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Using Aotearoa New Zealand's Open Data with QGIS and Blender to create two map styles

Andrew Tyrrell

South Arrow Maps - andrew@southarrowmaps.co.nz

Abstract: This article explores the use of open data, QGIS, and Blender in the creation of two distinct map styles. The New Zealand government's commitment to open data is demonstrated by the availability of extensive geographical data through the LINZ Data Service and other free providers. The first map style, Natural Basemap, uses land cover and elevation data to produce a pseudo-realistic map. Terrain shading and texture application are used to enhance visual realism. The second style, Perspective Linework, uses Blender's Freestyle non-photorealistic rendering engine to depict topographical features such as ridgelines and creases from 3D terrain models. Both styles offer innovative approaches to visualising New Zealand's topography, using open data and software to create visually compelling maps.

Keywords: QGIS, Blender, Open Data

1. Open Data in Aotearoa New Zealand

In 2011, Aotearoa New Zealand made a declaration on an Open and Transparent Government, and in 2017 signed up to the International Open Data Charter (data.govt.nz/toolkit/open-data/open-data-policy). The New Zealand Data and Information Management Principles (data.govt.nz/toolkit/policies/new-zealand-data-and-information-management-principles) provide seven guidelines around data, its quality, and its availability:

1) Open: data should be open for public access.
2) Protected: personal, confidential, and classified data are protected.
3) Readily available: data should be released proactively, and be easily discoverable and accessible online.
4) Trusted and authoritative: data should be accurate, and have an identified authoritative single source.
5) Well managed: data should be owned by the public, while the government and agencies act as stewards. They must cater for the long-term preservation of and access to data.
6) Reasonably priced: the use of data is expected to be free. A charge for the dissemination of data is only an option if it can be proved that this won't be a barrier to access.
7) Reusable: copyrighted and non-copyrighted data is licensed for reuse, and made available in non-proprietary formats.

Toitū Te Whenua Land Information New Zealand (LINZ) makes all of its geographical data available online via the LINZ Data Service (LDS; data.linz.govt.nz). The LDS contains a wealth of topographic and hydrographic vectors, along with aerial imagery and elevation rasters. It also hosts property and boundary data, as well as place names, road names, and addresses. All of the data is freely available to download in a variety of spatial and

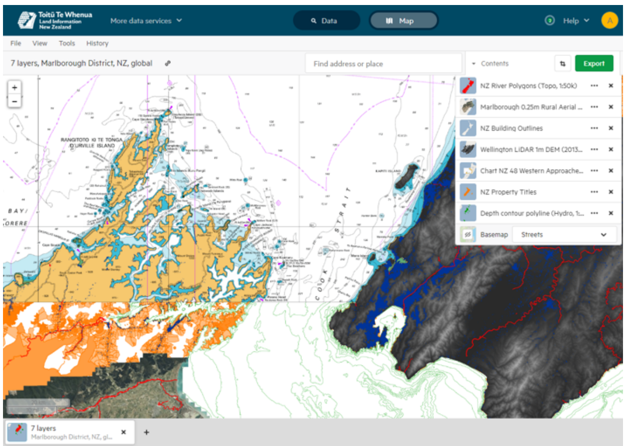

Figure 1. The LINZ Data Service provides access to a wide variety of data including topographic, hydrographic, aerial imagery, LiDAR, and property boundaries.

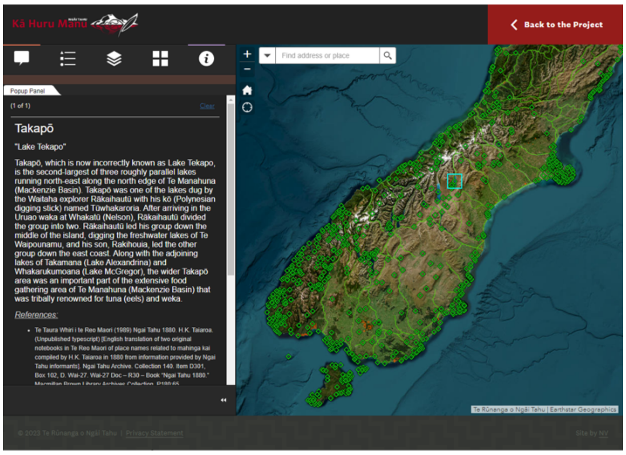

Figure 2. Kā Huru Manu contains the original Māori names of over 1,000 places across Te Waipounamu / South Island, as well as the stories behind them.

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non-spatial formats.

