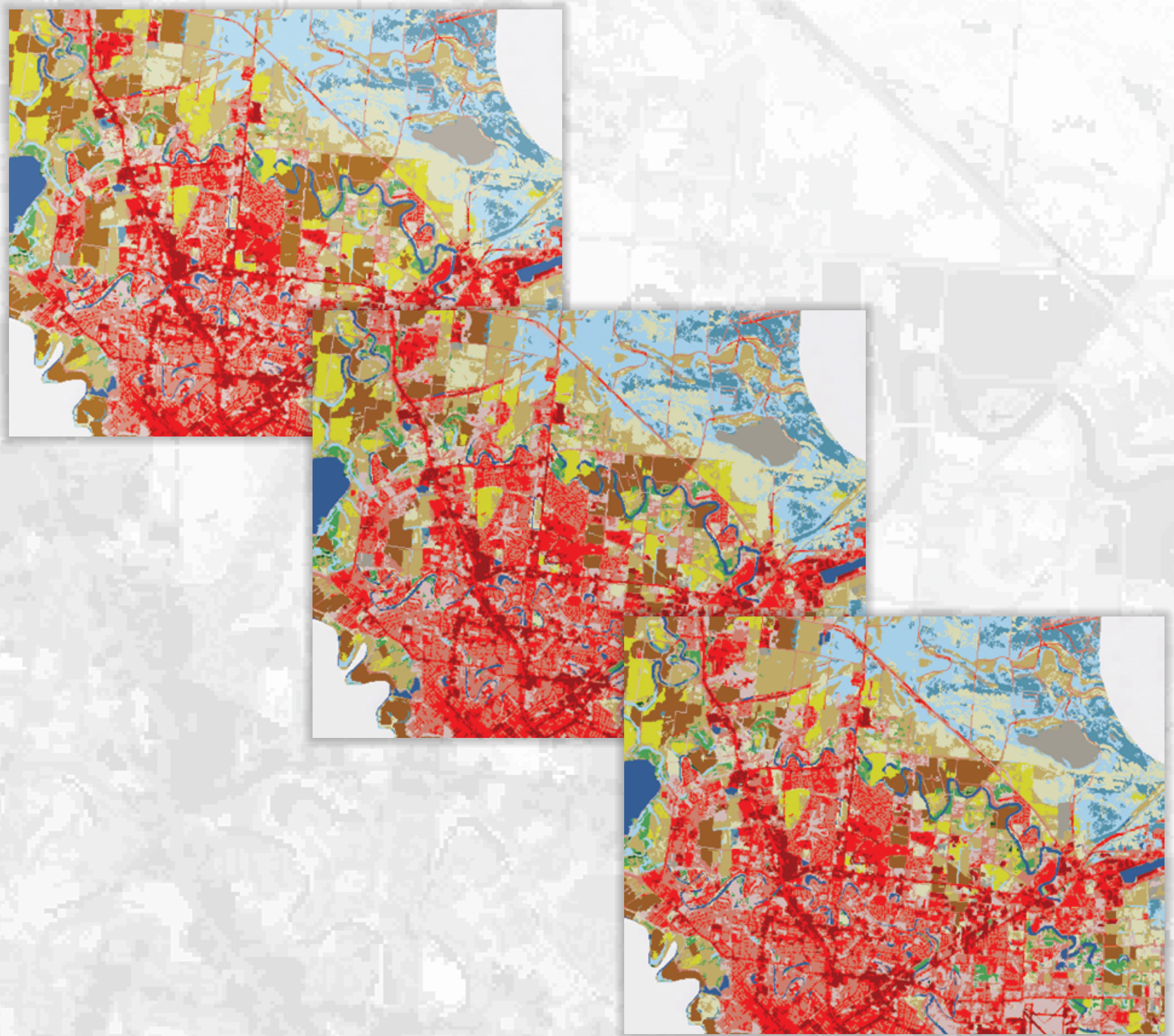
Land-Use and Land-Cover Change in the Lower Rio Grande Ecoregions, Texas, 2001–2011



Data Report 1185

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Cover. Images show land cover (from the National Land Cover Database) in Brownsville, Texas, from 2001 through 2011.

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Contents

Figures

Tables

Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Area	
hectare (ha)	2.471	acre

Abbreviations

AVA	aggregation, validation, and attribution
EPA	U.S. Environmental Protection Agency
GAP	Gap Analysis Project
LRG	Lower Rio Grande
LULC	land use and land cover
MSA	Metropolitan Statistical Area
TWRI	Texas Water Resources Institute
USGS	U.S. Geological Survey

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Abstract

Urban growth and other land-use changes were examined in the Lower Rio Grande Valley and Alluvial Floodplain ecoregions in Texas, along the United States-Mexico border. The analysis focused on understanding the types and causes of land change as well as the recovery of natural land-cover types between years 2001 and 2011. The purpose was to develop improved capabilities for understanding land change dynamics in urbanizing ecoregions and to provide data for further analyses. The spatial data, including metadata, allows further exploration and characterization of changes affecting this dynamic region.

