Monitoring *Plethodon cinereus*, the Eastern Red-backed Salamander, in Kejimkujik National Park and Historic Site

by
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This thesis is dedicated to the magical salamanders and to all those committed to conserving natural forest ecosystems.

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LIST OF ABBREVIATIONS

ACO ....artificial cover object
CWD ....coarse woody debris
EMAN........................Ecological Monitoring and Assessment Network
NCO ....natural cover object
SVL ....snout-vent length
TL...............................total length
USGS ....United States Geological Survey
VTL............................vent-tail length

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ABSTRACT

Monitoring of plethodontid (lungless) salamanders has been proposed as an integral part of a national, plot-based, long-term forest ecosystem monitoring initiative for Parks Canada. Plethodontids are candidate indicators of forest integrity due to characteristics of their physiology, ecological role and life history. It is thought that by monitoring plethodontids in conjunction with other forest ecosystem components, changes in ecosystem integrity can be detected, tracked and quantified. A 5-year pilot project using *Plethodon cinereus*, the only common plethodontid salamander in Nova Scotia, as one of several indicators of forest integrity was initiated in May 2003 in Kejimkujik National Park and Historic Site. This thesis provides an assessment of the first fall plethodontid salamander-monitoring season occurring in zonal, mesic eastern hemlock and hardwood dominated forest ecosystems. Preference for artificial cover objects of four native wood species (*Tsuga Canadensis*, *Pinus strobus*, *Picea sp*. and *Acer rubrum*) was tested and the temporal and spatial distribution of salamander detections across twelve study sites from 2 Aug - 26 Oct were determined. Results show that *Plethodon cinereus* uses artificial cover objects, and that use of the four wood species was not significantly different across all sites or at hemlock and hardwood sites separately. Salamander detections across sites cumulatively peaked on the weekend of 20-21 September. The four weekends of highest detections occurred consecutively from 20 Sept - 12 Oct. Interestingly, it was found that one of the eastern hemlock stands had the sites with both the most and least salamander detections. This was the only stand that contained sites that were significantly different from each other. More research is needed to explain the difference in these detections.

1.0 INTRODUCTION

1.1 The Need for Long-Term Ecological Monitoring

Global human impact on natural environments is extensive. With such consequential issues as urbanization, pollution, climate change, conversion of natural forest, unsustainable harvesting of natural resources, habitat fragmentation, and the introduction of invasive species, the future of natural ecosystems is uncertain. With so many unanswered questions and an uncertain future of natural environments it is necessary for long-term monitoring of natural ecosystems to exist. Long-term monitoring is essential in order to keep a close eye on how these ecosystems, their species composition and abundances, and processes and functions they perform are affected. Often studies occur only after human disturbance has had an obvious effect, resulting in no baseline data to be compared to, or studies have been too brief in duration to include generation turnover times and natural population cycles that must be taken into account. Long-term monitoring is also needed to conclusively prove what we often intuitively know, and to realize anthropogenic effects that we have not foreseen.

Even protected areas such as national parks are in jeopardy though heavy human use and by forest stressors such as air and water pollution and invasive species that are not limited by park boundaries (Parks Canada 2000). Parks Canada has recognized the need to have programs in place to monitor ecosystem integrity. An ecosystem, defined by Parks Canada, has integrity "when it is deemed characteristic for its natural region, including the composition and abundance of native species and biological communities, rates of change and supporting processes" (Parks Canada 2000). This definition also brings to light the need for baseline ecosystem knowledge and research in order to quantitatively determine what the natural state of a region is or was. Parks Canada is required to report every two years on the state of ecological integrity in national parks (Woodley 1997). This requires parks to evaluate ecosystem integrity by assessing known threats and a suite of indicators that address both ecosystem structure and function (Woodley 1997).

It is believed that by monitoring an array of environmental factors and indicator species, changes in ecosystem integrity can be detected, tracked and quantified. Long-term data is gathered to follow ecosystem changes caused by long-range, long-term stressors such as acid rain, climate change, and air, water, and soil pollution, as well as local park management activities and regional impacts associated with land use outside parks. Ecological monitoring in parks is also needed to serve as a reference for similar ecosystems outside of protected areas and as a warning of more widespread forest issues (Parks Canada 2000). Parks Canada, in conjunction with the Ecological Monitoring and Assessment Network (EMAN) and other academic institutions and community groups have developed monitoring programs and suggested standardized protocols for monitoring environmental factors and potential indicator species.

One of these initiatives is the monitoring of forest integrity, for which plethodontid salamanders have been proposed as candidate indicator species. A five-year pilot project was initiated in May 2003, in Kejimkujik National Park and Historic Site to research and implement integrated long-term, plot-based monitoring through the use of national standardized protocols.

1.2 Indicators of Ecosystem Integrity

Ideally all plants, animals and physical factors could be monitored to create a picture of ecosystem health, but the number of species and factors that could be monitored would involve an impractical amount of time, money, and analytical expertise (Welsh and Droege 2001). Therefore, what is needed is a subset of organisms and factors at varying ecosystem levels that can be monitored and in conjunction would reflect the health of an ecosystem. Thus, monitoring of indicators species can be likened to monitoring heart rate, blood pressure or cholesterol level where concerned with human health. Indicator species should be a sensitive species that serve as early warnings of an environmental stressor and/or demonstrates a cause and effect relationship with the environmental condition (Woodley 1997). Sensitive species are just one of many types of indicators, and the concept of indicator species will depend on the issue and purpose of concern (see Simberloff 1998 for a discussion on umbrella, flagstone and keystone species and Power et al. 1996 for a discussion on keystone species).

Choosing indicator species is complicated, and even the idea of bio-indicators is somewhat problematic and controversial. Landres et al. (1998) argue that there is a lack of precise definitions, procedures, and confirmatory research to support the ecological reasons for using vertebrates as indicators species. Landres et al. conclude that using indicators to directly assess environmental contaminants has been done successfully and seems justified; however, they suggest that new techniques of directly measuring contaminants may be more accurate and cost effective. They also conclude that using indicators to assess population trends and habitat suitability for other species is not appropriate until the confirmatory research exists.

1.3 Plethodontid Salamanders

Plethodontid salamanders are candidate indicator species of forest integrity. Plethodontid salamanders belong to the Family Plethodontidae and are characterized by a lack of lungs and nasolabial grooves (Petranka 1998). Plethodontidae is the largest family of salamanders, composed of 27 genera and about 240 species, representing more than half of all known salamander species (Petranka 1998). Plethodontids are found throughout North and Central America. There are also two genera in South America and two species in southern Europe and Sardinia (Petranka 1998).

In Nova Scotia there are only two native plethodontid salamanders: *Hemidactylum scutatum*, the four-toed salamander, and *Plethodon cinereus*, the eastern red-backed salamander (Figures 1 & 2). The four-toed salamander is the province's most rare salamander, while the eastern redback salamander is the most common (Gilhen 1984). Because there is only one common plethodontid in Nova Scotia, the initiative to monitor plethodontids in Kejimkujik effectively becomes the monitoring of *P. cinereus* (See Appendix 1 for details on the biology and ecology of *P. cinereus*).

1.4 Reasons For *P. cinereus* as an Candidate Indicator of Forest Integrity

Plethodontid salamanders have been proposed as indicator species of forest integrity based on their physiology, ecological role and life history attributes. This discussion focuses on reasons why *P. cinereus* is considered an indicator species.

Physiologically, *P. cinereus* is sensitive to desiccation. Because plethodontid salamanders breathe through their glandular skin they are reliant on cool damp soils, rain

Figure 1: Photo of *Plethodon cinereus* (Green), the eastern red-backed salamander (photo by Catherine Earley).

Figure 2: Photo of two of *P. cinereus'* colour variations: red-backed (right) and leadback (left). This leadback has an autotomized tail, a strategy used to escape predators. The third colouration of *P. cinereus* (not shown) is an all red or erythrisitic variation.

saturated leaf and moss layers and natural habitats such as coarse woody debris to maintain their skin moist for respiration. Breathing through its skin also likely makes *P. cinereus* vulnerable to contaminants in the soil. Studies document that clear-cutting, forest conversion to spruce plantations and acidic conditions have negative consequences for *P. cinereus* abundances (Wyman and Hawksley-Lescault 1987; Wyman 1988; DeGraaf and Yamasaki 1992; Frisbie and Wyman 1992; Wyman and Jancola 1992; Petranka et al. 1993; Ash 1997; Waldick et al. 1999).

Eastern red-backed abundance is drastically reduced by clear-cutting forestry practices (DeGraaf and Yamasaki 1992; Petranka et al. 1993; Ash 1997). Clear-cuts result in more sun and wind action reaching the forest floor causing greater water evaporation and greater temperature fluctuations in the upper soil levels and forest floor (Welsh and Droege 2001). Eastern clear-cutting practices also eliminates natural cover objects, reducing plethodontid habitat. In addition, logging road construction and the use of large harvesting equipment causes soil compaction that can eliminate the underground networks used by salamanders (Welsh and Droege 2001). In the southern Appalachians, Petranka et al. (1993) found that almost all species of salamanders were negatively effected by timber removal and that 50-70 years were required for populations to return to pre-cut levels. In the southern Blue Ridge Mountains, North Carolina, Ash (1997) found that the number of plethodontids decreased 30-50% in first year following clear cutting and were almost completely eliminated in the second year. Ash reports that the salamanders returned 4-6yr later but estimates based on linear regression predict 20-24 years for the establishment of pre-cut abundances, which correlates well with the amount of time required for the reformation of leaf litter. Thus, the effects of clear cutting on microclimate and microhabitat dramatically decrease plethodontid populations.

In New Brunswick Waldick et al. (1999) found that conversion of natural mixed forest to black spruce (*Picea mariana*) plantations also had negative consequences for *P. cinereus*. *P. cinereus* was ubiquitous in natural mixed-species forests, yet it only occurred in one of the 33 converted spruce plantations studied. The negative consequences of conversion to spruce plantations are also related to microclimate and microhabitat. Young spruce plantations have incomplete canopy cover resulting in drier and greater temperature fluctuations of forest floor conditions, while plantation management reduces potential inputs of large woody debris (Waldick et al. 1999; Fleming and Freedman 1998).

It is also conceivable that *P. cinereus* may be negatively affected by the warmer and drier conditions that may result due to climate change. *P. cinereus* relies on cool, moist conditions in the spring and fall for mating and optimal foraging behaviours that occur on the soil surface. Because *P. cinereus* is so vulnerable to desiccation, it is conceivable that with the advent of climate change that critical mating and foraging periods may be reduced if warmer and drier climatic conditions result.

Cutaneous respiration also makes *P. cinereus* sensitive to acidic pH levels and likely to air, water and soil pollution. The distribution of *P. cinereus* is influenced by soil pH or a related factor that negatively affects sodium balance (Wyman 1988; Frisbie and Wyman 1992; Wyman and Jancola 1992). Wyman and Hawksley-Lescault (1987) found that the lethal pH was between 2.5 and 3 and the chronically lethal pH between 3 and 4. The acidity of soils common in spruce plantations and forests (<4) may in part explain why Waldick et al. (1998) reported reduced numbers of *P. cinereus* in converted spruce plantations. Atlantic Canada has often been called the “tailpipe of North America” because of wind patterns that pick up pollutants from major industrial centers in the industrialized Midwestern U.S, the Great Lakes region and the Eastern Seaboard of the United States and transports them to Atlantic Canada (Parks Canada 2000). It is possible that increases in acidic deposition and other pollutants such as heavy metals will have detrimental effects on *P. cinereus*, especially in areas with soils that have low buffering capacities.

Other reasons why *P. cinereus* is a candidate indicator of forest integrity are associated with its ecological role. *P. cinereus* can reach surprisingly high densities in many mature to old-growth forest floor habitats. In the Hubbard Brook Experimental Forest the mean population density observed was $0.41/m^2$ (Ducey et al. 2003) and the biomass of five salamanders species was measured to be about twice that of birds during the peak-breeding season and about equal to the biomass of small mammals (Burton and Likens 1975a). The biomass of *P. cinereus* represented 94% of the total salamander biomass. Because *P. cinereus* can reach such high densities it plays an important role in ecosystem food webs and detrital dynamics (Burton and Likens 1975b; Wyman 1998). *P. cinereus* forages on small invertebrates such as mites, fly larvae, ants, beetles, spiders and ticks (see Burton 1976 and Gilhen 1984 for more complete lists). Redbacks themselves are preyed upon by snakes such as the northern ringneck (*Diadophis punctatus edwardsii)* and juvenile maritime garter snakes (*Thamnophis sirtalis pallidula Allen)*, ground feeding birds and likely small mammals (Gilhen 1984; Fenster and Fenster 1996). The eggs and young also fall prey to carnivorous beetles and conspecifics (Gilhen 1984, Petranka 1998). *P. cinereus* is extremely efficient at metabolizing its prey and converting assimilated energy into tissue with higher protein content than that of birds and mammals, thus representing a high quality food source for predators (Burton and Likens 1975b). In addition, Wyman (1998) found that by consuming invertebrates, *P. cinereus* indirectly reduced the rate of decomposition of forest litter by 11-17%. More studies are needed to thoroughly understand *P. cinereus'* role in forest ecosystems.