The LDS is hosted online via the Koordinates platform (koordinates.com). Other government organisations use the same platform to host their own data such as Stats NZ Tatauranga Aotearoa (datafinder.stats.govt.nz) and Manaaki Whenua Landcare Research (lris.scinfo.org.nz).

Many local and regional councils across New Zealand, along with other government organisations, choose to host their open data via Esri, allowing it to be seamlessly integrated into ArcGIS Online web maps and dashboards. Examples include Auckland Council Te Kaunihera o Tāmaki Makaurau (data-aucklandcouncil.opendata.arcgis.com) and the Department of Conservation Te Papa Atawhai (doc-deptconservation.opendata.arcgis.com).

Kā Huru Manu (kahurumanu.co.nz/atlas) is an online atlas developed by the Ngāi Tahu iwi (tribe) covering their rohe (territory) on Te Waipounamu / South Island and Rakiura / Stewart Island. It contains over 1,000 Māori place names and kā ara tawhito (traditional travel routes), providing details about the original names of locations across the islands. Kā Huru Manu has been accepted by the New Zealand Geographic Board Ngā Pou Taunaha o Aotearoa as an authoritative source for Māori place names.

In my work, I have made use of the wealth of free and open data provided by Aotearoa New Zealand to craft two map styles.

2. Natural Basemap style

Achieving a pseudo-realistic basemap requires detailed land cover data. Manaaki Whenua Landcare Research publishes the New Zealand Land Cover Database (LCDB; lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand); a seamless polygon dataset dividing the land into over 30 classes. Each class can be given an appropriate simple colour fill in QGIS, resulting in a colourised 2D map of land cover classes, which can be draped, blended, or combined with a hillshade to create a more realistic terrain map.

A national 8m resolution DEM for New Zealand was created by Geographx using LINZ Topo50 data (data.linz.govt.nz/layer/51768-nz-8m-digital-elevation-model-2012). While this elevation model is not as accurate as more recent LiDAR surveys, it has national coverage and was created for the purposes of terrain visualisation, making it a perfect resource for terrain shading.

Various derivative rasters can be created from the DEM using the Relief Visualization Toolbox (zrc-sazu.si/en/rvt) plugin for QGIS (plugins.qgis.org/plugins/rvt-qgis). Of particular use is the Anisotropic Sky-View Factor method, which simulates diffuse lighting of the terrain, weighted towards a chosen direction. When rendered with a dark-to-light colour ramp, this results in a raster where flat open areas and ridges are bright, and incised valleys and cliff edges are dark, combined with a general "hillshade" effect where aspects facing towards the anisotropy azimuth are lighter than those facing away.

In addition to rasters created with the Relief Visualization Toolbox, Leland Brown's texture shading method (textureshading.com) can also be used to enhance local features in the landscape such as small ridges and valleys.

Multiple terrain shading rasters can be combined with each other and the underlying land cover colour using

