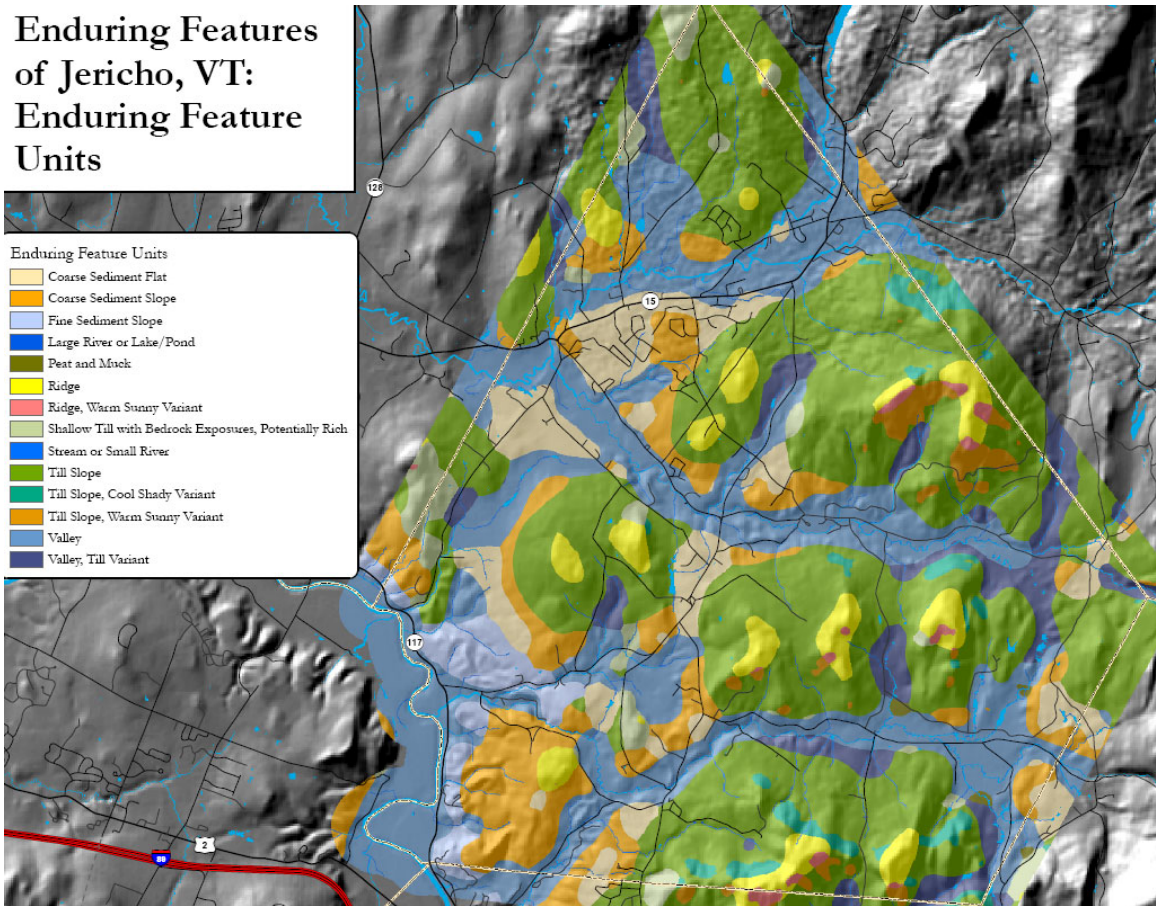
Enduring Features of Jericho, Vermont:
An Analysis for Conservation, Restoration, and Climate Change Adaptation Planning



Prepared by
Jesse Mohr
Native Geographic, LLC
PO Box 241
Pike, NH 03780
NativeGeographic@gmail.com
Phone: 603.989.5121
Web: www.NativeGeographic.com

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I-The Enduring Feature Units of Jericho, Vermont: A Synergistic Approach to Understanding Enduring Feature Diversity

The concept of an ecosystem—the complete community of living organisms and their non-living surroundings functioning as a single interacting unit—has been taught in our grade school classrooms since the 1960's. While the concept gives a formal nod to "non-living surroundings", the biological and generally above-ground components—wildlife, plants, vegetative communities—have come to dominate the concept, conservation planning, and public interest. To broaden conservation and public interest in the full ecosystem and improve the utility of existing wildlife and vegetation studies in Jericho, Vermont, this study focuses its attention on the town's "non-living surroundings".

An ecosystem can be thought of as a layered volumetric entity (a cylinder, for example) that extends from the atmosphere to the foundation of our earth's surface, bedrock. At any given site, this cylinder could include numerous interacting layers: climate, wildlife, trees, shrubs, herbaceous plants, soil, landform, surficial deposits, and bedrock geology. Many of these layers are explained in greater detail below. Scientists, farmers, and gardeners (to name a few) have long recognized that the non-living layers—climate, soil, surficial deposits, landform, and bedrock geology—exert a strong influence on the composition and quality of the living layers. This is a two-way interaction with soil, to a limited degree, and micro-climate, to a lesser degree, being shaped by the vegetation they support.

With the concept of a layered volumetric ecosystem in place, now consider the residency of each layer. Bedrock geology, surficial deposits, landforms, and even the beginnings of our contemporary soils have been in place for nearly 10,000 years since the last major glacial retreat. Our vegetation and wildlife, on the other hand, have dramatically changed since tundra-like systems dominated our landscape 10,000 years ago. These non-living features act as an enduring stage from which the more mobile vegetation and extremely mobile wildlife flow in and out; this study focuses on these enduring features of Jericho, Vermont.

An understanding of Jericho's enduring features is important because:

- Enduring features are good predictors of mobile wildlife and vegetation;
- Enduring features have intrinsic value in themselves (this probably goes under-appreciated in less geologically spectacular places like the northeast, but is easily recognized in other portions of the world where geological features, like Devil's Tower, are the focus of conservation efforts); and
- Enduring features can be used to develop climate change adaptation strategies.

To these ends, a synergistic classification and map of Jericho's enduring features was created for analysis. The remaining portion of this section highlights the components and results of this classification scheme. Section II details how well each enduring feature classification is protected in Jericho. Section III provides guidance on the how results of this analysis can be used to guide conservation, restoration, and climate change adaptation planning efforts in the town.

Layers Used in Development of Jericho's Enduring Feature Classification

To develop a classification scheme and map of Jericho's enduring features a number of existing datasets were evaluated for use. Layers evaluated for use in this project had to meet the following criteria:

- Inclusive of the whole town (soils data, for example, was not used because it is not available for all of Jericho);
- Expected to be resilient as climate changes (temperature isotherms, for example, were not used because they are expected to change as larger climate patterns shift); and
- Based on local knowledge, believed to be a primary driver of vegetation at intermediate geographic scales in the town (moisture, for example, was not used because it can vary over very small distances).

The following subsections describe the layers selected for use in developing Jericho's enduring feature classification scheme.

Bedrock Geology: Bedrock is the consolidated material that underlies the surface of the earth. In the Jericho area, most of the bedrock is derived from ancient sea deposits, including near shore sand, coral, and deep sea marine silts and clays. Under tremendous geologic forces driven be tectonic activity, these sediments were metamorphosed into the metasedimentary bedrock types that are found in Jericho today. Millions of year later, these metasedimentary rocks still bear the legacies of their marine origins. Bedrock derived from ancient coral formations tends to be high in available calcium, often creating an enriched or pH neutral soil environment where nutrients are readily available to growing plants. The sand and silt/clay-derived materials tend to weather at much slower rates and with less available calcium, often creating soil environments where nutrient availability is limited due to acidic conditions.

The Ecological Bedrock Groups dataset derived by the Vermont Biodiversity Project (Thompson, 2002) was used in this analysis. During VBP, the 136 types of bedrock found in Vermont were grouped into 9 categories of bedrock with similar geochemistry and mineralogy, thus having similar influences on vegetation. Of these 9 categories, only three occur in Jericho (See Bedrock Geology Map):

- ***non-calcareous slate, graywacke and conglomerate-*** locally graphitic and sulphidic;
- ***non-calcareous schist, phyllite, gneiss, and granofels-*** may be interlayered and locally calcareous, locally graphitic, and locally sulphidic; and
- ***metamorphosed, mafic volcanic and clastic sedimentary-*** minor carbonate

In some settings, deep surficial deposits cover the underlying bedrock, minimizing the effect bedrock may have on vegetation and biodiversity distribution. Where this occurs in Jericho—deep recent alluvium, deep coarse sediments, and deep fine sediments (see Surficial Deposits below)—the overlying surficial material is the primary driver of vegetation, not the underlying bedrock. In these locations, underlying bedrock was not included in this analysis (See Ecological Substrate Groups Map).

Bedrock geology, and its influence on biodiversity distribution, varies over the largest geographic area of all the factors considered in this analysis. The VBP Bedrock dataset used in this analysis is based on the 1961 statewide Centennial Bedrock Geology Map. Due to the scale at which this original map was completed and the limited technology available at the time, this layer of the analysis has the poorest locational accuracy.

