

STUDIES OF *CICINDELA PURITANA* AND *C. DORSALIS* IN MARYLAND, 2015



Photo by Chris Wirth



Photo by Kevin Fielding

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ABSTRACT

The total number of adult *C. puritana* at all Calvert sites in 2015 was 2733, a significant increase from 1660 in 2014 and more similar to the 3663 in 2013. The increase in 2015 is probably a result of good conditions for recruitment, survival and development from the large 2013 population. Other recent counts were 1927 in 2012, 2769 in 2011, 3043 in 2010, and 2118 in 2009. The greatest increases from 2014 were at Calvert Cliffs State Park (151 to 807), an increase which accounted for much of the total increase in 2015. Other significant increases were at Little Cove Point (360 to 526) and Calvert Beach (159 to 332). Warrior Rest declined slightly from 648 to 620. The count of 332 at Western Shores/Calvert Beach in 2015 is surprising since the site continues to experience increased vegetation growth on the back beach, cliff base and cliff face. Tree and shrub growth has been significant in the past 10-15 years causing loss of cliff habitat and probably creating a barrier for adults moving to the cliffs. The **total count for adult *C. dorsalis* in 2015 was 1873**, all but 2 at Western Shores. The high count was surprising since the shoreline was narrow in much of the occupied area. The 2015 count was two times the total for any year since 2003 when 3013 adults were counted. Most counts in the intervening years were in the 500-700 range with low counts of 190 and 78 in 2008 and 2009. Overall, the Calvert *C. dorsalis* metapopulation has experienced a progressive, stepped and significant decline of abundance since the early to mid-1990s when numbers ranged from 3000 to over 10,000 and included viable populations at Flag Ponds, Scientists Cliffs and Cove Point. Surveys were also conducted at a recently discovered *C. puritana* site and other areas of potential habitat along the **Severn River** near Annapolis. Among the 15 sites surveyed, the one known site had a count of 23 adults and another new site nearby had 12 adults. Both sites were small with very limited cliff habitat and apparent marginal populations.

The results of annual surveys at all **Sassafras sites produced a count of 1132** adults in 2015, a significant decline from the exceptionally high count of 3395 in 2014. The 2015 count was the lowest since 837 in 2009. Other recent counts were 1864 in 2013, 1478 in 2012, 1530 in 2011, and 2726 in 2010. In 2015, the significant decline was primarily due to the exceptionally large declines at East Lloyd (714 to 27), West Betterton (614 to 164), West Turner (481 to 101), and East Turner (397 to 42). The causes of these very large declines are unknown, but likely a result of habitat changes (breakdowns and larval mortality?) at these sites which have had a history of large increases and decreases. Survey results for the five cliff sections that were included in the vegetation control study were again used as a post treatment count. These 2015 results were consistent with other post treatment counts that although not statistically analyzed provide some evidence that beetle numbers were more stabilized or increased in the vegetation removal plots while decreasing in the control plots.

The total number of **adult *C. d. dorsalis* counted at Janes Island was 1570** in 2015 compared to 725 in 2014. This 2015 count was the highest since 3081 in 2005. The trend in recent years is a generally progressive and significant decline since 2005 and 2006 (3081). The adult count at **Cedar Island was 1990** in 2015 compared to 1893 in 2014. Other recent counts were 1476 in 2013, 1653 in 2012, 1691 in 2011, 1439 in 2010, 974 in 2009 and 2454 in 2006. As indicated these counts have been relatively consistent in recent years except for this significant increase in 2015 which is the highest count since the two previous high counts of 2464 in 2002 and 2475 in 2006.

INTRODUCTION

Annual surveys for *C. puritana* and *C. d. dorsalis* in Calvert County, Maryland were initiated in 1986 and have been conducted every year from 1988 through 2015. These long term surveys are believed to be among the longest periods of monitoring population size for any insect species. Both species are listed as Threatened by the U. S. Fish and Wildlife Service. Surveys for *C. puritana* at sites around the mouth of the Sassafras River have been conducted in most years since 1991 and surveys for *C. dorsalis* at Janes and Cedar Islands in all years since 2009 and in several years from 2002 to 2009. This year we also surveyed sites along the Severn River in Maryland where a new small population of *C. puritana* was discovered in 2014. The objectives of these surveys are to determine the distribution and abundance of these two rare species at all current sites in Maryland and to compare the results with previous years so trends of abundance can be identified. In all years we have used the same methods and conducted surveys during the season of peak adult abundance and most often on days when conditions are optimum. Despite these attempts for consistency in survey conditions, variations in weather, tidal conditions and seasonal variations in adult peak activity contributed to some of the observed variations in adult estimates. But, importantly these annual surveys have provided an understanding of population dynamics of these two species at the various sites so that strategies for protection and management can be implemented.

METHODS

As has been the case in previous surveys, those in 2015 were conducted during the period of peak abundance for both of the target species. All 2015 surveys were conducted between June 30 and July 16. On most survey days conditions were ideal with clear skies, temperatures in the low 80's to mid- 80's and at mid- to low tide when the sun was on the beach and cliff base. Under these conditions a high level of adult activity along the water edge is expected. On one survey day, July 8 conditions were cool and cloudy, upper 70s to low 80s during the morning so the planned survey for Sassafras River sites was postponed until the following week. Survey conditions on the follow up survey were suitable but not optimum, low 80's and mostly cloudy. The survey method we used, as in previous years, involved one person walking slowly along the shoreline near the water edge and counting all adults that were seen on the ground surface 5-10 m ahead. In areas where there was a narrow beach or cliffs near the water, the base of the cliffs was also examined and beetles there included in the count. In sections of wider beach the surveyor moved more slowly so the back portions of the beach could be surveyed. At most sites one person conducted the survey but in a few sites, two individuals surveyed different sections. Since 2004 counts have been made and reported within the same sections of shoreline and these verified using a GPS unit to reference these specific locations. This report uses the same standard or recently renumbered waypoints used in last year's report. These point locations are shown as numbered waypoints on aerial photos and topographic maps included with this report; adult numbers within these sections are shown in tables below. The tables and text also includes any notable changes in the shoreline characteristics at the sites.

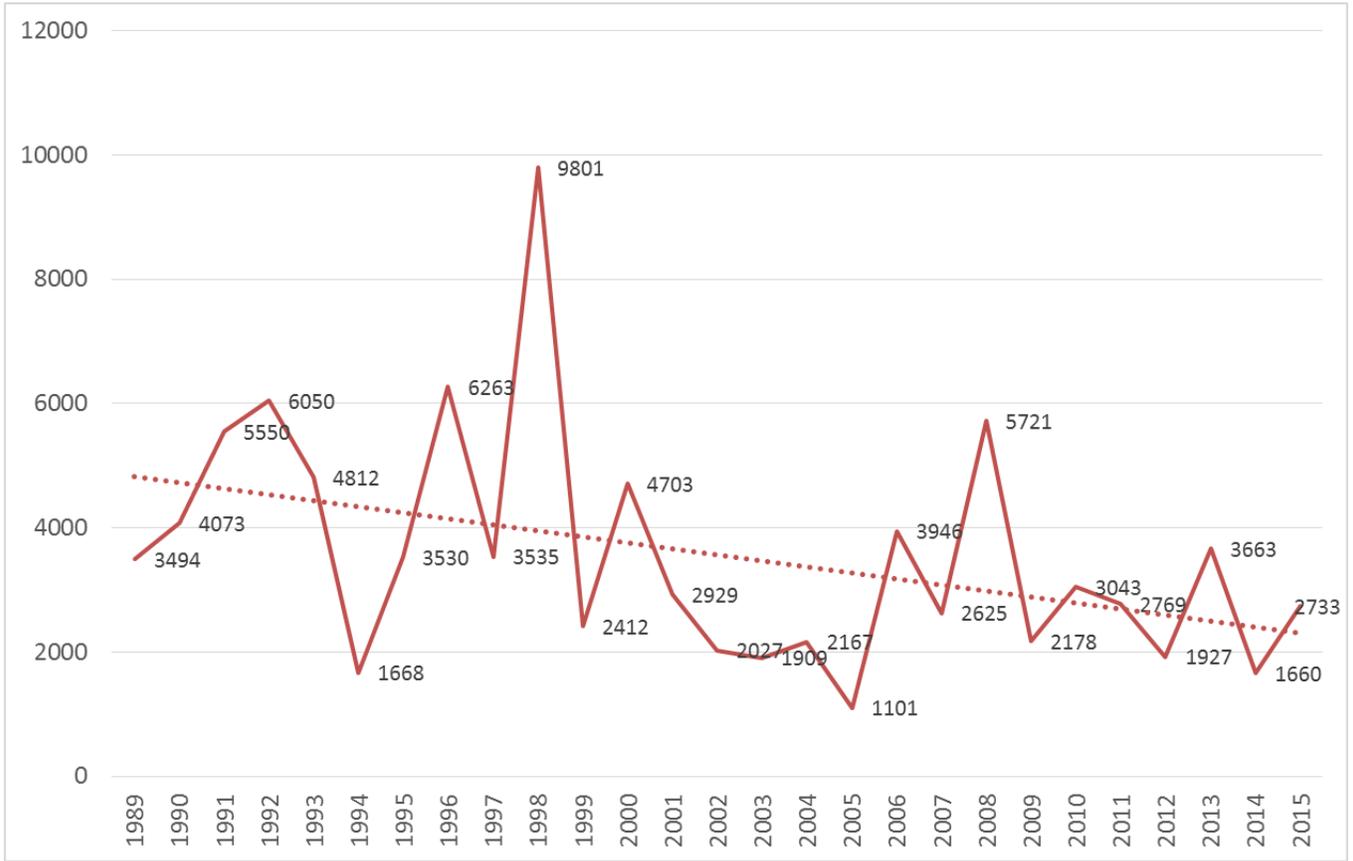
RESULTS AND DISCUSSION

Summary of Calvert *C. puritana* Trends. The total number of adult *C. puritana* at all Calvert sites in 2015 was 2733, a significant increase from 1660 in 2014 and similar to 3663 in 2013 (Table 1, Fig. 1). The increase in 2015 is apparently due in large part to good conditions for recruitment from the large population in 2013 and a survival and development of larvae from that cohort. Other recent counts were 1927 in 2012, 2769 in 2011, 3043 in 2010, and 2118 in 2009 (Table 1, Fig. 1). Overall, despite the relatively high counts in 2010, 2011, 2013 and 2015, the significant downward trend continues, largely a result of the high counts in the early 1990s (Fig. 1). It is likely that there is an alternate year factor because of the two year life cycle, although habitat factors caused by shoreline changes can obviously alter this pattern. This was seen in 2011 when higher counts were found in odd years compared to many previous years. In 2015, all but two small sites and one large site had an increase in adult numbers from 2014. The greatest increases were at Calvert Cliffs State Park (151 to 807), an increase which accounted for much of the total increase in 2015. Other significant increases were at Little Cove Point (360 to 526) and Calvert Beach (159 to 332). Warrior Rest declined slightly from 648 to 620. Overall, observations during the surveys did not indicate any major changes in the shoreline since 2013 that would account for this decline. There were few observed significant changes in the shoreline or bluffs to account for any observed changes, although shoreline recession and breakdowns continue to occur and are indicated in the discussion of sites below. It should be noted, however that there has been no detailed monitoring of shoreline/cliff changes so causes of changes in adult numbers could be easily overlooked.

Table 1. Total index counts for *C. puritana* at all Calvert County sites, 1986 to 2015.

Year	Rand	CRsv	Bays	Wrest	ScCI	WS+CB	CCNPP	RckPt	CCSP	LCov	CofC	Total
1986	200	20	72		1000					250		1542
1988	93	73	22		3571	4891			2194	328	259	11431
1989	119	4	6		1491	1052			702	85	35	3494
1990	133		64		1342	1747			643	102	42	4073
1991	57	17	38		2057	1653			835	738	155	5550
1992	65	10	75		2029	767			2565	232	307	6050
1993	68	2	68		2007	731			1177	538	221	4812
1994	24		19		681	101			756	87		1668
1995	82	12	119		1146	1150			541	340	140	3530
1996	45	0	66		1904	1489			919	927	913	6263
1997	75	2	51		1091	851	119		507	525	195	3535
1998	83	1	44		3792	2597	616		984	566	502	9801
1999	29	0	41		408	1169	49			373	294	2412
2000	11	0	22		2317	1161	367			462	363	4703
2001	234	2	109		1375	502				352	355	2929
2002	52	0	28		691	621	80			397	158	2027
2003	31	0	149		256	577	226			586	84	1909
2004	27	0	0		447	1279	121			251	42	2167
2005	31	0	2	155	111	232			242	298	30	1101
2006	25	0	6	1366	218	1123	105		338	612	111	3904
2007	21	0	14	631	206	273	276		292	740	172	2625
2008	23	0	5	958	218	841	122		1609	1116	829	5721
2009	7	0	1	466	45	143	241		666	330	219	2118
2010	31	0	20	534	26	402	191	72	1102	554	111	3043
2011	33	0	37	1256	183	110	213	98	572	203	64	2769
2012	29	0	53	883	105	120	177	59	199	223	79	1927
2013	53	0	69	1234	164	272	167	316	940	371	77	3663
2014	24	0	33	648	70	159	103	72	151	360	40	1660
2015	25	0	47	620	44	332	169	132	807	526	31	2733

Fig. 1. Total index counts for *C. puritana* adults in Calvert County, 1988 to 2015.



