

Investigating the relationship between abiotic factors and species richness at the Fant Wildlife Area, Maidstone, Kent

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Abstract

This investigation examines the following hypothesis: ‘*The nettle is the dominant species of flora in Fant Wildlife Park (Grid reference Sheet 188 TQ 745547) excluding other species; therefore as the percentage cover of nettles increase the species richness should fall. It is expected that several abiotic factors will influence the growth of nettles and therefore species richness.*’

The abiotic data to be collected and analyzed from two transects included light intensity, soil temperature and altitude. Soil samples were also taken from the second transect and tested for moisture content and pH. The transect method aimed to discover patterns in some abiotic factors such as altitude, water content and light which may underlie distribution of flora.

It was found that species richness can be inhibited by abiotic factors that make the local position unsuitable for successful growth. In areas where *Urtica dioica* dominates the species richness decreases as other species can no longer compete with the nettles for resources.

There was little correlation between nettle cover, species richness, altitude, light intensity or soil water content when the survey was carried out.

The key abiotic factor found to affect the percentage cover of nettles in this investigation was soil temperature, with a 0.734 Spearman’s rank correlation coefficient between the two variables (showing a significant correlation where $P < 0.05$). This is thought to be due to the fact that an increase in soil temperature will cause an increase in the metabolic activities of the nettle. This includes the catabolism of the starch in their rhizomes into substrates for respiration and the new growth it drives. This store of nutrients thus provides a natural advantage over the competition that is accentuated by an increase in temperature. Rising soil temperature adds to the effect of light intensity in driving photosynthetic production of hardy generalists like *U. dioica*.

Introduction

When visiting Fant Wildlife Area (see cross hatched area on attached map) in the summer (July 2006, previous unpublished work) it is clear to see that stinging nettles, *Urtica dioica* L, are abundant and some what monopolize the habitat, to the exclusion of many other species in the area. Revisiting in the early spring the scene tells a very different story. Competition is rife between the nettles, which are rapidly establishing themselves, and the numerous other species found in the area. Through a preliminary survey and with the aid of local knowledge it is not hard to deduce many factors that may be important in understanding the area. The area lies on the edge of the river Medway and previously formed part of its flood plain; this was until it was cut off by the embankment from the train track that was laid down between what is now the wildlife park and the river. The area was also formerly an allotment and is

currently in a state of sub-climax from the recent conversion. The combination of the park constituting both a flood plain and allotments in the past leads to the area having incredibly fertile soil. Fertile soil has been noted to be conducive to large nettle populations, even to the extent that a 'presence of nettle signals a fertile soil'¹.

This investigation aims to examine the relationship between Common Nettle, *Urtica dioica*, and other species that may compete with it, as well as taking into account the abiotic factors that may affect their distribution. The significance of the correlation between any of the abiotic factors and species richness can be tested using the Spearman's rank correlation coefficient. This is a test designed to determine whether there is a significant linear correlation between any two sets of data.

Plan

The process that will be used in order to survey the distribution of each species will be to estimate percentage cover of a particular species along two transects across the site. Using percentage cover should provide a clear indication of success of a particular species over the competition, i.e. the more successful a species is, the greater the percentage cover should be. Percentage cover is a useful indicator as it is quick and easy to estimate; an important factor when collecting data in many quadrats. Each transect has a change in altitude of approximately 7m from one side of the park to the other. The transect method will hopefully provide a gradient for a few abiotic factors such as altitude, water content and even light; providing a varied species distribution across the area. A number of readings will also be taken that indicate the abiotic factors that influence that particular quadrat or that transect as a whole. Comparisons will also be made with other transect samples collected in other surveys.

Hypothesis: The nettle is the dominant species of flora in Fant Wildlife Park, excluding other species; therefore as the percentage cover of nettles increase the species richness should fall. It is expected that several abiotic factors will influence the growth of nettles and therefore species richness.

Risk assessment

Before constructing a planned procedure it is important to consider the possible hazards that might arise collecting the data and the ethics involved in such an investigation.

Hazard	Likelihood	Severity	Score	Evasive measure
Tripping (brambles, rabbit holes, uneven ground)	3	2	6	Sensible foot wear and walking carefully
Burns from Giant Hogweed	1	4	4	Be careful not to touch any if found and wear gloves. Report sightings to Fant Wildlife Group for removal.
Stinging from nettles	5	1	5	Wear gloves
Drowning	1	5	5	Avoid working too close to water

Each hazard rated out of 5 for the likelihood of it occurring (1 very unlikely – 5 very likely) and severity (1 minor – 5 fatal). Formulate a score by multiplying the two.

There are few ethical dilemmas in such an investigation as it is only the flora that will be examined; however, as with any ecosystem it is important to keep the impact of data collection to a minimum. This will be achieved mainly in the technique employed, aiming to minimize trampling and avoiding disturbance of rare species. The effect of the trampling in such a habitat is expected to be overcome very quickly.

Equipment

- 0.5m x 0.5m quadrats, single square and 100 square divisions.
- Tape measure (30m)
- Calculator
- Light meter (Phillip Harris 'Logbook')
- Temperature probe (Phillip Harris 'Logbook')
- Ranging poles
- Theodolite
- Gloves
- The Concise British Flora in Colour, W Keble Martin, 1965.

Method

1. Select the location of the transects using the random number generator function on a calculator.
2. Lay down tape measure along the length of the transect
3. Position equipment at one end of the transect.
4. Insert the temperature probe into the ground.
5. Lay down quadrat and estimate as carefully as possible the percentage cover of each species for that transect (including percentage cover of 'other species' noting what those species are believed to be using a suitable key).
6. Note the species richness of the quadrat.
7. Register the light intensity of that quadrat.
8. Note soil temperature having allowed time for the thermometer to equilibrate and once reading is stable.
9. Move on to the next data collection point 2.5m along the transect.
10. Repeat steps 4-7.
11. To measure change in altitude; place a theodolite at data collection point one and stand a ranging pole at the next sample point. Line up the theodolite horizontal by eye and note the level the theodolite comes up to on the ranging pole. Compare this level to the original height of the theodolite and the change in height will equal the change in altitude. See fig. 1

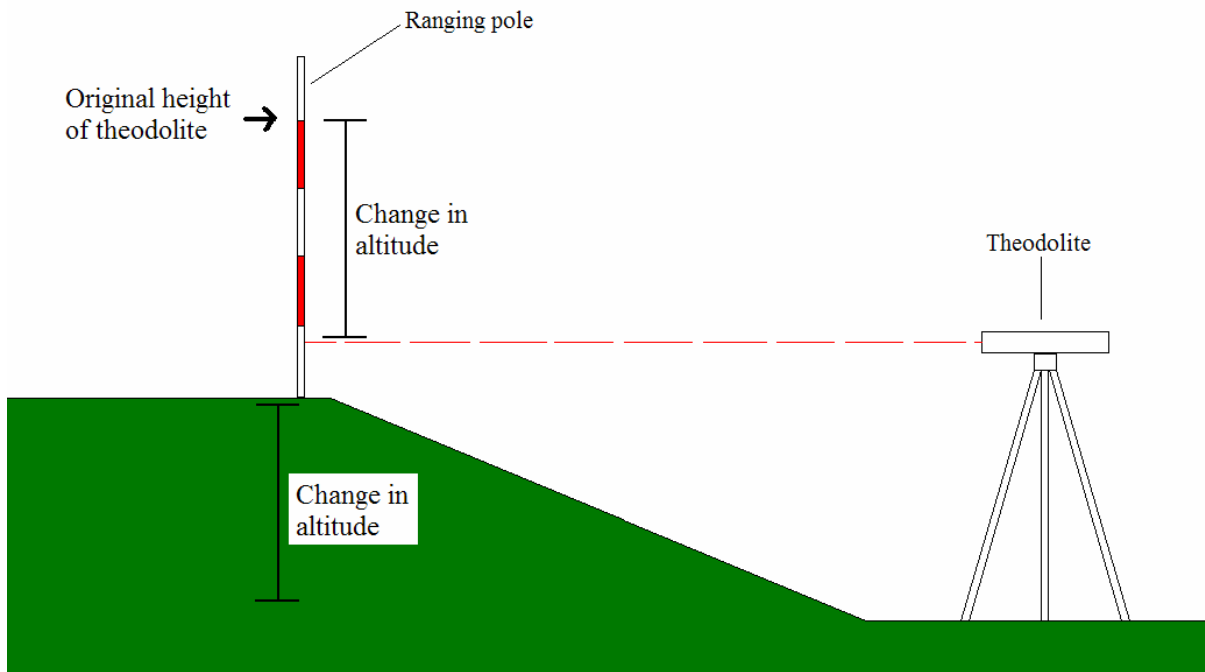


Fig.1

Implementation of investigation into the relationship between abiotic factors and species richness at Fant Wildlife Area.

