National Cycle TURAS Tool: Preliminary results and questions

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1 Introduction to the tool

The National Cycle Trip Uptake and Routing for Alternative Scenarios (TURAS) Tool is a research, modelling and open source software project that will result in a web application for strategic cycle network planning. TURAS will enable users to explore current levels of cycling and future scenarios of growth in cycling down to the route network segment level across the Republic of Ireland, building on our experience developing and deploying methods underlying the Propensity to Cycle Tool (Lovelace et al. 2017, 2020; Morgan and Lovelace 2020) .

This report outlines work for the delivery of **Milestone 1**: to develop regional baseline networks. To generate Milestone 1 deliverables, we have undertaken several stages of analysis, focusing on the case study counties of Kildare and Limerick. For these counties, we have visualised the local cycle networks, mapping journeys by residents for travel to work and school, providing an overview of the current state of cycling across each county at unprecedented levels of geographic resolution and highlighting different route options, ranging from 'fast' networks likely used by experienced cyclists to 'quiet' networks which are key to for newcomers to cycling who are key to growth in cycling.

The work presented in this report will provide a foundation on which the subsequent stages will build, which have the following milestones:

- **Milestone 2**: generation of potential networks highlighting mode shift potential under scenarios of change for the case study regions
- **Milestone 3**: completion of a prototype tool for the case study regions
- **Milestone 4**: refinement and scaling-up of the cycle TURAS tool and deployment nationwide across the 26 counties of the Republic of Ireland

2 Input data

We used POWSCAR origin-destination (OD) data from the 2016 Census to represent existing cycling levels. This encompasses all journeys undertaken by local residents for work or educational purposes, with educational journeys including primary, secondary and tertiary education. The POWSCAR data represents flows between Electoral Divisions. In future stages of this project, genuine school and college locations will be used as destinations for the educational journeys, but currently both educational and work journeys are represented with their origins and destinations set as random points within the appropriate Electoral Division.

In some cases, large numbers of people travel between the same pairs of Electoral Divisions. To create a more realistic, spatially distributed cycle network, we have disaggregated the flows, assigning multiple randomly selected origin and destination points within each Electoral Division, in a process we call ‘jittering’. Various different inputs can be specified for the jittering process, including the location of possible start and end points to sample from and the maximum number of trips that are allowed per disaggregated OD pair, set to 25 in the results presented in this report. Variables that can be further tweaked include ensuring that all journeys start and end on a public road and enforcing a minimum threshold journey length.

3 Routing strategies

After jittering, the flow datasets are routed on the road network, using three different routing strategies (these being ‘fast’, ‘balanced’ and ‘quiet’ routes) as explained below. Once routes have been calculated for each routing strategy, these routes are then converted into route networks (thus creating ‘fast’, ‘balanced’ and ‘quiet’ networks), which when mapped show the number of cyclists on each road segment within the network.

The route network results allow a range of different variables to be shown at the network segment level. In the work presented in this report we focus on baseline cycling levels and the quality of cycle provision on each route network segment, represented using a variable named ‘quietness’. This is a subjective metric based on crowd-sourced findings (and therefore continuously evolving and variable in terms of quality) which incorporates data on factors such as road/path type, whether the way is shared with pedestrians or motor vehicles, number of traffic lanes, presence of cycle lanes, cycle lane width, speed limit, presence of car parking, and surface quality, where available from OSM tags.

The quietness metric also plays a key role in differentiating between the three routing algorithms we use. For each county, three types of cycle network were generated, using algorithms developed by https://www.cyclestreets.net/. The ‘fastest’ network uses the fastest available routes between origin and destination, accounting for the effect of hills, but ignoring ‘quietness’. The ‘quietest’ network uses routes that maximise the ‘quietness’ metric as explained above. The ‘balanced’ network is a compromise between the other two approaches, in which both speed and quietness contribute to the route selection.

4 Questions for stakeholders

It is worth seeing the preliminary results presented below in the context of questions we would like feedback on from future users of the tool. When viewing these results, please keep the following questions in mind:

- What gaps are there in the existing evidence on cycling?
- Do the results, in terms of estimated current levels of cycling (proportional to width of network lines) and quietness (represented by colour of route network lines) seem reasonable?
- Which network type (‘fastest’, ‘balanced’, ‘quietest’) would you find most useful for your work?
- How could the information presented be of use to your work?
- Which if any colourschemes shown in the appendix (Section 11) do you prefer?
- The data will be made available as interactive maps and to download as GIS data. Which formats or visualisations would you find most useful in your work?
- What additional data or analysis would you like to see?

5 Current travel behaviour

Using the jittered desire line data, we can see that currently, in both Kildare and Limerick, there are large numbers of journeys by car. Breakdowns by mode and euclidean distance are shown in Figure 5.1, revealing that there are also large numbers of journeys on foot, for distances of up to 1km, but relatively few people currently cycle to work or school.

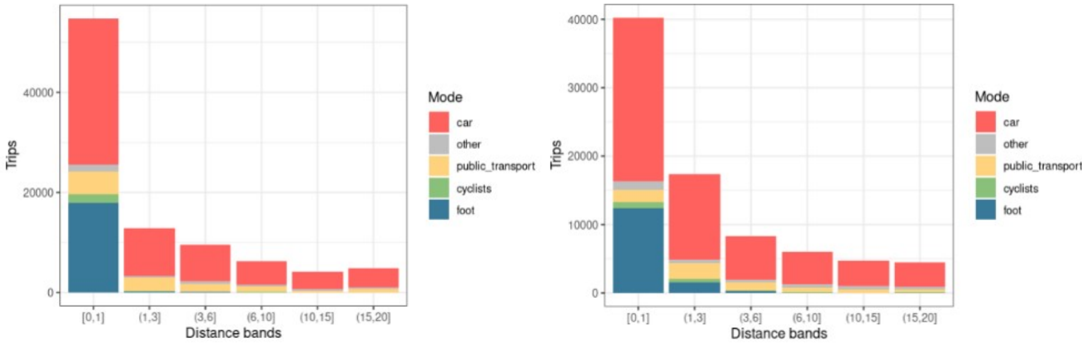


Figure 5.1: Mode and distance plots for work and educational journeys in Kildare (left) and Limerick (right). Journeys by car drivers and car passengers have been combined into a single category, since most school pupils will be too young to drive themselves.