Accounts for Individual Calvert Sites. Table 3 below gives the detailed results for Calvert sites in 2015 along with previous years since 2004. Included are the numbers of adult *C. puritana* within each waypoint section, shoreline characteristics for each section, and the coordinates for each waypoint. The locations of these waypoints are shown on the aerial photos and topo maps included in the appendix of this report. An additional series of maps showing more counts of adults within the standard waypoints are also included in the Appendix.

Randall Cliff. This is the northernmost *C. puritana* site in Calvert County. It has had consistently low numbers, especially in recent years. Numbers of adults have been less than 100 since 1990, except for a count of 234 in 2001. The count of 25 in 2015 is similar to the consistently low counts in the past 10+ years. The distribution was also similar with adults confined to several small sandy patches of beach in the middle portion of the site. No significant changes at the site were apparent in the past few years. The low numbers at this site seem to be due to the very narrow shoreline which limits adult foraging activity, but perhaps more importantly to dry bluffs and limited sandy layers needed for oviposition. Also significant has been the progressively narrowing shoreline

as evidenced by the need to wade through deeper water, even at low tide, to access the small patches of exposed sand where adults occur.

Camp Roosevelt. No survey was done at this site in 2015. This site was always considered marginal and even in earlier years counts have been low, except for 73 in 1988. Records from collectors in the 1950's and 1960's suggest this site may have once supported a larger population. It includes a long length of shoreline and cliffs, but much of the beach is narrow and/or with dry cliffs with little sand content, and little apparent suitable oviposition and larval habitat.

Bayside Forest. The count of 47 adults in 2015 was within the range of counts since 2010, after the population rebounded from a significant decline due to severe shoreline from Hurricane Isabel in 2005. Numbers remained low from 2004 to 2009. Most of the shoreline and especially the southern portion where beetles were always most common lost several meters or more of cliff face with extensive cliff breakdown and trees littering the beach and cliff base. There were also tracks and compaction from heavy equipment on the beach, apparently being used to clear the beach of downed trees. By 2007 to 2009 it appeared that the beach and cliffs had generally recovered from these earlier disturbances, but there was no evidence of the beetle population recovering until 2010. Adult numbers responded to this apparent recovery of this site to earlier conditions with 20 counted in 2010, 37 in 2011, 53 in 2012 and 69 in 2013. Although the 2015 survey was done at mid-tide, water levels were extremely high with no beach exposed at the southern end of the site just north of the access. As usual the beetles were present along a several hundred m section just to the north of this access area where they have typically been found on a wider beach with medium cliffs.

Warrior Rest and Scientists Cliffs. This long section of shoreline was separated into two sites because of differences in ownership and management. In previous years the beetle counts were combined and listed as the Scientists Cliffs site (Table 1). Both sites have experienced continuing shoreline recession as evidenced by several sections that require wading in several m deep water even at low tide. In 2015, Warrior Rest had a count of 620 compared to 648 in 2014. These two counts are about the average since 2006 with a high of 1366 in 2006 and a low of 466 in 2009 during this period. It has been enigmatic that this site has supported such high numbers despite a very narrow shoreline with little or no beach even at mid-tide along most sections. Observations during the surveys indicated that the shoreline at this site has become more recessed in recent years. Consequently, many adults have been found along the low cliff base and possibly others on the cliff face where they may have been missed in the surveys. Despite the limited beach foraging area for adults the population continues at high density, apparently because of an extensive area of high quality cliff habitat that can support optimum recruitment and larval development. Adults are apparently successful foraging along the narrow beaches and cliff bases during the day when tide levels reach the base of the cliffs and cover much foraging habitat. The distribution of adults at this site had been similar in most years with a high proportion of adults at the south end of the site (waypoints 35-38) and relatively few in the northern half of the site.

Bordering Warrior Rest to the south is Scientist Cliffs. The 2015 adult count was 44, the second lowest count ever (26 in 2010) and compared to 70 in 2014. Groins are present along nearly the whole length of the site which also includes mostly heavily vegetated or low cliffs with unsuitable substrate. Adults have typically been restricted to the far north end bordering Warrior Rest and the same several small patches of open cliffs which seem to be maintained by occasional breakdowns. Adult numbers have been less than 100 since the two highest counts of 218 and 206 in 2007 and 2008 respectively. The southern portion of the site (waypoints 51-59) supported moderate numbers of adults in the early 1990s, but they gradually declined after groins were placed and vegetation growth increased on the cliffs with the coincidental loss and elimination of larval habitat. No adults were found in this south section after 2012 after the progressive decline: 3 adults in 2012, 19 adults in 2011, 3 in 2010, and 14 in 2009 compared to over 50 in all years from 2004 to 2008. Two adults of *C. dorsalis* were found at the far south end.

Western Shores/Calvert Beach. These two sites have been combined because they are adjacent shoreline sections and have comparable private ownership. This is also logical because they are part of the same section of shoreline and the same populations of *C. puritana* and *C. dorsalis*. This is the only current site in Maryland with populations of both species. The total number of *C. puritana* in 2015 was 332, the highest count since 402 in 2009 and significantly higher than the 159 in 2014. Other recent counts were 272 in 2013, 120 in 2012 and 110 in 2011. This high count in 2015 is surprising since the site continues to experience increased vegetation growth on the back beach, cliff base and cliff face (Figs. 2, 3). Although the beach is wide in many sections and ideal for adult foraging, the amount of suitable bare cliffs is very limited and decreasing. Tree and shrub growth has been significant in the past 10-15 years causing loss of cliff habitat and probably creating a barrier for adults moving to the cliff tops where the most favorable oviposition substrate occurs. Much of the vegetation is invasive and may have increased because of apparent natural widening of the beach. Periodic breakdowns apparently maintain adequate recruitment habitat and sustain the population. But, these recent year counts (except 2015) are significantly lower than the counts of over 500 to over 1000 in most years prior to 2007. Adults have been absent from the southern portion of the site since groins were put in place in the late 1980s. These resulted in full vegetation cover on the cliffs and total elimination of larval habitat with coincidental absence of adults. The vegetation is increasing developing further north in the area of current *C. puritana* habitat.

Calvert Cliffs Nuclear Power Plant. This shoreline site has consistently supported a medium sized but fluctuating population of *C. puritana*. Counts ranged from 49 in 1999 to 616 in 1998 but have been relatively consistent in recent years. The count was 169 in 2015 compares to 103 in 2014, the lowest of any counts since 2006 when 105 were counted. The distribution at the site has also been fairly consistent over the years with most adults in the southern part of the site (waypoints 116-118) where there is wider beach with suitable cliffs. In some years there has been a moderate abundance of beetles in the middle section but very few adults in the northern third. Nearly all of this site, except the southern end, has a very narrow and rocky beach which is not optimum for

adult foraging and probably contributes to the overall lack of suitable habitat in these sections.

Fig. 2. Middle area of Western Shores near south end of the large C. dorsalis population showing vegetation (kudzu, coltsfoot?) encroachment from cliffs onto the beach.



Fig. 3. Extensive vegetation growth on cliff face and back beach at Calvert Beach. This vegetation has covered the south end at Matoaca Cottages and is developing in areas further north.



Calvert Cliffs Nuclear Power Plant. This shoreline site has consistently supported a medium sized but fluctuating population of *C. puritana*. Counts ranged from 49 in 1999 to 616 in 1998 but have been relatively consistent in recent years. The count was 169 in 2015 compares to 103 in 2014, the lowest of any counts since 2006 when 105 were counted. The distribution throughout the site has also been fairly consistent over the years with most adults in the southern part of the site (waypoints 116-118) where there is wider beach with suitable cliffs. In some years there have been a moderate abundance of beetles in the middle section but very few adults in the northern third. Nearly all of this site, except the southern end, has a very narrow and rocky beach which is not optimum for adult foraging and probably contributes to the overall lack of suitable habitat in these sections.

Rocky Point. Surveys at this site were begun in 2010 with counts ranging from 59 to 316. The 2015 count was 132 compared to 72 in 2014. The site was not surveyed until recently because it was difficult to access and required a boat to access in most years because of the narrow rocky shoreline. The adults at this site are found in several small patches of beach situated among the mostly very narrow shoreline. The cliff habitat at this site appears to be of relatively high quality and can support a moderate population of adults despite limited adult foraging area. Low counts at this site may be due in part to fewer adults on the exposed beach and perhaps others on the cliff face.

Calvert Cliffs State Park. The count at this site increased significantly in 2015 to 807 from 151 in 2014. This recent high count is probably due in large part to the large adult population in 2013 (940) leading to high recruitment and survival during the two years. Other recent counts were 572 in 2011, 1102 in 2010, 666 in 2009 and 1609 in 2008. Adult numbers at this site have varied quite significantly over the years, apparently due to the effects of variations in shoreline and especially cliff erosion on larval recruitment. The low count in 2014 was believed to be related to an especially narrow shoreline and reduced adult foraging area with some adults foraging on the cliff face. In all years, adults have been abundant along the three major cliff sections of the site which are separated by two marsh beaches. In contrast to most other recent years, most adults in 2015 were in the northern half of the site. Over the years, this site has experienced significant shoreline and cliff erosion resulting in closure of the cliff sections to the public about 15 years ago, but despite the narrowing of the beach, the site continues as very good habitat. Significant cliff breakdowns were observed at this site in 2010 and 2012 but nothing of note was observed in 2014 and 2015.

Little Cove Point. This long section of shoreline has extensive cliffs and mostly narrow to moderate width beaches. It has consistently (except for a very few years) supported a medium to large population of *C. puritana*. The 2015 count of 526 is the second highest count since 2008 and a significant increase from the 2014 count of 360. Other recent counts were 371 in 2013, 223 in 2012 and 203 in 2011. Despite significant variations, the population at Little Cove Point has been fairly stable between the 300s and 600s in most years since 1991. Observations during surveys in the past five years found this site has experienced small and large breakdowns although there were only a few in 2015 compared to 2014 and the previous few years. In 2015 adults were most abundant at

waypoints 147 to 151 and 159 to 162, a distribution similar to most previous years. This site especially where the high densities of adults has extensive areas of good cliff habitat and mostly narrow beaches. Several revetments (or near shore breakwaters) have been constructed at this site in recent years. The south revetment where reef balls were previously placed had some suitable shoreline and 36 adults counted. Two other revetments to the north had no beetles with the cliffs behind the structures becoming vegetated and stabilized with a reduction of larval habitat (Fig. 4). There was also little or no beach in front of the structure for adults to forage. Regardless, the site overall continues to have sections of good cliff habitat and suitable beaches to support a viable population.

Fig. 4. Shoreline of Little Cove Point near waypoint 156 looking north at nearshore breakwater. Note vegetation growing behind the structure.



Cliffs of Calvert. This site borders the above site and is a part of the same *C. puritana* population within a continuous shoreline. The adult count in 2015 was 31 which was second lowest count (30 in 2005) and a continuation of counts of less than 100 since 2010 when 111 was counted. These recent counts document a trend of significant decline from 829 in 2008 followed by 219 in 2009, and 111 in 2010. As with many other sites the numbers here have fluctuated greatly, but obviously a trend downward in recent years. The decline may be due to the observed significant recent erosional events and/or shoreline structures, both which could have probably eliminated recruitment/larval habitat and increased larval mortality. For example, the site includes two fairly recently constructed nearshore breakwaters and some smaller revetment sections. Invasive

vegetation (kudzu, Phragmites) was found colonizing these and other more stabilized cliff sections. Observed breakdowns at this site in 2009, 2010 and 2011 have affected a much higher proportion of the shoreline than at Little Cove. Few adults have been found in these breakdown sections and although adult numbers are low, the bare cliffs should be ideal for larval recruitment and subsequently produce more adults unless erosion is too rapid for successful larval development their two year development period. Only one new small breakdown was seen in 2014 and several minor slumps in 2015. In the past two years adults were much more restricted in distribution than previous years, with all adults restricted to only four waypoint sections.