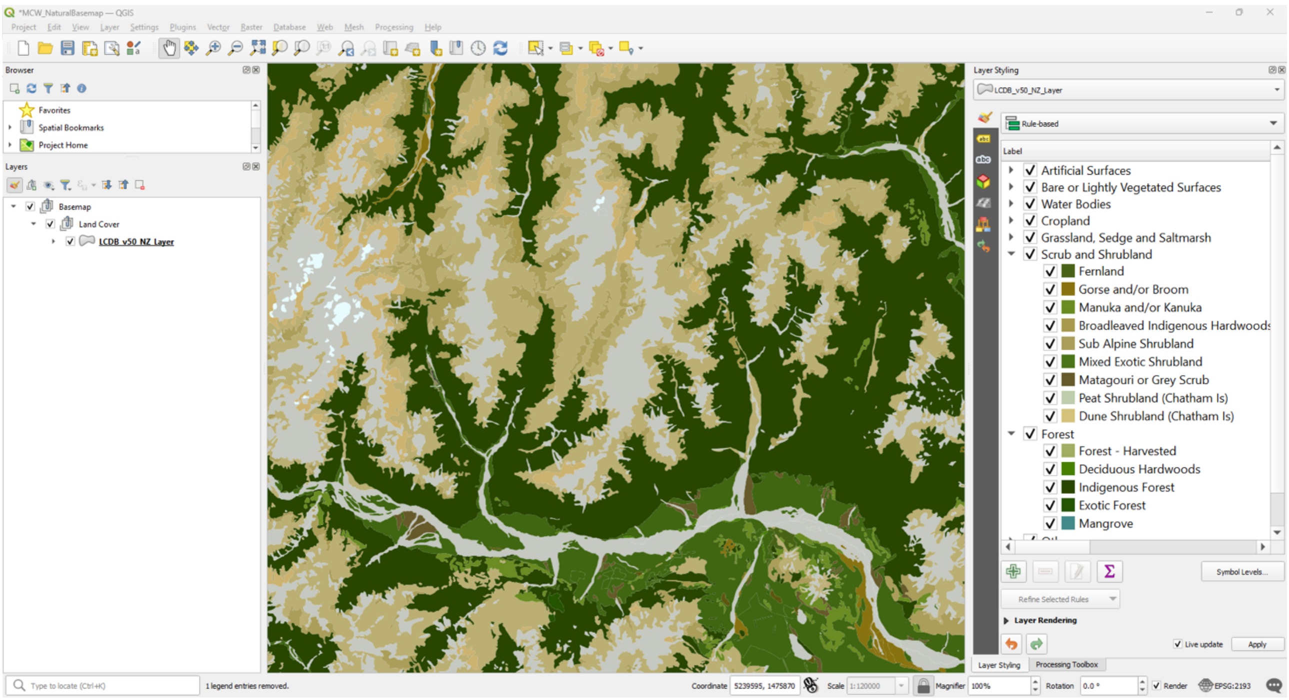

Figure 3. Manaaki Whenua Landcare Research's Land Cover Database contains over 30 classes of land cover. These can be assigned simple colour fills in QGIS to provide the foundation for the natural basemap.

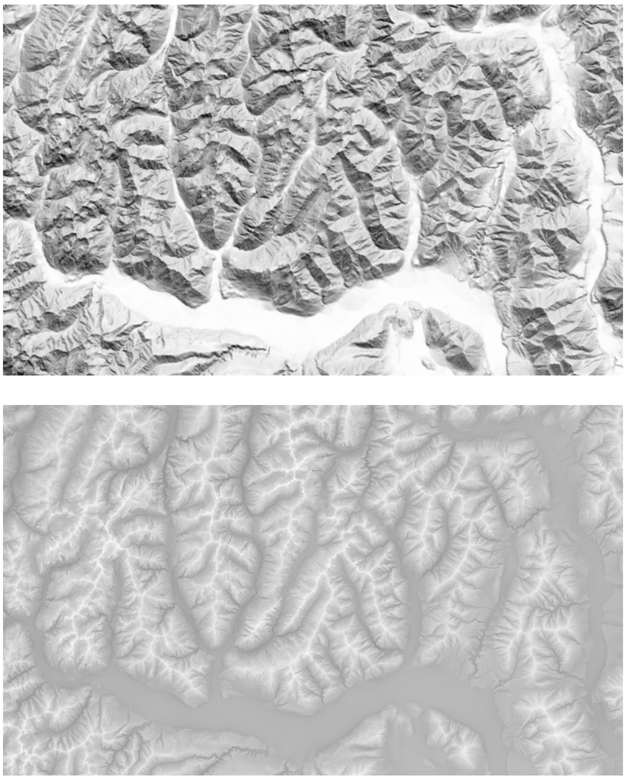

Figure 4. Several terrain visualisation rasters can be created from the DEM to enhance certain features of the landscape. Top: Anisotropic Sky-View Factor created using the Relief Visualization Toolbox plugin for QGIS. Bottom: texture shading created using Leland Brown's algorithm.

layer blending modes in QGIS. This results in a colourful map that appears 3D, given the depth of shadows and highlights.

However, the actual land itself can still feel quite smooth and uniform, due to the single colour fill for each land cover class. In reality, there are natural variations in colour and lightness. This is particularly noticeable in areas of dense forest, where the smooth green is not wholly representative of the rough canopy that can be seen in aerial imagery. An additional land cover texture layer can be added to the basemap to roughen up the smooth colours.

In his "Textures & Patterns" livestream (youtu.be/MqJtQDAl4aY; part of Daniel Huffman's "How To Do Map Stuff" event: youtube.com/playlist?list=PLF-xwVTEFobPaLdmE41iPMX8rQVW8TF1e), Dylan Moriarty describes a process for using Photoshop to create seamless tiled textures from photos of everyday household objects. The object itself can be completely unrelated to the map feature that it will come to represent. In searching for a suitable texture for New Zealand native forest, the fluffy woollen tufts of an electric blanket were found to be an ideal candidate.

