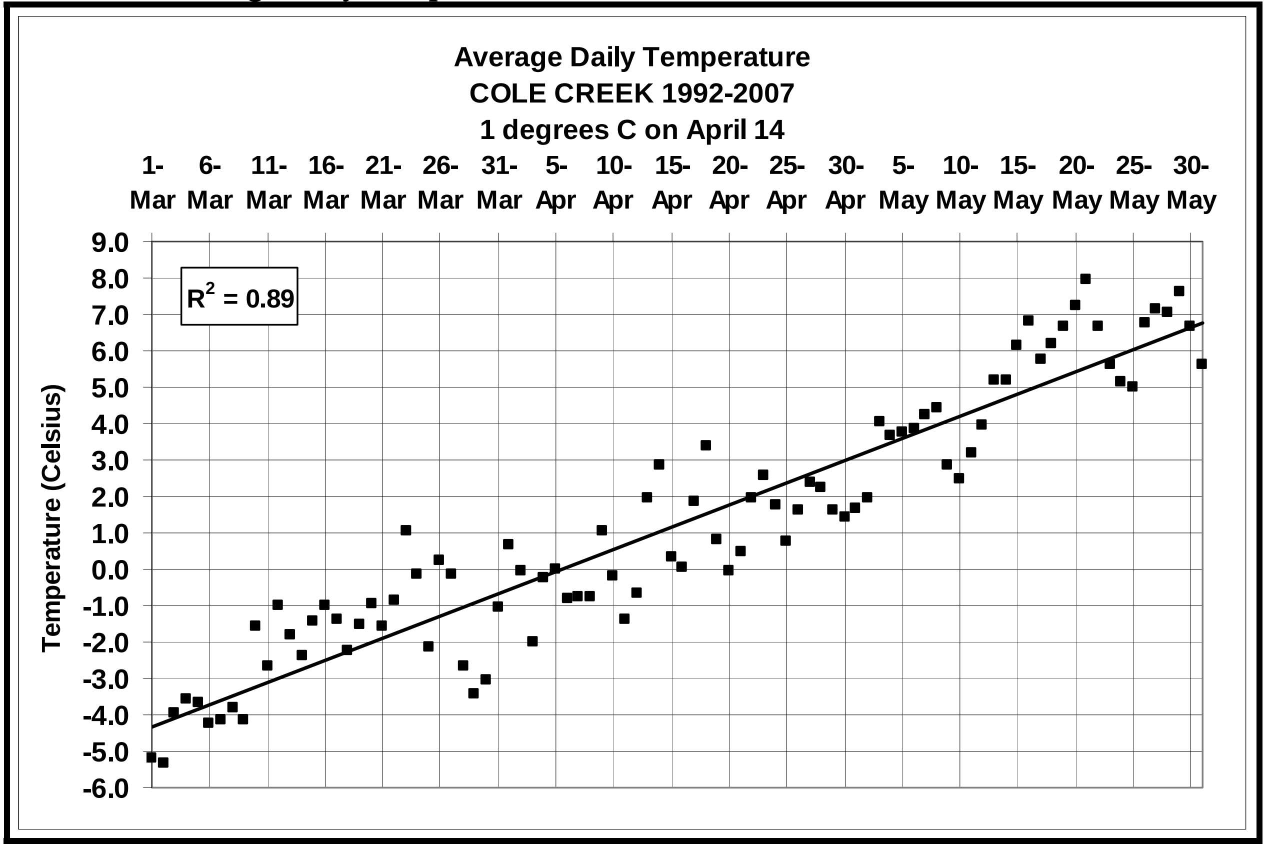


Table F-2 identifies the date when average daily temperature reached 1ºC for the 13 SNOTEL sites. R^2 values were all very good and are also shown in Table F-2. These dates were then plotted against the corresponding site elevation in order to develop a correlation to extrapolate the dataset to the Pryor Mountains. The R^2 value for this correlation is relatively high at 0.84. Again, this means approximately 84 percent of the variation in the date that average daily temperature reached 1ºC can be explained by elevation. The remaining 18 percent can be explained by inherent variability, or other variables in sites characteristics as discussed previously. Chart F-2 depicts this correlation as the date when **melt begins**.