Introduction

Urban expansion and associated changes to the surrounding land use and land cover (LULC) are significant contributors to ecoregion change. Urbanization impacts biodiversity, animal migrations, and other ecosystem characteristics across multiple scales that often require new management approaches (McDonald and others, 2008; Howard and Davis, 2009; Alberti, 2010). Urban growth directly replaces natural land cover and prior land uses. Urbanization and related social and economic changes can also cause changes in the surrounding region, such as expansion of intensive agriculture or land conservation to satisfy recreation, aesthetic, or wildlife habitat needs.

Here, we examine land use, land cover, and urban dynamics between 2001 and 2011 in the Lower Rio Grande (LRG) Valley and LRG Alluvial Floodplain ecoregions of Texas, along the southernmost extent of the United States-Mexico border. Urbanization in the LRG was driven by one of the fastest growing metropolitan populations in the United States during the study period (Frey, 2012). This diverse natural landscape is becoming increasingly urban but retains remnants of unique habitats shaped at the convergence of subtropical, temperate, coastal, and desert influences (Griffith and others, 2007).

Examination of the changing balance between development and landscape conservation is relevant to habitat management and policy; however, the necessary temporal information is often difficult to discern from existing LULC data—such as those in the National Land Cover Database (Dewitz and U.S. Geological Survey, 2021)—which are meant for regional-scale analysis rather than site-specific studies of change (Drummond and others, 2015; Homer and others, 2015). Without detailed information about the causes of change, the dynamics of change and elements of landscape recovery across urban landscapes are often lacking (Drummond and others, 2015). Therefore, our efforts focused on using an existing method for the aggregation, revision, and validation of many different existing LULC data to improve the understanding of urbanization and landscape change (Drummond and others, 2017).

In this framework, the dynamics of landscape recovery were given equal consideration to the more common analysis of habitat loss. Changes were also examined to identify the processes and causes of land conversion. As a result, we can better understand the underlying factors and relative importance of the distinct types of change that ultimately impact the southern Texas ecosystem.

Study Area

The Lower Rio Grande (LRG) study area is the combination of two U.S. Environmental Protection Agency (EPA) level IV ecoregions: the Lower Rio Grande Valley (LRG Valley) ecoregion (34e) and the Lower Rio Grande Alluvial Floodplain (LRG Floodplain; ecoregion 34f) (EPA, 2013) (fig. 1). The LRG covers an area of approximately 602,000 hectares (ha) and extends to parts of Cameron, Hidalgo, and Willacy Counties. Urbanization in the LRG region of Texas is predominantly driven by population growth in Hidalgo County's McAllen-Edinburg-Mission, Texas, Metropolitan Statistical Area (MSA), which was ranked amongst the five fastest growing metropolitan areas during 2001–2004 and 2007–2010 (Frey, 2012). Metropolitan population growth for Cameron County's Brownsville-Harlingen, Texas, MSA and the McAllen-Edinburg-Mission MSA both exceeded the percent population growth for Texas and the United States from 2001 to 2011. Population in Cameron, Hidalgo, Willacy, and Starr Counties is expected to more than double between 2003 and 2050 (Knight, 2009).

