Transportation Network Analysis
Shimbel Index

In measuring accessibility, there are five important aspects that need to be addressed:

1. **Placement –** where links are located within a network.
2. **Direct / indirect links** – both need to be considered.
3. **Attenuation –** differences between direct and indirect linkage need to be considered.
4. **Redundancy –** remove the effects of meaningless routes.
5. **Unequal Links –** not all links are equal and adjustments need to be made.

Connectivity addresses attenuation to some degree.

- The impact of a given link is inversely related to the number of preceding links.

- However, this is an incomplete treatment.

Shimbel distance addresses both attenuation and redundancy.

Shimbel distance – topologic network analysis that is restricted to the shortest routes between nodes.

- Rather than examine all steps between *i* and *j*, examine only the number of steps in the shortest route between *i* and *j*.

Shimbel Distance Characteristics:

1. Measures shortest topologic distance (steps).

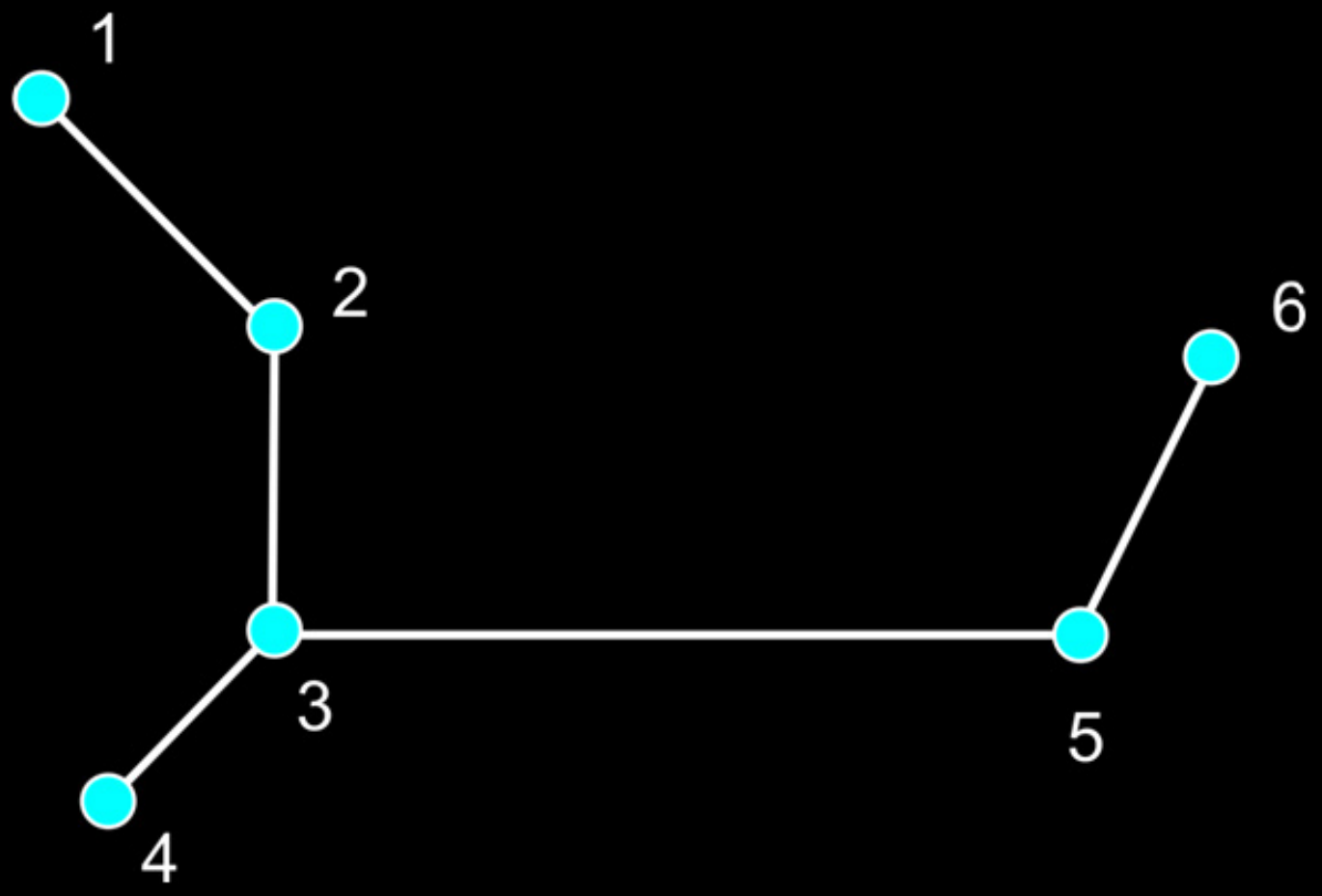
2. Each route must be less than or equal to the diameter.

3. Row sums equal fewest number of steps to connect one node to all other nodes.

4. Uses the connectivity procedure to determine new, shortest connections.

The procedure is similar to determining connectivity.

