FINAL REPORT

Success Determination using Literature-Based Success Criteria (LBSC) Methodology for Wildlife Mitigations in New Jersey: Year 2 - Frosted Elfin (*Callophrys irus*) Mitigations Compared with Natural Reference Sites

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Abstract:

Surveys were conducted at frosted elfin butterfly (*Callophrys irus*) mitigation sites in New Jersey to determine the relative success of mitigation projects with respect to habitat functionality and species utilization. Parameters characteristic of natural habitats with healthy elfin and host species (i.e. wild indigo - *Baptisia tinctoria*) populations were gleaned from the literature, and measured at select reference and mitigation sites. The success of each mitigation site was later evaluated using an adaptation of the Literature-based Success Criteria (LBSC) methodology, developed by Short et al. (2000) for salt marsh and mud flat habitats. Other statistical methods were employed for comparison to the LBSC method and for quantifying the effective ranges (i.e. 95% confidence intervals) of each habitat parameter. Results from the previous year's study (Year 1, 2006) concluded the LBSC methodology to be an incongruous evaluation method for animal species, and difficult to apply when reference data were lacking or incomplete. The Year 2 study (2007) sought to reapply the LBSC method to a new species, in addition to measuring parameters at both reference and mitigation sites in order to rectify complications arising in the former. Elfin surveys completed for mitigation sites found only one out of three to presently support *C. irus*, although other elfin species were observed at each site. Soil chemistry was nearly identical for reference and mitigation sites, along with *Baptisia tinctoria* density. Vegetation composition differed significantly between reference and mitigation sites ($P = 0.008$), where mitigation sites generally contained 13.9% more herbaceous vegetation than reference sites. This was especially evident in comparisons of graminoid (i.e. grasses and sedges) composition, of which the mitigation sites were more often densely composed (mitigation sites = 53.5%, reference sites = 28.8%). Species richness was comparable between reference and mitigation sites (14.5 and 11.0, respectively), slightly higher for reference sites although not significant. The Year 2 study concludes that the LBSC method is useful for pre-restoration consideration and habitat planning for short-ranging species, however it is not recommended as a universal mitigation monitoring method. Exploration of other methods, or combinations thereof, should be continued to assess and evaluate wildlife mitigation success. It is also recommended that long-term post-mitigation monitoring be in place to ensure species presence, site utilization, and re-establishment of natural conditions to effectively provide for the species' unique requirements.

Introduction:

New Jersey presently does not use a standardized universal method for assessing the success of wildlife mitigation projects. Monitoring of projects is limited, or in some cases does not occur and/or is not conducted over the long term. The performance history of wetland mitigation projects and other types of land use mitigation has been generally fair to poor, often due to the lack of consistent and/or reliable indices for assessment of success and failure, as well as evaluation feedback to improving mitigation construction design (Torok 2002). One common problem that often occurs while gauging success is inaccurately reporting the result as an administrative indicator (e.g. product output such as the number of plants seeded or planted, or organisms released, etc.) rather than the biological outcome of a mitigation (Wilkins et al. 2003). Many researchers agree (Wilkins et al. 2003, McCoy and Mushinsky 2002, Short et al. 2000, Fleishman et al. 2000, Zedler and Callaway 1999, Treweek and Thompson 1997, Brinson and

Rheinhardt 1996) that there is no generally accepted method for evaluating and gauging the effectiveness of proposed mitigation measures.

Quality control of mitigations is becoming an increasingly popular issue, with both the regulatory community and designers realizing the importance of monitoring mitigation success (Wilkins et al. 2003, McCoy and Mushinsky 2002, NJDEP 2002, Zedler and Callaway 1999, Brinson and Rheinhardt 1996). For example, New Jersey conducted a survey on 90 wetland mitigation sites for the purpose of assessing whether the mitigation has achieved meeting its design criteria (NJDEP 2002). The NJDEP (2002) study also included the development of three study indicators (i.e. wetland area achieved, concurrence evaluation, and wetland mitigation quality assessment) to monitor performance of NJDEP's wetland mitigation program. This study found that on average, only 48% of the study sites concurred with the project design, and would generally have the potential to function as natural wetlands through time. However, following this study, the Department (NJDEP) still recognizes that challenges exist within the current framework of the wetland monitoring program, and that changes to the current evaluation methodology must take place based on both results from present surveys and current evaluation techniques (L. Torok, Pers. Comm., NJDEP 2002).

Although a considerable amount of attention has been paid to wetland mitigations, mitigations designed specifically for wildlife habitat restoration are few (NJDEP 2005). Presently, private property owners/developers are not required to protect habitats suitable for threatened and endangered (T&E) animal species, and no requirements are in place for T&E plant species (L. Niles and B. Cartica, Pers. Comm.). Wildlife mitigations in the past have occurred through negotiation between Department programs as a precondition required for grant of permits (depending on the project). If new rules are proposed that require developers to meet new criteria, or specifically provide guidelines for characterizing habitat suitability, determining areas where activities will adversely modify habitat and characterizing the impact of proposed activities on habitat, along with detailed conservation measures, this could increase the number of wildlife mitigations in New Jersey. However, individual habitat conservation plans and regional habitat conservation agreements may provide an alternative to rules on a smaller or regional scale (D. Jenkins and M. Kaplan, Pers. Comm.).