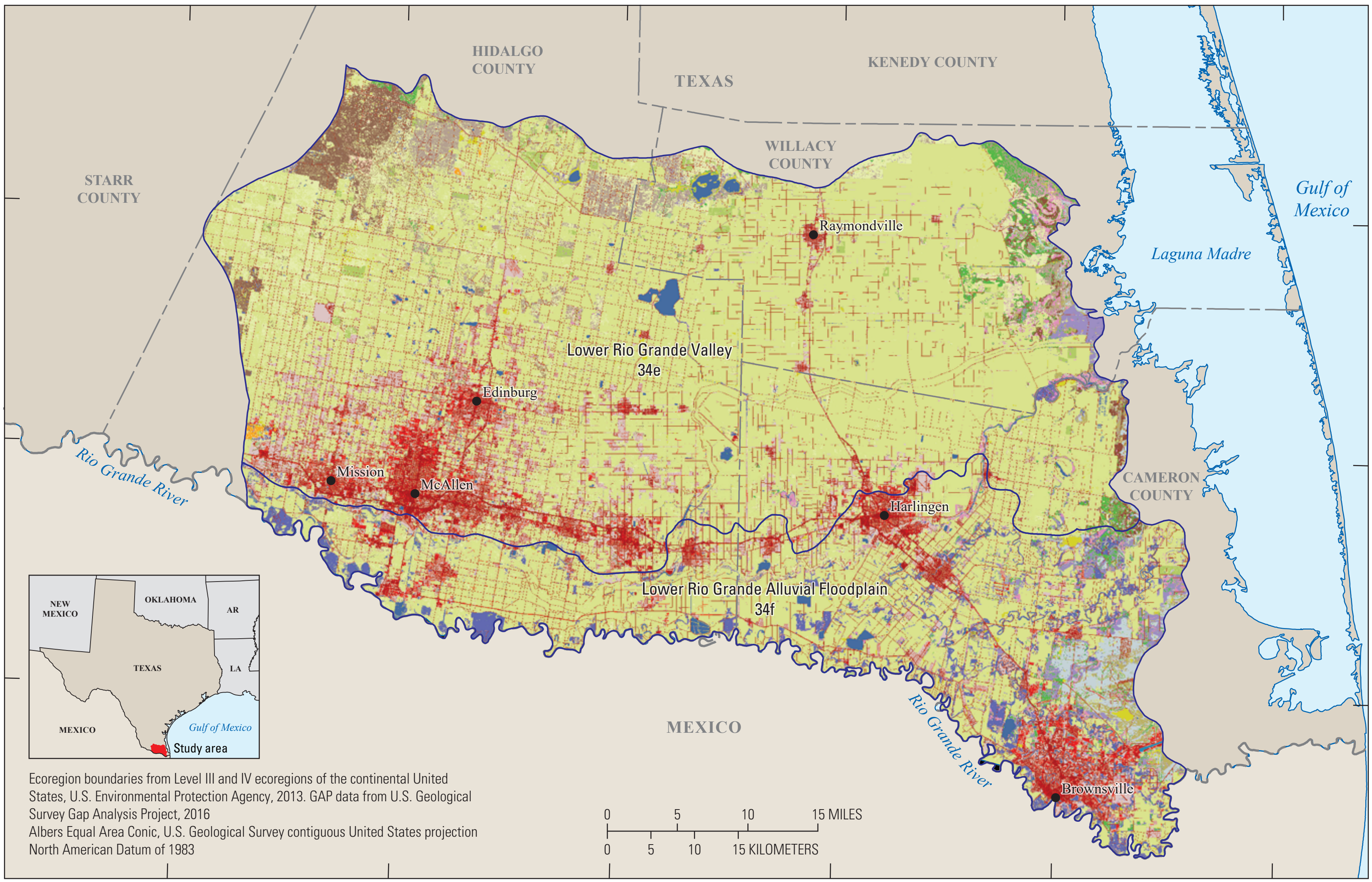
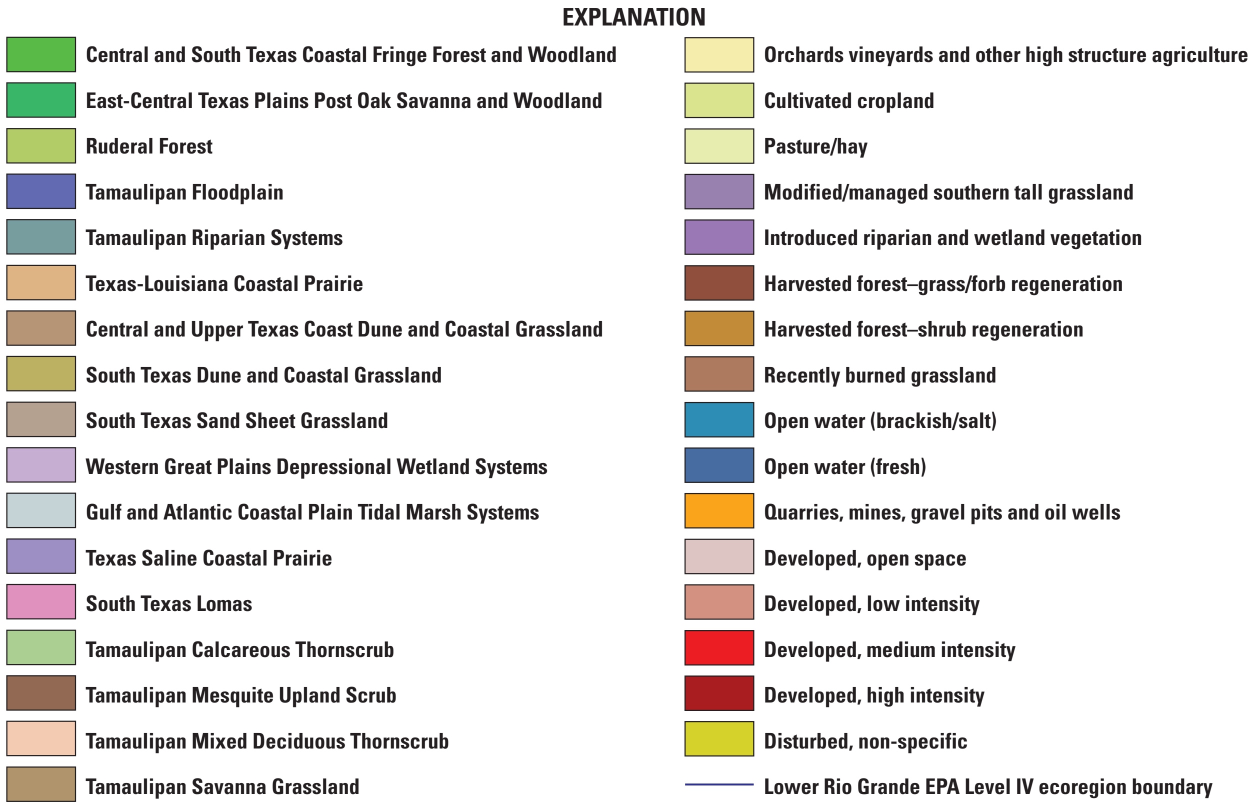