TABLE F-2. Date When Average Daily Temperature Reaches 1ºC

SITE	DATE WHEN AVERAGE DAILY TEMPERATURE REACHES 1ºC	COEFFICIENT OF DETERMINATION - R^2
Placer Basin	May 6	0.93
Box Canyon	April 6	0.93
Monument Pk	May 1	0.94
Cole Ck	April 14	0.89
Silver Run	NA*	NA*
White Mill	April 30	0.94
NE Entrance	April 12	0.94
Wolverine	April 10	0.93
Tie Ck	April 10	0.87
Burgess Jct	April 23	0.92

TABLE F-2. Date When Average Daily Temperature Reaches 1ºC

SITE	DATE WHEN AVERAGE DAILY TEMPERATURE REACHES 1ºC	COEFFICIENT OF DETERMINATION - R^2
Sucker Ck	April 27	0.90
Dome Lk	April 27	0.91
Big Goose	NA*	NA*
Sylvan Rd	April 16	0.96
Sylvan Lk	April 28	0.94

* Not available due to limited period of record.

As spring progresses, average daily temperature increases, causing more rapid snowmelt and thawing of frozen ground. With the excess amount of melt water, road surfaces/subsurfaces and adjacent soils become saturated. This is the point at which routes and adjacent soils are deemed the most susceptible to rutting and displacement. Only when the ground is completely thawed and excess water begins to infiltrate through the soil layers does susceptibility begin to decrease. Only when soil moistures drop to normal summer levels does the risk of rutting and displacement reach its lowest level. Soil moisture and soil temperature data is not available to determine this point in time for the Pryor Mountains. However, SNOTEL data can help define a starting point by providing an average date when snowpacks melt completely.

SNOTEL snowpack data is expressed as snow water equivalents (SWE) with units in inches of water. In other words, SWE is the depth of water generated by melting a column of snowpack. To begin this analysis, every year of record (between 1981 and 2007) for each individual site was reviewed to identify the date when SWE first reached zero. Significant spring storms that extended the date when SWE again reached zero were included, but only if the second date was within the normal range of dates for each individual site. An average date was then calculated for the site based on 27 years of data. This process was duplicated for all 15 sites. The results are provided in Table F-3. These average dates were then plotted against the corresponding site elevation in order to develop a correlation to extrapolate the site data to the Pryor Mountains. The R^2 value for this correlation is moderate at 0.64. This means approximately 64 percent of the variation in the date when SWE drops to zero can be explained by elevation. The remaining 36 percent can be explained by inherent variability, or other variables in site characteristics as discussed previously. Chart F-2 depicts this correlation as the date **melt ends**.

F.2 CONCLUSION

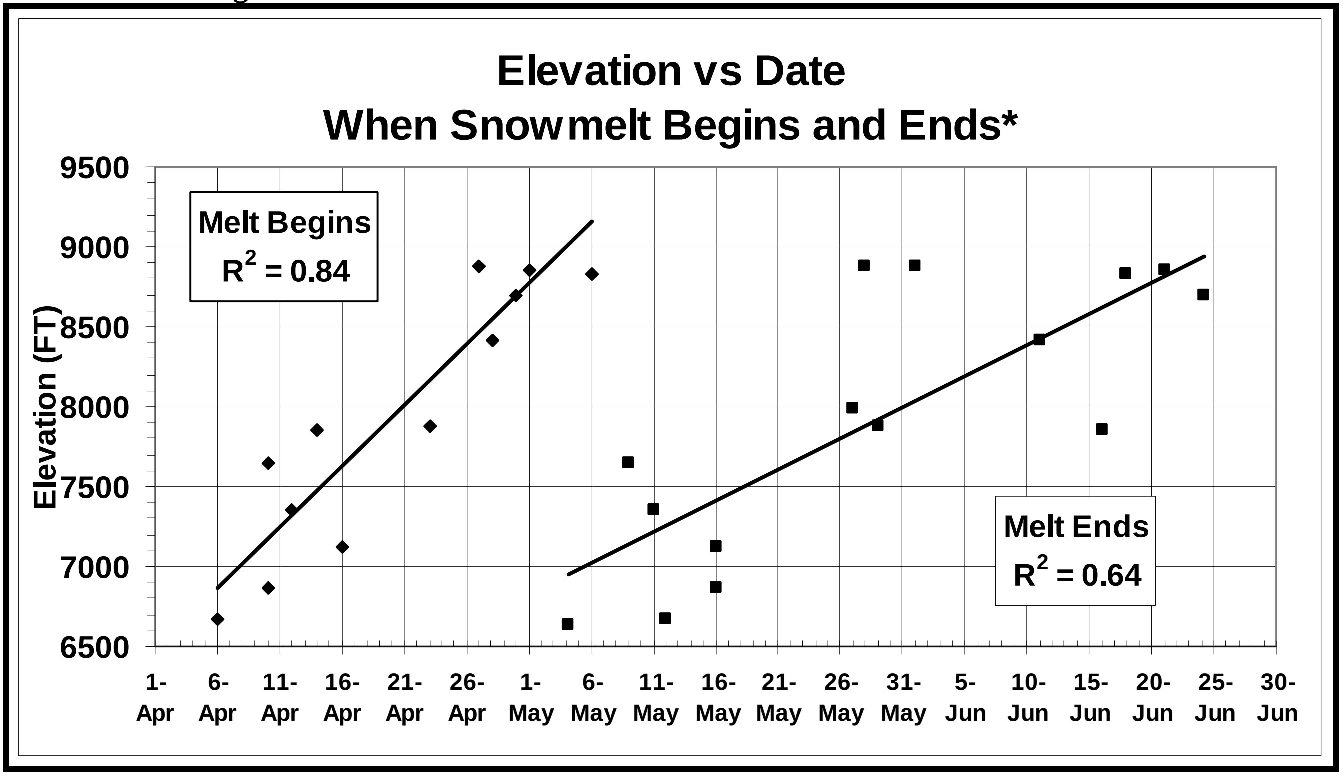
The Pryor Mountains were divided into four areas for the purpose of determining a SOU for motorized travel. Two areas have no SOU proposed. One area is at the north end of the unit where routes access private land. Historically, access to this private land has been allowed yearlong and the proposal is to continue this management. The other area encompasses most lower elevation routes across the unit including the south and west areas, and Crooked Creek Canyon and Commissary Ridge. Lower elevation areas generally have intermittent snowpack as melting occurs off and on throughout the winter. Two other areas have a SOU proposed. Both areas are at higher elevations than the areas with no proposed SOU. One area is the north and east portions of the unit. The other area encompasses higher elevations routes from Red Pryor to Big Pryor and further west.

