UrbanFootprint Technical Documentation

BASE CANVAS CREATION

Revision Date: 11/06/2017

Table of Contents

OVERVIEW

UrbanFootprint scenarios are built on a base-year geospatial dataset that describes the existing environment. This detailed "canvas" of data constitutes a baseline assessment of land use, demographic characteristics, and other conditions, providing the context for scenario painting and the foundation for analysis by the modules. Base loading processes involve cleaning, compiling, and processing geographic and tabular data that come from a wide variety of sources. The UrbanFootprint canvas encompasses data from the following general categories:

- Residential fields
- Employment fields
- Parcel area fields
- Building area fields
- Irrigated area fields
- Roadway intersection density
- Built form type and land development category

The default scale for new projects in UrbanFootprint is the US Census Block. For each block, UrbanFootprint generates raw counts of population, dwelling units, jobs, and other demographic fields by using a combination of census data sources, including the 2010 Census Summary File 1 (SF1: blocks, from the short form), the 2012 American Community Survey 5-year data (available for the block group level), 2010 Longitudinal Employer-Household Dynamics (LEHD: blocks), the Environmental Protection Agency's Smart Location Database, and the Census Bureau's Area Landmarks dataset. As new versions of the source data becomes available, the UrbanFootprint base canvas is updated.

UrbanFootprint also supports base canvases (which are suitable for parcel-based scenarios) at the parcel scale. User-supplied data can be used to generate parcel-scale datasets if it is more refined than existing census data, and pre-generated processes can be used to import data from a census block canvas for the purpose of assigning the corresponding census data to parcels on the basis of parcel-level land use codes.

METHODOLOGY

Overview

The following section explains the definition of each field in the UrbanFootprint canvas. The fields are grouped into the following categories: Dwelling Units, Population, and Households; Employment; Building Area; Parcel Area; Irrigated Area; Intersection Density; and Built Form Types. The sources and method used to generate the base-year value of each attribute in the default block-level canvas are also detailed.

Dwelling Units, Population, and Households

Overview

Residential fields in the UrbanFootprint canvas include population, households, and dwelling units. Dwelling units are divided into four categories: large lot detached single-family, small lot detached single-family, attached single-family (townhomes), and multi-family.

The default source for counts of population, household, and total dwelling units is the US Census Bureau's Decennial Census, a survey of the US population that is collected every ten years. Dwelling unit counts that are categorized by type are not available via the Decennial census. Instead, dwelling unit count data is collected from the American Community Survey (ACS), which surveys a sample of the US population every year. The data from these surveys is then used to calculate one--, three--, and five-year averages on the basis of the data's geographic specificity. Dwelling unit by type fields are determined according to five-year averages calculated at the census block group scale. These averages are first converted to percentages, such as the percentage of dwelling units in the block group that are multi-family units. Next, these percentages are multiplied by the total number of dwelling units listed in the Decennial census to estimate the number of dwelling units in each category. Because the percentage fields derived from the ACS are just estimates from a sample of the population, the percentages may not exactly match real conditions, especially at small scales. The default UrbanFootprint process for determining the number of dwelling units of each type involves rounding the resulting values such that they are all integers (not fractions of a dwelling unit) and their sum is equal to the original number of total dwelling units. Table 1 includes the field definitions and the method used to calculate their base canvas values.

Table 1: Default Source and Definition of Residential Fields in the UrbanFootprint Canvas

UrbanFootprint Canvas Field	Census API Field Code	Census Field Description	Description (from US Census)
Decennial Census Variables (SF1)[1]			
Population	P0160001[2]	Population	A household includes all the people who occupy a housing

---

[1] https://www.census.gov/

[2] UrbanFootprint uses 'Population in Households' instead of 'Total Population' as the default population variable. In the decennial census, Total Population = Population in Households + Population in Group Quarters.

