Skomer's Botanical Microcosms:

A Campfire Meditation (1969-2015)

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1 Where it all began

In the 1960s and early 70s informal meetings were held at the Zoological Society of London to discuss the trend for many former university departments of zoology to merge into larger administrative units, encompassing more amorphous concepts, such as environmental science, resource management, earth sciences and molecular biology. This change was taking place in a piecemeal fashion and these new adhoc subjects were covering areas traditionally taught as small parts of general zoology courses. Key figures in these deliberations were Julian Huxley, Solly Zuckerman, John Philips, Sam Berry, Denis Bellamy and Con Waddington. A major concern was that teaching the theory of evolution was under threat because historically. zoology was always taught within a well defined evolutionary context. Indeed, evolution is still the backbone of zoology as a classical discipline and provides an efficient and striking explanation for how organisms today are different from organisms in the past and why there is such an amazing diversity of fascinating animals with awe inspiring lifestyles and body plans. Yet the Zoologcal Society group recognised that there was a need for novel generalisms to position the old specialisms in a less confrontational and more holistic perspective. In other words the aim should be to keep zoology in the mainstream of natural history and at the same time open up its traditional ideational boundaries. It was in this context that Julian Huxley's idea-system of evolutionary humanism came to the fore.

An idea-system is defined as a process and a social environment for empowering people, allowing for continuous improvement. In this context, Huxley had in mind that evolutionary humanism could be defined as a system of beliefs and practices by means of which a group of people struggles with the ultimate problems of human life, which at the moment are poverty, inequalities and education.. Traditionally these beliefs and practices characterised religion. In contrast, evolutionary humanism is a secular perspective based on an understanding that every one of us is an organism built on the same biochemical body plan as all other living things whilst recognising we have unique cognitive properties and exhibit dominant destructive relations with the rest of nature. Huxley's idea-system is organized round the facts and ideas of evolution that tell us we are part of a comprehensive evolutionary process and therefore at one with nature in everything we do. Huxley added then codicil that being human means we cannot avoid playing a decisive role in this process to achieve a better future for ourselves whilst ensuring the survival of our sentient cousins. He clarified this position in Essays of a Humanist (1964):

"Man is not merely the latest dominant type produced by evolution, but its sole active agent on earth. His destiny is to be responsible for the whole future of the evolutionary process on this planet. . . This is the gist and core of Evolutionary Humanism, the new organization of ideas and potential action now emerging from the present revolution of thought, and destined, I prophesy with confidence, to become the dominant idea-system of the new phase of psychosocial evolution".

“The world has become one de facto. It must achieve some unification of thought if it is to avoid disaster. . . and this can only come about with the aid of education. We must remember that two-fifths of the world's adult population. . . are still illiterate, that the world's provision for education at all levels is lamentably inadequate, and that the underdeveloped countries are all clamorously demanding more and better education. . . make no mistake, the basic task before the educational profession today is to study and understand the evolutionary humanist revolution in all its ramifications, to follow up its educational implications, and to enable as many as possible of the world's growing minds to be illuminated by its new view of human destiny”.

Sadly, after five decades of humankind’s rapacious occupation of Earth, evolutionary humanism remains on the periphery of education for living sustainably.

A focus for testing the value of evolutionary humanism as an educational concept is the field course. Zoological field courses were traditionally organised in places of high species diversity, like the sea shore, where a variety of animals could be collected and classified. This kind of interaction can improve students' interest and engagement with selfhood because watching, thinking, touching - are all the familiar behaviours of young people as they try to get to grips with the world that surrounds them. Zoology field courses cannot be codified and the role of the teacher is as a tutor facilitator, often having to cope with the unexpected student discovery that can set an individual and a class on a course of self motivated discovery. It was this kind of a self learning environment that motivated Sam Berry and Denis Bellamy to test Huxley’s idea practically on the Island of Skokholm. The island had been the place where Julian Huxley had developed the concept of evolutionary humanism in the 1930s. A small group of second year Cardiff zoology students participated in a common project in the 1970s to investigate the natural selection of lifespan in the island’s feral house mouse. At the same time each had a personal project on the life history of another of the island’s species. Denis Bellamy went on to develop the idea further on the adjacent island of Skomer. After being appointed to the Chair of Zoology in Cardiff in 1969 he reorganised the first year zoology course taken by 100 students as a self learning humanistic pedagogy based on small group tutorials. Second year field courses adopted the Pembrokeshire island’s model.

2. Humanistic Education

Humanistic education, is an approach to learning based on the work of Abraham Maslow and Carl Rogers. In the 1970s the term "humanistic education" became less popular after conservative groups equated it with "Secular Humanism" and anti religion. It was therefore re-labelled as "person-centered learning", also named self-appropriated learning. Carl Rogers devoted much of his efforts toward applying the results of his psychological research to person-centered learning where empathy, caring about students, and genuineness on the part of the learning facilitator were found to be the three key traits of the most effective practitioner. Fascilitated person-centred learning is the essence of a humanistic education. The closest most learners can come this is to engage in an Oxford/Cambridge type of tutorial.

Some basic principles of the humanistic approach used to develop educational objectives are:

1. Students will learn best what they want and need to know. That is to say, when they have developed the skills of analyzing what is important to them and why as well as the skills of directing their behavior towards those wants and needs, they will learn more easily and quickly. Most educators and learning theorists would agree with this statement, although they might disagree on exactly what contributes to student motivation.
2. Knowing how to learn is more important than acquiring a lot of knowledge. In our present society where knowledge is changing rapidly, this view is shared by many educators, especially those taking a cognitive perspective.
3. Self-evaluation is the only meaningful evaluation of a student's work. The emphasis here is on internal development and self-regulation. While most educators would likely agree that this is important, they would also advocate a need to develop a student's ability to meet external expectations. However, meeting external expectations runs counter to most humanistic theories.
4. Feelings, such as spirituality are as important as facts. Much work from the humanistic view seems to validate this point and is one area where humanistically-oriented educators are making significant contributions the knowledge base of selfhood.
5. Students learn best in a non-threatening environment. This is one area where humanistic educators have had an impact on current educational practice. The orientation espoused today is that the environment should be psychologically and emotionally, as well as physically, non-threatening. However, there is some research that suggests that a neutral environment is best for older, highly motivated students.

2 Skomer; a learning island

The following description of the educational experience that lay in store for visitors to Skomer in the 1950s comes from Chapter 4 of the summary of the first survey of the Island.