6 Preliminary findings in Limerick

Our findings for County Limerick can be viewed using interactive online maps:

- Quiet route network
- Balanced route network
- Fast route network

A comparison between the ‘fast’ and ‘quiet’ networks in Limerick is shown below. In this map, and subsequent maps, width is proportional to the estimated number of one way cycle trips to school and work, while colour represents ‘quietness’ as determined by CycleStreets.net based on OSM tags: https://www.cyclestreets.net/help/journey/howitworks/.

The results in Figure 6.1 demonstrate the importance of considering quiet as well as direct routes. The quiet route network is displayed on the right, compared to the network of more direct ‘fast’ routes (left). Both of these cycle networks contain sections that have both high levels of usage and poor quality provision, as illustrated by the wider dark red sections in the maps shown below.

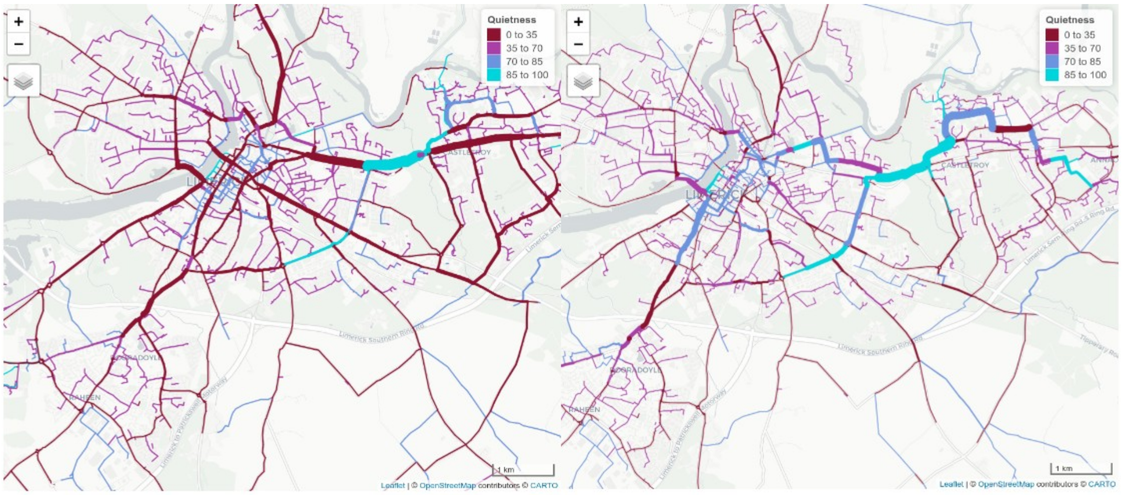


Figure 6.1: 'Fast' (left) and 'quiet' (right) network results in and around central Limerick. Line width represents number of cyclists; line colour represents the segment level quietness.

For example the South Circular Road and the R526 bridge over the N18 appear to form a key link between Limerick city centre and its southern suburbs, but as shown in Figure 6.2 they have relatively poor quality cycle infrastructure.

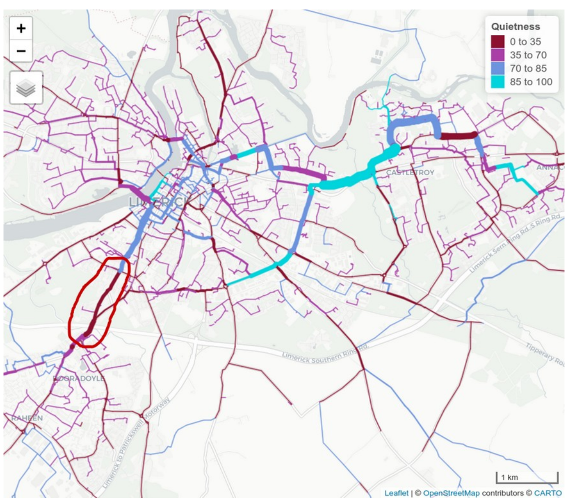


Figure 6.2: Example of a key link which may benefit from improved cycle provision, as shown in the 'quiet' cycle network for Limerick

Used together with local knowledge, these maps may help to solve problems, such as identifying where best to install new cycle infrastructure. An example is shown in Figure 6.3. Dublin Road is used heavily in the fastest route network, while Plassey Park Road and Rhebogue Road feature more strongly in the quietest route network - all of these look like they could benefit from cycle infrastructure improvements.

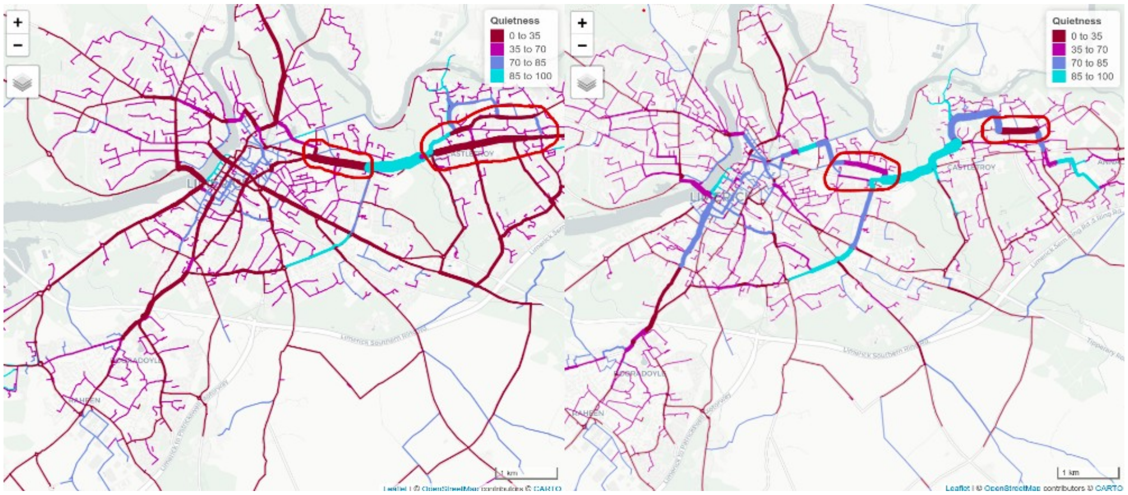


Figure 6.3: Examples in which the 'fast' and 'quiet' route networks could be used together with local knowledge to decide how best to invest in cycle improvements

7 Preliminary findings in Kildare

We have generated fast, quiet and balanced route networks for Kildare, for baseline (i.e. 2016 Census) cycling levels. An overview of the baseline 'quiet' network is shown in Figure 7.1. High usage is made of the Grand Canal towpath into Dublin. However, there appear to be few quiet route options in the south of the county.

