

# Geographic Information Systems

ESM 263 - Winter 2023

# Attribute Tables and Tabular Data

# Outline

- Scales of measurement
- Attribute tables
- “Joins” and “relations”
- Relational databases
- Importing tabular data

# Attributes: Scales of Measurement

- Nominal
  - distinction (“a” is/is-not “b”)
  - e.g. land cover class
- Ordinal
  - significance (“a” is Xer than “b”)
  - Sortable
  - e.g. good → better → best
- Interval
  - relative magnitude (“a” is N units Xer than “b”)
  - Interpolable
  - e.g. degrees Celsius

# Attributes: Scales of Measurement

- Ratio
  - absolute magnitude (“a” is N times Xer than “b”)
  - Scalable
  - true zero: absence of attribute
  - e.g. degrees Kelvin
- Cyclic
  - Direction
  - more common in geography than in other disciplines
  - “wrap-around” discontinuity at  $2\pi$  ( $360^\circ$ )
  - tricky to interpolate
  - e.g. terrain exposure (“south-facing slope”)

# Attributes



Name	FIPS	Pop90	Area	PopDn
Whatcom	53073	128	2170	59
Skagit	53057	80	1765	45
Clallam	53009	56	1779	32
Snohomish	53061	466	2102	222
Island	53029	60	231	261
Jefferson	53031	20	1773	11
Kitsap	53035	190	391	485
King	53033	1507	2164	696
Mason	53045	38	904	42
Grays Harbor	53027	64	1917	33
Pierce	53053	586	1651	355
Thurston	53067	161	698	231
Pacific	53049	19	945	20
Lewis	53041	59	2479	24

Attribute  
or Item

Record

Name	FIPS	Pop90	Area	PopDn
Whatcom	53073	128	2170	59
Skagit	53057	80	1765	45
Clallam	53009	56	1779	32
Snohomish	53061	466	2102	222
Island	53029	60	231	261
Jefferson	53031	20	1773	11
Kitsap	53035	190	391	485

- row = spatial feature
- column = attribute
- $row_i \cap column_j = \text{value of attribute } j \text{ for feature } i$

