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# Strange Attractors in the Norwegian Stone Age

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## Abstract

This paper explores an application of concepts from chaos theory and nonlinear system theory, and argues that nonlinear system theory is a useful tool in understanding the use of landscape and the creation of taskscapes by prehistoric and modern people around Lake Vavatn in Lærdalsfjellene (the Lærdal Mountains), a part of the high mountains in South Norway. It is necessary to replace a static model based on duration and stability with a model that can focus on change and variability in recorded archaeological material that is the result of past and present events. Sites and areas that have artefacts indicating many events are seen as focal points in the landscape. The trajectories of movements and events in time and space are described as strange attractors. These strange attractors are visualised through the Poincaré set created by sites and single artefacts. In the case of Lake Vavatn, traces of human activity from several periods have created points in the Poincaré set; the typologically dated stone artefacts from earliest Middle Mesolithic at several early intervals, possible pastoralist activities from the Neolithic, the probably medieval animal fall pits at a later time, the modern shieling, cottages for leisure, and archaeological surveying today. The sum of observations does not allow statements about continuation during this over 8000-year period of archaeological and modern history, but it does show that Lake Vavatn has been attractive throughout multiple periods.

**Keywords:** Chaos theory, strange attractor, Lærdalsfjellene, Lake Vavatn, MUSITark

## Introduction

This paper will explore an application of concepts from chaos theory and nonlinear system theory in relation to the distribution of traces of human activities in the high mountains in South Norway. Archaeological artefacts found in the landscape are remains of past activities registered through modern archaeological activity. These activities take place in a four-dimensional phase-space, consisting of the three-dimensional landscape and the fourth dimension time. The activities are a range of tasks of shorter and longer duration. It is events of shorter duration, like hunting and butchering, where flint knapping to produce elaborate or expedient tools can be even more ephemeral events prior to or during a hunt. It is also events of longer duration like a year cycle consisting of movement coast-inland, and finally events belonging to archaeological survey or other activity that leads to the discovery of archaeological artefacts. All these activities can be cycles of shorter or longer duration, and create taskscapes that people relate to (Ingold 1993). This is a chaotic system, a system of stochastic determinism. The performance of the activities follow trajectories that describe the system — the system's strange attractor. The strange attractor cannot be described directly, as the distribution in time is gone. However, the remains of the prehistoric activities are now found in the three-dimensional landscape forming a Poincaré set that describe the system indirectly.

The paper uses material from the national MUSIT database, which is published as open data.

The Norwegian university museums have since the early 1990s cooperated to create common database solutions for the archaeological collections in Norway (Matsumoto & Uleberg 2015; Ore 1998). This cooperation has been organised in MUSIT (MUSeumIT) since 2007. As of October 2019 more than 1.4 million georeferenced entries are published online as open data.[1] The dataset consists of converted artefact catalogues from 1829 until 2002. After a transient period until 2004, all catalogues are entered in the MUSIT artefact database, archaeology (MUSITark). The earlier catalogues are written to give an easily readable overview of the artefacts. The more recent catalogues are entered with detailed context information, which makes it possible to conduct site analyses directly. The museums also publish photos of artefacts and from sites with a CC BY-SA 4.0 licence.[2] This way of publishing archaeological artefacts opens new venues for archaeological research in Norway. The material used in this paper is exclusively taken from MUSITark.

## Stone Age Sites in the High Mountains

The major part of the known Stone Age sites in the high mountains in Norway has been found during archaeological surveys for construction of hydroelectric dams. This work started in the late 1950s and continues even today as renewed surveys at existing constructions (Indrelid 2006). In some areas, like around Lake Vavatn that we will discuss later, essential knowledge also comes from private initiatives. All in all this provides an extensive knowledge base for Stone Age sites in the Norwegian high mountains.

Groups of hunter-gatherers came to the high mountains shortly after the end of the Last Ice Age (ca 10 000 BP). The following warm periods made it possible for trees to grow at a much higher altitude than today. The high forest limit probably continued until the beginning of the Iron Age / the climatic Sub-Atlantic period. The existence of a birch belt above the deciduous forest can be found in pollen analysis and especially macrofossils like tree trunks at high altitudes (Faarlund & Aas 1991). This implies that today's high mountain sites were mainly in forested areas.

The oldest mountain sites in South Norway are found at Store Fløyrlivatnet (Figure 1: 7), where five sites are dated to the interval between 9750 ± 80 and 9360 ± 80 BP. Analyses of the charcoal show that the vegetation consisted of birch and willow. Pieces of oak and pine from this early stage indicate that wooden objects have been brought from the coast to the mountain sites, probably reflecting seasonal movements between coast and inland (Bang-Andersen 2000: 27–32). The fact that there are Early Mesolithic sites both at the coast and in the inland in Western Norway indicates that the pioneers were not specialised, neither as reindeer hunters nor with a marine adaptation (Persson 2017: 207).

The earliest sites in Lærdalsfjellene (Figure 1:1–6), the area we will concentrate on here, are dated to around 8500 BP. Organic material like bone and charcoal are rarely found, as at other Norwegian Stone Age sites, and consequently the sites are often only typologically dated. It is also rare to find sites with stratigraphy, since they are mainly open-air sites with artefacts in or directly below a thin layer of turf. Sites in Lærdalsfjellene can have material ranging from Early Mesolithic to Late Neolithic (Matsumoto & Uleberg 2002; Uleberg 2002; Uleberg 2003; Uleberg 2004), and the site Hein 33 at Halnefjorden in Hardangervidda is reported to have at least six different visits over a span of almost 4000 years (Indrelid 1994: 218).

