Material Traces

Mapping Habitat Loss in Northern
British Columbia

by

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Abstract

This material research examines the movement of data between digital and analog space, tracing its migration between states, the falling away of its meaning and its reconstruction. This idea was tested by visualizing ecological data models through an automated reduction process to simulate a continuity of wildlife migratory patterns. This process explores material as a vector for accumulated knowledge, illustrating a recession of Woodland Caribou populations in British Columbia through a contraction of their herd ranges over a twenty-two year period. The use of modern GIS and digital manufacturing processes references visually a history of narrative and spatial representation, such as bass relief carving, cartographic projection, and cognitive mapping, relevant today as the meaningful interface between man, the wilderness, the wood matrix and landscape changes. The wood matrix, our forestry industry is composed of primary, secondary and tertiary sectors. The primary sector processes raw materials, including saw milling, pulp and paper, and composite panel manufacturing. The secondary 'value-added' sector covers re-manufactured wood products, engineered components, mill work, furniture, pallets and containers. Tertiary sector covers equipment supply, education, research, consulting, transport and distribution. These historical examples of spatial representation and digital manufacturing processes have informed the production of artifacts, which record a body of data that points towards a probabilistic future, a forewarning of a vanishing point of biodiversity.

Glossary

Abject prop: Abject prop refers to a fictional object that has been discarded or cast off. Abject comes from "abjectus," of the Latin verb abicere, meaning "to cast off." Its original meaning in English was "cast off" or "rejected". Prop, refers to an object used on stage by actors, but in this context it could also be read as a hyphenated version of 'propositional object', a term used in critical design discourse to denote a object used for a design fiction. In literary terms a proposition is the meaning of a sentence.

CAD - computer-aided design: software is used by architects, engineers, drafters, artists, and others to create precision drawings or technical illustrations.
CAD software can be used to create two-dimensional (2-D) drawings or three-dimensional (3-D) models.

CAM - computer-aided machining: Is the use of computer software to control machine tools and related machinery in the manufacturing of work pieces.

CNC – computer numerical control: This means a computer converts the design produced by Computer Aided Design software (CAD), into numbers. The numbers can be considered to be the coordinates of a graph and they control the movement of the cutter.

GIS – geographic information systems: A space-based navigation system that provides spatial and temporal information in all weather conditions (Leyequien et al., 2007).

GPS - global positioning systems: Is a space-based navigation **system** that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more **GPS** satellites.

RSF – resource selection function model: Is any model that yields values proportional to the probability of use of a resource unit. A RSF is defined as any function that is proportional to the probability of use by an organism.

SDM - species distribution models: Are numerical tools that combine observations of species occurrence or abundance with environmental estimates. They are used to gain ecological and evolutionary insights and to predict distributions across landscapes, sometimes requiring extrapolation in space and time.

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Chapter 1: Framing Research

1.1 Introduction

My research plan was framed by these Primary questions: How can one facilitate or create visual metaphor by working with a combination of additive and reductive manufacturing processes? To what extent does perceived value shift through mediating material context? And, secondarily: Could my goal of developing a broader skill-set of (CAD) computer-aided design tools and applying this new knowledge to digital manufacturing processes become a means of visualization? This research follows the migration of data between immaterial and material states. A methodology was developed to translate data from the real world into digital models and redistribute it through a material reduction process. Exporting simulations of cast off artifacts and ecological models drew upon the relief process as a method for communicating narrative. Spatial models were used from a study which measured the distribution of vanishing caribou herds to quantify relationships between habitat loss and anthropogenic impact.

Therefore to explore these questions, my Primary objective was to apply manual and automated manufacturing techniques towards the visualization of data. This goal required developing an iterative material practice with additive lamination and reductive CNC processes. My secondary objective was to examine notions of value-added processes and link the accumulation of markings in material with the sedimentation of historical knowledge and meaning. The word 'sedimentation' is

used here in reference to anthropologist Natalie Seremetikis's use of the term which proposes that material artifacts preserve layers of personal and cultural histories which are catalyzed by physical encounters (Seremetakis, 1994) . This proposition validated a personal understanding, that objects can provide a real potency in the physical experience of space. Additional research strategies and actions draw from critical design theory, methods, and cite practitioners Anthony Dunne and Fiona Raby, whose work explores potential futures by creating fictional design objects and scenarios. One example of their work, *the Foragers*, uses photography to document a desing fiction in which people use speculative design objects to adapt to existential threats such as environmental collapse and lack of food.

My theoretical framework references the French philosophers Jean Baudrillard and Henri Bergson. In the first lines of the opening chapter of his seminal book *Simulacra and Simulation* titled, The Implosion of Meaning in the Media, Baudrillard wrote, 'We live in a world where there is more and more information and less and less meaning." The cause for this loss of meaning in modern times Baudrillard attributes to the 'dissolving, dissuasive action of information', by which he meant the media and the mass media. His reference to the simulacra, a derivative copy of an original, reflected a dystopian observation on the hyper mediated reality created by technology in the later part of the 20th century.

Between 1992 and 2012, a study was conducted by environmental scientists from the University of Northern British Columbia (UNBC) to monitor declining caribou

populations in northeastern British Columbia (Johnson, Ehlers, & Seip, 2015). Animals were tracked and monitored using GPS (Global Positioning Systems) collars, and their coordinates were recorded as point data locations on a map. GPS is a space-based navigation system that provides spatial and temporal information in all weather conditions (Leyequien et al., 2007). The point data locations were used to ascertain density of herd distribution across five different herds units visualized through Habitat Suitability Models (HMS) which integrate the GPS data with Geographical information systems (GIS) mapping software. GIS software involves filtering, interpreting, and analyzing data to produce a mosaic of environmental features that constitutes a homogenous landscape.

This study has documented the first empirically recorded extinction of a sub-species in Canada (Johnson et al., 2015). It determined that the loss of one of the herds units, Burnt Pine, and probable extinction of the remaining four, Narraway, Moberly, Bear-hole, and Red Willow, was correlatively if not causatively linked to negative anthropogenic impacts to their environment (Johnson et al., 2015). Northern British Columbia contains one of Canada's richest natural gas reserves and has seen significant increases of industrial development to the area since this study was initiated in 1992. While GIS technology has advanced in the last decades to provide important risk assessment aids for scientists, it falls short in communicating the implications to a wider audience. Ultimately much of the value of this important research is lost in translation. Communicating this meaning is necessary as a catalyst for future change.

1.2 Rationale

This material research uses digital manufacturing processes to visualize empirical data from ecological models. I set out looking for ways of translating this data into material by first asking: How can one reinterpret meaning by working with a combination of automated and analog manufacturing processes? Initial design objectives were framed by an axiological approach that explored notions of original and counterfeit through the simulation of objects. What interested me in this transferal of data between digital and analog space was how mediating material context could influence the meaning of data and open up new interpretations and meanings.