Landscape Position: Landscape position refers to the relative topographic location of a given area (see figure 1 below). This GIS-derived metric considers the elevation and topographic relief of a given location relative to its neighbors. It then groups adjacent locations with similar elevation and topographic relief.

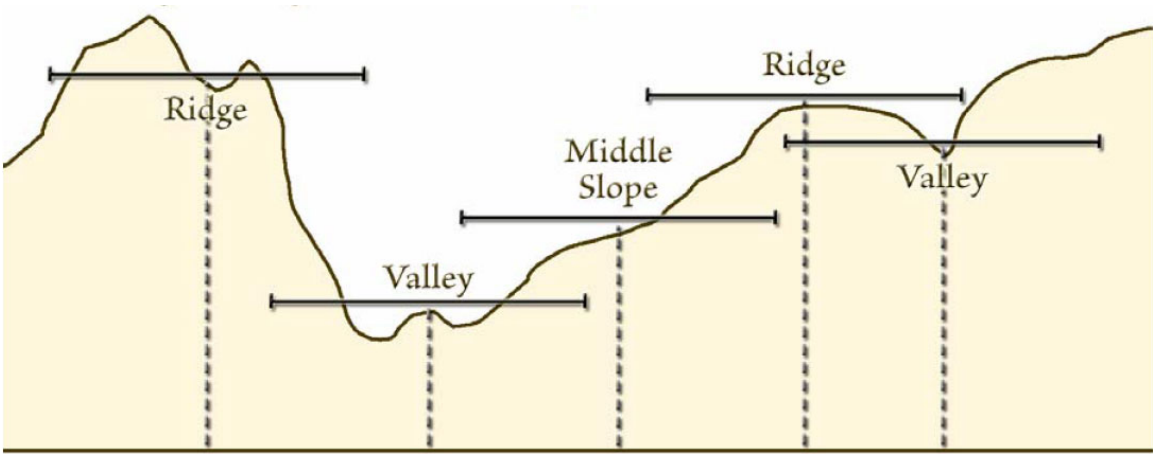

Figure 1 Landscape Position: The above diagram is an example of landscape positions. The landscape positions in this diagram are similar, but not exact to the landscape positions used in this project. Jericho has many non-valley flats that are not highlighted in the above diagram. Source: Jenness, 2006.

For this analysis, locations were placed into one of four landscape position classes (See Landscape Position Map): ***Valley, Gentle Slope and Non-valley Flats, Slope, and Ridge.***

The locational accuracy of this metric exceeds that of the Surficial and Bedrock Geology datasets used in this analysis. There is a very strong correlation between Slope Position and the processes responsible for Jericho's contemporary Surficial Deposits: valley positions being heavily shaped by alluvial and glacio-lacustrine processes; slopes and ridges being primarily underlain by till and partially shaped by ice movement; and gentle slopes and flats being shaped by glacio-lacustrine, glacio-fluvial, and ice-contact processes. Because the locational accuracy of the Landscape Position dataset is much better than that of the Surficial Deposits dataset, it was used to improve the Surficial Deposits dataset by removing typically valley bottom deposits (recent alluvium and deep fine sediments) from ridge and higher elevation slope locations. Till deposits were not removed from valley bottom locations, because this geologic anomaly is somewhat common and can be explained by a complicated set of geologic processes.

Solar Radiation: Solar radiation is the energy received by incoming sun rays and is the primary energy source for many of the earth's biological and physical processes. Besides providing energy for photosynthesis, solar radiation also plays a critical role in the warming of the earth's surface and, in conjunction with warming atmospheric temperatures, helps trigger soil microbial activity each spring. By affecting growing season length, soil temperature, and available energy, the amount of solar radiation received during periods of vegetation and soil microbial activity has a strong influence on biodiversity distribution.

For this analysis, locations were placed into one of three solar radiation classes based of the amount of incoming solar energy received from March 1-November 1, an approximation of soil microbial activity and growing season (See Solar Radiation Map): ***warm and sunny, shady and cool, or intermediate***.

This GIS-derived metric, and its influence on biodiversity distribution, varies over an intermediate geographic area as compared to other factors considered in this analysis. The locational accuracy of this metric exceeds that of the Surficial and Bedrock Geology datasets used in this analysis.

Surficial Deposits: Surficial deposits include the unconsolidated mineral and organic materials that overlie the earth's bedrock. Surficial deposits are of more recent origin than bedrock. In Jericho, the surficial deposits are a result of advancing and retreating glaciers, glacial and post-glacial lakes, glacial and post-glacial running waters, and the post-glacial buildup of organic materials. These processes create deposits of differing texture, moisture and nutrient holding capacity, compactness, and geochemistry. Each of these attributes can, in turn, have a dramatic effect on vegetation and biodiversity.

The statewide Surficial Geology dataset derived by the Vermont Geologic Survey (VGS) was used in this analysis. This dataset contains 32 types of surficial deposits found in Vermont, of which only 12 occur in Jericho. These twelve types of surficial deposists were then grouped into six classes based on similarities in texture, moisture and nutrient holding capacity, compactness, and geochemistry (See Surficial Geology Map and Ecological Substrate Groups Map): ***deep fine sediments, deep coarse sediments, peat and muck, shallow till with bedrock exposures, deep recent alluvium, and till***.

Surficial deposits and their influence on biodiversity distribution vary over an intermediate geographic area as compared to other factors considered in this analysis. The dataset used in this analysis is based on a mosaic of 15-minute Surficial Geology maps compiled by the VGS from 1956-1970. Due to the scale at which these original maps were completed and the limited technology available at the time, this layer has poorer locational accuracy than many of the others used in this analysis. As such, attempts were made to improve its accuracy through overlay analysis with the Landscape Position dataset (See Landscape Position).

Jericho's Enduring Feature Classification

Evaluating Jericho's enduring features one layer at a time is an extremely complex task and, in many ways, is unnecessary because there is a strong degree of correlation between many of the layers. As such, the layers presented above have been combined into one synergistic classification scheme. This classification was developed to:

- Reduce the complexity of evaluating the landscape one enduring feature layer at a time;
- Find suitable breaks in generally continuous environmental gradients; and
- Utilize correlations or synergies between different enduring feature layers.

Developing the classification was an iterative three-step process consisting of: 1.) combining all the layers together to create a list of all the unique combinations of bedrock geology, surficial deposits, solar radiation, and landscape positions that exist in Jericho; 2.) assigning unique combinations that were the result of poor locational accuracy (the ridge position recent alluvium combination, for example, which is detailed above under the Landscape Position description) to their most likely correct combination; and then 3.) aggregating those unique combinations into units that had a similar influence on vegetation. In step three, for example, the three deep fine sediment over bedrock combinations were combined into a single entity because the deep fine sediment accumulations mask the effect of the underlying bedrock.

Enduring Feature Unit	% of Jericho
Coarse Sediment Flats	6.6
Coarse Sediment Slope	9.4
Fine Sediment Slope	2.4
Large River or Lake/Pond	0.9
Peat and Muck	0.1
Ridge	4.3
Ridge, Warm Sunny Variant	0.5
Shallow Till with Bedrock Exposures, Potentially Rich	2.7
Stream or Small River	1.8
Till Slope	37.8
Till Slope, Cool Shady Variant	1.8
Till Slope, Warm Sunny Variant	1.3
Valley	24.3
Valley, Till Variant	6.0

Table 1-Enduring Feature Units: The above table highlights the distribution of Enduring Feature Units in Jericho, Vermont.

In the end, eight major combinations of enduring features (Enduring Feature Units or EFUs) and four variants were identified. The Enduring Feature Units Map shows the distribution of those units in Jericho. Table 1 (see left) highlights the town-wide coverage by percent of each of the EFUs.

The following subsections contain descriptions of Jericho's major EFUs and variants as defined by this project. Each EFU description contains a general overview, defining characteristics, expected variability, town-wide distribution and associated natural communities.

Coarse Sediment Slope: This EFU primarily consists of west facing slopes with lesser amounts of south, southwest and southeast facing sandy slopes. The abundance of west facing slopes of this EFU is not a result of solar radiation analysis and is instead a product of the pro- and post-glacial processes responsible for laying down the surficial deposits associated with this EFU. These areas are underlain by deep sand and sand with gravel surficial deposits. Slopes range from 3-61 degrees, with an average slope of 9 degrees. However, in some locations streams have eroded down through the highly erodible sands creating locally steep ravines. The sand and sand with gravel deposits are generally deep enough to minimize immediately underlying bedrock influence and have generally weathered into acidic loamy sands to sandy loams.

This EFU makes up almost 10% of the town. Small un-mapped examples of this EFU can also be found in narrow ravines of the "Coarse Sediment Flats" EFU.