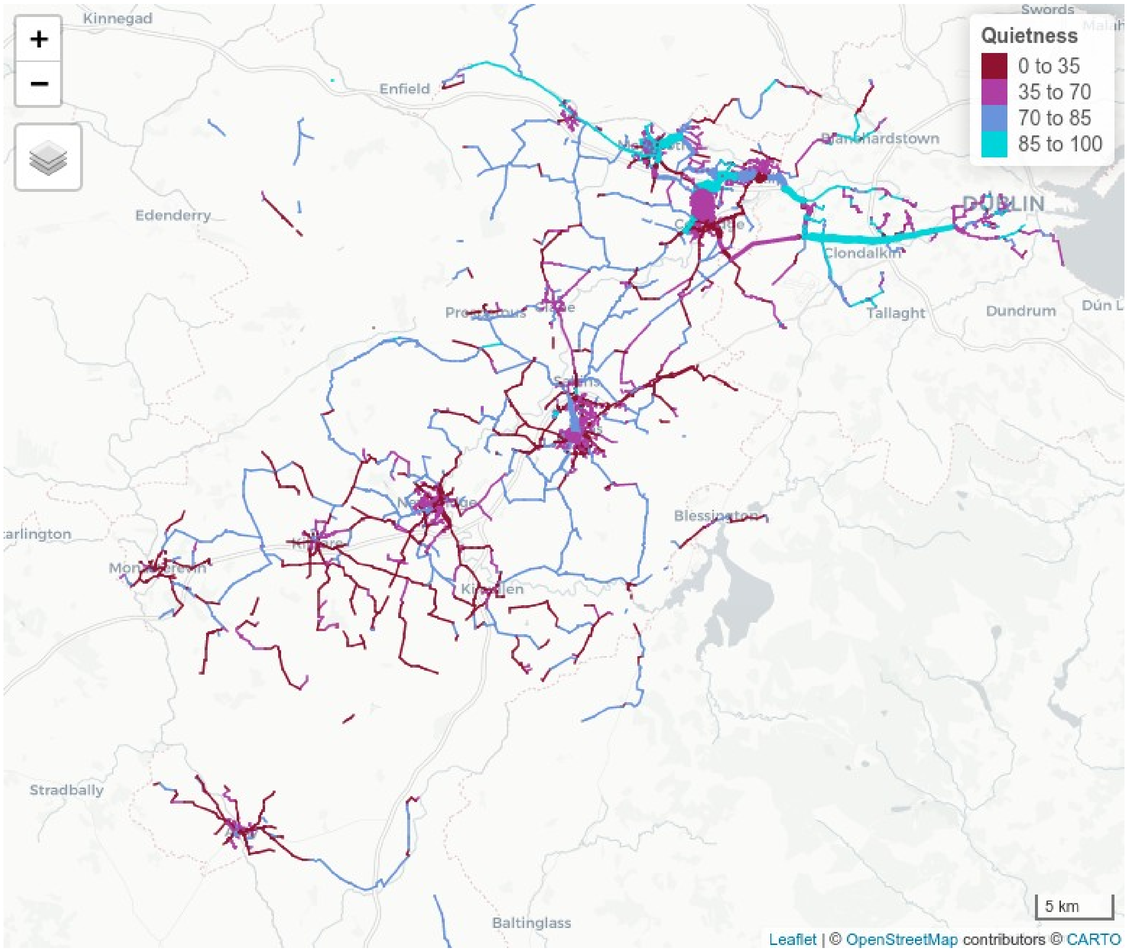


Figure 7.1: Quiet route network in County Kildare. Line width represents number of cyclists; line colour represents the segment level quietness.

There are some considerable differences between the three route network versions in Kildare. Interactive versions of the route networks for Kildare can be viewed online (click on hyperlinks below):

- Quiet route network
- Balanced route network
- Fast route network

The route networks resulting from the fastest and quietest route settings from CycleStreets, for the area including Maynooth, Celbridge and Leixlip were as follows. As Figure 7.2 shows, a higher proportion of the network is quiet in the 'quietest' route network, but there is substantial cycling activity on some busy links in every network. Key differences include greater use of the Grand Canal towpath in the quiet route network, and greater use of direct roads between towns, such as between Maynooth and Leixlip, in the fast route network. The quiet network also appears to be considerably sparser than the fast route network, as cyclists detour to avoid busier roads.

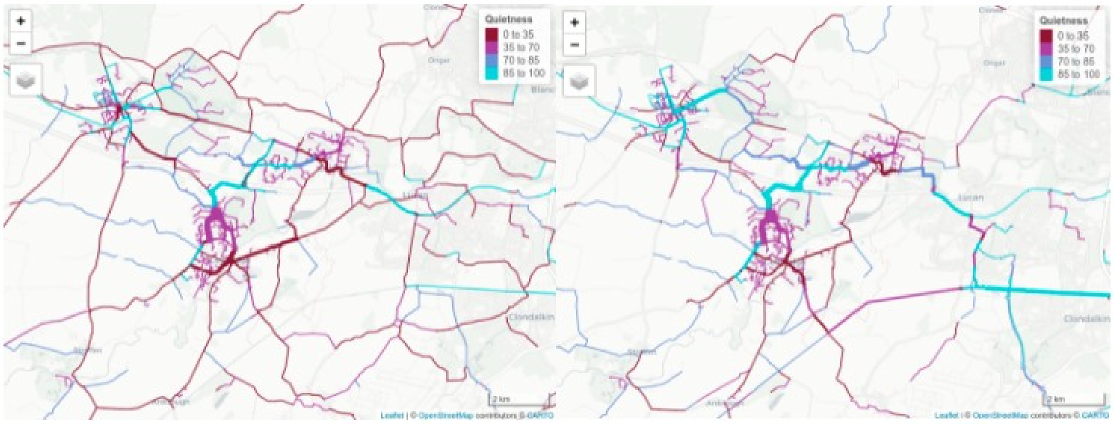


Figure 7.2: Fast (left) and quiet (right) route networks for the Maynooth, Celbridge and Leixlip area, County Kildare. Line width represents number of cyclists; line colour represents the segment level quietness.