Due to the ubiquity of digital media today, information is communicated to a larger audience mainly through digital images for ease of distribution. We only have so much time give to the mediated images which constantly compete for our attention and there is a disconnection between the sign value of digital images and the reception of their meaning (Massumi, 1998). We have become desensitized to the overload of content in images competing for our attention at any given moment. Scientists often grapple to communicate their research to a wider audience, finding that their academic environments are isolated and do not enable direct public engagement (Curtis, Reid, & Ballard, 2012).

The presentation of facts alone is less likely to result in long-term changes in feelings and opinions (Johnson, Seip, & Boyce, 2004). Design and the arts can be

useful in the extension of natural resources management issues such as land water degradation, biodiversity, conservation, catchment protection and vegetation management (Curtis, 2011). Studies have shown five areas where alternative methods of data visualization might be utilized to help improve understanding and knowledge of natural resources issues: improving presentations; improving public campaigns and general awareness-raising; aiding facilitation and community development; reinforcing values and beliefs; and fostering environmental sustainability (Curtis, 2011). This design project fills a need for developing alternative methods for communicating data as a form of knowledge translation. The majority of this research cycle was spent developing these digital and material models. Through exhibition they will help improve these five areas as tools for the distribution of knowledge into the public domain, both openly and subversively. The project does not aim to simplify or sentimentalize a predicted loss of woodland caribou in British Columbia, into fleeting notions about the fragility of life, but rather question how it could be possible to raise public perception abound the historical relevance of this loss of biodiversity.

This data represents the first recorded sub-species extinction in Canada.

1.3 Design Methodology

I set out with a design strategy, which was to apply manual and automated manufacturing techniques towards the visualization of data. This design process employs a methodology of bricolage, working with a closed set of material

constraints to develop new ideas (Turkle, 2011). Additionally, this research explored merging two or more existing systems into something singular using both manual and automated reduction processes. The process of inscribing linear tool paths into material was used to illustrate a narrative of accumulation, subtraction, and loss.

I was interested in combining these tool path markings with the stratified layers of material as a way connecting empirical data with the passing of time (Seremetakis, 1994). In this instance the removal of substance was used to show the loss of something ephemeral. This reduction of data into material serves as a memento for the subtraction of living bodies and the subtle traces that they leave behind.

This research utilizes the ability of objects to connect with people on an emotional level and looks at the material as a vector for data, which can move between fluid digital and fixed material states. Leading authorities have shown that emotional and cognitive functions such as memory are integrated with the body (Massumi, 1998). Sensory perceptions forms the basis for how we construct meaning, this has far reaching implications for digital technology, which mediates the interface between our perceptions and the physical world (Verbeek, 2010). Recent developments in the fields of humanities and natural sciences challenge the established Cartesian logic that the mind and body are separate entities. It has been argued that this dualistic paradigm, upheld for centuries by the scientific model of materialism, allows humans to feel we are somehow separated and superior to nature(Walker, 2013). In fact Cartesian ideas were challenged as early as the 17th century when

Dutch philosopher Benedict Spinoza published his treatise *Ethics*. According to Spinoza, 'By emotions I mean the modifications of the body, whereby the active power of the…body is increased or diminished, aided or constrained... "(de Spinoza & Curley, 1985). Spinoza clearly advocated that body and mind are parallel and inseparable.

This research began through a series of open-ended material experiments, which set out to reinterpret notions of the artifact and skew towards developing a new additive method of fabrication. I experimented with bent wood lamination processes, both two-part compression molds and vacuum bag systems, for the forming of wood veneer stock which was then put through an automated reduction process. The digital manufacturing process allowed for the direct transfer of data topologies into the material. As a result these objects combine elements of machine guided precision, human error and organic abnormalities.

The capture of an artifact, (an analog form) translating it into digital form, (data – a 3d file) and transforming it back into a material thing (an analog form) explores the transcendent nature of things as they shift between material states. This cycle was first illustrated through capturing a shed moose antler with a 3D scanner, and its fabrication through a combination of digital CAD modeling software (Rhino/Modo) and CNC reduction processes, as a metaphor for the analog to digital to analog process.

The transition between digital and analog space took place by 3D modeling topology from 2D spatial contour maps which were then transcribed into material via the automated reduction process. This is achieved by converting GIS based topographic maps embedded with GPS derived data (spatial temporal models) into an X,Y,Z grid of topography that can be exported through linear tool paths into additive or subtractive machining processes. This translation was achieved using computer aided design (CAD) software for modeling, computer aided manufacturing (CAM) software for interpreting the tool path commands, and computer numeric control (CNC) machine to transfer the CAM ready file through the automated reduction process. Using the CNC machine allows for the accurate reproduction of surface topologies within the constraints of the CNC machines three-axis (x,y,z) capacity. The material stock was made from alternating layers of coloured and non-coloured maple veneers, through a vacuum lamination process. The materials were then milled using either a single stage or double-sided reduction process.

The antler, a regenerating appendage of the animal's body, served as a platform for knowledge creation, which was then 'released' back into the landscape through photo essay. Its placement into locations in British Columbia acts as a positional marker, which also reveals a narrative of migration through natural and urban environments as an abject prop; something which has been rejected and cast aside.

Chapter 2: Theory and Practice

2.1 Adding and Subtracting

The GPS derived spatial models from the above-mentioned study, were translated into a series of digital CAD models (Johnson et al., 2015). This work brought together a collection of topographic and spatial data illustrating the distribution patterns of five Caribou herds collected over a twenty-two year period. The translation of these digital simulations into material objects explored the artifact as a tool for visualizing a continuity of data. One of the design propositions I am making here is that objects can create a real potency in the physical experience of space. These wooden objects reference the history of relief objects used to tell stories, relevant today as the interface between the forestry industry and landscape is changing. They relay the predictions of a probable future, making visible the invisible loss of ephemeral systems, while warning of a lethal envelope or vanishing point, beyond which any species cannot survive (Hirzel & Le Lay, 2008). A side note of interest, this pre-requisite for life in ecological models is positive growth and enough space to expand. This is the same as the economic model of exponential expansion, where positive growth is needed for an economic system to function.

The influential French philosopher Henri Bergson, believed that attention was connected to the body, but that it would become a catalyst for action only when it was linked to the deeper activity of memory (Crary, 1989). This suggests that a physical encounter can animate dormant meanings in an object, linking it to personal associations and memories. According to Bergson, we engage with objects

on a physical level by relating to them with our bodies, but this attention has to be connected to the internal memory process for it to leave a lasting imprint. Bergson wrote about the connection between perception and memories using the example of an after image, an inverse optical echo which is left on the retina after seeing an object.

> 'Memory thus creates anew present perception…It is true we are dealing here with images photographed on the object itself, and with memories following immediately upon the perception of which they are but the echo. But behind these images, which are identical with the object, there are others, stored in memory which only resemble it (Bergson, Paul, & Palmer, 2004).

The *after affect* here is a corollary to the founding principle of colour theory wherein physiological colour, the complimentary colour of what is seen externally is produced internally in the minds eye (von Goethe & Eastlake, 1840). The example is given of looking through a window frame, when the viewer closes their eyes the negative image of the window remains imprinted for a few moments on the retina. Bergson's analysis elevates the phenomenal world as a source of sensory meaning, while reducing the mediated image to redundancies of representation and the stagnation of creative imagination. This suggests that the phenomenal world is the source of sensory meaning making, and that physical objects can provide a direct link to our feelings through the senses.