Visits to Skomer are usually made at the breeding season of the seabirds in May, June and July. These are often also the months of the finest weather in the west, when the cliff flowers, the most arresting of the floral sequence of the island, are at their best, seen as they are against a background of ultramarine sea and of hosts of seabirds coming and going against the paler blue of the sky. In May the high eastern slopes are purple-blue with large strong-stemmed bluebells; and below are snow-white drifts of sea-campion, which has succeeded (and partly mingles with) the greener white of the early-flowering scurvy-grass. In June the general colour changes to a delicate pink as acres of the beautiful thrift or sea-pink come into blossom, especially on the exposed western and southern cliffs; and on the sheltered ledges of the north-east side where there is sufficient soil, the luxuriant maritime variety of the red campion triumphs over the fading flowers of the primrose, bluebell and sea-campion. Towards the end of June the bracken begins to dominate completely large areas of Skomer; its crozier-like shoots have been slow to unfold *in the cool Atlantic winds (a month later perhaps than in sheltered mainland situations), and the plant does not reach a great stature; it forms a dense low cover from one to three feet high which effectively banishes or limits the growth of vegetation in areas where the bracken has long been established. In July, therefore, Skomer has assumed a viridescent colouring made up of the pale grass-green of the rabbit-grazed turf and the darker green of the maturing bracken. This is relieved in August by bright yellow patches of ragwort. The first high winds of autumn quickly turn the exposed areas of the bracken a russet colour.*

These general changes of colour might easily be observed by the watcher on a headland of Pembrokeshire opposite Skomer. But the lover of flowers who visits the island will find that the details hidden in this long-distance view are many and exciting. A close examination by the knowledgeable amateur will enable him to make an interesting list of the flowers, interesting not because of the great number of rare species but rather because there are few species, some of which are often individually very numerous and may form pure communities. The more serious student of plant ecology will instantly recognise the characteristic grouping of species into associations or societies peculiar to certain types of country; and the general naturalist finds that certain species of mammals, birds, insects and other creatures frequent these territories dominated by one or two typical plants. This linking up of animal and plant with terrain can be most conveniently studied on a small sub-Atlantic island, where the limitations of isolation and area seem to make possible an intensive investigation of its restricted ecology. Skomer exhibits a very considerable diversity of plant habitats, due to several factors: the topography of its high plateau with steep cliff walls, the imperviousness and acidity of much of the volcanic rock, the varying proximity of the sea, the climate with its frequent fierce winds, the alkaline and nitrogenous droppings of the seabirds, the effects of overgrazing by rabbits.

3 Should rabbits be managed?

In the 1970s, this was no longer the educational picture. The rabbit population had greatly increased. Rabbits were recovering from the first wave of the myxomatosis pandemic and there was talk of a management plan to maintain the visually attractive maritime grassland of the central fields. By then, the springy, flower-rich turf that had so delighted the team who made the first botanical survey in 1946 had all but disappeared because of intensive rabbit activity and expansion of colonies of nesting gulls. Although there were no rarities at stake there was a fear that rabbits could turn the island into a degraded exposed pasture with the danger of soil erosion.

Research was started in 1972 to answer the question should rabbits be culled. After 13 seasons of data gathering by students from the zoology department at Cardiff and two PhD programmes the answer was that rabbits and vegetation are likely to have evolved in a dynamic equilibrium over the centuries that have elapsed since rabbits had been introduced as a medieval meat and fur enterprise and there was no need for any human interference. Although the last project report on the rabbit work was produced in 2000, the follow up has continued intermittently by day visits to the present.

The value of rabbits as a window into the mechanisms by which botanical diversity is generated and maintained is evident when it is realised that their behaviour, in conjunction with climate, affects the scenic appearance of Skomer's landscape from season to season and year on year. Their visible presence unconstrained and their botanical impact contributes to the island being a wild, heterogenous botanical puzzle in the eyes of visitors.

In this respect, Skomer is a reminder that challenges to the management of biodiversity, such as predicting the ecological causes and consequences of global climate change, require the interfacing of phenomena that occur on very different scales of space, time, and ecological organization. On Skomer, at any moment, the surface of the island consists of many distinct patches and strips of vegetation of various sizes. Many of these patches consist of asynchronous stages in cycles of change from bare ground to dense monocultures of a few species that rabbits do not eat. These dense local monocultures, which defy national classification devised for relatively stable mainland ecosystems, in turn die away to be replaced by bare ground and the cycles begin again. The periods of these cycles are measured in decades and only become synchronous following the island-wide impact of salt spray from the occasional severe winter storm.

Taking a very long-term view, it is now evident that Skomer's vegetation cycles operate against a shifting background of the processes of ecological succession that began when the island was taken out of agricultural production in the 1950s. For example, maritime heath, which had been controlled by burning in the days of sheep-grazing and rabbit-trapping, has slowly declined. In contrast, bluebells, with a five year seed-to-seed development time, have spread slowly decade by decade, aided by free-ranging rabbits, which provide the bare ground seed bed. Also, climate change now has to be factored into botanical models, particularly with respect to the long-term dynamics of clifftop vegetation. Looking backwards against all this visual complexity, which is hardly understood, it is now evident that sporadic attempts made in the past to maintain or eliminate individual plant assemblies using herbicides or rabbit-proof exclosures were bound to fail because insufficient was known about the population dynamics of the dominant plants .

4 Skomer's botanical microcosms

A visitor walking the island's footpaths determined to reach the Puffin display at the Wick, is oblivious to the highly ordered patterns of botanical biodiversity in the central fields. To appreciate this phenomenon is a 'hands and knees job' because it is a small scale characteristic of the closely grazed patches of grassy sward, sometimes described as 'rabbit lawns'. Depending on the grazing pressure these grassy ecosystems can support about a dozen dicots and several mosses in equilibrium with a rabbit population that peaks at about forty animals per acre in the central fields . The dicots are mixed with grasses in microcosms cropped and trampled by rabbits to a few millimetres in height. To study this widespread feature of Skomer's biodiversity requires skills to identify their dwarfed non-flowering parts.

Broadly speaking, the rabbit habitat of the central fields is defined by four visual elements characterised by the dominant plant species; bracken, woodsage, ground ivy and grasses, with bare ground being the fifth element, exposed by burrowing and scraping The first two plants are not eaten by rabbits but it is the distribution of all four species in time and space that produces the rabbit's everchanging diverse landscape imprint. These dominants elicited the following statement, which summarised the botanical significance of these dominants in 1946..

They were interesting, the author's remarked: …... *"not because of the great number of rare species, some of which are often individually very numerous and may form pure communities. The more serious student of plant ecology will instantly recognise the characteristic grouping of species into associations or societies peculiar to certain types of country…..* ".

To place Skomer in a wider perspective, it is at this micro-landscape level that the problem of pattern and scale actually models the central problem in ecology, which entails unifying population biology, ecosystems science and marrying basic and applied ecology of conservation. In this broad scheme of things, the issue of ecological pattern is inseparable from the problem of the generation and maintenance of biodiversity. Not only is the heterogeneity of the environment often essential to the coexistence of species, but the very description of the spatial and temporal distributions of species is really a description of patterns of diversity. Thus, an understanding of botanical pattern in the low level landscape, its causes and its consequences, is central to understanding principles of evolution, such as speciation, as well as current ecological processes governing succession, community development, and the spread and persistence of individual species.

Although the concept of evolutionary humanism was the invention of a zoologist it can probably be appreciated better by the amateur botanist. Plants respond to the behaviour of rabbits to produce a dynamic, resilient,high topographical diversity in the low-biodiversity maritime grassland microcosm of Skomer's central fields and cliff tops. Rabbits thus hold the key to the existence of a range of mechanisms for generating pattern in landscapes further afield on greater scales. The resultant visual diversity is celebrated in a digital gallery of snapshots taken at various points around the island on 15th May, 2015. The gallery incidentally highlights a new aspect of the art of imaging micro-landscapes, which expresses the fortuitous ground level aesthetics arising through the dynamics of the island's botanical microcosms.