In an ideal cycle network, the most direct route should also be the quietest. The maps suggest that people trade-off quietness and comfort for speed when making decisions. These results can be interpreted in different ways but a key message that they convey is the need for a cohesive cycle network including a mix of both off-road and quiet on-road routes to get between key trip attractors.

Specific insights depend on interpretation of the results by people who know the transport system and who have local knowledge. For example, one route segment that shows up strongly in the maps above is Willowbrook Road, shown in Figure 7.3. This road is shown as having high cycle usage, but lower quality provision than neighbouring route segments. Creating a high quality route, with a good surface and clear signposting along that road could potentially help join-up the network.

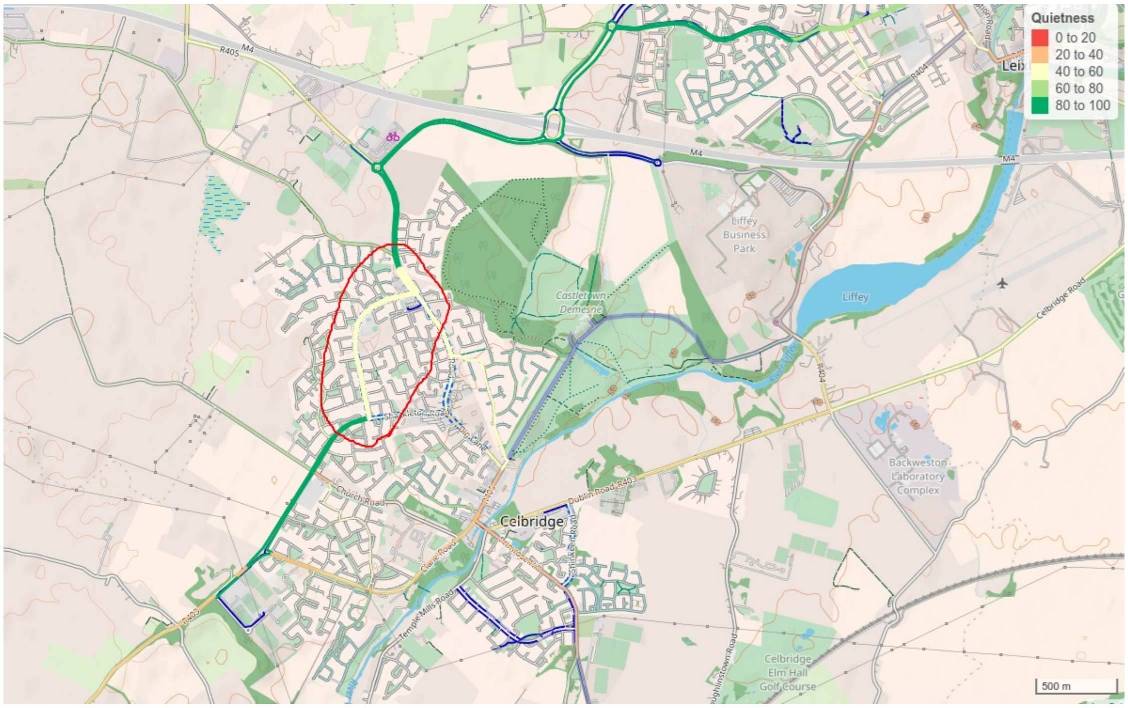


Figure 7.3: Example of link that could potentially benefit from higher quality cycle infrastructure, on a more informative basemap. Line width represents number of cyclists; line colour represents the segment level quietness.

Another finding is that there appears to be strong demand for journeys between Celbridge and Leixlip, but the route between these towns is not very direct. This may be a case where a new off-road route would prove popular. Further such insights would be possible from the tool.

8 Preliminary results for Dublin

To ensure our methods are scaleable, we tested them in Dublin, the County with the largest road network in the Republic of Ireland. Part of the quiet route network for Dublin is shown in Figure 8.1.

