2011 ACUB Project Progress Report

1. **Reporting Date:** 26 October 2011

2. **Project Title:** Captive rearing and translocation of Taylor's checkerspot in south Puget Sound: 2010-2011

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4. **Project Site:** Captive rearing - Oregon Zoo; Release and monitoring sites –Scatter Creek South (SCS; WDFW) – 2007-2011 releases; Range 50 (R50; Joint Base Lewis-McChord) – 2010-2011 releases; Pacemaker (PCM; JBLM) - 2009 release; Scatter Creek North (SCN; WDFW) – 2009 release; and Range 76 (R76; JBLM) – population source site.

5. **Executive Summary**

The goal of this project is to establish new populations Taylor's checkerspot in south Puget Sound and reduce the likelihood of extinction. Funding was awarded to support captive rearing and reintroduction of Taylor's checkerspot in South Puget Sound, Washington in 2010-2011. This is the sixth year of a multi-year recovery project; results to date for both captive rearing and translocation portions of the project are summarized and include analyses of 2010 distance sampling data for all reintroduction sites (SCS, R50, PCM, and SCN) as well as raw data for the R76 source site. Observations of Taylor's checkerspot captive mating, oviposition and hatching success in 2008-2011 suggest that sunlight may be a key factor affecting success. Survival rates for offspring of captive-bred females from egg to hatching in 2011 was low (44.7) relative to those of wild females (90.0), although it is not clear whether this resulted from lack of natural sunlight in the lab, poor viability of captive-bred females, or a combination of these. Survival from hatching to postdiapause was similar for both groups, with survival in all life stages exceeding 90.0 percent. Only postdiapause larvae from wild females were retained for rearing to the adult stage in 2011. Translocation success has been generally favorable, although with mixed results between years, apparently due to cool, wet and cloudy springs which have persisted since 2008. As result of such conditions, postdiapause larvae released in 2009 and those released at SCS in 2011 appear largely to have perished. Four reintroduction sites (SCS, R50, PCM, and SCN) were monitored during the 2010 flight season and two (SCS and R50) were monitored in 2011. The source site at R76 has been monitored annually since 2007, although funding from JBLM to support this work is currently lacking. Numbers of adults at R50 and R76 in 2011 exceeded expectations, while those at SCS were well below expected levels. Potential explanations for these results are complex but include climatic perturbations that differentially affected the 2011 release at SCS compared to R50, differences in site management history, especially fire, which may be affecting predator and parasite loads, and differences in overall site condition related to soil type, soil moisture and other factors.

6. **Project Goals, Objectives and Interim status**

The goal of this project is to reduce the likelihood of extinction by establishing new populations Taylor's checkerspot (*Euphydryas editha taylori*) in South Puget Sound, Washington. The goal

of the 2010-2011 project year was to maximize the size and effectiveness of releases using the best available sites.

Objectives of the 2010-2011 captive propagation and release programs are to:

1) Maintain captive propagation at the Oregon Zoo at full capacity and retain a captive colony. *The Oregon Zoo is functioning at a maximum capacity of approximately 2,600-3,000 late-instar larvae and 300 adults. We do not have a captive colony (i.e., successive captive-bred generations) at this time, as the source population at Range 76 was of sufficient size in 2010 and 2011to support the needed annual take of adults for oviposition and other purposes.*
2) Mate captive-reared and/or wild adult Taylor's checkerspots. *Complete.*
3) Continue training and establishment of a captive propagation program at a second facility. *Update included in ACUB Interim report for:* Development of a Captive Rearing Facility for Taylor's Checkerspot (*Euphydryas editha* taylori) at Mission Creek Correctional Center for Women.
4) Release about 2000 postdiapause larvae and any excess prediapause larvae produced in captivity. *Complete*.
5) Continue release trials with adult Taylor's checkerspots. *Complete.*
6) Review progress and proposed tasks in January 2011; adjust spring 2011 protocols if needed. *Complete*.

Monitoring objectives for propagation and release of Taylor's checkerspot in 2010-2011:

1) Quantify stage-specific survival of captive animals at Oregon Zoo institution. *Complete*.
2) Quantify results of captive-mating trials at the Oregon Zoo. *Complete.*
3) Quantify frequency of host plants and percent cover of functional plant groups (e.g., host by species, other forb, bunchgrass, etc.) in release plots. *Complete*.
4) Conduct transect surveys of release plots to quantify postdiapause larval numbers in 2011 release plots and plots where releases have occurred within the past two years. *Transect surveys in 2011 release plots were completed as conditions allowed; no surveys were conducted in release plots from 2010.*
5) Quantify numbers and distribution of adults at release sites using distance sampling. *Surveys, data entry, and data summaries for 2011 complete; distribution, density and abundance analyses forthcoming. Density and abundance analyses for 2010 reintroduction sites are complete.*
6) Conduct transect sampling of marked (released) vs. unmarked (eclosing in the wild) adults by netting, to compare their relative contribution to overall numbers. *Complete.*
7) Conduct focal animal sampling to document oviposition locations. *Completed in conjunction with release of adult females*.
8) Conduct transect surveys of release plots to document reproductive activity and quantify prediapause larval occurrence. *Complete*.

7. Methods

Captive rearing

Captive mating and oviposition

In 2010, eight wild females showing light wing wear were collected from the source site (R76) on JBLM, to expand the founder population at the Oregon Zoo and increase genetic diversity of captive stock. Captured adults were transferred to jars then moved to a captive site in Olympia, Washington, where netted enclosures containing pots of *Plantago lanceolata* and fresh flowers

for nectar were provided for egg-laying; females were also fed artificial nectar daily. Egg masses were harvested by cutting the *Plantago* leaf and transferring it to a clear, labeled jar; eggs were transferred to the Oregon Zoo for rearing prior to hatching. These methods are the same as those used at the Oregon Zoo (see Barclay et al. 2009); further details on methods used at the Oregon in 2010 are available in Wendt et al. (2011). Wild females were released back at the source site after 1-2 clusters of eggs had been laid (target about 75 eggs per female). Eggs from wild females supplemented those obtained via captive mating at the Oregon Zoo. Males and females from both $F_{1\text{-}08}$ (second diapause in captivity from eggs laid in 2008) and $F_{2\text{-}09}$ (captive-bred from eggs laid by F_1 females in 2009) generations.

The large population at R76 allowed us to collect 24 wild females for egg laying in 2011, expanding the size of the founder population and reducing the potential influence of captive propagation on stock used for reintroduction. Upon capture, adults were transferred to jars and transported to the Oregon Zoo in a slightly chilled cooler. Eggs from wild females supplemented those obtained via captive mating. Captive mating was achieved by co-locating a female with a group of males inside a netted enclosure. All mating attempts were documented. Cups containing mated pairs were placed near the window and checked frequently to note the time copulation was complete, at which point males were returned to their sibling groups and females fed and placed in an oviposition chamber. If no copulation occurred females were fed and returned to the refrigerator for future mating attempts. Oviposition methods followed those of Barclay et al. (2009).

Rearing to adult

Captive rearing from hatching to adult followed methods described in Barclay et al. (2009); more detail on captive propagation methods used in 2010-2011 can be found in Wendt et al. (2011). As a result of postdiapause larval rearing trials in 2009-2010, all postdiapause larvae held for rearing to the adult stage at the Oregon Zoo were reared in an outdoor enclosure; outdoor (vs. indoor) rearing produced larger adults, and their phenology was more closely aligned with that in the wild. Postdiapause larvae destined for release are only held in captivity for a few weeks and were reared indoors to maximize use of space.