# Rendering the Attribute Table

	fid	OBJECTID	APN	LAYER	SITUS1	SITUS2	ACREAGE	LANDUSE	USECODE	TRA
1	1	1	037-161-040	GROUND	0000 UNKN...	SANTA BARB...	0.08	RIGHTS OF ...	8500	002042
2	2	2	029-660-CA1	CONDO FIRS...			0			
3	3	3	029-660-001	CONDO FIRS...	820 LOWEN...	SANTA BARB...	0	CONDOS.CO...	0300	002001
4	4	4	029-201-001	GROUND	827 E ANAP...	SANTA BARB...	0.14	RESIDENTIA...	0422	002001
5	5	5	029-201-003	GROUND	915 E ANAP...	SANTA BARB...	1	VACANT	0050	002001
6	6	6	031-570-CA1	GROUND			0			
7	7	7	017-071-008	GROUND	1316 E MON...	SANTA BARB...	0.25	SINGLE FAM...	0100	002001
8	8	8	017-071-002	GROUND	1312 E MON...	SANTA BARB...	0.24	SINGLE FAM...	0100	002001
9	9	9	017-071-003	GROUND	1335 SYCAM...	SANTA BARB...	0.31	SINGLE FAM...	0100	002001
10	10	10	017-071-004	GROUND	1313 E MON...	SANTA BARB...	0.10	SINGLE FAM...	0100	002001
11	11	11	017-071-005	GROUND	1301 E MON...	SANTA BARB...	0.26	SINGLE FAM...	0100	002001
12	12	12	031-391-001	GROUND	432 N CANA...	SANTA BARB...	0.12	SINGLE FAM...	0100	002001
13	13	13	031-391-002	GROUND	1306 E HALE...	SANTA BARB...	0.12	SINGLE FAM...	0100	002001
14	14	14	031-391-003	GROUND	1310 E HALE...	SANTA BARB...	0.12	SINGLE FAM...	0100	002001
15	15	15	031-391-004	GROUND	1314 E HALE...	SANTA BARB...	0.12	SINGLE FAM...	0100	002001
16	16	16	031-391-005	GROUND	1318 E HALE...	SANTA BARB...	0.12	SINGLE FAM...	0100	002001
17	17	17	031-391-006	GROUND	1322 E HALE...	SANTA BARB...	0.12	SINGLE FAM...	0400	002001
18	18	18	031-391-007	GROUND	1326 E HALE...	SANTA BARB...	0.12	RESIDENTIA...	0400	002001
19	19	19	031-391-008	GROUND	433 ALAMED...	SANTA BARB...	0.14	SINGLE FAM...	0100	002001
20	20	20	031-391-009	GROUND	431 ALAMED...	SANTA BARB...	0.14	RESIDENTIA...	0400	002001
21	21	21	031-391-010	GROUND	427 ALAMED...	SANTA BARB...	0.15	CONDOS.CO...	0300	002001
22	22	22	031-391-011	GROUND	415 ALAMED...	SANTA BARB...	0.16	RESIDENTIA...	0421	002001
23	23	23	031-391-013	GROUND	411 ALAMED...	SANTA BARB...	0.16	RESIDENTIA...	0400	002001
24	24	24	031-391-014	GROUND	407 ALAMED...	SANTA BARB...	0.15	RESIDENTIA...	0400	002001
25	25	25	031-391-016	GROUND	1325 E GUTI...	SANTA BARB...	0.12	SINGLE FAM...	0100	002001
26	26	26	031-391-017	GROUND	1321 E GUTI...	SANTA BARB...	0.12	SINGLE FAM...	0100	002001
27	27	27	031-391-018	GROUND	1317 E GUTI...	SANTA BARB...	0.12	SINGLE FAM...	0100	002001
28	28	28	031-391-019	GROUND	1313 E GUTI...	SANTA BARB...	0.12	SINGLE FAM...	0100	002001

