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Spatial Ecology of the Spotted Salamander *Ambystoma maculatum* During the Nonbreeding Season.

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Spatial Ecology of the Spotted Salamander, *Ambystoma maculatum*, During the Nonbreeding Season

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by

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ABSTRACT

Spatial Ecology of the Spotted Salamander, *Ambystoma maculatum*, During the Nonbreeding Season

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Spotted Salamanders, *Ambystoma maculatum*, are a widely distributed pond-breeding amphibian that spends an estimated 95% of its life in woodlands surrounding breeding ponds. Their terrestrial ecology remains poorly understood. Few studies have tracked the movement patterns of Spotted Salamanders, and they have given limited information on fine scale patterns. Studies of distribution around vernal pool environments have brought increased attention to their terrestrial ecology. To this end a sample of Passive Integrated Transponder (PIT) tagged animals with a Radio Frequency Identification Device (RFID). Quadrat-variance methods and a Poisson distribution were used to analyze spatial distribution patterns over 2 years. The home range of 10 Spotted Salamanders was calculated using the revised minimum area method. A clumped distribution was found at larger spatial scales, except in the first year of the study. Home range size was shown to be limited and highly variable among 10 individuals (Mean=4.29m^2, Standard Deviation=6.25).

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CHAPTER 1

INTRODUCTION

Considering recent worldwide amphibian declines, conservation of amphibian species has gained much attention. With threats of disease, climate change, and habitat loss, many efforts are being put into place to not only maintain populations but to understand fully the complex life histories of these animals (Lehtinen et al. 1998, Weldon et al. 2004, Bosch et al. 2007, Gray et al. 2009). With their susceptibility to disruptions in the environment they have become important indicators of problems in both aquatic and terrestrial environments. Many pond-breeding amphibians such as the Spotted Salamander, *Ambystoma maculatum*, are well studied. The vernal pool breeding and larval development habitats of this species have been defined. Pond parameters such as leaf litter, hydroperiod, and sunlight that allow for good breeding habitat have been determined (Egan 2004). The effects of size at metamorphosis and at developing at high population density have been closely examined (Newman 1994, Walls 1998). However, much recent research has shifted attention from the aquatic environment to the surrounding terrestrial environment for conservation practices, because encompassing both is necessary for protecting populations (Semlitsch 1998). Many pond-breeding amphibians use terrestrial nonbreeding environments to a far greater extent than ephemeral wetlands (Petranka 1998). Spotted Salamanders will remain in the aquatic environment for a period of 4 to 6 weeks, depending on how much sunlight the eggs are receiving. Once hatched, larvae develop quickly to transformation, usually within 4 months, and adults are in the pool for a matter of days during the short breeding period (Petranka 1998).

Woodland habitats are inhabited by Spotted Salamanders for the extended period between breeding seasons for about 95% of the year and are necessary for the maintenance of viable populations (Trenham 2005, Veysey et al. 2009). Terrestrial buffer zones, "life zones", surrounding vernal pool environments are needed for Spotted Salamanders to complete their complex life history and are the primary proposed management tool for pond-breeding amphibians (Semlitsch 2003, Veysey et al. 2009). In buffer zones Spotted Salamanders mature, overwinter, and meet energetic requirements for reproduction (Maerz 2005). Previously it was thought that regulation of amphibian populations occurred during the larval stage at high density breeding sites, but population size has been shown to be associated with the survival of metamorphs of pond-breeding amphibians (Pechman 1994, Altweg 2004). The American Toad, *Bufo americanus,* exhibited terrestrial density dependence in its growth (Pechman 1994). Newly metamorphosed Wood Frogs, *Rana sylvatica*, were shown to be experiencing population regulation that was density dependent when they were kept in enclosures at high density. More drastic effects were seen in the larvae in the aquatic environment than in the newly metamorphosed juveniles, but a clear decrease in growth rates was seen at high densities in the terrestrial field enclosures (Altweg 2004). Considering these observations, conservation efforts should consider terrestrial habitats and the ecology of these environments in management decisions (Marsh 2001). The primary reason so little is known about this part of the life history of amphibians is the difficulty in observing them. Spotted Salamanders are fossorial during the nonbreeding season, spending little time above ground. Their fossorial nature makes tracking and observing difficult during this period. This research focused on the terrestrial environment and fine scale dispersion during the nonbreeding season. The goal was to discover patterns of distribution at various scales over different time periods. The size of the home range of individual Spotted Salamanders that have a discernable home range was defined. these analyses were done to test the hypothesis that Spotted Salamanders would have a clumped distribution because of underlying heterogeneity in the terrestrial habitat.

Terrestrial Ecology

The Spotted Salamander, *Ambystoma maculatum*, is a medium to large Ambystomid of 15-25 cm in total length. They have a wide distribution throughout Eastern North America, ranging from Canada to the Gulf Coast. The species typically breeds in late Winter and early spring during rainy or foggy nights when the temperature exceeds 10°C (Petranka 1998). The Spotted Salamander, like many amphibians, has specialized habitat requirements. They inhabit woodland areas associated with vernal pool breeding sites that are “patchy” or irregular in their distribution. Vernal pools may be widely distributed; however, they are not ubiquitous (Calhoun and deMayndier 2008). Distribution about the vernal pool habitat remains unclear. Spotted Salamanders are found within a limited area surrounding the vernal pool during the nonbreeding season. It is estimated that suitable protected habitats need to extend as far as 150m from the breeding pool to protect at least 95% of the adult population (Rittenhouse et al. 2007). From the pools edge it is estimated that 95% of amphibian populations occur within 664 m of the edge of the wetland, but management practices generally only protect a 30m radius about the vernal pool (Rittenhouse et al. 2007, Harper 2008). Without proper understanding of the nonbreeding habitat usage of pond-breeding amphibians conservation efforts are unlikely to succeed and cannot maintain viable populations for extended times (Dodd et al. 1998, Harper 2008).

Within the life zones Spotted Salamanders are associated with areas that maintain suitable microhabitats. Typically, Spotted Salamanders are found inhabiting small mammal burrows beneath the leaf litter. It has been shown that the abundance of these burrows affects salamander density in field enclosure experiments, and that 95% of the located animals were found in the burrows of small mammals (Regosin 2003). Spotted Salamanders are active in the burrows of the Short Tailed Shrew *Blarina brevicauda* during the warmer Summer and Spring months. During the Winter periods Spotted Salamanders use deeper *Peromyscus sp.*(Deer Mouse) type burrows (Madison 1997, Faccio 2003). Spotted Salamanders have also been shown to be more likely to emigrate from an area once small mammal burrows have been removed (Regosin 2003). Other factors that may affect abudance may include moisture, amount of leaf litter, and the slope of the terrain (Faccio 2003). Alterations of factors that influence dispersion and density have the potential to reduce survival and reproduction (Rittenhouse et al. 2007).

Spatial Patterns

Spatial Ecology is the study of the patterns of distributions of organisms and their relationship to ecological variables. A widely distributed and common animal may seem on a home range map to be very evenly dispersed, but on a finer scale that distribution may be found to be associated with a specified microclimate. Small scale studies have been done on home range size to examine habitat usage and activity in Spotted

Salamanders and have shown a limited home range size with an average of 9.83 m^2. However, this was done in a sample of only 9 individuals (Kleeberger and Warner 1983). Long-term studies of spatial distribution patterns have not been done in Spotted Salamanders because of their fossorial nature.

There are 3 possible patterns of spatial distribution of organisms in the environment (Brown 1970). They may be random, even, or clumped in their distribution. Nonrandom distribution patterns may be caused by associated biotic or abiotic variables (Brown 1970). Such variables have been frequently linked to spatial distribution patterns. Such patterns may, therefore, be used to infer the underlying cause of the pattern of distribution (Stoll et al. 2009).

An even distribution results from competition or avoidance and is the most spatially efficient way to apportion habitat among competitors (Stoll et al.. 2009). On fine scales in aquatic systems caddis fly larvae species: *Parargyractis confusalis*, *Rhetanytarsus* sp., and *Eukiefferiella* sp*.,* clumped in the limited space of the stream bed. Sessile caddis fly larvae are exposed to strong conspecific competition and will aggressively defend their location under rocks against other caddis fly larvae (McAuliffe 1984). Though seedlings in plants have a high degree of clumping around the parent trees, they begin to undergo self-thinning that ultimately leads to a uniform pattern of distribution (Stoll et al. 2005). Competition has been associated with even patterns of distribution in Thale Cress, *Arabidopsis thaliana*, as the degree of competition was driven by the size of individuals, leading to density dependant mortality. At the end of their experiment an even distribution pattern emerged from the initial clumped pattern. (Stoll et al. 2005). Competition between Ambystomatids in the terrestrial environment has only recently been investigated in lab and field studies. During the metamorph stage Ambystomatid species express aggression towards other salamanders, both conspecificly and heterospecificly. Competition results when there are a limited number of burrows relative to population size. These burrows are important for protection against predation and desiccation in both metamorphs and adults (Smyers et al. 2002). Later work examined the degree of competition in adult life stages in field enclosures. Experimental removal of small mammal burrows directly affected the densities of the Spotted Salamanders in experimental enclosures but did not have major impacts on growth or fecundity (Regosin 2003).

In a probabilistic view of clumped distributions, events of interest are close in time or space. One would expect some areas with little to no events and other areas with multiple events if those events are independently distributed (Ludwig 1988). In an ecological context such patterns are typically associated with environmental variables (e.g., prey, suitable habitat, moisture, soil type, pH, and temperature), and those variables themselves may have a clumped distribution in the environment at some scale (Haase 1996). A common example given for a clumped distribution pattern is the larvae of carpenter bees, *Xylocopa sp*., on the stalks of the Soaptree Yucca plant, *Yucca elata* (Ludwig 1988). The spatial distribution pattern of Wood Frogs, *Rana sylvatica*, was examined as part of a larger study that analyzed habitat selection in response to land use, and it was shown that Wood Frogs had a clumped distribution (Rittenhouse et al. 2007). The microclimatic data indicated that Wood Frogs were clumped in drainages that produced areas of increased moisture levels in the middle of upland habitat. The observation of water clumped in distribution on a microgeographic scale was interpreted as evidence that Wood Frogs were clumped in response to moisture availability because of its general importance in water and ion balance for the animal (Rittenhouse 2007).

Patterns such as those above are a distinct contrast to randomness where it is equally likely that an event will occur at any location within the habitat, and the location of one event is not affected by the location in space and time of any other event (Brown 1970). Most studies concerned with the spatial ecology of amphibians implemented the use of drift fence arrays in concentric circles to define the spacing of animals above ground. These data can then be analyzed using kernel density estimators. Kernel density estimators allow inferences about entire populations based on a finite sample. (Rittenhouse 2007). For California Tiger Salamanders, *Ambystoma californiense*, this spatial modeling was done at varying distances from the pond edges to gain a better understanding of how the animals were distributed about the pond. In Red-backed Salamanders, *Plethodon cinereus*, home range measurements were made by capture/recapture methods in order to study the variation in home range among males and females (Mathis 1990). For a fossorial species detection below ground is not possible by conventional means. Passive detection below ground is required for understanding locations of Mole Salamander species. Other tagging methods such as radiotelemetry that rely on battery powered tags have significant limitations. However, such methods are the source of most data regarding the terrestrial ecology of species such as the Mole Salamander, *Ambystoma talpoidium* (Semlitsch 1981). Previously, Ambystomatid salamander species were detected below ground using radiotelmetry (Faccio et al. 2003). Eastern Tiger Salamanders, *Ambystoma tigrinum* implanted with

Passive Integrated Transponder (PIT) tags were shown to be detectable in subterranean locations (Cabarle et al.. 2007). The sensitivity of detection below ground using Radio Frequency Identification Devices (RFID) differs according to sensitivity of the antennae and environmental conditions (Hamed et al. 2008). Fine scale spatial analysis with Wood Frogs was previously reported. Using Ripley's K function, Wood Frogs, were measured to be clumped in their distribution associated with isolated moist areas (Rittenhouse et al. 2007).

Home Range

Measuring the size of the home range for amphibian species is an important step in understanding the amount of habitat required by individual animals and can be difficult to determine for some species. The Green Salamander, *Aneides aeneus,* has both an arboreal and terrestrial nature, so the home range of the animal should also include the height of its use of trees to gain an adequate understanding of its home range size (Waldron 2005). Home ranges for pond-breeding amphibians include portions of the terrestrial habitat in which they are active but do not include the pond-breeding environment (Semlitsch 1981). Wood Frogs have been reported to have a larger home range size (70.59 m^2) than that of Spotted Salamander (9.83 m^2) (Bellis 1965). The degree of movement and home range size of Wood Frogs in the previously mentioned study was shown to be variable. Home range size for other salamander species have shown similar variable results. The Fire Salamander, *Salamandra salamandra*, had an average home range size of 9.8m^2 among males and an average home range size of 12.8m^2 among females (Degani et al. 1978). The Ensatina Salamander, *Ensatina eschscholtzi*, was found to have large differences between males and females in home range size, with males having an average home range size of 1194m^2 and females a mean home range size of 314m^2 (Stebbins 1954). For Red-Backed Salamanders, home range size positively correlates with snout-vent length of adults (Mathis 1990). Home range size in the studies above was estimated with capture/recapture methods (Mathis 1990). Besides using Kernel density estimators, the home range of an animal can also be determined by calculating the area of a polygon based on locations in which the animal is found. For a fossorial species like the Spotted Salamander, the home range is identified primarily on the basis of activity centers or areas of habitat used for extended periods of time (Semlitsch 1981). This is similar to the home range usage of the Mole Salamander. Because of this a modified minimum area method is considered a better estimation of the home range size. This method disregards most of the habitat used as a pathway to the activity center rather than simply maximizing dimensions of the polygon (Harvey 1965, Semlitsch 1981). For the Mole Salamander usage of the modified minimum area method of home range analysis yielded a range of area between 0.02–0.21 m^2, whereas the standard minimum area method yielded ranges from 0.11-23.3 m^2 (Semlitsch 1981). The modified minimum area method yielded a home range that was smaller but less variable than using the standard minimum area method traditionally used to measure the size of an animal’s home range. The limited size of the home range is reflective of the animals’ restricted movements once inside the home range.

CHAPTER 2

METHODS AND MATERIALS

Capturing and Tagging

A drift fence that completely surrounded the vernal pool was constructed of silt fence material supported by wooden stakes 30 cm in height. The fence had the bottom 5 to 10 cm buried in the substrate to prevent as much movement as possible beneath the fence. However, field observations did reveal both Spotted Salamanders and Marbled Salamanders migrated beneath the fence in small mammal burrows during migration nights. Along the fence an array of 22 pitfall traps was constructed on both the inner and outer perimeters of the fence. The traps were constructed from 1 gallon metal paint buckets, with three 5 mm holes punched into the bottom to allow for water drainage. The pitfall traps were buried bellow ground, where the opening was flush with the ground surface. The buckets were numbered with surveying flags to identify the location where the animal was collected. During the nonbreeding season pitfall traps were closed to prevent capture of other species. Adult Spotted Salamanders were collected during the return migration from the breeding pond after the breeding period so as to not interfere with reproduction. Salamanders were also collected by hand from the road that bisects the site. The animals were brought into the lab for tagging with Biomark TX-1411-SST PIT tag. Tags were placed in the posterior lateral side near to the hind limbs. Animals were prepared for tagging by being anesthetized in a 1% solution of Tricaine Methanesulfonate (MS-222) buffered with sodium bicarbonate prior to tagging. Each salamander was measured for snout-vent length and total length, weighed, and the sex was determined by observing the cloacal region or vent. Males in breeding condition have a swollen vent that females do not posses (Petranka 1998). PIT tags were injected using a 12 gauge needle inserted into the lateral side of the animals after creating an incision with dissecting scissors (Hamed et al. 2008). Animals were immediately placed in a room temperature water bath to allow recovery from anesthesia. After the recovery period salamanders were returned to the vernal pool and allowed to disperse naturally. A total of 378 animals were tagged during the study.

Study Site

The study area is located in Sullivan County, Tennessee, on the Tennessee Valley Authority (TVA) South Holston Weir Dam Property (36.5239°N, 82.1100°W). The study site is adjacent to a vernal pool, and a 2-lane paved road, Holston View Dam Road, which separates the property from the vernal pool. The study area is a mixed deciduous, disturbed forest of 0.79 ha in area and located to the north of the vernal pool. The study plot vegetation consists primarily of Virginia Pine (*Pinus virginiana*), Boxelder (*Acer negundo*), and Sycamore (*Plantus occidentailis*) (Hamed et al.. 2008). Spotted Salamanders are sympatric with Marbled Salamanders (*Ambystoma opacum*), Eastern Newts (*Notophthalmus viridescens*), and Wood Frogs at this site. The study plot has dimensions of 70m by 30 meters in size, 2100 m^2 (.21 hectares).

Locating and Tracking

Animals were located in the field using a Radio Frequency Identification (RFID) system (FS 2001 Destron reader with a Biomark® triangular multidirectional antenna). The study area was searched in a linear search pattern beginning at the southern end of the study plot moving to the northern side of the study plot. While in the search pattern the antennae was oscillated from side to side giving sufficient overlap to cover the ground completely. All areas were searched by moving logs and searching among fallen tree limbs. Large logs were also scanned for salamander presence because the Ambystomatids are known to be located in rotting logs above ground as well (Gordon 1968). One area contained a large number of downed trees was searched as thoroughly as possible by inserting the antennae into the slash. After being initially detected and located, the salamander's position was marked with a surveying flag, and then tracked during each subsequent visit to the study site. The survey flag labeled with the tag number, and date of detection indicated the position of each animal. The same information was also logged in a field notebook. If a salamander was not found at the previously known location, it was searched for starting at the last point detected in a circular pattern until it was detected or determined to not be detectable. If animals were determined to be undetectable, it was assumed that they were beyond the range of the device. Salamanders were found at different times of the nonbreeding season and were not all found throughout the study period during each visit to the study site.

Mapping

To study the spatial pattern and home range, the locations of each salamander were given a coordinate position by measuring the distance from the edges of the study site on the X/Y axis. The individual positions were identified during the 2007 and 2008 nonbreeding seasons. Maps made during each season contained all locations indentified for each salamander.

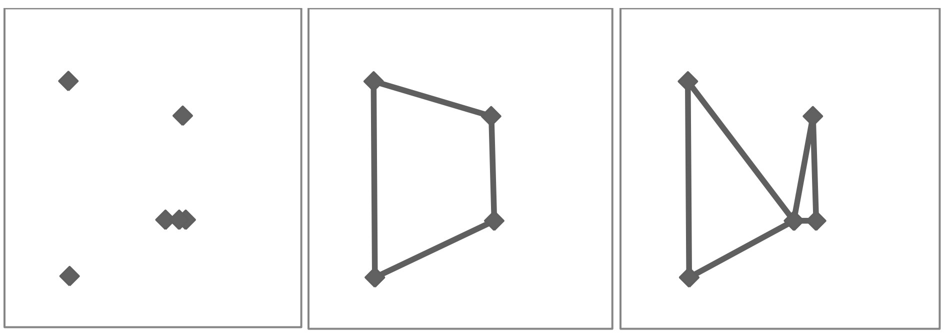
Spatial Analysis

The variance to mean ratio, the index of dispersion (ID), can be used to examine the distribution pattern. The distribution patterns were analyzed with a Poisson model and quadrat analysis. Quadrat analysis is based on data obtained from a series of mapped points on an array of quadrats overlying the observed distribution. Quadrats on a number of scales may be drawn over the mapped pattern to illustrate the relative distributions of salamanders at each sale. The distributions of marked and recovered animals were examined at the following scales: 0.5m, 1m, 2m, 5m, 10m, 15m, and 20m, to determine at what scale of resolution salamanders would be found in a nonrandom distribution. The pattern of distribution was examined by the variance to mean ratio. The variance and mean under a Poisson distribution would be equal to each other under a random distribution pattern, having a variance to mean ratio of one. Departures from randomness can be quickly identified by having a ratio that is more or less than one. If the ratio were greater than one, the pattern suggests a clumped distribution. If the ratio was determined to be of a value less than one, the pattern could be uniform.

The observed numbers of salamanders per quadrat are compared to the values of salamanders expected under a Poisson distribution. This value is calculated for each scale and at each time period analyzed. The value is calculated from the formula $p^r=(\mu^r(e^{-\mu}))/r!$ where p is the probability of finding the number of squares with number of salamanders r, and μ is the mean number of salamanders per quadrat (Ludwig 1988). These expected values are then compared to observations using a Chi-square analysis. Expected numbers of quadrates with r numbers of salamanders having a value of less than one are lumped such that all expected numbers in the test are greater than one. Quadrat based methods have shown that variance fluctuates in a random pattern when the quadrat size changes. In a uniform pattern there is little change in the variance, so the affect of scale has little impact (Ludwig 1988). When a clumped pattern can be measured the variance will tend to peak. If the peak of the variance is sharp and falls quickly, this indicates that the clumps are tight (Ludwig 1988).

Home Range Calculations

A revised minimum area method was used for calculating home range sizes for 10 Spotted Salamanders (Figure 2). First the range length, the 2 points furthest apart in the home range, was measured. Secondly one-fourth of the range length was calculated as determine in the previous step. Begnining at one of the points that comprised the range length a line was drawn to the next point that is no more than one-fourth the distance from the 2 furthest points. This is done so that points that are more than one-fourth the distance of the 2 furthest points are not included as part of the perimeter of the polygon. If that second direction was clockwise to the first point, continue drawing the home range polygon in the clockwise direction for all home ranges until I had an intact polygon. The same method was used for subsequent polygons, going in the same direction as the first polygon was drawn. The home range size varies when the direction the polygon drawn is changed (Harvey et al. 1965). For animals with home ranges determined by only 3 points, the area of the simple triangle is calculated as the home range size.



A B C

Figure 1

Depiction of home range size: by A: coordinate locations. B: Minimum area method. C: Revised minimum area method.

The home range of each animal is comprised of activity centers and locations where the animal was detected at some point in time. These locations are represented in the same manner as the points used for spatial analysis, an X,Y coordinate system. To determine the area of the polygon that forms the home range, the polygon is first dissected into triangular pieces. Each triangle is then represented by 3 points or vertices. The length between points are calculated by using the distance formula, $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ The resulting triangle area can be determined by Heron's Formula, $A = \sqrt{s(s-a)(s-b)(s-c)}$. Where A= the area, s= the semi-perimeter (a+b+c)/2), and a,b,c are the length of each side of the triangle. The area of the complex polygon is then determined by summing the area of all triangles. All descriptive statistics for spatial pattern, and home range were done using SPSS student edition. Maps and graphs were produced with Microsoft Excel 2007.