Major traditional research foci related to the high mountain Stone Age has been seasonal movement and site continuity (Johansen 1978; Mikkelsen 1989). The models, especially in Arne B. Johansen's studies of Lærdalsfjellene in the 1970s, have underlined the stability in these systems, with the same annual cycle continuing throughout millennia (Johansen 1970; Johansen 1978). A hiatus in the utilisation of the high mountains after 6000 BC has been explained by climate deterioration (Moe, Indrelid & Kjos-Hanssen 1978). A climate change would have given worse conditions for the reindeer and consequently fewer sites. This has later been described as a "classic hiatus" (Selsing 2010: 162 ff.), but has also been criticised as it could be a result of skewed sampling. Per Persson

1 http://www.unimus.no/portal/

2 https://creativecommons.org/

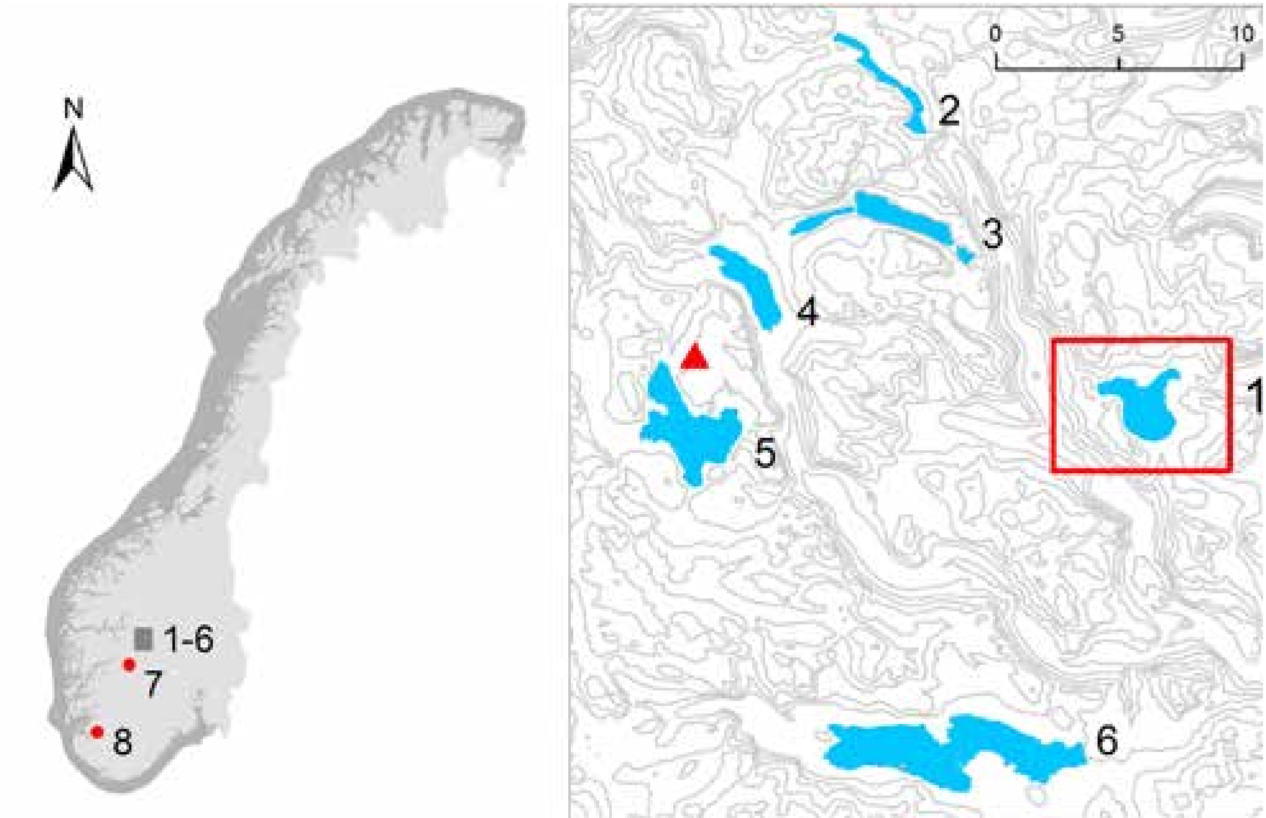


**Figure 1.** Major lakes (1-6) in Lærdalsfjellene, Hein 33 at Halnefjorden (7) in Hardangervidda, and Store Fløyrlivatnet (8) in Rogaland. 1. Vavatn, 2. Sulevatnet, 3. Juklevatnet, 4. Eldrevatnet, 5. Øljusjøen, 6. Gyrinosvatnet/Flævatn. ▲Kjølskarvet quartzite quarry. Contour interval is 100 m. Red frame indicates Lake Vavatn and surroundings shown in Fig. 5.

suggests this hiatus could mark the end of an Early Mesolithic pioneer phase (Persson 2017: 200).