A	B	C	D	E	F	G	H
fid	OBJECTID	APN	LAYER	SITUS1	SITUS2	ACREAGE	LANDUSE
1	1	037-161-040	GROUND	0000 UNKNOWN OWNER PARCEL	SANTA BARBARA, CA 93101	0.08	RIGHTS OF WAY,SEWER, LAND FIL
2	2	029-660-CA1	CONDO FIRST FLOOR			0	
3	3	029-660-001	CONDO FIRST FLOOR	820 LOWENA DR	SANTA BARBARA, CA 93101	0	CONDOS,COMMUNITY APT PROJ
4	4	029-201-001	GROUND	827 E ANAPAMU ST	SANTA BARBARA, CA 93103	0.14	RESIDENTIAL INCOME, 2-4 UNITS
5	5	029-201-003	GROUND	915 E ANAPAMU ST	SANTA BARBARA, CA 93103	1	VACANT
6	6	031-570-CA1	GROUND			0	
7	7	017-071-008	GROUND	1316 E MONTECITO PL	SANTA BARBARA, CA 93103	0.25	SINGLE FAMILY RESIDENCE
8	8	017-071-002	GROUND	1312 E MONTECITO PL	SANTA BARBARA, CA 93103	0.24	SINGLE FAMILY RESIDENCE
9	9	017-071-003	GROUND	1335 SYCAMORE CANYON RD	SANTA BARBARA, CA 93108	0.31	SINGLE FAMILY RESIDENCE
10	10	017-071-004	GROUND	1313 E MONTECITO ST	SANTA BARBARA, CA 93103	0.25	SINGLE FAMILY RESIDENCE
11	11	017-071-005	GROUND	1301 E MONTECITO ST	SANTA BARBARA, CA 93103	0.26	SINGLE FAMILY RESIDENCE
12	12	031-391-001	GROUND	432 N CANADA ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
13	13	031-391-002	GROUND	1306 E HALEY ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
14	14	031-391-003	GROUND	1310 E HALEY ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
15	15	031-391-004	GROUND	1314 E HALEY ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
16	16	031-391-005	GROUND	427 ALAMEDA PADRE SERRA	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
17	17	031-391-006	GROUND	1322 E HALEY ST	SANTA BARBARA, CA 93103	0.12	RESIDENTIAL INCOME, 2-4 UNITS
18	18	031-391-007	GROUND	1326 E HALEY ST	SANTA BARBARA, CA 93103	0.12	RESIDENTIAL INCOME, 2-4 UNITS
19	19	031-391-008	GROUND	433 ALAMEDA PADRE SERRA	SANTA BARBARA, CA 93103	0.14	SINGLE FAMILY RESIDENCE
20	20	031-391-009	GROUND	431 ALAMEDA PADRE SERRA	SANTA BARBARA, CA 93103	0.14	RESIDENTIAL INCOME, 2-4 UNITS
21	21	031-391-010	GROUND	427 ALAMEDA PADRE SERRA	SANTA BARBARA, CA 93103	0.15	CONDOS,COMMUNITY APT PROJ
22	22	031-391-011	GROUND	415 ALAMEDA PADRE SERRA	SANTA BARBARA, CA 93103	0.17	RESIDENTIAL INCOME, 2-4 UNITS
23	23	031-391-013	GROUND	411 ALAMEDA PADRE SERRA	SANTA BARBARA, CA 93103	0.16	RESIDENTIAL INCOME, 2-4 UNITS
24	24	031-391-014	GROUND	407 ALAMEDA PADRE SERRA	SANTA BARBARA, CA 93103	0.15	RESIDENTIAL INCOME, 2-4 UNITS
25	25	031-391-016	GROUND	1325 E GUTIERREZ ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
26	26	031-391-017	GROUND	1321 E GUTIERREZ ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
27	27	031-391-018	GROUND	1317 E GUTIERREZ ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
28	28	031-391-019	GROUND	1313 E GUTIERREZ ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
29	29	031-391-020	GROUND	1309 E GUTIERREZ ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
30	30	031-391-021	GROUND	1305 E GUTIERREZ ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
31	31	031-391-022	GROUND	1301 E GUTIERREZ ST	SANTA BARBARA, CA 93103	0.12	RESIDENTIAL INCOME, 2-4 UNITS
32	32	031-391-023	GROUND	410 N CANADA ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
33	33	031-391-024	GROUND	1308 BLANCHARD ST	SANTA BARBARA, CA 93103	0.12	RESIDENTIAL INCOME, 2-4 UNITS
34	34	031-391-025	GROUND	1310 BLANCHARD ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE
35	35	031-391-026	GROUND	1314 BLANCHARD ST	SANTA BARBARA, CA 93103	0.12	SINGLE FAMILY RESIDENCE

# Table Characteristics

- All tables
  - Row order doesn't matter
  - rows can be ordered on any column value(s)
- Columns are typed
  - QGIS: integer (32- and 64-bit), real, text, date
- Feature attribute tables
  - 1 row per feature
  - table row ← feature ID → geometry object
- 1 table per feature class
  - shapefile, coverage, geodatabase feature class, ...



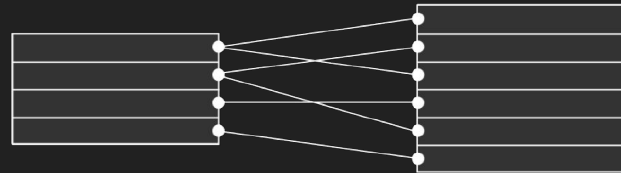
# Connecting Tables

- What if attributes are in more than 1 table?
- Create relationships between tables
- Cardinality:

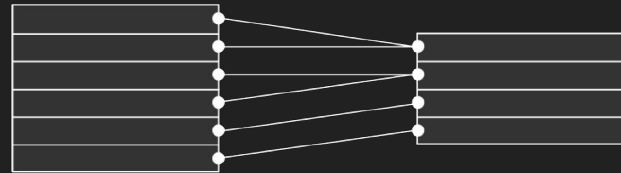
$$\#rows_{(table1)} \leftrightarrow \#rows_{(table2)}$$