1. The matrix is powered (multiplied by itself).
2. New non-zero cells (dyads) are recorded.
3. The power of the matrix is entered into these cells.
4. The new matrix is added to the original.
5. The process continues until all zero cells are removed.


1
2
3
4
5
6

The non-diagonal zero cells are coded as null in the D^1 matrix. The ones represent one step or direct connections.

$C^1 =$

	1	2	3	4	5	6
1	0	1	0	0	0	0
2	1	0	1	0	0	0
3	0	1	0	1	1	0
4	0	0	1	0	0	0
5	0	0	1	0	0	1
6	0	0	0	0	1	0

Original connectivity matrix

$D^1 =$

	1	2	3	4	5	6
1	0	1	-	-	-	-
2	1	0	1	-	-	-
3	-	1	0	1	1	-
4	-	-	1	0	-	-
5	-	-	1	-	0	1
6	-	-	-	-	1	0

New Shimbel matrix

The blue circles represent the cells that have changed during the second powering. All of these except for the diagonal will be coded as 2.

$C^1 =$

	1	2	3	4	5	6
1	0	1	0	0	0	0
2	1	0	1	0	0	0
3	0	1	0	1	1	0
4	0	0	1	0	0	0
5	0	0	1	0	0	1
6	0	0	0	0	1	0

$C^2 =$

	1	2	3	4	5	6
1	1	0	1	0	0	0
2	0	2	0	1	1	0
3	1	0	3	0	0	1
4	0	1	0	1	1	0
5	0	1	0	1	2	0
6	0	0	1	0	0	1

10 changed cells

Note that all new non-zero cells are entered in the D^2 matrix as a 2 since this is the second powering. The diagonal stays as zeros.

$C^2 =$

	1	2	3	4	5	6
1	1	0	1	0	0	0
2	0	2	0	1	1	0
3	1	0	3	0	0	1
4	0	1	0	1	1	0
5	0	1	0	1	2	0
6	0	0	1	0	0	1

$D^2 =$

	1	2	3	4	5	6
1	0	1	2	-	-	-
2	1	0	1	2	2	-
3	2	1	0	1	1	2
4	-	2	1	0	2	-
5	-	2	1	2	0	1
6	-	-	2	-	1	0

10 cells coded as 2

The third powering results in 3-step routes. Note that the C matrices are being run thru the connectivity procedure independently.

$C^2 =$

	1	2	3	4	5	6
1	1	0	1	0	0	0
2	0	2	0	1	1	0
3	1	0	3	0	0	1
4	0	1	0	1	1	0
5	0	1	0	1	2	0
6	0	0	1	0	0	1

$D^2 =$

	1	2	3	4	5	6
1	0	1	2	-	-	-
2	1	0	1	2	2	-
3	2	1	0	1	1	2
4	-	2	1	0	2	-
5	-	2	1	2	0	1
6	-	-	2	-	1	0

All zero values, except for the diagonal, are filled and the process in completed.

$C^4 =$

	1	2	3	4	5	6
1	2	0	4	0	0	1
2	0	6	0	4	5	0
3	4	0	11	0	0	4
4	0	4	0	3	4	0
5	0	5	0	4	6	0
6	1	0	4	0	0	2

$D^4 =$

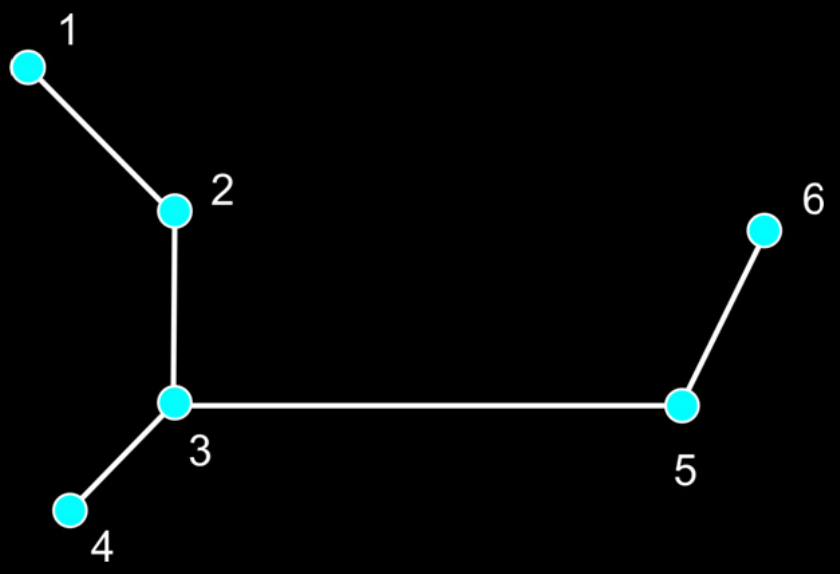
	1	2	3	4	5	6
1	0	1	2	3	3	4
2	1	0	1	2	2	3
3	2	1	0	1	1	2
4	3	2	1	0	2	3
5	3	2	1	2	0	1
6	4	3	2	3	1	0

The matrix represents shortest routes in number of steps.