While these textures are intended to provide subtle variation to the land cover data, it is the colour itself that separates each land cover class. Therefore it is not necessary to assign a unique texture to each class; classes

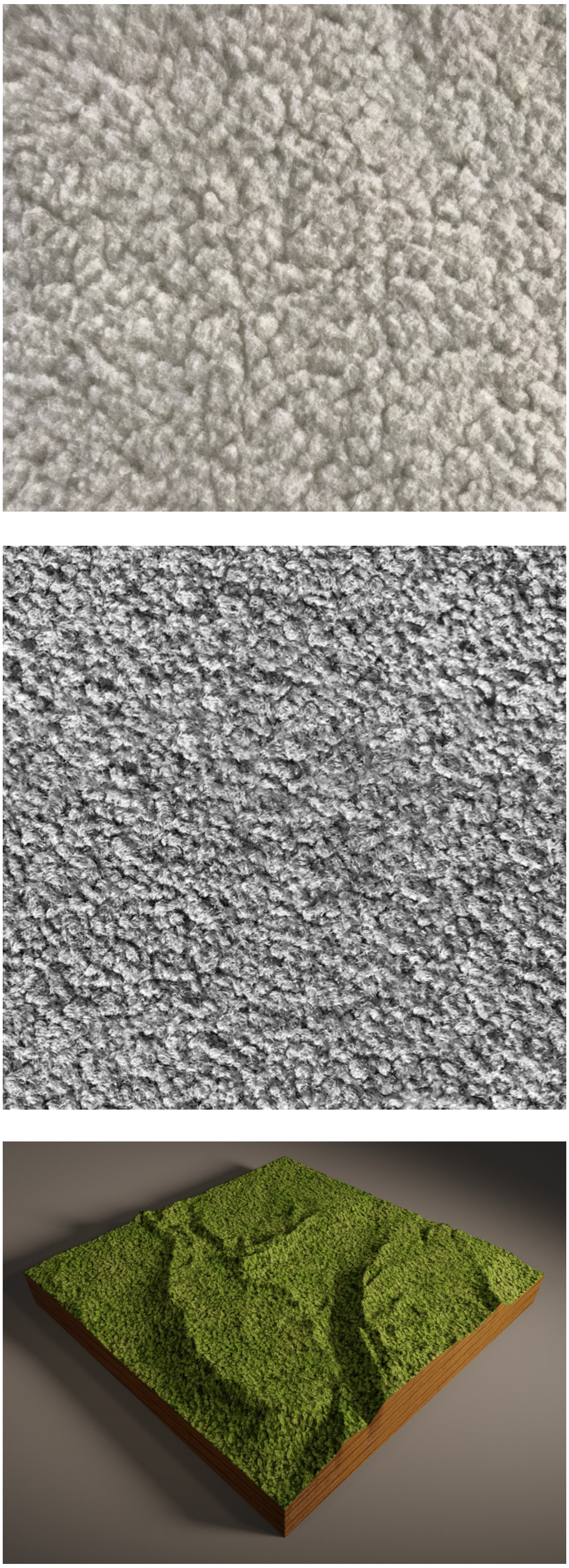

Figure 5. A woolly electric blanket makes the ideal texture for New Zealand native forest. Top: the original photo of the electric blanket. Middle: edited into a seamless square tile. Bottom: an early test of the texture.