Summary of Calvert County *C. d. dorsalis* Trends. The total count for adult *C. dorsalis* in 2015 was 1873. This is two times the total for any year since 2003 when 3013 adults were counted. Most counts in the intervening years were in the 500-700 range with low counts of 190 and 78 in 2008 and 2009 (Table 2, Fig. 6). Overall, the Calvert *C. dorsalis* metapopulation has experienced a progressive, stepped and significant decline of abundance since the early to mid-1990s when numbers ranged from 3000 to over 10,000 and included viable populations at Flag Ponds, Scientists Cliffs and Cove Point. Populations have been lost at all of these three sites, most recently at Flag Ponds in 2010, but total numbers were as high as 3014 in 2003, even with the significant decline of the Cove Point and Scientist Cliffs populations in 2000. Overall totals then declined to relatively consistent counts in the 600s for most years between 2004 and 2014, except for 2008 and 2009.

Warrior Rest/Scientists Cliffs. Two sections of the shoreline at this site supported populations of *C. d. dorsalis* in the 1990s and until 2003. A population became established on the beach near the mouth of Parker Creek in 1991, reaching a peak of 752 in 1992, then disappearing by 1994. A few were found there in a few subsequent years. It is uncertain if these were immigrants from the Scientists Cliffs site to the south, but it seemed apparent that the habitat was not suitable for sustaining a viable population, probably because of its small size and narrow beach that was subject to frequent overwash. A larger and more persistent population became established in the public beach area at Scientists Cliffs in 1988, but after a progressive increase to 2465 in 1991, numbers began a dramatic decline, disappeared by 2001 and have not been found on the public beach area since that time. Small numbers of adults have been found in some years at the far south end of Scientists Cliffs, but none were found from 2006 to 2014. Interestingly however, 2 adults were found at the far south end in 2015. These were probably individuals that dispersed from the large Western Shores population to the south. As we have known from earlier studies, dispersal is more likely to occur when populations are high.

Western Shores/Calvert Beach. The number of *C. dorsalis* at this site was 1871 in 2015. As indicated above this was more than twice as high as any counts since 2003. The numbers at this site were unusually consistent from 2004 to 2007 (716 in 2007, 699 in 2006, 623 in 2005 and 627 in 2004). Then numbers dropped precipitously to only 188 in 2008 and 72 in 2009 before the significant increase to 589 in 2010, 436 in 2011, and 601 in 2012. As in most previous years adults in 2015 were found within waypoints 63 to

74, but numbers were significantly higher at most waypoints in 2015. Highest counts were in waypoint sections 67 and 68 where over 300 were counted and in waypoint 71 where 242 were found. This high count is somewhat puzzling since the beach narrower along most of the shoreline in 2015 where adults were found; in fact many adults were found in sparse grass behind the narrow bare intertidal (Fig. 5). The apparent explanation for this very high count was optimum conditions for larval recruitment and development in the past two years. It seems unlikely that such a high population can be sustained because of the narrow beach for larvae development and survival in much of the shoreline at this site. There was also observed continuing recession along the north end of the site where no adults have been found in any recent years.

Fig. 5. Two photographs of the shoreline at Western Shores where despite a narrow beach (at mid tide) a high density of adults were present, some in the sparse vegetation.





Flag Ponds. The one large population of adult *C. dorsalis* at this site declined dramatically to 2 adults in 2008, 6 in 2009, and none found after 2009. Numbers at this site had been consistently low since 2004 with counts of 51 in 2007, 61 in 2006, 121 in 2005 and 80 in 2004. The decline here has been significant and progressive since the mid-1990s when there were consistently over 1000 adults. Numbers were even higher into the early 1990s when they reached peaks of over 3000 in several years. The only high count (over 225) in the past 12 years was 748 in 2003. That count suggested the population was building back up as adults were recruiting significantly in the northern part of the shoreline at the site. The declines in 2004 and 2005 could have been due to impacts from Hurricane Isabel eroding out many developing larvae in September 2003, thus reducing numbers of adults emerging in 2004 and 2005. However, if the habitat was suitable recovery from this event should have occurred within a few years as was seen in many Virginia sites. As noted above regular use of a small 4-wheeled vehicle for patrols by park personnel along the shoreline and increased human foot traffic in the past 8-12 years may contributed to the decline, especially after numbers dropped to the recent low levels.

Cove Point. The population at this site experienced gradual but progressive decline during the 1990's until 2004 when only 11 individuals were counted, and none since then. As with the above Calvert sites, there is no obvious explanation for the extinction except that the section where most beetles occurred in later years was a section that has experienced significant erosion, including a major erosion event in 2008.

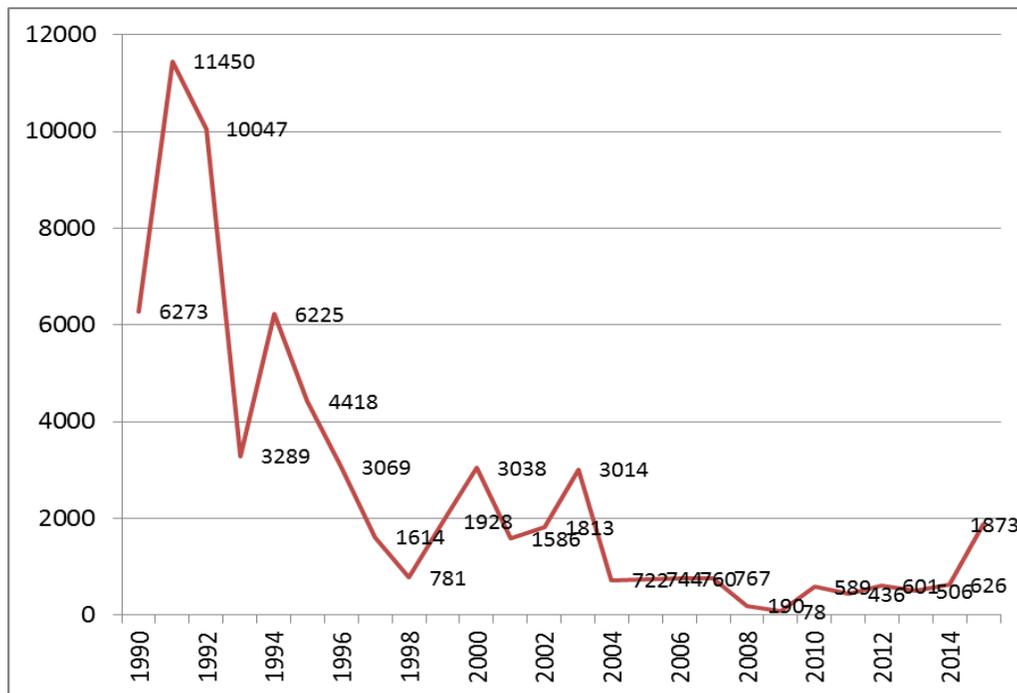
***Cicindela dorsalis* Population Trends.** In the early 1990's there were four large populations of *C. dorsalis* in Calvert County. The population at Cove Point declined gradually throughout the 1990's and was gone by 2003. At Scientists Cliffs there was a larger population peaking at 2465 in 1991, before experiencing an even greater decline to extinction in 2004. The two populations at Flag Ponds and Western Shores have been the largest and most persistent, but these also declined significantly from the mid-1990s to the present, reaching lowest ever counts in 2008 and 2009 with the Flag population lost in 2010. There has been no obvious cause identified for this recent major decline, but shoreline changes (the formation of the spit) at Flag eliminated the section of beach where most of the population occurred into the early 1990's. Beetles never really increased in the new spit which formed adjacent to the original shoreline, and numbers remained relatively low since 1997, except for one year (2003) when over 700 were counted.

Compared to many *C. dorsalis* population in VA and those in Maryland's Eastern Shore (Janes and Cedar), the size of shoreline habitat occupied by Calvert *C. dorsalis* is small, especially Scientists Cliffs and Cove Point, and even at Flag Ponds after the spit formation. That could be a factor contributing to the decline, especially where the habitat is not of high quality. Beetles have occupied a much greater portion of the shoreline at Western Shores, and the distribution has changed somewhat over the years. It is possible that when these populations drop to levels of less than 200-500 they are doomed to extinction because of the effects of small population genetic (inbreeding depressing) or ecological (Allee effects) factors, as occurred with the Cove, Scientists Cliffs, and Flag Pond populations. Human impacts may also be involved, perhaps not a singular cause but a contributing factor when populations are stressed or at low numbers. The localized beach where *C. dorsalis* occurred at Scientists Cliffs was quite heavily used, more so during the time of decline. It is difficult to determine if beach walkers have caused impacts at Flag, but that along with the use of a small 4-wheel vehicle ("Mule") to monitor the beaches several times per day may be having effects on larval recruitment and development. There has also been evidence of 4-wheel vehicle use in a section of Western Shores in the past several years. This seems minimal and probably not a major factor. Another potential factor is a change in sand particle size on the beach which seemed to be significantly coarser at least at Flag Ponds, compared to earlier years. Despite the significant increase in numbers at Western Shores in 2010, the Calvert population remains susceptible to extinction. There is also an extensive offshore bar along the Flag Ponds and Western Shores section which could have increasingly stabilized the shoreline and impacted the habitat.

Table 2. Index counts for the total *C. dorsalis* population at all Calvert County sites, 1986-2015

Year	CRsv	Bays	Wre	ScCI	WS+CB	Flag	Cove	LCov	CofC	Total
1986	0	0	0	0	3500	500	100	0	0	4100
1988	3	0	0	464	4157	2857	427	0	0	7908
1989	0	0	0	1634	3392	3084	202	0	0	8313
1990		20	0	1874	1479	2188	707	0	5	6273
1991	16	37	328	2465	4198	3995	406	5	0	11450
1992	0	10	752	1189	3407	4351	335	1	1	10047
1993	0	2	49	473	1344	1218	196	7	0	3289
1994		9	0	633	3860	1445	278	0	0	6225
1995	8	4	0	688	2450	1080	188	0	0	4418
1996	1	5	5	673	1380	810	192	3	0	3069
1997	0	0	15	510	841	216	32	0	0	1614
1998	0	0	0	263	418	68	32	0	0	781
1999	0	0	0	23	1639	210	56	0	0	1928
2000	0	1	7	24	2813	171	22	0	0	3038
2001	0	0	1	0	1353	221	11	0	0	1586
2002	0	4	0	31	1635	130	13	0	0	1813
2003	0	0	1	13	2209	748	42	0	1	3014
2004	0	0	0	0	627	80	11	0	0	722
2005	0	0	0	0	623	121	0	0	0	744
2006	0	0	0	0	699	61	0	0	0	760
2007	0	0	0	0	716	51	0	0	0	767
2008	0	0	0	0	188	2	0	0	0	190
2009	0	0	0	0	72	6	0	0	0	78
2010	0	0	0	0	589	0	0	0	0	589
2011	0	0	0	0	436	0	0	0	0	436
2012	0	0	0	0	601	0	0	0	0	601
2013	0	0	0	0	506	0	0	0	0	506
2014	0	0	0	0	626	0	0	0	0	626
2015	0	0	0	2	1871	0	0	0	0	1873

Fig. 6. Graph of index counts for the total population of *C. d. dorsalis* at all Calvert County sites, 1990 to 2015.