The basic principle of vegetation dynamics on Skomer is that rabbit grazing severely restricts the growth of species that are palatable as seedlings or mature plants. Their burrowing and scraping produces a seed bed for colonisation by unpalatable species, which grow as clumped monocultures shaped by their constant nibbling. These visually dominant clumps eventually die and are colonised all over again. The time scale of this cycle is measured in decades but we know little about the factors governing lifespans of the main botanical players. At the moment the sequence of species cannot be predicted but over the past forty years it has involved sorrels and docks, scentless mayweed, Yorkshire fog, woodsage, ground ivy, white campion, heather, red campion and bluebells. All of these species exist in mainland coastal scrub, which in the absence of rabbits would surely dominate the landscape of Skomer. This assembly of gorse/ bramble/ blackthorn/ bracken is currently the visually dominant feature of Marloes Deer Park on the mainland. There, with a very low rabbit population, it is managed by burning and grazed with beef cattle. It is also found along the coastal slopes of West Wales, where it is sometimes grazed by sheep. The place of trees in this maritime habitat can be imagined from the ancient woodland of Pinderi Cliffs Nature Reserve, which clings to the precipitous slopes above the sea north of Llanrhystud in Ceredigion. The principal biological interest of this site is the steeply west-facing sunted Sessile Oak woodland, which includes an interesting assemblage of other species such as Blackthorn, Hawthorn, Hazel, Small-leaved Lime, Spindle, Rowan, and Wych Elm.

5 A digital gallery of Skomer ecotopes

Regarding the current tree-free landscape of Skomer, the following images are snapshots into the various stages of 'rabbit-driven' processes that were evident on 15th May, 2015. They highlight the interactions between spatial pattern and ecological process, which are both studied as the causes and consequences of spatial heterogeneity of environment across a range of scales. Thus, we can define spatial patterns as ecological land units, or ecotopes as they have been named. Ecotopes are generally regarded as the smallest ecological landscape units that can be painted, photographed or measured. They are sometimes addressed as 'landscape cells'. Ecotopes are best defined as homogeneous ecological units, their spatial expression being predominantly determined by their structural characteristics. They are characterized by their species composition and the flows of energy, matter and information between organisms and the non-living elements of the visual ‘island’ cell.

1 Degraded maritime heath; north facing coastal slope

Fig 2 Above Bull Hole; clumps of dead thrift colonised by white campion.

Fig 3 Pigstone Bay; Clumps of nibbled thrift

Fig 4 Central grassland: Field 1; patch of ground ivy with rabbit lawns

Fig 5 Field 1: Large warren with woodsage and moss.

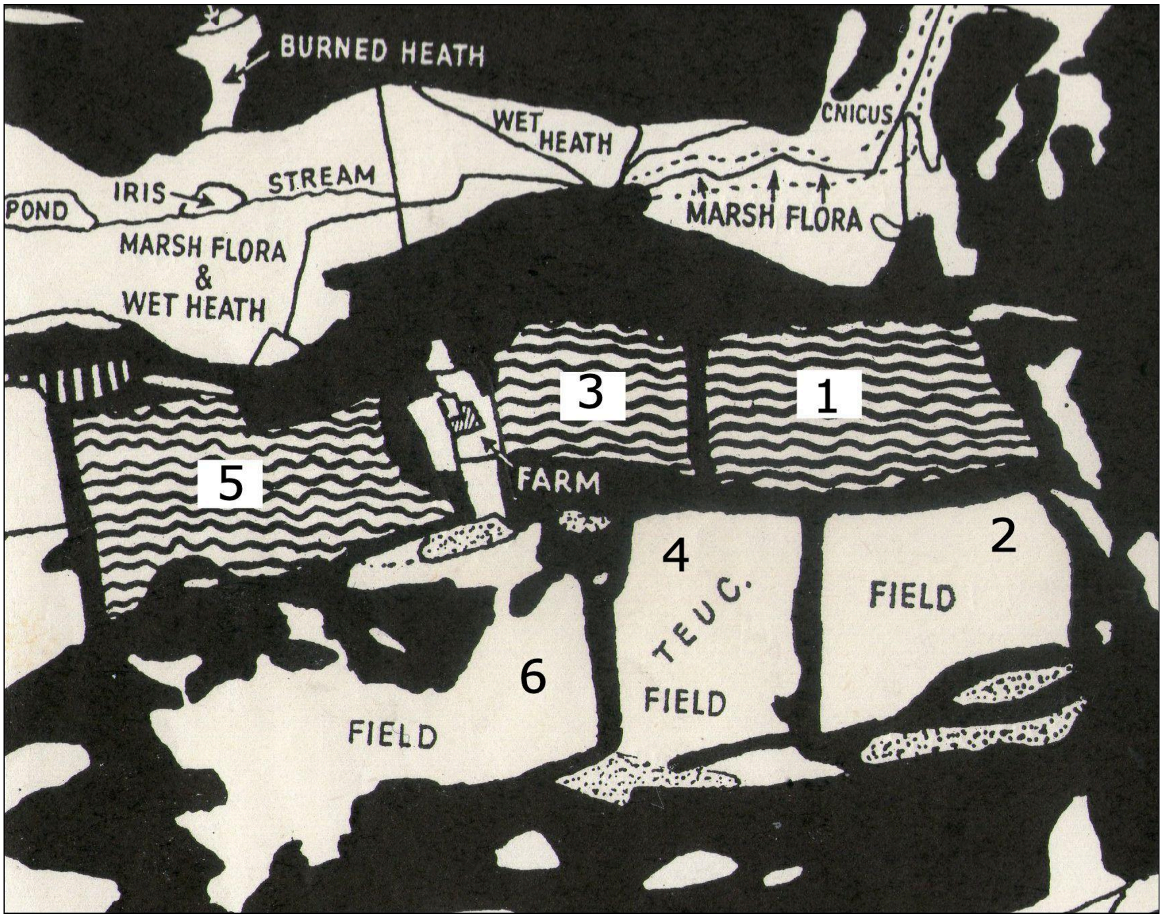
6 Imaging vegetation patterns in space, time and scale

‘Community assembly’ best describes the process which produces habitat patterning whereby species are filtered into ecological communities. Concurrent, multiple processes, which often operate at different spatial and temporal scales, are thought to act synergistically to influence the number and identity of species in local communities. Thus, a key challenge in the field is to identify those processes and determine their relative importance. This requires examining a particular pattern at various times, with a variety of methods and covering a range of scales. Over the years, the following four approaches have been brought to bear on Skomer’s central fields