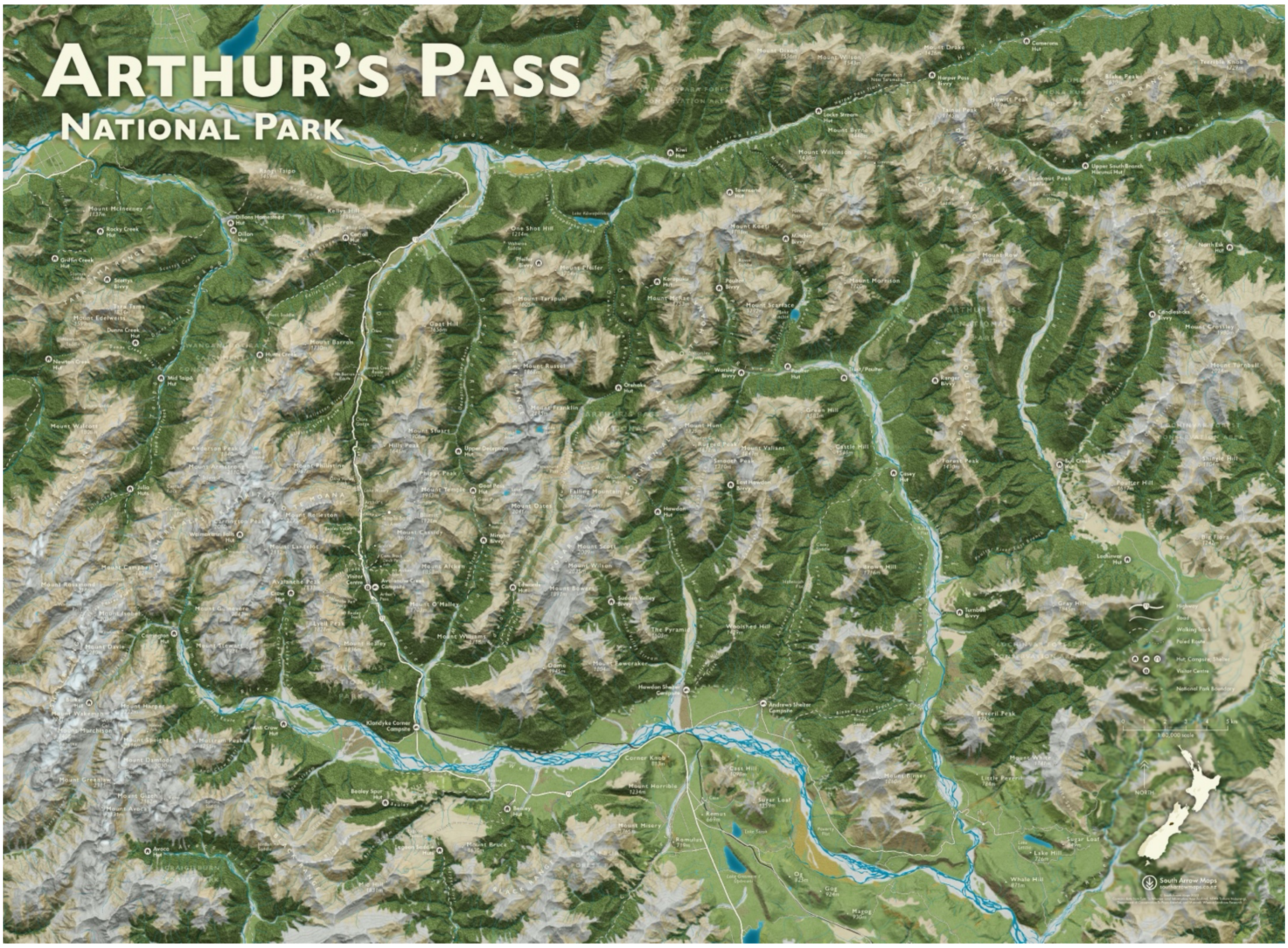

Figure 6. Arthur's Park National Park. The natural basemap provides a pseudo-realistic image of the land cover and terrain. Further elements such as road and track networks, icons and labels, and marginalia can be added within QGIS, or using separate graphics software.

can be grouped into fewer broad texture categories with each category given a raster fill using an appropriate texture image. As with the terrain shading, the texture layer can be combined with the remainder of the basemap using an appropriate blend mode in QGIS.

The final element of the natural basemap is water. The LCDB contains classes of "River" and "Lake or Pond." Unfortunately these classes only represent large bodies of water, and do not necessarily exactly align with the terrain data, often resulting in the edges of lakes unrealistically sloping uphill. A better source of water data for this basemap is LINZ Topo50 Hydrography Data (data.linz.govt.nz/set/4781-nz-topo-50-hydrography-data). This depicts a continuous network of streams, rivers, and lakes, and since it is essentially the same data source as the DEM, it aligns to the terrain.

The shallower margins of water polygons (lakes and wider river channels) can be represented using a shapeburst or buffered gradient fill in QGIS, with a colour ramp to lighten the edges and provide a sense of changing depth.

When added to the land cover colour, terrain shading, and texture, this completes the natural basemap, and provides a pseudo-realistic image of the land.

3. Perspective Linework style

Blender (blender.org) is free and open-source 3D creation software that can be used to create high quality images and videos using its photorealistic rendering engine called Cycles (docs.blender.org/manual/en/latest/render/cycles). Blender also includes a non-photorealistic engine named Freestyle (docs.blender.org/manual/en/latest/render/freestyle). While Cycles creates a raster image by calculating how light interacts with objects and materials to model reflections and shadows, Freestyle detects certain edges of 3D objects and applies vector styles.

Daniel Huffman describes a workflow using a scaled DEM to displace a 2D plane into 3D space within Blender (somethingaboutmaps.wordpress.com/2017/11/16/creating-shaded-relief-in-blender), which can then be lit with a virtual sun and rendered using Cycles to create a hillshade image. While this method creates terrain that is as detailed as the DEM itself, unfortunately the virtual 3D model is not visible to Freestyle; Freestyle will only detect the four edges of the original 2D plane.