P. cinereus has several life history traits that make it a good indicator of forest integrity as well. They are completely terrestrial, occupy small home ranges and have stable population sizes under normal conditions (Jaeger 1980; Kleeberger and Werner 1982;). The fact that *P. cinereus* is completely terrestrial and has a small home range means that the population being monitored is completely associated with the target forest ecosystem and is not being affected by changes in other ecosystems. Therefore it is easy to relate changes in salamander detections to the integrity of the forest ecosystem of interest. *P. cinereus* also has a relatively long life span, high annual rates of survivorship and low birth rates, which under normal conditions results in stable population sizes (Hairston 1987; Jaeger 1980; Droege et al. 1997; Zorn and Blazeski 2002). Therefore, if a decline does occur it is more likely to indicate an actual stressor rather than a natural swing in population size or a shift in home range.

Although biological reasons for indicator selection are of fundamental importance, other factors such as cost and level of expertise needed are also practical issues. One of the costs of sampling depends on the sampling effort required to detect desired trends. Welsh and Droege (2001) reported that the coefficient of variation in counts of individuals among studies was lower in plethodontids (27%) than in lepidoptera (93%), passerine birds (57%), small mammals (69%) or other amphibians (37-46%). The significance of low variation is that greater statistical power can be achieved at a given sample size. In Canada salamanders are easy to identify, which reduces observer bias and expertise needed. *P. cinereus* and other plethodontids also readily use artificial cover objects that can be used as a standard non-destructive way to sample terrestrial salamanders. Furthermore, *P. cinereus* is linked with soil and forest floor processes and small invertebrates, which are difficult to monitor (Welsh and Droege 2001). Monitoring plethodontid salamanders may be a more feasible way to indirectly monitor these life forms and processes (Welsh and Droege 2001).

1.5 Reasons Against *P. cinereus* as an Indicator of Forest Integrity

Choosing indicator species is complicated because most proposed species have attributes that argue against their use, including *P. cinereus*. Reasons against using *P. cinereus* as an indicator species are: their ecology is not well understood; they are not especially sensitive to habitat fragmentation; they are common in disturbed ecosystems such as sub-urban wooded environments; they may be slow to respond to certain disturbances; they are not significant ecosystem nutrient sinks or agents of nutrient movements and they are absent in certain forest ecosystems. These arguments are discussed in detail below.

The ecological role of red-backed salamanders is poorly understood. Because of the inconspicuous life history of *P. cinereus*, relatively little is known about its ecology, especially during the cold winter and hot summer months when they retreat to natural habitat objects and downward in the soil column. Most studies and observations have occurred on the soil surface. Although the surface is a critical habitat for foraging and mating, low recapture rates in mark and recapture studies, as well as removal studies show that the surface is only a small fraction of their habitat and that the majority of *P. cinereus* reside within the soil (Taub 1961; Monti et al.2000).

Spatial variation is also poorly understood. Frisbie and Wyman (1992) found that *P. cinereus* was 4-5 times more abundant in beech than in hemlock forests in the Huyck Reserve in central NY, a pattern that was unexplained. Davis (1998) found that on Vancouver Island, *A. ferreus* was more abundant than *P. vehiculum* at more northern sites, and opposite in more southern sites. He reported no obvious site differences that would explain this difference. Without being able to understand these types of natural distribution and abundance patterns it will be difficult to interpret increases or decreases in monitored relative population sizes in terms of forest integrity.

P. cinereus is not especially sensitive to habitat fragmentation and is common in disturbed forests. Gibbs (1998) found that the eastern redback was the least sensitive to fragmentation when compared to wood frogs (*Rana sylvatica*), spotted salamanders (*Ambystoma maculatum*), and red-spotted newts (*Notophthalmus v. viridescens*). It was also found in a study in southern New England oak forests that the number of eastern redbacks was neither significantly affected by the disturbances of thinning nor white tailed deer density (Brooks 1999). In addition, Knapp et al. (2003) found that *Plethodon* spp. populations in herbicide (Garlon4) treated forests in the southern Appalachians did not decline.

There is some evidence suggesting that *P. cinereus* may be slow in responding to certain environmental disturbances. The eastern redback can go without food for many months (Feder 1983), and thus may be slow to respond to disturbances affecting food sources. Jaeger (1980) also reports that *P. cinereus* was able to avoid the effects of a 28 day drought stress by retreating to moist subterranean refuges. In contrast, co-occurring *P. shenandoah*, which resides in taluses apparently excluded from deep soils by *P. cinereus*, experienced a population crash (Jaeger 1970; Jaeger 1972; Jaeger 1974; Jaeger 1980). Thus, changes in *P. cinereus* population counts will not necessarily occur quickly after certain disturbances.

As part of the Hubbard Brook, NH, study on ecosystem energy flow and nutrient cycling, Burton and Likens (1975b) found that five species of salamanders, including *P. cinereus*, were insignificant "sinks" for forest nutrients, with the possible exception of sodium. These researchers concluded that salamanders were not significant agents for the movement of nutrient into or out of the ecosystem and that they only utilized 0.02-0.03% of net primary production. Nonetheless, as discussed above, these researchers did find that salamanders were efficient at converting ingested energy into new tissue high in protein content, thus representing a high quality food source for its predators.

Plethodontids are also absent from drier forests; therefore, they cannot be used as indicators as forest health in those of ecosystems.

1.6 Study Description and Objectives

This study monitoring *P. cinereus* is part of a 5-year pilot project initiated in Kejimkujik National Park and Historic Site to research the development and implementation of integrated, long-term, plot-based monitoring of forest integrity, for which plethodontids have been proposed as indicator species. This thesis provides a summary of the first fall sampling season of *P. cinereus* monitoring.

There are many ways to sample terrestrial salamanders such as transect counts, quadrat searches, pitfall traps, removal studies, funnel traps, surface surveys, night searches and artificial cover objects. This study used artificial cover objects (ACOs), as a standard non-destructive method to sample salamanders, which is more conducive to long-term monitoring. ACOs can be anything that is placed on the forest floor that mimics natural habitat. Wood ACOs have proven to result in the highest sampling numbers and were used in this study (Binckley et al. ND). ACO sampling however is a relatively new sampling method and there are many issues of validity and bias that need further study.

One of the goals of this study was to determine if the wood species of the ACOs affected salamander detections by testing four different native wood types (*Tsuga Canadensis*, *Pinus strobus*, *Picea sp*., and *Acer rubrum*). Other study objectives were to collect the first fall data set for salamanders in Kejimkujik National Park and Historic Site, and to determine the temporal distribution of salamander detections from the beginning of August to the end of October and the spatial distribution of salamander detections across and within six study sites.

2.0 SITES AND METHODS

2.1 Site Selection

Candidate forest polygons representing zonal eastern hemlock (*Tsuga canadensis*) dominated and hardwood (*Acer rubrum*/*Quercus borealis*/*Pinus strobus*/*Betula alba*/*Betula alleghaniensis*/*Fagus grandifolia*) dominated ecosystems greater than 10 hectares in size were located on GIS maps derived from the 1972 biophysical inventory. Selected polygons were overlain with a 200 m x 200 m grid to identify potential sample points. Grid points were visited and assessed against site criteria that assessed consistent features of soil, vegetation and canopy structure. Briefly, soils were well-drained bouldery till, sandy loam to silt loam texture. Characteristic vegetation of hemlock dominated sites included *Gaultheria procumbens*, *Bazzania trilobata* and *Trientalis borealis*; whereas hardwood dominated sites commonly had *Kalmia augustifolia*, *Vaccinium augustifolium*, *Gaultheria procumbens* and *Pteridium aquilinum*. Lastly, the canopy layer had to be comprised of ≥ 75% of the classified forest type, without any large gaps.

If a point did not meet the above site criteria, one of the cardinal directions was randomly chosen and the point was moved 50 meters in that direction. If the point still did not meet the site criteria, another cardinal direction was randomly chosen until all directions were exhausted, in which case the point was discarded. Suitable stands and sites were used as forest songbird sampling points (Gullage and Staicer 2004).

Selected forest songbird sites were then assessed against a criterion for salamander monitoring. Sites had to be ≥100m away from trails, roads or forest edges, and relatively flat. Furthermore, sites could not contain a large amount of boulders in order to be conducive to setting out ACOs. Lastly, sites could not be in the true backcountry, due to accessibility restrictions.

From the stands and sites deemed acceptable, six stands: three hemlock dominated stands and three hardwood dominated stands were randomly selected. Within each forest stand, two suitable salamander sites were also randomly selected resulting in a

Table 1: GPS coordinates and set-up dates for the 12 salamander monitoring sites.

Site	**Stand Type**	**GPS coordinates (NAD 83)**		**Set-Up Date**
		Easting	**Northing**	
BD-A	Hemlock	319684	4925163	July 21, 2003
BD-B	Hemlock	319084	4925163	July 21, 2003
CFR-A	Hemlock	325800	4918796	July 19, 2003
CFR-B	Hemlock	325400	4918596	July 19, 2003
NCL-A	Hemlock	322767	4910688	July 22, 2003
NCL-B	Hemlock	322767	4910238	July 22, 2003
CLT-A	Hardwood	319774	4923544	July 22, 2003
CLT-B	Hardwood	319774	4923894	July 22, 2003
CL-A	Hardwood	322386	4907960	July 20, 2003
CL-B	Hardwood	322186	4907810	July 20, 2003
PL-A	Hardwood	312091	4908829	July 20, 2003
PL-B	Hardwood	312891	4908029	July 20, 2003

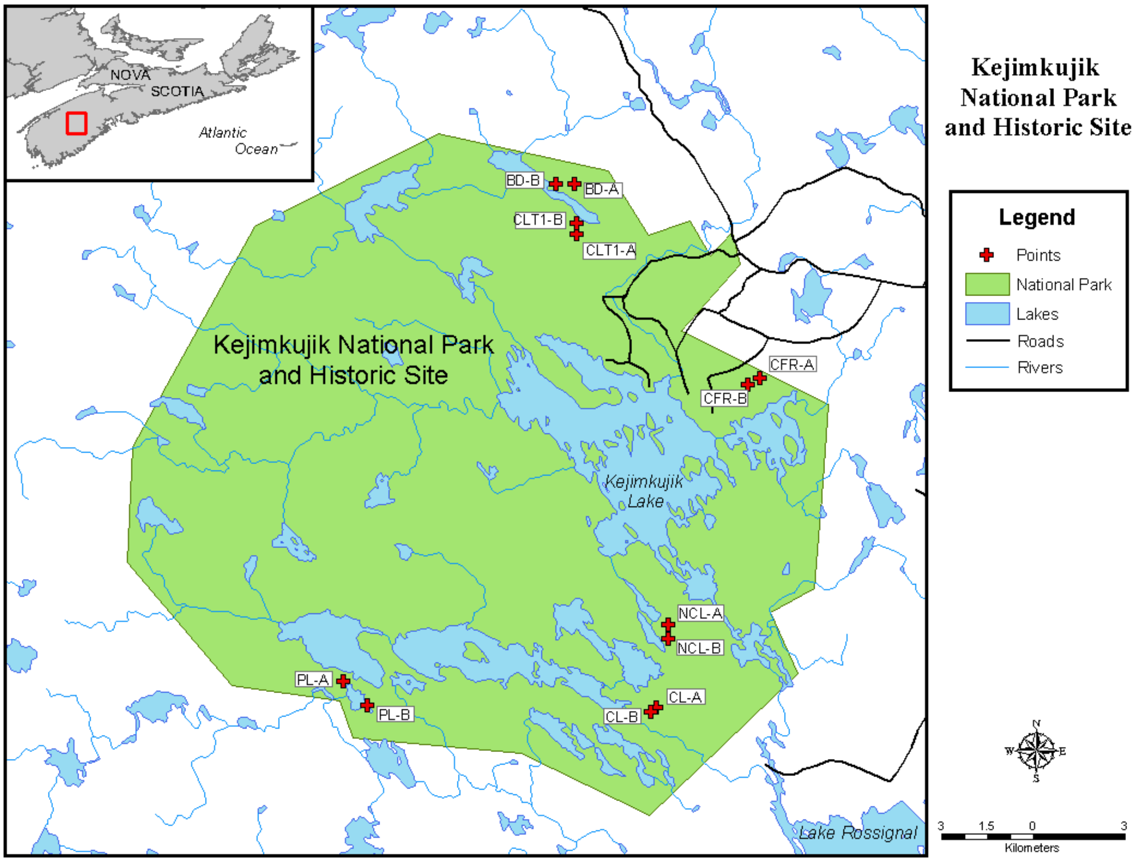


Figure 3: Map of Kejimkujik National Park and Historic Site showing the location of the 12 salamander monitoring sites.

total of 12 terrestrial salamander-monitoring sites (Table 1; Figure 3; Appendix 2. Site Access). All terrestrial salamander-monitoring points also correspond to permanent forest songbird points. These were marked by a permanent marked stake and are at least 200 meters from any adjacent point in the grid.