CHAPTER 3

RESULTS

Spatial Distribution Pattern

Analysis of Year 1 of the study yielded complete spatial randomness at all scales except the 15 meter scale (ID=1.97, P=0.05). All scales larger than 0.5 have an estimated Index of Dispersion greater than one; however, when the observations are compared to an expected random pattern under a Poisson distribution using a Chi-square test there is no difference (P>0.05). This represents 4.2% (N=16) of the overall tagged population. As seen in Table 1 below, the 15 meter scale is the only scale in which the spatial distribution pattern is significant.

Table 1: Spatial Distribution Pattern for Year 1

Scale(m)	Index of Dispersion	P=
.5	0.99	0.99
1	1.24	0.62
2	1.73	0.33
5	1.71	0.5
10	1.76	0.40
15	1.97	0.05
20	1.64	0.6

N=16

Table 2 below clearly shows that Year 2 had a significant clumping at the 2m and 10m scale (ID=1.17, P=0.0001) (ID=2.38, P=0.002) respectively. The 0.5m, 1m, 5m, 15m, and 20m scales were all determined to have a random distribution when compared to a random pattern under a Poisson distribution. The sample analyzed in the second year of the study represented 11.9% (N=45) of the tagged population.

Table 2: Spatial Distribution Pattern for Year 2

Scale(m)	Index of Dispersion	P=
.5	0.99	0.9
1	1.03	0.91
2	1.17	0.0001
5	1.29	0.08
10	2.38	0.002
15	2.80	0.28
20	6.33	0.1

N=45

The Summer of Year 2 had no discernable clumping in the distribution pattern. The P values for all scales analyzed were all greater than 0.05. The estimated Indices of Dispersion were quite small for this time period analyzed, with the largest variance to mean ratio being 1.7 for the 20m scale. Five and one-half percent (N=21) of the tagged population was detectable during the Summer season of the study. (See Table 3.) All P values are greater than 0.05.

Table 3: Spatial Distribution Pattern for Year 2 Summer

Scale(m)	Index of Dispersion	P=
.5	0.99	0.99
1	0.99	0.99
2	1.02	0.96
5	1.06	0.78
10	1.37	0.47
15	1.14	0.99
20	1.74	0.78

N=21

The Fall of Year 2 was found to have a clumped distribution pattern at all scales larger than 5m. The 0.5m, 1m, and 2m scales all had estimated Indices of Dispersal less than one, and the chi-square test results show that they are no different from a random distribution. During the Fall of Year 2 5.8% (N=22) of the tagged population were detected in the study area. See Table 4 below.

Table 4: Spatial Distribution Pattern for Year 2 Fall

Scale(m)	Index of Dispersion	P
.5	0.99	0.99
1	0.99	0.98
2	0.98	0.96
5	1.04	0.03
10	2.14	0.03
15	3.71	0.005
20	5.94	0.05

N=22

The Winter of Year 2 had a consistently random pattern starting at the 0.5m (ID=0.99, P=0.99), 1m (ID=1.11, P=0.99) 2m (ID=1.43, P=0.36), and 5m (ID=1.56, P=0.19) scales. The pattern of distribution is significantly clumped at the 10m (ID=2.39, P=0.000007), 15m (ID=4.0, P=0.003), and 20m (ID=10.18, P=0.002) scales. Table 5 below shows that $P<0.05$ for all scales greater than 10 meters square.

Table 5: Spatial Distribution Pattern for Year 2 Winter

Scale(m)	Index of Dispersion	P
.5	0.99	0.99
1	1.11	0.99
2	1.43	0.36
5	1.56	0.19
10	2.39	0.000007
15	4.0	0.003
20	10.18	0.002

N=19

Home Range

All home range data can be seen in Table 6 below. The mean home range size for 10 Spotted Salamanders based on a revised minimum area method was 4.29 m^2, with a standard deviation of 6.25. The home range sizes ranged from 0.0-16.67 m^2. Each animal was located at multiple locations during the study period. Those positions are denoted as sites. The average number of sites for 10 animals was 4.2 with a standard deviation of 0.95. The sites ranged from a minimum of 3 sites to 6 sites. Animals were variable in the number of times that they could be detected during the time period. The mean number of times detected for all animals was 8.50 times, with a standard deviation of 3.37. The greatest variation is seen in the number of days that the 10 animals were followed. The mean time length followed is 130.6 days with a standard deviation of 99.12.

Table 6: Home Range Data

Individual	Home Range (Area m^2)	Number of sites	Times Detected	Time Period Followed	# Days Followed
1	0.0	3	6	15 Jul-23 Oct	100
2	11.79	5	9	7 May-27 Jan	265
3	0.01	4	9	15 Jul-6 Nov	114
4	16.67	5	5	14 May-1 Jul	48
5	0.40	6	13	30 Sep-27 Jan	119
6	0.72	3	6	18 Aug-11 Sep	24
7	10.57	4	11	15 Jun-23 Oct	130
8	2.56	4	4	8 Apr-15 Dec	251
9	0.09	5	14	10 Apr-6 Nov	210
10	0.13	4	8	4 Sep- 27 Jan	145
Mean	**4.29**	**4.2**	**8.50**		**130.6**
StDev	**6.25**	**0.95**	**3.37**		**99.12**

Summary home range data for *Ambystoma maculatum.*

CHAPTER 4

DISCUSSION

Spatial Distribution Pattern

All time periods analyzed were observed to have a clumped distribution at some scale, except for the Summer of Year 2. A clumped distribution was observed in Year 1 at the 15 meter scale (ID= 1.97, p=0.05). Year 2 had a clumped distribution starting at the 2 meter scale (ID=1.18, p=0.0001) and the 10 meter scale (ID=2.39, p=0.002). It was expected most of the clumping to occur during the Summer season, based on Spotted Salamanders being closely associated to soil moisture as previously stated (Facio 2003, Rittenhouse 2007). It was also expected that the variable of soil moisture would be clumped due the heterogeneity of the study site; therefore, the salamanders would be clumped in distribution as well. However, the Summer of Year 2 did not show significant clumping at any scale. The time period analyzed for the Fall of Year 2 displays a clumped distribution at the 5 meter scale (ID=1.04, p=0.03). All larger scales analyzed were found to be clumped. Table 7 below indicates the spatial pattern at each time period, for each scale analyzed during the 2 years of the study.

Table 7: Summary Table of Spatial Distribution Patterns

Time Period	0.5	1.0	2.0	5.0	10.0	15.0	20.0
Year 1	Random	Random	Random	Random	Random	Clumped	Random
Year 2	Random	Random	Clumped	Random	Clumped	Random	Random
Summer	Random	Random	Random	Random	Random	Random	Random
Fall	Random	Random	Random	Clumped	Clumped	Clumped	Clumped
Winter	Random	Random	Random	Random	Clumped	Clumped	Clumped

Multiple methods have been employed to analyze the degree of clumping based on quadrat methods (Ludwig 1988). One method, which I am implementing here, is to determine which time period has a clumped distribution found at the smallest scale. The period in time that has a clumped pattern found at the smallest scale has a higher degree of clumping. An example of this is the Fall and Winter time periods of the second year. The Fall was shown to be clumped in distribution at the 5m scale, whereas the Winter was shown to be clumped at the 10m scale. This suggests that the Fall of Year 2 has a tighter clumping pattern than the Winter.

Six animals were not observed to move from June 9, 2007, until the breeding season on February 17, 2008. Two animals were verified to have died during the study by extracting a tag from the soil. The increased soil moisture may be a contributing factor to the pattern determined for that season. A previous study with pond-breeding amphibians has suggested that moisture was the primary variable affecting distribution patterns (Rittenhouse 2007). Previous terrestrial studies found that Spotted Salamanders are more likely to be located in areas that are well shaded, have dense leaf litter, and have increased levels of soil moisture (Faccio 2003, Montith et al. 2006). Evaporative loss can be a major factor in determining the movements and distributions of amphibian species (Baughman 2007). After clear-cuts Spotted Salamanders were observed to evacuate habitats, with an observed ratio of 40:71 of immigrating to emigrating individuals (Semlitsch et al.. 2008). In the Mole Salamander desiccation rates were greater for those animals exposed to clear-cut conditions compared to those of intact woodland conditions (Rothermel 2005). These previous studies suggest that soil moisture levels are a factor influencing the observed movements and distributions of Spotted Salamanders in this study.

Home Range

Home range size was highly variable. The mean home range size for this study was estimated to be 4.29 m^2, with a standard deviation of 6.25. Individual salamanders had long periods of time detected in the same locations. These points are referred to as activity centers. Animal 2 for example was found in the same location from 10/23/08-1/27/09 (96 days), whereas animal 6 was located in the same position from 1/7/08-1/27/08 (20 days). A correlation matrix was generated (Table 8 below) to analyze potential correlations the size of the home range size may have with other variables. From this small sample it does not appear that the amount of time the animals were followed, the numbers of sites where the animal was located, or the number of times the animals were detected have an impact of the size on the estimated home range

Table 8. Pearson's Correlation Matrix of Home Range Variables.

		Area	Number of Sites	Times Detected
Number of Sites	Pearson Correlation	.295		
	Sig. (2-tailed)	.408		
	N	10		
Times Detected	Pearson Correlation	-.196	.573	
	Sig. (2-tailed)	.588	.084	
	N	10	10	
Time Followed	Pearson Correlation	.002	.315	.216
	Sig. (2-tailed)	.996	.375	.549
	N	10	10	10

Animal 4 was followed for 48 days, detected 4 times at 4 sites, and had a home range size estimate of 16.67m^2. Animal 9 had a home range of 0.09m^2 and was followed for 210 days, detected 14 times, and found at 5 different positions. The size of the home ranges and the number of days detectable for each animal was highly variable. Previous studies of Spotted Salamander home ranges were limited to a period of 50 days of following an animal. Kleeberger et al. (1983) followed 6 animals for an average of 45.17 days and estimated the average home range to be 9.83m^2. In this study the salamanders that had a home range defined by 3 or more locations were followed for an average of 130.60 days, (range 24-265 days. This suggests that Spotted Salamanders have a limited home range size, and this is highly variable among individuals. The activity center use of these home ranges is potentially the greatest factor affecting the limited home range size in this animal. Home range size has been shown to be a reflector of habitat quality and inversely correlated to the quality of the habitat. In mammals such as the Eurasian Lynx*, Lynx lynx*, area with depleted prey densities support smaller home range sizes (Herfindal 2005). In amphibian species such as the Common Toad *Bufo bufo spinosus* and the Green Toad, *Bufo viridis,* prey density and habitat quality have inverse correlations with the home range size (Indermaur et al. 2009). A potential explanation for the variation in home range size for the 10 individual Spotted Salamanders would be the heterogeneity of the study site. With high variability in the habitat individuals would need to increase or decrease their home range size in order to meet energetic requirements during the Nonbreeding season. A low home range size has also been linked to higher dispersal rates (Indermaur et al. 2009). The primary difference in the observations of home range size in this study from previous studies is the difference in the number of times animals were detected. Animals followed during the study would go long periods of time out of detection range and were then redetected very near to the previous location. Previous studies report an average of 20.33 detections per animal (Kleeberger et al.. 1983). This study had an average of 8.50 detections for the 10 home range estimates. Some animals in the study were only detectable during the Summer. To insure relocation of animals that had become undetectable, the entire field site was completely covered at least 5 times. The southeastern corner of the study plot was chose to be the locations to begin the search pattern to detect any early movement toward the vernal pool.

The findings of this study support the hypothesis that Spotted Salamanders have a clumped distribution; however, a clumped distribution is not seen through each season. Smaller scales, which are less affected by variance, are less useful for detecting significant distribution patterns. Scales larger than 5 meters may be the best scale to observe spatial phenomena in Spotted Salamanders, such as long term home range fidelity. The 15 meter scale was the only scale in which a consistent significant pattern could be detected over each time period studied. This suggests that scales larger than 15 meters may be too large to use in spatial studies in Spotted Salamanders. The average home range size was expected to limited and highly variable, as noted by a previous study (Kleeberger et al. 1983). This was further supported by my study. Further research is needed, however, to determine if the minimum area method does accurately estimate the home range size of Spotted Salamanders.

Included in the Appendix, (Page 40) is the raw spatial coordinate data used to analyze all aspects of the Spotted Salamander's spatial ecology found in this thesis. To further make the data clear, maps have been included showing the locations of all animals in this study. All expected values under a Poisson distribution were presented in tables showing the values used in calculating those values. Maps, Poisson distribution calculations, and data analysis can be found on pages 52-143. The line graphs of the fluctuations of the variance to mean ratio at the scales used in the analysis of spatial distribution pattern were included in the appendix to show visually the changes in the Index of Dispersion. Following all data for spatial analysis is included the home range depictions used in estimating home range size. These diagrams were used to determine the vertices that define the home range estimates.

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APPENDIX

Spatial Coordinate Data

Table 9: Spatial Coordinate Data for Year 1

ID	X	Y
1	3.3	3
2	2	8.45
3	2.55	12.35
3	2.35	12.98
3	2.5	12.83
4	2.7	12.81
4	3.1	12.56
4	2.9	13.17
4	2.7	12.81
5	3.3	13.45
5	3.3	13.45
5	3.3	13.45
5	3.25	13.13
5	3.25	13.13
6	3.25	13.53
7	7.8	10.35
7	7.5	10.1
7	7.85	10.1
8	14.95	16.59
8	15.5	17.7
9	17.55	22.15
9	13.75	18.41
10	24.56	33.51
11	35.83	50.69
12	26.4	11.24
13	30.65	-21.45
13	31.5	-21.84
13	29.8	-22.85
14	30.78	-21.73
14	29.8	-21.85
15	31.7	-17.2
15	31.47	-17.3
15	31.5	-17.65
16	31.5	-9.55

Each point Located for each animal.
N=16

16	31.95	-9.89

Table 10: Average Locations for Each Animal for Year 1

D	X	Y
1	3.3	3
2	2	8.45
3	2.466667	12.72
4	2.85	12.8375
5	3.28	13.322
6	3.25	13.53
7	7.716667	10.18333
8	15.225	17.145
9	15.65	20.28
10	24.56	33.51
11	35.83	50.69
12	26.4	11.24
13	30.65	-22.0467
14	30.29	-21.79
15	31.55667	-17.3833
16	31.725	-9.72

N=16

Table 11: Spatial Coordinate Data for Year 2

ID	X	Y
985.161000967347	36.9	-22.5
985.161000967347	32.9	-20.7
985.161000960579	22.95	-4.45
985.161000042185	28.6	-9.65
985.161000042185	32.6	-2.55
985.161000042185	32.6	-2.4
985.161000042185	33.5	-1.7
985.161000042185	33.7	-1.95
985.161000915---	17.53	7.95
985.161000915---	17.72	6.25
985.161000985081	15.55	7.46
985.161000978978	7.5	2.86
985.161000978978	7.6	2.9
985.161000045485	3.6	4.55
985.161000045485	3.58	5
985.161000045485	5.5	4.92
985.161000045485	5.55	4.68
985.161000045485	5.21	4.68
985.161000045485	5.44	4.68
985.161000045415	3.65	4.84
985.161000969422	4.34	14.3
985.161000969422	4.25	14.1
985.161000969422	4.15	14.2
985.161000044623	1.9	16.7
985.161000044623	1.8	16.8
985.161000044623	1.5	27.5
985.161000044623	1.7	28.2
985.161000042644	2	30.3
985.161000981187	-1	31.8
985.161000042759	0.2	32
985.161000967578	3.49	41.35
985.161000967578	3.48	38.59
985.161000966648	1.3	42.99
985.161000966648	1.75	45.45
985.161000966648	1.52	37.3
985.161000966648	1.2	36.4
985.161000974642	3.15	29.37
985.161000964011	5.9	29.85
985.161000967542	8.4	29.25
985.161000967542	8.5	29.1

Containing all locations for each animal detected during the entire field season. Each animal is identified by its tag number to denote the number of times it was located in a different locations.

985.161000967542	3.8	62.3
985.161000967542	4	64
985.161000967542	4	64.01
985.161000974642	10.4	26.1
985.161000974642	10.35	26.3
985.161000974642	10.3	26.5
985.161001294644	10.6	23.7
985.161001294644	2.82	19.29
985.161000064456	1.5	63.8
985.161000064456	1.3	63.55
985.161000064456	1.8	64.6
985.161000064456	1.75	64.55
985.161000064456	1.85	64.5
985.161000968460	24	63.8
985.161000044244	27.98	52
985.161000460503	19.22	57.5
985.16100008405-	18.3	52.1
985.161000971202	18.3	50.3
985.161000971202	18.21	50.5
985.161000041940	17.6	7.7
985.161000041940	17.49	7.75
985.161001299246	4.4	16.35
985.161001299246	4.5	17
985.161000014566	0.98	17.6
985.161000968456	5.3	22.15
985.161000979103	3.7	74
985.161000979103	4.1	76
985.161000963014	19.9	23.8
985.161000963014	-0.35	25.47
985.161000968546	0.99	0.23
985.161000967776	5.34	15.2
985.161000041674	11.4	19.5
985.161000041674	11.25	18.9
985.161000041674	11.35	19.2
985.161000041674	11.5	19.5
985.161000970950	13.7	14.1
985.161000970950	13.53	14.32
985.161000046566	20.87	33.6
985.161000044591	1.05	0
985.161000962950	20	33.03
985.161000966648	12.83799	21.40548
985.161000966648	13.00101	20.81553

985.161000041246	14.77	26.58
985.161000041246	18.57	41
985.161000041246	18.51	41.15
985.161000046129	29.45	33.65
985.161000046129	29.5	33.52
985.161000963017	15.1	27.5
985.161000970991	3.15	26.5
985.161000963280	13.1	22.9
985.161000963280	13.2	23

Table 12: Average Locations for Each Animal for Year 2

ID	X	Y
985.161000967347	34.9	-21.6
985.161000960579	22.95	-4.45
985.161000042185	32.2	-3.65
985.161000915	17.625	7.1
985.161000985081	15.55	7.46
985.161000978978	7.55	2.88
985.161000045485	4.813333	4.751667
985.161000045415	3.65	4.84
985.161000969422	4.246667	14.2
985.161000044623	1.725	22.3
985.161000042644	2	30.3
985.161000981187	-1	31.8
985.161000042759	0.2	32
985.161000967578	3.485	39.97
985.161000966648	1.4425	40.535
985.161000974642	3.15	29.37
985.161000964011	5.9	29.85
985.161000967542	5.74	49.732
985.161000974642	10.35	26.3
985.161001294644	6.71	21.495
985.161000064456	1.64	64.2
985.161000968460	24	63.8
985.161000044244	27.98	52
985.161000460503	19.22	57.5
985.16100008405	18.3	52.1
985.161000971202	18.255	50.4
985.161000041940	17.545	7.725
985.161001299246	4.45	16.675
985.161000014566	0.98	17.6
985.161000968456	5.3	22.15
985.161000979103	3.9	75
985.161000963014	9.775	24.635
985.161000968546	0.99	0.23
985.161000967776	5.34	15.2
985.161000041674	11.375	19.275
985.161000970950	13.615	14.21
985.161000046566	20.87	33.6
985.161000044591	1.05	0
985.161000962950	20	33.03
985.161000966648	12.9195	21.1105

Average Locations: N= 45

985.161000041246	17.28333	36.24333
985.161000046129	29.475	33.585
985.161000963017	15.1	27.5
985.161000970991	3.15	26.5
985.161000963280	13.15	22.95

Table 13: Year 2 Summer Season Spatial Coordinate Data

985.161000041246	18.57	41
985.161000044591	1.05	0
985.161000046566	20.87	33.6
985.161000970950	13.7	14.1
985.161000970950	13.53	14.32
985.161000041674	11.5	19.5
985.161000971202	18.3	50.3
985.161000971202	18.21	50.5
985.161000044244	27.98	52
985.161000064456	1.5	63.8
985.161000042759	0.2	32
985.161000044623	1.8	16.8
985.161000044623	1.5	27.5
985.161000044623	1.7	28.2
985.161000044623	1.8	16.8
985.161000044623	1.5	27.5
985.161000044623	1.7	28.2
985.161000969422	4.34	14.3
985.161000969422	4.25	14.1
985.161000045485	3.6	4.55
985.161000045485	3.58	5
985.161000978978	7.5	2.86
985.161000978978	7.6	2.9
985.161000985081	15.55	7.46
985.161000967347	36.9	-22.5
985.161000967347	32.9	-20.7
985.161000042185	28.6	-9.65
985.161000042185	33.5	-1.7
985.161000042185	33.7	-1.95
985.161000042185	33.5	-1.7
985.161000967578	3.49	41.35
985.161000974642	3.15	29.37
985.161000960579	22.95	-4.45
985.161000042185	32.6	-2.55
985.161000042185	32.6	-2.4
985.161000967542	8.4	29.25
985.161000967542	8.5	29.1

Taken from each location of each animal detected over the period of the Summer season. The months that were lumped together were: August, June, July, and May. May was included because there were not enough data to gather April and May into one month to depict the spatial pattern for Spring.

Table 14: Year 2 Fall Season Spatial Data

ID	X	Y
985.161000044591	1.05	0
985.161000046566	20.87	33.6
985.161000970950	13.7	14.1
985.161000970950	13.53	14.32
985.161000041674	11.4	19.5
985.161000041674	11.25	18.9
985.161000963014	19.9	23.8
985.161000963014	-0.35	25.47
985.161000979103	3.7	74
985.161000979103	4.1	76
985.161000014566	0.98	17.6
985.161001299246	4.4	16.35
985.161001299246	4.5	17
985.161000044244	27.98	52
985.161001294644	10.6	23.7
985.161001294644	2.82	19.29
985.161000967542	8.5	29.1
985.161000967542	3.8	62.3
985.161000967542	4	64
985.161000967542	4	64.01
985.161000042759	0.2	32
985.161000044623	1.9	16.7
985.161000969422	4.34	14.3
985.161000969422	4.25	14.1
985.161000969422	4.15	14.2
985.161000978978	7.5	2.86
985.161000978978	7.6	2.9
985.161000045485	3.6	4.55
985.161000045485	3.58	5
985.161000041246	18.51	41.15
985.161000046129	29.45	33.65
985.161000046129	29.5	33.52
985.161000963017	15.1	27.5
985.161000970991	3.15	26.5
985.161000963280	13.1	22.9
985.161000963280	13.2	23
985.161000041246	14.77	26.58

Taken from each location of each animal detected over the period of the Summer season. The months that were lumped together were October, and September. This was sufficient to gain enough numbers to conduct analysis.

