Soil Report

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Chappie – Shasta OHV Post Fire Soil Erosion Monitoring

Executive Summary

This report documents the Chappie-Shasta OHV Park BAER treatments effectiveness after the Motion Fire of June 2008 above the Sacramento River near Keswick Dam, Redding, CA. The Motion Fire burned the Chappie-Shasta OHV Park causing main hub trails to be burned severely and erosion expected to be high (see right pic below) due to the lack of cover on adjacent hillsides. The fire burned over four past OHV trail erosion monitoring sites so data was available to evaluate the effects of fine on OHV trail erosion (using prefire data vs. postfire data, see Appendix A & B). In October 2008 the area was helicopter mulched and trail SWECO treatments providing an additional opportunity to evaluate mulch effectiveness and rolling-dips on curbing trail erosion after fires.

OHV19 trail pre-fire sediment collection trough area

OHV19 trail post-fire sediment collection trough area

Introduction

Past erosional data for the Chappie-Shasta OHV Park was lacking for accurate assessment of erosion from OHV use. Because erosion data was missing for accurate assessments for normal use and event use, monitoring sites were established on the two main soil types, Holland and Goulding series. Monitoring was

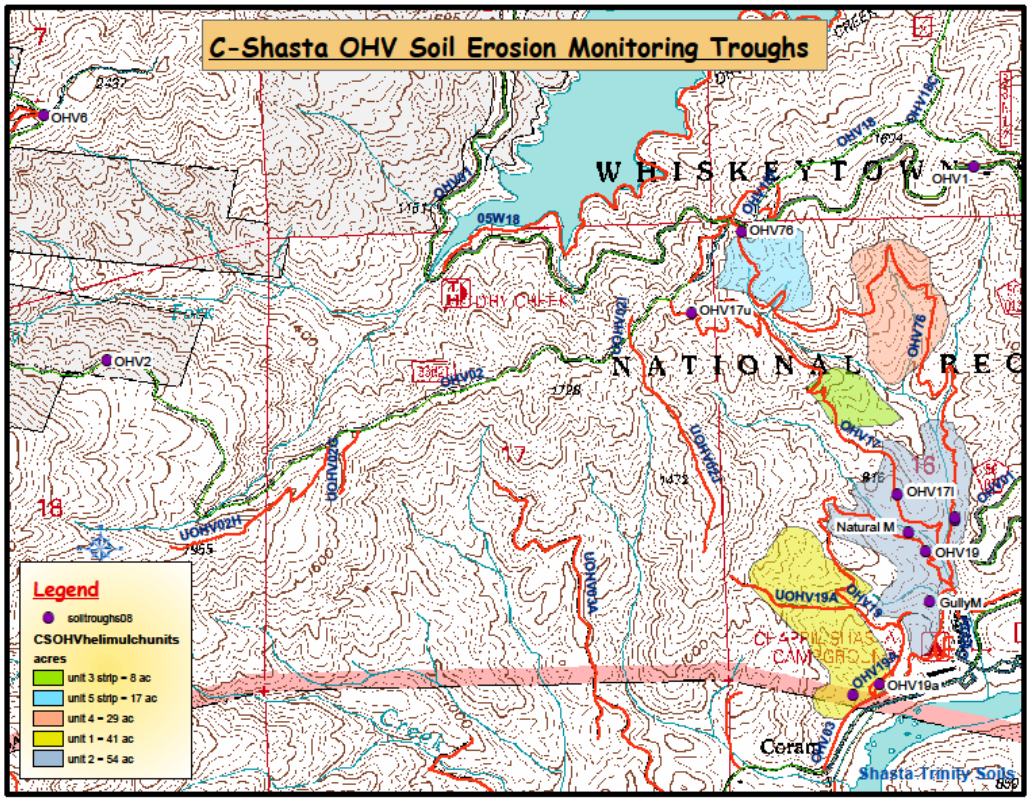
established on types of routes (roads, OHV, and trails), difficulty (easy, moderate, difficult), and use level (light, moderate, high).