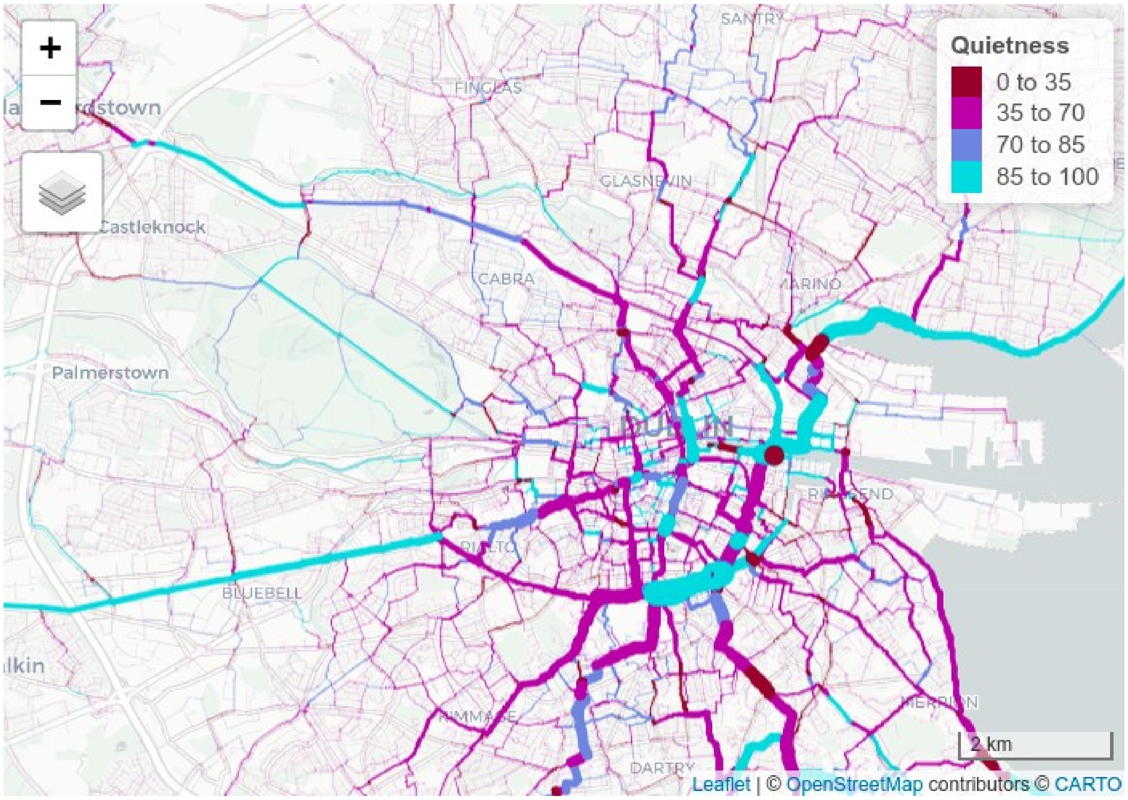


Figure 8.1: Quiet route network for Dublin. Line width represents number of cyclists; line colour represents the segment level quietness.

9 Potential uses of the tool

This section provides examples of how the results from the tools could be used. Visualisions of local cycle networks can be used in many ways. Under the baseline scenario, they can be used a glance how cycling varies within each county, from one town to another, as well as in rural areas. Looking at the roads featured on the maps helps planners and other stakeholders understand the characteristics of the areas where cycling takes place. This can be the first stage of an assessment of whether demand for cycling is matched by provision of appropriate cycle infrastructure, and how best to promote greater cycling uptake.

Knowledge of off-road and on-road routes can be useful for cycle network planning. Well-surfaced off-road routes often prove popular, especially with families and for leisure cycling, due to the lack of traffic danger. However, concerns about personal safety may lead people (especially women, children and the elderly) to avoid some off-road routes after dark, or at other times. A good quality cycle network will include a mix of off-road and on-road routes that caters for a wide range of potential uses.

Based on this understanding, some countries (particularly those with successful pro cycling policies) have implemented ‘quiet way’ interventions, to reduce traffic speeds and increase cycleability and non motorised travel in general on roads with low levels of motor traffic. Various names have been given to this type of intervention, including ‘quiet lanes’ (and the related concept of home zones), which has become part of British legislation and local interventions in some local authorities, including Suffolk, UK. A related concept is ‘quiet streets’ defined by an EU ‘interreg’ document as roads on which there is “only residential access function for motorised traffic”, supported by a range of policy, planning and legal mechanisms including rules stating that cars are not allowed to overtake cyclists on quiet streets.

Cycle network visualisation may show that in some places there is a lack of direct cycle routes between popular destinations. This will be revealed by the circuitousness of the routes that are mapped, and suggests potential demand for new off-road cycle paths. In other places, cycling levels may be depressed because existing roads are poor quality for cyclists, perhaps due to high traffic speeds or volumes, or a lack of dedicated cycle infrastructure. It can be particularly revealing to compare the fastest, balanced and quietest route networks for the same region, and see how these three networks differ from one another. In an ideal cycle network, the most direct route should also be the quietest. When this is not the case, people will have to trade-off speed against comfort or safety. People who are new to cycling or riding with someone who is less confident like a child, are some of the key people we need to get cycling, and are likely to prefer the quieter routes.

Visualisation of current and future estimates of cycling demand on the road network can also help with prioritisation. National cycle infrastructure standards and guidance such as the ‘LTN/1120’ guidance in the UK (Department for Transport 2020) and The Netherlands (CROW 2017) give specific advice based on peak hour cycle flows, with segments on which there are more than 300 trips per hour having a desirable minimum width of 3 m according to LTN/120 guidance, for example. Estimates of cycle flows currently and under scenarios of change can enable planners to design not only for current levels but for the future, increasing cost effectiveness and the longevity of infrastructure. Furthermore, when compared with existing infrastructure characteristics including in relation to speed limits and real world speeds (using visual and automated computational analysis techniques), estimates of cycling levels and potentials can help determine what to build where. For example LTN/120 states that any road on which the speed limit is above around 60 kph should have fully segregated cycling infrastructure (not stepped curbed next to the road and certainly not unprotected cycle lanes on the carraigeway demarcated with pain) (Department for Transport 2020).

10 Next steps

The next phase of work involves shifting from a focus on existing cycling levels to modelling cycling potential, under policy-relevant scenarios of change. We are currently planning to model the following scenarios:

1. Baseline: the current level of cycling
2. Climate action plan 2021 scenario of "increasing the proportion of kilometres driven by passenger electric cars to between 40 and 45% by 2030, in addition to a reduction of 10% in kilometres driven by the remaining internal combustion engine cars", in addition to increasing the number of stages by sustainable modes by 500,000, around 14%

- We will also explore a more ambitious decarbonisation scenario in which car km driven reduces by 30% by 2030 (following guidance from TII)

1. 1980s: back to the school cycling levels recorded during the 1986 Census (see what data there are from CSO)
2. Go Dutch (as used in the Propensity to Cycle Tool for England and Wales)
3. Ebikes scenario: Flemish
4. A possible Low Traffic Neighbourhood scenario (reflecting changes to make local neighbourhoods safer)
5. A possible 'County Target' scenario reflecting local ambition

One factor to note is that in these scenarios, uplift in cycling will typically be modelled using distance decay curves. Therefore, if the route between any two given points is longer using the 'quiet' route algorithm than with the fast route algorithm, the modelled uplift in cycling between those two points will be smaller in the quiet route network than in the fast route network. This reflects the fact that longer, more circuitous routes may discourage some people from cycling.