$D^4 =$

	1	2	3	4	5	6	Total
1	0	1	2	3	3	4	13
2	1	0	1	2	2	3	9
3	2	1	0	1	1	2	7
4	3	2	1	0	2	3	11
5	3	2	1	2	0	1	9
6	4	3	2	3	1	0	13

Sum = 62



The diagonal remains coded as zero because these represent single origin-destination trips.

- Origin-destination trips are redundant. We are rarely concerned with the number of ways a location is connected with itself.

- No trip along the diagonal can be coded as a 1 since it takes at least 2 steps to return to the origin.

The most accessible node is # 3, which takes 7 steps to connect it to all other nodes.

$D^4 =$

	1	2	3	4	5	6	Total
1	0	1	2	3	3	4	13
2	1	0	1	2	2	3	9
3	2	1	0	1	1	2	7
4	3	2	1	0	2	3	11
5	3	2	1	2	0	1	9
6	4	3	2	3	1	0	13

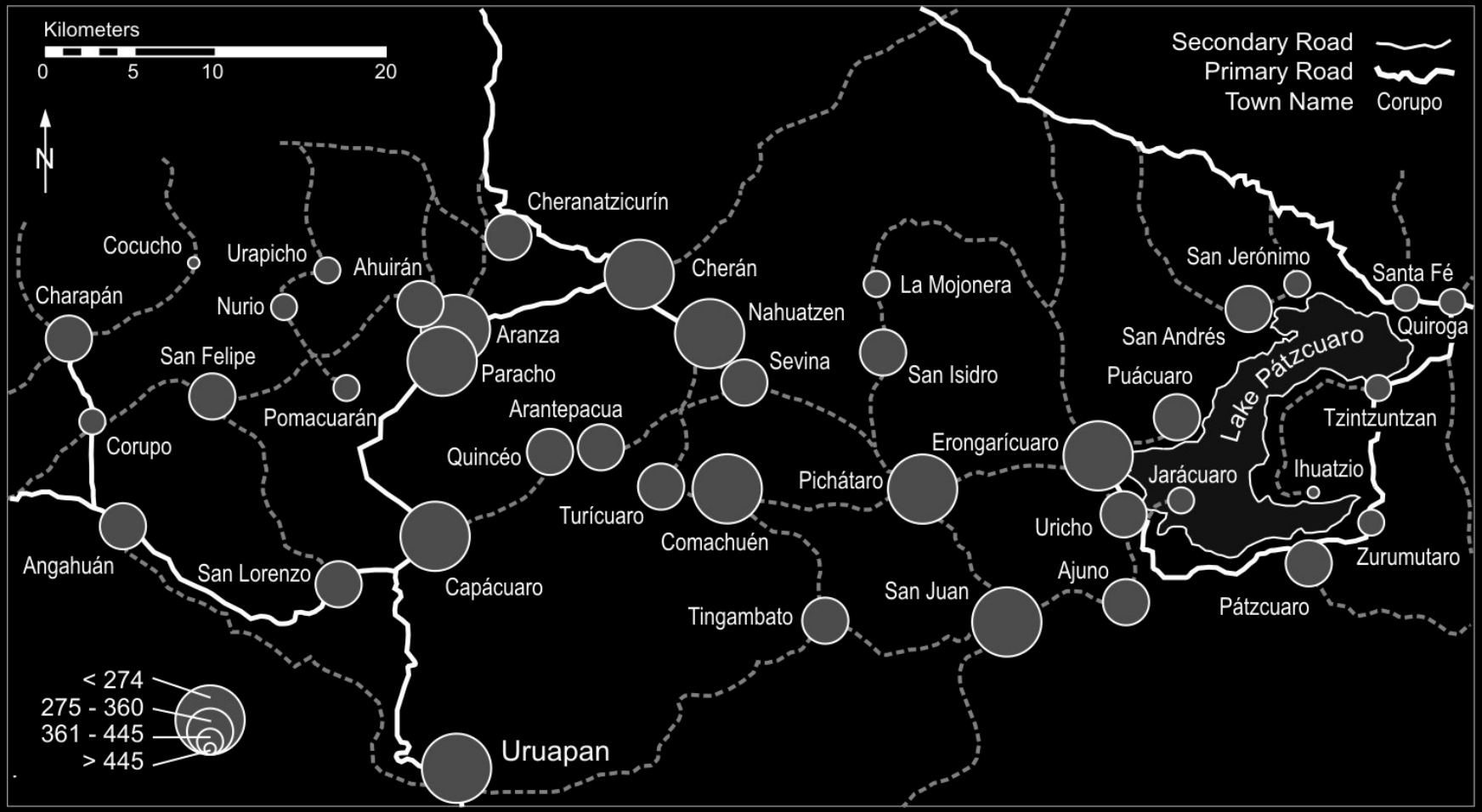
Sum = 62

Shimbel Distance example: *The Meseta Tarasca in Michoacán, Mexico.*

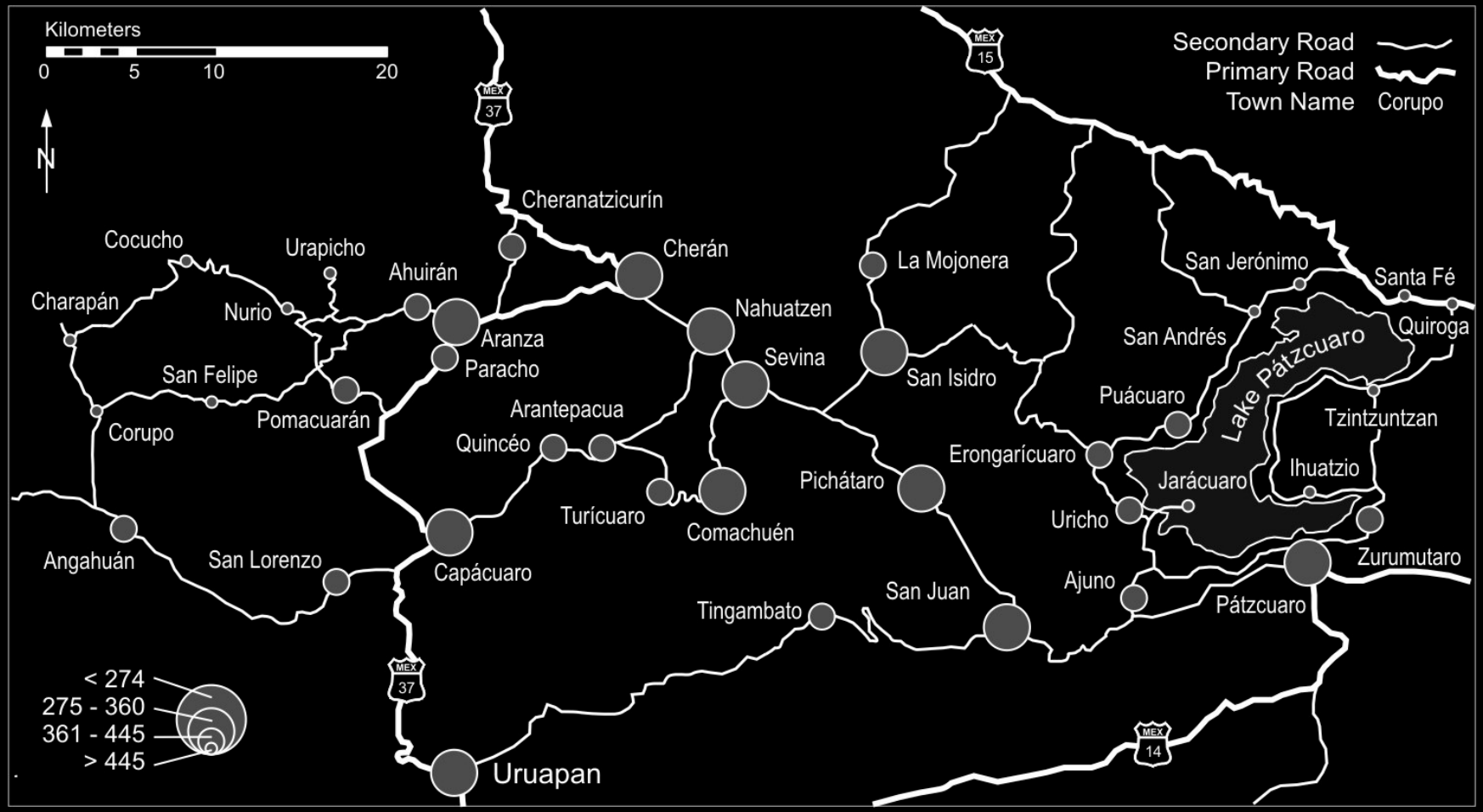
Note that larger circles represent LOWER Shimbel distances and are therefore MORE accessible.

Thus we are mapping accessibility.