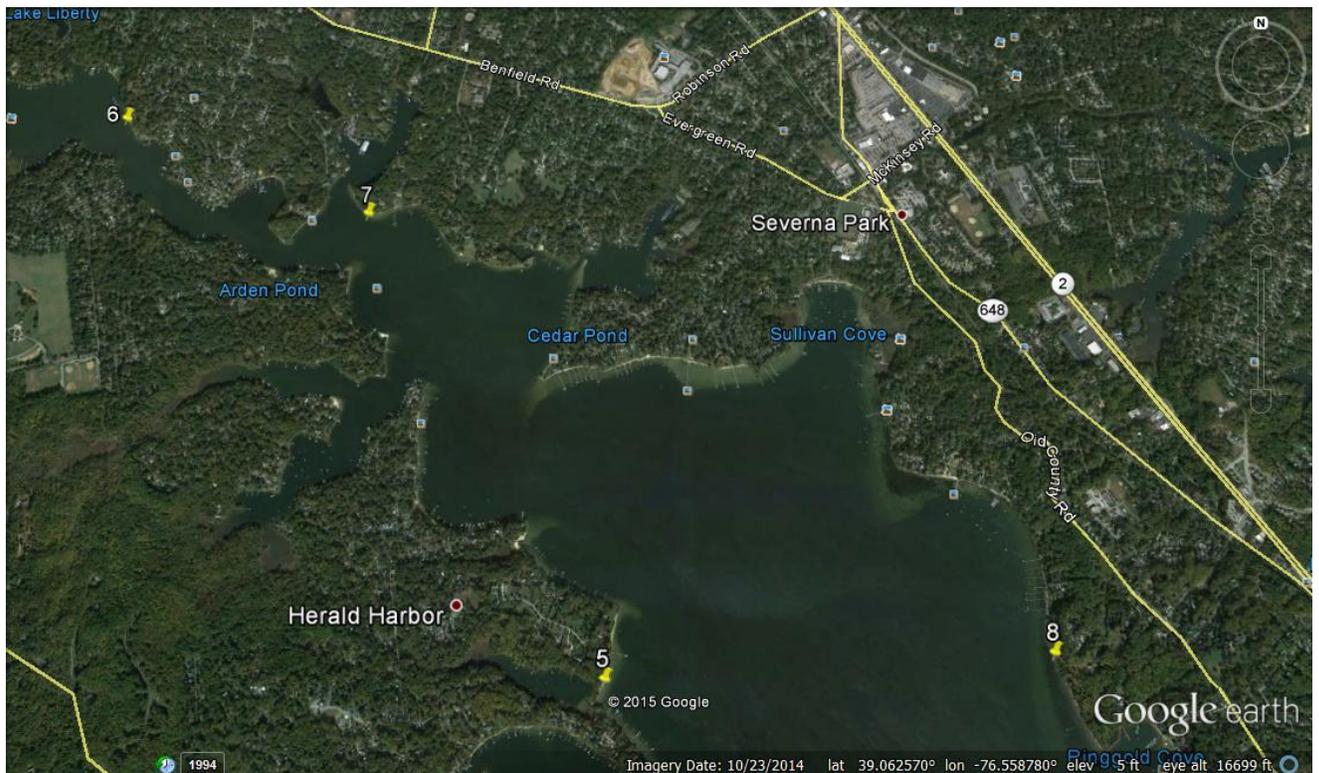


	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004				
201	0	0	0	0	0	0	0	0	0	0	0	0	156	22	55	11	28	320	60	228	3	20	0		Farthest N that can be accessed, rocky shoreline, no beach, even at low tide	38.410619	-76.413577	
202	0	0	0	0	0	0	0	0	0	0	0	0	64	30	65	38	162	89	44	68	125	41	30		N end of cliffs; Here to north, very narrow, little beach habitat, but cliffs good	38.407380	-76.412335	
203	0	0	0	0	0	0	0	0	0	0	0	0	327	5	53	18	56	280	215	318	23	9	0		wider beach sections and good cliffs start cliffs, no beach, inaccessible marsh and beach section, no habitat	38.406440	-76.411091	
204	0	0	0	0	0	0	0	0	0	0	0	0	102	35	195	48	52	253	120	264	87	168	110		tall cliffs, tree rubble, narrow beach, then 4-5 m wide beach with most beetles	38.405157	-76.409898	
205	0	0	0	0	0	0	0	0	0	0	0	0	0	29	52	22	50	23	0	97	0	28	70		beach narrows, little or no width trail accessing beach, very narrow beach, dry cliffs, then good top cliff area	38.403890	-76.408831	
206	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	2	0	0	12	46	5	8	0		marsh area and beach, no cliffs, no habitat	38.402805	-76.407665	
207	0	0	0	0	0	0	0	0	0	0	0	0	108	11	0	32	135	100	158	475	29	30	11		very narrow beach, excellent cliffs; new breakdown in 2009	38.401794	-76.407050	
208	0	0	0	0	0	0	0	0	0	0	0	0	23	23	202	18	44	30	15	67	7	8	10		arc beach, 0-1 m wide beach, then 2-3 m wide	38.400150	-76.405815	
209	0	0	0	0	0	0	0	0	0	0	0	0	8	15	55	10	45	7	4	46	13	26	11		mid, tall cliffs, good, 2-4 m wide beach, end at Rocky Point	38.398581	-76.405144	
210	0	0	0	0	0	0	0	0	0	0	0	0	0	3	96											south end of site, cliffs no beach		
	0	0	0	0	0	0	0	0	0	0	0	0	807	151	940	199	572	1102	666	1609	292	338	242					
Cove Point																												
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		Cove Point start at north end, N of pier where beach starts; 2-3 m marsh behind	38.393299	-76.401073
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		same	38.392880	-76.400384
122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		pier	38.392250	-76.399484
123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		narrow arc beach, with water behind	38.391734	-76.399166
124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		dense Phragmites behind, coarse sand, narrow beach, 0-2 m	38.391059	-76.398037
125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		GPS tube about 8 m offshore, phragmites on beach	38.390545	-76.397233
126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		narrow beach	38.389946	-76.396547
127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		beach wider, 1-2 m then widens to 5-7 m	38.389539	-76.395474
128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		wide beach, 6-10 m wide; still Phragmites behind	38.389168	-76.393962
129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		start first trees on back of beach; 8-12 m wide	38.388857	-76.392828
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		same, beach wider	38.388365	-76.390935
131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		very wide beach, 20+ m	38.387847	-76.389809
132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		same, intertidal sand is soft	38.387501	-76.387131
133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		same	38.387054	-76.384615
134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		end at north end of lighthouse	38.386510	-76.382668
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Little Cove Point																												
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		cliffs, avg 20ft back-beach to cliffs, end open cliffs at this point	38.371858	-76.390341
141	0	0	0	0	0	0	0	0	0	0	0	0	3	0	58	28	15	12	0	47	14	21	8	14		cliffs, avg 4ft back-beach, lower 2/3 fully vegetated in 2009	38.371335	-76.390388
142	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	31	0	0	0	0	0	0	0		Cove Point Lake/Cove Lake, cliffs, beach end of cliffs	38.370678	-76.390318
144	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0		start revetment	38.369853	-76.389959
145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	16	0	60	25	0	0	0	0		end revetment	38.368850	-76.389413
146	0	0	0	0	0	0	0	0	0	0	0	0	10	0	30	6	4	13	7	99	29	22	0	11		Bannister point, arc beach, small breakdown	38.368280	-76.388899
147	0	0	0	0	0	0	0	0	0	0	0	0	110	18	30	18	26	25	16	161	13	40	0	3		same	38.367658	-76.388898
148	0	0	0	0	0	0	0	0	0	0	0	0	70	18	33	11	23	47	20	67	61	39	53	7		start point, then arc beach, low but good cliffs, breakdown area	38.366446	-76.388543
149	0	0	0	0	0	0	0	0	0	0	0	0	5	0	3	0	27	30	19	85	24	17	30			same, then high cliffs; good cliffs, wide beach; deck and stream entry	38.365510	-76.388411
150	0	0	0	0	0	0	0	0	0	0	0	0	60	14	55	16	5	14	9	17	3	2	4	0		no cliffs, then low cliffs; wood steps, terrace, rock revetment, set back	38.364444	-76.387830
151	0	0	0	0	0	0	0	0	0	0	0	0	12	16	0	0	2	12	22	8	43	11	5	0		point, then narrow arc beach, cliffs get lower	38.363841	-76.387051
152	0	0	0	0	0	0	0	0	0	0	0	0	9	13	14	10	1	56	3	73	52	0	0	0		another point section, then arc beach, no cliffs	38.362773	-76.386676
153	0	0	0	0	0	0	0	0	0	0	0	0	0	8	2	4	9	14	59	73	24	23	5			same, point breakdown; 4th, N most pipe on back; breakdown; N end balls	38.361152	-76.387343
154	0	0	0	0	0	0	0	0	0	0	0	0	5	0	7	4	13	0	30	22	24	15	0			start point, no beach, good cliffs, break; drainage pipes on cliff sand bags	38.360298	-76.387899
155	0	0	0	0	0	0	0	0	0	0	0	0	16	11	33	24	6	28	0	3	15	26	4	16		2009: south end reefballs, fully submerged at low tide, cliffs behind stabilizing	38.359206	-76.388783
156	0	0	0	0	0	0	0	0	0	0	0	0	19	0	16	17	0	3	13	0	19	6	0	0		same, medium cliffs, wide beach; stream channel and steps	38.358387	-76.389476
157	0	0	0	0	0	0	0	0	0	0	0	0	7	0	3	3	19	12	77	27	11	6	2			wide beach, low cliffs; hard cliffs	38.357897	-76.389799
158	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	4	9	3	7	21	5	90	9	4		same; massive breakdown	38.356799	-76.390396
159	0	0	0	0	0	0	0	0	0	0	0	0	42	3	0	0	4	37	0	46	23	33	22	6		same; breakdown, very high cliffs; massive breakdown	38.356019	-76.390782
160	0	0	0	0	0	0	0	0	0	0	0	0	61	12	0	13	46	31	34	24	74	39	17			mini-point, then recessed arc beach, narrow beach, good cliffs	38.355236	-76.391488
161	0	0	0	0	0	0	0	0	0	0	0	0	81	73	36	7	6	62	5	85	18	58	18	33			tree rubble but 1 m beach and good cliffs; breakdown	38.354644

Survey of Severn River Sites for *C. puritana*. We surveyed one site along the Severn River where *C. puritana* was recently found and additional sites that appeared to have potential habitat for the Puritan Tiger Beetle on July 16, 2015. A brief summary of the results of this survey is included below along with a listing of several additional sites surveyed in 2014 by Ben Pagac (Fig. 7).

Site 1. This site along the eastern shore of the Middle Severn River was surveyed on July 11 and 12, 2014 by Ben Pagac who found approximately 20-36 *C. puritana*, including numerous mating pairs along with 12-24 *C. hirticollis*, few *C. repanda* and one *C. sexguttata*. Our 2015 survey found 23 *C. puritana*, 4 *C. repanda*, 2 *C. marginata*, 3 *C. hirticollis* and 1 *C. punctulata*. This site includes a 100-150 m long shoreline with much of the cliff face behind the narrow sandy beach exposed and apparently providing the suitable larval habitat for *C. puritana*. Much of the cliff face and beach is shaded part of the day due to its orientation and existing trees and shrubs. Additional adjacent shoreline is backed by heavily vegetated cliffs which likely was more open and suitable habitat in the past.

*Fig. 7. Aerial photos (top north, lower south) showing location of 15 Severn River survey sites. Sites 1 and 8 are those where small populations of *C. puritana* were found. Not included is Gibson Island.*



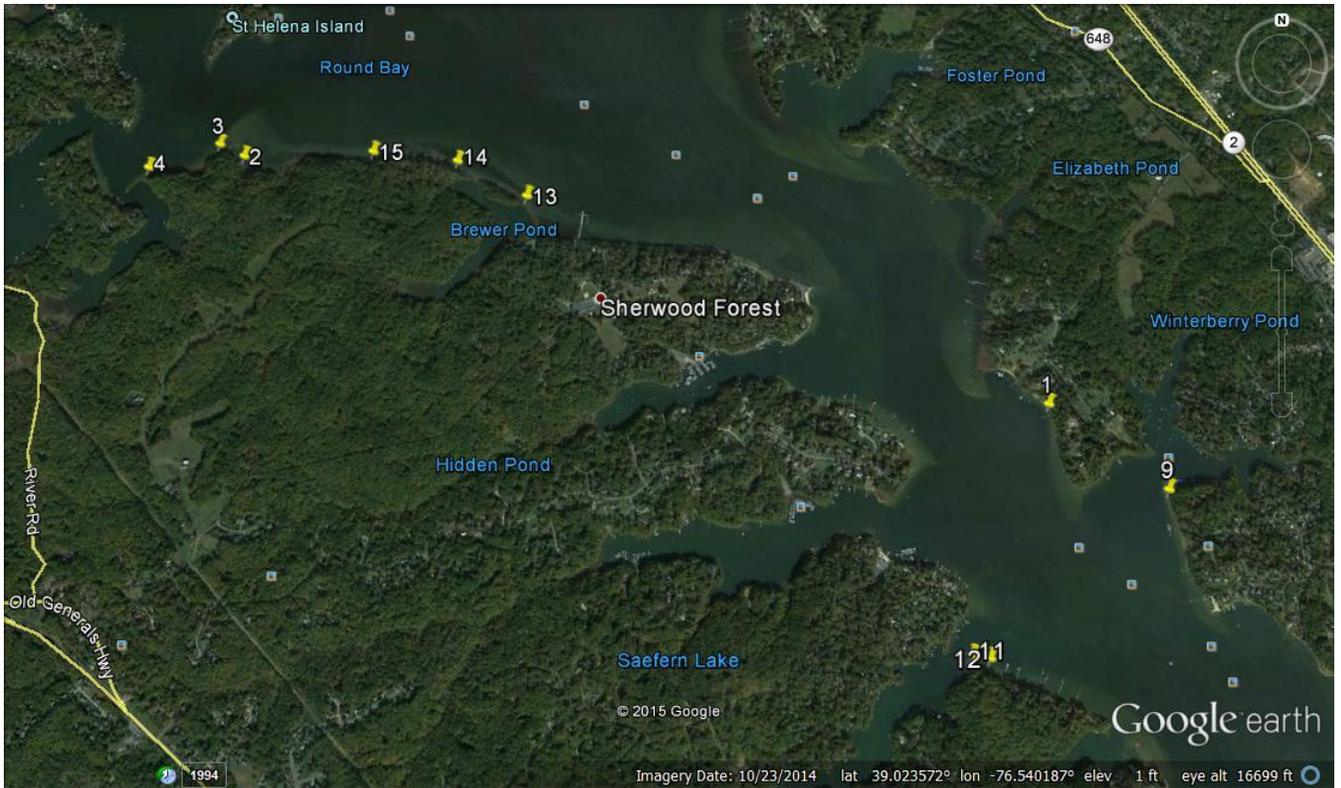
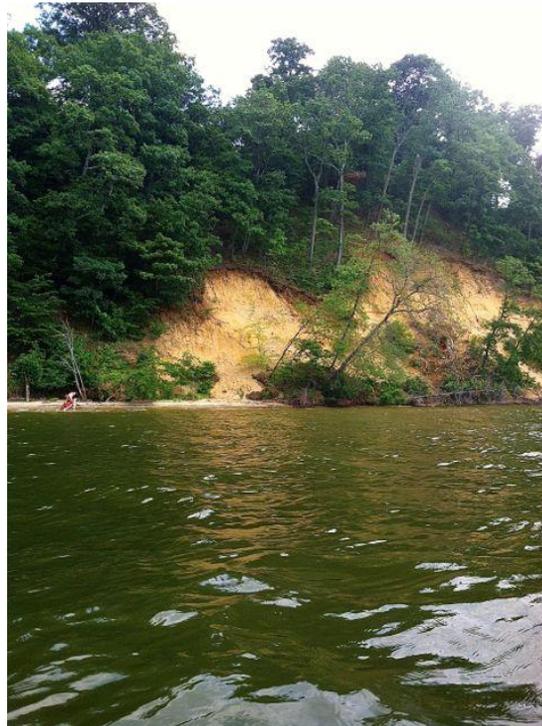