Annotated mapping

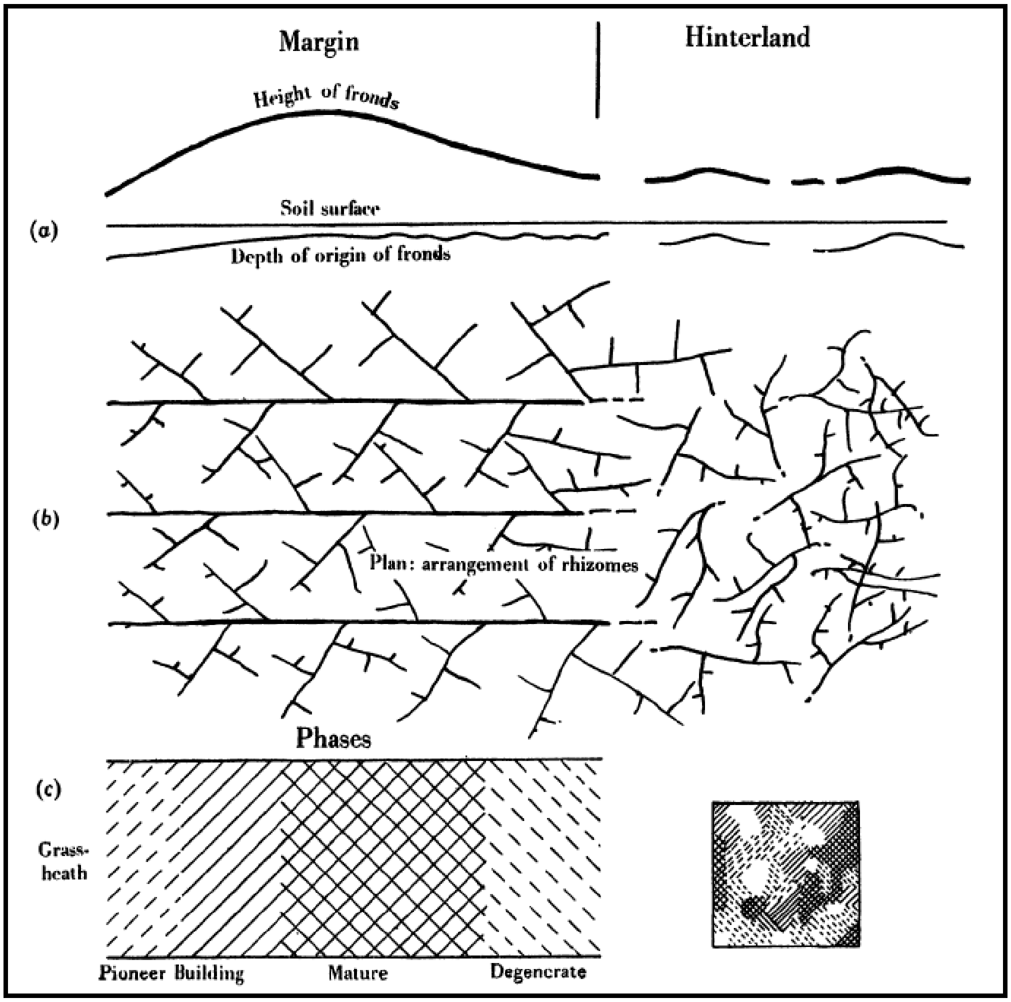
The first botanical map of Skomer was made by J Sadd as a contribution to the first field survey of the island which was carried out in 1946. A sketch map of the six fields clustered around the farmhouse (Fig 6) has been taken from his vegetation map of the whole island. At that time, the fields numbered 1, 3 and 5 were being cultivated for potatoes. The black areas represent the distribution of bracken. The wavy hatching shows the arable fields, The white areas are grassland and the mottled features are the rock outcrops. The apparently endless spread of bracken was the management issue of the time.

Fig 6 Skomer Island: central fields as delineated by J Sadd, 1947



The development of bracken into old fields was well understood from research of in the English Brecklands (Fig 7). The vanguard of the bracken consists of scattered fronds, short, deep set in the soil with short petioles showing above ground. The fronds then increase in number, grow taller, have longer petioles, and eventually form a continuous canopy of live fronds and a mat of dead fronds covering the ground and shading out the grass.

Fig 7 Spatial and temporal relations between the phases in the marginal belt and in the hinterland of a bracken community on Lakenheath Warren (Breckland).



http://campus.lakeforest.edu/menke/PDFs/Bio373/Watt_1947_JEco.pdf

The zone up to the point where continuous canopy is formed is referred to as the advancing margin. Behind, the fronds become still more numerous and taller with longer petioles: in fact, the fronds reach their maximum height here forming the crest of a wave advancing on the grass heath. Thereafter the fronds are somewhat shorter but are still tall with long petioles, and a relatively uniform height and density are maintained over a considerable but varying width. From the point where the canopy is formed to the further end of this zone of uniform height, the bracken is completely dominant. Then the dense and tall bracken ceases abruptly along a wavy line giving way to a hinterland in which the bracken is patchy: there are patches where the fronds are few and short with short petioles, others with more and taller fronds with longer petioles, and still others with fronds reaching the average height of the dense uniform belt. In some of the patches these three phases grade into each other forming roughly concentric zones around a nucleus of tall bracken (Fig 7).

In the centre of some of these there are small circular areas free from fronds, in others larger circular areas with few scattered short fronds, and there is the same abrupt change in height and number as in the change from the advancing belt of uniform bracken to the hinterland of patchy bracken. In fact, the phenomena of the patches in the hinterland largely repeat those of the main body, but with this difference, that the various zones instead of being in alignment with each other are concentric.

This dynamic of bracken was first revealed by the a research of Alexander Watt in 1929 who began studying the ecology of the Breckland area of north west Suffolk in 1929. In particular he studied the soil factors determining the composition of vegetation and later the effects of grazing by rabbits. Over an extended period from the 1930s to 1973 he made detailed study of the changes affecting different types of grassland. In the course of this work Watt became interested in the behaviour of bracken and studied the stages by which it advanced into grassland. From this work he was to develop a general concept of 'dynamic stability' in the plant community, envisaging it as a patchwork of vegetation at different stages of a long term repetitive cycle of composition. This system has been described on Skomer where Watt's steady state cycle of dynamic stability influences all plants affected by rabbit grazing.

In Fig 7 (a) is the change in height and in continuity of cover of the fronds: also the change in depth of origin of the fronds. In (b) the relative size and direction of growth of the main axes of the bracken plants are shown. In the marginal belt the axes are parallel, in the hinterland they form a network. In (c) the phases in the margin are in linear series: in the hinterland they are irregularly arranged.

These phases, are dynamically related to each other to produce an orderly change which accounts for the persistence of the pattern in the plant community. But on Skomer there are also departures from this inherent tendency to orderliness caused by fortuitous obstacles to the normal time sequence. For example, a large isolated patch of bracken to the east of Saunder's Fist disappeared in the 1990s. At any given time, therefore, structure is the resultant of causes which make for order and those that tend to upset it.

Satellite imaging

The field system sketched in Fig 6 is clearly defined in the satellite image that was available through Google Maps in February 2015. The image was shot in late summer/early autumn because the bracken shows up as brown patches along the edges of walls and outcrops in a pattern very similar to that depicted in Sadd's survey made some seven decades earlier. During the intervening period the only management activity was the almost total removal of bracken from Field 1 by applying a schedule of annual cutting with a tractor-drawn mower. This field was enclosed with a rabbit-proof fence in 1979 and used to study the population dynamics of rabbits and vegetation that remained within the 7 acre enclosure. The fence was removed after about a couple of decades

It is remarkable that Field 1 is still largely bracken-free. Before the programme of bracken cutting the frond density was similar to that shown in Fig 6 for the adjacent field to the west (Field 3). When the enclosure was established in Field 1 it made a large visual impact in the autumn colour pattern which had changed from brown bracken fronds to green grassland. This, together with the initial surge in grass productivity attracted an overwintering flock of barnacle geese. Bracken colonised the field that was under the plough in 1946 and the fact that bracken is also still confined to the the field edges in the southern fields 2, 4, and 6 remains a puzzle. On Skomer, the fortuitous obstacles to the spread of bracken are rabbit mortality, soil depth and composition,, climate change and storm spray. Both sets of causes must be appreciated to understand why Field 1 did not return to the uniform bracken cover of the early 1970s when the rabbit exclosure was removed..