Equipment

- As in the plan above.

Method

As in plan, with additions as follows:

Two suitable transects were identified spanning the width of the park with no obvious obstacles that would interfere with the collection of data. The tape measure was placed along the length of the transect. At station one, the temperature probe was inserted into the ground. The quadrat was placed to allow estimation of the percentage cover of each species for that quadrat (including percentage cover of 'other species' noting what those species are believed to be using a suitable key). Note the species richness of the quadrat using leaf shape as a diagnostic feature. The light intensity at that quadrat was recorded, ensuring the logbook sensor is level. Soil temperature was noted having allowed time for the thermometer to equilibrate and reading to stabilise. The temperature probe was carefully removed so as to not damage the connections. Move on to the next data collection point which should be a suitable distance along the transect (2.5m intervals where visual examination suggests noticeable differences in the distribution, or at 5m intervals where there is no visible change.) This process was repeated until the transect was complete. Measurement of the change in altitude was done by placing a theodolite at data collection point one and standing a ranging pole at the next sample point. The theodolite is lined up horizontally using the spirit level by eye and then the level on the ranging pole is recorded. Comparison of this level to the original height of the theodolite allows calculation of the change in altitude. Further abiotic factors were measured and the methods for these procedures are referenced in the appendix.

The areas selected for the transects are shown on the attached map.

The method of using a transect, as opposed to random samples, provides a gradient for a few abiotic factors such as altitude, water content and even light; providing a varied species distribution across the area. There is a compromise to be struck when selecting the transect site. Although it would be ideal to take a random transect across anywhere in the park, it is not always either safe or representative. At some places the vegetation is too dense to carry

out the transect safely. At some places there has been overt human management, artificially influencing the vegetation composition. It is therefore important to select a manageable transect that is representative of the park. It would also of course be ideal to take a large number of transects, however, with the time constraints, only two were possible.

To survey the relative success of each species, a 0.5m x 0.5m quadrat was used. The size of the quadrat can have an important influence in the results. 'Different vegetation types require different quadrat sizes. Vegetation with smaller plants, greater plant density or greater species diversity needs smaller quadrats. Increasing the size of quadrat generally results in a lower variance in observations, but more work in getting them.'² There are no definitive guidelines of what size quadrat to use, however, 0.25m² has been recommended for 'grassland, tall herb, short shrub.'²

It is also important to pay due attention to the shape of the quadrat. There are however conflicting problems regarding shape.²

It is useful to try and minimize the circumference for two reasons; to avoid subjective decisions when something lies on the edge of the quadrat, and also to avoid flattening plants when lying down the quadrat which can make it hard to judge accurately percentage cover of species. For the sake of this purpose a circle is most desirable followed by square then rectangle.

However, 'long thin quadrats are better than circular or square ones of the same area. The reason for this is habitat heterogeneity: long quadrat cross more patches.'² For this purpose the ideal quadrat is opposite to the shapes listed above. (i.e. Rectangle is best followed by square and then circle)

In this investigation a traditional square quadrat will be used as a compromise between the above two points and will also make it easier to estimate percentage cover quickly and accurately.

Using percentage cover should provide a clear indication of success of a particular species over the competition, i.e. the more successful a species is, the greater the percentage cover should be. Percentage cover is a useful indicator as it is quick and easy to estimate; an important factor when collecting data in many quadrats.

Species richness has been defined as 'the simplest measure of biodiversity and is simply a count of the number of different species in a given area'³. It differs from species diversity as it does not give any weight to the number of each particular species. It is a simple and effective measure of biodiversity and varies depending on a vast number of factors.



In the example of Fig. 3 it is not hard to estimate the percentage cover in the quadrat shown is made up as follows

- 10% nettle
- 40% grass
- 50% bare ground

This provides a quick indication of the success of each species without the need to count individual organisms.

The species richness is therefore 2.

Fig. 3

An important part of the investigation was to collect data on the abiotic factors present at each quadrat in order to analyze the factors that are important in the success of the various species.

The abiotic data to be collected and analyzed were: light intensity, soil temperature and altitude. Soil samples were also be taken from the second transect and tested for moisture content and pH in the laboratory using a suitable pH indicator.

The investigation will be looking for a correlation between altitude and species richness that has been noted previously as ‘a decrease in species richness with altitude’⁴.

The light intensity was monitored by using an integrated light meter/data logger. It is a quick and straight forward reading to take. Light is of course essential for photosynthesis and may therefore be a limiting factor affecting the rate of which a plant can photosynthesize and become successful and competitive. Too much light however, may lead to desiccation.

Soil temperature can be easily monitored by inserting a soil probe into the ground and using a data logger to note the temperature. The temperature of the soil may have an effect on the metabolic activity of the plants and therefore their enzyme activity. It may also indirectly indicate how saturated the soil is with water, as more water is likely to cause lower temperatures. Too much water in the soil may result in the root network not being exposed to adequate levels of oxygen for aerobic respiration. As with sunlight, water is vital for photosynthesis and may therefore be a limiting factor affecting the rate of which a plant can photosynthesize and become successful and competitive.

The significance of the correlation between any of the abiotic factors and species richness can be tested using the Spearman's rank correlation coefficient. This is a test designed to determine whether there is a significant linear correlation between any two sets of data. It relies on finding the difference between two sets of data, each ranked in ascending order, and using a formula to produce a number indicating the strength of the correlation. The significance of the correlation can be analysed using the correlation coefficient and critical values that depend on the size of the sample.