An ironic aspect of memory is that it can bring about a heightened experience of the present. Cultural anthropologist Nadia Serimitakis writes about the object as a vector embedded with historical meanings.

> 'The sensory landscape and its meaning endowed objects bear with them an emotional and historical sedimentation that can provoke and ignite gestures, disclosures and acts – acts which open up these objects statigraphi. Thus the surround of material culture is neither stable nor fixed, but inherently transitive demanding connection and completion by the perceiver (Seremetakis, 1994).

In this passage objects are spoken of through the perspective of a sensory encounter, as containers of emotion and historical content that can provoke and ignite actions. These 'acts and gestures' suggest physical interactions with the objects, which add to the layers of meaning they carry. This accumulation of temporal evidence in material reinforces the proposition of the object being a recorder of historical change. Serimitakis also points out that the fleeting nature of material culture requires the active participation of people, that the senses play an important role in how we understand material as a historical record. A central theme throughout this research explores the physical layering of material and reduction of data topologies into material, as a knowledge accumulation process.

2.2 Analog to Digital Loop

This material research focused on developing a routine for bringing the scanned CAD file back into material form. Working through this process of addition and reduction synthesized my understanding between subject matter, material and production method. As the results multiplied, the reduction process began to uncover a hidden narrative in the layers of laminated veneers, which suggested contour lines in topographic maps. Each stage of the material testing was followed by documentation and discussion of the results with my advisor, which lead to further readings, reflection and sustained experimentation.

The material studies all share an underlying research question: To what extent does an object's perceived value shift through mediating its material context? Changing a things material composition allows value connotations to be interrupted and re-directed into new associations. An example of this would be the recycling of spent mass produced goods to extend their life cycle. This tertiary value-added sector is becoming more common as demand for sustainable, low environmental impact goods production increases. Some contemporary designers focus primarily on using recycled materials in their practice, one example of this is Mieke Meijer's news paper wood project at the Design Academy Eindhoven. This project re-processes used news paper into solid stock which resembles wood grain when it is milled and used for furniture applications.

2.3 Case Study: Photo Essay

After discussing the initial iterative physical works, the re contextualized antler, I committed to using a manner of photo-essay and visual journaling in order to further re-contextualize, reflect and test my assumptions of the physical artifacts. This photo-essay looked at stabilizing, or encapsulating the artifacts' spatial context to encourage new interpretations by placing it into different environments as an abject prop. The initial scenes; Northern British Columbia past 100 Mile House, on forestry roads, and following tertiary paved roads to their end provided a context of natural and modified backdrops.

These photographs from Northern BC chronicle the artifact along boundary lines of urban expansion and rural back roads. It was also deployed in disenfranchised parts of the city (Vancouver) to suggest impacting socio-economic circumstances. The antler acts as an itinerant traversing these two environments, a talisman for migration through natural and artificial environments. It indicates both a direction of travel along a path and a bearing of location (latitude/longitude). Another facet of the antler is its regenerating capacity, which typically grows and sheds seasonally. This characteristic links the appendage to the language of cyclical consumption, growth, and decay, present in both natural and artificial systems.

Figure 1. Photo Essay, 51°32’37.14 N 121°14’02.83” W, Northern BC

Figure 2. Photo Essay, 49°16'18.22"N / 123° 5'52.29"W, East Vancouver

2.4 Value-added processes

After the photo essay, I was thinking about using the automated linear tool path in material as a narrative to show the recorded movements of animals along a line of travel. The migration routes of animals can be seen as corridors that reflect the health of the ecosystems (Johnson et al., 2004). To accomplish this would require translating landscape patterns and the behavioural processes of animals into CAM tool paths. Translating data into a reductive mark-making process interprets the physical landscape as a record of behavioural responses left by the animal's passage. This technique illustrates their migration as a palimpsest of material traces in a material.

Some early examples of secondary value-added processes, of turning raw material into something valuable include, palimpsest, gilding, and scrimshaw. Palimpsest was an ancient method of re-writing on parchment as a way to conserve scarce material. The parchments were made from the skins of animals and pulp of plants that were taken through a laborious process of preparation. The word translates to, 'scratched again', and originally refers to the surface markings left by words that were erased in old documents. Any errors made by the hand of the scribe could be scraped away with a penknife. These manuscripts reveal the markings that were left behind by previously written texts. The word manuscript comes from the Latin word 'handwritten'.

Another traditional craft guild was illumination, which refers to the application of paint and precious metals (gilding) to manuscripts. Illumination often marked important passages in the text, or enhanced and commented on their meaning (Library, 2016). It served as a visual aid for interpreting and punctuating important themes or areas in complex scriptures. One might make the comparison today to data analysts who decipher code to bring out the underlying messages. Beyond its utility function the gilding process has been used in painting and decorative arts to venerate objects with spiritual meaning, or imply power through demonstrations of obscene wealth in architecture or domestic objects. I've been incorporating craft based value-added processes such as water gilding, to develop a lexicon of material language, which can be drawn from to make value propositions.

The collection and re-purposing of something which has been previously used and discarded, supports the idea of material as a vector of personal or autobiographical meaning. There is a strong re-purposing tradition among indigenous and maritime cultures. One example would be the scrimshaw carvings that were originally made by mariners to tell stories about their journeys. They used needles to make inscriptions into the surfaces of durable whale bones and tusks, onto which ink was rubbed and cleaned off leaving permanent black lines where it had been inscribed. This form of engraving uses the line as a graphic technique to indicate the passage of time, and does not attempt to conceal any mistakes made in the process. On the contrary the accumulation of imperfections on a surface can add value to things and may lead to new discoveries when repeated through the automated manufacturing

process. I see the linear (x,y,z) tool paths of the CAM reduction process as an extension of this way of demarcating time.

The evidence of human error or damage can give a surface an added dimension of value known as patina. As marks from previous actions accumulate, these subtle signs elicit a sensory encounter with material (Seremetakis, 1994). The use of mistake and repair was explored in different ways through the material studies. For example a broken ceramic plate implies a thing that was once whole. I looked at precedents in Japanese Kintsugi, fixing broken ceramics with gold to highlight the repair of something and give it added value. Wood also relays history through evidence of damage, in traditional woodworking these defects are often hidden or removed altogether, but in one case study I explored a way of drawing attention to the mistake by filling surface errors and defects with a contrasting resin. The objects (This photo-essay looked at stabilizing, or encapsulating the artifacts' spatial context to encourage new interpretations by placing it into different environments as an abject prop. The initial scenes; Northern British Columbia past 100 Mile House, on forestry roads, and following tertiary paved roads to their end provided a context of natural and modified backdrops) were designed in CAD and cut by CAM, where in the machines' chip errors (where the wood grain "blew out") were "*programmed*" on the surface of he artifact which were then most obvious. By filling these intended defects with automotive body filler - something that had little value and presented as a defect - is now made apparent and in part, grammatical. This case study was informed and set in context by visiting regional ethnographic

museums and observing evidence of historical damage and curatorial restoration in the artifacts.