Table 15: Spatial Distribution Pattern for Fall , Average Positions

ID	X	Y
985.161000044591	1.05	0
985.161000046566	20.87	33.6
985.161000970950	13.615	14.21
985.161000041674	11.325	19.2
985.161000963014	9.775	24.635
985.161000979103	3.9	75
985.161000014566	0.98	17.6
985.161001299246	4.45	16.675
985.161000044244	27.98	52
985.161000967542	5.075	54.8525
985.161000042759	0.2	32
985.161000044623	1.9	16.7
985.161000969422	4.246667	14.2
985.161000978978	7.55	2.88
985.161000045485	3.59	4.775
985.161000041246	18.51	41.15
985.161000046129	29.475	33.585
985.161000963017	15.1	27.5
985.161000970991	3.15	26.5
985.161000963280	13.15	22.95
985.161000041246	14.77	26.58
985.161001294644	6.71	21.495

The average position for each animal for the Fall of Year 2. N=22

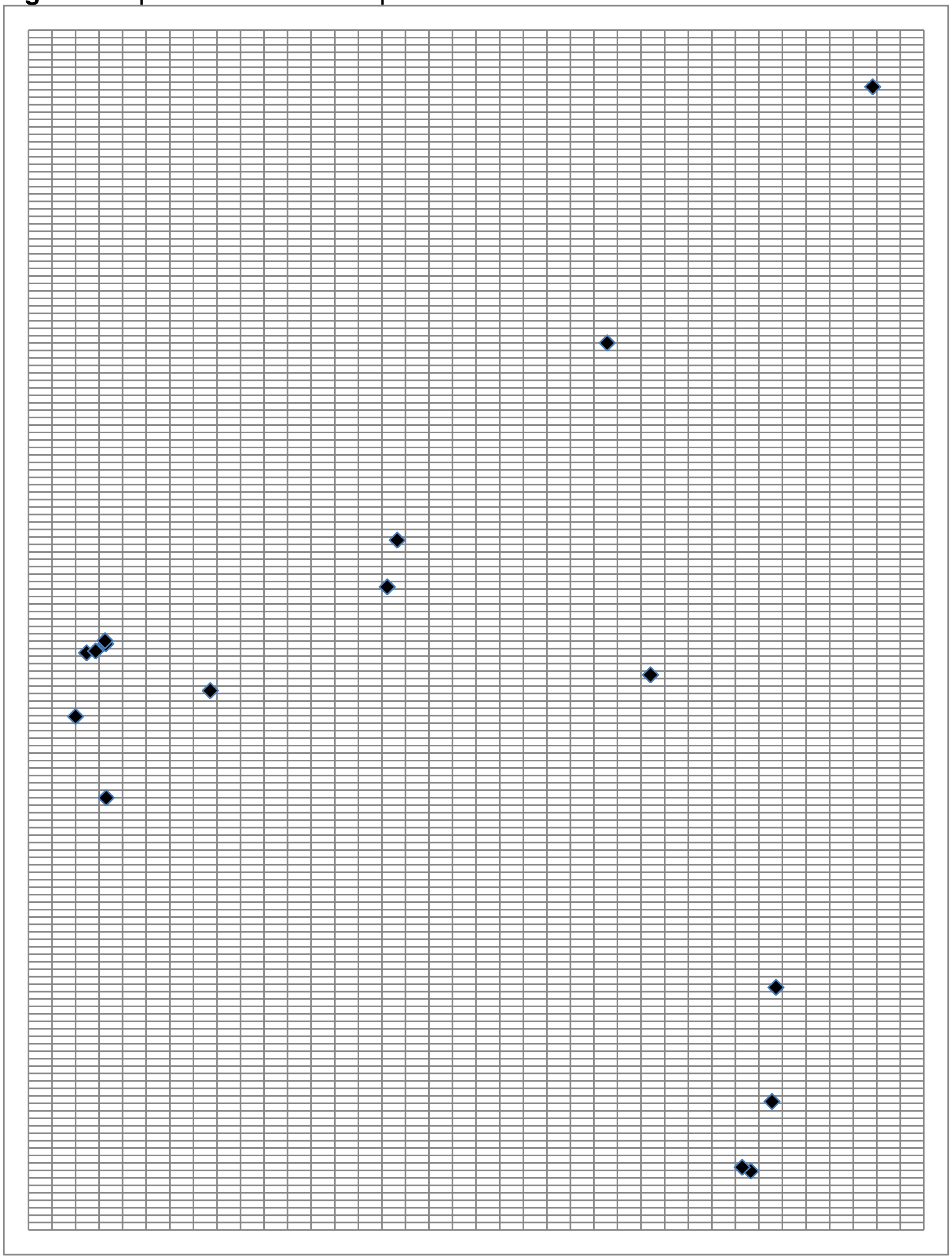
Table 16: Year 2: Winter Spatial Data

985.161000041674	11.5	19.5
985.161000970950	13.53	14.32
985.161000962950	20	33.03
985.161000968546	0.99	0.23
985.161000968456	5.3	22.15
985.161000044244	27.98	52
985.161000967542	8.4	29.25
985.161000967578	3.48	38.59
985.161000042759	0.2	32
985.161000045485	5.21	4.68
985.161000045485	5.44	4.68
985.161000966648	12.83799	21.40548
985.161000966648	13.00101	20.81553
985.161000044591	1.05	0
985.161000041674	11.25	18.9
985.161000041674	11.35	19.2
985.161000041674	11.4	19.5
985.161000967776	5.34	15.2
985.161000045485	5.55	4.68
985.161000045485	5.5	4.92
985.161000969422	4.15	14.2
985.161000044623	1.9	16.7
985.161000966648	1.52	37.3
985.161000966648	13.00101	20.81553
985.161000044244	27.98	52
985.161000046566	20.87	33.6
985.161000962950	20	33.03
985.161000041674	11.5	19.5
985.161000970950	16.765	23.675
985.161000968546	0.99	0.23
985.161000968456	5.3	22.15
985.161000044244	27.98	52
985.161000967542	8.4	29.25
985.161000967578	3.48	38.59
985.161000042759	0.2	32
985.161000045485	5.325	4.68
985.161000966648	12.9195	21.1105
985.161000044591	1.05	0
985.161000041674	11.33333	19.2
985.161000967776	5.34	15.2
985.161000045485	5.525	4.8

Taken from each location of each animal detected over the period of the Summer season. The months that were lumped together were the following: January, December, and November. This was sufficient to gain enough numbers to conduct analysis.

985.161000969422	4.15	14.2
985.161000044623	1.9	16.7
985.161000966648	7.260506	29.05776
985.161000046566	20.87	33.6
985.161000962950	20	33.03

Figure 2: Spatial coordinate map Year 1



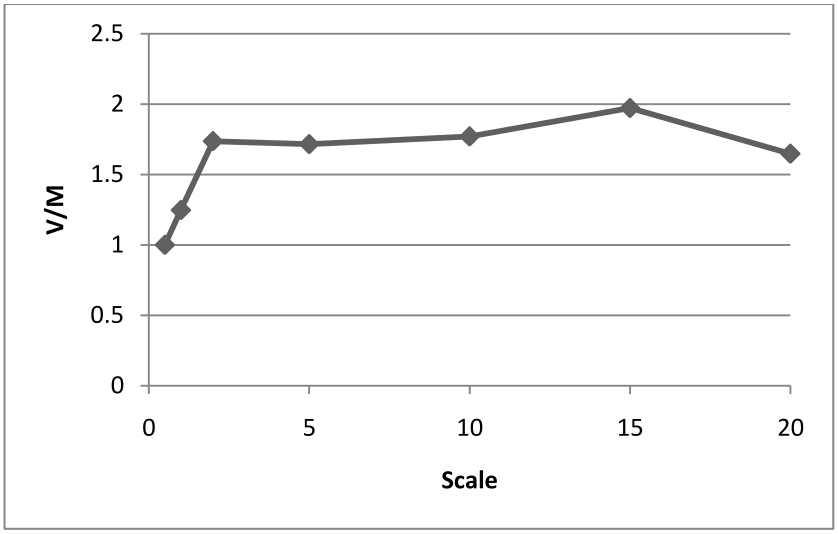


Figure 3: Variance to mean ratio by scale for Year 1.

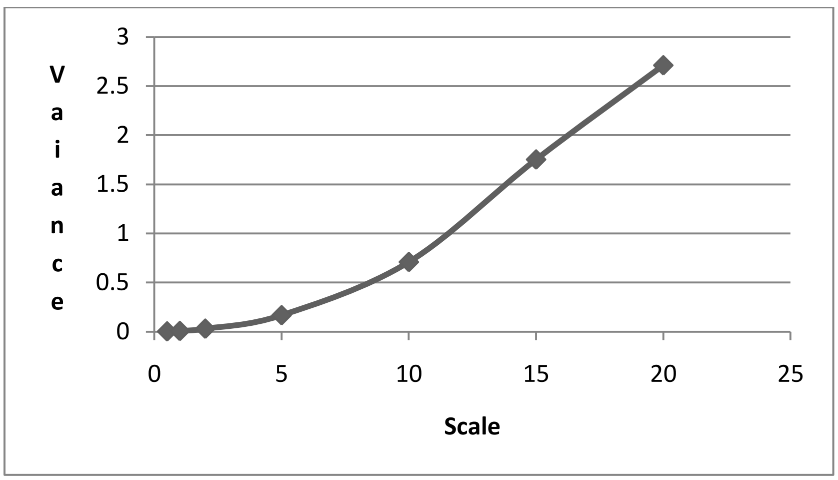


Figure 4: Variance fluctuations by scale for Year 1**.**

Table 17: Variance to Mean Ratio by Scale for Year 1

Scale (m)	Mean	Variance
.5	0.001023	0.001022
1	0.004103	0.005113
2	0.01641	0.028478
5	0.096774	0.165899
10	0.4	0.707692
15	.888889	1.751634
20	1.646545	2.711111

Table 18: Expected and Observed Salamanders per Quadrat. 0.5 m Scale

Class	Expected	Observed
0	15624.00846	15624
1	15.98336066	16
2	0.008175489	0
3	2.78784E-06	0
4	7.12991E-10	0
5	1.45878E-13	0
6	2.48722E-17	0
7	3.63489E-21	0
8	4.64812E-25	0
9	5.28336E-29	0
10	5.40488E-33	0
11	5.02654E-37	0
12	4.28512E-41	0
13	3.37206E-45	0
14	2.46401E-49	0
15	1.68046E-53	0
16	1.07444E-57	0

Table 19: X^2 Analysis: 0.5 m Scale for Year 1

Classes	Expected	Observed	P	Pattern
0	15624.008	15624		
1 or more	15.991539	16		
			0.99	**Random**

Table 20: Expected and Observed Salamanders per Quadrat. 1.0 m Scale, Year 1

Class	Expected	Observed
0	3884.031083	3886
1	15.93617953	12
2	0.032693072	2
	4.47132E-05	0
4	4.58646E-08	0
5	3.76365E-11	0
6	2.57371E-14	0
7	1.50856E-17	0
8	7.73703E-21	0
9	3.52723E-24	0
10	1.44722E-27	0
11	5.39813E-31	0
12	1.84571E-34	0
13	5.82535E-38	0
14	1.70724E-41	0
15	4.66988E-45	0
16	1.19753E-48	0

Table 21: X^2 Analysis: 1.0 m Scale for Year 1.

Classes	Expected	Observed	P	Pattern
0	3884.031	3886		
1 or more	15.96892	14		
			.62	**Random**

Table 22: Expected and Observed Salamanders per Quadrat. 2.0 m Scale, Year 1

Class	Expected	Observed
0	959.1308128	963
1	15.73933664	10
2	0.129141257	0
	0.000706403	2
4	2.89802E-06	0
5	9.51129E-09	0
6	2.60134E-11	0
7	6.09828E-14	0
8	1.25091E-16	0
9	2.28083E-19	0
10	3.74283E-22	0
11	5.58363E-25	0
12	7.63561E-28	0
13	9.63849E-31	0
14	1.12977E-33	0
15	1.23597E-36	0
16	1.26764E-39	0

Table 23: X^2 Analysis: 2.0 m Scale for Year 1

Classes	Expected	Observed	P	Pattern
0	959.1308	963		
1 or more	15.86919	12		
			.33	**Random**

Table 24: Expected and Observed Salamanders per Quadrat. 5.0 m scale, Year 1

Class	Expected	Observed
0	141.6107374	144
1	13.7042375	10
2	0.66310694	0
	0.021390504	2
4	0.000517511	0
5	1.00163E-05	0
6	1.61553E-07	0
7	2.23345E-09	0
8	2.70175E-11	0
9	2.9051E-13	0
10	2.81138E-15	0
11	2.47335E-17	0
12	1.99464E-19	0
13	1.48484E-21	0
14	1.02638E-23	0
15	6.62181E-26	0
16	4.00512E-28	0

Table 25: X^2 Analysis: 5.0 m Scale for Year 1

Classes	Expected	Observed	P	Pattern
0	141.6107	144		
1 or more	14.38926	12		
			0.5	**Random**

Table 26: Expected and Observed Salamanders per Quadrat. 10.0 m scale, Year 1

Class	Expected	Observed
0	26.81280184	30
1	10.72512073	7
2	2.145024147	3
3	0.28600322	0
4	0.028600322	0
5	0.002288026	0
6	0.000152535	0
7	8.71629E-06	0
8	4.35814E-07	0
9	1.93695E-08	0
10	7.74781E-10	0
11	2.81739E-11	0
12	9.39129E-13	0
13	2.88963E-14	0
14	8.25608E-16	0
15	2.20162E-17	0
16	5.50405E-19	0

Table 27: X^2 Analysis: 10.0 m Scale for Year 1

Classes	Expected	Observed	P	Pattern
0	26.8128	30		
1	10.72512	7		
2 or more	2.462077	3		
			0.40	**Random**

Table 28: Expected and Observed Salamanders per Quadrat. 15.0 m Scale, Year 1

Class	Expected	Observed
0	7.400020403	12
1	6.577796736	2
2	2.923465582	4
3	0.866212132	0
4	0.192491609	0
5	0.034220735	0
6	0.005069739	0
7	0.000643776	0
8	7.15307E-05	0
9	7.06476E-06	0
10	6.27979E-07	0
11	5.07458E-08	0
12	3.75895E-09	0
13	2.57022E-10	0
14	1.63189E-11	0
15	9.67044E-13	0
16	5.37247E-14	0

Table 29: X^2 Analysis: 15.0 m Scale for Year 1

Classes	Expected	Observed	P	Pattern
0	7.4002	12		
1	6.577797	2		
2	2.923466	4		
3 or more	1.098717	0		
			.05	**Clumped**

Table 30: Expected and Observed Salamanders per Quadrat. 20.0 m Scale, Year 1

Class	Expected	Observed
0	1.927145884	3
1	3.17313242	3
2	2.612352661	1
3	1.433785404	2
4	0.590198047	0
5	0.194357529	1
6	0.053336403	0
7	0.012545827	0
8	0.002582159	0
9	0.000472404	0
10	7.77835E-05	0
11	1.16431E-05	0
12	1.59757E-06	0
13	2.02344E-07	0
14	2.37978E-08	0
15	2.61228E-09	0
16	2.68827E-10	0

Table 31: X^2 Analysis: 20.0 m Scale, for Year 1

Classes	Expected	Observed	P	Pattern
0	1.927146	3		
1	3.173132	3		
2	2.612353	1		
3 or more	2.87369	3		
			0.6	**Random**

Table 32: Calculations of Expected Values. 0.5 m Scale. Year 1

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.998977523	15624.00846
1	0.001021954	15.98336066
2	5.22729E-07	0.008175489
3	1.78251E-10	2.78784E-06
4	4.55876E-14	7.12991E-10
5	9.32723E-18	1.45878E-13
6	1.59029E-21	2.48722E-17
7	2.3241E-25	3.63489E-21
8	2.97194E-29	4.64812E-25
9	3.37811E-33	5.28336E-29
10	3.4558E-37	5.40488E-33
11	3.2139E-41	5.02654E-37
12	2.73985E-45	4.28512E-41
13	2.15605E-49	3.37206E-45
14	1.57546E-53	2.46401E-49
15	1.07446E-57	1.68046E-53
16	6.86983E-62	1.07444E-57

Table 33: Calculations of Expected Values. 1.0 m Scale. Year 1

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.995905406	3884.031083
1	0.0040862	15.93617953
2	8.38284E-06	0.032693072
3	1.14649E-08	4.47132E-05
4	1.17602E-11	4.58646E-08
5	9.65038E-15	3.76365E-11
6	6.59925E-18	2.57371E-14
7	3.8681E-21	1.50856E-17
8	1.98385E-24	7.73703E-21
9	9.04417E-28	3.52723E-24
10	3.71082E-31	1.44722E-27
11	1.38414E-34	5.39813E-31
12	4.73259E-38	1.84571E-34
13	1.49368E-41	5.82535E-38
14	4.37755E-45	1.70724E-41
15	1.19741E-48	4.66988E-45
16	3.0706E-52	1.19753E-48

Table 34: Calculations of Expected Values. 2.0 m Scale. Year 1

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.983723911	959.1308128
1	0.016142909	15.73933664
2	0.000132453	0.129141257
3	7.24516E-07	0.000706403
4	2.97233E-09	2.89802E-06
5	9.75517E-12	9.51129E-09
6	2.66804E-14	2.60134E-11
7	6.25465E-17	6.09828E-14
8	1.28298E-19	1.25091E-16
9	2.33931E-22	2.28083E-19
10	3.8388E-25	3.74283E-22
11	5.7268E-28	5.58363E-25
12	7.8314E-31	7.63561E-28
13	9.88563E-34	9.63849E-31
14	1.15874E-36	1.12977E-33
15	1.26766E-39	1.23597E-36
16	1.30014E-42	1.26764E-39

Table 35: Calculations of Expected Values. 5.0 m Scale. Year 1

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.907761137	141.6107374
1	0.087847676	13.7042375
2	0.004250686	0.66310694
3	0.000137119	0.021390504
4	3.31738E-06	0.000517511
5	6.42072E-08	1.00163E-05
6	1.0356E-09	1.61553E-07
7	1.4317E-11	2.23345E-09
8	1.73189E-13	2.70175E-11
9	1.86224E-15	2.9051E-13
10	1.80217E-17	2.81138E-15
11	1.58548E-19	2.47335E-17
12	1.27861E-21	1.99464E-19
13	9.51819E-24	1.48484E-21
14	6.57938E-26	1.02638E-23
15	4.24475E-28	6.62181E-26
16	2.56739E-30	4.00512E-28

Table 36: Calculations of Expected Values. 10.0 m Scale. Year 1

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.670320046	26.81280184
1	0.268128018	10.72512073
2	0.053625604	2.145024147
3	0.00715008	0.28600322
4	0.000715008	0.028600322
5	5.72006E-05	0.002288026
6	3.81338E-06	0.000152535
7	2.17907E-07	8.71629E-06
8	1.08954E-08	4.35814E-07
9	4.84238E-10	1.93695E-08
10	1.93695E-11	7.74781E-10
11	7.04347E-13	2.81739E-11
12	2.34782E-14	9.39129E-13
13	7.22407E-16	2.88963E-14
14	2.06402E-17	8.25608E-16
15	5.50405E-19	2.20162E-17
16	1.37601E-20	5.50405E-19

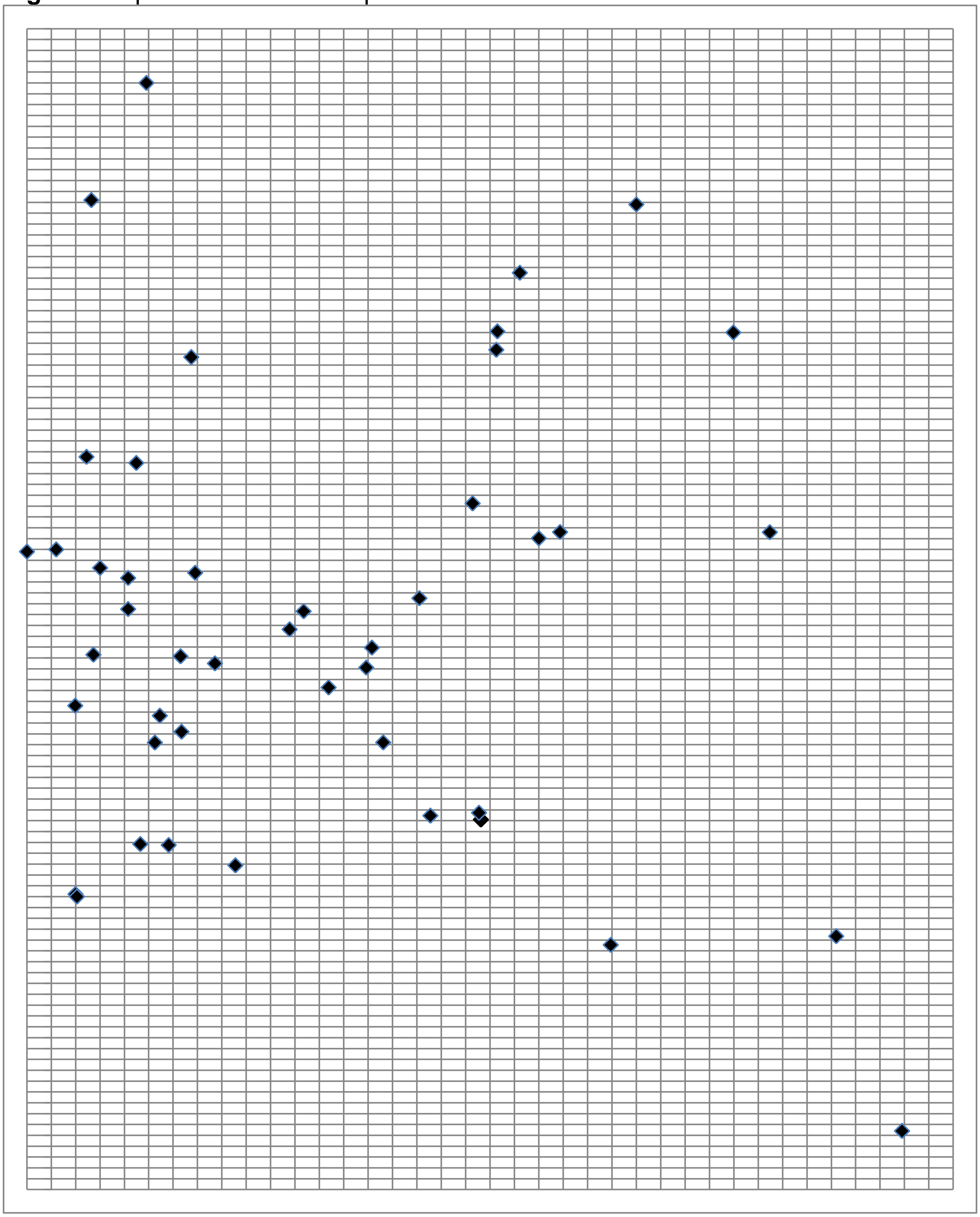
Table 37: Calculations of Expected Values. 15.0 m Scale. Year 1