Hemlock-Northern Hardwood, Hemlock-White Pine-Northern Hardwood and Hemlock Forests are the dominant natural communities of this EFU. The acidic nature of the soils within this EFU often favors eastern hemlock and other less nutrient-demanding hardwood species, such as American beech and red maple. Due to the limited cohesion of sand particles on steep slopes, sloughing and turnover of topsoil is common in this EFU; coupled with the sunny westerly aspects, this ongoing process can create opportunities for natural regeneration of white pine, a phenomenon that is probably best represented by this EFU.

Additionally, silty-textured soils are sometimes found in thin bands at the base of this EFU. Groundwater often travels along this sand-silt contact zone, emerging in the form of seeps at the base of steep slopes within this EFU. In these locations, seep and small forested wetland communities are common.

Coarse Sediment Flats: This EFU primarily consists of level and gently sloping (less than 3 degrees) sand deposits. However, in some locations streams have eroded down through the highly erodible sands creating locally steep ravines. The sand and lesser amounts of sand with gravel deposits are generally deep enough to minimize immediately underlying bedrock influence and have generally weathered into acidic loamy sands and sandy loams

This EFU makes up almost 7% of the town. Small un-mapped examples of this EFU can also be found in the "Coarse Sediment Slopes" EFU.

This EFU has been subject to extensive agricultural and residential conversion (See Section II: Representative Assessment), more so than any other EFU derived in this analysis. Most of the vegetation currently supported by this EFU is the result of relatively recent agricultural abandonment, which greatly complicates understanding patterns of natural vegetation associated with this EFU. It is likely that this area once supported Hemlock-Northern Hardwood and Northern Hardwood Forests of less nutrient demanding species, such as the Beech-Red Maple-Hemlock-Northern Hardwood Forest variant. It is possible this EFU also supported Hemlock-White Pine-Northern Hardwood Forests. Additionally, this EFU may have supported the uncommon White Pine-Red Oak-Black Oak (Black Oak often not present in more northerly occurrences) and the exceptionally rare Pine-Oak-Heath

Sandplain Forests. Some portions of this EFU have many commonalities with the more extensive sand plains of the Camp Johnson area in Colchester, Vermont.

Fine Sediment Slope: This EFU primarily consists of west facing slopes with lesser amounts of south, southwest and southeast facing slopes. The abundance of west facing slopes of this EFU is not a result of solar radiation analysis and is instead a product of the pro- and post-glacial processes responsible for laying down the surficial deposits associated with this EFU. These areas are underlain by deep silt and sometimes clay surficial deposits. Slopes range from 1-53 degrees, with the majority having moderate slopes of less than 12 degrees. However, in some locations slope failure associated with ground water emergence and/or stream down-cutting has created locally steep slopes. The overlying surficial deposits are generally deep enough to minimize immediately underlying bedrock influence. Silts and clays have naturally high nutrient retention and buffering abilities and, as a result, often weather into neutral or even basic soils with high amounts of available nutrients.

In this EFU, silty-textured soils are often found overlying clayey-textured soils. Cohesion between the two soil textures can sometimes be limited, thereby increasing the likelihood of slope failure. Additionally, in this EFU groundwater often travels along this silt-clay contact zone, emerging in the form of seeps on the steep slopes of this EFU. A similar phenomenon also occurs in the Coarse Sediment Slopes EFU where sandy-textured soils overlie silty-textured soils. The emergence of groundwater and high water retention capabilities of silty and clayey soils often results in moist soil conditions, which also can increase the likelihood of slope failure.

This EFU makes up less than 3% of the town. Small un-mapped examples of this EFU can also be found in narrow ravines of the "Valley" EFU and in narrow bands along the lower elevations of the "Coarse Sediment Slopes" EFU.

Northern Hardwood and even the slightly enriched Sugar Maple-White Ash-Jack-in-the Pulpit Northern Hardwood Forests are the dominant natural communities of this EFU. Seeps are also common. Small, sloping Red Maple-Black Ash Swamps are sometimes found associated with the larger seeps.

Shallow Till with Bedrock Exposures, Potentially Rich: This EFU primarily consists of shallow-to-bedrock slopes and knobs with occasional exposed bedrock in the form of ledges and small outcrops. Slopes range from 0-52 degrees, but are generally less than 12 degrees. Where soil exists, it is primarily derived from a thin mantle of till and the direct breakdown of bedrock. The bedrock underlying this EFU is known to contain calcareous pockets and seams. Portions of this EFU, primarily in the northwest part of Jericho, are underlain by bedrock with a minor amount of carbonates too. The calcareous and carbonate components of the bedrock are easily to moderately weathered, becoming available for plant uptake. Additionally, as these materials weather they buffer soil acidity and generally lead to development of neutral or basic soil conditions with high amounts available nutrients.

This EFU makes up less than 3% of the town. Small un-mapped examples of this EFU can also be found in the "Till Slopes" EFU.

Northern Hardwood, Rich Northern Hardwood, and the slightly enriched Sugar Maple-White Ash-Jack-in-the Pulpit Northern Hardwood Forests are the dominant natural communities of this EFU. Warmer portions of this EFU may support Dry Oak-Hickory-Hophornbeam Forest or its Sugar Maple variant. The EFU also contains small occurrences of the shallow-to-bedrock Northern Hardwood Limestone Forest and Northern Hardwood Talus Woodland. Vernal Pools can also be found in bedrock and till hardpan depressions throughout this EFU; many of these bedrock pools may be too ephemeral to support viable populations of pool-dependent species.

Peat and Muck: This EFU consists of areas supporting organic soils that developed in now extinct lakes associated with times of increased rainfall since the last major glacial advance. The soils of this EFU are derived from partially decomposed organic matter, including mosses, sedges, grasses, and other herbaceous and woody plants. The soils may be highly variable in their degree of decomposition, from highly decomposed where plant parts are largely unrecognizable (muck) to poorly decomposed where plant matter is easily recognized (peat). These soils develop under wet (hydric) conditions where organic matter accumulation exceeds that of decomposition. Organic accumulations in this EFU may range from 18 inches-30 feet.

Acidic conditions may develop in portions of this EFU. The breakdown and decomposition of organic matter acidifies the soil environment. Portions of this EFU supporting sphagnum mosses are further acidified by the biological processes (calcium ion uptake and hydrogen ion release) associated with this genus of mosses.

Hydric conditions and the separation of plants from mineral soil are the primary attributes of this EFU and the primary drivers of vegetation and biodiversity associated with this EFU.

This EFU makes up less than .1% of the town. Small un-mapped examples of this EFU can also be found in the "Valley" and Valley, Till Variant" EFUs

Wetland natural communities and beaver-created ponds are the dominant natural communities of this EFU. Poor Fen (with many Dwarf Shrub Bog characteristics) would be the primary community associated with the portions of this EFU underlain by soils that developed from poorly decomposed sphagnum mosses (peat). Areas underlain by muck, highly decomposed peat, and non-sphagnum peat are most likely to support forest or shrub dominated swamps (Alder, Hemlock, and Red Maple-Black Swamps) and open herbaceous marshes (Shallow Emergent, Deep Broadleaf and Cattail Marshes and Sedge Meadows).

Ridge: This EFU primarily consists of north, east and northeast facing ridges or shaded south, southwest, and west facing ridges underlain by till deposits. Slopes range from 0-60 degrees, with an average slope of 13 degrees. The till deposits underlying this EFU are variable in depth and include many shallow-to-bedrock areas. The majority of this till is

underlain by non-calcareous bedrock types. Most of the till contains non-calcareous bedrock fragments that have weathered into slightly acidic loamy soils. With little or no upslope drainage areas, increased sun and wind exposure, and generally convex slope shapes, this EFU is often dry (xeric) to moderately dry.

This EFU makes up a relatively small portion of the town. Depending on the solar radiation threshold used to separate this EFU from its warm variant (see Ridge, Warm Sunny Variant below), this EFU may occupy between 3-5% of the town.

Mesic Red Oak-Northern Hardwood and Northern Hardwood Forests are the dominant natural communities of this EFU. Shallow-to-bedrock knobs and ridgeline benches within the lower elevations of this EFU may support Dry Oak-Hickory-Hophornbeam Forest. The higher elevation occurrences of this EFU may also contain red spruce components and support the Red Spruce-Heath Rocky Ridge Forest. Some portions of this EFU also support Dry Oak Forests, although that community is largely restricted to the warm variant (see Ridge, Warm Sunny Variant below) of this EFU.

Ridge, Warm Sunny Variant (Variant of Ridge EFU): This EFU consists of un-shaded south, southwest, and west facing ridges underlain by till deposits. Slopes range from 0-56 degrees, with an average slope of 17 degrees. The till deposits underlying this EFU are variable in depth and include many shallow-to-bedrock areas. The majority of this till is underlain by non-calcareous bedrock types. Most of the till contains non-calcareous bedrock fragments that have weathered into slightly acidic loamy soils. With little or no upslope drainage areas, increased wind exposure, generally convex slope shapes, and high levels of solar radiation this EFU is often dry (xeric).

Depending on the solar radiation threshold used to separate this variant from the Ridges EFU (see Ridges above), this EFU may occupy between .5-3% of the town.