Translocation

Release plots

Release plot selection was based on a qualitative assessment of host plant abundance; secondary consideration is given to nectar abundance and diversity, with overall prairie quality, including low vegetation stature, factored in. Sites with more open ground, lower grass and moss density, and a background scatter of host and nectar plants are typically selected; nectar and host plants were added to the plots to increase habitat quality and attraction. Two release plots 20 x 30 m in size were set up at each site; 3 additional 5 x 5-m plots were established in between those at SCS to assess differences in detectability between surveyors. Plots at SCS were enhanced with additional *Plantago* as needed to insure a minimum of one mature plant (10 cm diameter) per 1-3 postdiapause larvae; size and distribution of plants was also considered when adding *Plantago* to a plot. Plots at R50 were typically chosen to contain a similar amount of *Plantago*; no additional plants were added. All plots were seeded with *Collinsia parviflora, Plectritis congesta* and *Castilleja hispida*. Native nectar was enhanced using plugs and/or seed of preferred species (e.g., *Balsamorhiza deltoidea*, *Armeria maritima*, and *Lomatium* spp.). Additional habitat

treatments include grass-specific herbicide, controlled burning, and spraying, pulling and mowing of Scot's broom, where appropriate. One additional 15 x 15-m plot was added at R50 during the postdiapause release, when one release plot was found to lack sufficient host plant for the designated number of larvae. This occurred when plot boundaries unknowingly shifted as a result of disturbance by military personnel.

Vegetation sampling

Percent cover of functional vegetation groups (e.g., host, grasses, thatch, nectar, forbs, etc.) and frequency of host plants by species were sampled in release plots at SCS and R50 in February and March 2011 using a 0.5 X 1.0-m grid frame with 36 intersections. Release plots were sampled systematically by dividing each plot into 5 x 5-m sections and collecting one grid sample in each section. These baseline data provide a snapshot view of the resources available at the time postdiapause larvae are released. These data can be used to account for similarities and differences between sites but cannot be used as experimental replicates due to lack of independence between plots within a site and our inability to adequately control for habitat and climate-related variables between sites. Average number out of 26 grid intersections, and average percent cover and standard deviation are presented.

2011 Postdiapause larval release

On 6 March 2011, a total of 1,096 (542 in Plot F; 462 in Plot G; 32, 35, and 25, respectively in Test plots 1-3) postdiapause Taylor's checkerspot larvae were released at Scatter Creek in South Puget Sound. Due to poor weather and access constraints, the subsequent release of 1,119 larvae (560 in Plot F; 333 in Plot G; 226 in Plot H) did not occur at Range 50 until 20 March 2011. Larvae were released in groups of 2-5 in the largest and/or densest patches of *Plantago lanceolata*; dense patches of *Collinsia parviflora* and *Plectritis congesta* were also used for release at Scatter Creek. Weather on 6 March was partly sunny with temperatures around 50 °F with little or no wind; anticipated clearing did not occur as forecast at Range 50, although temperatures did reach 50 °F with little wind. Two wild Taylor's checkerspot larvae were observed inside release plots at Range 50, suggesting that adults from the 2010 release oviposited in the area.

Post-release monitoring of postdiapause larvae

Post-release surveys of postdiapause Taylor's checkerspot larvae are designed to: 1) document persistence of larvae post-release, and 2) gather baseline data on detectability and density of 2011 larvae following release. All 2011 plots were to be monitored two times each in the weeks following release of larvae, however heavy rain and access issues confounded release and subsequent survey efforts. Surveys consisted of 2-m wide belt transects (one meter either side of line) spaced 5 m apart on an east-west orientation through the release plots to neutralize visibility. Surveys are conducted on days with temperatures > 8º C, wind < 15 mph, and at least a soft shadow; direct sunlight appears to reduce the influence of minimum temperature and wind speed on larval activity. Data recorded include start and stop time, number of larvae in group, larval substrate (host plant by species, moss/bare or grass/forb), and behavior (basking, traveling, or foraging). The first survey is to be conducted the day following release or as soon thereafter as possible, with a second survey conducted at least 1 day after the first survey or as soon thereafter as possible but not later than 20 March. After this point larvae are more likely to pupate or return to diapause.

2011 Release of adults

Adult Taylor's checkerspots were released from captivity at SCS for the second consecutive year. Released adults were those not needed in mating trials and females that had achieved oviposition targets in captivity (i.e., sufficient to represent their lineage). All were marked on the wing with a felt tip pen prior to release (Barclay et al. 2009). In addition, wild females from R76 that had been laying eggs at the Oregon Zoo and wild males and females from R76 were released. A subset of these females were released in such a way as to provide a comparison between the release response of captive-reared, wild-caught, and wild-caught females held in captivity at the Oregon Zoo. All females tracked as part of the behavioral response to release were first released onto a nectar flower and then tracked until lost or for at least 30 minutes post-release. Behavioral data were collected using a voice recorder and include release date and time, location, duration of each behavior, approximate distance flown, if any, and substrate. Weather conditions at the time of release were forecast to be $\geq$11.7 °C, with wind $\leq$ 10 mph and at least a soft shadow.

2010 and 2011 Distance sampling

Distance sampling was used to estimate the abundance and distribution of adults at each site in 2010 and 2011. Standardized distance estimation training and routine weekly testing is conducted each year to insure consistency in decision-making and survey technique by all participating staff and is critical for reducing variance around distance estimates. Four sites [R50, SCS, Scatter Creek North (SCN) and Pacemaker (PCM)] plus one extant site (R76) were monitored for adult checkerspots during the 2010 flight season. Transects at SCN and PCM were spaced 25 m apart with segment markers every 25 m; those at SCS and R50 were 30 m apart with segments every 50 m. There were 11 transect lines at SCS in 2010; each was 550 m in length for a total line length of 6,050 m in the survey area. There were 13 transect lines 400 m in length at R50 in 2010, for a total line length of 5,200 m. At PCM there were 8 transect lines 350 m in length in 2010, for a total line length of 2,800 m; SCN had 6 transect lines 400 m in length for a total line length of 2,400 m.

Three sites (SCS, R50 and R76) were monitored during the 2011 flight season using distance sampling. On reintroduction sites (SCS, R50), survey transects covered an area that included all release plots and a buffer sufficient in size (e.g., up to 200 m) to capture most adult movements and provide context for population growth over time; transects at R76 (extant site) cover the majority of occupied habitat. Transects at SCS and R50 were spaced 25 m apart with segment markers every 50 m; transects at R76 are 50 m apart with segments every 50 m and have been standardized since 2007. The closer transect spacing at reintroduction sites insures that a sufficient number of butterflies are detected to calculate abundance estimates. Distance sampling was conducted up to 3 times each week throughout the flight season with a target minimum of 3 good sampling days per site; actual surveys are conducted opportunistically as weather and access allow. Sites were spot checked to identify the start and end of the flight season. Distance sampling followed established methods (Linders and Olson 2009) preferably with ambient temperatures >11.7 °C; sufficient sunshine to cast at least a soft (fuzzy) shadow, OR bright skies with faint (shadow detected but edges nondescript) or no shadow if temp is >15.5 °C (60 °F); and sustained winds <10 mph.