On June 21st, 2008 the Motion Fire part of the larger SHU-Lighting Complex of fires burned over the Chappie-Shasta OHV Park. Soil burn severity was pronounced in areas of conifer and manazita on south and west-facing slopes. Many of these areas were around the Chappie-Shasta OHV staging area which burned many critical hub trails that access the rest of the park. It was expected with burned trails and hillslopes trail erosion will be magnified due to lack of cover and live vegetation to remove excess hillslope water which would release more water on to these trails thus increasing erosion over unburned sites (see cover pics).

Background erosion and disturbance erosion on Holland and Goulding soils was collected using pre-fire soil collection troughs. Soil erosion was measured for a period of 2 years that developed preliminary OHV Chappie-Shasta erosion database estimating OHV erosional trends. Additionally, sites were monitored (collected sediments eroded and weighed) after each major storm event and correlated with the State of California Shasta Dam weather station to put erosion on a per storm basis (erosion per inch of rainfall, see Appendix A & B). Seven pre-monitoring soil troughs (see map below) were placed near the Chappie-Shasta OHV staging area on routes OHV19, OHV19a, OHV17, OHV1, OHV76, OHV2, and OHV6. Erosion was monitored from late winter 2006 to late winter of 2008.

On June 2008 several pre-fire erosion monitoring sites were burned over by the Motion Fire (see cover pics) providing an opportunity to measure the effects of fire on erosion on OHV routes. Additionally OHV19, OHV17, OHV19a routes were reworked with additional rolling dips for erosion control. On October 2008, a portion of the OHV Park was helimulched with weed-free rice straw at a rate of 1.5 tons/acre to curb excess erosion around the Chappie-Shasta OHV staging area. Post fire monitoring troughs were relocated on past monitoring trails that were burned over and mulched (OHV19); trails that were burned over without mulch (OHV17 upper and OHV19a); trails that were burned over with only hillslopes mulched (OHV17 lower); and natural hillslopes mulched and unmulched (natural and gully).

Map of Erosion Plots (Pre & Post - Fire):



Pre-fire Results:

Pre-fire results showed areas adjacent to the Chappie-Shasta OHV staging area had the most use and had the highest erosion rates (see map above and Table 1 below). OHV19 had the highest erosion rates due to its proximity to the main staging area and being a high use trail. OHV17 and 19 were also event trails so they had additional erosion due to large (500+ riders) hare-scramble events every year.

Erosion ratios (total rainfall / total erosion) showed trails with the most erosion per total rainfall experienced confirmed OHV19 had the highest rate followed by OHV17 and OHV76 showing proximity and textures as key elements. OHV1, OHV2, OHV6, and OHV76 were moderate use OHV routes at locations not adjacent to the OHV staging area showed much lower erosion rates.

Table 1: Pre-fire Erosion rates for five OHV routes (Feb. 2006 – Mar. 2008)

Route	Soil Type	Type/Level/Use	Size (ft2)	Erosion Rate (t/a/y)
OHV19a	Goulding coarse-seds	OHV/Diff/Low	1573	2.2
OHV19	Goulding coarse-seds	OHV/Mod/High	807	10.0
OHV17U	Goulding coarse-seds	OHV/Mod/High	1290	5.0
OHV1	Goulding coarse-seds	Road/Easy/High	6458	2.0
OHV76	Holland fine-seds	Trail/Mod/Mod	357	5.0

Post-fire Results:

Post-fire results (see Table 2 below) showed mulching had the biggest effect on reduction of erosion with complete trail and hillslope mulching being the most effective. SWECO trail improvement (rolling dips) did reduce erosion significantly due to decreasing slope lengths but was not as effective as full mulching. With SWECO trail work and hillslope mulching only, erosion was still very high due to bare fine-textured soils. When the OHV Park was re-opened in late April 2009, erosion levels jumped up significantly especially main trails close to the staging areas (see Appendix B below).