Figure 3. Bent lamination plate, wood veneer with Bondo repair

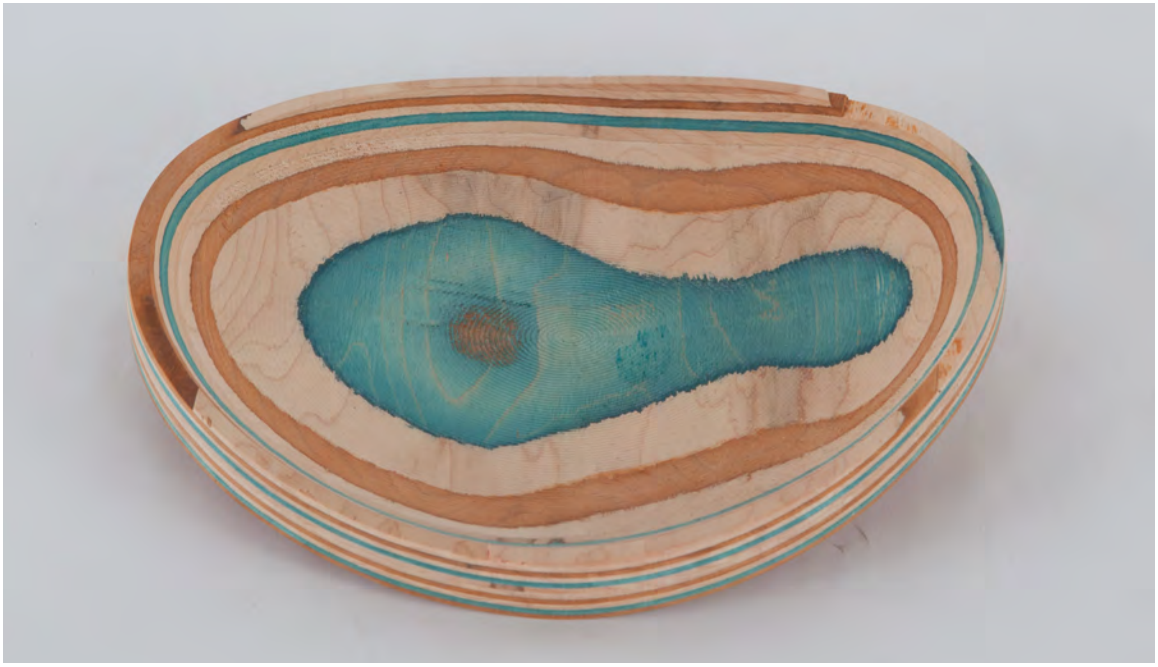

Figure 4. Bent lamination plate, wood veneer with radial tool pattern

2.5 Spatial Representation and Landscape

The discovery of linear perspective in Florence during the16th century explains a shift in spatial understanding of the time. In pre-renaissance European painting the size of the features in the compositions reflected their symbolic importance in the scene (Hall, 1992). Specific colours such as blue, pink, and gold were also reserved for central elements in the composition. Different types of perspective used in picture making (linear, single, two-point, multiple point, axial) could be compared to projections of space used in cartography, such as Mercator and Orthographic projection. Orthographic projection is defined by Oxford dictionary as a "method of projection in which an object is depicted or a surface mapped using parallel lines to project its shape onto a plane." In both cases the subjects proportion changes according to the method of representation being used.

The techniques currently used by environmental scientists to quantify natural systems arise from the positivist Cartesian view of time and space. This view conceives that the worlds of matter and that of spirit are two separate things. Constructing simultaneous meanings of space and place, brings about the idea of landscape as both a physical place and a non-physical entity (Tilley, 1994). In archaeology, a critique of the concept of landscapes has developed into a vision of landscape as a 'palimpsest of material traces, revealed by an assemblage of real-world features – natural, semi natural and wholly artificial" (Thomas & Hodder, 2001).

Cognitive mapping and memory-scapes from indigenous societies describe another kind of spatial understanding, connected to the body and its relation to features within a landscape. This type of directional way finding relies on memories of landmarks and knowledge of weather systems (Tilley, 1994). The Inuit used navigational aids such as drift wood carvings that intentionally distorted coastline features to indicate length of travel time instead of their physical proportion (Tilley, 1994). The description of topographic features into readily available materials facilitated navigation across large stretches of flat land (Tilley, 1994). This example shows the use of wooden objects as personalized navigation devices which corresponded to an individual's sensory relationship with a landscape.

As discussed earlier the antler was used as a both a record of place, and a geographical marker. The reference to topographic contours in laminated materials suggests both the topology of a body and physical environments. This connection was pivotal for establishing a relationship between the body and the landscape in the ensuing habitat models.

2.6 Relief

Images were used to communicate narrative before writing or printing technology was common and carving them into material was one of the ways which images could be made to endure. Relief refers to the projection of a picture into three-dimensional form through either additive or subtractive methods. The distinction

between projection and recession of the image onto a surface is described in terms of positive or negative relief. The depth of the image is measured as relief value as low, high, or full round. Early forms of relief such as bas-reliefs (low relief), and religious polychrome sculptures (high relief), were used to represent historical events and often commissioned by the Catholic Church. This is an early example of using the wooden object to disseminate information. In Europe, wood carving workshops were numerous and allowed for a local distribution of objects, which were durable and light enough to be transported by one person between locations.

The representation of geo spatial mapping tools through relief carving traces back to the image/object relationship which was central to my primary question: To what extent does value shift through mediating material context? How is data's meaning interpreted differently with regards to digital or material mediation and the historical meaning these imply? I've spoken about the artifact as a bridge between historical meaning and its affective interpretation. If nothing more material can convey a sense of geological time and weight which is an tacit way of visualizing data and information processing.

2.7 Terrain Mapping

The exchange between two-dimensional images and three-dimensional space also corresponds to cartography and mapping, which work contrastingly to relief surfaces, by translating three-dimensional space onto two-dimensional images. This connection between the projected images in maps and relief carving was a pivotal

breakthrough that enabled a new phase of the design iterations. These new iterations were built upon skills and understanding from previous material research projects such as, two-part molds, antler molds, and plates. An earlier connection had been made between the contour lines of maps and the laminated layers of material during the construction of the antler prototype (Fig 5,6,7). It was now feasible to apply this lamination and reduction processes to terrain elevation models. The next phase of material testing involved the translation of sections of topographic maps combined with GIS data from the ecological study first mentioned in this paper. This initiated an intensive period of secondary research and skills building to facilitate the translation of spatial topography data into relief objects (Johnson et al., 2015). This next section will explain the projection of data based vector images into 3D terrain models and provide some background for understanding habitat suitability models.