Results

Analysis

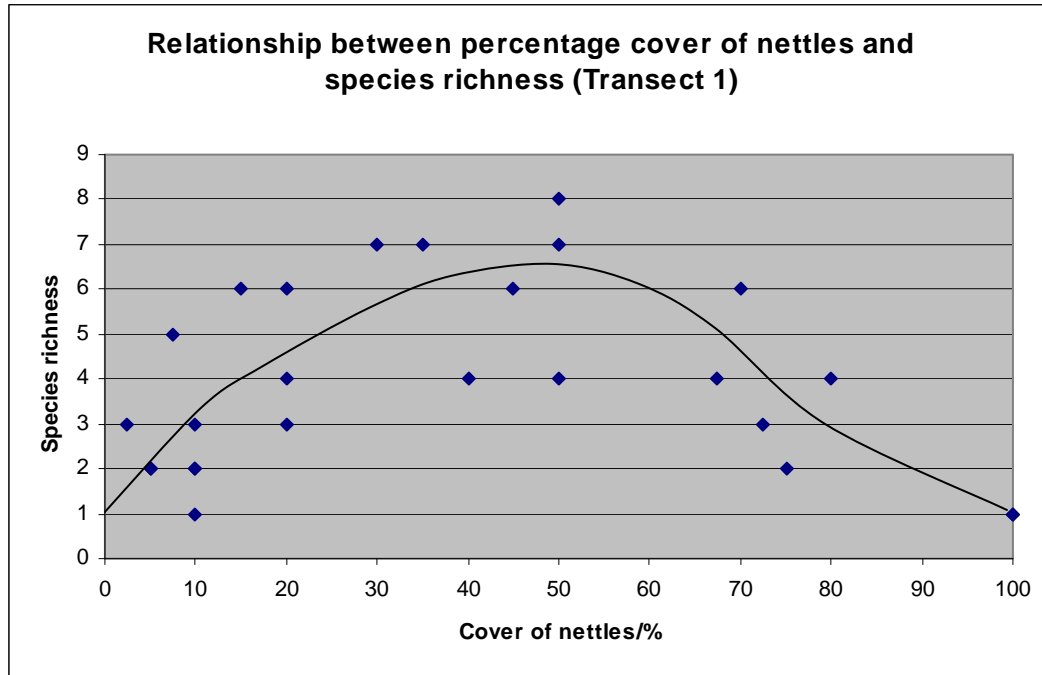


fig. 4

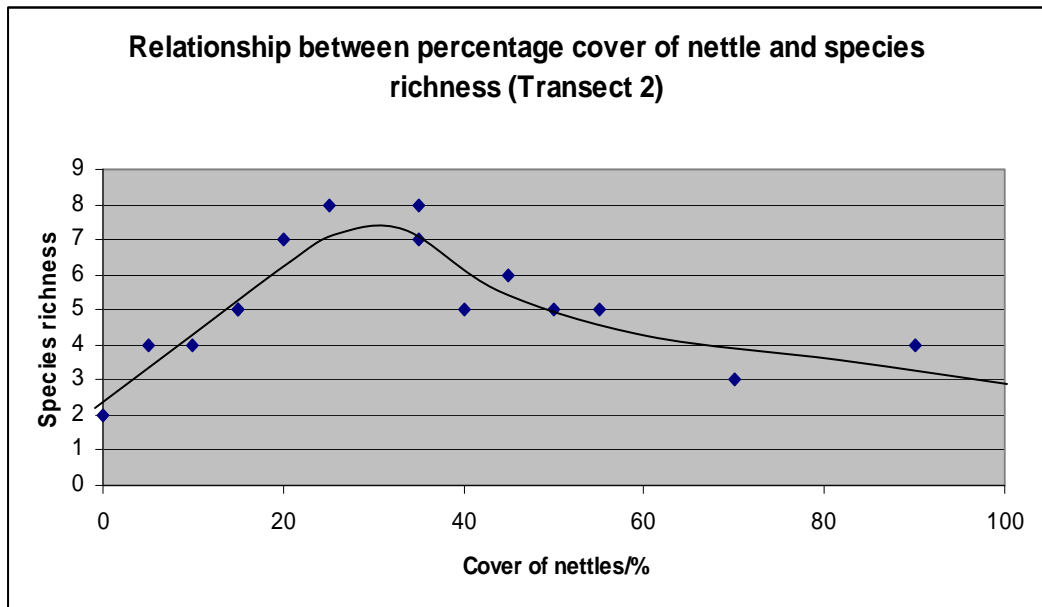


fig. 5

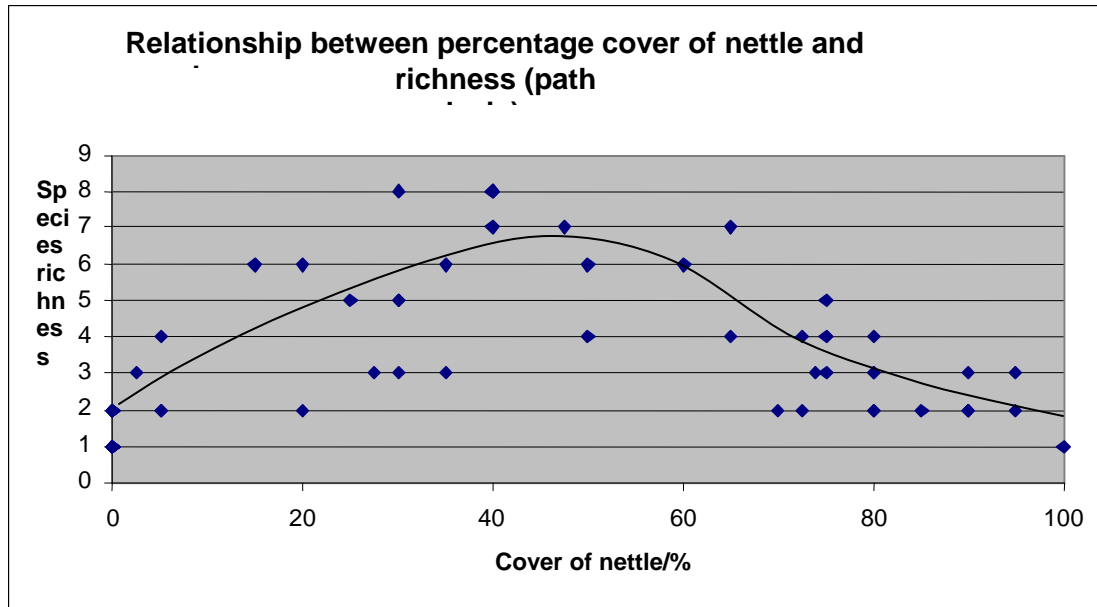


fig. 6

Fig. 4, 5 and 6 shows a clear relationship between percentage cover of nettles and species richness. Where there is approx. 0-25% cover of nettles the species richness also increases. This could be as where there are few nettles there are abiotic factors that also inhibit the success of other species. For example, in the centre of a path there will be much trampling and so little to no nettle cover; however for the same reason there will also be a low species richness.

Species richness reaches a maximum where percentage cover of nettles is between 25 and 50%. At this situation the conditions are likely to be suitable for reasonable growth, yet the habitat is not presently being dominated by the nettles.

At percentages above 50 the species richness falls. The likely reason for this would be that other species begin to become dominated by the nettles. This hypothesis is also supported by fig. 7.

To test the correlation between percentage cover of nettle and species richness the graph must first be split into a positive correlation section below 40% and a negative correlation above 40% and test each individually using Spearman's Rank Correlation Coefficient test. The data must be split as the Spearman's Rank Correlation Coefficient can only be used for a simple relationship, not a complex or compound pattern. 40% was chosen as the threshold level between a positive and negative correlation as it appears to be a suitable mean peak of the three data sets. See appendix for calculation details.

		Spearman's rank correlation coefficient	Critical value (P<5%)	Significant at 5% confidence level
Transect 1	Below 40% nettle coverage	0.6741	0.544	Yes
	Above 40% nettle coverage	-0.8394	-0.648	Yes
Transect 2	Below 40% nettle coverage	0.7788	0.648	Yes
	Above 40% nettle coverage	-0.6571	-0.886	No
Path analysis	Below 40% nettle coverage	0.8789	0.361	Yes
	Above 40% nettle coverage	-0.7424	-0.367	Yes

These results show that all but one correlation is proved to be significant. The result that does not prove to be significant has a notably smaller number of data points, therefore if more data was taken the result may have proven significant. An interesting point is that the correlation for the path analysis below 40% nettle cover is notably stronger than the others, which may have been caused by the greater intensity of trampling. A more likely explanation may be that the high correlation coefficient reflects the larger number of data points. This implies that should the other data sets have a similarly large size then their correlation may have been stronger and significant.

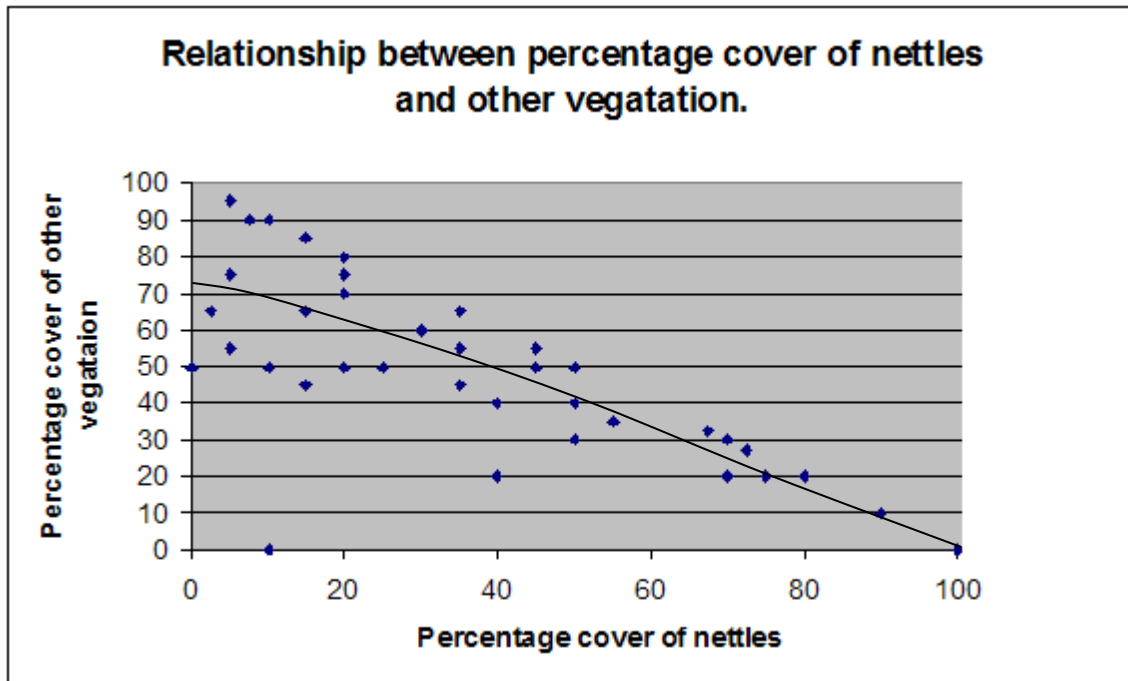


fig. 7

This scatter graph indicates that as the percentage cover of nettles increases the percentage cover of all the other vegetation combined decreases as they become dominated by the nettles. This graph does not however prove that nettles are the dominating species but rather presents a possible flaw in the percentage cover method of quantifying species success. The covering of a particular space in this investigation is mutually exclusive, either being covered by nettles or other vegetation, not both. This is demonstrated by the line of points that runs from 100% nettles to 100% other vegetation; as the space the nettles occupies decreases, it can then be filled by other species and crucially vice versa. The points deviating below this line can be explained by bare ground bringing the total percentage cover up to 100%. This is not an entirely realistic method of measuring the success of species as two species can simultaneously exist occupying the same area. For example a species of grass may survive living underneath the canopy of the nettles. In communities plants will exist on the very fringes of their envelope of ideal conditions (such as underneath other plants) and for this reason percentage cover does not provide a fully informative representation of the species existing in a given quadrat.