Fig. 8. Two photos of Severn River site 1 where *C. puritana* was found in 2014 and 2015. Photo provided by Dan Pagac.



Site 8 was about 3.5 km north of site 1, also along the eastern shore of the Middle Severn, just north of Ringgold Cove. The 2015 survey found 12 *C. puritana* along with 6-8 *C. repanda*, and 3-5 *C. marginata*. This small site included a 100-125 m long shoreline of narrow beach backed by 15-20 m tall cliffs. It was fragmented with several patches of bare areas alternating with vegetated areas. Site 9 was about 0.6 km south of Site 1 also along the western shore of the Middle Severn. Although no *C. puritana* were found this site was similar to site 1. The site included only a short section of shoreline, 60-80 m, with mostly bare 15-20 m tall cliffs. The only tiger beetle found was 1 *C. marginata*.

None of the additional sites surveyed below had any *C. puritana*. Like the above sites they included only short sections of shoreline with some cliffs and narrow sandy beach. Sites 2, 3, 4, 13, 14 and 15 were along the south shore of Round Bay. Site 2 was an 80-100 m long section with low cliffs (6-9 m tall) and a narrow sandy beach. The survey found 4-6 *C. repanda* and numerous larval burrows which were probably also *C. repanda*. Site 3 has cliff habitat similar to site one but no adult tiger beetles were found. Larvae of apparent *C. repanda* burrows were found on the low cliff face. Site 4 included 50 m of 10-12 m of bare cliffs; larval burrows and one adult of *C. marginata* were found. Sites 13, 14, and 15 were all along the same length of shoreline and surveyed by Ben Pagac in 2014. Site 13 had a relatively wide beach and a short but bare cliff section. Several *C. marginata* were found at this site. Site 14 had low cliffs and tree rubble littered shoreline while Site 15 was also a short site with heavy vegetation along the cliff base.

Sites 6 and 7 were along the Upper Severn. Site 6 was a short length of shoreline (40-50 m) with low cliffs (7-10m) but a suitable narrow sandy beach. No adult tiger beetles found but numerous larval burrows were present in the cliffs (probably *C. repanda*). Site 7 was only about 30 m long point with low cliffs (@ 5 m) and a chalky substrate. A small number of *C. repanda* and one *C. marginata* were found. Larval burrows, probably of *C. repanda* were found in the low cliff. Site 5 was near Herald Harbor along the western shore of the Severn. The site was 70-80 m long with 8-10 m tall cliffs, and did not appear to have suitable habitat. Ten adults of *C. repanda* were found. Sites 11 and 12 surveyed by Ben Pagac in 2014 were near the end of Severn Forest Drive. These included limited beach and no apparent suitable cliff habitat. No beetles were found at Site 11 and a few *C. repanda* at Site 12. Site 10 was a several hundred long shoreline with 3-10 m tall cliffs along the south shore of Dobbins Island. The cliff substrate was mostly hard gray clay and did not appear suitable for *C. puritana*. No larval burrows were seen.

Summary of *C. puritana* Trends at Sassafra River Sites, 1989 to 2015. The results of annual surveys at all sites produced a count of 1132 adults in 2015, a significant decline from the exceptionally high count of 3395 in 2014 (Table 4, Fig.9). Weather conditions during the survey were not optimum as the skies were partly cloudy and temperatures in the low 80s. This may have resulted in lower counts at some sites than if conditions were optimum, but the overall trend of decline was probably accurate

since numbers declined significantly at all sites. The 2015 count was the lowest since the 837 in 2009. Other recent counts were 1864 in 2013, 1478 in 2012, 1530 in 2011, and 2726 in 2010. The unusually high count in 2014 was primarily due to higher numbers in several of the large sites (Grove Point with 929, East Lloyd with 714 and West Turner with 481) and to significant increase in several sites with typically low numbers but with increasing numbers in the past few years (West Betterton with 614 and East Turner with 397). In 2015, the significant decline was primarily due to the large declines at East Lloyd (714 to 27), West Betterton (614 to 164), West Turner (481 to 101), and East Turner (397 to 42). The pattern for this metapopulation has been one of generally increasing abundance from 2006 to 2014 (except for the 837 in 2009) until the decline in 2015 (Table 4, Fig. 9). The results of the surveys for all years has resulted in a trend of population increase despite the significant decline in 2015.

Until 2014, the trend of abundance over the years in the Sassafras metapopulation generally paralleled that of the Calvert metapopulation. The 2014 and 2015 results deviated significantly from this parallel pattern. The Calvert metapopulation declined in 2014 and although increasing significantly in 2015, exhibited a downward trend line while the Sassafras metapopulation which decline in 2015 had an upward trend line with the progressive increase after the period of low abundance. The causes of these trends of abundance in these metapopulations are unknown. We have hypothesized the earlier decline of the Sassafras metapopulation was possibly a result of a progressive increase in bluff vegetation at many sites that resulted in reduced habitat quality, especially for recruitment and larval development. The cliff vegetation and especially that along the back beach and base of the cliffs could have reduced the amount of adult foraging habitat and restricted their movement to suitable oviposition sites on the cliff faces. It may also be that the composition of the vegetation on the cliffs is changing to more invasive species that are more resistant to erosion and/ or more effective in stabilizing the cliff faces. Shoreline and bluff erosion from Hurricane Isabel in 2003 could have countered this trend and reduced cliff face and base vegetation. Consequently, larval habitat improved, recruitment increased and populations of adults began to increase after this time. Because of the two year life cycle of *C. puritana* the improved conditions would take several years to be realized. Other lesser known storms and shoreline events also continue to cause localized erosion, cliff breakdown, etc. and these can complicate the understanding of population fluctuations. It also seems apparent that the vegetation control at West Turner and East Lloyd accounted from a significant part of the increased numbers of the Sassafras metapopulation in recent years (see below). To determine if the population trends are in fact driven mainly by storm and erosional effects on the shoreline and bluffs, differences in these factors over the years in Calvert County and the Eastern Shore of the Chesapeake Bay need to be documented. Especially useful would be finding out details of these shoreline changes in the past few years.

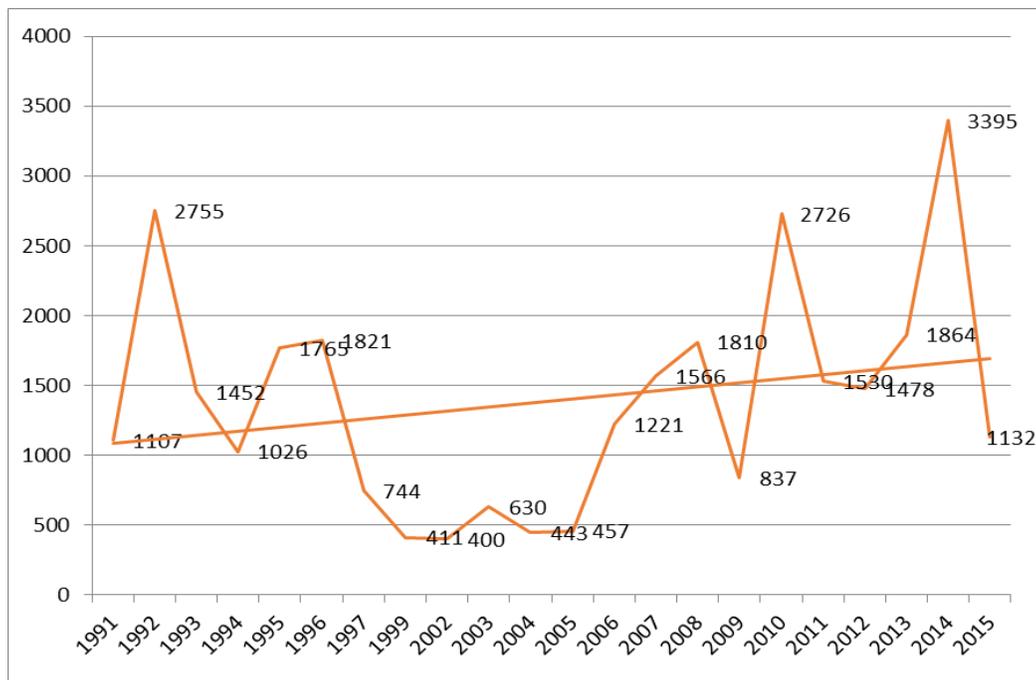
The above is only a hypothesis but the effects of vegetation changes in the vegetation study sites seem to provide support for the effects of vegetation (see below). It is also possible that other factors may be involved or more important. Density dependent factors and inherent population dynamics, parasitism or competition from co-occurring species (*C. repanda*) could also be driving some of the changes. Habitat studies at Sassafras in 2008 indicated larvae of both *C. repanda* and *C. puritana* were present in the

same bluff microhabitats. Larvae of *C. repanda* were at high densities in low cliff faces during early to mid-summer where adults of *C. puritana* were ovipositing and when their larvae developing in late summer into fall. This co-occurrence could have a strong competitive impact (food availability) on adult *C. puritana* and early instar larvae. Adults of *C. puritana* could also be preyed upon by *C. repanda* larvae on these cliff faces.

Table 4. Total index counts of *C. puritana* at all Sassafras sites, 1989-2015.

