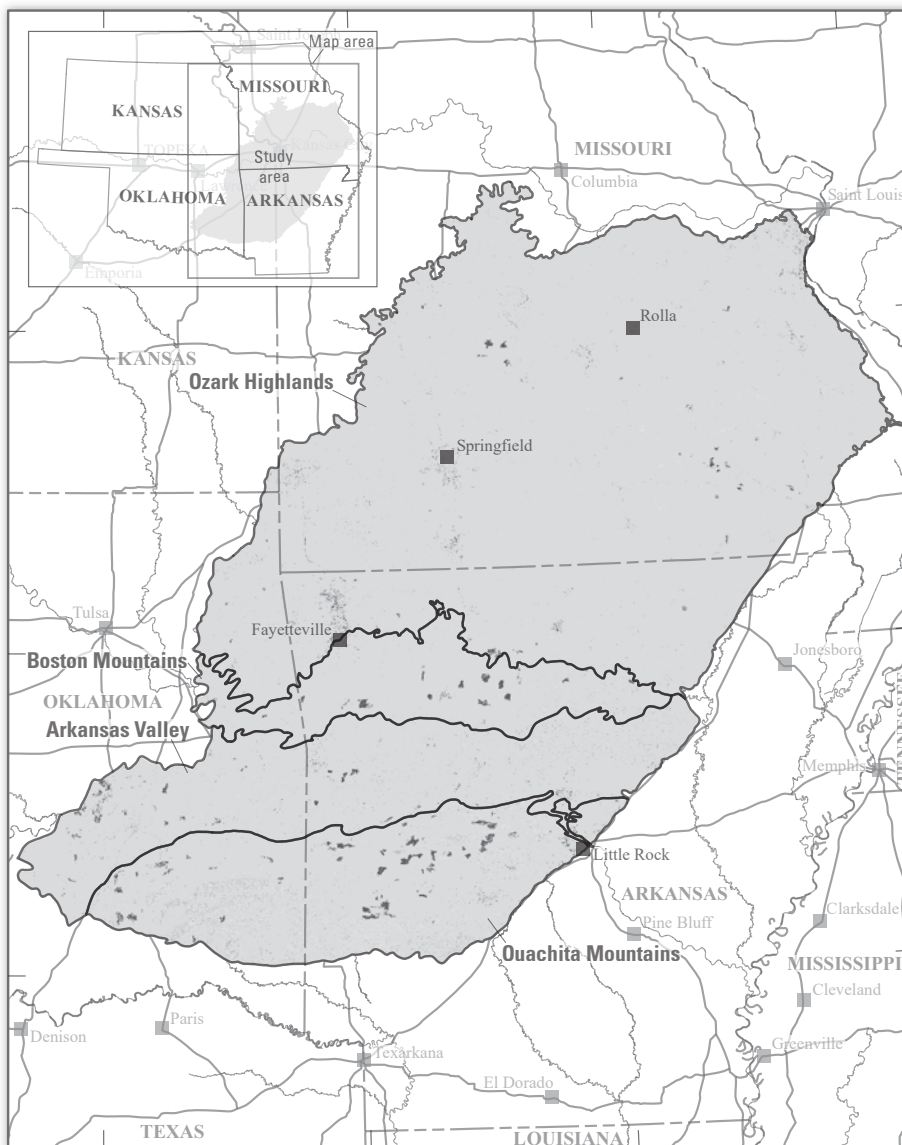


## Causes of Land Change in the U.S. Interior Highlands, 2001–2011



Data Series 1127

**Cover image:** A portion of the map (included as figure 1 in this report) showing the causes of land change from 2001 through 2011 in the U.S. Interior Highlands region.

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By Mark A. Drummond, Michael P. Stier, Jamie L. McBeth, Roger F. Auch,  
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Data Series 1127

**U.S. Department of the Interior**  
**U.S. Geological Survey**

**U.S. Department of the Interior**  
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James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2020

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Suggested citation:

Drummond, M.A., Stier, M.P., McBeth, J.L., Auch, R.F., Taylor, J.L., and Riegler, J.L., 2020, Causes of land change in the U.S. Interior Highlands, 2001–2011: U.S. Geological Survey Data Series 1127, 4 p., <https://doi.org/10.3133/ds1127>.