Figure 1. Map of the study area and the two U.S. Environmental Protection Agency (EPA) level IV ecoregions (EPA, 2013) examined—the Lower Rio Grande Valley (34e) and the Lower Rio Grande Alluvial Floodplain (34f). Ecological systems or land use classes according to the U.S. Geological Survey Gap Analysis Project (USGS GAP, 2016) are displayed.



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The northern extent of the LRG is largely covered by mesquite and other shrubs, and the southern extent has lost most of its native palm trees and floodplain forests (Griffith and others, 2007; U.S. Geological Survey Gap Analysis Project [USGS GAP], 2016) (fig. 1). The less-developed areas of the LRG Valley are primarily grassland, mesquite, and thornscrub (USGS GAP, 2016). The LRG Floodplain includes wet-mesic scrub forest, tidal marsh, and saline prairie (USGS GAP, 2016). The Rio Grande, which runs from south-central Colorado to the Gulf of Mexico, forms a natural border with Mexico within the study area; however, its water is mostly diverted for urban use and agricultural irrigation, such that little flow reaches the Gulf of Mexico (Griffith and others, 2007). Protected areas in the study area provide for recreation, wildlife habitat, butterfly migration, and avian stopovers that are an important part of the Central and Mississippi flyways (Griffith and others, 2007).

The LRG is a region of high-value agricultural crops including cotton, grain sorghum, pecans, citrus, sugar cane, vegetables, and melons that have an annual economic impact greater than $1 billion (Texas Water Resources Institute [TWRI], 2012). Agriculture in the drought-prone region requires as much as 85 percent of the area's water for irrigation, with an increasing share of water resources likely going to future urban growth demands (TWRI, 2012). Urban land development and periodic freezes have diminished the extent and importance of orchards and other cropland in the study area (Knight, 2009).

Methods

A data aggregation, validation, and attribution (AVA) approach (Drummond and others, 2015) was used in the analysis. The approach involved combining available sources of spatial data to create a refined, spatially explicit analysis of landscape change and facilitate the identification of proximate land-use and natural-disturbance causes of change.

Spatial data, including LULC maps and satellite imagery, are increasingly available at the national level and at multiple time steps. To take advantage of this accessibility, the AVA approach combined several thematic LULC change datasets to develop a final dataset. During the analysis, the data were further validated and attributed with land use information using a combination of spatial analysis, decision trees, and manual verification. The characteristics of landscape change were then compiled and summarized using EPA level IV ecoregions (EPA, 2013).

This AVA algorithm was used to step through a series of decisions to identify the type, reliability, and proximate cause of changes to LULC. Changes in LULC that were corroborated by agreement between two or more datasets were labelled as validated. The remaining unvalidated changes or those from only a single data source were analyzed using manual interpretation techniques, primarily by comparing the area of unvalidated change to high-resolution orthoimagery to determine if the change occurred. LULC datasets produced to date with this approach have an overall accuracy level of 95 percent. The algorithm methods and data are standardized and described in detail in Drummond and others (2015).

The causes of change were divided into three broad categories to aid the interpretation of the types of land change processes occurring in the study area: (1) replacement processes that resulted in the conversion of prior LULC due to built-up land uses and land clearance; (2) recurrent processes that were primarily the result of natural disturbance but included cyclical water reservoir drawdown caused by human action; and (3) recovery processes such as land reclamation, tree planting, and other human activities that resulted in recovery of prior ecological or aesthetic function. The spatial data and metadata with a full description of the methodology are available in the data release associated with this report, "Data release for land-use and land-cover change in the Lower Rio Grande ecoregions, Texas (2001 to 2006 and 2006 to 2011 time intervals)" (Drummond and others, 2024).