2.2 Artificial Cover Objects (ACOs)

Artificial cover objects, ACOs, were used to monitor salamanders (Figure 4). The ACOs used in this study were a simple, non-layered design. The dimensions of the boards were 5cm x 25cm x 30.5cm (or 2”x10”x12”), as are suggested in Zorn and Blazeski (2002). The boards were made out of four native wood species: eastern hemlock, white pine, spruce and red maple in equal numbers. In total 480 ACOs were used, 120 of each of the four wood types. The wood was un-milled, untreated and not kiln-dried. The boards were marked with permanent marker in a coded set of numbers and letters designating the polygon name (ex. CFR), the cross (A or B), the cardinal direction of the arm of the cross (N, E, S, W), the number of the board along the arm from the center point (1, 2, 3…10), and the type of wood (P for pine, M for maple, S for Spruce, H for hemlock). In the future it is recommended that the boards be marked in a more permanent fashion, such as stamping or attaching a metal tag.

2.3 Spatial Arrangement of Artificial Cover Objects

At each terrestrial salamander monitoring points, 40 boards were set out. Of these, ten boards were made out of each wood type. The boards were arranged in a cross, with the center of the cross being the actual GPS point (Figure 5). The arms of the cross

Figure 4: Photo of an artificial cover object (ACO). Dimensions are 5.0cm x 25.0cm x 30.5cm (or 2” x 10” x 12”).

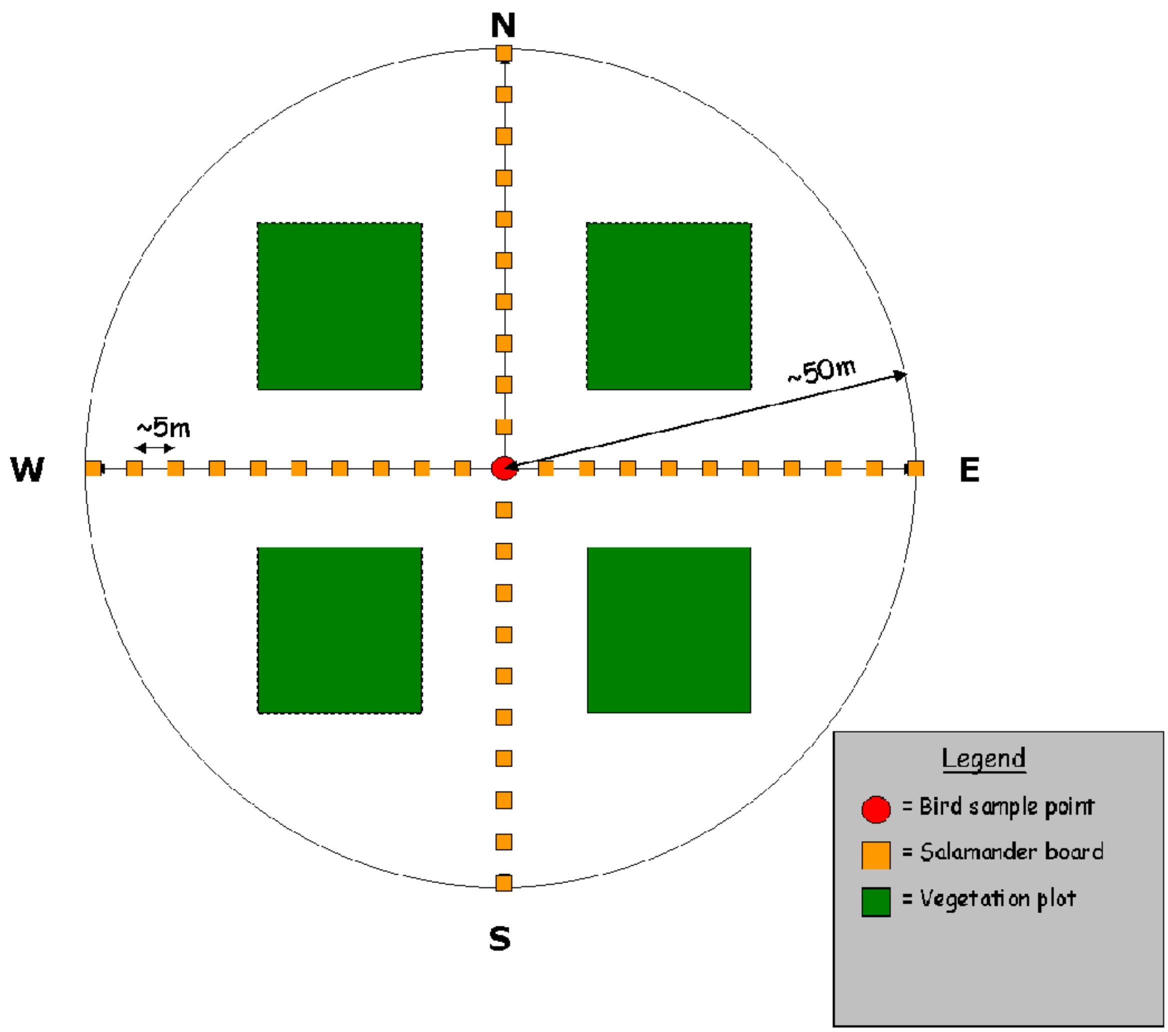


Figure 5: Schematic site diagram of the spatial arrangement of ACOs.

radiate outwards in the four cardinal directions. The four different boards types were randomly placed within the cross. The boards were placed at least 5m apart, and more if the landscape required. The surface leaf litter or moss layer was removed in the exact area that would be occupied by the board and the board was placed on direct humus layer soil and in some cases were there was a very thin humus layer, on mineral soil. The boards were placed so they sat flat on the ground to maximize the area in contact with the ground. Site set-up occurred 19-21 July (Table 1).

2.4 Handling Protocol

The salamander handling protocol followed recommendations in Zorn and Blazeski (2002). The person handling the salamander ensured that their hands were moist and free of all chemicals. After tilting up the ACOs the salamanders found were put into a clear moist fly fishing tackle box to minimize stress while measurements were made. The ACO was replaced as soon as the salamander(s) were retrieved so that the microhabitat did not dry out. The salamander was touch lightly so that it would change its shape to a more straight position. Snout-vent length (SVL) was measured from the tip of the snout to the posterior angle of the vent to the nearest millimeter with a clear ruler. The vent-tail length (VTL) was taken from the posterior angle of the vent to the tip of the tail. Any evidence of tail autotomy was also noted. Total length (TL) was calculated as these two measurements added together. The error of these procedures was not assessed.

The salamander was next placed in a moist Ziploc™ bag to be weighed with a 10 g Pesola® LightLine spring scale (precision ±0.3%) to 0.1g. The weight of the moist bag without the salamander was also measured. The weight of the salamander was calculated as the difference between these two measurements. After the measurements were completed, the salamander(s) were released next to the ACO and allowed to take refuge on their own so that the risk of being crushed was eliminated. The observer(s) then proceeded to the next board along the cross.

2.5 Data Collection

ACOs were checked once per week, every Saturday and Sunday, beginning on 2 Aug and ending on 26 Oct, for 13 weekends in total. Data recorded for every site visit included the date, names of observers, start and end time, air temperature, four soil temperature recordings (taken under board positions N4, E4, S4 and W4) and Beaufort sky and wind codes (Appendix 3). The amount of precipitation in the 24 hours and week prior to sampling dates was collected by Kejimkujik staff (a 24hr period was calculated from 12:00-12:00). For each ACO, the following were recorded: ACO number, presence and number of salamanders under the board, species and colour variation, snout-vent length (SVL; mm), vent-tail length (VTL; mm), total length (TL; mm), age class, weight and comments. Age determinations followed recommendations by Zorn and Blazeski (2002), also used in Brooks (1999) and derived from Sayler (1966) (young of the year SVL<30mm; juveniles SVL=30-40mm; mature or older than 2 years SVL>40mm).

Soil humus samples were taken for ten weekends (16 Aug – 19 Oct) and used to calculate soil moisture. Four samples were taken at each site within a 1meter radius from ACOs at the N4, E4, S4 and W4 positions. The samples were weighed wet, dried at 105°C for 24 hours and reweighed. Soil moisture was calculated as a percentage of dried soil weight using the following equation: $MC\% = (W2\text{-}W3 / W3\text{-}W1) \times 100$, where W1 is the weight of the tin (g), W2 is the wet weight of soil plus the tin and W3 is the dry weight of the soil plus the tin.

Coarse woody debris (CWD) was evaluated at each site on 25-26 Oct. The arms of the cross were walked and CWD quantity and quality were assessed. Data recorded for all CWD $\geq$ 8 cm in diameter at the point of intersection included the arm direction (N, E, S or W), the type of CWD (branch, trunk, stump, snag or unknown if indiscernible), decay class (1-5; Maser et al. 1979; Appendix 4), diameter or estimated diameter at the point of intersection, estimated length (height for stumps and snags, and length x width x height for log piles), tilt angle and comments (ex. tree species).

Tree data was collected for the four 20m x 20m plots at each site (Figure 3) by Stephen Gullage in Sept-Oct 2003. He recorded tree species, measured diameter at breast height in cm to calculate basal area, tree count to obtain a density measure, and estimated percent canopy cover by visual inspection (Gullage and Staicer 2004). Graphs of mean tree basal area are reproduced in the discussion section, with permission of the authors, to help explain differences in salamander detections among the sites.

2.6 Adaptations of the Joint EMAN/Parks Canada National Monitoring Protocol for Plethodontid Salamanders – Draft 2

This study followed basic recommendations in the Joint EMAN/Parks Canada National Monitoring Protocol for Plethodontid Salamanders – Draft 2 (Zorn and Blazeski 2002); however, certain deviations in methodology were taken. Firstly, the sites were chosen in a stratified random manner and sites were not scouted for salamanders prior to selection. Secondly, four different wood types of ACOs were tested. Thirdly, ACOs were set up in a cross, not around the perimeter of a 20 m x 20 m plot. Fourthly, ACOs were not cover with leaf litter debris or marked with a pin. In hemlock stands, there is no leaf litter and thus covering them would have been impossible. Fifthly, air temperature was only recorded once rather than eight times at each site, because it didn't change over the time it took to sample one site. Also, only four soil temperatures were taken under boards at the N4, E4, S4 and W4 positions instead of eight because temperatures were noticeably consistent. Sixthly, the posterior angle instead of the anterior angle was used for length measurements in order to be consistent with recommendations in the USGS Terrestrial Salamander Monitoring Program (Droege et al. 1997). However, the anterior angle was used in Sayler's study (1966) on which the age classifications are derived from (see Discussion on Age Class Data below). Lastly, sampling took place weekly instead of biweekly.

2.7 Statistical Analysis

All analyses were done on standardized salamander data to account for boards that were flipped, moved, floating in water or unable to be checked due to weather conditions. The effect of the ACO wood species on salamander detections was tested with ANOVA at the level of standardized site counts across all sites, and also hemlock and hardwood sites separately. A two-sample t-test was performed to compare the difference in standardized weekly average salamander detections between stand types. Kruskal-Wallis and Mann-Whitney rank-order analysis with a Bonferroni correction were used to compare differences in salamander detections at the level of standardized individual board averages between all sites and between sites within the same stand.

Scatterplots were made to compare standardized salamander detections with average percent soil moisture at the site and weekly level. Scatterplots were also used to explore how standardized salamander detections related to coarse woody debris total and average decay class, tree density, basal area, and canopy closure at the site level. A Pearson correlation matrix analysis was also done on these environmental measurements at the site level to analysis linear correlations (Zar 1984). Correlation analysis was used as a way to explore the data and does not prove causal relationships. Obviously, there were many other environmental factors that were not measured that would cause variation in salamander detections. These limitations must be taken into account when interpreting the output.

3.0 RESULTS

3.1 Species Detected

Over the 13 weekends of sampling, 757 salamander detections were recorded under the 480 ACOs. *P. cinereus* represented 99% of detections; 82% were the red-backed form, 18% were the leadback form of the same species, and no erythrisitic forms were detected (Figure 6). Using age classes derived from Sayler (1966) and recommended in Zorn and Blazeski (2002), 60% of the total detections were *P. cinereus* juveniles. There were 34 instances with two salamanders under one board and one instance of three.