To create a 3D terrain that is visible to Freestyle, the BlenderGIS add-on (github.com/domlysz/BlenderGIS) can be used to import a DEM raster image. This creates a mesh of vertices, where each horizontal coordinate is determined by the pixel location, and the vertical coordinate by the pixel value. This mesh is visible to Freestyle, but the quantity of vertices can impact performance. It may be useful to apply a scaling factor when importing the DEM to reduce the resolution of the 3D mesh.

After positioning Blender's camera at the desired viewing angle, Freestyle's "Silhouette" edge type can then be used to identify ridgelines. To provide additional texture to the terrain, the "Crease" edge type can also be used to identify locations where adjacent faces in the 3D model meet at an angle exceeding a user-defined threshold. Different vector line styles can be assigned to the silhouettes and creases, resulting in a minimal linework

Figure 7. Blender can be used to render photorealistic or non-photorealistic images. Top" Cycles can be used to render materials such as metal, glass, and stone. Bottom: Freestyle can be used to detect "Silhouette" (blue) and "Crease" edges (yellow) in 3D objects such as terrain or Blender's test monkey named Suzanne.

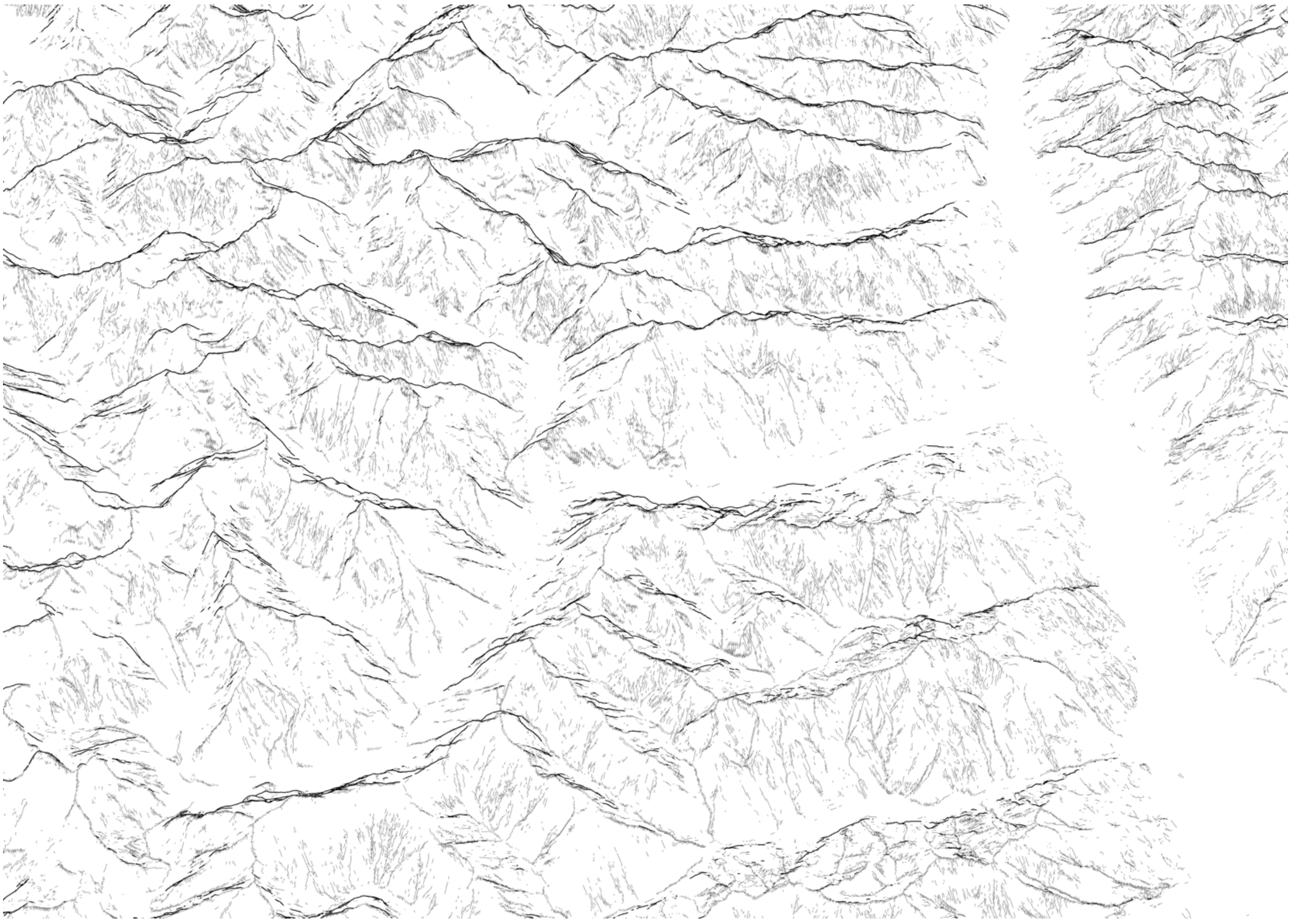

Figure 8. Freestyle Silhouettes (thicker lines) and Creases (thinner lines) combine to create a linework image of the terrain.

image that depicts the main features of the terrain.

Since Freestyle is only considering the physical shape of the terrain model, it is likely that the image produced does not include the edges of rivers and lakes, causing valleys to seem empty. To add these features, a simple 2D map image can be created in GIS, outlining the water features on a plain background.

This can then be added as an image texture in Blender, and used as the colour input to an emission shader in the terrain object's material. When rendered using Cycles, the output is a perspective view of the map, distorted and occluded according to the terrain. The use of an emission shader ensures that there are no shadows in this image. This can then be combined with the Freestyle linework either via the Blender compositor, or in external graphics software.