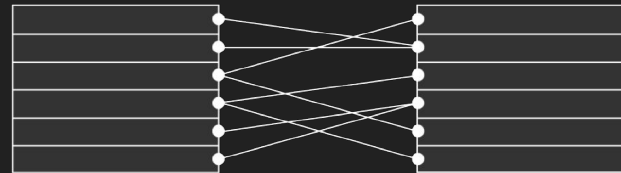
One-to-one relationship



One-to-many relationship



Many-to-one relationship



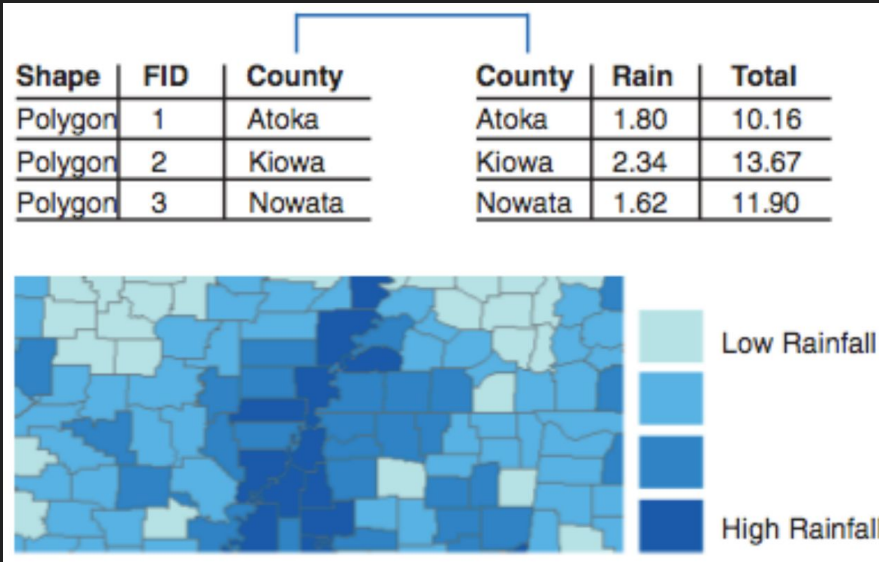
Many-to-many relationship

# Connecting Tables in QGIS

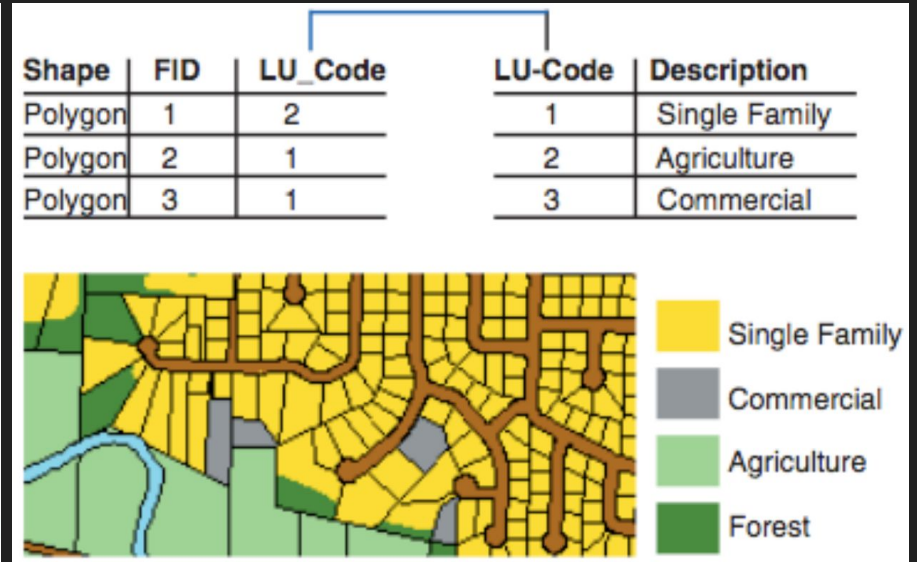
Connect tables using common key values

- join: concatenates
  - must be 1:1 or many:1
  - join attributes concatenated to target attribute table
  - property of layer within project
- relation: links (but keeps separate)
  - may be 1:many (many:many possible, but takes some fiddling)
  - only visible when features are queried (e.g. Identify)
  - property of project