Table 2: Post-fire Erosion rates for six OHV sites (Oct. 2008 – June 2009)

Route	Soil Type	Type/Level/Use treatment	Size (ft2)	Erosion Rate (t/a/y)*
OHV19a	Goulding coarse-seds	OHV/Diff/Low SWECO/unmulched	950	0.7
OHV19	Goulding coarse-seds	OHV/Mod/High SWECO/mulched	1855	0.5
OHV17L	Holland fine-seds	OHV/Mod/High SWECO/hillslope mulched	775	12.4
OHV17U	Goulding coarse-seds	OHV/Mod/High SWECO/unmulched	1628	5.5
Natural	Goulding coarse-seds	Burned hillside mulched	873	0.02
Gully	Goulding coarse-seds	Burned gulch mulched	26136	0.07

*Trail sizes are different due to burned landscape and SWECO treatments on trails. Fire occurred on 6/21/08 and was mulched 4 months (Oct 28th) later after 2 significant storms.

Conclusions:

Pre-fire conditions: showed erosion was concentrated in certain preferred lines of travel thus causing rolling-dip side-outlets to be bermed. Water did not flow off but concentrated down the main trail past outlets thus causing accelerated erosion down the center of trails (see left pic below).

OHV 17 trail with bermed outlet after large harescramble event (looking up trail with rolling dip at top of trail)

OHV 17 trail with treated rolling dip outlets after Motion Fire (looking up trail with treated rolling dip & removed berm)

Pre-fire trail erosion study results showed that it is crucial that eroded areas be treated or restored to protect established OHV route investments. If they are left untreated, then trails become severely eroded and side outlets become bermed and nonfunctional.

Post-fire conditions: showed SWECO trail work (see right pic above) and full mulching on OHV19 (high use trail) reduced erosion from 10.0 to 0.5 tons/acre/year. With only SWECO trail improvements, erosion was reduced on low use trails (OHV19a, 2.2 to 0.7 t/a/y) but had marginal effects on high use trails (OHV17, 5.0 to 5.5 t/a/y). After fire pre-mulch erosion rates were very high on OHV19 and OHV17 trails (3.3 to 4.5 t/a/3mts) vs. mulched erosion rates which remained low for OHV19 (0.05 to 0.36 t/a/3mts) and moderate to high for OHV17 (0.84 to 2.58 t/a/3mts). Background erosion levels for treated hillslopes (natural and gully sites) showed extremely low erosion rates (0.02 to 0.07 t/a/y). When the OHV park re-opened in April 2009 erosion rates for OHV19 was 0.50 t/a/3mts vs. OHV17 was 4.3 t/a/3mts showing mulch was still very effective in curbing erosion on high use trails.

On the upper part of OHV17 (see right pic above) where there was only SWECO trail improvements, erosion rates after the park opened were 3.3 t/a/3mts showing SWECO treatments as partially effective. This is not to say rolling-dips are not effective in reducing massive erosion (removing excess water and sediments off the trail) but inter-treatment erosion still remained high. If side outlets on rolling-dips are not maintained on an annual basis then the trail will become bermed and dips will become ineffective. Over time the trail will become trenched requiring SWECO trail treatments to reestablish rolling-dips and removing outside berms (see left pic above).

Conclusion of monitoring was full mulch treatments across trails and hillslopes effectively curbs most erosion and combined with seasonal closure allows trails and hillslopes to stabilize and naturally seed in. This treatment is most effective after SWECO trail work allowing newly formed rolling-dips to settle and re-vegetative without eroding before opening in late spring for OHV use.