TABLE F-3. Date When SWE Drops to Zero

Year	Placer Basin	Box Canyon	Monument Peak	Cole Creek	Silver Run*	White Mill	NE Entrance	Wolverine	Tie Creek*	Burgess Junction*	Sucker Creek	Dome Lake	Big Goose*	Sylvan Road*	Sylvan Lake
1981	6/26	5/14	6/20	6/9	5/15	6/21	5/16	5/1	**5/16**	5/19	5/29	5/29	**5/28**	**5/12**	6/8
1982	7/5	5/21	7/8	6/28	4/24	7/14	5/31	5/25	**5/21**	**6/2**	6/7	6/8	**6/6**	**5/28**	6/30
1983	7/5	5/22	6/25	6/29	5/13	6/27	5/27	5/29	**5/26**	6/8	6/16	6/17	**6/14**	**5/30**	6/23
1984	7/4	5/15	6/29	6/26	5/16	6/29	5/19	5/21	**5/27**	6/16	6/17	6/18	**6/15**	**5/25**	6/26
1985	5/29	5/2	6/10	5/26	4/18	6/22	5/3	5/5	**5/9**	5/23	5/16	5/16	**5/16**	**5/15**	5/28
1986	6/18	5/15	6/17	6/14	5/13	6/26	5/19	5/23	**5/18**	6/1	6/2	6/1	**5/31**	**5/26**	6/17
1987	6/6	4/23	6/2	5/29	4/22	5/18	4/25	4/28	**5/7**	5/13	5/7	5/12	**5/12**	**5/10**	5/10
1988	6/17	5/14	6/11	6/6	5/13	6/14	5/14	5/8	**5/16**	6/1	5/30	5/28	**5/27**	5/12	5/28
1989	6/29	5/7	6/20	6/10	5/1	6/22	5/10	5/1	**5/15**	5/19	5/19	5/27	**5/26**	5/15	6/13
1990	7/4	5/22	7/1	6/24	5/10	7/3	5/24	5/17	**5/21**	6/7	6/11	6/8	**6/6**	5/11	6/18
1991	6/30	5/28	6/27	6/26	5/18	6/24	5/25	5/20	**5/18**	6/4	6/9	6/1	**5/31**	5/24	6/16
1992	6/22	4/29	6/21	6/18	4/14	6/21	5/4	4/27	**5/7**	5/15	6/11	5/11	**5/11**	5/2	6/21
1993	6/20	5/12	6/26	6/19	5/1	6/23	5/15	5/10	**5/15**	5/27	5/17	5/27	**5/26**	5/15	6/19
1994	5/25	5/6	6/15	6/1	5/1	6/5	5/3	5/4	**5/8**	5/21	5/18	5/13	**5/13**	5/9	5/25
1995	6/26	5/13	7/7	7/10	5/15	7/5	5/18	5/18	5/24	5/15	6/23	6/23	**6/20**	5/23	6/28
1996	6/19	5/28	7/1	6/20	5/8	7/6	5/27	5/29	5/21	6/6	6/9	6/7	**6/5**	6/2	6/28
1997	6/17	5/15	6/24	6/11	5/7	7/6	5/18	5/17	5/19	6/4	6/8	6/3	**6/2**	5/20	6/8
1998	6/23	5/5	7/2	6/19	4/26	7/6	5/4	5/4	5/8	5/28	6/12	5/25	**5/24**	5/10	6/18
1999	6/20	5/20	6/29	6/17	**5/10**	7/1	5/21	5/17	5/24	6/7	6/10	6/6	6/2	5/25	6/25
2000	6/10	5/11	6/21	6/5	**5/9**	6/24	5/2	4/30	5/11	5/31	5/31	5/28	5/23	5/9	6/4
2001	5/26	5/6	6/20	6/21	**4/28**	6/18	5/2	5/1	5/8	5/18	5/15	5/15	5/13	5/9	6/18
2002	6/21	5/20	6/24	6/14	**5/4**	6/23	5/10	5/3	5/14	5/31	5/30	5/26	5/29	5/25	6/14
2003	6/15	5/21	6/19	6/27	**5/7**	6/30	5/15	5/15	5/19	6/8	6/10	5/30	5/29	5/21	6/9
2004	6/3	5/17	6/10	6/5	**4/23**	6/28	4/7	4/8	5/1	5/18	5/10	5/9	5/7	4/30	5/31
2005	6/20	5/13	6/18	6/21	**5/6**	6/24	4/27	5/2	5/16	5/28	6/11	6/1	5/27	5/7	5/26
2006	6/2	4/30	6/7	6/22	**4/23**	6/18	4/30	4/25	5/12	5/21	5/18	5/17	5/15	5/10	5/31
2007	6/10	4/28	5/29	6/10	**5/2**	6/13	4/24	4/24	5/11	6/10	6/10	5/22	5/23	4/30	5/23
81-07 average	**6/18**	**5/12**	**6/21**	**6/16**	**5/4**	**6/24**	**5/11**	**5/9**	**5/16**	**5/29**	**6/1**	**5/28**	**5/27**	**5/16**	**6/11**