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.411112245	7.400020403
1	0.365433152	6.577796736
2	0.162414755	2.923465582
3	0.048122896	0.866212132
4	0.010693978	0.192491609
5	0.001901152	0.034220735
6	0.000281652	0.005069739
7	3.57654E-05	0.000643776
8	3.97393E-06	7.15307E-05
9	3.92487E-07	7.06476E-06
10	3.48877E-08	6.27979E-07
11	2.81921E-09	5.07458E-08
12	2.0883E-10	3.75895E-09
13	1.4279E-11	2.57022E-10
14	9.06604E-13	1.63189E-11
15	5.37247E-14	9.67044E-13
16	2.9847E-15	5.37247E-14

Table 38: Calculations of Expected Values. 20.0 m Scale. Year 1

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.192714588	1.927145884
1	0.317313242	3.17313242
2	0.261235266	2.612352661
3	0.14337854	1.433785404
4	0.059019805	0.590198047
5	0.019435753	0.194357529
6	0.00533364	0.053336403
7	0.001254583	0.012545827
8	0.000258216	0.002582159
9	4.72404E-05	0.000472404
10	7.77835E-06	7.77835E-05
11	1.16431E-06	1.16431E-05
12	1.59757E-07	1.59757E-06
13	2.02344E-08	2.02344E-07
14	2.37978E-09	2.37978E-08
15	2.61228E-10	2.61228E-09
16	2.68827E-11	2.68827E-10

Figure 5: Spatial coordinate map Year 2



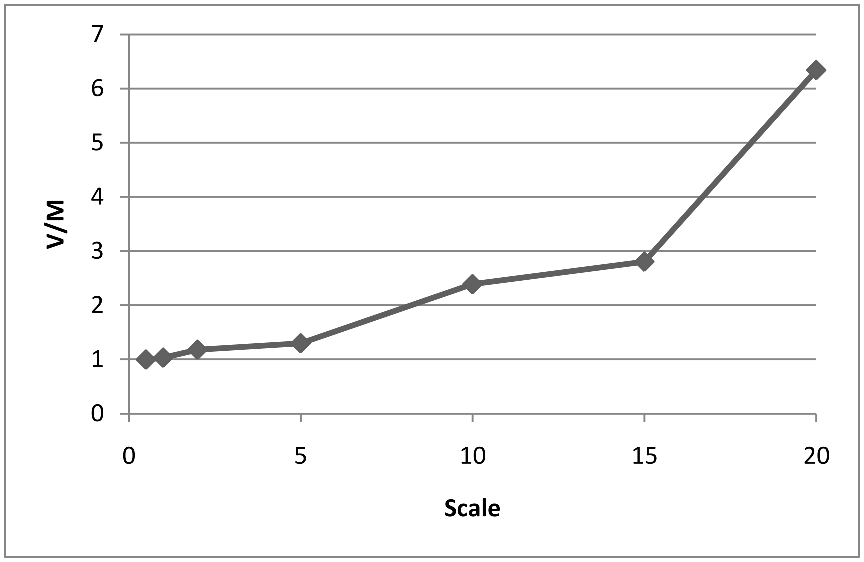


Figure 6: Variance to mean ratio by scale for Year 2

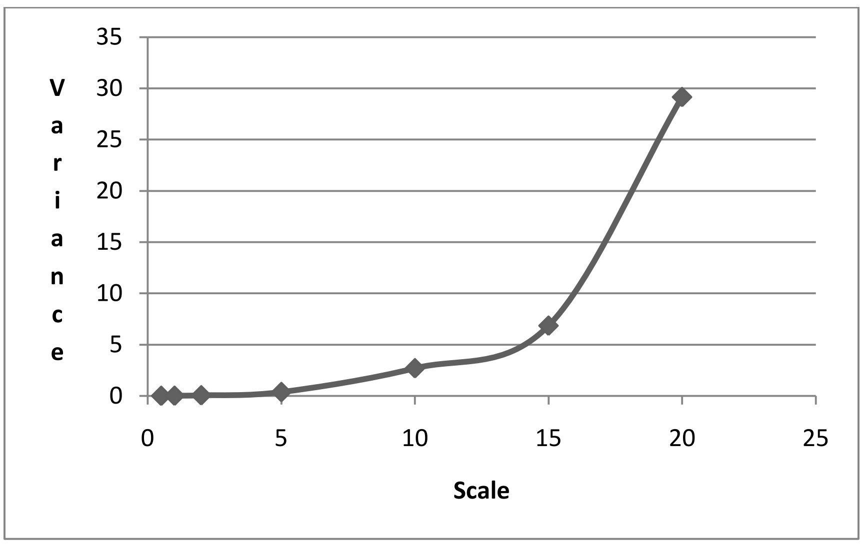


Figure 7: Variance by scale for Year 2**.**

Table 39: Variance to Mean Ratio by Scale for Year 2

Scale	Mean	Variance
.5	0.002933	0.002924
1	0.011795	0.012172
2	0.046154	0.054336
5	0.288462	0.374318
10	1.128205	2.693657
15	2.444444	6.849673
20	4.6	29.15556

Table 40: Expected and Observed Salamanders per Quadrat. 0.5 m Scale. Year 2

Class	Expected	Observed
0	15594.19509	15595
1	45.73777419	45
2	0.067074446	0
3	6.55764E-05	0
4	4.80839E-08	0
5	2.8206E-11	0
6	1.3788E-14	0
7	5.77719E-18	0
8	2.11806E-21	0
9	6.90253E-25	0
10	2.02451E-28	0
11	5.39809E-32	0
12	1.31938E-35	0
13	2.97673E-39	0
14	6.23625E-43	0
15	1.21939E-46	0
16	2.2353E-50	0
17	3.85655E-54	0
18	6.28404E-58	0
19	9.70058E-62	0
20	1.42259E-65	0
21	1.98688E-69	0
22	2.64888E-73	0
23	3.37789E-77	0
24	4.12807E-81	0
25	4.84305E-85	0
26	5.46333E-89	0
27	5.9348E-93	0
28	6.2167E-97	0
29	6.2874E-101	0
30	6.147E-105	0
31	5.8159E-109	0
32	5.3306E-113	0
33	4.7378E-117	0
34	4.087E-121	0
35	3.4249E-125	0
36	2.7904E-129	0
37	2.2119E-133	0
38	1.7073E-137	0
39	1.284E-141	0
40	9.4146E-146	0
41	6.7349E-150	0

42	4.7032E-154	0
43	3.208E-158	0
44	2.1384E-162	0
45	1.3938E-166	0

Table 41: X^2 Analysis: 0.5 m Scale for Year 2

Classes	Expected	Observed	P	Pattern
Pattern0	15594.19509	15595		
1 or more	45.80491426	45		
			0.9	**Random**

Table 42: Expected and Observed Salamanders per Quadrat. 1.0 m Scale, Year 2

Class	Expected	Observed
0	3854.269724	3855
1	45.4611114	45
2	0.268106904	0
3	0.001054107	0
4	3.1083E-06	0
5	7.33247E-09	0
6	1.44144E-11	0
7	2.42883E-14	0
8	3.58101E-17	0
9	4.69311E-20	0
10	5.53552E-23	0
11	5.93559E-26	0
12	5.83419E-29	0
13	5.2934E-32	0
14	4.45969E-35	0
15	3.50681E-38	0
16	2.58517E-41	0
17	1.79365E-44	0
18	1.17534E-47	0
19	7.2964E-51	0
20	4.30305E-54	0
21	2.41688E-57	0
22	1.29578E-60	0
23	6.64508E-64	0
24	3.26578E-67	0
25	1.5408E-70	0
26	6.98988E-74	0
27	3.05354E-77	0
28	1.2863E-80	0
29	5.23171E-84	0
30	2.05693E-87	0
31	7.8263E-91	0
32	2.88473E-94	0
33	1.03107E-97	0
34	3.5769E-101	0
35	1.2054E-104	0
36	3.9494E-108	0
37	1.259E-111	0
38	3.9079E-115	0
39	1.1819E-118	0
40	3.4851E-122	0
41	1.0026E-125	0

42	2.8156E-129	0
43	7.7234E-133	0
44	2.0704E-136	0
45	5.4267E-140	0

Table 43: X^2 Analysis: 1.0 m Scale for Year 2

Classes	Expected	Observed	P	Pattern
0	3854.27	3855		
1 or more	45.73028	45		
			0.91	**Random**

Table 44: Expected and Observed Salamanders per Quadrat. 2.0 m Scale, Year 2

Class	Expected	Observed
0	931.0225246	935
1	42.9704136	35
2	0.991628235	5
3	0.01525587	0
4	0.00017603	0
5	1.6249E-06	0
6	1.24992E-08	0
7	8.24129E-11	0
8	4.7546E-13	0
9	2.43827E-15	0
10	1.12536E-17	0
11	4.7218E-20	0
12	1.81608E-22	0
13	6.44765E-25	0
14	2.12561E-27	0
15	6.54035E-30	0
16	1.88664E-32	0
17	5.12213E-35	0
18	1.31337E-37	0
19	3.19039E-40	0
20	7.36245E-43	0
21	1.61813E-45	0
22	3.39468E-48	0
23	6.8121E-51	0
24	1.31002E-53	0
25	2.41851E-56	0
26	4.29323E-59	0
27	7.33888E-62	0
28	1.20971E-64	0
29	1.92527E-67	0
30	2.96197E-70	0
31	4.40989E-73	0
32	6.36045E-76	0
33	8.89576E-79	0
34	1.20757E-81	0
35	1.59241E-84	0
36	2.04156E-87	0
37	2.54665E-90	0
38	3.09311E-93	0
39	3.66049E-96	0
40	4.2237E-99	0
41	4.7546E-102	0

42	5.2249E-105	0
43	5.6081E-108	0
44	5.8826E-111	0
45	6.0335E-114	0

Table 45: X^2 Analysis: 2.0 m Scale for Year 2

Classes	Expected	Observed	P	Pattern
0	931.0225	935		
1 or more	42.97041	35		
2 or more	1.007062	5		
			0.0001	**Clumped**

Table 46: Expected and Observed Salamanders per Quadrat. 5.0 m Scale, Year 2

Class	Expected	Observed
0	116.908784	122
1	33.72374166	25
2	4.864008983	7
3	0.46769392	2
4	0.033727981	0
5	0.001945848	0
6	9.35505E-05	0
7	3.85511E-06	0
8	1.39007E-07	0
9	4.45535E-09	0
10	1.2852E-10	0
11	3.37028E-12	0
12	8.10165E-14	0
13	1.79771E-15	0
14	3.70407E-17	0
15	7.12323E-19	0
16	1.28424E-20	0
17	2.17914E-22	0
18	3.49222E-24	0
19	5.30196E-26	0
20	7.64706E-28	0
21	1.05042E-29	0
22	1.3773E-31	0
23	1.72739E-33	0
24	2.07619E-35	0
25	2.39561E-37	0
26	2.65786E-39	0
27	2.8396E-41	0
28	2.92541E-43	0
29	2.9099E-45	0
30	2.79798E-47	0
31	2.60359E-49	0
32	2.34699E-51	0
33	2.05157E-53	0
34	1.74059E-55	0
35	1.43455E-57	0
36	1.14948E-59	0
37	8.96167E-62	0
38	6.8029E-64	0
39	5.03174E-66	0
40	3.62866E-68	0
41	5.4396E-47	0

42	2.553E-70	0
43	1.75344E-72	0
44	1.17628E-74	0
45	7.71164E-77	0

Table 47: X^2 Analysis: 5.0 m Scale for Year 2

Classes	Expected	Observed	X^2	P	Pattern
0	116.9088	122	0.221715		
1 or more	33.72374	25	2.256679		
2 or more	5.367474	9	2.458371		
			4.936766	**0.08**	**Random**

Table 48: Expected and Observed Salamanders per Quadrat. 10.0 m Scale, Year 2

Class	Expected	Observed
0	12.94454487	21
1	14.60410024	8
2	8.238209456	5
3	3.0981297	2
4	0.873831354	2
5	0.197172181	1
6	0.037075107	0
7	0.005975474	1
8	0.000842695	0
9	0.000105637	0
10	1.1918E-05	0
11	1.22236E-06	0
12	1.14923E-07	0
13	9.97357E-09	0
14	8.03731E-10	0
15	6.04516E-11	0
16	4.26261E-12	0
17	2.82888E-13	0
18	1.77309E-14	0
19	1.05285E-15	0
20	5.93913E-17	0
21	3.19074E-18	0
22	1.63628E-19	0
23	8.02633E-21	0
24	3.77306E-22	0
25	1.70271E-23	0
26	7.3885E-25	0
27	3.08731E-26	0
28	1.24397E-27	0
29	4.8395E-29	0
30	1.81998E-30	0
31	6.62359E-32	0
32	2.33524E-33	0
33	7.98373E-35	0
34	2.6492E-36	0
35	8.53955E-38	0
36	2.67621E-39	0
37	8.16031E-41	0
38	2.42276E-42	0
39	7.00865E-44	0
40	1.9768E-45	0
41	5.4396E-47	0

42	1.46119E-48	0
43	3.83376E-50	0
44	9.83015E-52	0
45	2.46454E-53	0

Table 49: X^2 Analysis: 10.0 m Scale for Year 2

Classes	Expected	Observed	P	Pattern
0	12.94454	21		
1	14.6041	8		
2	8.238209	5		
3	3.09813	2		
4 or more	1.115016	4		
			0.002	**Clumped**

Table 50: Expected and Observed Salamanders per Quadrat. 15.0 m Scale, Year 2

Class	Expected	Observed
0	1.561938623	4
1	3.818071494	4
2	4.666530978	4
3	3.802357883	2
4	2.323662728	1
5	1.136012683	1
6	0.462819898	0
7	0.161619617	0
8	0.049383763	1
9	0.013412871	1
10	0.003278701	0
11	0.0007286	0
12	0.000148419	0
13	2.79078E-05	0
14	4.87278E-06	0
15	7.94083E-07	0
16	1.21318E-07	0
17	1.74444E-08	0
18	2.369E-09	0
19	3.04783E-10	0
20	3.72513E-11	0
21	4.33613E-12	0
22	4.81792E-13	0
23	5.12049E-14	0
24	5.21531E-15	0
25	5.09942E-16	0
26	4.79432E-17	0
27	4.34054E-18	0
28	3.78936E-19	0
29	3.19409E-20	0
30	2.6026E-21	0
31	2.05223E-22	0
32	1.56767E-23	0
33	1.16124E-24	0
34	8.34877E-26	0
35	5.83089E-27	0
36	3.95924E-28	0
37	2.61572E-29	0
38	1.68262E-30	0
39	1.05464E-31	0
40	6.445E-33	0
41	3.84254E-34	0

42	2.2364E-35	0
43	1.27134E-36	0
44	7.06299E-38	0
45	3.83669E-39	0

Table 51: X^2 Analysis: 15.0 m Scale for Year 2

Classes	Expected	Observed	P	Pattern
0	1.561938623	4		
1	3.818071494	4		
2	4.666530978	4		
3	3.802357883	2		
4	2.323662728	1		
5 or more	1.827438269	3		
			0.28	**Random**

Table 52: Expected and Observed Salamanders per Quadrat. 20.0 m Scale, Year 2

Class	Expected	Observed
0	0.100518357	2
1	0.462384443	1
2	1.063484219	2
3	1.630675802	1
4	1.875277173	1
5	1.725254999	1
6	1.322695499	1
7	0.8691999	0
8	0.499789942	0
9	0.255448193	0
10	0.117506169	0
11	0.049138943	0
12	0.018836595	0
13	0.006665257	0
14	0.002190013	0
15	0.000671604	0
16	0.000193086	0
17	5.22468E-05	0
18	1.3352E-05	1
19	3.23258E-06	0
20	7.43494E-07	0
21	1.62861E-07	0
22	3.40527E-08	0
23	6.81053E-09	0
24	1.30535E-09	0
25	2.40185E-10	0
26	4.24942E-11	0
27	7.23976E-12	0
28	1.18939E-12	0
29	1.88662E-13	0
30	2.89281E-14	0
31	4.29256E-15	0
32	6.17056E-16	0
33	8.60138E-17	0
34	1.16372E-17	0
35	1.52946E-18	0
36	1.9543E-19	0
37	2.42968E-20	0
38	2.94119E-21	0
39	3.46909E-22	0
40	3.98946E-23	0
41	4.47597E-24	0

42	4.90226E-25	0
43	5.24428E-26	0
44	5.48265E-27	0
45	5.60449E-28	0

Table 53: X^2 Analysis: 20.0 m Scale for Year 2

Classes	Expected	Observed	P	Pattern
2 or less	1.626387	5		
3	1.630676	1		
4	1.875277	1		
5	1.725255	1		
6	1.322695	1		
7 or more	1.819709	1		
			0.1	**Random**

Table 54: Calculations of Expected Values. 0.5 m Scale. Year 2

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.997071297	15594.19509
1	0.00292441	45.73777419
2	4.28865E-06	0.067074446
3	4.19287E-09	6.55764E-05
4	3.07442E-12	4.80839E-08
5	1.80345E-15	2.8206E-11
6	8.81589E-19	1.3788E-14
7	3.69386E-22	5.77719E-18
8	1.35426E-25	2.11806E-21
9	4.41338E-29	6.90253E-25
10	1.29445E-32	2.02451E-28
11	3.45146E-36	5.39809E-32
12	8.43595E-40	1.31938E-35
13	1.90328E-43	2.97673E-39
14	3.98737E-47	6.23625E-43
15	7.79664E-51	1.21939E-46
16	1.42922E-54	2.2353E-50
17	2.46583E-58	3.85655E-54
18	4.01793E-62	6.28404E-58
19	6.20241E-66	9.70058E-62
20	9.09584E-70	1.42259E-65
21	1.27039E-73	1.98688E-69
22	1.69366E-77	2.64888E-73
23	2.15978E-81	3.37789E-77
24	2.63943E-85	4.12807E-81
25	3.09658E-89	4.84305E-85
26	3.49318E-93	5.46333E-89
27	3.79463E-97	5.9348E-93
28	3.9749E-101	6.2167E-97
29	4.0201E-105	6.2874E-101
30	3.9303E-109	6.147E-105
31	3.7186E-113	5.8159E-109
32	3.4083E-117	5.3306E-113
33	3.0293E-121	4.7378E-117
34	2.6132E-125	4.087E-121
35	2.1899E-129	3.4249E-125
36	1.7841E-133	2.7904E-129
37	1.4143E-137	2.2119E-133
38	1.0916E-141	1.7073E-137
39	8.2094E-146	1.284E-141
40	6.0195E-150	9.4146E-146
41	4.3062E-154	6.7349E-150

42	3.0071E-158	4.7032E-154
43	2.0512E-162	3.208E-158
44	1.3673E-166	2.1384E-162
45	8.9116E-171	1.3938E-166

Table 55: Calculations of Expected Values. 1.0 m Scale. Year 2

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.988274288	3854.269724
1	0.011656695	45.4611114
2	6.87454E-05	0.268106904
3	2.70284E-07	0.001054107
4	7.96999E-10	3.1083E-06
5	1.88012E-12	7.33247E-09
6	3.69601E-15	1.44144E-11
7	6.22777E-18	2.42883E-14
8	9.18207E-21	3.58101E-17
9	1.20336E-23	4.69311E-20
10	1.41936E-26	5.53552E-23
11	1.52195E-29	5.93559E-26
12	1.49595E-32	5.83419E-29
13	1.35728E-35	5.2934E-32
14	1.14351E-38	4.45969E-35
15	8.99181E-42	3.50681E-38
16	6.62865E-45	2.58517E-41
17	4.59911E-48	1.79365E-44
18	3.0137E-51	1.17534E-47
19	1.87087E-54	7.2964E-51
20	1.10335E-57	4.30305E-54
21	6.19713E-61	2.41688E-57
22	3.32251E-64	1.29578E-60
23	1.70387E-67	6.64508E-64
24	8.3738E-71	3.26578E-67
25	3.95076E-74	1.5408E-70
26	1.79228E-77	6.98988E-74
27	7.82959E-81	3.05354E-77
28	3.29822E-84	1.2863E-80
29	1.34146E-87	5.23171E-84
30	5.27419E-91	2.05693E-87
31	2.00674E-94	7.8263E-91
32	7.39673E-98	2.88473E-94
33	2.6438E-101	1.03107E-97
34	9.1716E-105	3.5769E-101
35	3.0908E-108	1.2054E-104
36	1.0127E-111	3.9494E-108
37	3.2282E-115	1.259E-111
38	1.002E-118	3.9079E-115
39	3.0305E-122	1.1819E-118
40	8.9361E-126	3.4851E-122
41	2.5708E-129	1.0026E-125

42	7.2196E-133	2.8156E-129
43	1.9804E-136	7.7234E-133
44	5.3087E-140	2.0704E-136
45	1.3915E-143	5.4267E-140

Table 56: Calculations of Expected Values. 2.0 m Scale. Year 2

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.954894897	931.0225246
1	0.044072219	42.9704136
2	0.001017055	0.991628235
3	1.5647E-05	0.01525587
4	1.80543E-07	0.00017603
5	1.66656E-09	1.6249E-06
6	1.28197E-11	1.24992E-08
7	8.4526E-14	8.24129E-11
8	4.87652E-16	4.7546E-13
9	2.50079E-18	2.43827E-15
10	1.15421E-20	1.12536E-17
11	4.84287E-23	4.7218E-20
12	1.86265E-25	1.81608E-22
13	6.61297E-28	6.44765E-25
14	2.18011E-30	2.12561E-27
15	6.70805E-33	6.54035E-30
16	1.93502E-35	1.88664E-32
17	5.25347E-38	5.12213E-35
18	1.34705E-40	1.31337E-37
19	3.27219E-43	3.19039E-40
20	7.55123E-46	7.36245E-43
21	1.65962E-48	1.61813E-45
22	3.48173E-51	3.39468E-48
23	6.98676E-54	6.8121E-51
24	1.34361E-56	1.31002E-53
25	2.48052E-59	2.41851E-56
26	4.40331E-62	4.29323E-59
27	7.52706E-65	7.33888E-62
28	1.24073E-67	1.20971E-64
29	1.97464E-70	1.92527E-67
30	3.03792E-73	2.96197E-70
31	4.52297E-76	4.40989E-73
32	6.52353E-79	6.36045E-76
33	9.12385E-82	8.89576E-79
34	1.23854E-84	1.20757E-81
35	1.63324E-87	1.59241E-84
36	2.0939E-90	2.04156E-87
37	2.61195E-93	2.54665E-90
38	3.17242E-96	3.09311E-93
39	3.7544E-99	3.66049E-96
40	4.332E-102	4.2237E-99
41	4.8765E-105	4.7546E-102