The 2-inch in 48 hour wet weather policy for OHV use is a general guideline that seems a reasonable rate for a trigger point. OHV route erosion data (see Appendix A & B below) shows consistently 2-inch events over 48 hours and higher intensity rates (2-inches in 24 hours) had the highest erosion per inch of rainfall, thus confirming the rational of this policy. Recent rainfall events (6 inches in 3 days) on October 12 to 15th illustrate

this (see Appendix B below). The 2 year pre-fire monitoring data shows (see Appendix A) when you have 2-inches of rain over a period of 2 days, produce high amounts of erosion. But it depends upon duration and intensity of the rainfall. Data shows that 1 day events with high rainfall intensity and duration can produce higher rates due to thunderstorm downpours (see Appendix A). Erosion rates are also dependent on traffic level, compaction, and tread surface textures. Areas that have steep treads on shallow sandy soils with high use (OHV19 and OHV17 routes) are the most susceptible to high intensity rainfall events. Proximity to stream crossings in these sensitive areas determine what areas need storm-proofing from high intensity rainfall events.

Events that had more rainfall but over a longer period of time had less erosion per inch of rainfall. The period of greatest damaging rainfall according to data collected below seems to be from December to March thus giving credence to seasonal closure that would greatly reduce erosion and trail maintenance. This would allow reduction in erosion, allow vegetative recovery and lessen the expense of trail maintenance. Current policy is the 2-inch in 48 hour wet weather restriction on event use only. Other than this policy, the park is open year-round, allowing unrestricted riding on soft trails causing excessive erosion, sedimentation, and berning of trails.