Figure 5. Plate with mountain topology

Figure 6. Antler prototype (bottom)

Figure 7. Antler prototype (top)

2.8 Niche Theory

This section defines some terms for understanding what spatial models are and how their data is gathered and interpreted. It will discuss ecological niche theory and two stages of the data migration, collection and analysis. In addition it will suggest how art and design can be used to extend natural resources management issues.

Ecological niche theory is based on the understanding that individual species only thrive within definite ranges of environmental conditions (Chase and Leibold 2003). Habitat suitability models can be seen as 'operational applications' of ecological niche theory, that predict the likelihood of occurrence of species on the basis of environmental variables, which are used to predict the presence/absence or the abundance of a species throughout the study area (Hirzel & Le Lay, 2008).

As a method of observation data collection is the process of gathering and measuring information on targeted variables. The collection and flow of information (data) is a valuable resource, for changing environmental policies, which increasingly fail to find a balance between conservation agendas and short-term economic incentives of industrial growth, which outweigh the long-term consequences (Walsh, 2009). Surveillance of caribou using Global positioning systems (GPS) collars first requires the animals to be captured and collared. GPS works with GIS software to provide point data locations, which give scientists a way of measuring animals behavioural responses in relation to anthropogenic and natural disturbances (Johnson et al., 2015). One of the ways they do this is by

interpreting positive and negative environmental features that inhibit or assist the animals movements between different habitat (Johnson et al., 2004). The ease or difficulty of movement between habitat zones in ecology is known as 'environmental grain'. Course grain refers to infrequent movements between habitats, and fine grain refers to a population who's members move frequently between habitats (Vandermeer, 1972) . By monitoring these movements over time they can construct a clearer understanding of positive and negative behavioral influences.

Data analysis is used as a forecasting tool for making future predictions which involve analyzing large quantities of data. The analysis of data today relies heavily on visual representations to comprehend complex networks of information. This technology is used both by primary sector (petroleum, mining, forestry etc.) companies to explore for natural resources and the environmental sector (resource management) to quantify the threats and impacts from these operations.

2.9 GIS Geographical Information Systems

Spatial science is a discipline incorporating fields such as surveying, GIS hydrography and cartography (Queensland University of Technology, 2016). The field is involved in filtering and interpreting data (informatics) to construct a representation of space. Through GIS it is possible to integrate a large quantity of spatial data with geographical features which are visualized through mapping models. These simulations provide risk assessment tools to measure and predict,

weather patterns, climate change, and ecosystems over time.

The idea of complete objectivity assumed in modern science and cartography is actually false. For example, the projection of the earth's surface onto a flat picture plane requires a distortion of its topology. Different map projections are used depending on the applications (Mercator, conic, cylindrical etc.). In GIS applications such as ArcView, features such as roads, hydrography, vegetation, and data visualizations can be isolated as layers to construct a spatial representation of environments. For ecologists, environmental features are factored into their analysis to make educated assumptions about their subject's behaviours. For example, the summer and winter ranges of caribou are separated because of their different seasonal foraging patterns.

2.10 Data Visualization

I see my role as a designer in this project as multidisciplinary, by bringing together different fields of knowledge and integrating material and digital systems to distribute these new insights. My final design project consists of a series of wooden artifacts translated from spatial distribution models from the above-mentioned ecological study. I first conducted interviews with both Drs. Chris Johnston, and Anna Skarin who are doing parallel research on habitat fragmentation, which use habitat suitability models that rely on niche theory as a framework. I interviewed Dr. Johnston, a professor of Ecosystem and Science Management at UNBC, last summer following the photo essay exercise in northern British Columbia.

Permission to use the spatial data for this project was provided as a direct result of this dialogue. Dr. Johnson's group have been collecting data on woodland caribou in British Columbia and Alberta for over two decades using GPS collars to track the animals' movements which is converted into spatial models using GIS software(Johnson et al., 2015).

The resource selection function model models (Fig 9, 10) are based on point data locations collected by GPS collars, which measure density of a herd units distribution from core to the extent. One of the functions of these models is to mitigate threats to wildlife by proposing counter measures. An example of one such intervention that is currently happing in BC is a government sanctioned wolf cull. Wolves are the primary predators of caribou; they have adapted to using the deforested corridors and cut blocks to hunt more effectively. The wolf cull attempts to counter this but it will not solve the problem because it does not address the real issue, which is the loss of good quality habitat.

The animals zone of avoidance extends far beyond the roads themselves (Johnson et al., 2015). Research has shown that animals typically exhibit avoidance behaviours up to five kilometers from linear barriers within their view shed (Skarin & Åhman, 2014). View shed has been described as anything within the animals field of vision (Skarin, Nellemann, Rönnegård, Sandström, & Lundqvist, 2015). Furthermore, linear barriers or permanent interventions, such as roads, pipelines, and wind farms restrict their options for movement and access to high value habitat and food

(Skarin & Åhman, 2014). However, the cause of habitat fragmentation is known to be more cumulative, i.e. spread out over a number of minor irritants, rather than one major cause. In ecological terms the ability of an animal to move unimpeded through a landscape is termed 'environmental grain' (Hirzel & Le Lay, 2008).

This RSF sequence (Fig 9,10) shows the Burnt Pine herds distribution patterns between summers of 1992 and 2012. Their use value is designated by colour in order of low, moderate, high, to very high. The models show a seasonal comparison of caribou habitat selection, which allow their changing habitat use patterns to measure over time. This herd is an evolutionarily significant unit because it is considered to be an extirpated species; the first time a sub-species extinction has been documented in Canada.

In the revised spatial model described below (Fig 11) this reduction of contour lines (isopleths) in the herd group, indicates a future contraction of the herd range from core to the extent (Johnson et al., 2015). They reveal habitat loss that currently threatens the survival of these five herd units, namely, Narraway, Moderly, Burnt Pine, Bearhole, and Red Willow.

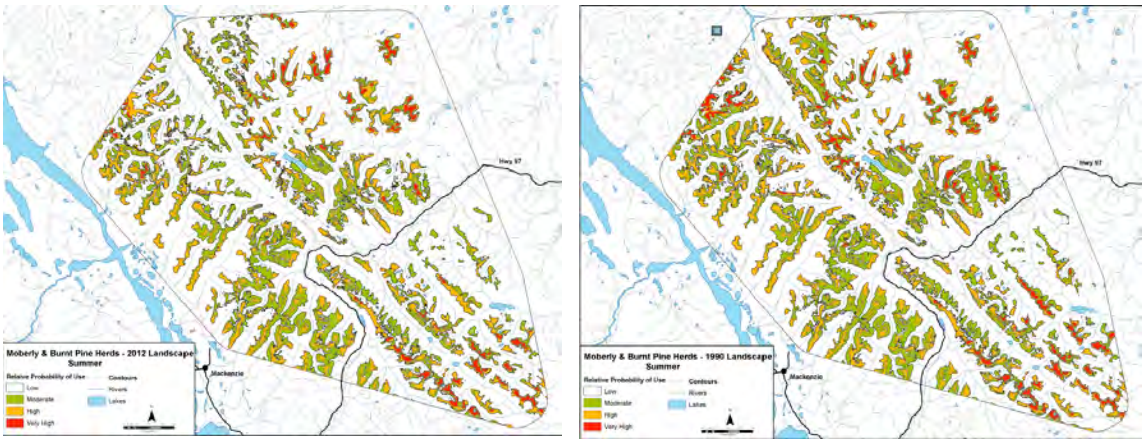

Figure 8. (Left) Burnt Pine herd, habitat suitability model, summer 1992 © Chris Johnson