Dry Oak Forests are the dominant natural community of this EFU. Excessively well drained and droughty portions of this EFU may also support Dry Oak Woodland. Areas with a history of fire disturbances may support Red Pine Forest.

Till Slope: This EFU primarily consists of northeast, east, and southeast facing slopes with minor flats underlain by deep till deposits. The till deposits underlying this EFU are variable in depth and include some shallow-to-bedrock areas. The majority of the EFU is underlain by non-calcareous bedrock types. Most of the till contains non-calcareous bedrock fragments that have weathered into slightly acidic loamy soils. The EFU does contain an unknown number of small rich inclusions; these locations are generally associated with colluvium (a loose deposit of rock or organic debris accumulated through the action of gravity at the base of a cliff or slope) or with till deposits containing a concentration of calcareous rock fragments picked up by the glacier from more westerly locations.

This EFU makes up approximately 40% of the town. Depending on the solar radiation thresholds used to define "shady" and "sunny", this EFU may occupy between 35-45% of the town.

Northern Hardwood Forests are the dominant natural community of this EFU. Cool shady areas with shallow soils within the EFU support Hemlock and Hemlock-Northern Hardwood forests, while warm sunny areas with shallow soils support Red Oak-Northern Hardwood Forest. Higher elevation occurrences of this EFU may also contain red spruce components. Small cliffs, supporting Temperate Acidic Cliff communities and downslope Northern Hardwood Talus Woodlands, are also found with this EFU. Vernal Pools and Seeps can also be found throughout this EFU.

Till Slope, Cool Shady Variant (Variant of Till Slope EFU): This EFU primarily consists of north-northeast facing slopes with minor flats underlain by deep till deposits. Slopes range from 0-61 degrees, with an average slope of 18 degrees. The till deposits underlying this EFU are variable in depth and include some shallow-to-bedrock areas. The majority of the EFU is underlain by non-calcareous bedrock types. Most of the till contains non-calcareous rock fragments that have weathered into slightly acidic loamy soils. The EFU does contain an unknown number of small rich inclusions; these locations are generally associated with colluvium (a loose deposit of rock or organic debris accumulated through the action of gravity at the base of a cliff or slope) or with till deposits containing a concentration of calcareous rock fragments picked up by the glacier from more westerly locations.

This EFU makes up a relatively small portion of the town. Depending on the solar radiation threshold used to define "shady", this EFU may occupy between 2-5% of the town. Small un-mapped examples of this EFU can also be found in narrow ravines of other till-derived EFUs, primarily of the "Slope" landscape position.

Northern Hardwood, Hemlock-Northern Hardwood, and Hemlock Forests are the dominant natural communities of this EFU. The cool shady nature of this EFU often favors eastern hemlock. The slightly acidic soil conditions also associated with this EFU not only favor eastern hemlock, but are also maintained by the decomposing needles of this species. Regardless, many hardwood species native to Jericho are also capable of thriving in this EFU and in many areas are likely more dominant than eastern hemlock. Higher elevation occurrences of this EFU may also contain red spruce components.

Till Slope, Warm Sunny Variant (Variant of Till Slope EFU): This EFU primarily consists of un-shaded south, southwest, and west facing slopes with minor flats underlain by till deposits. Slopes range from 0-63 degrees, with an average slope of 19 degrees. The till deposits underlying this EFU are variable in depth and include some shallow-to-bedrock areas. The majority of the EFU is underlain by non-calcareous bedrock types. Most of the till contains non-calcareous rock fragments that have weathered into slightly acidic loamy soils. The EFU does contain an unknown number of small rich inclusions; these locations are generally associated with colluvium (a loose deposit of rock or organic debris

accumulated through the action of gravity at the base of a cliff or slope) or with till deposits containing a concentration of calcareous rock fragments picked up by the glacier from more westerly locations.

This EFU makes up a relatively small portion of the town. Depending on the solar radiation threshold used to define "sunny", this EFU may occupy between 1-4% of the town. Small un-mapped examples of this EFU can also be found in the Till Slopes EFU.

Mesic Red Oak Northern Hardwood Forest is the dominant natural community of this EFU. Areas with deeper soils are likely to support Northern Hardwood Forest. Xeric convex knobs within this EFU likely support small examples of Dry Oak Forest.

Valley: This EFU primarily consists of valley bottom flats and minor hills underlain by deep water-deposited sediments. These deposits are generally deep enough to mask the effects of underlying bedrock. During glacial advance and early retreat, coarse outwash sands and gravels were deposited along the margins and tip of the glacier. During glacial retreat, a series of massive glacial lakes inundated valleys. Silts and clays were deposited in the deepwater areas and sands were deposited in the shallow-water and shoreline areas. Since these lakes disappeared approximately 10,000 years ago, the Winooski, and to a lesser degree Jericho's smaller rivers, have eroded, moved and re-sorted many of these glacial outwash and glacial lake deposits. Prior to large-scale flood control efforts, the Winooski and other small rivers of the area regularly flooded much of this EFU, depositing alluvial silts and clays over much of the existing surficial deposits.

Soil pH, nutrient availability, and droughtiness are variable within the EFU and, outside of the active river floodplains, are the primary drivers of biodiversity distribution. Soils developing from sand and gravel deposits tend to be more acidic, lower in available nutrients, and are more prone to droughtiness when removed from the water table. Silts and clays, on the other hand, have naturally high nutrient and moisture retention abilities and, as a result, often develop into neutral or even basic soils with high amounts of available nutrients and are less prone to droughtiness. Soils developing in the active river floodplain receive annual nutrient inputs in the form of overbank flows.

Slopes in this EFU range from 0-59 degrees, but are generally less than 5 degrees.

This EFU makes up almost 25% of the town. Small un-mapped examples of this EFU are likely found along small rivers and large streams throughout the town.

Valley landscape positions throughout the area have been extensively cleared for agriculture and residential purposes and currently support limited amounts of natural vegetation. Most of the vegetation currently supported in Valley landscape positions throughout the state is a result of relatively recent agricultural abandonment. The extensiveness and long-tenure of land clearing greatly complicates understanding patterns of natural vegetation associated with this EFU.

This EFU once supported extensive floodplain communities: Silver Maple-Ostrich Fern Floodplain Forest with inclusions of Silver Maple-Sensitive Fern Forest in wet depressions, old meander channels, and the lowest floodplain elevations along the Winooski and possibly lower gradient sections of Mill Brook and Lee and Browns Rivers; Sugar Maple-Ostrich Fern Floodplain Forest along the moderate gradient sections of Mill Brook and Lee and Browns Rivers and possibly on the high terraces (abandoned floodplains) of the Winooski; and Alluvial Shrub Swamps and Shallow Emergent Marshes in back- and still-water portions of the once active floodplains. The annual ice and water scour, sediment deposition, and fluctuating water levels associated with Jericho's rivers and streams also support a dynamic mosaic of rivershore communities: Rivershore Grassland, River Mud Shore, River Cobble Shore, and River Sand or Gravel Shore.

Beyond the influences of the river and stream floodwaters, this EFU would have likely supported numerous non-floodplain wetland communities, including Red Maple-Black Ash Swamp, Alder Swamp, Shallow Emergent Marsh, Red or Silver Maple-Green Ash Swamps, mixed hardwood-conifer swamps, and the occasional peatland community, such as Poor Fen, in the headwater basins of this EFU. The EFU also likely supported more upland communities such as Northern Hardwood Forest, Hemlock-Northern Hardwood Forest, Mesic Maple-Ash-Oak-Hickory Forest, and smaller occurrences of Valley Clayplain forest.

Valley, Till Variant (Variant of Valley EFU) This EFU primarily consists of valley bottom flats and minor hills underlain by glacial till. The till is primarily of non-calcareous origin, but does contain inclusions of silt. To a limited degree, the smaller rivers of this EFU have eroded moved and re-sorted these till deposits. This EFU is primarily found along higher gradient stretches of smaller rivers and larger streams, often with limited floodplain development.

Most of the till within this EFU has weathered into loamy soils of moderate acidity and, depending on local micro-topography, may range from being somewhat excessively well drained to poorly drained. Areas underlain by silt tend to be moist with higher levels of available nutrients. With little floodplain development, nutrient enrichment from overbank flows is limited.

Slopes range from 0-56 degrees, but are generally less than 10 degrees.

This EFU makes up almost 6% of the town. Small un-mapped examples of this EFU are likely found along small rivers and large streams throughout the town and within the Valley EFU.

This EFU supports limited floodplain communities; Sugar Maple-Ostrich Fern Floodplain Forest occurs on sections of Mill Brook and Lee and Browns Rivers. River Cobble Shores and River Sand or Gravel Shores are found throughout this EFU. Alder Swamps and Red Maple-Black Ash Swamps are found in wet, low-lying areas underlain by silt and/or till. Hemlock and Hemlock-Hardwood Swamps are likely found in the some of the small headwater basins in this EFU. These same headwater basins also support a small number of Poor Fens.