Two periods of inland activity during the Mesolithic have been demonstrated by Joel Boaz (1998) based on radiocarbon dating and typology. This pattern has recently been substantiated by new sets of radiocarbon dating on osteological material. They indicate a period of less use of the inland regions after 8500 BC, and a renewed higher interest in the interior lowland areas from around 6900 BC (Persson 2017: 210).

However, the site distribution can be indications of more fluctuation and serves as a good example of a non-linear system where the stability is interrupted by exogenous or endogenous factors, passing through a period of instability and then finding a new, relatively steady state.

Reindeer hunting continues to be the focus for the understanding of site distribution in the high mountains. There are two reasons why this cannot be the only explanation through all of the Stone Age. One reason is that the higher forest limit will have influenced the reindeer trails and the species that could be hunted. A higher forest limit will give better conditions for moose, and moose bones have been found at a site 1130 m a.s.l. at Hardangervidda (Indrelid 1994: 37, 236–241). The other reason is that Neolithic sites tend to covariate with the Iron Age and modern sites used for shieling. This can indicate that such a place in the landscape was chosen on basis of the interests of pastoralists and not hunters (Meløe 1989; Prescott 1995).

The sites in the high mountains are generally found around the lakes. The obvious reason is that the surveys were concentrated in areas inflicted by dam constructions. Some sites are spatially quite concentrated and well-defined, but in other cases archaeological material can be found along shoreline stretches. In the latter case, it could be more useful to describe this as continuous activity areas with remains from separate activities (events) taking place at shorter or longer, continuous or separated time intervals. In the frame of chaos theory and strange attractors, each artefact will be a point in the Poincaré set.

## Stability and Change—Movement in the Landscape

The archaeological material is the source to understand the prehistoric landscape as experienced and created by humans. The quest for the landscapes of past people will start at the recorded landscape, move on to the reconstructed landscape, then on to the utopian landscape, and finally try to reach the experienced landscape (Welinder 1988: 50–53). The recorded landscape is the site distribution map, the results of surveys enriched with more knowledge about the excavated sites, but where humans are anonymous groups leaving artefacts at certain points in the landscape. This recorded landscape is transformed into the reconstructed landscape through pollen analysis and other methods to reconstruct the environment. In systems theory this has often been presented as a site-catchment analysis, where the site is the centre of a certain form of subsistence maintained by optimising groups. The utopian landscape catches the movement between the larger sites, and the series of events that happened between these sites. It is not possible to document all traces in the landscape, but the smaller off-site artefact clusters and single finds shed some light on the activities. All these landscapes are the landscapes of the researchers. The experienced landscape belongs only to the people living in it and re-creating it every day through acting and sharing experiences. The experienced landscape eludes us, and we can never really understand it fully.

The flow and continuous activity that Stig Welinder describes as the utopian landscape can to a certain extent be approached by using chaîne opératoire. The research method chaîne opératoire concentrates on the sequence of prehistoric human actions. These actions can be in one place over a short time span, like the production of tools. Chaîne opératoire can however also be used in a wider context, over longer periods and larger areas. It can describe movement through the landscape with a series of repeating actions at different places (Conneler 2006). Chaîne opératoire targets these events in themselves. Tim Ingold's taskscape (Ingold 1993) focuses on how these events let the actors create their own landscape and in this way approaches Welinder's experienced landscape. Groups with different subsistence patterns will observe and be conscious about different aspects of the landscape (Meløe 1989). Their perception of the landscape is dependent on their actions, which again are connected to their mode of subsistence. A hunter-gatherer will be aware of other qualitative aspects than a pastoralist. Hunter-gatherers will look for animal trails and think of how to hunt. Pastoralists will look for areas well suited for herding and grazing and think of how to protect their animals. In a similar way, archaeologists will look for places suitable for prehistoric events. Sites are registered where modern events of surveying coincides with prehistoric choices (cf. Fig. 6).

The chaîne opératoire behind certain tools and artefacts can be demonstrated by conjoining the remaining pieces. The conjoining can illustrate movement at a site; that different work sequences have been performed at different places. Conjoining can also show traces of movement in the landscape. An example of this can be found at the Lake Gyrinosvatn (Figure 1: 6), only 20 km South-West from Lake Vavatn. There are several excavated sites around Lake Gyrinosvatn with the characteristic local greenish quartzite known as Lærdalskvartsitt, and it has been possible to put together pieces from several of these. This shows that nodules have been taken from one site and brought to another to be used further (Schaller-Åhrberg 1990). This example is intriguing especially because neither the nodule nor the other pieces can be dated with any certainty. It is therefore not possible to know whether it is the same person who used this nodule or whether the nodule was left at one site and picked up again shortly or several years later. In this way there is a continuity and connection not only through space but possibly also through a vast timespan.

Movement in the landscape can also be inferred from the use of quartzite outcrops. Quartzite nodules can be found several places in Lærdalsfjellene, but there are also several quartzite outcrops known to have been used during the Stone Age and Bronze Age.

## Quarries

The most prominent quartzite quarry in Lærdalsfjellene is at Kjølskarvet (Figure 1: ▲). The quartzite found here is an easily recognizable greenish type of Lærdalskvartsitt. Kjølskarvet is a promontory in a landscape without vegetation (Figure 2). The top is well above 1400 m a.s.l. and it has therefore always been above the local tree limit. There are also several smaller quarries close to the main site. Numerous activity areas are scattered in the vicinity and along the possible routes to and from the quarry. Arne B. Johansen's publication (1978) shows a model of the quarry with survey transects and areas with artefacts (Figure 3). Today we can see this as an illustration of a series of single events; the prehistoric distribution in time is not visible and the archaeological survey intersects the Poincaré set formed by the Stone Age artefacts.