In 2006, the Division of Science, Research, and Technology (DSRT) in collaboration with the Division of Fish and Wildlife, Endangered and Non-game Species Program (DFW-ENSP) and Division of Land Use Regulation (DLUR), conducted a pilot study to test methodologies that may be used to quantitatively assess the overall success (in terms of percentages or benchmarks) of completed wildlife mitigations in New Jersey. Given that only a few species' habitats have been mitigated (L. Torok, DLUR, Pers. Comm.), two species (the Pine Barrens treefrog - *Hyla andersonii* and the northern pine snake - *Pituophis m. melanoleucus*) were chosen for testing novel success evaluation methodologies. The methods chosen for success evaluation and assessment were the Literature-based success criteria (LBSC) method developed by Short et al. (2000), and the use of confidence intervals calculated using habitat parameter data gleaned from the literature. The LBSC method is designed to quantify habitat attributes through ranking based on field measurements, and can be adapted to varying sites of interest. Field measurements taken from natural reference sites (or found in the literature) of habitat characteristics best defining the

requirements of the target organism, are used as qualifiers for determining whether past wildlife mitigations can be deemed successful.

Although both the LBSC method and confidence intervals were useful for comparing natural site conditions to the mitigated sites, the 2006 study concluded that reference sites should be measured directly rather than heavy reliance on the literature as a data source. The literature is however, invaluable for determining what parameters the investigator should measure. This study is a continuation of work performed in 2006. The 2007 field study is designed to evaluate the success of restored frosted elfin butterfly (*Callophrys irus*) habitats compared with natural reference sites, using the previously mentioned methods (i.e. LBSC method and confidence intervals) and comparison among them.

Methods and Study Sites:

The frosted elfin is a state-threatened species with a statewide range limited to the southern portion of New Jersey (Figure 1) (ENSP 2005). Consequently, New Jersey supports one of the largest single populations worldwide (e.g. Atlantic County is considered to be the best region for frosted elfin globally), although *C. irus* often tends to be isolated and extremely localized (ENSP 2005, Pyle 1981, Shapiro 1966, 1974). Habitat characteristics identified as most favorable for the survival and proliferation of *C. irus* were measured at naturally occurring and mitigation sites for this species. Since the frosted elfin is host-specific for the wild (false) indigo plant – *Baptisia tinctoria*, efforts were focused on measuring wild indigo habitat characteristics (i.e. associated plant species, soil chemistry, and other features). Table 1 below summarizes the ecological parameters identified as important attributes of frosted elfin/wild indigo natural habitat.

Table 1. Summary of critical habitat parameters and species life history traits for the frosted elfin butterfly (*Callophrys irus*) and its host wild indigo (*Baptisia tinctoria*).

Species	Survey Period	Reference Sites	Key Habitat Features	Species Surveys
***Callophrys (Incisalia) irus* - Frosted Elfin**	May – July: (May/June - plant surveys, ovi-position; June/July - host plant flowering)	Literature: ENSP FE management report (2005), Swengel and Swengel (2000), Swengel (1996)	*1)* Presence/density of *Baptisia tinctoria* 2) Open canopy 3) Soil pH 4) Substrate 5) Hydrology 6) Associated plant spp.	1) No. of adults 2) Presence of egg masses and/or larvae

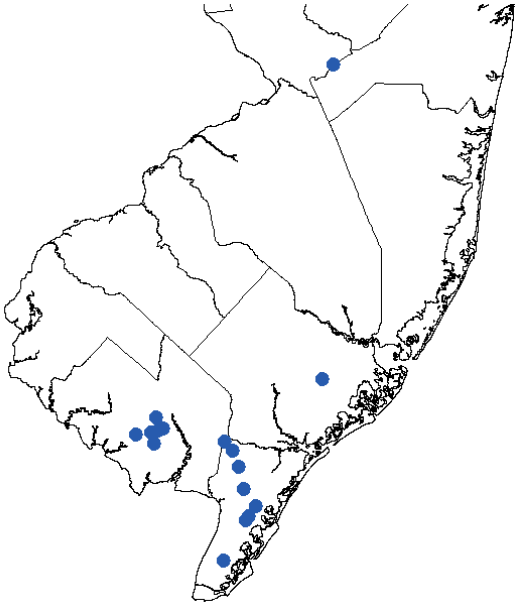

Figure 1. Frosted elfin butterfly sites and relative distribution in New Jersey, represented by the dots above (Source: ENSP 2005).