II- Enduring Feature Representation

The following section contains the results of EFU-based analysis conducted for this project. First is a brief subsection highlighting how natural/semi-natural vegetation is distributed across Jericho's EFUs. Second is a brief subsection highlighting the degree to which each EFU is included or represented in the town's conserved area system.

The Distribution of Natural/Semi-natural Vegetation

Natural/semi-natural vegetation cover is not evenly distributed over Jericho's enduring feature diversity. Table 2 (see below) provides a breakdown of natural/semi-natural vegetation cover by EFU.

Enduring feature Unit	% in Natural/Semi-natural Cover	% Conserved
Coarse Sediment Flats	42.0	18.3
Coarse Sediment Slope	79.3	24.1
Fine Sediment Slope	86.8	8.6
Large River or Lake/Pond	NA	17.5
Peat and Muck	65.5	50.9
Ridge	95.4	43.6
Ridge, Warm Sunny Variant	100.0	70.6
Shallow Till with Bedrock Exposures, Potentially Rich	87.6	8.0
Stream or Small River	NA	28.4
Till Slope	87.4	35.0
Till Slope, Cool Shady Variant	99.6	42.3
Till Slope, Warm Sunny Variant	100.0	77.9
Valley	48.4	21.0
Valley, Till Variant	79.6	56.9

Table 2-Enduring Feature Analysis Results: The above table highlights the percent of each EFU that supports natural/semi-natural vegetation and the percent of each EFU that is conserved.

In pre-settlement times, forested natural communities would have been the dominant vegetation of Jericho. Of that forested area, a relatively small percent (~1-3%) would have been in early successional shrubby states due to natural disturbance (Lorimer and White, 2003). While forested wetlands were likely the dominant wetland cover, there were and continue to be wetlands dominated by herbs and shrubs throughout the town. As such, the extent of natural/semi-natural vegetation cover was determined by lumping the following covertypes: deciduous, evergreen and mixed forests; forest-shrub, scrub-shrub, and emergent wetlands; and open shores and water. High-, medium-, and low-intensity developed areas,

developed open space, cultivated crops, hay, pasture, grasslands (often lawns) and bare land were excluded.

Naturally shrubby and herbaceous areas present a problem for natural/semi-natural vegetation cover analysis like this, as the primary data source for vegetation cover is derived from satellites and aerial photos. Areas of natural shrub and herb cover are not easily differentiated from anthropogenic covers, such as lawns and fields. As such, natural/semi-natural vegetation cover estimates on EFUs that support large amounts of naturally occurring shrub and herbs covers is likely underestimated. I believe that natural/semi-natural vegetation cover for the Peat and Muck EFU is higher than indicated by this analysis. I believe errors associated with remote sensing differentiation between natural and anthropogenic shrub and herb covers is insignificant in the remaining EFUs.

The Till Slope and Ridge EFUs and their variants support extensive natural/semi-natural vegetation cover. The warm sunny variants of both EFUs support 100% cover. The Coarse and Fine Sediment Slope EFUs also support extensive natural vegetation cover. The Shallow Till with Bedrock Exposures EFU supports at least 87% natural vegetation cover; the percent of natural/semi-natural vegetation cover for this EFU is likely higher as it does contain some naturally occurring bare rock exposures.

The Valley EFU supports less than 50% natural/semi-natural vegetation cover. This EFU supports easily farmed and very productive agricultural soils, hence the high degree of clearing. What little natural/semi-natural vegetation cover exists on this EFU is likely the result of old field regeneration. The Valley, Till EFU variant does support more natural/semi-natural vegetation cover, as these areas were more difficult and less productive to farm. Similar analysis in the state and region also indicates that our valley landscape positions support a relatively limited amount of natural/semi-natural vegetation cover (Thompson, 2002; Thompson et al., 2003).

The Coarse Sediment Flats EFU supports approximately 42% natural/semi-natural vegetation cover. These areas are comprised of readily developed lands. The flat topography presents limited challenges for residential and commercial development. Additionally, the coarse sediments soils of the EFU are ideal for septic systems and present limited drainage issues.

The Distribution of Conserved Areas

Like natural/semi-natural vegetation cover, conserved areas are not evenly distributed over Jericho's enduring feature diversity. Table 2 (see above) provides a breakdown of conserved area coverage by EFU.

Conservation easements and other forms of conservation action are developed for a variety of reasons, ranging from protection of productive agricultural lands to strict protection of nature and biodiversity. Easements designed to protect productive agricultural lands afford little or no protection for natural/semi-natural vegetation cover. Unfortunately, the most up-to-date database on conserved lands in Vermont, which is maintained by the Vermont Land

Trust, does not allow for differentiating which conserved lands provide some level of protection for natural/semi-natural vegetation cover. As highlighted below, this lack of conserved area function detail can complicate analysis of EFU conserved area representation (i.e. to what degree is natural/semi-natural vegetation of each EFU protected).

The majority of conserved lands in Jericho appear to support natural/semi-natural vegetation—it can be assumed that easements in these areas provide some level of protection for natural/semi-natural vegetation. A relatively small portion of the conserved area system supports agricultural covers—it can be assumed that easements in these areas provide little or no protection for natural/semi-natural vegetation. These agricultural conserved areas are almost entirely in the Valley and Coarse Sediment Flats EFUs.

Analysis of Valley EFU representation indicates that 21% of this EFU is protected by perpetual conservation easements. A very small portion of these conserved areas actually protect natural/semi-natural vegetation, though, because these easement target protection of productive agricultural lands. While the percent of this EFU conserved is considerably higher than a few other EFUs in Jericho, in terms of natural/semi-natural vegetation protection, this EFU is likely the second least or least protected of Jericho's EFUs. Due to its more limited agricultural productivity and high degree of inclusion in the Ethan Allen Firing Range, the natural/semi-natural vegetation of the Valley, Till Variant EFU is relatively well protected.

The Coarse Sediment Flats EFU, which supports 42% natural/semi-natural vegetation cover, is poorly represented with only 18.3% protected by conservation easements. Much like the Valley EFU, a large portion of these conserved areas support agricultural covers, likely with easements providing little protection for natural/semi-natural vegetation. In terms of natural/semi-natural vegetation, this EFU is likely the second least or least protected of Jericho's EFUs.

Even though the Shallow Till with Bedrock Exposures, Potentially Rich EFU supports a high percentage of natural/semi-natural vegetation cover (almost 88%), only 8% of the EFU is represented in Jericho's conserved area system. The largest occurrences of this EFU are in the western portion of the town, were there is a limited amount of conserved lands.

The Fine and Coarse Sediment Slopes EFUs, which support 86.8% and 79.3% natural/semi-natural vegetation cover, respectively, are relatively poorly represented in Jericho's conserved area systems. Only 8.6% of the Fine Sediment Slope EFU and 24.1% of the Coarse Sediment Slope EFU are protected by conservation easements. Again, these EFUs are concentrated in the western portion of the town, were there is a limited amount of conserved lands.

The Till Slope EFU and its variants (Cool Shady Till Slope and Warm Sunny Till Slope) and the Ridge EFU and its variant (Warm Sunny Ridge) support a high degree of natural/semi-natural vegetation cover (ranging from 87.4%-100%) and are all relatively well represented (ranging from 35%-77.9%) in Jericho's conserved area system. The easements covering these EFUs are generally developed to protect working forests and wildlife habitat; these easements generally provide good protection for natural/semi-natural vegetation cover.

With the exception of one occurrence, the entire extent of the Peat and Muck EFU is within the Ethan Allen Firing Range. While much of this area was once cleared, the Firing Range largely supports and protects natural/semi-natural vegetation cover, making this EFU well protected in Jericho's conserved area system. As this EFU generally supports wetland soils, wetland vegetation, and wetland hydrology, it is also afforded some level of protection through wetland regulation. The occurrence of this EFU outside the Firing Range does support natural/semi-natural vegetation cover; this occurrence is outside of the conserved area system, but is mapped as a class-II wetland.

III- Implications for Conservation Action, Restoration Planning, and Climate Change Adaptation

> "Conservation biologists estimate that if we protect multiple viable examples of all natural communities, we would likely protect 80-90% of all native species in the process…But protecting multiple examples of all natural communities may be difficult for two reasons: 1.) we do not have distribution and location information for all communities, and 2.) natural communities change over time. With this in mind, we use ***enduring features*** of the physical landscape as another surrogate for biological diversity. We assume that if we protect a diversity of physical features over large areas, then we will have some assurance of protecting the full diversity of natural communities [and biodiversity] of the state…"(Thompson, 2002)

The utility of enduring features in conservation planning is not always readily apparent nor easily explained, so I have borrowed this eloquently simple quotation from the Vermont Biodiversity Project (Thompson, 2002). Ensuring that the full diversity of enduring features are represented in Jericho's conserved area system is, in essence, a double surrogate for protecting Jericho's full array of biodiversity: protect the full diversity of enduring features and you protect most of the town's natural community diversity; protect most of the natural community diversity and you protect most of the town's biodiversity. Designing a conserved area system that protects the full diversity of a given region is widely cited as one of the most important considerations in conserved area design and selection (Margules and Pressey, 2000; Pressey 2006).