Appendix A: Pre-Fire Erosional Data – Chappie-Shasta OHV Park

Chappie-Shasta OHV Storm Soil Erosion Monitoring

Tray	Soil	Type/Difficulity/Use	Dates	Days of Rain	Rainfall (in)	Total Erosion (t/ac)	Erosion per inch of rainfall (t/ac/in)
							ratio:
OHV19a	Goulding (L-Skl, S)	OHV/D/L	1/28 to 2/2/2006	6	4.10	0.04	0.01
	20% slope	(weathered pm)	2/27 - 3/07 + 3/11-17	12	12.50	0.63	0.05
	(1,573ft2 area)		3/24-25; 3/28 - 4/6	12	7.90		
	(bearmed, eroded)		4/11-16/06	4	7.50	0.51	0.07
			11/13-17; 11/22-3, 27	7	6.50	0.20	0.03
			12/09-14/06	6	7.60	0.35	0.05
			12/27 1/4/2007 (2)	2	3.40	0.71	0.21
			1/4 (1)	1	1.15	0.53	0.46
			2/8-11 (6)	6	6.72	0.50	0.07
			2/21-23, 25 (4)	4	5.00	0.90	0.18
					62.37	**4.37**	0.1
OHV19	Goulding (L-Skl, S)	OHV/M/H	/27 - 3/07 + 3/11-17/200	12	12.50	1.9	0.15
	15% slope	(weathered subsoil)	3/24-25; 3/28 - 4/6	12	7.90	1.95	0.25
	(807ft2 area)		4/11-16/06	4	7.50	2.42	0.32
	(bermed, eroded)		11/13-17; 11/22-3, 27	7	6.50	1.95	0.30
	close to stagging		12/09-14/06	6	7.60	2.98	0.39
			12/27 1/4/2007 (2)	2	3.40	2.28	0.67
			1/4 (1)	1	1.15	2.11	1.83
			2/8-11 (6)	6	6.72	2.31	0.34
			2/21-23, 25 (4)	4	5.00	1.86	0.37
					58.3	**19.76**	0.3
OHV17	Goulding (L-Skl, S)	OHV/M/H					
	20% slope	(weathered subsoil)	3/24-25; 3/28 - 4/6/2006	12	7.90	0.56	0.07
	(1,290ft2 area)		4/11-16/06	4	7.50	1.04	0.14
	(bermed, eroded)		11/13-17; 11/22-3, 27	7	6.50	1.16	0.18
	event route		12/09-14/06	6	7.60	1.06	0.14
			12/27 1/4/2007 (2)	2	3.40	1.15	0.34
			1/4 (1)	1	1.15	1.28	1.11
			2/8-11 (6)	6	6.72	1.83	0.27
			2/21-23, 25 (4)	4	5.00	1.83	0.37
					45.8	**9.91**	0.2
OHV1	Goulding (L-Skl, S)	R/E/H	2/8-11/2007 (6)	6	6.72	0.34	0.05
	3% slope	(old gravel surface)	2/21-23, 25 (4)	4	5.00		
	(6,458ft2 area)		2/28 3/1 (2)	2	0.95	0.33	0.35
	(insloped, eroded)		4/12 4/14-15 (3)	3	0.50	0.11	0.22
			4/22 (1)	1	2.30	0.17	0.07
			7/18-19 (2)	2	2.70	0.59	0.22
			10/10 (1)	1	1.30	0.24	0.18
			10/16-20 (5)	5	2.60	0.44	0.17
			11/11(1)	1	0.40	0.18	0.45
			12/2-4 12/7 (4)	4	3.41	0.23	0.07
			12/17-20 (4)	4	6.83	0.21	0.03
			1/4-6/2008 (3)	3	5.04	0.26	0.05
			1/8-10 (3)	3	2.94	0.13	0.04
			1/25-28 (4)	4	4.72	0.16	0.03
			1/30-2/3 (5)	5	5.49	0.07	0.01
			2/22-25 (4)	4	6.34	0.44	0.07
					57.2	**3.90**	0.1
OHV76	Holland (F-L, MD)	T/M/L	2/8-11/2007 (6)	6	6.72	0.34	0.05
	10% slope	(weathered subsoil)	2/21-23, 25 (4)	4	5.00		
	(357ft2 area)		2/28 3/1 (2)	2	0.95		
	(outsloped, eroded)		4/12 4/14-15 (3)	3	0.50		
			4/22 (1)	1	2.30		
			7/18-19 (2)	2	2.70	2.71	1.00
			10/10 (1)	1	1.30	2.14	1.65
			10/16-20 (5)	5	2.60	1.00	0.38
			11/11(1)	1	0.40		
			12/2-4 12/7 (4)	4	3.41		
			12/17-20 (4)	4	6.83	0.70	0.10
			1/4-6/2008 (3)	3	5.04	1.46	0.29
			1/8-10 (3)	3	2.94	0.16	0.05
			1/25-28 (4)	4	4.72	0.18	0.04
			1/30-2/3 (5)	5	5.49	0.04	0.01
			2/22-25 (4)	4	6.34	1.28	0.20
					57.2	**10.01**	0.2
OHV2	Holland (F-L, MD)	R/E/H	7/18-19/2007 (2)	2	2.70	0.40	0.15
	5% slope	(native surface)	10/10 (1)	1	1.30	0.70	0.54
	(3,853ft2 area)		10/16-20 (5)	5	2.60	0.37	0.14
	(outsloped, eroded)		11/11(1)	1	0.40		
	event route		12/2-4 12/7 (4)	4	3.41	0.12	0.04
			12/17-20 (4)	4	6.83	0.37	0.05
			1/4-6/2008 (3)	3	5.04	0.44	0.09
			1/8-10 (3)	3	2.94	0.10	0.03
			1/25-28 (4)	4	4.72	0.12	0.03
			1/30-2/3 (5)	5	5.49	0.12	0.02
			2/22-25 (4)	4	6.34	0.56	0.09
					41.8	**3.30**	0.1
OHV6	Holland (F-L, MD)	OHV/M/M	7/18-19/2007 (2)	2	2.70	0.75	0.28
	5% slope	(native surface)	10/10 (1)	1	1.30	0.71	0.55
	(2,177ft2 area)		10/16-20 (5)	5	2.60	0.27	0.10
	(outsloped, eroded)		11/11(1)	1	0.40		
	event route		12/2-4 12/7 (4)	4	3.41		
			12/17-20 (4)	4	6.83	0.04	0.01
			1/4-6/2008 (3)	3	5.04	0.34	0.07
			1/8-10 (3)	3	2.94	0.03	0.01
			1/25-28 (4)	4	4.72	0.04	0.01
			1/30-2/3 (5)	5	5.49	0.07	0.01
			2/22-25 (4)	4	6.34	0.50	0.08
					41.8	**2.75**	0.1