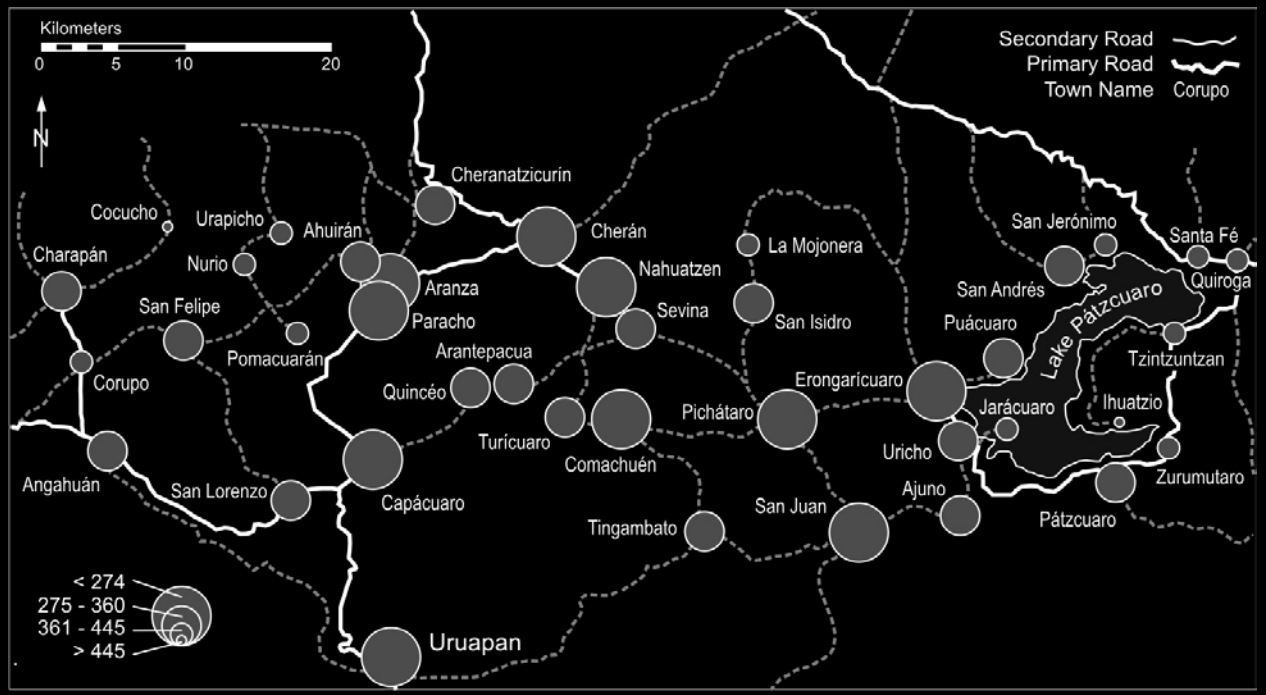
Accessibility (Shimbel Distance), 1940: Michoacán, Mexico



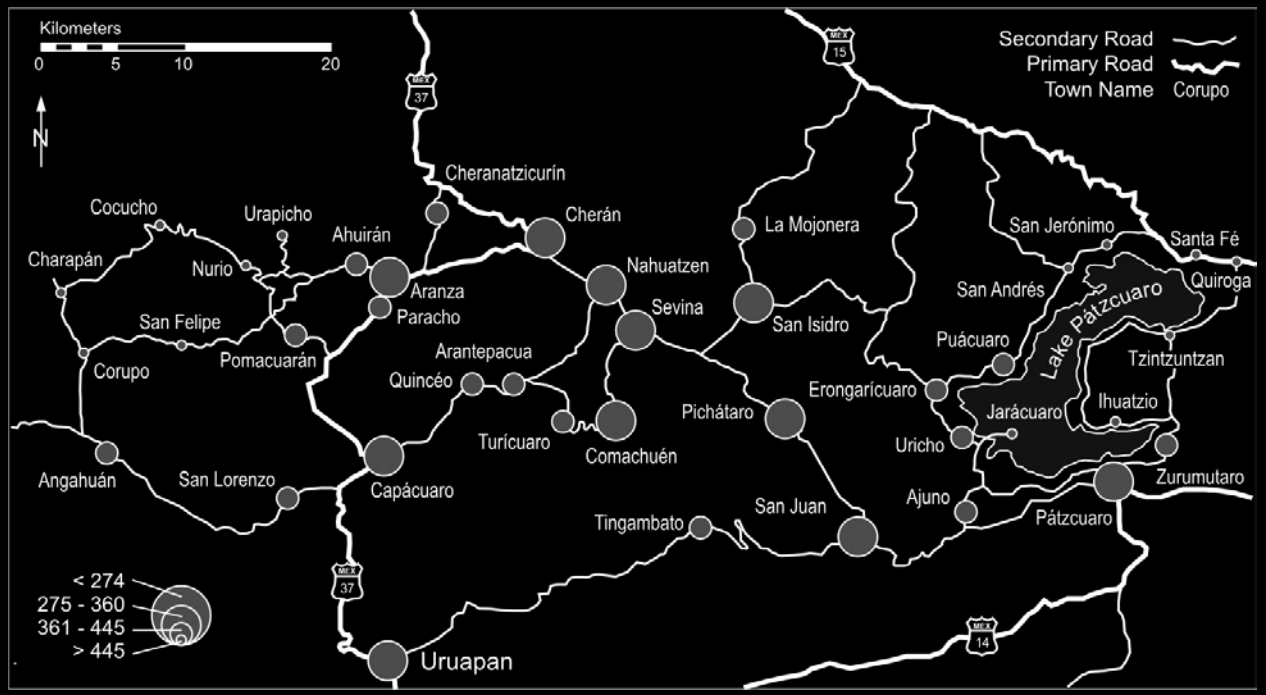
Accessibility (Shimbel Distance), 2004: Michoacán, Mexico