A. Species Description and Habitat - The frosted elfin butterfly (Figure 2) is one of four types of butterflies grouped in the gossamer wing family (Lycaenidae), which includes the blues, coppers, hairstreaks and the Harvester. *Callophrys irus* is a member of the blue category, along with about 9-10 known elfin species in North America (Pyle 1981). The frosted elfin occurs throughout the eastern United States and lower Canada (specifically the Carolinian region of southern Ontario), however it is generally localized in small patches throughout its range (Shapiro 1966, Pyle 1981, Packer 1990, Swengel 1996). In the mid-Atlantic region, frosted elfin distribution is limited to the Pine Barrens plains and serpentine plains of Pennsylvania (Shapiro 1966). *Callophrys irus* is also a univoltine species (i.e. one brood per year), which contributes to its rarity and sparseness (Shapiro 1974). It is also has a high susceptibility to habitat disappearance and disturbance, thus the frosted elfin is listed as a threatened species in New Jersey.

Figure 2. Adult frosted elfin on one of its host plants, wild lupine – *Lupinus perennis* (left photo – John Shaw, WIDNR). Spring emergence of wild indigo (*Baptisia tinctoria*), the host species in New Jersey, often coincides with elfin phenology (right photo – ENSP 2005).

The frosted elfin is host specific in terms of food type, feeding on the flowers and pods of either wild lupine (*Lupinus perennis*) or wild indigo (*B. tinctoria*), depending on the subspecies (Shapiro 1966 and 1974, Pyle 1981, Swengel 1996, Nadeau 2001). The mid-Atlantic population, *Callophrys i. arsace*, feeds solely on *B. tinctoria*. *Baptisia tinctoria* also serves as larval host for the wild indigo duskywing (*Erynnis baptisiae*), a moth species of similar size (Pyle 1981). Wild indigo prefers textured, well-drained soils with neutral pH to mild acidity, has a high tolerance for low nitrogen (capable of nitrogen fixation), and is very drought tolerant (Pyle 1981, USDA - NRCS 2007). Given that soils of the Pine Barrens fit this description, disturbed areas with high light intensity are well suited for wild indigo colonization (Shapiro 1966). Although tolerant to the above conditions, predation by deer and powdery mildew can decimate some populations (ENSP 2005, Missouri Botanical Garden 2007). Frosted elfin phenology commences with adult flights in late April – early May, and continues for approximately one month from time of emergence (Pyle 1981, Packer 1990, Swengel 1996, Swengel and Swengel 2000). Peak flight activity occurs during daylight hours (0710-1750) and at temperatures ranging from 15 – 32°C (Nadeau 2001). Oviposition and metamorph lifecycle occur exclusively on the host plant, and over-wintering of chrysalis occurs in duff and leaf litter in surrounding forested habitats (Pyle 1981). Preferred breeding/feeding habitats are typically open canopy areas with dry, sandy substrates, and composed of large patches of *B. tinctoria* (or *L. perennis* and other subspecies) and associated herbaceous nectar-producing vegetation (Swengel 1996, ENSP 2005, Shapiro 1966).

B. **Reference and Mitigation Sites** - Frosted elfin study sites were chosen based on historical distribution and presence of the host plant species wild indigo (ENSP 2005). In New Jersey, much of the existing habitat for the frosted elfin currently occurs on state- and federal-owned lands (ENSP 2005). Mitigation sites for the frosted elfin are actively managed by NJDEP (DFW) with assistance from companies owning/maintaining utility right-of-way's

(R.O.W.'s) (D. Golden and L. Petite - ENSP, Pers. Comm.). This is considered by the Department as being essential for the long-term viability of this species in the state. The location, history and descriptions of the mitigation and reference sites, respectively, are as follows:

Mitigation Sites:

1. Frosted Elfin Mitigation Site – **FE-1** (Figure 3): The FE-1 site (Cumberland County) was documented as frosted elfin habitat until it was improperly managed via disking operations in spring 2004. The 2002 frosted elfin population at this site had a Heritage Conservation Status Rank of "B", indicating a "good estimated viability". However, the May 2004 survey documented only one frosted elfin male. Inspections in the summer of 2004 found *B. tinctoria* recolonizing from seeds following disking. In 2006, *B. tinctoria* plugs were planted throughout the site, along with staggerbush (*Lyonia mariana* - provides an additional nectar source for *C. irus* and other elfin species) in order to restore the site's value as butterfly habitat.

Figure 3. FE-1 mitigation site (Cumberland County, NJ). Flags (yellow) in photo indicate 2006 *B. tinctoria* plantings, red flags (3 - bottom left corner and center photo) for staggerbush (*Lyonia mariana*).

2. Frosted Elfin Mitigation Site – **FE-2** (Figure 4): Historically, the FE-2 site (Monmouth County) contained a small but persistent population of frosted elfin along a 30-m section of a utilities right-of-way (R.O.W.). In 2003, woody vegetation was manually removed from the area where *B. tinctoria* was growing to reduce competition for this species. Deer browse was a reported problem at this site, and may have intensified following ENSP's habitat management. Frosted elfin surveys conducted in 2004 reported negative results.