Colour can be added in a very similar way. In QGIS, basic land cover features can be given simple colours depicting water, forest, scrub, bare land, and snow. This coloured 2D map can again be applied to the 3D terrain in Blender as an image texture. However, some extra work is required in the material node setup in order to create a "posterised" look, limiting the render to a few discrete shades of each colour.

In place of the simple emission shader used for the water outlines, a group node can be created to split the render into discrete bands of shading. A diffuse shader passes through a "Shader to RGB" node and into a "ColorRamp" node. Setting the colour ramp to four shades of grey splits the continuous shading of the diffuse shader into bands. Separately, the colour from the image texture is adjusted using two "Gamma" nodes, creating a lighter and darker version of the 2D coloured map.

A "Mix" node can then be used to recombine these two colours, with the output of the "ColorRamp" node setting the factor to mix the two: from just the dark colour, through two mid-level combinations of light and dark, to just the light colour. Finally, the resulting colour feeds

Figure 9. Water outlines can be rendered separately and combined with the Freestyle lines. Top: a 2D map of water outlines is created in QGIS. Middle: the map is added to the terrain in Blender as a texture image feeding into an emission shader. Bottom: the water lines and Freestyle lines provide a complete perspective linework image.

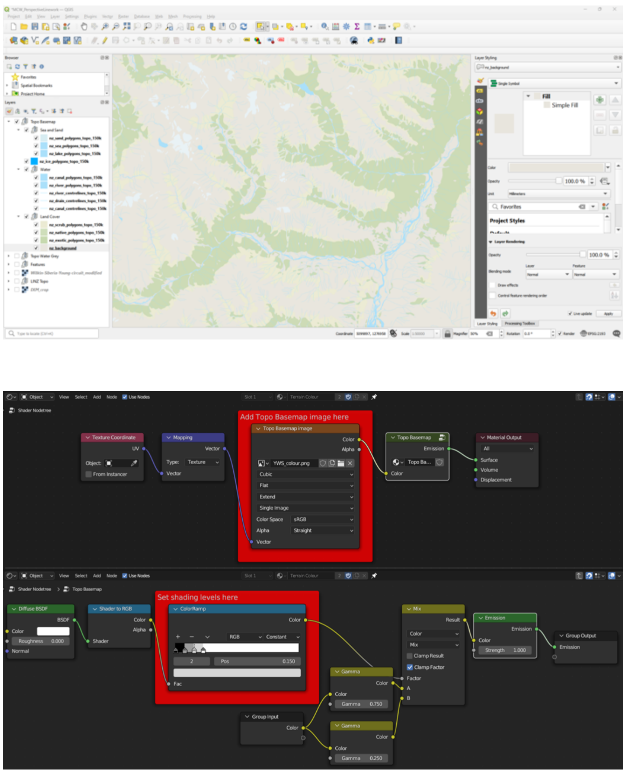

Figure 10. Colour can be included in the map with the addition of some extra nodes in the terrain material setup. Top: a 2D map of simple colours is created in QGIS. Middle: the node setup is edited to include the colour and separate it into four shades. The lower panel shows the node setup contained within the "Topo Basemap" group node in the upper panel.

into an emission shader to complete the node setup for the material.