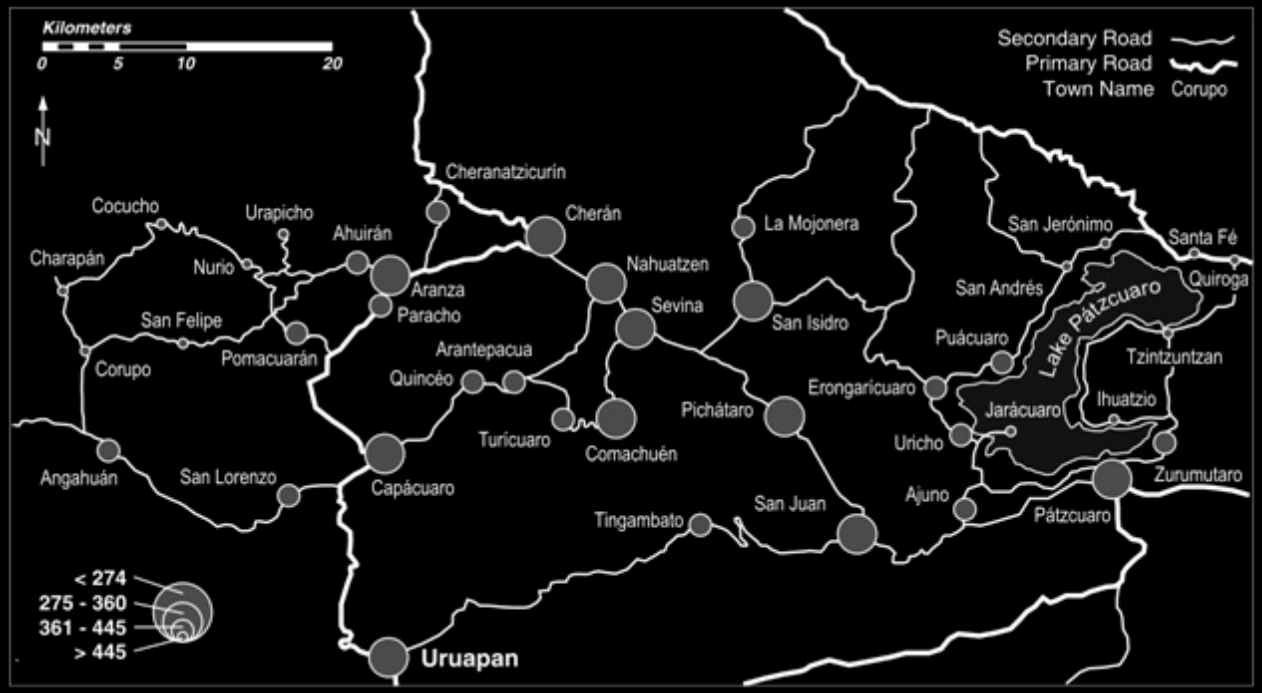
Shimbel Distance



1940



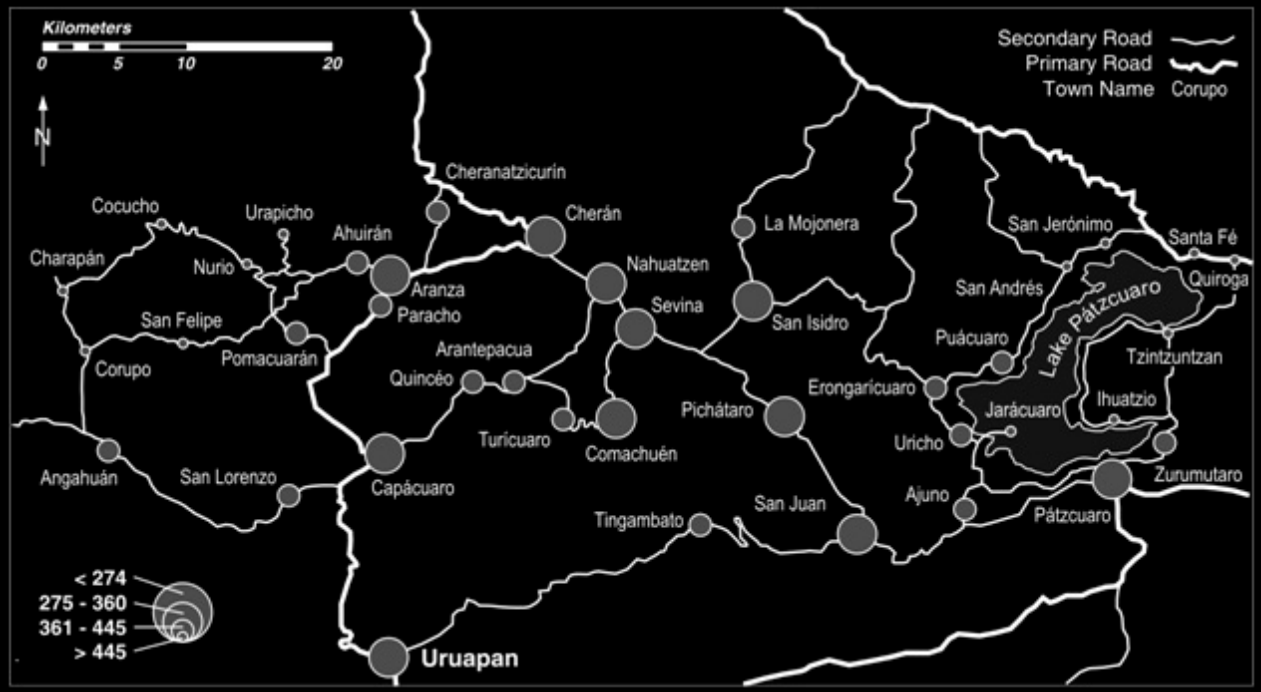
2004

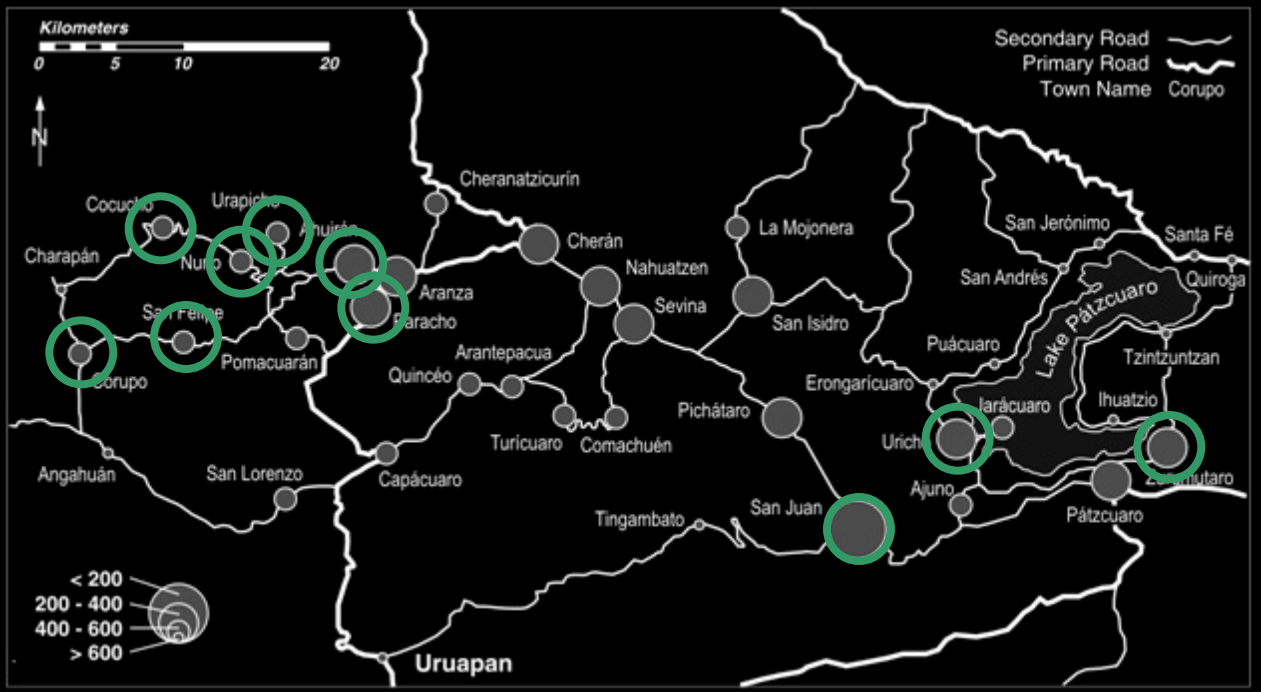


Decreases

Shimbel Distance

Total Connectivity





Increases

Shimbel Distance

Total Connectivity

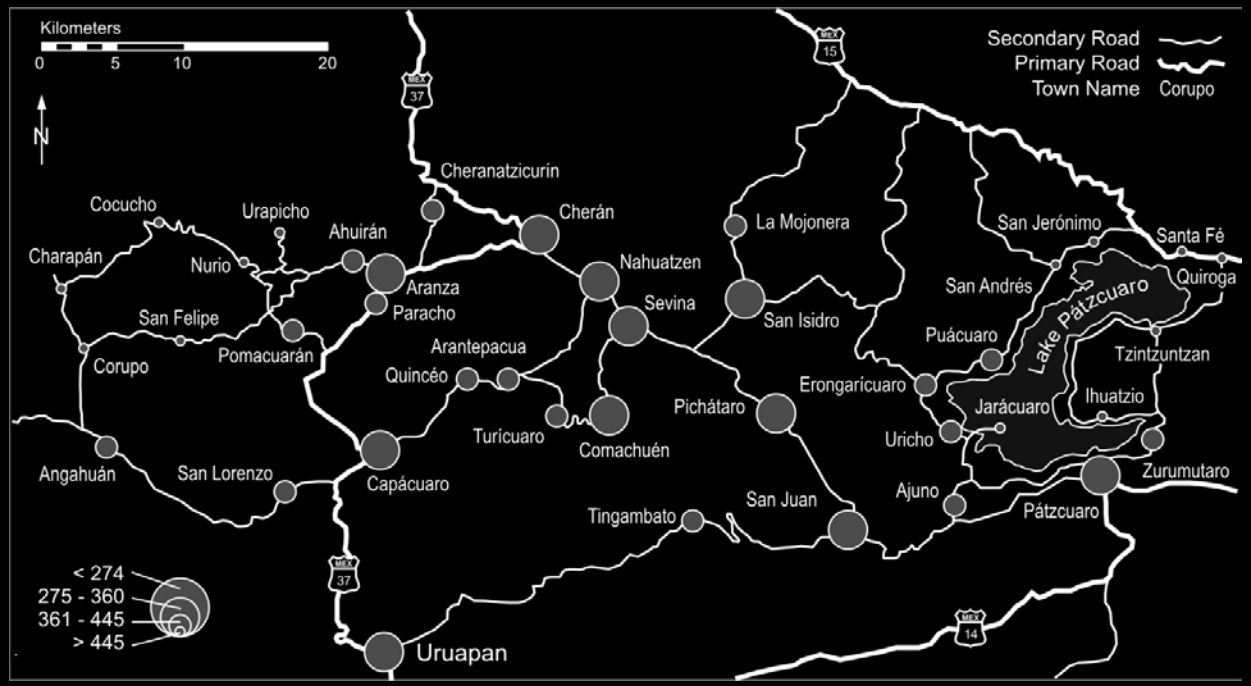
Remember that the changes in connectivity and Shimbel distance values are relative:

1. They are not directly comparable.

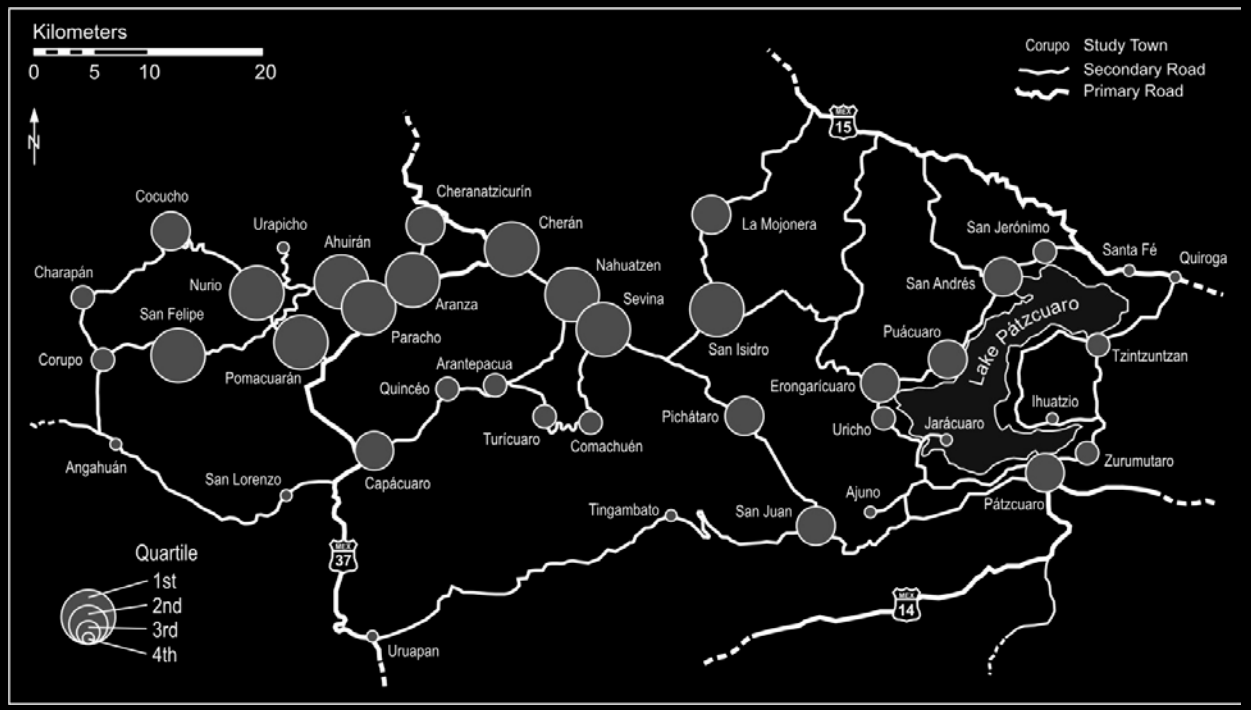
2. Connectivity measures ALL steps in ALL routes.

3. Shimbel distance measures the number of steps in the shortest routes.

2004 Maps



Shimbel Distance



Total Connectivity

Shimbel distance more accurately represents the high isolation in the western part of the study area.

Shimbel distance is a better measure of relative accessibility.

- **This is because it measures *shortest* *topologic* routes.**

Connectivity is a better measure of situation within a network.

- **This is because it measures total connections *regardless* of topologic or real world distance.**