Distance sampling data analyses 2010: Detection function fitting and all subsequent analyses were done using Program Distance (Version 6.0; Thomas et al. 2010) and the Conventional Distance Sampling engine. The detection function process was begun by running a suite of 6 models made up of recommended key function + adjustment term combinations (see Buckland et al. 2001). A combination of default settings and user specified setting were then used to select which of the many available models best fit the distance data, including Akaike's Information Criterion (AIC) and goodness-of-fit tests.

After determining the detection function(s) to use, density estimates were computed by date using Program Distance. Variance estimates of density were calculated using a relatively new method (Fewster et al. 2008) that takes advantage of the sequential (evenly spaced) layout of transects to reduce variance estimates over those assuming that transects are placed randomly. Of the two methods of this type available in Program Distance, we chose to use method O2, which is generated by creating overlapping strata among adjacent transects and has been shown to increase precision with little change in bias (Fewster et al. 2008). Variances generated from the O2 method were also used to estimate 95% Confidence Intervals. Density estimates were computed by survey date because of the expectation that population numbers change on nearly a daily basis due to eclosion and mortality of individuals.

Net sampling

All released adults were marked to distinguish them from those eclosing in the field. Net surveys are typically conducted no sooner than 48 h post-release in an effort to document distribution and persistence of marked adults. The 48-hr delay allows adults to normalize their behavior following release. Surveyors walked north-south transects on the distance sampling grid to equalize likelihood of encounter between transects. Checkerspots were netted as encountered unless flying rapidly, in which case they were noted but not pursued to avoid chasing them from the site. All captured adults received a small color mark on the right ventral hind wing, with unique colors used to indicate capture date; wing wear was scored to assess relative age according to methods established by Edith's checkerspot butterflies (Ehrlich and Davidson 1960). We attempt to conduct net surveys on the same day as distance sampling, so ratios of marked and unmarked animals can be expressed relative to abundance estimates for that day. We expected marked adults to be distributed in a similar fashion to those eclosing naturally.

Prediapause larval surveys

We conducted transect surveys in release plots at SCS using belt transects as described for postdiapause surveys to document reproduction and quantify prediapause larval density. Release plots are chosen and enhanced to represent the highest quality larval habitat available on site, so we assumed they would also be attractive to egg-laying females. Time, number of larvae in group, host species, plant size (perpendicular length and width as well as height), and number of host plants within 10 cm of the oviposition plant were recorded. Surveyors walked parallel transects through release plots on days with temperatures > 8º C, wind < 15 mph, and at least a soft shadow. Each release plot was surveyed at least once between late May and early-June. Additional surveys in the vicinity of the release area at SCS were also conducted to locate oviposition sites; a portion of the 2012 release area where host plant was prevalent and broom overstory limited was also surveyed, as this area will be burned in fall 2011. Lack of access prevented us from conducting prediapause surveys at R50 or R76 for comparison.

2011 Prediapause larval release

An excess of prediapause larvae in captivity resulted in a total of 1,036 prediapause larvae (4^{th} and 5^{th} instar) being released at SCS. Larvae were from two sources: offspring of captive-reared and -mated females and offspring of wild females ovipositing at the Oregon Zoo. Larvae were brought from the Zoo on 7 July 2011 and placed in groups of 7-17 on the large, dense patches of *Plantago lanceolata* in the vicinity of Plots F and G. One post-release check was made on 13 July 2011. Weather conditions at the time of release were temperature 15.2 °C, average wind speed 3.9 mph, max wind 11.2 mph, with overcast skies, no shadow and no precipitation.

8. Results and Discussion

Captive rearing

Captive mating and oviposition

Of 157 mating attempts, 35 captive females (6 $F_{1\text{-}08}$, 29 $F_{2\text{-}09}$) copulated with 31 captive males (6 $F_{1\text{-}08}$, 25 $F_{2\text{-}09}$) in 2010 (22.3 percent; Table 1). Captive females laid 281 egg clusters totaling 7,050 eggs, 825 of which were laid by $F_{2\text{-}08}$ females. The first egg cluster was collected on 19 April 2010 and the last on 14 June 2010. Overall, the number of eggs laid by a single female ranged from 1 to 640, with an average number of 201.4 (SD 161.4) eggs per female; the average number of clusters per female was 8.03 (SD 4.77). Only 14 of 35 females (40.0 percent) laid eggs that hatched (Table 1), producing 4,130 eggs from 13 $F_{2\text{-}09}$ females and 247 from 1 $F_{1\text{-}08}$ female. The average number of eggs laid by these 13 $F_{2\text{-}09}$ females was 317.7 (SD 161.9); the average number of eggs laid by $F_{2\text{-}09}$ females whose eggs did not hatch was 130.9 (SD 122.0). The average number of eggs laid by the other five $F_{1\text{-}08}$ females was 115.6 (SD 115.5).

Table 1. Copulating pairs of Taylor's checkerspot butterflies and resulting numbers of eggs laid, larvae counted (2^{nd} instar), and larvae entering diapause at the Oregon Zoo in Portland in 2010. ID numbers reflect: hatch year – pupation year -founding female parent - specific individual ID from a given founding female. Bold text indicates females with eggs that hatched.

Female ID	Male ID	Eggs	#larvae	#larvae in diapause
08-10-40-04	08-10-43-01	98	0	0
08-10-44-05	08-10-45-02	98	0	0
08-10-45-05	08-10-46-07	311	0	0
08-10-46-02	08-10-48-02	6	0	0
08-10-48-04	08-10-39-01	65	0	0
08-10-48-10	**08-10-39-04**	**247**	**8**	**7**
09-10-C1-05	09-10-E-01	17	0	0
09-10-C1-08	09-10-E-16	1	0	0
09-10-C1-17	**09-10-E-19**	**151**	**93**	**85**
09-10-C2-05	09-10-E-16	29	0	0
09-10-C2-09	09-10-E-21	21	0	0
09-10-D2-08	09-10-R-01	296	0	0
09-10-D2-22	09-10-M-25	307	0	0
09-10-D2-24	**09-10-M-23**	**334**	**60**	**57**
09-10-D2-26	**09-10-M-24**	**337**	**40**	**39**
09-10-E-08	09-10-N-05	86	0	0
09-10-E-10	**09-10-N-06**	**332**	**219**	**213**
09-10-E-24	**09-10-N-17**	**399**	**150**	**146**

09-10-i1-05	**09-10-D-16**	**38**	**8**	**8**
09-10-i2-14	09-10-M-04	234	0	0
09-10-i2-24	**09-10-D-17**	**286**	**190**	**189**
09-10-K-28	09-10-C1-16	63	0	0
09-10-K-29	09-10-C1-21	317	0	0
09-10-K-30	09-10-C1-19	308	0	0
09-10-M-07	09-10-D1-03	128	0	0
09-10-M-12	09-10-R-18	120	0	0
09-10-M-22	**09-10-R-17**	**359**	**320**	**309**
09-10-M-30	**09-10-R-16**	**348**	**30**	**29**
09-10-N-03	09-10-O-17	147	0	0
09-10-N-04	09-10-O-20	4	0	0
09-10-N-20	**09-10-O-17**	**399**	**169**	**169**
09-10-O-06	09-10-i2-05	17	0	0
09-10-O-21	**09-10-i2-21**	**452**	**68**	**67**
09-10-R-02	**09-10-K-17**	**55**	**9**	**8**
09-10-R-19	**09-10-K-17**	**640**	**591**	**583**
	Total	7050	1955	1909

A total of 13 egg clusters were brought to the Oregon Zoo for rearing by WDFW, collected from the 8 wild-caught females in 2010. The first egg cluster was collected on 7 May 2010 and the last on 16 May 2010 for a total of 762 eggs. The average number of eggs per female was 95.3 (SD 27.8), range 68-139. All 8 females laid eggs that hatched (Table 2).