(pop)		in Households	unit. (People who don't live in households are considered to be living in group quarters.) A housing unit is a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or intended to be occupied) as separate living quarters. Separate living quarters are those in which the occupants live separately from any other people in the building and which can be directly accessed from the outside of the building or a common hall. The occupants may be a single family, one person living alone, two or more families living together, or any other group of related or unrelated people who share living arrangements. In the 2010 Census data products, the count of households or householders equals the count of occupied housing units.[3]
Population - Group quarters (pop_groupquarters)	P0430001	Population in group quarters	Group quarters are places where people live or stay in a group living arrangement, owned or managed by an entity or organization that provides housing and/or services for the residents. This is not a typical household-type living arrangement. These services may include custodial or medical care as well as other types of assistance, and residency is commonly restricted to those receiving these services. People living in group quarters are usually not related to each other. Group quarters include places such as college residence halls, residential treatment centers, skilled-nursing facilities, group homes, military barracks, correctional facilities, and workers dormitories.[4]
Households (hh)	H0030002	The total number of occupied housing units.[5]	A housing unit is classified as occupied if it is the current residence of the person or group of people living in it at the time of the interview or if the occupants are only temporarily absent from the residence for two months or less, that is, away on vacation or a business trip. If all the people staying in the unit at the time of the interview will be staying there for two months or less, the unit is considered to be temporarily occupied, and it is classified as "vacant." The occupants may be a single family, one person living alone, two or more families living together, or any other group of related or unrelated people who share living quarters. Within any group quarters, the living quarters occupied by staff personnel are separate housing units if they satisfy the housing unit criteria of separateness and direct access; otherwise, they are considered group quarters. Occupied rooms or suites of rooms in hotels, motels, and similar places are classified as housing units only when occupied by permanent residents, that is, people who consider the hotel to be their current place of residence and people who have no other place of residence. If any of the occupants in rooming or boarding houses, congregate housing, or continuing care facilities live separately from others in the building and have direct access, their quarters are classified as separate housing units.

---

[3] https://www.socialexplorer.com/data/C2010/metadata/?ds=SF1&table=P0160
[4] https://www.socialexplorer.com/data/C2010/metadata/?ds=SF1&table=P0430
[5]
https://www.socialexplorer.com/data/C2010/documentation/a8275d61-31b5-4018-abe5-4824ddbe4564#a8275d61-31b5-4018-abe5-4824ddbe4564

| Dwelling Units (du) | H00010001 | Total Housing Units | A housing unit may be a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or intended for occupancy) as separate living quarters. Separate living quarters are those in which the occupants live separately from any other individuals in the building and which can be directly accessed from the outside of the building or a common hall. The criteria of separateness and direct access are applied to the intended occupants of vacant units whenever possible. If that information cannot be obtained, the criteria are applied to the previous occupants.

Both occupied and vacant housing units are included in the housing unit inventory. Boats, recreational vehicles (RVs), vans, tents, railroad cars, and the like are included only if they are someone's current residence. Vacant mobile homes are included if they are intended to be occupied where they stand. Vacant mobile homes on dealers' sales lots, at the factory, or in storage yards are excluded from the housing inventory. Also excluded are quarters that are being used entirely for nonresidential purposes, such as a store, an office, or quarters in which business supplies or inventory, machinery, or agricultural products are stored. |
|---|---|---|---|
| American Community Survey 5-year Average Fields[6] | | | |
| Detached Single-Family Dwelling Units (du_detsf) | B25024_002E | 1 Unit - Detached[7] | This is a one-unit structure that is not attached to any other house, that is, with open space on all four sides. Such structures are considered detached even if they have an adjoining shed or garage. A single-family house that contains a business is considered detached as long as the building has open space on all four sides. Mobile homes to which one or more permanent rooms have been added are also included. |
| | B25024_010E | Mobile Home | Both occupied and vacant mobile homes to which no permanent rooms have been added are counted in this category. Mobile homes used only for business purposes or for extra sleeping space and mobile homes that are on a dealer's lot for sale, are at the factory, or are in storage are not counted in the housing inventory. |
| | B25024_011E | Boat, RV, Van, Etc. | This category is for living quarters that are occupied as a housing unit and do not fit the previous categories. Examples include are houseboats, railroad cars, campers, and vans. Recreational vehicles, boats, vans, tents, railroad cars, and the like are included only if they are someone's current residence. |
| Attached Single-Family Dwelling Units (du_attsf) | B25024_003E | 1-Unit, Attached | This is a one-unit structure that is separated from adjoining structures by one or more walls that extend from the ground to the roof. In row houses (sometimes called townhouses), double houses, or houses attached to nonresidential structures, each house is a separate, attached structure if the dividing or common wall extends from the ground to the roof. |