Sites	1989	1991	1992	1993	1994	1995	1996	1997	1999	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Grove Farm WMA																				2	0	7	11
Cabin John																			5	1	0		0
North Grove Pt.	0	0	0	0	0	0	0	0	0	0	45	0	0	0	0	0	0	0	11	0	0		0
Grove Point		1000+	1667	750	567	920	1230	452	150	78	195	254	190	273	843	986	347	1343	750	283	736	929	706
Ordinary Point	650	12	215	88	110	208	78	45	120	0	9	40	28	30	53	100	41	24	75	40	43	164	15
North Stillpond.			217	190	87	133	138	92	44	220	119	42	26	143	66	120	99	54	70	95	12	38	42
W. Betterton		79	281	234	160	210	131	78	64	69	126	34	52	23	6	92	55	66	112	196	208	614	164
E. Betterton		0	20	19	40	44	21	28	7	11	16	6	12	6	12	34	15	59	52	12	69	51	24
East Lloyd		9	205	139	15	94	118	30	16	8	160	11	96	554	368	179	115	559	249	346	258	714	27
West Turner	150	0	51	12	47	88	80	19	10	12	3	3	18	172	218	296	165	589	203	406	291	481	101
East Turner	150	7	99	20	0	68	25	0	ns	2	2	8	35	20	0	3	0	32	3	97	247	397	42
Totals	950	1107+	2755	1452	1026	1765	1821	744	411	400	630	443	457	1221	1566	1810	837	2726	1530	1478	1864	3395	1132

Fig. 9. Total numbers of *C. puritana* at all Sassafras River sites, 1991 to 2015



Summary Results for Individual Sassafras Sites. Adult counts within the same standard waypoint sections for each of the Sassafras sites 2004-2015 are given in Table 5 along with shoreline characteristics for each section of shoreline. The adult

population at Grove Point has been consistently the largest population of the Sassafras sites and in many years accounting for more than half of the metapopulation total. **The total count at this site in 2015 was 706 compared to 929 in 2014.** As indicated above weather conditions may have resulted in a moderate underestimate of actual numbers present. However, significant declines in other sites suggest the 2015 may be relatively accurate. Counts have fluctuated significantly at this site from a high of 1667 in 1992 to lowest counts of 78 in 2002 and 150 in 1999. Except for the 283 in 2012 and 347 in 2009, numbers at this site have been >700 since the major decline from 1999 to 2005 when the whole metapopulation was low. In essentially all years the highest densities of adults have been within the shoreline of waypoints 13 to 18 where the best combination of beach and especially excellent cliff habitat was present. Significant numbers have also been found in 2015 and other years within several waypoint sections north and south of this high density section. Few adults have been found in all years along the northern and southern portions of the shoreline. In the past two years we have not observed any significant breakdown or other cliff changes. However, a new nearshore breakwater was constructed in 2011 near waypoint 14 (Fig. 3). This section had a wide area of shoreline with fine sand behind the middle of the breakwater and gravel/coarse sand at south end (see photos below). The 100 m section of beach behind and near this breakwater supported a large number of adults in 2013 (165) and 2014 (210). However, in 2015 this area has become more stabilized with an accumulation of logs and other debris, obviously a factor in finding only 14 adults this year.

The Cabin John site was first surveyed in 2011 when 5 adults were counted. Subsequent counts were 1 in 2012 and none in 2013 and 2014. It was not surveyed in 2015. This is a small site with marginal cliff quality which is unlikely to support a viable population. It is uncertain if the adults counted there in previous years were resident individuals or dispersals from another site.

Another new site surveyed first in 2011 was the Grove Farms Wildlife Management Area along the north shore of the Sassafras River east of Grove Neck. This is a potential translocation and vegetation removal site. Survey results indicated no *C. puritana* were present at this site in 2011 or 2013 but 2 *C. puritana* adults were found here in 2012 and seven in 2014. In 2015, 14 adults were found.

The count of adults at Ordinary Point was 15 in 2015 compared to 164 in 2014. The 2014 count was the highest since 208 in 1995 while the 15 was one of the lowest ever counts and the lowest since 9 in 2003. The low count is not especially unusual since most counts since 2002 were less than 50 and other Sassafras sites had significant declines from 2014 to 2015. Most adults have been concentrated in the northern portion of the site where the only significant portion of exposed cliff occurs. Some adults were found further south in 2014. Most of the site is heavily vegetated with very narrow beach and extensive tree rubble along the beach and intertidal zone. Much of the site is also shaded during much of the day by vegetation and the sites orientation. Population size at this site might be increased by vegetation removal since there appears to be ideal cliff substrate that is negatively impacted by the dense vegetation.

North Still Pond had 42 adults in 2015 compared to 39 in 2014. Other recent counts were 12 adults in 2013 (the lowest ever count at this site) and a range of 54 to 95 between 2010 and 2012. There was no observed shoreline or cliff changes in the past two-three years that might have affected counts, although most of the recent counts have been at times when much of the shoreline was at least partially shaded. This could reduce adult activity along the water edge and produce lower counts. This shading is also due to the orientation of the beach and cliffs. The beach is also relatively narrow and rocky, both not ideal as foraging habitat for adults.

The count at East Betterton was 24 in 2014 compared to 51 in 2014 and 69 in 2013 which was the highest ever count at this site. In most years the counts here ranged between 6 and 40. Despite the relatively low count in 2015, this site has supported higher numbers since 2010 indicating some improved habitat patches for better recruitment and development compared to all previous years. Regardless, this is a site with a relatively short shoreline on limited areas of suitable open cliff habitat suggests it is a marginal site which could be lost with increasing cliff vegetation or other factors impact the habitat. .

West Betterton has had an interesting pattern of changing trends on abundance, seemingly a result of changing habitat quality from increasing cliff vegetation to recent breakdowns to create more open cliff habitat. The 2015 count was 164 a significant decline from the highest ever count of 614 in 2014. In the early 1990s many years had counts of over 200 before declining to less than 70 in most years between 1997 and 2010. The lowest ever counts during this period were 6 in 2007 and 23 in 2006. Numbers began a gradual increase after 2007 to 92 in 2008, 196 in 2013 and 614 in 2014. These recent higher counts seem to be a result of an observed increase of bare cliff area from recent bluff erosion in several distinct sections in the eastern part of the site, waypoints 58-62 where nearly all adults were found. The decline in 2015 is consistent with other declines as Sassafra sites. West Betterton includes a much longer length of shoreline and has more areas of bare cliff than East Betterton although nearly all of the long western portion of the site has always been non-habitat because it is too heavily vegetated.

East Turner Creek. Counts at this site have been highly variable but mostly low for many years. Prior to 2011 counts were consistently low, 0 to 10 or fewer adults for many years between 2002 and 2011. Numbers began to increase significantly to 97 in 2012, 247 in 2013, and 397 in 2014. The previous high counts were 150 in 1989 and 99 in 1992. Numbers declined to 42 in 2015. The long period of decline and low counts until recently seemed to be associated with a significant increase in vegetation growth on the cliffs, possibly a result of the pier and breakwater constructed at the east end of the site in the early 1990's. The beach is also narrow along most of the length. In 2010 there was some significant cliff breakdown creating bare cliff habitat in the western portion of the site that probably increased the area for oviposition and larval development which produced the adult increase in the past few years. This site along with East Lloyd had the highest adult densities, with adults present in swarms in localized sections of the shoreline in 2014. It seemed unlikely this high density could be sustained because of the

short length of shoreline and available habitat. The low count in 2015 may bear out this prediction although there remains at least a small amount of good quality cliff habitat.

Two adjacent sites on the south shoreline of the Sassafras that have experienced significant changes in numbers in the past five years are East Lloyd and West Turner Creek. These sites include five cliff areas that are part of experimental study of the effect of vegetation removal on the *C. puritana* population, two cliff sections where vegetation was removed and three control sections. Details of these cliff sections are discussed in the following section of this report. East Lloyd had 714 adults in 2014, the highest ever count but an astonishing decline to 27 in 2015. This site has a history of extreme fluctuation with low counts of 15, 30, 16, 8, and 11 between 1994 and 2004, but all counts of over 100 often much higher since 2006. The possible explanation for this extreme fluctuation is that the site includes a relatively short length of bare open cliffs which seemed to have ideal habitat but can experience severe erosion and breakdown resulting in washout and loss of larvae followed by a population crash as in 2015. In the absence of these events, numbers could build up rapidly because the cliff substrate appears ideal and could support very high recruitment. For example, observations during surveys suggested the declines in 2008 and 2009 may have been the result of significant cliff breakdown and erosion which seem more prevalent at this site than others in the area. This in turn could have led to significant recruitment and large numbers in 2010-2014.

West Turner numbers declined to 101 adults in 2015 compared to 481 in 2014 and 291 in 2013. This site includes two sections that were a part of the vegetation removal study, cliff A (removal) and B (control). Other recent counts were 406 in 2012, 203 in 2011, and 589 in 2010. This site had a dramatic and progressive increase from 2004 to 2008 (3 in 2003 and 2004, 18 in 2005, 172 in 2006, 218 in 2007, 296 in 2008) before a decline to 165 in 2009. The recent increases are believed to be a primarily a result of the vegetation control work done in 2006 and possibly additional erosion of ideal recruitment conditions to produce the very high counts of this whole shoreline section in 2014. Counts also suggest that since then a pattern of alternative year abundance (higher numbers in even years due to the two year life cycle) has developed. This may account for the decline from 2012 to 2013 and again in 2015. Interpretation of results of the vegetation removal study are complicated by the many factors, many unknown, that could affect population dynamics of this species. For example all Sassafras populations declined throughout the mid 1990s and reached lows in 2005, then experienced significant and progressive increase, peaking at most sites in 2008 and even higher in 2010 and in 2014.

Table 5. Numbers of adults and shoreline characteristics at waypoint sections of all Sassafras sites, 2004 to 2015.

Previous Points	New Points	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	Latitude	Longitude	Shoreline Characteristics
Cabin John																
	1	ns	0	0	1	5								39.465628	-75.954766	narrow beach, limited cliff habitat
	2													39.465127	-75.955422	
Grove Point																
057	22	0	0	0	0	0	0	0	0	0	0	0	0	39.387346	-76.038800	E end of site; dry cliffs, sand and some pebbles/very dry cliffs, 6-7 m beach, all bare
058	21	10	0	0	0	3	3	0	3	0	0	0	0	39.387846	-76.039295	very rocky, no beach, -1 m wide, cliffs vegetated/gets rocky, then trees;
059	20	32	23	19	0	33	12	4	11	7	3	5	4	39.388576	-76.040328	wider beach, good cliffs, 1 m, then tree rubble/wide beach, 6 m, ok cliffs
060	19	63	73	11	6	22	48	33	93	25	11	2	1	39.389473	-76.040759	narrow, -1 m wide, very good cliffs, then 1 m wide
061	18	41	110	72	12	165	166	44	169	143	39	7	15	39.390028	-76.041151	good cliffs, 1 m wide beach, earlier this was best prime section; cliff breakdown in 2009
062	17	101	54	112	30	87	96	41	113	111	92	14	0	39.390585	-76.041322	start pebble and stone beach, very narrow, cliffs veg., no habitat
063	16	40	170	154	45	50	161	125	353	166	81	61	146	39.391090	-76.041318	start good cliffs, 0-1 m wide, previously good, beach narrow, massive cliff breakdown in 2009
					49	60	171			78						
					38	155	196			139						
064	15	240	151	49	39	75	220	72	123	59	18	39	29	39.392832	-76.040960	good cliffs, same beach but then narrows// southern half very good sand beach and
065	14	72	210	165	44	19	176	21	47	49	11	7	18	39.393392	-76.040887	good cliffs but pebble, rocky beach, Area of new breakwater in 2013
066	13	30	31	48	2	18	27	0	6	6	0	0	6	39.394303	-76.040680	very rocky, good cliffs end, then vegetated and non-habitat, road enters shoreline
067	12	15	80	36	0	11	7	0	6	12	0	0	12	39.395089	-76.040506	start N of road, narrow beach, 0-1 m, good upper cliffs
068	11	40	17	0	5	12	4	8	12	8	12	3	6	39.396285	-76.039723	same, some ok cliffs, 0 m beach
069	10		0	0	9	0	6	0	0	0	3	0	0	39.397091	-76.039328	low cliffs, no beach, -2 m wide
					0	6										south end of revetment; all logs and sticks behind revetment in 2007
070	9		16	36	0	0	24	0	0		0	18	8	39.397471	-76.039101	start bare cliffs, newly eroded, narrow beach/same
					0	0				38						N end of revetment
071	8	10	4	0	0	5	9	0	0	0	0	0	0	39.398424	-76.038337	cliffs are ok habitat, beach ok, cliffs end, no habitat
072	7	10	0	0	0	0	0	0	0	0	0	0	3	39.398841	-76.038019	start low cliffs, ok habitat
073	6		0	19	1	6	11	0	0	2	0	0	0	39.399150	-76.037791	continue low, no cliffs
199	5		0	4	0	0	0	0	0	0	0	0	0	39.399150	-76.037733	end, meet bk
198	4	4	0	0	0	0	6	0	0		3	0	5	39.400367	-76.036740	gray clay, 12 m high, then red sand top, very rocky beach
197	3	8	0	0	0	0	0	0	0	0	0	0	1	39.402334	-76.034389	gray clay then red sand and rock; large sand stones on beach
196	2		0	0	0	3	0	0	0		0	0	0	39.403475	-76.031723	very rocky with many trees down/metal stakes; photo looking south, pier at top
195	1		0	11	3	20	0	0	0	0	0	0	0	39.403985	-76.030046	Grove Neck, north end; gray clay, 12 m high then lower
		706	929	736	283	750	1343	347	986	843	273	156	254			
North Grove Point																
074	-1	ns	ns	0	0	0	0	0	n	n	no	0	0	39.407455	-76.019713	rocky with sand, 1.5 m low dry cliffs, tree rubble
075	-2			0	0	0	0	0	n	n	survey	0	0	39.407048	-76.020962	red sand cliffs at top, bare, ok habitat
076	-3			0	0	0	8	0	n	n	in	0	0	39.406550	-76.022244	all clay cliffs, no habitat
077	-4			0	0	0	0	0	n	n	2006	0	0	39.406356	-76.022764	end, meet jim, photo
200	-5			0	0	0	0	0	n	n		0	45	39.405855	-76.024452	rocky beach, trees down; going N, new site, north of 200
201	-6			0	0	0	0	0	n	n		0	0	39.406328	-76.022844	end site
				0	0	0	8	0				0	45			
Grove Farm WMA																
	4		3	0										39.38489	76.00567	west end of site
	3		0	0										39.38465	76.00364	
			0	0										39.38487	76.00196	
			0	0										39.38501	76.00124	
	1		4	0										39.38504	76.00026	
														39.38512	75.99910	East end of site
	11		7	0	2											at east end of site
Ordinary Point																
083	23	0		0	0	0	0	0	0	0	0	0	3	39.383911	-75.993722	Ordinary Pt. West, N end, dry stoney cliffs, 0-1 m wide
084	24	9	40	5	6	11	7	11	15	10	2	1	0	39.383535	-75.993438	good cliffs, no beach, then rocky cliffs, fully vegetated, tree rubble
85	25	0	71	9	13	17	9	21	33	0	5	15	22	39.383031	-75.992316	good cliffs, tree rubble, narrow beach, sandy
86	26	4	28	12	16	33	6	9	24	40	23	12	12	39.382791	-75.991941	breakdown, then ok cliffs, sandy 1 m wide
87	27	0	4	12	2	10	2	0	22	0	0	0	0	39.382285	-75.990947	end habitat
88	28	2	4	3	3	0	0	0	0	3	0	0	0	39.381312	-75.987833	continue Ordinary, N end, veg cliffs narrow to no beach, all tree rubble
089	29	0	11	2	0	4	0	0	0	0	0	0	3	39.380866	-75.987269	1 m beach and very veg. cliffs
090	30	0	6	0	0	0	0	0	0	0	0	0	0	39.380474	-75.986788	same
091	31	0		0	0	0	0	0	0	0	0	0	0	39.379767	-75.986186	same, end site
207	32	0		0	0	0	0	0	0	0	0	0	0	39.379088	-75.985538	variable beach width
208	33	0		0	0	0	0	0	0	0	0	0	0	39.379758	-75.986197	end of site
		15	164	43	40	75	24	41	100	53	30	28	40			