Table 2. Wild Taylor's checkerspot females and resulting numbers of eggs laid, larvae counted (2nd instar), and larvae entering diapause at the Oregon Zoo in Portland, 2010. ID numbers reflect founder lineages: wild - pupation year - collection location (Fort Lewis) - individual female ID.

Female ID	Eggs	# larvae counted	# larvae in diapause
W-10-FL 01	96*	98*	99*
W-10-FL 02	80	69	69
W-10-FL 03	139	108	104
W-10-FL 04	68	50	49
W-10-FL 05	133	117	117
W-10-FL 06	101	106	106
W-10-FL 07	70	65	65
W-10-FL 08	75	73	71
Totals	762	686	680

*Accuracy counting large eggs clusters is constrained by visibility, as parts of the egg cluster may be several layers deep.

Observations of Taylor's checkerspot captive mating, oviposition and hatching success since 2008 suggest that sunlight may be a key factor affecting the outcome of these activities. A more detailed look at these relationships may be possible at the new greenhouse facility built for captive rearing at Mission Creek Corrections Center for Women (MCCCCW). Survival rates for offspring of captive females from egg to hatching in 2011 was low (44.7) relative to those of wild females (90.0) (Table 3) and captive-bred females in 2009 (79.0 percent) (Wendt et al.

2011), although it is not clear whether this resulted from lack of natural sunlight in the lab, poor viability of captive-mated females, or a combination of these.

Rearing to adult

The first eggs hatched on 10 May 2010 and the last on 21 June 2010. Due to their small size, tight clustering and fragile nature, larvae are not counted until 2nd instar. A total of 2,641 larvae reached 2nd instar in 2010 and began to diapause on 28 June; all 2,589 larvae were in diapause by 31 July 2010. Survivorship was high during diapause, with a loss of only 22 larvae (Table 3).

Table 3. Number, percent of cohort and percent of total cohort to reach each life stage or disposition for Taylor's checkerspot reared at the Oregon Zoo in Portland, in 2010-2011. Only $F_{1\text{-}08}$ & $F_{2\text{-}09}$ females with eggs that hatched are included.

Life stage or disposition	Wild females	% stage survival	Captive $F_{1\text{-}08}$ & $F_{2\text{-}09}$	% stage survival	2010 total	% cohort survival
Eggs	762	na	4,377	na	5,139	na
Egg to 2nd instar	686	90.0	1,955	44.7	2,641	51.4
2nd instar to diapause	680	99.1	1,909	97.6	2,589	98.0
Diapause to end diapause	677	99.6	1,888	98.9	2,565	99.1
Postdiapause release	373	55.1	1,877	99.4	2,250	87.7
Postdiapause to pupation	279[1]	91.8	Na	na	279	91.8
Postdiapause to eclosion	273	97.8	Na	na	273	97.8
Adult release	181	66.3	Na	na	181	66.3
2nd diapause	15	4.9	Na	na	15	4.9

[1] Out of 304 individuals kept for breeding.

Larvae were removed from diapause on the 20-21 February 2011. Three hundred four larvae selected for captive breeding were placed in the outdoor screen tent on 2 March 2011. The first pupa was found on 25 April 2011, 65 days after removal from diapause; the last pupae was found 25 May 2011. There were no obvious differences between lineages in rate of pupation versus return to diapause (Table 4). Larvae began returning to 2nd diapause by 2 May 2011, with a total of 4.9 percent entering 2nd diapause ($F_{1\text{-}10}$; Table 4). Two thousand two hundred fifty larvae (1,877 captive, 373 wild) hatched in 2010 were reared for release as postdiapause larvae.

Table 4. Number of larvae reared to the adult stage at the Oregon Zoo in Portland that entered 2nd diapause, pupated and eclosed by female founder line in 2011.

Lineage ID	#larvae	2nd diapause	# pupae	# eclosed
FL 01	38	1	35	35
FL 02	38	3	33	33
FL 03	38	6	31	31
FL 04	38	1	34	32
FL 05	38	0	38	36
FL 06	38	3	35	35
FL 07	38	0	37	35
FL 08	38	1	36	36
Total	**304**	**15**	**279**	**273**

Of the 273 adults that eclosed in 2010, 151 were females and 122 were males. Eight (2.9 percent) butterflies showed noticeable malformation due to improper eclosion; no difference in rate of improper eclosion was seen between males (4) and females (4), or between lineages.

Translocation

Vegetation sampling

Percent cover of functional vegetation groups (Table 5) and frequency of host plants by species (Table 6) for 2011 release plots at SCS and R50 are presented below. Aside from differences in host plant availability (Table 6 and below), notable differences between sites include more grass and less bare ground and an absence of bracken fern at R50 compared to SCS. A lack of fire at R50 may account for a portion of these differences, although thatch was not noticeably different between sites, perhaps because R50 typically burns every year.

Table 5. Percent cover of functional plant groups in two plots at two sites where postdiapause Taylor's checkerspot larvae were released in late winter 2011. SCS = Scatter Creek South; R 50 = Range 50; PLLA = *Plantago lanceolata*; COPA = *Collinsia parviflora*; PLCO = *Plectritis congesta*; FESC = Fescue; OG = Other grass; FORB = all non-host forbs; FERN = Bracken fern; WOOD = Woody debris; THAT = Thatch; MOSS = Moss; BARE = Bare ground; ROCK = Rock; FRVI = *Fragaria virginiana*; ARMA = *Armeria maritima*; LOUT = *Lomatium utriculatum*; POGR = *Potentilla gracilis*.

	SCS Plot F			SCS Plot G			R50 Plot F			R50 Plot G		
Group	Ave # pts	% cover	% StDev	Ave # pts	% cover	% StDev	Ave # pts	% cover	% StDev	Ave # pts	% cover	% StDev
PLLA	0.79	2.2	3.3	0.71	2.0	4.2	1.13	3.1	5.0	0.54	1.5	3.5
COPA	1.79	5.0	12.7	2.29	6.4	11.2	0.00	0.0	0.0	0.00	0.0	0.0
PLCO	0.46	1.3	4.0	0.33	0.9	2.9	0.00	0.0	0.0	0.00	0.0	0.0
FESC	3.04	8.4	10.9	0.33	0.9	2.4	15.54	43.2	23.6	13.42	37.3	26.8
OG	5.17	14.4	11.0	4.04	11.2	11.8	6.42	17.8	16.8	11.71	32.5	17.6
FORB	3.96	11.0	6.7	5.33	14.8	7.6	4.79	13.3	11.6	3.96	11.0	7.0
FERN	0.67	1.9	3.2	0.63	1.7	4.8	0.00	0.0	0.0	0.00	0.0	0.0
WOOD	0.33	0.9	1.6	0.29	0.8	1.9	0.00	0.0	0.0	0.00	0.0	0.0
THAT	2.54	7.1	5.8	3.00	8.3	8.4	2.54	7.1	9.0	0.63	1.7	3.2
MOSS	6.79	18.9	11.7	3.79	10.5	11.6	3.33	9.3	6.9	3.50	9.7	9.6
BARE	9.29	25.8	14.2	14.46	40.2	19.0	1.67	4.6	8.4	1.71	4.7	6.7
ROCK	1.04	2.9	2.9	0.79	2.2	3.1	0.58	1.6	4.1	0.54	1.5	2.2
TOTAL	**36.00**	**100.0**		**36.00**	**100.0**		**36.00**	**100.0**		**36.00**	**100.0**	
FRVI	0.17	0.5	1.3	0.50	1.4	2.3	0.00	0.0	0.0	0.00	0.0	0.0
ARMA	0.04	0.1	0.6	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
LOUT	0.04	0.1	0.6	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0
POGR	0.38	1.0	2.3	0.17	0.5	2.3	1.04	2.9	6.7	0.00	0.0	0.0