The remaining 1% of salamanders found under ACOs comprised either unknowns (e.g., salamanders retreated into a burrow that existed under the boards) or other species. Other species observed were two yellow-spotted salamanders (*Ambystoma maculatum*),

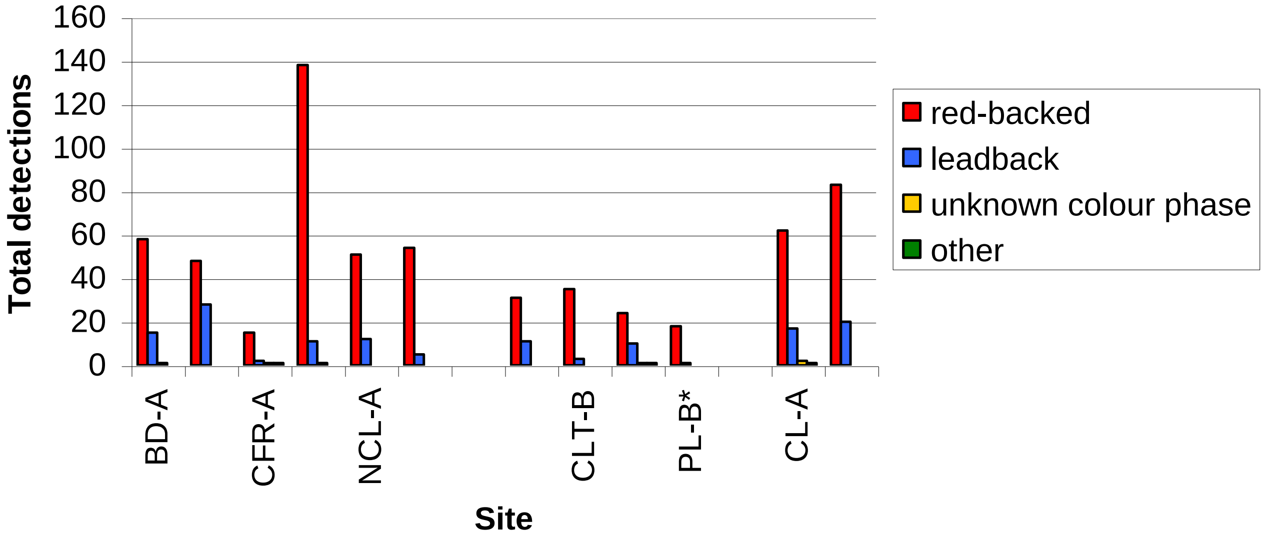


Figure 6: Colour variations of salamanders detected at sampling sites. *P. cinereus* represent 99% of total detections. 82% of these salamanders were red-backs and 18% leadbacks. Other species detected were two yellow-spotted salamanders *(Ambystoma maculatum*) and one red eft (Notophthalmus viridescens *viridescens*). PL sites (*) were only sampled 12 times, compared to 13 times for all other sites, due to weather. CL sites were hardwood sites but were different from the other hardwood stands in that they had more beech trees.

one on 23 Aug at PL-A (TL=70mm), the other on 14 Sept at CFR-A (TL=36mm), and one red eft (*Notophthalmus viridescens viridescens*) on 13 Sept at CL-A (TL=49mm).

3.2 Wood Type Effects

More salamanders were found under the ACOs of white pine and less under spruce, but this difference was not statistically significant (ANOVA, pine n=12, hemlock n=12, spruce n=12, maple n=120, p=0.405; Figure 7). When looking at board use in hemlock and hardwood stands separately there were also no significant effects (ANOVA, pine n=6, hemlock n=6, spruce n=6, maple n=6, p=0.890 and p=0.303).

3.3 Temporal Distribution

Salamanders were found under ACOs on the first week of sampling. The temporal distribution of standardized total salamander detections (Figure 8) cumulatively peaked on the weekend of 20-21 Sept. Salamander detections at individual sites peaked between 6 Sept and 18 Oct. The four weekends of highest detections occurred consecutively from 20 Sept - 12 Oct. During this period of peak detections the air temperature was roughly between 23°C and 11°C, and the soil temperature between 17°C and 11°C (Figure 9). Visual inspection of precipitation data for the sampling period does not reveal any obvious trends for this period of peak detections (Figure 10 & 11). The greatest percentage of young of the year (28.7%) was observed on the weekend of 20-21 Sept and the greatest percentage of adults was observed on the weekend of 4-5 Oct (Figure 12).

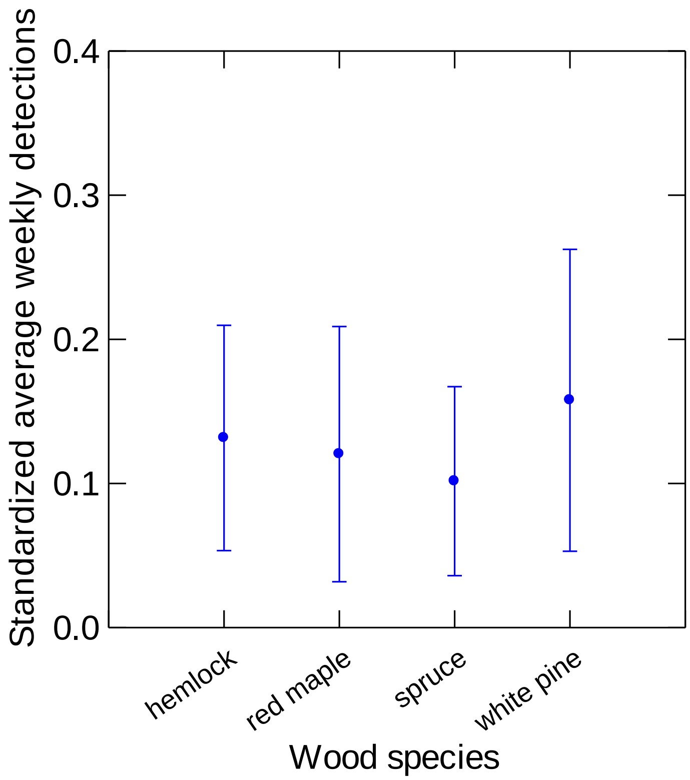


Figure 7: Detections under the 4 types of wood ACOs. The effect of wood species on ACO use was not significant (ANOVA, p=0.405). Standard deviation bars are shown.

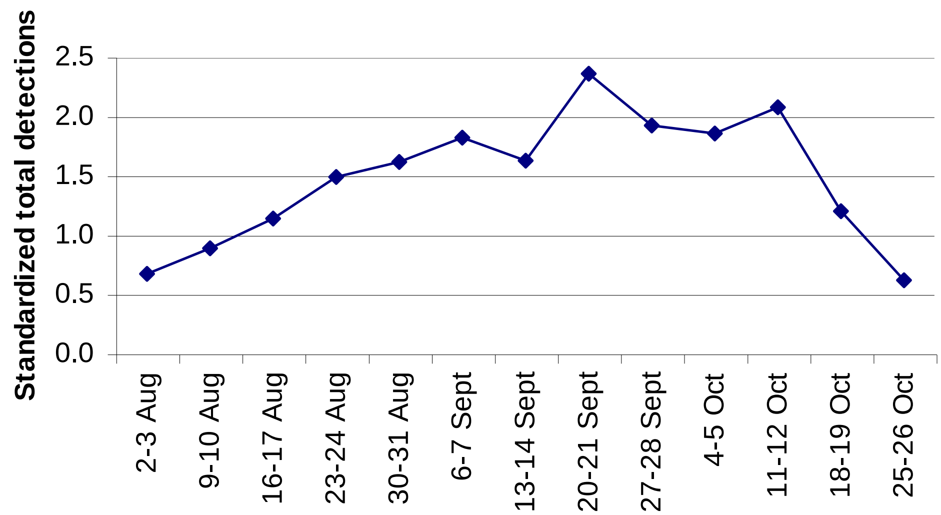


Figure 8: Temporal distribution of salamander detections; fall 2003.

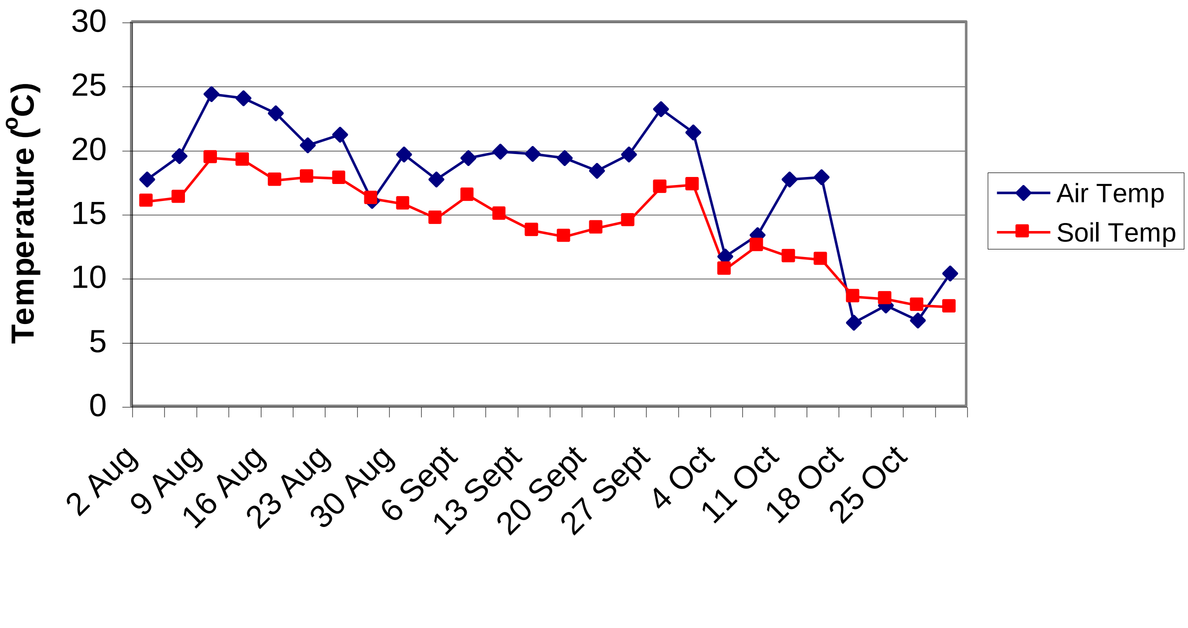


Figure 9: Air and soil temperatures during the fall sampling season.

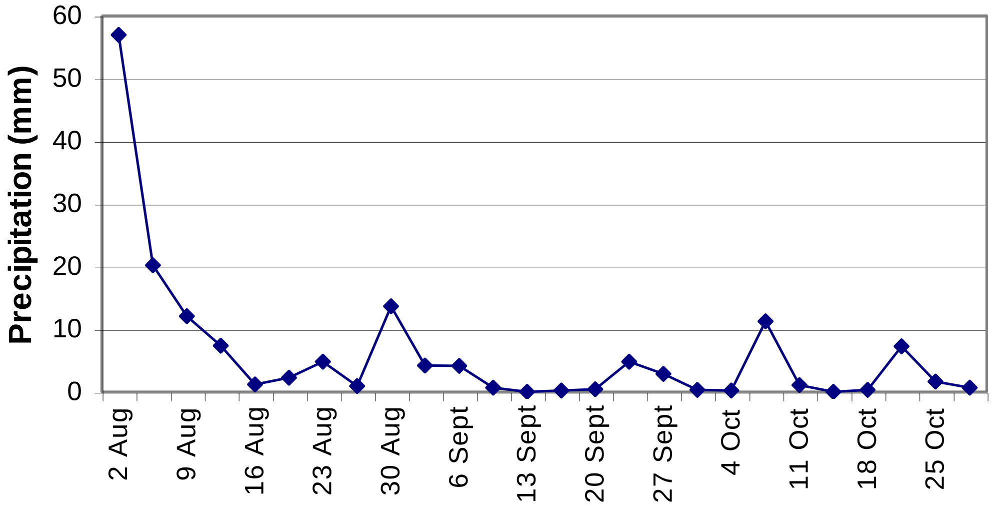


Figure 10: Amount of rainfall 24hr prior to sampling; fall 2003 (data courtesy of the Kejimkujik staff).

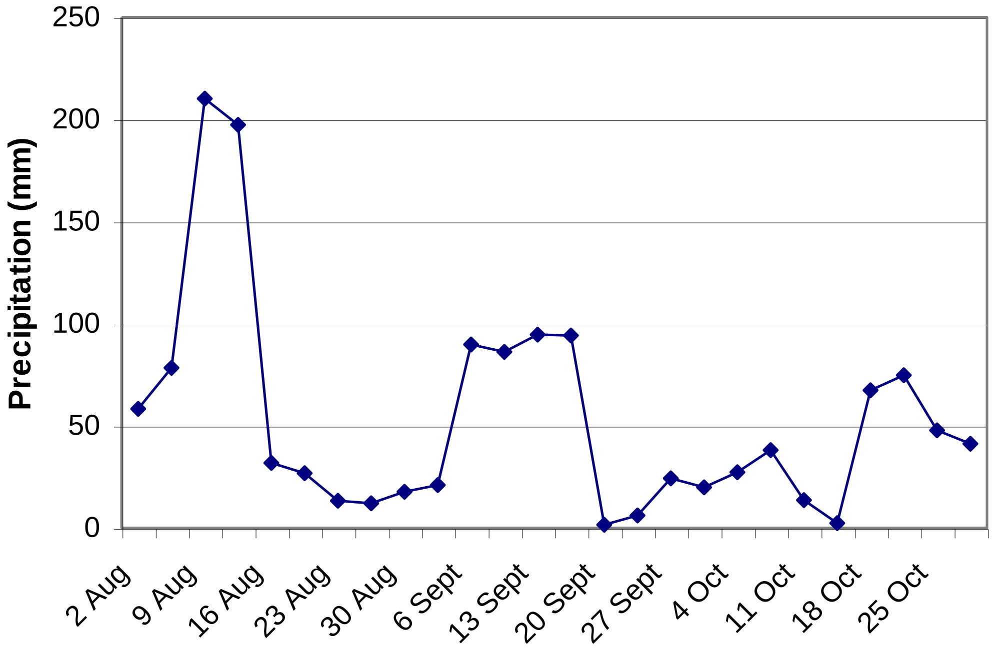


Figure 11: Amount of rainfall over the week prior to sampling (data courtesy of the Kejimkujik staff).