In the baseline networks presented above, all trip purposes are treated the same. In the next phase we will create separate route network results for educational and work trips. Educational trips will be routed to genuine school locations.

10.1 Requirements relating to upcoming work

- We currently have data on school locations and sizes but **we require data on tertiary level educational establishments represented in the OD data, such as universities and colleges**.
- Information on county-level targets could enable county-specific 'County target' scenarios as mentioned above.
- We also require count data to verify the results before initiating the scaling up stage, ideally by May.

11 Appendix: Colourschemes and aesthetics

There are many options and a large parameter space to explore when thinking how to present the data. Perhaps the most fundamental question is: which datasets to show. In the maps above we have opted for a grey, unobtrusive basemap and to show cycling potential in proportion to width. The use of interactive maps allows other variables to be shown, including options enabling the user to see estimates under different scenarios of change, for different route types (fast, balanced quiet), and other variables such as change in cycling at zone, route and route network levels.

We could potentially also present contextual data such as the locations of cycle parking points and other datasets not directly used in the uptake models but of relevance to cycling uptake.

General feedback on the visual presentation of the data would be welcome and any feedback on the way the data is presented is welcome, based on the preliminary results shown above and some further experiments with colourschemes shown below.

A variety of colourschemes were tested using the `colorspace` R package (Zeileis et al. 2020), illustrated in Figure 11.1.

Which colourscheme types are preferable? We can try a range of colourschemes.

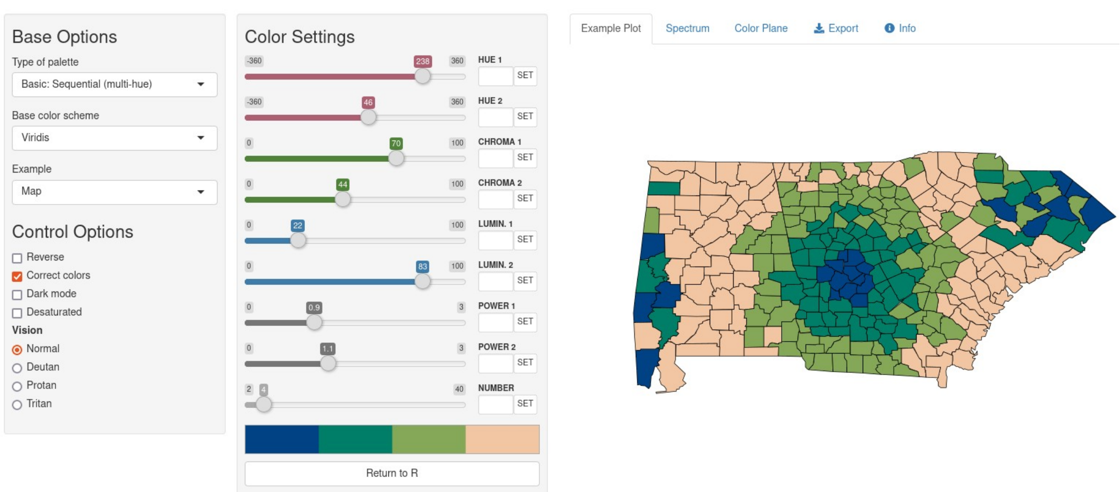


Figure 11.1: An illustration of the colorspace R package.

The visual performance of different schemes was evalutated, including with colour spectrum plots like in Figure 11.2.

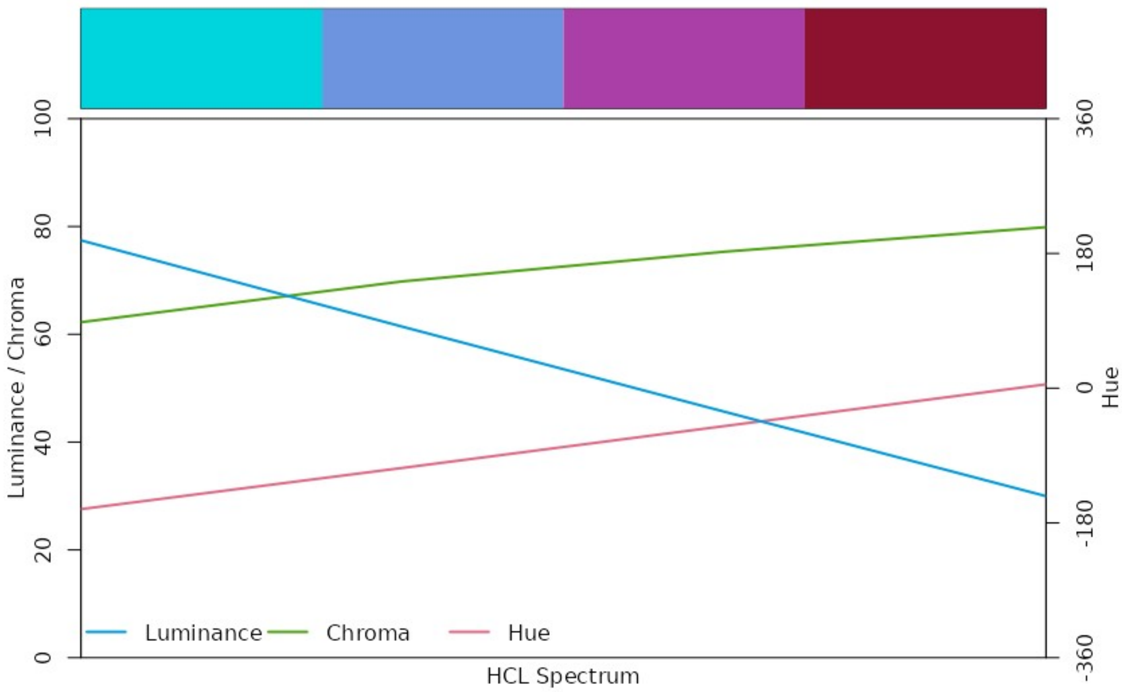
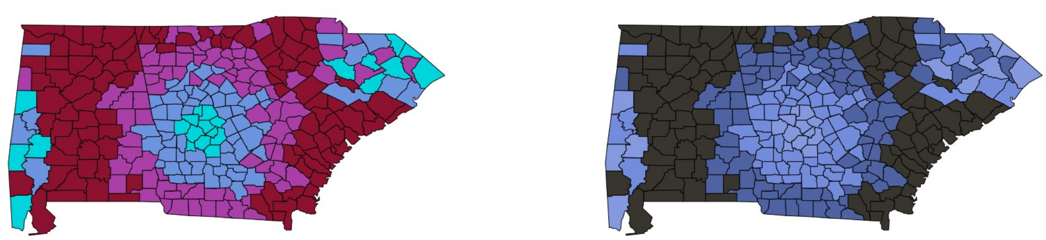


Figure 11.2: Colour spectrum plot for a colour scheme.