# Join



1 to 1



many to 1

# Relation

1 to many (e.g. one soil map unit → two soil components)

## *mapunit*

musym	mukey
34	79523

## *component*

mukey	component
79523	Helmer
79523	Thatuna



NB: can't join 1-to-many: why? → would have to replicate features

# Summary: Tables in QGIS

QGIS isn't quite a database

- Enforces 1 feature  $\leftrightarrow$  1 attribute table row  
Joins and relations are part of project, not data
- Can't query multiple tables simultaneously  
Have to explicitly join or relate them first

# Tables in a Database

- Table = entity (a kind of thing)
  - e.g. teacher
- Row = instance of an entity (a single thing)
  - e.g. Niklas
  - also called: tuple
- Column = attribute of an entity
  - e.g. shoe size

A database is really picky about what you put in a table...

# Table Rules

- Only one value in each cell (intersection of row and column)
- All values in a column are about the same subject
- Each row is unique
- Column order doesn't matter
- Row order doesn't matter

# Usually Need More than 1 Table

- Avoid redundancy:  
if single table, then attribute values shared by  $>1$  instance must be repeated in each instance
  - e.g. 58 students taking ESM 263
  - ESM 263 meets in ~~Bren 1414~~ Bren 1424
  - 58 student records have Bren 1424 as meeting "place"
  - what happens when class "moves"?
- Consequences of redundancy
  - more sensitive to typos and transcription errors
  - fragile updates: have to change multiple copies
  - confusion: which one is the truth?



# How Databases Use Multiple Tables

- Eliminate redundancy by normalizing single table into multiple tables
  - Each table = single kind of thing
  - Each row = single thing
- Preserve relationships by references between tables
  - Collapse redundant attributes into single key (attribute shared between tables)
  - Relationships implied by matching key values

# How Databases Use Multiple Tables

Forests

Forest Name	Forest-ID	Location	Size
Nantahala	1	N. Carolina	184,447
Cherokee	2	N. Carolina	92,271

Trails

Trail Name	Forest-ID
Bryson's Knob	1
Slickrock Falls	2
North Fork	1
Cade's Cove	1
Cade's Cove	2
Appalachian	1
Appalachian	2