Astrid J. Nyland's study of Stone Age and Bronze Age quarries in South Norway ranks Kjølskarvet as a lithic extraction site with a high level of activity. It is in use from the Middle Mesolithic to the Pre-Roman Iron Age, with lower activity in the first and last part of this long period. It is estimated that 100 m3 were extracted over a period of 8000 years (Nyland 2017a; Nyland 2017b).

**Figure 2.** Kjølskarvet, Quarry II, Lærdal, Sogn and Fjordane County. Photo: Arne B. Johansen. CC BY-SA 4.0.

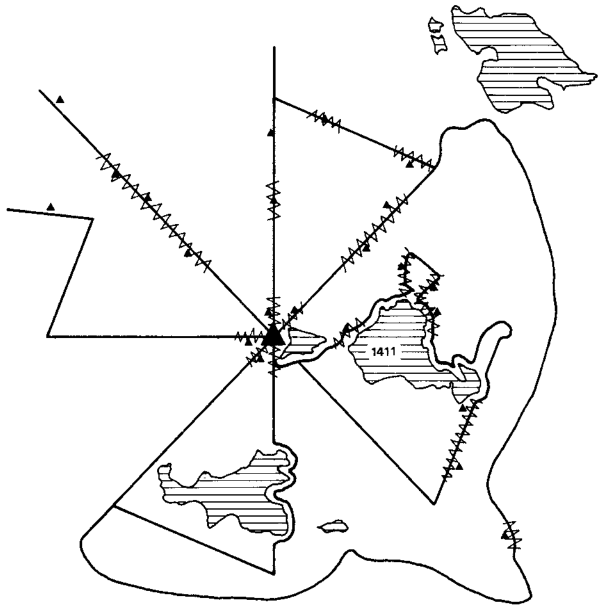


**Figure 3.** A schematic presentation of the survey around Kjølskarvet quartzite quarry. Trajectories show the lines of survey centripetally from the quarry, and scatters of artefact distributions are depicted where the survey event coincides with a prehistoric event. artefact, trajectory, quartzite quarry. North upwards (after Johansen 1978: 74).

## Chaos Theory and the Human Trajectory in the Landscape

There was a high interest in chaos theory through the 1980s. James Gleick's book entitled Chaos. Making a New Science (1987) introduced a wide audience to the idea of random determinism. The most well-known concept connected to chaos theory is "the butterfly effect", which refers to the sensitive dependence on minor variations in initial conditions that can have large consequences in a later state. This term was coined approximately one and a half centuries earlier by the American mathematician and meteorologist Edward Norton Lorenz. He noticed that small variations in the initial conditions in his weather models would give large variations. The "butterfly effect" demonstrates this by saying that a butterfly flapping its wings can lead to a tornado at another location several days later (Gleick 1987). An important point is the contrast to traditional system theory. Linear system theory will see minor variations as noise that should be filtered away, but nonlinear system theory, and especially chaos theory, can focus on small variations and events that lead to great changes. An example from anthropology could be the introduction of steel axes to the aborigine Yir Yoront group in Australia. Axes could suddenly be owned not only by older men but also by women and younger men, and this in turn uprooted the traditional relations between older men and the other members of the society (Sharp 1952). An example from Scandinavian archaeology could be the transition from the Mesolithic to the Neolithic in Denmark. The transition period was very short, only some 50 years. This indicates a total shift from one system to another. The old system, the Mesolithic way of life, collapsed, and it has been suggested that catastrophe theory could

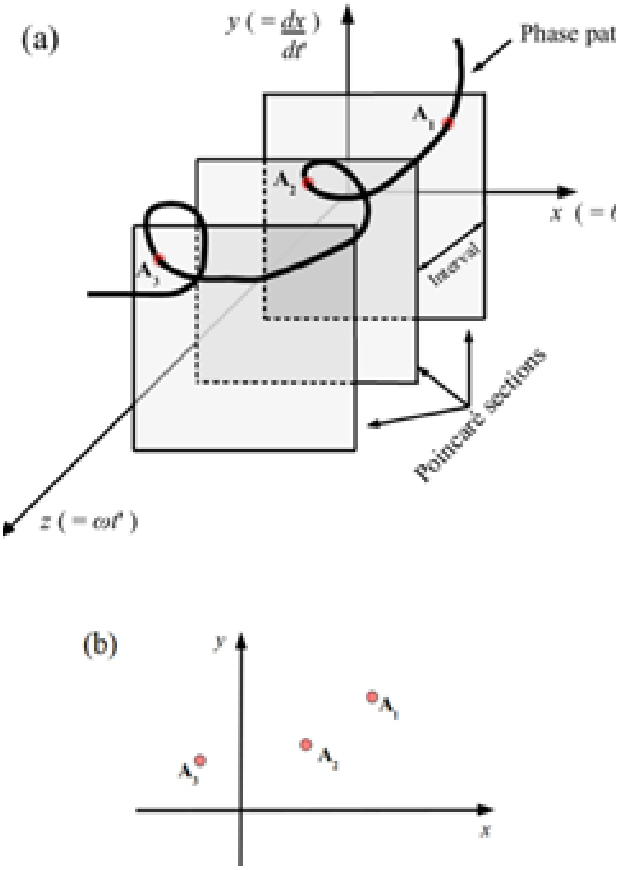


**Figure 4.** Poincaré's phase space diagrams. Parallel planes (a) showing sections through the motion, with crossing points A1, A2, A3, which are projected on the 2D plane (b) (Cattani et al. 2017: figure 4).

be used as a model to explain this; a catastrophe that leads to the total breakdown of the system (Madsen 1987; Madsen 1988). However, explaining a sudden change like this by chaos theory would imply that the system continues, but enters another steady state.