Figure 9. (Right) Burnt Pine herd, habitat suitability model, summer 2012 © Chris Johnson

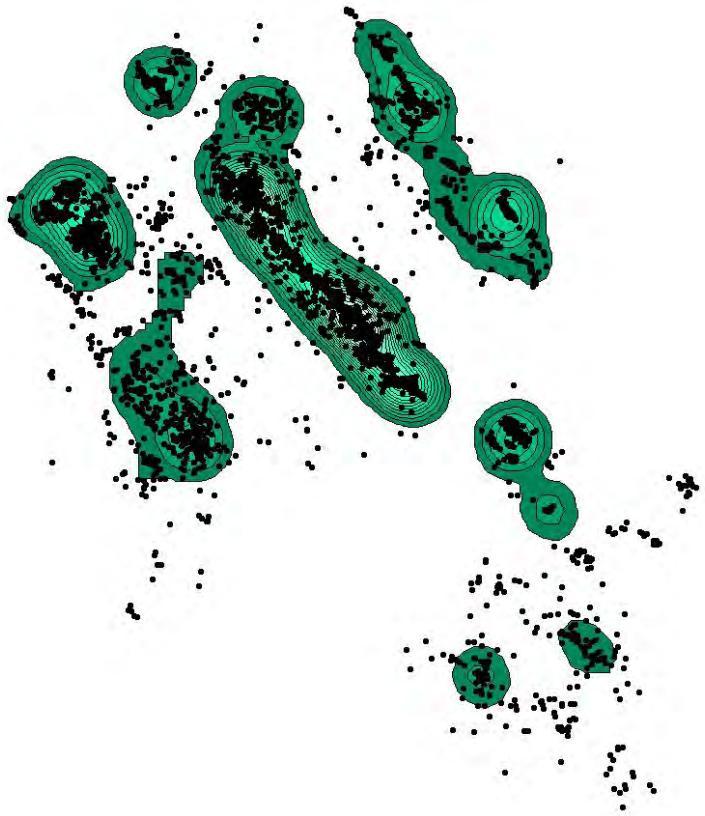

Figure 10. Burnt Pine herd range kernels with point data locations © Chris Johnson

As previously mentioned my aim was to use the reduction process, as a way of showing this loss and disappearance. The solution to the primary objective, which was to apply manual and automated manufacturing techniques towards the visualization of data provides an alternative to digital media distribution. It relies instead on material context to give a sense of historical weight and meaning to the content.

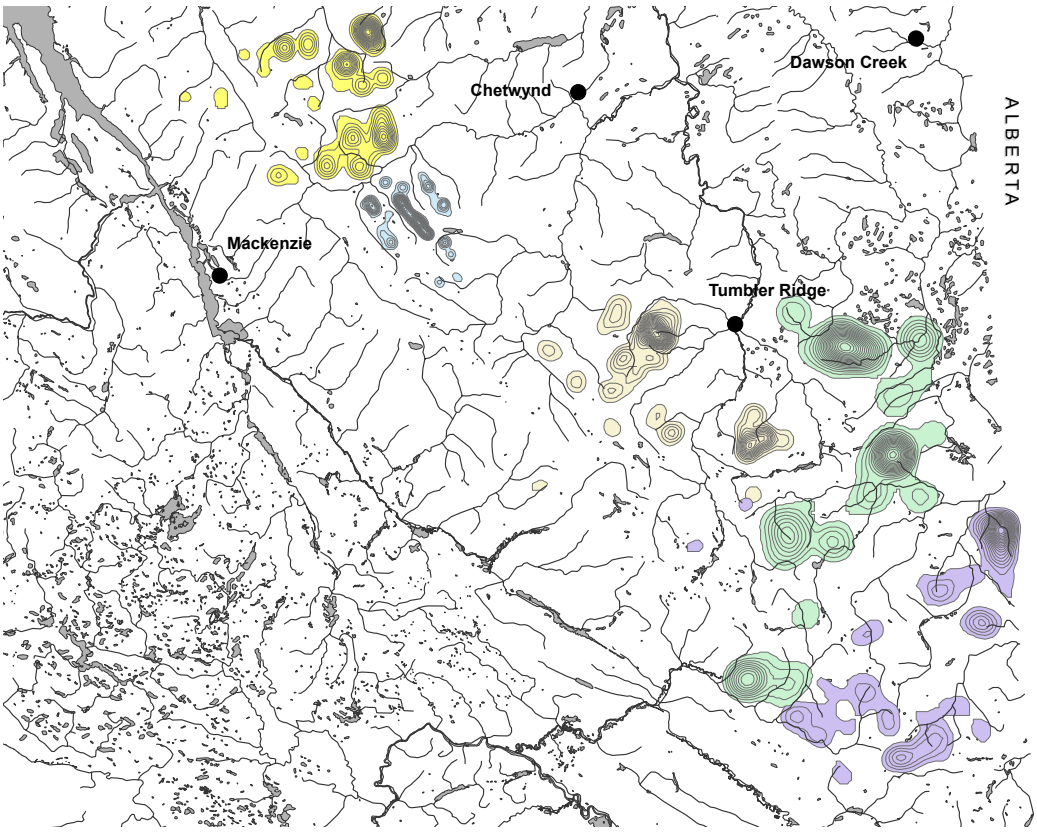

Figure 11. Woodland Caribou Herd Range contours, South Peace Region, BC © Chris Johnson

The first design ideations for these models considered showing the cumulative loss of habitat using before and after comparisons of the density of each herd units distribution between 1992 and 2012. These HSM models (Fig 6,7) employ a stylistic arrangement known as parallelism, a techniques which allows the audience to detect visual patterns or repetitions that echo similarities or differences between two compositions (Malbin, 2008). The first models that were provided (Brownian Bridge Models) relied heavily on complimentary colours to distinguish between layers of herd use values ranging from low, mid, high, to very high. As a result of a discussion with one of my instructors, I came to the decision that a monochromatic value gradation would be a more effective way of showing these intervals of value. Consequently, based on the previous work conducted by Dr. Skarin's group the parallel Brownian Bridge models were discarded and replaced by a unified rendering of the data in the form of contour Kernels (Fig 8) (Skarin et al., 2015).