Associated data for this publication:

Drummond, M.A., Stier, M.P., McBeth, J.L., Riegler, J.L., Auch, R.F., and Taylor, J.L., 2019, Data release for the land change causes for the United States Interior Highlands (2001 to 2006 and 2006 to 2011 time intervals): U.S. Geological Survey data release, <https://doi.org/10.5066/P9W4SF05>.

ISSN 2327-638X (online)

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## Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
Length		
yard (yd)	0.9144	meter (m)
Area		
acre	0.4047	hectare (ha)

International System of Units to U.S. customary units

Multiply	By	To obtain
Length		
meter (m)	1.094	yard (yd)
Area		
hectare (ha)	2.471	acre



# Causes of Land Change in the U.S. Interior Highlands, 2001–2011

By Mark A. Drummond,<sup>1</sup> Michael P. Stier,<sup>2</sup> Jamie L. McBeth,<sup>3</sup> Roger F. Auch,<sup>4</sup> Janis L. Taylor,<sup>5</sup> and Jodi L. Riegler<sup>2</sup>

## Abstract

The causes of land change from 2001 through 2011 for the Interior Highlands region of the south-central United States were assessed using satellite imagery, historical land-use and land-cover data, and digital orthophotos. The study was designed to develop improved regional land-use and land-cover change information, including identification of the proximate causes of change. The four leading causes of land change involved various stages of forest change: harvest (376,497 hectares), reforestation (105,150 hectares), stand loss to fire (98,875 hectares), and thinning (54,029 hectares). The study provides baseline spatial data for understanding human and ecological dynamics in the region. The spatial data, including metadata, are available in the data release associated with this report at <https://doi.org/10.5066/P9W4SF05>.

## Introduction

The causes of land change from 2001 through 2011 in the Interior Highlands region of the south-central United States were assessed using satellite imagery, historical land-use and land-cover data, and digital orthophotos. The assessment developed estimates of the extent, type, location, direction, and proximate cause of changes in the following four ecological regions (ecoregions) of the Interior Highlands: Ozark Highlands, Boston Mountains, Arkansas Valley, and Ouachita Mountains (fig. 1). The study provides baseline spatial data for understanding human and ecological dynamics in the region.

The low mountains and plateaus of the Interior Highlands extend across parts of Missouri, Kansas, Oklahoma, and Arkansas, covering approximately 17.5 million hectares. Vegetation cover is primarily temperate broadleaf forest, including oak (*Quercus* spp.) and hickory (*Carya* Nutt. spp.), mixed with pine (for example, shortleaf pine, *Pinus echinata* Mill.) and areas of eastern red-cedar (*Juniperus virginiana* L.) (U.S. Department of Agriculture, Forest Service, 1999; Chastain and others, 2006). Grassland glades are a major element of the biological diversity of the region, but they have been invaded by trees and shrubs, including the eastern red-cedar, owing largely to historical fire suppression and human disturbance (Chastain and others, 2006; Miller and others, 2017). The dominant historical changes to forest cover were timber harvest, reforestation, and land clearance for pasture and cropland (Karstensen, 2009, 2010; Auch and Karstensen, 2015). Examination of the Interior Highlands causes of land change data for 2001 through 2011 for the Ozark Highlands and Arkansas Valley ecoregions show substantial agricultural land use, whereas the Ouachita Mountains ecoregion has a large amount of industrial silviculture and timber harvest activity.

## Methods

The study was designed to develop enhanced regional land-use and land-cover change information with an emphasis on identifying the proximate causes of change. A proximate cause is defined as a specific local action that is the explanation for a change in land use or land cover. The approach involved aggregating numerous historical spatial data sources to assess the amount and cause of change (Drummond and others, 2019). During the analysis, areas of change were validated and attributed with a land-use classification using the available spatial data supplemented with manual interpretation of aerial photos when necessary. The type and extent of change were considered validated if corroborated with two or more datasets. All other potential changes without corroboration were verified using manual interpretation techniques, primarily by comparing the area of prospective change to high-resolution orthoimagery to