In 1986, The Royal Society in London defined chaos as stochastic behaviour in a deterministic system (Stewart 2002: 17). Although there are a set of rules for how a system develops, the system can go from a steady state to chaos and to a new steady state. It is an inherent aspect of the system that it can shift from one state to another without any external impact. This is consistent with Luhmann's theory of autopoiesis — self-referencing systems. A self-referencing system is self-contained, thus it does not need input from other systems. A self-referencing system can also contain mechanisms that allow it to change states — it can go from a steady state to chaos and return to another steady state (Luhmann 1992).

Chaos theory was introduced in Scandinavian archaeology in 1989/90 with a discussion in the periodical META (Welinder 1989; Wienberg 1989a; Wienberg 1989b). This discussion inspired a paper that suggested that chaos theory could be used to explain the sudden shift from a Mesolithic to a Neolithic subsistence by focusing on small changes (Welinder 1991: 245–247). Kristina Jennbert's theory that gift exchange is the main reason for the shift to a Neolithic economy (Jennbert 1984) could be seen as such a small change that has large consequences.

Traditional system theory is a useful concept to outline models and gives new insight in past cultures. Cultures can be in equilibrium in the way that, at certain scales, they can act as static systems; the same subsistence patterns are repeated over centuries. With this approach, erratic changes will be seen as disturbing noise that can be disregarded. However, such a model can be over-simplifying. Some of the most interesting aspects might not be taken into account, how humans have responded to change, for example — not only slow changes over time, but also sudden environmental changes or simply fresh ideas. New ideas are not necessarily due to external influences but can also be internal and can lead to a total disruption of an existing order.

In this way, nonlinear system theory allows a different approach to systems that cannot be described with traditional systems theory. Suzanne M. Spencer-Wood argues convincingly that culture can be treated as a nonlinear system. Her arguments focuses on that culture is a nonlinear system because it is complex, dissipative, and self-organising, and that culture is a chaotic system because it is sensitive to initial conditions, irreversible, and has an evolutionary path that cannot be accurately predicted (Spencer-Wood 2013: 6-7).

All possible states of a system are contained in the system's phase space. Within the phase space, regular systems will converge to a steady state. One example of a simple, regular system is the pendulum, where the steady state will be a point. The state the system converges to can be called an attractor, and in case of the pendulum, the attractor is periodic. More complex systems can have an attractor like a circle or a torus, but it will still be a stable attractor that can be predicted. The nature of the nonlinear system is such that the attractor cannot be predicted, because of its reliance on initial conditions. The set of equations describing the system can be fairly simple, but the development can be unpredictable. However, the system can be described through describing its attractor. Such a non-periodic attractor is called a strange attractor.

A strange attractor in an m-dimensional hyperspace can be described by observing it, but in some cases it is not possible to observe the attractor directly. A remaining option is to observe the attractor's Poincaré set. The Poincaré set is made up of points on an (m-1)-dimensional hyperplane through the m-dimensional phase space. The attractor is described by the points where the attractor passes through the hyperplane. This can be shown by drawing the movement as a time sequence. In Fig. 4, parallel planes illustrate stroboscopic sections of the motion, and the points A1, A2, A3 are where the strange attractor passes the hyperplane (Cattani et al. 2017).

The connection to the archaeological material is made by regarding sites in the landscape as points on a hyperplane. Describing activities and movement in the landscape (events) through this point scatter, is describing the attractor. Events take place in a 4D space-time hyperspace, and remain as points on the 3D landscape. In this way, all archaeological evidence, both larger sites, single artefacts within a site and stray finds, can be used at different scale levels in the same model to describe a flow of events. This is especially useful in a setting like the Norwegian high mountains where there is hardly any stratigraphy, and a concept like non-site archaeology could be more useful than to work with defined sites. Using Welinder's terms, the strange attractor is the utopian landscape, and the Poincaré set is the recorded landscape.

Each site and trace of prehistoric activity will, at different scale levels, be a point on the hyperplane. Areas with many events will have several points and can be recognised as magnet locations (Binford 1987: 26), or focal points. Such sites in the Norwegian high mountains are generally found at lakes, especially at river mouths, and often close to reindeer trails. As an example of a focal point, an area where several events have taken place in prehistory and the present, we will look more closely at the material from Lake Vavatn.

## Lake Vavatn

The Lake Vavatn in Hemsedal is situated at 1124.5 m a.s.l. (Figure 5). It is one of a group of larger lakes with several Stone Age sites within a radius of 20 km; Sulevatnet, Juklevatnet, Eldrevatnet, Øljusjøen, and Gyrinosvatnet/Flævatn (Figure 1: 1–6). The lakes in this area are regulated for hydroelectric power, and there were extensive surveys in the 1960s as part of the investigations in Lærdalsfjellene (Johansen 1970; Johansen 1978; Schaller-Åhrberg 1990). Most of the lakes can therefore have a higher water level than earlier, but Lake Vavatn is regulated in the way that the water level can be lowered to as much as 8 m below normal height.