Findings—Summary of Land-Use and Land-Cover Change in the Lower Rio Grande Ecoregions

Land-cover totals are summarized for each of the Lower Rio Grande (LRG) ecoregions in table 1. The largest absolute changes between 2001 and 2011 occurred in agriculture (pasture/hay and cultivated crops land-cover types), which decreased by 11,022 ha. Within the agricultural classes between 2001 and 2011, cultivated crop cover decreased by 2.7 percent and pasture/hay lands decreased by 3.9 percent. Developed land cover (low-, medium-, and high-intensity developed and open space) also had a large change, increasing by approximately 9,966 ha. Within the developed classes, open space increased by 8 percent, and all other developed classes increased by 10.1 percent. Other land-cover changes included a 2.9 percent (1,777 ha) increase in shrubland, a 4.6 percent (−1,221 ha) decrease in grassland, and a 1 percent (−207 ha) decrease in wetland types. Temporal land-cover change for a portion of the LRG is shown in figure 2.

The spatial location and causes of land-use and land-cover change are shown in figure 3. For the combined 2001 to 2006 and 2006 to 2011 time intervals, identified replacement processes (13 total) affected 13,748 ha (table 2). Recurrent processes (five total) affected 2,196 ha. Recovery processes (seven total) affected 5,057 ha.

Urban growth was the most extensive type of change in the study area and increased by 9.4 percent between 2001 and 2011 (table 1). The study identified 9,788 ha of new urbanization (table 2). An additional 92 ha were cleared for urbanization in the 2006 to 2011 time-interval. A total of 1,518 ha of urban intensification between 2001 and 2011 are primarily infill within the existing urban area.

Mining reclamation accounted for 315 ha of land recovery (table 2). Expansion of oil and gas pads in the northwest part of the study area is relatively small in total extent but affects a larger area as part of a development network of roads and site pads (fig. 3).

When considering land-cover conversions greater than 100 ha, more than 3,500 ha were converted from agricultural land cover (pasture/hay and cultivated crops cover types) to natural cover types (grassland/herbaceous, shrub/scrub, and barren land) through processes of habitat recovery (table 3). Most of the land-cover conversion to development occurred on former agricultural land.

Table 1. Land-cover types and approximate extent of change in hectares for the Lower Rio Grande (LRG) ecoregions for years 2001–2011.

Land-cover type	Area (hectares)			Change in area (hectares)		
	2001	2006	2011	2001–2006	2006–2011	2001–2011
LRG Valley (34e)						
Open water	3,115	2,968	3,123	−147	155	8
Developed, open space	26,499	27,980	28,626	1,481	646	2,127
Developed, low intensity	26,230	27,595	28,363	1,365	768	2,133
Developed, medium intensity	11,393	12,169	12,904	776	735	1,511
Developed, high intensity	3,014	3,289	3,660	275	371	646
Barren land	3,319	3,720	3,897	401	177	578
Deciduous forest	946	920	907	−26	−13	−39
Evergreen forest	269	266	266	−3	0	−3
Mixed forest	193	188	187	−5	−1	−6
Shrub/scrub	42,285	41,957	43,534	−328	1,577	1,249
Grassland/herbaceous	16,958	16,703	16,759	−255	56	−199
Pasture/hay	54,461	53,275	52,617	−1,186	−658	−1,844
Cultivated crops	227,554	225,217	221,437	−2,337	−3,780	−6,117
Woody wetlands	3,978	3,964	3,965	−14	1	−13
Emergent herbaceous wetlands	4,327	4,329	4,298	2	−31	−29
LRG Floodplain (34f)						
Open water	3,974	4,005	4,087	31	82	113
Developed, open space	9,727	10,266	10,519	539	253	792
Developed, low intensity	16,406	17,239	17,872	833	633	1,466
Developed, medium intensity	10,070	10,471	10,957	401	486	887
Developed, high intensity	2,346	2,487	2,750	141	263	404
Barren land	1,892	1,879	1,960	−13	81	68
Deciduous forest	2,389	2,370	2,359	−19	−11	−30
Evergreen forest	150	150	184	0	34	34
Mixed forest	349	344	337	−5	−7	−12
Shrub/scrub	18,228	17,918	18,756	−310	838	528
Grassland/herbaceous	9,369	9,200	8,347	−169	−853	−1,022
Pasture/hay	13,250	12,812	12,448	−438	−364	−802
Cultivated crops	77,438	76,509	75,179	−929	−1,330	−2,259
Woody wetlands	8,676	8,641	8,563	−35	−78	−113
Emergent herbaceous wetlands	3,303	3,276	3,251	−27	−25	−52