42	5.3588E-108	5.2249E-105
43	5.7519E-111	5.6081E-108
44	6.0335E-114	5.8826E-111
45	6.1882E-117	6.0335E-114

Table 57: Calculations of Expected Values. 5.0 m Scale. Year 2

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.749415282	116.908784
1	0.216177831	33.72374166
2	0.031179545	4.864008983
3	0.002998038	0.46769392
4	0.000216205	0.033727981
5	1.24734E-05	0.001945848
6	5.99683E-07	9.35505E-05
7	2.47122E-08	3.85511E-06
8	8.91068E-10	1.39007E-07
9	2.85599E-11	4.45535E-09
10	8.23845E-13	1.2852E-10
11	2.16044E-14	3.37028E-12
12	5.19337E-16	8.10165E-14
13	1.15238E-17	1.79771E-15
14	2.3744E-19	3.70407E-17
15	4.56617E-21	7.12323E-19
16	8.23229E-23	1.28424E-20
17	1.39688E-24	2.17914E-22
18	2.2386E-26	3.49222E-24
19	3.39869E-28	5.30196E-26
20	4.90196E-30	7.64706E-28
21	6.73348E-32	1.05042E-29
22	8.82888E-34	1.3773E-31
23	1.1073E-35	1.72739E-33
24	1.33089E-37	2.07619E-35
25	1.53565E-39	2.39561E-37
26	1.70376E-41	2.65786E-39
27	1.82025E-43	2.8396E-41
28	1.87527E-45	2.92541E-43
29	1.86532E-47	2.9099E-45
30	1.79358E-49	2.79798E-47
31	1.66897E-51	2.60359E-49
32	1.50448E-53	2.34699E-51
33	1.31511E-55	2.05157E-53
34	1.11576E-57	1.74059E-55
35	9.19584E-60	1.43455E-57
36	7.36847E-62	1.14948E-59
37	5.74466E-64	8.96167E-62
38	4.36083E-66	6.8029E-64
39	3.22547E-68	5.03174E-66
40	2.32607E-70	3.62866E-68
41	1.63654E-72	

42	1.124E-74	2.553E-70
43	7.54026E-77	1.75344E-72
44	4.94336E-79	1.17628E-74
45	3.16882E-81	7.71164E-77
		4.94337E-79

Table 58: Calculations of Expected Values. 10.0 m Scale. Year 2

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.323613622	12.94454487
1	0.365102506	14.60410024
2	0.205955236	8.238209456
3	0.077453242	3.0981297
4	0.021845784	0.873831354
5	0.004929305	0.197172181
6	0.000926878	0.037075107
7	0.000149387	0.005975474
8	2.10674E-05	0.000842695
9	2.64092E-06	0.000105637
10	2.9795E-07	1.1918E-05
11	3.0559E-08	1.22236E-06
12	2.87307E-09	1.14923E-07
13	2.49339E-10	9.97357E-09
14	2.00933E-11	8.03731E-10
15	1.51129E-12	6.04516E-11
16	1.06565E-13	4.26261E-12
17	7.0722E-15	2.82888E-13
18	4.43272E-16	1.77309E-14
19	2.63211E-17	1.05285E-15
20	1.48478E-18	5.93913E-17
21	7.97685E-20	3.19074E-18
22	4.09069E-21	1.63628E-19
23	2.00658E-22	8.02633E-21
24	9.43265E-24	3.77306E-22
25	4.25678E-25	1.70271E-23
26	1.84713E-26	7.3885E-25
27	7.71828E-28	3.08731E-26
28	3.10993E-29	1.24397E-27
29	1.20988E-30	4.8395E-29
30	4.54996E-32	1.81998E-30
31	1.6559E-33	6.62359E-32
32	5.8381E-35	2.33524E-33
33	1.99593E-36	7.98373E-35
34	6.623E-38	2.6492E-36
35	2.13489E-39	8.53955E-38
36	6.69053E-41	2.67621E-39
37	2.04008E-42	8.16031E-41
38	6.05691E-44	2.42276E-42
39	1.75216E-45	7.00865E-44
40	4.942E-47	1.9768E-45
41	1.3599E-48	5.4396E-47

42	3.65296E-50	1.46119E-48
43	9.5844E-52	3.83376E-50
44	2.45754E-53	9.83015E-52
45	6.16135E-55	2.46454E-53

Table 59: Calculations of Expected Values. 15.0 m Scale. Year 2

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.086774368	1.561938623
1	0.212115083	3.818071494
2	0.259251721	4.666530978
3	0.211242105	3.802357883
4	0.129092374	2.323662728
5	0.063111816	1.136012683
6	0.025712217	0.462819898
7	0.008978868	0.161619617
8	0.002743542	0.049383763
9	0.00074516	0.013412871
10	0.00018215	0.003278701
11	4.04778E-05	0.0007286
12	8.24547E-06	0.000148419
13	1.55043E-06	2.79078E-05
14	2.7071E-07	4.87278E-06
15	4.41157E-08	7.94083E-07
16	6.7399E-09	1.21318E-07
17	9.69136E-10	1.74444E-08
18	1.31611E-10	2.369E-09
19	1.69324E-11	3.04783E-10
20	2.06952E-12	3.72513E-11
21	2.40896E-13	4.33613E-12
22	2.67662E-14	4.81792E-13
23	2.84472E-15	5.12049E-14
24	2.8974E-16	5.21531E-15
25	2.83301E-17	5.09942E-16
26	2.66351E-18	4.79432E-17
27	2.41141E-19	4.34054E-18
28	2.1052E-20	3.78936E-19
29	1.7745E-21	3.19409E-20
30	1.44589E-22	2.6026E-21
31	1.14013E-23	2.05223E-22
32	8.70929E-25	1.56767E-23
33	6.45132E-26	1.16124E-24
34	4.63821E-27	8.34877E-26
35	3.23938E-28	5.83089E-27
36	2.19958E-29	3.95924E-28
37	1.45318E-30	2.61572E-29
38	9.34791E-32	1.68262E-30
39	5.85909E-33	1.05464E-31
40	3.58055E-34	6.445E-33
41	2.13475E-35	3.84254E-34

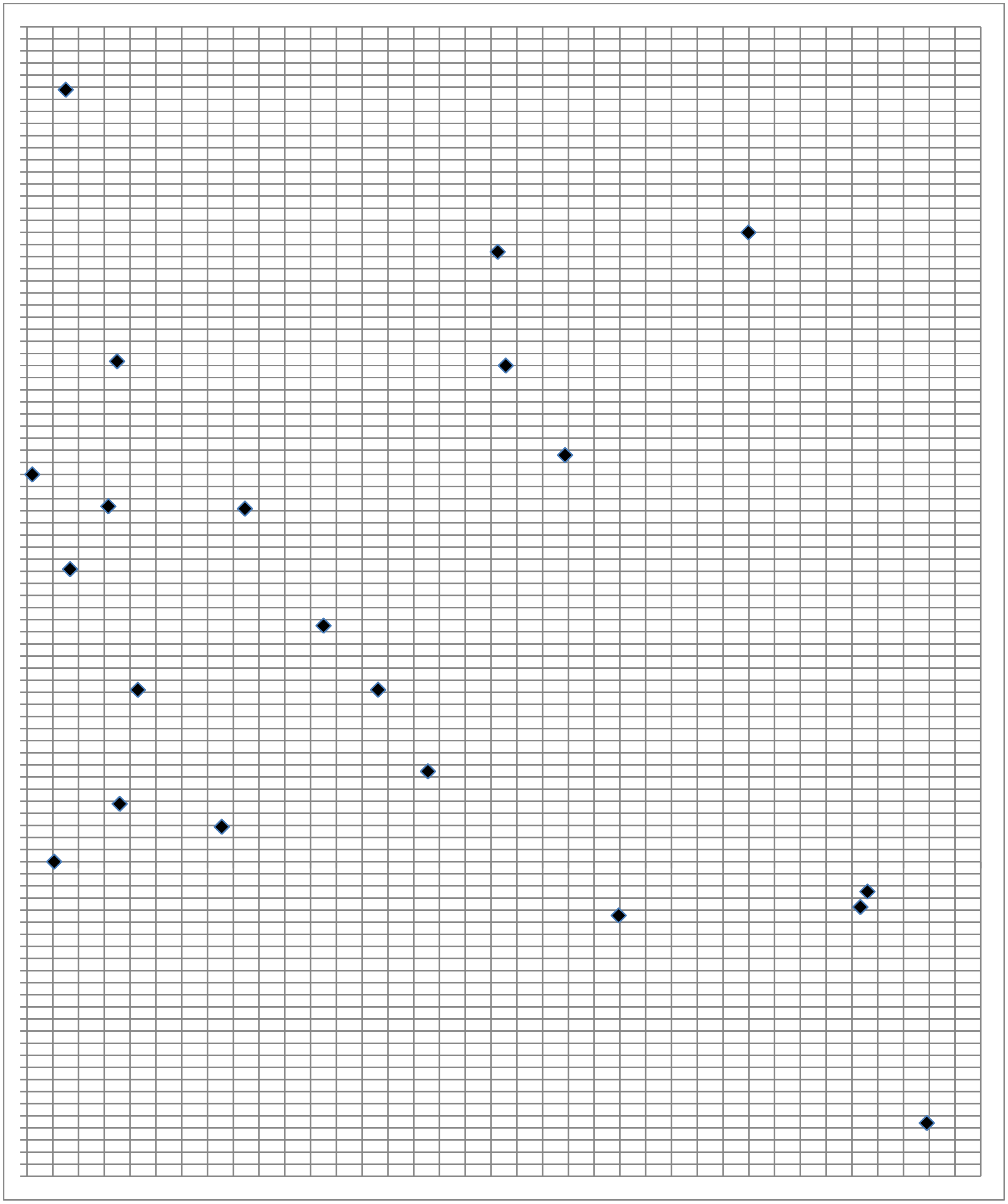
42	1.24244E-36	2.2364E-35
43	7.06299E-38	1.27134E-36
44	3.92388E-39	7.06299E-38
45	2.13149E-40	3.83669E-39

Table 60: Calculations of Expected Values. 20.0 m Scale. Year 2

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.010051836	0.100518357
1	0.046238444	0.462384443
2	0.106348422	1.063484219
3	0.16306758	1.630675802
4	0.187527717	1.875277173
5	0.1725255	1.725254999
6	0.13226955	1.322695499
7	0.08691999	0.8691999
8	0.049978994	0.499789942
9	0.025544819	0.255448193
10	0.011750617	0.117506169
11	0.004913894	0.049138943
12	0.001883659	0.018836595
13	0.000666526	0.006665257
14	0.000219001	0.002190013
15	6.71604E-05	0.000671604
16	1.93086E-05	0.000193086
17	5.22468E-06	5.22468E-05
18	1.3352E-06	1.3352E-05
19	3.23258E-07	3.23258E-06
20	7.43494E-08	7.43494E-07
21	1.62861E-08	1.62861E-07
22	3.40527E-09	3.40527E-08
23	6.81053E-10	6.81053E-09
24	1.30535E-10	1.30535E-09
25	2.40185E-11	2.40185E-10
26	4.24942E-12	4.24942E-11
27	7.23976E-13	7.23976E-12
28	1.18939E-13	1.18939E-12
29	1.88662E-14	1.88662E-13
30	2.89281E-15	2.89281E-14
31	4.29256E-16	4.29256E-15
32	6.17056E-17	6.17056E-16
33	8.60138E-18	8.60138E-17
34	1.16372E-18	1.16372E-17
35	1.52946E-19	1.52946E-18
36	1.9543E-20	1.9543E-19
37	2.42968E-21	2.42968E-20
38	2.94119E-22	2.94119E-21
39	3.46909E-23	3.46909E-22
40	3.98946E-24	3.98946E-23

41	4.47597E-25	4.47597E-24
42	4.90226E-26	4.90226E-25
43	5.24428E-27	5.24428E-26
44	5.48265E-28	5.48265E-27
45	5.60449E-29	5.60449E-28

Figure 8: Spatial coordinate map Year 2 Summer



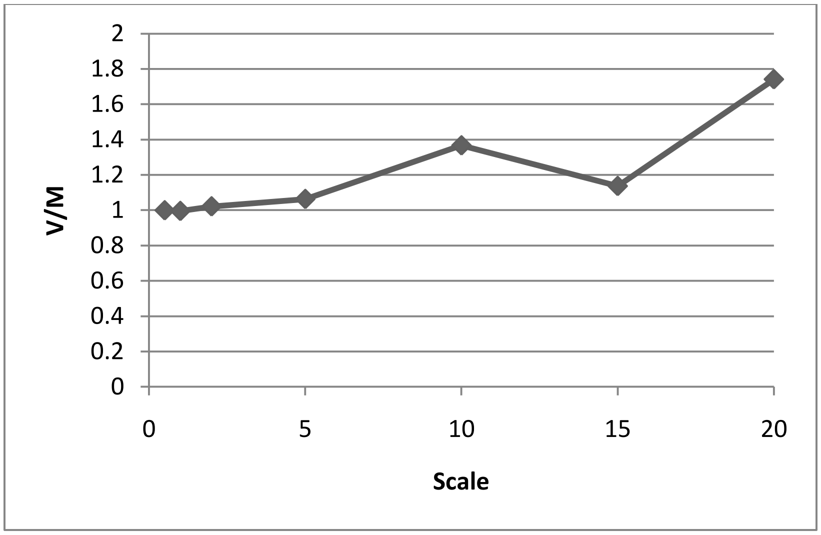


Figure 9: Variance to mean ratio by scale for Year 2 Summer

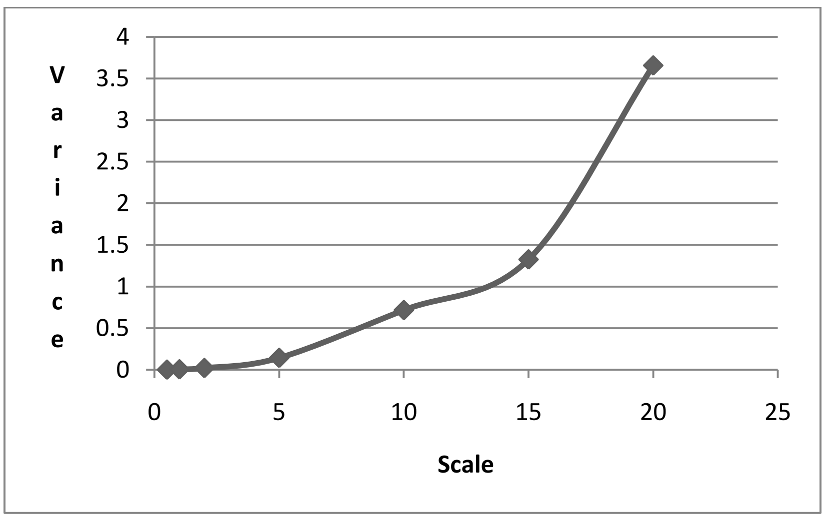


Figure 10: Variance by scale for Year 2 Summer

Table 61: Variance to Mean Ratio by Scale for Summer

Scale	Mean	Variance
.5	0.001343	0.001341
1	0.005385	0.005357
2	0.021538	0.021096
5	0.134615	0.143052
10	0.525	0.717308
15	1.166667	1.325529
20	2.1	3.655556

Table 62: Expected and Observed Salamanders per Quadrat. 0.5 m Scale. Summer

Classes	Expected	Observed
0	15619.00958	15619
1	20.97632986	21
2	0.014085606	0
3	6.30566E-06	0
4	2.11712E-09	0
5	5.6866E-13	0
6	1.27285E-16	0
7	2.44205E-20	0
8	4.0996E-24	0
9	6.11751E-28	0
10	8.21581E-32	0
11	1.00308E-35	0
12	1.12261E-39	0
13	1.15974E-43	0
14	1.11252E-47	0
15	9.9608E-52	0
16	8.36084E-56	0
17	6.60507E-60	0
18	4.92811E-64	0
19	3.4834E-68	0
20	2.3391E-72	0
21	1.49591E-76	0

Table 63: X^2 Analysis: 0.5 m Scale for Summer

Classes	Expected	Observed	P	Pattern
0	15619.01	15619		
1 or more	20.99042	21		
			0.99	**Random**

Table 64: Expected and Observed Salamanders per Quadrat. 1.0 m Scale, Summer

Classes	Expected	Observed
	3879.054945	3879
1	20.8898746	21
2	0.056249121	0
3	0.000100973	0
4	1.35942E-07	0
5	1.46418E-10	0
6	1.31417E-13	0
7	1.01103E-16	0
8	6.80589E-20	0
9	4.07241E-23	0
10	2.19312E-26	0
11	1.07369E-29	0
12	4.81845E-33	0
13	1.99606E-36	0
14	7.67814E-40	0
15	2.75661E-43	0
16	9.27822E-47	0
17	2.93918E-50	0
18	8.79353E-54	0
19	2.49241E-57	0
20	6.71119E-61	0
2	1.72104E-64	0

Table 65: X^2 Analysis: 1.0 m Scale for Summer

Classes	Expected	Observed	P	Pattern
0	3879.055	3879		
1 or more	20.94622	21		
			0.99	**Random**

Table 66: Expected and Observed Salamanders per Quadrat. 2.0 m Scale, Summer

Classes	Expected	Observed
0	954.2249793	954
1	20.5520976	21
2	0.221325539	0
3	0.00158897	0
4	8.55581E-06	0
5	3.6855E-08	0
6	1.32297E-10	0
7	4.07059E-13	0
8	1.09591E-15	0
9	2.62262E-18	0
10	5.64861E-21	0
11	1.106E-23	0
12	1.98508E-26	0
13	3.28882E-29	0
14	5.05962E-32	0
15	7.26494E-35	0
16	9.77951E-38	0
17	1.23901E-40	0
18	1.48254E-43	0
19	1.68058E-46	0
20	1.80981E-49	0
21	1.85618E-52	0

Table 67: X^2 Analysis: 2.0 m Scale for Summer

Classes	Expected	Observed	P	Pattern
0	954.225	954		
1 or more than 1	20.77502	21		
			0.96	**Random**

Table 68: Expected and Observed Salamanders per Quadrat. 5.0 m Scale, Summer

Classes	Expected	Observed
0	136.3521677	137
1	18.35504705	17
2	1.23543233	2
3	0.055435908	0
4	0.001865626	0
5	5.02283E-05	0
6	1.12691E-06	0
7	2.16713E-08	0
8	3.64661E-10	0
9	5.45431E-12	0
10	7.34232E-14	0
11	8.98534E-16	0
12	1.00797E-17	0
13	1.04375E-19	0
14	1.0036E-21	0
15	9.00667E-24	0
16	7.57771E-26	0
17	6.00043E-28	0
18	4.48749E-30	0
19	3.17938E-32	0
20	2.13996E-34	0
21	1.37177E-36	0

Table 69: X^2 Analysis: 5.0 m Scale for Summer

Classes	Expected	Observed	P	Pattern
0	136.3522	137		
1	18.35505	17		
2 or more	1.292785	2		
			0.78	**Random**

Table 70: Expected and Observed Salamanders per Quadrat. 10.0 m Scale, Summer

Classes	Expected	Observed
0	136.3521677	137
1	18.35504705	17
2	1.23543233	2
3	0.055435908	0
4	0.001865626	0
5	5.02283E-05	0
6	1.12691E-06	0
7	2.16713E-08	0
8	3.64661E-10	0
9	5.45431E-12	0
10	7.34232E-14	0
11	8.98534E-16	0
12	1.00797E-17	0
13	1.04375E-19	0
14	1.0036E-21	0
15	9.00667E-24	0
16	7.57771E-26	0
17	6.00043E-28	0
18	4.48749E-30	0
19	3.17938E-32	0
20	2.13996E-34	0
21	1.37177E-36	0

Table 71: X^2 Analysis: 10.0 m Scale for Summer

Classes	Expected	Observed	P	Pattern
0	23.66221	26		
1	12.42266	9		
2 or more	3.915123	5		
			0.47	**Random**

Table 72: Expected and Observed Salamanders per Quadrat. 15.0 m Scale, Summer

Classes	Expected	Observed
0	5.605256158	6
1	6.539467386	6
2	3.814690399	4
3	1.483491134	1
4	0.432685038	1
5	0.100959871	0
6	0.019631092	0
7	0.00327185	0
8	0.000477145	0
9	6.18521E-05	0
10	7.21608E-06	0
11	7.65342E-07	0
12	7.44083E-08	0
13	6.67767E-09	0
14	5.56473E-10	0
15	4.32812E-11	0
16	3.15592E-12	0
17	2.16583E-13	0
18	1.40378E-14	0
19	8.6197E-16	0
20	5.02816E-17	0
21	2.79342E-18	0

Table 73: X^2 Analysis: 15.0 m Scale for Summer

Classes	Expected	Observed	P	Pattern
0	5.605256	6		
1	6.539467	6		
2	3.81469	4		
3 or more	2.040586	2		
			0.99	**Random**

Table 74: Expected and Observed Salamanders per Quadrat. 20.0 m Scale, Summer

Classes	Expected	Observed
0	1.224564281	2
1	2.57158499	3
2	2.70016424	1
3	1.890114968	2
4	0.992310358	1
5	0.41677035	0
6	0.145869623	1
7	0.043760887	0
8	0.011487233	0
9	0.002680354	0
10	0.000562874	0
11	0.000107458	0
12	1.88051E-05	0
13	3.03775E-06	0
14	4.55663E-07	0
15	6.37928E-08	0
16	8.3728E-09	0
17	1.03429E-09	0
18	1.20667E-10	0
19	1.33369E-11	0
20	1.40037E-12	0
21	1.40037E-13	0

Table 75: X^2 Analysis: 20.0 m Scale for Summer

Classes	Expected	Observed	P	Pattern
0	1.224564	2		
1	2.571585	3		
2	2.700164	1		
3	1.890115	2		
4 or more	1.613572	2		
			0.78	**Random**