Plots at both SCS and R50 were seeded with *Collinsia parviflora*, *Plectritis congesta* and *Castilleja hispida*, however germination rates for *Collinsia parviflora* and *Plectritis congesta* at Scatter Creek were very high relative to Range 50 (Table 6), where only a few small plants of either species were observed. The same was true for *Castilleja hispida* (Fig. 1), although data in Table 6 do not reflect this because *Castilleja* did not germinate until after these data were collected. The discrepancy in germination response between sites may be due to a variety of factors, one of which is the effect of fire, which was present at SCS but lacking at Range 50 in 2010; both sites were seeded at the same time. A Master's Thesis study by Carl Elliott (pers.

comm.) on the effect of smoke water on germination of native prairie plants shows a significant improvement in germination rates for *Plectritis congesta* and *Castilleja hispida* but not *Collinsia parviflora*. Other factors that may affect germination include but are not limited to soil type, soil moisture, percent cover of moss and lichens, and seeding technique. Additional research on this topic would aid in management decisions pertaining to seed production and distribution among restoration sites.

Table 6. Host plant frequency per square meter in two plots at two sites where postdiapause Taylor's checkerspot larvae were released in late winter 2011. SCS = Scatter Creek South; R50 = Range 50; PLLA = *Plantago lanceolata*; COPA = *Collinsia parviflora*; CAHI = *Castilleja hispida*; PLCO = *Plectritis congesta*.

	SCS Plot F		SCS Plot G		R50 Plot F		R50 Plot G	
Host	**Ave/m2**	**StDev/m2**	**Ave/m2**	**StDev/m2**	**Ave/m2**	**StDev/m2**	**Ave/m2**	**StDev/m2**
PLLA	5.7	0.2	5.4	0.2	5.3	0.2	1.6	0.1
COPA	129.4	10.9	170.5	7.2	0.0	0.0	0.0	0.0
CAHI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PLCO	45.8	4.3	29.4	3.2	0.0	0.0	0.0	0.0

Fig. 1. Seedlings of *Castilleja hispida*, a native host plant for Taylor's checkerspot larvae, in plots at Scatter Creek South where larvae were released in late winter (postdiapause) and early summer (prediapause), 2011.

Post-release monitoring of postdiapause larvae

Surveys were conducted between 1144 and 1730 h; temperatures ranged from 9.1 to 15.5 °C; Average wind speed was 0.6-7.0 mph; max wind speed 2.0-12.4 mph; cloud cover ranged from clear to overcast, with shadows ranging from none to distinct. Re-sightings of larvae were few

overall; all larvae observed were singles, except one group of two at SCS. As expected, most larvae were observed less than 5 cm from host plants, basking or foraging (Table 7). Two observers re-sighted only 2 of 96 larvae each, among the three 5 x 5-m test plots at SCS, rendering efforts to measure differences in detectability between observers useless. Lack of access prohibited conducting similar surveys at R76 (extant site), although some reconnaissance was done on 17 April 2011 (Table 7). Hundreds of larvae were observed at R76 in addition to those recorded on the survey; they were observed to occupy every location checked across the site in similar densities and were spaced about 1 m apart in any direction.

Table 7. Distance from host and behavior of postdiapause Taylor's checkerspot larvae observed at reintroduction (SCS, R50) and extant (R76) sites in Spring 2011. SCS = Scatter Creek South; R50 = Range 50; R76 = Range 76.

Site	Distance from host plant			Behavior				Site Total
	0-5 cm	5-10 cm	> 10 cm	Bask	Forage	Travel	Pupa	
SCS	28	2	1	21	5	5	0	31
R50	0	2	1	1	0	1	1	3
R76	36	1	1	20	15	1	2	38

The low numbers of larvae observed during postdiapause surveys may have been the result of the late date of surveys relative to release date (11-17 d. post-release at SCS; 27 d. post-release at R50). High mortality at SCS in the weeks following release of postdiapause larvae may also have been a factor; this is supported by the relatively small numbers of adults observed there in 2011 compared to R50 (see Table 11 below). Mortality at SCS may have resulted from heavy rains, which would have made it difficult for newly released larvae to locate a suitable hiding place among saturated vegetation and soils. The number of larvae at SCS basking on bare ground and small pieces of wood (Table 8), in spite of abundant host plants (Fig. 2), suggests warmth and protection may have been more limiting than food. Given the late dates at which larvae were still observed at R50 and R76 (Table 8), it is unlikely this was the result of larvae wandering in search of a location in which to pupate.

Table 8. Distribution of postdiapause Taylor's checkerspot larvae observed by site and substrate during post-release surveys at two reintroduction sites (SCS, R50) and one extant site (R76), in South Puget Sound, Washington, Spring 2011. Surveys at release sites took place inside release plots; surveys at R76 were conducted along one side of a dirt roadway with a vegetated edge and median. SCS = Scatter Creek South; R50 = Range 50; R76 = Range 76; PLLA = *Plantago lanceolata*; COPA = *Collinsia parviflora.*

Site	Date	PLLA	COPA	Grass/Forb	Bare/Moss	Wood	Total Obs.
SCS	17-23 Mar	3	4	7	9	8	31
R50	16-Apr	0	NA	3	0	0	3
R76	17-Apr	32	NA	3	3	0	38

Fig. 2. Typical release location (flag) at Scatter Creek South (SCS) showing abundant host plants of *Plantago lanceolata* (PLLA) and *Collinsia parviflora* (COPA).