Table from Relational Join

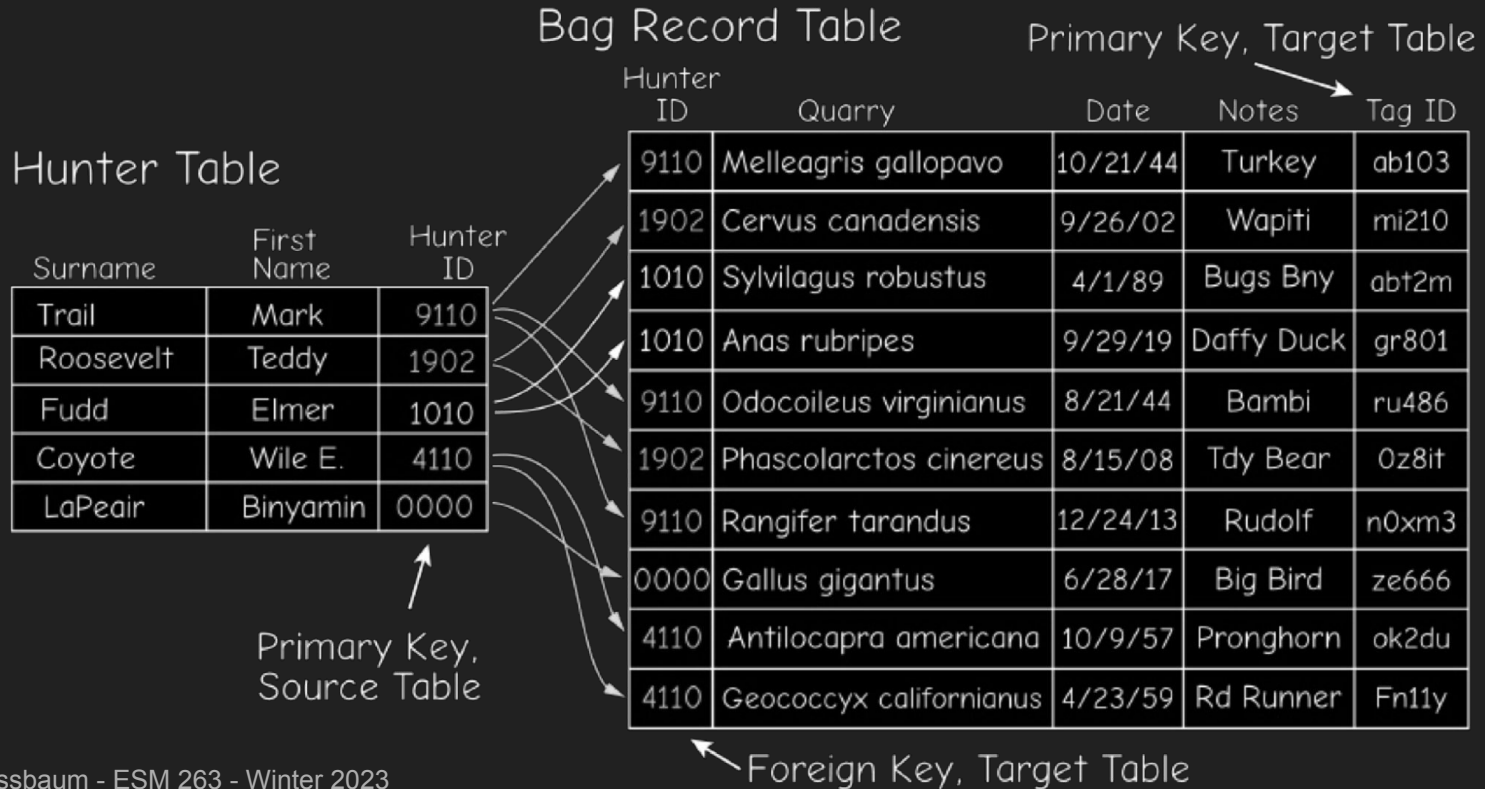
Forest Name	Forest-ID	Location	Size	Trail Name
Nantahala	1	N. Carolina	184,447	Bryson's Knob
Nantahala	1	N. Carolina	184,447	North Fork
Nantahala	1	N. Carolina	184,447	Cade's Cove
Nantahala	1	N. Carolina	184,447	Appalachian
Cherokee	2	N. Carolina	92,271	Slickrock Falls
Cherokee	2	N. Carolina	92,271	Cade's Cove
Cherokee	2	N. Carolina	92,271	Appalachian

# Keys

A key uniquely identifies, and can therefore be used as a reference to, a single row

- **Primary key:** attribute whose value uniquely identifies a row
  - Data values that are naturally unique  
may be more than 1 attribute
  - Arbitrary/synthetic value  
e.g. auto-incrementing counter
- **Foreign key**
  - attribute whose value corresponds to another row's  
(usually in another table) primary key
  - Foreign keys are how databases maintain explicit relationships  
between rows, within or between tables