The impact of different colourschemes on people with different types of colourblindness was checked with plots. Figure ??, for example simulates deuteranopia (red-green colourblindness, which affects ~1% of people), compared with the original.



There are many alternative colour scheme options. An ‘off the shelf’ colourscheme as in Figure 11.3 shows ‘quiet’ and ‘busy’ links well, but has limitations for those with red/green colour blindness:

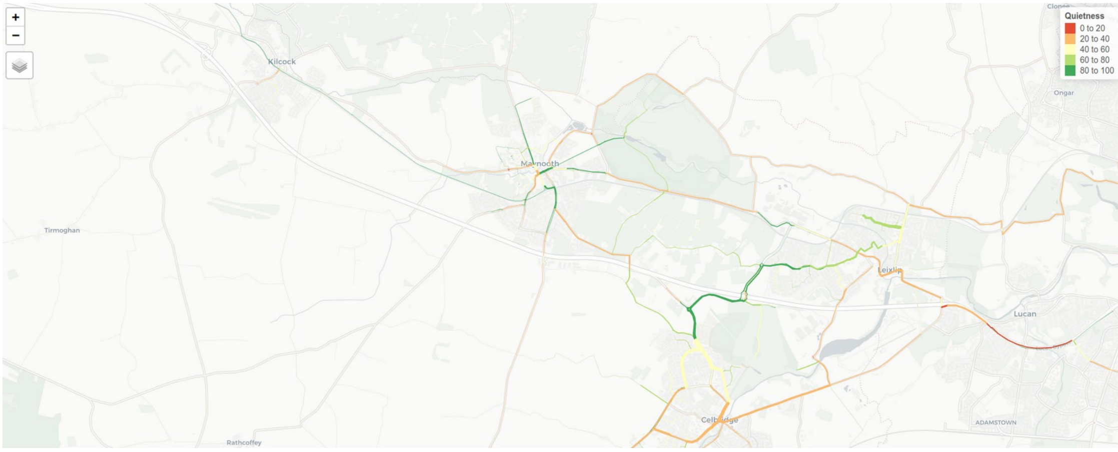


Figure 11.3: Route number in the northern part of Kildare shown using a red-yellow-green colour scheme.

An alternative colourscheme going from pink to green is shown in Figure 11.4.

Figure 11.4: A colour scheme that avoids pale yellow tones and has less of a red-green clash.

Another option is shown in Figure 11.5.

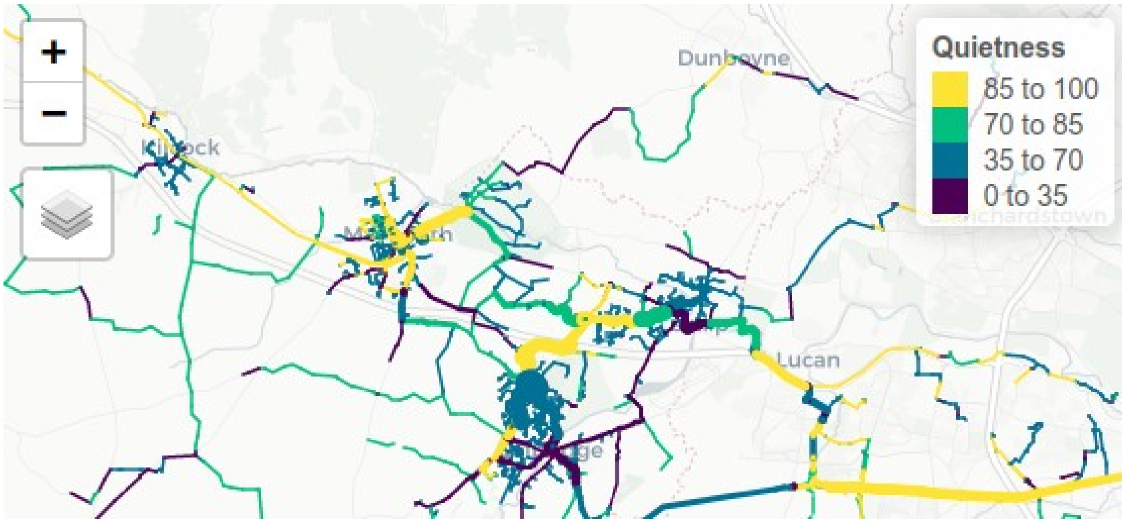


Figure 11.5: A colour scheme that avoids pale yellow tones and has less of a red-green clash.

Preventing line widths going below a certain threshold resulted in Figure 11.6, building on the previous figure.