The importance of protecting the full diversity of Jericho's enduring features is only compounded by predictions of climate change. Ensuring that the full diversity of enduring features is protected and allowed to support natural/semi-natural vegetation is believed to be an important strategy to help native biodiversity adapt to climate change (Halpin, 1997; Noss 2001; Secretariat of the Convention on Biological Diversity, 2003; Pyke and Fischer, 2004) and to help planners cope with the uncertainty of climate change. At the species and natural community levels, climate change is expected to result in substantial alteration of contemporary ranges, as species migrate to follow suitable climate conditions. Additionally, paleoclimatic and quaternary studies also indicate that species generally respond to climate change in a very individualistic manner, meaning that many of the species and natural community assemblages we recognize today may not persist as climate changes.

Unlike species and natural communities, enduring features will remain relatively stable as climate changes. By protecting the full diversity of its enduring features, Jericho can maximize the likelihood that migrating species and any new natural community assemblages will find favorable habitats.

Based on analysis conducted during this project, I propose the following recommendations to improve enduring feature representation in Jericho's conserved area system, guide restoration planning efforts, and maximize the likelihood that species migrating in response to climate change will find favorable habitats:

1. **Focus simultaneous restoration and conservation efforts on the Coarse Sediment Flats and Valley EFUs**. There are limited opportunities to increase overall conserved area representation of these EFUs without first restoring native vegetation. Projects seeking to restore native vegetation to these EFUs and ensure permanent protection through conservation easements or acquisition should be a priority in the town. Unfortunately, projects like this may conflict with existing goals to protect prime agriculture and highly developable lands. Increasing protection and opportunities for development of natural/semi-natural vegetation of these EFUs will increase the likelihood that species migrating in response to climate change will find favorable habitats. Due to their high development and agricultural values, conservation and restoration projects targeting these EFUs will likely be more costly than projects listed under the second recommendation below.

2. **Focus conservation efforts on the Coarse Sediment Slope, Fine Sediment Slope, Shallow Till with Bedrock Exposures, Potentially Rich EFUs**. There are many opportunities to increase protection and overall conserved area representation of these EFUs. All of these EFUs support a high degree of natural/semi-natural vegetation, but are poorly represented in the conserved area system. These EFUs largely occur in the western portion of town, where little conservation work has been conducted. Increasing protection of these EFUs will increase the likelihood that species migrating in response to climate change will find favorable habitats. Because these EFUs are less desirable for farming and development and extensive restoration is generally not needed, projects listed under this recommendation will likely be more cost efficient than those listed under the previous recommendation.

3. Improve this analysis by maintaining a conserved lands database that allows for differentiation of easements that provide protection of natural/semi-natural vegetation from easements that do not provide such protection.

4. Broaden the geographic scope of conservation work in Jericho to include lands in the western portion of the town.

5. As development pressures and conservation priorities shift, seek to maintain a conserved area system that is representative of Jericho's full enduring feature diversity.

The Chittenden County Uplands Conservation Project (CCUCP) represents an unparalleled opportunity in Chittenden County and the westerly Northern Green Mountain foothills for landscape-scale conservation, but the project has dramatically skewed the ecological representation and geographic scope of conservation efforts in the town. The CCUCP should certainly remain a centerpiece of Jericho's efforts to conserve well-connected habitats for area-sensitive and interior forest species. These admirable efforts, however, should be supplemented with efforts to increase conservation in the western portion of the town focusing on enduring features that are less well protected than the till-derived soils and slope and ridge landscape positions of the CCUCP project area.