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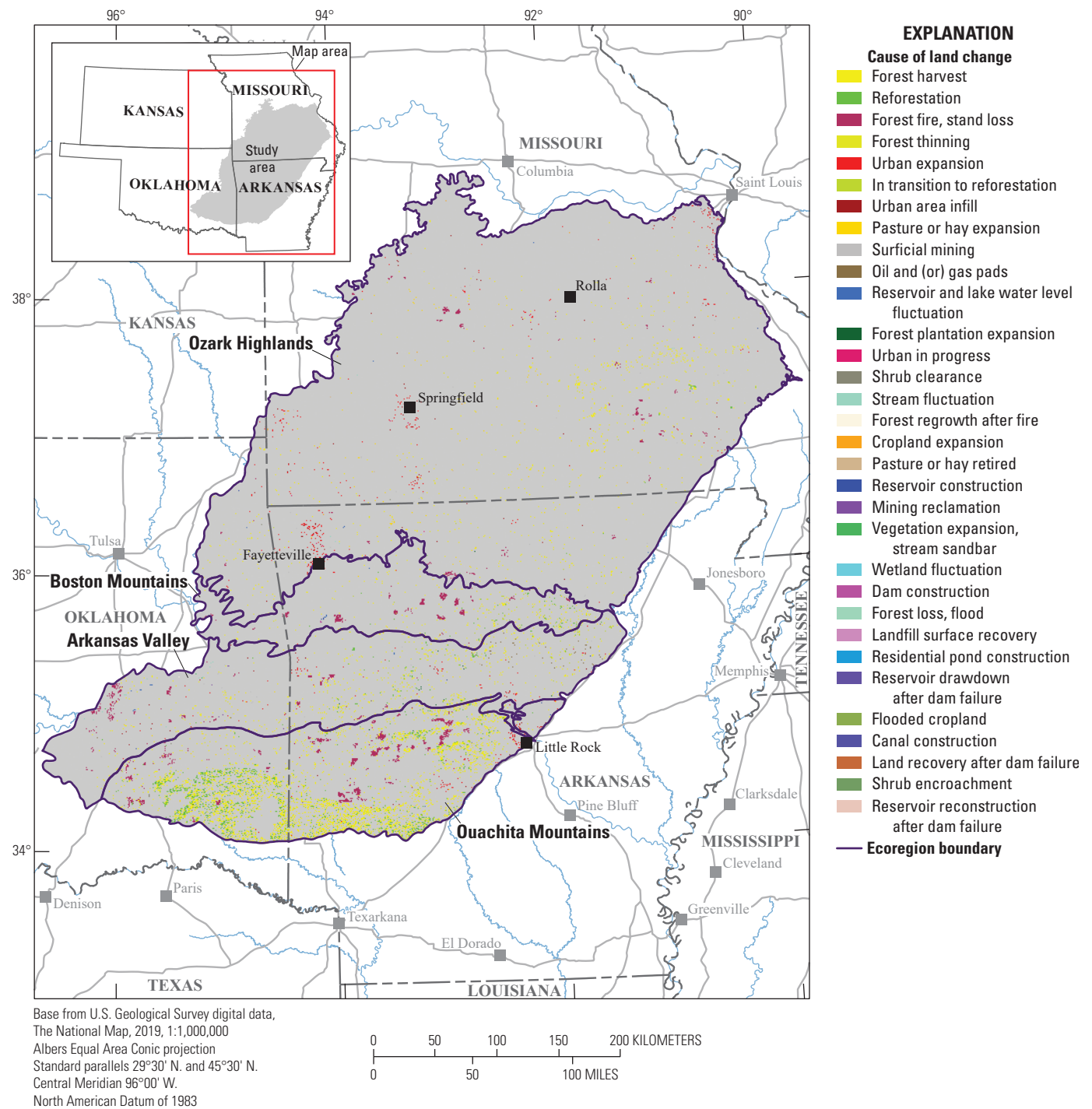
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<sup>5</sup>Stinger Ghaffarian Technologies, Inc., under contract to the U.S. Geological Survey.