False colour imaging

Natural colour images, like the one in Fig 8, tend to be low in contrast and somewhat hazy in appearance. This is because blue light is more susceptible than other bandwidths to scattering by the atmosphere. However, these are of interest for some applications because landcover is associated with familiar colors, e.g. grass with green. Satellite images have much more to reveal by applying so called false colour filters. From this point of view, the colours and structures in digital images are neither ‘true’ nor ‘false’, but are representative of the different physical processes underlying the subjects of the images. Both natural and false color images enable the user to highlight specific parts of the image by utilizing the most suitable portion of the spectrum for specific applications. In doing so, this aids in image interpretation and visualization. A natural colour composite is an image displaying a combination of visible red, green and blue bands approximately matching the spectral range of vision for the human eye. Therefore these images appear to be close to what we would expect to see in a normal colour photograph. Integrating colour raster data, such as an elevation tint, with grayscale raster data, such as a hillshade, is an important visualization function in satellite remote sensing and geographic information systems. There are a number of methods that have traditionally been used to combine the bit mapped images by transforming the original data, such as Red-Green-Blue (RGB)/ Intensity- Hue- Saturation (IHS) transformation.

Fig 8 Central fields from natural colour composite cropped from Google Maps: February 2015

Just like the pictures downloaded from the Hubble space telescope the colour enhanced pictures are a way to represent in a single image as much information as possible that's available in the data. The aim is therefore to create a sense of wonderment in the viewer and a desire to explain the botanical diversity that underlies them.

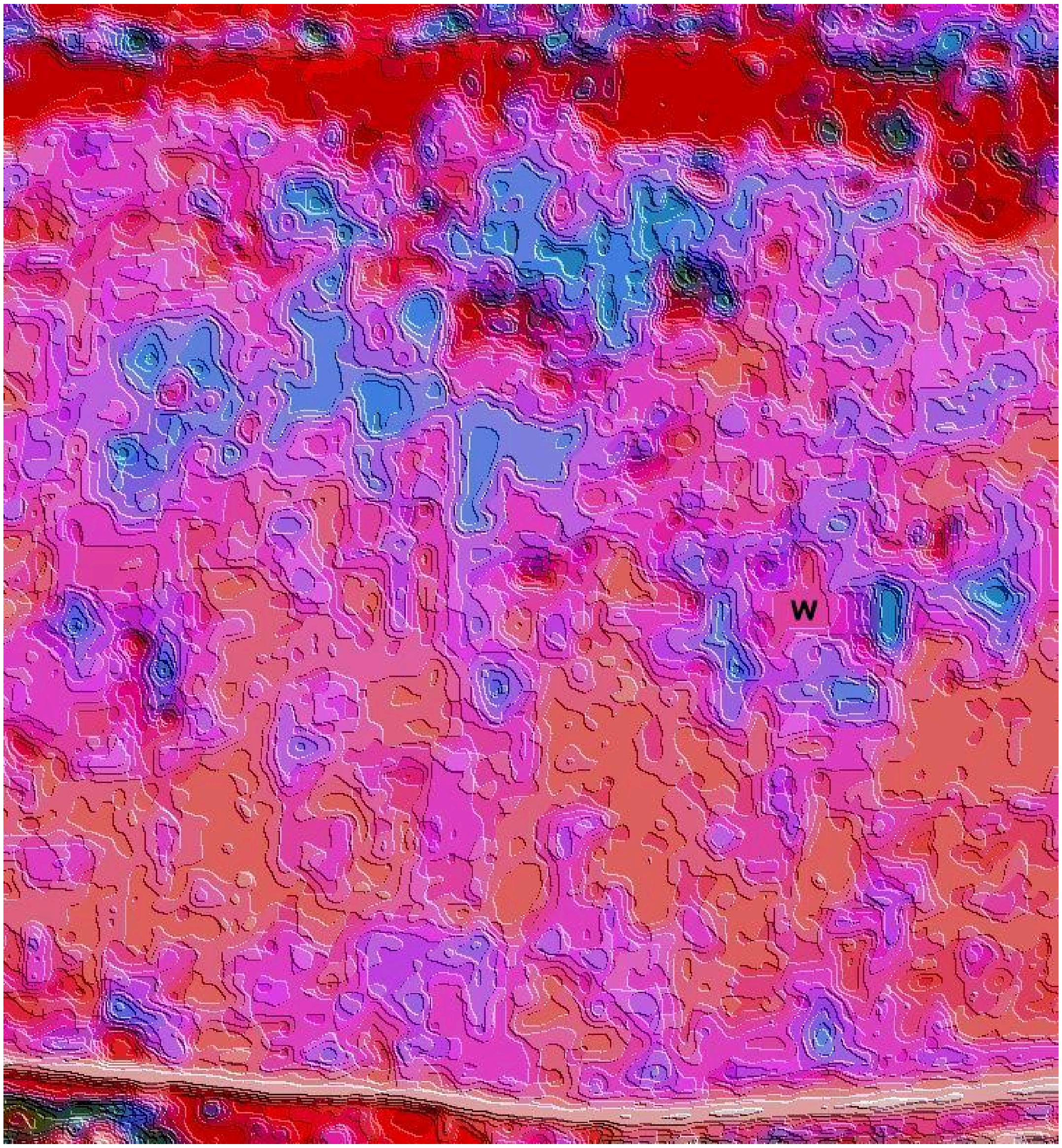
False-color images such as the above are a representation of a multi-spectral image produced using bands other than visible red, green and blue as the red, green and blue components of an image display. Using bands such as near infra-red increases the spectral separation and often the interpretability of the data. Images generated from a variety of bands such as Landsat bands 7, 4, 2 or 4, 3, 2 are common selections. The near infra-red band is particularly useful as vegetation reflects much more energy in this part of the spectrum than it does for visible green. The resulting images are more sensitive to variations in vegetation type and condition (Fig 9).

Fig 9 False colour composite of the image in Fig 2 obtained by applying the the Red-Green-Blue (RGB)/Intensity-Hue-Saturation (IHS) transformation (PaintshopProX5)

An example of digital colour enhancement of part of Field 1 can be seen in Fig 9. The site of the warren in Fig 10 is marked (W).

The image was produced from the Google satellite image using the enhancement tools of Corel PaintShop Pro5X for adjusting saturation and hue and then applying the topography tool.