---

[6] https://www.census.gov/programs-surveys/acs/

[7] https://www.socialexplorer.com/data/ACS2013_5yr/metadata/?ds=ACS13_5yr&var=B25024002

UrbanFootprint.com

Multi-family Dwelling Units (2 to 4 Units) du_mf_2to4	B25024_004E, B25024_005E	2 to 4 Apartments	These are units in structures containing 2–4 housing units.
Multi-family Dwelling Units (5 or more Units) du_mf_5p	B25024_006E, B25024_007E, B25024_008E, B25024_009E	5 or more Apartments	These are units in structures that contain 5 or more housing units and have "5 to 9," "10 to 19," "20 to 49," or "50 or more apartments."

Calculations

UrbanFootprint divides detached single-family homes into two categories: large lot detached single-family homes and small lot detached single-family homes. By default, UrbanFootprint considers lot sizes under 5,500 sq. ft. to be small lots and classifies lots that have an area greater than 5,500 sq. ft. as large lots. Users can change this default during the canvas generation process. These categories are handled differently when the canvas is parcel based and simply categorize single-family detached units according to the area of their parcel geometries. At the block scale, imputing these fields is slightly more difficult. When parcel data is available, the percentage of lots on either side of the lot size threshold can be used to impute the number of large lot and small lot units. When parcel data is unavailable, units are assumed to be evenly distributed between the two categories.

Employment

Overview

Employment in the UrbanFootprint canvas is directly tied to North American Industry Classification System (NAICS)[8] codes. In general, UrbanFootprint employment categories map to two-digit NAICS codes, which outline broad employment categories. The actual crosswalk of NAICS codes to UrbanFootprint employment categories appears in Table 2. By default, UrbanFootprint uses employment data from the US Census Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES) dataset[9], which is released yearly. In particular, the default base canvas utilizes the Workplace Area Characteristics (WAC) dataset, which gives general block-level data on job locations. The specific WAC field codes used to populate UrbanFootprint employment categories are in Table 2.

Table 2: Crosswalk from LEHD Employment Counts to UF Types

UrbanFootprint Canvas Employment Category	LODES WAC Field Code	NAICS Sector
Extraction Employment	CNS01	Number of jobs in NAICS sector 11 (Agriculture, Forestry,

---

[8] https://www.census.gov/eos/www/naics/
[9] https://lehd.ces.census.gov/data/#lodes