Distance sampling 2010

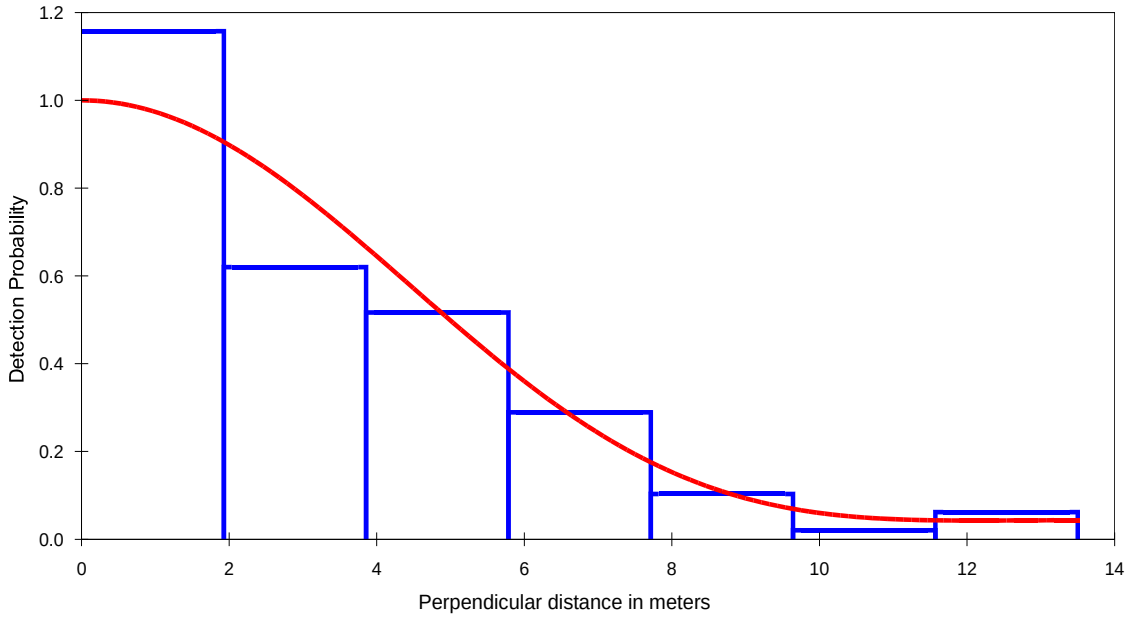
Scatter Creek South. Six surveys were conducted by three observers at SCS in 2010 (Table 9); complete surveys were conducted on five days. Density estimates were not generated for the incomplete survey on May 27, although these data were included in detection function analyses. Minimum known flight season length at SCS was 40 days with the greatest number (46) of checkerspots observed on 9 May (Table 9). This was the only one of three sites to receive larvae in 2009 that produced sizeable numbers of adults that year (see 2010 Interim report); flight season surveys in 2010 (Table 9), suggest that a high rate of return to diapause is not a likely explanation for these differences. Alternatively, the number of adults observed at SCS in 2009 may be better explained by on-site reproduction resulting from previous releases in 2007 and 2008, although high rate of return to diapause in previous years cannot be ruled out. These topics will be addressed in greater detail in a 5-year project summary currently being compiled.

Distance sampling data were combined into a single detection function for all three SCS observers in 2010 (Fig. 3A) despite differences in detection functions by observer, because there was not enough data to estimate observer-specific densities by date and then combine them into one pooled estimate per date. A uniform function with two cosine adjustment terms was used as it seemed to fit the SCS distance data best overall (Fig. 3A). Density estimates with 95% Confidence Intervals are presented by date in Table 10; also presented are abundance estimates by date with 95% Confidence Intervals applied to the entire survey area. A total of 134 observations of Taylor's checkerspots were used in these analyses; data from the incomplete survey on 27 May were included in detection function analyses, but no density estimates were generated for this date.

Table 9. Number of Taylor's checkerspots counted in distance sampling surveys by site and date in South Puget Sound, Washington, Spring 2010; extent refers to the number of transects surveyed. SCS = Scatter Creek South; R50 = Range 50; PCM = Pacemaker; SCN = Scatter Creek North; R76 = Range 76.

Site	Date	Extent	Count
SCS	18-Apr-10		1st obs. (1)
	22-Apr-10	11	25
	7-May-10	11	29
	9-May-10	11	46
	13-May-10	11	36
	15-May-10	11	17
	27-May-10	5 of 11	1
SCS Total			***155***
R50	23-Apr-10	13	9
	6-May-10	13	41
	8-May-10	13	40
	12-May-10	13	67
	14-May-10	13	50
	19-May-10	6 of 13	4
	26-May-10		Last obs. (1)
R50 Total			***211***
PCM	23-Apr-10	8 of 8	0
	30-Apr-10	8	0
	6-May-10	8	0
	8-May-10	8	0
	12-May-10	8	0
	14-May-10	8	0
PCM Total			***0***
SCN	25-Apr-10	6 of 6	0
	1-May-10	6	0
	9-May-10	6	0
	15-May-10	6	0
SCN Total			***0***
R76	19-Apr-10	Site check	1st obs.
	29-Apr-10	12	101
	6-May-10	8 of 12	171
	7-May-10	12	207
	8-May-10	12	352
	12-May-10	12	255
	13-May-10	12	307
	14-May-10	12	296
	17-May-10	12	170
	25-May-10	4 of 12	5
	27-May-10	Site check	Last obs. (6)
R76 Total			***1871***

A



B

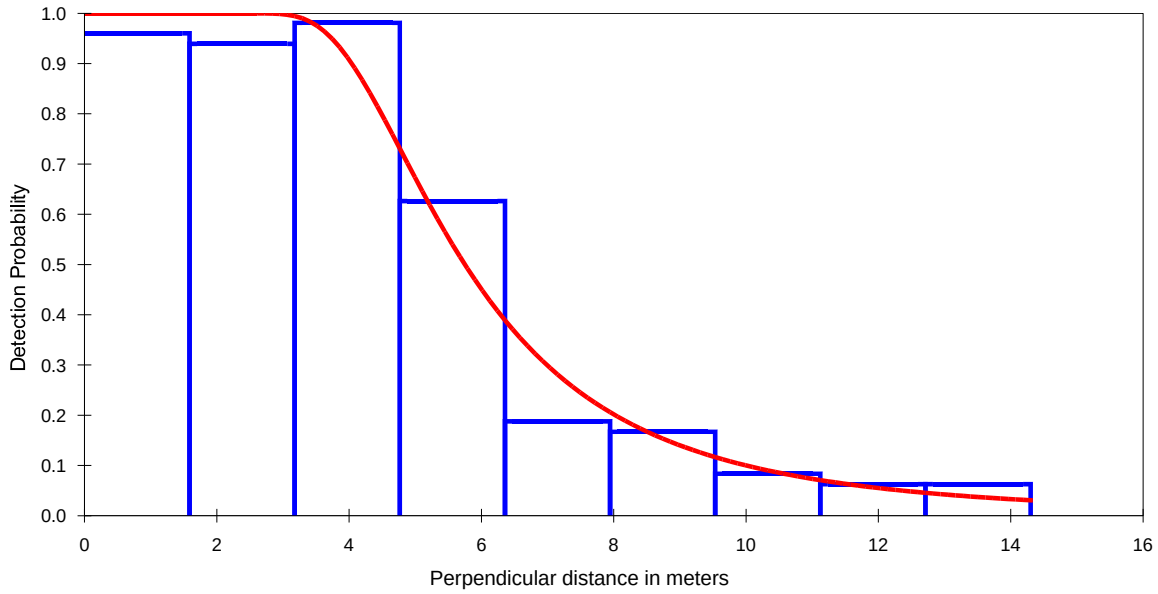


Fig. 3. Detection function (A) for all Scatter Creek South (SCS) surveyors combined in 2010 based on a uniform function with two cosine adjustment terms. Detection function (B) for all Range 50 (R50) surveyors combined in 2010, based on a Hazard rate model.

Range 50. Six surveys were conducted by four observers at R50 in 2010 (Table 9); complete surveys were conducted on five days. Density estimates were not generated for the incomplete survey on 19 May, although these data were included in detection function analyses. Minimum known flight season length was 34 days; although no monitoring occurred in the week prior to the first count due to access and weather restrictions. The greatest number (67) of checkerspots observed at R50 was on 12 May (Table 9).