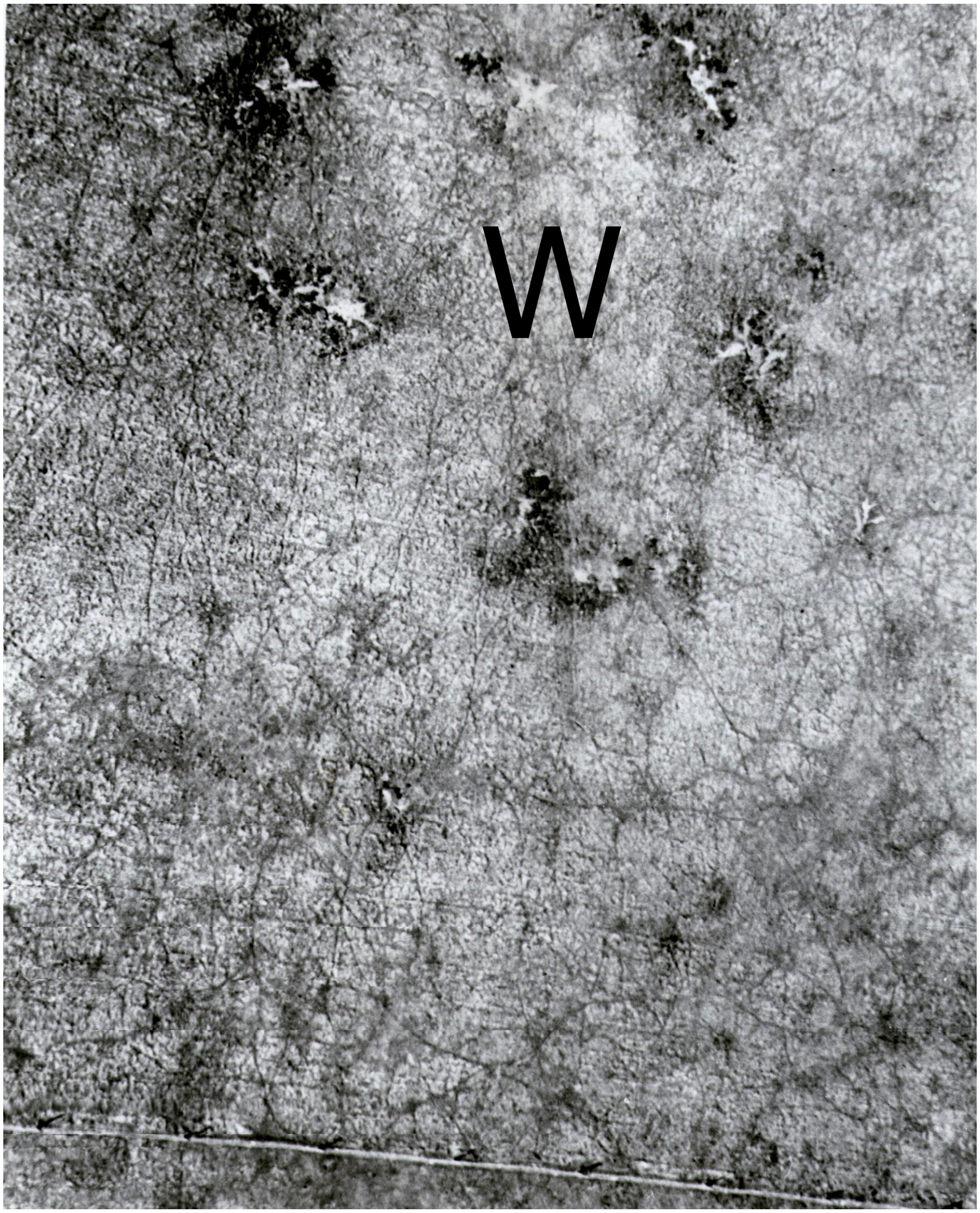
Fig 9 Part of Field 1 using the false colour mapping and topographic tools in PaintShop ProX5 to enhance the Google satellite image of Skomer which was current in January 2015



Close up vertical aerial photography

Helicopter view of five warren entrances, marked (W) in the eastern part of the Field 1 enclosure: shot from a helicopter with a hand-held camera in 1982.

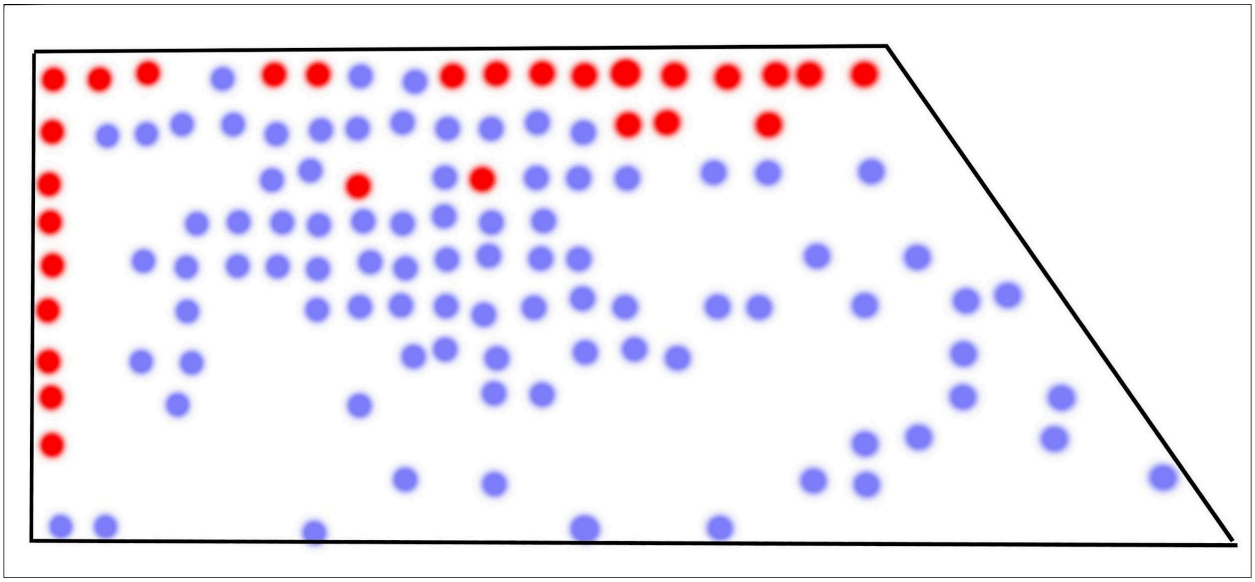
Fig 10 Aerial photography: Field 1 1982



Quadrat mapping

An example of a coarse pattern of vegetation is presented in Fig 11. It was obtained by walking Field 1 in 2005 guided by a permanent grid that was originally created to count the rabbit population. In each grid square a quadrat (0.5 x 0.5m) was thrown at random and the patch of vegetation enclosed by the quadrat was categorised by eye into one of the three ecological elements defined above.

Fig 11 Distribution of the three major botanical pattern-forming elements in Field 1, also known as ‘Calves Park’ (2005)



Red = bracken dominant; Blue = woodsage dominant; the rest of the field was dominated by grass.