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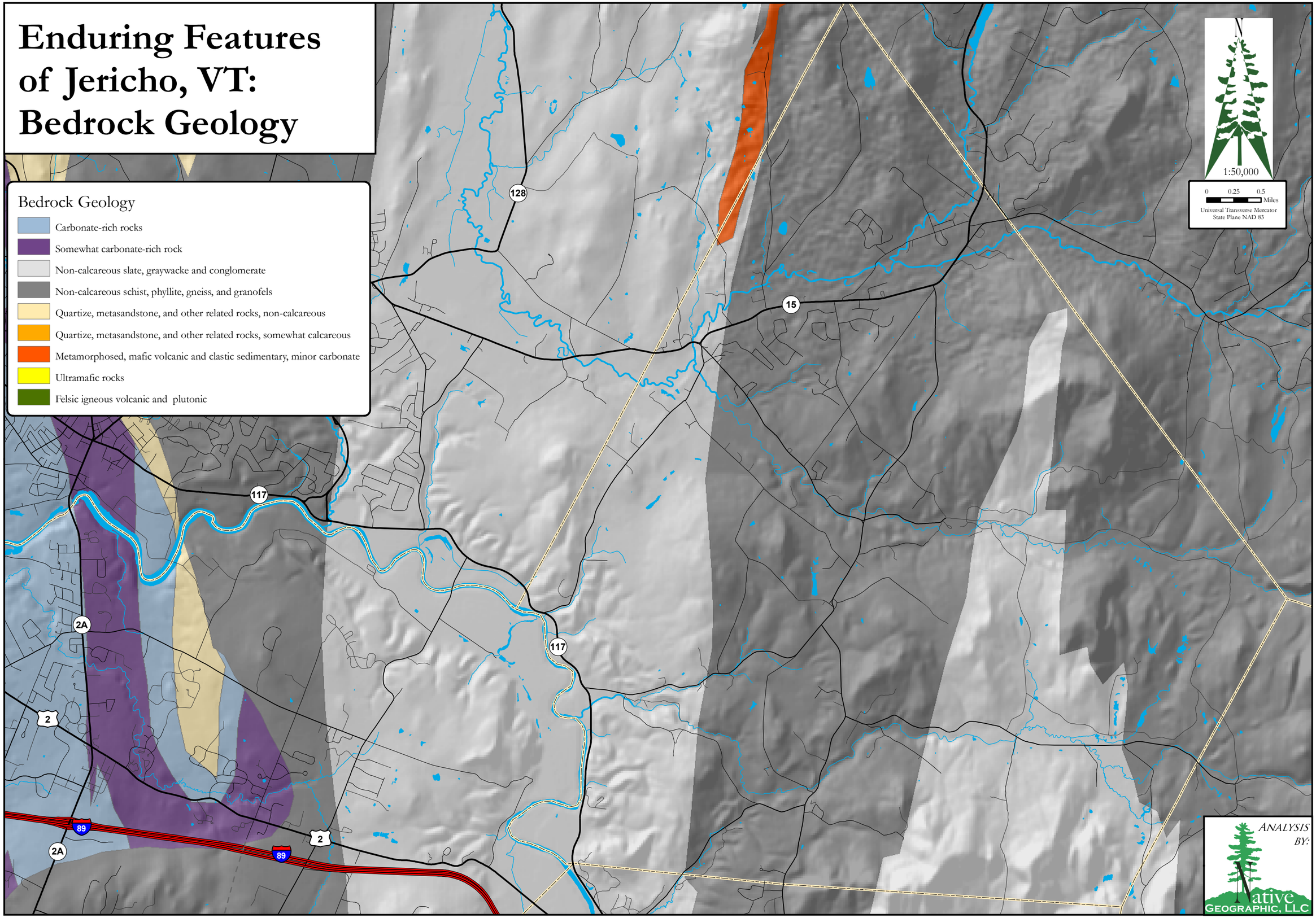
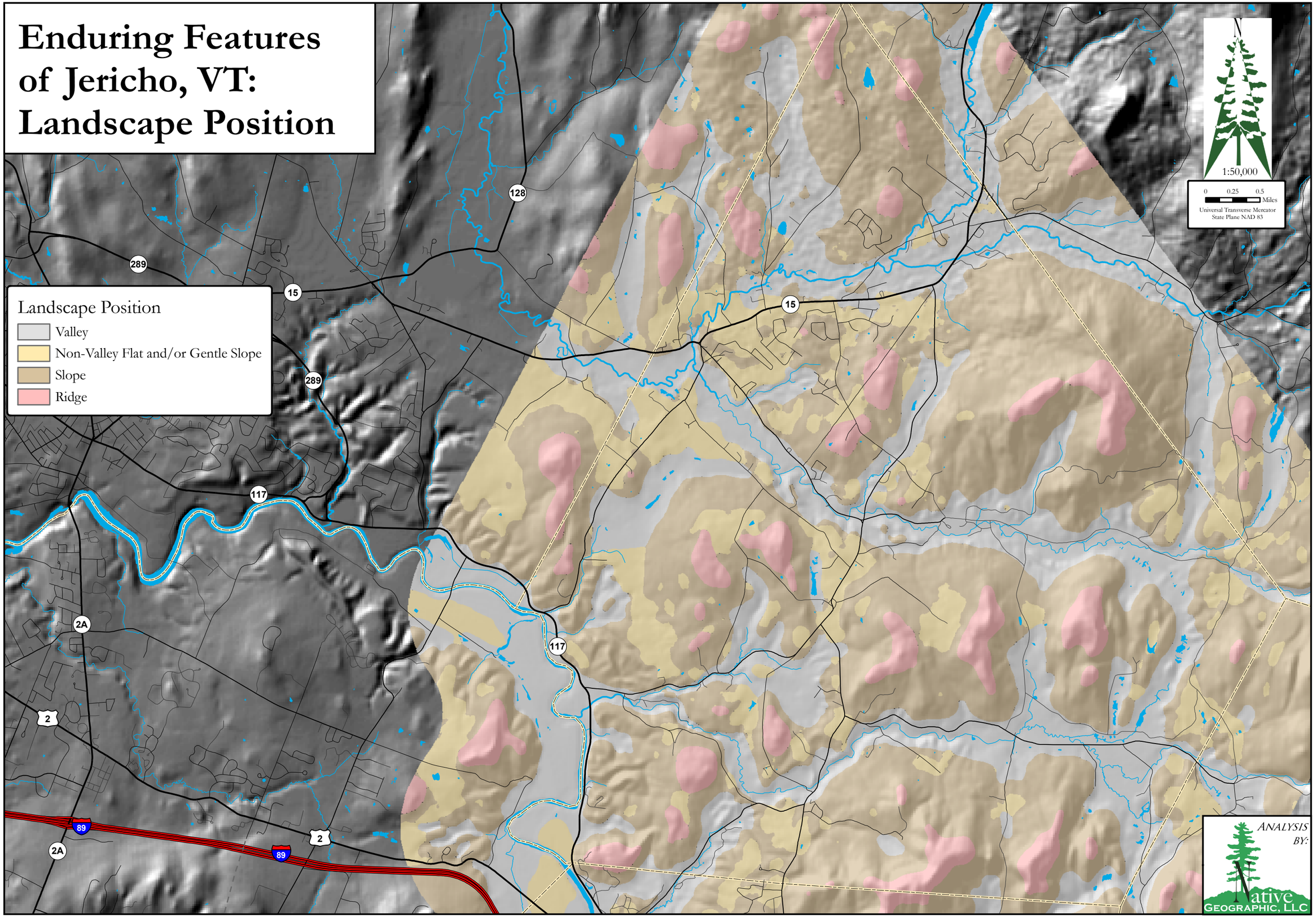
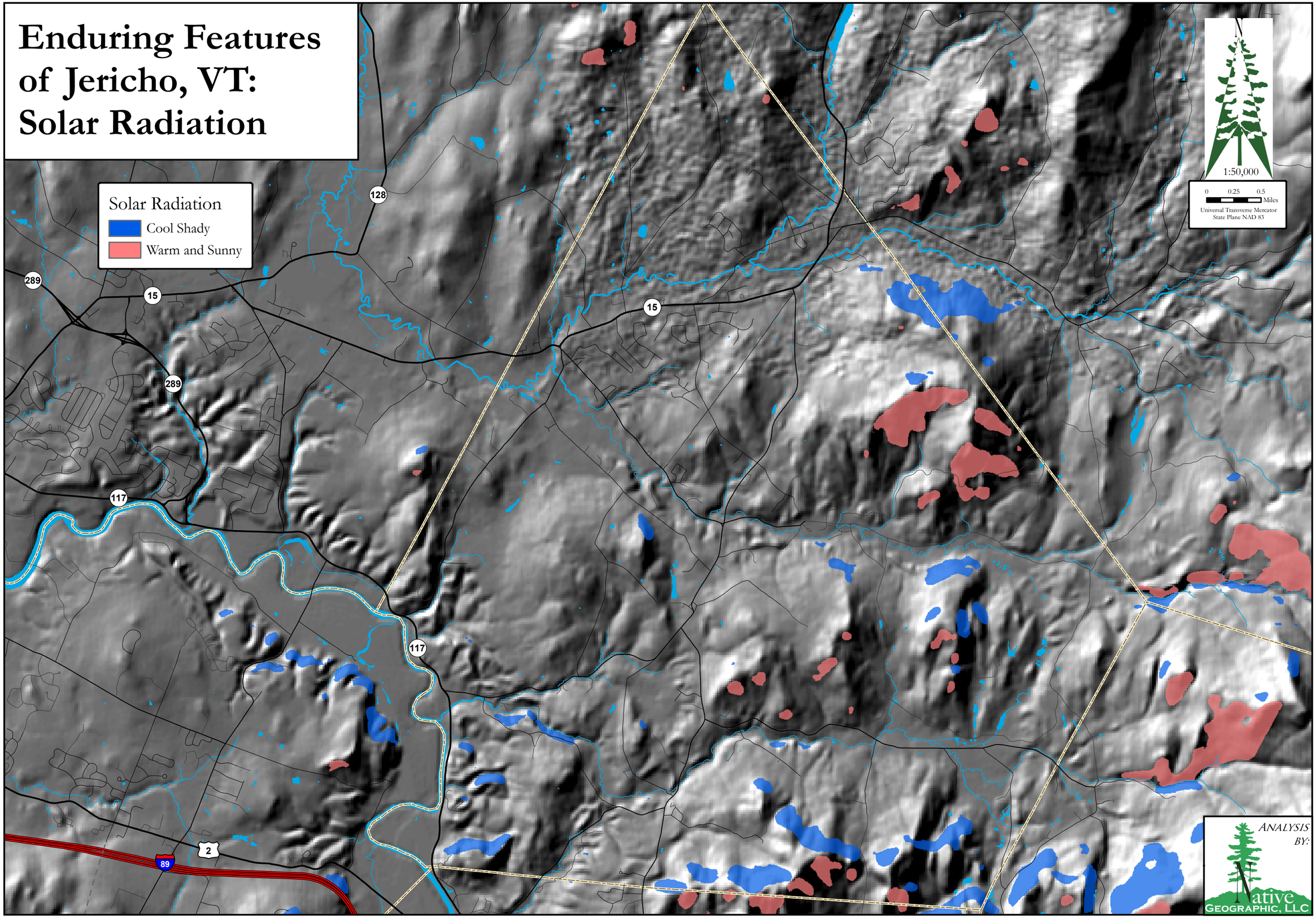
Enduring Features of Jericho, VT: Bedrock Geology



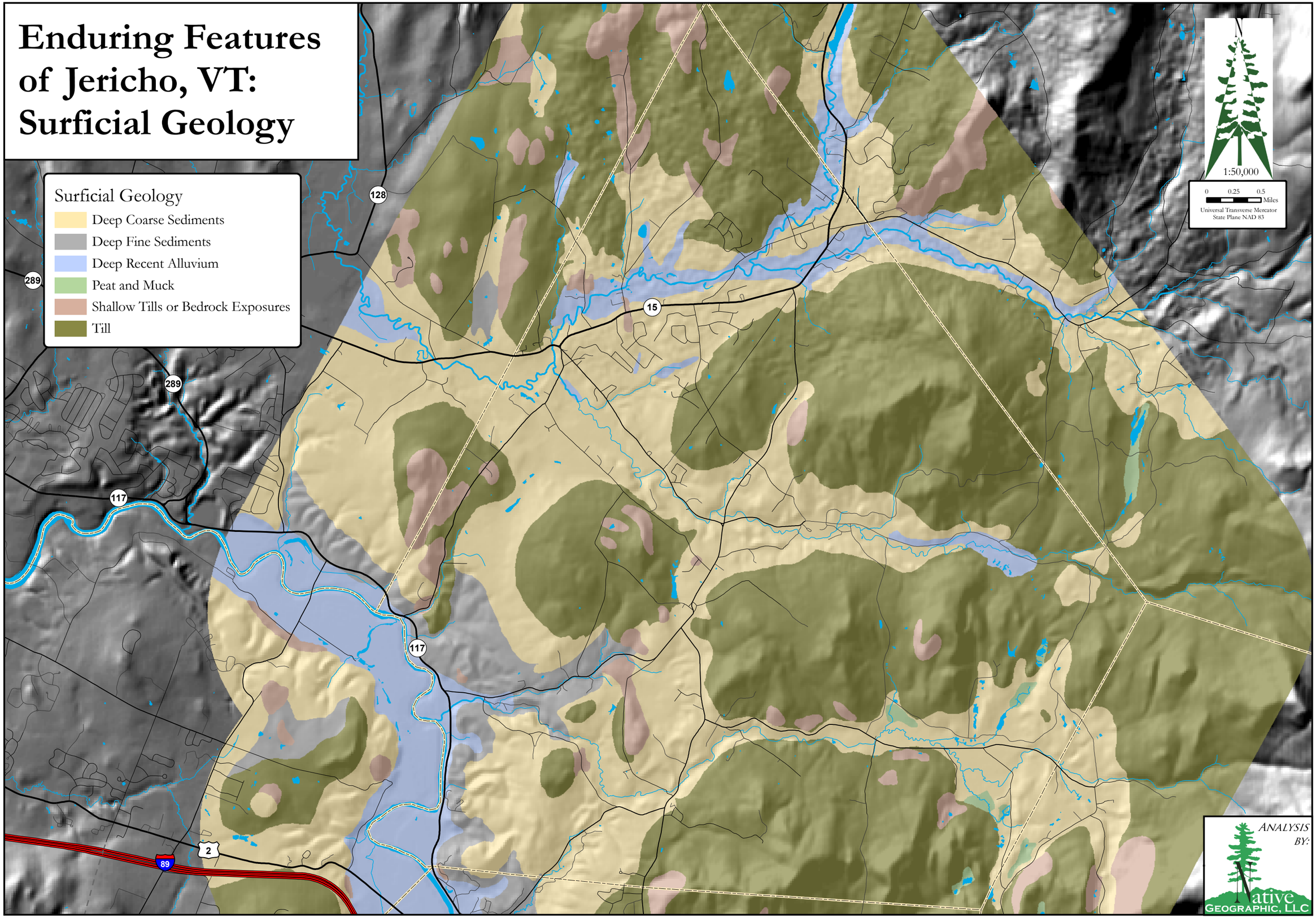
Enduring Features of Jericho, VT: Landscape Position