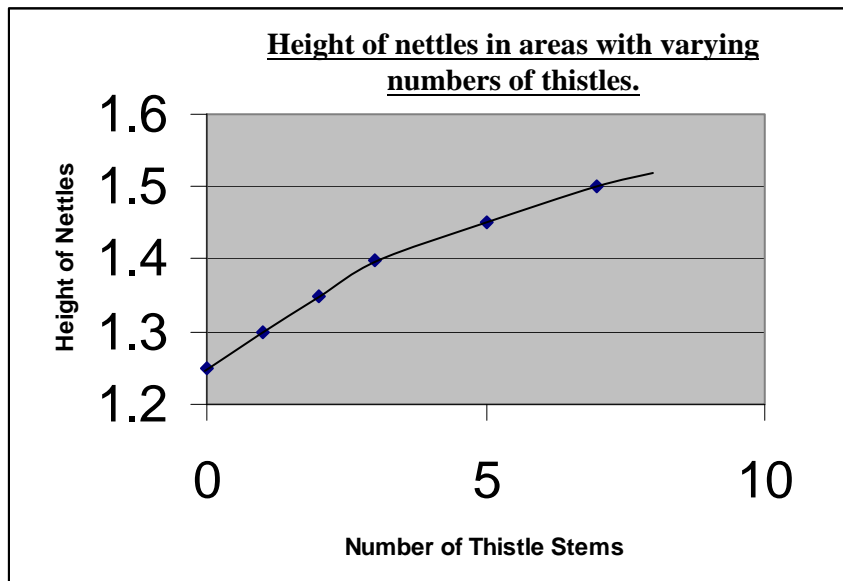
The areas of high percentage cover of vegetation and low percentage cover of nettles appear to contradict the idea that where there are few nettles, there are external abiotic factors that also inhibit the success of other species. However, when looking at such areas (which tended to be the heavily trampled areas) it can be seen that certain species flourish in these areas that nettles cannot successfully inhabit. Nettles, thistles and brambles appear unable to tolerate the trampling that occurs on the paths and so are essentially non-existent in such areas. The monocotyledonous grasses appear to do comparatively well in the more intensely trampled areas. This is as the grasses meristem is positioned at the bottom of the plant in an area that is more unlikely to be damaged; in addition to this they will not have to compete with the nettles. *Plantago lanceolata* (one of the more common 'other species') is also very successful. A previous study carried out by 'Project Elgon' on the effect of trampling on vegetation also noted this of another closely related plantain; commenting 'The morphology of *Plantago palmata* accounts for its high resistance; it has a basal rosette form of stalked, ovate leaves. Sun and Liddle (1993) list several trampling studies which indicate that plants with such a rosette form are frequently identified as having trampling resistance. Liddle (1991) goes so far as to state that 'There is little doubt that smaller plants survive better in trampled areas; plants that are not able to grow in rosette, creeping or other low-growing form do not survive long on new pathways and rarely appear in the trampled flora'⁵.'

This illustrates that some areas may have external influences, such as trampling, that inhibit the growth of nettles and many other species leading to the correlating low species richness. The negative correlation between percentage cover of nettles and percentage cover of 'other species' can also be explained. Although there may be the external influences that may inhibit the success of nettles and lead to low species richness, there may be certain species that can tolerate the inhibiting factor (such as the grasses and *Plantago lanceolata* in the case of trampling), and flourish unimpeded by the nettles.

It is very hard to prove the nettles dominance statistically with the data collected, however, by observation of the park alone it is quite clear to see that nettles are by far the most

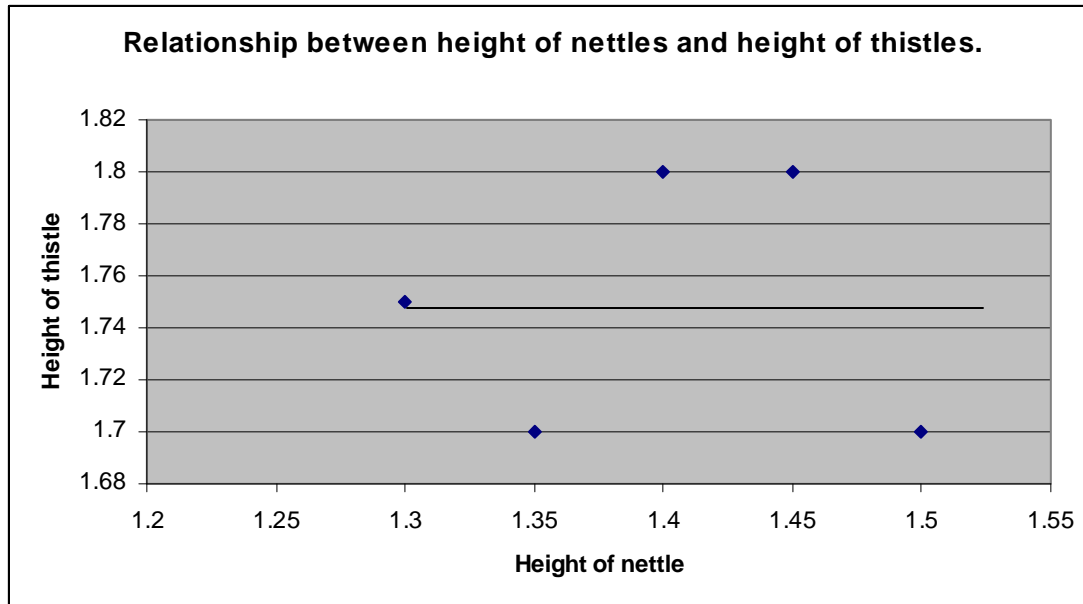
numerous of the species found. In addition to this, when digging soil samples from transect 2, dense networks of nettle roots and rhizomes would be found underground, and very small amounts of others; demonstrating again their dominance.

The previous summer a similar investigation was undertaken investigating the interaction between nettles and thistles, their competition. At that time of the year it is extremely difficult to use the percentage cover method as the vegetation is too tall and dense to make an accurate judgment. Instead, the indicators of number of stems of each species per quadrat and average height of each species were used to measure success. The following extract will demonstrate how these factors are more effective at determining which species is dominant.



As you can see there appears to be a striking correlation showing that as the competition from the taller thistles increases the nettles grow taller in order to reach the sunlight...

The following graph helps illustrate what effect the nettle height had on thistle height and it rather unsurprisingly came up with very little correlation as shown.



This lack of correlation was unsurprising as the thistles are naturally taller than stinging nettles they do not have to grow taller to out-compete nettles for sunlight.

This shows that thistles dominate over nettles. The nettles have to adapt to be competitive to the thistles, whereas the thistles do not need to adapt at all in areas of high nettle density.

Such a method could also be used in this investigation to help conclude that the nettles are dominating the other vegetation at this time. With the negative correlation between percentage cover of nettle and species richness above 40% in mind, in order to encourage species richness and biodiversity it is worth considering the factors that promote and inhibit nettle growth and, in turn, species richness. The data recorded on the abiotic factors revealed some very interesting relationships between the success of nettles and their situation.

A correlation between altitude and species richness has been previously recorded in other studies as 'a decrease in species richness with altitude'⁴. The data in this study did not produce any such correlation, or a correlation between altitude and nettle coverage. This is most likely due to the small scale of this project, with samples taken over a relatively small change in altitude of approximately 7m as opposed to the thousands of meters that the previous research had been carried out over. It might not have been extraordinary to find some form of correlation as, being a former flood plain, altitude would have thought to be crucial to the soil composition. However, the railway embankment built in the late 1800's will have formed a 'defense' against the flood water and the fertile silt brought with it. It may then be reasonable to assume that soil composition is much more greatly determined by the areas time as an allotment, and so be independent of its altitude.

The following graphs show that there are few notable patterns with regards the altitude gradient and the species richness or nettle growth.

The most obvious abiotic factor that would be expected to affect the growth of nettles would be light intensity. Light is of course essential for photosynthesis and may therefore be a limiting factor affecting the rate of which a plant can photosynthesize and become successful and competitive. However, when analyzing the data collected, there does not appear to be any significant relations. This is demonstrated by fig. 8.