Data were pooled across all four observers at R50 despite evident differences in individual detection functions because of unequal distribution of transects by observers and insufficient sample sizes to estimate detection function by date for each observer. The net result of this pooling was a classic detection function that was well fit by the Hazard rate model (Fig. 3B). Density estimates from the pooled observer detection function for R50 by date, are given in Table 10; abundance estimates by date are also presented for the entire survey area.

Pacemaker and Scatter Creek North. Protocol weather conditions and six complete surveys by three observers at PCM failed to produce Taylor's checkerspot sightings in 2010 (Table 9). Similarly, no checkerspots were observed in four protocol surveys conducted by three observers at SCN (Table 9). Equal numbers of postdiapause larvae were released at SCS, PCM and SCN in 2009, suggesting most postdiapause larvae likely perished prior to the 2009 flight season.

Table 10. Density estimates with 95% Confidence Intervals and butterfly abundance for the 2010 survey areas with 95 percent Confidence Intervals for Scatter Creek South (SCS) and Range 50 (R50) Estimates for SCS were derived from a Uniform + cosine detection function pooled over all observers and dates; those for R50 were derived from a Hazard rate detection function pooled over all observers and dates.

Date	#/ha	95% CI	Survey area #	Area: 95% CI
SCS				
22-Apr-10	3.68	1.69 - 8.01	72.86	33.46-158.60
7-May-10	3.42	2.10 - 5.56	67.72	41.58-110.09
9-May-10	7.69	5.13 - 11.53	152.26	101.57-228.29
13-May-10	5.86	3.86 - 8.90	112.46	76.43-176.22
15-May-10	2.22	1.09 - 4.51	43.96	21.58-89.30
27-May-10[2]	0.42	0.026 - 6.78	8.32	0.51-134.24
R50				
23-Apr-10	1.43	0.68 - 3.00	24.02	11.42-50.40
6-May-10	6.18	2.44 - 15.65	103.82	40.99-262.92
8-May-10	5.71	3.26 - 10.00	95.93	54.77-168.00
12-May-10	9.99	6.06 - 16.48	167.83	101.81-276.86
14-May-10	8.07	4.27 - 15.27	135.58	71.74-256.54
19-May-10[1]	1.78	0.95 - 3.37	29.90	15.96-56.62

[1] Incomplete survey on the lowest density transects.
[2] Incomplete survey on <50% of lines.

Range 76. Nine surveys (6 complete and 2 partial) were conducted under protocol weather conditions by four observers at R76 in 2010 (Table 9). Minimum known flight season length at was 39 days in 2010, with the greatest number of checkerspots observed on 8 May. Higher counts on 13, 14 May relative to dates on either side, suggest a second peak in the flight season. Distance sampling data for R76 have not been analyzed due to a funding shortage.

Distance sampling 2011

A minimum of six complete distance sampling surveys were conducted at each site surveyed; one partial survey each of R50 and R76, and 7 partial surveys of SCS were also conducted (Table 11). Flight season initiation and length were likely the same for R50 and R76, although restricted access prohibited confirmation; unlike previous years, flight season initiation and length differed at SCS (Tables 9 & 11). Effort expended at R50 and R76 were similar, totaling 53,050 m and 53,200 m of line length surveyed, respectively; more than twice as much effort was expended at SCS, with 111,000 m of line length surveyed.

Table 11. Number of Taylor's checkerspots counted in distance sampling surveys by site and date at three sites in South Puget Sound, Washington, Spring 2011. Extent equals the number of transects surveyed. SCS = Scatter Creek South; R50 = Range 50; R76 = Range 76.

Site	Date	Extent	Count
SCS	4 May	6 of 14	0
	9 May	4 of 14	0
	10 May	14	0
	12 May	11 of 14	1st obs.
	13 May	14	0
	14 May	14	6
	17 May	14	5
	18 May	14	17
	20 May	14	4
	24 May	14	9
	28 May	14	4
	3 Jun	14	15
	5 Jun	12 of 14	18
	6 Jun	12 of 14	6
	15 Jun	6 of 14	0
	16 Jun	8 of 14	0
SCS Total			***84***
R50	4 May	Site check	1st obs. (20-25)
	10 May	3 of 16	0 - survey aborted
	13 May	16	207
	20 May	16	391
	24 May	16	155
	29 May	16	87
	4 Jun	16	63
	17 Jun	16	0
R50 Total			***903***

R76	3 May	Site check	1st obs.
	9 May	4 of 12	48
	12 May	12	389
	19 May	12	1,896
	23 May	12	1,199
	29 May	12	637
	4 Jun	12	715
	12 Jun	12	70
R76 Total			***4,953***

Distance sampling surveys generated a combined total of 8,716 records across three sites (R76, R50, and SCS) in 2011, with a total of 5,940 individual butterflies counted (Table 11), comprising 5,426 groups. Butterflies were in groups of 1-8 with 5,015 single butterflies observed; 345 groups of two; 47 groups of three; 9 groups of four; 5 groups of five; 3 groups of six; and 1 group each of seven and eight individuals. Distance estimates ranged from 0.0 to 23.0 m, with an average detection distance of 3.5 m $\pm$ 2.9 m SD; average detection distance was similar between R 76 (3.5 $\pm$ 2.9 m SD) and R 50 (3.4 $\pm$ 2.9 m SD), with a shorter detection distance at SCS (3.1 $\pm$ 3.1 m SD). Statistical analyses will be conducted in winter 2011-2012.

Nectar observations were recorded opportunistically during distance sampling surveys at the three sites surveyed for Taylor's checkerspot. Fifteen different nectar species were recorded across the three sites (Table 12). Two plant species, *Balsamorhiza deltoidea* and *Lomatium triternatum*, accounted for the majority of all nectaring observations (90.3 percent). R50 differed from the other sites with only two nectar species used; SCS was notable in that five nectar species were recorded across just 10 observations (Table 12).

Mardon skipper butterfly sightings were also recorded opportunistically during distance sampling surveys for Taylor's checkerspot at the three sites visited in 2011. A total of 115 mardon skipper observations were made (Table 13); most (70) were observed as singles, however 11 groups of two, 5 groups of three, and 2 groups of four were also observed.

Table 12. Number and species of plant on which Taylor's checkerspots nectared during distance sampling surveys at two reintroduction sites (R50 = Range 50, SCS = Scatter Creek South) and one extant site (R76 = Range 76) in South Puget Sound, Washington, 2011. ACMI – *Achillea millefolium*; ARMA – *Armeria maritima*; BADE - *Balsamorhiza deltoidea*; CAQU - *Camassia quamash*; ERLA – *Eriophyllum lanatum*; FRVI - *Fragaria virginiana*; HYRA – *Hypochaeris radicata*; LECA – *Lepidium campestre*; LOTR- *Lomatium triternatum*; LOUT-*Lomatium utriculatum*; LULE - *Lupinus lepidus*; PLCO- *Plectritis congesta*; POGR – *Potentilla gracilis*; RAOC - *Ranunculus occidentalis*; SAIN - *Saxifraga integrifolia*.