The lake was surveyed in the 1960s, but the first sites there were found much later: First as occasional finds and by a private initiative, and later through archaeological surveys (Matsumoto & Uleberg 2002). Several examples can show that repeated surveys by the same or different people will produce more sites (Indrelid 1994; Prescott 1995).

The sites around Lake Vavatn are concentrated around the northeastern bay of the lake, over a stretch of 2.4 km east–west and generally at a height between 1125 and 1140 m a.s.l. (Figure 5). The landscape in the west consists of relatively flat bogs closer to the water and moraine ridges on the hills up towards the high mountains. Further to the east, the terrain rises steeper from the lake. The shieling are placed on plateaus above a steep descent towards the lake. The terrain goes up to the top of Primstøyten 1179 m a.s.l. in the east, from where there is a good view over Lake Vavatn towards the west (Matsumoto & Uleberg 2002).

The site at Primstøyten is 170 m and one more site further southeast is almost 280 m from the lake. The view from the Primstøyten site over Lake Vavatn might indicate that it can be related to the other activities around the lake. Several of the finds have been made below normal water level. The richest sites are found close to the existing shieling and cottages at Fauskostølen. A short distance east of this there are animal fall pits and a reindeer trail coming down from the mountains to the north. There are also an animal fall pit in the northwest bay of the lake (Figure 5) (Matsumoto & Uleberg 2002).

The chronology for the sites around Lake Vavatn falls within a rather wide range between the Meso-

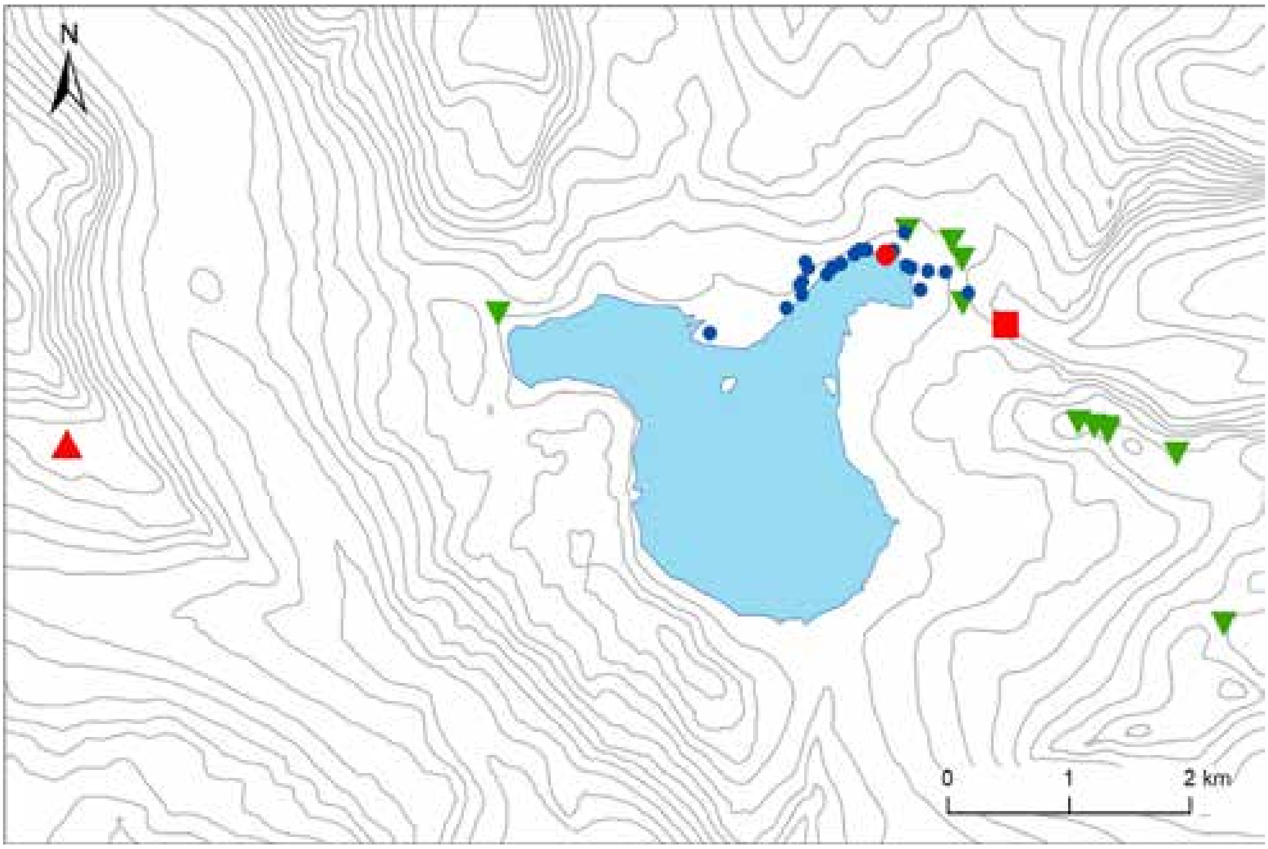


**Figure 5.** Lake Vavatn with • Stone Age sites and ● Fauskostølen along the north-eastern bay, and ■ Primstøyten to the east. a quartzite quarry to the west and ▼ animal fall pits Contour interval is 50 m. The Vabuleino area shown in Figure 6 is the NE part