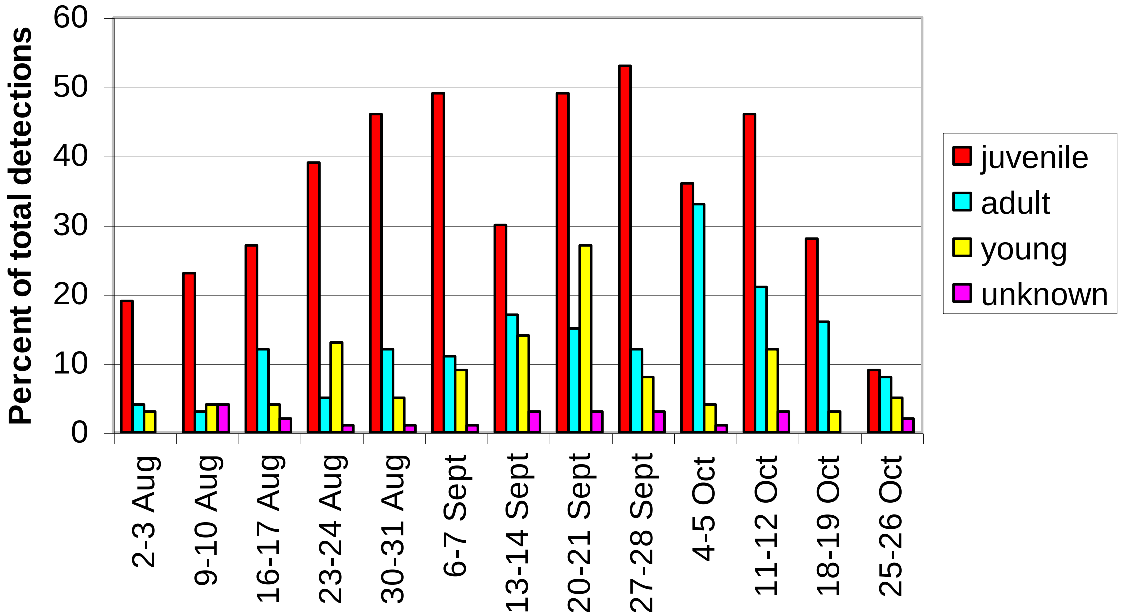


Figure 12: Temporal distribution of the different age classes.

3.4 Spatial Distribution

Variation among sites was noticeable and consistent over time. Sites with higher salamander detections were consistently higher compared to those with consistently lower detections (Figure 13). Standardized weekly average detections were not significantly different between stand types when including all sites (two sample t-test, hemlock n=6, hardwood n=6, p=0.431). When the CL sites, which had more beech trees, were excluded, a lower p-value was obtained, though still not significant (two sample t-test, hemlock n=6, hardwood n=4, p=0.081).

The CFR eastern hemlock stand contained the site with the highest (CFR-B) and lowest (CFR-A) salamander detections. The CFR stand was the only stand in which the two sites (CFR-A and CFR-B) were significantly different when detections were compared at the level of standardized individual board (Mann-Whitney U-test, CFR-A n=40, CFR-B n=40, p=0.000).

3.5 Environmental Correlations

Standardized weekly average detections for sites were significantly positively correlated with CWD average (df=10, r= 0.667, 0.02<p>0.01; Figure 14). Salamander detections were also positively correlated with basal area (df=10, r= 0.527, 0.10<p>0.05; Figure 14) and negatively correlated with density (df=10, r= -0.517, 0.10<p>0.05; Figure 14) though at a lesser significance. CWD average and basal area were significantly correlated with each other (df=10, r= 0.669, 0.02<p>0.01). Canopy cover and basal area (df=10, r= 0.464, 0.20<p>0.10) and CWD total and basal area (df=10, r= 0.468, 0.20<p>0.10) also showed a degree of positive correlation. CWD total and density

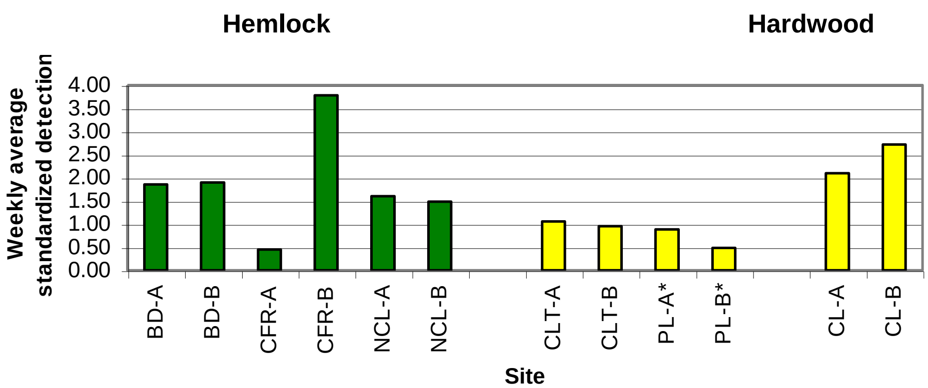
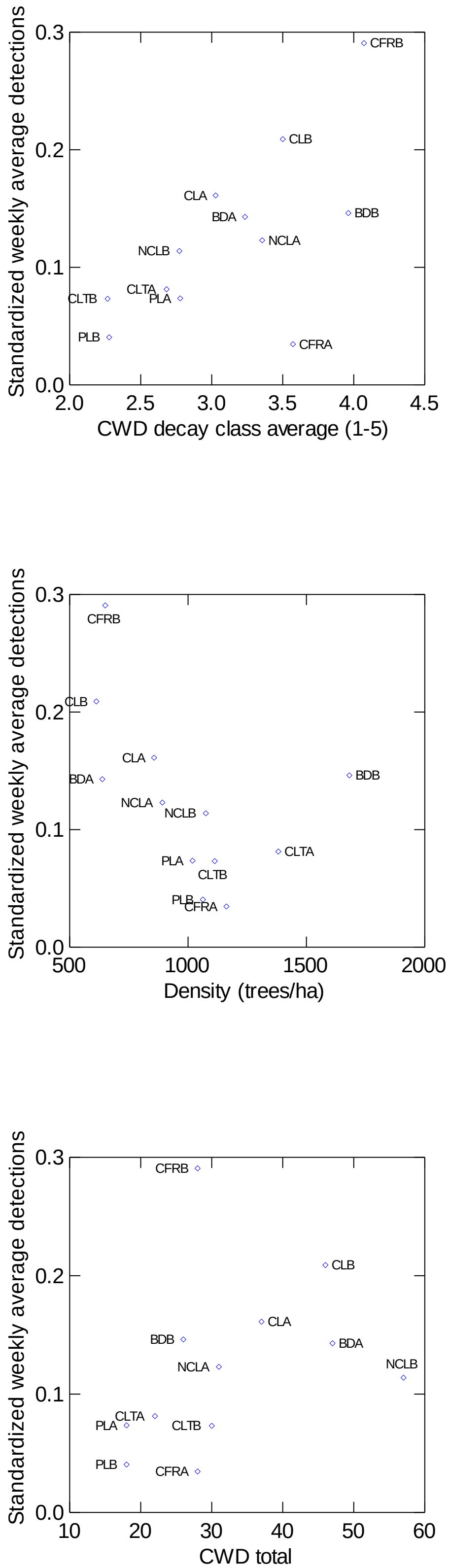


Figure 13: Spatial distribution of detections among the monitoring sites. The two stand types were not significantly different (two sample t-test, p=0.431). The CFR stand was the only stand in which the two points (CFR-A and CFR-B) were significantly different from each other (Mann-Whitney U-test, p=0.000). PL sites (*) were only sampled 12 times, compared to 13 times for all other sites, due to weather. CL sites were hardwood sites but were different from the other hardwood stands in that they had more beech trees.



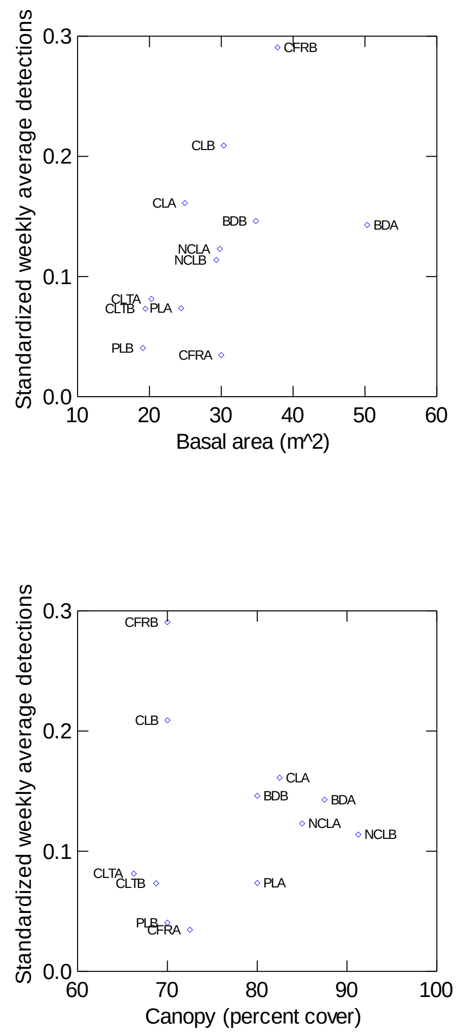


Figure 14: Scatterplots of standardized weekly average detections and stand characteristics. At p=0.05 the only significant correlation is that between standardized salamander detections and CWD decay class (r=0.667, 0.02<p>0.01).

(df=10, r= -0.429, $0.20<p>0.10$) also showed a negative correlation at a lesser significance.

4.0 DISCUSSION

4.1 Artificial Cover Object Use

Salamanders were found under ACOs the first week of sampling when the boards had only been in place for 11-15 days. Kejimkujik experienced a lot of precipitation in the beginning of August, which may have aided in weathering the board making them more appealing to salamanders. Bennett et al. (2003) also found that salamanders occupied ACOs in place only one week prior to sampling. Monti et al. (2000) found no significant difference between salamander detections under new and old cedar shingles at established stations. However, fewer salamanders were found under ACOs at newly established stations in the beginning of the season, suggesting that data from the first few months following installation will be biased.

The Joint EMAN/Parks Canada National Monitoring Protocol for Plethodontid Salamanders and the USGS Terrestrial Salamander Monitoring Program suggests that ACOs should be left to weather for a year before using their data in a long-term monitoring program (Zorn and Blazeski 2002; Droege et al. 1997). The 2003 fall data should be compared to future fall data sets to determine the effect of ACO weathering on salamander detections. If weathering does affect salamander affinity for the boards as they age and decay, then a source of bias is introduced. Assuming that ACOs in fall 2003 were all similarly affected, the data can be used to assess whether salamanders prefer certain wood types and whether their abundances differ across sites. Temporal trends within the first fall season can also be examined to identify optimal sampling times. Thus the data are valuable even if they cannot be used for long-term trend detection.

It was thought that plethodontids might demonstrate a preference for the ACO wood type due to differing drying periods and/or chemical compounds in the wood. It was also thought that ACO wood species common to the stand type might be preferred (i.e. in hemlock stands, it was predicted that hemlock boards would be preferred). However, salamander use of ACOs of the four different wood species was not significantly different across all sites or in the hemlock and hardwood dominated sites alone. Wood preference should continue to be monitored in case a preference develops later, after the boards weather. A recent study by Bennett et al. (2003) in north central Pennsylvania that tested salamander preference to ACOs of four wood species, American basswood (*Tilia Americana*), American beech (*Fagus grandifolia*), white oak (*Quercus alba*) and eastern white pine (*Pinus strobus*) also reported no significant effect. Based on a June to November monitoring period, Bennett et al. (2003) recommended that white oak be used for sampling as it appeared to decay the slowest. ACOs in Kejimkujik did not appear to have significantly decayed during the sampling season, which ran from the beginning of August to the end of October. Different weather conditions or the length of the monitoring seasons may explain the difference in weathering between the Pennsylvania and Nova Scotia ACOs. Durability of boards in Kejimkujik should be monitored, as it is of practical concern for a long-term monitoring program.

Another potential biases involved with ACO sampling include salamander territoriality. The literature suggests that a certain portion of red-backed population establishes territories based around cover objects in the summer (Jaeger 1979). Yet studies using ACOs report lack of site fidelity and aggregations of conspecifics under boards even in the summer (Monti et al. 2000; Brooks 1999). If salamanders were territorial around ACOs, then those salamanders holding territories would be over represented and those salamanders that are floaters would be under represented in ACO monitoring data. On the other hand, if territories were established under natural cover objects only, then those territorial salamanders would be under represented and floaters over represented under ACO. Territoriality may also result in specific age classes or a sex of the species being over or under represented. More research is needed to explore effects of territorial behaviour on sampling counts.

During the fall monitoring season in Kejimkujik, there were 34 instances of two salamanders under one ACO, and one instance of three. Based on age classifications recommended by Zorn and Blazeski (2002), which were developed from Sayler's study (1966), most of these instances were of two juveniles. Only four of the cases involved two adults. Unfortunately, salamanders were not sexed in this study, so it cannot be confirmed that these were male-female pairs. Monti et al. (2000) also reported *P. cinereus* in doubles, triples and quadruples under ACOs and low-mark-and-recapture rates, both of which suggest lack of site fidelity under ACOs.

Another issue that may influence occupation is the size of ACOs, although the literature is not clear on this matter. The percentage of *P. cinereus* juvenile detections in the present study contrasts with Brooks (1999) findings. Using ACOs to sample terrestrial salamanders in a New England oak forest, Brooks found that more than 75% of *P. cinereus* salamanders sampled were sexually mature using the same age classification.