Figure 4. FE-2 mitigation site (Monmouth County, NJ). *Baptisia tinctoria* habitat located just beyond creek crossing.

3. Frosted Elfin Mitigation Site – **FE-3** (Figure 5): Habitat for frosted elfin existed historically along this utilities R.O.W. The FE-3 site (Cumberland County) held large patches of *B. tinctoria* prior to 2002. Heavy off-road vehicle (ORV) use at this site destroyed much of the suitable frosted elfin habitat and left the R.O.W. impassible. The road was repaired and the site leveled and disked in 2002. The area was allowed to revegetate and is now heavily colonized by warm season grasses. Only isolated *B. tinctoria* plants are present, and nectar sources are limited. As with the FE-1 site, FE-3 was also planted in 2006 with *B. tinctoria* plugs and *L. mariana* plants in order to entice elfins to return.

Figure 5. FE-3 mitigation site (Cumberland County, NJ), view to the east.

Reference Sites:

1. **BRS** (Cumberland County**)**: The BRS site contained a small but persistent population of frosted elfin until subjected to herbicide application in September 2002. The herbicide destroyed 95% of all woody vegetation and impacted grasses and forbs in the target area. While *B. tinctoria* was little affected by the herbicide application, all nectar plants were destroyed. A site visit in 2003 found that deer browse on *B. tinctoria* was intense. It is believed that herbivory was more concentrated on this species than normal because it was one of the few herbaceous plant species available at the site following the 2002 herbicide application. In addition, the spring of 2003 was wet and cold, and few frosted elfin were observed. On site visits in 2004, *B. tinctoria* appeared to be growing vigorously and some of the nectar plants had recolonized. However, frosted elfin were absent from the site.

2. **BVS-N** (Cape May County): The BVS-N site is a utilities R.O.W. Three to four *C. irus* adults were found along this R.O.W. in May of 2003. The extent of this habitat continues for approximately 1 km. The history of occurrence at this site for frosted elfin is unknown, although conditions here are quite favorable. The BVS-N site was mowed in 2006 resulting in successful suppression of the woody vegetation, and it also appears that the *B. tinctoria* population is healthy and vigorous (D. Golden and L. Petite - ENSP, Pers. Comm.; Personal Observation).

3. **BVS-S** (Cape May County): Similar to the site characteristics above, the BVS-S site is located approximately 1 km south of BVS-N. As with BVS-N, this site was mowed in 2006 and now has a thriving *B. tinctoria* population.

4. **FL** (Cumberland County): The FL mitigation site is a small pocket of suitable frosted elfin habitat. Frosted elfin have been sighted here historically, although never in great numbers. The area was disked in 2002. *Baptisia tinctoria* is present in vigorous, though not numerous, clumps. Nectar plants, such as lowbush blueberry (*Vaccinium pallidum*) and violets (*Viola* spp.), are present though not in profusion. Surveys for the frosted elfin have not been conducted here for several years.

C. Vegetation Composition – Vegetation surveys were conducted for *B. tinctoria* within each study area and quantified using the line transect method (Brower et. al. 1990). Randomly selected points were staked and vegetation types (i.e. graminoid and herb/forb = herbaceous-combined; shrub/sub-shrub and tree = woody-combined) were recorded along 50 ft (15.24 m) transects (ENSP 2005). Percent vegetation composition was calculated using the linear density index for each vegetation type, in addition to estimation of percent vegetation coverage (Brower et al. 1990).

D. Soil Chemistry – Soil samples were randomly collected from each site and analyzed for pH, nitrogen (N), phosphorus (P), and potassium (K) using a field soil test kit (Model EL-5679, LaMotte Company). Samples (three per site) were collected from a depth of about 10 cm, and air dried for at least one week prior to analyses. Samples were later prepared according manufacturer's instructions, analyzed, and results recorded.

E. Species Surveys – The following information was recorded during each field visit: 1) presence/absence of butterflies, 2) activity level, if any, on host plant (i.e. feeding, resting, oviposition, etc.), 3) presence/absence of other elfin species, and 4) presence/absence of egg cases and/or larva on host plants. During surveys, numbers of individuals and activity were recorded, along with weather conditions at time of sighting. Days with wind speeds in excess of 15 mph can skew results since *C. irus* are weak fliers and tend to fly within a few feet from the ground surface (Pyle 1981). Days with temperatures below 65°F and/or with precipitation are also unfavorable for observation.

F. Data Analyses – Measures of habitat characteristics were compared for data gathered from select reference sites and mitigation sites, and described in the ENSP's Frosted Elfin Management Plan (2005). An adaptation of the LBSC method was performed for data parameters recorded at the above sites. For comparison, single factor and multi-factor Analysis of Variance (ANOVA) were also used to test for significance between soil characteristics and vegetation composition at all sites, and for significant differences between sites. Where appropriate, confidence intervals (95%) were applied to each habitat criterion using the above, and used to identify target intervals for the mitigation site habitat criteria.