Table 76: Calculations of Expected Values. 0.5 m Scale. Summer

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.998657901	15619.00958
1	0.001341198	20.97632986
2	9.00614E-07	0.014085606
3	4.03175E-10	6.30566E-06
4	1.35366E-13	2.11712E-09
5	3.63593E-17	5.6866E-13
6	8.13842E-21	1.27285E-16
7	1.56141E-24	2.44205E-20
8	2.62123E-28	4.0996E-24
9	3.91145E-32	6.11751E-28
10	5.25308E-36	8.21581E-32
11	6.41353E-40	1.00308E-35
12	7.17781E-44	1.12261E-39
13	7.41523E-48	1.15974E-43
14	7.11332E-52	1.11252E-47
15	6.3688E-56	9.9608E-52
16	5.34581E-60	8.36084E-56
17	4.22319E-64	6.60507E-60
18	3.15097E-68	4.92811E-64
19	2.22724E-72	3.4834E-68
20	1.49559E-76	2.3391E-72
21	9.56465E-81	1.49591E-76

Table 77: Calculations of Expected Values. 1.0 m Scale. Summer

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.994629473	3879.054945
1	0.005356378	20.8898746
2	1.44229E-05	0.056249121
3	2.58905E-08	0.000100973
4	3.4857E-11	1.35942E-07
5	3.75431E-14	1.46418E-10
6	3.36968E-17	1.31417E-13
7	2.59239E-20	1.01103E-16
8	1.7451E-23	6.80589E-20
9	1.04421E-26	4.07241E-23
10	5.62338E-30	2.19312E-26
11	2.75305E-33	1.07369E-29
12	1.2355E-36	4.81845E-33
13	5.11811E-40	1.99606E-36
14	1.96875E-43	7.67814E-40
15	7.06822E-47	2.75661E-43
16	2.37903E-50	9.27822E-47
17	7.53635E-54	2.93918E-50
18	2.25475E-57	8.79353E-54
19	6.39079E-61	2.49241E-57
20	1.72082E-64	6.71119E-61
21	4.41291E-68	1.72104E-64

Table 78: Calculations of Expected Values. 2.0 m Scale. Summer

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.978692286	954.2249793
1	0.021079074	20.5520976
2	0.000227001	0.221325539
3	1.62971E-06	0.00158897
4	8.77519E-09	8.55581E-06
5	3.78E-11	3.6855E-08
6	1.35689E-13	1.32297E-10
7	4.17497E-16	4.07059E-13
8	1.12401E-18	1.09591E-15
9	2.68987E-21	2.62262E-18
10	5.79344E-24	5.64861E-21
11	1.13436E-26	1.106E-23
12	2.03598E-29	1.98508E-26
13	3.37315E-32	3.28882E-29
14	5.18935E-35	5.05962E-32
15	7.45122E-38	7.26494E-35
16	1.00303E-40	9.77951E-38
17	1.27078E-43	1.23901E-40
18	1.52055E-46	1.48254E-43
19	1.72367E-49	1.68058E-46
20	1.85622E-52	1.80981E-49
21	1.90377E-55	1.85618E-52

Table 79: Calculations of Expected Values. 5.0 m Scale. Summer

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.874052357	136.3521677
1	0.117660558	18.35504705
2	0.007919438	1.23543233
3	0.000355358	0.055435908
4	1.19591E-05	0.001865626
5	3.21976E-07	5.02283E-05
6	7.2238E-09	1.12691E-06
7	1.38919E-10	2.16713E-08
8	2.33757E-12	3.64661E-10
9	3.49635E-14	5.45431E-12
10	4.70662E-16	7.34232E-14
11	5.75983E-18	8.98534E-16
12	6.46133E-20	1.00797E-17
13	6.69071E-22	1.04375E-19
14	6.43335E-24	1.0036E-21
15	5.77351E-26	9.00667E-24
16	4.8575E-28	7.57771E-26
17	3.84643E-30	6.00043E-28
18	2.87659E-32	4.48749E-30
19	2.03807E-34	3.17938E-32
20	1.37177E-36	2.13996E-34
21	8.79339E-39	1.37177E-36

Table 80: Calculations of Expected Values. 10.0 m Scale. Summer

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.591555364	23.66221457
1	0.310566566	12.42266265
2	0.081523724	3.260948945
3	0.014266652	0.570666065
4	0.001872498	0.074899921
5	0.000196612	0.007864492
6	1.72036E-05	0.000688143
7	1.29027E-06	5.16107E-05
8	8.46738E-08	3.38695E-06
9	4.93931E-09	1.97572E-07
10	2.59314E-10	1.03725E-08
11	1.23763E-11	4.95053E-10
12	5.41465E-13	2.16586E-11
13	2.18668E-14	8.74674E-13
14	8.20006E-16	3.28003E-14
15	2.87002E-17	1.14801E-15
16	9.41726E-19	3.7669E-17
17	2.90827E-20	1.16331E-18
18	8.48246E-22	3.39298E-20
19	2.34384E-23	9.37535E-22
20	6.15257E-25	2.46103E-23
21	1.53814E-26	6.15257E-25

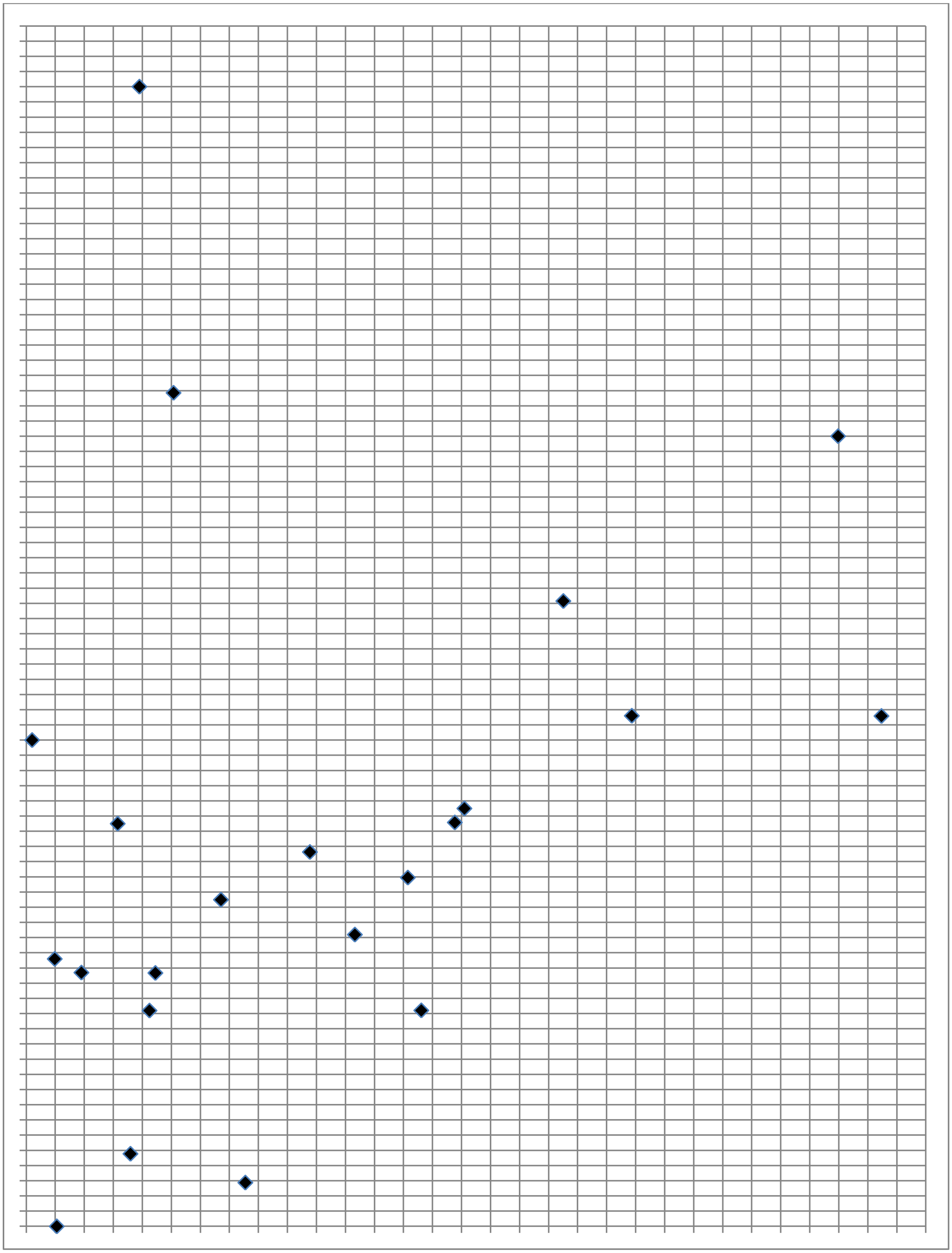
Table 81: Calculations of Expected Values. 15.0 m Scale. Summer

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.31140312	5.605256158
1	0.363303744	6.539467386
2	0.211927244	3.814690399
3	0.082416174	1.483491134
4	0.024038058	0.432685038
5	0.005608882	0.100959871
6	0.001090616	0.019631092
7	0.000181769	0.00327185
8	2.6508E-05	0.000477145
9	3.43623E-06	6.18521E-05
10	4.00894E-07	7.21608E-06
11	4.2519E-08	7.65342E-07
12	4.1338E-09	7.44083E-08
13	3.70982E-10	6.67767E-09
14	3.09152E-11	5.56473E-10
15	2.40451E-12	4.32812E-11
16	1.75329E-13	3.15592E-12
17	1.20324E-14	2.16583E-13
18	7.79877E-16	1.40378E-14
19	4.78872E-17	8.6197E-16
20	2.79342E-18	5.02816E-17
21	1.5519E-19	2.79342E-18

Table 82: Calculations of Expected Values. 20.0 m Scale. Summer

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.122456428	1.224564281
1	0.257158499	2.57158499
2	0.270016424	2.70016424
3	0.189011497	1.890114968
4	0.099231036	0.992310358
5	0.041677035	0.41677035
6	0.014586962	0.145869623
7	0.004376089	0.043760887
8	0.001148723	0.011487233
9	0.000268035	0.002680354
10	5.62874E-05	0.000562874
11	1.07458E-05	0.000107458
12	1.88051E-06	1.88051E-05
13	3.03775E-07	3.03775E-06
14	4.55663E-08	4.55663E-07
15	6.37928E-09	6.37928E-08
16	8.3728E-10	8.3728E-09
17	1.03429E-10	1.03429E-09
18	1.20667E-11	1.20667E-10
19	1.33369E-12	1.33369E-11
20	1.40037E-13	1.40037E-12
21	1.40037E-14	1.40037E-13

Figure 11: Spatial coordinate map Year 2 Fall



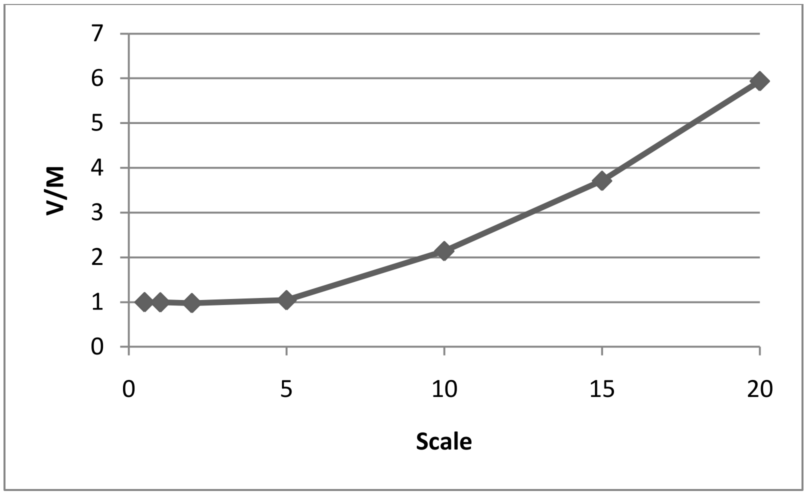


Figure 12: Variance to mean ratio by scale for Year 2 Fall

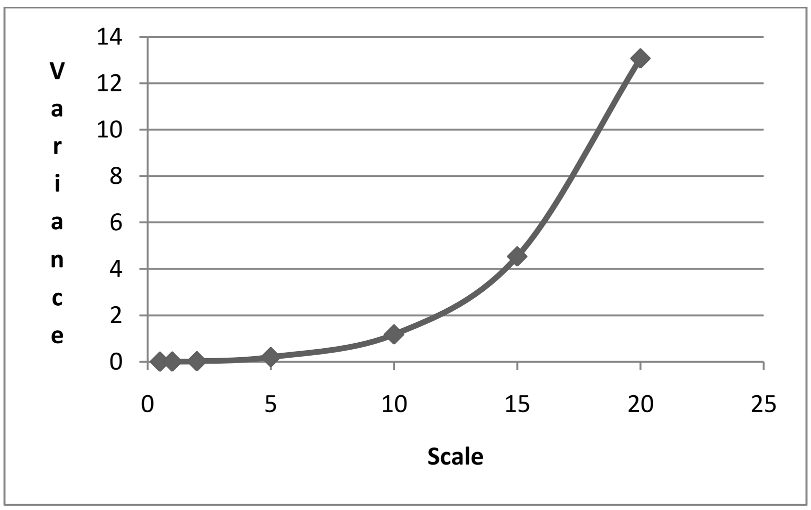


Figure 13: Variance by scale for Year 2 Fall

Table 83: Variance to Mean Ratio by Scale for Fall

Scale	Mean	Variance
.5	0.001407	0.001405
1	0.005641	0.005611
2	0.022564	0.022078
5	0.141026	0.199338
10	0.55	1.176923
15	1.2222	4.535948
20	2.2	13.06667

Table 84: Expected and Observed Salamanders per Quadrat. 0.5 m Scale. Fall

Classes	Expected	Observed
0	15618.00999	15618
1	21.97454006	22
2	0.015459089	0
3	7.25031E-06	0
4	2.5503E-09	0
5	7.17654E-13	0
6	1.6829E-16	0
7	3.38262E-20	0
8	5.94919E-24	0
9	9.30057E-28	0
10	1.30859E-31	0
11	1.67381E-35	0
12	1.96254E-39	0
13	2.12407E-43	0
14	2.13469E-47	0
15	2.00234E-51	0
16	1.76081E-55	0
17	1.45733E-59	0
18	1.13914E-63	0
19	8.43566E-68	0
20	5.93448E-72	0
21	3.9761E-76	0
22	2.5429E-80	0

Table 85: X^2 Analysis: 0.5 m Scale

Classes	Expected	Observed	P	Pattern
0	15618.01	15618		
1 or more	21.99001	22		
			0.99	**Random**

Table 86: Expected and Observed Salamanders per Quadrat. 1.0 m Scale, Fall

Classes	Expected	Observed
0	3878.062034	3878
1	21.87614793	22
2	0.061701675	0
	0.00011602	0
4	1.63617E-07	0
5	1.84592E-10	0
6	1.73548E-13	0
7	1.39855E-16	0
8	9.8615E-20	0
9	6.18097E-23	0
10	3.48669E-26	0
11	1.78804E-29	0
12	8.40526E-33	0
13	3.64723E-36	0
14	1.46958E-39	0
15	5.52658E-43	0
16	1.94847E-46	0
17	6.46547E-50	0
18	2.02621E-53	0
19	6.0157E-57	0
20	1.69673E-60	0
21	4.55773E-64	0
22	1.16864E-67	0

Table 87: X^2 Analysis: 1.0 m Scale

Classes	Expected	Observed	P	Pattern
0	3878.062	3878		
1 or more	21.93797	22		
			0.98	**Random**

Table 88: Expected and Observed Salamanders per Quadrat. 2.0 m Scale, Fall

Classes	Expected	Observed
0	953.2464465	953
1	21.50905282	22
2	0.242665134	0
3	0.001825165	0
4	1.02958E-05	0
5	4.64627E-08	0
6	1.74731E-10	0
7	5.63232E-13	0
8	1.5886E-15	0
9	3.98279E-18	0
10	8.98676E-21	0
11	1.84343E-23	0
12	3.46626E-26	0
13	6.01636E-29	0
14	9.69666E-32	0
15	1.45864E-34	0
16	2.05704E-37	0
17	2.7303E-40	0
18	3.42258E-43	0
19	4.06459E-46	0
20	4.58567E-49	0
21	4.92719E-52	0
22	5.0535E-55	0

Table 89: X^2 Analysis: 2.0 m Scale

Classes	Expected	Observed	P	Pattern
0	953.2464	953		
1 or more	21.75355	22		
			0.96	**Random**

Table 90: Expected and Observed Salamanders per Quadrat. 5.0 m Scale, Fal

Classes	Expected	Observed
0	135.4808101	139
1	19.10631672	13
2	1.347243711	3
3	0.063332131	1
	0.002232869	0
5	6.29785E-05	0
6	1.48027E-06	0
7	2.98223E-08	0
8	5.25715E-10	0
9	8.23773E-12	0
10	1.16173E-13	0
11	1.48941E-15	0
12	1.75037E-17	0
13	1.89883E-19	0
14	1.91275E-21	0
15	1.79832E-23	0
16	1.58506E-25	0
17	1.31491E-27	0
18	1.0302E-29	0
19	7.64659E-32	0
20	5.39184E-34	0
21	3.6209E-36	0
22	2.3211E-38	0

Table 91: X^2 Analysis: 5.0 m Scale

Classes	Expected	Observed	P	Pattern
0	135.4808	139		
1	19.10632	13		
2 or more	1.412873	4		
			0.03	**Clumped**

1

Table 92: Expected and Observed Salamanders per Quadrat. 10.0 m Scale, Fall

Classes	Expected	Observed
0	23.07799241	29
1	12.69289582	5
2	3.490546352	3
3	0.639933498	1
4	0.087990856	2
5	0.009678994	0
6	0.000887241	0
7	6.97118E-05	0
8	4.79269E-06	0
9	2.92886E-07	0
10	1.61088E-08	0
11	8.05438E-10	0
12	3.69159E-11	0
13	1.56183E-12	0
14	6.13575E-14	0
15	2.24977E-15	0
16	7.7336E-17	0
17	2.50205E-18	0
18	7.64514E-20	0
19	2.21307E-21	0
20	6.08593E-23	0
21	1.59393E-24	0
22	3.98484E-26	0

Table 93: X^2 Analysis: 10.0 m Scale

Classes	Expected	Observed	P	Pattern
0	23.07799	29		
1	12.6929	5		
2 or more	4.229112	6		
			0.03	**Clumped**

2

Table 94: Expected and Observed Salamanders per Quadrat. 15.0 m Scale, Fall

Classes	Expected	Observed
0	5.302464737	11
1	6.480672402	2
2	3.960338905	1
3	1.61344207	2
4	0.492987224	1
5	0.120505797	0
6	0.024547031	0
7	0.004285912	0
8	0.00065478	1
9	8.89191E-05	0
10	1.08677E-05	0
11	1.2075E-06	0
12	1.22984E-07	0
13	1.15624E-08	0
14	1.0094E-09	0
15	8.22455E-11	0
16	6.28253E-12	0
17	4.51677E-13	0
18	3.06689E-14	0
19	1.97282E-15	0
20	1.20559E-16	0
21	7.01652E-18	0
22	3.898E-19	0

Table 95: X^2 Analysis: 15.0 m Scale

Classes	Expected	Observed	P	Pattern
0	5.302465	11		
1	6.480672	2		
2	3.960339	1		
3 or more	2.256524	4		
			0.005	**Clumped**

Table 96: Expected and Observed Salamanders per Quadrat. 20.0 m Scale, Fall

Classes	Expected	Observed
0	1.108031582	4
1	2.437669481	1
2	2.681436429	3
3	1.966386715	1
4	1.081512693	0
5	0.475865585	0
6	0.174484048	0
7	0.054837844	0
8	0.015080407	0
9	0.003686322	0
10	0.000810991	0
11	0.000162198	0
12	2.97363E-05	1
13	5.0323E-06	0
14	7.9079E-07	0
15	1.15983E-07	0
16	1.59476E-08	0
17	2.06381E-09	0
18	2.52243E-10	0
19	2.92071E-11	0
20	3.21278E-12	0
21	3.36577E-13	0
22	3.36577E-14	0

Table 97: X^2 Analysis: 20.0 m Scale for Fall

Classes	Expected	Observed	P	Pattern
0	1.108032	4		
1	2.437669	1		
2	2.681436	3		
3	1.966387	1		
4 or more	1.806476	1		
			0.05	**Clumped**

Table 98: Calculations of Expected Values. 0.5 m Scale. Fall

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.998593989	15618.00999
1	0.001405022	21.97454006
2	9.88433E-07	0.015459089
3	4.63575E-10	7.25031E-06
4	1.63062E-13	2.5503E-09
5	4.58858E-17	7.17654E-13
6	1.07602E-20	1.6829E-16
7	2.1628E-24	3.38262E-20
8	3.80383E-28	5.94919E-24
9	5.94666E-32	9.30057E-28
10	8.36694E-36	1.30859E-31
11	1.07021E-39	1.67381E-35
12	1.25482E-43	1.96254E-39
13	1.3581E-47	2.12407E-43
14	1.36489E-51	2.13469E-47
15	1.28027E-55	2.00234E-51
16	1.12584E-59	1.76081E-55
17	9.31794E-64	1.45733E-59
18	7.28353E-68	1.13914E-63
19	5.39364E-72	8.43566E-68
20	3.79443E-76	5.93448E-72
21	2.54227E-80	3.9761E-76
22	1.6259E-84	2.5429E-80

Table 99: Calculations of Expected Values. 1.0 m Scale. Fall

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.994374881	3878.062034
1	0.005609269	21.87614793
2	1.58209E-05	0.061701675
3	2.97486E-08	0.00011602
4	4.1953E-11	1.63617E-07
5	4.73314E-14	1.84592E-10
6	4.44994E-17	1.73548E-13
7	3.58602E-20	1.39855E-16
8	2.52859E-23	9.8615E-20
9	1.58486E-26	6.18097E-23
10	8.94022E-30	3.48669E-26
11	4.58471E-33	1.78804E-29
12	2.15519E-36	8.40526E-33
13	9.35188E-40	3.64723E-36
14	3.76814E-43	1.46958E-39
15	1.41707E-46	5.52658E-43
16	4.99607E-50	1.94847E-46
17	1.65781E-53	6.46547E-50
18	5.1954E-57	2.02621E-53
19	1.54249E-60	6.0157E-57
20	4.35058E-64	1.69673E-60
21	1.16865E-67	4.55773E-64
22	2.99652E-71	1.16864E-67