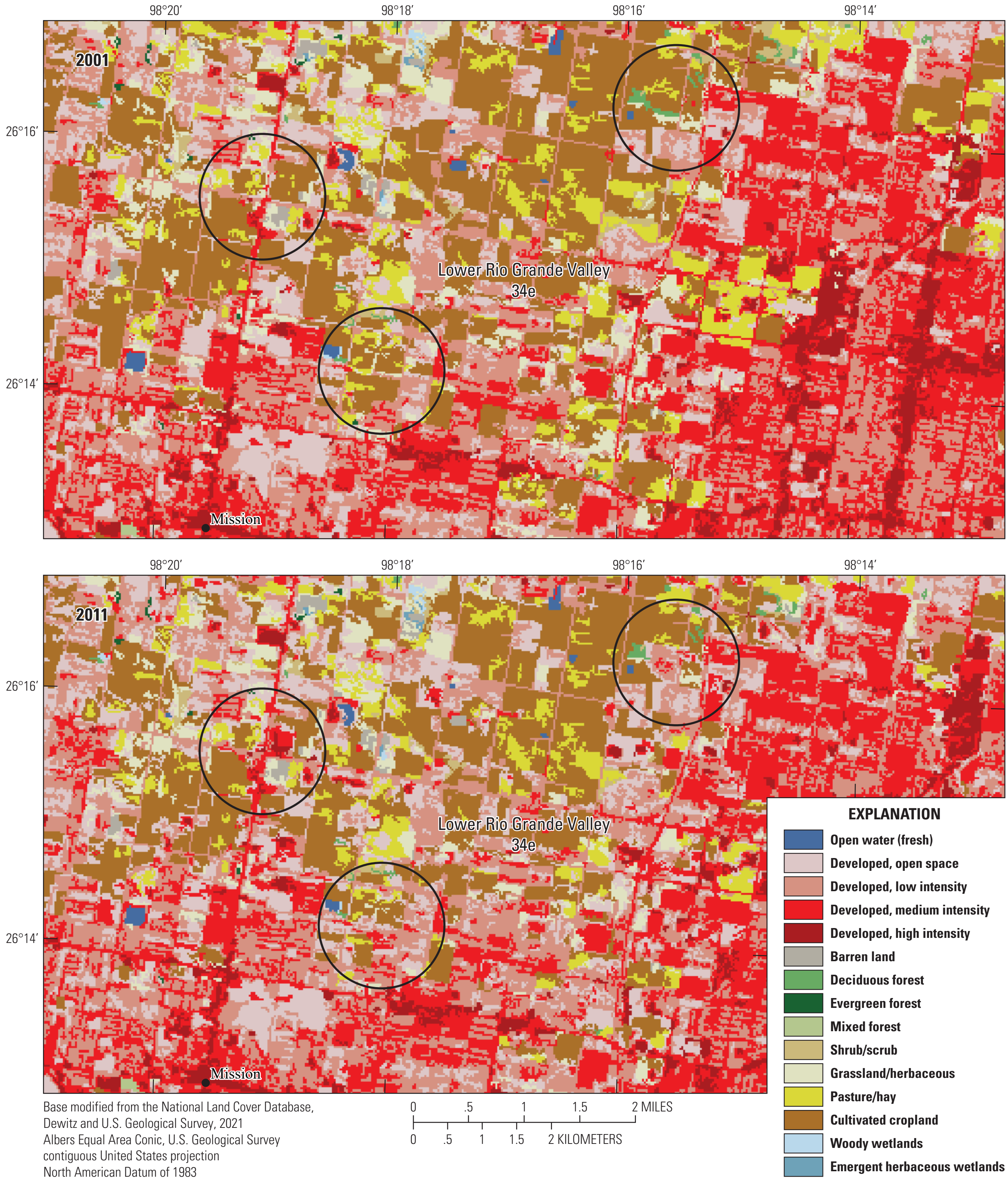

Figure 2. Land cover for an area northeast of Mission, Texas, for the years 2001 and 2011. Black circles highlight examples of the predominant land-cover changes in this portion of the study area—urban area infill and urban expansion at the expense of agricultural land.