- <u>LBSC Methodology</u>:
  The following methodology was used for the evaluation of habitat criteria:

  A. Measurement of Key Habitat Variables (adaptation of Short et. al., 2000 methodology):

     1. Choosing Restored Sites/Reference Sites and Target Species: Frosted Elfin butterfly – Use existing Land use/wildlife mitigation projects implemented in New Jersey as examples of restored sites. Areas of naturally occurring frosted elfin populations can be used as reference sites for comparison and assessment of candidate indicators of core habitat (literature can be used as substitute if data are present).

     2. Choose candidate indicators (CI's) – Candidate indicators were chosen based on the recommendations of ENSP biologists and those found in the literature. CI's are measurable representatives of functions and values of a habitat containing target species and are used to quantitatively evaluate a restoration project. The CI's are prioritized to rank the relative importance of each function, or key habitat variable. Examples of key habitat variables may include (1) Canopy Structure, (2) Water quality, (3) Vegetation composition, (4) Prey density/abundance, and (5) Phenology, etc.

     3. Measure CI's at selected reference sites – This involves quantitative measurement of the above for each reference site (i.e. field measurements). Attention must be placed on site-specific characteristics, seasonal dynamics, life cycle, etc., so as to establish the background conditions on which the success criteria (SC) will

eventually be based. It is necessary that consultation of established methodology for particular habitat/species in the literature should be completed.

4. Rank the CI's – Create a table with CI's compiled with mean, standard deviation (SD), and coefficient of variation (CV = SD/mean). The CV's are used to rank the CI's (In general, the lower the CV, the higher the rank).

5. Selection of CI's as qualifying indicators – Qualifying indicators represent the top ranked CI's (those with lowest CV's). The CI's are compiled, and then compared with data gleaned from the restoration/mitigation project to calculate success criteria (SC) for functions of the restored habitats.

6. Calculate SC for each qualifying indicator – Qualifying indicators (from step 5) are used to compare the monitoring data from the restoration site to a mathematically derived representation of the reference site. The SC can then be calculated as follows:

$$SC = 100^* \left(\frac{\text{Mean of all reference sites} - 1\text{ S.D.}}{\text{(Mean of reference sites)}}\right)$$

where "1 S.D." is defined as one standard deviation. Depending on the function/value used as the qualifying indicator, the percentage of its distribution and importance within the habitat or the presence of target species will determine its importance as a SC unit.

7. Determine time frame of assessment – Time frame is important in knowing the time needed for the establishment of the important functions used as qualifying indicators. Depending on the species or habitat, the time needed to accurately assess the SC may take anywhere from one growing season to 5-10 years. This needs to be established for each mitigation project, however the given study will only assess success during a snapshot rather than an extended monitoring period.

8. Calculate the success ratio (SR) for each indicator – The SR is the measure of how successful each restoration site is compared with the selected reference site for the functional characteristics being evaluated. SR is calculated as follows:

$$SR = 100^* \left(\frac{\text{Mean of one restoration site}}{\text{(Mean of reference sites)}}\right)$$

When the SR for a given indicator equals or exceeds the SC, the restoration is deemed successful. As the restored habitat develops, further application of the SC will indicate if reference conditions are achieved. Knowledge of suitable parameters is necessary for this assessment, since in some instances (e.g. pH) values in excess of the SC (20% or greater) may also disqualify the success of a parameter for a given site (Short et al. 2000).

9. Apply success ratio – Short et. al. (2000) recommend that at least three (3) reference sites be included in the sampling plan in order to avoid inadequate sample sizes. The goal for the SR's (as in species richness, if a qualifying indicator) is show achievement of success at all sites.

B. Confidence Intervals (95% confidence) – Habitat parameters measured from mitigation sites were compared to reference site data using a 95% confidence interval ($\alpha = 0.05$). Mitigation site parameters falling within the range of the confidence interval are accepted as meeting the standard for a given habitat criterion (in this study, ± 1 standard deviation from the mean). Confidence interval calculations follow general biostatistical methods (Brower et al. 1990, Zar 1996).

Results and Discussion:

Species Surveys: Equal-effort surveys were conducted at all frosted elfin sites beginning on May 14th and continuing through June 7th, 2007. Independent surveys by NJDEP-ENSP staff were also conducted at other frosted elfin sites not used in this study. Data from the later served the purpose of comparison to phenology and general numbers for this season, as compared to past seasons. Frosted elfin numbers for the 2007 season at the study sites (Table 2), as well as other New Jersey sites not used in this study, were low compared to previous seasons (D. Golden, ENSP, Pers. Comm., Pers. Observation). Swengel and Swengel (2000) reported that frosted elfin density and observation was influenced significantly by weather, and in general are subject to marked fluctuation in numbers among years. The 2007 season was hampered by below normal temperatures in late May, which delayed *B. tinctoria* emergence and *C. irus* phenology by as much as three weeks.