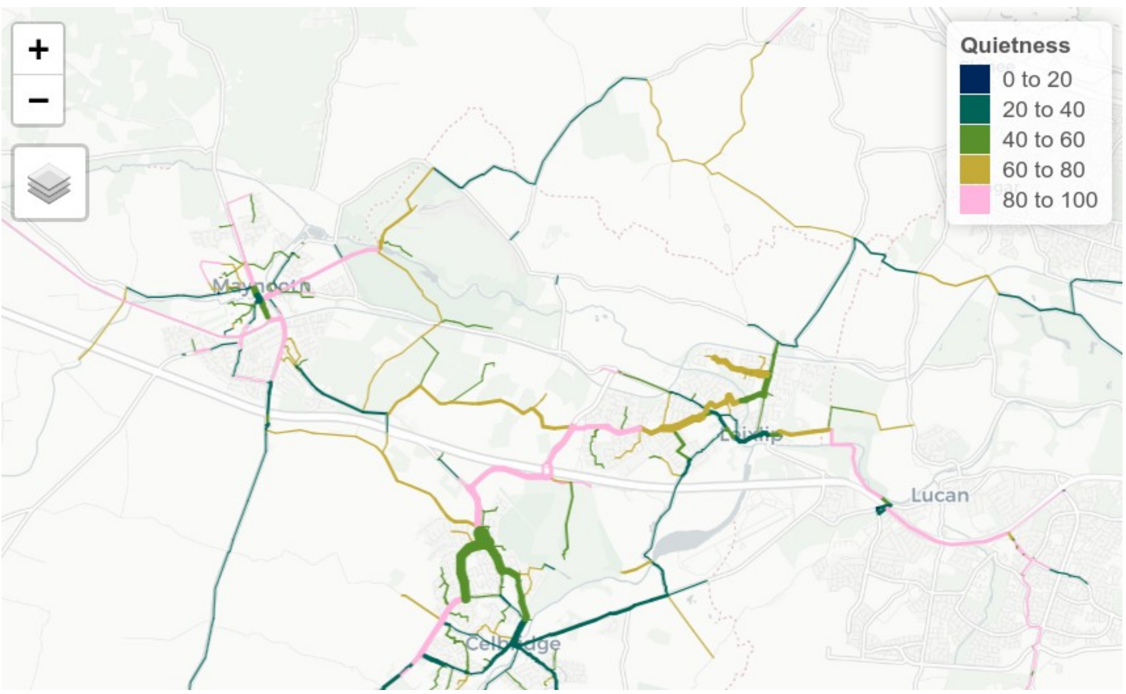


Figure 11.6: Improving the previous image by preventing thin lines that are hard to see.

Finally, reversing the colour scheme can sometimes make images more intuitive. In this case it results in Figure 11.7.

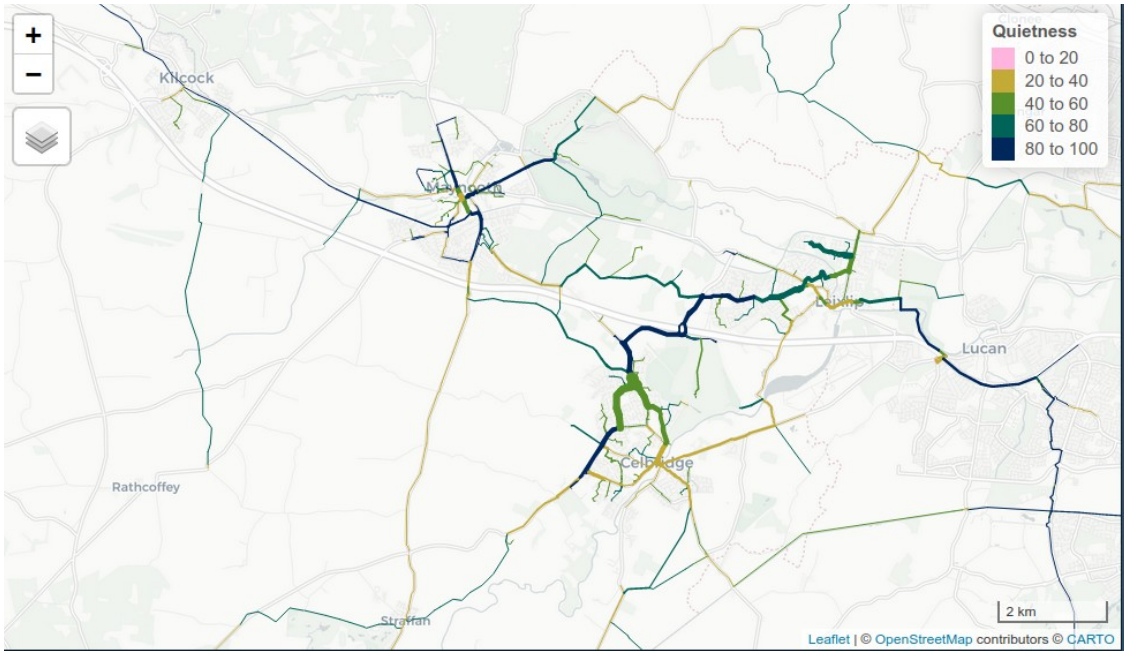


Figure 11.7: Reversing the directionality of the colour scheme in the previous figure.

11.1 A few more colourschemes

Turbo colour scheme:

```
##
## Attaching package: 'tmap'

## The following object is masked from 'package:datasets':
##
##     rivers

## tmap mode set to 'view'
```

Custom scheme (currently in there):

```
## Deprecated tmap v3 code detected. Code translated to v4

## Warning: As of version 4.0, tm_scale_bar has been renamed to
tm_scalebar and is
## therefore deprecated
```

Turbo again:

```
## Deprecated tmap v3 code detected. Code translated to v4

## Warning: As of version 4.0, tm_scale_bar has been renamed to
tm_scalebar and is
## therefore deprecated
```

Viridis:

```
## Deprecated tmap v3 code detected. Code translated to v4

## Warning: As of version 4.0, tm_scale_bar has been renamed to
tm_scalebar and is
## therefore deprecated
```

Plasma:

```
## Deprecated tmap v3 code detected. Code translated to v4

## Warning: As of version 4.0, tm_scale_bar has been renamed to
tm_scalebar and is
## therefore deprecated
```

Hokusai2:

```
## Deprecated tmap v3 code detected. Code translated to v4

## Warning: As of version 4.0, tm_scale_bar has been renamed to
tm_scalebar and is
## therefore deprecated
```

Greek:

```
## Deprecated tmap v3 code detected. Code translated to v4

## Warning: As of version 4.0, tm_scale_bar has been renamed to
tm_scalebar and is
## therefore deprecated
```

Hokusai3:

```
## Deprecated tmap v3 code detected. Code translated to v4

## Warning: As of version 4.0, tm_scale_bar has been renamed to
tm_scalebar and is
## therefore deprecated
```

VanGogh3:

```
## Deprecated tmap v3 code detected. Code translated to v4

## Warning: As of version 4.0, tm_scale_bar has been renamed to
tm_scalebar and is
## therefore deprecated
```

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