Type = OHV - off highway vechicle, T- trail, R - road
Difficulity = E - easy, M - moderate, D - dificult
Use Level = L - low, M - moderate, H - high

Appendix B: Post-Fire Erosional Data – Chappie-Shasta OHV Park

Post Motion Fire Chappie-Shasta OHV Soil Erosion Monitoring (10/4/08 - 10/15/09)							
Tray	Soil	Type/Difficulty/Use	Rainfall Dates	Days of Rain	Rainfall (in)	Total Erosion (t/ac)	*Erosion per inch of rainfall (t/ac/in)
OHV19a	Goulding (L-Skl, S)	OHV/M/H	12/29, 1/02/2009 (2)	2	0.80	0.00	0.00
	15% slope	(weathered subsoil)	2/11-18 (8)	8	12.00	0.17	0.01
	(950 ft2 area)		2/22-24 (3)	3	6.00	0.31	0.05
	(bermed, eroded)		3/2-4 (3)	3	4.00	0.05	0.01
	close to stagging		3/16 (1)	1	1.60	0.00	0.00
	burned, SWECO		3/22 (1)	1	1.70	0.00	0.00
	unmulched	#	4/9-11 (3)	3	3.10	0.00	0.00
	#park opened		5/2-5 (4)	4	7.30	0.00	0.00
			6/4-6 (3)	3	1.20	0.12	0.10
			6/10 (1)	1	0.66	0.00	0.00
			10/13-15 (3)	3	5.92	0.53	0.09
				32	**44.28**	**1.18**	**0.03**
OHV19	Goulding (L-Skl, S)	OHV/M/H	10/4/2008 (1)	1	3.20	1.01	0.32
	15% slope	(weathered subsoil)	10/31-11/3 (4)	4	3.50	0.92	0.26
	(1855 ft2 area)		11/4 (1)	1	1.40	0.85	0.61
	(bermed, eroded)	*	12/15, 12/24-25, 12/29 (4)	4	2.90	0.00	0.00
	close to stagging		12/29, 1/02/2009 (2)	2	0.80	0.00	0.00
	burned, SWECO		2/11-18 (8)	8	12.00	0.00	0.00
	*mulched 11/20/08		2/22-24 (3)	3	6.00	0.06	0.01
	#park opened		3/2-4 (3)	3	4.00	0.31	0.08
			3/16 (1)	1	1.60	0.05	0.03
			3/22 (1)	1	1.70	0.00	0.00
		#	4/9-11 (3)	3	3.10	0.00	0.00
			5/2-5 (4)	4	7.30	0.00	0.00
			6/4-6 (3)	3	1.20	0.12	0.10
			6/10 (1)	1	0.66	0.36	0.55
			10/13-15 (3)	3	5.92	0.96	0.16
				39	**49.36**	**4.64**	**0.09**
OHV17l	Holland (F-L, MD)	OHV/M/H	10/4/2008 (1)	1	3.20	1.9	0.59
	10% slope	(weathered subsoil)	10/31-11/3 (4)	4	3.50	0.95	0.27
	(775 ft2 area)		11/4 (1)	1	1.40	1.65	1.18
	SWECO	*	12/15, 12/24-25, 12/29 (4)	4	2.90	0.00	0.00
	event route		12/29, 1/02/2009 (2)	2	0.80	0.06	0.08
	*hill mulch 11/20/09		2/11-18 (8)	8	12.00	0.00	0.00
	#park opened		2/22-24 (3)	3	6.00	0.84	0.14
			3/2-4 (3)	3	4.00	1.54	0.39
			3/16 (1)	1	1.60	0.98	0.61
			3/22 (1)	1	1.70	0.11	0.06
		#	4/9-11 (3)	3	3.10	1.40	0.45