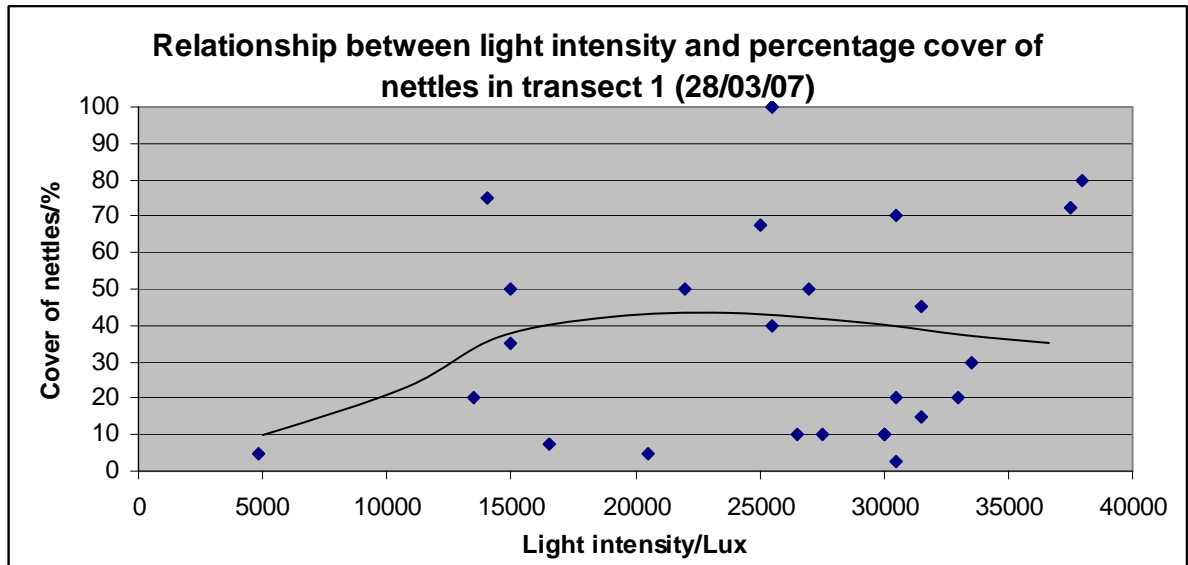


fig. 8

This may not be the best time of year to look for such correlations as the growth of nettles in the spring is dictated by and reflects the store of nutrients in the underground rhizomes.

The likely reason for the lack of correlation is a result of poor method. The reading on the light meter fluctuated wildly making it difficult to establish the reading at any point. In addition to this the readings were carried out over several hours, on an afternoon with varying cloud cover. Due to the results being taken in an afternoon, the readings for light intensity may gradually decrease as it get progressively darker, not reflecting accurately the relative light intensity between quadrats. The varying cloud cover will affect the readings for light intensity, creating inconsistencies between readings and therefore not provide an accurate representation of relative light intensity. So this data must be discounted from further consideration.

Another possible reading that could provide an indication of solar output would be soil temperature; this, unexpectedly, provided a positive correlation as shown in fig. 9 and 10.

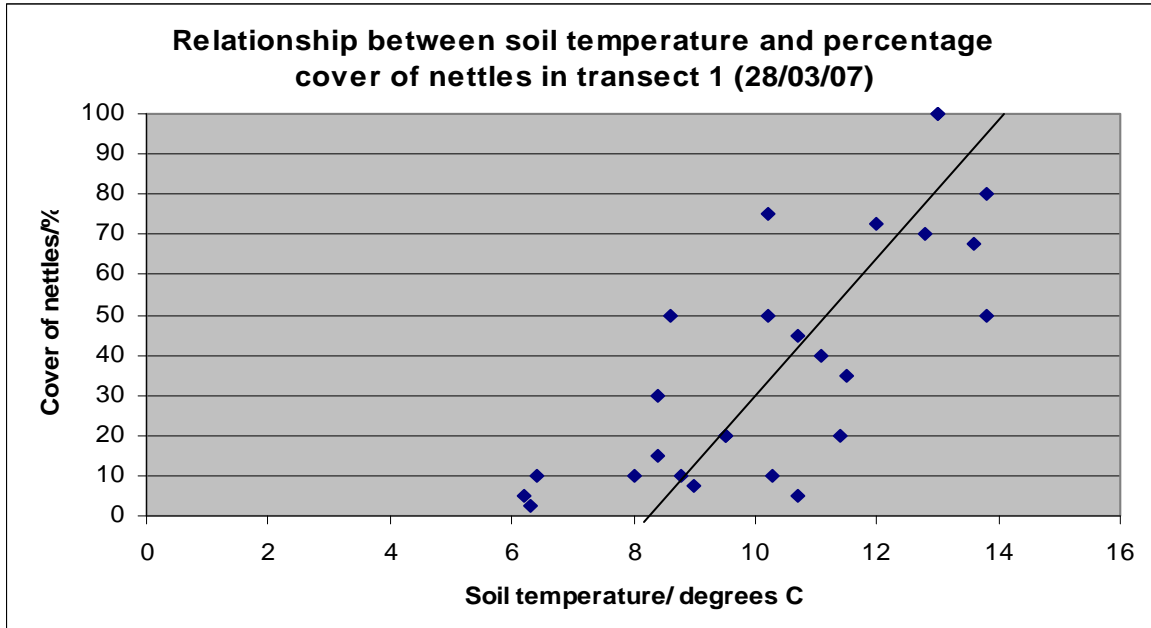


fig. 9

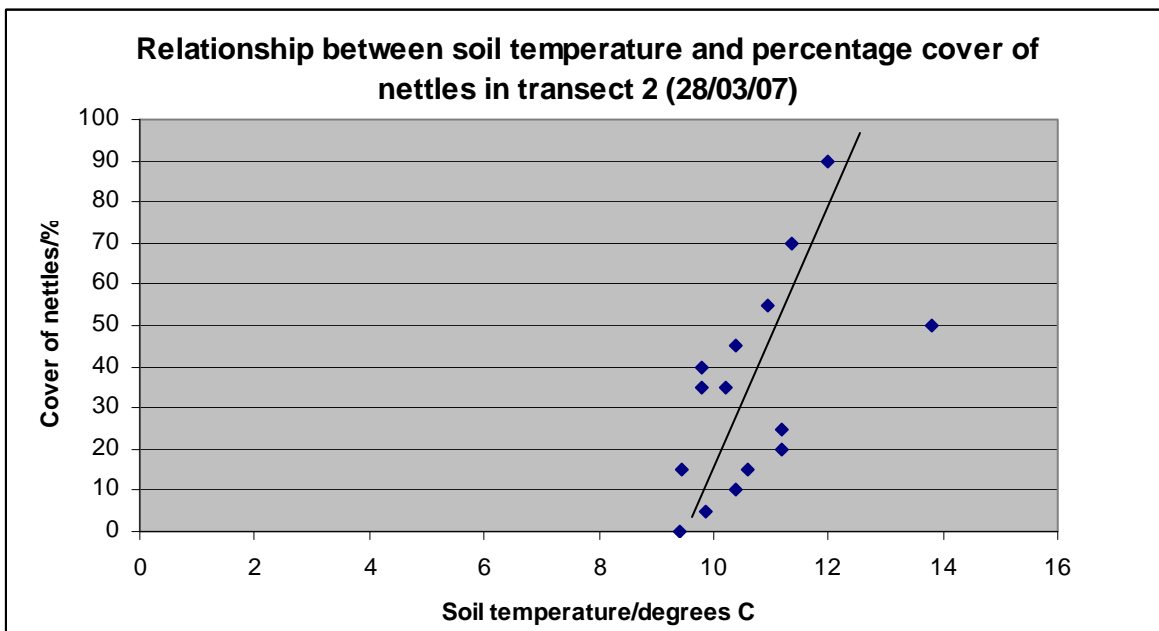


fig. 10

The significance of the correlations will be analyzed using the Spearman rank correlation test.

Null Hypothesis: *There is no correlation between soil temperature and percentage cover of nettles.*

Transect 1

See appendix for details of calculations.

At a 5% significance level where $N=26$ R_s must be greater than the 0.330⁶ critical value to reject the null hypothesis and for the correlation to be considered significant. As the Spearman rank correlation coefficient for the data is 0.734, (Critical value for $P<0.05$) this indicates that there is a strong positive correlation between soil temperature and percentage cover of nettles.

Transect 2

At a 5% significance level where $N=15$ R_s must be greater than the 0.441⁶ critical value to reject the null hypothesis and for the correlation to be considered significant. As the Spearman rank correlation coefficient for the data is 0.623, (Critical value for $P<0.05$) this indicates that there is a reasonably strong positive correlation between soil temperature and percentage cover of nettles.