UrbanFootprint.com

(emp_extraction)		Fishing and Hunting)
Agriculture Employment (emp_agriculture)	CNS02	Number of jobs in NAICS sector 21 (Mining, Quarrying, and Oil and Gas Extraction)
Utilities Employment (emp_utilities)	CNS03	Number of jobs in NAICS sector 22 (Utilities)
Construction Employment (emp_construction)	CNS04	Number of jobs in NAICS sector 23 (Construction)
Manufacturing Employment (emp_manufacturing)	CNS05	Number of jobs in NAICS sector 31-33 (Manufacturing)
Wholesale Employment (emp_wholesale)	CNS06	Number of jobs in NAICS sector 42 (Wholesale Trade)
Retail Services Employment (emp_retail_services)	CNS07	Number of jobs in NAICS sector 44-45 (Retail Trade)
Transport Warehousing Employment (emp_transport_warehousing)	CNS08	Number of jobs in NAICS sector 48-49 (Transportation and Warehousing)
Office Services Employment (emp_office_services)[10]	CNS09	Number of jobs in NAICS sector 51 (Information)
	CNS10	Number of jobs in NAICS sector 52 (Finance and Insurance)
	CNS11	Number of jobs in NAICS sector 53 (Real Estate and Rental and Leasing)
	CNS12	Number of jobs in NAICS sector 54 (Professional, Scientific, and Technical Services)
	CNS13	Number of jobs in NAICS sector 55 (Management of Companies and Enterprises)
	CNS14	Number of jobs in NAICS sector 56 (Administrative and Support and Waste Management and Remediation Services)
Education Employment (emp_education)	CNS15	Number of jobs in NAICS sector 61 (Educational Services)
Medical Services Employment (emp_medical_services)	CNS16	Number of jobs in NAICS sector 62 (Health Care and Social Assistance)
Arts & Entertainment Employment (emp_arts_entertainment)	CNS17	Number of jobs in NAICS sector 71 (Arts, Entertainment, and Recreation)

---

[10] emp_office_services is the sum of employment counts for NAICS sectors 51 - 56.

Restaurant Employment (emp_restaurant)[11]	CNS18	Number of jobs in NAICS sector 721 (Accommodation)
Accommodation Employment (emp_accommodation)[12]		Number of jobs in NAICS sector 722 (Food Services)
Other Services Employment (emp_other_services)	CNS19	Number of jobs in NAICS sector 81 (Other Services [except Public Administration])
Public Administration Employment (emp_public_admin)	CNS20	Number of jobs in NAICS sector 92 (Public Administration)
Military Employment (emp_military)[13]	-	Number of jobs in NAICS sector 9281 (National Security)

Nesting Categories for Employment Fields

To make it easier to compare changes across scenarios, employment categories are nested in the UrbanFootprint canvas. Table 3 outlines the nesting structure for employment fields.

Table 3: UrbanFootprint Employment Categories

UrbanFootprint Grouped Employment Categories	UrbanFootprint Canvas Employment Types
All Agriculture Employment (emp_ag)	emp_extraction
	emp_agriculture
All Industrial Employment (emp_ind)	emp_utilities
	emp_construction
	emp_manufacturing
	emp_wholesale
	emp_transport_warehousing
All Office Employment	emp_office_services

---

[11] Restaurant and Accommodation employees are grouped into the same two-digit NAICS sector. Accommodation and Food Services employees are assumed to be equally split between restaurant and accommodation sectors for the purpose of separating these sectors for the default block-level canvas.
[12] Restaurant and Accommodation employees are grouped into the same two-digit NAICS sector. Accommodation and Food Services employees are assumed to be equally split between restaurant and accommodation sectors for the purpose of separating these sectors for the default block-level canvas.
[13] Four-digit NAICS codes are not available in the census LODES dataset, making it difficult to differentiate military employees from general public administration employees. emp_military therefore defaults to 0 in the block-level canvas. When better NAICS employment data or land use codes are available, military employees should be separated from emp_public_admin.

(emp_off)	emp_medical_services
All Retail Employment (emp_ret)	emp_retail_services
	emp_arts_entertainment
	emp_restaurant
	emp_accommodation
	emp_other_services
All Public Employment (emp_pub)	emp_education
	emp_public_admin
All Military Employment (emp_mil)	emp_military

Intersection Density

Overview

The calculation of intersection density is based on a reference dataset of all known intersections, which is compiled at the Census block level. The method used to create this block-level intersections database is outlined below. From this cleaned and validated intersections reference, each component of the base canvas (e.g., each parcel or Census block) derives its intersection density value.

Unique intersections are derived from OpenStreetMap (OSM) data. Intersections are cleaned by the consolidation into a single intersection of all intersections that are within 15 meters (about 50 feet) of another intersection. This resolves cases such as boulevards, which would be represented as single intersections that include multiple nodes in OSM data. An intersection is defined as the intersection of any two walk or drive network segments. The intersection density of each Census block is the ratio of all intersections that lie within 400 meters of the the parcel to the block's equivalent buffered area. To ensure relative consistency between census blocks, the buffered area is used to generate a floating point average that normalizes all locations with respect to their surroundings.