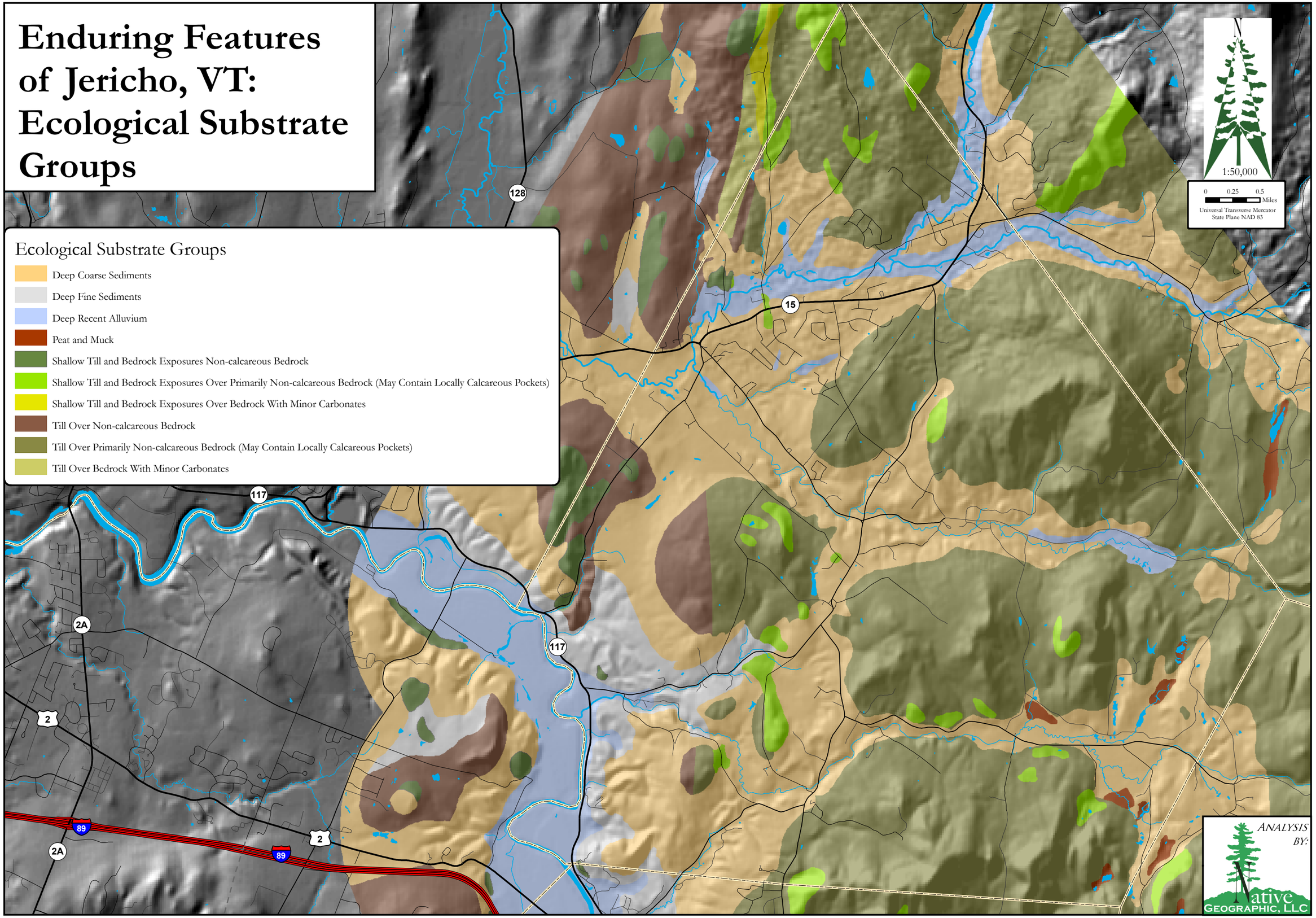
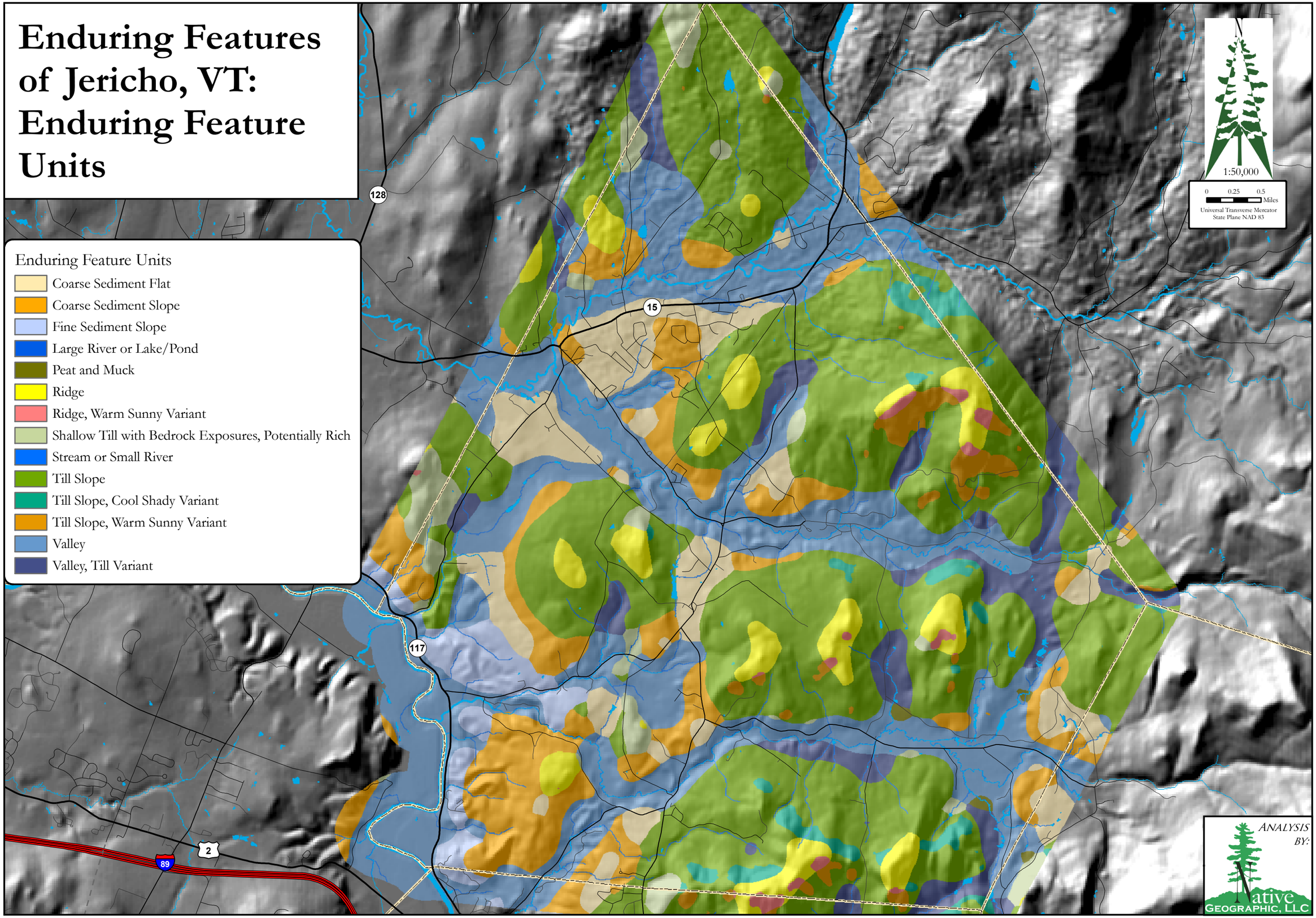
Enduring Features of Jericho, VT: Solar Radiation



Enduring Features of Jericho, VT: Surficial Geology



Enduring Features of Jericho, VT: Ecological Substrate Groups



Enduring Features of Jericho, VT: Enduring Feature Units