This unexpectedly strong result could be explained in a number of ways. First of all it may indirectly represent the correlation looked for between light intensity and nettle growth. The greater the light intensity at a point should reflect directly the soil temperature, indicating solar intensity. For the purpose of this investigation soil temperature may actually give a more accurate representation of solar intensity than the light readings as they will maintain their heat throughout the day and the readings will not fluctuate as greatly due to cloud cover, providing a more stable reading. With this in mind it may be reasonable to assume the correlation may be due to an increase in light intensity. The greater the light intensity the greater the rate of photosynthesis can be allowing the nettles to grow faster and produce more photosynthetic product.

In order to understand the next explanation for the correlation between soil temperatures and nettle growth it is important to look at their anatomy and mechanisms nettles use to enhance their success.



Nettles establish rhizomes seen in field, similar to those in fig.11; underground food stores providing a rich source of starch that can be utilized the following season, giving the nettle a head start over their competition. Nettle rhizomes were found abundantly in the soil of the area when soil samples were taken.

It is also important to emphasize an increase in temperature causes an increase in metabolic activity

fig. 11.⁷

It is the combination of these factors that explain the correlation between soil temperature and nettle growth.

An increase in soil temperature will cause an increase in the metabolic activities of the nettle. This includes the catabolism of the starch in their rhizomes into sucrose for transportation then into glucose for respiration. This store of starch thus provides a natural advantage over the competition that is accentuated by an increase in temperature.

This concept is thought to work in combination with the idea of the areas with greater soil temperature have a greater solar intensity and therefore light intensity. Once the nettles have established an advantage over their competition using their rhizomes the nettles in these areas of greater light intensity can reap the benefits of a greater rate of photosynthesis, allowing the nettles in that area a further advantage.

The affect of temperature on rhizome metabolic activity has been backed up by research undertaken by the International Society for Horticultural Science on ornamental ginger. 'Rhizomes of three ginger species were stored for 0 to 16 weeks at 15, 20 or 25°C to determine the effect on growth, flowering, respiration rates, and carbohydrate content. After treatment application, rhizomes were planted in a soilless medium and placed in a greenhouse with temperatures set at 25°C day/21°C night with 40% shade. Production time, days to emergence and days to flower, were reduced with an increased storage temperature and duration for all species.⁸'

This same advantage over the competition in nettles would provide great benefits that are accentuated by an increase in temperature, explaining the correlation between soil temperature and percentage cover of nettles.

Another factor that may influence the readings for soil temperature could be percentage of water contained within the soil. Water has a very high specific heat capacity requiring more energy to raise its temperature than the soil. Therefore two quadrats with equal solar intensity may have different soil temperatures due to the percentage water of the soil; the more water contained in the soil will result in cooler temperatures. Therefore it might be expected that the correlation between soil temperature and nettle growth maybe linked to the water content of the soil.

This theory however can be disproved by data collected on percentage of soil that is water. The data was collected on transect 2 at each data collection point and the method for obtaining this data is referenced.

Figure 12 shows the correlation between percentage soil water and soil temperature. Testing this correlation using the Spearman's Rank Correlation Coefficient showed there was a significant negative correlation of -0.7054. (exceeding the critical value for $P < 0.05$)

Relationship between soil water and soil temperature

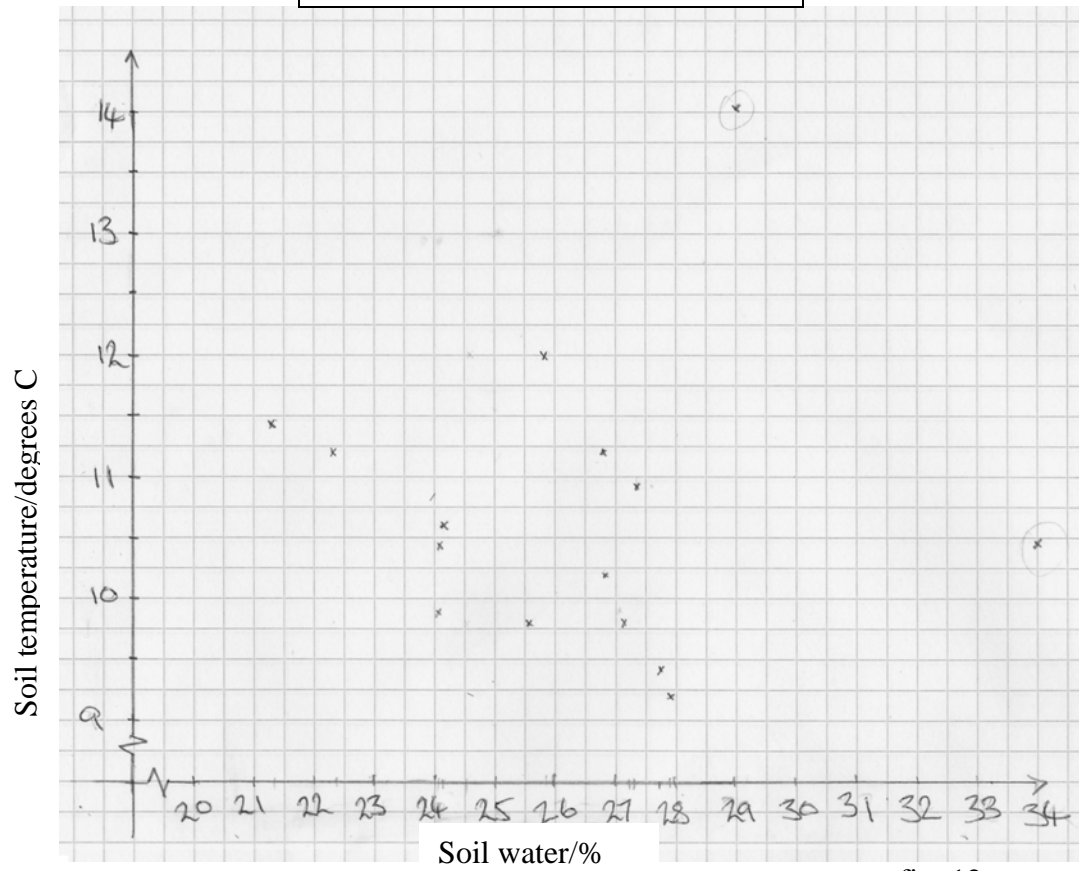


fig. 12

This correlation supports the idea that the correlation between soil temperature and percentage cover of nettle is linked by water content in the soil. The more water there is in the soil the cooler the soil will be and the lower the percentage cover of nettle. This implies that nettles do not grow well in soil with high water content.

To confirm whether the correlation between soil temperature and nettle cover was indeed connected by water content a graph illustrating the relationship between water content of the soil and percentage cover of nettles was constructed.

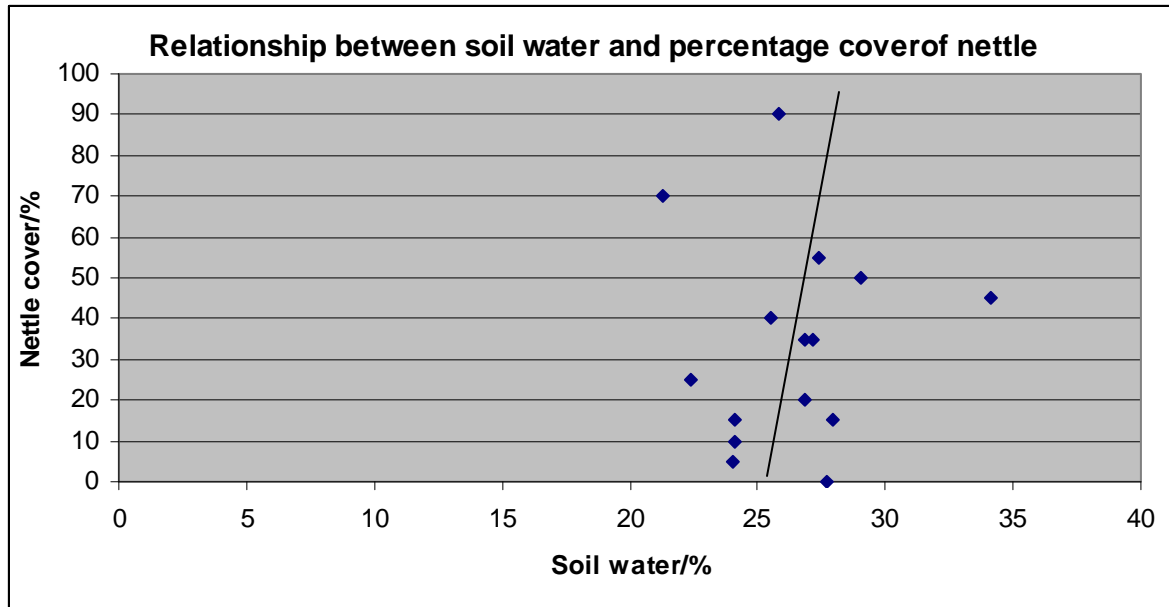


fig. 13

Figure 13 shows there is very little correlation between the two variables. This shows that although there is a correlation between the soil temperature and water percentage, it appears unlikely that this is the reason behind the soil temperature/nettle cover correlation.