lithic Phase 2 and the Norwegian Bronze Age, in the period 6300–600 BC. All material is from surveys and surface collections, and the dating is based solely on typology. The finds at the largest site, Fauskostølen, are in an area covering 20 × 27 m; almost 20 m along the shore and 27 m down from the shieling and into the lake. The total weight of the finds from this site is 2.9 kg, of which 2.7 kg is quartz/quartzite tools and debitage. This site has also the only slate artefact known at Vavatn — a fragment of a Neolithic point. The relative composition of the major raw materials — quartz, quartzite, flint, and rock crystal — is the same as the total of all sites around the lake (Matsumoto & Uleberg 2002).

The north-eastern bay of Lake Vavatn was a focal point for movement and activities in the Stone Age, but activities were not as frequent here as around other lakes in Lærdalsfjellene (Figure 1). There are no indications that the repeated and occasional visits to the larger and smaller sites around Lake Vavatn were continuous; rather that periods of activity were separated by longer or shorter intervals. There has been a range of activities at Lake Vavatn. The activity during the Mesolithic will have been concentrated on hunting, as the lakes in Lærdalsfjellene are not known to be rich in fish (Johansen 1978). The animal fall pits close to the lake have not been dated, but the general dating of this kind of constructions in the high mountains are the Medieval Period, showing that the area has been used for hunting also in later periods. The character of the Neolithic occupation is not known in detail, but both hunting and shieling is possible. Modern activity is shieling and leisure, as there are several cottages close to the shieling. There is no reindeer hunting there today because the reindeer grazing in this area are domesticated.

Three types of modern activities at Lake Vavatn can be mentioned: The first, and oldest, is the pastoralism, as seen in the shieling. The second is leisure, connected to the cottages. The third is the archaeological survey. The fact that Lake Vavatn, especially the north-eastern bay area, was chosen for shieling, can indicate an understanding and reading of the landscape in common with Neolithic herders. Leisure activity in the high mountains starts in the 19th century, and a combination of these two event types triggered a renewed archaeological interest in Lake Vavatn. The third, and shortest, activity is the archaeological survey, where archaeologists aimed to read and understand the landscape in the way it was understood in prehistory. Sites are recorded where archaeologists and others find traces of prehistoric activity, or to phrase it differently; sites are found where reading of the landscape by archaeologists and prehistoric people results in activities at the same focal points in the landscape — the archaeologist digs at a place of a prehistoric event.

## Past and Present in the Landscape

Spatial intersection of prehistoric and recent events can lead to increased knowledge of prehistory. Figure 6 depicts prehistoric and archaeological events leading to recognition of Stone Age activity, populating a Poincaré set. Plane A presents a hypothetical Stone Age sequence of movement and events. Places in the landscape where the activity left traces that can be found today is marked with blue points. Plane B presents a possible trajectory of an archaeologist surveying the area. The survey method is digging test pits, and test pits are marked with points. The grey points are test pits without finds, and the green are test pits with Stone Age artefacts. The red points in Plane C are the positive test pits in the real landscape. The trajectory in Plane A is one of the lines in the strange attractor of the Stone Age events at Lake Vavatn, and the red points in Plane C are the Poincaré set that virtually illustrates the strange attractor in the modern landscape.

Figure 6 is a simplified model that delineates the Poincaré set of only two hyperplanes — one representing Stone Age (oldest) actors and the other recent (newest). At Lake Vavatn, there are traces of other actors that can be plotted as points on several Poincaré sections. Densely populated Poincaré sections will give a good impression that the place is attractive. On the other hand, it is challenging to find a refined and suitable interval scale within the Stone Age to compare landscape utilisation at other lakes in Lærdalsfjellene. This is because Stone Age sites in the high mountains are the least datable, and therefore the most inspiring in an application of concepts from chaos theory and nonlinear system.

## Conclusion

This paper argues that chaos theory and nonlinear system theory are a useful tool in understanding the use of landscape and the creation of taskscapes during the Stone Age in the Norwegian high mountains. It is necessary to replace a static model based on duration and stability with a model that can focus on change and variability. Small variations in the system can lead to total changes, and the system can change states, even independent of external influence.

The recorded archaeological material is the result of past and present events. As shown in Figure 6, a positive point on the map indicates a place where past and present understanding of a suitable site coincides. The mountain sites have in general no stratigraphy, and the artefacts can be picked up from the ground or be found in or just under the turf. This means that the once existing distribution in time is gone. One could describe it in the way that all events are projected onto the landscape parallel to the time axis and only the spatial distribution remains.

A continuation of this line of thought is to see the archaeological distribution as a Poincaré set. The Poincaré set describes the system by making the footprints of the attractor visible. The attractor is the trajectory of the events in time–space. The events are concentrating, recurring, at focal points, not because of a constant regularity, but because underlying factors attract attention to certain places. The sites at Lake Vavatn is one such place of importance.