However, Brooks' study used much larger ACOs (1m x 25cm x 4cm). Mathis (1990) reported that SVL was significantly positively correlated with cover object size. However, Moore et al. (2001) found that *P. cinereus*' size and weight were significantly positively correlated with cover object size during the only spring sampling season, one of three sampling periods conducted. Gabor (1995) reports that SVL was not significantly correlated with cover object size. Clearly, results from studies using ACOs of different dimensions should be compared cautiously. Considering the equivocal results, it has been suggested that once dimensions are chosen they should remain constant from year to year (Zorn and Blazeski 2002).

Environmental factors such as precipitation, air humidity, soil moisture and leaf litter moisture may also introduce sampling bias. Scatterplots of standardized weekly detections and average percent soil moisture at the site and weekly level, and to precipitation either the week or day before sampling did not suggest any significant trends. A relationship between increased rainfall and low detections in the beginning of August should not be inferred because confounding variables, such as seasonality effects and recent placement of the ACOs, are likely more explanatory. In contrast Bennett et al. (2003) reported that salamander detections under ACOs had a significant positive correlation to precipitation in the week prior to sampling. Although not made in this study, leaf litter and humidity measurements may have influenced detections. Increased precipitation, air humidity and litter layer moisture may result in more salamander detections occurring in the litter layer and fewer under ACOs.

More research is needed to test the validity of using ACO counts as an index of actual population size. ACO sampling provides an index of abundance rather than actual abundance of salamanders. Long-term monitoring depends on (1) the relative number of detections being strongly correlated to actual population size, and (2) consistent year to year ACO abundances with respect to population size, despite environmental differences. One study that has addressed this issue of validity of area-constraint searches of natural cover objects (NCOs) is that of Smith and Petranka (2000). In eastern Tennessee and western North Carolina, these researchers found that surface detections of *P. jordani* and *D. ochrophaeus* under NCOs were strongly correlated with estimates of absolute population size. Similar studies are needed to test the validity of ACOs.

4.2 Fall Monitoring Season in Kejimkujik

In order to minimize seasonality, it is important for monitoring programs to establish periods of times for monitoring that will maximize the number of salamanders detected and minimize the amount of variation in detections (Droege et al. 1997). Salamander surface activity is highest in the spring and fall. Data sets from these two seasons; however, must be kept separate (Zorn and Blazeski 2002). This first year of fall data suggests a sampling period of early Sept through mid-Oct would be the most suitable fall monitoring season in Kejimkujik. Bennett et al. (2003) reported similar findings in Pennsylvania, with *P. cinereus* detections peaking in mid-to-late Sept. Detections will likely peak at slightly different times from year to year due to varying weather conditions. During the four-week period of peak detections at Kejimkujik, the air temperature was roughly between 11°C and 23°C and the soil temperature was between 11°C and 17°C. These temperatures are within the range 5°C to 25°C, which Taub (1961) reported for captures of *P. cinereus*.

The number of times ACOs are sampled from year to year should be controlled. The sampling effort required for monitoring programs will depend on the amount of variation in the data and the desired power. High effort sampling can be costly and increase stress to the salamanders and forest ecosystem. Smith and Petranka (2000) found that annual repeatability was moderate to high for areas sampled with ACOs. Because of low variation in repeated measures, less sampling is needed to achieve a desired power. It is recommended that during the 5-year pilot phase of the project in Kejimkujik that the data be assessed in a program review to determine if more or less sampling is needed to achieve the desired objectives and statistical power (Zorn and Blazeski 2002).

Good experimental design, including randomization, often results in accessibility, practicality and cost becoming more of a problem. Accessibility in Kejimkujik is greatly increased during the fall monitoring season compared to the spring. The Fire Tower Road and the road leading to Mason’s cabin are closed in early spring due to wet weather. For this reason the fall monitoring season in Kejimkujik is more practical, unless only certain sites that are easily accessible were to be monitored in the spring. After the 5-year pilot period, it may or may not be determined that some sites with low accessibility, low detections and high variability are not suitable for long-term monitoring.

4.3 Spatial Distribution

Although salamander detections were not significantly different between the two stand types, some trends were evident. Graphs of tree basal area for the sites may explain some of these trends (Figure 15; Gullage and Staicer 2004). The CL sites differed from the other two hardwood-dominated stands, CLT and PL, by having more beech trees. CLT and PL sites had lower detections compared to other sites (with the exception of CFR-A; see below). CLT and PL sites had the lowest decay class averages and basal areas of all the sites. Average decay class was the only environmental variable measured at the site level that was significantly correlated (positively) with salamander detections. More salamanders were detected in sites with average CWD decay class between 3 and 4. Waldick et al. (1999) reported that *P. cinereus* was most commonly associated with CWD in decay classes 2 or 3 (on a scale 1 to 5).

Interestingly, the two sites in the CFR stand, had the highest (CFR-B) and lowest (CFR-A) salamander detections. The CFR stand was the only stand in which salamander detections differed statistically between the two sites within the same stand. CFR-A had more red spruce (*Picea rubens*) and less American beech (*Fagus grandifolia*) than CFR-B, which may help explain this difference (Figure 15). More research is needed to explain this drastic difference in detections. An environmental study of the CFR sites including measurements of pH, humidity at ground level, invertebrate sampling, soil analysis, rock cover, leaf litter and moss layer measurements and herbaceous and shrub cover may help to explain the difference. Without being able to explain such existing distribution patterns in natural ecosystems, it will be difficult to interpret changes in relative population indices in terms of forest integrity.

4.4 Discussion on Age Class Data

Most age classifications used are based on Sayler's (1966) findings in Maryland relating snout-vent length to age class. Sayler reports that the young of the year grew

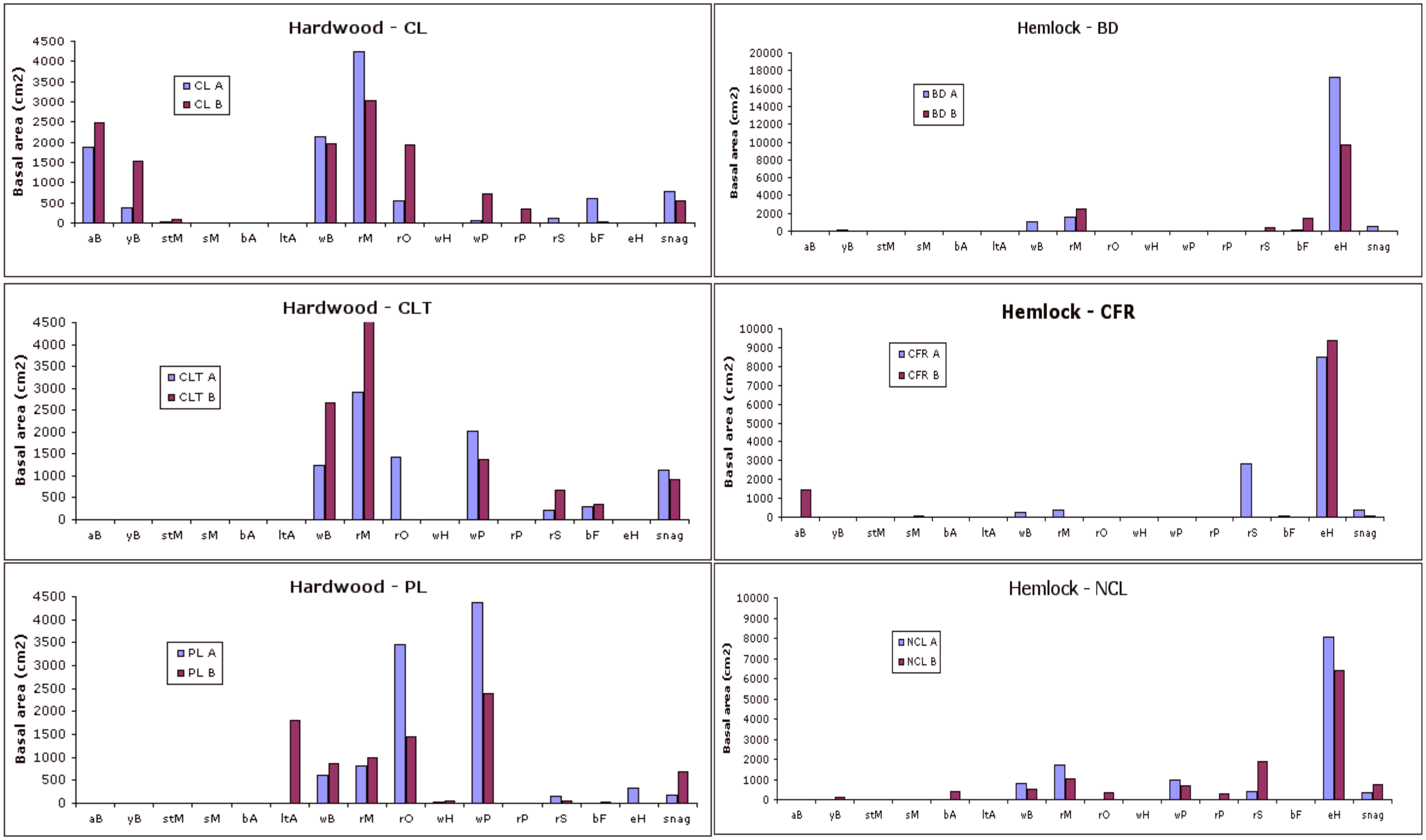


Figure 15: Comparison of stand composition of the six stands (Gullage and Staicer 2004). Each of which contained two plots (A and B), for a total of 12 plots. Data are average basal areas per tree, for the 4 quadrats per plot. Trees are arranged by typical associations. Tree codes: aB: American beech, yB: yellow birch, stM: striped maple, bA: big-toothed aspen, wB: white birch, rM: red maple, rO: red oak, wH: witch hazel, wP: white pine, rP: red pine, rS: red spruce, bF: balsam fir, eH: eastern hemlock, snag: standing dead tree.

rapidly the first year, less so the following year and reached sexual maturity at the end of their second year. Sayler's data shows some overlap and, based on her study, different classifications have been used. Age classification in this study followed the recommendations of the Joint EMAN and Parks Canada National Protocol (young of the year SVL <30mm; juvenile SVL =30mm-40mm; adult SVL >40mm; Zorn and Blazeski 2002). This age classification system was also used by Brooks (1999). Knapp et al. (2003), however, used a different system (max SVL of 34 mm for juveniles); if used in the present study, more adults would have been detected. Jaeger (1995) also used a slightly different classification (1 year olds SVL =23-30; 2 year olds SVL =31-36). Furthermore, these measurements and growth patterns may vary with latitude or geography. Different herpetologists also take SVL measurements to different angles of the vent. The USGS Terrestrial Salamander Monitoring Program recommends the posterior angle (Droege et al. 1997); however the anterior angle was the angle used by Sayler's (1966) study. Age class data should be interpreted with these possible inaccuracies in mind.

4.5 *Plethodon cinereus* as an Indicator of Forest Integrity

Future research on the biology, ecology and distribution of *P. cinereus*, as well as on the artificial cover object methodology will provide insight into the effectiveness of *P. cinereus* as an indicator of forest integrity. Relatively little is known about its ecological role within the soil. Thus, there may be other, yet unknown ecologically pertinent reasons that may argue for this species' use as an indicator. Also, relatively little is known about the physiological or environmental requirements of this species during it hibernacula. More research is needed on the sensitivity of *P. cinereus* to environmental stressors and the amount of time required for detections to reflect a change in forest integrity.

Convincing arguments for using *P. cinereus* as an indicator of forest integrity are based on its vulnerability to desiccation, acidity, pollutants and its role in forest food and detrital dynamics (Burton and Likens 1975a; Burton and Likens 1975b; Wyman and Hawksley-Lescault 1987; Wyman 1988; DeGraaf and Yamasaki 1992; Frisbie and Wyman 1992; Wyman and Jancola 1992; Petranka et al. 1993; Ash 1997; Wyman 1998; Waldick et al. 1999; Ducey et al. 2003). On the other hand, *P. cinereus* is not especially sensitive to habitat fragmentation or to a certain level of disturbance and it may be slow to respond to certain environmental disturbances (Feder 1983; Gibbs 1998; Brooks 1999; Knapp et al. 2003). Therefore, there are both reasons for and against using *P. cinereus* as an indicator of forest integrity. This same situation exists for many candidate indicator species. Just because a perfect indicator of forest health does not exist, it definitely does not follow that nothing should be monitored. In part it seems that the phrase "indicator of forest integrity" is problematic, because there is not one species that by itself can be wholly indicative of forest integrity. Nonetheless, indicator choice needs to be well thought out and a subset of indicators chosen that in conjunction are sensitive to a wide array of stressors.

There is also something to be said for just monitoring a certain species for the sake of monitoring, which is different than monitoring a certain species as an indicator of forest health. Any long-term monitoring data, whether or not as part of an indicator study, is invaluable with the current uncertain future of global ecosystems and existing concerns about declining amphibians (Wilbur et al. 1990; Wake 1991; Blaustein et al. 1994).