In hindsight, having not found a correlation between altitude and species richness but rather soil temperature and species richness, it would have been more appropriate to use a random sampling method rather than a transect to investigate this relationship.

Evaluation

To conclude the findings, the species richness is intrinsically linked to the environment. Species richness can be inhibited by abiotic factors that make the local position unsuitable for successful growth. *Urtica dioica* is also so well adapted to this environment and hugely successful in out competing rivals. In areas where it starts to dominate the species richness decreases as other species can no longer compete with the nettle for resources.

The key abiotic factor found to affect nettle growth in this investigation was soil temperature. This was thought to be due to the idea that an increase in soil temperature will cause an increase in the metabolic activities of the nettle. This includes the catabolism of the starch in their rhizomes into glucose for respiration and the new growth it drives. This store of starch thus provides a natural advantage over the competition that is accentuated by an increase in temperature. It may also be related to the connection between soil temperature and light intensity.

These results appear accurate reassured by the correlation, and the accuracy of the digital temperature probe used. However, to improve reliability it may be necessary to take repeated

readings as opposed to the one reading taken at each data collection point. This correlation was extremely surprising and something that would be interesting to investigate further in the future, by means of taking multiple readings at a number of locations, and perhaps also at other times of the year. The phenomenon would be expected to be strongest in the early spring when the nettles benefit from getting a head start over their competition. Once an advantage is established growth driven by photosynthetic production will maintain the advantage.

The key piece of further study to confirm this hypothesis, however, would be possible by growing rhizome sections in the laboratory at different constant temperatures, and observing their comparative success.

This should be done by planting similar rhizomes from the same plant, each in a similar situation (e.g. same soil medium, water content, light incidence). Yet the soil temperature for each could be varied by keeping each in a water tight container in a water bath. It is important that each container is water tight as to not allow variation in moisture content (either increasing from the water bath or decreasing from higher temperatures). With the data from this investigation it should be possible to prove that soil temperature is the abiotic factor influencing Nettle growth.

It is difficult to come to any definitive conclusions about the effect light has on nettle growth with the data collected. However, through data recorded on soil temperature it may be possible to indirectly deduce a connection. In order to establish the relationship more conclusively improvements would need to be made in the method for gathering data on light intensity.

It would be very difficult to avoid the problem of varying light intensities due to time of day; however could be done by setting up data loggers along the transect and leave to run for several days and using ICT to analyze the data. Having made these changes to the method it may be possible to establish a more conclusive relationship between light intensity and nettle growth, distinguished from soil temperature.

No reference has been made to the pH of the soil samples as the pH indicator used was not sufficiently discriminating to uncover any relationships as all samples resulted in a close pH range between approximately pH8-9. A more accurate pH indicator will have to be used in future investigations to infer any correlations. It seems unlikely that pH variation is the cause of any differences in distribution across the transect surveyed.

The choice of quadrat was suitable for the investigation providing quick and easy readings which appeared to make a reasonable representation of the area sampled. A minor flaw in the method of using percentage cover may need to be overcome for future research. It is not an entirely accurate method of measuring the success of species as two species can simultaneously exist occupying the same area. For example a species of grass may survive living underneath the canopy of the nettles. In communities plants will exist on the very fringes of their envelope of ideal conditions (such as underneath other plants) and for this reason percentage cover does not provide a truly accurate representation of the species

existing in a given quadrat. However, given the time constraints and the large quantity of quadrat-data to be collected it did give a good and fairly representative indication of the successful species in a given area.

The main hindrance found in the investigation was the time restraint. This investigation only examines the interaction of nettles and their surroundings during the spring growing season. It is usual to expect that the situation of the nettles changes dramatically throughout the year. For example the correlation between soil temperature and nettle growth would be nearly as strong any other time of year as spring, as the rhizome food store will have been exhausted and so the soil temperature can have little effect on the catabolic rate of the rhizomes. During summer however, soil water may be expected to have a greater effect as the water available to the vegetation may be the limiting factor in the Nettle growth.

This investigation only examined the effects of nettle populations on the species richness of flora. Further study could however also be conducted looking at the effect on the species richness of fauna and total species richness, this is important as although nettles may dominate competing vegetation, nettles may provide a habitat for fauna encouraging their species diversity.

A scheme the Fant wildlife trust is currently trialing in order to increase biodiversity and encourage native species is to remove the extremely fertile layer of top soil that nitrophilous species such as nettles find great success in. The nutrients are left behind from when the park was allotments. It would be interesting to investigate into what success this scheme has on the nettle population, and also to test the soil for mineral nutrient content and pH (using a more accurate pH indicator) at the different locations to examine what affect the soil quality has on nettle growth.

References

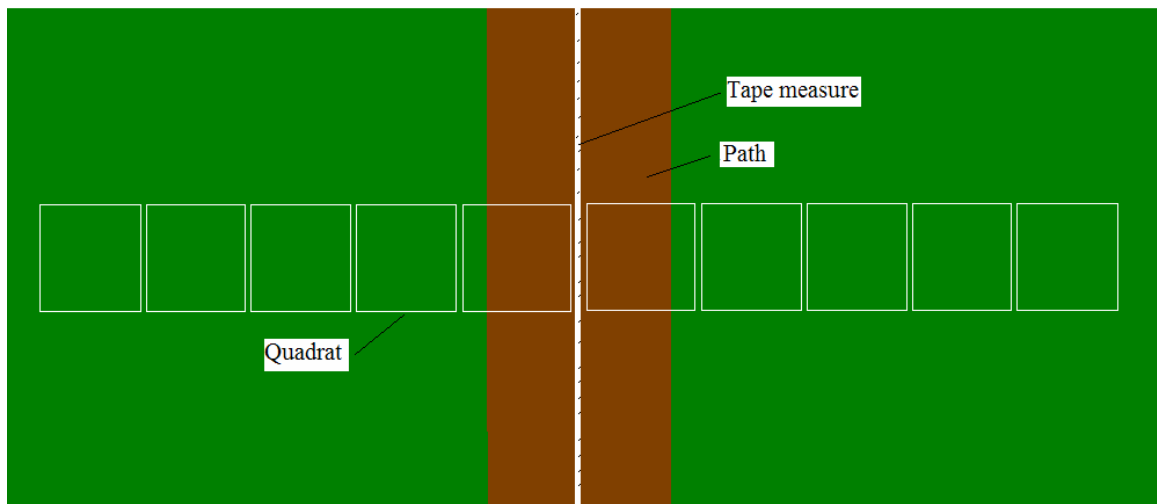
1. <http://earthnotes.tripod.com/nettle.htm>
2. <http://www.psychology.ex.ac.uk/lundy/quadrat.htm>
3. http://en.wikipedia.org/wiki/Species_richness
4. <http://www.blackwellpublishing.com/townsend/Chapters/EOEC10.pdf>
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- 6.

No. of pairs (N)	Significance level
	5%
-	-
6	0.886
10	0.648
14	0.544
29	0.367
34	0.361

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Appendix 1
Method for analysis of path-

1. Lay 60m of tape measure along the centre of the path.
2. Using the random number generator on a calculator select 6 random numbers between 0 and 60. Let these numbers equal the distances along the tape in meters where one would collect data.
3. Place quadrats side by side either side of the tape so 5 0.5m x 0.5m quadrats are taken over the 2.5m either side of the tape. fig. 14



4. Estimate as carefully as possible the percentage cover of each of the dominant species (also including percentage cover of 'other species' noting what those species are believed to be) in each quadrat.
5. Note the species richness of the quadrat.
6. Repeat steps 3 to 5 at each of the predetermined distances along the tape.

For the purpose of recording data and for reference the quadrats across the path have been labeled A-J from right to left of the path as shown on fig. 15.

Each set of data A-J will be labeled a data set, and each will be referred to by the number of meters along the tape they will be taken.