Map Pt.				2013	2012	2011	2010	2009	2008	2007	2006	2005	2004			Shoreline Characteristics
East Turner																
024	39	0	95	83	10	0	0	0	3	0	0	3	0	39.362879	-75.977858	East Turner Ck.; 0 m wide beach, tree rubble, good cliffs
025	38	25	136	59	18	3	0	0	0	0	0	1	0	39.363083	-75.977234	same
026	37	0	119	90	24	0	0	0	0	0	0	0	5	39.363175	-75.977026	same, good cliffs
027	36	17	0	4	20	0	20	0	0	0	17	30	0	39.363367	-75.976680	1 m beach width, cliffs low and very vegetated
028	35	0	47	11	16	0	12	0	0	0	3	1	3	39.363651	-75.976162	
029	34	0	0	0	9	0	0	0	0	0	0	0	0	39.364016	-75.975529	end at breakwater, shaded; photos 1, 2
			42	397	247	97	3	32	0	3	0	20	35	8		
West Turner																
082	42	0	107	36		16	153	35	71	45	104	8	0	39.366812	-76.003776	West end of site; gravelly beach, many small trees down
206	41	43	222	132	360	69	230	90	155	152	68	18	3	39.368551	-75.999668	many downed trees, many larvae in fall down (repanda?); Section A
205	40	58	152	123	46	118	86	40	67	21	0	0	0	39.369744	-75.998211	east end of site
			101	481	291	406	203	469	165	293	218	172	26	3		
Previous Points																
	New Points	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	Latitude	Longitude	Shoreline Characteristics
East Lloyd																
078	49	5	370	40	45	15	101	29	67	35	347	44	8	39.361874	-76.022509	West Lloyd, photo; west end, good bare cliffs, no beach-Section E, Control Site
079	48	5	105	81	93	88	88	22	16	28	134	12	0	39.362008	-76.021629	narrows, -1 and rocky, but cliffs ok
080	47	4	77	32	33	12	16	12	25	245	10	3	0	39.362360	-76.020450	sandy narrow beach
081	46	3	1	0	0	6	0	0	3	10	0	3	0	39.362398	-76.020265	end site
202	45	2	20	15	16	2	51	14	13	10	0	0	0	39.364039	-76.015971	W. side of E. Turner Ck. Narrow beach, red sand, small stones; Section D
203	44	7	239	84	146	115	213	38	55	40	63	11	3	39.364765	-76.014402	no beach, many downed trees; all red sand bluff
204	43	1	11	6	13	11	0	0	0	0	0	0	0	39.365756	-76.013337	trees down up river; end at end of bluff
			27	714	258	346	249	559	115	179	368	554	73	11		
East Betterton																
030	50	0	0	0	0	0	2	0	0	0	0	0	0	39.369175	-76.043488	East Betterton, east end at pier, no cliffs
031	51	0	0	0	0	0	0	0	0	0	0	2	2	39.369163	-76.043790	low cliffs, very vegetated, 1 m wide
032	52	0	0	0	0	0	0	0	1	0	0	1	2	39.369213	-76.044266	heavy tree rubble, some bare cliffs
033	53	3	6	0	0	1	2	0	0	0	0	0	0	39.369484	-76.045164	all very narrow beach, 0 m wide; bank swallows
034	54	9	16	18	0	10	13	4	11	1	0	0	0	39.369753	-76.046364	start good cliffs but no beach, tree rubble
035	55	0	14	44	11	21	22	5	10	3	3	3	0	39.369705	-76.047652	end of survey, meet jim from west
180	56	12	15	7	1	20	20	6	12	8	3	6	2	39.370030	-76.049653	E. Betterton, start at W. end (bk east end)
			24	51	69	12	52	59	15	34	12	6	12	6		
West Betterton																
036	57	0	0	0	0	0	10	0	2	0	0	2	6	39.371356	-76.072148	start east end, very good cliffs, 2 m wide
														39.371337	-76.072276	W end of revetment
037	58	21	47	52	13	18	12	1	17	0	0	12	10	39.371343	-76.072647	very good cliffs, 2 m wide
038	59	48	275	43	35	45	12	13	25	0	3	10	6	39.371378	-76.073727	continue same, 1-2 m wide beach
039	60	50	112	62	56	29	18	20	17	0	8	11	8	39.371405	-76.074633	point, tree and cliff breakdown, no beach, major cliff recession
040	61	21	105	28	53	14	2	10	10	0	11	17	2	39.371446	-76.075395	beach wider but fully tree covered
43	62	24	47	5	34	6	16	2	21	6	0	0	0	39.371029	-76.076415	
042	63	0	28	6	3	0	6	9	0	0	1	0	1	39.371018	-76.076578	West Betterton; heavily veg. west end, east end more open
183	64	0	0	0	0	0	0	0	0	0	0	0	0	39.370445	-76.081085	W of West Betterton; very extensive riprap, east end, no cliffs, trees
044	65	0	0	6	0	0	1	0	0	0	0	0	0	39.370233	-76.086398	tall mostly vegetated cliffs, non-habitat; 1 m beach
045	66	0	0	6	2	0	0	0	0	0	0	0	0	39.370241	-76.087420	Tall, part bare cliffs, 1-2 m each, then continue poor habitat
046	67	0	0	0	0	0	0	0	0	0	0	0	0	39.370390	-76.089848	cliffs low and most vegetated
047	68	0	0	0	0	0	0	0	0	0	0	0	0	39.370489	-76.090802	start 50 m rip rap section
048	69	0	0	0	0	0	0	0	0	0	0	0	0	39.370528	-76.091406	end rip rap but no habitat
049	70	0	0	0	0	0	0	0	0	0	0	0	0	39.370621	-76.092151	same, no habitat
050	71	0	0	0	0	0	0	0	0	0	0	0	0	39.370917	-76.094187	same, no habitat
051	72	0	0	0	0	0	0	0	0	0	0	0	0	39.371298	-76.096747	end
052	73	0	0	0	0	0	0	0	0	0	0	0	1	39.371623	-76.099526	Scout camp, go west to east, bk east to west; cliffs stabilized, trees
187	75	0	0	0	0	0	0	0	0	0	0	0	0	39.371810	-76.100725	end, meet bk
186	76	0	0	0	0	0	0	0	0	0	0	0	0	39.371976	-76.104152	many trees on bluffs
			164	614	208	196	112	66	55	92	6	23	52	34		
North Still Pond																
189	80	0	0	0	0	0	0	0	0	0	0	0	0	39.345443	-76.136622	S end of Still Pond; rip rap area; then wider beach, many trees
190	79	11	8	0	17	10	17	42	55	12	10	2	14	39.346316	-76.136659	gully, many hirticollis larvae; start eroded bluff, rocky
191	78	15	6	6	28	30	13	20	25	4	28	7	14	39.348510	-76.136254	rocky, recent erosion on bluff, hardened sandstone
192	77	9	24	3	12	16	11	25	34	24	50	17	11	39.350620	-76.135116	ending bluff, beach 3-5 m wide
193	76	7	0	3	26	6	12	12	6	18	44	0	3	39.352854	-76.132436	end bluff, beach 3-5 m wide
194	75	0	0	0	12	8	0	0	0	8	11			39.353239	-76.130853	end
			42	38	12	95	70	54	99	120	66	143	26	42		
Southwest of Still Pond																
053	ns	ns	ns	ns				0	ns		no	no	0			New site; G80rock, pebble on much of beach; 25-30' cliffs
054								0		survey	survey		0			same, rubble at base, 0-1 m wide, cliffs rocky
055								0		in	in		0			more rocky cliffs
056				ns		ns	ns	0			2006	2005	0			no habitat, rocky cliffs, end
Totals			3395	1864	1478	1530	2526	837	1810	1566	1221	457	443			

Summary Results of Vegetation Control Study at Sassafras WMA The experimental vegetation removal study at the Sassafras Wildlife Management Area included 5 separate cliff areas; at two of these cliffs sections (A and D) vegetation was removed using herbicides while three other cliff sections (B,C, E) were left as controls. Herbicide treatment was carried out in August 2006 after the adult activity period. Conclusive results in this study could not be determined because of the many factors that affect the population dynamics of this species (as with other tiger beetles) and the pattern of erratic fluctuations of adult numbers from year-to-year. In addition, practical limitations of the study did not allow for an experimental design suitable for appropriate statistical analysis. Also, all sections except C had a very significant increase in adult numbers from 2005 to 2006 during the summer before the fall removal and significant declines at all sites in 2009 (Table 6). But, now with 9 years of post-removal counts, there is evidence of a positive effect of the removal. By 2014, combined means of adult counts for the two experimental removal sites (A and D) increased from 260 and 61 to 261 and 107 while the two main control sites declined (Table 6).

Table 6. Comparison of adult counts in removal and control groups in the vegetation removal study before (2005-2006) and after (2007-2015) removal.

Year	remA	cB	cC	remD	cE
pre2005	49	3	0	8	96
pre2006	341	66	1	84	713
pre mean	260	46	1	61	539
2007	187	45	4	60	334
2008	226	71	6	73	102
2009	130	35	0	52	63
2010	536	22	1	264	205
2011	187	16	2	124	121
2012	360	39	13	162	171
2013	255	36	3	100	155
2014	374	65	11	292	553
2015	98	3	1	9	14
post mean	261	37	4	107	256

Surveys for *Cicindela dorsalis dorsalis* on Janes and Cedar Islands. These two sites on Maryland’s Eastern Shore have had the two largest populations of *C. d. dorsalis* in Maryland since the decline of the Calvert metapopulation. They are at the northern end of the species range within the Chesapeake Bay, both relatively isolated from Virginia sites, with long lengths of shoreline and not affected by human related impacts. However, these are marsh beaches and experience significant rollover due to continual shoreline erosion. The adult counts for the standard waypoint sections for 2015 and previous years’ numbers along with relevant shoreline sections are given in Table 7. An aerial photo of these islands with the standard waypoints is included in the Appendix of this report. **The total number of adult *C. d. dorsalis* counted at Janes Island was 1570 in 2015 compared to 725 in 2014.** This 2015 count was the highest since 3081 in 2006. The trend in recent years prior to 2015 was a generally progressive and significant decline since 2005 and 2006. The relatively high count at this site as well as the high

count at Cedar Island and Western Shores suggest conditions in the two previous years were apparently ideal for recruitment and survival. The distribution has varied somewhat during this decline; most significant is the decline in adults in the northern portion of the island, waypoints 1 to 22, especially 1 to 13. In earlier years this section often had near or over 1000 adults but only a few hundred or less in recent years including in 2015. The decline is apparently a result of the significant shoreline erosion in this section, from 4-10 m in much of its length to less than 4 m in recent years. In general numbers have been relatively high and consistent in the middle of the island, 24-32. Numbers in this section plus waypoint 33 increased significantly in 2015 accounting for the overall total increase in numbers at Janes. In summary, this site continues to have a large and viable population despite the decline in the recent years prior to 2015. The site has a very long shoreline with numerous sections of suitable habitat that may can buffer it against erosional even. *Cicindela hirticollis* and *C. marginata* have also been common at this site.