Comparison of the detail in the three images demonstrates that here is no single natural scale at which ecological phenomena should be studied; systems generally show characteristic variability on a range of spatial, temporal, and organizational scales. The observer and his or her method imposes a perceptual bias, a filter through which the system is viewed. This has fundamental evolutionary significance, since every organism is an "observer" of the environment, and life historical adaptations, such as dispersal and dormancy, alter the perceptual scales of the species, and the observed variability. This has fundamental significance for the study of ecological systems, since the patterns that are unique to any range of scales will have unique causes and biological consequences.

The key to predicting and understanding long term ecological changes lies in the elucidation of mechanisms underlying an observed pattern. Typically, these mechanisms operate at different scales than those on which the patterns are observed. In some cases, the patterns must be understood as emerging from the collective behaviors of large ensembles of smaller scale units. In other cases, the pattern is imposed by larger scale constraints. Examination of such phenomena requires the study of how pattern and variability change with the scale and time of description, and the development of investigative procedures for simplification, aggregation, and scaling. Ideally, such an analysis should begin with the finest scale of recording possible. It is here that enhancement of digital images from satellite or aerial surveys can be of help in highlighting patterns that can then be checked out for meaning with a ground survey using a hand-held GPS mapping device (Figs 2 and 3, and Appendix 1). An example of what this comparison might reveal is evident in the photograph taken looking north east across Field 1 in May 2015 (Fig 12). .

Fig 12 Snapshot of vegetation in Field 1; May 2015

7 Some Conclusions

Five decades have passed since the rabbit vegetation project was launched on Skomer and we are only now just starting to understand the functional details of Watt's concept of long-term dynamic stability as it appears in the old field systems, many of which were created and last used more than two millennia ago.

It is only in the last decade that digital imaging has entered ecology as a surveillance tool. But we can be sure that a combination of digital imaging with the older ground-based methods of quadrating etc will open up new lines of enquiry, particularly in relation to climate change, where Skomer is a key European observatory. In so far as a vegetation classification provides a means for humans to conceptualise a complex phenomenon and to communicate about it for purposes such as conservation, management, and environmental education, we only summarise our achievements in the words used in 1946.

"The vegetation of these sub-Atlantic islands can perhaps best be described in general terms as an intricate series or pattern of interlocking plant association , and we have attempted to describe only the main features of this pattern on Skomer....

Appendix 1

Enhancement of digital images: using tools in Corel PaintShop ProX5

1 Adjusting saturation and hue

Saturation is the purity or vividness of a color, expressed as the absence of white. A color with 100% saturation contains no white. A color with 0% saturation corresponds to a shade of gray.

A hue is the property that defines a particular color. For example, blue, green, and red are all hues.

Hue refers to the actual color (such as red or yellow). Saturation is the vividness of the color. Imagine bright orange, which is a highly saturated color. As the saturation is reduced (keeping the hue and lightness unchanged), the orange color becomes brownish, then taupe, and finally a middle neutral gray (after the saturation has been reduced to zero). Reducing the saturation drains the color away, leaving just the grayscale component. Taupe and mauve are low-saturation colors because they are quite neutral, with just a touch of color. Apple red and banana yellow are high-saturation colors. Saturation is a measure of how different a color is from a neutral gray of the same brightness.

In digital images, increasing the saturation can give the image brilliant color and "punch," but too much saturation distorts colors and causes problems such as unnatural-looking skin tones. You can use the Vibrancy control to target only those areas that are low on saturation without affecting the rest of the image. For example, you can boost color in less saturated parts of an image without significantly altering other

Corel PaintShop Pro gives you four ways to alter the hue and saturation of a selection or of an entire image:

2 Recolourising parts of an image

You can replace all colors with a single color and saturation while leaving the lightness values unchanged. You can create sepia tones, like the brownish tones seen in old photographs, and other single-color effects.

You can shift all colors and change their strength and lightness. Changing the hue shifts all pixels in an image to a different point on the color wheel. For example, if you change the red pixels to green, the green pixels turn to blue, and the yellow pixels turn to cyan. Adjusting the saturation changes the amount of gray in a color. (The level of gray increases as the saturation decreases.) Adjusting the lightness changes color brightness.

You can replace one or more colors. For example, you can shift all greens to blues. You can also change the saturation or the lightness. When you adjust these values, all colors (both original and shifted colors) are adjusted.

You can adjust only the least saturated colors in the image using the Vibrancy control and thus leave unaltered those pixels that are already relatively saturated. The result is that you will get a general improvement in the saturation in the colors of an image but not to the extent where colors become unrealistically bright.

You can use the Color Changer tool to realistically recolor an object or a region in an image. What sets the Color Changer tool apart from other tools and commands (such as the Flood Fill tool, some of the retouching brushes, or the Colorize, Hue/Saturation/Lightness, or Hue Map commands) is that it takes into account the shading of the specified color. The Color Changer tool detects and analyzes variations in image brightness and applies the recoloring based on that illumination. It lets you adjust Tool Options palette settings for Tolerance and Edge Softness, and it updates the current recoloring as you modify settings on the Tool Options palette or modify the color in the Materials palette.

The Color Changer tool works best on matte objects such as clothing, carpet, and painted objects that are a solid color. It may not work as well on shiny or reflective objects and is not designed to work with gradients or patterns.

3 Trace contour

The Trace Contour effect traces a series of single-pixel lines around areas of contrast and turns the remaining pixels white

4 Topography

The Topography effect gives an image a three-dimensional look so that the image appears to have been created from a system of terraces. You can access the Topography dialog box by choosing Effects Artistic Effects Topography.
The Topography dialog box contains the following controls:

- Width - controls the size of each terrace or layer
- Density - sets the number of terraces
- Angle - affects which edges appear light and shadowed. The needle points to the direction of the light source, measured in degrees of rotation around the circle. To set the value, you can click in the circle, drag the needle, or set or type a number in the control.
- Color - lets you choose a color for the light shining on the sides of the terraces. To change the light color, you can click a color in the original image, click the color box to access the Color dialog box, or right-click the color box to access the Recent Colors dialog box.

Appendix 2 By the campfire

We're hearing so much about
Indigenous knowledge lately
Knowledge about the natural world

We want to know that knowledge
To understand what we've done wrong
To make things better

But knowledge alone won't do that for us

Stories we hear
From indigenous mouths
Are not stories of
Knowledge of place alone
They are stories of
Sense of place

Not what to know about
A place you live in
But how to live in
A place you know

Not just
Humans in nature but
Nature in humans

Stories not of
Knowledge alone
But of wisdom which is
Lessons we draw from knowledge

Information alone is nothing if
There's no lesson to draw

Luisa Maffi
Tucson, April 1996
http://www.unep.org/pdf/Cultural_Spiritual_thebible.pdf

6.