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Appendix 1. Details on the Biology and Ecology of *Plethodon cinereus* (Green), eastern red-backed salamander

Kingdom Animalia
Phylum Chordata
Sub Phylum Vertebrata
Class Amphibia
Order Caudata or Urodela
Family Plethodontidae
Genus Plethodon
Species *Plethodon cinereus*

In Canada *P. cinereus* ranges from the Maritime provinces west to northwestern Ontario. In the United States it stretches from the Maritime states west to northwestern Minnesota and southeastern Missouri and south to North Carolina (Gilhen 1984). *P. cinereus* inhabits deciduous, northern conifer and mixed deciduous-conifer forest that are well drained, and have deep soils and natural habitat such as downed logs, decaying stumps and rocks (Petranka 1998). *P. cinereus* is a completely terrestrial species, laying eggs in damp cavities in decaying downed wood and passing the larval stage within the egg. Based on limited data for other plethodontids species, these salamanders have relatively long life spans (mean generation time 5-10 years; Hairston 1987).

P. cinereus has three colour variations: red-backed, lead-backed and erythrisitic. All colour variations have a mottled gray and black ventral side (Gilhen 1984). *P. cinereus* has an average of 18-20 costal grooves, short legs relative to body size, 5 toes on the hind limbs and protruding eyes (Gilhen 1984; Petranka 1998). Most eastern redbacks are less than 102 mm in total length (Gilhen 1984).

P. cinereus reaches sexual maturity at the end of their second year of growth (Sayler 1966). Mating can occur from fall to early spring (Petranka 1998). Males breed annually and females either annually or biennially depending on latitude (Petranka 1998). Courtship displays include nose taps, males raising and undulating their tails, abrading the females dorsal skin and rubbing mental gland secretions onto the abrasions, and a tail straddle walk characteristic of plethodontids (Petranka 1998). The male deposits a spermatophore and the female picks it up with the cloaca and stores it until it is needed to fertilize her eggs. After mating the pair separates. Females usually oviposit in late spring and early summer laying 4 to 17 eggs in a cluster usually suspended from a damp cavity (Sayler 1966; Gilhen 1984; Petranka 1998). Usually only the female guards the eggs; however, in New Brunswick, Friet reported cases of both a female and male accompanying eggs (Friet 1995). The average incubation period is about a month and a half and hatching usually occurs in August or September (Davidson and Heatwole 1960). The larval stage is passed within the egg and young hatch as miniature adults about 19-25 mm in total length (Gilhen 1984). Hatchlings may stay in the nest for up to four weeks (Burger 1935)

Sexually active males have a crescent shaped mental gland on their lower jaw, swollen nasolabial glands, enlarged premaxilliary teeth resulting in a squarer snout, and a whitish slightly enlarged area lateral to the cloaca (Gillette and Peterson 2001). Females lack mental glands, have rounder snouts, are 0-4% larger and have shorter inter nares distances than males (Sayler 1966; Quinn and Graves 1999). Sexing sexually active salamanders during the courting season by these characteristics is relatively easy; however, external morphology is not reliable outside the breeding season and cannot be applied to sexually immature individuals.

Studies show that a certain portion of red-backed population establishes territories in the summer (Jaeger 1979). Territorial behaviour includes territorial marking, snapping, lunging, an all trunk-raised posture and biting directed at the nasolabial grooves (Jaeger 1984). Jaeger et al. (1995) found overlapping territories of the oppositely sexed individuals, but not between similarly sexed individuals in a Virginia population. They also found that males and females with established territories were less aggressive towards juveniles. Other studies report conspecifics aggregated under logs in the summer and a lack of site fidelity (Petranka 1998; Monti et al. 2000; Brooks 1999). Kleeberger and Werner (1982) estimated the average daily movement of *P. cinereus* as 0.43m and home ranges as about 12.97m^2 for males and 24.34m^2 for females.

The majority of red-backs on a given day reside underground (Taub 1961). *P. cinereus* is the most active on the soil surface in spring and fall when moisture and temperature levels are ideal, except in montane regions where they are also active in the summer (Petranka 1998). During the hot and dry summer months, *P. cinereus* migrates horizontally to moist microhabitats such as beneath logs and rocks and within decaying logs and stumps and downwards in the soil column. In the winter, they again retreat further in the soil column beneath tree roots, in decaying root systems and other possible moist microhabitats below the frost line or where the temperature remains above freezing. In the month of February in Massachusetts, Hoff and Hoff (1977) found 86 hibernating redbacks beneath the stumps of six recently cut white oaks at depths of 30-36 inches in rotted out root channels and one under a large taproot of a sour gum (Hoff and Hoff 1977). It is also interesting to note that a stomach analysis of 9 of these hibernating redbacks, revealed that 6 of the stomachs were empty and the other three contained fragments of carpenter ants, *Camponotus* sp. During winter *P. cinereus* has also been found 1 meter (36 inches) deep in the soil (Grizzell 1949).

The optimal time for foraging occurs at night following or during rain. Jaeger (1974) found the number of prey ingested was positively proportional to the level of moisture. Other studies though show that *P. cinereus* will feed opportunistically throughout the day and within the soil (Burton 1976; Hoff and Hoff 1977). *P. cinereus* forages on small invertebrates such as mites, fly larvae, ants, beetles, spiders and ticks (see Burton 1976 and Gilhen 1984 for a more complete lists). During rainy nights these salamanders have also been observed to climb plants to forage (Burton 1976). Redbacks themselves are preyed upon by snakes such as the northern ringneck, *Diadophis punctatus edwardsii* and juvenile maritime garter snakes, *Thamnophis sirtalis pallidula Allen*, ground feeding birds and likely small mammals (Gilhen 1984; Fenster and Fenster 1996). The eggs and young also fall prey to carnivorous beetles and conspecifics (Gilhen 1984, Petranka 1998). *P. cinereus* has the amazing ability of regeneration. They are able to drop of all or part of its tail and regrow it. They can also regrow toes and some other body tissues. This ability is important in escaping predators. How this is done still largely remains a mystery.

Appendix 2. Site Access

Hemlock-Dominated Stands

Big Dam Lake (BD): The Big Dam Lake stand is the largest of the selected hemlock polygons. It extends along a large section of the northern shore of Big Dam Lake and has 2 salamander-sampling sites and 12 bird-sampling sites. This stand is accessible by foot from the Big Dam parking lot. The hike takes approximately 30-40 minutes.

Canningfield Road (CFR): This polygon is located approximately 2 kilometers up the Canningfield Road and includes 2 salamander-sampling points and 5 bird-sampling points. The polygon consists primarily of mature hemlock, some of which has been defoliated by the bent-wing gray caterpillar. CFR-A is appears younger than CFR-B and is about 120 m south of a boggy wetland about 1 ha in size. This polygon is readily accessible by vehicle to the end of the Canning Field Road (the park boundary) and then a short hike (approx. 600m).

North Cranberry Lake (NCL): This stand of hemlock is located on the eastern shore of North Cranberry Lake and extends south near the Fire Tower Road intersection. This hemlock stand is younger than the other two mature hemlock stands and has previously been cut judging by log piles and tree stumps. There are 2 salamander-sampling points and 5 bird-sampling points in this stand. This polygon is accessed with a 4x4 truck by driving 1.5 km up the Fire Tower Road, followed by a short hike. This stand may not be accessible by truck in early spring as the road is closed until late spring because of wet weather. Biking or canoeing is an option.

Hardwood-Dominated Stands

Channel Lake Trail (CLT): This mature stand is about 750 m down the Channel Lake South Trail. There are 2 salamander-sampling points and 5 bird-sampling sites in this polygon. This polygon can be accessed by foot from the Big Dam Lake parking lot.

Pebbleloggitch Lake (PL): This mature stand is located on the northern shore of Pebbleloggitch Lake and the southern shore of Peskawa Lake, near the Mason’s cabin. It has 2 salamander sampling points and 6 bird sampling points. This polygon is accessible by 4x4 truck. This stand is not accessible by truck in the early spring because the road is closed until late spring. Biking or canoeing is an option.

Cobrielle Lake (CL): This mature stand is situated off Peskowesk Road near the southern shore of Cobrielle Lake, approximately 2 km west of the Fire Tower Road turnoff. This stand has more beech trees than the other two hardwood dominated sites. There are 2 salamander-sampling points and 5 bird-sampling points. It is accessible with a 4x4 truck followed by a short hike. This stand is not accessible by truck in the early spring as the road is closed until late spring because of wet weather. Biking or is an option.

Appendix 3. Beaufort Sky and Wind Codes

Sky Code	Description
0	Clear (no cloud at any level)
1	Partly cloudy (scattered or broken)
2	Cloudy or overcast
3	Sandstorm, dust storm or blowing snow
4	Fog, thick dust or haze
5	Drizzle or light rain
6	Rain
7	Snow or snow and rain mixed
8	Showers
9	Thunderstorm

Wind Code	Wind Speed (mph)	Wind Speed (km/h)	Description	Visual Cues
0	0-1	0-1	Calm	Smoke rises vertically
1	1-3	1-5	Light air	Smoke drifts
2	4-7	6-11	Light breeze	Leaves rustle
3	8-12	12-19	Gentle breeze	Lighter branches sway
4	13-18	20-28	Moderate wind	Dust rises, branches sway
5	19-24	29-38	Fresh wind	Small trees sway
6	25-31	39-49	Strong wind	Larger branches move
7	32-38	50-61	Near gale	Trees move
8	39-46	62-74	Gale	Twigs break
9	47-54	75-88	Strong gale	Branches break
10	55-63	89-102	Storm	Trees fall
11	64-72	103-117	Severe storm	Violent blasts
12	>72	>117	Hurricane	Structures shake

Appendix 4. Coarse Woody Debris Decay Index. A 5-class system of decay adapted from Maser et al. (1979) originally based on Douglas-fir trees.

Decay Class	**Texture**	**Shape**	**Portion of Tree on the Ground**	**Branches**	**Bark (does not apply to birch trees)**	**Snag Characteristics**
1	Hard wood	Round	Elevated on support points	Present	Intact	Dead
2	Hard to partly hard	Round	Elevated but slightly sagging	No large branches	Intact	Dead, loose bark to clean
3	Decayed, hard large pieces	Round	Sagging near ground or broken	No branches	Trace	Dead, clean, broken
4	Decay advanced, smaller soft blocky pieces	Round to oval	All on the ground	No branches	Absent	Dead, decomposed
5	Decay advanced, soft and powdery	Oval	All on the ground, partly sunken	No branches	Absent	Dead, down material, decomposed stump

Appendix 5: Count Data Summary

Date	BD-A	BD-B	CFR-A	CFR-B	NCL-A	NCL-B	CLT-A	CLT-B	PL-A	PL-B	CL-A	CL-B	Total
Aug 2-3	2	1	2	4	5	3	1	0	1	1	2	4	26
Aug 9-10	2	4	1	7	3	3	3	2	1	2	2	4	34
Aug 16-17	7	5	1	11	3	1	0	2	2	0	5	8	45
Aug 23-24	13	6	1	6	2	6	4	3	3	0	7	7	58
Aug 30-31	6	10	2	14	5	5	2	3	n/a	n/a	9	8	64
Sept 6- 7	8	7	2	15	4	5	6	2	5	3	4	9	70
Sept 13-14	2	7	3	11	7	5	4	5	3	2	8	7	64
Sept 20-21	8	12	1	22	6	11	6	1	3	0	11	13	94
Sept 27-28	4	4	0	16	9	8	5	3	3	0	8	15	75
Oct 4- 5	6	9	1	21	4	2	5	7	4	2	5	8	74
Oct 11-12	10	4	1	14	10	4	3	6	3	5	13	9	82
Oct 18-19	3	5	2	4	3	5	3	3	5	2	5	7	47
Oct 25-26	3	2	1	4	2	1	0	1	2	2	2	4	24
Total	74	76	18	149	63	59	42	38	35	19	81	103	757

Appendix 6: Standardized Count Data Summary

Date	BD-A	BD-B	CFR-A	CFR-B	NCL-A	NCL-B	CLT-A	CLT-B	PL-A	PL-B	CL-A	CL-B	Total
Aug 2-3	0.051	0.025	0.050	0.100	0.143	0.075	0.027	0.000	0.025	0.025	0.050	0.100	0.671
Aug 9-10	0.051	0.100	0.025	0.175	0.075	0.075	0.075	0.050	0.025	0.051	0.077	0.108	0.888
Aug 16-17	0.175	0.125	0.025	0.275	0.075	0.025	0.000	0.050	0.050	0.000	0.132	0.205	1.137
Aug 23-24	0.325	0.150	0.025	0.150	0.053	0.154	0.100	0.075	0.075	0.000	0.179	0.200	1.486
Aug 30-31	0.150	0.250	0.050	0.350	0.125	0.125	0.053	0.075	n/a	n/a	0.225	0.211	1.613
Sept 6-7	0.205	0.175	0.050	0.375	0.100	0.125	0.150	0.050	0.125	0.083	0.114	0.265	1.817
Sept 13-14	0.050	0.175	0.075	0.275	0.175	0.125	0.100	0.125	0.075	0.050	0.205	0.194	1.625
Sept 20-21	0.200	0.300	0.025	0.550	0.154	0.275	0.150	0.025	0.079	0.000	0.275	0.325	2.358
Sept 27-28	0.100	0.100	0.000	0.436	0.225	0.200	0.128	0.077	0.079	0.000	0.200	0.375	1.920
Oct 4-5	0.150	0.225	0.025	0.525	0.100	0.051	0.125	0.175	0.100	0.051	0.125	0.200	1.853
Oct 11-12	0.250	0.100	0.025	0.368	0.250	0.100	0.075	0.150	0.075	0.125	0.325	0.231	2.074
Oct 18-19	0.075	0.125	0.050	0.100	0.075	0.125	0.075	0.075	0.125	0.050	0.135	0.189	1.199
Oct 25-26	0.075	0.050	0.025	0.100	0.050	0.025	0.000	0.025	0.050	0.050	0.053	0.114	0.617
Total	1.858	1.900	0.450	3.779	1.599	1.480	1.058	0.952	0.883	0.486	2.095	2.717	19.260