Table 100: Calculations of Expected Values. 2.0 m Scale. Fall

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.977688663	953.2464465
1	0.022060567	21.50905282
2	0.000248887	0.242665134
3	1.87196E-06	0.001825165
4	1.05598E-08	1.02958E-05
5	4.7654E-11	4.64627E-08
6	1.79211E-13	1.74731E-10
7	5.77674E-16	5.63232E-13
8	1.62933E-18	1.5886E-15
9	4.08491E-21	3.98279E-18
10	9.21719E-24	8.98676E-21
11	1.8907E-26	1.84343E-23
12	3.55514E-29	3.46626E-26
13	6.17063E-32	6.01636E-29
14	9.94529E-35	9.69666E-32
15	1.49604E-37	1.45864E-34
16	2.10979E-40	2.05704E-37
17	2.80031E-43	2.7303E-40
18	3.51034E-46	3.42258E-43
19	4.16881E-49	4.06459E-46
20	4.70325E-52	4.58567E-49
21	5.05353E-55	4.92719E-52
22	5.18308E-58	5.0535E-55

Table 101: Calculations of Expected Values. 5.0 m Scale. Fall

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.868466731	135.4808101
1	0.122476389	19.10631672
2	0.008636178	1.347243711
3	0.000405975	0.063332131
4	1.43133E-05	0.002232869
5	4.03708E-07	6.29785E-05
6	9.4889E-09	1.48027E-06
7	1.91169E-10	2.98223E-08
8	3.36997E-12	5.25715E-10
9	5.28059E-14	8.23773E-12
10	7.44701E-16	1.16173E-13
11	9.54748E-18	1.48941E-15
12	1.12204E-19	1.75037E-17
13	1.2172E-21	1.89883E-19
14	1.22612E-23	1.91275E-21
15	1.15277E-25	1.79832E-23
16	1.01606E-27	1.58506E-25
17	8.4289E-30	1.31491E-27
18	6.60386E-32	1.0302E-29
19	4.90166E-34	7.64659E-32
20	3.45631E-36	5.39184E-34
21	2.32109E-38	3.6209E-36
22	1.48788E-40	2.3211E-38

Table 102: Calculations of Expected Values. 10.0 m Scale. Fall

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.57694981	23.07799241
1	0.317322396	12.69289582
2	0.087263659	3.490546352
3	0.015998337	0.639933498
4	0.002199771	0.087990856
5	0.000241975	0.009678994
6	2.2181E-05	0.000887241
7	1.7428E-06	6.97118E-05
8	1.19817E-07	4.79269E-06
9	7.32216E-09	2.92886E-07
10	4.02719E-10	1.61088E-08
11	2.01359E-11	8.05438E-10
12	9.22897E-13	3.69159E-11
13	3.90457E-14	1.56183E-12
14	1.53394E-15	6.13575E-14
15	5.62443E-17	2.24977E-15
16	1.9334E-18	7.7336E-17
17	6.25511E-20	2.50205E-18
18	1.91128E-21	7.64514E-20
19	5.53267E-23	2.21307E-21
20	1.52148E-24	6.08593E-23
21	3.98484E-26	1.59393E-24
22	9.96209E-28	3.98484E-26

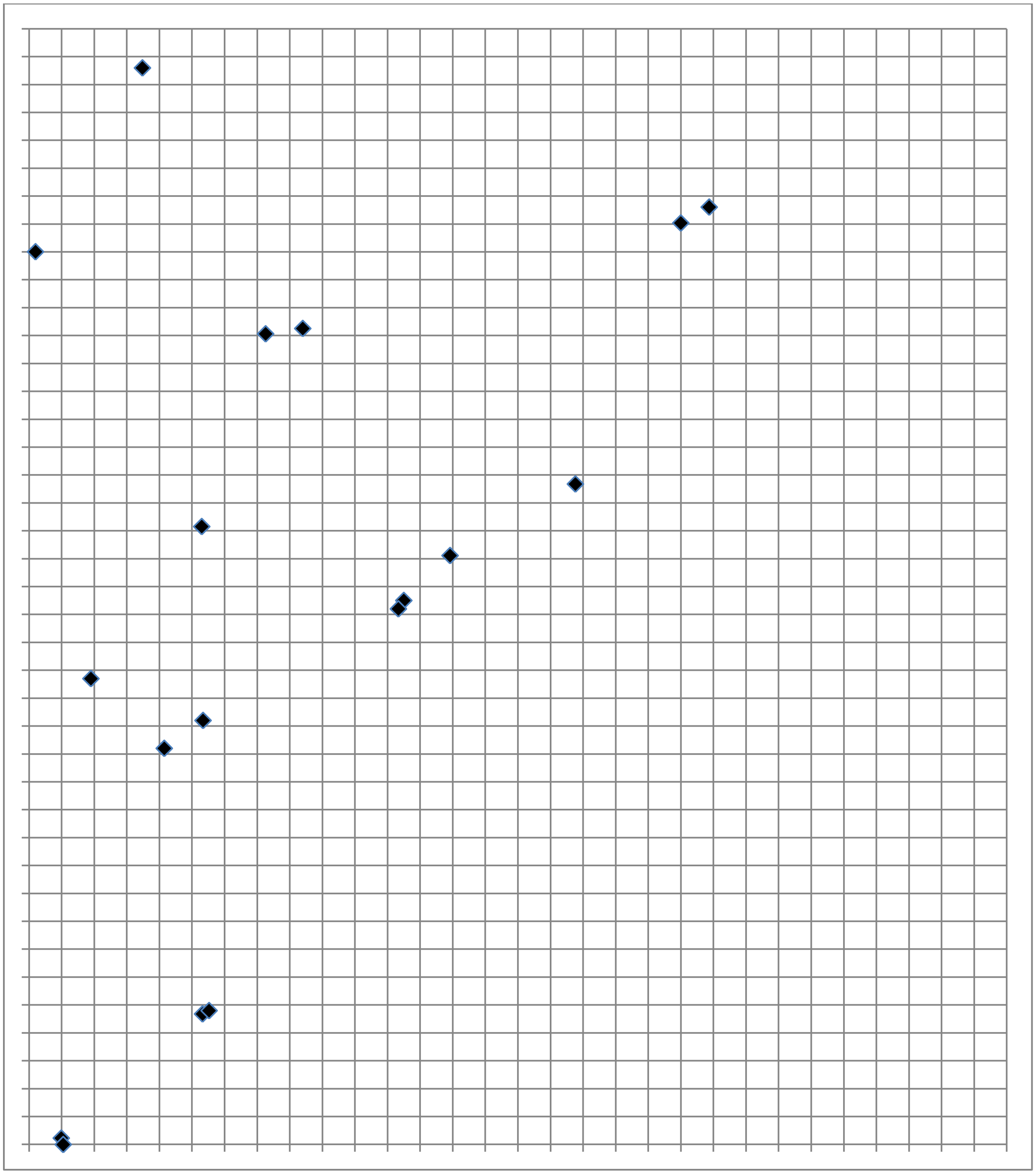
Table 103: Calculations of Expected Values. 15.0 m Scale. Fall

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.294581374	5.302464737
1	0.360037356	6.480672402
2	0.220018828	3.960338905
3	0.089635671	1.61344207
4	0.027388179	0.492987224
5	0.006694767	0.120505797
6	0.001363724	0.024547031
7	0.000238106	0.004285912
8	3.63767E-05	0.00065478
9	4.93995E-06	8.89191E-05
10	6.03761E-07	1.08677E-05
11	6.70833E-08	1.2075E-06
12	6.83244E-09	1.22984E-07
13	6.42354E-10	1.15624E-08
14	5.60775E-11	1.0094E-09
15	4.5692E-12	8.22455E-11
16	3.4903E-13	6.28253E-12
17	2.50932E-14	4.51677E-13
18	1.70383E-15	3.06689E-14
19	1.09601E-16	1.97282E-15
20	6.69771E-18	1.20559E-16
21	3.89807E-19	7.01652E-18
22	2.16555E-20	3.898E-19

Table 104: Calculations of Expected Values. 20.0 m Scale. Fall

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.110803158	1.108031582
1	0.243766948	2.437669481
2	0.268143643	2.681436429
3	0.196638671	1.966386715
4	0.108151269	1.081512693
5	0.047586558	0.475865585
6	0.017448405	0.174484048
7	0.005483784	0.054837844
8	0.001508041	0.015080407
9	0.000368632	0.003686322
10	8.10991E-05	0.000810991
11	1.62198E-05	0.000162198
12	2.97363E-06	2.97363E-05
13	5.0323E-07	5.0323E-06
14	7.9079E-08	7.9079E-07
15	1.15983E-08	1.15983E-07
16	1.59476E-09	1.59476E-08
17	2.06381E-10	2.06381E-09
18	2.52243E-11	2.52243E-10
19	2.92071E-12	2.92071E-11
20	3.21278E-13	3.21278E-12
21	3.36577E-14	3.36577E-13
22	3.36577E-15	3.36577E-14

Figure 15: Spatial coordinate map Year 2 Winter



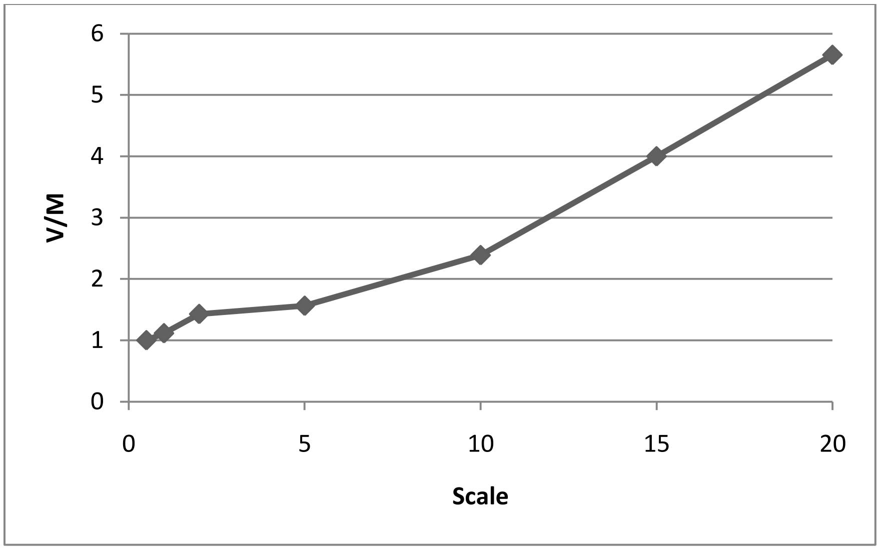


Figure 16: Variance to mean ratio by scale for Year 2 Winter

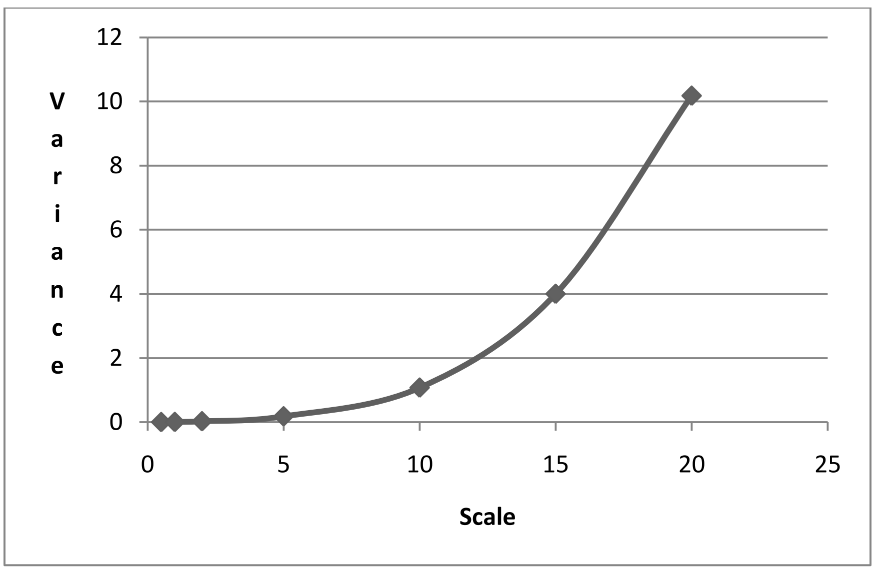


Figure 17: Variance by scale for Year 2 Winter

Table 105: Variance to Mean Ratio by Scale for Winter

Scale	Mean	Variance
.5	0.001151	0.00115
1	0.00436	0.004855
2	0.018462	0.026353
5	0.115385	0.180149
10	0.45	1.074359
15	1	4
20	1.8	10.17778

Table 106: Expected and Observed Salamanders per Quadrat. 0.5 m Scale. Winter

Classes	Expected	Observed
0	15622.00872	15622
1	17.98093203	18
2	0.010348026	0
3	3.97019E-06	0
4	1.14242E-09	0
5	2.62986E-13	0
6	5.04494E-17	0
7	8.29533E-21	0
8	1.19349E-24	0
9	1.52634E-28	0
10	1.75682E-32	0
11	1.83827E-36	0
12	1.76321E-40	0
13	1.56112E-44	0
14	1.28346E-48	0
15	9.84843E-53	0
16	7.08472E-57	0
17	4.79677E-61	0
18	3.06727E-65	0

Table 107: X^2 Analysis: 0.5 m Scale for Winter

Classes	Expected	Observed	P	Pattern
0	15622.01	15622		
1 or more	17.99128	18		
			0.99	**Random**

Table 108: Expected and Observed Salamanders per Quadrat. 1.0 m Scale, Winter

Classes	Expected	Observed
0	3883.033015	3883
1	16.93002394	16
2	0.036907452	1
3	5.36388E-05	0
4	5.84663E-08	0
5	5.09826E-11	0
6	3.70474E-14	0
7	2.30752E-17	0
8	1.2576E-20	0
9	6.09237E-24	0
10	2.65627E-27	0
11	1.05285E-30	0
12	3.82536E-34	0
13	1.28297E-37	0
14	3.99552E-41	0
15	1.16137E-44	0
16	3.16472E-48	0
17	8.11658E-52	0
18	1.96602E-55	0

Table 109: X^2 Analysis: 1.0 m Scale for Winter

Classes	Expected	Observed	P	Pattern
0	3883.033	3883		
1 or more	16.96699	17		
			0.99	**Random**

Table 110: Expected and Observed Salamanders per Quadrat. 2.0 m Scale, Winter

Classes	Expected	Observed
0	957.1646943	961
1	17.67117459	10
2	0.163122613	4
3	0.001003857	0
4	4.6333E-06	0
5	1.7108E-08	0
6	5.26413E-11	0
7	1.38838E-13	0
8	3.20403E-16	0
9	6.57253E-19	0
10	1.21342E-21	0
11	2.03656E-24	0
12	3.13325E-27	0
13	4.44969E-30	0
14	5.86787E-33	0
15	7.22218E-36	0
16	8.33349E-39	0
17	9.05017E-42	0
18	9.28246E-45	0

Table 111: X^2 Analysis: 2.0 m Scale for Winter

Classes	Expected	Observed	P	Pattern
0	957.1647	961		
1 or more	17.83531	14		
			0.36	**Random**

Table 112: Expected and Observed Salamanders per Quadrat. 5.0 m Scale, Winter

Classes	Expected	Observed
0	138.9995933	144
	16.03846807	6
2	0.925299319	6
3	0.035588554	0
4	0.001026596	0
5	2.36908E-05	0
6	4.55593E-07	0
7	7.5098E-09	0
8	1.08315E-10	0
9	1.38866E-12	0
10	1.6023E-14	0
11	1.68074E-16	0
12	1.6161E-18	0
13	1.43442E-20	0
14	1.18221E-22	0
15	9.09399E-25	0
16	6.55818E-27	0
17	4.45127E-29	0
18	2.85339E-31	0

Table 113: X^2 Analysis: 5.0 m Scale for Winter

Classes	Expected	Observed	P	Pattern
0	138.9996	144		
1 or more	17.00041	12		
			0.19	**Random**

Table 114: Expected and Observed Salamanders per Quadrat. 10.0 m Scale, Winter

Classes	Expected	Observed
0	25.50512606	33
1	11.[illegible]730673	0
2	2.582394013	4
3	0.387359102	2
4	0.043577899	1
5	0.003922011	0
6	0.000294151	0
7	1.89097E-05	0
8	1.06367E-06	0
9	5.31835E-08	0
10	2.39326E-09	0
11	9.7906E-11	0
12	3.67148E-12	0
13	1.2709E-13	0
14	4.08502E-15	0
15	1.22551E-16	0
16	3.44674E-18	0
17	9.12371E-20	0
18	2.28093E-21	0

Table 115: X^2 Analysis: 10.0 m Scale for Winter

Classes	Expected	Observed	P	Pattern
0	25.50513	33		
1	11.47731	0		
2 or more	3.017567	7		
			7.7303E-05	**Clumped**

Table 116: Expected and Observed Salamanders per Quadrat. 15.0 m Scale, Winter

Classes	Expected	Observed
0	6.621829937	13
1	6.621829937	1
2	3.310914969	1
3	1.103638323	0
4	0.275909581	2
5	0.055181916	0
6	0.009196986	0
7	0.001313855	1
8	0.000164232	0
9	1.8248E-05	0
10	1.8248E-06	0
11	1.65891E-07	0
12	1.38242E-08	0
13	1.0634E-09	0
14	7.59573E-11	0
15	5.06382E-12	0
16	3.16489E-13	0
17	1.8617E-14	0
18	1.03428E-15	0

Table 117: X^2 Analysis: 15.0 m Scale for Winter

Classes	Expected	Observed	P	Pattern
0	6.62183	13		
1	6.62183	1		
2	3.310915	1		
3 or more	1.445425	3		
			0.003	**Clumped**

Table 118: Expected and Observed Salamanders per Quadrat. 20.0 m Scale, Winter

Classes	Expected	Observed
0	6.621829937	13
1	6.621829937	1
2	3.310914969	1
3	1.103638323	0
4	0.275909581	2
5	0.055181916	0
6	0.009196986	0
7	0.001313855	1
8	0.000164232	0
9	1.8248E-05	0
10	1.8248E-06	0
11	1.65891E-07	0
12	1.38242E-08	0
13	1.0634E-09	0
14	7.59573E-11	0
15	5.06382E-12	0
16	3.16489E-13	0
17	1.8617E-14	0
18	1.03428E-15	0

Table 119: X^2 Analysis: 20.0 m Scale for Winter

Classes	Expected	Observed	P	Pattern
0	1.652989	6		
1	2.97538	0		
2	2.677842	2		
3	1.606705	0		
4 or more	1.087084	2		
			0.002	**Clumped**

Table 120: Calculations of Expected Values. 0.5 m Scale. Winter

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.998849662	15622.00872
1	0.001149676	17.98093203
2	6.61639E-07	0.010348026
3	2.53849E-10	3.97019E-06
4	7.30449E-14	1.14242E-09
5	1.68149E-17	2.62986E-13
6	3.22567E-21	5.04494E-17
7	5.30392E-25	8.29533E-21
8	7.63101E-29	1.19349E-24
9	9.75922E-33	1.52634E-28
10	1.12329E-36	1.75682E-32
11	1.17537E-40	1.83827E-36
12	1.12737E-44	1.76321E-40
13	9.98157E-49	1.56112E-44
14	8.20628E-53	1.28346E-48
15	6.29695E-57	9.84843E-53
16	4.52987E-61	7.08472E-57
17	3.06699E-65	4.79677E-61
18	1.96117E-69	3.06727E-65

Table 121: Calculations of Expected Values. 1.0 m Scale. Winter

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.995649491	3883.033015
1	0.004341032	16.93002394
2	9.46345E-06	0.036907452
3	1.37535E-08	5.36388E-05
4	1.49914E-11	5.84663E-08
5	1.30725E-14	5.09826E-11
6	9.49933E-18	3.70474E-14
7	5.91672E-21	2.30752E-17
8	3.22461E-24	1.2576E-20
9	1.56215E-27	6.09237E-24
10	6.81096E-31	2.65627E-27
11	2.69962E-34	1.05285E-30
12	9.80861E-38	3.82536E-34
13	3.28966E-41	1.28297E-37
14	1.02449E-44	3.99552E-41
15	2.97786E-48	1.16137E-44
16	8.11467E-52	3.16472E-48
17	2.08117E-55	8.11658E-52
18	5.04106E-59	1.96602E-55

Table 122: Calculations of Expected Values. 2.0 m Scale. Winter

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.981707379	957.1646943
1	0.018124282	17.67117459
2	0.000167305	0.163122613
3	1.0296E-06	0.001003857
4	4.7521E-09	4.6333E-06
5	1.75467E-11	1.7108E-08
6	5.39911E-14	5.26413E-11
7	1.42398E-16	1.38838E-13
8	3.28618E-19	3.20403E-16
9	6.74105E-22	6.57253E-19
10	1.24453E-24	1.21342E-21
11	2.08878E-27	2.03656E-24
12	3.21359E-30	3.13325E-27
13	4.56379E-33	4.44969E-30
14	6.01833E-36	5.86787E-33
15	7.40736E-39	7.22218E-36
16	8.54717E-42	8.33349E-39
17	9.28223E-45	9.05017E-42
18	9.52047E-48	9.28246E-45

Table 123: Calculations of Expected Values. 5.0 m Scale. Winter

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.891023034	138.9995933
1	0.102810693	16.03846807
2	0.005931406	0.925299319
3	0.000228132	0.035588554
4	6.58075E-06	0.001026596
5	1.51864E-07	2.36908E-05
6	2.92047E-09	4.55593E-07
7	4.81398E-11	7.5098E-09
8	6.94326E-13	1.08315E-10
9	8.90164E-15	1.38866E-12
10	1.02712E-16	1.6023E-14
11	1.0774E-18	1.68074E-16
12	1.03596E-20	1.6161E-18
13	9.19497E-23	1.43442E-20
14	7.5783E-25	1.18221E-22
15	5.82948E-27	9.09399E-25
16	4.20396E-29	6.55818E-27
17	2.85338E-31	4.45127E-29
18	1.8291E-33	2.85339E-31

Table 124: Calculations of Expected Values. 10.0 m Scale. Winter

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.637628151	25.50512606
1	0.286932668	11.47730673
2	0.06455985	2.582394013
3	0.009683978	0.387359102
4	0.001089447	0.043577899
5	9.80503E-05	0.003922011
6	7.35377E-06	0.000294151
7	4.72742E-07	1.89097E-05
8	2.65918E-08	1.06367E-06
9	1.32959E-09	5.31835E-08
10	5.98315E-11	2.39326E-09
11	2.44765E-12	9.7906E-11
12	9.17869E-14	3.67148E-12
13	3.17724E-15	1.2709E-13
14	1.02126E-16	4.08502E-15
15	3.06377E-18	1.22551E-16
16	8.61684E-20	3.44674E-18
17	2.28093E-21	9.12371E-20
18	5.70232E-23	2.28093E-21