## 2 Causes of Land Change in the U.S. Interior Highlands, 2001–2011



**Figure 1.** The causes of land change from 2001 through 2011 in the U.S. Interior Highlands region. The map also shows the extent of the four U.S. Environmental Protection Agency-defined ecological regions (ecoregions) examined—Ozark Highlands, Boston Mountains, Arkansas Valley, and Ouachita Mountains (U.S. Environmental Protection Agency, 2018). The study area covers approximately 17.5 million hectares that encompass parts of Missouri, Kansas, Oklahoma, and Arkansas, including the cities of Springfield, Missouri; Rolla, Missouri; Fayetteville, Arkansas; and Little Rock, Arkansas. Data are from Drummond and others (2019).



determine if a change had occurred. Because the historical data had various spatial resolutions, final interpretations were assigned to the National Land Cover Dataset 30-meter (m) digital pixels (Drummond and others, 2015, 2017, 2019; Homer and others, 2015). The results were compiled and summarized by U.S. Environmental Protection Agency Level III ecoregions (U.S. Environmental Protection Agency, 2018). Some fine-scale changes, such as incremental shrub

invasion of grassland glades, could be underrepresented at the 30-m scale. The causes of land change data shown in [figure 1](#) and [table 1](#), the land-use classification system, and the metadata with a full description of the methodology are available in the data release associated with this report, “Data release for the land change causes for the United States Interior Highlands (2001 to 2006 and 2006 to 2011 time intervals)” (Drummond and others, 2019).

**Table 1.** The causes and extent of land change from 2001 through 2011 for the Interior Highlands region of the United States.

[Data are from Drummond and others (2019). —, less than 0.05 percent]

Rank	Cause of land change	Change (in hectares)	Percentage of total change
1	Forest harvest	376,497	50.7
2	Reforestation	105,150	14.2
3	Forest fire, stand loss	98,875	13.3
4	Forest thinning	54,029	7.3
5	Urban expansion	45,594	6.1
6	In transition to reforestation	18,282	2.5
7	Urban area infill	14,438	1.9
8	Pasture or hay expansion	12,021	1.6
9	Surficial mining	3,516	0.5
10	Oil and (or) gas pad	3,087	0.4
11	Reservoir and lake water level fluctuation	2,219	0.3
12	Forest plantation expansion	1,550	0.2
13	Urban in progress	1,277	0.2
14	Shrub clearance	1,133	0.2
15	Stream fluctuation	1,098	0.1
16	Forest regrowth after fire	764	0.1
17	Cropland expansion	564	0.1
18	Pasture or hay retired	527	0.1
19	Reservoir construction	473	0.1
20	Mining reclamation	421	0.1
21	Vegetation expansion, stream sandbar	283	—
22	Wetland fluctuation	84	—
23	Dam construction	71	—
24	Forest loss, flood	69	—
25	Landfill surface recovery	28	—
26	Residential pond construction	23	—
27	Reservoir drawdown after dam failure	21	—
28	Flooded cropland	17	—
29	Canal construction	12	—
30	Land recovery after dam failure	12	—
31	Shrub encroachment	8	—
32	Reservoir reconstruction after dam failure	8	—
<b>Total amount of change</b>		<b>742,150</b>	<b>100</b>

## Findings—Summary of the Causes of Land Change in the Interior Highlands

The assessment data show a total of 32 proximate causes of land change for the period from 2001 through 2011, which affected 742,150 hectares (fig. 1; table 1). For example, forest harvest was the most extensive cause, affecting 376,497 hectares, which is more than one-half (50.7 percent) of the total amount of change in the Interior Highlands (table 1). The four leading causes of land change involved various stages of forest change: harvest (376,497 hectares), reforestation (105,150 hectares), stand loss to fire (98,875 hectares), and thinning (54,029 hectares). Urban expansion affected 45,594 hectares. Land clearance for pasture or hay expansion affected 12,021 hectares, and an additional 564 hectares were cleared for cropland expansion. Shrub encroachment into grassland and reservoir reconstruction after a dam failure each affected 8 hectares and were the least significant causes of change. The results will contribute to studies of cumulative effects of the many different causes of land change on regional ecological systems.

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Publishing support provided by the Science Publishing Network, Denver and Reston Publishing Service Centers  
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