The effect of this is to apply the colour from the 2D map onto the 3D terrain, but in discrete shading bands ranging from dark to light, creating a posterised effect rather than a realistic rendering of the terrain. After being rendered in Cycles, the coloured perspective can be combined with the Freestyle linework to create the final image.

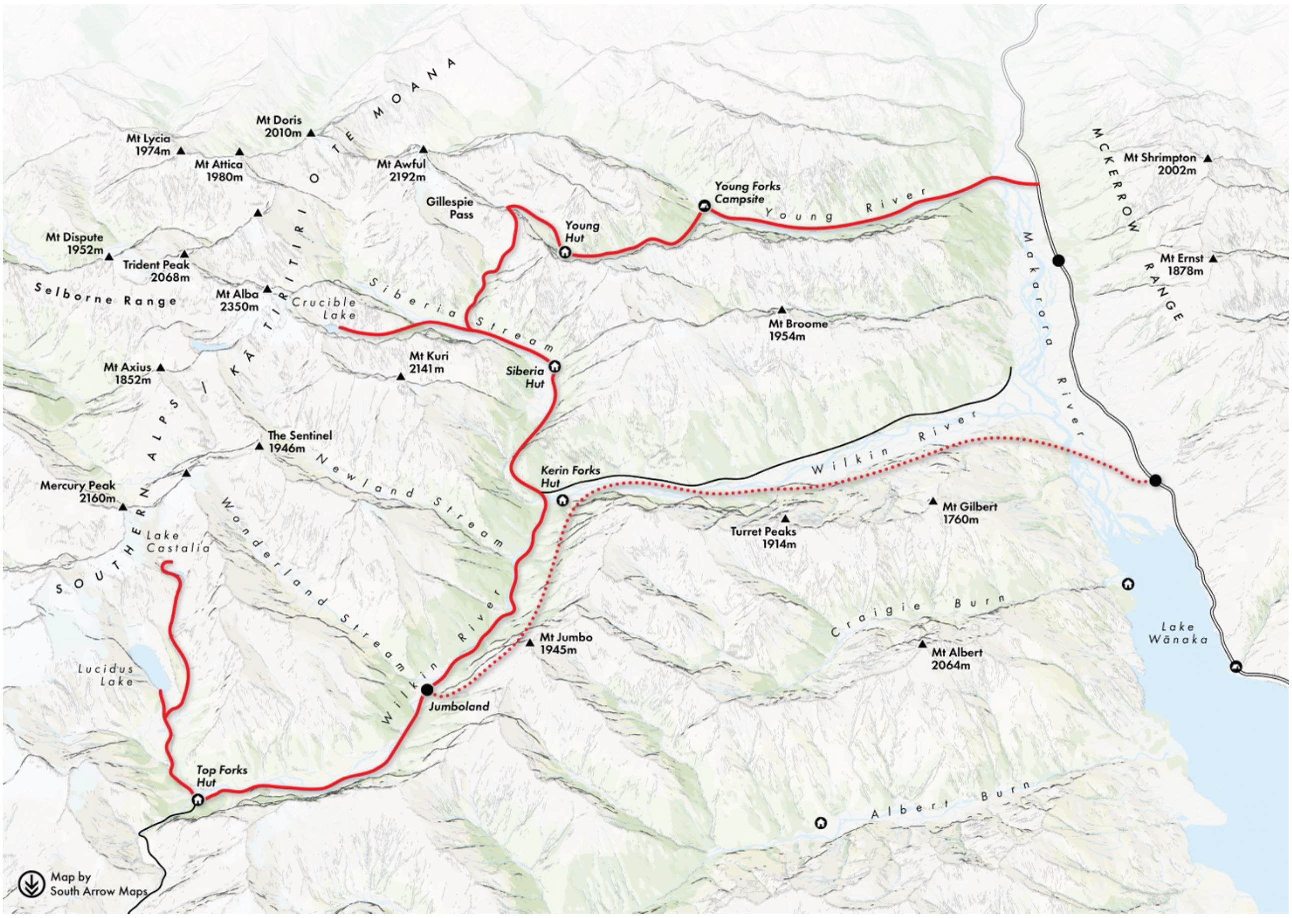

Figure 11. Young-Wilkin-Siberia Circuit. The perspective linework map picks out important ridges, and adds subtle colour and shading to further define the shape of the terrain. Further elements such as road and track networks, icons and labels, and marginalia can be added using separate graphics software.

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