Place Type & Land Development Category

Overview

Each UrbanFootprint canvas geometry, whether census block, parcel, or other, is classified by UrbanFootprint built form type (a place type or building type) as well as general land use type, the Land Development Category (LDC). Together, these designations are used to represent land development patterns as indicated by the information related to each canvas geometry. The built form and LDC classifications are important aspects of scenario modeling and analysis.

Land Development Category (LDC)

Land Development Category is a classification based on four broad development patterns: Urban Infill ("Urban"), Compact Walkable ("Compact"), Suburban ("Standard"), and Rural. The Urban LDC represents areas (typically within moderate and high density urban centers) that have the highest intensity and mix of uses. Compact areas are less intensely developed than Urban areas but very walkable in part because of their mix of residential, commercial, and civic uses. "Standard" represents auto-oriented, separate-use suburban development patterns, and "Rural" represents rural development.

LDC is assigned to canvas geographies according to two criteria: intersection density per square mile and activity density (i.e., dwelling units and employment densities). The LDC classification is used for some analysis functions (namely, those within the Fiscal Impacts module), and serves to communicate scenario concepts and results simply.

LDC represents four classifications:
- Urban: intersection density >= 150 per sq. mi. and (emp/gross-acres > 70 or du/gross-acres > 40
- Compact: intersection density >= 150 per sq. mi. and (emp/gross-acres <= 70 or du/gross-acres <= 40)
- Standard (suburban): intersection density < 150 per sq. mi.
- Rural: guidelines based on local conditions

The given guidelines are UrbanFootprint defaults. Users can specify different guidelines for each classification as part of the canvas generation process.

Built Form Key (Building Type/Place Type)
UrbanFootprint includes a library of more than 35 place types and more than 50 building types, which make up the palette of development options used to translate or "paint" scenarios. Users can use their own Built Form libraries to include new land use types or types that are calibrated to regional conditions. The process of building new type libraries will be documented after the feature is released.

Calculations
Built form keys are assigned to canvas geographies on the basis of comparisons between data in the canvas geographies and data in the place types or building types. Aggregate base canvases such as census blocks are assigned place types by default, and parcel-scale base canvases are assigned building types.

From the default library's 35 place types, 3 mutually exclusive sets of place types and canvas geographies are compiled:
1. Intersection density >= 150
2. Intersection_density < 150 AND (number of retail employees <= 30% of total employees OR retail employee density < 3 employees/acre)
3. Intersection density < 150 AND number of retail employees > 30% of total employees AND retail employee density > 3 employees/acre

Within each set, the canvas geographies are assigned the place type that "most closely" matches them. "Closeness" is the standardized difference between the place type and canvas geography of default, dwelling units, and employment density.

First, the geometry data of the place type and the canvas geography attributes is standardized by subtracting the mean and dividing by the standard deviation of the corresponding place types set. Second, each canvas geography's standardized attribute score is compared to the standardized score of the attribute in the corresponding place types. The differences are then squared and summed. The place type which corresponds to the least sum-of-squares is assigned to that canvas geography. If the dwelling unit density and employment density were the axes of a two-dimensional graph, this sum-of-squares would represent the distance between a canvas geography data point and a place type data point. Therefore, the least sum-of-squares would represent the place type that is "closest" to the canvas geography data point. Similarly, multiple attributes could be represented on an n-dimensional graph.

Built form keys are assigned to base parcel canvases in a similar manner, except base parcel canvases are assigned building types and the mutually exclusive sets are more fine-grained than the sets used in the place typing process. Each geography of each parcel canvas will be associated with a UF-based land use code. This land use code will be associated with a list of building types; this association effectively limits the number of building types the geography can be assigned. The process of typing building types by "closeness" will be the same as described in the previous paragraph.