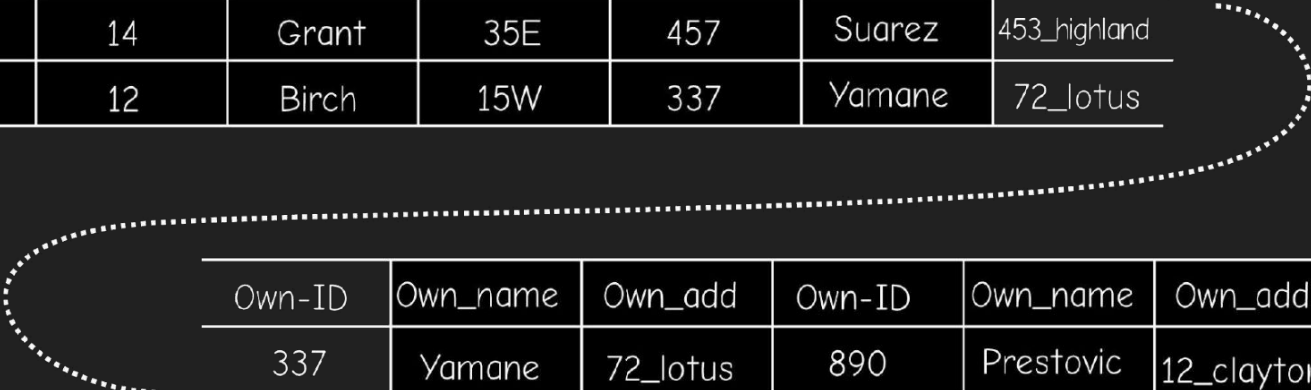
# Keys



# Normalization

Land Records table, unnormalized form

parcel-ID	Alderman	Tship-ID	Tship_name	Thall-add	Own-ID	Own_name	Own_add
2303	Johnson	12	Birch	15W	122	Devlin	123_pine
618	DeSilva	14	Grant	35E	457	Suarez	453_highland
9473	Johnson	12	Birch	15W	337	Yamane	72_lotus



Own-ID	Own_name	Own_add	Own-ID	Own_name	Own_add
337	Yamane	72_lotus	890	Prestovic	12_clayton
890	Prestovic	12_clayton	231	Sherman	64_richmond
-	-	-	-	-	-

# Normalization

Land Records table, first normal form (1NF)

parcel-ID	Alderman	Tship-ID	Tship_name	Thall-add	Own-ID	Own_name	Own_add
2303	Johnson	12	Birch	15W	122	Devlin	123_pine
2303	Johnson	12	Birch	15W	337	Yamane	72_lotus
2303	Johnson	12	Birch	15W	890	Prestovic	12_clayton
618	DeSilva	14	Grant	35E	457	Suarez	453_highland
618	DeSilva	14	Grant	35E	890	Prestovic	12_clayton
618	DeSilva	14	Grant	35E	231	Sherman	64_richmond
9473	Johnson	12	Birch	15W	337	Yamane	72_lotus

# Normalization

Land records tables, second normal form (2NF)

Land Records Table 1

parcel-ID	Alderman	Tship-ID	Tship_name	Thall-add
2303	Johnson	12	Birch	15W
618	DeSilva	14	Grant	35E
9473	Johnson	12	Birch	15W

Land Records Table 2

Own-ID	Own_name	Own_add
122	Devlin	123_pine
337	Yamane	72_lotus
890	Prestovic	12_clayton
457	Suarez	453_highland
231	Sherman	64_richmond

Land Records Table 3

parcel-ID	Own-ID
2303	122
2303	337
2303	890
618	457
618	890
618	231
9473	337

# Normalization

## Land records, third normal form

### Land Records 1a

FD: Parcel-ID → Tship-ID

Parcel-ID	Tship-ID
2303	12
618	14
9473	12

### Land Records 1b

FD: Tship-ID → Tship\_name, Thall\_add, Alderman

Tship-ID	Tship_name	Thall_add	Alderman
12	Birch	35W	Johnson
14	Grant	35E	DeSilva

### Land Records 2

FD: Own-ID → Own\_name, Own\_add

Own-ID	Own_name	Own_add
122	Devlin	123_pine
337	Yamane	72_lotus
890	Prestovic	12_clayton
457	Suarez	453_highland
231	Sherman	64_richmond

### Land Records 3

No Functional Dependencies

Parcel-ID	Own-ID
2303	122
2303	337
2303	890
618	457
618	890
618	231
9473	337



# References

- Chang, K.T., “Introduction to Geographic Information Systems, 5 th ed.” ISBN 007729436X
- Bolstad, P., “GIS Fundamentals, 6th ed.” ISBN 978-1-59399-552-2