* A portion of the data for this site was extrapolated from adjacent sites because the period of record was less than 1981-2007. Extrapolated data in bold.

CHART F-2. Begin and End Snowmelt Dates



* Beginning date corresponds to date when average daily temperature reaches 1ºC. Ending date corresponds to date when SWE reaches zero inches. Refer to narrative for clarification.

The 8000 foot elevation zone was chosen as a starting point to extrapolate data from Chart F-2 for these higher elevation routes. Doing so provides a starting SOU date of May 31 and an ending date of April 21. Local observations indicate that the lower energy aspects of the north and east area of the Pryors hold snowpacks longer than the higher energy aspects of the southwest area of the unit. Also, due to these differences in aspects, soils take longer to dry out in the north and east areas as compared to the southwest area. Therefore, the SOU starting date for higher elevation routes on the southwest side was moved back to May 22. This date also accounts for public comments that requested the SOU to include Memorial Day weekend. The starting date for higher elevation routes, in the north and east areas, was moved forward to June 15. This date also accounts for BLM comments that requested a later SOU starting date for the Sykes Ridge area. The initial ending date of April 21 was moved back to April 15 to further reduce the risk of impacts from a high use period during the initial week of spring black bear hunting season.

F.3 RED LODGE ROUTE 2141

A similar analysis was used to determine an appropriate SOU for the main route through the West Fork Red Lodge watershed. However, in this case the Burnt Mountain SNOTEL site was located within the watershed and adjacent to the route of concern. Average daily temperatures between February 1 and April 30 were evaluated for the years 2001 through 2007. The data indicates that on the average, average daily temperature reaches 1ºC on March 8. The R^2 value is 0.73. SWE data for the years 2002 through 2007 suggests that on the average, snowpacks completely melt by May 1. Because of the north facing aspect of this watershed, the SOU beginning date was extended two weeks to provide additional drying time. Therefore, the SOU proposed for this route is 5/15 to 3/8.

F.4 REFERENCES

USDA- NRCS. 2007. SNOTEL Data for sites on the Big Horn, Custer, and Gallatin National Forests and Yellowstone National Park. U.S. Department of Agriculture, Natural Resource and Conservation Service. [Online]. Available: http://www3.wcc.nrcs.usda.gov/nwcc/sweavg.jsp?state=WY, and ftp://ftp.wcc.nrcs.usda.gov/data/snow/ads/mt/mt7100sn.html.

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- End of Appendix F -