Area Fields

Overview
The UrbanFootprint canvas includes several "area" fields that contain information related to various aspects of the built environment. These fields include gross area, net (parcel), right-of-way area, and the net area field for a given development condition. Combined, these fields allow for planning with both aggregate geometries (such as census blocks) and disaggregate geometries (such as parcels). The following section describes each of these area fields in greater detail.

Gross Area
The acreage of each canvas geography of the geometry, including right-of-ways and other areas dedicated to civic infrastructure.

Net Area (Parcel)
The total parcel acreage of each canvas geography. Unlike "gross" area, parcel area is considered equivalent to "net" developable area. For block-level base canvases, "area_parcel" is the total area of the parcel geometries in in a given block; for parcel-level canvasses, it represents the area of the given parcel. The parcel area of base canvases at the parcel scale can be 100% of the canvas geographies' gross area.

Right-Of-Way Area (ROW)

ROW represents the total acreage of the right-of-way area (roadways + sidewalks) in each canvas geography of the base canvas.

Net Area (Parcel) For The Given Development Condition (area_dev_condition)

This represents the total acreage of a given subtype development condition table (constrained, unconstrained, or by dev-condition). This field represents the same thing as parcel area represents in the base canvas, however, it is different in UrbanFootprint 'Breakout' canvases, which are used to keep track of data on the basis of its land use category and whether it is constrained in a particular scenario.

Parcel Area By Use Type

Beyond the simple Net Area field, the UrbanFootprint canvas includes several fields that represent parcel area by type . These fields contain information about how much of a certain geometry pertains to different land uses. The "by type" parcel area fields of disaggregative geometries (such as parcels) are equal to the parcel area if the parcel contains any of the particular use type (i.e., multi-family dwelling units).

Building Square Footage

Overview

Building floor area fields for various commercial and residential uses are included in the UrbanFootprint canvas to facilitate a detailed assessment of a project's land use. Users can populate these canvas fields with empirical inputs or more accurate modeling. If empirical data is not available, UrbanFootprint uses a model to estimate these fields. In this model, building area is tied to the number and type of dwelling units or employees. It is also related to whether the building is located in a suburban or an urban environment, as specified by the UrbanFootprint Land Development Category (LCD) field. The default value of 150 intersections per square mile differentiates Urban areas from Compact areas and Suburban areas from Rural areas. Building area per dwelling unit and per employee are usually lower in Urban/Compact areas than in Suburban/Rural areas, reflecting the smaller housing types and higher-intensity commercial building types that comprise compact development patterns. The default assumptions, which are based on studies of areas in various parts of the US, are summarized in Table 4. Note that these factors are starting points; project work that is more detailed typically involves calibration with local data.

Table 4: Default Building Area Assumptions

Building Area Field	Square Feet Multiplier per Dwelling Unit or Employee	
	Urban/Compact (Intersection Density >= 150 per square mile)	*Suburban/Rural (Intersection Density < 150 per square mile)*
Small Lot Detached-	1,650	2,400

Single-Family		
Large Lot Detached- Single-Family	2,100	3,000
Attached- Single-Family	1,800	1,800
Multifamily (2– 4 units in structure)	1,850	2,000
Multi-family (5+ units in structure)	1,200	1,200
Retail Services	475	750
Restaurant	475	750
Accommodation	1,850	2,000
Entertainment	900	1,200
Other Services	650	850
Office Services	280	350
Public Admin	620	700
Education	900	1,050
Medical Services	725	800
Transport/Warehousing	1,200	1,700
Wholesale	600	660

Residential & Commercial Irrigated Area

Overview
Estimates of the irrigated area of the base canvas are based on National Land Cover Dataset[14] (NLCD) land use categories. The NLCD is the most comprehensive land cover dataset that is available nation-wide. The amount of pervious land in each parcel can be categorized according to the NLCD system, and the irrigated portion of the parcel can be estimated. In UrbanFootprint, land use classifications are reduced to four major land use types—urban, greenfield, woodland, and agriculture—on the basis of the corresponding NLCD pixel values, as shown in Table 5. Each geometry is then assigned a percentage of area coverage for each land use type on the basis of analysis that overlays NLCD pixel-based data with the given canvas.