The adult count at Cedar Island was 1990 in 2015 compared to 1893 in 2014. Other recent counts were 1476 in 2013, 1653 in 2012, 1691 in 2011, 1439 in 2010, 974 in 2009 and 2454 in 2006. As indicated these counts have been relatively consistent in recent years except for this significant increase in 2015 which is the highest count since the two previous high counts of 2464 in 2002 and 2475 in 2006. There was no apparent significant change observed at the site to account for the increase. The high counts in a much shorter length than Janes indicates an extremely high density of beetles, over a 2/ m of shoreline in some sections. In all years adults have been present along the whole length of the island’s shoreline but much more abundant in the southern half of the site, waypoints 8 to 12. However, numbers were much higher in the northern half of the site (waypoints 1-7) than in previous years. *Cicindela hirticollis* and *C. marginata* have also been common at this site. Also in contrast to Janes Island, this site has had a trend of progressive increase since the count of 974 in 2009.

Fig. 10. Population counts at Janes Island and Cedar Island, 1997 to 2015.

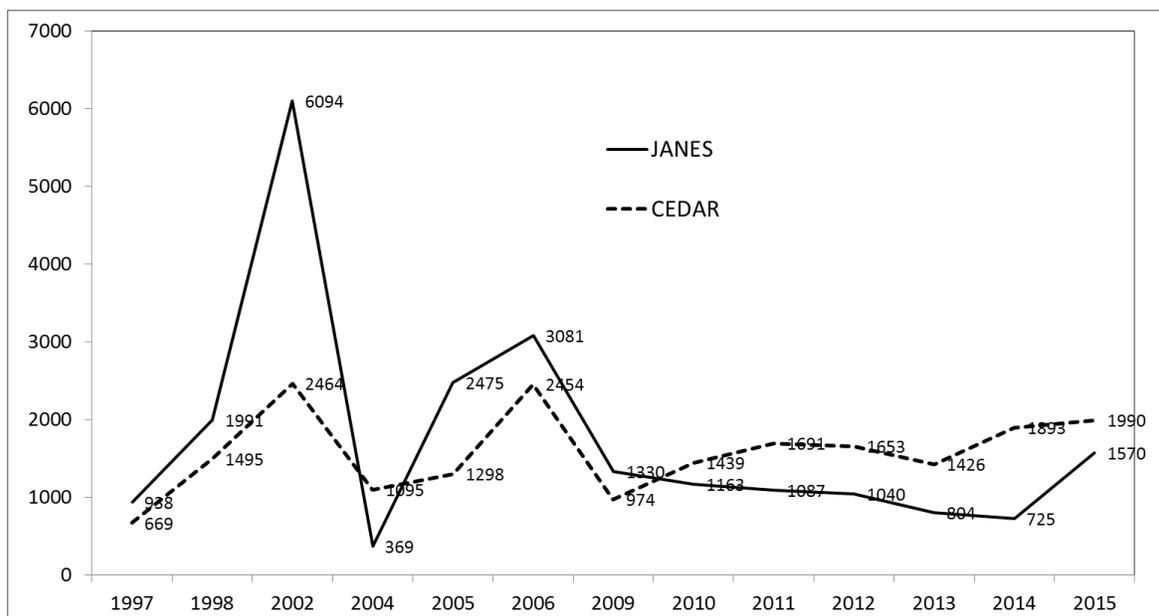


Table 7. Numbers of adults of *C. dorsalis* at Janes and Cedar Islands, 2002-2015.

Waypt	2015	2014	2013	2012	2011	2010	2009	2005	2004	2002	Shoreline	Longitude	Latitude
JANES ISLAND													
1	0	0	0	6	22	50	17	18	48		Far NE tip; unveg. narrow spit w/some mudflats; little wrack	-75.84613	38.03122
2	17	0	0	0	3	7	17	52	15		narrow beach, 1-3 m with 4' ridge	-75.84732	38.03315
3	20	0	0	7	22	32	20	33	17		continue narrow beach	-75.84790	38.03450
4	17	68	0	4	68	57	36	30	19	585	narrow beach as above	-75.85098	38.03652
5	4	6	0	13	70	96	65	67			beetles in wider patch rest continues narrow	-75.85442	38.03775
6	0	0	0	0	8	0	83	1		11	same	-75.85632	38.03828
7	0	0	0	0	0	0	8	8	42	180	narrow beach, marginal habitat, some wrack	-75.85835	38.03835
8	0	0	0	14	33	9	82	112			beach widens, good habitat section	-75.86267	38.03750
9	42	3	1	128	197	217	12	279			same	-75.86854	38.03537
10	110	12	56	66	88	66	82	26			wide beach, 3-5 m	-75.87176	38.03346
11	27	116	2	10	19	0	91	0		258	N of Rock Hole, wide beach, good habitat	-75.87290	38.03037
12	0	0	0	16	30	16	25	60		880	same	-75.87357	38.02765
13	0	2	0	80	61	101	40	57	46		sandy beach but stumps in intertidal, some sections look good but few beelts	-75.87152	38.02718
14	0	152	12	0	0	13	39	4	1		E shore of Rock Hole; all Cdd concent. in 30-40 m section; 12-20 m sandy; little Cdd habitat elsewhere	-75.87054	38.02747
15	2	2	25	0	0	3	20	18	12		E shore Rock Hole; steep narrow beaches with wrack shores; little or no beach;	-75.87030	38.02855
16	0	2	0	0	0	0	4	0			Series of short wide, 20-30 m sand beaches w/intervening <i>S. alterniflora</i> line beaches and mud flats.	-75.86650	38.02627
17	93	0	0	2	7	0	0	0	6		Began at small creek outlet; 15-40 m wide by 70-80 m long.	-75.86738	38.02317
18	0	0	0	2	8	0	0	0		130	Little sand beach; most shoreline bordered by <i>S. alterniflora</i> , thick wrack w/5-15 m wide beach behind	-75.86840	38.02168
19	8	0	16	0	9	5	0	15			Nice long (200-300 m) beach w/well developed foredune but few Cdd; section ends at picnic area	-75.87010	38.01945
20	33	0	0	30	30	55	8	456		280	most narrow beach.	-75.87115	38.01754
21	16	0	0	66	37	38	49	280			long section of marsh beach, wide 3-5+ m	-75.87246	38.01564
22		0	4	34	37	11	57	74		304	similar good habitat	-75.87287	38.01507
23		0	39	25	28	40	47	58			same	-75.87294	38.01335
24	85	94	41	160	0	123	168	119			sandy marsh beach, 3-6 m wide; good habitat	-75.87615	38.00902
25	48	0	0	0	29	0	0	12		1822	beach narrows	-75.87925	38.00517
26	232	18	35	145	96	0	0	81		440	march behind beach	-75.88620	37.99420
27	180	81	60	115	60	66	87	188			Creek outlet	-75.88660	37.99210
28	145	9	62	23	89	78	0	292	72		Stumps in intertidal	-75.88690	37.99140
29		21	177	11	22	11	53	57	86		Green buoy	-75.88780	37.98880
30	72	0	0	0	2	0	0	37	27		end of section;	-75.88960	37.98570
31	120	49	7	11	12	0	112			718	good Cdd habitat, sandy beach but 1-4 m	-75.89090	37.98380
32	18	25	138	0	0	0	0	7	9		good Cdd habitat. Most w/30-100 m long sections of 8-12 m wide sandy beach	-75.89430	37.97980
33	210	9	55	0	0	0	0	0	2		Half of section w/5-10 m wide beaches; wrack w/narrow, 2-6 m wide coarse beach	-75.89660	37.97660
34	53	47	0	3	0	51	72	0		177	small sections of 10-15 m wide sandy beach but most with intertidal peat/tump	-75.89790	37.97510
35	12	4	42	0	0	0	17	0				-75.89700	37.97370
36	2	0	11	56	0	0	3	0	2		N of SW tip, no suitable habitat. Much beach covered by wrack.	-75.89360	37.97250
37	4	1	0	11	0	0	4		2		4th rock groin; 40-50% shoreline armored by large rock; 10-18 m wide sand beach	-75.89120	37.97170
38		2	13	0	0	0				309	at 3rd rock groin. 10-15 m wide sand beach w/10-20% wrack cover. No foredune behind beach.	-75.89010	37.97000
39		2	5	0	0	2	0		5		Began at 2nd rock groin. 10-15 m wide sand beach w/30% wrack cover.	-75.881318	37.971969
40		0	3	2	0	8	12				S end of Island; House Cove and started at large rock groin; 10-15 m wide beach w/30% wrack	-75.878657	37.970029
	1570	725	804	1040	1087	1163	1330	2475	369	6094	0		
CEDAR ISLAND													
1	26	18	16	0	9	30	7			25	spit on south side	-75.88943	37.95370
2	23	20	2	0	11	12	16	22		318	wrack on beach, 0-3 m wide	-75.88967	37.95143
3	127	26	11	27	15	29	14	103	33	203	same, beach widens, much wrack on beach	-75.89040	37.94992
4	121	97	66	50	57	61	79	122	35		start open sand spit, some veg.	-75.89055	37.94723
5	91	194	119	165	144	176	43	71	18	368	west end, wide beach and open sand spit	-75.89005	37.94555
6	43	59	41	19	35	17	26	107	86	533	begin peat area, wide beach, 30% wrack cover	-75.89130	37.94292
7	141	74	29	21	29	95	62	5	70		good habitat; long 10-15 m wide sandy beach w/30% wrack cover and well developed foredune. .	-75.89190	37.94152
9	143	30	322	180	202	252		214	185	746	same, beach widens, much wrack on beach	-75.89292	37.934846
8	235	460	225	349	288	336	454	344	354	208	good habitat; most wide (10-15 m) arcbeach.	-75.89253	37.939338
10	230	165	240	151	249	239	100	321	273		8-14 m wide sandy beach w/30-50% wrack cover. Beach narrower .	-75.89320	37.92995
11	330	485	152	424	115	111	48	39	10	20	Narrow, 5-10 m wide beach w/heavily wrack-lined shoreline.	-75.894285	37.927397
12	480	265	203	267	273	81	125	50	6	68	arc beach, good habitat, some areas of wrack	-75.895783	37.926117
	1990	1893	1426	1653	1691	1439	974	1298	1095	2464			

Management Recommendations

Discussed here are recommendations for management and in some cases, related studies that are important for the conservation of these two Federally Threatened tiger beetles. The recommendations are primarily site specific and made despite the fact that most sites are under private ownership and not available for management. Most of the recommendations below refer to *C. puritana* except where indicated for *C. d. dorsalis*.

1. Continue annual monitoring populations using the same approach as in previous years.
2. For the next annual survey, prepare a map/aerial in the report showing shoreline structures, other notable shoreline features, and the mean numbers of adult per shoreline waypoint section for the most recent five years.
3. Map the shoreline at high tide line at all sites and produce a map comparing it with any available previous shoreline GPS points to determine shoreline recession. An alternative approach may be comparison of old and new Google earth photos.
4. Resurvey the Severn River as in 2015 to determine population size at the two existing sites, determine ownership and options for management that might improve habitat and increase population size. Evaluate negative sites to determine if they have potential habitat if management (vegetation removal) is possible.
5. Vegetation management. Several sites have heavy vegetation cover on the cliffs that are almost certainly reducing or eliminating habitat for larvae in some sections. Sites where this is a significant problem are Calvert Beach, Calvert Cliffs South, Ordinary Point, Sassafras WMA, Grove and Farms WMA. Recently, there has been encroachment of shoreline vegetation (some of it invasive species) at Western Shores onto the beach probably reducing adult and larval habitat for *C. d. dorsalis*. Control of this vegetation should be considered if feasible.

TOPO MAPS AND CORRESPONDING AERIAL
PHOTOGRAPHS OF ALL MARYLAND SURVEY
SITES SHOWING STANDARDIZED WAYPOINTS
(SEE REPORT TABLES FOR BEETLE COUNTS)

STANDARD CALVERT SITES

KEY CALVERT SITES WITH ADDITIONAL
DETAILED COUNTS

STANDARD SASSAFRAS SITES

JANES AND CEDAR SITES