This project required the translation of elevation topography into 3D models, which was achieved by importing vector contour maps into 3D modeling software as grey scale raster images. The raster images were converted into height fields, a CAD command that assigns elevation based on the value of pixels, white being the highest and black being the lowest. The height field threshold (highest and lowest elevations), and resolution of the mesh are independently controlled

The data contours were modeled manually in CAD (Rhino software) as terraces because they did not come with assigned grey scales values. These were registered

with the data contours models charting the caribou habitat usage. The measurements of 'use' value were transferred between the data collection source (GPS collar) and the digital elevation models, where it was then rendered through stratification of the contours as height values. The strata contours were then transferred into the block of wood through the CNC milling process. This approach to rendering the contours as negative space relies on the terrain to be the 'positive' supporting material, which shows the data as a reduction. Alternatively the strata layers could also be represented in positive forms, similar to the mountain plate study, which could have the visual appearance of sinking islands. This format would also work well with a sequential or animated visualization of the habitat disappearing, giving an appearance of a rising water line. The use of line was used as a recurring device through the research as a way of showing a continuity of time, and migration through a physical space. This linear narrative also extended to the movement of data between software and machine tool paths.

This data visualization project synchronized together the 3d contour kernel models and the 3d modeled terrain elevation imported from topographic maps of the area. The laminated stock used to mill a relief of the models was composed of alternating red and natural coloured veneers. The herd range data was milled as a negative relief demarcated by the study areas surrounding terrain and framed by a circular boundary. Using the automated reduction process to render these models translated well into the laminated material because of the similarity of its layered composition to elevation contours. The recesses in the terrain model suggest a removal of

material such as extraction of material from a mine pit. The lamination of material layers connected the processes of data accumulation and material sedimentation, while the reduction of the interpolated habitat area was set to correspond with the transition to red material. Colour reinforces the idea of a wound and finally, the latitude and longitude of the epicenter of the predicted vanishing point, was inscribed into the underside of the object.

Figure 12. Burnt Pint herd range relief model (back)

Figure 13. Burnt Pine Herd range, relief model (front)

Chapter 3: Conclusion

3.1 Discussion

That an objects changes state is perhaps the most persuasive quality they contain. This evidence of time reminds us that all material matters are transient. We project our bodies into things, surrounding ourselves with objects that become extensions of these bodies. The materials, which hold our stories, record imprints of sensory memories, and organize and animate our lives, they are the things through which we define and add meaning to our personal spaces. Their exchange value indicates the taxonomy and stratification of materials through the market place. As objects filter from high street boutiques, to homes, to second hand junks shops, somewhere along this process we inscribe them with value.

This research focused on transforming data into wooden artifacts as a knowledge translation exercise. It used automated manufacturing to process digital code into relief as a medium for communicating its narrative. These environmental simulations are used as metrics for the health of ecosystems, whose survival is threatened by anthropogenic impacts. The collection and analysis of information is increasingly used as a tool for predicting future trends and involves processing large quantities of data. These specialized skills rely heavily on visualization to illuminate the content of data. Visualizing terrestrial movements of animals into physical forms, this research explored parallel inquiries into material and immaterial mediation. It follows the quantitative and qualitative path of things, the falling away

of their meaning and its reconstruction. I looked at how the artifact can facilitate the communication of knowledge, combining modern and historically obsolete technologies to carry predictions. If the physical form allows us a deeper understanding of this meaning then the use of material is justified and surpasses any 'novel' aspect that could be drawn from the visual aesthetic. This thesis opens with exploring how artifacts are effective carriers of meaning and messages. I argue that a direct physical encounter can provide a more potent experience of the data. I see the use of speculative design objects in this project as a bridge between science and a wider audience, by setting up the conditions in which people can engage with the objects.

Technology has created a new internal landscape of the senses for us (Seremetakis, 1994; Whitridge, 2004). For all of the benefits we have gained from technologies in our daily lives, our relationship with nature has been altered. What shields and protects us from the environment has also buffered us from direct contact with it. As a result we no longer see or feel directly the consequences of our consumption because what is out of sight is out of mind. Our resource driven economy in Canada has been built largely around the extraction of natural resources from the land - which supports life. The wood material references a history of the domestic and narrative relief object, relevant today through the interface between forestry (the wood matrix) and landscape change (Johnson, 2015, personal communication).

Mapping anthropogenic impact on the ecosystem opens up a discussion about

resource management and how land is divided and used; its resources measured in units of profit without regard for living things. We use technology to mediate human error, and to quantify nature into units of currency, but it stands to reason that rational thought has put us in this position and alone it is not enough to compel us onto another course.

Tracking the behavioral responses of animals using satellite telemetry is one way these systems are being remotely measured and simulated (Cagnacci, Boitani, Powell, & Boyce, 2010) . These artifacts were made to illustrate a continuity of this data, as signals travel from GPS collars to satellites in space; silently witnessing terrestrial behaviors and changes. Visualizing this stream of predictions of a probable future might bring more attention to the diminishing seasonal returns of keystone species, a species that are a significant part of our biodiversity.

Jean Baudrillard defined modernity as the moment when the sign value overcomes use value. His response to the modern human experience - the mediation of our perceptions through mass media and the artificial environments they create – is the notion of simulacra, a simulation without an original. According to Baudrillard the desire to produce 'equivalences' that are hyper-realistic representations can be traced back to the Italian Renaissance with perspective painting (Crary, 1989). In a filmed interview in 2002, Baudrillard makes a reference to the symbolic murder of the real by the image. He compares the 'genuine' dying photographic film image with an animal species about to disappear and its replacement by the digital image

as an ‘artificial resurrection’ (Baudrillard, 2004).

The representation of nature throughout the epochs has transitioned from verisimilitude to photorealism to the interactive Google Earth satellite imagery that allows us a remote sense of dominance over nature. The output of pre-industrial craft traditions and post-industrial mechanized production tells the story of two colliding visions of nature; the shifting of the animistic towards the Cartesian, the subjective towards the objective (Olalquiaga, 2002). The emergence of GIS systems and CAD environments allows for the taxonomy of nature to be computed at unprecedented levels of detail. Data from natural systems is collected, analyzed and reduced into its individual elements, but a deconstruction of nature requires a sophisticated understanding to illustrate how the individual parts work as a whole. Spinoza wrote, that nature and god are the same. And centuries later Baudrillard speculated on some of the repercussions of unbridled technological growth; the loss of real meaning and substance, ‘today abstraction is no longer that of the map, the double, the mirror, or the concept. Simulation is no longer that of a territory, a referential being, or a substance. It is the generation by models of a real without origin or reality: a hyperreal. The territory no longer precedes the map, nor does it survive it (Baudrillard, 1994).’

This material research has attempted to look at these map territory relations; the relationship between an object and a representation of that object. We bestow great faith upon the predictions generated through data and trust that those who

illuminate it do so accurately. Its mediation into material exposes the limitations and artifice of simulating environments as well as their potential to inform and influence our perceptions. The Dutch philosopher Don Ihde elucidated that any transformation of our perception has a result of either amplification or reduction (Verbeek, 2006). This reminds us that representation is always a process of abstraction because the fidelity of the reproduction is always altered in transit between digital and analog.

3.2 Future Directions

This research methodology explored visualizing data through additive and digital manufacturing processes to developed new forms of knowledge transfer. This methodology could find applications in multiple extension scenarios as scientists and conservation organizations are actively seeking new forms of outreach for their research (Audubon, 2013).