8 Beliefs about culture ecology and settlement history.

Every culture making a living out of Skomer has had, in its time, some kind of belief system behind its understanding of the ecosystems that govern the availability of the island's natural resources. The notion of a conservation belief system has been defined as the sum total of the knowledge and skills which people in a particular geographical area possess in order to partake of its material riches by managing it as a sustainable resource. This is obviously the top cultural objective on an island as small as Skomer. Much of this knowledge and these skills would have been passed down from earlier generations, but individual men and women in each new generation would adapt and add to this indigenous knowledge in a constant adjustment to changing economic circumstances and environmental conditions. They in turn would pass on their body of knowledge to the next generation and the belief system changes. This is the way humankind has developed a global conservation culture, which rests on knowing about places where the concepts and practices for sustaining natural resource management help people to build what has been termed a "visceral vocabulary of place". The vocabulary provides a legacy for the survival of future generations. In this way, beliefs about how natural resources should be managed can become inextricably bound to the routines of daily life. At the root of it, a belief system is a quest for harmony between an individual, and his or her imaginings about nature and society. In fact, there is a complementary relationship between the two, with the imaginative often being more powerful than the material. Also, there is a belief community of the dead as well as of the living. This has led to the belief that leadership training should have a built in element of mysticism and scientists should not back away from this with feelings of shock/horror.

Even today, the unseen world of the imagination is as much a part of reality as that which is seen and on Skomer in the past we would expect that the spiritual would have been as much a part of the island's culture as the material. In nature, behind visible objects lie essences, or powers of the imagination, which constitute the cultural nature of Skomer's rocks, cliffs, soils flowers and seabirds. For the prehistoric farmers of Skomer there were no doubt stories told about the lines of huge boundary stones their ancestors had left, stretching out to the west, across the wild coastal slopes towards Grassholm. At the very least the stones symbolise the uncovering of a fertile soil that enabled demarkation of family settlement and survival in a limited area of cultivatable land. The distinctive feature of indigenous belief systems is that they are ways of life with the purpose of ordering relationships with fellow non-human beings, particularly on Skomer, where the numerous sea birds returned year on year to nest on the cliffs and coastal slopes. The birds would have contributed to the islander's nutrition as well as being a reminder of the great unknown of the West into which they disappeared at the summer's end.

Imagination is certainly brought into play when mainlanders meet up with the conceptual mapping of the survival strategies and creativity of past islanders depicted in their earthworks.

Visitors become islanders through the very act of conceptualising their experiences of walking through the landscape. Take for example, the imaginative essence in the next paragraph.

"The first test of a visitor to Skomer Island is to make sense of 'the Harold Stone' situated high above the north landing. This is a mysterious man-sized megalith from which the eye takes in an impresssive theatrical field of view encompassing St Bride's Bay. Beyond the mainland cliffs to the East lies the Neolithic mainland culture expressed in a scattering of up-ended stones stretching as far as Stonehenge'. On the island, behind the Harold Stone to the West the densely packed small enclosures of fields and homesteads supported a handful of families living cheek by jowl with the uncertainties of tribal life."

Meditating on this deeper cultural significance of fields, Tim Dee makes us look anew at where we live and how. In his book entitled Four Fields, published in 2013, Dee says *"fields offer the most articulate description and vivid enactment of our life here on earth, of how we live both within the grain of the world and against it"*. He argues that we must attend to what we have made of the wild, to look at and think about the way we have messed things up, but also to notice how we have kept going alongside nature, trying to listen to the conversation we have had with grass and fields. Dee's four fields, which he has known for more than twenty years, begin with the fields reclaimed from wild fen wetland at the bottom of his Cambridgeshire garden, then comes an account of a field of view in the Zambian Serengeti grassland biome, across which the vast herds of Wikdebest migrate back and forth. Then follows his accounts of the prairie battlefield of Little Bighorn, Montana, USA, and a deserted grass meadow in the exclusion zone of the wrecked nuclear power station at Chernobyl.

In this context, Skomer's fields are a few hundred acres standing for the real world. They can still be walked, mapped, mown and known. *"Each has lived, at least for some time, as an apparently flat and plain place but also as a living sheet on which people sketched or screened various dreams for a while"*. On Skomer, every stone has been dragged or lifted by hands and these hands represent human endeavour bridging the centuries, In their ubiquity and in their endless difference fields are places of continuity and security and also of risk and transformation. On Skomer, the field makers were trying to live within the grain of planet Earth to crop the land sustainably. Now, it is in the deserted fields that we can tune into the burgeoning human assault on the environment. The up ended stones carry a cultural message as significant as Stonehenge

One of the the beginnings of the mainland assault on the islands of north west Europe can be dated to May 15th, 1741 when the botanist Linnaeus set off on a journey of scientific exploration on behalf of the Swedish parliament. His destination was the islands of Öland and Gotland where it was thought that Linnaeus would make discoveries that would help to strengthen Sweden's economy. Chinese porcelain was being imported at great expense to meet the wants of the expanding Swedish middle class. It was the start of global consumerism and perhaps Linnaeus could find clay suitable for making china in Sweden. Plants to dye cloth for the mass production of textiles were also to be looked for. Six students accompanied Linnaeus on his journey. Together they explored the flora on Öland and were impressed by the great number of orchids found. During their three weeks on Öland they found time to examine everything from runic inscriptions to the enormous appetites of the locals. Among all that fascinated him on Gotland was the profusion of birds. On the little island of Fårö he noted that the peasants even put up nesting-boxes near their houses. Why? They wanted to listen to the bird-song! A sign that the human population was still trying to live with the biological grain of the planet.

Table 1 Definitions of field

Agrcultural compartment
- Productive
- Deserted

Field of view (e.g. as far as the eye can see)
- Landscape
- Territory

Field of battle

Optical representation (e.g.macro/microcosms)
- Microscope
- Field glasses
- Astronomical telescope
- Camera

Expertise e.g, (not my field)

Place for research (e.g. field station)

Outdoor research (e.g.research in the field)

9 Facts about settlement history

New ecological models emphasize the ubiquity of change; to persist in the presence of environmental variability means that a system has features that make it resilient. What persists is the overall state of the system and the types of ecological and social controls that shape the system. The Resilience Alliance (2002) has proposed that resilient social ecological systems exhibit three characteristics: the ability to buffer disturbance, the ability to self-organize, and the ability to learn. Humans are assumed to be part of the ecosystem and a potential source of variability. There may be a list of characteristics that societies need to have in order to cope with particular characteristics of their environment. To cope with “temporary abundance,” one could say that “to cope” is “to be resilient.”

There is a relationship between settlement pattern within an island group and the stability of potential of the population inhabiting those islands. Extinction probability is based on island carrying capacity, frequency and amplitude of fluctuation in resources determining carrying capacity, and the net costs of contact and exchange between population units. It will determine island settlement patterns, resulting in nonsettlement of islands with low carrying capacities and settlement of all islands with high carrying capacities.

The Marshall Island group includes both settled and unsettled islands, and represents a homogeneous culture that has remained unchanged for many generations. The mesophytic index (rainfall x land area), used as an indicator of atoll human carrying capacity, was related to island settlement patterns. No atolls with mesophytic indices exceeding 2000 units were uninhabited, although 4 with values under 2000 units were inhabited, suggesting an overlap zone between inhabitable and uninhabitable islands. Population size and settlement existence were also related. Only 2 of 21 inhabited islands had populations below 100, and none of the uninhabited islands contained more than 78 individuals. These results may be of relevance to earlier atoll colonization patterns. The prerequisites for atoll colonization appear to have been colonizing groups exceeding 80 individuals, contact with an established population source, and a horticultural subsistence mode and maritime technology. It is concluded that small population instability should be considered in terms of the colonization process and settlement pattern of island groups.

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Appendix 4 Managing natural beauty