			5/2-5 (4)	4	7.30	0.31	0.04
			6/4-6 (3)	3	1.20	2.58	2.15
			6/10 (1)	1	0.66	0.08	0.12
			10/13-15 (3)	3	5.92	1.74	0.29
				39	**49.36**	**14.14**	**0.29**
OHV17u	Goulding (L-Skl, S)	OHV/M/H	12/29, 1/02/2009 (2)	2	0.80	0.00	0.00
	20% slope	(weathered subsoil)	2/11-18 (8)	8	12.00	0.00	0.00
	(1628 ft2 area)		2/22-24 (3)	3	6.00	0.46	0.08
	SWECO		3/2-4 (3)	3	4.00	1.01	0.25
	event route		3/16 (1)	1	1.60	0.51	0.32
	unmulched		3/22 (1)	1	1.70	0.01	0.01
	#park opened	#	4/9-11 (3)	3	3.10	0.43	0.14
			5/2-5 (4)	4	7.30	0.50	0.07
			6/4-6 (3)	3	1.20	1.53	1.28
			6/10 (1)	1	0.66	0.91	1.38
			10/13-15 (3)	3	5.92	1.35	0.23
				29	**38.36**	**6.71**	**0.17**
Gully	Goulding (L-Skl, S)	nontrail/eroded	10/4/2008 (1)	1	3.20	0.00	0.00
	35% slope		10/31-11/3 (4)	4	3.50	0.00	0.00
	(26136ft2 area)		11/4 (1)	1	1.40	0.05	0.04
	(old deep eroded gully)	*	12/15, 12/24-25, 12/29 (4)	4	2.90	0.00	0.00
	Corum smelting		12/29, 1/02/2009 (2)	2	0.80	0.00	0.00
	*mulched 11/20/09		2/11-18 (8)	8	12.00	0.00	0.00
			2/22-24 (3)	3	6.00	0.00	0.00
			3/2-4 (3)	3	4.00	0.01	0.00
			3/16 (1)	1	1.60	0.00	0.00
			3/22 (1)	1	1.70	0.00	0.00
			4/9-11 (3)	3	3.10	0.00	0.00
			5/2-5 (4)	4	7.30	0.00	0.00
			6/4-6 (3)	3	1.20	0.00	0.00
			6/10 (1)	1	0.66	0.00	0.00
			10/13-15 (3)	3	5.92	0.01	0.00
				39	**49.36**	**0.07**	**0.00**
Natural	Goulding (L-Skl, S)	nontrail/natural	10/4/2008 (1)	1	3.20	0.00	0.00
	40% slope		10/31-11/3 (4)	4	3.50	0.00	0.00
	(873 ft2 area)		11/4 (1)	1	1.40	0.00	0.00
	natural burned over	*	12/15, 12/24-25, 12/29 (4)	4	2.90	0.00	0.00
	*mulched 11/20/09		12/29, 1/02/2009 (2)	2	0.80	0.00	0.00
			2/11-18 (8)	8	12.00	0.00	0.00
			2/22-24 (3)	3	6.00	0.02	0.00
			3/2-4 (3)	3	4.00	0.00	0.00
			3/16 (1)	1	1.60	0.00	0.00
			3/22 (1)	1	1.70	0.00	0.00
			4/9-11 (3)	3	3.10	0.00	0.00
			5/2-5 (4)	4	7.30	0.00	0.00
			6/4-6 (3)	3	1.20	0.00	0.00
			6/10 (1)	1	0.66	0.00	0.00
			10/13-15 (3)	3	5.92	0.02	0.00
				39	**49.36**	**0.04**	**0.00**
Type = OHV - off highway vechicle							* Based on Shasta Dam weather station
Difficulty = E - easy, M - moderate, D - dificult							
Use Level = L - low, M - moderate, H - high							