Site	ACMI	ARMA	BADE	CAQU	ERLA	FRVI	HYRA	LECA	LOTR	LOUT	LULE	PLCO	POGR	RAOC	SAIN	Total
R50	0	0	113	0	0	0	0	0	0	0	0	0	0	0	6	119
R76	3	14	618	3	12	46	1	1	621	5	3	0	3	4	37	1371
SCS	0	2	2	1	0	0	0	0	1	0	0	4	0	0	0	10
Total	**3**	**16**	**733**	**4**	**12**	**46**	**1**	**1**	**622**	**5**	**3**	**4**	**3**	**4**	**43**	**1500**

Adult release 2011

A total of 167 adult Taylor's checkerspots were released from captivity on 30 May (89 females, 22 males) and 9 June 2011 (43 females, 13 males); in addition, 21 males from R76 and 8 wild females from R76 that had been laying eggs at the Oregon Zoo were released on 30 May. Eight females from R76 were released at SCS on 24 May 2011 to compare their release response with those of captive females as well as wild-caught, captive-held females. Behavioral data pertaining to these releases is still being transcribed. Thirty-four females and 9 males from R76 (source site) were released at SCS on 4 June 2011 to supplement the site because numbers at R76 remained very high throughout the flight season, whereas those at SCS were quite low (Table 11). Most released butterflies remained in place or flew to nearby vegetation upon release and proceeded to bask and nectar. A few adults were observed to fly 20 or more meters upon release, although nearly all of them restricted their flight elevation to about one meter above the ground, suggesting little or no intention to disperse longer distances (50+ m), which has been observed to occur at a height of two or more meters (M. Linders, pers. obs.). All adults were released freely by either allowing them to fly or more often, by placing them on a nectar plant.

Table 13. Number of mardon skipper butterflies observed by date and site during distance sampling surveys targeting Taylor's checkerspot butterflies in Spring 2011 at three sites in South Puget Sound, Washington. Only the first two "0" survey days for mardon skipper are included in the table. SCS = Scatter Creek South; R50 = Range 50; R76 = Range 76.

Site	Date	# mardons
R50	10 May	0
	13 May	0
	20 May	1
	24 May	9
	29 May	19
	4 Jun	21
	17 Jun	0
R50 Total		***50***
R76	23 May	0
	29 May	0
	4 Jun	8
	12 Jun	8
R76 Total		***16***
SCS	18 May	0
	20 May	0
	24 May	1
	28 May	7
	3 Jun	17
	5 Jun	18
	6 Jun	4
	15 Jun	0
	16 Jun	2
SCS Total		***49***

Net Surveys

One complete net survey was conducted at SCS on 3 June 2011. Because only five checkerspots were observed, including a single capture on 3 June, a partial survey was conducted on 5 June 2011, covering a smaller area with more closely-spaced (25-m) transects, in an effort to increase the rate of encounter. Ten checkerspots were observed with 2 captures as a result, suggesting no change in density in spite of the increase in data. Overall, Taylor's checkerspot densities at SCS in 2011 limited the effectiveness of this technique for assessing ratios of marked to unmarked adults. The limited number of good weather days available to conduct flight season surveys also limits opportunity to conduct such surveys unless dedicated surveyors can be made available. Once all field notes have been transcribed, additional anecdotal data collected during focal follows may provide supplemental information.

Taylor's checkerspot prediapause larval surveys

A total of 16 oviposition sites were located at SCS in 2011, confirming that reproduction is occurring at the site. This is double the number of oviposition sites found in 2010 in spite of a smaller adult population in 2011. One post-release check of prediapause release locations, made on 13 July 2011, revealed few larvae, little foraging sign; many molted skins were located and staff from the Oregon Zoo confirmed that many released larvae were ready to diapause at the time of release. Both *Plantago lanceolata* (introduced host) and *Castilleja hispida* (native host) were used for oviposition, suggesting some level of genetic diversity has been retained in the source population (R76) is being imparted to captive and reintroduced stock. Additional results forthcoming once all field notes have been transcribed.

Key considerations for future direction

Since 2008, abrupt increases in copulation, oviposition and egg development in captivity have been observed by Oregon Zoo staff to follow sharp increases in sunlight. We recommend using standardized protocols to collect temperature humidity and light data at both the Oregon Zoo and the new greenhouse facility at MCCCCW to elucidate the nature of this relationship.

Discrepancies in germination rates between sites may be due to a variety of factors, including but not limited to the effect of fire, soil type, soil moisture, percent cover of moss and lichens, and seeding technique. We recommend additional research to determine which factors most affect germination; key factors should be considered in production of see resources, assignment of these resources to priority sites and included in restoration guidelines.

No detailed data on vegetation condition and larval densities have been collected from extant sites in Washington. Knowing how reintroduction sites measure up to the only remaining extant site in the Puget Lowlands (R76) is a key factor limiting our understanding of reintroduction success and failure. We recommend conducting vegetation sampling and surveys for pre- and postdiapause larvae at R76, which would provide a range of baseline conditions for a naturally occupied site. Vegetation sampling should also be extended to large-scale sampling of host and nectar plant diversity and abundance, vegetation structure. Collecting data on soil characteristics at all sites, especially gravel content and soil moisture, may provide insight into the environmental conditions available to diapausing larvae, a factor that may have contributed to mortality of released postdiapause larvae at SCS in 2011.

9. Future Plans

This is the sixth year of a multi-year recovery project. Translocation data from 2007-2011 are being compiled in a five-year report. Statistical analyses on 2011 distance sampling data are scheduled for completion in winter 2011-2012. Additional funding will be required to complete 2009-2010 distance sampling analyses for Range 76. Data for this source/reference site provide critical context for reintroduction sites which are smaller size and more vulnerable to environmental perturbations. Plans for 2012 include additional releases at Scatter Creek South and the addition of up to two new sites: Glacial Heritage Preserve (Thurston County) and Pacemaker Airstrip (JBLM); due to difficulty with access and the added expense of purchasing EOD coverage, it has not yet been determined whether additional releases will occur at R50 in 2012. Funds for the 2011-2012 field season and rearing year have been secured; those for the 2012-2013 field season and rearing year are being requested from USFWS and ACUB. Goals are to retain the large size of releases and also maximize the number of release sites to offset the influence of climatic perturbations on translocation success. Additional sources of funding and new conservation partnerships are being explored.

10. Further Information Available

Literature Cited and More Information on the captive rearing program can be found in:

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11. Questions for Further Research

1) What is the average and range of survival rates for prediapause Taylor's checkerspot larvae in an established population in South Puget Sound? What are the primary sources of mortality? Are they similar or different from those at reintroduction sites?
2) Little data exist on adult life span for Taylor's checkerspot, although anecdotal observations from 2006 suggest they were similar to those published for another subspecies of Edith's checkerspot. Flight seasons in 2010 and 2011 were about 6 weeks in length, double what they have been prior to 2009. This was true even where population estimates differed by an order of magnitude between sites. Is the extended flight season the result of 1) larger populations, 2) longer individual life spans, or 3) a combination of these factors?
3) Does fire play a significant role in controlling invertebrate predators and parasites?
4) How do baseline conditions for host and nectar plant diversity and abundance and vegetation structure at an extant site compare to reintroduction sites?
5) What factors account for differences in seed germination rates between sites? How can these be used to guide seed production and restoration efforts?
6) In contrast to the clustering typical of Taylor's checkerspot larvae during much of their life cycle, most postdiapause larvae appear to be found as singles within about a week of their emergence from diapause. Do larvae in the postdiapause stage exhibit social spacing independent of host plant density, thereby limiting their density overall? If so, these data would act as a check on the size of release plots and the number of larvae that can be accommodated in each.