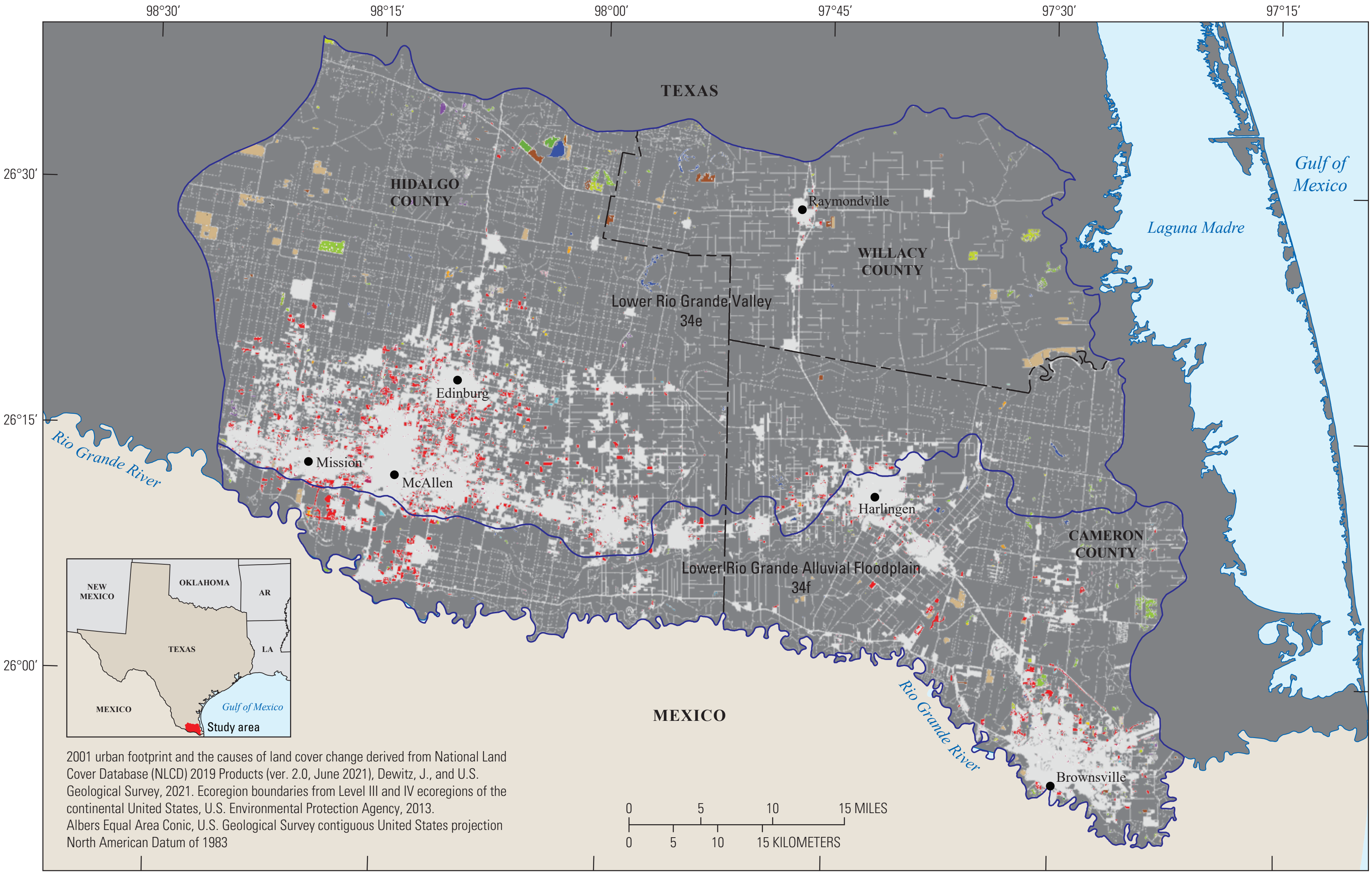

Figure 3. Urban growth and other causes of landscape change in the Lower Rio Grande Valley (34e) and Lower Rio Grande Alluvial Floodplain (34f) between 2001 and 2011.

EXPLANATION

- 2001 urban footprint
- Urban expansion
- Urban in progress
- Urban area infill
- Surficial mining
- Oil and(or) gas pad
- Reservoir construction
- Pasture or hay expansion
- Cropland expansion
- Shrub clearance
- Forest harvest
- Canal construction
- Residential pond construction
- Landfill construction or operation
- Reservoir and lake water level fluctuation
- Cropland flooded
- Wetland fluctuation
- Stream fluctuation
- Shrub encroachment
- Urban land use, abandoned
- In transition to reforestation
- Cropland retired
- Pasture or hay retired
- Managed wetland
- Revegetation, conservation
- Mining reclamation
- Reforestation
- County boundary
- Lower Rio Grande EPA Level IV ecoregion boundary

Figure 3. Urban growth and other causes of landscape change in the Lower Rio Grande Valley (34e) and Lower Rio Grande Alluvial Floodplain (34f) between 2001 and 2011.—Continued

Table 2. Land-use causes and extent of change in hectares for the study area, 2001–2011.