Table 125: Calculations of Expected Values. 15.0 m Scale. Winter

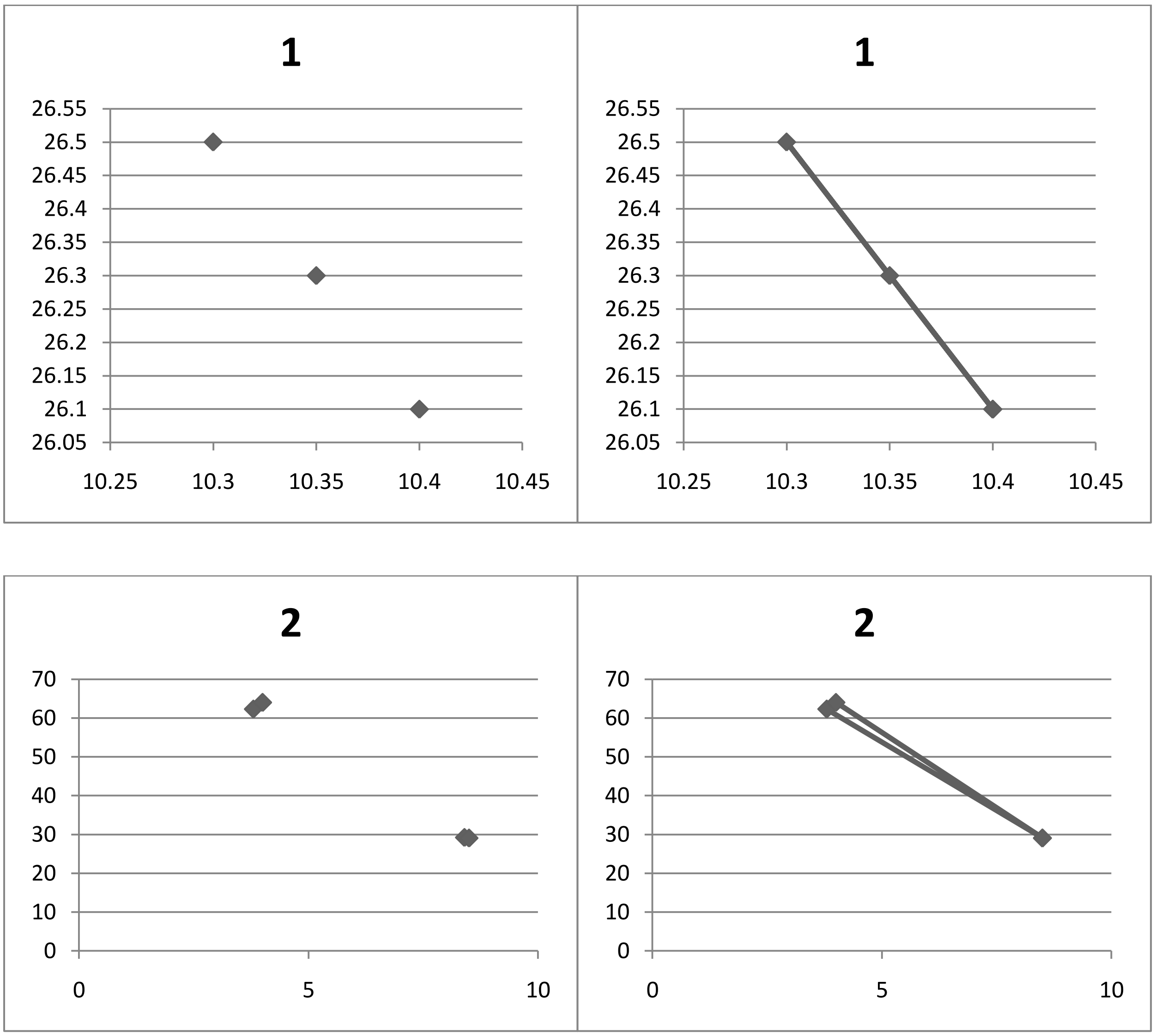
Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.367879441	6.621829937
1	0.367879441	6.621829937
2	0.18393972	3.310914969
3	0.06131324	1.103638323
4	0.01532831	0.275909581
5	0.003065662	0.055181916
6	0.000510944	0.009196986
7	7.2992E-05	0.001313855
8	9.12399E-06	0.000164232
9	1.01378E-06	1.8248E-05
10	1.01378E-07	1.8248E-06
11	9.21616E-09	1.65891E-07
12	7.68013E-10	1.38242E-08
13	5.90779E-11	1.0634E-09
14	4.21985E-12	7.59573E-11
15	2.81323E-13	5.06382E-12
16	1.75827E-14	3.16489E-13
17	1.03428E-15	1.8617E-14
18	5.74599E-17	1.03428E-15

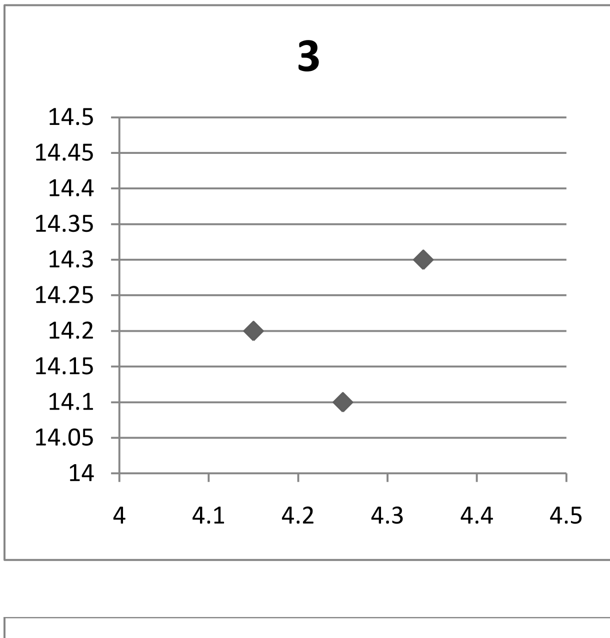
Table 126: Calculations of Expected Values. 20.0 m Scale. Winter

Number per quad (r)	Probability of finding (r) salamanders in a quad	Expected value
0	0.165298888	1.652988881
1	0.297537998	2.975379985
2	0.267784199	2.677841986
3	0.160670519	1.606705192
4	0.072301734	0.723017336
5	0.026028624	0.260286241
6	0.007808587	0.078085872
7	0.002007922	0.020079224
8	0.000451783	0.004517825
9	9.03565E-05	0.000903565
10	1.62642E-05	0.000162642
11	2.66141E-06	2.66141E-05
12	3.99211E-07	3.99211E-06
13	5.52754E-08	5.52754E-07
14	7.10684E-09	7.10684E-08
15	8.52821E-10	8.52821E-09
16	9.59424E-11	9.59424E-10
17	1.01586E-11	1.01586E-10
18	1.01586E-12	1.01586E-11

Below: Dipictions of the home range of animals 1-10. On the left the individual locations where the animals were located are given. To the right the home range is depicted using the Revised Minimum Area Method as taken from Harvery and Barbor 1965. The scale is given in meters.

Figure 18: Home Range Dpections

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14.4
14.35
14.3
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14.1
14.05
14
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4.2
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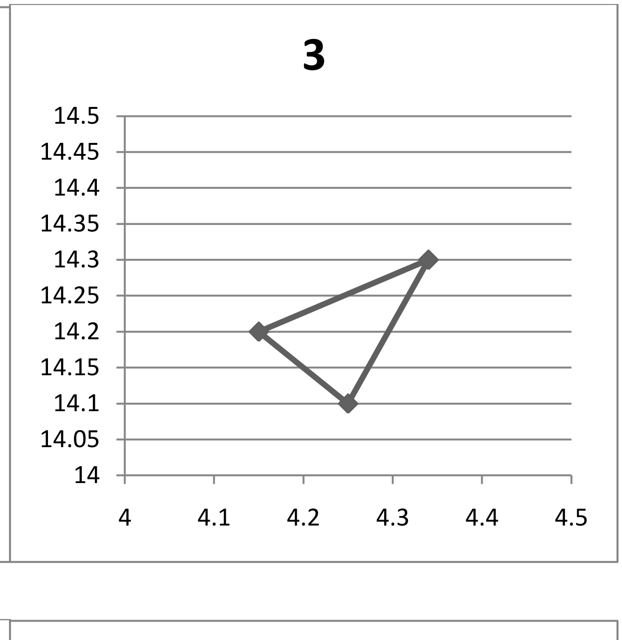
4.4
4.5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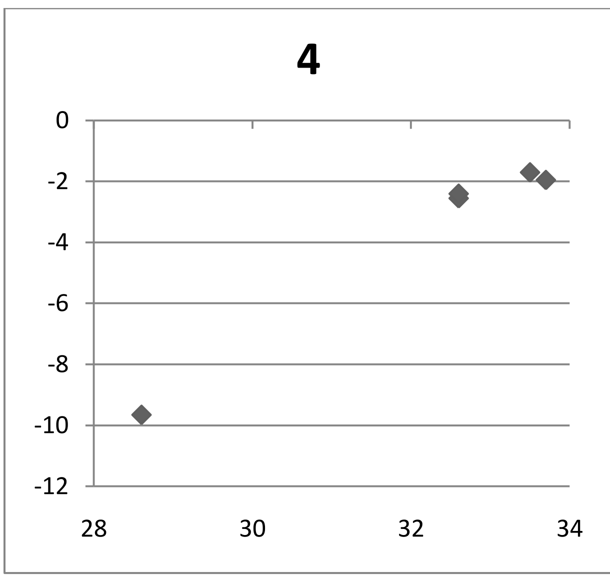
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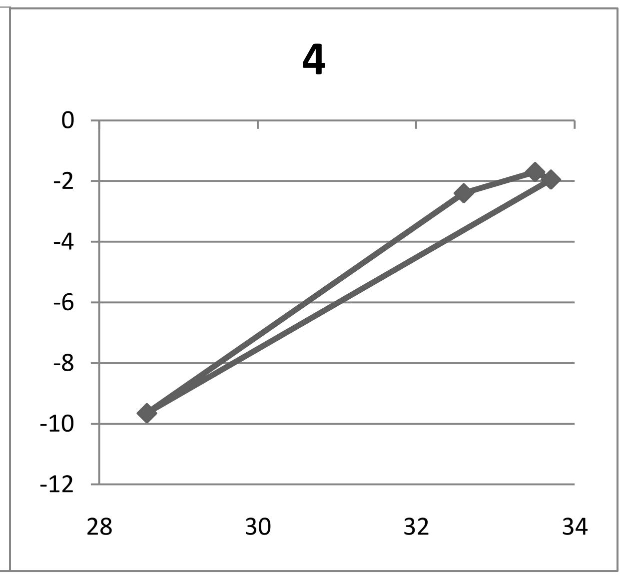
-10
-12
28
30
32
34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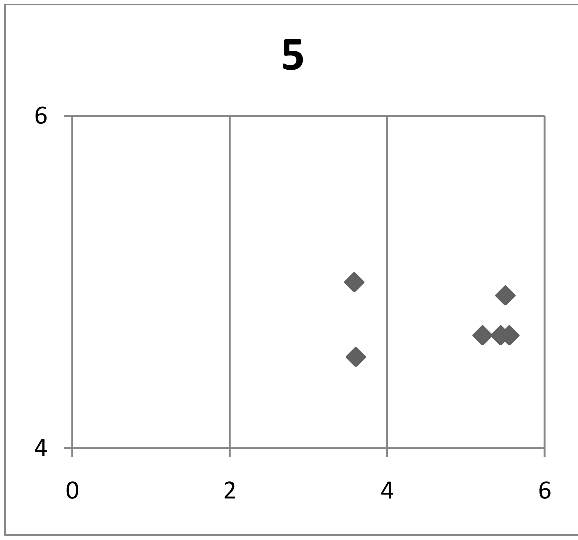
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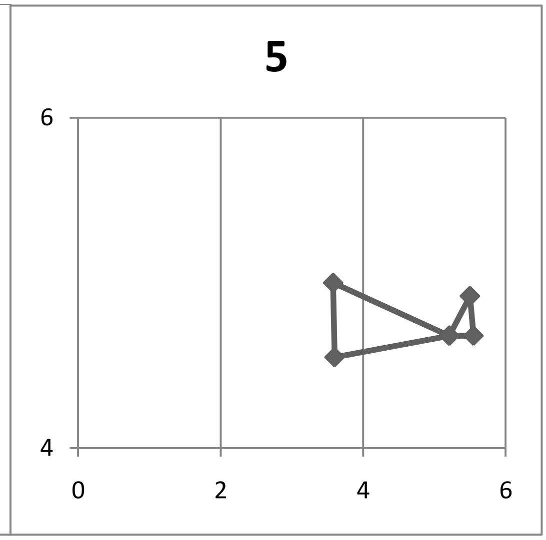
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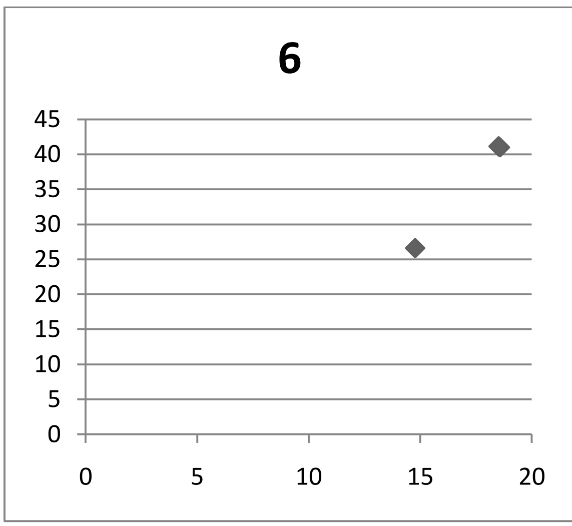
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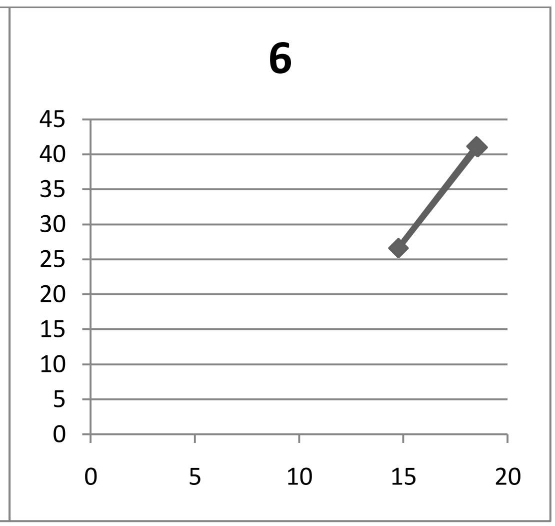
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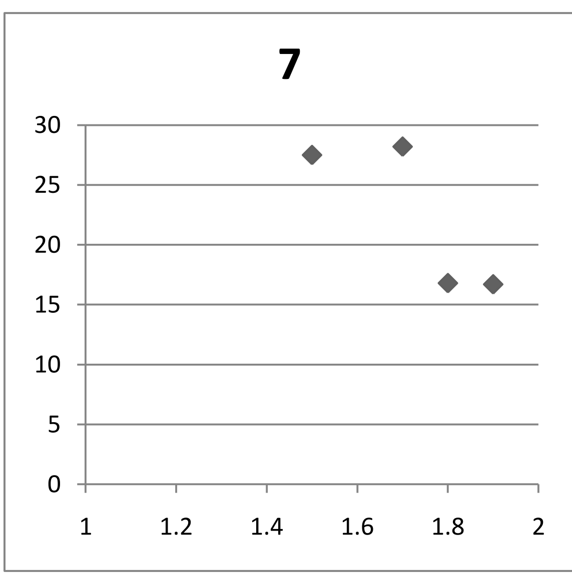
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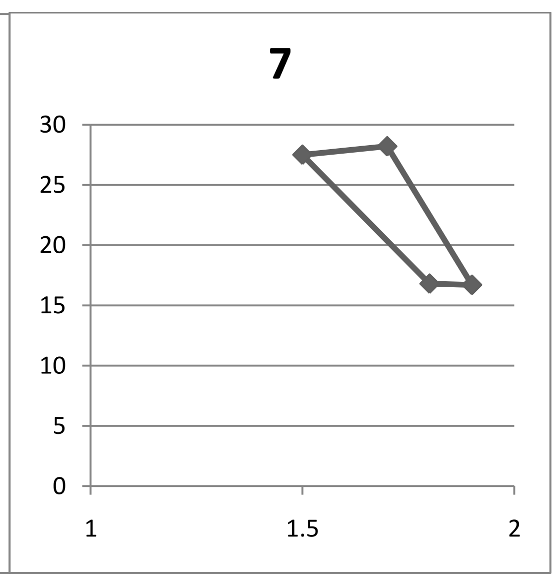
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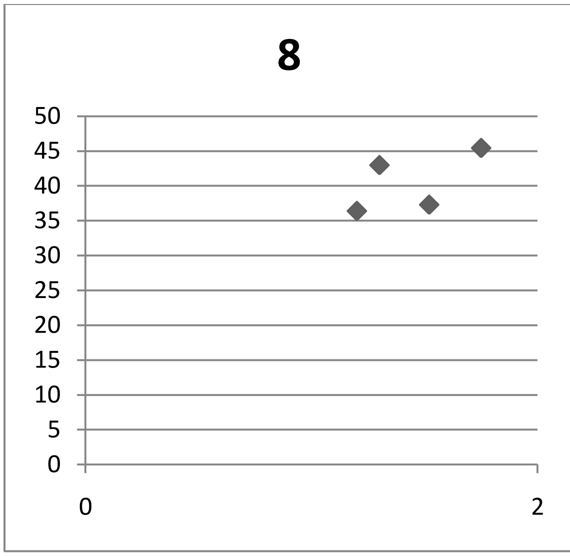
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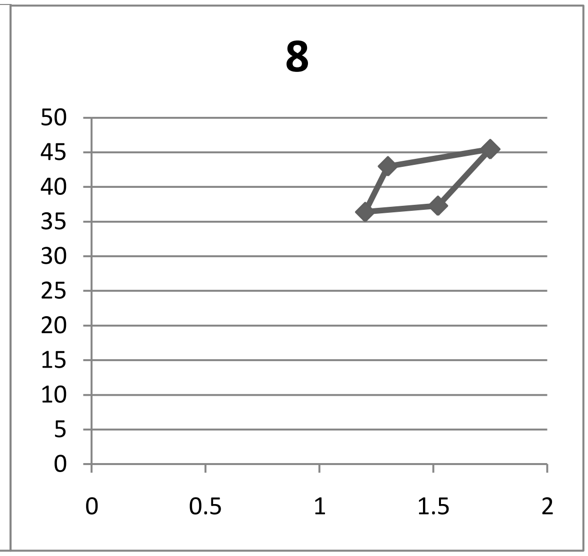
0
2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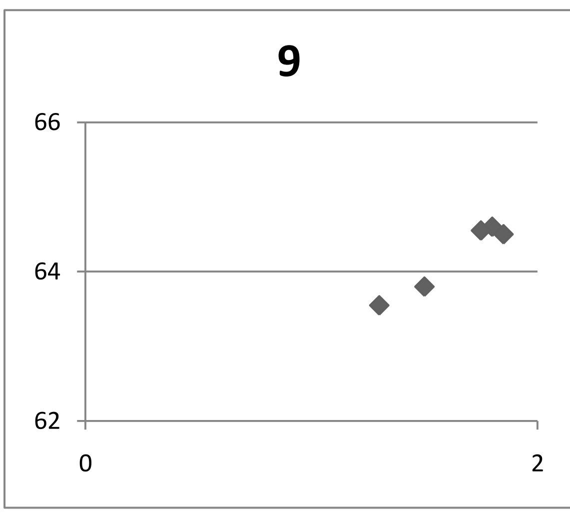
1.5
2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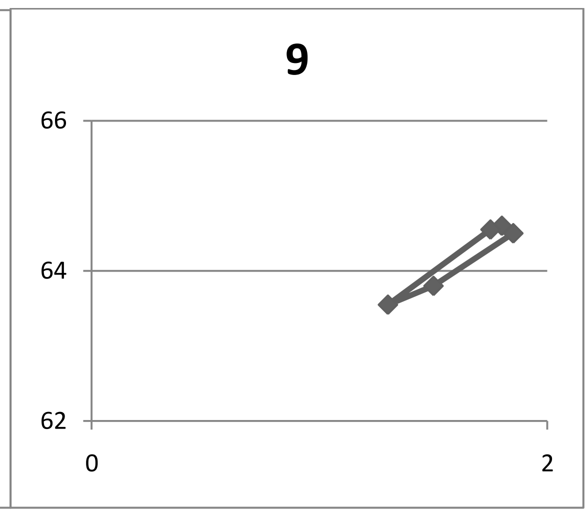
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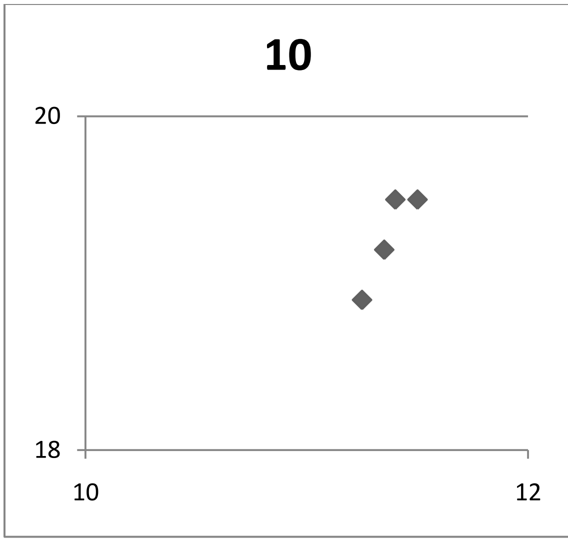
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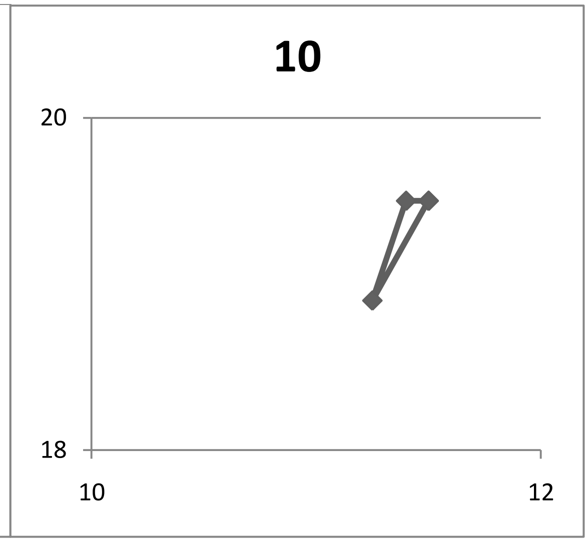
20
18
10
12


10
20
18
10
12

VITA

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