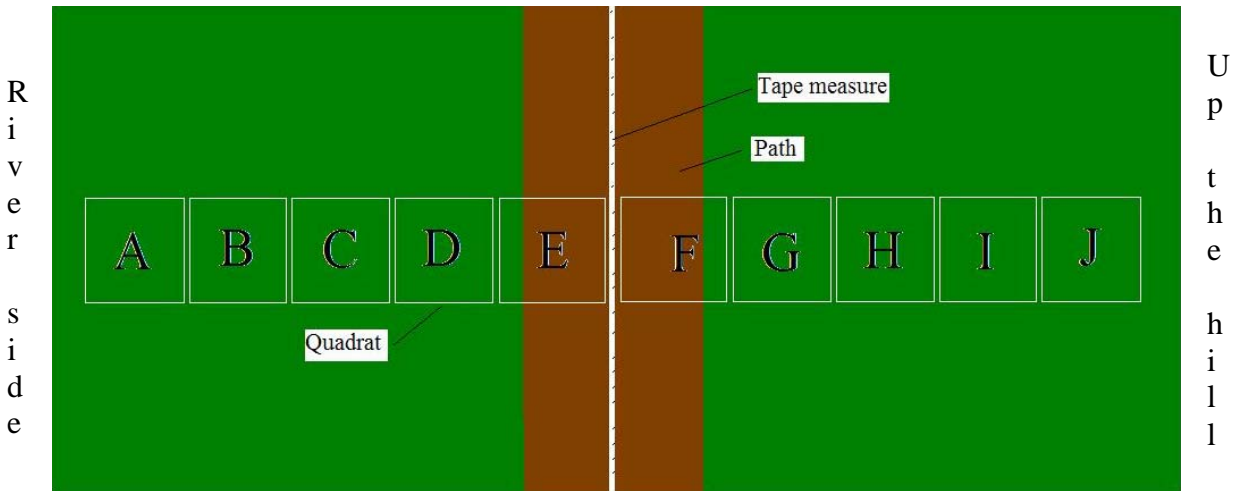


fig. 15.

Appendix 2

Method for collecting data on soil water percentage.

1. Over 1kg of soil from the ground and sealing it in water tight plastic bags.
2. The samples were left for a day for the water in the soil to equilibrate, dispersing evenly throughout the soil.
3. Samples were selected from each bag without living material or stones.
4. The samples were weighed in 100ml beakers of known mass.
5. The samples were baked at 100°C for 24 hours.
6. The samples were then reweighed and results tabulated.
7. Appropriate calculations were then undertaken to calculate the percentage soil water.

Appendix 3

Spearman's rank:

$$\text{Using: } R_s = 1 - \frac{6\sum D^2}{N(N^2 - 1)}$$

R_s = Spearman rank correlation coefficient

D = Difference in corresponding ranks

N = Number of ranks in data sets

Correlation between soil temperature and percentage cover of nettle in transect 1

Rank; % cover of nettle	Rank; soil temperature	Difference	Difference squared
1	2	-1	1
2.5	1	1.5	2.25
2.5	15.5	-13	169
4	9	-5	25
6.5	3	3.5	12.25
6.5	4	2.5	6.25
6.5	8	-1.5	2.25
6.5	14	-7.5	56.25
9	5.5	3.5	12.25
11	10.5	0.5	0.25
11	10.5	0.5	0.25
11	18	-7	49
13	5.5	7.5	56.25
14	19	-5	25
15	17	-2	4
16	15.5	0.5	0.25
18	7	11	121
18	12.5	5.5	30.25
18	25.5	-7.5	56.25
20	24	-4	16
21	21	0	0
22	20	2	4
23	12.5	10.5	110.25
24	25.5	-1.5	2.25
25.5	22.5	3	9
25.5	22.5	3	9
		ΣD^2	779.5

N=26

$$R_s = 1 - \frac{(6)(779.5)}{(26)(675)} = 0.734$$

Correlation between soil temperature and percentage cover of nettle in transect 2

Rank; % cover of nettle	Rank; soil temperature	Difference	Difference squared
1	1	0	0
2	5	-3	9
3	7.5	-4.5	20.25
4.5	2	2.5	6.25
4.5	9	-4.5	20.25
6	11.5	-5.5	30.25
7	11.5	-4.5	20.25
8.5	3	5.5	30.25
8.5	6	2.5	6.25
10	4	6	36
11	7.5	3.5	12.25
12	15	-3	9
13	10	3	9
14	13	1	1
15	14	1	1
		ΣD^2	211

$$R_s = 1 - \frac{(6)(211)}{(15)(224)} = 0.623$$

Correlation between percentage cover of nettles and species richness in transect 1 below 40% nettle coverage

Rank; % cover of nettle	Rank; Species richness	Difference	Difference squared
1	7	-6	36
2.5	3.5	-1	1
2.5	3.5	-1	1
4	10	-6	36
6.5	1	5.5	30.25
6.5	3.5	3	9
6.5	3.5	3	9
6.5	7	-0.5	0.25
9	11.5	-2.5	6.25
11	7	4	16
11	9	2	4
11	11.5	-0.5	0.25
13	13.5	-0.5	0.25
14	13.5	0.5	0.25
		ΣD^2	149.5

N=14

$$R_s = 0.6714$$

Correlation between percentage cover of nettles and species richness in transect 1 above 40% nettle coverage

Rank; % cover of nettle	Rank; Species richness	Difference	Difference squared
1	7.5	-6.5	42.25
2.5	9	-6.5	42.25
2.5	10	-7.5	56.25
4	5.5	-1.5	2.25
5	7.5	-2.5	6.25
6	4	2	4
7	3	4	16
8	5.5	2.5	6.25
9.5	1.5	8	64
9.5	1.5	8	64
		ΣD^2	303.5

N=10

$$R_s = -0.8394$$

Correlation between percentage cover of nettles and species richness in transect 2 below 40% nettle coverage

Rank; % cover of nettle	Rank; Species richness	Difference	Difference squared
1	1	0	0
2	2.5	-0.5	0.25
3	2.5	0.5	0.25
4.5	5	-0.5	0.25
4.5	5	-0.5	0.25
6	7.5	-1.5	2.25
7	9.5	-2.5	6.25
8.5	7.5	1	1
8.5	9.5	-1	1
10	5	5	25
		ΣD^2	36.5

N=10

$$R_s = 0.7788$$

Correlation between percentage cover of nettles and species richness in transect 2 above 40% nettle coverage

Rank; % cover of nettle	Rank; Species richness	Difference	Difference squared
1	4	-3	9
2	6	-4	16
3	4	-1	1
4	4	0	0
5	1	4	16
6	2	4	16
		ΣD^2	58

N=6

$$R_s = -0.6571$$

Correlation between percentage cover of nettles and species richness in the path analysis below 40% nettle cover

Rank; % cover of nettle	Rank; Species richness	Difference	Difference squared
8.5	5	3.5	12.25
8.5	5	3.5	12.25
8.5	5	3.5	12.25
8.5	5	3.5	12.25
8.5	5	3.5	12.25
8.5	5	3.5	12.25
8.5	5	3.5	12.25
8.5	5	3.5	12.25
8.5	5	3.5	12.25
8.5	14.5	-6	36
8.5	14.5	-6	36
8.5	14.5	-6	36
8.5	14.5	-6	36
8.5	14.5	-6	36
8.5	14.5	-6	36
8.5	14.5	-6	36
17	21.5	-4.5	20.25
19	14.5	4.5	20.25
19	14.5	4.5	20.25
19	24	-5	25
21	29	-8	64
22.5	14.5	8	64
22.5	29	-6.5	42.25
24	26	-2	4
25	21.5	3.5	12.25
27.5	21.5	6	36
27.5	26	1.5	2.25
27.5	26	1.5	2.25
27.5	33	-5.5	30.25
30.5	21.5	9	81
30.5	29	1.5	2.25
33	31	2	4
33	33	0	0
33	33	0	0
		ΣD^2	792.5

N=34

$$R_s = 0.8789$$

Correlation between percentage cover of nettles and species richness in the path analysis above 40% nettle cover

Rank; % cover of nettle	Rank; Species richness	Difference	Difference squared
2	26	-24	576
2	28.5	-26.5	702.25
2	28.5	-26.5	702.25
4	26	-22	484
5.5	19	-13.5	182.25
5.5	23.5	-18	324
7	23.5	-16.5	272.25
8.5	19	-10.5	110.25
8.5	26	-17.5	306.25
10	6	4	16
11.5	6	5.5	30.25
11.5	19	-7.5	56.25
13	13.5	-0.5	0.25
15	13.5	1.5	2.25
15	19	-4	16
15	22	-7	49
19	6	13	169
19	6	13	169
19	13.5	5.5	30.25
19	13.5	5.5	30.25
19	19	0	0
22	6	16	256
24.5	6	18.5	342.25
24.5	6	18.5	342.25
24.5	6	18.5	342.25
24.5	13.5	11	121
27.5	6	21.5	462.25
27.5	13.5	14	196
29	1	28	784
		ΣD^2	7074

N=29

$$R_s = -0.7424$$