True population estimates are often difficult to determine since *C. irus* are known to establish small localized, dispersed populations that are rarely abundant where located (Shapiro 1974, Pyle 1981). Populations may also fluctuate with host availability and other factors (Swengel 1996, Swengel and Swengel 2000). *Callophrys irus* were observed at all reference sites, and at only one of the three mitigation sites (Table 2). However, other elfin species (i.e. Henry's elfin – *C. henrici*, eastern pine elfin – *C. niphon*, brown elfin – *C. augustinus*, hoary elfin – *C. polios*) were present and observed at all three mitigation sites (J. Bilinski, Personal observation). This observation can be interpreted as encouraging since elfin species are sympatric (i.e. often found together), which can be indicative of the potential presence of the target elfin species, its phenological progress, or suitability of habitat (Shapiro 1966, Pyle 1981, Swengel 1996, Swengel and Swengel 2000).

Table 2. Observations of frosted elfin adults absent/present at selected study sites (May through June 2007).

Study Site	Site Type[a]	Present (+)/Absent (-)	No. of Individuals Observed	Comments
BRS	R	+	1	Site rich in numerous butterfly species and all five elfin species observed (see above paragraph for species).
BVS(N)	R	+	12	All five elfin species observed, especially Henry's and the brown elfin.
BVS(S)	R	+	2	Same as for BVS(N), except no Hoary elfin (*C. polios*).
MV	R	+	2	*C. irus* egg mass observed on host plant, numerous in Henry's and brown elfins; few eastern pine elfins seen.
FE-1	M	+	2	All five elfin species observed.
FE-2	M	-	0	Only brown elfin (few, < 5 total) observed – *C. augustinus*.
FE-3	M	-	0	*B. tinctoria* relatively small (most ≤ 10" high), did not reach maturity during 2007 season (Henry's, brown, and e. pine elfin also present).

a: R = Reference sites, M = Mitigation sites.

Vegetation Composition and Wild Indigo Density: Vegetation composition (i.e. herbaceous vs. woody) differed significantly between reference and mitigation sites (P = 0.008) (Table 3). Mitigation sites generally contained 13.9% more herbaceous vegetation than reference sites. This was especially evident in comparisons of graminoid (i.e. grasses and sedges) composition, of which the mitigation sites were more often densely composed (Graminoid composition: Mitigation sites = 53.5%, Reference sites = 28.8%). Species richness was comparable between reference and mitigation sites (Mean no. of species per site: 14.5 – Ref., 11.0 – Mitg.). Although slightly higher for reference sites, the difference was not significant. Wild indigo density was also comparable (with the exception of FE-3) between sites (11.0% vs. 9.5%, respectively). For example, *B. tinctoria* transplants at FE-1 were doing very well; plants reached maximum size at maturity and produced flowers/seed. In contrast, the FE-3 site had very few, stunted wild indigo plants (only 1.9% of the total number of plants counted at this site), of which very few have reached maturity. The FE-2 site was the most successful site in terms of wild indigo vigor (Figure 6). Plants (Figure 7) were among the largest observed for the three mitigation sites (also compared to some reference sites), and many were found established growing in open areas in the woods adjacent to the R.O.W. Unfortunately, no frosted elfin presence was observed at FE-2 (with the exception of brown elfin adults, *C. augustinus*) during the 2007 survey.

Figure 6. Area of *B. tinctoria* concentration at the FE-2 site (Monmouth County, NJ), most plants growing in depression located in left of photograph, and along adjacent forest edge.

Figure 7. Mature *B. tinctoria* growing at the FE-2 site (Monmouth County, NJ). Above plant (center photo) measured at a height of 44 in., and crown width of approximately 36 in.

Vegetation composition success ratios (SR's) calculated for the mitigation sites varied greatly compared to the success criteria (SC's) (Table 4). For both herbaceous and woody vegetation, success ratios exceeded the reference SC's (the exception being the FE-2 site woody vegetation SR). This discrepancy may be most likely due to the higher percentage of herbaceous vegetation observed at the mitigation sites. The proportion of graminoid species was also a greater component of the collective herbaceous vegetation estimate. The degree of site manipulation, technique (e.g. disking, mowing, and/or herbicide application), as well as timing between applications may also factor in to the differences observed in the ratios of vegetation type. However, this did not appear to affect *B. tinctoria* at either FE-1 or FE-2 (FE-3 had low success), regardless of the plant ratios observed. Sites with mixed vegetation and open soil patches are

most favorable for the establishment of wild indigo, conditions present on all sites investigated in this study (USDA-NRCS 2007). Graminoid density can be an especially significant factor in affecting the successful establishment of *B. tinctoria.* This is due to species' reduced seed propagation abilities as compared to more aggressive colonizers (e.g. warm season grasses). Seedlings generally have low vigor and little tolerance to fire (USDA-NRCS 2007). However, dry, open, and poor sandy sites prone to drought are preferred where competition is not as intense.