The occupation at Lake Vavatn is of long duration. The first visitors at the sites arrived as hunters/gatherers, and animal fall pits shows later hunting activity close by. The places were later visited by pastoralists, and the tradition of bringing sheep and goats to Lake Vavatn for grazing during the summer continues even today. The sum of observations does not allow statements about continuation during this over 8000-year period of archaeological and modern history, but it does show that Lake Vavatn has been attractive throughout multiple periods. The typologically dated stone artefacts can point at several early

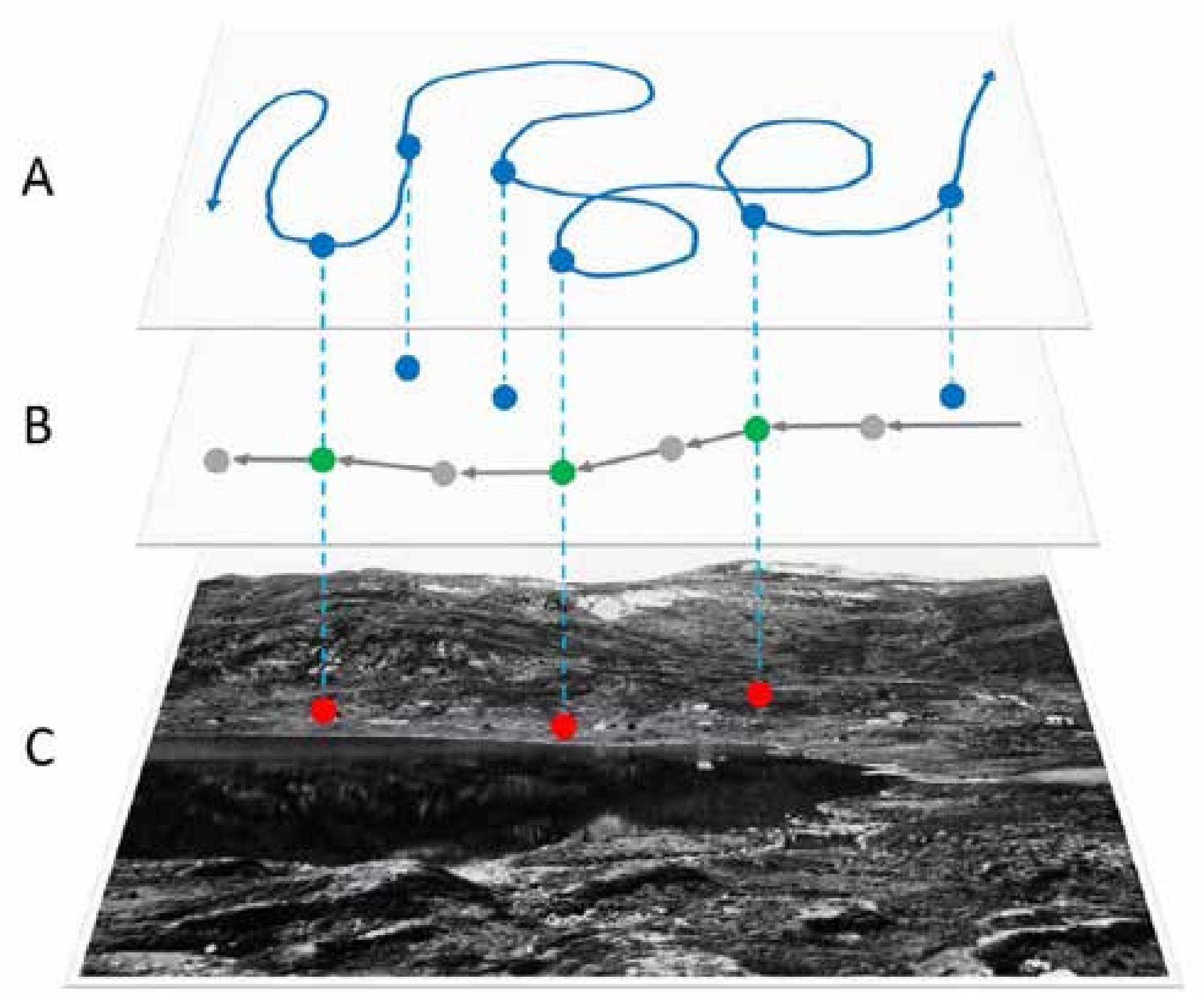


**Figure 6.** Schematic depiction of two Poincaré sets (prehistoric and present), with archaeological sites in a strange attractor projected on the real landscape. Plane A: Prehistoric path (trajectory) in the landscape, leaving traces of living or activity in the attractor (●). Plane B: Present archaeologist's movement in the landscape, revealing places of prehistoric attractors by positive test pit dig or surface registration (●). When no discovery, then no hits (●), while no hits by archaeologist, no projection of the prehistoric attractors (stray blue points). Plane C: Crossing point is recorded on the real landscape as a site (●). Picture is taken towards north, with modern shieling and cottages in Vabuleino, between the lake shoreline and the steep downhill in the backgound, northeastern bay of Lake Vavatn, Hemsedal, Buskerud County. Photographed in 1960 by Ola Rudvin. ©Hemsedal Bygdearkiv.

intervals, the probably medieval animal fall pits at a later time, and today the modern shieling, cottages and archaeological surveying creates more points in the Poincaré set. Further studies can focus on different scale levels and include material with different degree of provenience to get a more holistic understanding of past societies in the Norwegian high mountains.

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