Appendix 7: Randomized ACO Wood Species Placement at Sampling Sites

BD-A

Set up date: 21/07/03

BD-A-N10-M
BD-A-N9-M
BD-A-N8-P
BD-A-N7-S
BD-A-N6-H
BD-A-N5-M
BD-A-N4-H
BD-A-N3-S
BD-A-N2-H
BD-A-N1-S

BD-A-W10-M BD-A-W9-P BD-A-W8-P BD-A-W7-H BD-A-W6-S BD-A-W5-P BD-A-W4-P BD-A-W3-H BD-A-W2-S BD-A-W1-S

BD-A-E1-H BD-A-E2-P BD-A-E3-M BD-A-E4-P BD-A-E5-M BD-A-E6-P BD-A-E7-H BD-A-E8-M BD-A-E9-S BD-A-E10-H

BD-A-S1-S
BD-A-S2-H
BD-A-S3-M
BD-A-S4-P
BD-A-S5-P
BD-A-S6-H
BD-A-S7-M
BD-A-S8-S
BD-A-S9-M
BD-A-S10-S

BD-B

Set up date: 21/07/03

BD-B-N10-P
BD-B-N9-S
BD-B-N8-M
BD-B-N7-M
BD-B-N6-P
BD-B-N5-M
BD-B-N4-P
BD-B-N3-H
BD-B-N2-M
BD-B-N1-S

BD-B-W10-H BD-B-W9-H BD-B-W8-S BD-B-W7-M BD-B-W6-H BD-B-W5-M BD-B-W4-P BD-B-W3-S BD-B-W2-M BD-B-W1-M

BD-B-E1-H BD-B-E2-H BD-B-E3-P BD-B-E4-M BD-B-E5-S BD-B-E6-H BD-B-E7-S BD-B-E8-H BD-B-E9-S BD-B-E10-H

BD-B-S1-P
BD-B-S2-P
BD-B-S3-H
BD-B-S4-S
BD-B-S5-P
BD-B-S6-P
BD-B-S7-S
BD-B-S8-P
BD-B-S9-S
BD-B-S10-M

CFR-A

Set up date: 19/07/03

CFR-A-N10-P
CFR-A-N9-M
CFR-A-N8-P
CFR-A-N7-M
CFR-A-N6-M
CFR-A-N5-P
CFR-A-N4-H
CFR-A-N3-H
CFR-A-N2-H
CFR-A-N1-P

CFR-A-W10-H
CFR-A-W9-P
CFR-A-W8-M
CFR-A-W7-M
CFR-A-W6-H
CFR-A-W5-S
CFR-A-W4-P
CFRF-A-W3-S
CFR-A-W2-S
CFR-A-W1-M

CFR-A-E1-S
CFR-A-E2-S
CFR-A-E3-S
CFR-A-E4-S
CFR-A-E5-P
CFR-A-E6-S
CFR-A-E7-M
CFR-A-E8-P
CFR-A-E9-H
CFR-A-E10-H

CFR-A-S1-M
CFR-A-S2-H
CFR-A-S3-S
CFR-A-S4-M
CFR-A-S5-S
CFR-A-S6-M
CFR-A-S7-P
CFR-A-S8-P
CFR-A-S9-H
CFR-A-S10-H

CFR-B

Set up date: 19/07/03

CFR-B-N10-P
CFR-B-N9-P
CFR-B-N8-M
CFR-B-N7-H
CFR-B-N6-H
CFR-B-N5-S
CFR-B-N4-M
CFR-B-N3-M
CFR-B-N2-S
CFR-B-N1-M

CFR-B-W10-P
CFR-B-W9-H
CFR-B-W8-S
CFR-B-W7-S
CFR-B-W6-M
CFR-B-W5-H
CFR-B-W4-P
CFRF-B-W3-P
CFR-B-W2-H
CFR-B-W1-H

CFR-B-E1-M
CFR-B-E2-S
CFR-B-E3-H
CFR-B-E4-S
CFR-B-E5-M
CFR-B-E6-H
CFR-B-E7-M
CFR-B-E8-M
CFR-B-E9-P
CFR-B-E10-H

CFR-B-S1-S
CFR-B-S2-H
CFR-B-S3-S
CFR-B-S4-M
CFR-B-S5-P
CFR-B-S6-P
CFR-B-S7-S
CFR-B-S8-P
CFR-B-S9-S
CFR-B-S10-P

NCL-A

Set up date: 22/07/03

NCL-A-N10-S
NCL-A-N9-H
NCL-A-N8-S
NCL-A-N7-S
NCL-A-N6-M
NCL-A-N5-S
NCL-A-N4-S
NCL-A-N3-S
NCL-A-N2-P
NCL-A-N1-M

NCL-A-W10-P
NCL-A-W9-H
NCL-A-W8-P
NCL-A-W7-H
NCL-A-W6-M
NCL-A-W5-H
NCL-A-W4-M
NCL-A-W3-H
NCL-A-W2-M
NCL-A-W1-H

NCL-A-E1-M
NCL-A-E2-H
NCL-A-E3-P
NCL-A-E4-H
NCL-A-E5-M
NCL-A-E6-P
NCL-A-E7-M
NCL-A-E8-M
NCL-A-E9-S
NCL-A-E10-S

NCL-A-S1-S
NCL-A-S2-H
NCL-A-S3-P
NCL-A-S4-P
NCL-A-S5-P
NCL-A-S6-M
NCL-A-S7-P
NCL-A-S8-P
NCL-A-S9-H
NCL-A-S10-S

NCL-B

Set up date: 22/07/03

NCL-B-N10-P
NCL-B-N9-P
NCL-B-N8-M
NCL-B-N7-H
NCL-B-N6-S
NCL-B-N5-M
NCL-B-N4-P
NCL-B-N3-M
NCL-B-N2-S
NCL-B-N1-S

NCL-B-W10-H
NCL-B-W9-P
NCL-B-W8-H
NCL-B-W7-P
NCL-B-W6-H
NCL-B-W5-P
NCL-B-W4-M
NCL-B-W3-M
NCL-B-W2-P
NCL-B-W1-P

NCL-B-E1-M
NCL-B-E2-H
NCL-B-E3-H
NCL-B-E4-S
NCL-B-E5-P
NCL-B-E6-M
NCL-B-E7-M
NCL-B-E8-H
NCL-B-E9-M
NCL-B-E10-S

NCL-B-S1-S
NCL-B-S2-S
NCL-B-S3-H
NCL-B-S4-P
NCL-B-S5-H
NCL-B-S6-S
NCL-B-S7-H
NCL-B-S8-S
NCL-B-S9-M
NCL-B-S10-S

CLT-A

Set up date: 22/07/03

CLT-A-N10-S

CLT-A-N9-M

CLT-A-N8-H

CLT-A-N7-H

CLT-A-N6-P

CLT-A-N5-S

CLT-A-N4-M

CLT-A-N3-S

CLT-A-N2-M

CLT-A-N1-M

CLT-A-W10-H CLT-A-W9-M CLT-A-W8-M CLT-A-W7-M CLT-A-W6-P CLT-A-W5-H CLT-A-W4-S CLT-A-W3-S CLT-A-W2-S CLT-A-W1-S

CLT-A-E1-P CLT-A-E2-S CLT-A-E3-H CLT-A-E4-P CLT-A-E5-S CLT-A-E6-P CLT-A-E7-H CLT-A-E8-S CLT-A-E9-M CLT-A-E10-H

CLT-A-S1-H

CLT-A-S2-P

CLT-A-S3-P

CLT-A-S4-P

CLT-A-S5-P

CLT-A-S6-M

CLT-A-S7-H

CLT-A-S8-H

CLT-A-S9-M

CLT-A-S10-P

CLT-B

Set up date: 22/07/03

CLT-B-N10-P
CLT-B-N9-M
CLT-B-N8-M
CLT-B-N7-M
CLT-B-N6-S
CLT-B-N5-P
CLT-B-N4-M
CLT-B-N3-H
CLT-B-N2-M
CLT-B-N1-S

CLT-B-W10-S
CLT-B-W9-P
CLT-B-W8-H
CLT-B-W7-P
CLT-B-W6-S
CLT-B-W5-H
CLT-B-W4-M
CLT-B-W3-M
CLT-B-W2-P
CLT-B-W1-P

CLT-B-E1-H
CLT-B-E2-M
CLT-B-E3-S
CLT-B-E4-S
CLT-B-E5-P
CLT-B-E6-H
CLT-B-E7-H
CLT-B-E8-P
CLT-B-E9-S
CLT-B-E10-H

CLT-B-S1-M
CLT-B-S2-S
CLT-B-S3-H
CLT-B-S4-S
CLT-B-S5-H
CLT-B-S6-H
CLT-B-S7-P
CLT-B-S8-S
CLT-B-S9-P
CLT-B-S10-M

PL-A

Set up date: 20/07/03

PL-A-N10-S
PL-A-N9-M
PL-A-N8-M
PL-A-N7-H
PL-A-N6-S
PL-A-N5-M
PL-A-N4-P
PL-A-N3-S
PL-A-N2-S
PL-A-N1-S

PL-A-W10-H
PL-A-W9-H
PL-A-W8-P
PL-A-W7-M
PL-A-W6-S
PL-A-W5-M
PL-A-W4-H
PL-A-W3-S
PL-A-W2-M
PL-A-W1-M

PL-A-E1-M
PL-A-E2-P
PL-A-E3-P
PL-A-E4-P
PL-A-E5-P
PL-A-E6-S
PL-A-E7-H
PL-A-E8-H
PL-A-E9-S
PL-A-E10-P

PL-A-S1-M
PL-A-S2-S
PL-A-S3-H
PL-A-S4-M
PL-A-S5-P
PL-A-S6-H
PL-A-S7-P
PL-A-S8-P
PL-A-S9-H
PL-A-S10-H

PL-B

Set up date: 20/07/03

PL-B-N10-P
PL-B-N9-M
PL-B-N8-P
PL-B-N7-P
PL-B-N6-H
PL-B-N5-S
PL-B-N4-S
PL-B-N3-H
PL-B-N2-S
PL-B-N1-H

PL-B-W10-H PL-B-W9-H PL-B-W8-P PL-B-W7-P PL-B-W6-M PL-B-W5-M PL-B-W4-P PL-B-W3-H PL-B-W2-S PL-B-W1-H

PL-B-E1-M PL-B-E2-M PL-B-E3-S PL-B-E4-M PL-B-E5-P PL-B-E6-S PL-B-E7-M PL-B-E8-S PL-B-E9-S PL-B-E10-M

PL-B-S1-M
PL-B-S2-S
PL-B-S3-S
PL-B-S4-M
PL-B-S5-P
PL-B-S6-H
PL-B-S7-P
PL-B-S8-P
PL-B-S9-H
PL-B-S10-H

CL-A

Set up date: 20/07/03

CL-A-N10-M
CL-A-N9-S
CL-A-N8-S
CL-A-N7-M
CL-A-N6-S
CL-A-N5-S
CL-A-N4-P
CL-A-N3-P
CL-A-N2-P
CL-A-N1-S

CL-A-W10-M CL-A-W9-M CL-A-W8-P CL-A-W7-M CL-A-W6-S CL-A-W5-P CL-A-W4-S CL-A-W3-H CL-A-W2-H CL-A-W1-H

CL-A-E1-M CL-A-E2-H CL-A-E3-H CL-A-E4-H CL-A-E5-M CL-A-E6-M CL-A-E7-H CL-A-E8-M CL-A-E9-P CL-A-E10-S

CL-A-S1-S
CL-A-S2-M
CL-A-S3-H
CL-A-S4-P
CL-A-S5-P
CL-A-S6-P
CL-A-S7-S
CL-A-S8-H
CL-A-S9-P
CL-A-S10-H

CL-B

Set up date: 20/07/03

CL-B-N10-M
CL-B-N9-P
CL-B-N8-P
CL-B-N7-S
CL-B-N6-S
CL-B-N5-S
CL-B-N4-H
CL-B-N3-M
CL-B-N2-S
CL-B-N1-M

CL-B-W10-M CL-B-W9-S CL-B-W8-M CL-B-W7-P CL-B-W6-M CL-B-W5-P CL-B-W4-P CL-B-W3-S CL-B-W2-P CL-B-W1-S

CL-B-E1-S CL-B-E2-H CL-B-E3-H CL-B-E4-H CL-B-E5-M CL-B-E6-M CL-B-E7-S CL-B-E8-M CL-B-E9-H CL-B-E10-H

CL-B-S1-P
CL-B-S2-S
CL-B-S3-H
CL-B-S4-H
CL-B-S5-P
CL-B-S6-H
CL-B-S7-P
CL-B-S8-M
CL-B-S9-P
CL-B-S10-H