---

[14] https://www.mrlc.gov/nlcd2011.php

Table 5: Aggregate NLCD Classification and Irrigation Percentages

NLCD Pixel Value	UrbanFootprint Land Use Classification	Percent Previous Land Use	Percent Irrigated Portion
21	Urban	90%	70%
22	Urban	65%	70%
23	Urban	35%	70%
24	Urban	10%	70%
11	Greenfield	0%	0%
12	Greenfield	0%	0%
31	Greenfield	15%	0%
51	Greenfield	100%	0%
52	Greenfield	100%	0%
72	Greenfield	100%	0%
73	Greenfield	100%	0%
74	Greenfield	100%	0%
90	Greenfield	100%	0%
95	Greenfield	100%	0%
41	Woodland	100%	0%
42	Woodland	100%	0%
43	Woodland	100%	0%
71	Agriculture	100%	100%
81	Agriculture	100%	100%
21	Agriculture	100%	100%

Eq. 1: Irrigated acres per geometry

$$\sum_{i=0}^{N} \% \ coverage \ of \ pixel \ value_i \ \times \% \ pervious \ land \ of \ pixel \ value_i \ \times$$

$\% \ irrigated \ land \ of \ pervious \ coverage \ of \ pixel \ value_i \times total \ geometry \ area$, for i in pixel value

Eq. 2: Residential irrigated acres per geometry

$$\sum_{i=0}^{N} \% \text{ coverage of pixel value }_i \times \% \text{ pervious land of pixel value }_i \times$$

$$\% \text{ irrigated land of pervious coverage of pixel value}_i \times (\text{residential acres} + 0.5 \times \text{mixed use acres}) ,$$
for i in pixel value of urban classification

Eq. 3: Commercial irrigated acres per geometry

$$\sum_{i=0}^{N} \% \text{ coverage of pixel value }_i \times \% \text{ pervious land of pixel value }_i \times$$

$$\% \text{ irrigated land of pervious coverage of pixel value}_i \times (\text{commercial acres} + 0.5 \times \text{mixed use acres}) ,$$
for i in pixel value of urban classification

OUTPUT

The result of this process is the complete UrbanFootprint canvas. Table 6 summarizes the schema of the canvas table and provides the specific field names and units used.

Table 6: UrbanFootprint Complete Canvas Schema

Column name	Definition	Data type	Unit
id	Unique, UF-generated id	int	--
id_source	ID from original source data	int or varchar	--
geometry	Geometry key	geometry	--
UF DEVELOPMENT TYPOLOGIES			
land_development_category	UF Land Development Category	categorical string	--
built_form_key	UF Building/Place types	categorical string	--
intersection_density	Road intersections density	float (density)	intersections per sq. mi.

AREA	Definition	Data type	Unit
area_gross	Gross area of canvas geography	float	acres
area_parcel	Parcel area of canvas geography	float	acres
area_row	Right-of-way area (roads + sidewalks)	float	acres

area_dev_condition	Parcel area of given development condition	float	acres

DEMOGRAPHICS	Definition	Data type	Unit
pop	Resident population	float	person
pop_groupquarter	Resident pop. in group quarters	float	person
hh	Households (occupied dwelling units)	float	housing units
du	**SUM OF ALL DWELLING UNITS**	**float**	**housing units**
du_detsf	**Sum of detached single-family units**	float	housing units
du_detsf_ll	Detached single-family, large lot	float	housing units
du_detsf_sl	Detached single-family, small lot	float	housing units
du_attsf	**Attached single-family (townhomes)**	**float**	**housing units**
du_mf	**Sum of multi-family units**	**float**	**housing units**
du_mf_2to4	Multi-family, 2 to 4 units	float	housing units
du_mf_5p	Multi-family, 5 or more units	float	housing units
emp	**SUM OF ALL EMPLOYMENT**	**float**	**person**
emp_ret	**Sum of emp retail subtypes**	float	person
emp_retail_services	Emp retail services	float	person
emp_restaurant	Emp restaurant	float	person
emp_arts_entertainment	Emp arts and entertainment	float	person
emp_accommodation	Emp accommodation	float	person
emp_other_services	Emp other services	float	person
emp_off	**Sum of emp office subtypes**	float	person
emp_office_services	Emp office services	float	person
emp_medical_services	Emp medical services	float	person
emp_pub	**Sum of emp public subtypes**	float	person
emp_public_admin	Emp public administration	float	person