Soil chemistry: Soil chemistry did not differ significantly within the limits of the testing method used, or between/among sites for all factors: pH, nitrogen (N), potassium (K), and phosphorus (P). Soil samples collected from reference and mitigation sites were extremely close in composition, and exhibited little variation (Table 3). All sites were found to contain soils in the mid-acidic range (Mean pH = 4.3), and trace amounts of nitrogen, phosphorus and potassium. Success ratios calculated for all soil factors were within the required range established by the reference site SC's (Table 4). Large, if any differences, were not expected since only trace amounts of each nutrient were measured (i.e. ranks were from both sites for N and K). Thus, mitigation site soil chemistry SR's were often within 100 percent of the reference site SC's.

The soil parameter results were consistent with measures reported in other studies performed on Pine Barrens' soils (Boyd 1991, Dighton et al. 2003). In general, Pinelands' soils can be classified as sterile, acidic (range: 3.6 – 5.5), sandy, podzol, very porous, and nutrient poor (high in iron, low in calcium, magnesium, potash) with little humus accumulation (Boyd 1991). Dighton et al. (2003) reported (from Belleplain State Forest, Cape May and Cumberland Counties) total mean N and P from spring soils at 0.5 mg/g and 0.05 mg/g, respectively. These results further illustrate the nutrient-poor nature of Pinelands soils. *Baptisia tinctoria* is often found growing in open sandy soils with low vegetation density (ENSP 2005, USDA-NRCS 2007). Disturbed areas in the Pine Barrens offer these conditions (maintained R.O.W.'s, burned areas). These characteristics can be owed to the unusually porous nature of these soils, which have intensively leached upper layers. The USDA-NRCS (2007) describes the growth requirements for *B. tinctoria* as having adaptation/preference for soils of mild acidity, coarse and medium texture (Pine Barrens soils are made up largely of coarse sands and gravels), high drought tolerance/low moisture usage, high fire tolerance, low soil fertility.

Table 3. Mean values for habitat features measured at frosted elfin (*C. irus*) mitigation sites compared with reference sites.

Habitat Parameter[1]	**Reference Sites (n = 4)**	**Mitigation Sites (n = 3)**
Mean pH	4.3 (± 0.3, 0.1)	4.3 (± 0.2, 0.04)
[2]Mean nitrogen (N)	1.0 (± 0.0, 0.0)	1.0 (± 0.0, 0.0)
[2]Mean phosphorus (P)	1.0 (± 0.0, 0.0)	1.0 (± 0.0, 0.0)
[3]Mean potassium (K)	4.8 (± 0.5, 0.1)	4.7 (± 0.6, 0.1)
Graminoid composition (%)	28.8 (± 10.9, 0.4)	53.5 (± 12.6, 0.2)
Herb/forb composition (%)	30.4 (± 7.9, 0.3)	19.6 (± 2.8, 0.1)
Shrub/sub-shrub composition (%)	27.2 (± 12.4, 0.5)	15.2 (± 12.7, 0.8)
Tree composition (%)	13.6 (± 16.3, 1.2)	11.6 (± 5.5, 0.5)
% *B. tinctoria* per site	11.0 (± 0.04, 0.4)	9.5 (± 0.1, 0.7)

1 - Data represented as "percentage (± 1 standard deviation – S.D., coefficient of variation – C.V.)".
2 - Soil data for N and P are represented as "rank (± 1 standard deviation – S.D., coefficient of variation – C.V.)"; For N & P: 1 = Trace, 2 = Low, 3 = Medium, 4 = High
3 – Soil data for K are represented as "rank (± 1 standard deviation – S.D., coefficient of variation – C.V.)"; For K: 0-8 = 1 (Trace), 9-10 = 2 (Very Low), 11-12 = 3 (Low), 13-14 = 4 (Medium), 15-16 = 5 (Med. High), 17-18 = 6 (High), 19+ = 7 (Very High).

Table 4. Success Criteria (SC) and Success Ratios (SR's) calculated for frosted elfin (*C. irus*) data from mitigation sites compared to reference site (REF) data. Underlined values represent SR's that lie outside of the ± 20 percent (%) SC margin calculated for each given parameter.

	REF Sites (%)	**Mitigation Sites SR's (%)**		
Parameter	**(SC)**	**AS**	**SM**	**BL**
Mean pH	**92.1**	96.3	100.2	104.0
Mean nitrogen (N)	**100.0**	100.0	100.0	100.0
Mean phosphorus (P)	**100.0**	100.0	100.0	100.0
Mean potassium (K)	**89.5**	105.3	105.3	84.2
Herbaceous vegetation composition	**72.0**	<u>141.2</u>	<u>106.3</u>	<u>122.9</u>
Woody vegetation composition	**59.3**	40.3	<u>90.2</u>	66.7
B. tinctoria patch density	**61.5**	<u>118.4</u>*	<u>17.6</u>*	<u>123.5</u>*

* - *B. tinctoria* density was greater at AS and BL than those observed for the reference sites; SM wild indigo density much less than all other sites (reference and mitigation).