Process	2001 to 2006			2006 to 2011		
	Valley	Floodplain	Total	Valley	Floodplain	Total
Replacement						
Urban expansion	3,743	1,883	5,626	2,591	1,571	4,162
Urban in progress	165	41	206	42	50	92
Urban area infill	350	267	617	618	283	901
Surficial mining	247	32	279	208	85	293
Oil and (or) gas pad	131	4	135	114	0	114
Reservoir construction	8	5	13	55	50	105
Pasture or hay expansion	79	20	99	9	10	19
Cropland expansion	92	2	94	59	44	103
Shrub clearance	124	46	170	381	74	455
Forest harvest	21	16	37	58	12	70
Canal construction	0	7	7	1	0	1
Residential pond construction	0	0	0	0	1	1
Landfill construction or operation	0	0	0	80	69	149
Replacement process totals	4,960	2,323	7,283	4,216	2,249	6,465
Recurrent						
Reservoir and lake water level fluctuation	441	51	492	286	50	336
Cropland flooded	6	0	6	0	0	0
Wetland fluctuation	0	0	0	0	6	6
Stream fluctuation	0	16	16	0	6	6
Shrub encroachment	50	17	67	682	585	1,267
Recurrent process totals	497	84	581	968	647	1,615
Recovery						
Revegetation, conservation	0	0	0	214	0	214
Mining reclamation	100	5	105	176	34	210
Reforestation	0	0	0	6	41	47
In transition to reforestation	0	0	0	34	139	173
Cropland retired	757	156	913	2,123	557	2,680
Pasture or hay retired	440	28	468	163	67	230
Managed wetland	0	0	0	6	11	17
Recovery process totals	1,297	189	1,486	2,722	849	3,571

Table 3. Total study area land-use and land-cover conversions for 2001–2006 and 2006–2011, for conversions greater than 100 hectares (ha).

Land-use and land-cover conversion	Area (ha)
Years 2001 to 2006	
Cultivated crops to developed, open space	1,252
Cultivated crops to developed, low intensity	1,079
Pasture/hay to developed, open space	671
Pasture/hay to developed, low intensity	486
Cultivated crops to grassland/herbaceous	426
Cultivated crops to developed, medium intensity	375
Grassland/herbaceous to developed, open space	315
Developed, open space to developed, medium intensity	311
Grassland/herbaceous to developed, low intensity	304
Shrub/scrub to developed, open space	287
Pasture/hay to developed, medium intensity	240
Shrub/scrub to grassland/herbaceous	177
Grassland/herbaceous to developed, medium intensity	175
Developed, open space to developed, low intensity	172
Open water to barren land	172
Grassland/herbaceous to barren land	141
Shrub/scrub to developed, low intensity	138
Developed, open space to developed, high intensity	138
Cultivated crops to developed, high intensity	109
Pasture/hay to shrub/scrub	106
Years 2006 to 2011	
Cultivated crops to shrub/scrub	1,780
Grassland/herbaceous to shrub/scrub	1,434
Cultivated crops to developed, open space	938
Cultivated crops to grassland/herbaceous	906
Cultivated crops to developed, low intensity	814
Shrub/scrub to grassland/herbaceous	513
Developed, open space to developed, medium intensity	419
Cultivated crops to developed, medium intensity	375
Pasture/hay to developed, open space	297
Pasture/hay to developed, low intensity	275
Developed, open space to developed, low intensity	260
Developed, open space to developed, high intensity	231
Grassland/herbaceous to developed, low intensity	227
Pasture/hay to shrub/scrub	211
Grassland/herbaceous to developed, open space	202
Cultivated crops to developed, high intensity	201
Developed, low intensity to developed, open space	190
Grassland/herbaceous to barren land	183
Barren land to open water	180
Shrub/scrub to barren land	176
Cultivated crops to barren land	159
Grassland/herbaceous to developed, medium intensity	146
Pasture/hay to developed, medium intensity	136
Shrub/scrub to developed, open space	128
Barren land to grassland/herbaceous	118

Conclusion

Examination of land-use and land-cover (LULC) change in the Lower Rio Grande Valley and Alluvial Floodplain ecoregions in southern Texas between 2001 and 2011 using the data aggregation, validation, and attribution approach to LULC analyses allowed identification of the types of LULC change and the causes of land conversion. The study gave equal focus to not only land-cover change from habitat loss but also to identification of the processes of recovery to natural land cover. Understanding of the processes of landscape recovery in urbanizing ecoregions, along with habitat loss, may be beneficial to habitat management and policy.

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