emp_education	Emp education	float	person
emp_ind	**Sum of emp industrial subtypes**	float	person
emp_manufacturing	Emp manufacturing	float	person
emp_wholesale	Emp wholesale	float	person
emp_transport_warehousing	Emp transport warehousing	float	person
emp_utilities	Emp utilities	float	person
emp_construction	Emp construction	float	person
emp_ag	**Sum of emp agricultural subtypes**	float	person
emp_agriculture	Emp agriculture	float	person
emp_extraction	Emp extraction (mining)	float	person
emp_military	**All emp military**	float	person

BUILDING AREA BY TYPE	Definition	Data type	Unit
bldg_area_detsf_sl	Small lot detached single-family building area	float	sq. ft.
bldg_area_detsf_ll	Large lot detached single-family building area	float	sq. ft.
bldg_area_attsf	Attached single-family building area	float	sq. ft.
bldg_area_mf	Multi-family building area	float	sq. ft.
bldg_area_retail_services	Building area utilized by retail services	float	sq. ft.
bldg_area_restaurant	Building area utilized by restaurants	float	sq. ft.
bldg_area_arts_entertainment	Building area utilized for arts and entertainment	float	sq. ft.
bldg_area_accommodation	Building area utilized for accommodation	float	sq. ft.
bldg_area_other_services	Building area utilized by 'other services" employment	float	sq. ft.
bldg_area_office_services	Building area utilized by office services	float	sq. ft.
bldg_area_medical_services	Building area utilized by medical services	float	sq. ft.

bldg_area_public_admin	Building area utilized for public administration	float	sq. ft.
bldg_area_education	Building area utilized for education	float	sq. ft.
bldg_area_transport_warehousing	Building area utilized for transportation and warehousing	float	sq. ft.
bldg_area_wholesale	Building area utilized for wholesale	float	sq. ft.
residential_irrigated_area	Outdoor area covered with turfgrass and associated with residential buildings	float	sq. ft.
commercial_irrigated_area	Outdoor area covered with turfgrass and associated with commercial buildings	float	sq. ft.

PARCEL AREA BY USE TYPE	Definition	Data type	Unit
area_parcel_res	Sum of area in residential use	float	acres
area_parcel_emp	Sum of area in commercial use	float	acres
area_parcel_mixed_use	Sum of area in mixed-use	float	acres
area_parcel_no_use	Sum of area with 'other' use	float	acres
area_parcel_res_detsf	Parcel area with detached single-family use	float	acres
area_parcel_res_detsf_sl	Parcel area with small lot detached single-family use	float	acres
area_parcel_res_detsf_ll	Parcel area with large lot detached single-family use	float	acres
area_parcel_res_attsf	Parcel area with attached single-family use	float	acres
area_parcel_res_mf	Parcel area with multi-family use	float	acres
area_parcel_emp_ret	Parcel area with retail employment use	float	acres
area_parcel_emp_off	Parcel area with office employment use	float	acres
area_parcel_emp_pub	Parcel area with public employment use	float	acres
area_parcel_emp_ind	Parcel area with industrial employment use	float	acres

area_parcel_emp_ag	Parcel area with agricultural employment use	float	acres
area_parcel_emp_military	Parcel area with military employment use	float	acres

UrbanFootprint.com