One of Dr. Johnson's colleagues in Sweden, Dr. Anna Skarin, is conducting parallel studies involving reindeer in northern Lapland. The distinction between these cases in Canada and Sweden is in northern Sweden, the reindeers have been semi-domesticated for thousands of years; they have had a much longer, gradual adjustment to living with humans, compared to the sudden environmental developments in BC in the last 50 years. The survival of species largely depends on their ability to adapt to changing environments. Ecologists are interested in how animals respond to human modifications to the landscape. For example one of the

studies Dr. Skarin produced monitored reindeers responses to a wind farm installation in their territory. Since my initial meeting with her there has been discussion about using this methodology in Sweden, as an extension project, involving the Sami reindeer-herders. In the up coming year I'm extending this methodology through a collaboration with the Uppsala University project taking place between 2016-2018, *Contested Landscapes: navigating competing claims on cumulative impacts - CO-LAND*. As a designer I'll be developing new works in response to a study in Lapland connecting science, art, design, reindeer husbandry, and sami/indigenous traditions.

Since exhibiting the completed models at the graduation show at Emily Carr I've been asked to exhibit a larger body of this work at the Penticton Art Gallery. This public space will allow for a precise transfer of knowledge to occur between the artifacts and the viewer. It is fitting to locate this exhibition in central and northern BC to shine a light on the contested landscape and connect to relevant dialogues on the environment and technology. In ecology the term 'environmental grain' refers to the ease or difficulty of a species ability to move between habitats. Human disturbances such as roads and resource extraction cause fragmentation to migration corridors, impeding animals ability to move freely over land. Data visualization can provides a glimpse of this epidemic collapse of natural systems otherwise invisible to us. Two upcoming residencies will also assist in the distribution of this work. This work has received the Joseph Plaskett Scholarship for a residency which takes place this summer in Northern BC. There I'll begin to

document the signs along the highway and collect artifacts from the area using 3D scanning. The resulting artifacts and photographs will be shown in an exhibition. I'm also expecting to begin a period of residency at the Wood Innovation Design Center in Prince George this fall followed by a public exhibition.

The methodology developed here is also transferable to other materials and processes. This automated process works well for showing time based data sequentially and is also applicable to other materials, data sources and scales. Exploring the methodology in coal or plastic (hydrocarbon industry), and recycled or composite materials would be equally as interesting. These prototypes were intended to answer some initial questions, namely, can material improve the communicative aspect of data? In addition to their use of artifacts as vectors, the repetition and patterning of material and colours developed through this material process present opportunities for innovation in furniture and product design.

The potential to scale this project could be applied to public and site-specific installations. One such proposal is under development in northern BC. This area resides near the Pine Le Moray Provincial Park, connected by highway 97 between Mackenzie and Dawson Creek British Columbia. This is a concept for two or more large satellite dish shaped discs approximately 10-20 feet in diameter that would be mounted along the sides of the highway near the epicenter of the predicted caribou disappearance. The GPS derived 'before and after' spatial models would be rendered as reliefs in their concave surfaces. The discs would be pitched upward indicating

the sending and receiving of signals out into space as if relaying messages between different time periods. This brings to mind the Jorge Luis Borges short story 'On Exactitude in Science', a fictional narrative about an old discarded 1:1 scale map 'inhabited by animals and beggars' that was looked upon by future generations as a pitiful reminder of their past (Borges, 2002). It would seem to suggest the inevitable obsolescence of technology and the error in mistaking the simulated of nature for reality.

> In that empire, the art of cartography attained such perfection that the map of a single province occupied the entirety of a city, and the map of the empire, the entirety of a province. In time, those unconscionable maps no longer satisfied, and the cartographers guilds struck a map of the empire whose size was that of the empire, and which coincided point for point with it. The following generations, who were not so fond of the study of cartography as their forebears had been, saw that that vast map was useless, and not without some pitilessness was it, that they delivered it up to the inclemency's of sun and winters. In the deserts of the west, still today, there are tattered ruins of that map, inhabited by animals and beggars; in all the land there is no other relic of the disciplines of geography. (Borges, 2002)

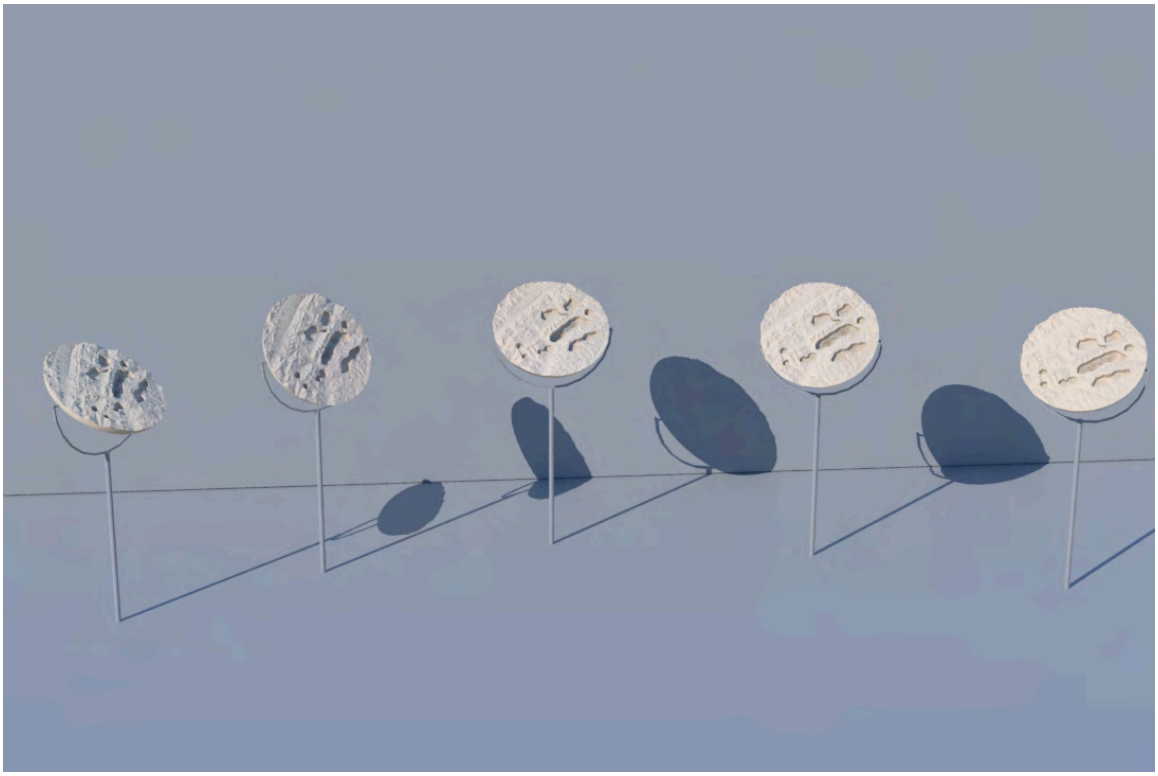

Figure 14. Modo rendering of habitat suitability models for five Caribou Herds

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