Overall Success Evaluation: The success determination for the frosted elfin mitigation projects can be divided into two tiers, the first being successful establishment of *B. tinctoria*, and second the presence and use of sites by *C. irus*. The first category can be deemed successful based on empirical evidence that these sites have established (in two out of three cases, flourishing) and continue to maintain healthy *B. tinctoria* populations. However, the second is difficult to determine since only one mitigation site was found to host the target species. Caution should be taken in drawing an immediate conclusion, since there may be other unseen factors at work that may have prevented frosted elfin from finding and utilizing these sites. From historical accounts, all of the above mitigation sites were host to *C. irus*. Due to site/habitat alteration, *C. irus* has not been observed for a number of years, with the duration of time varying for each site (ENSP 2005). It may take a number of generations and chance for the frosted elfin to locate and reestablish at the mitigation sites, or human intervention may be required as in the form of capture/relocation. Other difficulties arise in fully assuming success. There is the question as to what draws frosted elfin to a given site, what determines its long-term presence, or are there indeed cyclical patterns as suggested by Shapiro (1974), Swengel (1996), and Swengel and Swengel (2000). The results illustrate the need for more than one survey year to adequately assess elfin population dynamics at these sites. Moreover, long-term behavior and breeding studies will be required to effectively address these questions and better understand this species and its ecology.

Summary and Conclusions:

Although the temptation exists for applying a 'catch-all' method to assessing wildlife mitigation success, variation in species' requirements and life history necessitates novel methodologies and survey procedures unique to a particular species. The derived conclusions for using the LBSC methodology in 2007, as a tool for success evaluation for frosted elfin mitigations are similar to those of the 2006 study. Simply stated the LBSC methodology is limited to geographically, short-ranging species. However, when the application is solely intended for a species fitting these criteria, it may very well be appropriate. It is also a relatively easy technique to apply without using complicated statistical methods or matrices. Statistical analyses other than the LBSC method are still required to verify the significance of the resultant data and helpful for comparison. Problems associated with the LBSC methodology include discrepancies that arise between the calculated SR's and the SC's gleaned from the reference site data. One may interpret a higher SR as equivalent to greater success, however Short et al. (2000) caution that an extreme overshoot can be due to data with large variances or unequal balance in an ecosystem. Success criteria and SR's calculated for certain parameters may be falsely labeled as an unimportant ecological factor (i.e. disqualifying candidate indicator) for species success, showing widely fluctuating percentages (greater than ± 20 percent) and/or high variation (large CV's). In addition, long-term monitoring is required and a repeat of parameter measurement is necessary to ultimately gauge whether a mitigation has been truly successful. Four main conclusions/suggestions can be drawn from the results observed in this study:

1. Multiple parameters are important for evaluating the successful colonization, utilization, and reproductive capacity of a species, and how a restored/mitigation site effectively recreates these conditions. Measuring only one or two parameters may not produce an accurate

indication of success. For example in the 2006 study, the J. J. White treefrog mitigation site parameters closely resembled a successfully functioning *H. andersonii*-breeding habitat, however the absence of treefrogs suggests otherwise.

2. Measurement of habitat parameters must be species-specific. The LBSC methodology, as illustrated by this study, cannot be effectively applied universally, but with focus on each individual species and its unique requirements. Confidence intervals and/or other statistical analyses must be applied to test for significance, and for ranges by which the means should be bound.

3. Utilization of the LBSC methodology is most appropriate for species (i.e. animals) with small home ranges and/or those geographically isolated (e.g. pond, hillside, along a utility R.O.W., etc.). This method is especially appropriate for plant species (i.e. for which it was originally developed).

Overall Recommendation: Based on the results produced from the two years of study conducted by DSRT, it is recommended that other methodologies continue to be explored, or combinations of methodologies to evaluate mitigation success. Mitigation success evaluations may be broken into categories to accommodate differences in species life histories and habitat requirements. Specifically, vegetation and animal species evaluations can be treated differently from one another. For example, the Floristic Quality Assessment Index (FQAI) method, developed by Floyd Swink and Gerould Wilhelm (1994), has been applied as an evaluation tool for determining the current status of vegetative quality and a predictive metric following disturbance. This method, with some success, has already been applied in New Jersey (and through the upper mid-west) for wetland quality assessment (B. Hazen, DSRT, Pers. Comm., Taft et al. 1997, Mushet et al. 2002, Lopez and Fennessy 2002, Rothrock and Homoya 2005). Study designs developed for animal species may employ multivariate analytical tools. For example, Canonical Correspondence Analysis (CCA) may prove useful since the design infers species-environment relationships from the species community and habitat data. Another approach that appears to hold merit is the multimetric method developed by McCoy and Mushinsky (2002), which calculates an index of compositional difference (ICD) between reference and mitigation sites. This method designed to retain the advantages achieved from the use of ordination and cluster analyses, however is condensed for use in comparing multiple sites and species. In summary, utilization of a combined-methods approach should result in a more inclusive assessment of species-habitat parameter interactions, and determination of critical qualifying indicators necessary for successful use and reestablishment of the target species.

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